ECOSYSTEM OF THE COASTAL LOWLANDS, SOUTHERN QUEENSLAND

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The Ecosystem of the Coastal Lowlands ("Wallum") of Southern Queensland

By J. E. Coaldrake

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THE ECOSYSTEM OF THE COASTAL LOWLANDS ("WALLUM") OF SOUTHERN QUEENSLAND

By J. E. Coaldrake*

[Manuscript received July 18, 1960]

Summary

The ecosystem described in this work is part of a natural region extending from Gladstone in Queensland to Coff's Harbour in New South Wales. This in turn is part of a discontinuous belt of lowland country extended along the eastern and southern coasts of the continent; this belt has certain common features such as assured rainfall, soils with a degree of similarity in morphology and lack of fertility, and plant communities with marked floristic and structural affinities.

The geology, climate, soils, and vegetation of the region studied are described in whatever detail is possible from present knowledge, including much new material resulting from the present study.

The major rock systems are Triassic sandstones of the Bundamba Group and Cretaceous sediments of the Maryborough Formation and Burrum Coal Measures. These are overlain extensively by a mantle of Quaternary siliceous sands, parts of which are piled into high sandhills.

Fossil organic-cemented sands are common on beaches in the region; their derivation from soil hardpans, peats, or swamp muds, and serious limitations on their use as marker beds are discussed. Detailed evidence of Quaternary history in the area is limited; widespread benching and two extensive degraded scarps give general evidence of eustatic oscillations of sea-level but these have yet to be dated by fossil evidence.

The physiography of the Coastal Lowlands is dominated by undulating to low rolling country; there is little true coastal plain.

The Coastal Lowlands have a mild subtropical climate with a marked dominance of summer rainfall and a small but significant winter rainfall. Thunderstorms and cyclones contribute substantially to total annual rainfall, which is extremely variable and not so effective as in temperate regions. While temperatures are generally mild, frosts occur in most years. The most noticeable effect of wind is mechanical damage to forests by cyclonic winds.

Climate can be conducive to very rapid growth in the early summer months of those years with a good rainfall, since this rainfall then coincides with high levels of energy. The conventional "spring" period is normally one of acute water stress. The common climatic indices are of little use for typing the Coastal Lowlands.

The soils are described and grouped at the level of the Great Soil Group. The common pattern is a steady trend from deep red-yellow podzolics on rises through gleyed podzolics to gley and humic gley soils on low areas of impeded drainage. In poorly drained areas with a mantle of Quaternary sand ground-water podzols with a strongly developed hardpan are common. There is little profile development in the sandhills except under vine forest where podzols occur. Acid bog and fen peats are common in areas receiving continual drainage from sandhills. It is suggested that a pronounced microrelief of whorled hummocks in certain sandy areas was formed originally under the influence of peat.

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Except for some alluvial soils, nutrient status is universally low, and physical differences, derived chiefly from topographic control of perched water-tables, seem to be the main factors governing plant distribution. Nodular accumulation of iron and manganese is widespread, and the formation of soil nodules in relation to oscillation of the water-table is discussed.

Surface litter and organic matter are low in many of the mineral soils, and this is ascribed chiefly to rapid destruction of litter by fire. An $A_0$ layer occurs in small areas protected from fire. Mound soils similar to but not identical with the "egg-cup" podzols of New Zealand are described.

Fire is a major factor in the environment of the Coastal Lowlands and is responsible for much of the essential instability of the plant communities. It is suggested that this importance of fire predates European settlement.

Obvious biotic effects within the ecosystem are largely confined to human activities through logging and burning.

The vegetation consists essentially of a large common element of woody shrubs, sedges, and grasses overtopped by varying combinations of species of eucalypts to form forest and woodland communities. The more extreme habitats support specialized communities of heath, mangroves, or a "herbfield" of sedges. Subtropical vine forest occurs in small areas throughout the region.

While the flora (exclusive of vine forest) is moderately rich in species with a total of approximately 500, two families, Myrtaceae and Leguminosae, supply one-quarter of the total flora, while there are only six other families represented by ten or more species. Sedges outnumber grasses.

The vegetation is classified on a structural basis at the level of the formation, since this gives a better correlation with the environment than formal floristic units such as the association. Ecotonal oscillation between areas acting as floristic reservoirs is considered to be the most important dynamic trend within the vegetation, and only two clearly defined examples of succession are given.

Finally, the constituent units and the overall pattern of the ecosystem are described by annotated diagrams and in text. A single large map is presented showing subdivision of the region into 20 landscapes, units which are based on the pattern resulting from the interplay of the major factors of the ecosystem. Each landscape is also described briefly in the text. The detailed patterns of topography–soil–vegetation occurring over the Coastal Lowlands are recorded in a series of 13 sample maps at a scale of 1 mile to the inch.

I. CONSPECTUS

(a) Introduction

On the seaboard of southern and eastern Australia there is a discontinuous belt of lowland country, the units of which have many characteristics in common. They result largely from the impact of Quaternary geological events, including eustatic oscillations, on a terrain mostly derived and tectonically stabilized beforehand. They receive a rainfall which is more than adequate for the support of a vigorous flora, both above and below ground level, while temperature extremes are not great. Nutrient status of the soils (many of them have a mantle of sand) is low, with universal deficiencies of nitrogen and phosphorus, sporadic deficiency of potassium, and deficiency of varying combinations of the minor elements. Fire has always been a major factor of the environment. Prior to European settlement, these regions supported a fauna in which grazing animals were not dominant.
This general environment supports a surprising bulk of vegetation which varies in form from dense forest to depauperate heath and sedge communities. Certain families, notably Myrtaceae, Leguminosae, and Proteaceae are consistently prominent, this constancy extending in many cases to the level of the genus.

The poverty of these lowlands has protected them to a large degree from the gross disturbance of closer settlement so that they remain richly suited to investigation of the natural systems.

Considered with regard to the common factors of plant, animal, and human ecology mentioned above, these regions extended half way around the continent form a single “ecosystem” in the broad sense of Tansley’s (1935) original discussion of the term. Certain major differences immediately divide this grand ecosystem; each of the resultant regions, however, still satisfies Tansley’s general criteria, and his statement that ecosystems “are of the most various kinds and sizes”.

Since these regions of coastal lowlands extend through 30 degrees of latitude and 40 degrees of longitude major climatic variation is inevitable. Apart from expected differences in photoperiod and temperature, there is a gross change in rainfall pattern from winter to summer dominance, and there are also substantial differences in the total quantity of light received during the main period of precipitation. However, variation in temperature is not great since the regions are all at low elevation and temperature differences arise primarily from difference in latitude. The mantle of sand so common throughout these coastal lowlands varies between complete dominance by calcareous sand and complete dominance by siliceous sand.

These differences establish the regional ecosystems given below and illustrated in Figure 1; it should be noted that each of these is still extensive. These regional ecosystems are:

The south-western region of Western Australia.
The lower south-east, the upper south-east, and part of Eyre’s Peninsula in South Australia.
Northern Tasmania.
The islands of Bass Strait.
The coastal region east of Bairnsdale in Victoria and small areas on the west coast of Victoria.
The coastal lowlands from Coff’s Harbour in New South Wales to Gladstone in Queensland.
The sandy coastal lowlands of north-east Queensland which extend intermittently along the coast to Cape York.

The present Bulletin deals with the northern half of the Coff’s Harbour–Brisbane–Gladstone region. At the level of detail encompassed it is physically impossible to include in a single project a belt of country extending over approximately 500 miles and so an artificial boundary was imposed at the northern limit of the closer settlement which hinges on Brisbane. This area comprises some 3500 square miles on the mainland and over 1000 square miles on the coastal

ECOSYSTEM OF WALLUM COUNTRY, QUEENSLAND 7
Fig. 1.—Map showing the location of the Coastal Lowlands and of some analogous regions elsewhere in Australia. Key references are Teakle (1938), Gardner (1942) (Western Australia); Crocker (1944), Coaldrake (1951) (South Australia); Leeper (1948) (Victoria); Brass (1953) (Cape York, Queensland); Stephens (1941), Hubble (1946) (Tasmania).
islands. Broad reconnaissance has shown that the region south of Brisbane differs only in minor detail with regard to those units of the ecosystem which persist to Coff's Harbour. The most outstanding feature is that the belt narrows markedly with the virtual absence of extensive forest belts and is dominated by deltas and heath dunes.

The belt of coastal lowlands from Brisbane to Gladstone is especially interesting as a member of the continental ecosystem mentioned earlier. It occupies an intermediate latitudinal position with the result that the climate contains features characteristic of the regions both to the north and to the south. It is also notable for having the most massive accumulation of sand found anywhere on the eastern or southern coasts of Australia.

This area is known locally as the "Wallum"; the name is of aboriginal origin but uncertain meaning. "Wallum" is also used in a variety of local contexts and to avoid confusion the general title of "Coastal Lowlands" is used throughout the text.

The work is divided on a subject basis indicated by the subtitles; cross-reference is by the series number of the Section concerned, e.g. Section II refers to the geological section.

All place names mentioned in the text are shown on the large map included with this Bulletin.

(b) Historical

This history of human occupation of the area bears on the present work at several points. It has been estimated that Queensland carried one-third of the aborigines in Australia, and the Coastal Lowlands were one of the more densely populated areas in Queensland. This means that burning has always been an important factor of the environment since the local aborigines often started fires deliberately as a part of their system of hunting, and of management of the vegetation.

While early explorer-botanists like Cunningham have left useful detailed accounts of undisturbed natural vegetation further inland, such accounts of the Coastal Lowlands are fragmentary.

The low fertility of the Coastal Lowlands, and the hindrance to movement caused by the extensive marshy areas diverted the first European settlers further inland. Maryborough was the first coastal settlement north of Brisbane, being firmly established by 1850. By 1870 Gympie and Bundaberg were settled and the exploitation of natural timbers was becoming extensive. This timber trade, together with agricultural development on the better soils under areas of vine forest led to the rapid extinction of most of the larger areas of vine forest; it also resulted in the virtual destruction of much of the fringing forest (vine forest) along the main rivers and creeks.

The establishment of coal mines around Howard led to heavy selective cutting of local eucalypts for mine timber from 1875 onwards. By 1900 logging of hardwoods had become widespread throughout the Coastal Lowlands, but this has
always been highly selective and the main effect on natural communities has been to alter the relative frequency of certain dominant trees. In particular it has left scribbly gum, *Eucalyptus micrantha,* as the apparent most frequent tree species in many areas, whereas it is fairly certain that originally this was the role of bloodwood, *E. intermedia.*

Later the small pockets of better soil scattered through the forest ridges of the Coastal Lowlands were selectively developed for citrus, pineapples, and small crops. The Queensland Forestry Service is now developing large areas to exotic species of *Pinus.* Finally, the growth of a number of seaside resorts has led to serious derangement of the natural communities in their environs.

The net effects of this historical pattern are:

1. There are few detailed accounts of the vegetation prior to European settlement and these cover only very limited areas.
2. The vegetation remains completely undisturbed only in areas difficult of access and understanding of the ecosystem has to develop outwards from these areas.
3. Certain types of vegetation, chiefly the vine forests and fringing forests, are now almost impossible to study under truly undisturbed conditions except in the more remote areas of sandhills.

(c) Working Concepts

Most of the ecological work on other continents has been based on the concepts of the Cowles–Clements–Tansley group, or those of the Montpellier and Uppsala schools. Early ecological studies in Australia generally followed the first group, but in the last 15 years an increasing number of Australian ecologists have turned, from rigid adherence to the concepts of succession and floristic ecology, towards an attitude based primarily on the recording of information, with little or no emphasis on interpretation according to philosophical concepts imported from the northern hemisphere.

In some quarters this change of emphasis has been labelled a “revolt against succession”; this is unfortunate because in fact the processes of succession are not denied, but simply laid aside for later study after a first general ecological survey of a region has given the ecologists basic information regarding the ecosystem.

The return to descriptive ecology may invite criticism on the grounds of lack of interpretation, but synthesis based on inapplicable concepts is worthless. If the European and American concepts produce confusion in temperate Australia (see Crockr and Wood 1947) then this effect can only be exaggerated in subtropical and tropical Australia. That this desire for new working concepts in lower latitudes is not restricted to Australia is evidenced by Richards’s (1956) account of a symposium at Colombo in which he states: “There was a general feeling that the methods and concepts of ecology are too largely based on

*The authorities for all plant names are given in a roneographed Appendix available from the Librarian, Cunningham Laboratory, C.S.I.R.O., Brisbane.
experience in temperate countries where the vegetation has been modified by human activities for a very long period of time."

Tansley's (1935) stress on the constant interrelationship between all the factors of the ecosystem has been the basic working concept in the present project. This interrelationship has been reiterated more recently by such workers as Billings (1952) and Crocker (1952).

The present study is an attempt to assemble the maximum amount of information which could be gained in the time available regarding six major components of the ecosystem — climate, geology, soils, vegetation, fire, and the effect of man and animals. Tansley (loc. cit.) has referred to the "very big gap" between the plant and animal kingdoms and to "the practical necessity in field work of separating and independently studying the animal communities". This separation has been followed in the present work and as a result the influence of animals is referred to only where it has immediate and obvious effects.

The profusion of ecological concepts and terminology which now confronts Australian ecologists has been summarized by Moore (1953) who in turn suggested further modifications. Moore's survey of the problem is brought to completion by reference to the statistical approach of such workers as Pidgeon and Ashby (1942) and Goodall (1953).

All this work centres on the desire to classify vegetation by vegetation alone in the hope that the units derived can then be correlated with the environment. The classification of vegetation per se is a useful and necessary step in approaching an understanding of the ecosystem, but by itself vegetal classification has no meaning in ecological work, and is no more important than classification of parent rock, climate, soils, or any other units in the system. Vegetation is an environmental unit in itself with an "obverse" effect on some of the other units, e.g. microclimate and soils. The integrated classification adopted by Christian and his colleagues (Christian 1952) is the basis used in this work.

The term "dominant" with its connotations of importance in the community might well be dropped from ecological usage for describing the tallest or most obvious species. Too often its use results in diverting attention from species which are highly significant to the environment, and yet not so obvious to the eye. In the present work the author has used the term "obvious species" to indicate those plants which are prominent in the community over its geographic range.

Many Australian workers have used the association as the basic unit of vegetal classification, but the variety of definitions of the association given by the authors quoted by Moore (1953) points to a conflict of ideas, rather than to the accumulated knowledge necessary to the establishment of a sound unit of classification.

All the definitions stress grouping of species with a substantial overlap in environmental range, and tolerance within any grouping. Eucalypts are commonly stressed as key species in an association but the unsatisfactory taxonomic status of the genus, currently emphasized by workers such as Pryor (1957), immediately
weakens the status of any unit referred to two or three eucalypts. On the Coastal Lowlands units referred to eucalypts can be so broad as to be meaningless; in one case the soils concerned include deep, well-drained podzolics, waterlogged gleys, and ground-water podzols.

Statistical techniques such as those proposed by Goodall (1953), while suited to detailed work of the type described by Rayson (1957), are obviously impossible to use in regional surveys.

In the present work, for the reasons outlined above, there has been no search for dominance and associations. While structure is sometimes accepted as one characteristic of the association, its usefulness on the Coastal Lowlands is lessened when it is confounded with floristics. Therefore, the vegetation is categorized on a structural basis alone since this is readily observed in the field, is not subject to any taxonomic limitations, and is less subjective than the selection of key species. Furthermore, many of the species which are most sensitive to environmental changes occur in the tree and shrub layers. Consequently local changes in the environment frequently are reflected in changes of structure through the presence or absence of such species.

Most of the structural units of vegetation have been correlated, within regions of parent material, with topographic position and soils* (see Section VI). The elementary unit of separation is thus a complex of vegetal, soil, and topographic characteristics (climate and geology only varying broadly), and is equivalent to the "land unit" of Christian (1952). These are further combined in terms of their recurrence in the landscape into units equivalent to Christian's "land system". The land systems are finally combined in terms of pattern into "landscapes". These units are described in Section VI.

This system permits a first subdivision of the ecosystem for the guidance of later workers and should be useful in its stress on interrelationships, rather than on vegetation, as the objective of study. However, its imperfections are inherent in our incomplete knowledge of the units of the ecosystem and their interactions. Finally, while process and pattern are both discussed, the present author makes no claim that the categories used represent a genetic system. The units and changes enumerated are the result of observations over too short a period to remove the discussion of end points from the realm of speculation.

(d) The System of Mapping

In previous ecological surveys in Australia, it has been customary to produce a map giving complete coverage of the region showing the distribution of plant communities at the level of classification adopted, normally the association. Frequently a more generalized map of the soils is also prepared together with rainfall and geological maps.

* On the Coastal Lowlands, given any three of these four variables, it is possible to predict the fourth.
In the present case the rainfall map has been incorporated into a larger rainfall map of south-eastern Queensland published separately by Coaldrake and Bryan (1957). The only overall map to be produced from the present project is one showing the subdivision of the region into “landscapes”, broad scale units based on the pattern resulting from the operation of all the factors of the ecosystem. These landscapes are also described in the text in general terms.

Diagrams are presented showing the structure of each plant assemblage, its topographic position in the landscape, and the type of soil on which it occurs. Detailed mapping within each landscape is confined to a “sample map” of a portion of the landscape. Each sample map includes a delineation of topographic, soil, and vegetal classes. The data presented in the sample maps can be interpreted for purposes other than the original, and this avoids the rigidity of use of many more formal maps. There is also a written description of the major features of each landscape.

II. GEOLOGY AND PHYSIOGRAPHY

(a) Introduction

The whole of the surveyed region of the Coastal Lowlands falls within the area of the “Maryborough Basin” (Hill 1951) concerning which Hill states “its true nature is not yet clear”. There is general agreement (e.g. Bryan and Jones 1944; David 1950) that this area rests on the varied sediments and metasediments of the Tasman Geosyncline together with the plutonic intrusions associated with the tectonics of this structure; the whole assemblage dates ultimately to early Palaeozoic times. These older beds outcrop at places along the western boundary of the Coastal Lowlands, which has been fixed partly by reference to them.

The present landscape is derived from rocks formed since the Tasman Geosyncline became a “dead” system at the end of the Palaeozoic. According to Ridley (1960), sedimentary accumulation during the Triassic and lower Jurassic led to subsidence of some 12,000 ft. This subsidence was more or less synchronous with emplacement of a linear series of marginal plutons, and was followed by the extensive andesitic and rhyolitic extrusions of the Graham’s Creek Formation. Subsequent marine transgressions during the lower Cretaceous were followed by terrestrial sedimentation. This whole system was then affected by folding and faulting during the upper Cretaceous, and possibly the early Tertiary.

Since then the major geological process has been degradation with its ancillary sedimentation near to and beyond a fluctuating coastline. The combined effects of ocean currents and winds on these fresh sediments have produced a massive accumulation of siliceous sand on various parts of the coastline; some additional sand seems to have been moved into the area from the south by oceanic drift.

Igneous activity subsequent to that of the Graham’s Creek Formation has been confined to widely scattered extrusions of basalt and other igneous lavas from middle to late Tertiary times, with a minor continuance into the Quaternary.
(b) Sedimentary Rocks

The geological history outlined above has produced three major zones of sedimentary formations within the Coastal Lowlands, together with the scattered occurrences of igneous rocks. They are:

(A) The lower Mesozoic sediments south of Maryborough.
(B) A zone, from Maryborough north, consisting of the Maryborough Formation, the Burrum Coal Measures, and the Elliott Formation.
(C) The sandhills.

A complete bibliography for zone A is presented by Bryan and Jones (1944), and for zone B by Ridley (1960) and only key papers will be listed here. Zone C is discussed in detail in another paper (Coaldrake 1960).

Zone A. The Lower Mesozoic Sediments South of Maryborough

These consist of variable textured freshwater sediments ranging from conglomerates to fine-grained sandstones which are largely devoid of fossils. Their relationships with the better known Mesozoic rocks of the Moreton Basin near Brisbane and of western Queensland have been discussed by numerous authors (e.g. Whitehouse 1952; Woods 1953). The only agreement so far is that at least a substantial part of them is equivalent to the Bundamba Group of Upper Triassic age (Whitehouse 1954). These coastal Bundamba sandstones have been referred to in the past as the Landsborough Sandstone at the southern end, and as the Myrtle Creek Formation at the northern end, in the region of Maryborough. Their lithology and stratigraphy have been discussed recently by Woods (loc. cit.) for the Caboolture area, Ferguson (1948) for the area east of Pomona, Hill (1947) for the Noosa district, Bryan and Massey (1926) for the area north of Gympie, and Ridley (1960) for the area east of Gympie.

The general strike of the rocks is in a north-westerly direction. South of Noosa dips seem to be gentle, except near the inland boundary, but to the north there has been strong disturbance by numerous zones of faulting.

Scattered through the northern part of this region of “Bundamba sandstones” there are beds of the Tiaro Coal Measures (shales and small coal measures) which occur with increasing frequency from south-east to north-west.

Tweedale, Campbell, and Hawthorne (1953) have mapped most of this area as “Quaternary” alluvia and sand dunes. From evidence gathered during this survey it is possible to trace the Bundamba–Tiaro group eastward to a line roughly following the Noosa River from Lake Cootharaba through Mt. Bilewilam to the head of Tin Can Bay. There is also a small area east of Lake Cooroibah centred on Halls Hill, and Ball (1924) states that they occur beneath the Teewah sandhills at a depth of 200 ft below sea-level in a bore put down just behind the beach. Thus it seems that the Mesozoic sandstones in this area must slope sharply under the sandhill belt in what is possibly a buried coastline but may also be the result of the downwarping associated with the formation of the Great Barrier Reef and the subsidence off the coast of New South Wales, both of which are described by
Browne (1945) as being of post-Tertiary age. Bryan (1939) also refers to this bench.

**Zone B. The Maryborough–Burrum–Elliott Zone**

From the southern edge of the Boonooroo Plain near Maryborough to the northern boundary of the surveyed region at Baffle Creek, the rocks are a mixture of beds dominated by the Maryborough and Burrum sediments with lesser areas of the Elliott Formation. This is the coastal area covered during the marine incursions of lower Cretaceous times which also covered large areas of inland Australia (David 1950). The Maryborough Series is 6000 ft thick (Hawthorne 1960), and consists of grits, sandstones, and impure cherty rocks. It is overlain conformably by the freshwater beds of the Burrum Coal Measures. The whole sequence of Maryborough and Burrum beds was folded in late Cretaceous times (David, loc. cit.).

Unconformably overlying both of the foregoing is the Elliott Formation described and mapped by Ridley (1956). These are level-bedded freshwater sediments, mostly coarse to fine grained ferruginous sandstone with some small beds of conglomerates. They attain their greatest extent between the Gregory and Kolan Rivers.

At the northern end of the surveyed region, i.e. immediately north of Baffle Creek, there are small areas of Mesozoic sandstone apparently of the same type as the Bundamba equivalent in the south (Ridley 1960).

The boundary between zones A and B at the southern edge of the Boonooroo Plain carries associated sharp changes in topography, soils, and vegetation, all of which are described later.

**c) Igneous Rocks**

There are two main groupings of igneous rocks on the Coastal Lowlands, neither of them being extensive. The first is a series of spectacular alkaline trachyte plugs, which extends from Mt. Miketeebumulgrai near Caboolture to Mt. Tinbeerwah near Tewantin; at the southern end a group of them were named collectively The Glass Houses by Captain Cook in 1770, eight of these being clustered in an area of 20 square miles. The highest, Mt. Beerwah, rises 1500 ft above the surrounding country with almost sheer walls. Richards (1915) points out that these alkaline trachytes are more or less restricted to this area, the (?) contemporary igneous outpourings to the south and the west being mainly rhyolitic. The age of these trachyte plugs is still conjectural. If they were formed as plugs roughly at contemporary surface level, then they must be older rather than younger to allow for the erosion which has exposed them to their present extent. Some of these trachytic plugs are of particular ecological interest inasmuch as they support certain plant species which are not found elsewhere in the region.

The second major igneous grouping is the series of basalt flows which occurs in the northern part of the region. Two main groups occur; the older and more common group is chiefly in the Childers region extending into the southern edge of the Cordalba landscape, its upper layers being at a height of approximately
240 ft. Its age is generally considered to be part Pliocene. Younger basalt, some of it vesicular, occurs at The Hummock, east of Bundaberg. The boundaries of this basalt are denoted by the boundary of the Hummock Landscape. This basalt is much younger than the other at Childers (David suggests its age as Quaternary) since it overlies Ridley’s (1956) Elliott Formation (there is an excellent exposure at Elliott Heads) whereas the Childers basalt does not. There is also a small development of flow basalt at Dundowran, north-west of Pialba, which is shown on a map by Jones (1948).

One small area of basalt, south of the main groups, is worth special consideration. This is the mass of a few acres which still tops the Mesozoic sediments of Mt. Coondoo, and preserves it as a monadnock owing, presumably, to the fact that the basalt is more resistant to weathering than the surrounding sedimentary rocks. Ridley (1960) indicates that this is homologous with the basalts of the Woondum–Wolvi group just to the west. Round Mountain nearby probably owes its existence to the same mechanism, although all the basalt is now gone. It is possible that some of the other high isolated hills in the area have the same origin, e.g. Mt. Bilewilam and Mt. Mullen.

On the coast there is a series of headlands which are either wholly or partly of igneous rock; those of Noosa Headland are described in detail by Houston (1959). David (1950) refers to invasion and alteration of sedimentary rocks at Point Arkwright and Noosa Head by igneous material. These and other headlands, which extend from Point Lookout on Stradbroke Island to Waddy Point on Fraser Island, seem to have played a major part in the formation of the present coastline, and the belts of sandhills.

(d) Fossil Organic Deposits

The author (Coaldrake 1955) has already published a brief account of coastal sandrock and fossil soil hardpans, and divided these occurrences into three types, viz. truncated fossil B horizons from podzols; buried peats and peaty sands; and buried swamp deposits. In that paper, it was suggested that they might yield information on eustatic fluctuations in the Pleistocene; McGarity (1956) has subsequently used such beds for this type of interpretation.

These formations are common near and on the beaches fronting the Coastal Lowlands (Plate 1, Figs. 1 and 2) and extend southward to Newcastle. Away from the beaches they combine with a mantle of sand to form an apparent ground-water podzol; these composite profiles are easily confused with the true ground-water podzols common in the region. A good example of such a composite profile occurs near Teewah Creek at Cooloolah 236606.*

The nature and origin of these fossil organic beds and their use as geological markers are discussed below.

*Throughout this Bulletin locality references of this type are from the grid system of the Australian Military 1-mile series of maps.
**Fossil Hardpans**

Throughout the Coastal Lowlands sites with a mantle of sand and topographically exposed to high temporary water-tables frequently carry a type of soil classified by Stephens (1956) as a ground-water podzol. The main characteristics of this soil are a mantle of pale-coloured loose sand underlain by an horizon of sand cemented into a dark “hardpan” by organic matter, or iron, or both. On the Coastal Lowlands the accumulation of iron within or below the organic pan is frequently very slight, and there may be a pale coloured and very hard pan layer just above the organic pan, i.e. at the bottom of the A₂ horizon. Further details regarding these soils on the Coastal Lowlands are given in Section IV.

That such organic pans can persist for long periods is demonstrated by a radiocarbon age of 30,000 years for material obtained during this study. That they are surprisingly resistant to water erosion is demonstrated by their frequent occurrence within the zone of wave action on ocean beaches with a strong surf.

There are many facts which have been overlooked by previous authors in using these old organic pans as indicator beds.

If the pan forms close to the surface it tends to have an even top; if formed below about 30 in. the top of the pan can be very uneven. Thickness of the pan varies from a few inches to many feet and seems to be a function of both age and environment. The quantity and distribution of iron vary widely and are difficult to use as a criterion. Such organic pans are forming today from Tasmania to tropical Queensland, and so they give scant indication of temperature regime, apart from absence of extreme lowering. They require a fairly high minimum rainfall: about 20 in. per year in areas of dominant winter rainfall, and 40 in. per year under summer rainfall of high intensity. McGarity (1956) has pointed out that they have a fairly characteristic range of content of organic matter which is lower than that of peaty or swamp deposits.

