A Reconnaissance Survey of Soils in the Boonah-Beaudesert District, Queensland

T. R. Paton

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By T. R. PATON*

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Summary

The Boonah–Beaudesert area lies 20–40 miles south of Brisbane and covers 500 sq miles. It has a subhumid and subtropical climate with an annual average rainfall of over 30 in. which is characterized by marked seasonal distribution and a high degree of unreliability.

The main rural industries are dairying and grazing for beef production, utilizing native pastures with some supplementary forage crops. Potatoes are grown under irrigation in the upper valleys of Reynolds and Warrill Creeks. Rural development is generally of a low intensity except in the Fassifern scrub area and along the main valley floors. About 10% of the total area is too steep or broken to be economically used under the present farming system.

The soils have been classified at the great soil group level and then subdivided on parent material differences. The soil map shows associations of these great soil group/parent material units. Three local patterns of soil occurrence can be recognized coinciding with the three major physiographic divisions:

(1) In the Beaudesert basin prairie soils, black earths, and grey clays have formed in fine alluvium and prairie soils have developed on the basic igneous and fine-grained sedimentary rocks.

(2) In the central mountain area, where coarse-grained sandstone is the main parent material, podzolic soils occur in the steeper, more mountainous country, while soloths and solodics are confined to the lower gentle slopes.

(3) The western lowlands have thin-surfaced soloths and solodics, and prairie soils developed on fine-grained sediments; prairie soils, black earths, and grey and brown clays occur in the wide aggraded valleys.

Crop and pasture production in the district is limited by acute deficiencies of plant nutrients and soil moisture. There is widespread evidence of both nitrogen and phosphorus deficiencies and in addition some trace-element deficiencies are expected in many of the soils. The irregular and unreliable rainfall distribution coupled with the narrow range of available water in many of the soils results in moisture stress during the growth cycle of most pasture and agricultural crops. More effective use of the present rainfall could be achieved by improving the nutrition and by introducing improved species of grasses and legumes, which should lead to greater infiltration and retention of rainfall.

I. INTRODUCTION

The Boonah–Beaudesert area is situated from 20 to 40 miles south of Brisbane and includes portions of the valleys of the Logan River and Warrill Creek, a southern tributary of the Brisbane River. The total area is about 500 sq miles and its general

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location is shown in Figure 1; it includes portions of the counties of Churchill, Stanley, and Ward. The boundaries are those of the Flinders 1-mile military map sheet.

This area is typical of the subcoastal lands of southern Queensland, and investigations here will provide basic data that can be extrapolated to adjoining areas from the New South Wales border north to the Brisbane–Toowoomba highway.

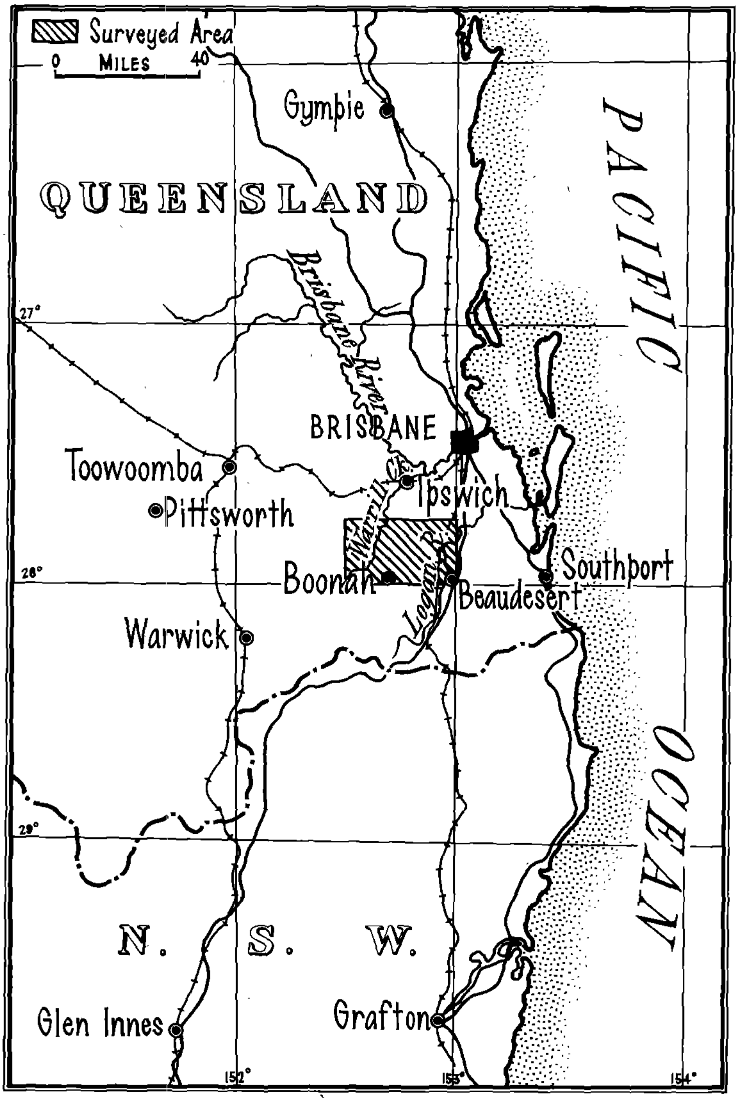


Fig. 1.—Locality map.

Soil investigations were made during the period March 1962 to November 1963. The objectives were to examine the field properties of the soils and to classify and map the important soil and landscape systems. This soil information is discussed in its relation to the environment and present land use.

II. Environment and Landscape

(a) *Climate*

This area is subhumid and subtropical with an average annual rainfall of 30–35 in. However, there is a marked summer maximum and a low reliability of rainfall, which causes soil moisture conditions to fluctuate between extreme drought and saturation.

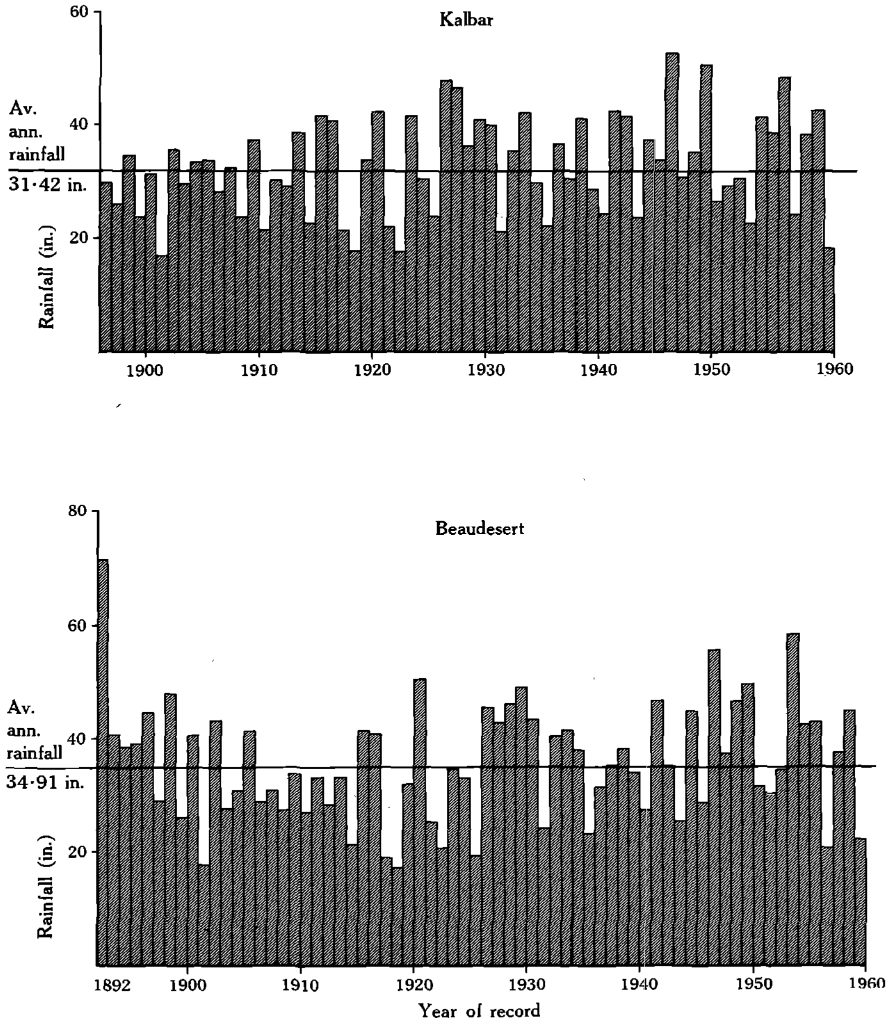


Fig. 2.—Annual rainfall data for Kalbar and Beaudesert.

Beaudesert on the south-eastern boundary had a mean annual rainfall of 34·91 in. over the period of record (1893–1960),* while Kalbar towards the western margin averaged 31·42 in. from 1897 to 1960 (Fig. 2). The variability of rainfall in this period

* Meteorological data from Rainfall Observations in Queensland, Commonw. Bur. Met., 1940; Book of Normals No. 1, Rainfall, Commonw. Met. Branch.

was considerable; at Beaudesert there was an absolute maximum of 71·25 and a minimum of 17·09 in., while comparative figures for Kalbar are 52·37 and 16·90 in.

No temperature records are available for places within the area, but data* from Ipswich immediately to the north probably are very similar. Here the mean maximum for the year is 81·5°F and the mean minimum 56·4°F. According to Foley (1945), the frost-prone period at the same station extends from June 11 to August 24, with an average of six frosts in the year. The frost-free period averages 319 days.

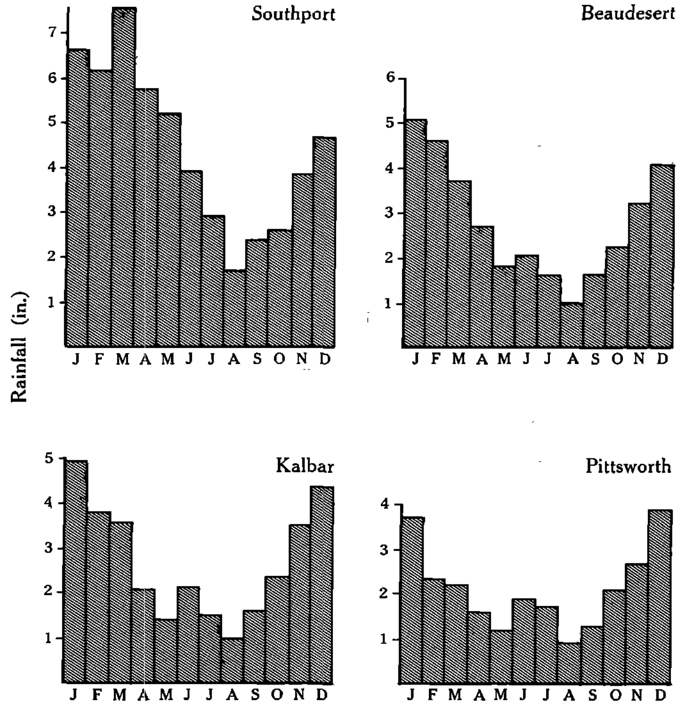


Fig. 3.—Mean monthly rainfall for coastal and inland stations.

In Figure 3 the mean monthly rainfalls are compared for Beaudesert and Kalbar within the region, Southport on the coast, and Pittsworth on the Darling Downs. A marked summer maximum and August minimum are evident at each centre, as is also a secondary winter maximum in June for the three inland stations. The gradual decrease in the total rainfall inland from the coast is clearly evident and is paralleled by a decrease in the average number of rain days, 91 at Beaudesert to 76 at Kalbar.

An analysis of monthly rainfall probabilities (Fig. 4) shows that Kalbar has consistently lower values than Beaudesert, this difference being particularly marked in winter.

Due to the high intensity of rainfall, particularly during the summer months, floods can occur fairly frequently in the Logan River and Warrill Creek valleys; the incidence of flooding is largely confined to the first six months of the year.

* See footnote on page 7.

The effectiveness of rainfall in this part of Queensland is reduced by its seasonal incidence, irregularity, and the high intensity of falls. Despite the apparent adequacy of recorded annual or growing-season rainfall temporary droughts are not uncommon. Using the concept of potential evapotranspiration, Stirk (1963), working at Samford

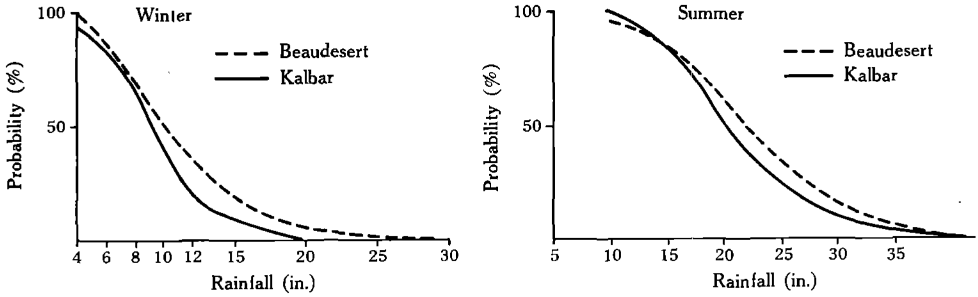


Fig. 4.—Winter and summer rainfall probabilities.

10 miles north-west of Brisbane, calculated the number of drought days to which pasture plants have been subjected in the period 1861–1961 (a drought day is defined as one in which there was no available water within root depth). A mean value of 65 drought days per annum was obtained, 42 occurring in the period September 1–January 31 (Fig. 5). The Boonah–Beaudesert area has a lower annual rainfall than Samford (35 against 41 in.) and would be expected to experience a slightly greater number of drought days per year.

