Soils and Land Use in the Beenleigh–Brisbane Area, South-eastern Queensland

G. G. Beckmann

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By G. G. Beckmann*

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Summary

A reconnaissance survey has been made of about 400 sq miles of the mainland section of the area covered by the Beenleigh and Brisbane 1-mile military maps. The soils of the district, which are derived from sedimentary and metamorphic sedimentary rocks, basalt, and alluvium, are described and their behaviour under land use is discussed. Twenty-six associations of the great soil groups present have been mapped and described. Chemical data of significance to agriculture are presented for the major soils.

The soils of the district are generally of low fertility, most being deficient in all the major plant nutrients. Amounts of "available" phosphorus are low in all soils except in certain soils on alluvium, and reserves of phosphorus are also low. Satisfactory levels of potassium are found only in certain of the podzolic soils on shale, in some of the soils on alluvium, and in certain of the soils on basalt. Nitrogen levels are low to very low in almost all the soils except those on basalt. Trace element deficiencies have also been found in certain of the soils.

The soils occupying the greatest area are various podzolic soils, including red-yellow podzolics, lateritic podzolics, grey podzolics, and meadow podzolics. These are generally low in most nutrients and, with the exception of the lateritic podzolics, have poor physical properties. The soils most common in areas used for horticulture and agriculture at present (including red earths, krasnozems, some of the dark clay soils on basalt, alluvial soils, and humic gleys) also have low nutrient contents but have fair to good physical properties. These soils have proved highly productive under good management but occupy only a small proportion of the area. Much of the district, though very close to the city of Brisbane, is still undeveloped and only a small portion is being used for horticulture, dairying, or agriculture (particularly sugar-cane growing), even though the annual rainfall is moderate and slopes are often moderate to gentle.

Intensive horticulture in this area has been dependent upon underground water of suitable quality for irrigation. Supplies of good underground water seem to be limited mainly to those areas that are most used for crop growing at present. While the underground water found in most of the rest of the area is unsuitable for agriculture, surface storages to hold the high run-offs from moderate to heavy falls which occur during summer may hold sufficient water for some irrigation of the more suitable soils. Only limited expansion in the use of underground and river water on the Logan and Albert Rivers seems possible.

The area of the better soils available for horticultural development is decreasing, so that poorer soils may have to be used in future. If adequate fertilizers are applied and sufficient water is provided, increased production could be maintained on many of these. Sugar-cane production has increased with recent increases in the area of assigned land, but even with increased use of fertilizers, yields per acre are low when compared with those of other cane areas. Dairy production, which is now dominantly of whole milk, is also low. Both these industries would benefit by a programme of agronomic research directed toward their special problems.

* Division of Soils, CSIRO, Cunningham Laboratory, Brisbane.

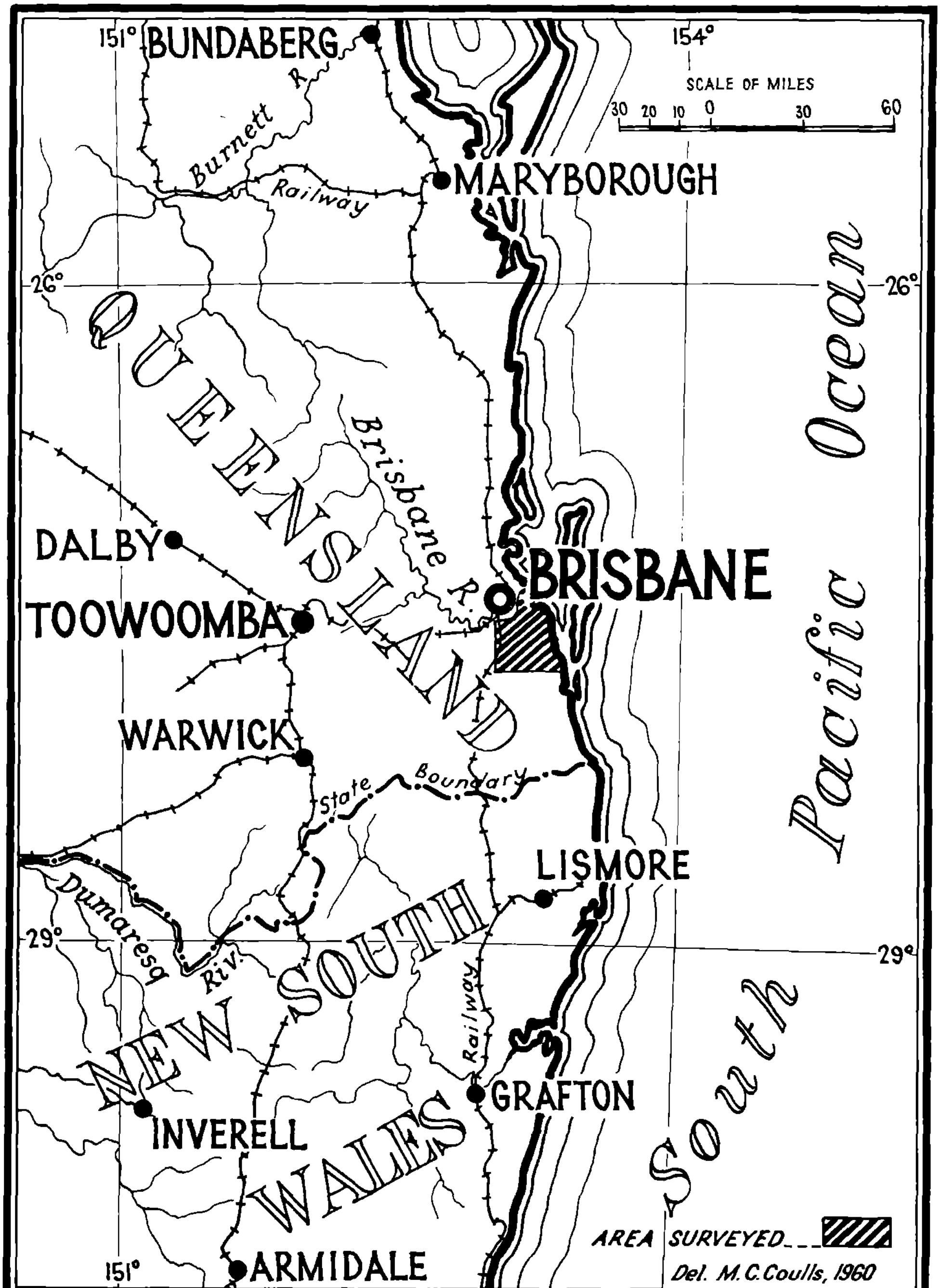

Fig. 1.—Locality plan.

I. Introduction

The Beenleigh–Brisbane area discussed in this report covers the mainland portion of the Beenleigh 1-mile military map sheet (G56/15/193) and that portion of the Brisbane 1-mile military map sheet (G56/15/183) south of the Brisbane River.* It is made up of approximately 400 sq miles of country to the immediate south-east of the city of Brisbane, and includes part of the Greater Brisbane area (Fig. 1). Despite its proximity to the city, the greater part of this district is still under the original eucalypt forest, though much of it has been modified as a result of timber-cutting. Clearing for cultivation of fruit, vegetables, and sugar-cane and for dairying commenced over 100 years ago, but has been largely restricted to the better alluvial soils and to two areas that are dominantly of friable red soils. Extension of farming into the timbered country has taken place only in the last few years with subdivision of parts of it into farmlets.

It is important to know the distribution and extent of soils suitable for development in the vicinity of Brisbane. As some of the limited areas of better soils now producing vegetables and other foodstuffs for the local market are absorbed by urban development, other areas of suitable soils may have to be found locally or poorer soils may have to be utilized, possibly through a programme of fertilization and irrigation.

II. Physical Environment

(*a*) *Geology and Topography*

(i) *Rock Types and Landscape.*—This is an area of generally low relief, consisting of hills 100–400 ft above sea level, with a few peaks such as Mount Cotton and Mount Gravatt (836 and 737 ft high respectively) projecting above the general level (Figs. 2 and 3). The lower hills are of sedimentary, metamorphic, or basaltic rocks, those of metamorphic rock being slightly higher and more rugged. The higher hills are of quartzite.

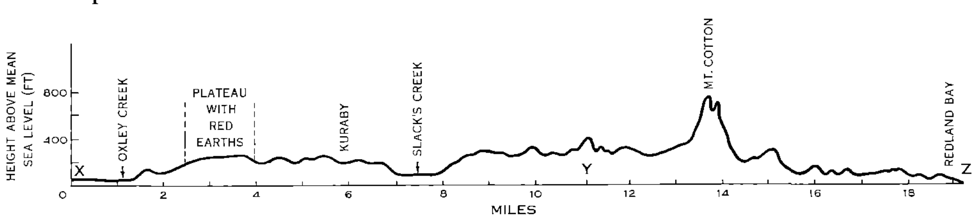

Fig. 2.—Landscape section, X–Y–Z, across Beenleigh area (approx. east–west).

The metamorphic rocks occupy much of the southern, central, and south-western portions of the area and are made up of Palaeozoic geosynclinal sediments of the Neranleigh–Fernvale Group (Marks 1910; Denmead 1928; Belford 1950; Bryan and Jones 1960*a*). The rock type most commonly encountered is greywacke,

* A separate and more detailed investigation has subsequently been carried out in this area. This work consists of a detailed soil survey of 1100 acres with additional soil association mapping in the Runcorn area, a highly developed horticultural district (Thompson and Pangudijatno, unpublished data).

but quartzites, shales, and slates are found also, the finer rocks being more common in the northern part of the area. The quartzite, which is associated with the greywacke as masses up to 1 mile wide, is often manganiferous and may have a banded appearance. Small areas of dark igneous rock, some of which have been referred to as altered basic tuff (Denmead 1928), are found with the quartzite in places, such as near Mount Cotton, and in a few places with the greywacke.

Mesozoic lacustrine sediments of the Ipswich Coal Measures and of the Bundamba Sandstones occur in the west, north-west, and north of the area (Marks 1910; Higginson 1946; Bryan and Jones 1960*b*). The Ipswich Coal Measures are mainly siliceous sandstones with which are interbedded some shales; locally there are some conglomerates. The Bundamba rocks are mainly coarse-grained, massive, siliceous sandstones with some thin beds of shales. There are small areas of the Brisbane Tuff, a welded rhyolitic tuff, in the Ipswich Coal Measures in the central and northern part of the area.

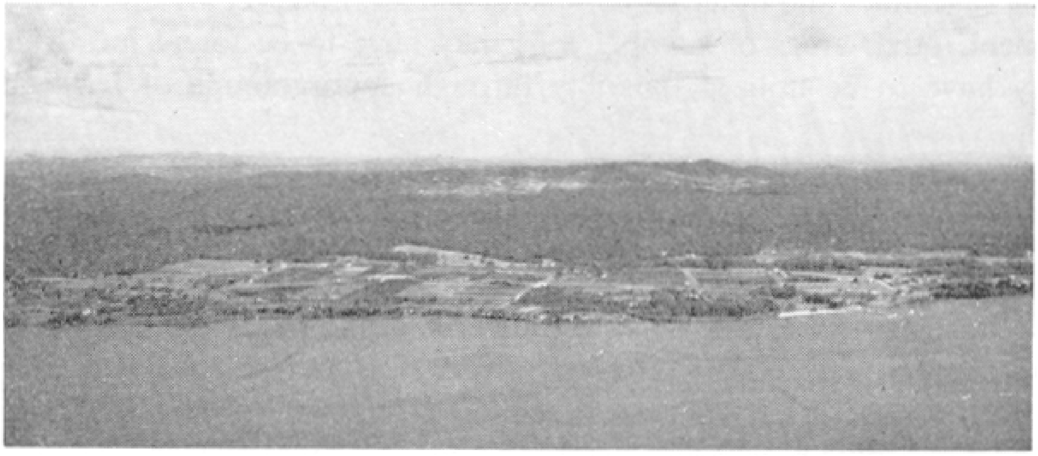

Fig. 3.—Low undulating surface west from Redland Bay; the long ridge of Mount Cotton is in the middle background. The smooth low hills (right) are in sedimentary rocks, while the more rugged of the low hills (left and centre) are in metasediments.

Early Tertiary sediments are restricted mainly to the area from Coopers Plains to Rochedale (Jones 1927; Denmead 1955; McTaggart 1960). The oldest of these lacustrine sediments is the Darra Formation, which in this area is represented by sands and organic clays and shales (McTaggart 1960) with which are some interbedded lenses of basalt. Other basalts overlie the Darra Formation at Archerfield and at Sunnybank and Eight Mile Plains. A sandy group of sediments, the Sunnybank Formation (McTaggart 1960), overlies this basalt at Eight Mile Plains and overlies the Darra Formation at Rochedale and at Acacia Ridge. Basalts of Tertiary age are found in the low hills along the coast from Wynnum to Redland Bay, and there is another small area of basalt at Capalaba.

In the Sunnybank–Rochedale area there is a group of low hills, 100–300 ft high, with flat to very gently sloping crests on which a group of red soils is commonly found. These are the "Red Earth Residuals" of Bryan (1939), and the red soils, some of which contain lateritic* materials, have developed on both the sedimentary and the basaltic rocks. The flat-topped hills appear to be the remnants of a former erosion surface that once occupied much of the area but is indicated now only by the low rounded hills with the few peaks which were hills in the old surface also projecting above them. Lateritic soils have developed also in the coastal basalt area, in the course of the development of the parent materials of the red soils characteristic of it.

Recent unconsolidated alluvium is found along the floors of the valleys of all the major streams and along the coast south from the mouth of the Logan River. The materials of which it is composed range in texture from sands to heavy clays depending on position on the flood-plains and also on their position along the river. This alluvium on most of the streams occurs in two major groups of terraces. On the Logan–Albert system, the higher terrace is usually of clayey material and varies in height from 20 ft above water level near the mouth to about 50 ft above water level in upstream positions such as near Chambers Flat. The lower terraces include a number of banks and depressions and are covered during high floods, small amounts of material being deposited in places. Close to the mouth (near Alberton) the lower terrace is only a few feet above water level, but rises to about 30 ft above water level upstream. On the smaller coastal streams the higher terrace is usually 12–15 ft above the stream and the lower only a few feet above the stream along much of its length. The alluvial plain south of the mouth of the Logan River is made up of a series of broad banks and swampy depressions, the greatest height being little more than 10 ft above sea level. Swampy depressions are found in a few places on the high terraces of the Logan and Albert Rivers and at many places on the younger alluvial plains, especially where they adjoin the higher terraces or fringing hills.

(ii) *Nutrients in Parent Rocks*.—All of the sedimentary materials will have been through at least one cycle of weathering, erosion, and deposition, and many may have been through several such cycles. As a result of this the parent materials of many of the soils will have been progressively reduced in nutrients, those parent materials that may still have moderate amounts being part of the younger alluvium and little-weathered igneous rocks. Since their deposition into their present positions, the metasediments and the Mesozoic and Tertiary sediments have been exposed to further weathering and leaching processes. This has been accentuated and perhaps accelerated by the processes that resulted in the formation of laterite in some soils on an old surface. The sedimentary rocks exposed on younger surfaces below the level of that with laterite may also have been subjected to lateritization in the past and may have suffered the same intense leaching. Even the weathered basalts appear to be lower in nutrients than are many such materials of southern Queensland. This may partly be due to the influence of the lateritizing processes, but may be partly the result of a low level of certain constituents in the unaltered rock.

* "Laterite" is a term used for accumulations of "ironstone", either nodular or vesicular, often associated with red soil materials, and is usually regarded as being the result of long continued and/or intense leaching in association with ground-water movement in the course of which there has been a concentration of hydrated iron oxides and alumina. It is frequently associated with old surfaces of low relief and commonly occurs in a profile consisting of red highly ferruginous material (the "ferruginous zone") overlying a layer of mottled red and grey material (the "mottled zone").

(*b*) *Vegetation*

The area covered by this survey was originally forested. Even now, only a small part, on areas of the more productive soils, has been cleared for agriculture or for dairying. The vegetation of the whole of south-east Queensland has been described in detail by Herbert (1951), and most of the vegetation communities described by him are found in this area. Lists of common species of each community are given in Appendix I.

(i) *Eucalypt Forests.*—Fairly dense eucalypt forest with trees up to 60–80 ft high covers the greater part of the area. These forests are broadly uniform but variations in common species are encountered. The climate is fairly uniform across the area and it is apparent that differences from place to place may be related to microhabitat generally, including parent rock, soil, and drainage. Partial clearing of the forests may have changed the initial proportions of different species. The grass cover in the forests is generally poor, largely wire grasses (*Aristida* spp.) with a mixture of other species. There is a scattered shrub layer also.

(ii) *Vine Woodland.*—This vegetation, which is a reduced form of subtropical rain forest generally associated with lower rainfalls (60 in.) and possibly with lower soil nutrient status, occurs in only a few localities. Examples are found at Mount Cotton, Bahr's Scrub Hill, Yellowwood Hill, and a few other places. These are principally higher hills of quartzite and manganiferous quartzite with which are associated other more weatherable rocks including schists and basic igneous rocks.

(iii) *Tea-tree Forests.*—These are found in freshwater swamps of the coastal plain, on the low alluvial plains of most of the small streams, and in swampy depressions or seepage patches on hill slopes. The most common tree is a paperbark tea-tree, generally *Melaleuca viridiflora.* A variety of other plants are associated with it, including rushes, sedges, and grasses, the species being related to position in the swamp.

(iv) *Salt Marsh.*—Salt marshes are found in depressions in the coastal plain seaward from the freshwater swamps and also on low parts of flood-plains of the Logan River and certain of its tributaries. They are intermittently flooded by spring tides and the plants on them are succulents, such as *Salicornia australis*, with grasses. There is a transition from salt marsh to salt meadow, which is largely made up of salt-water couch, *Sporobolus virginicus.*

(v) *Mangroves.*—These forests are found fringing the coast and along the lower reaches of the rivers, on mudflats that are covered by tides, and where the salinity of the soil is high. They may be extending landward at the present time, in places where drains have allowed salt water to penetrate into swamps.