The effects of beach erosion must also be understood in using these beds as indicators of former beaches. The block diagram in Figure 2 and the example in Plate 1, Figure 2, show the essential features concerned. These are:

1. A sloping bench of sandrock from 3 to 6 ft above H.W.M. and sometimes extending into the littoral zone. The surface of this bench may be even or deeply pitted, depending mainly on the original surface.

2. An undercut vertical face backing the beach. This may show a visible gradation down the face, depending on the depth of the original layer and the extent now exposed. This face may extend along the beach for several hundred yards and have a sloping or abrupt end.

3. Small outcrops of sandrock standing above the sand in the littoral zone and frequently extending below low water mark. These are often bleached in varying degree.

4. Fragments of wood and lenses of gravel and stone may be included.
The critical indications of a former beach are the undercut vertical face and the bench sloping at variance to the main body of sandrock. To date the author has never seen this away from an existing beach. McElroy (1953) records fossil hardpans behind the beach near Port Kembla, but these exposures were the result of excavation and were clearly related to more recent dune history. On the Teewah cliffs there are numerous exposures of vertical faces but these are related to present erosion even though the hardpans can only be fossil in view of their present situation.

Fig. 2.—Block diagram showing the effects of beach erosion on coastal sandrock.

**Compressed Swamp Deposits**

Naturally, these will vary widely but can be expected to include larger fragments of preserved wood, and they may have a markedly silty texture. If they include trees buried in the position of growth, there should be a sharp textural break near the base of the stump. Such stumps may predate the surrounding organic matter since a hardpan could have formed long after they were buried.

The identity of such trees or other buried plant material is only a broad clue to previous conditions, except for species which are known to be very restricted in habitat; e.g. *Agathis robusta* is not so restricted as claimed by Bamber and McGarity (1956).

**Buried Peats**

These are obvious in the field from their texture and general structure, even after they have been exposed for some time.

Contemporary peats on the Coastal Lowlands occur over a wide range of altitude, though they are most common below the 100-ft contour. They also occur as "mound peats", i.e. extending *above* the surrounding land surface and acting as their own aquifer (Plate 4, Fig. 1). In the valley of Poyungan Creek on Fraser Island a bed of modern peat extends from a few feet above the mangroves to a final elevation of over 50 ft above sea-level 2½ miles up the valley. When buried
this peat will give a subsequent exposure at any point through a height interval of approximately 50 ft.

Thus buried peats cannot yield any information on sea-level through water-table relationships at the time of their formation. The buried peats described by Gill (1956) from north-western Tasmania are different since they are interbedded with material clearly of marine origin.

Buried peats often contain well-preserved large fragments of plant material. If several species are present these become safe indicators of general environment but it must be remembered that modern peats are forming from Tasmania right through to those recorded by Mohr (1944) from the Indonesian lowlands. The criteria for beach erosion are the same as for the fossil hardpans.

(e) Physiography

The major units of physiography on the Coastal Lowlands are:

(i) The stranded beach lines
(ii) The sandhills
(iii) The heath downs and swamps
(iv) Two degraded scarps
(v) The low rolling ridges
(vi) The rolling hills
(vii) True coastal plain
(viii) The river deltas.

(i) The Stranded Beach Lines.—Scattered along the coastline from Bribie Island north are groups of arc-shaped low sand dunes conforming to the present beach line. These are always restricted to the first half-mile inland from the beach and their base level suggests that they are tied to the last relative adjustment of sea-level. These old strand lines are never high, usually being only about 10 ft above base level; there is generally a tendency for basement level to slope upwards through a few feet running inland. The areas between these dunes are usually marshy, sometimes swampy; the dunes themselves are remarkably well preserved and stabilized by woodland communities. On the southern end of Fraser and Stradbroke Islands there is a long dune immediately fronting the beach, behind which lies an extensive shallow swamp with only very restricted outlets to the beach. In places there may be the remnants of stranded dune lines intersecting this swamp. These occurrences seem to be the obvious explanation of the more extensive and now completely stranded areas of dune lines elsewhere; the Hercules landscape (Section VI) consists almost entirely of areas of these stranded dune lines.

(ii) The Sandhills.—The systems of major sandhills adjoining the coastline have been discussed in detail elsewhere (Coaldrake 1960). Physiographically they fall into two main categories. Fronting the beach south of Double Island Point and Noosa Heads, and occupying most of the large coastal islands, there are
extensive areas of high dunes. These extend from up to 200 ft below sea-level to 900 ft above sea-level. They are formed entirely of siliceous sand and developed in a confused pattern of dune shape and size. The second type is a system of low dunes (less than 25 ft high) close to and conforming to the present beachlines. These occur on Bribie Island and in many places on the mainland.

(iii) The Heath Downs and Swamps.—Immediately on the inland side of the giant sandhills, and scattered elsewhere on the Coastal Lowlands, there are extensive areas of low rolling downs. These consist either of deep siliceous sands of oceanic origin interspersed with small swamps and marshes, or of shallow siliceous sand mantling truncated soils. The topography in these areas varies through a height of only 10-15 ft. Basement is low so that, for the majority, the highest points rarely reach a total elevation of 100 ft above sea-level. They are most commonly at a height of 25-50 ft above sea-level.

The origin of these sands seems to be quite complex, some representing deposition in shallow water, some being from aeolian transport (and sorting) of sands from the massive sandhills and, finally, some apparently derive from direct weathering and stream transport from the Mesozoic sandstones on the inland side. These areas commonly carry a heathy type of vegetation, and in the wetter parts soil-forming processes may become very active with the deposition of organic pans and peat formation. On parts of the Noosa Downs these sands give way abruptly at a depth of only 3-4 ft to a mottled, heavy kaolinitic clay suggesting that they have been deposited on a truncated soil.

(iv) Degraded Scarps.—In the southern end of the Coastal Lowlands there are two extensive degraded scarps — the Glass House scarp and the Como scarp; these are both indicated on Figure 3. These scarps have several features in common. They are incised into the same system of Mesozoic sandstones; there is a major change of soil pattern at each scarp; they are almost completely continuous throughout their length; each scarp surface is a major watershed, and each conforms roughly to the present coast.

However, they differ in several features. Red earth residuals (Bryan 1939) occur both above and below the Glass House scarp. If Bryan’s conclusions concerning these red earth residuals as ancient fossil soils are correct, then the Glass House scarp must be comparatively old. Red earth residuals occur only above the Como scarp which suggests that it is of a different age to the Glass House scarp and possibly much younger. This reasoning based on red earth residuals is invalid if the Glass House scarp is a fault scarp; so far there is no evidence that it is.

The foot of the Glass House scarp is at approximately 200-250 ft above sea-level, whereas the Como scarp starts from approximately 100 ft and their respective heights are 250 ft and 150 ft.

The difference in basement height may be allied to structural warping, such as that which is considered to have brought about the formation of the Great Barrier Reef, but it is more likely that they are of different ages. It seems very likely that the Como scarp represents a Pleistocene shore line, possibly the original.
(v) The Low Rolling Hills.—Proceeding inland from the heath downs country the next physiographic unit encountered is that of the low rolling hills. The ridges only reach a height of about 25 ft and streams are few and small. They lie below the degraded scarps and the soils on them are normally shallower and not so highly developed as those above the scarps. The shallow soils in this type of country probably result from a restricted period of pedogenesis after marine inundation. North of the Boonooroo Plain this topography of low rolling hills becomes the dominant type, e.g. it occupies practically the whole of the Colton landscape.

(vi) The Rolling Hills.—Above the degraded scarps topography becomes much more accentuated and ridges 50 ft in height are common. While slopes are steeper than in the low rolling hills they are still commonly only of the order of 10-15°. The soils are deep and well developed, and the drainage pattern is complex. This type of country is common near the Glass Houses, and to the north and south of Tin Can Bay road on the inland side of the Como scarp. It is less common north of Maryborough.

(vii) True Coastal Plain.—True coastal plain, as defined by Lobeck (1939), does not occur on the southern part of the Coastal Lowlands. East of Maryborough the Boonooroo Plain represents this type of topography and contrasts sharply with the hilly topography on Mesozoic sandstones immediately to the south. From its proximity to the mouth of the Mary River, from the complexity of the soils (double profiles occur), and from the pattern of islands and channels at the present mouth of the river, it is easy to infer that the Boonooroo Plain is the area over which the delta of the Mary River has wandered. Whitehouse (1951) has commented on a tendency commonly shown by rivers in this part of the continent to migrate northward and this was probably the mechanism that produced the Boonooroo Plain. A small area of this type of country occurs immediately to the north of the Mary River though here the soils are not so commonly nodular as south of the river.

Coastal plain also occurs between the Burrum River and Bundaberg; there is a close correlation with the occurrence of coarse sedimentary rocks of the Elliott Formation which have been described by Ridley (1956). Relief in these areas is slight, usually about 5 ft with slopes of only 1-2°.

(viii) The River Deltas.—Cutting across the Coastal Lowlands there is a series of river deltas of which the most extensive is the Maroochy. This comprises virtually the whole of the Maroochy landscape. The delta is only a few feet above high tide level and is subject to flooding during prolonged summer rains. Terraces do not develop in this part of the valley, although it does show a well-developed contemporary levee bank. The only other streams to show any extensive contemporary delta formation are the Mooloolah, the Mary, the Burnett, and the Kolan.

Steep Ridges.—Scattered throughout the Coastal Lowlands are blocks of ridges which are much higher and steeper than the normal for this region; these occur particularly between Lake Cootharaba and the Boonooroo Plain. Ridges
of a height of 300-400 ft above basement level occur. These ridges seem to
derive from the residual structural effects of tectonic movements (Ridley 1960).
North of Maryborough they are absent from the Coastal Lowlands except in the
Takura landscape.

(f) Quaternary History

As illustrated in Figures 7 and 23 Quaternary history has played a major
part in the derivation of many of the landscapes on the Coastal Lowlands, chiefly
through effects on pedogenesis.

Browne (1945) gives a comprehensive review of the literature on the
Quaternary period in Australia and presents a "Post-Tertiary Chronology" for
Australia. Subsequently there have been numerous additions to the knowledge of
this period in southern Australia, e.g. Crocker (1946), Hossfeld (1950), Fairbridge
and Teichert (1952), Sprigg (1952), and Gill (1956). The only detailed contribu-
tion for north-eastern Australia is Fairbridge's (1950) paper on the Great Barrier
Reef which deals, inter alia, with some evidence pertinent to the Coastal Lowlands.
The reader is referred to this paper for a very complete bibliography for the
Quaternary in north-eastern Australia.

From the works quoted above, a possible pattern for Quaternary history in
the Coastal Lowlands may be summarized. At the outset of the Pleistocene
sea-level was about 130 ft above the present level along a coastline generally
similar in outline to the present, but a few miles further inland. Eustatic oscillations
produced a sequence of emergence and submergence of the Coastal Lowlands
through an altitudinal range from 130 ft above to 250 ft below present sea-level.
The most recent adjustment of sea-level was a relative downward movement
(emergence) of about 10 ft. Browne (1945) also postulates some down-warping
of the coast during the late Pleistocene. The younger, more restricted basalts
(e.g. The Hummock at Bundaberg) were placed during the period late Pleistocene
to early Recent. There were several major oscillations in temperature and rainfall,
culminating in a warmer period in mid-Recent times.

Unfortunately there is very little good evidence in the area concerned here
to support this summary. The dearth of fossil evidence is especially notable. The
Coastal Lowlands are virtually a blank page between the crowded record of the
Great Barrier Reef immediately to the north, and the fairly ample records of the
regions to the south and west. However, the present study has produced some
positive evidence and some negation of earlier work which is assembled below.

(i) Mid-Recent Aridity.—There is no evidence within the region to suggest
that the pluvial effects of this period of relative aridity postulated for southern
Australia extended into the Coastal Lowlands. Any shift of temperature during
this period would be cushioned by sufficiency of moisture and by the wide thermal
tolerance of the native flora.

(ii) The Sand Dunes.—Coaldrake (1960) has pointed out that the coastal
sand dunes of the region give positive evidence of high sea-levels at +10, +5 and
+2 ft, but do not show evidence for higher levels as claimed by some workers.
Formation and modification of the giant dunes have apparently continued throughout the Pleistocene in such a way as to make them difficult to use in the study of climatic changes.

(iii) Fossil Evidence.—The fossil organic deposits and scattered shell beds related to the 10-ft emergence of the mid Recent are the only fossil evidence related to Quaternary history in this region.

In a bed of brown coal at the edge of the Teewah beach, Ball (1924) collected wood specimens identified as roots of the mangrove *Ceriops candelleana*. The author has also collected from this bed fossil wood which has been identified* as "*Podocarpus* (possibly *P. amara")"; this was not in the position of growth. These fossils together with the presence of a few inches of varved clayey material both above and below the brown coal, suggest estuarine conditions and a former sea-level at about the same level as present sea-level. Temperatures could have been the same as, or warmer than, at present. The plant fossils from King’s Bore (Coaldrake 1960) clearly establish a low sea-level and also indicate that environmental conditions were similar to the present, except that temperatures could have varied widely in either direction.

The only fossil shells in the area are the raised shell beds near Brisbane, discussed most recently by Woods (1953) who correlates them with the 10-ft emergence and similar occurrences near the beach at Dundowran (Pialba 919 565) and just south of Baffle Creek (Baffle 235 374).

(iv) Tectonics.—Fairbridge (1950) gives a closely detailed consideration of the structural movements associated with the formation of the Great Barrier Reef and concludes that there was subsidence along the east coast during the Pleistocene. Browne (1945) has postulated subsidence south of the Coastal Lowlands during the same period but there is no concrete evidence for subsidence in the Quaternary in the Coastal Lowlands themselves. Some of the contour lines off shore can be interpreted in terms of subsidence but this cannot be confirmed by observation.

(v) Physiographic Evidence.—The Glass House and Como scarps are now degraded to an extent that makes precise interpretation of heights unsafe. Basal height of the Glass House scarp suggests that it was beyond the reach of the eustatic oscillations; that it predates the Pleistocene is also suggested by the presence of red earth residuals (Bryan 1939) below the scarp; antiquity is also suggested by the degree of stream incision on its face. The Como scarp starts at a height of approximately 100 ft above sea-level and this scarp may represent a former shore line. However, beach lines stranded in this type of rock are ephemeral, and it has not been possible to find any significant benching on the Como scarp. Inundation up to some point on the Como scarp is suggested by (1) the presence of extensive deposits of sands with the grain characteristics of the local marine sands below the scarp, and (2) the fact that the soils formed purely from weathering of Mesozoic sandstone are much less mature below the scarp than above it.

* Identification by Dr. H. E. Dadswell, Division of Forest Products, C.S.I.R.O.
The general sequence of topography from the coast to the inland boundary shows terracing at heights which are strikingly uniform over the entire length of the Coastal Lowlands, viz. 50, 90, 150, and 200 ft above sea-level. These general heights for benching suggest former marine influence since they are imposed on several systems of rock over a length of more than 200 miles. However, the correlation of such widespread benches requires further careful checking in the field; there is, as yet, no fossil evidence to verify any of them. Woods (1953) also refers to the frequent contiguity of the 25-ft and 50-ft contour lines and suggests that this may signify an old sea-level, but here again there is an absence of corroborative evidence.

III. Climate

(a) Introduction

The essential features governing climate in the Coastal Lowlands are their subtropical location, their proximity to the sea, and certain physiographic features. With regard to rainfall and temperature they are within the influence of weather systems centred on the tropical zone to the north and on the temperate zone to the south; in any year these may be additive over the Coastal Lowlands, or they may operate singly, or they may both contract. The Coastal Lowlands are also on the fringe of a region of acute thunderstorm activity and in some months of the year derive a substantial portion of their rainfall from storms. Consequently, variability of rainfall is great and for most months of the year it can vary between excess and dearth. The highest constancy of rainfall is in the dry months of May, July, and August. There is no completely assured march of seasonal rainfall and in most years there is a pronounced dry period which becomes more acute through winter into spring. This combines with increased temperatures to place stress on the vegetation and to make “spring” more of a tradition than a reality.

In describing the climate of a large region there is no alternative but to use formal meteorological records. These are taken from instruments located in cleared areas and can give only a general indication of the climatic surround of the natural vegetation. However, these are the only records available and they do allow broad comparison with other regions for which similar records exist.

In discussing climatic factors as a part of the environment of the plant, Mason (1936) stated that “In any given region the extremes of these factors may be more significant than the means”. The importance of temperature in this regard is readily apparent but the principle can apply equally to other factors such as rainfall and wind. While the ultimate effect of climatic extremes on a natural flora is to help to determine limits of distribution, the immediate effect is to govern growth and reproduction in any one season. A full assessment of such effects would be a study on its own but certain obvious results can be detected on the Coastal Lowlands and these are discussed.

In this paper the major climatic elements are first treated separately and some major features of the resulting climate are discussed briefly. No attempt is made to categorize climate according to any of the numerous climatic indices available since, for reasons given later, it is considered that such formal exercises are
misleading. Wherever possible the data used are from stations spread over the region, but some types of data are only available from the central station at Brisbane; the degree to which these can be extrapolated over the remainder of the Coastal Lowlands is indicated in the text. Hubble (1954) and Andrew and Bryan (1955) have published formal climatic data for some stations on the Coastal Lowlands; additional data are available in publications of the Commonwealth Meteorological Bureau and so extensive detail is avoided here.

(b) Rainfall

The detailed rainfall pattern of the Coastal Lowlands is included in a larger map of south-eastern Queensland by Coaldrake and Bryan (1957). This map is accompanied by mean annual rainfall figures for numerous stations on the Coastal Lowlands. The general order of mean annual rainfall is indicated by key isohyets in Figure 3.

Mean monthly and annual rainfall for key stations are shown in Table 1. As Andrew and Bryan (1955) point out, summer rainfall is dominant but there is also an appreciable winter component in many years.

Rimmer, Hall, and Hossack (1939) in a paper dealing, inter alia, with the Coastal Lowlands, discerned four major components in the rainfall and estimated the contribution of each to total annual rainfall at Brisbane, viz. coastal instability (25%), thunderstorm (29%), cyclonic (15%), and rainfall of other types, chiefly frontal (31%). While these figures are a guide for the Coastal Lowlands the contribution of the different elements changes northwards from Brisbane in the manner discussed below.

Coastal instability (orographic) rain is closely governed by physiography and on the Coastal Lowlands there are two main results. As the first line of ranges veers towards the coast, rainfall of this type increases, i.e. from Caboolture north to Maroochydore; it reaches its peak at Tewantin and then declines steadily northwards to Maryborough. Secondly, the high sandhills at the coast cast a narrow rain-shadow immediately on their inland side.

Thunderstorm rains are an extremely important component throughout the Coastal Lowlands and are discussed separately below.

Cyclonic rains are of low frequency but significant because of their high yield over short periods. Rimmer and Hossack (1939) concluded from a short-term study that “in Queensland cyclones were responsible for about one-third of the good rain which fell during the first three months of the year, for much less between April and July and for very little between August and December”. Brunt and Hogan (1956) have recently summarized available knowledge of Australian tropical cyclones. They state that on the east coast of Queensland the main cyclonic season is from mid December to mid April with the highest probability over the Coastal Lowlands in February and March, when \( P = 0.16 \) for each month. It should be noted that Brunt and Hogan only deal with “tropical” cyclones; while other types are of lower frequency they can be equally productive of rainfall and damage to vegetation. This applies especially to winter cyclones.
Fig. 3.—Map showing the distribution of the Coastal Lowlands in southern Queensland, the general pattern of mean annual rainfall, and the placement of storm-breeding grounds.
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<tr>
<td>Mean rainfall (in.)</td>
<td>57</td>
<td>6.80</td>
<td>6.50</td>
<td>5.38</td>
<td>3.37</td>
<td>2.51</td>
<td>2.28</td>
<td>1.75</td>
<td>1.31</td>
<td>1.60</td>
<td>2.80</td>
<td>3.01</td>
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<tr>
<td>Mean rainfall (in.)</td>
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<td>8.17</td>
<td>6.90</td>
<td>5.59</td>
<td>3.27</td>
<td>2.69</td>
<td>2.60</td>
<td>2.11</td>
<td>1.24</td>
<td>1.53</td>
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<td>Mean max. temp. (°F)</td>
<td>33</td>
<td>83.6</td>
<td>85.8</td>
<td>84.2</td>
<td>81.2</td>
<td>76.6</td>
<td>72.4</td>
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<td>83.2</td>
<td>85.6</td>
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<tr>
<td>Mean min. temp. (°F)</td>
<td>33</td>
<td>69.7</td>
<td>69.5</td>
<td>67.2</td>
<td>62.4</td>
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<td>Mean R.H., 9 a.m. (%)</td>
<td>33</td>
<td>69</td>
<td>71</td>
<td>73</td>
<td>72</td>
<td>72</td>
<td>75</td>
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<td>65</td>
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<tr>
<td>Mean R.H., 3 p.m. (%)</td>
<td>31</td>
<td>63</td>
<td>64</td>
<td>63</td>
<td>61</td>
<td>58</td>
<td>59</td>
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<td>53</td>
<td>55</td>
<td>58</td>
<td>60</td>
<td>61</td>
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</table>

* Percentage contribution of thunderstorm rainfall to total rainfall.
The rainfall yield of cyclones on the Coastal Lowlands may be gauged from some specific examples in the records of the Commonwealth Meteorological Bureau. The figures below are for the 24-hour period of highest rainfall during a cyclone; in every case they can safely be increased by 5 in. to give the total yield over a 3-day period.

<table>
<thead>
<tr>
<th>Location</th>
<th>Rainfall (in.)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bargara</td>
<td>17.77</td>
<td>17.v.26</td>
</tr>
<tr>
<td>Mooloolah</td>
<td>29.11</td>
<td>3.ii.1893</td>
</tr>
<tr>
<td>Pialba</td>
<td>17.22</td>
<td>16.i.13</td>
</tr>
<tr>
<td>Inskip Point</td>
<td>15.20</td>
<td>24.i.28</td>
</tr>
</tbody>
</table>

A figure of 10 in. in 24 hours over widespread areas during this type of disturbance is quite common. However, the zone of distribution of extremely heavy rainfall from a cyclone is quite narrow, which increases its effect on overall variability of rainfall. Flooding or severe waterlogging is a natural result of such extreme rains with consequent drowning of species which have spread temporarily beyond their usual topographic limits; there is also preliminary evidence (see Section IV) to suggest associated gross changes in the soil microflora.

Rainfall from slow-moving widespread cloud systems is the most stable element in the rainfall of this region. This type and coastal instability rains are both delivered at lower intensities than cyclonic and thunderstorm rains and are, therefore, more effective.

(c) Thunderstorms

Thunderstorms are particularly important to any study of climate in relation to vegetation and soils on the Coastal Lowlands. They normally supply the “opening rains” after the dry period of late winter–spring and their overall contribution to annual rainfall is substantial. While yield and intensity of rainfall vary widely, run-off is generally high so that this type of rainfall is not very effective per unit. The high run-off can also produce substantial erosion in disturbed areas. Wind damage may be great, but lightning damage to trees is only slight. Finally, fires can be started by lightning during a “dry” storm.

Barkley (1934) shows a region of very high incidence of thunderstorms south and west of Brisbane with a steady decline in number of storms per year northwards through the Coastal Lowlands, viz. 50 “thunder days” per year at Brisbane, 40 at Caboolture, and 15 at Maryborough. While Prentice (1955) refines Barkley’s findings, his work supports this general pattern. Prentice discusses the difficulties in defining “storm days”, and both the foregoing works are based on a limited number of stations and were not intended to study the contribution of thunderstorm rain to total rainfall.

In the author’s experience over five years the decline in thunderstorm activity over the Coastal Lowlands between Brisbane and Maryborough is of the order found by Barkley (loc. cit.) and Prentice (loc. cit.), but it is not a steady decline. There seems rather to be an initial decline between Brisbane and Caboolture and then very little decline to the region of the Tin Can Bay road, followed by a sharp decline to Maryborough. This pattern seems to be directly associated with the
system of mountain ranges (see large map), which are virtually the inland boundary of the Coastal Lowlands through this belt. As indicated by Prentice’s (loc. cit.) directional roses, these ranges are the breeding grounds for storms which expend themselves over the Coastal Lowlands, while moving in a general north-easterly direction. While certain general paths exist, fluctuations are great and storm paths can best be described as erratic. The notable exception to this life history are the storms which breed over the sandhill massif of Fraser Island and the mainland just to the south. It is suggested that storm patterns account for a good proportion of the difference in total annual rainfall through the Coastal Lowlands.

The contribution of thunderstorm rains to total rainfall in Brisbane is shown in Table 1. These figures are from 40 years of records and should therefore be a safe mean, but they are limited by two factors. Even a 40-year period gives only a general indication with such a variable factor; Prentice (loc. cit.) refers to a cyclic trend in the frequency of thunderstorms in this region, with a downward trend over the last ten years. Secondly, the separation of thunderstorm rain from other rains involves personal interpretation of hourly notes and cannot therefore be completely objective; this is only a minor difficulty during the main thunderstorm season of September–December, and the figures for this bracket of months are safer than for the remainder of the year. Brisbane is the only centre for which there are usable records; the results from Brisbane can be extrapolated northwards after allowing for the decrease in the number of storms.

The yield of individual storms may reach 3 in., with yields of 1-2 in. very common, and there may be two or three storms in a week during the main season. Intensity is usually very high in the early part of the storm; the author has recorded a total of 1-80 in. of rain in 35 min, most of this falling in 15 min at the peak of the storm. Intensities of 6-8 in. per hour for periods of 5-10 min are not uncommon, with higher intensities occurring.

Hail is frequently associated with thunderstorms in south-eastern Queensland but is not so severe on the Coastal Lowlands as further inland.

(d) Rainfall Pattern

The pattern of total rainfall over the Coastal Lowlands results from interaction between physiography and the various types of rain system discussed above. In addition to the effects of coastal instability and thunderstorm rainfall there is also a latitudinal decline northwards in winter rainfall from frontal systems. From Maryborough to Bundaberg–Baffle Creek mean annual rainfall varies by only a few inches; there is little physiographic control here and the winter rainfall component (cyclones excepted) has steadied at a low figure.

Hubble (1954) suggests that the pattern of rainfall south of Tewantin is “probably due to some sheltering of the southerly stations from the influence of the SE. trade winds by the larger islands off the coast”. While this may be suggested by geographical conformation, it conflicts with the genesis and distribution of thunderstorm and orographic rainfall. The coastal islands reach peak heights of 800-900 ft but the general elevation is only 400-500 ft above sea-level; it is difficult
to see how a narrow belt of country of this height can cause a rain-shadow 15-20 miles from its lee-side in the case of Stradbroke and Moreton Islands, and up to 40 miles in the parallel case of Fraser Island affecting Bundaberg.

(e) Variability of Rainfall

Statistical assessment of the variability of rainfall on the Coastal Lowlands is complicated by the marked positive skewness of the rainfall distribution and the shortness of records. Loewe (1948) examined different indices of variability and advocated the use of Maurer’s (1936) “average variability index” (A.V.I.) as being most satisfactory although laborious to determine; it permits comparison of rainfalls for centres with widely differing annual totals under diverse climatic patterns.

The average variability index is used here according to Loewe’s directions.* He refers to the need for computing the index on a year which does not impose an artificial break of the main wet season, and points out that use of the formal period January–December can give artificial values for regions with marked summer dominance of rainfall (cf. the two figures for Brisbane in Table 2). For this reason the Queensland values are based on an annual period of October–September, which also avoids partition of winter rains and the spring drought.

Table 2 shows the average variability index for a number of stations on the Coastal Lowlands and for selected stations elsewhere in Australia. Loewe (loc. cit.) quotes Maurer’s assessment that stations with an index of over 150 have “unfavourably high variability”, while stations with values of over 300 are “extremely unfavourable” with regard to variability of rainfall. The high variability over the Coastal Lowlands is one of the factors which lowers the effectiveness of total rainfall as compared with other areas of similar rainfall but with a more stable pattern.