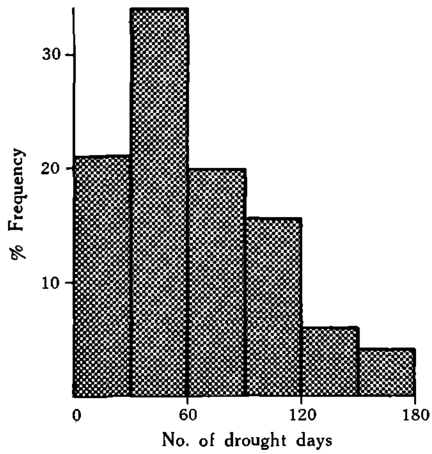


Fig. 5.—Frequency of drought days at Samford (1861–1961).

(*b*) *Geology*

Previous geological investigations in the district have been reported by Wilson (1958), Pearce (1959), and several other authors (Hill and Denmead 1960). These provide the basis for the ensuing geological discussion.

The rocks and unconsolidated materials may be divided into seven main groups: coarse-grained sedimentary rocks; fine-grained sedimentary rocks; little altered basic volcanic rocks; deeply altered basic igneous rocks; intermediate to acid volcanic and intrusive rocks; Tertiary limestones, shales, and sandstones; and unconsolidated riverine sediments.

(i) *Coarse-grained Sedimentary Rocks*

These are the sandstones and conglomerates making up the Triassic–Jurassic, Bundamba–Marburg succession. The general formation consists of interbedded sandstone, siltstone, and carbonaceous mudstone with thin coal seams. The rock varies from white coarse sandstone to dark grey and chocolate-coloured mudstone. It is sporadically enriched in carbonate in certain bands. In general the grain size decreases in an upward direction. These rocks occur throughout the east central part of the area between the Boonah–Ipswich road and the interstate railway line.

(ii) *Fine-grained Sedimentary Rocks*

These are the Jurassic Walloon coal measures. Lithologically they consist of light grey shale, siltstone, fine sandstone, and thin coal seams. The siltstone and thinly bedded sandstones are often micaceous. The dominant arenaceous type is a soft, massive, poorly sorted sandstone that often contains a high proportion of dark lithic fragments. Lenticular masses of iron carbonate up to 1 ft thick are fairly common. The shales also carry in places thin concordant veins of calcium carbonate that have a maximum thickness of several inches and frequently exhibit cone-in-cone structure.

The Walloon rocks are dominant throughout the area west of the Boonah–Ipswich road and also occur as a small area in the Logan valley round Cedar Grove–Kagaru and south to Bromelton.

(iii) *Little Altered Basic Volcanic Rocks*

Extremely resistant Tertiary basalt lavas form isolated hills or small plateaux. The largest area, the Mt. Walker residual between the Bremer River and Warrill Creek, is a remnant of the basalts from the main range. Isolated hills and lower plateaux occur east of Hillside, on the Boonah–Aratula road, at O'Connell's Hill, east of Boonah, and south of Bromelton school, west of Beaudesert.

(iv) *Deeply Altered Basic Igneous Rocks*

These are mostly coarse-grained intrusives in which the ferro-magnesian minerals are rich in alkalis (teschenites), but there are also some deeply altered basalts. They are confined to the area of Walloon strata between Purga and Warrill Creeks and to the area north of Beaudesert.

(v) *Intermediate to Acid Volcanic and Intrusive Rocks*

These rocks are variously named trachytes, comendites, microsyenites, and analcite dolerites; they range in composition from intermediate to acid, and are characterized by ferro-magnesian minerals that are rich in alkalis. In contrast to the teschenites, all give rise to definite hill features. Mt. French west of Boonah, the largest of these areas, is regarded as a sill of comendite (Stevens 1960). Porphyritic trachyte and trachyte breccia form Flinders Peak in the central northern part of the area, and related rocks form the neighbouring Mt. Goolman, Ivory's Rock, Mt. Perry, Mt. Blaine, Mt. Elliott, and Mt. Welcome. The microsyenites and andesites form a complex of smooth hills at lower elevation, fringing Warrill Creek on its eastern margin south from Harrisville and between the Warrill View–Mt. Walker road and the Aratula–Tarome road.

(vi) *Tertiary Limestones, Sandstones, and Shales*

The limestones are confined to Limestone Ridges south of Flinders railway station, where they form an area 3 miles long and 1 mile wide. This material is quarried for use as a dolomitic fertilizer. The only other area of undoubted Tertiary sediments lies between Beaudesert and Woodhill, where they are intimately associated with deeply altered basic igneous rocks and consist of coarse cobble conglomerate, sandstones, siltstones, and very thinly bedded black shales. There is also a considerable amount of billy, a form of quartzite. Thinly bedded black shales associated with deeply altered basalt lava flows and probably of Tertiary age also occur near Teviotville and Roadvale.

(vii) *Unconsolidated Riverine Sediments*

Except where locally derived from sandstone these materials are of a heavy texture. In all areas they show a considerable degree of layering and numerous buried soils are evident. They have a wide occurrence along the Logan River, Warrill and Purga Creeks, and the Bremer River.

There is a strong possibility that the surface spread of sandy materials in the Flagstone Creek area (NE. part of the sheet) is a Tertiary or Quaternary cover over Bundamba sandstones.

(*c*) *Physiography*

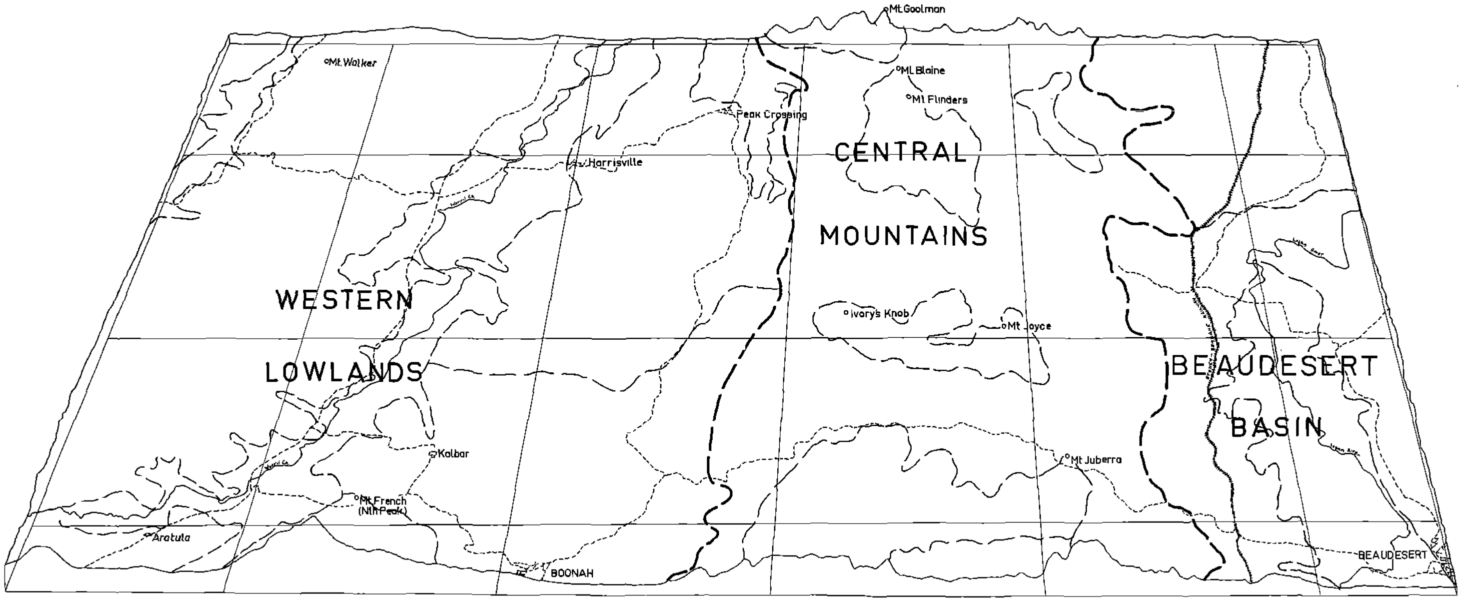
The major landscape features are a reflection of the underlying geological structure. This consists of a central anticline in which are exposed the lower rocks of the Triassic–Jurassic succession (Bundamba and Marburg sandstones). This structure is flanked by complementary synclines containing younger and generally finer-grained rocks (Jurassic Walloon sediments and Tertiary sedimentary and igneous rocks). The rocks of the anticline form rugged hill country, while the synclines give rise to gently undulating lowlands. Thus it is possible to make a threefold breakdown of the area: the Beaudesert basin, corresponding to the eastern syncline; the central mountain area, corresponding to the anticline; and the western lowlands, corresponding to the western syncline.

Landscape units will be described within these three major divisions.

(i) *Beaudesert Basin*

(1) Low hills of Tertiary sediments and igneous rocks extend along the eastern border from Beaudesert to a little north of Woodhill. The hills of sedimentary rocks have slopes of 10–12° while those of deeply altered basic igneous rock have gentle slopes of 2–4°. Gullying is common on the sediments, particularly where the land is partially cleared.

(2) The low hills of Cedar Grove, Kagaru, and Bromelton on Walloon sediments extend up the western flank and round the nose of the Beaudesert basin. These very gentle hills rise to a maximum height of 250 ft. Slopes are generally 2–4° but rise to a maximum of 6°. In places they grade imperceptibly into the alluvium of the Logan valley. This area has been almost completely cleared.


Mt Goolman
Mt Walker
Mt Blaine
Mt Flinders
Peak Crossing
Harrisville
CENTRAL
MOUNTAINS
WESTERN
LOWLANDS
Ivory's Knob
Mt Joyce
BEAUDESERT
BASIN
Kalbar
Mt Juberra
Mt French
(Nth Peak)
Aratula
BOONAH
BEAUDESERT

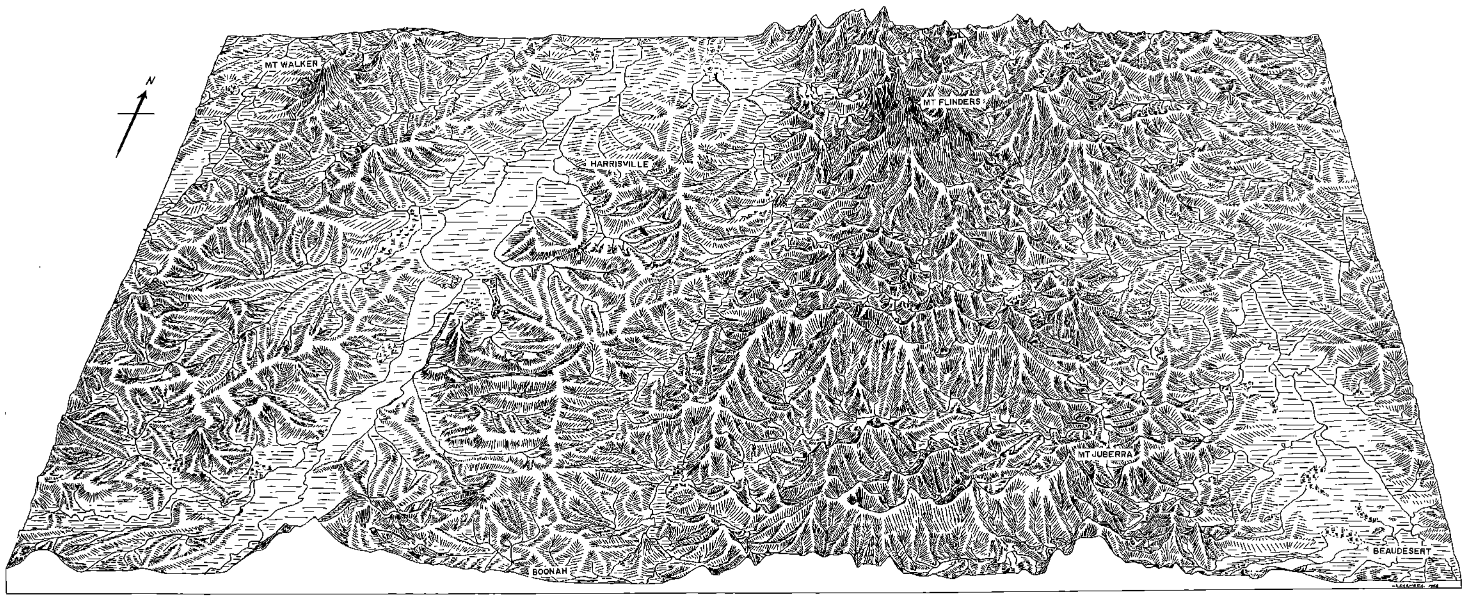


Fig. 6.—Physiography of the area covered by the Flinders 1-mile military map.

(3) The riverine alluvium extends from Beaudesert 10 miles north to the junction of the Logan River and Teviot Brook. Throughout this area there is a strong development of river terraces.

(4) The Wirraway–Greenbank plateau occurs on the north-east boundary of the area and is an undulating surface varying in height from 150 to 200 ft a.s.l. Its junction with steep hill country to the west is clearly defined by a sharp break at 350–400 ft a.s.l. This low plateau is equivalent to the ridge areas of the coastal lowlands (Coaldrake 1961).

(ii) *Central Mountain Area*

(1) Mountain areas include very steep and precipitous hill slopes; gradients exceed 25° in the strongly dissected sandstone country and 30° on the trachytic and rhyolitic plugs of the Mt. Flinders areas. There are three main areas of this landscape development: Mt. Juberra, Mt. Crumpet, and Mt. Moy in the south; Mt. Joyce–Ivory's Knob in the centre; and the Mt. Flinders area in the north, where a maximum height of 2229 ft is reached on Flinders Peak itself.

(2) Steep hills occur in the country between 400 and 800 ft elevation. These hills are characterized by gentle convex crests and side slopes of up to 10°; where stream erosion is active slopes increase to 25°. As a whole the region is strongly dissected but the ridges are generally long and continuous. The underlying rock is sedimentary, consisting largely of thick sandstone beds although there are some small trachyte intrusions. The main occurrences are between the Mt. Joyce–Ivory's Knob ridge and the Flinders Peak area, and on either side of the Mt. Moy–Mt. Juberra mountain area. There are also two smaller areas on either side of the upper reaches of Oxley Creek.