(*c*) *Climate*

The Beenleigh–Brisbane area is a summer-rainfall area with a mean annual rainfall varying from 38 to 49 in., there being a progressive decrease inland from the coast (Coaldrake and Bryan 1957). The pattern may be altered locally near the peaks which project above the lowland, e.g. the local higher averages at Mount Cotton are related to its higher elevation. The rainfall varies not only with geographical position but also with time. The range in annual rainfall for many of the stations is over 40 in., and the extremes may be encountered in successive years. The data for Mount Cotton and Sunnybank (Fig. 4) suggest that there is a roughly regular pattern in which a series of years of low rainfall is succeeded by a series of years with higher rainfall. This variability in the mean annual rainfall in Queensland has been commented

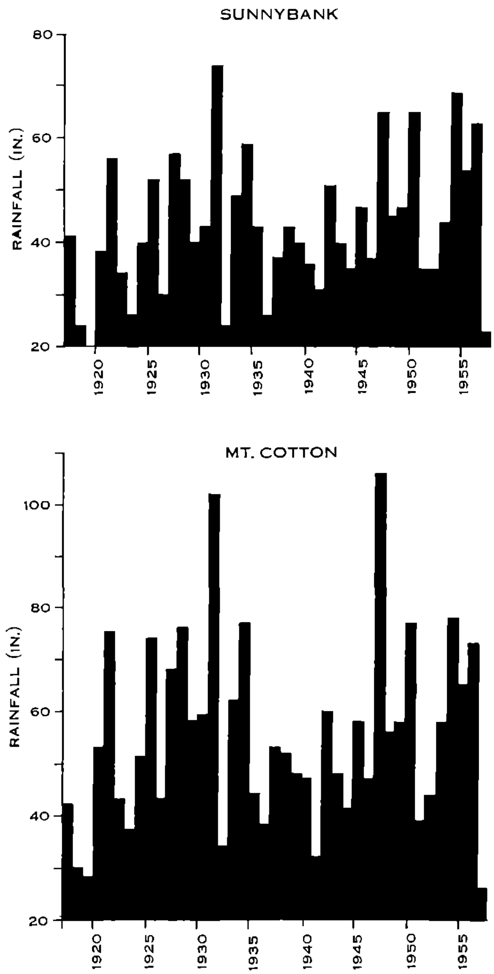

Fig. 4.—Variations in mean annual rainfall at Sunnybank and Mount Cotton for period 1917–58.

on previously by Dick (1958), who concluded that in this district the annual rainfall is commonly 20–25% greater or lower than the mean annual rainfall.

The summer incidence of the rainfall is quite marked, two-thirds of the annual precipitation falling from November to April. January, February, and March are the wettest and July, August, and September the driest months. This is illustrated by data for Brisbane, Oxley, and Manly in Figure 5. The character of the rain at different seasons also varies. Storms are common in early summer and frequent showers or extended periods of heavy rain are common in late summer. In this latter period there is also the possibility of cyclones. The rain during the rest of the year usually falls as showers.

Though there is no distinct dry season in south-eastern Queensland, periods of drought days, i.e. days in which there is no available water in the soil down to 24 in., occur frequently (about one year in two) in either October, November, or December, or in all of these months (Stirk 1963). In most years there is one pronounced drought period of this type of about 6 weeks' duration, although the time at which it occurs is variable.

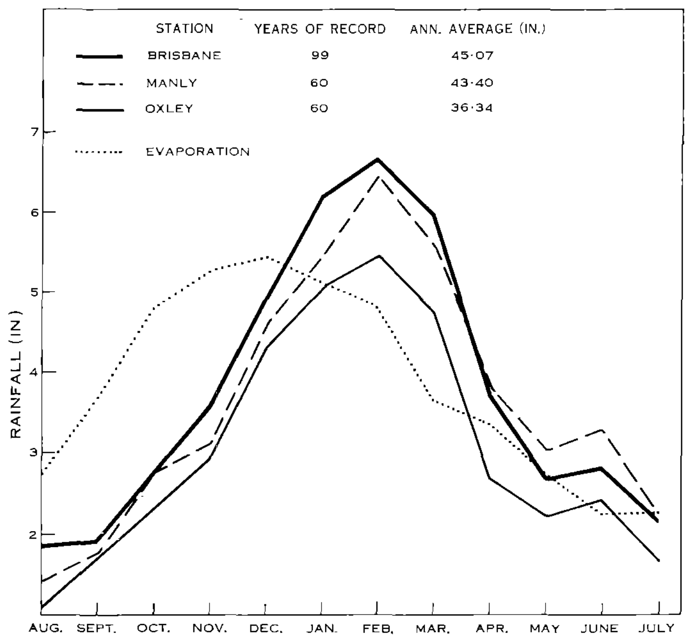

Fig. 5.—Monthly rainfall distribution for selected stations and calculated evaporation for Brisbane.

The temperature range is uniform across the area. Summers are hot (mean max. temp. 83·1°F) and winters are cool (mean min. temp. 52·6°F). A summary of the climate of Brisbane, immediately to the north-west of the area, is presented in Table 1. In this are given temperature, rainfall, humidity, saturation deficit, and derived evaporation data. (The evaporation has been calculated from saturation deficit, using the formula: evaporation = s.d. × 16, after Farmer, Everist, and Moule 1947.) Relating these evaporation figures to those of the seasonal distribution of rainfall, it appears that, especially in the later part of the year, there is on the average an excess of evaporation over rainfall and additions of water will be necessary to maintain the growth of many plants.

TABLE 1

METEOROLOGICAL DATA FOR BRISBANE

		No. of Years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Normal (av.) maximum temperature (°F)		53	85·4	84·5	82·3	78·9	73·6	69·2	68·4	71·2	75·5	79·5	82·4	84·8	78·0
Normal (av.) minimum temperature (°F)		53	69·0	68·4	66·4	61·3	55·6	51·4	48·7	49·9	54·7	60·1	64·2	67·4	59·8
Normal (av.) relative humidity (%)	9 a.m.	53	66	69	72	71	73	73	72	69	64	60	60	62	67
	3 p.m.	53	59	60	60	56	55	54	51	49	51	53	57	56	55
Saturation deficit*		53	0·32	0·30	0·23	0·21	0·17	0·14	0·13	0·17	0·23	0·30	0·33	0·34	0·24
Evaporation†			5·12	4·80	3·68	3·36	2·72	2·24	2·08	2·72	3·68	4·80	5·28	5·44	
Mean annual rainfall (in.)		99	6·19	6·67	5·94	3·69	2·69	2·82	2·14	1·83	1·89	2·74	3·54	4·92	45·07

* Using mean temperature and 9 a.m. humidity figures.

† Calculated as s.d. × 16 (Farmer, Everist, and Moule 1947).

Only low-lying localities, making up a relatively small proportion of the area, are affected by frosts, which may be expected from late June to late August (Foley 1945). Heavy frosts have occurred on the low coastal plain in the south of the area and can be severe enough to kill even tall cane and to retard the growth of bananas. Cold westerly winds occur occasionally during the late winter months and can affect the setting of certain fruit crops, while dry winds in the early summer can also be damaging (Morgan 1950).

(*d*) *Hydrology*

Though the annual rainfall over the whole area is quite good, much of it falls during the summer and plants may suffer moisture stress during the late winter. Even during summer the intensity of falls may be such that considerable quantities of water are lost by run-off, and only a small proportion remains in the soil for the use of plants. Many soils, too, have a low range of available water and constant additions might be needed to maintain a satisfactory rate of growth in some plants.

Little water of satisfactory quality has been obtained from most of the areas of metasediments, but good supplies have been found in the areas of quartzite and associated rocks. The quality of the underground water over much of the area where Mesozoic sedimentary rocks occur is too poor for irrigation. High discharges over slopes during the wet season may, however, be utilized by surface storages to help overcome this lack of usable underground water. Satisfactory supplies of good water are found in the Tertiary basins from Coopers Plains to Rochedale, though the basalt areas here frequently have poor water. Appreciable supplies of good-quality water are obtained in basalts along the coast, and it has been obtained from the alluvial plains of the larger streams and from shallow wells on the coastal plain.

III. Soils

(*a*) *Introduction*

The soils have been mapped as associations of great soil groups, following Stephens's (1962) classification, the identification being based almost exclusively on soil characteristics observed in the field. Where practicable and of possible significance, subgroups have been recognized. Soils that are sufficiently different from any of the established groups have been placed in special tentative groups for the purposes of discussion.

The following descriptions indicate the broad profile form of each group or major subgroup, and include notes on the range of topographic positions in which they are found, the localities at which they are most common, and, very broadly, the proportion of the total area they cover.

(*b*) *Description of Soil Groups*

(i) *Lithosols*.—This term is used here instead of Stephens's (1962) name of "skeletal soils" for such profiles, to emphasize the predominance of rock fragments in the profile. These extremely shallow soils are found on hill crests and steep slopes. They are stony and show little profile development except for some darkening of the surface. Very thin soils (<6 in. thick) on metamorphic rocks may show differentiation into horizons.

Lithosols on greywacke are grey to light brownish grey and vary in texture from sandy or silty loam to loam. The structure is crumb, the units being from $\frac{1}{16}$ to $\frac{1}{8}$ in. in size. The fragments of gravel may include both quartzite and greywacke and may be up to 2 in. in size. These soils are generally 3–8 in. in depth but may be as deep as 16 in. Certain of the loam-textured lithosols that are associated with quartzites range in texture from loam to clay loam, and the colour ranges from grey to brown. These have more quartz gravel (up to 2 in.) than most lithosols with loam textures.

The small areas of lithosols associated with the sedimentary rocks are mainly on conglomerates or coarse sandstones. Those on sandstone are grey or grey-brown, vary in texture from sand to clayey coarse sand, and contain fragments of sandstone. The structure is single-grain and the soil is loose and very permeable.

(ii) *Red-yellow Podzolics.**—This group, which is the most extensive single soil group in the area, is made up of soils with differentiated profiles, i.e. soil with a light-textured poorly structured surface layer clearly separated from a heavier-textured subsoil. The A horizon is composed of structureless sand or clayey sand, or of crumb-structured sandy loam, the actual texture at any place being related to the grain size of the parent rock. There is a change from sand to sandy clay loam in the A horizon of certain soils, particularly those with sandy clay B horizons. The A horizons are dark grey to light brownish grey and do not have the obvious bleaching of the lower A horizons that is characteristic of most podzolic soils. The consistence of this surface material varies considerably with moisture content; when dry it is hard and pulverescent but may become saturated and almost fluid during prolonged wet periods.

The change to the B horizons, which may occur from 3 to 24 in. but which occur in most soils at 10–15 in., is abrupt over $\frac{1}{2}$ in. A great variation in the depth to the top of the B horizon may occur over a few chains. The B horizons are generally mottled yellowish grey and reddish brown with some yellow-brown, but in some profiles they are dominantly reddish brown. The textures are sandy clay to heavy clay and the upper parts commonly have well-developed blocky structure. At greater depths the B horizons are massive (Fig. 6). The depth of the solum varies from 18 to 78 in., but is generally more than 40 in.

Soils of this group are found on almost all the hills of sedimentary and metamorphic rocks, in all positions from crests to lower slopes. A variant with a consistently thin A horizon and a texture change more gradual than normal from the A to the B horizon is found mainly on crests and slopes in the Daisy Hill area. A typical profile has a brownish grey loam surface with a fine granular structure with a change at 2–4 in. to yellowish to brownish grey clay loam. The B horizon, below 4–6 in., consists of light reddish to orange-brown and light grey heavy clay with well-developed blocky structure. This variant is always derived from shale, encountered at about 20 in.

* As here used the term "red-yellow podzolic" includes both the red and yellow podzolics of Stephens (1962), as soils intermediate between the two groups are more common in this area than are soils characteristic of either of his groups.

(iii) *Grey Podzolic*.*—The A horizon of the soils of this group is brownish grey to rather dark greyish brown sandy loam, either weakly blocky or apedal (massive) breaking to single grains. The consistence is brittle and pulverescent when dry, and friable to loose when moderately moist. There is no distinct A_2 horizon and there is a clear boundary between the A and the B horizons at 6–12 in., the B horizon being dark olive-grey or very dark grey-brown heavy clay. The structure of this layer is moderately well-developed blocky ($\frac{1}{2}$ in. units), and the consistence is firm and friable when moderately moist. Lighter-coloured stiff heavy clay is found below 24 in. in some profiles, parent material being entered at 20 to more than 80 in. The parent rock is usually Mesozoic shales or clay, and occasionally greywacke. The sandy horizon is sometimes too coarse to have been derived from the underlying shale, and appears to have been derived from a sandstone layer at a higher level.

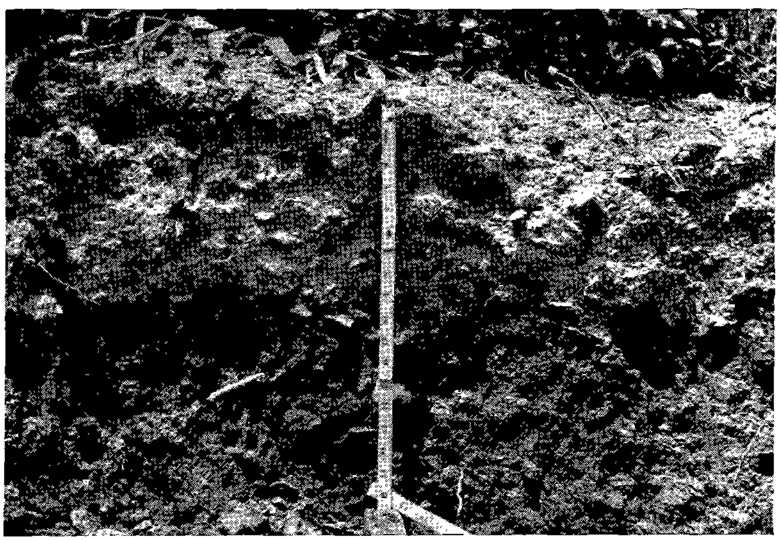

Fig. 6.—Profile of typical red-yellow podzolic soil showing the distinct separation of the light-textured surface horizon and the clay B horizon. (Scale is 18 in. long.)

(iv) *Lateritic Podzolic*.—This is another of the more extensive soil groups and is found on coarser sandstones throughout the area. Though many of its distinctive characters are common to all the soils of this group, there is sufficient profile variation to recognize a number of subgroups.

(1) *Normal Subgroup*.—The surface is brownish grey to dark grey-brown sand, which is loose when dry or moderately moist. Pale yellow to yellow-brown colours appear first from 3–4 in. and are dominant throughout the profiles, a mottle with reddish brown appearing in the clay layer. There is usually a very gradual increase in texture down the profile, through clayey sand or sandy clay loam, to sandy clay

* The term "grey podzolic" is used for this group, as the predominantly grey colours of the B horizon would exclude it from any of the established groups. Stephens's (1962) group of grey-brown podzolics is dominantly yellow-brown in the B and grey-brown in the A horizon.

or heavy clay below 22–54 in. In profiles with a heavy clay subsoil there is commonly a clear boundary between the sand and the clay. Parent sandstone may occur at depths ranging from about 36 in. to more than 80 in.

Ferruginous nodules are generally present in at least low to moderate amounts. They may appear from 6–12 in. but often occur only below 24 in., there being moderate to high amounts in the sandy clay loam and sandy clay layers (Fig. 7). The nodules include true soil nodules and pieces of ferruginous sandstone; in some profiles there are also soft ferruginous segregations up to ½ in. in size, which appear to be rudimentary nodules. There are, nevertheless, some profiles with all the other features of this subgroup but without nodules.

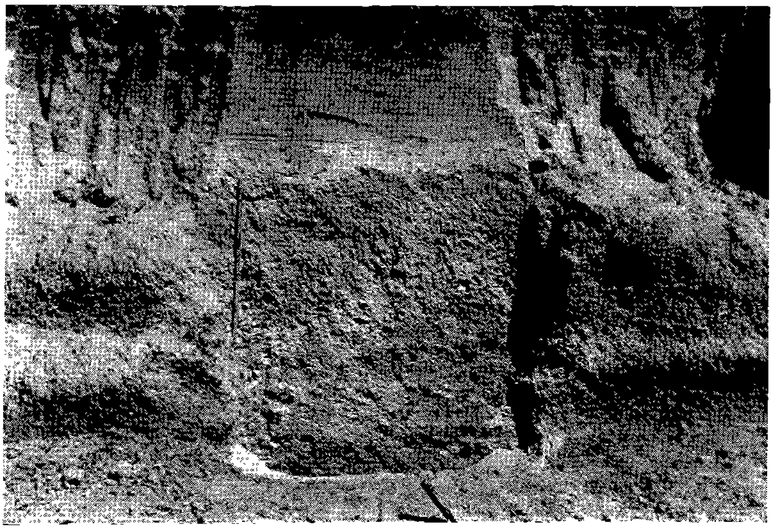

Fig. 7.—Typical profile of a lateritic podzolic soil showing the high concentration of nodules in the lower part of the sandy A horizon. (Scale is 30 in. long.)

(2) *Light-textured Subgroup—Sandy Profiles.*—The soils of this subgroup are light yellow-brown and yellow-grey sand to the depth of the parent rock, which is usually encountered by 60 in. Moderate to high amounts of nodules may occur from 12–18 in.

(3) *Heavy-textured Subgroup.*—These soils have the same colour pattern as the soils of subgroup (1), but the textures at corresponding depths through the profiles are heavier. The texture at the surface is sandy loam, at depths ranging from 6 to 12 in. it is sandy clay loam, and at 12–30 in. it is sandy clay. Stiff heavy clay may appear by 48 in. Small amounts of ferruginous nodules are found from 12 in. and moderate to heavy amounts below 18–24 in.

The soils of all these subgroups are usually associated with the crests and upper slopes of broadly convex hills at heights of at least 100 ft above mean sea level. Only in one or two places are they found on the slopes of low hills at less than 100 ft.

They occur on high points of plateaux at 300 ft above mean sea level over the red earths, among the red earths on plateau surfaces, and occasionally on the upper parts of slopes below them.