(f) Temperature and Humidity

Mean monthly maximum and minimum temperatures and relative humidity for key stations on the Coastal Lowlands are given in Table 1. These figures indicate a mild regime but do not reveal the wide variation in temperature and humidity under different types of vegetation over short distances. They also give no indication of the wide diurnal range in the sand dune areas, despite their proximity to the sea. These differences in microclimate which are so important to the plant require close instrumentation of a type not yet undertaken on the Coastal Lowlands.

Mason’s (1936) emphasis on the importance of climatic extremes applies particularly to temperature. The upper limits of temperature on the Coastal Lowlands are not severe, temperatures above 90°F being uncommon. Swain (1928) emphasized the importance of low temperatures when he correlated the broad

* The author is indebted to Dr. E. A. Cornish and Mr. K. P. Haydock of the Division of Mathematical Statistics, C.S.I.R.O., for critical guidance in the selection of a suitable index and to Mr. Haydock for arranging the computation of some of the indices collected.
distribution of vegetation in Queensland with the minimum temperature of the
coldest month of the year.

On the Coastal Lowlands temperatures at the lower end of the range are
normally mild, but here Mason's (loc. cit.) factor of the extreme becomes
significant with regard to frosts. Foley (1945) states that in the region embracing
the Coastal Lowlands “frosts do not occur in localities exposed to the open sea
but a few miles inland they can be expected from the end of June to late in
August, and may occasionally be severe in July”. Using Foley's criteria of
determining a “light” frost by a screen temperature of 36°F and a “heavy” frost
by a screen temperature of 32°F, records from several stations on the Coastal

<table>
<thead>
<tr>
<th>Station</th>
<th>Interval</th>
<th>Annual Period</th>
<th>Mean Annual Rainfall (in.)</th>
<th>A.V.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brisbane*†</td>
<td>1880-1955</td>
<td>Jan.-Dec.</td>
<td>43</td>
<td>320</td>
</tr>
<tr>
<td>Brisbane*</td>
<td>1840-1955</td>
<td>Oct.-Sept.</td>
<td>—</td>
<td>263</td>
</tr>
<tr>
<td>Tewantin*</td>
<td>1898-1955</td>
<td>Oct.-Sept.</td>
<td>66</td>
<td>201</td>
</tr>
<tr>
<td>Howard*</td>
<td>1899-1955</td>
<td>Oct.-Sept.</td>
<td>42</td>
<td>274</td>
</tr>
<tr>
<td>Bundaberg*</td>
<td>1883-1955</td>
<td>Oct.-Sept.</td>
<td>44</td>
<td>321</td>
</tr>
<tr>
<td>Cairns, Qld.</td>
<td>1887-1955</td>
<td>Oct.-Sept.</td>
<td>86</td>
<td>287</td>
</tr>
<tr>
<td>Pittsworth, Qld.</td>
<td>1887-1955</td>
<td>Oct.-Sept.</td>
<td>28</td>
<td>134</td>
</tr>
<tr>
<td>Armidale, N.S.W.</td>
<td>1880-1955</td>
<td>Jan.-Dec.</td>
<td>31</td>
<td>128</td>
</tr>
<tr>
<td>Wagga, N.S.W.*†</td>
<td>1888-1937</td>
<td>Jan.-Dec.</td>
<td>21</td>
<td>140</td>
</tr>
<tr>
<td>Bridgewater, S.A.</td>
<td>1862-1950</td>
<td>Jan.-Dec.</td>
<td>43</td>
<td>108</td>
</tr>
<tr>
<td>Adelaide, S.A.</td>
<td>1839-1950</td>
<td>Jan.-Dec.</td>
<td>21</td>
<td>82</td>
</tr>
<tr>
<td>Perth, W.A.*†</td>
<td>1888-1937</td>
<td>Jan.-Dec.</td>
<td>36</td>
<td>75</td>
</tr>
<tr>
<td>Darwin, N.T.*†</td>
<td>1888-1937</td>
<td>Jan.-Dec.</td>
<td>60</td>
<td>125</td>
</tr>
</tbody>
</table>

* Stations on Coastal Lowlands.
† Data after Loewe (1948).

Lowlands indicate that the main season of frost is from May to August with the
most severe frosts likely in July–August. Despite the indications of generalized
maps (e.g. Anon. 1934) that the Coastal Lowlands are frost-free, the records of
the Commonwealth Meteorological Bureau and of the Queensland Forest Service
show that up to 20 frosts may occur in a season over much of the region, about
one-third of them heavy; screen temperatures may drop to 25°F and a run of up to
five consecutive heavy frosts can occur. The corresponding grass temperatures
cannot safely be estimated since Foley (loc. cit.) points out the wide variation
between screen temperatures and temperatures close to the ground. Heavy frosts
may also occur within a half-mile of the beach where the country is flat and
especially where there is a mantle of sand. North of Maryborough the number of frosts per year is reduced, but severity is not.

(g) Wind

The strength and pattern of winds over the Coastal Lowlands are typified by observations from Double Island Point and Maryborough, which are summarized in Table 3 and in Figures 4 and 5.

Double Island Point represents the coastal strip and Maryborough those parts of the Coastal Lowlands further inland. The higher wind strengths at the coast produce marked “wind planing” of the vegetation, especially in the valleys between major sandhills where there is pronounced funnelling. The desiccating south-west winds which are a notable feature of the winter climate further inland are reduced in their effects over the Coastal Lowlands, but still significant. This effect diminishes sharply approaching the coast and is well illustrated by the difference in the wind roses for Maryborough and Double Island Point for the winter months.

The significance of the northerly wind components has been either overlooked or deprecated by previous workers, especially geomorphologists who have interpreted shore-line and sandhill dynamics solely in terms of south-easterly effects.

A notable, though intermittent, effect of winds on the Coastal Lowlands is mechanical damage caused by cyclonic winds. Although this occurs perhaps only once in 20 years on any given area, the destruction of mature trees in forests (both eucalypt and rain-forest) can be quite catastrophic and imposes major changes on forest communities. This is another case of the importance of extremes (cf. Mason 1936). Eucalypt forests may also be completely denuded by leaf fall spread over several weeks after cyclonic winds. In areas of high relief this effect is sharply controlled by aspect which suggests that the cause is purely mechanical. Chemical damage by rain-borne salts from sea-spray seems unlikely since aspect control is very pronounced in the areas of high sandhills within one mile of the sea where salt accession should be highest.

(h) Light

The most interesting effect of light in this environment is that the main period of high light, i.e. September–December, coincides with high temperature and, in many years, a good supply of water in the soil. This coincidence of light and temperature, and hence total energy for growth, with adequate moisture, is in direct contrast to southern Australia where the main period of precipitation is in the months of low light and low temperature.

(i) Climatic Indices

Marshall (1954) points out that while systems of climatic classification such as those of Köppen and Thornthwaite are useful in comparing regions at a semicontinental scale, “local climates are best studied in terms of detailed analyses
**Table 3**

Mean monthly wind strength (%) at Double Island Point (30-year record) and at Maryborough (6-year record) at 3 p.m. Percentage of calms is shown in Figures 4 and 5. The length of record is the maximum available for each station; a 5-year period is considered by the Commonwealth Meteorological Bureau to give a safe indication of wind regime.

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<td>1-12</td>
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<td>64.2</td>
<td>72.8</td>
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<td>38.1</td>
<td>36.7</td>
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<td>8.2</td>
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<td>6-7</td>
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<td>1.6</td>
<td>0.6</td>
<td>0.6</td>
<td>—</td>
<td>—</td>
<td>0.6</td>
<td>1.1</td>
<td>—</td>
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<td>8-10</td>
<td>39-60</td>
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</tbody>
</table>

Ecosystem of Wallum Country, Queensland
Fig. 4.—Directional wind roses for Double Island Point for 9 a.m. and 3 p.m. The figures against each diagram represent the percentage of calms (30-year record).
Fig. 5.—Directional wind roses for Maryborough for 9 a.m. and 3 p.m. The figures against each diagram represent the percentage of calms (6-year record).
of the climatic elements and not within the framework of classification". Daubenmire (1956) is more forthright in his condemnation of fashionable climatic indices such as those of Köppen and Thornthwaite, and concludes that they are meaningless when applied within particular regions of the size being dealt with here.

The climatic indices most widely used by Australian workers in the last two decades are Davidson's and Prescott's various modifications of the Transeau and Meyer Ratios; these have been summarized by Prescott, Collins, and Shirpurkhar (1952), and subsequently modified further, e.g. Butler and Prescott (1955). These formulae in addition to including assumptions regarding the drainage of water through soil, and the transpiration rates of vegetation, also rely in part on data from tank evaporimeters and temperature screens.

Bonython (1950) has shown that the types of tank evaporimeter commonly used in Australia may give erroneous readings due to rim-effects, heat conduction through the walls, and irregular topping-up. Moreover such evaporimeters and temperature screens are operated in cleared areas where atmospheric conditions are different from those obtaining in natural vegetation.

Collins (1954), using Prescott's formula, has shown the limitations of the arithmetic mean of long-term records as compared with consideration of climate year by year. This limitation will apply to any other system of climatology in a region of variable rainfall.

However, these limitations have not prevented the ideas of Prescott, in particular, from stimulating much work of permanent value. In the temperate and tropical zones there is a regular seasonal march of climate which lends itself to classification by indices but for the subtropical regions of the east coast with their highly variable rainfall a satisfactory climatic index is still wanting.

Farmer, Everist, and Moule (1947) have applied Prescott’s $P/E$ index in these latitudes further inland, but their findings are limited by the assumptions involved in the earlier work of Prescott and Davidson, by the difficulties discussed by Bonython (1950), and Collins (1954), and finally by such problems as reverse transpiration at night when dew conditions permit. Finally, on the Coastal Lowlands the use of climatic indices based on orthodox meteorological records is complicated by the fact that the majority of the soils are subject to "natural irrigation" by the temporary perched water-table discussed in Section IV. By comparison, Butler and Prescott (1955) specifically refer to the absence of a water table in their experiments, while Thornthwaite's calculations of evapotranspiration involved the maintenance of a water-table at a fixed depth.

The effects of all the limitations discussed above may be demonstrated by example. In 1953 a wet summer with fluctuating perched water-tables in the soils was followed by a dry winter. After three months of very low rainfall, the natural vegetation in two areas east of Gympie, both of which included a heavy cover of the grass *Themeda australis*, showed no symptoms of water stress. Calculation of Prescott's index indicated acute water stress by the end of May. In the first week of August, with no intervening rainfall, the vegetation was still unaffected and the soils contained from 2% to 5% of available water within the root zone.
At Beerwah, 70 miles to the south, experimental pastures containing a wide range of grasses and legumes produced an average of approximately 1 ton of dry matter per acre (W. W. Bryan, unpublished data) during the same winter period, under similar conditions of rainfall and temperature.

(j) Discussion

Much close instrumentation in the field will be needed for a truly adequate assessment of climate surrounding the plant in this region and water-table effects must be integrated. However, the formal climatic data presented above indicate a mild subtropical climate with marked summer dominance of rainfall.

There are several outstanding characteristics of the climate as it affects the natural vegetation.

(1) The drought period of late winter—"spring" may be quite severe in many years; such dry periods are commonly associated with the maximum frequency of severe frost. The combination produces ideal conditions for widespread bushfires. In Swain's (1928) words: "Springtime becomes the supreme testing time for all Queensland vegetation".

(2) The coincidence of high light, high temperature, and high water status in the first half of many summers can produce very rapid growth and surprisingly rapid recovery after fires.

(3) Winds are normally of low strength and the most notable seasonal effect is one of desiccation by westerly winds in winter. However, devastating cyclonic winds can completely upset the balance of communities, such effects being haphazardly placed in time and space.

(4) Although total annual rainfall seems high by standards prevailing in the temperate zone the unit effectiveness of this rainfall is low by comparison. The high intensities often cause considerable loss by run-off once the perched water-tables are raised. Again, much of the annual rainfall occurs at times when conditions immediately afterwards are conducive to high rates of evapotranspiration.

(5) Consideration of any facet of climate in this region is limited inevitably by its variation, from year to year for every month in the year; this is especially true of rainfall.

Such a climate with its unpredictable alternation between optimum and stress can scarcely be conducive to steady dynamic trends in vegetal pattern. For many species there is an oscillation of the areal limits of those factors of the environment associated with climate. Sometimes the changes are quite abrupt, e.g. the changes of community structure governed by the effects of water-tables, which are discussed in Section V.

IV. THE MINERAL SOILS AND PEATS

(a) Introduction

The majority of the soils of the Coastal Lowlands are derived from arenaceous sediments whose nature is such that they are a poor parent material with regard to both the chemical and physical characteristics of the soils derived from them.
Many of the soils acquired a mantle of siliceous sand during the Quaternary, an addition which did not enhance their chemical status. These features combine with seasonal rainfall, often of high intensity, and with a gentle topography to produce a pattern of soils in which physical differences are usually the most important.

Consequently, throughout this study of the soils the emphasis has been on (1) their relationship to topography and, thus, to the seasonal variation of perched water-tables which are a conspicuous feature; (2) the effects of Quaternary geological history. The interrelationships of soils and vegetation are considered mainly in terms of vegetal effects on soils; soil-vegetation patterns are dealt with in Sections V and VI.

The soils are classified at the level of the Great Soil Group with some subdivision of those groups showing pronounced variation. The morphology, and physical and chemical characteristics, of representative profiles are described, and supporting analytical data presented.

Field examination was carried out with a standard soil auger, supplemented by more detailed studies of a limited number of pit profiles in each of the major groupings. Note stations were located on traverses selected, wherever possible, to cross the topographic pattern. In addition to this open sampling at some 450 sites on the 3500 square miles involved, close sampling at fixed intervals on surveyed traverse lines resulted in the examination of a further 140 sites. At sites selected by the author 21 profiles were described in detail, and sampled for chemical analysis by officers of the Division of Soils, C.S.I.R.O.

The first detailed account of any of the soils of this region was given by Tommerup (1934) who named and mapped ten soil series in an area of 50 square miles north of Maryborough. Vallance (1938) carried out a detailed survey of 3500 acres in the Glass House area and named four soil types.

Bryan (1939) named and described his “red earth residuals” from areas south of Brisbane, but this relic type of soil is scattered throughout the Coastal Lowlands.

King (1949) assembled the very extensive knowledge of the “sugar cane soils” of the Bundaberg district and named three soil series, and one unusual minor type—a yellow podzol. Teakle (1950) referred briefly to some of the types of soil occurring on the Coastal Lowlands, while Young (1940) has discussed the physical and chemical characteristics of certain soils in the southern half of the Coastal Lowlands in relation to the incidence of “fused-needle” disease of pines.

Hubble (1954) described the morphology, classification, and chemical status of a group of representative soil profiles selected by the author on the southern end of the Coastal Lowlands. Thompson (1957) and Talbot and Rossiter (1959) have recently published the results of “spot surveys” in the Beerwah and Coolum districts respectively.

From the sources quoted above much detail is available regarding the morphology, classification, and chemical status of the types of soils on the Coastal Lowlands but there is no comprehensive account of the region as a whole.
(b) Classification and Nomenclature

Prescott (1931) placed the whole of the Coastal Lowlands in his zone of "podzolised soils". Bryan and Hines (1931), while agreeing that "what one may term the podzolic process has been the dominating operation" considered that the common type of soil found on the Coastal Lowlands (i.e. on the better drained soils) had more in common with the "yellow earths of the United States than with the podzols of Eurasia, both with regard to colour and the almost entire absence of that leaf mould which forms the A horizon". Such differences of opinion have continued through to the present, and reflect a wider situation summarized by Leeper (1948) with the comment that "The classification of soils is still in a confused state". Robinson (1949) has also discussed this problem, and stressed the difficulty of distinguishing between features of natural significance, and characteristics whose significance is assumed rather than proven.

No particular "school" of classification is followed in this paper. The soils are divided into groups at the level of the Great Soil Group. Table 4 shows these groupings and their synonymy with some of the common schemes of classification in use in Australia. The general characteristics distinguishing these soil groupings are shown in Table 5. A typical profile from each of the groupings is described in Appendix I. Most of these groups are so broad as to require much subdivision, but this needs detailed work of the type described by Thompson (1957) for a small area at the southern end of the region.

Table 4 includes the relationship between these soil groupings and the categories used by Litchfield and Hubble (unpublished data) in a small-scale map of a large region which includes the southern half of the Coastal Lowlands. The mapping of soils presented in the detailed maps in Section VI is based on the classes used by these authors, to permit of integration with their broad-scale regional map.

(c) Physical and Chemical Characteristics

Detailed results of mechanical and chemical analyses for 12 profiles have been prepared in a separate roneographed Appendix which is available on request from the Librarian, Division of Tropical Pastures, C.S.I.R.O., Cunningham Laboratory, Brisbane. Data for another six profiles are given by Hubble (1954). Only the general trends of these figures will be discussed here.

(i) Mechanical Analysis.—In the A horizons south of Maryborough there is a general tendency for coarse sand to predominate over fine sand, and for the percentage of silt and clay to be low except in the Boonooroo and Beerwah groups. North of Maryborough fine sand tends to assume dominance over coarse sand. This is probably a reflection of differences in parent rock and, possibly, of accession of sand from outside sources such as marine deposition, or aeolian distribution during Quaternary times.

The clay content of the B horizons of the podzolic soils normally increases down the profile to a final level of about 50% clay. The characteristics of weathering Bundamba sandstones in areas occupied by the Toolara podzolics suggest that this clay content at depth is the product of direct weathering, rather
### Table 4
NOMENCLATURE OF SOIL GROUPS, TOGETHER WITH THE CLASSIFICATION OF THESE GROUPS AT THE LEVEL OF THE GREAT SOIL GROUP ACCORDING TO VARIOUS AUTHORS

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<tbody>
<tr>
<td>Ground-water podzol</td>
<td>Podzol</td>
<td>Ground-water podzol</td>
<td>Ground-water podzol</td>
<td>Gley podzol (?)</td>
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<tr>
<td>Podzolic Toolara</td>
<td>Podzolic</td>
<td>Red, yellow, and lateritic podzolic</td>
<td>Red-yellow podzolic</td>
<td>Lepto- and amphi-podzols</td>
<td>Warrah</td>
<td>Glass House</td>
<td>Gooburrum</td>
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<tr>
<td>Podzolic Howard</td>
<td>Podzolic</td>
<td>Red, yellow, and lateritic podzolic</td>
<td>Red-yellow podzolic</td>
<td>Lepto- and amphi-podzols</td>
<td>Warrah</td>
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<tr>
<td>Podzolic Gooburrum</td>
<td>Podzolic</td>
<td>Red podzolic</td>
<td>Red-yellow podzolic</td>
<td>Euchrozem</td>
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<td>—</td>
<td>Gooburrum</td>
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<tr>
<td>Podzolic gley—Tinana</td>
<td>Podzolic gley</td>
<td>Meadow podzolic</td>
<td>—</td>
<td>Meadow soil</td>
<td>Wallum and Warrah</td>
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<td>Podzolic gley—Theodolite</td>
<td>Podzolic gley</td>
<td>Meadow podzolic</td>
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<td>Meadow soil</td>
<td>Warrah</td>
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<td>Gley</td>
<td>Gley</td>
<td>Meadow podzolic</td>
<td>Low humic gley</td>
<td>Meadow and marsh soils</td>
<td>Warrah</td>
<td>Beerwah</td>
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<td>Humic gley</td>
<td>Humic gley</td>
<td>Wiesenboden (?)</td>
<td>Humic gley</td>
<td>Meadow soil</td>
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<td>Humic</td>
<td>Humic</td>
<td>Acid swamp soils</td>
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<td>Marsh soil</td>
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<td>Regosol</td>
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<td>Lithosol</td>
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<td>Peat and peaty sand</td>
<td>Peat and peaty sand</td>
<td>Moor podzol peats and acid swamp soils</td>
<td>Bog soil</td>
<td>Bog soil (?)</td>
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<tr>
<td>Peaty gley</td>
<td>Peaty gley</td>
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<td>Bog soil (?)</td>
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<td>Alluvial</td>
<td>Alluvial</td>
<td>Scrubby and Cherwell</td>
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<td>Burnett</td>
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<td>Tidal mud flats</td>
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<td>Saline soils</td>
<td>Beerburrum</td>
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<tr>
<td>Red earth residual</td>
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<td>Lateritic red earth</td>
<td>Laterite</td>
<td>Beerburrum Redphase (?)</td>
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Table 5

DISTINGUISHING CHARACTERISTICS OF THE SOIL GROUPS

(N.B. Except for some of the solodics all the soils are acid throughout, and organic matter is generally low)

Descriptions of typical profiles from each group are given in Appendix I

The common species of each vegetal unit are given in Appendix II

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Geology</th>
<th>Topography</th>
<th>Drainage and Water-Table (W.T.)</th>
<th>Main Profile Features</th>
<th>Vegetation</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Ground-water podzol</td>
<td>Quaternary sands, partly aeolian. Some stripplings from sandstone area. Some soils in this group probably result from deposition of sand over compressed swamp deposits or truncated lateritic soils</td>
<td>Flat to gently undulating or on lower slopes of rolling country</td>
<td>External nil. Internal slow owing to topographic position. W.T. high and prolonged</td>
<td>A horizons sandy throughout. A&lt;sub&gt;00&lt;/sub&gt; up to ¼ in. thick if unburnt. Bleached A&lt;sub&gt;2&lt;/sub&gt; leading abruptly into an organic pan layer. Com- pacted “fragipan” may occur in the lower A&lt;sub&gt;2&lt;/sub&gt; but is not invariable. Zones of iron accumulation occur but are exceptional. Very acid (4.5-5.5). Depth to pan layers varies between 12 in. and 6 ft. B horizons vary in texture from sands to clays. A typical member with soft brown organic pan over clay may occur where Leptospermum flavescens is prominent in the shrub layer</td>
<td>Forb heath, tree forb heath, low sclerophyll shrub woodland. Some layered forest and vine forest thicket</td>
<td>Widespread especially in the Hercules, Noosa, Tin Can, and Elliott landscapes</td>
</tr>
<tr>
<td>Soil Group</td>
<td>Geology</td>
<td>Topography</td>
<td>Drainage and Water-Table (W.T.)</td>
<td>Main Profile Features</td>
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<tr>
<td>Podzolic—Toolara</td>
<td>Mesozoic sediments chiefly</td>
<td>Broad-topped rises, slopes, and</td>
<td>External fair.</td>
<td>A horizons up to 48 in. deep of loamy sand to sandy loam with some organic matter in the A₁. Coarse sand-fine sand fractions about equal or dominated by former. A₀₀ sparse, A₀ absent except at one site. Gradual transitions throughout the profile leading ultimately to strongly mottled kaolinitic medium to heavy clays. Nodules common and may be a massive band at A₀/B. pH 5.5-6.5 in A horizons increasing slightly down the profile to about 3 ft and then decreasing. Further details by Hubble (1954) and Vallance (1938).</td>
<td>Layered and grassy forest, dry sclerophyll forest. Layered woodland</td>
<td>Widespread south of Maryborough in the Glass House and Coondoo landscapes. Sporadic in the Tin Can, Womalah and Cootharaba landscapes. Small areas in the Gregory, Elliott, and Kolan landscapes</td>
</tr>
<tr>
<td>Soil Group</td>
<td>Geology</td>
<td>Topography</td>
<td>Drainage and Water-Table (W.T.)</td>
<td>Main Profile Features</td>
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<tr>
<td>Podzolic—Howard</td>
<td>Upper Mesozoic sedimentary rocks of Maryborough and Burrum Series</td>
<td>As for Toolara</td>
<td>As for Toolara</td>
<td>Have some features in common with the Toolara soils but A horizons finer textured with fine sand dominant over coarse. Boundaries between horizons more abrupt. A₀₀ sparse, A₀ absent. Upper clay horizon not so brightly coloured as Toolara. Profiles not so deep as Toolara with parent rock often encountered at 3-4 ft. pH 5.5-6.5 with no consistent trends down the profile. Nodules common but generally smaller and with a more pronounced pellicle than in Toolara. Surface horizons erode badly if bared.</td>
<td>Structural units as for Glass House but there are some floristic differences, notably the presence of <em>Grevillea banksii</em></td>
<td>Widespread north of Maryborough, especially in Colton and Gregory landscapes</td>
</tr>
<tr>
<td>Podzolic—Gooburrum</td>
<td>Various sandstones (chiefly Elliott). Some basaltic enrichment (?)</td>
<td>Mainly flat to gently undulating</td>
<td>Good. W.T. not common</td>
<td>Profiles deep. A horizons of yellow-grey sandy loam up to 5 ft deep give way gradually to red clay loam which continues to 120+ in. in some cases. Nodules sometimes present</td>
<td>Layered and grassy forest commonly including <em>E. drepanophylla</em> as a prominent tree</td>
<td>Kolan and Elliott landscapes mainly. Described at length by King (1949) who suggested basaltic enrichment.</td>
</tr>
<tr>
<td>Soil Group</td>
<td>Geology</td>
<td>Topography</td>
<td>Drainage and Water-Table (W.T.)</td>
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<tr>
<td>Podzolic gley—</td>
<td>Deeply weathered</td>
<td>Flat to gently</td>
<td>Poor. W.T. high and prolonged</td>
<td>A horizons fine sandy to silty loam, tend to compact when dry. Dense root mat in upper 4-6 in. Boundaries normally diffuse, sometimes abrupt. B horizons increase steadily in texture to heavy clay, with dull mottling yellow-brown and grey in upper part and strongly mottled red, grey, and white at depth. Dense band of nodules commonly at A/B with nodules continuing down the profile. Prismatic structure common in upper part of B horizons. Gleying on root channels and interfaces of structural units may extend almost to surface</td>
<td>Low layered woodland. Shrub savannah, tall woodland, forb heath, and tree forb heath. Much Xanthorrhoea</td>
<td>Boonooroo, Tin Can, Womalah, Elliott, Colton landscapes</td>
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<tr>
<td>Tinana</td>
<td>sedimentaries and</td>
<td>undulating</td>
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<td></td>
<td>younger alluvium</td>
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<td>Soil Group</td>
<td>Geology</td>
<td>Topography</td>
<td>Drainage and Water-Table (W.T.)</td>
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<tr>
<td>Podzolic gley—Theodolite</td>
<td>Chiefly sandstones of Elliott Formation. Some other sandstones</td>
<td>Flat to gently undulating</td>
<td>A horizons fine textured (silty loam), packs hard when dry. A₀₀ sparse. Trace fine organic matter in A₁. Abrupt boundary to silty clay B horizons with some lodging of organic matter in upper 2 in. Nodular layer not so pronounced as in Tinana group and nodules tend to be smaller. Gleying on root channels almost to surface.</td>
<td>Depauperate forb heath, thicket, and shrub thicket. Some depauperate sclerophyll shrub woodland</td>
<td>Buxton, Kinkuna, and Elliott landscapes. Occurs on low-lying country and in broad drainage lines with very slow fall.</td>
<td></td>
</tr>
<tr>
<td>Gley</td>
<td>Various</td>
<td>Flats, drainage lines and lower slopes</td>
<td>A horizons loamy sand to sand, A₁ with moderate amount of organic matter. A₂ paler in colour, often with gleying on root channels. A₂/B sometimes abrupt. Medium to heavy clay in B with dull mottlings of yellow-brown in dominantly grey clay. Mottlings become stronger with depth. Nodules absent or slight.</td>
<td>Tall and low sclerophyll shrub woodland. Forb heath. Low layered forest. Savannah woodland</td>
<td>A widespread and variable group. Thompson (1957) indicates some of the variants.</td>
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<tr>
<td>Soil Group</td>
<td>Geology</td>
<td>Topography</td>
<td>Drainage and Water-Table (W.T.)</td>
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<tr>
<td>Humic gley</td>
<td>Alluvium</td>
<td>Flat</td>
<td>Poor with W.T. high and prolonged</td>
<td>Profile clayey throughout; upper 4-6 in. of clay loam with fair content of highly decomposed organic matter and dense root mat. Usually a medium to heavy clay with 18 in. of surface. Gleying pronounced in upper 24 in. Below about 36 in. texture varies widely. Prismatic structure prominent in gleyed zone</td>
<td>Grassy forest with <em>Melaleuca quinquenervia</em> tall woodland. Low woodland</td>
<td>Better nitrogen status than most soils on the Coastal Lowlands</td>
</tr>
<tr>
<td>Humic</td>
<td>Alluvium</td>
<td>Flat to undulating</td>
<td>Poor. Subject to seasonal inundation</td>
<td>Fine sandy loam—sandy clay loam A horizons with much organic matter. Fairly sharp transition into clay B at about 18 in. in which dull yellow-brown is most prominent colour. Some &quot;gilgal&quot; microrelief</td>
<td>Dense grassy forest with <em>Melaleuca quinquenervia</em></td>
<td>Extensive in the Maroochy landscape</td>
</tr>
<tr>
<td>Soil Group</td>
<td>Geology</td>
<td>Topography</td>
<td>Drainage and Water-Table (W.T.)</td>
<td>Main Profile Features</td>
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<tr>
<td>Solodic</td>
<td>Sandstones of Elliott Formation</td>
<td>Flat to gently undulating</td>
<td>External slow. Water tends to lie on compacted surface. W.T. not so common as elsewhere on the Coastal Lowlands</td>
<td>Shallow (2-3 in.) A_s with slight organic matter; loamy fine sand which packs hard when dry. Progresses through silt loam to silty clay loam at 12-18 in. Often a silica pan at about 36 in. pH increases down the profile through general range of 5.5-8.0. Total soluble salts increase down the profile to level suggesting weak solodization but morphology does not conform. Some gleying in upper 12-18 in.</td>
<td>Layered woodland. Low woodland. Low grassy forest. <em>Casuarina luehmannii</em> is common in tree layer and is a diagnostic species for this group</td>
<td>The most arid soils on the Coastal Lowlands. Mainly Buxton landscape with some in Kinkuna, NW. corner of Burrum, and western portion of Kolan.</td>
</tr>
<tr>
<td>Regosol</td>
<td>Quaternary sands, High sandhills originally marine, partly windsorted and strand lines</td>
<td>Good</td>
<td></td>
<td>Deep siliceous sands with some accumulation of organic matter in upper 12 in. No other profile development apparent in the field. pH increases down the profile through a general range of 5.5 to 6.5. There may be more massive accumulation of organic matter under vine forest. Buried profiles occur under the current (surface) profiles</td>
<td>Dry and wet sclerophyll forest. Grassy forest. Vine forest heath</td>
<td>These soils support a surprising bulk of vegetation, the forests being up to 100 ft in height. Noosa, Coooloolah, Fraser, Hercules landscapes</td>
</tr>
</tbody>
</table>