(3) Low hills occur below 400 ft and down to 100 ft a.s.l. There is an abrupt break of slope at 400 ft but the boundary below 100 ft is frequently imperceptible, the hills merging into the riverine alluvium. Generally slopes are of the order of 4–6° increasing to a maximum of 10°. These areas have been cleared to a much greater extent than the mountainous and steep hilly areas. They occur along Teviot Brook, Allan, Woolaman, Undullah, and Bundamba Creeks, and to a lesser extent Oxley Creek.

(4) Riverine alluvium is found along most streams almost to their sources. It is much more sandy than the alluvium of Logan River or Warrill Creek.

(iii) *Western Lowlands*

Rolling topography interspersed by isolated hills or mountains.

(1) Mt. French in the south-west of the area between Boonah and Aratula has a markedly flat-topped summit at 1300 ft. It is composed of comenditic lava flows or sill-like intrusives. The summit is heavily forested, while the 10–15° slopes are partially cleared.

(2) Mt. Walker, 1540 ft high, consists of a hard basalt lava. This is an erosion residual from the main range left in the north-west of the area between Mt. Walker Creek and the Bremer valley. It is surrounded by long pediment slopes developed in deeply altered basalt, basaltic colluvium, and Walloon sediments.

(3) The Purga–Kalbar hills around the junction of the watersheds of the Teviot Brook and Purga and Warrill Creeks lie to the north and north-west of Boonah. These

hills rise to a maximum height of 600 ft and fall to 250 ft near the streams. They are maturely dissected, consisting of gentle convex summits with slopes of 6–10° down to the streams, the smooth fall of the slopes being interrupted by platforms due to the outcrop of more resistant rock. The slopes steepen considerably near the stream. The bed-rock consists of highly calcareous sandstones, ironstones, and shales with deeply altered basic igneous rocks.

(4) The low hills of Warrill and Purga Creek valleys occur throughout the area to the north-west of the Purga–Kalbar country. They are gently rolling smooth features, with slopes never in excess of 6°, rising to a height of 400–450 ft and falling to 200–250 ft at the streams on either side. The valleys are open and are not incised as in the Purga–Kalbar area. The bed-rock consists of gently dipping Walloon sandstones, mudstones, and shales which have been intruded by a very coarse-grained deeply altered basic igneous rock (teschenite).

(5) Small hills of the microsyenite intrusives occur throughout landscape (4), particularly on either side of Warrill Creek, rising to a maximum height of 900 ft. Generally they have almost flat summits, upper slopes of up to 10–15°, and gentle lower slopes of 2–3°.

(6) Fine-textured riverine alluvium occupies wide areas along the Bremer River and Warrill and Purga Creeks, and differs from the alluvium of the Logan valley in not being markedly terraced. Much of the area has been cultivated, particularly in the southern part of Warrill Creek.

(*d*) *Natural Vegetation*

The original vegetation was mainly a grassy forest dominated by eucalypts, with some patches of brigalow and softwood scrub in places. Within the grassy forest the common species were spotted gum (*Eucalyptus maculata*), Moreton Bay ash (*E. tessellaris*), scribbly gum (*E. racemosa*), blue gum (*E. tereticornis*), grey gum (*E. propinqua*), gum-topped box (*E. hemiphloia*), red stringybark (*E. resinifera*), yellow stringybark (*E. acmenioides*), narrow-leaved ironbark (*E. crebra*), and red bloodwood (*E. gummifera*), together with two species of the allied genera *Tristania* and *Angophora* (Herbert 1951; Blake and Roff 1958).

On the riverine alluvium broad-leaved and rough-barked apple trees (*Angophora subvelutina* and *A. intermedia*) occupy the coarser-textured better-drained materials, while blue gum occurs on finer-textured rather poorly drained soils. Along the stream courses the river she-oak (*Casuarina cunninghamiana*), water gum (*Eugenia ventenatii*), and red bottlebrush (*Callistemon viminalis*) are common.

The more sandy hill soils of the eastern half of the area carry spotted gum together with forest oak (*Casuarina torulosa*) on the shallower stony areas and broad-leaved ironbark (*E. siderophloia*) on the deeper soils.

Silver-leaf ironbark (*E. melanophloia*) and Moreton Bay ash are typical of the gently rolling hill country of the western lowland.

On more acid igneous rocks such as Mt. French, narrow-leaved ironbark, red stringybark, and red bloodwood are common.

In the north-east of the area the Wirraway–Greenbank plateau represents a small extension of the coastal lowlands where red bloodwood, scribbly gum, and narrow-leaved grey gum (*E. seeana*) are common on the better-drained sites, while swamp messmate (*E. robusta*) and paper-bark tea-tree (*Melaleuca quinquenervia*) occur in the depressions.

A brigalow (*Acacia harpophylla*)–"softwood scrub" community has developed in the Purga–Kalbar hill area. Towards the eastern more hilly area pure stands of brigalow occur on the finer-textured soils and pure stands of "softwood scrub" on the coarser-textured soils. In the lower western half of this area brigalow is fairly evenly spread throughout the softwood scrub. A smaller area of softwood scrub also occurs immediately south-east of Flinders Peak.

III. Soil Classification and Soil Survey

The Boonah–Beaudesert area was covered in the mapping of the Brisbane 4-mile sheet by G. D. Hubble and W. H. Litchfield (unpublished data, 1954–1957); Beckmann (1967) mapped the Beenleigh area to the north-east of the present survey and a small part was included in the brigalow lands (Isbell 1962).

The present work is based on an investigation of all the landscape units previously defined.

(*a*) *Great Soil Group Classification*

Soils representative of 14 of the Australian great soil groups (Stace *et al.* 1968) were examined in this district during the survey. These are shown in Table 1, arranged in relation to the landscape units previously described. Most of the soil groups occur in more than one landscape unit but the dominants differ between units. The soils of eight of the groups are of major importance in the district (Table 2), the remainder being of little areal significance.

Soil distribution indicates that parent material exerts a major control over soil development in this area; the podzolics and solodics are confined to areas of coarse-grained quartzose sediments and to the more acid igneous rocks as well as to areas of sandy alluvium; prairie soils, black earths, and grey clays* have developed on the finer-grained sediments, the more basic igneous rocks, and the main development of valley alluvium. On the other hand lithosols are dependent on topography and are found only on the steepest slopes, but even here parent material differences are evident in the texture of the soil. Along the western boundary of the Logan valley deep siliceous sands occur where the stream gradients have suddenly decreased, depositing thick layers of coarse sediments. Such soils are too immature to reflect soil-forming processes.

Some of the soils are not readily placed with any of the Australian great soil groups and for convenience are regarded as variants of the group they most closely resemble. Within the area of Tertiary sediments, to the north of Beaudesert, grey- and reddish-mottled heavy clays have developed with a coarse polyhedral to parallelepiped structure and strongly acid reaction throughout the profile. Similar soils also occur on the third terrace of the Logan valley alluvium. These soils are regarded as acid variants of the grey, brown, and red clays. Surface structure variants of this group are also tentatively recognized for the grey clay soils with strongly developed surface structure and organic accumulation in the surface 6–12 in.

* Grey members of the grey, brown, and red clay group.

A group of soils under softwood scrub and brigalow occurs along the eastern boundary of the Purga–Kalbar hill area. These have a loam to clay loam surface texture, increasing to a sandy clay at 20 in. and to medium clay below this depth; sandstone occurs at just over 3 ft. In the softwood scrub the soils are apedal below the surface crumb-structured horizon, but under brigalow the subsoil is pedal. The pH increases

TABLE 1

PHYSIOGRAPHIC UNITS, SOIL ASSOCIATIONS, AND GREAT SOIL GROUPS

Physiographic Unit	Soil Association	Dominant Great Soil Group
Beaudesert Basin		
Valley alluvium	Bromelton–Beaudesert	Prairie soils; grey clays
Low hills of Tertiary materials	Churchbank–Veresdale	Prairie soils; soloths
Low hills of Walloon sediments	Brooklands–Anthony	Prairie soils; solodics
Wirraway–Greenbank plateau	Wirraway–Greenbank	Red and yellow podzolics; lateritic podzolics
Central Mountain Area		
Steep hills	Flinders–Juberra	Lithosols; red and yellow podzolics
Hills	Goolman–Juberra	Lithosols; red and yellow podzolics
Low hills	Undullah–Wyaralong	Soloths; solodics
Valley alluvium	Logan–Teviot	Alluvial soils; solodics
Western Lowlands		
Valley alluvium	Bromelton–Fassifern	Prairie soils; wiesenbodens
Hills		
(i) of Walloon and/or Tertiary sediments	Kulgun–Churchbank	Grey clays; prairie soils
(ii) of Marburg sandstone	Purga	Red earth over acid clay
Low hills		
(i) of fine-grained Walloon sediments	Peak–Churchbank	Prairie soils
(ii) of coarser-grained Walloon sediments	Rosevale–Churchbank	Soloths; prairie soils
(iii) of Tertiary limestone	Ibis–Churchbank	Rendzinas; prairie soils
Complex of upper terrace and low hills	Harrisville–Peak	Prairie soils; soloths
Isolated hills	Kengoon–Frazer	Solodized solonetz; lithosols
Mt. French	Edwards–Reynolds	Red and yellow podzolics
Mt. Walker	Walker–Warroolaba	Lithosols; prairie soils

from about 6·0 at the surface to nearly 8·0 in the subsoil and then decreases to 5·0 in the underlying clay. These are layered soils and will be referred to as the Purga subgroup.

In addition, there is an extremely complex pattern on parts of the highest terraces of the Logan River and Warrill Creek, consisting of small areas of soloths and solodized solonetz soils. This pattern has been named the Harrisville complex.

A brief description of each of the great soil groups as they occur in this area is given below:

(1) Red and yellow podzolic soils have sandy loam surfaces overlying friable clay subsoils. The surface has a weakly developed structure while the clay subsoil has a well-developed blocky structure. The soil reaction is generally slightly acid at the surface, becoming strongly acid with depth.

(2) Lateritic podzolic soils have up to 4 ft of sand to sandy loam, with a gradual to clear change to a mottled red and yellow-brown sandy clay deep subsoil. The surface 4 in. shows organic accumulation, and lateritic ironstone nodules are concentrated above the clay subsoil. The surface is slightly acid, becoming strongly acid with depth. Structure is weak throughout.

(3) Humus podzols are dominantly sandy to a depth of 6 ft and have a dark grey surface layer of organic accumulation about 12 in. thick, grading into a light grey subsoil. At 2–3 ft there is a very abrupt boundary to a dark reddish brown indurated organic pan up to 6 in. thick. This grades down into a pale waterlogged clayey sand. The soil is very poorly structured throughout.

(4) The solodic soils have up to 2 ft of sand abruptly overlying very tough poorly structured clays. There is slight organic accumulation in the surface 3 in., but this is underlain by a thick conspicuously bleached subsoil. The soil reaction is neutral in the surface layer, becoming moderately acid in the bleached subsoil, and then moderately alkaline in the underlying clay.

(5) The solodized solonetz soils have up to 6 in. of poorly structured loam to sandy loam surface abruptly overlying tough, very sticky clays. The first 6 in. of the clay horizon is marked by a strong columnar structure grading into a blocky structure below. The loam surface is moderately to slightly acid and the top of the clay slightly alkaline, becoming strongly alkaline with depth.

(6) Soloths differ from the solodic and solodized solonetz soils in being extremely acid throughout the profile. The clay subsoils generally have blocky structure but instances with strongly developed columns are known.

(7) The grey, brown, and red clays are cracking clays with a strongly developed coarse blocky structure and uniform or gradational texture profiles. Free carbonate occurs in both soft and nodular form below 1 ft. The soil reaction is slightly acid in the surface, becoming strongly alkaline from 1 to 3 ft, and then neutral at greater depths.

Two variants of this soil group are found in the area: one under softwood scrub vegetation has a highly organic and strongly developed crumb structure in the surface 6 in.; the other, on the third river terrace, is either apedal or poorly structured in the surface inch and may be transitional to the thin-surfaced solodic soils.

(8) The black earths are dark cracking clays with weak horizon differentiation. They have a strong fine granular surface up to 3 in. thick, grading through coarse blocky parallelepiped structure below 18 in. Hard carbonate nodules generally occur below this depth.

(9) Wiesenbodens are very similar to black earths, but seasonally wet conditions are indicated by ochreous spotting, dark bluish grey colours, and increased manganese deposition on ped faces.

(10) The rendzinas are dark clay soils with strong crumb to blocky structure and overlie limestone at shallow depth. Where the subsoils are seasonally wet, ochreous spotting and dark bluish grey colours reflect the poorer drainage and the soils are generally deeper.

(11) The prairie soils have clay textures, strongly developed fine blocky structure, soft consistence, and a neutral reaction. They are generally reddish brown or dark brown in colour and 2–3 ft deep to underlying parent material.

(12) The red earths are soils with gradational profiles increasing from sandy loam at the surface to clay loam at depth. They are extremely porous and friable. The soil reaction is slightly acid, though it sometimes becomes strongly acid at depth.

(13) Siliceous sands are deep sands in which there is no pedological development apart from some organic accumulation at the surface.

(14) Alluvial soils are layered alluvium, generally lacking pedological development except for a darker surface horizon.

(15) Lithosols are shallow soils dominated by slightly weathered rock fragments.

(*b*) *Subgroups*

As used in this report, a subgroup includes soils of one great soil group developed on a particular parent material. These subgroups have considerable local significance and have been given local names. Thus within the soloth great soil group a number of subgroups are recognized, e.g. the Undullah, for soils developed on Bundamba sandstones, and the Rosevale, for those on fine-grained Walloon sandstones. The more important subgroups are listed and described briefly in Table 2.