(v) *Meadow Podzolics*.—These are poorly drained acid soils with light- to medium-textured surface horizons over grey and yellow-grey clay subsoils, commonly with some ochreous mottle. These are differentiated soils on transported materials and correspond to the low humic gleys of the Beerwah area described by Hubble (1954). The A horizon is grey, slightly lighter in the lower part of the horizon than at the surface. It is almost always sandy loam or silty loam and is usually massive, breaking to fragments or single-grain units. The B horizon, from 10–24 in., is dull-coloured—a mottle of yellow-grey, grey, and yellow-brown. It is composed of silty clay, sandy clay, or heavy clay, and is massive and very firm when moderately moist. There is generally a change to a mottle of light grey, yellowish grey, and red or reddish brown at about 30–36 in., and this material continues to beyond 80 in.

These soils occupy much of the higher terraces of the small creeks between the red soil hills from Cleveland to Redland Bay; they also occur in poorly drained sites on the hills of sedimentary and metamorphic rocks.

(vi) *Yellow Podzolics* (*on Alluvium*).—The soils of this group have developed in mixed sandy clay alluvium of tributaries of the Logan River system deposited during some period of high sea level in the recent past and now forming a terrace.

The yellow podzolics on alluvium make up a variable group of differentiated soils. The A horizon (8–14 in. thick) may be dark grey-brown or light brownish grey silty or fine sandy loam which is massive and may be vesicular. Light yellow-brown loamy fine sand occurs in the subsurface of the sandier profiles and overlies brown sandy light clay at 14 in. The B horizon of the siltier profiles may be as shallow as 8 in., and it is dull yellowish grey medium to heavy clay with weak angular blocky structure. These soils are deeper than 36 in. The most important differences between them and the meadow podzolics are the slightly brighter colours and the better-defined structural units of their B horizons.

(vii) *Red Earth*.—The red earth group includes some of the more important agricultural soils of the district. They are all deep, red, permeable soils with textures ranging from sand to sandy clay. There is generally weak profile differentiation and horizon boundaries are gradational. Ferruginous nodules, in low to high amounts, are common in the B horizon in most profiles, especially below about 36 in.

Two major types of profile occur. In the first, the soil is more or less uniform in texture to a depth of about 6 ft, and consists of red (or red-brown) sandy clay loam or sandy clay which is massive and may be traversed by a few major cracks. The soils of the other type have more distinctly differentiated profiles. The A horizon of these profiles is massive sand or sandy loam; it is grey-brown at the surface grading into yellowish brown or reddish brown below. The B horizon, encountered from about 18 in., consists of red sandy clay or sandy heavy clay. This is generally massive and firm but friable when moist. In a few profiles the clay is weak sub-angular blocky. Few profiles have the mottled deep subsoil found in many krasnozems, and the red clay continues beyond 82 in. with little change of colour.

The soils of this group occur on the gently undulating crests of small plateaux from Rochedale to Acacia Ridge and in the Manly district, and on convex slopes fringing the plateaux. They are usually derived from Early Tertiary sandstones.

(viii) *Krasnozem.*—These soils are deep red, friable, permeable clays with well-developed fine blocky structure. The surface consists of dark brown to dark reddish brown clay loams with well-developed subangular blocky structure. This layer is thin (2–4 in.), the bulk of the profile being red to red-brown medium or heavy clay with fine blocky structure. The dominant aggregates are about ½ in. in size and break readily to finer and more irregular units. The red or red-brown clay may contain ferruginous nodules (sometimes in sufficient amounts to warrant the name "lateritic krasnozem" for the soil) or small pieces of weathered rock. The red colour may continue to 78 in. and beyond, but in the lateritic krasnozems there may be a change to a distinctly mottled light grey and red puggy heavy clay at 48 in. Parent rock has been encountered at this depth also.

The krasnozems have developed on a variety of parent materials—basalt, clay, shale, lateritic clay, and schist. The profile features described above are those of soils on basalt or lateritic clay. The soils on shales, clays, and schists are commonly lighter-coloured than these, but a more important difference is the lighter texture in the upper portion of the profile. The surface is loam or clay loam, the texture increasing to light clay between 3 and 12 in. Both light and heavy clays have been encountered below this depth. Ferruginous nodules occur in some soils on these rocks but in lesser amounts than have been found in soils on basalt or lateritic clays.

Krasnozems are the soils characteristic of the "red soil" area along the coast from Wynnum to Redland Bay, and they are also common in the Eight Mile Plains district. Smaller areas are found throughout all the hills, their occurrence depending on the presence of particular parent rocks.

(ix) *Yellow Clay Soils.*—These soils, which are found at several places downslope from the krasnozems, to which they are broadly similar, vary in thickness from 48 in. approximately to more than 80 in. The surface horizon is dark grey, darkish brown, or yellowish grey clay loam to light clay with fairly well-developed angular blocky or polyhedral structure. This layer is firm and friable when moderately moist. Yellowish grey to olive-grey or yellow-brown heavy clay with subangular blocky or angular blocky structure is encountered at 3–8 in. Some profiles are light yellowish grey throughout, but red or red-brown is sometimes the dominant colour in the lower B horizon. Light grey or light yellowish grey stiff heavy clay occurs in the lower B horizon and may show diagonal shear planes or slickensides. Moderate amounts of red or black nodules occur in some profiles, especially in the upper portions.

(x) *Shallow Black Earth.*—The shallow black earths are very dark grey to black heavy clay soils that are generally 14–30 in. thick to the parent weathered basalt. They crack when dry and are stiff and sticky when wet. These soils are found at Manly and Archerfield and from Runcorn to Kuraby, and at Brown's Plains.

In the Archerfield and Manly areas they are usually uniformly coloured throughout, but a mottle of olive and yellowish grey has been observed just above the parent rock. The usual structure is well-developed angular blocky ($\frac{1}{2}$ in.), but it may be subangular blocky at the surface and it becomes coarser with depth. Small fragments of weathered basalt may be found through the profile. Carbonates are not common but have been found both as nodules and as soft smears and patches.

The surface horizons of profiles found in the Brown's Plains area are dark brown to very dark brownish grey clay loam with an irregular to subangular blocky structure. At 3–4 in. there is a change to very dark brown to very dark brownish grey light clay. This has a well-developed blocky structure that breaks to very fine granular units. The soil may continue very dark brown to the weathered basalt or may become mottled dark brown and yellowish brown from about 18 in. Specks of weathered basalt are found from 15 in. and there may be small amounts of black concretions.

(xi) *Prairie-like Soils.*—These are slightly differentiated olive-grey clay soils with dark loam to light clay surface horizons and slightly acid to neutral reaction through most of the profile. They are shallow to moderately deep (24–36 in.) to weathered basalt parent material, which is grey, yellow-brown, yellowish grey, and light greenish grey and appears to be more highly weathered than that under black earths.

The surface is grey-brown, brownish grey, or grey loam to light clay with irregular to subangular blocky structure that breaks down to granular units. At 3–6 in. there is a gradual change to medium to heavy clay with blocky structure, this material commonly being moist and plastic. The characteristic olive-grey or dull yellowish grey colour may appear from 3 in., sometimes mottled with grey, though in certain profiles it is not evident above 9–18 in. The deeper subsoil material is commonly mottled olive-grey, yellowish grey, and grey with reddish brown or red and is a puggy heavy clay, very firm or plastic when moderately moist. Specks of weathered basalt are found in the lower parts of the profile, and black nodules of up to 1 in. may be found thoughout. Carbonates have been found in the lower parts of the profile but they are rare (Fig. 8).

A very slight development of microrelief, which is unusual in soils that are less than 30 in. to parent rock, has been observed. These soils are found on gentle slopes on sides of low basalt hills and occasionally across broad convex hill crests.

(xii) *Dark Acid Clays.*—This is a general name for a group of dark clay soils that range in depth from about 10 to about 30 in., but have in common strongly acid reaction (pH below 5·5) throughout the whole profile.

The deeper soils are very dark grey-brown blocky-structured medium clay at the surface with mottled dark grey-brown and yellowish brown blocky heavy clay at 6–15 in. Fragments of basic igneous rock occur in light grey-brown and reddish brown massive light clay at about 18–24 in. The parent rock is encountered at depths ranging from 27 to 36 in.

The shallower soils of this group are lighter-textured throughout and are about 8–12 in. thick. The surface, to about 2 in., is very dark grey-brown clay loam grading into fine blocky-structured light to medium clay that is dark grey-brown sometimes mottled with yellowish brown. A few rock fragments appear from 4–6 in. in dark brownish grey light clay.

(xiii) *Gleyed Soils on Basalt.*—These soils are uncommon and occur only on flat to very gently sloping areas of low saddles between red soil hills in the Thornlands district. These are differentiated soils with deep profiles and dull-coloured B horizons, and are derived from basalt or from mixed parent materials, partly basalt and partly alluvium.

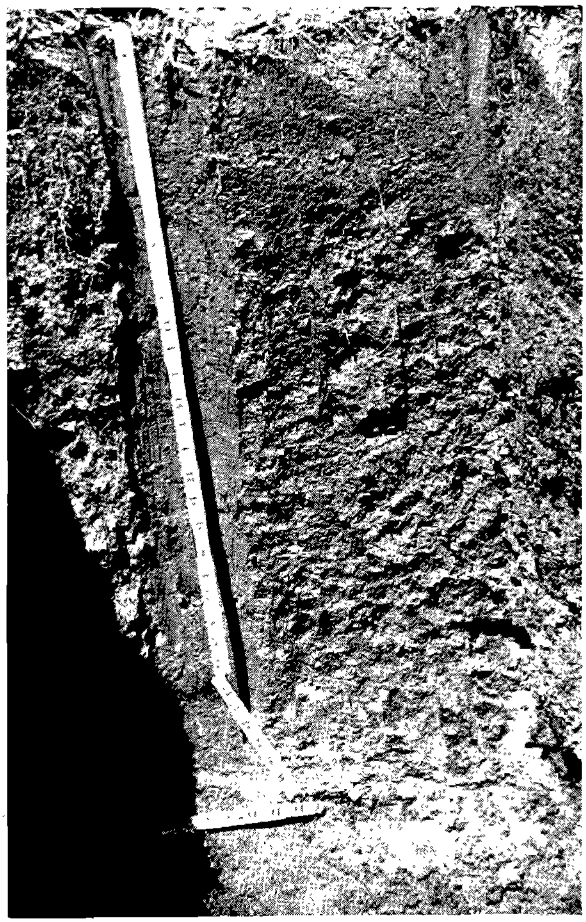

Fig. 8.—Profile of a "prairie-like" soil showing layer of finer structural units at the surface overlying blocky-structured clay.

The A horizon is grey sandy loam to clay loam, massive in the lighter-textured members and irregular blocky or polyhedral in the heavier. There is a texture increase at about 12–15 in. to the clay B horizon, which is yellow-grey or grey and yellowish grey or yellow-brown and consists of clay with oxides. This layer may contain up to moderate amounts of ferruginous nodules, $\frac{1}{4}$–$\frac{3}{4}$ in. in size. Weathered basalt is usually encountered at depths from 30 to 50 in., but the clay layer may continue beyond 78 in. and may contain rounded quartz pebbles.

(xiv) *Thin Differentiated Soils on Basalt*.—This is a group of shallow soils that has been found near Capalaba and south of Manly West. The basalt that underlies it may be as deep as 20 in. but is sometimes encountered at 8–10 in. In the deeper profiles the surface is dark brown sand to sandy loam with dark greyish brown to dark brownish grey sandy clay loam at 3–4 in. Yellowish grey or olive massive and puggy heavy clay is encountered at depths up to 14 in., and there is a change at 16–18 in. to grey, yellow, and yellow-brown clay with specks and fragments apparently of very weathered basalt. In the shallower profiles the changes are at correspondingly shallower depths, and the sandy clay loam layers may be absent.

(xv) *Alluvial Soils*.—The characteristic feature of the soils of this group is their very weak profile development, except for a slight amount of darkening due to organic matter. Textures are very variable both from profile to profile and within one profile, and range from sands through sandy loams to sandy clays. Variations between profiles are the result of differences in the types of materials deposited on different parts of the flood-plains, variations within profiles being due to layering in the parent alluvium. The colour in the upper layers varies from dark brown to very dark grey and this may extend through the whole profile, although the lower layers are commonly lighter-coloured. The more clayey soils are usually crumb-structured at the surface with well-developed subangular blocky or blocky units below 2 in., while the sandier soils may be single-grain or crumb throughout.

Alluvial soils are found on the lowest terraces and on the banks of the flood-plains of the larger streams. They are young soils and are still covered by occasional floods, from which a small amount of sediment is deposited in places.

(xvi) *Gilgaied Acid Clays*.—These soils are dark-coloured heavy clays usually with only small changes of colour down the profile, and have gilgai microrelief. They are usually yellowish grey to olive-grey with small amounts of grey, yellow, and red. Though they are usually heavy clays throughout, there is in some places a thin surface layer (3–6 in. thick) of loam, clay loam, or light clay of similar colours to the layers underneath but often with a subangular blocky or blocky structure. The upper parts of the heavy clay may also be blocky-structured (units up to 1 in. in size) but most of this material is massive and puggy. It is stiff, sticky, and plastic when moist, and very firm when moderately moist.

Gilgai microrelief occurs in many localities. Puffs, shelves, and depressions are present, depressions being well separated, the puffs being joined by low saddles that form the shelves. Puffs and depressions have similar profiles, though the lighter-textured finer-structured surface may extend to slightly greater depths (to 12 in.) under the puffs. The microrelief is only slight, puffs being up to 12 ft apart with an amplitude of 3 to 4 in.

Soils with these features are found on the high terrace of the Logan River along almost all the length of the stream examined, and have formed on the surface of bodies of clay alluvium deposited at some time of higher sea level in the fairly recent past.

There are several profiles in which the greater part of the profile has characteristics similar to those outlined above, but the surface (3–10 in. thick) is composed of light grey-brown to light brownish grey loam to fine sandy loam (or dark brown sand) with a subangular blocky structure (or is apedal, depending on texture), and is friable when moderately moist. Small amounts of black nodules up to $\frac{1}{8}$ in. occur in this layer in some profiles.

(xvii) *Humic Gleys*.—The profile of these poorly drained soils to 12 in. is dark-coloured due to organic matter, and commonly ranges from clay loam to heavy clay though sandy profiles do occur. The structure of this layer may be crumb, granular, or subangular blocky. Mottled material occurs from 12 in., and this is grey, yellowish grey, and yellow-brown clay (or sand). The mottle becomes coarser with depth, the soil consisting essentially of dull-coloured clay and coarse ochreous patches. The lowest layers are moist to wet and plastic or sticky, and in some profiles, the lowest parts of the profile below the water-table are uniformly pale grey to bluish grey with few or no pockets of oxides. A similar profile pattern is found no matter what the texture of the material.

The humic gleys are poorly drained soils on broad plains close to sea level. These soils are extremely common on low alluvial plains, at most only a few feet above high-water mark, south of the Brisbane River and on the low coastal plain south of the Logan River.

(xviii) *Peaty Gleys*.—The overall colour pattern and texture profile of these soils are very similar to those of the humic gleys, but the dark grey to black surface horizon is peaty and may continue to 24–30 in., though a change to lighter-coloured material at about 12 in. occurs in places.

The surface is highly organic, often peaty loam, and there are commonly pieces of only partly decomposed woody material in this layer, which has a crumb to polyhedral structure. These soils are often wet and sticky below about 12 in., even after a prolonged dry period. The greater part of the profile is always below the water-table and some soils are permanently under water.

(xix) *Saline Gleys*.—These soils are broadly similar to the peaty gleys but are strongly saline and the peaty surface is thin. A peaty loam surface horizon with roots and fibrous material overlies, at 6–7 in., a layer of mottled grey and yellow heavy clay, which is moist to wet and sticky. The colours in the lower parts of the profile are sometimes darkish grey to grey with no light yellow oxides. They are intermittently saturated by salt water and the lower parts of the profiles may be permanently saturated.

(xx) *Podzols and Podzol–Regosol Intergrade*.—Soils classed as podzols are sandy thoughout the profile and are dark grey to grey-brown at the surface, changing at 8 in. to light brownish grey which may continue beyond 45 in. Profiles occur that are dominantly yellow-brown to yellow-grey throughout, but usually yellow-brown to yellowish grey colours occur from 12–18 in. below brownish grey sand. Coffee-coloured humic horizons are present in many profiles below 12–24 in., more than one such layer being found in some cases. They are minor soils and are found on slightly raised banks on the surface of a terrace of Oxley Creek and at a few places on terraces of some of the other small streams.

(xxi) *Regosols*.—These are found on a series of small sand banks less than 10 ft above sea level from Lota to beyond Redland Bay. Both gravelly and gravel-free profiles have been found, the form of the profiles of the two groups being quite different.

The gravelly regosols are yellow-brown and yellow, or reddish brown sand to sandy loam, the surface horizon being dark grey-brown or dark reddish brown. There is an increase in texture to sandy clay loam in a few profiles. These soils often have moderate to high amounts of ferruginous nodules derived from the laterite of nearby hills or quartz gravel throughout the profile and these may be cemented into a hard layer below 24 in. The maximum depth examined was 24–30 in.

The non-gravelly soils are less common than the gravelly group and were encountered only at Cleveland and west of Point Halloran. They consist of grey sand containing a few shell fragments or of a light-coloured sand made up of shell fragments. Such non-gravelly profiles may be more common than the gravelly, but there is little on the surface to indicate which type is present.

(xxii) *Solodics*.—The term "solodic" is used here in the general sense for soils that have light-textured surface horizons which change abruptly to tough solonized clay subsoils. The surface horizon is brownish grey to greyish brown sandy loam, 6–12 in. thick, which may become very light brownish grey from 3 in. The top of the B horizon is grey, yellowish grey, and dark grey-brown medium clay, which may be massive and extremely hard or may have well-developed columns at the top of the layer with prismatic units below the columns. From 30–36 in. the soil is grey-brown to dark brown and light yellowish grey sandy clay to light clay, and continues as such beyond 45 in. These soils are mainly restricted to the lower portions of a terrace of Oxley Creek on the clayey parts of the alluvium, but small areas may occur in similar positions on some of the other streams.