**Table 5 (Continued)**

_Ecosystem of Wallum Country, Queensland_
<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Geology</th>
<th>Topography</th>
<th>Drainage and Water-Table (W.T.)</th>
<th>Main Profile Features</th>
<th>Vegetation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithosol</td>
<td>Various</td>
<td>Steep ridges or rocky outcrops on gentler ridges</td>
<td>Good W.T. nil</td>
<td>Skeletal soils sometimes with included pockets of clay</td>
<td>Layered, dry sclerophyll, and grassy forest. Layered woodland. Sclerophyll shrub woodland</td>
<td>Occurs only in scattered small areas</td>
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<tr>
<td>Peat</td>
<td>—</td>
<td>Drainage lines and broad flats</td>
<td>Slow. W.T. permanent</td>
<td>Deep very acid peats, not woody. Humified in the lower layers. Usually overlie a hardpan. Maximum development in valleys between sandhills, up to 20 feet deep</td>
<td>Herbfield (sedges) : some woody shrubs. Forb heath, tree forb heath, thicket</td>
<td></td>
</tr>
<tr>
<td>Peaty gley</td>
<td>Alluvium</td>
<td>Flat</td>
<td>Poor. W.T. high prolonged</td>
<td>Shallow fibrous and humified peat overlying a gleyed heavy clay</td>
<td>Herbfield and grassy (tea-tree) forest. Thicket</td>
<td>Not extensive, mainly in Maroochy landscape</td>
</tr>
<tr>
<td>Soil Group</td>
<td>Geology</td>
<td>Topography</td>
<td>Drainage and Water-Table (W.T.)</td>
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<tr>
<td>Alluvial</td>
<td>Alluvium</td>
<td>Flat to undulating</td>
<td>Good. W.T. short duration or nil</td>
<td>Typical layered alluvium with little profile development</td>
<td>Fringing forest. Tall woodland. Grassy forest. Savannah woodland</td>
<td>Restricted to levee banks and flood plains of major rivers</td>
</tr>
<tr>
<td>Tidal mud flats</td>
<td>—</td>
<td>Flat</td>
<td>Nil</td>
<td>Tidal mud flats and saline soils, some with puffy black surface</td>
<td>Mangroves or low woodland of tea-tree and <em>Casuarina glauca</em></td>
<td>Extensive in Pumicestone Channel and Great Sandy Strait. Occurs along tidal creeks and rivers up to 10 miles inland</td>
</tr>
<tr>
<td>Red earth residual</td>
<td>Mainly Mesozoic</td>
<td>Rolling</td>
<td>Good</td>
<td>Deep friable red clay loam at or near surface overlying mottled kaolinitic clay. Dense band of nodules conforming to former landscape</td>
<td>Layered and grassy forest. Dry sclerophyll forest</td>
<td>Scattered small areas of a relict soil. More common south of Maryborough. See Bryan (1939) for details</td>
</tr>
</tbody>
</table>
than of accumulation from upper horizons. The gleys and solodics normally have a lower clay content than the podzolics but silt content is higher, and may become very pronounced with a total figure of over 30-50% of silt.

In the ground-water podzols and regosols the dominance may change from coarse sand to fine sand down the profile, and in some areas there is an horizon of very fine sand at a depth of 3-4 ft. Where a pan layer is developed in these deep sands there may be a slight accumulation of the clay and silt fractions in the pan.

The only profile of humic gley analysed shows a marked silt content throughout, with sand content increasing down the profile. Hubble (1954) suggests that this represents grading of parent alluvium, rather than any pedogenic effect.

(ii) Soil Reaction.—All surface soils and the majority of subsoils on the Coastal Lowlands are acid. The general trend is for pH to increase from about 5·5 at the surface to about 6·5 in the lower part of the A_2 horizon, and then to decrease to about 5·5 in the B horizon. The poorly drained soils such as the gleys and podzolic gleys are more acid, with pH as low as 5·0. The solodics have a range of pH down the profile from 5·5 at the surface to 8·0 at a depth of 2 ft; there is a high proportion of magnesium and sodium ions in the exchange complex at this depth.

The deep sandy soils of the ground-water podzols and regosols groups are very acid with a general range of pH 4·5 to 5·5. Where these deep sands are highly enriched with organic matter (not necessarily a pan layer) pH may drop below 4·0.

The peats are extremely acid with pH values in a general range of 4·0-4·5, but reaching as low as 3·5.

(iii) Organic Matter.—The content of organic matter of the soils is generally low, except in the humic and humic gley soils. Isolated pockets of the gleys and podzolics can have a moderate content (up to 4%) in the surface horizon, but carbon/nitrogen ratios are in the range 20-30. The poor status of the majority of the soils is accentuated by the fact that the small amount of organic matter present normally shows a wide carbon/nitrogen ratio. The only group which shows a carbon/nitrogen ratio of less than 15 is the humic gleys; no figures are available for the humic soils and the peaty gleys but these would probably have fair to good carbon/nitrogen ratios.

(iv) Nitrogen.—Total nitrogen in the A horizons is generally below 0·1% in the humic soils, so that throughout most of the Coastal Lowlands a deficiency of available nitrogen is to be expected. This is in spite of an appreciable number of legumes in the natural flora, one third of which have been recorded by Bowen (1956) as showing nodulation.

(v) Total Soluble Salts.—Hubble (1954) commented that in spite of expected accession of cyclic salt, the total salt content of the soils was so slow as to indicate effective leaching. Much of this salt may be removed by drainage during those periods when the perched water-table is in the A horizon. The solodic soils are
exceptional for the Coastal Lowlands in their content of salts, and show an increase down the profile to nearly 0.3% at a depth of 4 ft in one case. The topographic situation of this particular sample suggests that it may be subject to accession from adjoining areas through ponding effects.

(vi) Phosphorus.—Total phosphorus content and available phosphorus (determined by the method developed by the Queensland Bureau of Sugar Experiment Stations) are generally extremely low except in the humic gleys. While Coaldrake and Haydock (1957) have shown that the total phosphorus content of many of the soils varies extremely, especially in the surface soil (the range is from 10 to over 500 p.p.m. of total P), this variation is all in the range of low phosphorus content.

(vii) Exchangeable Cations.—Total exchange capacity and exchangeable metal ions are low except in the peats, in the humic gleys, and in some of the gleys. One peat profile analysed gave a total exchange capacity of 192 m-equiv/100 g but the saturation percentage is only 12%. Similarly where a high total exchange capacity exists in the gleys this is offset by the low saturation percentage.

Although calcium is frequently the dominant metal cation in the upper part of the profile, its total content is still low. Climate does not necessarily account for the paucity of calcium since there is a well-developed layer of nodules of calcium carbonate in a chernozemic type of soil at Yandina on the western boundary of the Coastal Lowlands. Magnesium generally replaces calcium as the dominant cation in the lower horizons and in the solodic-gley profile in this region. These show a high saturation percentage (62-97%) but most of this is accounted for by magnesium and sodium (up to 64% and 31% respectively). Potassium is extremely low throughout the region.

In the deep sandy soils with a heavy accumulation of organic matter total exchange capacity varies widely but is always strongly dominated by the hydrogen ion.

(viii) Minor Elements.—While no chemical determinations are available, experimental work by Andrew and Bryan (1955) and by Andrew (unpublished data) with a range of grasses and legumes show that these soils have low levels of many of the minor elements. Copper, zinc, boron, and molybdenum are the elements chiefly involved but copper is the only element which is consistently low. These experiments cover the podzolic, gley, podzolic-gley, solodic, and humic gley soils. On geochemical grounds it seems safe to predict that the remainder of the soils are similar, with the possible exception of the humic, Gooburrrum podzolic, and alluvial soils.

Coulter (1954) in pointing out that copper deficiency may result from fixation of copper as well as from actual shortage, states that in some soils copper can be "rendered ineffective through the action of sulphate reducing bacteria, e.g. H₂S-forming bacteria such as Vibrio desulphuricans". On the Coastal Lowlands it is common to find a strong smell of hydrogen sulphide in auger holes after a period of high water-tables and Coulter's explanation may account for some of the apparently low levels of copper; this effect could be seasonal rather than perennial.
(ix) *General Nutrient Status.*—The bulk and vigour of natural vegetation produced by these soils reflect the results of natural selection rather than a high fertility in the soils. While it is probable that the natural vegetation would respond to dressings of artificial fertilizer, it is fairly certain that any introduced species of economic importance will require artificial fertilizer. Young (1940) has shown that exotic species of *Pinus* require additional phosphate, while Andrew and Bryan (1955) have shown that for a wide range of pasture species calcium and phosphorus are the two primary deficiencies, either element assuming the role of initial limiting deficiency. Deficiency of potassium and nitrogen are widespread, while shortage of the minor elements is sporadic, but there is usually a need for at least one.

*(d) Ground-Water*

Perched water-tables* are a very conspicuous feature of many of the soils on the Coastal Lowlands. While there is a general seasonal trend they may occur at any time of the year; a rainfall of 3-4 in. in 48 hours will overload the solum, irrespective of the previous degree of dryness. The significance of these perched water-tables with regard to pedogenesis and vegetal distribution is discussed later, but it is necessary first to describe their behaviour and to indicate the chemical content of the water.

Figure 6 shows the fluctuation of the perched water-table in a gley soil from the southern end of the Coastal Lowlands.† Numerous observations by the author elsewhere on the Coastal Lowlands suggest that this particular soil has medial characteristics, i.e. fluctuation of some water-tables is slower, of others faster. All of them have the common feature of rising to within 1 ft of the surface several times during a normal wet season and of receding to below 12 ft during a dry season. When a wet summer leads into a dry winter the water-table may not recede below 5 ft for 12 weeks with obvious advantages to deep-rooted species. Recession from above 3 ft can be halted by a rainfall of 1 in., but if a water-table is deep a rainfall of at least 3 in. in 7 days is necessary to bring it within 3 ft of the surface. Prolonged heavy rain is necessary to maintain a water-table within 1 ft of the surface for more than a few days, except in drainage lines.

Chemical analyses of 45 samples of ground-water from representative sites over the whole of the Coastal Lowlands show a consistently low content of total soluble salts, the highest content being 0·014% with the majority less than 0·01%.

The frequency and range of fluctuation of the water-tables seem to depend primarily on topographical position and to a lesser extent on the relative thickness and permeability of the A and B horizons. A broad relationship exists between extremity of water-table effects and certain features in the profiles as shown in Table 6.

*A perched water-table is defined here as a temporary accumulation in the soil of free water resulting from local rainfall.*

† The author is indebted to Mr. W. W. Bryan, Division of Tropical Pastures, Brisbane, for permission to use the unpublished data on which this figure is based.
The comparative purity of the water, and its persistence in the root zone for up to three months after cessation of a heavy rainfall amounts to a natural irrigation system for species able to tolerate the lack of aeration during periods of high water. The significance of this in climatological studies of the Coastal Lowlands has already been referred to in Section II. There is also preliminary evidence that perched water-tables affect the soil flora. Mrs. S. G. Ducker (private communication) found marked changes in the fungal flora of soil samples supplied by the author from the same sites, but collected after a dry period of some months, and after a period of high water-tables.

Fig. 6.—Level of the perched water-table in a gley soil during a period of approximately one year. The figure at each point on the graph represents the amount of rain (0.01-in. units) received in the interval from the preceding point. There is no permanent staff at the field station concerned; hence the irregular spacing.

(e) Soil Nodules

Bryan (1952) in discussing macroscopic inclusions in the soils suggested that the term “nodule” be used in preference to “concretion” with its immediate implications of process. The presence of soil nodules on the Coastal Lowlands was noted by Prescott (1931) who used them as an indication of fluctuations in the level of ground-water. Tommerup (1934) also recorded nodules in soils near Maryborough, while Vallance (1938) has described their occurrence near Caboolture at the southern end of the Coastal Lowlands. From chemical analyses
Vallance showed that although they are frequently referred to as "ferruginous concretions" there is in fact a substantial accumulation of aluminium in addition to that of iron. He also pointed out and confirmed by analysis that a small percentage of the nodules are manganiferous.

**Table 6**

**THE RELATIONSHIP BETWEEN WATER-TABLE EFFECTS AND SOME PEDOGENIC FEATURES ON THE COASTAL LOWLANDS**

<table>
<thead>
<tr>
<th>Profile Feature</th>
<th>Topographic Position</th>
<th>Drainage</th>
<th>Permeability</th>
<th>Water-Table Fluctuations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massive nodule</td>
<td>Flats or very gentle slopes</td>
<td>Very poor</td>
<td>Shallow permeable A</td>
<td>Rapid in the narrow nodular zone</td>
</tr>
<tr>
<td>Strong nodule</td>
<td>Upper slopes and ridge tops</td>
<td>Fair</td>
<td>Deep permeable A</td>
<td>Rapid and wide</td>
</tr>
<tr>
<td>Some nodule, usually gleying</td>
<td>Lower slopes</td>
<td>Poor</td>
<td>Shallow permeable A</td>
<td>Modestly slow but wide</td>
</tr>
<tr>
<td>Gleying with no nodule</td>
<td>Flats or poorly drained soils</td>
<td>Poor</td>
<td>Relatively impermeable A</td>
<td>Slow but wide</td>
</tr>
<tr>
<td>Organic pan, with or without impacted siliceous capping</td>
<td>Gentle slopes or flats</td>
<td>Slow on slopes, poor on flats</td>
<td>Permeable sands</td>
<td>Slow but wide</td>
</tr>
<tr>
<td>Incipient organic pan layer</td>
<td>Gentle slopes</td>
<td>Internal good but some topographic impedance</td>
<td>Permeable sands</td>
<td>Rapid and wide</td>
</tr>
<tr>
<td>Peat over sand with organic pan</td>
<td>Flats, drainage lines</td>
<td>More or less permanently waterlogged</td>
<td>Good in sand, poor in pan layer</td>
<td>Slow and narrow</td>
</tr>
<tr>
<td>Peat over gleyed clay</td>
<td>Flats, drainage lines</td>
<td>More or less permanently waterlogged</td>
<td>Impermeable in gley horizons</td>
<td>Slow and narrow</td>
</tr>
</tbody>
</table>

On the Coastal Lowlands nodules are a prominent constituent of those soils where the water-table fluctuates freely in the upper horizons, cf. Table 6. This short-term fluctuation, i.e. several times in each wet season, and sporadically at other times of the year, seems to be the essential condition for initiation and growth of nodules in these soils.
The concentration of nodules and the size of individual nodules reach their maximum in soils of deep (3+ ft), light textured (loamy sand–sandy loam) A horizons overlying fairly impermeable B horizons of yellow-brown sandy clay or clay. In these soils there may be a densely packed layer of nodules commonly up to 12 in. but sometimes over 3 ft in thickness. Such a layer usually includes a size range from less than ¼ in. to over 2 in. in diameter. Shape varies widely, but sphericity is the dominant trend.

As texture for the upper horizons becomes heavier, or as they become shallower, density of aggregation becomes extremely variable and size range is reduced, with dominance of nodules less than ¼ in. in diameter. Shape is more constant with a high degree of roundness, and dominance of sphericity. This type of nodular growth is at a maximum where several feet of red clay loam is overlain by about 1 ft of sandy loam. The profile resembles Bryan’s (1939) red earth residuals, but that it is contemporary is proved by its conformation to the present landscape.

The changeover between the two types described above is often discernible in the field when clay colour changes from the yellow to the red side of 5YR 5/8 Munsell, moist.

On the Coastal Lowlands initiation and accretion seem to be restricted mainly within the existing layer of nodules, i.e. the layer tends to become denser rather than to increase upwards or downwards. This suggests that the changes in ground-water level necessary to produce very thick deposits of nodules in older soils, could have resulted from changes in topography without climatic change, equally as well as from changes in climate over a stable topography.

Te Punga (1954) presented evidence for a minimum age of some beds of nodules in New Zealand, and argued from this that the formation of a nodule layer requires “considerably longer than 3000 years”. Evidence on the Coastal Lowlands, from areas exposed by the mid-Recent adjustment of sea-level, suggests that the formation of a nodule layer is more rapid in this region.

(f) \(A_0\) and \(A_{00}\) Horizons

Stephens (1949) has drawn attention to the “thin and discontinuous” nature of the \(A_{00}\) horizon in Australia, excepting under rain-forest. Regarding the \(A_0\) horizon he states “in Australia it has not been recorded under natural conditions. It is certainly absent in all but the rain forest areas; it may occur there but no published descriptions of podzols and podzolic soils indicate its presence”. Stephens attributes this contrast with Europe and North America to differences in vegetation and soil fauna, and to fire. Hatch (1955) recorded substantial increases in the litter under Jarrah forest in Western Australia after protection from fire but he did not report the development of an \(A_0\) (duff) layer.

Observations on the Coastal Lowlands (vine forests excluded) suggest that fire is the primary deterrent to litter accumulation. Throughout the region any area protected from fire for more than three years shows the beginnings of a continuous litter layer (\(A_{00}\)) and on forest reserves after 20 years of protection there may be 3-4 in. of unconsolidated litter.
On the Coastal Lowlands a thin duff layer less than 1 in. in thickness was observed on a Howard podzolic soil under a *Eucalyptus* forest south of Bundaberg. There was a thin layer of leafy litter above it and the plant community included a well-developed shrub layer. While this isolated instance does not furnish conclusive evidence that a duff layer will form under all *Eucalyptus* forest on the Coastal Lowlands, if circumstances permit, it does prove that it is possible. A duff layer can also develop under vine forest in valleys between high sandhills on the Coastal Lowlands; in one example seen on Fraser Island, the duff layer was up to 3 in. thick.

### Table 7

**SOME MORPHOLOGICAL, PHYSICAL, AND CHEMICAL CHARACTERISTICS OF A "MOUND SOIL" AND AN ADJOINING PODZOLIZED SAND ON FRASER ISLAND**

Physical and chemical data are on an oven-dry basis.

<table>
<thead>
<tr>
<th></th>
<th>Mound Podzol</th>
<th>Deep Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizon</td>
<td>A₀₀ A₀ A₁ A₂</td>
<td>A₁ A₂</td>
</tr>
<tr>
<td>Colour</td>
<td>10R 3/4 10R 3/6 2.5YR 6/2 10YR 8/2</td>
<td>5YR 5/2 10YR 8/2</td>
</tr>
<tr>
<td>pH</td>
<td>3.3 3.6 4.1 5.9</td>
<td>4.7 5.4</td>
</tr>
<tr>
<td>Loss on Ignition (%)</td>
<td>65.5 20.2 4.8</td>
<td></td>
</tr>
<tr>
<td>Coarse Sand (%)</td>
<td>70 84 74</td>
<td></td>
</tr>
<tr>
<td>Fine Sand (%)</td>
<td>22 14 22</td>
<td></td>
</tr>
<tr>
<td>Silt (%)</td>
<td>2 0 1</td>
<td></td>
</tr>
<tr>
<td>Clay (%)</td>
<td>3 2 2</td>
<td></td>
</tr>
<tr>
<td>Nitrogen (%)</td>
<td>0.58 0.24</td>
<td>0.43</td>
</tr>
<tr>
<td>Organic Carbon (%)</td>
<td>37.1 10.9 2.9 0.03*</td>
<td>0.78*</td>
</tr>
<tr>
<td>Total Phosphorus (P₂O₅%)</td>
<td>0.03 0.015 0.005 0.017</td>
<td></td>
</tr>
<tr>
<td>Exchangeable Cations (m-equiv/100 g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td>52.9</td>
<td>3.7</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.57</td>
<td>0.30</td>
</tr>
<tr>
<td>Magnesium</td>
<td>2.85</td>
<td>0.35</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.21</td>
<td>0.08</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.54</td>
<td>0.08</td>
</tr>
</tbody>
</table>

* Walkley-Black determination.
In other areas on Fraser Island there is an horizon (see Plate 3, Fig. 1) above the sand which acts as a duff layer (up to 24 in. thick). It consists of decomposed organic matter with a dense mat of living roots, but seems to consist almost entirely of decomposed bark from Syncarpia hillii F. M. Bail. This duff layer is formed as a mound around individual trees of this species only and is conspicuously restricted to a circle under each tree extending outwards from the trunk for up to 10 ft.

Table 7 presents some chemical and physical data from such a “mound soil” and an ordinary deep siliceous sand nearby. The two sites sampled were 60 ft apart, the latter being under developing rain-forest dominated by Backhousia myrtifolia Hook & Harv. (Carrol scrub). The A₀ horizon of the mound soil was divided for sampling at the point where macroscopic fragments of bark were no longer visible. In both profiles there was a trace of finely divided organic matter in the A₁. Apart from this, and increasing the acidity of the sand just below it, the litter does not seem to exert any other marked effects down the profile. Deep boring was not possible at this site, the sand being too dry, but boring to a depth of 14 ft under similar communities elsewhere on Fraser Island did not reveal any organic pan layer.

Field evidence at the sites sampled did not suggest the “egg cup” formation discussed by Bloomfield (1953) for soils associated with Agathis australis in New Zealand. Finally, it is worth noting that Agathis robusta (C. Moore) F. M. Bail. is a common species in this type of forest on Fraser Island but the mounding is restricted to Syncarpia hillii.

(g) Types of Pan Layer

The typical ground-water podzol of the region has a brownish black mildly cemented organic pan, the surface of which may be comparatively even or deeply indented, and which may be over 3 ft in thickness. In the Hercules landscape (see Section VI) many of these organic pans show no relation to present topography and it is suspected that such profiles may consist of “new” A horizons deposited over “old” B horizons by marine or aeolian action. These organic pans disintegrate with varying rapidity when a hand specimen is held in water, but some of them now exposed on ocean beaches withstand severe wave action.

It is common (but not invariable) to find this organic pan overlain by a layer of whitish impacted siliceous sand, which although extremely hard in the profile, frets quite easily in the hand specimen. This combination of white pan over black is restricted mainly to lower elevations, where it shows little relationship to present topography or vegetation; but it has also been found at elevations of up to 300 ft above sea-level. It is normally associated with deep siliceous sand, occurring at a depth of from 2-5 ft in the profile, but in some areas it occurs within a few inches of the surface. In one profile it was below 4-6 in. of sandy clay.

In many of the solodic soils a siliceous pan develops at a depth of 2-3 ft, and is for all effective purposes the bottom of the soil profile. This type of pan differs from the white pan just discussed in being composed of finer-textured material.
Seen under a hand lens it has the appearance of being cemented by silica which has moved into the layer in solution, whereas the white pan does not seem to have any cementing material between the grains.

A second type of organic pan is a thin, soft layer of dull brown organic-enriched sand, or sandy clay, which rests on clay of low permeability. This type of pan is more likely to have a zone of iron accumulation underneath it than the first type discussed, and occurs on more or less flat country of severely impeded drainage.

In small patches, often only 30-40 yd in diameter, a bright reddish brown organic pan may overlie the B horizon of light to medium clay. This type of pan is very soft and is easily penetrated with an auger. It occurs on sloping ground, usually under forest vegetation which always includes a tall myrtaceous shrub, *Leptospermum flavescens*, and the litter from this shrub seems to play some part in its formation.

(h) The Peats

So far as the present author is aware the only specific mention of peats in the subtropical and tropical zones of Australia is through brief references in botanical papers such as that by Herbert (1951). Their presence is not unexpected in view of the records of extensive areas of peat in Indonesia (Mohr 1944) and in Malaya (Coulter 1950).

The nomenclature and definitions used by authors such as Costin (1954) and Stephens (1956) for peats in southern Australia do not readily include the peats on the Coastal Lowlands, while the terminology of many overseas authors (e.g. Sjörs 1948; Osvald 1949; Kubiéna 1953) is so varied as to make the selection of terms difficult. The terminology used here is based on Tansley's (1949) classification.

The peats on the Coastal Lowlands are all oligotrophic peats dependent on drainage water rather than on direct precipitation and a continually moist atmosphere. There are small areas of acid fen peat formed in drainage lines, or in swamps, in which much of the material comes from species of *Melaleuca*, chiefly *M. quinquenervia* or *M. viridiflora* (type A or "tea-tree" peats). The majority of the peats are a mixture of two other types; acid fen peats formed chiefly from the remains of sedges and woody plants (type B), and a type with many of the field characteristics of an acid bog peat (type C). However, in the latter the contributions of *Sphagnum* are greatly exceeded by those from a more or less continuous mat of fine root material which covers the surface of the peat. Dr. W. D. Billings (private communication) has suggested that this is an aerial extension of the root system of one or more of the angiosperms growing on the peats. Further examination of this material is required before it can be identified and described with certainty.

In the areas of types B and C the water-table is permanently close to the surface. These two types form chiefly over siliceous sand which may be bound into an organic pan close to the bottom of the peat. From the limited field examination possible it seems that in many sites there is a succession from type C
to type B. These two types occur chiefly in the Fraser and Cooloolah landscapes and to a lesser extent in the Hercules landscape (see Section VI). Type A occurs chiefly in the Glass House, Cootharabula, Kolan, and Hercules landscapes.

For the purposes of further discussion types B and C will be considered together since they occur in close admixture at any given site. In each of three distinct topographic positions this mixture of peats has characteristic features which are discussed below.