(*c*) *Soil Associations and the Soil Map*

The mapping unit employed is an association of soil subgroups within a particular landscape unit. Eighteen such units have been defined for this area (see soil map). Each association is named from the two dominant subgroups within it, with one exception, the Purga association where only a single name is used. A number of subgroups occur in more than one association, thus the Churchbank subgroup of prairie soils developed on deeply altered basic igneous rocks is found in most of the associations of the western lowlands.

The soil associations are largely coincident with the physiographic units previously defined, though in the western lowlands further division has been necessary due to areas of particular parent materials. Toposequences can be established for those associations where alluvial deposition or colluvial movement has been of considerable significance. However, in most of the associations the soils are related to the nature of the parent rock and the relief (Tables 1 and 3).

TABLE 2

DESCRIPTION OF SUBGROUPS IN EACH GREAT SOIL GROUP

Great Soil Group	Subgroup	Situation	Description
Lithosols*	Flinders	Slopes of up to25°; on acid igneous intrusive and volcanic rocks	Brown clay loams <12 in. thick with strong crumb structure and large amounts of rock fragments
	Aratula	6–15° Slopes around Mt. French; on acid igneous rocks	Dark brown silty clay loams with blocky structure, grading into dark reddish brown massive light clays; soil 12 in. thick to igneous rock with rock fragments throughout, the subsurface bleached when dry; pH decreases from 7·0 at the surface to 6·0 at 12 in.
	Frazer	Short 10° slopes on microsyenite hills	<6 in. of reddish brown clay loam with strong crumb structure, large amounts of microsyenite fragments throughout
	Walker	Flat plateau surfaces or slopes of up to 25°; on relatively unweathered basalt	<6 in. of dark reddish brown strongly structured clay loam to light clay
	Windsor	Gentle slopes on outcrops of "billy" sandstone	Yellowish brown massive loamy sand <18 in. thick; slight organic staining in top 3 in.; large amounts of "billy" boulders with depth
	Juberra	Slopes of up to 25° or very restricted flat areas; on coarse sandstones	Brown sandy loams <6 in. thick, massive or weakly structured
	Overflow	Gently rounded crests at 400 ft	Loose, yellowish brown coarse sands, generally <12 in. thick
Siliceous sands*	Fernlea	Gentle low hill slopes of 6°	Dark brown to yellowish brown coarse sands, 24–36 in. deep, single-grain structure; mottling at depth and suggestion of an A_2 horizon
	Swan Creek	Hummocky topography slightly above main valley floor	Deep, dark yellowish brown, loose sands
Alluvial soils	Logan	Uneven terraces below main terrace development of the area	<1 ft of dark brown silty clay loam over yellow-brown sand

Red earths	Charlwood	Flat sites at 900 ft around Mt. French	Red to yellowish red loam to clay loams increasing to light to medium clay at depth; slight organic staining in first few inches; "earthy" fabric throughout apart from a slight surface crumb development; soil reaction acid throughout; soil depth usually < 4 ft
Prairie soils*	Peak	Gently rounded low hills on Walloon ironstones	<4 in. of dark brown clay loam surface over red to reddish brown, medium to heavy clays with strong blocky to polyhedral structure and mellow consistence; pH from 6·0 to 8·0; soil depth <2 ft
	Warroolaba	Gently rounded low hills on Walloon siltstones	Dark brown to dark reddish brown soils similar to Peak subgroup
	Brooklands	Gently rounded low hills on Walloon shales	Similar to, but deeper than Warroolaba soils; below 2 ft grades into highly calcareous pale brown light clay
	Churchbank	Gently rounded low hills on basic igneous rock	Brown light clay increasing to medium clay with depth; strong blocky to polyhedral structure; slight organic staining at surface; gradational boundary to deeply altered basic igneous rock at <2 ft
	Bromelton	On better-drained areas of second terrace of Warrill Creek and Logan valley	Dark brown to very dark brown gradational soil, clay loam at surface increasing to medium clay with depth; strong blocky to polyhedral structure; overlies strongly developed buried soils at <4 ft
Minimal prairie	Woolaman	Better-drained sites of second terrace of streams within central mountainous area	>4 ft of yellowish brown sandy loam to sandy clay loam; top 12 in. rich in organic matter and has moderately developed blocky structure
Rendzinas	Ibis	Low but rather irregular ridges with 10–15° slopes; on soft dolomitic limestone with sporadic silicification	Black medium clay with strong granular surface grading to strong blocky subsoil, generally not > 12 in. deep
	Normanby	Middle and lower slope positions on highly calcareous shales	<12 in. of black clay grading into grey clay subsoil; strong blocky structure throughout; parent material at about 3 ft

* Group of major importance within the area.

TABLE 2 (*Continued*)

Great Soil Group	Subgroup	Situation	Description
Black earths*	Cyrus	Colluvial and valley sites, some with considerable slope	Black to very dark grey heavy clay; strongly developed blocky structure grading to parallelepiped units with depth; calcareous subsoil
Wiesenboden	Fassifern	Depressed sites on second terrace of Warrill Creek and Logan valley	Very dark grey to dark grey mottled heavy clay; moderately developed blocky structure grading to parallelepiped with depth; calcareous subsoil
Grey clays	Beaudesert	Third terrace of Logan River	Thin weakly structured brown loams over dark greyish brown medium to heavy clays with strongly polyhedral structure; carbonate nodules common below 12 in.
	Kulgun	Rolling hills with slopes of 6°, on fine-grained sediments (probably Walloon Formation)	Very dark brown loams to clay loams with strong granular to crumb structure, overlying very dark grey strongly structured heavy clays; strong slickenside development from 2 ft down to parent rock at 4 ft; both soft and concretionary carbonate occur below 12 in.
Soloth*	Undullah	Crests and upper part of gentle slopes below 400 ft; on coarse-grained sandstones	Greyish brown loamy coarse sand grading to white coarse sand, with very sharp break at 12 and 18 in. to medium to heavy clay strongly mottled in reddish yellow and yellowish brown. Clay, markedly columnar in places, grades at 30 in. into sandstone. pH of surface 6·5–6·0, pH of clay 4·0–5·0
	Wirraway	Gentle convex crests of Greenbank–Wirraway plateau; on sandstones	12 in. of very dark brown loamy sand with little suggestion of a subsurface bleach abruptly overlying a heavy brownish grey clay with a coarse blocky structure; soil abruptly overlies sandstone at *c.* 2 ft; pH decreases from *c.* 7·0 at surface to 5·5 at *c.* 1 ft in clay
	Veresdale	Gentle slopes of about 4°; on Tertiary sandstones and siltstones	Brown clay loams grading to well-defined bleached subsurface, with very sharp lower boundary at 12 in. to dark red heavy clay with a strong blocky structure and becoming distinctly mottled with depth; pH decreases from 6·0–6·5 at surface to 4·5 in clay and to as low as 3·5 in parent material

	Rosevale	Low hill slopes of 2–4°; on Walloon sandstones	Thin dark brown surface grading into strongly bleached hard-setting fine sandy loams; sharp boundary at 6 in. to mottled brown medium to heavy clays with moderate polyhedral structure and sticky plastic consistence; pH decreases from 6·0 at surface to 4·5 in clay
	Woodhill	Third terrace of Logan Valley near junction with marginal hills	Dark brown sandy clay loam grading into a light brown massive subsurface with ironstone nodules particularly at its base; at 4–6 in. there is a very sharp boundary to brown clay with coarse columnar structure and prominent mottling with depth; pH decreases from 6·0–6·5 at surface to 4·0–5·0 in clay
Solodized solonetz	Kengoon	Gentle summits of microsyenite hills	Brown to reddish brown soil with up to 6 in. of weakly structured loam surface, abruptly overlying medium to heavy clay with strong columnar structure in first few inches and increasing amounts of carbonate below 10 in.; well-developed bleach at loam/clay junction; pH 6·0 at surface, 8·0 at top of clay, and 9·0 at 2 ft
Solodic*	Moy	Restricted to more gently sloping sites (up to 10°) within mountainous area; derived from coarse sandstone	Pale brown massive sandy clay loams with abrupt boundary at less than 6 in. to mottled reddish yellow medium clays with weak structure; soil depth *c.* 3 ft to highly calcareous parent material; pH decreases from 7·0 at surface to 5·5 in clay and rises to 9·0 in weathered rock
	Wyaralong	Relatively depressed site on rolling topography below 400 ft on coarse sandstone	Massive sandy loams to loamy sands 15 in. thick, with thin dark surface and bleached base, abruptly overlying yellowish to greyish brown sandy medium clay with weak blocky structure; pH decreases from 7·0 at surface to 5·5 at 4 ft
	Waraperta	Very gentle lower slopes surrounding abrupt hills of microsyenite	Brown soil with 12 in. of weakly structured fine sandy clay loam, with stone line at its lower boundary, sharply overlying calcareous heavy clay with coarse blocky structure
	Milora	Gentle slopes associated with Walloon ironstones	Brown clay loam surface, with slight development of bleach at depth of 4–5 in. where it overlies reddish brown medium to heavy clay with coarse blocky to columnar structure; pH 6·0 at surface, 5·5 at top of clay, and 7·5+ in clay; carbonate may be present

* Group of major importance within the area.

TABLE 2 (*Continued*)

Great Soil Group	Subgroup	Situation	Description
Solodic* (*continued*)	Anthony	Gentle slopes associated with Walloon siltstones	<6 in. of grey to greyish brown clay loam with slight bleach at base; overlies dark greyish brown medium to heavy clay with strong blocky structure; carbonate nodules common below 12 in.
	Teviot	Third terrace of streams within central mountain area	<24 in. of dark brown coarse sand over yellowish brown sandy clay, with strong blocky structure and some mottling with depth; pH increases from 6·0 at surface to 8·0 at 4 ft
Red and yellow podzolics*	Waters	Slopes of up to 7° associated with Tertiary sandstones	Weakly structured greyish brown to light brown sandy loams grading into mottled reddish sandy clays with blocky structure; mottling increases with depth; pH decreases from 7·0 at surface to 5·5 at 4 ft
	Greenbank	Gentle convex ridge crests of Wirraway plateau; on sandstone	Brown to yellowish brown loamy sands to sandy loams with weak structure grading at 12 in. to mottled red and white sandy medium clay with moderate coarse blocky structure; soil depth usually >4 ft, parent rock deeply altered; pH decreases from 5·5 at surface to 4·0 in deep subsoil
	Goolman	Hilly and mountainous country with slopes up to 20°	Loamy sand to sandy loam surface grading to light brownish grey subsurface with abrupt boundary at 12 in. to mottled red and pale yellow medium to heavy clay with blocky structure and rather friable consistence; soil depth 3–4 ft to sandstone; pH decreases from 6·5 at surface to about 4·0 in weathered rock
	Edwards	Gentle crest of Mt. French	Very dark brown loam to silt loams grading at about 6 in. into reddish brown clay loams; surface has fine blocky structure which grades into medium blocky units in subsoil, and boundary to underlying rock is very sharp

	Reynolds	5–15° Slopes around Mt. French, on mixture of acid igneous rocks and Walloon sediments	Dark brown crumb-structured silty clay loams grading into massive brown or pale brown light clays which at 2 ft abruptly overlie reddish brown medium clay with strong blocky structure; depth of soil to lithic sandstone is *c.* 6 ft; pH decreases from 6·5 at surface to 4·5 in clay
Lateritic podzolics	Jimboomba	Gently undulating crests of Wirraway plateau near its junction with much more abrupt sandstone hills	About 4 in. of grey sandy loam overlying 4 ft of yellowish coarse sandy loam, grading into yellow coarse sands with ironstone nodule layer about 2 ft thick; pH about 6·0 throughout profile
Humus podzol	Goodna	Depressed sites with very gentle slopes on Greenbank plateau	About 10 in. of dark grey sand grading into about 20 in. of pinkish grey sand, with abrupt boundary to very dark reddish brown loamy sand hardpan which grades into waterlogged clayey sand below 3 ft
Gilgaied acid grey clays	Gleneagle	Slopes of up to 6° on Tertiary shales and mudstones	Dark greyish brown clay loams 2 in. thick overlying grey heavy clays; weak structure development throughout; acid soils with pH 3·5–4·0
Red earth overlying an acid pedal clay—a two-layered soil	Purga	Slopes of 10–15° on Marburg sandstones	Reddish brown crumb-structured loams grading at 2 in. to red massive sandy clay loams to sandy clays overlying at 20 in. mottled red heavy clays with moderate blocky structure; pH 6·0–8·0 in top 20 in., 4·0–5·0 in clay
Soloth and solodic	Harrisville complex	Fourth terrace of Logan River and Warrill Creek with barely perceptible boundary to surrounding gentle hill slopes; flat areas have sporadic gilgai development	Duplex soils with up to 4 in. of silty loam or silty clay loam abruptly overlying coarse-structured heavy clays; pH extremely variable, between 3·5 and 8·5; "billy" boulders occur throughout clay and as local accumulations on surface; areas with pronounced gilgai occur where surface silty loam is very thin. Soil pattern extremely complex along bevelled margins of unit

* Group of major importance within the area.

(i) *Bromelton–Beaudesert Association*

This association includes all soils formed on the Logan valley alluvium. Four terraces are evident, the second and third covering the greatest area. Soil relationships are complex and will be dealt with at greater length. The alluvium is generally fine-textured, being derived from Walloon sediments and Tertiary basalts.

The dominant soils on the second terrace are the prairie soils of the Bromelton subgroup and the wiesenbodens of the Fassifern subgroup; the former occur along the riverine edge of the terrace and the latter along its rear margin. Where tributaries enter the main valley from the basalt areas to the east, black earths of the Cyrus subgroup replace the Bromelton soils.

On the third terrace grey clays of the Beaudesert subgroup occur in association with soloths of the Woodhill subgroup and with gilgaied acid grey clays. Alluvial soils of the Logan subgroup are found on the weakly developed first terrace and as a patchy cover over the second and third terraces along the western margin of the valley.