(xxiii) *Miscellaneous Gravelly Red Clays*.—This is a general name for a number of soils found on the lower slopes of the hills of quartzite, the soils having a number of features in common though they are not of any particular great soil group. The surface layer is grey, greyish brown, or brown loam to clay loam with moderate amounts of angular quartz gravel and is 6–12 in. thick. Below this is a layer of light reddish brown to red light clay, occasionally medium to heavy clay, which often has sub-angular blocky structure and commonly has high amounts of angular quartz gravel up to 4 in. in size. The maximum depth of those soils that could be examined ranged from 18 in. to more than 30 in. The parent materials could not be determined.

IV. Soil Associations and Soil Map

(*a*) *Mapping Technique and Map Units*

The area has been mapped into associations of great soil groups, each association having the name of a district in which it occurs. A summary of the associations, presented in Table 2, shows that in most of them one or two great soil groups are dominant while several other soil groups are present in varying but lesser proportions.

Boundaries on roads were plotted on 30-chain aerial photographs in the field. As much of the country is still timbered and access and visibility are thus restricted, these boundaries were extended subsequently by stereoscopic examination and interpretation of photo pattern. Boundaries in many parts of the area are thus only approximate, especially in those parts where there are few roads. Variations in the reliability of the different boundaries are indicated on the map.

A number of line sections have been included with the descriptions. These give a general picture of the relative position of the soils in the landscape, but do not refer to any particular locality or to every occurrence of the association. The distribution of the soils and the proportions of each may vary in different directions also.

(b) *Descriptions of Associations*

(i) *Priestdale.*—This is one of the least extensive associations, being found only to the north of Slacks Creek and to the south-east of Waterford on narrow hill crests and on the steep upper slopes of ridges of coarse sandstone (Fig. 9).

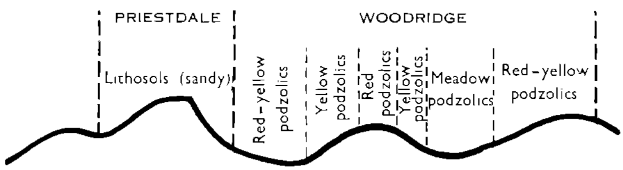

Fig. 9.—Landscape section showing relative positions of soil groups in the Priestdale and Woodridge associations.

The association is composed almost exclusively of sandy lithosols, though small areas of thin podzolics may be found. Many coarse sandstone boulders project through the soil both on the crests and on the steep slopes.

(ii) *Bark Hill.*—This association, in which loamy lithosols are dominant, is common in the southern and south-eastern portion of the area, especially on convex hill crests and on fairly steep slopes of hills (Fig. 11). The parent materials are derived from greywackes and similar rocks, though small areas of these soils are on quartzites, e.g. on a hill south-west of Gilberton. Though loamy lithosols occupy the greater part of the association, thin podzolics occur where rock structure has allowed slightly deeper weathering or where slopes are slightly flatter and thus less subject to erosion.

There is a transition to the Beenleigh association on the lower slopes of spurs, though the ridges on which the Bark Hill association is found are quite distinct from those on which podzolics are dominant. Red clays form a fair proportion of an occurrence just west of Carbrook to the north of the Logan River; such soils occur sporadically throughout the association.

(iii) *Mount Cotton.*—This association is found on comparatively steep slopes of moderately high (200–760 ft) hills of quartzite at Mount Cotton, Mount Petrie, Mount Gravatt, Yellowwood Hill, and Bahr's Scrub Hill and on the colluvial slopes at lower levels (Fig. 10). Part of the higher elevations is composed of small areas of igneous rocks.

Lithosols that have a loam texture are found on the steep upper slopes and contain large pieces of a quartzite that is often manganiferous. Red clays are also found on the steeper slopes in places, and at Mount Cotton are associated with igneous

TABLE 2

SOIL ASSOCIATIONS AND COMPONENT SOILS, BEENLEIGH–BRISBANE AREA

General Soil Group and Association	Dominant Soils	Other Soils	Topography
Shallow stony soils			
Priestdale	Lithosols (sand textures)	Thin red-yellow podzolics	Narrow ridge crests and steep slopes
Bark Hill	Lithosols (loam textures)	Thin red-yellow podzolics	Narrow ridges and spurs
Mount Cotton	Lithosols, miscellaneous red clays	Miscellaneous soils on colluvium	Crests and steep slopes of high ridges
Podzolic soils on hills			
Beenleigh	Red-yellow podzolics (on greywacke, etc.)	Lithosols (loam), grey-brown podzolics, krasnozems, meadow podzolics	Low hills
Woodridge	Red-yellow podzolics (on sedimentary rocks)	Lithosols, meadow podzolics, krasnozems, grey-brown podzolics, lateritic podzolics	Low hills
Coopers Plains	Red-yellow podzolics, lateritic podzolics	Meadow podzolics, gleys, some peaty gleys	Low hills
Park Ridge	Lateritic podzolics, sandy red-yellow podzolics	Red-yellow podzolics (other types), sandy lithosols	Low hills
Compton Road	Lateritic podzolics, red-yellow podzolics, sandy lithosols		Moderately high hills
Red soils			
Sunnybank	Red earths, nodular podzolics	Red-yellow podzolics, gleys, krasnozems	Gently undulating surface
Manly	Krasnozems, red earths	Red-yellow podzolics, gleyed soils	Gently undulating surface
Redlands	Krasnozems (and lateritic krasnozems)	Red earths, yellow clay soils, prairie-like soils	Low hills and ridges
Birkdale	Krasnozems, prairie-like soils	Yellow clay soils, yellow-grey clay (on shale), clayey gleys	Low hills

Dark clay soils on basalt			
Runcorn	Prairie-like soils, shallow black earths	Dark acid clays, shallow red clay soils	Low hill crests and gentle slopes
Archerfield	Shallow black earths	Clayey gleyed soil	Low hills
Thornlands	Differentiated and gleyed soils on basalt		Narrow depressions between ridges
Capalaba	Thin differentiated soils on basalt	Thin acid clays, krasnozems, shallow podzolics	Low hills and gentle slopes
Soils on transported materials			
Carbrook	Yellow podzolics with alluvial soils and gleys	Peaty gleys	Low terrace and flood-plain
Eprapah	Meadow podzolics with alluvial soils and gleys	Peaty gleys	Low terrace and flood-plain
Waterford	Gilgaied acid clays	Alluvial soils, peaty gleys	Highest terraces of Logan and Albert Rivers
Logan	Alluvial soils, gleys	Peaty gleys	Low alluvial plains
Woongoolba	Humic gleys	Peaty gleys, saline gleys	Low plains with narrow depressions
Swamps	Peaty gleys		Broad shallow depressions
Salt marsh	Saline gleys	Tidal solonchaks	Very low plains
Coastal mud flats	Tidal solonchaks	Saline gleys	Zone between tide limits
Lota	Regosols, gleys	Saline gleys	Low beach ridges and plains
Blunder	Podzols, solodics	Humic gleys, alluvial soils	Low terrace and flood-plain

rocks that are either very fresh or very weathered. The red soils on the higher slopes of Mount Petrie are gravelly red podzolics.

The red clays south of Mount Gravatt and also those on Yellowwood Hill and north of Bahr's Scrub Hill are found on the colluvial lower slopes, the profiles south of Mount Gravatt approximating to red earths. Light- to medium-textured red-yellow podzolic soils containing high amounts of angular quartz gravel have developed on colluvial deposits, or outwash fans, associated with large gullies on Yellowwood Hill.

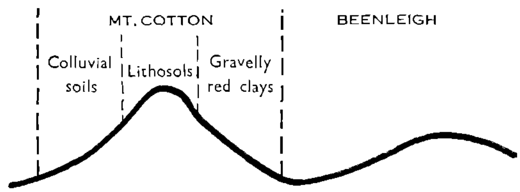

Fig. 10.—Landscape section showing relative positions of soil groups in the Mount Cotton association.

(iv) *Beenleigh.*—The two associations that are dominantly of red-yellow podzolics, Beenleigh and Woodridge, are among the most extensive in the area. The Beenleigh association is associated mainly with convex hills and spurs of low relief (usually about 50–100 ft) though the elevation of the hills ranges from less than 50 ft near the coast to over 400 ft near Mount Cotton (Fig. 11).

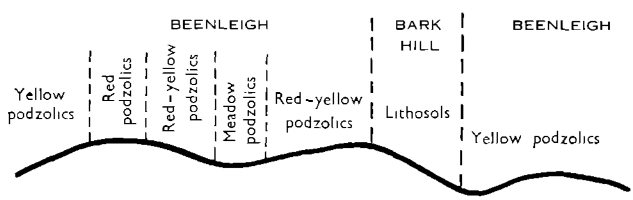

Fig. 11.—Landscape section showing relative positions of soil groups in the Beenleigh and Bark Hill associations.

The red-yellow podzolics in this association are generally derived from greywacke, profiles with mottled B horizons being characteristic. Red podzolics are slightly more common on hill crests, but yellow podzolics occur on all positions of the landscape and are the dominant soils on the low hills north of the Logan River near Carbrook and on the hills at higher level south-west of Mount Cotton.

Lithosols with loamy textures are common, especially near the crests of hills. Grey podzolics occur on certain of the low spurs at Carbrook. Krasnozems are found scattered through the association at various positions on slopes; their position is determined by occurrence of a particular parent rock, a basic igneous rock associated with the metasediments.

The soils found on the low hills to the north of the mouth of the Logan River are sandier than are many in the group, being associated with a sandier phase of the greywacke than that to the west and north (Marks 1910).

Small areas of meadow podzolics are found on narrow drainage lines, with gleys on the floors of the slightly larger areas.

(v) *Woodridge*.—This association of red-yellow podzolics on Mesozoic sedimentary rocks occupies much of the central and northern part of the area, and is associated with a landscape of low convex hills and a gently undulating surface up to about 200 ft elevation (Figs. 9 and 12).

Fig. 12.—Aerial view east over plateau remnants of the Sunnybank association at Rochedale, and over low hills of Beenleigh and Woodridge associations to Mount Cotton.

The dominant red-yellow podzolic soils have moderately thick A horizons and mottled clay B horizons, though profiles that are dominantly red or dominantly yellow occur. The redder profiles are usually on hill crests and yellower profiles on slopes, but yellower soils do occur on crests.

Lithosols are not common, their presence being related to conglomerate layers or coarse grits, and there are only a few areas of lateritic podzolics. Meadow podzolics are encountered on lower hill slopes and high up on some narrow drainage channels. The few small areas of krasnozems have developed on clays and often occur on hill crests, about on the same level as the red earths at Sunnybank or the lateritic krasnozems on basalt at Thornlands. Krasnozems may be found at other topographic positions also. There is one such occurrence on a small saddle on a low hill in the coastal plain at Rocky Point. Other krasnozems, which may have been truncated, are found on the slopes of spurs south of Daisy Hill.

The relatively few occurrences of lateritic podzolics in this association can be attributed to dominance over considerable areas of finer-textured parent rocks—clayey sandstones, sandy mudstones, and shales. While the shallow podzolic soils that have a thin A horizon and an orange-brown clay B horizon are dominant in the Daisy Hill district, only a few profiles of this form have been encountered elsewhere, particularly south of Mount Petrie on Broadwater Road. Another minor soil group whose distribution seems to be controlled by parent material is the group of grey podzolics, which is almost invariably found on grey shales or clays. Humic gleys and swamp soils are found on the floors of minor drainage lines.

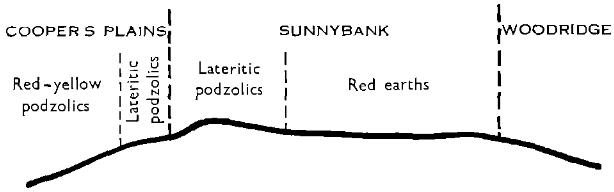

Fig. 13.—Landscape section showing relative positions of soil groups in the Coopers Plains and Sunnybank associations.

(vi) *Coopers Plains.*—This association is restricted to the hills near the red earth area in the Sunnybank–Rochedale area (Figs. 13 and 15). Its presence there is related to the presence of coarser layers in the Tertiary sediments and in certain of the Mesozoic rocks. Red-yellow podzolics are the dominant soils in the association but lateritic podzolics occur repeatedly, mainly on hill crests, but also lower in the landscape. Small areas of thin dark soils on basalt and areas of gleyed soils along creeks are included.

(vii) *Park Ridge.*—This association, one of the more extensive, is composed dominantly of lateritic podzolic and sandy podzolic soils. These soils occur on low hills up to 250–300 ft high with smooth gentle to moderate slopes forming a gently

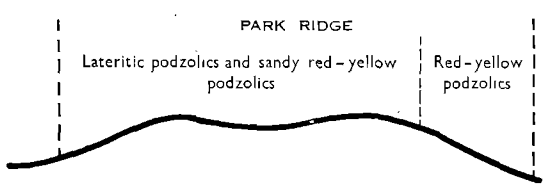

Fig. 14.—Landscape section showing relative positions of soil groups in the Park Ridge association.

undulating surface (Fig. 14) with a moderately wide ($\frac{1}{2}$ mile) stream spacing. The association also includes hills with slightly higher relief, such as those near Chambers Flat, on which there are some rock outcrops.

The relative extent of the two dominant soils is indeterminate as the surface horizons of the two soils are similar and profiles intermediate between those of the two groups are found. Many sandy podzolics have been found in certain parts along the Beaudesert Road south of Acacia Ridge and may be the dominants in that locality.

The south and south-western slopes of a hill near Woodridge are covered by red-yellow podzolics whose presence appears to be decided by more clayey parent materials, while the north and north-eastern slopes have sandier soils. It appears that the distribution of layers of sandstone, conglomerate, and other rocks has considerable influence on the type of soils encountered.

On most of the occurrences of this association lateritic podzolics are found on the higher parts of the landscape on the undulating crest. East of Capalaba, however, they occur in mid positions on slopes and in one place extend almost to the floor of the drainage line.

Red-yellow podzolic soils with thick sand A horizons are found on slightly steeper slopes above streams. Such soils occur at Brown's Plains. There are red-yellow podzolics with sandy loam surfaces at low levels in the landscape at many points along the Beaudesert Road, but the podzolic soils in the south-western corner of the area are mainly yellow podzolic soils.

Sandy lithosols are found on a scarp near Chambers Flat and there are also very small areas of krasnozems on the road to Greenbank near Park Ridge.

Fig. 15.—Aerial view south over Altandi. Most of the cultivated area (right) is Sunnybank association; the timbered area is Coopers Plains association. The cleared area (left centre) is part of the Runcorn association of dark clay soils.

(viii) *Compton Road*.—A separate but related association is found on slightly higher hills with moderately steep slopes west of Woodridge. In addition to the lateritic podzolic and the sandy podzolic soils there are moderate areas of lithosols on the scarps and ridge crests.

(ix) *Sunnybank*.—This association is made up mainly of red earths derived from Tertiary and Mesozoic sedimentary rocks, principally sandstones, and occupies a gently undulating surface that varies in height from over 100 to 300 ft above sea level (Figs. 13, 15). Most of the area has gentle gradients with a few broadly convex eminences; a few wide shallow drainage lines cross parts of it. The association is bounded by comparatively steep slopes, the upper parts of which have been included in places as one group of soils is found both on them and on the flat crests.

After the red earths, which may have nodular layers, the lateritic podzolics are the most common soils. They occur on the highest parts of the landscape, e.g.

south of Runcorn, mixed with the red earths in other places, as at Rochedale, and in some places they occur at the top of the steeper slopes fringing the association.

Small areas of red-yellow podzolic soils have been found on the highest parts of the landscape south of Altandi and north of Eight Mile Plains. Soils that are transitional from deep sandy red-yellow podzolics to lateritic podzolics occur on gentle slopes at Kuraby and Rochedale below crests on which red earths are found. Small areas of gleys are found on the shallow drainage lines. There are also a few very small areas of krasnozem on basalt and on shale.

(x) *Manly*.—The Manly association of red earth and krasnozem is found only in the Manly–Lota district, and has been established because the two groups are very closely associated in this locality. The surface on which it is found is generally undulating and from 80 to more than 150 ft above sea level (Fig. 16). To the south and east above Lota Creek it is fringed by moderately steep scarps, while slopes towards the north and west to the small tributaries of the Brisbane River and Wynnum Creek are more gentle.

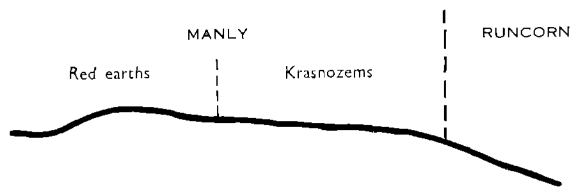

Fig. 16.—Landscape section showing relative positions of soil groups in the Manly association.

The soils have developed from Mesozoic sandstones and adjacent basalts. The red earth is generally at higher levels, but is at comparable levels to the krasnozems on basalt on slopes in areas beyond the limits of the basalt. The krasnozem extends beyond the gently undulating surface onto the upper parts of the slopes below.

Small areas of red-yellow podzolics with a gradual texture change are found below the red earths along the drainage lines running north. A similar red-yellow podzolic is found on the western limits of the association on the gently undulating surface, at slightly higher level than the krasnozem. Very small areas of gleyed soils are found on the floors of the small drainage lines.

(xi) *Redlands*.—This association, which is composed dominantly of krasnozems and lateritic krasnozems, is found only in a narrow strip from ¼ to 2 miles wide along the coast south from Wellington Point to a short distance beyond Redland Bay. It occurs as a number of small areas separated by hills with podzolic soils and by the alluvial plains of small streams. The landscape consists of a number of broadly convex or elongate hills up to 100–150 ft high, the lower slopes being straight or slightly concave (Fig. 17). Gullies are generally broad and are only minor depressions in the surface of the slope. Those portions of the hills close to the sea, such as those at Wellington Point, often have steep scarps that have resulted from wave attack in recent times.

The krasnozems and lateritic krasnozems, which generally overlie mottled clays, occur on all parts of the landscape except the floors of gullies. A few of the krasnozems are derived directly from basalt and include soils on hills near Thornlands School and south of Wellington Point and soils at Birkdale and south-east of Wellington Point at low level in the landscape.