(1) *The valley peats* extend up narrow valleys between the sandhills for upwards of 2 miles, commencing at the coast just behind the mangroves and reaching to a final elevation of 50 ft above sea-level. Alternatively they may merge with an area of plains peat where the sandhills end some distance from the sea. They are commonly 10 ft deep, while one was proved to a depth of 19 ft, and the water-table is permanently high. The surface of the valley peats tends to be much less broken than the surface of the other two types below; there may be scattered small pools up to 6 ft in diameter, and 3 ft in depth.

Humification increases rapidly down the profile (Plate 3, Fig. 2) and in some areas the peat is fibrous only in the top 6-9 in. The upper 9 in. of a profile near Double Island Point had a pH of 4·1, a total soluble salt content of 0·25%, and a total exchange capacity of 192 m-equiv/100 g. The percentage of the various ions was: hydrogen 88%, magnesium 8%, calcium 3%, sodium 0·8%, and potassium 0·2%.

(2) *The plains peats* (Plate 3, Fig. 3) cover areas of up to 100 acres beyond the limits of the valley peats with which they are usually continuous. There is little or no slope and they are shallower than the valley peats, being commonly 2-4 ft in depth. The surface is commonly broken by shallow pools up to 30 ft in diameter. They are more subject to drying out, and hence to burning, which is suspected as the major cause of the pools. They tend to carry more woody vegetation than the valley peats and type B is the dominant type. Apart from the breaks caused by pools the surface tends to be fairly even.

(3) *The mound peats* (Plate 4, Figs. 1 and 2) occur as distinctive mounds up to 100 yd in width on the lower slopes of sandhills but above drainage lines, or on gently sloping sandy areas receiving external drainage. They appear to grow outwards from the slope, or from central areas on the second type of site, and reach a height of 4-5 ft above the basement of siliceous sand. The upper layers are more fibrous than in the other peats, but this seems to be the effect of a dense mat of living roots of sedges. There was a conspicuous layer of root material at the surface of all those examined. These mounds develop a sharp microrelief with vertical-sided hummocks up to 12 in. in height. The striations resulting from these hummocks were either concentric or normal to the slope of the underlying ground in the areas examined. This type of microrelief resembles that described from the northern hemisphere by authors such as Sjörs (1948). Small pools are common and reach a depth of 3 ft. pH determination (glass electrode) on one area showed a range of 3·6-4·0 in the upper 20 in. of peat with no clear stratification, and a range of 4·3-4·5 in the tops of adjoining pools.
The vegetation of these three types of peat is described briefly in Section V under the category of "herbfield". Peats of type A occur chiefly in small drainage lines or swamps and are widespread on the Coastal Lowlands although the individual areas are usually only a few acres in extent. They occur over both sand and mineral soil. They are shallower than the other peats, being usually only about 2 ft in depth. The water-table may recede completely so that they are liable to periodic destruction by fire. The rate of accumulation may be judged from one area in which 24 in. of peat had formed in 26 years between two fires; the ash of this peat proved to consist largely of diatomaceous skeletons and phytoliths when examined microscopically.

(i) Whorled Hummock Formations

Apart from the microrelief already mentioned in Table 5 for the humic soils and that described in certain types of peat, there is another expression of microrelief on the Coastal Lowlands which will be referred to as "whorled hummocks". An example is shown in Plate 4, Figure 3.

This type of microrelief is common on low-lying, more or less flat, areas of sandy soils supporting heath. It consists of sharp-sided hummocks, usually 12-18 in. in height, 6-8 ft in width and up to 50 yd in length. The trenches between are flat and vary in width from a few feet to 30 ft. Where the trenches broaden, small, more or less circular hummocks 4-5 ft in diameter may be scattered in no apparent pattern. The trench–hummock sequence bears no relation to the horizons underneath, being an effect imposed and maintained purely on the upper horizon of sand.

The field evidence suggests that this hummock relief is developed while climate and drainage favour development of sandy peat from which the organic matter is subsequently lost. Evidence from widely scattered areas shows that the size and pattern of microrelief is identical with that found in many of the peats and sandy peats on the Coastal Lowlands. In one sequence across 70 yd of ground with a fall of not more than 2 ft, the size and sharpness of the hummocks increased steadily down the slope, and reached their maximum in a small drainage line at the bottom where the hummocks consisted of sandy peat. In similar localities elsewhere the sandy peat had dried irreversibly and seemed to be breaking down. This loss of organic matter was leaving the original sandy matrix to be maintained in hummock form by vegetal difference.

While these whorled hummocks bear superficial resemblance to the "contour trench formations" of the Kosciusko region described by McElroy (1951), they are not so clearly related to contours and do not originate from solifluction or the other primary mechanisms postulated by McElroy. They resemble McElroy's formations in being apparently maintained by "ecological adjustment" (cf. McElroy, loc. cit.). This is chiefly involved through the maintenance of separate communities on hummock and trench, plants with a lower tolerance to high water-tables being restricted to the hummocks.
There may be some biological accentuation of individual hummocks (chiefly through the piling of ant heaps).

(j) Genesis of the Soils

A suggested scheme for the origin of the soils on the Coastal Lowlands is set out in Figure 7. In this scheme Quaternary history and topography are given equal or greater importance than country rock.

Although the precise levels cannot be determined yet (vide Section II) it seems certain that much of the Coastal Lowlands has been within the range of relative fluctuations in sea-level during the Quaternary period. These events produced erosion, deposition of imported material, and reworking of local material in varying combination at any place. Some more elevated areas escaped these effects.

Topographic position seems to be the selective factor determining which pedogenic process will operate in a given place, and it combines with the mixture of parent material to produce the complex pattern of the soils. A difference of 3 ft in elevation can produce widely differing soils from similar parent material, e.g. a ground-water podzol and a type of soil classified by Hubble (1954) as a lateritic podzolic. These differences seem to be imposed primarily by variation in the perched water-tables discussed earlier. It will be noticed that Figure 7 includes few references to present pedogenic processes. A reconnaissance survey does not normally permit the detailed studies necessary to complete discussion of pedogenesis and only the general trends can be discussed here.

The three common pedogenic processes throughout the Coastal Lowlands are podzolization, lateritization, and gleying, these having been discussed by Hubble (loc. cit.) for some of the soils at the southern end of the region. There is a general sequence, outside the areas of Quaternary sand, from podzolic soils on the best-drained sites through lateritic soils to gleyed soils on poorly drained sites. While clear examples of each occur, it is also common to find "intergrade" soils, particularly where perched water-tables produce gleying in the upper part of the profile.

Hubble (loc. cit.) has suggested that the Toolara podzolic soils are "of the same age" as Bryan's (1939) red earth residuals and that "they formed on a continuous peneplain surface which has since been dissected following slight elevation and are the result of essentially the same genetic process". While the similarity of process is quite possible, there seems little doubt that these (and the allied Howard and Gooburrum podzolics) are the result of processes operating within the present landscape. A series of traverses with a dumpy level in three areas between Caboolture and Toolara showed that the horizons followed the present landscape. While this is not conclusive evidence it contrasts with the red earth residuals which do not conform to present landscapes.

Soil formation on areas of Quaternary sand is also governed by topography with more or less undifferentiated sand (regosols) on the higher areas, and ground-water podzols on the lower areas subject to prolonged water-tables.
ECOSYSTEM OF WALLUM COUNTRY, QUEENSLAND

Parent rock *in situ*

see p. 62

Bundamba sandstone

Maryborough-Burrum sedimentaries

Elliott Formation

Upper slopes and ridge tops (free drainage)

Upper slopes and ridge tops (free drainage)

Upper slopes and ridge tops (free drainage)

Lower slopes and ridge tops (perched saddles)

Lower slopes and ridge tops

Lower slopes and ridge tops

Upper rises

Undulating to flat

With (?) cyclic salt accumulating

Podzolic (Toolara)

Gley

some Gley and Podzolic gley (Tinana)

some Podzolic gley (Theodolite)

some Podzolic gley (Theodolite)

some Podzolic gley (Theodolite)

some Gley (Gooburrum)

some Gley (Theodolite)

some Podzolic gley

Podzolic (Gooburrum)

Podzolic (Theodolite)

Podzolic gley

Podzolic (Howard)

Podzolic gley

Podzolic (Toolara)

Podzolic gley

Podzolic gley

Fig. 7.—Schematic presentation of the genesis of the soil groups.
Hubble has discussed the genesis and geographic relationships of the ground-water podzols. The "fragipan" which may occur in these soils is difficult to explain because of the variability of its position in the profile and its lack of correlation with vegetation. One notable exception to the general pedogenic relations of the deep sands occurs where a mildly developed organic pan forms on high sandy areas carrying vine forest.

In a region where there must be high accessions of cyclic salt none of the soils seem to show any strong morphological effects from salinity. The only soils showing accumulation of salts in the profile are the solodics. Here again there seems to be at least partial control by topography through the agency of temporary ponding. On better-drained sites soils from the same parent rock do not show the increase of total soluble salts down the profile which is found in the solodic soils.

Development of the peats has already been discussed. The humic and humic gley soils are mineral soils with appreciable quantities of organic matter. In both cases the accumulation of organic matter seems to be associated with restricted drainage producing conditions suited to dense stands of *Melaleuca quinquenervia* which is a prolific producer of litter. Inundation for long periods also reduces the rate of decomposition and the risk of destruction of this litter by fire.

Finally, there are the compound profiles suggested in various sections of Figure 2, i.e. soils with the general appearance of an uninterrupted profile but which really consist of two or more layers of material of separate origin. These are to be expected in alluvial areas near major streams on the Coastal Lowlands. They can also occur in other positions on the landscape, especially below the 100-ft contour where the effects of eustatic inundations seem to be more pronounced.

One of the hidden factors in soil genesis on the Coastal Lowlands is the effect of fire. The destruction of litter discussed earlier means that, in many of the soils, little of the nutrient capital is tied up in dead organic matter either above the mineral soil, or in the upper horizons. This is especially true of the podzolics, podzolic gley soils, gley soils, solodics, and regosols. The high intensity of much of the rainfall, especially the thunderstorms which are common just after the main fire season, means that some of the ash is inevitably carried off and ultimately lost in the streams. This represents a continual loss of nutrients from the ecosystem. While the loss per acre per annum may be small the total loss must be substantial since this mechanism has to be considered in terms of geological time. Such wastage can only accentuate the inherent lack of fertility in most of these soils which are derived from rocks poor in many of the elements important to plant growth.

V. FIRE AND VEGETATION

(a) Fire as an Environmental Factor

Many Australian authors have referred briefly to the effects of fire on natural vegetation and a few, such as Beadle (1940), Hatch (1955), Shaw (1957), and Specht, Rayson, and Jackman (1958), have made detailed studies of its effects.
on a particular aspect of vegetal growth. Herbert (1937) has suggested that a particular grassland community in an area normally carrying rain-forest and eucalypt forest is purely the result of aboriginal burning. However, so far as the present author is aware, there is no published statement that over much of Australia, fire is as important in the environment as any of the classical factors such as climate and soils.

Mitchell (1845) described in some detail the manner in which aborigines used fire as their only tool of “management”, and he states specifically that they were fully aware of its role in maintaining a grassy understorey at the expense of shrubs; fire was also used to expedite their hunting. The journals of other explorers give broad confirmation of the details sketched by Mitchell, while Herbert (1928) states that “periodic firing of the forest by natives restricted local distribution (of eucalypts) in Gippsland”. Captain Cook’s journal records many sightings of “big smoke” along the east coast under circumstances which point clearly to bush fires. Fires induced by lightning, while not so frequent as in some other parts of the world, are so well known in Australia as to require no proof here; it need only be pointed out that they are of much lower frequency than man-made fires.

The factor commonly overlooked in the historical assessment of fire is that before European settlement any single bushfire would have unhindered progress over enormous areas under the suitable weather conditions so common in this country. The now famous “Black Friday” in January 1939, when bushfires raged uncontrolled over much of Victoria, had a predecessor on February 6, 1851 (Russell 1882) when much of the State was still unsettled.

No generalized statement can be made regarding the effect of fire on vegetal composition in Australia, and extensive discussion is inappropriate here. On the Coastal Lowlands the effect of fire is to maintain a grassy understorey at the expense of shrubs on those sites suited to grasses, while elsewhere, i.e. on the wettest areas, excluding peats, the effect is to increase the prominence of Xanthorrhoea. Coaldrake (1951) in broad outline, and Specht, Rayson and Jackman (1958) in more detail, have described the regeneration of heath after burning on the Ninety-Mile Plain in South Australia. On the heaths of the Coastal Lowlands the sequence is generally similar, but differs sometimes in an early prominence of sedges which are more common on the Coastal Lowlands than on the Ninety-Mile Plain.

The effect of fire in forest and woodland communities is illustrated in the comparisons shown on Plates 5 and 6.

It is significant with regard to the prehistoric importance of fire in Australia that over much of the continent, the most successful groups of species are those with one mechanism or another for survival of fires. The major aerial axes may withstand fire, or the species may regenerate rapidly from growth buds just below the soil surface. Specht, Rayson, and Jackman (1958) have pointed out that fire recovery may stem equally from such underground shoots as from dormant aerial buds or lignotubers. There is also the cracking effect of heat on seeds
with a hard testa. The genus *Eucalyptus* is an outstanding Australian example of fire as a factor in natural selection. The strongly developed resistance to fire of many of the species suggests the long continued role of fire as an operational factor in the environment.

The effect of fire on soil nutrient status on the Coastal Lowlands has already been discussed in Section IV. The overall effect of fire on the vegetation is to maintain most of the communities in a state of flux which is, in a sense, seral since they are not fully developed, but which is also permanent. In the author’s experience there is very little country on the Coastal Lowlands (forest reserves excepted) which escapes burning for more than five years at a time. This means that pyric change in the vegetation is not only natural but is also a continuance of a prehistoric system. It is also additive to the longer variations involved in the “ecotonal oscillation” discussed below.

Beadle (1940) commented on the large numbers of seeds released by dehiscence of woody fruits after a fire, a characteristic common in the Proteaceae, Myrtaceae, and Casuarinaceae on the Coastal Lowlands. The species concerned show a great increase in density of seedlings after a fire. Even if there is heavy seedling mortality this mechanism frequently alters the floristic balance in some communities.

**(b) Animals and Man**

Herbivores have never been important on the Coastal Lowlands either before or after European settlement. Grazing is still only sporadic since cattle develop acute phosphate deficiency if depastured on the natural vegetation; copper deficiency may also develop. The occurrence of a large-seeded species like *Macrozamia paulo-guilemi* in small numbers in isolated atypical areas is probably due to aboriginal cartage or transport *in vivo* by emus.

Colonies of ants are numerous on the heaths and apart from their influence on hummock formation (see Section IV) they seem to be important in destruction of small seeds. Large channels of worm-cast material (up to \( \frac{1}{2} \) in. diameter) occur in soil profiles under forest vegetation but the general volume of material transferred through this agency does not seem great.

Apart from effects through burning there seems only one other important effect of man on the Coastal Lowlands. In Section I reference was made to the activities of timber-getters. Selective logging has concealed the original high frequency of certain species, chiefly bloodwood, *Eucalyptus intermedia*; this is especially true in the vicinity of Howard where cutting for mine-timbers has been very extensive. Grey ironbark, *E. drepanophylla*, is another species concerned in this concealed effect. With species such as blackbutt, *E. pilularis*, and white stringybark, *E. phaeotricha*, the effects of logging are more readily noticeable since they usually occur at higher densities.

Secondary effects of logging of a more temporary nature are the mechanical disturbance of the understoreys and the creation of canopy gaps with consequent alterations to microclimate. These are impossible to assess in a broad-scale survey but their reality and importance are stressed as a guide to later workers.
(c) Floristic Composition and Distribution

A total of 313 species was collected* and a further 20 species were observed. Tommerup (1934) recorded another 23 species from near Maryborough, while Blake (1938) listed 51 species from Coolum; the majority of the latter were sedges and grasses.

While this grand total of 407 species does not complete the flora it should represent at least 80% and it certainly includes all the common species. Vine forest is excluded from this discussion since the taxonomy of vine forests is a specialized study and the areas on the Coastal Lowlands have been discussed by Webb (1957).

Of the 81 families recorded only 11 are represented by 10 or more species. Two families, Myrtaceae and Leguminosae, supply one quarter of the total flora with 53 and 47 species respectively. The other prominent families are Cyperaceae, Restiaceae, Proteaceae, Gramineae, Epacridaceae, and Juncaceae.

The genera *Eucalyptus* (21 species), *Angophora* (2), *Tristania* (2), *Casuarina* (6), and *Melaleuca* (7) are conspicuous in the tree layer not so much through number of species as through their high frequency. The commonest species of trees throughout the region are *Eucalyptus intermedia*, *E. acmenioides*, *Angophora lanceolata*, *Melaleuca quinquenervia* (*M. leucadendra*), and *Casuarina littoralis* (ex *C. suberona*). South of Maryborough *E. micrantha* is also prominent.

The shrub layer is conspicuously leguminous in many of the forest communities, but the obvious families in the heaths are Proteaceae, Myrtaceae, Rutaceae, and Epacridaceae. As judged from less disturbed areas *Leptospermum*, *Banksia*, *Boronia*, *Hibbertia*, and *Acacia* are the most frequent genera of shrubs throughout the Coastal Lowlands.

In the ground layer sedges outnumber grasses both in range of species and in frequency, except in the grassy forests and some tall woodlands. In some woodland communities a cyperaceous species, *Ptilanthelium deusta*, occurs in dense stands superficially resembling the grass layer of a grassy forest. This seems to be another effect of fire. Except in the extremely wet areas, species of *Xanthorrhoea* are universal and frequently comprise a high percentage of the total ground cover or basal area.

Notes on individual species are included in Appendix III.

Most of the species are sharply excluded from the areas flanking the Coastal Lowlands but these barrier environments must be comparatively recent geologically, since there is evidence that many of the species (excluding *Eucalyptus*) occur beyond them. Blake (1940) referred to “a series of communities developed on and near the crest of certain parts of the Great Dividing Range” which are related to the communities of the Coastal Lowlands in floristic composition. Tommerup (1934) listed ten species common on the Coastal Lowlands which also occur with cypress pine, *Callitris glauca*, at Inglewood, 150 miles from the nearest

* A set of herbarium specimens has been deposited at the Cunningham Laboratory. A list of the species (including authorities) is given in a roneographed Appendix available from the Librarian, Division of Tropical Pastures, C.S.I.R.O., Cunningham Laboratory, Brisbane.
Coastal Lowlands. Mean annual rainfall here is only 25 in. although there is still a significant winter component, while winter temperatures are lower.

In a total of 117 species (excluding *Eucalyptus*) from near Newcastle, Osborn and Robertson (1939) include 54 species common to the Coastal Lowlands. This widespread distribution along the coast is in conformity with the parallel alignment of major physiographic barriers which Herbert (1928) discussed. The first major break in distribution of species southward from the Queensland Coastal Lowlands seems to occur at the skeletal soils of the Hawkesbury sandstones south of Newcastle.

While a consideration of the flora of the Coastal Lowlands in relation to its immediate environs suggests a highly selective environment and species of narrow tolerance, the evidence presented above indicates that *Eucalyptus* is probably the only group affected in this manner. Herbert (1928), in discussing the history of *Eucalyptus* in the coastal regions, postulated a series of climatically controlled north–south advances and retreats which is still proceeding. While such species as *E. intermedia* and *E. acmenioides* are widespread on the Coastal Lowlands, there are some species with contemporary distribution suggestive of active movement, either past or present.

*E. citriodora* occurs only on the northern half of the Coastal Lowlands, its southern boundary being at Howard, where it seems to be advancing (albeit slowly) on a broad front. *E. micrantha* is widespread and very common south of Maryborough, but the author has seen only one other area where this species occurs. There is an "island" of some hundreds of acres near the Elliott River (near Bundaberg) where it is now a very vigorous component of the tree layer. Topography, soils, and contemporary climate offer few restrictions to this species in the gap between Bundaberg and Maryborough, and its present disjunct distribution would seem to be the result of a previous climatic fluctuation. A similar mechanism seems to be the only way of accounting for a small pocket of a few acres of *E. maculata* which occurs on a steep ridge east of the Toolara Forest Station. This area is now encircled by a barrier of unsuitable country but there must have been continuity at some previous time if aboriginal transport is discounted, and this seems unlikely.

Three species of *Eucalyptus* normally found in tree form develop the "mallee" habit where they occur on sites less favourable to growth than those of their normal habitat. *E. micrantha* occurs as a very typical mallee on deep sands at the northern end of Moreton Island. Here it combines with other species to produce vegetation structurally similar to the mallee-heath of the Ninety-Mile Plain in South Australia described by Coaldrale (1951). Scattered clumps of a mallee form of *E. acmenioides* occur on the Boonooroo plain; with this species the lignotuber may take the form of a ring 4-6 in. thick and several feet in diameter. Finally, *E. exserta*, a species characteristic of the more arid soils on the northern half of the Coastal Lowlands, occurs in "mallee" form growing in rock ledges on the top of Mt. Tinbeerwah near Tewantin, which is 70 miles south of its main limit.
The flora of the Coastal Lowlands is best regarded as an assemblage of trees, shrubs, and herbs predominantly of wide potential environment with an infusion of species of much narrower potential environment. Species from either group impose the differences which distinguish the communities.

(d) Structural Units of Vegetation

The subdivision of vegetation used here is based on a scheme by Wood and Williams (1960) which depends on variations in density of the tallest layer in a community, and presence or absence of the other layers.

Table 8 shows those units of Wood’s and Williams’s scheme which occur on the Coastal Lowlands. Like the chemist’s periodic table Wood’s and Williams’s scheme allows for insertion of missing elements, and in the present work it has been necessary to add those units marked with an asterisk.

Two “habitat communities” are included in the Table because they occupy extensive areas on the Coastal Lowlands and the particular names concerned are indicative of the type of vegetation. It should be noted that mangroves may occur as vigorous well-developed trees up to 30 ft in height, and that two species of mangrove may occur together to give a distinctly two-layered community. The foredune complex is an admixture of depauperate types of other formations such as heath and woodland. It may also include dense thickets of Tristani a conferta and Eucalyptus tesselaris, tree species normally prominent in forest communities. The reader is referred to Blake (1938) and Herbert (1951) for more details of these two groupings. The soil groups on which these formations occur are shown in Table 5 in Section IV, and the floristics are given in Appendix II.

(e) Community Dynamics

Apart from a few simple cases discussed in the next section, it is unprofitable to consider the dynamic relations of the communities on the Coastal Lowlands in the orthodox sense of seral changes leading to climax communities.

Crocker (1952) has discussed the severely limiting assumptions of Jenny’s functional–factorial approach as applied to vegetation by Major (1951). Watt (1947) has described the continual turnover of species which can occur through biological interaction in an apparently mature and stable community. The demands of survey ecology preclude the study of such details but they must still be allowed for in the assessment of communities, even in broad-scale work.

The continual floristic and pedological modification by fire, the turnover of species in gaps resulting from damage by wind, and the slow mobility of the landscape in areas with a mantle of deep sand combine with climatic variations to maintain most of the vegetation in a state of flux. The rapidity of fluctuation is itself variable since it results from the interaction of the factors listed above, but the combination of factors is constantly changing so that the element of time is the greatest uncertainty in the system.

The vegetation of the Coastal Lowlands is best described as a continuum, segments of which are constantly trending towards one of several groupings, the
trends being definable from relative topographic position. Alteration in the state of one or more of the operational factors of the environment causes recurring setbacks. If the end point (i.e. the particular climax) is ever reached, it has a span of probably not more than five years before drastic alteration is imposed on one or more layers of the community.

In classical terminology it might be said that each community is permanently maintained as a disclimax. This may satisfy formality, but it avoids reality by focusing attention on a theoretical desideratum which is the exception and not the rule.

**Table 8**

**Structural forms of vegetation occurring on the coastal lowlands**

For the obvious species in each of these formations see Appendix II.

<table>
<thead>
<tr>
<th>Mapping No.</th>
<th>Structural Form</th>
<th>Formula</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Vine forest*</td>
<td>vd (TS_1S_2)</td>
<td>Wood’s and Williams’s (1960) “rainforest”</td>
</tr>
<tr>
<td>22</td>
<td>Fringing forest*</td>
<td>vd (TS_1S_2G)</td>
<td>Widespread on creeks and rivers. Probably assisted by nutrients imported from upstream</td>
</tr>
<tr>
<td>4</td>
<td>Layered forest (Plate 5, Fig. 2)</td>
<td>(d TS_1S_2G)</td>
<td>Commonest form of forest. Species content varies widely with fire history</td>
</tr>
<tr>
<td>1</td>
<td>Dry sclerophyll forest (Plate 6, Fig. 1)</td>
<td>(d TS_1S_2)</td>
<td>Develops only after protection from fires for at least five years. Of limited occurrence</td>
</tr>
<tr>
<td>2</td>
<td>Wet sclerophyll forest</td>
<td>(d TS_1S_2)</td>
<td>Tree ferns not conspicuous, palms common</td>
</tr>
<tr>
<td>3</td>
<td>Grassy forest (Plate 5, Fig. 1)</td>
<td>(d TG)</td>
<td>Maintained by fire. Narrow range of grass species</td>
</tr>
<tr>
<td>24</td>
<td>Low layered forest (Plate 7, Fig. 1)</td>
<td>(d T/S_1S_2G)</td>
<td>Species content essentially similar to layered forest but soils more prone to waterlogging. Trees depauperate</td>
</tr>
<tr>
<td>23</td>
<td>Low grassy forest*</td>
<td>(d T/S_1S_2G)</td>
<td><em>Melaleuca quinquenervia</em> becomes obvious in tree layer. “Grass” layer often cyperaceous</td>
</tr>
<tr>
<td>5</td>
<td>Tall sclerophyll shrub woodland</td>
<td>(d T/S_1S_2)</td>
<td>Essentially heath plus a tree layer</td>
</tr>
<tr>
<td>6</td>
<td>Low sclerophyll shrub woodland (Plate 7, Fig. 2)</td>
<td>(d T/S_1S_2)</td>
<td>Species composition as for 5. Trees depauperate. Waterlogging acute</td>
</tr>
</tbody>
</table>
Table 8 (Continued)

<table>
<thead>
<tr>
<th>Mapping No.</th>
<th>Structural Form</th>
<th>Formula</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Tall woodland (Plate 8, Fig. 1)</td>
<td>(md\ TG)</td>
<td>Mainly confined to broad water courses</td>
</tr>
<tr>
<td>8</td>
<td>Low woodland (Plate 8, Fig. 2)</td>
<td>(md\ T</td>
<td>S_1G)</td>
</tr>
<tr>
<td>9</td>
<td>Savannah woodland</td>
<td>(md/o TG)</td>
<td>Not very extensive. “Grass” layer often cyperaceous</td>
</tr>
<tr>
<td>10</td>
<td>Layered woodland (Plate 9, Fig. 1)</td>
<td>(md\ TS_1S_2G)</td>
<td>Widespread on gley soils on ridge slopes. Sedges prominent in (G)</td>
</tr>
<tr>
<td>17</td>
<td>Tree forb heath* (Plate 9, Fig. 2)</td>
<td>(TS_2G) (density varies)</td>
<td>Forb heath temporarily invaded by trees. Trees usually even-aged</td>
</tr>
<tr>
<td>11</td>
<td>Low layered woodland</td>
<td>(md\ T/S_1S_2G)</td>
<td>Species composition as for 10. Trees depauperate</td>
</tr>
<tr>
<td>12</td>
<td>Tree heath</td>
<td>(T/S_1S_2) (density varies)</td>
<td>Heath temporarily invaded by trees</td>
</tr>
<tr>
<td>21</td>
<td>Shrub savannah (Plate 10, Fig. 1)</td>
<td>(o T/S_1S_2G)</td>
<td>Trees depauperate as compared with 12. (G) largely cyperaceous</td>
</tr>
<tr>
<td>13</td>
<td>Thicket*</td>
<td>(vd\ T/S_1G)</td>
<td>Community poor in species. On shallow waterlogged soils. (G) sparse</td>
</tr>
<tr>
<td>14</td>
<td>Shrub thicket*</td>
<td>(vd\ T/S_1S_2)</td>
<td>Better drained sites than 13. Often on deep sand</td>
</tr>
<tr>
<td>15</td>
<td>Heath</td>
<td>(d S_2)</td>
<td>Not so common as 16</td>
</tr>
<tr>
<td>16</td>
<td>Forb heath* (Plate 9, Fig. 2)</td>
<td>(d S_2G)</td>
<td>Commonest form of heath. (G) cyperaceous</td>
</tr>
<tr>
<td>18</td>
<td>Herbfield</td>
<td>(d G)</td>
<td>Includes Xanthorrhoea and some small shrubs. Mainly sedges</td>
</tr>
<tr>
<td>20</td>
<td>Mangrove*</td>
<td>(vd\ T/S_1(S_2))</td>
<td>May be one or two layers present</td>
</tr>
<tr>
<td>25</td>
<td>Foredune complex*</td>
<td>Various</td>
<td></td>
</tr>
</tbody>
</table>

* Not included by Wood and Williams (1960).