(ii) *Churchbank–Veresdale Association*

This pattern of soils is confined to the area of Tertiary sediments and basic igneous rocks occurring to the north of Beaudesert. The relationship of the different types of bed-rock to one another is extremely complex and as each type of bed-rock gives rise to its own type of soil this is reflected in the soil pattern. Prairie soils of the Churchbank subgroup are formed from the deeply altered basic igneous rocks; gilgaied acid grey clays of the Gleneagle subgroup have formed from shales; lithosols of the Windsor subgroup overlie "billy" sandstones; red and yellow podzolics of the Waters subgroup have developed on relatively soft sandstones; and soloths of the Veresdale subgroup occur on siltstones.

(iii) *Brooklands–Anthony Association*

The association consists of prairie soils (Brooklands subgroup) and solodic soils (Anthony subgroup) derived from Walloon sediments. The former are derived from shales and the latter from coarser-grained sediments. Solodics of the Milora subgroup and prairie soils of the Peak subgroup occur on coarse- or fine-grained ironstones respectively. The topography consists of low rounded hills with gentle slopes.

(iv) *Wirraway–Greenbank Association*

The association consists of soloths of the Wirraway subgroup, red and yellow podzolics of the Greenbank subgroup, and humus podzols of the Goodna subgroup. The soils are developed on a gently undulating plateau of Bundamba sandstones, with an irregular covering of sands and conglomerates which are probably of Quaternary age. Soloths occur on the rounded crests and humus podzols have formed in depressions where there are deep accumulations of sand. The red and yellow podzolics are more generally distributed, occurring both on crests and in depressions. Lateritic podzolics of the Jimboomba subgroup have sporadic occurrence at the abrupt junction with soils of the Goolman–Juberra association, which occurs at 350 ft elevation.

(v) *Flinders–Juberra Association*

This soil association occurs in mountainous areas above 800 ft. It consists of shallow stony soils (lithosols) and bare rock surfaces. Soils of the Juberra subgroup are developed on Bundamba sandstones and those of the Flinders subgroup on trachyte. Small areas of shallow solodic soils (Moy subgroup) have developed on lenses of more calcareous sandstones on the less sloping sites.

(vi) *Goolman–Juberra Association*

This soil association occurs in the strongly hilly region between 400 and 800 ft and is developed on Bundamba sandstones and trachyte intrusives. Red and yellow podzolics of the Goolman subgroup and lithosols of the Juberra subgroup occur on the sandstones, with some lithosols of the Flinders subgroup on trachyte.

(vii) *Undullah–Wyaralong Association*

The dominant soils are soloths and solodics developed in coarse-grained sandstones of the Bundamba Formation on a gently rolling landscape which has a maximum elevation of 400 ft a.s.l. Soloths of the Undullah subgroup occur on the hill crests and upper slopes; solodics of the Wyaralong subgroup occupy the lower slopes. There is a gradual transition from the solodics of the lower slopes to soils of the Logan–Teviot association formed in the valley alluvium.

Some rounded crests, formed from massive sandstones, are included in the association and are usually at about 400 ft a.s.l. The soil cover on these is thin and stony (lithosols) and is classified as the Overflow subgroup. Sill-like intrusions of acid igneous rock occur in the northern part of the area and have a thin stony soil cover of lithosols of the Flinders subgroup.

(viii) *Logan–Teviot Association*

The association includes all those soils formed on the alluvial fill of valleys within the central mountain area. Three types of soil are developed: solodics of the Teviot subgroup; minimal prairie soils of the Woolaman subgroup; and alluvial soils of the Logan subgroup. This alluvial area is strongly terraced and solodics are dominant on the third terrace, minimal prairie soils on the second, and alluvial soils on the first. The general character of this association differs from that of the Bromelton–Beaudesert association in that the surrounding Bundamba sandstones have contributed a large amount of coarse sand to the alluvial fill.

(ix) *Bromelton–Fassifern Association*

This association includes all the soils formed on the alluvial fill in the valleys of the western lowlands, with the exception of those of the Harrisville complex, which is included in association (xv). Three types of soil are dominant, the prairie soil of the Bromelton subgroup, black earths of the Cyrus subgroup, and wiesenbodens of the Fassifern subgroup. This area differs from that covered by the Bromelton–Beaudesert association in the paucity of terrace development. In the southern part of Warrill Creek, prairie soils occur in the better-drained areas with wiesenbodens in depressions. In the northern part of Warrill Creek and in the Bremer valley, black earths occur in better-drained positions while wiesenbodens occur in depression sites. Swamps are common at the junction of small tributary streams with the main spread of valley alluvium.

(x) *Kulgun–Churchbank Association*

This association occurs throughout the hill country at the junction of the watersheds between Warrill Creek, Purga Creek, and Teviot Brook. The main soils are the grey clays of the Kulgun subgroup formed from fine-grained calcareous Walloon sediments, and the prairie soils of the Churchbank subgroup formed from basic igneous rock. The basic intrusive rocks are not related to the present topography and hence there is no particular topographic position where either Kulgun or Churchbank soils are consistently found. Under brigalow–softwood scrub vegetation these soils have developed a very friable crumb to granular surface, differing from the typical grey clays in this respect, while the tough subsoil character differentiates them from the prairie soils.

The soils of the Kulgun subgroup are included within the sedentary clay soils in the survey of the brigalow lands (Isbell 1962).

(xi) *Purga Association*

This association includes only one subgroup of the same name. These soils, with a marked texture and structure contrast between the surface and subsoil, occur in the strongly hilly area east and to the north of Boonah and to the south-east of Mt. Flinders. The underlying rock is Marburg sandstone. Under softwood scrub the surface layer is generally sandy loam and the subsoil has earthy fabric; under brigalow the texture increases to sandy clay with a moderate grade of blocky structure.

(xii) *Peak–Churchbank Association*

The soils of this association have been formed from Walloon sediments and from basic igneous rocks intruded into them. The association occupies the gently rolling landscape forming the low divide between Purga and Warrill Creeks south of Peak Crossing, and the higher areas of the divide between Warrill Creek and the Bremer valley. Prairie and solodic soils are dominant. Shallow prairie soils of the Churchbank subgroup are formed on the basic igneous rocks. The Walloon sediments have a varied lithology and are generally calcareous. This is reflected in the development of four distinct subgroups of soils. On fine-grained sediments reddish brown prairie soils of the Peak subgroup are developed on iron-rich materials, while dark brown prairie soils of the Warroolaba subgroup occur on the iron-poor shales and siltstones. Coarser-grained sediments, where iron-rich, give rise to reddish brown solodic soils of the Milora subgroup and, where iron-poor, to dark brown solodic soils of the Anthony subgroup. There is a slight development of linear gilgai on some of the soils formed from Walloon sediments.

(xiii) *Rosevale–Churchbank Association*

The soils of this association have been formed from Walloon sediments and from basic igneous rocks intruded into them, but the sediments differ from those of the previous association in being non-calcareous and much more quartzose. The association occurs on the gently rolling foothills below 400 ft a.s.l. in the watershed between Warrill Creek and the Bremer valley. As in the previous association prairie soils of the Churchbank subgroup have formed on the basic igneous rocks, and thin-surfaced soloth soils of the Rosevale subgroup have developed on the non-calcareous finely quartzose Walloon sediments.

(xiv) *Ibis–Churchbank Association*

The soils of this association have formed on cherty limestones and highly calcareous shales of the Tertiary Silkstone Formation and on intrusive basic igneous rocks. The association occurs in a rather irregular hilly area that rises to almost 700 ft south of Peak Crossing. Rendzinas of the Ibis subgroup are formed from the cherty limestone, while those of the Normanby subgroup have developed in depressed sites from calcareous shales. Prairie soils of the Churchbank subgroup occur on basic igneous rocks.

(xv) *Harrisville–Churchbank Association*

The soils of this association have formed on the alluvium of the highest terrace of Warrill Creek, Walloon sediments, and intrusive basic igneous rocks. The association occurs on the very gently rolling country forming the watershed between Warrill and Purga Creeks, north of Peak Crossing, and between Warrill and Mt. Walker Creeks, around Mutdapilly. Thin-surfaced soloths and the solodics of the Harrisville complex have developed on alluvium, and soils of the Peak–Churchbank association are found on the Walloon sediments and the basic igneous rocks. The Harrisville–Churchbank association was mapped as a separate entity because of the difficulty in separating the Harrisville complex from the gentle hill slopes with soils of the Churchbank, Peak, Milora, Warroolaba, and Anthony subgroups. It can in fact be regarded as a combination of the Peak–Churchbank association and the Harrisville complex.

(xvi) *Kengoon–Frazer Association*

The soils of this association have formed from intrusive masses of alkaline microsyenite. The association occupies the low hills which project above the general level of the area throughout the western lowlands, rising to a maximum height of some 900 ft. The summits of the hills are relatively flat, and in this position solodized solonetz soils of the Kengoon subgroup have formed from the microsyenite. Slopes of up to 15° surround the summit and on these lithosols of the Frazer subgroup have been formed. These slopes gradually decrease to 2–4° on the lower margins where solodic soils of the Waraperta subgroup occur.

(xvii) *Edwards–Reynolds Association*

The soils of this association have formed from the acid igneous rocks of Mt. French and their occurrence is restricted to this area. Red and yellow podzolic soils of the Edwards subgroup occur on the flat summit. The surrounding steeper slopes of up to 15° have lithosols of the Aratula subgroup, or red and yellow podzolics of the Reynolds subgroup which differs from the Edwards subgroup in the presence of a marked bleach in the A_2. Red earths of the Charlwood subgroup occur on various platform sites, at heights from 800 to 950 ft, on the shoulders of Mt. French.

(xviii) *Walker–Warroolaba Association*

Recent basaltic lavas and Walloon sediments are the parent materials of this association. Its main occurrence is around Mt. Walker which rises above 1500 ft in the north-west of the area. There are three other small areas where a hard basalt cap overlies Walloon sediments. On the surface of the hard basalt cap lithosols of the Walker subgroup are developed. The more elevated areas of Walloon sediments give rise to the prairie soils of the Warroolaba and Peak subgroups and to solodics of the Milora and Anthony subgroups. Soil development is related to the lithology of the Walloon sediments in the same way as in the Peak–Churchbank association, but here the

TABLE 3

LANDSCAPE FEATURES, LAND USE, AND PERCENTAGE OF AREA OCCUPIED BY SOIL ASSOCIATIONS

Association	% of Area	Landscape Features	Present Land Use
Bromelton–Beaudesert	6·0	River terrace landscape to north of Beaudesert	Dairying with irrigated pasture and fodder crops but with a considerable area of poor-grade volunteer pasture; small areas of potatoes
Churchbank–Veresdale	1·7	Low hills on Tertiary sediments and igneous rocks	Dairying and beef-raising on poor-grade volunteer pasture
Brooklands–Anthony	2·8	Low hills on Walloon sediments	Dairying and beef-raising on poor-grade volunteer and introduced pastures
Wirraway–Greenbank	4·8	Gently rolling plateau, maximum local relief of 50 ft	Partially cleared eucalypt forest with poor-grade volunteer pasture, scattered dairying and beef-raising, relief pasture in droughts
Flinders–Juberra	3·5	Very steep hills on sandstone and acid igneous rock	Partially cleared eucalypt forest with poor-grade volunteer pasture, some grazing by beef cattle
Goolman–Juberra	14·0	Steep hills on sandstone	Poor-grade volunteer pasture, used mainly for beef-raising
Undullah–Wyaralong	11·6	Rolling hills on sandstone	Poor-grade volunteer pasture, used mainly for beef-raising
Logan–Teviot	5·2	River terrace landscape within central hilly areas	Poor-grade volunteer pasture, mainly for beef-raising, small areas of fodder crops
Bromelton–Fassifern	13·4	Alluvium with little terrace development	Intensive production of potatoes and pumpkins under irrigation; irrigated pasture and fodder crops for dairy cattle; some improved pasture

Kulgun–Churchbank	7·0	Rolling hill country on Walloon sediments and basic igneous rock	Intensive dry-land production of fodder crops for dairy cattle; some introduced pastures
Purga	2·0	Steep hill country on Marburg sandstone	Partially cleared softwood scrub, developed to some extent for fodder crops for dairy cattle; some introduced pastures
Peak–Churchbank	7·5	Gently rolling hill country on Walloon sediments and basic igneous rocks	Mainly dairying on poor-grade volunteer and introduced pasture, small areas of fodder crops
Rosevale–Churchbank	9·5	Gently rolling hill country on Walloon sediments and basic igneous rocks	Mainly beef-raising on poor-grade volunteer and introduced pastures, small areas of fodder crops
Ibis–Churchbank	0·6	Low hills with rather rough topography	Poor-grade volunteer and introduced pastures, small areas of fodder crops; beef-raising and dairy cattle
Harrisville–Churchbank	3·2	Very low hill slopes and highest alluvial terraces	Partially cleared tea-tree forest, poor volunteer and introduced pastures; beef-raising and dairy cattle
Kengoon–Frazer	3·6	Isolated small hills	Partially cleared eucalypt forest, poor volunteer pasture; used largely for beef-raising
Edwards–Reynolds	1·2	Flat summit and strongly rolling slopes of Mt. French	Partially cleared eucalypt forest on summit, grazed by beef cattle. Flanks of hill partially cleared and former softwood scrub areas used for dairying; potatoes grown on red earth platforms and vegetables on restricted areas of alluvium along the northern slopes
Walker–Warroolaba	2·2	Flat-topped, steep-sided residual running out into gentle pediment slopes	Partially cleared eucalypt forest on highest point, sparse grazing by beef cattle. Fodder crops for dairy cattle on pediment slopes

Warroolaba soils are dominant. Prairie soils of the Churchbank subgroup formed from deeply altered igneous rock are also present. At lower elevations on less calcareous, more quartzose rocks occur soloths of the Rosevale subgroup.