Not all the spurs at low level are made up of basalt or mottled zone material. A few, such as one east of Thornlands School and one on the coast east of Weinam Creek, are of red ferruginous zone material containing moderate amounts of ferruginous nodules. Some small areas of krasnozem have been delineated south of Point Talburpin, on basalt or on igneous rocks associated with the Palaeozoic metamorphic rocks.

Small areas of red earths on the hill crests and slopes near the Raby Bay Cemetery have been derived from sediments associated with the basalt or from mixed parent materials. Yellow clay soils are found down-slope from the krasnozems at a number of places on basalt or on clayey sediments associated with the basalt, as at Pinklands (west of Point Halloran) and on slopes south-west of Raby Bay Station.

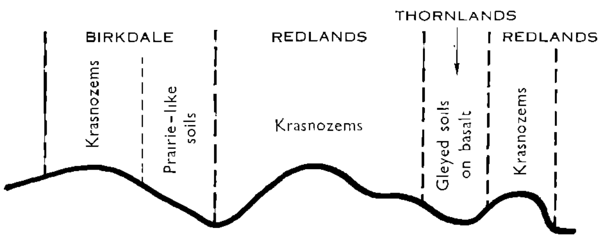

Fig. 17.—Landscape section showing relative positions of soil groups in the Birkdale, Redlands, and Thornlands associations.

A small area of a deep sandy soil occurs on the lower slopes of the hill above river terraces of Eprapah Creek west of Victoria Point. This soil, which is light yellow-brown sandy loam increasing to light yellow-grey sandy clay, has apparently been derived from a 12-ft layer of sediment that overlies the ferruginous and mottled clays of the laterite profile.

To the north-east of Thornlands School are small areas of shallow prairie-like soils on basalt on lower parts of slopes below the krasnozems (Fig. 18).

(xii) *Birkdale*.—The Birkdale association is made up of areas of krasnozems and prairie-like soils in the coastal area at Thorneside and also at Eight Mile Plains. These are on low hills made up of a rather small convex crest with long concave slopes below leading down to the drainage lines, the floors of which are about 100 ft below the crest (Fig. 17).

Near Thorneside, prairie-like soils and dark acid clays occupy the greater part of the association, with krasnozems occupying comparatively small areas on the crests and upper slopes. At Eight Mile Plains the krasnozems occupy a somewhat greater proportion of the association than they do at Thorneside, and extend down to about mid-slope positions. Yellow clay soils on basalt are found at intermediate positions on the slopes, and small areas of thin yellow clay soil on shale are also found on the lower slopes here. Clayey gleyed soils on narrow drainage lines are also included in the association.

(xiii) *Runcorn.*—This association consists of prairie-like soils, dark acid soils, and shallow black earths, and occurs on low convex hill crests and on concave lower slopes of slightly higher hills of basalt (Fig. 19). The local relief is 100 ft at the most and slopes are gentle.

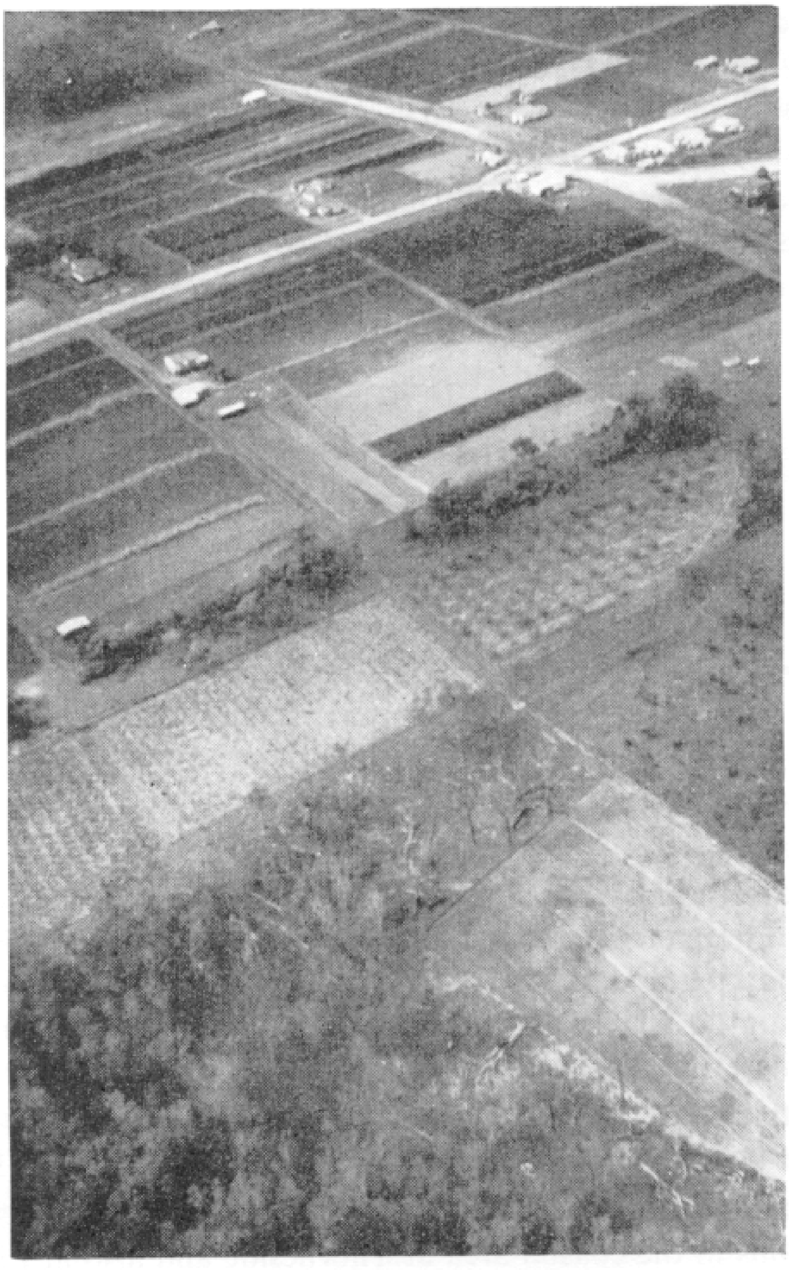

Fig. 18.—Aerial view near Thornlands School showing the sharp junction between the Redlands association (darker cultivated area in the distance) and the Woodridge association (lighter, partly timbered area in the foreground).

The composition of the association is somewhat variable. Generally, prairie-like soils are dominant, but shallow black earths occupy almost the whole of some low hills south of Lota and at Kuraby, while dark acid clays are usually found on mid to lower positions on slopes. Clayey gleyed soils are found on the small drainage lines. Small areas of prairie-like soils with very slight gilgai microrelief are found west of Manly and near Runcorn.

Small areas of a moderately deep red clay soil transitional to the krasnozems on the hill crests can occur. A very small area of lithosolic red clay soil is found on extremely weathered basalt on a low hill crest at Kuraby, up-slope from a shallow black earth.

(xiv) *Archerfield.*—The only areas that have been mapped as dominantly of black earths are on low hills with flat to convex crests and gentle slopes around Archerfield (Fig. 19) and at Brown's Plains. These occurrences are on low convex spurs with moderate slopes up to 8–10°. Foot slopes here are very small, the steeper slopes extending almost to the floors of the larger gullies.

In the Archerfield area shallow black earths occupy the rounded crest and much of the slopes. Gleyed clay soils are found on the drainage lines and there is an area of a soil with a slight development of gilgai microrelief adjacent to one of these areas. These gilgaied soils extend beyond the boundary of this survey.

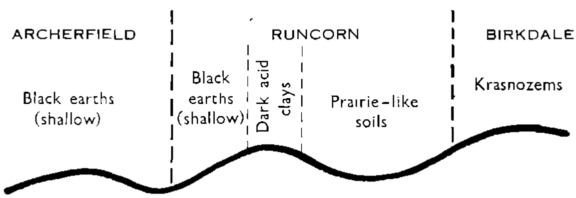

Fig. 19.—Landscape section showing relative positions of soil groups in the Archerfield, Runcorn, and Birkdale associations.

The dominant soils in the Brown's Plains occurrence are shallow black earths that have slightly lighter-textured A horizons than are commonly found. These are found on the crests and upper slopes with the more usual shallow black earths on the lower slopes and on the floor of the depression.

(xv) *Thornlands.*—This association of gleyed soil on basalt is one of the least extensive and occurs on low saddles between the lower slopes of moderately high hills, with krasnozems to the west and low hills also with krasnozems to the east (Fig. 17). All these saddles are less than 40 ft above sea level and are flat to slightly basin-shaped transversely with a gentle fall along their length.

Nearly all the soils are the gleyed soils on basalt. Considering their position in the landscape, their proximity to streams and the sea, and the fact that quartz pebbles occur in some profiles, it is evident that part of the material from which the soils are derived is alluvial.

(xvi) *Capalaba.*—The dominant soil of the Capalaba association, the differentiated soil on basalt, is derived from an extremely weathered basalt associated with certain sedimentary rocks and commonly occurs on gentle to moderate slopes below the level of the sandstones. Shallow prairie-like soils or dark acid clays are found on low rises where there is no sedimentary rock at higher level. The association also includes small areas of podzolics on sandstones or shales and small areas of krasnozems.

(xvii) *Eprapah*.—The Eprapah association occurs on the low terraces and flood-plain (Fig. 20) of small coastal streams from Capalaba to south of Redland Bay. The terrace surface is almost flat and is 10–15 ft above the stream. The flood-plain is small and rather uneven.

The soils of the association have developed on materials derived from sandstones, shales, greywackes, etc. Meadow podzolics occupy the whole of the higher terrace. Gleys with some alluvial soils are found on the flood-plain and occupy a greater proportion of the association than they do in the Carbrook association.

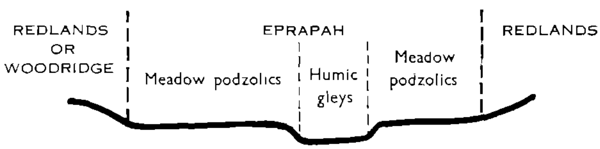

Fig. 20.—Landscape section showing relative positions of soil groups in the Eprapah association.

(xviii) *Carbrook*.—Like the Eprapah association, the Carbrook association is composed of soils on a terrace about 8–10 ft above the stream and on the flood-plain. All the occurrences are on tributaries on the left bank of the Logan River. Yellow podzolic soils tending towards meadow podzolics are almost universal on the higher terrace with alluvial soils, humic gleys, and some swamp soils on the comparatively narrow flood-plain.

Areas along Slacks Creek have, in addition, small areas of podzol–regosol intergrade on the higher banks.

(xix) *Waterford*.—This association, in which gilgaied acid clays are the dominant soils, is found along the valleys of the Logan and Albert Rivers from near the mouth to at least the south-western limit of this survey. The gilgaied acid clays are almost universal on an extensive high terrace, which has a flat to slightly uneven surface with some wide swampy depressions; hence surface drainage is poor. Also included in the association are the soils on dissected portions of the terrace and on small areas of low terraces on small streams traversing it (Figs. 21(*a*), 21(*b*), and 22).

Though gilgaied acid clays with a clay or clay loam surface are more common, soils with thin (up to 6 in.) light-coloured and light-textured A horizons are found at a few places, e.g. Carbrook and Loganholme and near Logan Reserve. The clays are apparently very deep (more than 20 ft), as profiles examined on dissected parts of the terrace have similar features to those on the highest remnants of the terrace. Alluvial soils, humic gleys, and swamp soils are minor members of the association.

Small areas of sandy alluvial soils occur west of Bethania and at a slightly higher level than the gilgaied acid clays on the left bank upstream from Waterford. Sandy soils with a slight development of microrelief occur near Logan Reserve.

Some areas mapped in this association may not be part of the same terrace as the majority of the occurrences. As well as the dissected remnants mentioned above, heavy clay soils are found on a low terrace about 12 ft above high water mark just north of the mouth of the Logan River. South-east of Alberton this association is at almost the same level as the low coastal plain, and grades imperceptibly into it.

(xx) *Logan*.—The Logan association consists of the soils of the alluvial plains of the Logan and Albert Rivers below the level of the clay terrace soils of the Waterford association and extending upstream from the junction of these rivers. In the upper reaches examined the alluvium consists of wide high level plains or a series of narrow banks up to 20 ft above the stream (Fig. 22). In the lower reaches there is a series of subparallel banks near the stream with broad lower areas away from the stream (Figs. 21(*a*) and 21(*b*)).

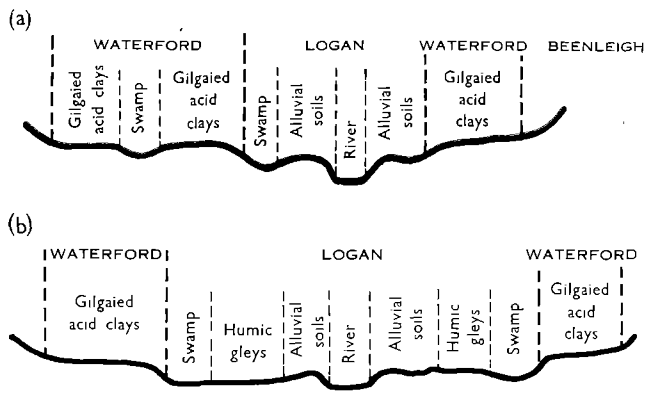

Fig. 21.—Landscape sections showing relative positions of soil groups in the Waterford and Logan associations above (*a*) and below (*b*) Loganholme.

Considerable variations in texture within the profiles are encountered. In upstream positions alluvial soils occupy the banks and gleyed clay soils are found on the flood-plain, while closer to the mouth humic gleys are dominant with moderate areas of alluvial soils. Peaty gleys are found along both streams in swamps, some of which represent minor depressions in the flood-plain, and others, such as those near Carbrook, represent the floors of old meanders of the rivers.

(xxi) *Woongoolba*.—This association includes humic gleys and peaty gleys on the extensive plains south of the mouth of the Logan River and on the alluvial plains of the Bulimba Creek and the Brisbane River, as well as on the plains of some of the smaller streams. The occurrences along the Logan River and on the Brisbane River consist of very gently undulating plains with depressions up to 10 chains across. Small areas are found between red soil hills along the coast.

The soils are characteristically poorly drained with shallow water-tables. Humic gleys, with both sandy and clayey profiles, are overwhelmingly dominant south of the Logan River on the coastal plain, which consists of flat to very slightly undulating banks up to 1 mile wide. There are minor areas of peaty gleys in small depressions and of salt marshes (Fig. 23).

Peaty gleys occupy a greater proportion of the association along the streams, becoming almost co-dominant with the humic gleys in places, and in the Runcorn–Sunnybank area also the proportion of peaty gleys is greater than it is near Woongoolba. The soils on the depressions between the red soil hills on the coast have thinner organic surfaces than the soils on the larger plains.

Fig. 22.—Portion of the Logan River valley near Waterford showing the Waterford terrace of gilgaied acid clays under grassland and the narrow cultivated strip of Logan association on low banks along the river.

(xxii) *Swamps*.—The greatest area of this association of peaty gleys is found on the coastal plain south of the Logan River, but small areas are found on the coast to the north on narrow valleys between hills on which there are associations of krasnozems. Many areas of peaty gleys are closely associated with humic gleys and some have been mapped with them. These soils are found in depressed areas, at most a few feet above stream level (Fig. 23), which may be elongate and sinuous or round with an uneven margin, and up to three-quarters of a mile wide. They are permanently wet in the lower parts but are sometimes comparatively dry on the slightly higher fringe. The soil pattern across these swamps is almost uniform.

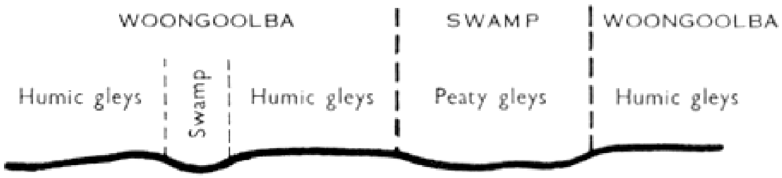

Fig. 23.—Landscape section showing relative positions of soil groups in the Woongoolba association and swamps.

(xxiii) *Salt Marsh*.—Occurrences are found on the coastal plain south of the Logan River, near the mouth of small streams in the red soil area along the coast, and on the lower reaches of the Logan River. The salt marshes are at most a few feet above sea level and are subject to occasional tidal inundation, so that the saline water-table is at most only a few feet below the surface even after prolonged dry periods.

The saline gleys that make up this association vary in texture, but have a similar colour pattern to that of the humic gleys. The mottles are coarser and grey may be dominant higher in the profile.

(xxiv) *Lota*.—Occurrences of this association of regosols and gleys are restricted to the coast from Lota to south of Redland Bay, and consist of a series of elongated banks, or occasionally single banks, generally less than 12 ft above sea level, with small alluvial plains (Fig. 24).

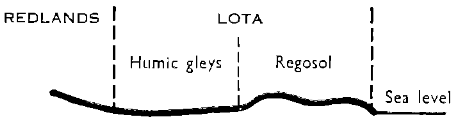

Fig. 24.—Landscape section showing relative positions of soil groups in the Lota association.

The composition of the Lota association ranges from dominantly regosols in small sand-banks to dominantly gley soils, with only small areas of sandy regosols. Gravelly regosols, in which the ironstone of the bottom of the profile may be cemented into blocks, are common in many of the banks. A few of the banks, such as some west of Point Halloran, are composed of loose grey sands with occasional bands of shells.

(xxv) *Blunder*.—This association, in which podzols and solodic soils are dominant, has been recognized only on the terrace and flood-plain of Oxley Creek near the Blunder (Fig. 25).

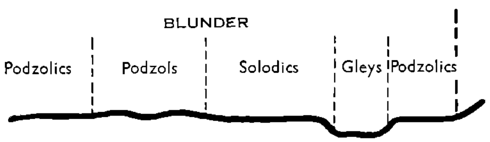

Fig. 25.—Landscape section showing relative positions of soil groups in the Blunder association.

Solodics are dominant on the flatter northern part of the high terrace and podzols are more common on small banks in the southern portion. Alluvial soils and gleys are found mainly on the flood-plain and occupy only small areas.