The commonest dynamic situation on the Coastal Lowlands is not a steady ecotonal advance towards a stable climax community appropriate to the environmental niche concerned. It is an oscillation of ecotones between floristic reservoirs which exist at certain specific points in the landscape, points which are referable to topography.* The relative frequency of species within these floristic reservoirs

* In Section IV it has been pointed out that soil variation is governed primarily by topography.
is subject to erratic change governed by the balance between operational factors of the environment.

The more obvious of such ecotonal relationships are summarized in Figure 8. Further work is needed to elucidate all the possible combinations. It should be noted that the number of species involved in these ecotonal oscillations varies from one to many. The amplitude of the oscillations is inversely proportional to the sharpness of topography.

Apart from widespread species of trees such as *Melaleuca quinquenervia*, *Eucalyptus acmenioides*, and *E. intermedia*, many of the species in the shrub and ground layers are ecological "wides" and in consequence there is a large common element between communities (Table 9). The proportion of common species to the total numbers shown in Table 9 is a fair indication of the extent of ecotonal oscillation between these groupings.

![Diagram](https://via.placeholder.com/150)

Fig. 8.—Diagrammatic representation of the potentialities for cross invasion between some of the more widespread formations on the Coastal Lowlands. The two single species shown impose major variation on the communities invaded by the addition of a tree layer. A single arrow indicates unidirectional movement followed by death.

The mean rate of oscillation is compounded from interspecific differences in life cycle, and the rapidity of fluctuation in the conditioning factors. The maximum rate results from the effect of catastrophic factors (e.g. frost, flooding) on annual species, or the effect of fire on species of varying resistance. The minimum rate results from slow changes (e.g. rainfall cycles, soil hardpan formation) operating on trees and other long-lived species such as *Xanthorrhoea* and *Macrozamia*. All rates are modified by the slow change connected with maturation of landscape, but even here there is still the contrast between movement of sandhills and the much slower denudation of the other landscapes.

(f) Successions

The best example of succession seen on the Coastal Lowlands occurs on the southern end of Bribie Island where the foreshore is prograding. The floristics of communities in such an environment on the Coastal Lowlands have been given by Blake (1938) for an area near Coolum, and by Herbert (1951) in more general terms for the whole coast. Such succession as will be described here is common where foreshore conditions permit on the Coastal Lowlands, but it is not invariable because many of the foredunes are being steadily eroded.
The stages of succession shown in Plate 10, Figure 2, commence with a monospecific community of *Cakile maritima* on the low berm which separates the beach from the first stranded dune. This first dune is sparsely covered with *Ipomea pes-caprae*, *Spinifex hirsutus*, *Oenothera drummondii*, and *Stackhousia spathulata*. The rear edge of this dune is being actively invaded by *Casuarina equisetifolia* which ultimately forms a complete canopy and a dense mat of fallen needles in which other species begin to form a new ground layer. At this stage the succession may continue into a dry sclerophyll forest centred on *Eucalyptus*, a sclerophyll woodland centred on species of *Bankia* and *Casuarina*, a depauperate community of vine forest species, or heath.

**Table 9**

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Symbol</th>
<th>Species Total</th>
<th>Common Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eucalyptus forest and woodland</td>
<td>E</td>
<td>200</td>
<td>H/50</td>
</tr>
<tr>
<td>Heath</td>
<td>H</td>
<td>110</td>
<td>E/50</td>
</tr>
<tr>
<td>Herbfield</td>
<td>S</td>
<td>70</td>
<td>H/50</td>
</tr>
<tr>
<td>Tea-tree marsh</td>
<td>T</td>
<td>40</td>
<td>S/25</td>
</tr>
</tbody>
</table>

Other clear-cut examples of succession on the Coastal Lowlands occur where lakes are silted over in the sandhill regions. Here there is the expected progression from sedges through small shrubs to woodland and, finally, to either vine forest or eucalypt forest. Where *Backhousia myrtifolia* (Carol) invades eucalypt forest as the precursor of vine forest in the sandhill regions, the most obvious change is canopy closure to give dense shade, but there may be other biological effects.

**VI. The Pattern of the Ecosystem**

(a) *Introduction*

This Section begins with a brief recapitulation of the major features of the environment and of the vegetation. The remainder of the Section is devoted to a subdivision of the region into ecological units at three levels of partition. There is no attempt to present complete maps of the soils or vegetation. The only complete map of the region is one showing landscapes, units which combine all the facets of an ecosystem. The 20 landscapes discerned in the region are each described in text, the units of vegetation–soil–topography comprising the landscapes being illustrated with annotated diagrams. A series of 13 sample maps of small portions of the region is included to provide a permanent detailed record of the natural ecological patterns in country which is now yielding rapidly to the demands of closer settlement.
(b) Recapitulation

The Coastal Lowlands described in this study are a part of a natural region extending from Gladstone in Queensland to Coff's Harbour in New South Wales. This region in turn is part of a belt of lowland country extended intermittently along the entire eastern and southern coasts of the continent.

The major rock systems are Triassic sandstones of the Bundamba group which extend from Caboolture almost to Maryborough, and Cretaceous sediments of the Maryborough Formation and Burrum Coal Measures from Maryborough northwards. Unconformably overlying both of these are scattered areas of the level-bedded freshwater sandstones of the Elliott Formation. Igneous rocks are restricted to the trachytic plugs of the Glass House type at the southern end, and small areas of basalt near Bundaberg. Much of the region now carries a surface mantle of siliceous sand apparently due to some eustatic oscillation of sea-level during the Quaternary. On the coastal islands and on parts of the mainland this sand is piled into high sandhills of comparative stability. There is no evidence yet for the gross climatic changes common in higher latitudes during the Quaternary.

The physiography of the Coastal Lowlands is dominated by undulating to low rolling country with most of the area below the 300-ft contour level, and much of it below the 100-ft level. There is little true coastal plain.

The Coastal Lowlands have a mild subtropical climate with a marked dominance of summer rainfall and a small but significant winter rainfall. Thunderstorms and cyclones contribute substantially to total annual rainfall which is, in consequence, extremely variable. Temperatures are generally mild but heavy frosts occur in most areas. High run-off resulting from high intensities lowers the effectiveness of the rainfall, but rain can promote rapid growth when it coincides with the high energy levels of the early summer months. The conventional “spring” months are normally a period of acute water stress.

The common soil pattern is one of deep podzolics on rises progressing downslope through gleyed podzolics to gley and humic gley soils on low-lying areas. In areas of impeded drainage with a mantle of Quaternary sand, groundwater podzols with a strongly developed hardpan are common. The deep sands of the sandhills and flanking areas show little profile development except in the areas of vine forest where podzols occur. Acid bog and fen peats are common in areas receiving continual drainage from the sandhills, while there are scattered areas of acid fen peat and peaty-gley soils away from the sandhills. On the flat areas of the Elliott sandstone solodic soils are common, these being the most arid sites on the Coastal Lowlands.

Except for some alluvial soils, nutrient status is universally low, and physical differences, derived chiefly from topographic control of perched water-tables, seem to be the main soil factors governing plant distribution. Surface litter and organic matter are minimal in most of the mineral soils, this being due chiefly to rapid destruction of litter by fire.

Fire is a major factor in the environment of the Coastal Lowlands and is responsible for much of the essential instability of the plant communities. Biotic
effects within the ecosystem are largely confined to human activities through burning and logging.

While the flora is moderately rich in species with a total of approximately 500, two families, Myrtaceae and Leguminosae, supply one quarter of the total flora. Only six other families are represented by ten or more species and sedges outnumber grasses.

The principal types of vegetation are various forms of eucalypt forest and woodland on the podzolic, gley, and solodic soils. "Heath" with a prominent ground layer of sedges is widely distributed on wetter areas, while the peats support communities in which small shrubs are scattered in a mat of sedges. Vine forest is more or less confined to the deep sands. The low-lying alluvia of many of the stream systems support a dense forest of *Melaleuca quinquenervia*.

There is a large common element of shrubs and sedges distributed through the forest, woodland, and heath communities. Some of these species are susceptible to seasonal extremes in the fluctuations of the temporary perched water-tables. This combines with pyric effects to produce an oscillation (up and down slopes) of ecotones between floristically stable areas of various adjoining communities.

Evidence has been presented in Section II which suggests that the development of the present ecological pattern of the Coastal Lowlands dates from varying periods during the Pleistocene, or earlier, depending chiefly on elevation above sea-level. A given unit of the pattern may represent the present end-point of continuous development for over one million years. Alternatively, in areas such as the sandhills, the stranded dune-lines from the mid-Recent adjustment of sea-level, or on prograding shore lines, the time involved may vary from a few thousand to a few years.

(c) *The Units of Subdivision*

For Australian conditions the most complete system of regional mapping based on the ecosystem is that devised by Christian's group (Christian 1952; Christian and Stewart, 1953), but this is not entirely adequate on the Coastal Lowlands for reasons now discussed.

The topographic control of soil type and vegetal pattern results in a pattern laid down on a scale of acres rather than of square miles. This pattern is on a much finer scale than those for which the Christian system was evolved although it seems comparable with those mapped by Christian's group in the Townsville-Bowen region (Christian et al. 1953). The present survey, however, has involved much more time in the field with the inevitable accumulation of greater detail. Application of this detailed knowledge to the mapping of "land systems" as defined by Christian (1952) produced units so small and so numerous that they could not sensibly be used as the basis for broad subdivision of the region.

The larger units of the Christian system are unsatisfactory for the present work for several reasons. Since it is impossible to predict ultimate land use with groups of introduced species whose management is still evolving, there is no basis for combining land system into "land use groups" in this region. Again, Christian's largest categories, the "geomorphological unit", the "land surface unit", and the "geomorphological subdivision" (loc. cit. 1952, 1953) are not defined but simply
described by the use of examples from northern Australia. This makes them difficult to apply in other regions, especially when there is apparently considerable overlap between the geomorphological unit and the more recently introduced land surface unit used in the Townsville–Bowen Region. These larger units also emphasize process rather than pattern and fail to recognize all the components of an ecosystem.

Therefore, while the "land unit"* and the "land system"† are used as the primary units a third unit, the "landscape", has been introduced to present a broad-scale separation of land patterns encompassing the detailed information available. A landscape is an aggregation of land systems with a constant pattern of climate, parent rock, topography, soils, and vegetation, and in which the relative areas of the constituent land systems are constant. The overall effect of fire is repeated in the composition and structure of the vegetation. Land systems may occur in more than one landscape but with varying dominance. While landscapes show a strong tendency to continuity this is not an essential criterion.

The land systems are at a level of subdivision analogous to, though not strictly comparable with, the "soil association" (Butler et al. 1942) and the landscapes bear a similar relationship to the "soil combination" (Downes and Sleeman 1955).‡

(d) The Land Units and Land Systems

The common land units and land systems occurring on the Coastal Lowlands are illustrated diagrammatically in Figures 9-22. The key to the components of each land unit is given in Table 10. Each land unit illustrated is described in text immediately after the figure and additional information is given on the geographic distribution of the land systems and any features which help to distinguish it from other land systems.

The combined symbol used in the diagrams consists of an arabic numeral for the vegetal formation, a letter for the soil group, and a Roman numeral for the topographic class. Thus 4GIII represents layered forest on a podzolic soil on rolling country with rises up to 50 ft in height, and slopes of less than 10°.

It should be remembered that the composition, and hence the structure of vegetation in a land unit, can change with varying rapidity, as discussed in Section V. In the following groups of vegetal classes the individual classes are especially labile with respect to the other members of the group: classes 1, 3, and 4; 12 and 15; 6, 16, 17, and 21.

For land units which are shown on the sample maps but not illustrated in Figures 9-22, the separate components may be seen in diagram by reference

* Land units are described by Christian (1952) as "distinctive and recurring units of topography with which are associated equally distinctive groupings of soil and vegetation".
† The land system is defined by Christian and Stewart (1953) as "an area, or groups of areas, throughout which there is a recurring pattern of topography, soils and vegetation".
‡ Note added in proof.—Downes et al. (1957) have developed an analogous system of ecological classification of land differing in the application of the terms "land unit" and "land system", and with emphasis on land use as the objective of classification.
## ECOSYSTEM OF WALLUM COUNTRY, QUEENSLAND

### Table 10

**Key to Symbols Used for the Classes of Vegetation, Soils, and Topography**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Vegetation Class</th>
<th>Soil Class</th>
<th>Topography Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dry sclerophyll forest</td>
<td>A Peats and peaty sand</td>
<td>I Flat</td>
</tr>
<tr>
<td>2</td>
<td>Wet sclerophyll forest</td>
<td>B Peaty gley</td>
<td>II Undulating. Rises to 20 ft, slopes &lt;5°</td>
</tr>
<tr>
<td>3</td>
<td>Grassy forest</td>
<td>C Humic</td>
<td>III Rolling. Rises to 50 ft, slopes &lt;10°</td>
</tr>
<tr>
<td>4</td>
<td>Layered forest</td>
<td>D Humic gley</td>
<td>IV Ridge. Rises to 200 ft, slopes 10°+</td>
</tr>
<tr>
<td>5</td>
<td>Tall sclerophyll shrub woodland</td>
<td>E Gley</td>
<td>V Sub-mountain. Rises over 200 ft, slopes 15-20°+</td>
</tr>
<tr>
<td>6</td>
<td>Low sclerophyll shrub woodland</td>
<td>F Podzol</td>
<td>VI Minor sandhill. Less than 100 ft high</td>
</tr>
<tr>
<td>7</td>
<td>Tall woodland</td>
<td>G Podzolic</td>
<td>VII Major sandhill. Over 100 ft high</td>
</tr>
<tr>
<td>8</td>
<td>Low woodland</td>
<td>H Podzolic gley</td>
<td>VIII Strand lines</td>
</tr>
<tr>
<td>9</td>
<td>Savannah woodland</td>
<td>J Solodic</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 9.—The Tuan Land System

Land Units

<table>
<thead>
<tr>
<th>Land Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4GIII</td>
<td>Layered or grassy forest on Toolara or Gooburrum podzolics on crests and upper slopes of rises up to 50 ft high. Slopes 5-10°.</td>
</tr>
<tr>
<td>10GIII</td>
<td>Layered woodland on Toolara or Howard podzolics in mid-slope positions.</td>
</tr>
<tr>
<td>11GII</td>
<td>Low layered woodland on Howard podzolics or podzolic gleys on lower slopes of less than 5°.</td>
</tr>
<tr>
<td>21EII</td>
<td>Shrub savannah on gley soils on floodplains of small creeks.</td>
</tr>
<tr>
<td>22</td>
<td>Fringing forest on banks of small streams.</td>
</tr>
</tbody>
</table>

Landscapes

Glass House, Currimundi, Coondoo, Burrum, Gregory, Elliott, and Kolan.

Ecotones

Narrow and oscillate slowly.

Remarks

Layered and grassy forest alternate on the same sites according to fire history. Understorey has a large common element from 4GIII through to 11GII. One of the commonest land systems south of Maryborough and north of Bundaberg.
Fig. 10.—The Sippy Land System

**Land Units**

16FI  Forb heath on ground-water podzol on flats.

11HII  Low layered woodland on podzolic gley or gley soils on gentle slopes of less than 5°.

4GIII  Layered or grassy forest on Toolara or Gooburrum podzolics on the crests and upper slopes of broad rises up to 50 ft in height.

**Landscapes**

Glass House, Maroochy, Coondoo, Tin Can, Coondoo, Currimundi, Elliott, Kinkuna, and Kolan.

**Ecotones**

Wide and oscillate freely.

**Remarks**

May straddle the boundary between two landscapes such as Currimundi and Glass House. Pyric alternation between grassy and layered forest. Microrelief (hummock–hollow) is common in 16FI—see discussion of “whorled hummocks” in Section IV. Layered forest may be replaced by layered woodland in 4GIII.
Fig. 11.—The Tinnanbar Land System

**Land Units**

| 16FI | Forb heath on ground-water podzol on flats or in broad drainage lines. |
| 6FII | Low sclerophyll shrub woodland on ground-water podzol on lower slopes. |
| 4GII | Layered or grassy forest on Toolara or Gooburrum podzolics on slopes of broad rises. Uphill trend into 4GIII. |
| 4GIII | Layered or grassy forest on Toolara or Gooburrum podzolics on upper slopes and crests of ridges up to 50 ft high and with slopes up to 10°. |

**Landscapes**

Coondoo, Tin Can, Womalah, Elliott, Kinkuna, Kolan.

**Remarks**

In the Womalah landscape this sequence sometimes differs in having heath over gley soils, i.e. 16EI instead of 16FI. Soils with a brown organic pan may occur as a narrow band along the upper margin of 6FII; indicated by a dense understorey of *Leptospermum flavescens*. Pyric alternation between layered and grassy forest.
Fig. 12.—The Tibrogargan Land System

Land Units

13Al Thicket (usually tea-tree) on peat in narrow drainage lines.
3DI Grassy forest on humic gley soil on flats or very slight slopes. Subject to inundation.
4GIII Layered or grassy forest on Toolara podzolics on upper slopes and crests of broad rises.

Landscapes
Glass House, Cootharaba, Kolan.

Ecotones
Narrow and oscillate slowly.

Remarks
Land units are clearly separated by minor changes in topography. 4GIII may occur on red earth residuals. Tree layer in 3 and 13 is predominantly *Melaleuca quinquenervia*. Pyric alternation between layered and grassy forest.
Fig. 13.—The Goodwood Land System

<table>
<thead>
<tr>
<th>Land Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11HII</td>
<td>Low layered woodland on podzolic gley soils on gentle slopes.</td>
</tr>
<tr>
<td>13EI</td>
<td>Thicket on gleyed soils in broad drainage lines.</td>
</tr>
<tr>
<td>10JII</td>
<td>Layered woodland on solodic soils on broad flats with a very slight slope.</td>
</tr>
<tr>
<td>24HII</td>
<td>Low layered forest on podzolic gley soils on the lower slopes of low rises.</td>
</tr>
<tr>
<td>4GII</td>
<td>Layered or grassy forest on Gooburrum or Howard podzolics on broad low rises.</td>
</tr>
</tbody>
</table>

Landscapes: Burrum, Buxton, Kinkuna.

Ecotones: Generally wide and prone to oscillate.

Remarks: Soils show a very clear relationship with parent rock, especially the solodics with the Elliott Formation. Very low relief with poor drainage. Soil surface packs and water tends to lie on top.
ECOSYSTEM OF WALLUM COUNTRY, QUEENSLAND

Fig. 14.—The Mullen Land System

Land Units

17EI  Tree forb heath on gley soils on flats.
10GII Layered woodland on Toolara podzolics on low rises.
16EI  Forb heath on gley soils on flats and in broad drainage lines.
11HII Low layered woodland on Tinana podzolic gleys on lower slopes of ridges.
4GIII Layered or grassy forest on Toolara or Gooburrum podzolics, on the upper slopes and crests of ridges up to 50 ft high.

Landscapes Womalah, Cootharaba, Tin Can.

Ecotones Generally wide and oscillate freely.

Remarks Some compound soil profiles in lower lying areas. Pyric alternation of layered and grassy forest. More or less restricted to areas below the Como Scarp.
Fig. 15.—The Cooroibah Land System

Land Units

<table>
<thead>
<tr>
<th>Land Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8DI</td>
<td>Low woodland on humic gley soil on flats.</td>
</tr>
<tr>
<td>24HII</td>
<td>Low layered forest on Tinana podzolic gley soils on very low rises.</td>
</tr>
<tr>
<td>3DI</td>
<td>Grassy forest on humic gley soils in marshy areas and in drainage lines.</td>
</tr>
<tr>
<td>19FII</td>
<td>Vine forest on podzol soils with a weakly developed organic pan.</td>
</tr>
</tbody>
</table>

Landscapes

- Cootharaba, Maroochy, Kolan.

Ecotones

- Narrow and oscillate slowly.

Remarks

- Vine forest (19FII) may be replaced by layered or grassy forest (4GII). Compound soil profiles are common. Microrelief of a gilgai type is common in the areas of humic gley soils.
Fig. 16.—The Mary Land System

Land Units

- **11HII**: Low layered woodland on Tinana and Theodolite podzolic gley soils on broad low slopes.
- **13DI**: Thicket on humic gley soils in drainage lines.
- **16HI**: Forb heath on podzolic gley soils on broad flats.
- **10GII**: Layered woodland on Howard podzolic soils on gentle rises a few feet higher than the surroundings.
- **4DI**: Layered or grassy forest on humic gley soils on low-lying areas.

Landscapes: Boonooroo, Burrum, Elliott.

Ecotones: Wide and oscillate freely.

Remarks: Largely confined to the former Mary River Delta. Compound soil profiles occur on truncated lateritic soils. Pyric alternation of layered and grassy forest.
Fig. 17.—The Colton Land System

Land Units

7EI Tall woodland on gley soils on flats and in broad drainage lines.

23HII Low grassy forest on Tinana podzolic gley soils on lower slopes of low rises.

3GII Grassy forest or layered forest on Howard podzolics on the crests of low rises.

23HI Low grassy forest on Tinana podzolic gley soils on broad gently sloping flats or in broad drainage lines.

22 Fringing forest on banks of permanent streams.

Landscapes Burrum, Gregory, Boonooroo.

Ecotones Wide and oscillate freely.

Remarks Land units tend to cover larger areas than is normal on the Coastal Lowlands.
Land Units

17EII  Tree forb heath on gley soils with a sandy A horizon, on gentle rises.
16EII  On lower (wetter) slopes below 17EII. Forb heath on gley soils with a shallower sandy A horizon than in 17EII.
17AI   Tree forb heath on margins of flat areas of peat in broad drainage lines.
18AI   Herbfield on peat, often with hummock–hollow microlief.
18AII  Herbfield on peat which rises a few feet on the lower slopes of a sandhill.
6FII   Low sclerophyll shrub woodland on ground-water podzol on a very low rise.
10HII  Layered woodland on Tinana podzolic gley on gentle rises up to 20 ft in height.

Landscapes  Womalah, Tin Can, Cootharaba.
Ecotones   Generally wide and oscillate freely.
Remarks    Compound soil profiles common. This land system occurs mainly in the vicinity of Mt. Bilewilam, being common in the lower areas.
**Fig. 19.—The Coolum Land System**

<table>
<thead>
<tr>
<th>Land Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3CI</td>
<td>Grassy forest with sedges prominent in the ground layer on flat areas of humic soils with some &quot;gilgai&quot; microrelief.</td>
</tr>
<tr>
<td>3BI</td>
<td>Grassy forest with sedges prominent in the ground layer on flat areas of peaty gley soils in low-lying areas subject to prolonged inundation.</td>
</tr>
<tr>
<td>22</td>
<td>Fringing forest on levee banks.</td>
</tr>
</tbody>
</table>

**Landscapes**
- Maroochy, Currimundi, Cootharaba, Glass House, Kolan, Hercules, Noosa.

**Ecotones**
- Narrow and oscillate slowly.

**Remarks**
The two principal land units in this system occur widely near the mouths of rivers and creeks throughout the Coastal Lowlands. This is the major land system of the Maroochy landscape.
Fig. 20.—The Cooloolah Land System

Land Units
- 18AI: Herbfield on peat in drainage lines and on broad flats.
- 6FII: Low sclerophyll shrub woodland on ground-water podzol on very low rises.
- 10NVI: Layered woodland on low sandhills.
- 4NVII: Layered or grassy forest on major sandhills usually over 100 ft in height.

Landscapes: Noosa, Cooloolah, Fraser, Hercules.

Ecotones: Wide and oscillate between 6FII and 10NVI. Others narrow and fairly stable.

Remarks: This is the major land system on the flanks of the major systems of sandhills. In the Hercules landscape the sandhills are not so high as in the others.
Table 1: The Teewah Land System

<table>
<thead>
<tr>
<th>Land Units</th>
<th>4NVII</th>
<th>Layered or grassy forest on major sandhills up to 300 ft in height.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19FVI</td>
<td>Vine forest on lesser sandhills and in valleys between sandhills. Soil profile shows varying degrees of podzol development with the organic horizon often developed into a soft “pan” layer.</td>
</tr>
</tbody>
</table>

Landscapes: Fraser, Cooloolah.

Ecotones: Narrow except where vine forest is invading eucalypt forest. On stable boundaries the ecotone may be only a few yards wide between 19FVI and 4NVII.

Remarks: Confined exclusively to the area of major sandhills on the larger islands, and on the coastline.

Fig. 21.—The Teewah Land System
Fig. 22.—The Bribie Land System

Land Units

<table>
<thead>
<tr>
<th>Land Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>20PI</td>
<td>Mangroves on tidal mud flats.</td>
</tr>
<tr>
<td>4NVI</td>
<td>Layered or grassy forest on low sandhills.</td>
</tr>
<tr>
<td>18CI</td>
<td>Herbfield on humic soils in drainage lines and on small flats.</td>
</tr>
<tr>
<td>13NVI</td>
<td>Thicket on low sandhills which have been burned frequently.</td>
</tr>
<tr>
<td>16NII</td>
<td>Forb heath on regosols on low rises and in well-drained hollows.</td>
</tr>
<tr>
<td>6FII</td>
<td>Low sclerophyll shrub woodland on ground-water podzol on broad low rises.</td>
</tr>
<tr>
<td>16FI</td>
<td>Forb heath on ground-water podzol on flats and in broad drainage lines.</td>
</tr>
<tr>
<td>1NVI</td>
<td>Dry sclerophyll forest on low sandhills with little profile development.</td>
</tr>
</tbody>
</table>

Landscapes
Hercules, Fraser.

Ecotones
Generally narrow but oscillate freely.

Remarks
Formed chiefly on strand lines left by the mid-Recent adjustment of sea-level. Covers almost the whole of Bribie Island.
The units are arranged in numerical sequence with regard to vegetation, and in alphabetical order with regard to soils allied with any vegetal unit.

<table>
<thead>
<tr>
<th>Land Unit</th>
<th>Figure No.</th>
<th>Land Unit</th>
<th>Figure No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1NVI</td>
<td>22</td>
<td>13EI</td>
<td>13</td>
</tr>
<tr>
<td>3BI</td>
<td>19</td>
<td>13NVI</td>
<td>22</td>
</tr>
<tr>
<td>3CI</td>
<td>19</td>
<td>16EI</td>
<td>14</td>
</tr>
<tr>
<td>3DI</td>
<td>12, 15</td>
<td>16EII</td>
<td>18</td>
</tr>
<tr>
<td>3GII</td>
<td>17</td>
<td>16FI</td>
<td>10, 11, 22</td>
</tr>
<tr>
<td>4DI</td>
<td>16</td>
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*No soil or topographic classes are shown for 22 (fringing forest) which is confined strictly to a narrow band along the banks of creeks and rivers where both soils and topography vary widely.
from Table 11 to the appropriate figure. If a vegetal component is not shown in any diagram this is because it is of very limited occurrence (Formation Nos. 2, 5, 9, 12, 15) or because its structure is clearly related to another unit which is illustrated. Thus, Formation No. 17 differs from 16 only in the presence of scattered trees.

The 14 land systems shown in Figures 9-22 characterize much of the region but reference to the landscape sample maps will show that there is a much larger number of land systems which occupy only small areas. Limitations of space preclude their illustration in this series of diagrams.