Pediment slopes have been cut in Walloon sediments beneath the basalt remnant. In the upper part of the pediment, localized depressions radiating from the basalt remnant and sharply demarcated from the surrounding Walloon sediments carry black earths of the Cyrus subgroup. In the lower part of the pediment, the distinction between the depressions with black earths and the sedentary prairie soil or solodic on the Walloon sediments largely disappears and the black earths increase considerably in extent.

IV. Land Use

(*a*) *Historical Development*

The Boonah–Beaudesert area was first explored by Logan in 1827 and first occupied in the 1830s by free settlers arriving via the Darling Downs. Between 1842 and 1846 all available land was taken up in cattle and sheep runs. No crops were produced apart from a little corn and grain grown on the river flats for local use. Originally sheep were dominant but they were not suited to the environment and were gradually replaced by beef cattle (Anon. 1944; Keane and Ziegler 1958; Anon. 1963).

Cotton was the first crop of any importance. It was grown from 1860 to 1875 during the period when North American production was greatly reduced by the Civil War. With the re-entry of the U.S.A. into the market, together with the increasing problem of pest control in Queensland, cotton production rapidly decreased. However, within this period a considerable plantation was established on the Logan valley flats near Veresdale, and around Ipswich 12,000 acres were planted, extending as far south as Anthony, some 10 miles north of Boonah.

The growing demand by the increasing population for locally produced food crops, together with the 1868 Conditional Purchase Act, led to farming settlement of parts of the area. Since pastoral interests held the more desirable land, the only areas available to the immigrant farmers, mainly German, were the softwood and brigalow scrubs. Thus, between 1870 and 1890 the whole of the Fassifern scrub around Boonah was cleared and occupied. The first crops after clearing were maize and lucerne. By 1900 most of these scrub farms had turned to dairying as the main source of income. This change was hastened by the opening of the railways (Harrisville 1882, Boonah 1887, and Beaudesert 1888), the appearance of mechanical cream separators in the 1880s, and the introduction of paspalum and Rhodes grass about 1900. The general size of the scrub farms was 80–160 acres.

Between 1909 and 1914 the leases of the large stations expired and they were subdivided into smaller farms. Only since this date has the development of the river flats of Reynolds and Warrill Creeks become possible, culminating in irrigation farming for potatoes and pumpkins. The initial opening up of the country was accompanied by the considerable development of a timber-cutting industry, and most small centres had a sawmill. However, since the original clearing the supply of timber has decreased, though a certain amount is still being felled in the central mountain area, and sawmills are active only at Boonah and Beaudesert.

(*b*) *Present Agricultural System*

Information on the agricultural system of the Boonah–Beaudesert area was obtained from the shire returns of the Commonwealth Bureau of Census and Statistics. The area under consideration is divided almost equally between the shires of Moreton, Boonah, and Beaudesert (Fig. 7). The figures for these three shires give a general idea of the trends since 1950 when the shire boundaries were changed. Before this it is difficult to obtain strictly comparable figures.

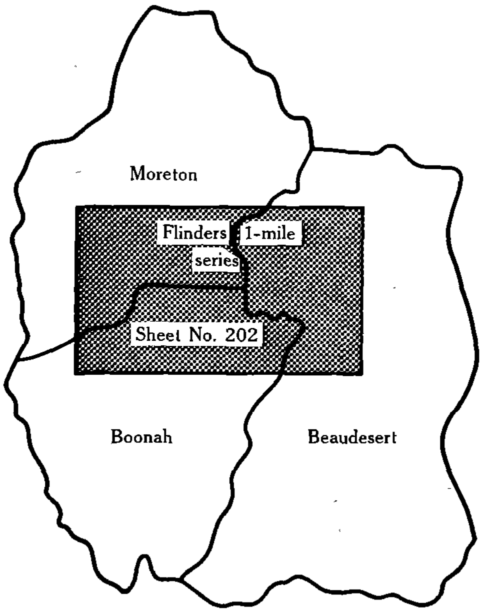


Fig. 7.—Relationship of survey area to the three statistical divisions.

Dairying is the main industry, whole milk being marketed from the area nearer Brisbane and cream for butter from the remainder of the district. The total number of dairy cattle is between 140,000 and 150,000; the main breeds are Australian Illawarra Shorthorn and Jerseys. In the period from 1951 to 1963 the ratio of dairy to beef cattle decreased from 3 to 1 to less than 2 to 1, while whole-milk production increased from 4½ million to over 8 million gallons. Both of these changes were at the expense of cream production which decreased from 25 million pounds to under 19 million in the same period (Figs. 8 and 9). The number of pigs remained more or less constant at about 45,000 until 1961, but in the last two years this declined to less than 40,000. This is probably a reflection of the smaller amount of skim milk available from cream production.

The amount of land used for cultivation is 10% in the case of Moreton and Boonah shires and 4% for Beaudesert, having increased from 82,000 acres in 1951 to 93,000 in 1963. Introduced pastures cover 12% of the three shires and increased from 117,000 acres to 136,000 between 1951 and 1963. The remaining 78% of the area consists of pastures of native grasses which may or may not have been improved by ring-barking of trees. The main grain crops are wheat, maize, barley, and sorghum, while the main

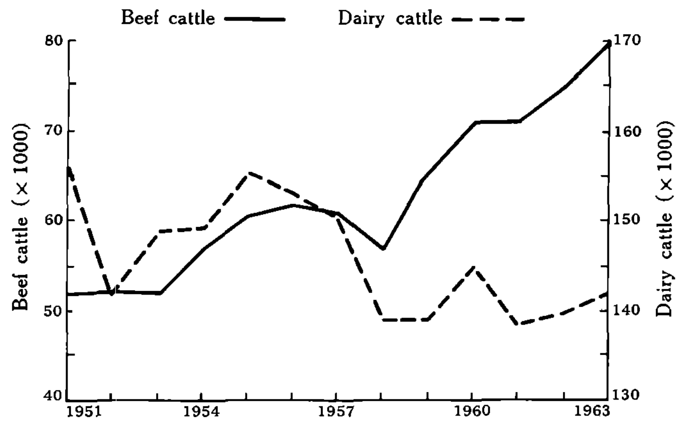


Fig. 8.—Changes in numbers of beef and dairy cattle (1951–63).

green feed crops are oats, lucerne, and sweet sorghum. The important cash crops are potatoes and table pumpkins, grown in Warrill and Reynolds Creek valleys; a considerable quantity of cattle pumpkins is also grown for stock feed.

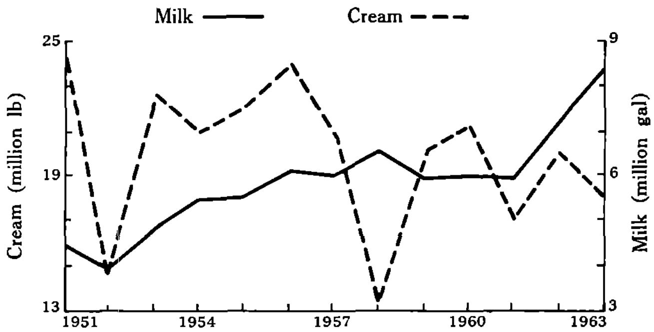


Fig. 9.—Changing trends in milk and cream production (1951–63).

The area of land under irrigation has risen from just under 8000 acres to over 15,000 acres in the period 1951–63. Of this total rather more than half is devoted to fodder crops; however, in Boonah shire the major crops under irrigation are potatoes

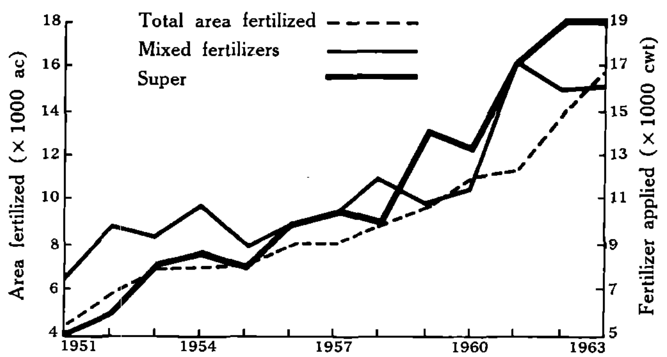


Fig. 10.—Fertilizer use (1951–63).

and pumpkins. This trend has been increased since the construction of the Moogerah Dam on Reynolds Creek.

The use of fertilizers within the area is relatively small but is gradually increasing (Fig. 10). In 1951 just over 5000 cwt of superphosphate and 7500 cwt of other and mixed fertilizers were used on 4500 acres. By 1963 this had risen to 19,000 cwt of superphosphate and 16,300 cwt of mixed fertilizers on 16,000 acres, but this is an extremely low figure considering that most of the soils have gross nutrient deficiencies, particularly of phosphorus. The fertilizer is applied mainly to fodder crops but a considerable amount is used on vegetables in Boonah shire. Only a small area of pastures has had fertilizer applied, 150 acres in 1951 rising to 3400 acres in 1963. Even so, this last figure is still only $2\frac{1}{2}\%$ of the total acreage growing introduced pasture species.

Future intensive farming development would appear to lie in the direction of larger-scale mechanized vegetable production on the valley floors.

V. Soil Features as Related to Agronomy

(*a*) *Reserves of Plant Nutrients*

Field trials by the Department of Primary Industries and CSIRO have shown a general response to applied nitrogenous and phosphatic fertilizers in both pastures and agricultural crops throughout most of coastal Queensland. Apart from the anticipated generally low levels of nitrogen and phosphorus, little is known of the nutrient status of the Boonah–Beaudesert district.

Table 4

Phosphorus status of surface soils (0–6 in.) of Boonah–Beaudesert area

Subgroup	Great Soil Group	Parent Material	Av. Available P* (p.p.m.)
Goolman	Red and yellow podzolics	Bundamba sandstone	4
Undullah	Soloth	Bundamba sandstone	6
Greenbank	Red and yellow podzolics	Bundamba sandstone	6
Wirraway	Soloth	Bundamba sandstone	4
Anthony	Solodic	Walloon sediments	5
Peak	Prairie	Walloon sediments	20
Kulgun	Grey clays	Walloon sediments	150
Churchbank	Prairie	Teschenite	600
Bromelton	Prairie	Alluvium	407
Beaudesert	Grey clays	Alluvium	21
Woodhill	Soloth	Alluvium	5

* Modified Truog method (Kerr and von Stieglitz 1938).

Part of the area (the Wirraway–Greenbank association) is really an extension of the coastal lowlands and may be expected to have similar very low plant nutrient contents and similar fertilizer requirements. Investigations by Andrew and Bryan (1955) in similar soils at Beerwah have shown that the limiting plant nutrients in

TABLE 5

CATION STATUS* OF REPRESENTATIVE SOILS OF BOONAH–BEAUDESERT AREA

	Clay (%)	T.E.C. (m-equiv. %)	Ca (m-equiv. %)	Mg (m-equiv. %)	K (m-equiv. %)	Na (m-equiv. %)	H (m-equiv. %)	Saturation (%)
B506 Red podzolic—Goolman subgroup (Dr 3.41†)								
0–3½ in.	10	14·1	2·2	1·8	0·6	0·04	9·5	33
11–15 in.	41	16·9	0·5	4·8	0·5	1·0	10·1	40
32–47 in.	38	27·9	0·24	7·8	0·15	5·7	14·0	50
B508 Soloth—Rosevale subgroup (Dy 3.41†)								
1–5 in.	22	15·3	1·5	4·2	0·4	0·7	8·5	45
7–21 in.	62	42·3	1·1	12·9	0·3	4·9	23·0	46
27–36 in.	43	33·6	1·1	12·4	0·17	6·6	13·3	61
B510 Grey clay—Kulgun subgroup (Gn 3.93†)								
0–2½ in.	46	68·8	37·9	6·0	1·6	0·3	23·0	66
10–21 in.	62	49·7	26·1	17·1	0·4	4·1	1·9	96
28–35 in.	55	47·6	19·0	17·3	0·3	6·5	4·6	90
B513 Prairie soil—Churchbank subgroup (Gn 3.92†)								
0–2 in.	N.d.	37·9	18·2	7·4	2·2	0·25	9·8	74
4–8 in.	N.d.	36·3	20·5	6·6	0·42	0·14	8·6	76
12–22 in.	N.d.	41·9	21·0	13·1	0·06	0·46	7·3	83
B504 Solodized solonetz—Kengoon subgroup (Dd 1.43†)								
0–2½ in.	17	25·6	5·1	3·1	0·46	0·6	16·4	36
7–12 in.	42	37·6	9·4	11·6	0·13	10·4	6·1	84
18–32 in.	31	29·8	6·8	9·1	0·04	10·4	3·4	88

* T.E.C. by direct determinations; metal cations after leaching at pH 8·4.

† Principal profile form (Northcote 1965).

decreasing order of importance are phosphorus, nitrogen, calcium, potassium, copper, zinc, molybdenum, and boron. For an efficiently nodulated legume added nitrogen is not required.

Pot experiments (Fergus, unpublished data) using a legume (*Phaseolus lathyroides*) have shown significant responses to the application of phosphorus, sulphur, and molybdenum on soils of the Peak and Undullah subgroups. In addition, a response to applied zinc was also obtained in the latter soil.

Samples were collected from the surface 6 in. of each subgroup and analysed for available phosphorus by a modified Truog method (Kerr and von Stieglitz 1938). Representative results are shown in Table 4.

The most important fact emerging from these results is the clear relationship between the amount of available P and the type of parent rock. The soils on Bundamba sandstones and on the more sandy of the Walloon sediments, whether they are red and yellow podzolics, soloths, or solodics, all have similar low P values of 4–6 p.p.m. In the prairie soils on the more lithic sandstones the available P rises to about 20 p.p.m., whereas the grey clays on calcareous siltstones and shales have an average available P content of 150 p.p.m. The prairie soils of the Churchbank subgroup are derived from basic intrusive igneous rock and have an average available P content of 660 p.p.m.; however, the values for this subgroup have a wide range from 450 to 2300 p.p.m.