(xxvi) *Coastal Mud Flats*.—This unit is made up of almost flat areas along the coast and lower parts of streams, at most a few feet above sea level, and includes bare areas within the tidal range and vegetated areas that may be only a few inches higher. Some parts are in materials eroded by wave attack, and have the appearance of the adjacent hill or terrace material. The purely alluvial materials are tidal solonchaks, with a range of textures from sandy clay in some profiles to stiff heavy clay in others, and have the characteristic colour profile of saline gleys, though the surface is thinner and is not peaty.

V. Soils in Relation to Land Use

(a) *Present Land Use*

(i) *Introduction.*—This area is on the border of the city of Brisbane and yet, notwithstanding its proximity to the city, only a small proportion of the area has been cleared and developed for agriculture in the more than 100 years since settlement commenced. Most of the clearing and cultivation has been restricted to the better agricultural soils. Besides occupying only a small area, these soils are so distributed that development has occurred in distinct pockets where land use is intensive, while the bulk of the area, of poorer agricultural soils, has remained under little-disturbed forest. Thus the "red soil" areas, composed of krasnozems, lateritic krasnozems, and red earths in a narrow strip along the coast from Manly to Redland Bay (Fig. 26)

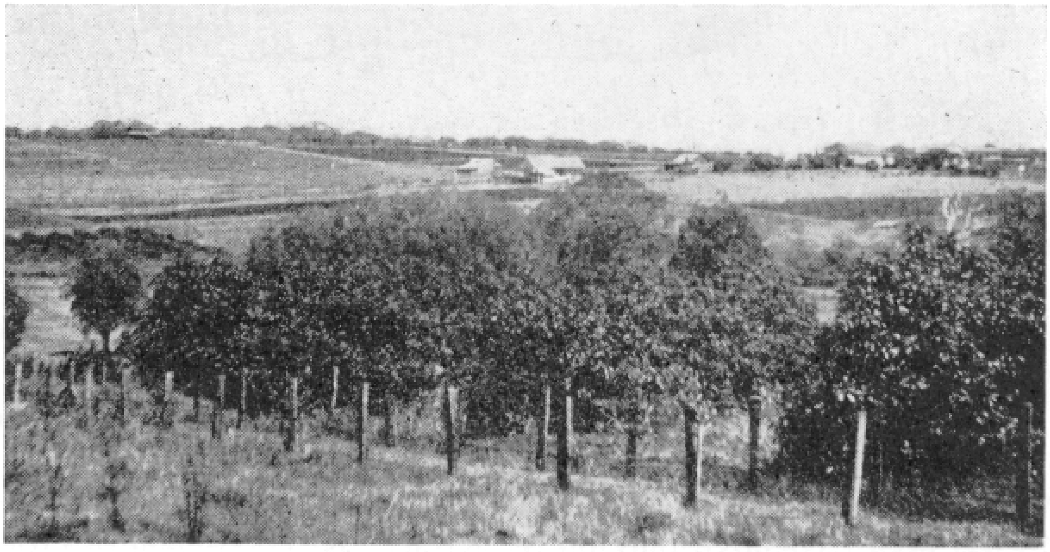

Fig. 26.—Typical landscape in the fruit- and vegetable-growing area of the Redlands association on the coast.

and on small dissected plateaux in the Sunnybank–Rochedale area, have been used for many years, particularly for fruit and vegetables. The other more important developed agricultural area is the valley of the Logan–Albert River system and the adjacent coastal plain, where dairying, mixed farming, and sugar-cane growing have been carried on for about 100 years. Very little of these areas is still untouched, and the demands for land in recent years have forced some development into the forest lands surrounding them.

(ii) *Horticulture.*—Though vegetable and fruit growing are restricted mainly to the Manly–Redland Bay area and the Sunnybank–Rochedale area, and are carried on particularly on the Redlands, Sunnybank, Birkdale, and Manly associations, there are some farms on the alluvial soils of the Logan and Albert Rivers, mainly on Logan and Woongoolba associations, some on the plains south of the Brisbane River, and a few on the hill slopes of Mount Cotton and Bahr's Scrub Hill. Crops are grown at all seasons, utilizing mainly natural rainfall during summer and employing supplementary irrigation, where possible, especially during the late winter to early summer period (Morgan 1950).

Data on production, such as those obtained by the Commonwealth Bureau of Census and Statistics, do not show any trends in overall horticultural production but only changes in individual crops. The Bureau's figures show that there has been a slight increase in the area of vegetables grown and a slight decrease in the area of fruit between the 1950 and 1963 statistical periods.*

Vegetables grown include potatoes and other root crops, tomatoes, beans, peas, cabbage, cauliflower, cucurbits, and lettuce. There have been substantial increases in the amounts of potatoes and tomatoes in the Redlands district and in the area south of the Brisbane River, while there has been a marked decrease in potato production in the Albert Shire. In the Redlands district there were increases from 36 tons of potatoes in 1950 to 444 tons in 1963, while tomato production rose from 228,000 half-cases to 437,000 half-cases. The amounts of the other vegetable crops produced have been about constant or slightly less.

The main fruits grown are bananas, papaws, citrus fruits, strawberries, custard-apples, and mangoes. The production of bananas has varied considerably in the 1950–63 period, while that of pineapples has decreased in recent years. There has been a marked increase in the production of strawberries, from 250,000 to 775,000 lb in the Redlands district, the main area where they are grown. There have been similar big increases in the production of citrus fruits, especially lemons (from 4000 to 24,000 bushels), in the Redlands district and corresponding, but much smaller, increases in other areas. Production of papaws has increased, while that of custard-apples, avocados, and mangoes has decreased over the area as a whole, though custard-apple production in the area south of the Brisbane River has been increasing. Some macadamia and pecan nuts are also grown but they are minor crops.

Bananas have been grown on red earths in the Sunnybank district, on krasnozems in the Redlands district, on lithosols, yellow clay soils, and thin podzolics near Mount Cotton, and on humic gleys on the coastal plain. Pineapples are grown on podzolics and on krasnozems, and strawberries on krasnozems, red earths, and podzolics. At Rochedale and Sunnybank, papaws are grown on light- and medium-textured soils, and on krasnozems in the Redlands district.

(iii) *Dairying*.—Dairying for milk and cream production is limited mainly to the terraces, flood-plain, and adjacent hill slopes of the valleys of the Logan and Albert Rivers, and to the coastal plain. There have been some farms south of the city and in the Redlands district, but the numbers of dairy cows in these districts have been decreasing in recent years. There has also been a slight decrease in the number of dairy cattle in the Albert Shire, of which the Beenleigh area is a part, and here there have been considerable changes in the major product (Fig. 27). There has been a substantial decrease in the amount of cream produced and a corresponding increase in the amount of whole milk, presumably to meet the needs of the growing city market.

The general level of dairying in this district is low. In the 1963 statistical period the average milk production was 294 gallons per cow, corresponding to a butter-fat

* A statistical period as referred to in this report extends from April 1 of one year to March 31 of the following year.

production of 120 lb per cow. (The State average is 184 lb butter-fat per cow per year.) In the Moreton district as a whole, a large proportion of the farms do little fodder cropping and there is only a small area of irrigated forage cropping (Young and Rayner 1962). By 1963 there were only 570 acres of irrigated pasture in the entire Albert Shire. It was also observed by Young and Rayner that only a limited amount of fodder conservation is practised and that a large proportion of the fodder of a dairy herd is purchased.

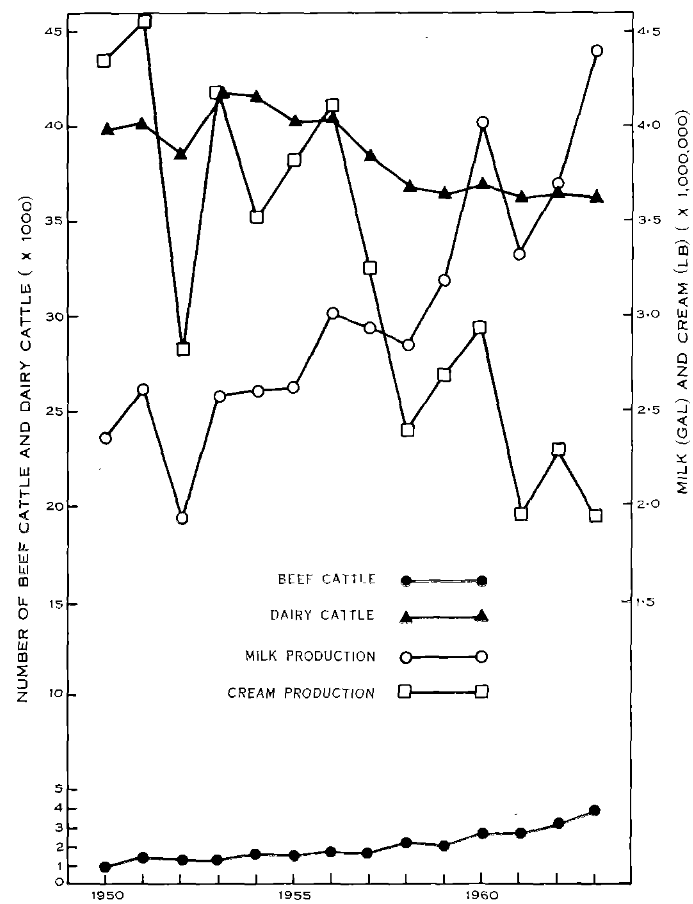

Fig. 27.—Numbers of beef and dairy cattle, and cream and milk production, Albert Shire, 1950–63.

There has been a slight but steady increase in the numbers of beef cattle in the Albert Shire, but the total by 1963 was still low, under 4000.

(iv) *Sugar-cane*.—Though the first sugar-cane in Queensland was grown at Ormiston in the Redlands district, all of the sugar-cane at present produced near Brisbane is grown in the lower Logan Valley and on the coastal plain south of the Logan River, the Rocky Point Mill area, which extends beyond the limits of the survey for some miles south along the coast. This was once a dairying and mixed farming district but is now concentrating almost entirely on sugar-cane production. The increases in acreage and in tons of cane crushed over the 1950–63 period are shown in Figure 28.

The trend to sugar-cane has been accelerated by the decisions of the recent (1963) Committee of Inquiry into the Australian Sugar Industry which recommended considerable expansion in many areas of the State, including some expansion in this area. The 1963 crop of 52,344 tons of cane has been vastly exceeded by the 1964 crop of 117,943 tons. The yields of cane here are low (only 20 tons per acre) over a period of years when compared to those in other areas of the State, such as those in the Townsville area where yields have been up to 44 tons to the acre.

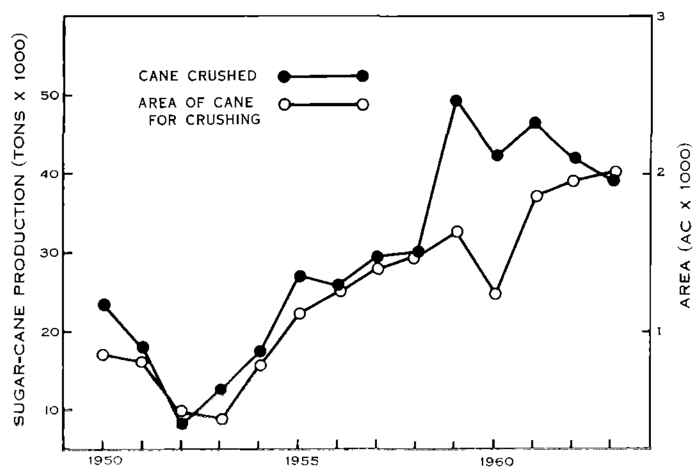

Fig. 28.—Sugar-cane production, Albert Shire, 1950–63.

(v) *Other Forms of Land Use*

(1) *Forestry*.—There is one small State Forest of 925 acres, State Forest Reserve 215, in the Daisy Hill district, north of Slack's Creek. This is managed as a forest of native eucalypts including narrow-leaved ironbark, tallowwood, white mahogany, and spotted gum.

(2) *Poultry*.—There are a number of poultry farms in the area and egg production doubled in the 1950–63 period in the Redlands Shire and in the area south of the Brisbane River. Few, if any, farms produce their feed requirements on the property.

(*b*) *Suitability of Soils for Agriculture*

(i) *General*.—Most of the soils of this area have extremely low inherent fertility (Table 3) and it has been found that repeated applications of fertilizers are needed to obtain satisfactory production of crops. The soils found to be most productive have good physical properties even though they are low in nutrients, but many of the soils have poor physical properties expressed by either low range of available moisture, poor internal drainage, or unsuitable condition of the surface. A summary of the

TABLE 5

CHEMICAL DATA FOR SOILS OF THE BEENLEIGH–BRISBANE AREA

Soil Group	Profile No.	Depth (in.)	pH	N (%)	C : N Ratio	Total P (%)	Available P (p.p.m.)	K (m-equiv./100 g soil)	K (% of total metal ions)	Ca (m-equiv./100 g soil)	Ca (% of total exch. cations)
Krasnozem	B341	0–6	6·2	0·28	18	0·026	9	1·7	13	6·6	24
		30–48	6·0	n.d.*	n.d.	0·017	n.d.	0·02	0	1·6	17
	B360	0–5	6·2	0·17	21	0·014	2	0·15	2	5·7	26
		16–30	6·1	n.d.	n.d.	0·005	n.d.	0·02	0	1·6	13
Red earth	B346	0–4	6·1	0·06	26	0·006	4	0·06	5	0·81	13
		28½–37½	6·0	n.d.	n.d.	0·005†	n.d.	0·02	0	1·1	13
	B347	0–5	6·0	0·06	28	0·005	4	0·04	2	1·2	19
		18½–26	5·7	n.d.	n.d.	0·009†	n.d.	0·01	0	0·11	1
Red-yellow podzolic	B350	0–6	5·7	0·05	19	0·005	6	n.d.	n.d.	n.d.	n.d.
		20–23	5·3	n.d.	n.d.	0·006	n.d.	0·16	10	<0·01	0
	B343	0–5	5·6	0·06	22	0·005	2	0·06	28	0·10	2
		13–22	5·5	n.d.	n.d.	0·011†	n.d.	0·02	1	0·05	0
	B348	0–5	5·6	0·08	27	0·005	<1	0·19	16	0·52	5
		14–22	5·8	n.d.	n.d.	0·011†	n.d.	0·11	3	0·11	1
	B344	1–3	5·4	0·08	27	0·009	2	0·28	24	0·51	11
		9–14½	5·3	n.d.	n.d.	0·013	n.d.	0·12	4	0·10	1
	B345	0–3	5·6	0·15	25	0·013	2	0·21	14	0·26	1
		12–17½	5·9	n.d.	n.d.	0·017	n.d.	0·10	2	0·05	0
	B356	1–3	5·3	0·20	22	0·048	21†	0·70	9	2·4	7
		10–16	5·1	n.d.	n.d.	n.d.	n.d.	0·55	7	0·27	1
Lateritic podzolic	B349	0–5	5·7	0·06	22	0·003	4	0·06	7	0·60	9
		28–39	5·6	n.d.	n.d.	0·009	n.d.	0·02	1	<0·01	0

Grey podzolic	B355	1–3	4·9	0·07	23	0·016†	6†	0·33	15	0·10	1
		5–9	5·1	n.d.	n.d.	n.d.	n.d.	0·48	10	0·05	0
Prairie-like soils	B340	0–4	5·8	0·27	14	0·023	4	0·44	3	5·9	22
		14–24	8·0	n.d.	n.d.	0·012†	n.d.	0·04	0	11·9	23
Dark acid clay	B364	0–4	5·4	0·40	14	0·031	4	0·88	3	4·8	7
		21–26	4·9	n.d.	n.d.	0·005†	n.d.	0·05	0	0·17	0
Black earth	B354	3–6	6·4	0·27†	14†	0·031†	2†	0·10	0	23·9	52
		9–16	7·3	n.d.	n.d.	0·034†	n.d.	0·04	0	36·3	59
Meadow podzolics	B342	0–5½	5·1	0·09	22	0·006	4	0·06	3	0·71	8
		30–45	4·6	n.d.	n.d.	0·003	n.d.	0·01	1	0·07	1
Alluvial soils	B353	0–7	5·9	0·10	11	0·039	45	0·31	4	5·4	41
		30–54	6·0	n.d.	n.d.	0·023†	n.d.	0·08	1	7·8	45
Gilgaied acid clay (depression)	B351	2–6	5·5	0·13	16	0·017	4	0·18	4	0·90	4
		38–54	4·6	n.d.	n.d.	0·016†	n.d.	0·24	3	0·05	0
Gilgaied acid clay (puff)	B352	2–4	5·6	0·10	16	0·010†	<1	0·07	9	1·3	5
		18–36	4·7	n.d.	n.d.	0·010†	n.d.	0·15	5	0·05	0
Humic gley	B357	0–6	4·6	0·60	14	0·085	17	0·40	3	4·6	9
		30–42	4·5	n.d.	n.d.	n.d.	n.d.	0·24	3	2·1	16

* n.d., Not determined.

† Such figures are those of an adjacent horizon.