(e) The Landscapes

The large map which accompanies this paper shows the distribution of the 20 landscapes which have been established.

Figure 23 shows the separation of landscapes by the sequential application of factors in decreasing order of areal extent. Rainfall is the only climatic factor used since the variation of other climatic elements is within landscapes rather than between them. Geological separation includes the influence of Quaternary history since these effects are inescapable over much of the Coastal Lowlands.

Appendix IV presents a series of sample maps showing the pattern of land units commonest in each landscape. These maps are not intended for the general reader but for those desiring a closer knowledge of the ecological patterns over the region.

The principal features of each landscape are described below, the sequence of presentation being the system of numbering used on the large map. These descriptions are intended to give the general reader a summary of the pattern and variation occurring in each part of the Coastal Lowlands. For the purpose of assessing rainfall “winter” is taken as the period from May to August inclusive.

(1) The Glass House Landscape

(Sample Map No. 1)

*Area.*—285 sq. miles.

*Rainfall.*—50-60 in. per annum increasing from south to north, with a winter element of about 12 in.

*Land Systems.*—Principally Tuan (Fig. 9) and Sippy (Fig. 10). Scattered small areas of Coolum (Fig. 19), and Tibrogargan (Fig. 12).

*Geology.*—Mainly Bundamba sediments, with a small area of tonalite in the south-west above the Glass House Scarp. Also includes the trachytic plugs of the Glass Houses. Mantling by Quaternary siliceous sands common below elevations of 100 ft.

*Topography.*—Undulating to hilly, mostly classes II and III (cf. Table 10). Some class IV (higher hills) in the western margin, and some extensive flats near the coast.

*Soils.*—Upper slopes and tops of rises mainly Toolara podzolics with small areas of Gooburrum podzolics. Podzolic gleys and gleys on lower slopes.
Ground-water podzols in broad drainage lines. Peats, peaty gleys, and humic soils restricted. Scattered red earth residuals, especially in western half. Soil pattern very complex, cf. the detailed map of one portion by Thompson (1957).

Vegetation.—Layered and grassy forests on the podzolics. Various types of woodland on the podzolic gleys and gleys. Forb heath on the ground-water podzols. Thicket on drainage lines, and fringing forest on stream banks. Some very small areas of dry sclerophyll forest and wet sclerophyll forest. Mangroves on the shores of Pumicestone Passage, and on the banks of tidal creeks.

Remarks.—Peats in this landscape are “tea-tree” peats and are easily burned out in dry weather. Much ribbon development along the forest ridges. One of the best-drained landscapes in the region.

(2) The Currimundi Landscape
(Sample Map No. 2)

Area.—50 sq. miles.

Rainfall.—60 in. per annum with a winter element of about 12 in.

Land Systems.—Principally Sippy (Fig. 10) and Coolum (Fig. 19). Small areas of Tuan (Fig. 9) near Caloundra and on western margin.

Geology.—Bundamba sediments with considerable mantling by Quaternary siliceous sands, and alluvium along the Mooloolah River. Some Tertiary sediments near the mouth of the Mooloolah River.

Topography.—Mainly extensive flats and low undulations, with a few ridges over 50 ft in height along the western margin.

Soils.—Chiefly ground-water podzols on the flats and low sand rises with pronounced hardpan layers of both whitish fragipan and organic pan; hummock-hollow microrelief usually pronounced. Gleys and podzolic gleys on the rises which may be compound profiles. Podzolics very restricted. Some humic soils along the Mooloolah River together with variable alluvial profiles.

Vegetation.—Various forms of heath and sclerophyll shrub woodland on the ground-water podzols with heath becoming the obvious form as drainage decreases. Floristic composition of these varies widely with fire history. Some heath on deep sand over truncated clays. Layered and grassy forests on the podzolics. Some small patches of wet sclerophyll forest and vine forest in elevated hollows along the western margin. The grassy forests on the low-lying areas are mainly of Melaleuca quinquenervia. Tall woodland, now grossly disturbed, along some of the alluvial flats of the Mooloolah River. Mangroves on the tidal mud flats along Pumicestone Passage, and on the lower reaches of streams.

Remarks.—This landscape is dominated by the old and the contemporary floodplains of the Mooloolah River. It is one of the worst-drained areas in the region.

(3) The Maroochy Landscape
(Not mapped*)

Area.—45 sq. miles.

Rainfall.—65 in. per annum with a winter element of about 15 in.

* See Talbot and Rossiter (1959).
Land Systems.—Coolum (Fig. 19), Cooriobah (Fig. 15), Sippy (Fig. 10). Chiefly Coolum on the upper reaches of the Maroochy River, and Sippy at the northern and southern ends of the landscape. Cooroibah along the western and southern boundaries.

Geology.—Bundamba sediments overlain by alluvials and by Quaternary sands, together with igneous intrusions at Point Arkwright. This area also includes the large igneous plugs of Mt. Coolum and Mt. Peregian.

Topography.—Chiefly flat with three-quarters of the landscape below the 25-ft contour line.

Soils.—Mainly humic and peaty gleys. Some deep alluvial soils on the levees of the Maroochy River. Extensive tidal mud flats. Podzolics on the ridges near Coolum and at the southern end.

Vegetation.—Chiefly grassy forest with Melaleuca quinquenervia on the humic and peaty gley soils. Layered or grassy forest, and some vine forest on the podzolics. Small areas of heath and sclerophyll woodland on ground-water podzols or gleys.

Remarks.—This landscape has been extensively cleared for development to pastures and sugar cane. Drainage is very poor and much of the area is subject to flooding.

(4) The Cootharaba Landscape

(Not mapped; patterns obscured by clearing)

Area.—95 sq. miles.

Rainfall.—65 in. per annum with a winter element of about 15 in.

Land Systems.—Chiefly Tibrogargan (Fig. 12) and Cooroibah (Fig. 15) with strips of Coolum (Fig. 19), especially near the lakes. Mullen (Fig. 14) occurs along the western boundary and becomes more extensive from south to north through this landscape.

Geology.—Bundamba and Walloon sediments with much mantling by Quaternary alluvia and sands.

Topography.—Changes steadily in an east–west direction from extensive flats around the lakes to broad ridges 25-50 ft in height along the western boundary. Over half the area is below the 50-ft level.

Soils.—Lake margins humic with scattered areas of peat and peaty gley, especially near Lake Weyba. Gleys and Toolara podzolics on the rises with some small red-earth residuals. Some ground-water podzols at the southern end.

Vegetation.—Grassy forest with Melaleuca quinquenervia on the humic soils and on some (acid fen) peats. Grassy forest with Casuarina glauca on the very low areas fringing Lake Cootharaba and the lower reaches of the Noosa River. Layered or grassy forests or vine forest on the podzolics. Various forms of woodland on the gleys of lower slopes. Some heath and sclerophyll shrub woodland, especially at the southern end.

Remarks.—This landscape has been extensively cleared for farming or disturbed by logging. Most of it is poorly drained and this combines with high
rainfall to make it one of the wetter parts of the Coastal Lowlands. There are numerous areas protected from fire where *Casuarina littoralis* forms dense thickets under the eucalypts with much suppression of the usual shrubs and grasses.

(5) The Cooloolah Landscape

(Sample Map No. 4)

*Area.*—100 sq. miles.

*Rainfall.*—55–65+ in. per annum with a winter element of about 15 in.

*Land Systems.*—Teewah (Fig. 21) in the high sandhills and Cooloolah (Fig. 20) on the western margins.

*Geology.*—Siliceous sands, Quaternary and older, overlying Bundamba sediments which are mainly below sea-level. Igneous intrusives at Double Island Point and Noosa Head. Stranded beach lines on the peninsula south of Inskip Point.

*Topography.*—Major sandhills reaching to heights of 300 ft south of Noosa and over 700 ft between Tewantin and Double Island Point. Some undulating deep sands along the western margin and north of Eight Mile Rocks. Cliffs up to 300 ft high fronting the beach.

*Soils.*—Mainly deep sands (regosols) with little profile development beyond the accumulation of organic matter in an A<sub>1</sub> horizon. Some podzols with organic pan layers in the areas of vine forest. Ground-water podzols and peats along the western margin.

*Vegetation.*—Layered and grassy forest or vine forest on the major sandhills. Sclerophyll shrub woodland and forb heath on the lower areas. Herbfield or forb heath on the peats.

*Remarks.*—This and the Fraser landscape include the giant sandhills. Cooloolah differs from Fraser in having a higher proportion of Teewah sand and proportionately less vine forest. Some species like *Macrozamia douglasii* which are more or less restricted to Fraser Island occur at the northern end of the Cooloolah landscape. The sandhills are a splendid natural catchment area yielding water steadily throughout the year. Moreton and Stradbroke Islands probably belong to this landscape but are not definitely included here because of insufficient field work.

(6) The Noosa Landscape

(Sample Map: Portions of Nos. 3, 4, and 5)

*Area.*—50 sq. miles.

*Rainfall.*—55-60 in. per annum with a winter element of about 15 in.

*Land Systems.*—Chiefly Cooloolah (Fig. 20) with some Coolum (Fig. 19) at the southern end.

*Geology.*—Bundamba sediments with a mantle of Quaternary alluvia and siliceous sands.

*Topography.*—Flat to undulating. Only a few very small areas exceed a height of 50 ft above sea-level.
Soils.—Chiefly regosols and ground-water podzols with varying development of peat in drainage lines and on low lying flats. Compound profiles are common where Quaternary sands now rest on previously truncated clays.

Vegetation.—Chiefly various forms of heath and sclerophyll shrub woodland on the ground-water podzols and regosols. Herbfield and forb heath on the peats. Small areas of grassy forest on the humic soils. Mangroves on the shores of Tin Can Inlet. Some layered forest on the peninsula south of Inskip Point.

Remarks.—This landscape contains the largest areas of peat. It is essentially a corridor between the coastal sandhills and the older landscapes to the west, and was probably once a continuation of Great Sandy Strait. Drainage is slow except on the higher sandy areas.

(7) The Womalah Landscape
(Sample Map No. 3)

Area.—60 sq. miles.

Rainfall.—60+ in. per annum with a winter element of 10-15 in.

Land Systems.—Chiefly Tinnanbar (Fig. 11) with small areas of Cooloolah (Fig. 20) along western margin. Scattered areas of Cooroibah (Fig. 15) near Noosa River and in other drainage lines.

Geology.—Bundamba sediments with a mantle of Quaternary siliceous sands in lower areas.

Topography.—Flat to undulating along the eastern margin. The bulk of this landscape is occupied by low ridges and broad drainage lines. Some higher ridges over 50 ft in height along the western margin.

Soils.—Shallow podzolics on rises trending steadily through podzolic gleys to gleys downslope into drainage lines. Some ground-water podzols near eastern boundary. Some large areas of gley soils on flats.

Vegetation.—Chiefly layered forest and layered woodland on the rises and slopes. Small areas of dry sclerophyll forest on some ridge-tops. Vegetation in drainage lines varies from thicket to forb heath. Some large areas of forb heath on low lying flats. Fringing forest along parts of the Noosa River.

Remarks.—This landscape is entirely below the Como Scarp and the soils are shallower than in areas above the scarp or else consist of compound profiles.

(8) The Coondoo Landscape
(Sample Map No. 7)

Area.—330 sq. miles.

Rainfall.—50-55 in. per annum with a winter element of about 10 in.

Land Systems.—Chiefly Tuan (Fig. 9) and Tinnanbar (Fig. 11). Scattered areas of Sippy (Fig. 10) south of Tin Can Bay road and near Tinnanbar in the north-west corner.

Geology.—Bundamba sediments with a mantle of Quaternary siliceous sands in lower areas.
Topography.—Chiefly broad ridges about 50 ft in height with wide drainage lines. A belt of steep ridges runs through the middle of this landscape and ends about 6 miles south of Tuan Creek.

Soils.—Toolara and Gooburrum podzolics on the rises, gleys on lower slopes and in some broad drainage lines. Ground-water podzols common in the drainage basins at the heads of Sandy and Coondoo Creeks, and near Tinnanbar. Alluvial soils along Tinana Creek. Lithosols on the steep ridges.

Vegetation.—Chiefly layered and grassy forest on the ridges with various types of woodland on the lower slopes and in drainage lines. Sclerophyll shrub woodland or forb heath on ground-water podzols. Some thicket on creek banks and dry sclerophyll forest on steep ridges. Grassy forests on low areas near the inlets mainly of Melaleuca quinquenervia or Casuarina glauca.

Remarks.—Lies entirely above the Como Scarp with most of the drainage to the Mary River. Includes the most extensive areas of forest on the Coastal Lowlands.

(9) The Tin Can Landscape
(Sample Map No. 6)

Area.—90 sq. miles.
Rainfall.—55-60 in. per annum with a winter element of 10-15 in.
Land Systems.—Chiefly Tinnanbar (Fig. 11) and Sippy (Fig. 10) with scattered areas of Tuan (Fig. 9).

Geology.—Bundamba sediments with much mantling by Quaternary siliceous sands.

Topography.—Undulating on the coastal side, rising slowly towards the west where there are broad rises up to 100 ft in height. Extensive flats below the 25-ft contour in the north-eastern quarter.

Soils.—Toolara podzolics on the higher ridges. Podzolic gleys and gleys on lower rises and slopes. Ground-water podzols common on the lower areas with scattered small areas of peat. Compound profiles common.

Vegetation.—Chiefly layered woodland, sclerophyll shrub woodland, and heath. Smaller areas of layered or grassy forest near the Tin Can Bay road. Extensive areas of mangrove on the tidal mud flats.

Remarks.—A badly drained landscape except on the western margin. Soils are generally shallower than in the Coondoo landscape and contain much more outcropping stone.

(10) The Fraser Landscape
(Not mapped*)

Area.—610 sq. miles.
Rainfall.—60-70+ in. per annum on the high massif which occupies most of the island south of Indian Head. 45-50 in. elsewhere with a winter element of 10-15 in.

* See vegetation types map by J. A. Craig, Queensland Forest Service.
Land Systems.—Teewah (Fig. 21) on the high sandhills and Cooloolah (Fig. 20) on the areas of lesser sandhills. Some Bribie (Fig. 22) near the western and southern coasts.

Geology.—Quaternary and older siliceous sands overlying Cretaceous sediments of the Maryborough and Burrum sediments. Igneous intrusives at Indian Head and Waddy Point are the only true rocks known on the island. Much coastal sandrock on both eastern and western beaches.

Topography.—Mostly rough sandhills reaching to a total height of up to more than 700 ft. Steep cliffs common on the east coast and extensive flats common on the west coast north of White Cliffs.

Soils.—Mainly deep sands (regosols) with some accumulation of organic matter in an A1 horizon and some organic staining below it. Podzols with organic pans common under vine forest. Peats and peaty sands extensive along the western margin. Multiple profiles can occur in valleys where podzols may be layered one above the other.

Vegetation.—Layered, grassy, dry, or wet sclerophyll forests and vine forests on the major sandhills. Layered woodland on lesser sandhills. Sclerophyll shrub woodland or heath on lower areas. Heath or herbage on the peats. Extensive areas of mangrove on the western coast.

Remarks.—Treated only on a reconnaissance basis during this study. The forest vegetation is discussed by Swain (1928).

(11) The Boonoooro Landscape
(Sample Map No. 8)

Area.—155 sq. miles.

Rainfall.—45-50 in. per annum with a winter element of 10 in.

Land Systems.—Chiefly Mary (Fig. 16) with small areas of Colton (Fig. 17) near the northern and western margins.

Geology.—Maryborough and Burrum sediments with younger alluvia and some mantling by Quaternary sands. Some Tertiary conglomerates and Graham’s Creek Formation in the south-west quarter. Three-quarters of this landscape is below the 50-ft contour.

Topography.—Flat to gently undulating. Most of this landscape is below the 100-ft level, much of it being less than 50 ft above sea-level.

Soils.—Various forms of gley and Tinana podzolic gley on the flats and low rises, with some podzolization on the higher rises. Compound profiles seem to be common especially near the eastern margin where there are buried truncated lateritics. Two general characteristics are fine textured A horizons which compact when dry, and a massive layer of ferruginous nodules at the A/B junction.

Vegetation.—Low layered woodland and forb heath on the flats and low rises. Layered woodland and some layered forest on higher rises. Thicket in many of the drainage lines. Sclerophyll shrub woodland on flatter areas where there is a mantle of sand over truncated laterite.
Remarks.—The sharp boundary between the Boonooroo and Coondoo landscapes apparently marks a major geological change between the older Bundamba sediments and the younger Maryborough–Burrum sediments. The Boonooroo landscape consists largely of the former delta of the Mary River. It is poorly drained and many of the soils are essentially arid owing to their low infiltration rates.

(12) The Burrum Landscape
(Sample Map No. 9)

Area.—390 sq. miles.

Rainfall.—40-45 in. per annum with a winter element of 8-10 in.

Land Systems.—Chiefly Colton (Fig. 17) and Tuan (Fig. 9) with small areas of Goodwood (Fig. 13) and Mary (Fig. 16) along the north-eastern margin.

Geology.—Maryborough and Burrum sediments. Scattered patches of Elliott Formation throughout. Each has its characteristic topography; broad flats on the Elliott Formation, broad low rises on the Burrum Series and sharper ridges on the Maryborough Formation.

Topography.—South of the Burrum river generally rolling with rises of about 20-50 ft (Burrum Series). Extensive flats north of the Burrum river (Elliott Formation). Steep ridges along the western margin and the boundary with the Takura landscape (Maryborough Formation).

Soils.—Chiefly Howard podzolics on crests and upper slopes changing to various forms of gley in the drainage lines. Some Toolara podzolics on higher ridges especially in the north-eastern corner. Podzolic gleys with a strongly developed nodular layer common on flats north and west of Howard. Compound profiles occur in the eastern portions.

Vegetation.—Layered or grassy forest on slopes and ridge tops. Tall woodland or low grassy forest on flats and in broad drainage lines. Thicket or low layered woodland in smaller drainage lines.

Remarks.—Some small areas of vine forests near the Burrum River. The vegetation has been extensively modified by selected logging. The western boundary of this landscape is very diffuse. Some details of vegetation and soils are given by Tommerup (1934).

(13) The Takura Landscape
(Not mapped)

Area.—70 sq. miles.

Rainfall.—45+ in. per annum with a winter element of 8-10 in.

Land Systems.—Not determined.

Geology.—Chiefly Maryborough and Burrum sediments with small areas of Tertiary basalt near Dundowran.

Topography.—Undulating to hilly.

Soils.—Lithosols on the steep ridges, red loams on the basaltic areas, gleys and podzolic gleys on the gentler slopes. Some humic soils in lower areas.
Vegetation.—Mostly removed by development, originally contained some extensive areas of vine forest and layered forest on the hills with various forms of woodland on the lower areas.

Remarks.—This landscape is now almost completely developed and the area was excluded from detailed study. The western boundary is clearly defined over most of its length by a pronounced change in topography.

(14) The Hercules Landscape
(Sample Maps Nos. 1, 10, and 13)

Area.—215 sq. miles.

Rainfall.—Bribie Island 50-55 in. per annum with a winter element of 10+ in. Northern segments 40-45 in. per annum with a winter element of 8-10 in.

Land Systems.—Bribie Island, chiefly Bribie (Fig. 22) with areas of Cooloolah (Fig. 20). Northern segments, chiefly Cooloolah with small areas of Coolum (Fig. 19).

Geology.—Quaternary strand lines of siliceous sands and river alluvia.

Topography.—Undulating to flat. Most of the areas are below the 25-ft contour.

Soils.—Chiefly ground-water podzols and regosols with small areas of gley, humic and peaty gley soils on low-lying areas near some streams.

Vegetation.—Layered forest, dry sclerophyll forest, or layered woodland on the regosols. Sclerophyll shrub woodland or forb heath on the ground-water podzols. Grassy forest or thicket with *Melaleuca quinquenervia* on humic soils and peaty gleys. Some small areas of a few acres each of vine forest on humic sands. Mangroves on stream banks.

Remarks.—This landscape is confined to the areas affected by the mid-Recent adjustment of sea-level. Stranded beach lines are common and there are well-preserved sets at the southern end of Bribie Island and near Woodgate. *Eucalyptus tesselaris* and *Callitris columellaris* are more or less confined to this landscape on the Coastal Lowlands. The northernmost segments include the only calcareous sands seen on the Coastal Lowlands. Near Littabella Creek (Baffle 243 370) and at Pialba 919 565 there are buried beds of fragmented shells.

(15) The Buxton Landscape
(Sample Map No. 10)

Area.—60 sq. miles.

Rainfall.—42 in. per annum with a winter element of 8-10 in.

Land Systems.—Goodwood (Fig. 13) and Tinnanbar (Fig. 11).

Geology.—Elliott Formation with small areas of younger alluvium.

Topography.—Flat to undulating. Like the Kinkuna landscape it lies below the 100-ft level but the relief is greater.
Soils.—Chiefly solodic and gley on flat areas and podzolic gley on low rises. Some ground-water podzols in the south-western quarter of the area. Scattered small areas of Toolara podzolics. Compound profiles occur.

Vegetation.—Layered and low layered woodland on the solodics and gley soils. Sclerophyll shrub woodland or forb heath on the ground-water podzols. Thicket (of Melaleuca nodosa), or woodland on the gley soils in drainage lines. Scattered small areas of layered forest on podzolic gleys on tops of rises.

Remarks.—The solodic soils can be distinguished readily in the field by the presence of Casuarina luehmannii. Poor water absorption makes this the most arid landscape on the Coastal Lowlands.

(16) The Gregory Landscape
(Sample Map No. 11)

Area.—80 sq. miles.

Rainfall.—42 in. per annum with a winter element of 8-10 in.

Land Systems.—Tuan (Fig. 9) and Colton (Fig. 17).

Geology.—Chiefly Burrum sediments with small areas of Maryborough sediments and Elliott Formation. Some laterite exposed in creek banks.

Topography.—Trending steadily from undulating on the eastern and northern edges to rolling hills on the western edge. Elevation rises from about 100 ft above sea-level on the eastern edge to 250 ft on the western edge.

Soils.—Toolara and Howard podzolics on rises and upper slopes with some small areas of Gooburrum podzolics. Podzolic gleys and gleys on lower slopes. Gleys in drainage lines.

Vegetation.—Grassy and layered forests on the rises, upper slopes, and well-drained flats. Layered woodland on lower slopes and poorly drained flats. Tall woodland in drainage lines. Some forb heath in drainage lines.

Remarks.—This landscape is essentially a broad transition zone between the developed uplands of the Childers area and the low-lying country of the Buxton, Kinkuna, and Elliott landscapes. The better (podzolic) soils are largely developed for sugar-cane.

(17) The Kinkuna Landscape
(Sample Map No. 12)

Area.—60 sq. miles.

Rainfall.—42 in. per annum with a winter element of 5-8 in.

Land Systems.—Chiefly Goodwood (Fig. 13) in the north-east and Tinnanbar (Fig. 11) elsewhere with some Mullen (Fig. 15) west of the railway line.

Geology.—Chiefly Elliott Formation with some mantling by Quaternary siliceous sands.

Topography.—Flat to undulating. Only the western fringe rises above the 100-ft level.
Soils.—Theodolite podzolic gley and gley on flats, with some solodics on flats in the eastern portion. Gooburrum podzolics and some Toolara podzolics on small rises. Tinana podzolic gleys on rises in the western portion. Ground-water podzols on lower areas, especially west of the railway line.

Vegetation.—Layered woodland and low layered forests on elevated areas. Sclerophyll shrub woodland on the ground-water podzols. Extensive thickets in broad drainage lines.

Remarks.—East of the railway line there is very slow drainage and much inundation after rain. The general pattern is one of shallow soils formed from chemically poor rock supporting depauperate vegetation under conditions of frequent prolonged waterlogging.

(18) The Elliott Landscape

(Sample Map No. 12)

Area.—180 sq. miles.

Rainfall.—42 in. per annum with a winter element of 5-8 in.

Land Systems.—Chiefly Sippy (Fig. 10) and Tinnanbar (Fig. 11) with small areas of Tuan (Fig. 9) and some Mary (Fig. 16).

Geology.—Elliott Formation with mantling by Quaternary siliceous sands in lower areas.

Topography.—Gently undulating south of the Elliott River and flat to the north. There is an overall slope from west to east, the elevation decreasing from 300 ft above sea-level to H.W.M.

Soils.—Gooburrum and Toolara podzolics on rises in the undulating areas, and on almost flat areas in the north-eastern quarter. Tinana podzolic gleys on flats in north-western quarter (e.g. Bundaberg 410 962), and towards Gooburrum. Ground-water podzols in the south-west along the Bruce Highway, and near the mouth of the Elliott River.

Vegetation.—Layered and grassy forest on the podzolics with some small areas of dry sclerophyll forest on transitional ground-water podzols. Layered woodland or low layered forest on the podzolic gleys. Forb heath and sclerophyll shrub woodland on the ground-water podzols. Thicket in some of the smaller drainage lines and fringing forest along parts of the Elliott River.

Remarks.—North-eastern boundary is delineated by the edge of the Hummock basalt flow. Many of the areas of podzolic soils are developed to sugar-cane. Some details of the soils are given by King (1949). At Cordalba 389 818 there is a small outlier of the Buxton landscape where Casuarina luehmannii occurs on a solodic soil. Adjoining the Bruce Highway between the Gregory and Elliott Rivers there are numerous areas of the wallum community under which the hard-pan is intermittent; in some of these areas yellow stringybark, E. acmenioides, occurs in mallee-type clumps which seem to be extending freely. If fire were excluded the dominance in these areas could probably change from Banksia aemula to yellow stringybark.
(19) The Hummock Landscape
(Not mapped)

Area.—50 sq. miles.
Rainfall.—43 in. per annum with a winter element of 5-8 in.
Land Systems.—Not determined.
Geology.—(? ) Quaternary basalt resting mainly on Elliott Formation.
Topography.—Flat to undulating on the margins with the central portion occupied by gentle slopes leading up to the Hummock itself.

Soils.—Mostly red loams and brown clay loams on the sloping basaltic areas with humic soils on low-lying areas. Some deep sands near Bargara and alluvials near the Burnett River. There is also a small area of yellow podzolic soils on the boundary of the north-eastern corner of the Elliott landscape at Bundaberg 530 053 (see King 1949).

Vegetation.—Almost totally removed. Formerly vine forest and grassy forest. Along the southern edge of the basalt there is a tall woodland on shallow humic soils with scattered trees of *E. tesselaris* and *E. drepanophylla* and some *Heteropogon contortus* (L.) Beauv. ex R. & S. in the ground layer.

Remarks.—This landscape is delineated by the basaltic flows associated with the Hummock. These define the western boundary over much of its length by a sharp "jump-up" of up to 15 ft which fluctuates about the 50-ft contour. Most of the area has been cleared and intensively developed, chiefly to sugar-cane. King (1949) describes the soils in some detail and gives a general account of the original vegetation.

(20) The Kolan Landscape
(Sample Map No. 13)

Area.—130 sq. miles.
Rainfall.—42 in. per annum with a winter element of 5-8 in.
Land Systems.—Chiefly Tuan (Fig. 9) with areas of Sippy (Fig. 10) and Goodwood (Fig. 13) in the south-western end; Cooroibah (Fig. 15) near the coast with 4NVI replacing 19FII; Tibrogargan (Fig. 12) near the coast but with only small areas of peat.

Geology.—Elliott Formation with some areas of Maryborough and Burrum sediments. Quaternary strand lines of siliceous and calcareous sands near beach.

Topography.—Mostly undulating with extensive flats near the coast. Elevation rises from about 20 ft on the coastal side to 150 ft in the south-western corner.