The last three subgroups in Table 4 are associated with the alluvial fill of the Logan valley. The prairie soils of the Bromelton subgroup occur on the second terrace of the Logan River and have an average available P value of just over 400 p.p.m. The Beaudesert subgroup (grey clays) and the Woodhill subgroup (soloths) occur on the third terrace and have much lower P values of 21 p.p.m. and 5 p.p.m. respectively. The low values for the Woodhill subgroup can be explained by the local supply of fine sandy alluvium from the Tertiary sandstones, but the different values for the Bromelton and Beaudesert subgroups are not explainable in this way and the possibility of different environmental conditions during formation must be considered.

The Queensland Department of Primary Industries claims good responses in most crops to applied phosphorus on a range of soils with less than 50 p.p.m. P_2O_5 (i.e. 21 p.p.m. P) as determined by the modified Truog method (von Stieglitz 1953). Applying this standard most of the soils of the Boonah–Beaudesert area have very low values, and applications of phosphatic fertilizer will be needed for high-yielding crops and pastures.

Carbon (Walkley and Black 1934) and nitrogen were determined on the same surface samples used for the available phosphorus analyses. The most extreme values obtained were 7·5% organic carbon for a grey clay under brigalow–softwood scrub and 1·1% for a soloth on Walloon sandstone under grassy forest. The C/N ratios do not show great extremes, with a minimum of 9·0 and a maximum of 14·0, both being within the range normally accepted for arable soils.

From the exchangeable cation data for representative profiles (Table 5) the soils may be divided into two groups, those with high base saturation, e.g. prairie soils, grey clays, and soils of the Purga association, and those with low base saturation, e.g. the soloths, solodics, and podzolics.

TABLE 6

PHYSICAL PROPERTIES OF SOME PROFILES FROM THE BOONAH–BEAUDESERT AREA

Sample Depth (in.)	Texture	Water Content (cm^3/cm^3)				Density (g/cm^3)		Porosity		Permeability Class	Swelling (%)
		0·1 Bar	15 Bar	Range	At Sampling	Bulk	Particle	Total	Macro		
		Profile B513, prairie soil of Churchbank subgroup (Gn 3.92)									
0–2	Light clay	0·39	0·20	0·19	0·20	1·23	2·71	55	16	Moderate	2
2–4	Light clay	0·41	0·18	0·23	0·21	1·20	2·65	55	13	Moderate	0
5–7	Light–medium clay	0·35	0·22	0·13	0·24	1·27	2·63	52	16	Moderate	2
9–11	Medium clay	0·34	0·20	0·14	0·22	1·31	2·67	51	16	Moderate	1
24–26	Sandy medium clay	0·35	0·22	0·13	0·22	1·47	2·71	46	11	Moderately slow	0
		Available water 0–2 ft = 3·60 in. Macroporosity and permeability high throughout the profile									
		Profile B510, grey clay of Kulgun subgroup (Gn 3.93)									
0–2	Clay loam	0·34	0·17	0·17	0·14	0·81	2·32	65	31	Rapid	8
2½–4½	Light clay	0·37	0·25	0·12	0·21	1·11	2·51	56	19	Moderately rapid	7
6–8	Light–medium clay	0·42	0·29	0·13	0·24	1·38	2·68	48	6	Slow	15
15–17	Medium clay	0·43	0·32	0·15	0·28	1·49	2·74	46	3	Slow	17
24–26	Medium clay	0·41	0·32	0·09	0·28	1·55	2·68	42	1	Very slow	15
		Available water 0–2 ft = 3·30 in. Macroporosity low below 12 in., very low below 2 ft									

				Profile B506, red podzolic of Goolman subgroup (Dr 3.41)							
½–2½	Sandy loam	0·24	0·07	0·17	0·20	1·54	2·54	39	15	Moderate	0
6½–8½	Very sandy loam	0·20	0·04	0·16	0·20	1·67	2·64	37	17	Moderate	0
12–14	Moderate heavy clay	0·35	0·20	0·15	0·26	1·50	2·69	44	9	Moderately rapid	4
19–21	Medium clay	0·37	0·23	0·14	0·30	1·61	2·62	38	1	Very slow	1
				Available water 0–2 ft = 3·66 in. Below 15 in. macroporosity low, permeability very slow							
				Profile B508, soloth of Rosevale subgroup (Dy 3.41)							
2–4	Fine sandy loam	0·20	0·09	0·11	0·14	1·44	2·71	47	27	Rapid	0
5–7	Medium–heavy clay	0·41	0·28	0·13	0·32	1·50	2·62	43	2	Very slow	5
16–18	Heavy clay	0·47	0·32	0·15	0·34	1·46	2·69	46	0	Very slow	2
24–26	Medium clay	0·41	0·34	0·07	0·30	1·59	2·72	42	1	Very slow	2
				Available water 0–2 ft = 3·12 in. Macroporosity very low or absent below 5 in.							
				Profile B537, gilgaied acid grey clay (Ug 5.24)							
2½–11	Medium–heavy clay	0·41	0·32	0·09	N.d.	1·41	2·70	48	7	Moderately slow	Considerable
11–18	Medium–heavy clay	0·45	0·32	0·13	N.d.	1·43	2·72	47	2	Slow	Considerable
18–26	Medium–heavy clay	0·46	0·34	0·12	N.d.	1·38	2·74	50	4	Slow	Considerable
26–34	Medium–heavy clay	0·49	0·33	0·16	N.d.	1·36	2·76	51	2	Slow	Considerable
34–38	Medium–heavy clay	0·47	0·34	0·13	N.d.	1·42	2·78	49	2	Slow	Considerable
				Available water 0–2 ft = 2·62 in. Aeration and permeability limited below 12 in.							

The order of cation dominance in the base-rich group is calcium, magnesium, potassium, and sodium. Exchangeable potassium is greater than 0·2 m-equiv.% and exceeds 2% of the exchangeable metal cations, indicating a sufficiency for plant growth (von Stieglitz 1953). The base-rich soils also have moderate to high amounts of available phosphorus, and because of their higher fertility have been preferred for cultivation throughout the area.

The soils with low base saturation have a totally different relative proportion of metal cations; magnesium is the dominant cation and becomes more so with depth, accompanied by a considerable increase in the amount of exchangeable sodium. Experience from field trials with *Phaseolus atropurpureus* var. Siratro (C. S. Andrew, personal communication) has shown that poor growth occurs on soils of this type and this may be associated with a low calcium/magnesium ratio in the plant, normal plants having a Ca/Mg ratio above unity and poor plants having a ratio of less than 1.

The solodized solonetz of the Kengoon subgroup does not readily fit either of the above subdivisions. Below the thin lighter-textured surface the cations in order of decreasing abundance are sodium, magnesium, calcium, and potassium. Exchangeable potassium is $<0 \cdot 2$ m-equiv.% below a depth of $2\frac{1}{2}$ in. and responses to applied potash are therefore anticipated. The high exchangeable sodium content is due to the occurrence of a sodium-rich amphibole in the parent microsyenite.

(*b*) *Physical Properties*

Determinations of the water content at 0·1 bar and 15 bars (representing field capacity and wilting point respectively), bulk and particle density, and total porosity and macroporosity were made on representative profiles (Table 6). In addition an estimate was made of the amount of available water in the surface 2 ft.

Macroporosity, defined as the percentage of total soil volume containing air at 100 cm tension or approximately field capacity, has been suggested by Stirk (1964) as a reasonable guide to aeration and is probably a more useful single indicator of structural condition than bulk density. Aeration difficulties are unlikely with macroporosity in excess of 10%. On this assessment the only soils that would not have aeration problems are the prairie soils (developed on both sedentary and alluvial materials). The grey clays have a considerable fall in macroporosity below the strongly structured surface, and this is even greater where a sandy surface overlies a clay as in the podzolics and the soloths. The susceptibility of these last soils to accelerated erosion when the junction between the surface and the clay B horizon is exposed, as in road cuttings, is probably due to the marked change in macroporosity at the top of the clay.

Profile B537, a gilgaied acid grey clay from the third terrace of the Logan River, shows extremely low macroporosity throughout the profile. In the field this is an extremely intractable clay soil and is included as a comparison with the other profiles.

The soils of the area can store only between 2·6 and 3·6 in. of available water in the 0–2-ft zone, i.e. sufficient for about 15 days' growth during the summer period (G. B. Stirk, personal communication). This limit, combined with the irregularity and unreliability of rainfall previously discussed, illustrates the likelihood of crop growth being restricted by moisture stress during some part of the growing season in most years.

Irrigation, from either dams on the main stream (such as Moogerah on Reynolds Creek) or small farm dams and wells, will overcome most of the existing moisture difficulties associated with effective utilization of the soils on alluvium, but the moisture problems of the sedentary soils are greater. Small farm dams high in the landscape could lead to better utilization of the rainfall. In addition, the growth of improved pasture with adequate fertilization may improve the porosity of the soils and so increase rainfall infiltration, particularly on the podzolics, soloths, and solodics.

(*c*) *Salinity*

Salinity is high enough to cause the death of vegetation through the narrow valleys where soils of Kulgun–Churchbank association are developed, particularly where these valleys join the main alluvium of Warrill Creek, Purga Creek, and Teviot Brook. At these points the salt-affected areas are most noticeable at the junction between the local alluvium and that of the main valleys. The restriction of strong effects of salting to such localized areas indicates that the salt is derived from the rocks of the local catchments, i.e. from Walloon sediments, Tertiary basic igneous rocks, and possibly some Tertiary sediments. Table 7 gives figures typical of the seepage water in such saline areas. The

TABLE 7

SALINITY OF WATER FROM UPPER VALLEYS WITHIN KULGUN–CHURCHBANK ASSOCIATION

		Purga Creek Drainage	Warrill Creek Drainage	Teviot Brook Drainage	Well Waters* Michigan, U.S.A.	Well in Sandstone† Ventura, U.S.A.
Salinity (p.p.m.)		6230	6800	25,510	21,660	27,400
% of Ions	Ca^{++}	17·0	9·3	9·0	20·7	21·1
	Mg^{++}	4·6	5·0	5·0	4·2	0·2
	K^{+}	2·6	2·9	2·2	1·9	0·4
	Na^{+}	10·1	11·8	17·5	8·7	15·1
	Cl^{-}	57·5	47·5	57·9	64·5	63·2‡
	SO_4^{--}	0·8	Trace	3·9		Trace
	HCO_3^{-}	7·4	23·5	4·5		Trace
		100·0	100·0	100·0	100·0	100·0

* Clarke (1924), p. 187. † Fleischer (1963), p. F32. ‡ Includes Br^{-} and I^{-}.

total salinity is stated in parts per million while the ions are stated as percentages of this total. The chemical composition is unusual for surface waters and resembles that of the sodium chloride–calcium chloride type from deep wells. Two such analyses (Clarke 1924; Fleischer 1963) are included for comparison.

(*d*) *Soil Erosion*

A large part of the area which originally carried brigalow and softwood scrub on the rolling hill country of the Kulgun–Churchbank and Purga associations has been cultivated for fodder crops. Extensive sheet erosion is now evident on most slopes of 6–15°. Observations on soils of the Kulgun subgroup show that clearing which started in the 1870s has led to almost complete removal of the 4–6 in. of very friable surface, which is now found only under the small remnants of virgin scrub. No steps have been taken to control erosion and it is essential that contour banks and contour ploughing should be instituted as soon as possible.

Ring-barking of trees is continuing on the podzolic and lithosolic soils of the Goolman–Juberra association on slopes of up to 20°. Such activity must increase the erosion hazard considerably, while the slight increase in carrying capacity gained will be more than offset by the cumulative erosion losses.

Recent road construction in the area has caused a great deal of gully erosion due to the lack of protection along road margins. This is particularly evident on the soils with strong texture contrast; examples are to be seen on the soloths and solodics of the Undullah–Wyaralong association, along the newly constructed road between Boonah and Beaudesert. This problem is general in south-east Queensland, and protective measures should be taken as soon after road construction as possible before the gullying reaches serious proportions.

VI. Conclusions

Rural production in the Boonah–Beaudesert area is limited by inadequate plant nutrition, poor utilization of the present rainfall, and unsuitable pasture species.

Observations in the field and results from pot experiments show that nitrogen, phosphorus, and molybdenum deficiencies are common throughout the area. These can be corrected by fertilizer application, but the low nitrogen level of pasture lands would probably be raised more economically by the use of legumes.

The present rainfall is inadequately used due to the low water storage capacity of the soils and the inability of the rainfall to penetrate the hard-setting surface of the soloths and solodics. Infiltration into hard-setting soils should increase with the establishment of improved pastures, while farm dams could be constructed to store run-off for irrigation and thus extend the growing season that otherwise would be limited by the depletion of soil moisture.

Field experimentation is necessary to show which species and pasture mixtures are most suited to the area, but experience at the CSIRO Pasture Research Station at Samford suggests that legumes such as *Lotononis bainesii*, Siratro, and lucerne could be used on the sedentary soils, *Glycine javanica* on the calcium-rich soils, and *Phaseolus lathyroides* would have a place as a pioneer legume on heavy soils. Grasses such as Rhodes grass on nearly neutral soils, green panic and *Setaria sphacelata*, particularly on areas with impeded drainage, and *Paspalum plicatulum* on poorer soils, would probably be well suited. On irrigated valley flats lucerne, white clover, setaria, prairie grass (*Bromus unioloides*), and *Phalaris* sp. are suggested (R. J. Jones, personal communication).

However, the three factors of improved plant nutrition, better use of water, and improved pastures cannot be dealt with separately. Improvement in one is dependent on improvement in the others. Planned farming, taking into account these three factors, could bring about a spectacular increase in production. Such an approach would do much to mitigate the natural environmental difficulties, such as the irregularity of the rainfall and the difficulty of water penetration into the soil. A great deal of this could be achieved without major irrigation works and could be carried out by individual farmers or groups of farmers.