TABLE 4

AGRICULTURAL CHARACTERISTICS OF SOILS IN THE VARIOUS ASSOCIATIONS

Association	Dominant Soils	Major Element Deficiencies	Minor Element Deficiencies	Acidity	Range of Available Moisture	Drainage	Other Physical Characteristics
Shallow stony soils							
Priestdale	Lithosols (sandy)	N, P, K likely	Likely, especially Mo	Moderate	Low	Excessive	Very shallow soils
Bark Hill	Lithosols (loamy)	N, P, K likely	Likely, especially Mo	Moderate	Low to moderate	Free	Very shallow soils
Mount Cotton	Lithosols, red clays	N, P, K likely	Cu, Mo	Moderate	Moderate in red clays	Free	Lithosols shallow, red clays deep
Podzolic soils on hills							
Beenleigh	Red-yellow podzolics	N, P (extreme)	Mo, Cu, Zn	Moderate	Surface low to moderate, subsoil moderate	Restricted by relatively impermeable subsoil	Moderately deep soils
Woodridge	Red-yellow podzolics	N, P, K (extreme)	Mo, Cu, Zn	Moderate	As for Beenleigh	As for Beenleigh	Moderately deep soils
Coopers Plains	Red-yellow podzolics and lateritic podzolics	N, P, K (extreme)	Mo, Cu, Zn, S	Moderate	Very low to moderate	Free in lateritic podzolics. Other podzolics restricted by B horizon	Moderately deep and deep soils
Park Ridge	Lateritic podzolics	N, P, K (extreme)	Cu, S, possibly Mo and Zn	Slight to moderate	Very low to low	Free	Deep soils
Compton Road	Lateritic podzolics, sandy lithosols	N, P, K	Probably as Park Ridge	Slight to moderate	Very low to low	Free	Sandy lithosols shallow, lateritic podzolics deep
Red soils							
Sunnybank	Red earths, lateritic podzolics	N, P, K (extreme)	Cu, Mo, Zn	Moderate	Very low	Free	Deep soils
Manly	Krasnozems, red earths	N, P, K	Mo, B, Zn, Cu	Slight to moderate	Low to moderate (krasnozem); low (red earth)	Well-drained	Deep soils
Redlands	Krasnozems	P, possibly K, probably N	Mo, B, Zn, Cu	Slight	Low to moderate	Well-drained	Deep soils
Birkdale	Krasnozems and prairie-like soils	P, probably N	Probably as Redlands	Slight to neutral	Low to moderate	Well-drained (krasnozem); slow ("prairie-like")	Deep (krasnozem) and moderately deep ("prairie-like") soils
Dark soils on basalt							
Runcorn	Prairie-like soils, shallow black earths	P, possibly N and K	Mo, B, Zn, Cu	Neutral (some strongly acid)	Moderate	Poorly drained internally	Shallow and moderately deep soils, sticky after rain
Archerfield	Shallow black earths	P, possibly N and K	Possibly S and Mo	Neutral	Moderate	Poorly drained	Shallow and moderately deep soils, sticky after rain
Thornlands	Gleyed soils on basalt	Probably P	Unknown	Unknown, probably neutral	Moderate	Very poorly drained	Deep soils, sticky after rain

Capalaba	Thin differentiated soils on basalt	Probably P, also N and K	Unknown	Unknown	Low in surface, moderate in subsoil	Slightly impeded internally by B horizon	Very shallow soils
Soils on transported materials							
Carbrook	Yellow podzolics, gleys	P, K, N	Mo	Moderate	Low in surface, moderate in subsoil	Restricted by relatively impermeable subsoil	Deep soils
Eprapah	Meadow podzolics	P and K extreme, N	B	Strong	As for Carbrook	As for Carbrook	Deep soils, surface horizons tend to slake
Waterford	Gilgaied acid clays	N and P extreme, possibly K	S, possibly Mo	Strong to very strong	Moderate	Poor internal and external drainage	Deep soils, sticky after rain
Logan	Alluvial soils, humic gleys	N	Unknown	Slightly acid	Moderate	Good internally	Deep soils
Woongoolba	Humic gleys	P	Cu, Zn, possibly Mo	Extremely acid	Low to moderate	Fair internally; depends on height of water-table	Deep soils
Swamps	Peaty gleys	P, possibly K	Unknown	Probably extremely acid	Low to moderate	Permanently or seasonally flooded	Deep soils
Salt marsh	Saline gleys	P, possibly K and N	Unknown	Unknown	Low	High saline water-table	Deep soils
Coastal mud flats	Tidal solonchak	P	Unknown	Unknown	Low	Intermittently flooded by salt water; high saline water-table	Deep soils
Lota	Regosols, gleys	P	Cu, Zn, B	Acid	Low to moderate	Regosols well-drained internally, gleys poorly drained	Deep soils
Blunder	Podzols, solodics	N, P, K	Zn, Cu, B, Mo	Podzols acid, solodics neutral to alkaline	Low in podzols and in surface of solodics, low to moderate in subsoils of solodics	Podzols well-drained throughout, impedance at top of subsoils of solodics	Surface of solodics tends to slake

properties relevant to agriculture, both chemical and physical, of the major soils of each of the associations is given in Table 4.

(ii) *Plant Nutrients and Fertilizer Responses.*—To obtain a picture of the major nutrient levels, complete profile samples have been taken of at least one representative of all the more important soils of the area, usually at virgin sites in timbered areas or, if this was not possible, in grassland. More than one profile of the more extensive groups was sampled to characterize such soils better. For this reason several profiles of the red-yellow podzolics, the most extensive group in the area, were sampled. Two profiles of the krasnozems and two profiles of the red earths were sampled, as these are among the more important groups of agricultural soils. Relevant data for all the soils sampled are presented in Table 3, in which information from two levels in the profile is given, one at the surface and one at some depth in the profile. The general picture gained in this way has been supplemented by reference in the text to data for representatives of a few of the groups derived from similar parent materials in coastal areas to the north.

While it is evident that the soils of this district are on the whole of low fertility, reference to the association descriptions and to the association map show that some of the least fertile soils occupy the greater part of the area. A few points can be mentioned particularly:

(1) There is an extremely low level of total phosphorus in the soils derived from basalt, a rock which often weathers to soils high in this element.

(2) The potassium level in some soils from shales is higher than that in most of the soils on other sedimentary rocks.

(3) There are high contents of soluble salts in the humic gleys at levels which in mineral soils would normally be expected to be damaging to crops.

(1) *Soil Reaction and Calcium.*—Almost all the soils of this district are acid, in the range of pH from 5·1 to 6·1, and some are extremely acid with pH down to 4·5. It is only in the lower layers of the "prairie-like" soils and the shallow black earths that neutral to alkaline reactions (pH 7·3–8·0) occur, and even these soils are slightly acid to neutral (pH 5·8 and 6·4 respectively) at the surface.

The amount of exchangeable calcium is also usually low, that of most soils being in the range of 0·0–2·4 m-equiv. per 100 g of soil. Only the shallow black earths and "prairie-like" soils on basalt, the alluvial soils, and the humic gleys have levels of exchangeable calcium greater than this throughout the profile, up to 36·3 m-equiv. % in the lower layers of the shallow black earth. The surface layers of the krasnozems and the dark acid clays on basalt have moderate levels (4·8–6·6 m-equiv. %) while the subsoils have levels of 0·17–1·6 m-equiv. %, comparable to those of many of the soils from sedimentary rocks.

Although no standards for satisfactory levels of calcium have been agreed on, it has been suggested by Leeper (1964, p. 184) that soils with less than 5 m-equiv. per 100 g of soil could be regarded as poor, and it has been found that responses to the application of lime have been obtained with a sandy soil at Kybybolite, S.A., containing less than 5 m-equiv. % of calcium (Cook 1939; Blackburn and Gibbons 1956). The only soils that meet this standard are the "prairie-like" soils, the shallow black earths, and the alluvial soils, while the krasnozems, dark acid clays, and humic gleys have about this level of calcium in a portion of their profiles. Similar conclusions can be drawn by the application of another criterion: that in soils with satisfactory levels of calcium, the exchangeable calcium should occupy at least 30% of the total exchange capacity (Stout 1951). The only soils that completely satisfy this requirement are the shallow black earths and the alluvial soils.

Comprehensive fertilization is practised in agricultural systems here at present. Such fertilizers would deal with most requirements of calcium in horticultural crops and probably pastures, though additions of lime might be necessary to modify the pH to a more desirable level for some crops. While the need for calcium in the nutrition of temperate-zone legumes that might be used here is well established, it has been shown by Norris (1956) that tropical legumes have much lower requirements of calcium and that application of lime is unnecessary to obtain satisfactory growth. This has been borne out by the work of Andrew and Bryan (1955), who demonstrated that on a low humic gley (similar to a meadow podzolic) and on a humic gley, calcium was, after phosphorus, the nutrient most limiting growth of temperate legumes (*Trifolium* spp.). They showed also (Andrew and Bryan 1958) that additions of calcium to a lateritic podzolic soil significantly increased yields of *Trifolium repens*, yet did not increase the yields of *Desmodium uncinatum* (a tropical legume) growing on the same soil.

(2) *Nitrogen*.—Only general statements of nitrogen contents and nitrogen relationships can be made, as the few analyses done are from virgin profiles and do not reflect conditions in cultivated soils. The total nitrogen content in surface soils in Queensland is usually less than 0·20% N, with a modal value at 0·05–0·10% N (Hubble and Martin, unpublished data). The values fall off rapidly with depth. The sandy soils, the red-yellow podzolics, the lateritic podzolics, and the red earths have typical low figures of 0·05–0·08% N (Table 3). A few soils, such as the krasnozems and dark clay soils on basalt, have higher levels, 0·27–0·40% N, while the humic gley, a poorly drained organic soil, has 0·60% N at the surface. Hubble and Martin suggested that nitrogen content reflects the inherent fertility status of the parent materials as indicated by total phosphorus, and this is illustrated by the low N figures of one group of clay soils, the gilgaied acid clays with total nitrogen contents of 0·10–0·13%. Such soils are low in total and available phosphorus and also in exchangeable potassium.

Soils with lower C : N ratios, e.g. 10–13, mineralize nitrogen more readily than do those with higher ratios, 22–27. It is seen from Table 3 that it is generally those soils with the highest N content, e.g. the clay soils, that have the narrowest C : N ratio while the sandy-surfaced soils with lower N content have wider ratios, up to 28. These sandier soils with lower N contents occupy most of the district while those with the higher contents are relatively minor. Soils with more than 0·15% N would respond to nitrogenous fertilizers but to a lesser degree than would those with less than 0·15% N.

The necessity for adding nitrogen fertilizers has been recognized in horticultural areas, and it has been found that nitrogen deficiency is more important than soil moisture stress in restricting growth of certain grasses growing under natural rainfall at Samford, some miles to the north-west of the area (Henzell and Stirk 1963). The increase in growth due to the fertilization far exceeds any loss due to temporary dry conditions. In their studies of a low humic gley and of a humic gley, Andrew and Bryan (1955) found that, after phosphorus, nitrogen was the main limiting nutrient in growth of grasses.

(3) *Phosphorus.*—The levels of total and available phosphorus in the soils of the Beenleigh–Brisbane area are also low. The amounts of total phosphorus range from extremely low (0·003–0·005%) for the podzolic soils, the most extensive in the area, through very low (0·012–0·031%) for the basalt soils, to moderate (up to 0·085%) for the humic gley (Table 3). Similar soils on basalt on the Darling Downs have up to 0·20% total phosphorus, indicating that phosphorus content of soils is probably a reflection of the phosphorus content of the parent rock and not of weathering, as there are similar soil types in the two areas (Thompson and Beckmann 1959).

With few exceptions the soils of this district are extremely low in available phosphorus. The most common level, which is also that of the most widely distributed soils, lies on the range of 1–6 p.p.m. of available phosphorus. By application of the standard of von Stieglitz (1953) that 50 p.p.m. available P_2O_5 (21 p.p.m. available P) represents a critical level below which many crops are likely to respond to phosphatic fertilizer, it is seen that there is a severe phosphorus deficiency over much of the area.

The only soils with levels near those adequate for plant growth by the standard given are the alluvial soils and the thin-surfaced podzolic soil on shale, and the latter soil barely meets the requirement. The humic gley has an available phosphorus content of 17 p.p.m. and resembles that in the Beerwah area to the north (Hubble 1954) which, though also high in total phosphorus, was low in available phosphorus. Phosphorus was found by Andrew and Bryan (1955, 1958) to be the principal nutrient limiting growth of legumes and grasses on a low humic gley and a humic gley and of legumes on a lateritic podzolic soil.

(4) *Potassium.*—Exchangeable potassium has proved to be a useful measure of potassium status in relation to plant growth. The range of exchangeable potassium levels in the surface layers of soils of this district is quite wide, from 0·04 to 1·7 m-equiv. per 100 g of soil (Table 3). The red earths, red-yellow podzolics on coarser sedimentary rocks, and the lateritic podzolics have levels at the lower end of the range, while many of the clay soils, the krasnozems, the "prairie-like" soils, and the dark acid clays have high levels at the surface but in the lower layers have levels comparable to those of the podzolics, which may reflect concentration at the surface from plant activity. Slightly higher levels also occur in the podzolic soils on shales (B356 and B355 in Table 3), which may indicate higher potassium levels in the parent materials of such soils.

The value accepted by the Queensland Department of Primary Industries as a guide to the need for potassium fertilization is that 0·2 m-equiv. % of exchangeable potassium is the level below which plants may be expected to respond to applications of potassium fertilizer. Even if there should be more than this amount present, responses may still be expected if the exchangeable potassium content is less than 2% of the total exchangeable metal cations (von Stieglitz 1953). Responses may be expected on the red earths, the lateritic podzolics, meadow podzolics, many of the red-yellow podzolics, and the shallow black earths. Plants grown on those soils with moderate levels and those with low levels in the subsoils may also respond to potassium, particularly if growth has been stimulated by the addition of other fertilizers.

(5) *Trace Elements.*—There are no data on trace-element contents of the soils of this district, on either total amounts present or the amounts of these elements available to plants. From a study of the total content of five trace elements in the surface layers of a number of great soil groups in Queensland, Giles (1959) found that the trace-element status of the red earths was approximately that of the average for the soils examined, that of the krasnozems about twice, and that of the lateritic podzolics and red-yellow podzolics about one-fifth of the average for all the soils. The trace-element status of the corresponding soils of the Beenleigh–Brisbane district may be regarded as being relatively the same as those in the State as a whole.

The following statement on responses obtained in various plants is based on information provided by officers of the Queensland Department of Primary Industries and of CSIRO, and by farmers. The major findings, presented in Table 4, should be regarded as a summary of experience and not as an authoritative statement of the levels of these elements over the whole district.

Responses to applications of one or more of the elements molybdenum, boron, zinc, and copper, have been observed on several of the soils used for small crops and fruit-trees, the deficiencies often showing up only after some years of cropping. The soils on which such deficiencies have been observed are the red earths, krasnozems, red-yellow podzolics, humic gleys, and podzols. Responses to boron have been found in pasture trials on low humic gleys (i.e. meadow podzolics), and responses to copper and zinc in trials on humic gleys (Andrew and Bryan 1955).

(6) *Salinity.*—The well-drained soils of this district, e.g. the krasnozems and red earths and many of the podzolics, are generally low in salts throughout the profile, total soluble salts being of the order of 0·01–0·03%. The meadow podzolics and the gilgaied acid clays have low salt contents in the upper layers but high amounts (at least 0·15% total soluble salts) below 60 in. and 40–50 in. respectively. This is below the major rooting zone of most plants and this high salt level is unlikely to present any problem. The humic gleys, which are important agricultural soils, have a high salt content throughout the profile (0·4–0·6% total soluble salts and 0·14–0·23% sodium chloride). Similar high values may be common in such soils on low areas near the coast, as a higher salt content has been found in a humic gley at Beerwah (Hubble 1954). The fact that this apparently high level has not seriously affected crop growth may be attributed in part to the fact that organic layers have a lower bulk density than do mineral horizons, so that salt figures calculated on a weight basis give the impression of higher salt contents per acre 6 in. than is actually the case. Furthermore, these layers are generally moist and salt contents, as determined on dry soil, will be effectively diluted by the soil solution.

(7) *Current Fertilization Practices.*—The general deficiency of major elements and deficiencies of many trace elements have been recognized in the horticultural and agricultural areas in the district, and fertilizer programmes to correct these deficiencies for the growing of various crops have been developed. The amounts and rates of application are shown in Figures 29–31. Figures 29 and 30 present the

acreages of vegetables and fruit, respectively, grown in the Redlands Shire in the statistical period 1950–63, with the amounts of fertilizer and rates of application during this period. Figure 31 presents similar data for sugar-cane grown in the

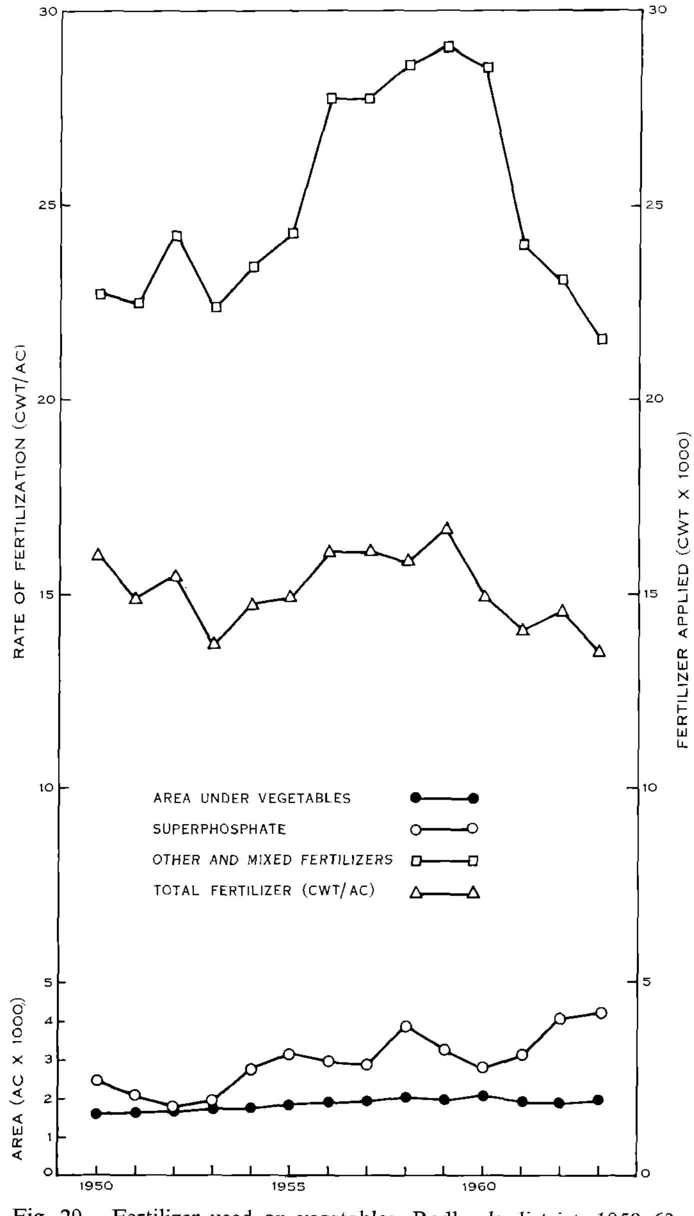

Fig. 29.—Fertilizer used on vegetables, Redlands district, 1950–63.

Albert Shire. The areas used for fruit and vegetables in the Redlands Shire were almost constant, as were the amounts of superphosphate applied, there being a slight rise in the amount used with vegetable crops. At the same time there were considerable changes in the amounts of other fertilizers, including mixed fertilizers, applied and hence in the rates of overall fertilization. There are differences in the trends in vegetables and fruits for which there is no ready explanation. There was a marked increase in the amounts of fertilizers applied to vegetables in the 1956–60 statistical period, with an even more sharp reduction subsequently. During the same period there was a drop in the amount of such fertilizers applied to fruit crops, including both orchard and plantation crops and strawberries, with a rise in the amount applied

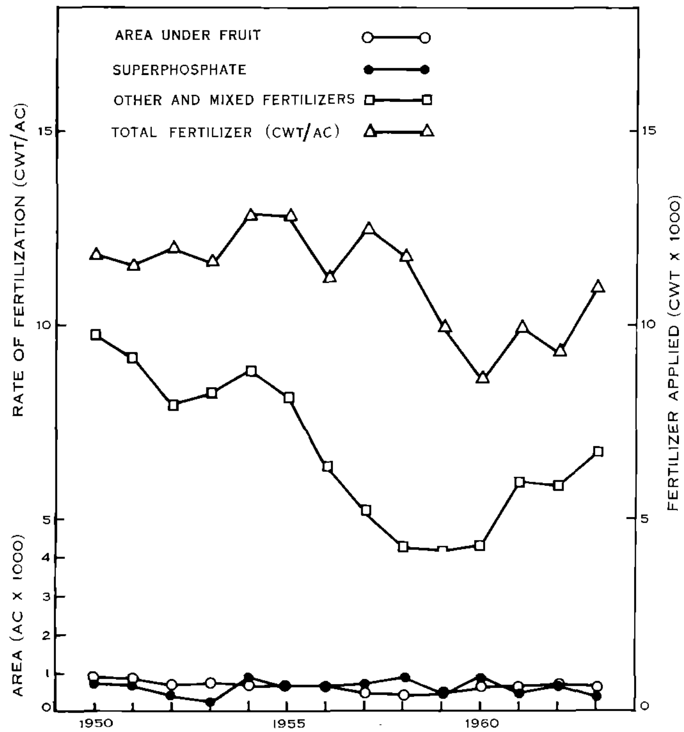

Fig. 30.—Fertilizer used on fruit, Redlands district, 1950–63.

in those years when less was being applied to vegetables. Changes in economic conditions are undoubtedly concerned in these trends, but they do not completely explain why fruit should follow different trends from vegetables.

The rates of continuous fertilization of a limited area are high, those for vegetable crops being very high (13–16 cwt per acre per annum). Even allowing for the increasing production of strawberries, an annual crop, the application to fruit crops, many of which are tree crops, is also high (4–10 cwt per acre per annum). While many of the applications are based on the requirements of plants with only minor consideration of the initial levels of the soils, some growers could be using heavier applications than necessary. Trials by the Department of Primary Industries at the Redlands Experiment Station, using tomatoes as a test crop, have shown that there seems little, if any, justification for extremely high rates of fertilization used on the red-brown soils of the district, except perhaps on virgin land with a low phosphorus and nitrogen status (Department of Agriculture and Stock, Queensland 1962). Over-use of fertilizer may produce problems, particularly nutrient imbalance which is responsible for such nutritional disorders in tomatoes as blossom end rot and pith rot (Menary, Fergus, and Hughes 1963). Though high amounts are applied and little of the nutrients is removed with the crop, there is little residual effect from the applied phosphorus, for example, and fertilizer must be applied to obtain satisfactory yields.

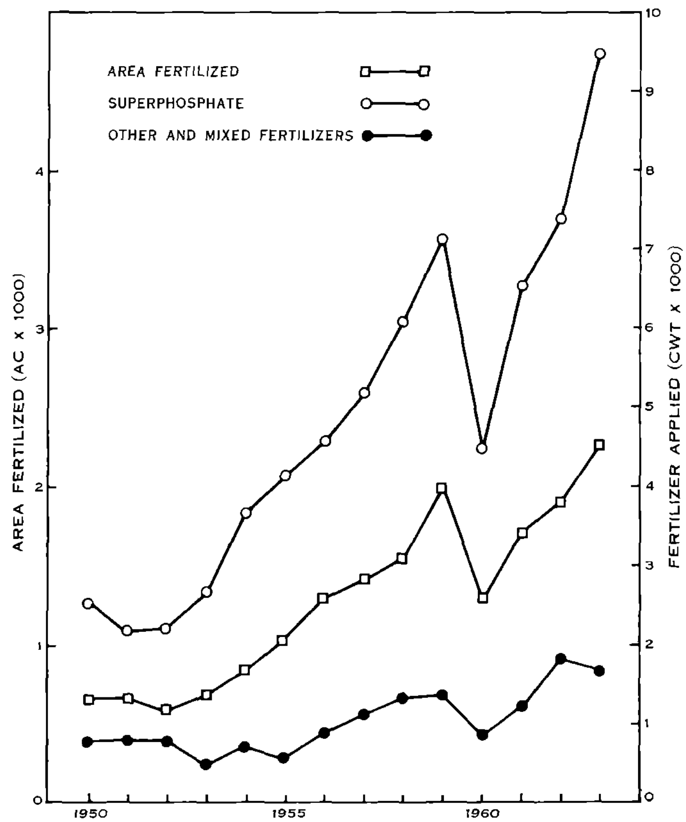

Fig. 31.—Fertilizer used on sugar-cane, Albert Shire, 1950–63.

In another study using tomatoes, Hughes and Searle (1964) concluded that the availability of the accumulated phosphorus was extremely low and that the higher yields on soils to which higher amounts of phosphorus had been applied were due to reduction of fixation in these soils, with consequent better utilization of the applied phosphorus. Fixation sites were blocked by previously applied phosphorus and with continued accumulation the later-applied phosphorus is available to the plant.

The data presented in Figure 31, showing areas of cane and fertilizer usage on sugar-cane in the Albert Shire, refer particularly to the humic gley soils of the Woongoolba association. Comparison of these data with those of Figure 28 on production shows that while the increases in amount generally follow the increases in acreage, there have been marked increases recently in the use of mixed fertilizers and of fertilizers other than superphosphate, but these have not necessarily been followed by increases in yields. Current climatic conditions would have to be considered in finding the explanation of this. It has been found by experience here, as in other areas, that fertilizer requirements are related in some degree to texture, the sandier members of the humic gleys requiring heavier applications than the more clayey members.

(iii) *Soil Moisture*.—In intensive agriculture such as that of the developed parts of the Beenleigh–Brisbane area where fertilizer costs are only a small part of total costs, physical properties of soils are as important as nutrient status in assessing the suitability of soils for development. Thus the soils that have been used most intensively in the past, the red earths and krasnozems, the lateritic podzolics, the alluvial soils, and humic gleys, have good physical properties and have been selected for that reason, while many of the other podzolics and also the gilgaied acid clays have poorer physical properties and development on them has been limited (Table 4).

Moisture characteristics and depth are the most important physical properties, and of these the most significant is the range of available moisture of the materials making up the profile, i.e. that fraction of the soil moisture that can be taken up by plants. In most cases this is represented by the water retained between field capacity (the storage following deep wetting and drainage) and the point at which plants wilt. The highest levels of available water are usually associated with loamy textures while those of sands or clays are often less. Most soils with good storage can retain about 2 in. of available water per foot of depth, but the storage in any particular soil can be determined more precisely from the range of available moisture of each of the layers making up the profile and from the thickness of these layers.

Some soils are shallow and few of the soil materials in this area have a good range of available moisture, so that the amount of water that can be retained for any considerable period by many of the soils is low. Short periods of moisture stress can occur at any time, but with the local seasonal distribution of the rainfall they are more likely during late winter and early summer.

Irrigation is used to overcome periodic moisture stress on soils growing horticultural crops and is being increasingly practised on pastures, though the total area is still small (only 570 acres in the entire Albert Shire by 1963). Lack of moisture need not, however, be the most important factor limiting the growth of grass in most years. At Samford, several miles to the north-west of the Beenleigh–Brisbane area, it has been found that nitrogen is the primary factor determining grass yield, and there is little likelihood that supplementary irrigation during dry spells would prove economic in those cases where nitrogen supply to the grass was limited (Henzell and Stirk 1963). The need for fertilizers in the Beenleigh–Brisbane area is as high as at Samford and the same conclusion may apply here for grasses, though the behaviour of legumes, whether tropical or temperate, may be quite different. Though dry periods could be expected about one year in two at Samford, their time of occurrence could not be predicted. As the extremely dry year has a relatively low frequency (about 1 in 10) and could be dealt with by pasture conservation (Stirk 1963), installation of irrigation equipment by farmers just for spring and summer production of pastures would probably not be justified.

Temporary waterlogging can occur in the surface horizons of certain of the podzolic soils with sandy highly permeable surfaces and relatively impermeable clay subsoils, but this is no great agricultural problem. Many soils in low topographic positions, such as the humic gleys and peaty gleys, may be permanently waterlogged to almost the entire depth of the profile due to the presence of a high water-table. Drainage of these soils is essential, and it is this that has permitted agriculture on the humic gleys of the Woongoolba district.

(*c*) *Possibility of Increased Irrigation in the District*

As the moisture requirements of many crops are high and the water storage of many soils is limited, frequent applications of water to supplement the natural rainfall have been found essential for the successful growing of many horticultural crops. There have also been marked increases since 1950 throughout the region in the areas of pasture and fodder crops irrigated, even though total acreage is still small. Only very small areas of sugar-cane land have been irrigated.

Until recent years most of the irrigation in horticultural areas in the hill country has been with underground water, but good supplies are mainly restricted to certain small areas, viz. the small basins of Tertiary sediments, the basalt areas along the coast, and in some places on slopes, particularly on colluvium on quartzite hills, and there seems little likelihood of expansion of such sources. Though supplies are usually fair, they drop considerably during prolonged dry seasons.

There has recently been a development which should overcome the lack of good underground water over much of the hill areas. It is a characteristic of the rainfall that there are intense falls of rain at certain periods with consequent high run-off from the hills, so that it is possible to store large amounts of water in surface dams in many parts of the area where there is a clay subsoil that can contain it. Such storages are common at present in the Mount Cotton district, on areas of podzolic soils. Though the use of such dams will extend the areas that can be irrigated, even these surface supplies could disappear during long droughts.

Good water for irrigation is found under the alluvial soils of the Logan and Albert valleys, and river water can be used for irrigation on those reaches of the rivers beyond the limits of salt water. Such sources are being utilized at the moment and no great increase can be expected. Fresh water has occasionally been found in bores on the coastal plain south from the Logan River, but the water below 12–15 ft is generally brackish. Constructing dams to store water here is generally impracticable, as sand is found beneath all soils at only a few feet from the surface. Some irrigation from the freshwater swamps that cross the plain is possible, but the amount that could be stored in them is not great. A great increase in irrigation on the plains of the Hemmant district south of the Brisbane River does not seem possible, as all the underground water beneath the plains is saline and all the major streams through the district are salt-water streams.

(*d*) *Erosion*

Relief is generally low and most slopes are gentle, so that the danger of severe erosion, especially in the timbered areas, is not great, but the steeper hill slopes such as those of Mount Cotton are prone to erosion, especially when clean cultivated. Tunnel erosion with some slumping has occurred in some clayey deposits on the north-eastern slope of Mount Cotton. The Beenleigh–Brisbane area is one with falls of high intensity, however, and soils even on gentle slopes can be eroded if unprotected. The sandy-surfaced soils, the lateritic podzolics, red earths, and many of the red-yellow podzolics have permeable surface horizons and are usually found on gentle slopes, but some effects of surface wash have been observed on these even in timbered country. Surface wash of this type can also cause erosion on ridges of krasnozem soils after heavy rains. Practices that could reduce erosion to a minimum in areas such as these have been outlined by Ladewig and Skinner (1951). They include contouring of orchards, plantations, and vegetable farms, and adopting practices of cover cropping, stubble mulching, and crop rotation. Improved pastures would also help in stabilizing the surface in areas that are not used for horticultural crops.

(*e*) *Current Trends and Future Development*

With the current growth of the city of Brisbane, much of the Brisbane–Beenleigh area is undergoing rapid change. The northern and north-western sections of the area are part of the city and many areas that until recently were farmland or under native forest are now being absorbed by suburban or industrial development. Expansion of the north-west of the city is limited to some degree by mountains and to the east will soon be restricted by unsuitable terrain, so that in time that part of the Beenleigh–Brisbane area now on the fringe of the suburbs, irrespective of its inherent suitability for agriculture, will become part of suburban Brisbane. Even today, urban centres up to 25 miles from the centre of the city, such as Cleveland and Beenleigh, are in effect already satellite townships.

It is, therefore, likely that prosperous agricultural areas such as the Sunnybank–Rochedale district and even the Redlands district will eventually go completely out of agricultural production. Any local horticultural industry will then have to be carried on either on the moderately fertile soils on level areas of alluvium further away from Brisbane, such as those of low terraces adjoining the Logan and Albert Rivers, the total area of which is not large, or on the less fertile soils on the hills bordering the city. The former are at present in well-established farming areas, while the latter can be developed successfully only at considerable expense for clearing, fertilization, and irrigation. If small farms should prove uneconomic for horticulture in the future and large areas of flat land are needed for a mechanized horticulture, areas beyond the Beenleigh–Brisbane area may have to be used.

As almost all the soils are of low inherent fertility, one of the major tasks in increasing primary production of any type—horticulture, sugar-cane growing, or dairying—is the correction of all nutrient deficiencies by the application of fertilizers including both major and minor elements. While this is being done at present in the established horticultural areas, application of fertilizers to the poorer podzolic soils of the hills would permit at least the growing of improved pastures and probably allow the production of horticultural crops also. Increased water storages are practicable in such areas and would make such development a more certain proposition. If the needs for fertilizers and adequate water supplies are met, many of the soil associations on which present development is low may be used to a much greater degree.

One of these is Park Ridge, an association found on gentle slopes and composed largely of lateritic podzolics, which are deep reasonably well-drained soils but have low inherent fertility. In the past, preference has usually been given to the red soils, the red earths and krasnozems, which are inherently no more fertile, but with fertilizer amendments and sufficient water the lateritic podzolics should prove fairly productive soils.

Both the Beenleigh and Woodridge associations are composed of infertile red-yellow podzolic soils on hills with moderate slopes on which are many places where water could be stored. If costs of clearing are not prohibitive, areas fertilized and supplied with water could support dairying and cattle-fattening industries, and possibly horticulture also. The Waterford association, which at present supports native or little-improved pastures, could, with water and adequate nutrition, be used for improved pastures, but its heavy clay soils are physically unsuitable for intense horticultural development.

Some associations, on the other hand, have little potential for development for primary production. These include both associations on areas with unsuitable topography such as those on hill crests with shallow soils, Priestdale, Bark Hill, and parts of Mount Cotton, and also some on alluvial plains such as Blunder, Eprapah, and Lota, where the poor structure of the soils or the poor drainage of the site could always limit development. The development of the associations of dark clay soils on basalt is limited also. Thornlands is composed of poorly drained soils, Capalaba of very shallow soils, and Archerfield and Runcorn are so located that they are likely to be absorbed soon by the spread of suburbs.

Major increases have recently occurred and further increases are to be expected in the amounts of sugar-cane grown around Woongoolba. The acreage of assigned land in the area served by the Rocky Point Mill was more than doubled in 1963 and 1964, from the earlier level of 3529 acres to 7817 acres. While the total amount of cane grown will be increased in this way, the yields of this district are still below the State average and there is room for considerable improvement in production by the application of better agronomic practices. This is one of the most favoured agricultural districts in the Beenleigh–Brisbane area—it has flat topography, moderately fertile soils that are easy to work, and good access to the city. Though its future as a sugar-producing area seems assured, it would be well suited to the large-scale production of other crops, such as vegetables or sown pastures. Drainage of the lower-lying portions, including the swamps, is a problem.

There is opportunity for considerable improvement in the local dairying industry. There is an assured market close by, the climate is on the whole suitable for satisfactory fodder production, and improved species of grasses and legumes are available. Application of techniques and materials available now should increase production considerably from its present low level.

For some years there was an increase in the number of small part-time farms, most commonly located on the less fertile podzolic soils of the hills and mostly bordering main roads. This trend now seems to have slackened. The observations made about fertilizer and water requirements in any development in the soils of the hills also apply to such small farms if production is to be maintained at an economic level. Provision of adequate water is especially difficult because they are too small to have sufficient catchment, and production may always be limited. Farms of this type are not likely to be important in the future agriculture of the area and make only a small contribution at present.

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Appendix I

COMMON SPECIES

	Common Name	Botanical Name
Eucalypt forest	Spotted gum	*Eucalyptus maculata*
	Scribbly gum	*E. micrantha*
	Blue gum	*E. tereticornis*
	Stringybark	*E. resinifera* *E. carnea* *E. umbra*
	Narrow-leaved ironbark	*E. crebra*
	Bloodwood	*E. gummifera* *E. trachyphloia*
	Swamp mahogany	*Tristania suaveolens*
	Brush box	*T. conferta*
	Rusty gum	*Angophora costata*
	Forest oak	*Casuarina torulosa*
	Red ash	*Alphitonia excelsa*
	Tea-tree	*Melaleuca* spp. *Leptospermum* spp.
Vine woodland	Hoop pine	*Araucaria cunninghamii*
	Yellowwood	*Flindersia xanthoxyla*
	Crow's ash	*F. australis*
	Bumpy ash	*F. scholtiana*
	Red cedar	*Cedrela australis*
	Vines	*Similax australia* *Vitis* spp. *Legnephora moorei*
Tea-tree forest	Paperbark tea-tree	*Melaleuca viridiflora*
Salt marsh	Succulents	*Salicornia australis* *Suaeda* sp. *Arthrocnemum* sp.
	Salt-water couch	*Sporobolus virginicus*
Mangroves	White mangrove	*Avicennia marina* var. *resinifera*

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