VII. Acknowledgments

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VIII. References

Andrew, C. S., and Bryan, W. W. (1955).—Pasture studies on the coastal lowlands of subtropical Queensland. I. Introduction and initial plant nutrient studies. *Aust. J. agric. Res.* **6**, 265–90.

Anon. (1944).—Fassifern District Centenary, 1844–1944. Fassifern Cent. Comm., Boonah, Qld.

Anon. (1963).—Harrisville District Centenary, 1863–1963. (Mirror Newspapers Pty. Ltd., Brisbane.)

Beckmann, G. G. (1967).—Soils and land use in the Beenleigh–Brisbane area, south-eastern Queensland. CSIRO Aust. Div. Soils, Soils and Land Use Ser. No. 50.

Blake, S. T., and Roff, C. (1958).—Honey flora of south-eastern Queensland. (Govt. Printer, Brisbane.)

Clarke, F. W. (1924).—The data of geochemistry. 5th Ed. U.S. Geol. Surv. Bull. No. 770. 841 pp.

Coaldrake, J. E. (1961).—The ecosystem of the coastal lowlands ("Wallum") of southern Queensland. CSIRO Aust. Bull. No. 283.

Fleischer, M. (Tech. Ed.) (1963).—Data of geochemistry. Ch. F, Chemical composition of sub-surface waters. U.S. Geol. Surv. Prof. Pap. 440-F.

Foley, J. C. (1945).—Frost in the Australian region. Bur. Met. Aust. Bull. No. 32.

Herbert, D. A. (1951).—The vegetation of south-eastern Queensland. In "Handbook for Queensland". (Aust. N.Z. Ass. Advmt Sci., Sydney.)

Hill, D., and Denmead, A. K. (Eds.) (1960).—Geology of Queensland. *J. Geol. Soc. Aust.* **7**, Ch. VIII–IX.

Isbell, R. F. (1962).—Soils and vegetation of the brigalow lands, eastern Australia. CSIRO Aust. Div. Soils, Soils and Land Use Ser. No. 43.

Keane, E., and Ziegler, O. L. (1958).—"The Story of the Gold Coast of Queensland and the Hinterland." (O. Ziegler Pub. Pty. Ltd., Sydney.)

Kerr, H. W., and von Stieglitz, C. R. (1938).—The laboratory determination of soil fertility. Qd Bur. Sug. Exp. Stns tech. Commun. No. 9.

Northcote, K. H. (1965).—A factual key for the recognition of Australian soils. 2nd Ed. CSIRO Aust. Div. Soils divl Rep. No. 2/65.

Pearce, L. G. G. (1959).—The geology of the Beaudesert area. Honours thesis, University of Queensland.

Stace, H. C. T., Hubble, G. D., Brewer, R., Northcote, K. H., Sleeman, J. R., Mulcahy, M. J., and Hallsworth, E. G. (1968).—"A Handbook of Australian Soils." (Rellim Tech. Publs, Glenside, S.A.)

Stevens, N. C. (1960).—Igneous rocks of the Kalbar district, south-eastern Queensland. Univ. Qd Pap. Geol. **5**(4).

von Stieglitz, C. R. (1953).—Methods used in Queensland for assessing soil fertility. Aust. Conf. Soil Sci., Summ. Pap. 1 (2–21).

Stirk, G. B. (1963).—Estimation of frequency of drought days at Samford, south-east Queensland. CSIRO Aust. Div. Soils divl Rep. No. 5/63.

Stirk, G. B. (1964).—Soil assessment. Commonw. Agric. Bur. Bull. 47.

Walkley, A., and Black, I. A. (1934).—An examination of the Degtjareff method of determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Sci.* **39**, 29–38.

Wilson, E. G. (1958).—The Bundamba Group in the area south-east of Ipswich. Honours thesis, University of Queensland.

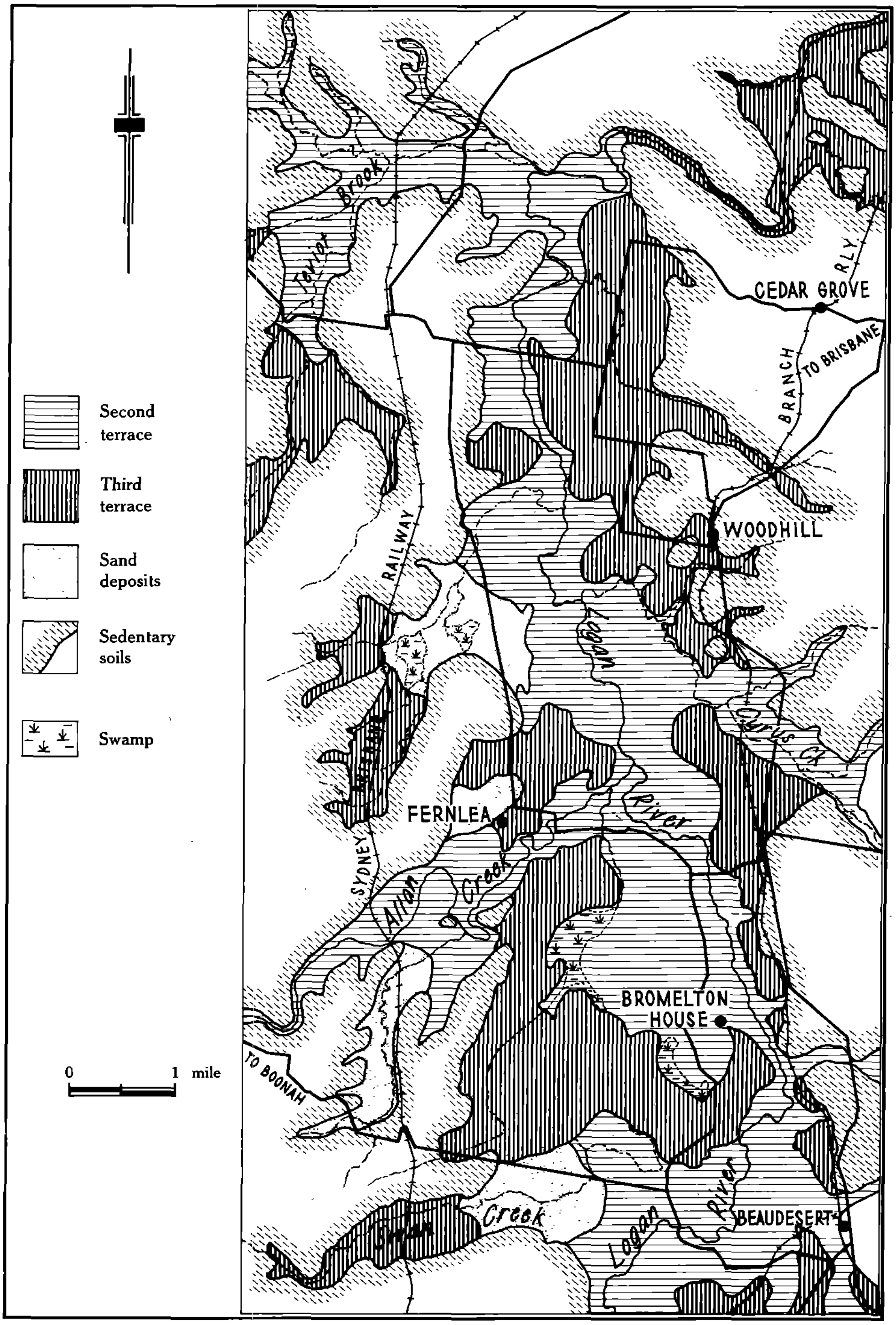

Fig. 11.—Soils of the Beaudesert basin.

Appendix I

Soils of the Beaudesert Basin

Because of the agricultural importance and high potential of the valley alluvium of the Logan River a more detailed examination was made of the area from Beaudesert north to Cedar Grove. Within this region there is a wide stretch of valley fill, which narrows abruptly to the north around Cedar Grove and to the south along the upper Logan River. This area is 12 miles long and up to 4 miles wide. The flow of the Logan River is from south to north through this basin, and from the west it is joined by Allan Creek and Teviot Brook, the latter at the extreme northern end of the basin. From the east the main tributary is Cyrus Creek. Throughout its length the Logan River and its main tributaries are incised about 35 ft below the general level of the alluvium.

Four distinct terraces have been cut in the alluvium and are easily recognizable at approximately 6, 35, 50, and 90 ft above the present stream level. Terrace 1 is restricted to very small areas along the present stream channel; terraces 2 and 3 cover the greater part of the area; and terrace 4 occurs only as small remnants.

Since 1947 there have been three floods over terrace 2. The 1947 flood covered terrace 3, but there was remarkably little deposition from it. The flood of 1893 is reported to have been 6 ft higher than that of 1947. In the northern part of the basin flooding of longer duration tends to occur as water banks up against the Cedar Grove ridge.

The soils of terrace 1 are alluvial soils of the Logan subgroup. They are subject to annual flooding and are not used agriculturally.

The main development of terrace 2 is in the areas immediately west of Beaudesert and between Bromelton House and Woodhill. Two soils occur on this terrace, a prairie soil of the Bromelton subgroup nearer the stream, and a wiesenboden of the Fassifern subgroup which occurs in depressed sites with some areas of surface swamp. These surface swamps generally occur near the junction of terraces 2 and 3.

The alluvium of the tributary valleys comes in at the level of terrace 2. Black earths of the Cyrus subgroup have formed on the higher parts of the alluvium of Cyrus Creek, and wiesenbodens of the Fassifern subgroup in the low sites.

Towards the western side of the valley, particularly where Teviot Brook joins the main stream, a soil is developed on terrace 2 level with features intermediate between the prairie soil of the Bromelton subgroup and the minimal prairie soil of the Woolaman subgroup.

The soils of the Bromelton and Cyrus subgroups are used for growing fodder crops under irrigation by pumping from the stream, as they occur within a short distance of the river. At the junction of Spring Creek and the Logan River, immediately west of Beaudesert and north of the Boonah–Beaudesert road, there is an area of Bromelton soils with a rather better structure and probably a higher nutrient status than is usual for the area. Potatoes are grown under irrigation on these soils and on similar soils in similar situations along Warrill and Reynolds Creeks.

Irrigation from the Logan River is restricted by its periodic low volume of flow to seasonal pumping from the stream to a maximum distance of 10 chains from the bank.

Water accumulating on the surface of the wiesenbodens feeds the swamps which occur at the junction of terraces 2 and 3. A little additional damming could perhaps make these a source of supplementary irrigation water.

Terrace 3 is the most widespread within the basin. It also has the most complex and variable soils. Two main groups are recognized:

(1) Grey or dark brown calcareous clays with a thin surface crust about 1 in. thick. These are included with the Beaudesert subgroup of grey clays and occur across the southern third and northern third of the basin.

(2) Reddish brown or dark grey gilgaied acid clays, occurring in the middle section of the basin. Similar soils are described by Beckmann (1967) from the lower Logan valley.

In places there has been a considerable lateral wash of sand across the acid clays, from both Tertiary and Bundamba sandstones. Due to the impervious nature of the clay, the soil moisture of this sandy surface layer ranges from saturation to extreme drought several times each year. This has led to conspicuous bleaching immediately above the clay and to the formation of ironstone nodules throughout the sandy layer. The marked moisture fluctuations have probably also contributed to the development of columnar structure in the underlying clay. The soil now has the morphological features of a soloth and is placed in the Woodhill subgroup.

At the present time the greater part of terrace 3 carries native grasses, and cropping is limited to an occasional sorghum crop from soils of the Beaudesert subgroup. Given an adequate supply of moisture these grey clays would be suitable for the growth of improved pasture and fodder crops. However, the central area with the gilgaied acid grey clays and the soloths of the Woodhill subgroup present both physical and nutritional problems to agricultural development.

Terrace 4 has been cut partly across alluvial fill and partly across Tertiary bed-rock and occurs as isolated remnants only on the east side of the valley. On the north and south sides of Waters Creek a terrace has been cut across deeply altered basic igneous rocks. The soils developed are dominantly the prairie soils of the Churchbank subgroup, though there are smaller patches of sandy lithosols of the Windsor subgroup developed on Tertiary sandstone.

A remnant of terrace 4 cut across alluvial fill occurs one mile north of Woodhill. Here the soil is a soloth with a pH of about 4·0 in the clay horizon and is part of the Harrisville complex, the main occurrence of which is in Warrill Creek. Scattered through the clay subsoil are occasional large round silicified boulders.

Along the western side of the valley streams draining the central mountain area have deposited sand across terraces 2 and 3. There were two periods of deposition. The older is marked by a sand-hill west of "Fernlea" farm, where Allan Creek enters the Logan basin. The soil developed is transitional between a siliceous sand and a yellow podzolic and belongs to the Fernlea subgroup. The younger deposit of sand is common to all the streams joining the main valley south of Teviot Brook, where it forms low-angle fans with an irregular surface sloping down to the main valley floor. The largest of these deposits, 400–500 acres in extent, is in Swan Creek to the south of the Beaudesert–Boonah road. The soils are siliceous sands of the Swan Creek subgroup which have crusty fine sandy surfaces and become progressively coarser-textured with depth. In other occurrences there is a large area of swamp associated with the siliceous sands.

The soils along Swan Creek would be suitable for horticultural crops, e.g. citrus, if sufficient irrigation water were available. The flow of Swan Creek disappears into the sand deposit and it is possible that it could be tapped as an underground flow by "spear wells". The other areas do not provide as large an acreage of freely drained sands, but with drainage and irrigation 10–15-acre blocks may be suitable for similar crops.

Thus within the Beaudesert basin small-scale irrigation and drainage work would increase the acreage suitable for fodder crops and improved pasture on terrace 2. A small amount of horticultural development is possible on the sandy soils of the Swan Creek subgroup along the western margin of the basin. More intensive utilization of terraces 2 and 3 would require irrigation water on a much larger scale than is available at present.