Soils.—Chiefly Gooburrum and Toolara podzolics on the rises, with podzolic gleys and gleys on lower slopes and flats. Scattered small areas of solodic soils in the south-western end between Bingeria and Bucca. Scattered areas of ground-water podzol below the 100-ft contour. Humic and humic gley soils and some small areas of peat in marshy areas. The frequency of the Gooburrum soils decreases from south to north.
Vegetation.—Grassy and layered forests and some small areas of dry sclerophyll forest on rises. Grassy forest with *Melaleuca quinquenervia* in marshy areas. Thicket and sclerophyll shrub woodland in drainage lines. Low sclerophyll shrub woodland on ground-water podzol. Small areas of forb heath on humic gley soils.

Remarks.—This is a northern analogue of the Glass House and Coondoo landscapes but differs in having gentler topography, less ground-water podzol, appreciable areas of Gooburrum podzolic, and some areas of solodic soil. Many of these differences can be traced to the presence of the Elliott Formation. Small outliers of the Kolan landscape beyond the western boundary shown on the map are located on residuals of Elliott Formation, e.g. near Bullyard railway station. There is a small area of shallow red loam at Winfield (Baffle 132 463) that is formed on rocks of the Maryborough Formation.

VII. Acknowledgments

Under the leadership of Mr. V. W. Grenning, Director, and Mr. A. R. Trist, Deputy Director, officers of the Queensland Forest Service have assisted throughout this study by providing accommodation in field camps, and by the provision of base maps, climatic records, and much local knowledge. The author is especially grateful to Foresters C. Price and T. Yorkston, and District Forester D. Markwell, who introduced him to the Coastal Lowlands.

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Dr. S. T. Blake of the Queensland State Herbarium identified many of the species and checked the identification of the remainder.

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Finally, it is pleasant to recall the unstinted efforts in the laboratory and in the field of Mr. W. F. Ridley and Mr. G. W. McHarg who have assisted in bringing this project to completion. Mr. McHarg is also responsible for the final delineation of all the diagrams and maps.

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Appendix I

Profile Descriptions

Profile descriptions of typical soils from the majority of the groups are given below. The lithosols and tidal mud flats were not examined in detail. The humic and alluvial soils are too variable to be characterized aptly by one or two profiles, and are not included here.

More detailed descriptions of profiles in some of the groups are given by Hubble (1954) and Thompson (1957). The general profile of the red earth residuals is described by Bryan (1939).

For more details of the vegetation occurring on these soils and on their distribution, the reader is referred to Sections V and VI of this series of papers.

The map references given are taken from the relevant sheet of the Australian Military 1-mile series of maps.

Some of the descriptions given are condensed from notes originally prepared by Mr. G. D. Hubble, Division of Soils, C.S.I.R.O., Brisbane, to whom grateful acknowledgment is made.

M = Munsell colour on moist sample, D = Dry.

Depth
(in.)

Ground-Water Podzols

(1) Location: Maroochydore 233786, Currimundi landscape. Gently undulating heath plain with pronounced microrelief of sharp-sided hummocks averaging 1 ft in height. Profile taken under hummock.

0-9 Grey (5YR 6/1M) loose sand speckled with finely divided organic matter. Dense root mat. Diffuses into

9-15 Pale grey (5YR 8/1M) loose sand. Organic matter and roots decreasing. Diffuses into

15-30 White (5Y 8/1M) mottled with pinkish grey (5YR 6/2M) and dark grey (5YR 3/1M) loose sand.

30-50 White (5Y 9/1M) mottled with dark grey (10YR 3/1M) and small lenses of black (5YR 2/1M) sand impacted into a massive pan layer; extremely hard in profile but frets easily when removed. Fairly abrupt but uneven boundary into

50-57 Black (5YR 2/1M) organic sandy pan; massive; hand specimen disintegrates easily in water.

57-63 Dark brown (7.5YR 3/2-5/2M) sandy, trending to loamy sand. Moderately developed organic pan.

(2) Location: Gundiah 149954, near Tinnanbar beach, Coondoo landscape. Flat carrying heath and low sclerophyll shrub woodland.

0-6 Dark grey (5Y 4/1M) granular, loose, sand flecked with a light amount of organic matter. Numerous fine roots. Diffusing into

6-30 White (2.5Y 8/2M) granular, loose, sand. Scattered fine roots.

30-32 Dark brown (10YR 3/3M) sand, mildly cemented into an organic pan.

32-44 Dark yellowish brown (10YR 3/4M) trending to light yellowish brown (10YR 6/4M) organic sandy pan strongly cemented in the profile.
Depth (in.)
48-78 Pale brown (10YR 7/3M) mottled with reddish yellow (7.5YR 6/8M) clayey sand. A few ferruginous nodules less than 1 in. in diameter.
78-82 Dark brown (10YR 3/3M) weakly cemented organic sandy pan.
82-94 White (2.5Y 8/2M) loose, coarse sand.
94-124 White (5YR 8/2M) finely mottled with red (2.5YR 4/6M) plastic, sandy clay.

Podzolic — Toolara

(3) Location: Caloundra 186656. East of Beerwah Forest Station. Glass House landscape. Upper slope of gentle ridge carrying dry sclerophyll forest. All changes in this profile are diffuse.

0-2 Light yellowish grey (2.5Y 7/2D) loamy sand friable when moist, with some charcoal. Fibrous root mat. Trace fine organic matter.
2-6 Light grey (10YR 7/1D) loamy sand; friable when moist; lighter concentration of roots.
6-17 Light yellow-grey (5Y 7/2D) finely mottled with pale brownish yellow (2.5Y 7/6D) sandy loam, friable when moist.
17-28 Brownish yellow (10YR 6/8M) mottled with brownish red (2.5YR 3/6M) sandy loam to sandy clay loam. Trace of ferruginous nodules, ½-in. diameter dominant.
28-38 Light grey (10YR 7/1D) mottled with dark red (10R 3/4D) and light red (10R 4/6D) clay loam. Moderate amount of ferruginous nodules up to 1 in. in diameter.
38-49 Mottled red (10R 4/6D) and light grey (2.5Y 8/0) with some brownish yellow (10YR 7/8). Medium clay. Blocky structure. Trace of subangular quartz gravel and ferruginous nodules.
49-71 Colour as above with some purplish red (10R 3/4D) heavy clay. Plastic when moist. Trace of ferruginous nodules.
71-169 Continuing as above with light grey tending to become dominant.

(4) Location: Hervey Bay 757604. Alongside road to Traviston. Burrum landscape. Broad top of low rolling ridge carrying grassy forest. All changes in this profile are diffuse.

0-4 Dark grey (10YR 4/1M) with coarse mottling of light brownish grey (10YR 6/2M) loamy sand with a moderate concentration of fibrous roots.
4-12 Light yellow-brown (10YR 6/3M) with patches of grey (10YR 5/1M) loamy sand trending to sand. Some fine fibrous roots.
12-23 Light yellow-brown (10YR 6/3M) sand. Some fine fibrous roots. Scattered darker coloured worm casts to ½ in. in diameter.
23-32 Colour as above with steadily increasing trend to (10YR 6/5M) clayey sand.
32-38 Light yellow brown (10YR 6/5M) mottled with (7.5YR 6/8M) and (5YR 5/8M). Clayey sand trending to sandy clay loam.
38-50 Colour as above with red mottlings becoming more prominent. Sandy clay loam, trend to sandy clay.
50-64 Strongly mottled yellow-brown (7.5YR 5/8M), yellowish red (5YR 4/8M), and light yellow-grey (2.5Y 6/3M) clay. There is a steady trend to grey (10YR 6/1M) mottled with dark red (10R 3/4). Heavy, plastic clay with some quartz grit.
Podzolic — Howard


Upper slope of rolling ridge with grassy forest.

All changes in this profile are diffuse.

<table>
<thead>
<tr>
<th>Depth (in.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>Pale brown (10YR 6/3M) gritty sand loam. Moderate amount of fine ferruginous nodules less than ¼ in. diameter with hard dark pellicle.</td>
</tr>
<tr>
<td>2-9</td>
<td>Light yellowish brown (10YR 6/4M) sandy loam. Moderate amount of ferruginous nodules up to ¾ in. diameter with hard dark pellicles.</td>
</tr>
<tr>
<td>9-15</td>
<td>Yellowish brown (10YR 5/6M) some mottling red (10R 4/8M) sandy loam, trend to light sandy clay. Heavy concentration of ferruginous nodules up to ¾ in. diameter, with hard dark pellicle.</td>
</tr>
<tr>
<td>15-26</td>
<td>Mottled red (10R 3/6M), greyish yellow-brown (2.5Y 6/3M) and yellow-grey (2.5Y 6/1M) heavy clay. Moderate concentration of ferruginous nodules up to 1 in. diameter; pellicles not so prominent.</td>
</tr>
<tr>
<td>26-50</td>
<td>Mottled as above but red decreasing and grey becoming more prominent. Heavy plastic clay. Chips of parent rock becoming apparent.</td>
</tr>
</tbody>
</table>

Podzolic — Gooburrum

(6) Location: Cordalba 1 mile 432815.

Low rise (10-15 ft) above broad undulating plains of the Elliott landscape. Layered forest and grassy forest. Thin and discontinuous layer of raw litter.

<table>
<thead>
<tr>
<th>Depth (in.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-8</td>
<td>Dark brown (10YR 4/3M) loose loamy sand with fine organic matter and fibrous roots. Diffusing into</td>
</tr>
<tr>
<td>8-32</td>
<td>Steady transition from yellowish red (5YR 4/6M) sand to red (10R 4/8M) clayey sand. Diffusing into</td>
</tr>
<tr>
<td>32-44</td>
<td>Red (10R 4/8M) sandy clay, friable when moist.</td>
</tr>
<tr>
<td>44-90</td>
<td>Red (10R 4/6M) light clay, friable when moist.</td>
</tr>
</tbody>
</table>

Podzolic Gley — Tinana

(7) Location: Maryborough 935203. Near 3½ mile peg on Boonooroo road, Boonooroo landscape.

Essentially level plain with very slow drainage. Low layered woodland. All changes in this profile are diffuse. Gleying is prominent.

<table>
<thead>
<tr>
<th>Depth (in.)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>Grey-brown (10YR 5/2M) fine sandy to silty loam. Dense mat of fine roots with rusty colouring on root channels. Some fine organic matter.</td>
</tr>
<tr>
<td>5-14</td>
<td>Grey-brown (10YR 5/2M), trend to light grey (10YR 7/2M), with rusty markings on root channels more pronounced. Fine sandy to silty loam. A few ferruginous nodules up to ¾ in. diameter.</td>
</tr>
<tr>
<td>14-19</td>
<td>Light grey (10YR 7/2M) and dull yellow (10YR 7/8) silty clay loam with some rusty markings on root channels. Trace of ferruginous nodules to ¾ in. diameter.</td>
</tr>
<tr>
<td>19-32</td>
<td>Finely mottled light grey (10YR 7/2M) and brownish yellow (10YR 6/8M) clay loam, trend to clay. Scattered ferruginous nodules.</td>
</tr>
<tr>
<td>32-34</td>
<td>Masses of nodules cemented in ferruginous aggregate.</td>
</tr>
<tr>
<td>34-44</td>
<td>Finely mottled yellow-brown, reddish brown, and red heavy clay.</td>
</tr>
<tr>
<td>44-48</td>
<td>Masses of cemented nodular aggregate.</td>
</tr>
<tr>
<td>48-66</td>
<td>Coarsely mottled red and light grey with some yellow-brown very heavy clay.</td>
</tr>
</tbody>
</table>
Podzolic Gley — Theodolite

(8) Location: Cordalba 582878, 4 miles east of north coast railway line between Goodwood and Kinkuna. Kinkuna landscape. Flat carrying shrub thicket. Tends to shed water owing to compacted surface layer.

- Depth (in.)
  - 0-2 Light grey (2.5Y 7/2M) silty loam which compacts when dry. Trace of fine organic matter. Light amount of fibrous roots. Abrupt boundary to
  - 2-20 White (10YR 8/2M) silty loam. A few fibrous and woody roots. Abrupt boundary to
  - 20-21 Pale yellow (5Y 7/3M) mottled with brown (7.5Y 5/2M) silty clay mildly compacted with some lodging of organic matter. Abrupt boundary to
  - 21-36 Grey-brown (2.5Y 5/2M) silty clay, friable when moist.

Gley


Gentle slope of low ridge with low layered woodland or heath. All changes in this profile are diffuse. Glass House landscape.

- Depth (in.)
  - 0-5 Dark grey (10YR 4/1M) sand with some fine organic matter and dense fibrous root mat.
  - 5-9 Light grey (10YR 8/1M) sand with patches of dark grey. Rusty markings on root channels.
  - 9-16 Light grey (10YR 7/2M) sand, trend to light grey with some yellow-brown flecks. Strong rusty markings on root channels.
  - 16-22 Light grey (10YR 7/1M) and brownish yellow (10YR 6/6M) clayey sand with rusty markings on root channels.
  - 22-29 Grey (10YR 6/1M) with patches of yellow-brown (10YR 6/6M) and red (10R 3/6M) sandy clay loam, trend to heavy clay. Fine root channels with rusty markings.
  - 29-50 Light grey (10YR 7/1M) with some brownish yellow (10YR 6/8M) medium clay with prismatic structure.
  - 50-70 Light grey, with markings of yellow-brown and yellow sandy clay.

Humic Gley

(10) Location: Glass House 161568. J. D. Johnston’s property. Gently sloping flat with grassy forest (tea-tree forest). Glass House landscape.

All changes in this profile are diffuse.

- Depth (in.)
  - 4-8 Very dark grey organic clay with rusty root markings. Structure tending to become blocky.
  - 8-13 Dark grey (10YR 4/1M) with some white (10YR 8/1) medium clay with fewer roots than layers above. Strong rusty root markings. Well-developed prismatic structure.
  - 13-18 Grey and white heavy clay with strong rusty root markings. Well-developed prismatic structure.
  - 18-26 Light brownish grey (10YR 6/2) and brownish yellow (10YR 6/8) silty clay loam. Rusty root markings not so strong as in layer above. Prismatic structure.
  - 40-48 Light grey (10YR 7/1M) and yellow-brown (7.5YR 5/6M) clay continuing deeper.
ECOSYSTEM OF WALLUM COUNTRY, QUEENSLAND

Depth (in.)

Solodic


0-2 Light grey (10YR 7/2M) loamy to silty fine sand which compacts when dry. Light concentration of fibrous roots.

2-8 As above but not compacted and with some yellow-brown markings around roots. Changes sharply into

8-13 Pale brown (10YR 6/3M) gritty fine sandy loam with yellow-brown markings around root channels.

13-18 Light grey (10YR 7/2M) very fine sandy loam with slight grit. Changing sharply into

18-22 Light brownish grey (10YR 6/2M) with some yellowish brown (10YR 5/6M) silty clay loam.

22-29 Light brownish grey (10YR 6/2M) and light olive-brown (2.5Y 5/4M) silty loam to silty clay loam. Changes abruptly to

29-34 Light grey (10YR 7/1M) cemented silica pan which continues.

Regosol


Thin layer of litter (A0) about 1 in. thick. Duff layer (A) 1/2 in. thick of comminuted organic matter with mat of fine living roots.

0-3 Grey (10YR 6/1M) loose, fine sand with organic matter. Dense mat of fine roots. Diffusing into

3-26 Pale grey (7.5YR 7/0M) loose fine sand, with slight organic matter in upper few inches. Root concentration decreasing. Diffusing into

26-96 White (<5Y 8/1M) loose sand with few roots. Fairly abrupt change to

96-120 Brown (7.5YR 5/2M) sand, slightly consolidated. (?) Incipient organic pan. Diffusing into

120-140+ Very pale brown (10YR 8/4M) loose sand.

APPENDIX II

FLORISTICS OF THE FORMATIONS

The species listed under each structural form are the obvious species which contribute substantially to the structure of the various layers and which dominate the floristic composition in terms of percentage of bulk in each layer.

Fringing forest Species lists are given by Swain (1928), and Tommerup (1934)

Layered forest Eugenia smithii, Castanospermum australe

Vine forest Eucalyptus intermedia, E. phaeotricha, E. micrantha, E. acmenioides, E. trachypholia, Casuarina littoralis, C. torulosa, Acacia complanata, Hakea plurinervia, Xylomelum pyriforme, Grevillea banksii, Daviesia umbellulata, Xanthorrhoea media, Themeda australis, Allopteropsis semi-alata, Imperata cylindrica

Dry sclerophyll forest E. pilularis, E. intermedia, E. phaeotricha, E. drepanophylla, Pultenaea villosa, Leptospermum flavescens, L. stellatum, Casuarina littoralis, Banksia oblongifolia, Macrozamia paulo-guilemii
Wet sclerophyll forest

E. pilularis, E. grandis, Tristania conferta, Syncarpia glomulifera, E. resinifera

Grassy forest

Eucalypts and casuarinas from layered forest or Melaleuca quinquenervia; Themeda australis, Imperata cylindrica, Xanthorrhoea media

Low layered forest

E. intermedia, E. micrantha, Angophora woodsiana, E. acmenioides, Tristania suaveolens. Shrubs etc. as for layered forest

Low grassy forest

Trees as for grassy forest plus Angophora woodsiana, Ptilanthelium deusta

Tall sclerophyll shrub woodland

E. acmenioides, E. micrantha, E. seeana var. constricta, B. oblongifolia, Xanthorrhoea media, Hibbertia spp.

Low sclerophyll shrub woodland

E. acmenioides, B. oblongifolia, Hakea gibbosa, B. aemula, L. flavaescens, Boronia falcifolia, Xanthorrhoea hastile

Tall woodland

E. tereticornis, Tristania suaveolens, Themeda australis, Fimbrystylis cinnamometorum

Low woodland

E. robusta, T. suaveolens, Lepidosperma laterale, Fimbrystylis cinnamometorum

Savannah woodland

E. seeana var. constricta, Angophora lanceolata, Rhynchospora rubra, Ptilanthelium deusta

Layered woodland

E. intermedia, E. acmenioides, T. suaveolens, Angophora woodsiana, B. oblongifolia, Rhynchospora rubra, Hypolaena fastigiata, Xanthorrhoea media

Low layered woodland

E. intermedia, E. acmenioides, T. suaveolens, A. woodsiana, Banksia robur, Melaleuca quinquenervia, B. oblongifolia, Hypolaena fastigiata, Caustis blakei, Fimbrystylis cinnamometorum, Schoenus apogon

Tree heath

Heath spp. plus Melaleuca quinquenervia, Banksia aemula

Shrub savannah

E. acmenioides, A. woodsiana, heath spp.

Thicket

Melaleuca nodosa, various sedges

Shrub thicket

M. nodosa, L. flavaescens

Heath

Leptospermum flavaescens, L. stellatum, B. oblongifolia, Monotocha scoparia

Forb heath

As for forb heath plus Melaleuca quinquenervia and Tristania suaveolens linearis, Petrophila shirleyae, Baeckea stenophylla, Boronia falcifolia, Leucopogon divaricata, Blandfordia flammae (summer aspect), Caustis recurvata, Hypolaena fastigiata, Schoenus brevifolius, Lepyrodictum scariosa

Tree forb heath

As for forb heath plus Melaleuca quinquenervia and Tristania suaveolens

Herbfield

Hypolaena fastigiata, H. lateriflora, Cladium glomeratum, C. teretifolium, Gahnia sieberiana, Lepidosperma laterale, Hibbertia salicifolia, Leptospermum liversidgii, Coleocarya gracilis

Mangrove

Avicennia marina var. resinifera, Aegiceras corniculatum, Rhizophora mucronata

Foredune complex

See Blake (1938) and Herbert (1951)
ECOSYSTEM OF WALLUM COUNTRY, QUEENSLAND

APPENDIX III

NOTES ON INDIVIDUAL SPECIES

Melaleuca quinquenervia is very widespread on the Coastal Lowlands and occurs in such a variety of habitats as to suggest morphologically indistinguishable physiological races. It is one of the species most frequently involved in ecotonal oscillation and seems subject to outbursts of regeneration, even-aged stands being common.

M. nodosa is commonly the single species present in the upper layer of thicket formations.

Eucalyptus pilularis (blackbutt) is comparatively restricted in its distribution on soils such as the Toolara, Howard, and Gooburrum groupings but occurs freely on the deep sands of the sandhills. It reaches its greatest frequency and size on the sandhills of Fraser Island.

E. resinifera has a limited distribution and is commonly found on soils with a soft reddish brown organic pan layer, i.e. the type of pan which seems to be associated with Leptospermum flavescens.

E. hemiphloia is not normally found on the Coastal Lowlands but a small island occurs in the Takura landscape near Walligan railway siding.

E. acmenioides is almost as widely distributed as E. intermedia and seems able to survive more acute waterlogging. Where it occurs in depauperate form among heath it is commonly in clumps resembling a mallee. However, the stems do not originate from a central lignotuber as in a true mallee but from a "ring lignotuber" with a circumference of over 10 ft.

E. tessellaris is normally restricted to more arid sites on the Coastal Lowlands. A depauperate form occurs together with Tristania conferta in dense thickets in wind-swept valleys near the beach.

E. exserta is normally found on the more arid soils north of Maryborough, but an outlier occurs on top of Mt. Tinbeerwah near Tewantin.

Callitris columellaris is restricted to the sand dune areas and small pockets near some of the estuaries where it may occur on heavy-textured soils with a massive nodular layer.

Casuarina torulosa is restricted to ridges with deep A horizons and free drainage.

C. luehmannii is restricted to the shallow heavy-textured soils formed on the Elliott Formation at the northern end of the Coastal Lowlands. It extends from just south of the Isis River to east of Goodwood. As in southern Australia it seems to be restricted to soils with an accumulation of soluble salts in the B horizons.

Monotoca scoparia is frequently a pioneer species after severe burning in sandhill country.

Banksia aemula is very widespread. Young (1946) claimed that it was always associated with a hardpan in the soil profile, but while this is common the
relationship is not absolute. It occurs freely on the tops of sandhills where it reaches its maximum size and the author has also found it growing on rocky slopes. The majority of specimens seen are really depauperate since this species will develop into a well-formed forest tree up to 40 ft in height. Frequent burning will reduce it to a dense clump resembling B. ornata on the heaths of the Ninety-Mile Plain in South Australia. It is killed by continued waterlogging.

B. robur will only occur where the water-table is at or close to the surface for prolonged periods. It is particularly useful as an indicator of the extent of severe waterlogging on slopes.

B. collina is normally restricted to the better developed forest soils but isolated clumps occur in a variety of atypical sites.

Grevillea banksii is restricted to the northern half of the Coastal Lowlands where it occurs freely on soils of the Howard grouping and is a prominent member of the tall shrub layer.

Xanthorrhoea spp. This group is still taxonomically obscure but two species can be distinguished clearly. X. macronema is of limited occurrence and restricted to layered forests with a deep sandy A horizon. X. hastile is restricted to wetter habitats and is especially common on poorly drained sites with a heavy clay subsoil, e.g. Boonooroo soil group. Hall (1955) has described the effects of temporary poisoning in cattle after consumption of this plant.

Ptilanthelium deusta is a very prominent sedge in many of the woodland communities where it is often the most obvious species and at first sight gives the appearance of a grassy understorey.

Blandfordia flammae presents a strong seasonal aspect in the wetter heaths when it flowers in early summer. It has been almost eliminated from the more accessible areas.

Livistona australis is scattered through the Coastal Lowlands and shows no marked restriction of habitat occurring on soils ranging from deep sands to waterlogged soils.

Araucaria cunninghamii reaches its maximum development on the deep sands of the Teewah sandhills and Fraser Island where it attains a height of 100+ ft and regenerates freely under natural conditions.

APPENDIX IV

SAMPLE MAPS OF CHARACTERISTIC PORTIONS OF THE REGION

This series of sample maps shows the pattern of land units commonest in each landscape. No sample map is given for the Cootharaba landscape since the natural pattern is now seriously confused by development. The only other landscape omitted from this series is the Fraser landscape owing primarily to difficulties of access. The Queensland Forest Service has prepared an unpublished map of the vegetation of Fraser Island based on forest types and this is a useful
source of information for other purposes. As shown in Figure 23 the Fraser landscape has much in common with the Cooloolah landscape.

These sample maps have been prepared by the marking of key aerial photographs (flown 1940-42) and the establishment of ground control in the field, followed by interpretation of aerial photographs over the remainder of the area. The principal points of the photographs are shown on each map. The location of each map was governed partly by the availability of ground control, and partly by the desire to make one map serve for two landscapes wherever possible. Consequently, while each sample map represents the majority of the patterns in the relevant landscapes, no claim is made for absolutely complete coverage.

On these maps the dominance of land units is indicated by the “T” system of Stephens (1950). This arrangement is illustrated in Figure 24 (p. 135).
Coastal Lowlands

Broad climatic regions

High rainfall (50-60+ in. p.a.)

Parent material

Quaternary dominant

Basalt
Alluvia

Quaternary siliceous sands

Shallow sands
Less ground-water podzol and more peat in Noosa

Deep sands
More vine forest and valley peats in Fraser

Pre-Quaternary dominant

Bundamba sandstone

Mainly below Como Scarp level (approx. 100 ft)

Different eustatic effects

Mainly above Como Scarp level

Mixed

Tonalite

Quaternary sand and Alluvia. Bundamba and Walloon Sandstones.

Intrusives

Differences in soil vegetation patterns

Hummock
Maroochy
Currimundi
Noosa
Cooloolah
Fraser
Tin Can
Womalah
Glass House
Coondoo
Cootharaba

1 Landscapes readily separable on vegetation alone.
2 These differences are too complex to enumerate briefly here. Refer to land system diagrams and sample maps.
3 There is a small area of tonalite in the south-western corner of the Glass House landscape. Vegetation and soils place this with the Coastal Lowlands.
Coastal Lowlands

Broad climatic regions

See p. 120

Low rainfall (40–50 in. p.a.)

Parent material

Both regions

Quaternary dominant

Marlyborough–Burrum sedimentsary

Maryborough–Burrum sedimentsary

Pre-Quaternary dominant

Elliott Formation

Some Areas of Quaternary siliceous sand

Topography

Topography

Very little Quaternary sands

Quaternary sands and swamp deposits

Classes III and IV

Classes II and III

Differences in soil vegetation patterns

Kinkuna

Elliott

Kolan

Buxton

Hercules

Topography

Boonooroo

Burrum

Gregory

Takura

Deposited partly over truncated laterite.

Largely developed; originally included much vine forest.

Fig. 23.—The separation of landscapes according to environmental differences. This diagram is intended for use in conjunction with the large map, the sample maps, and land system diagrams. It may be more useful in the field if used in the reverse direction.
Sample Map 1.—Glass House landscape and Hercules landscape (Bribie Island). There is a small section of the Currimundi landscape in the extreme top right corner.
Sample Map 2.—Portion of the Currimundi landscape.
Sample Map 3.—Womalah landscape with small portions of the Coondoo (bottom left), Noosa (centre right), and Tin Can (top right) landscapes.
Sample Map 4.—Cooloolah landscape with portion of the Noosa landscape at left.
Sample Map 5.—Portions of the Noosa landscape (left) and Cooloolah landscape (right).
Sample Map 6.—Tin Can landscape with portion of the Coondoo landscape at bottom left.
Sample Map 7.—Coondoo landscape with portion of the Tin Can landscape at top right.
Sample Map 8.—Bonooroo landscape with some large mangrove flats (20PI) at top right.
Sample Map 9.—Burrum landscape.
Sample Map 10.—Buxton (lower) and Hercules (upper) landscapes.
Sample Map 11.—Portions of the Gregory (lower) and Elliott (upper) landscapes.
Sample Map 12.—Elliott landscape with portion of the Kinkuna landscape at bottom.
Sample Map 13.—Kolan landscape (left) and portion of the Hercules landscape (right).
Fig. 24.—Key to symbols used in sample maps. For details of units refer to Table 4.
EXPLANATION OF PLATES 1-10

PLATE 1

Fig. 1.—Fossil pan layer exposed by wind erosion. In this example there is cementing by both organic matter and iron, the latter giving conchoidal structures. A continuation of the same bed may be seen in the left background. This site is 200 ft above sea-level at the top of beach cliffs.

Fig. 2.—Coastal sandrock on Coolum Beach showing the sloping bench at H.W.M. and scattered outcrops in the littoral zone. Tide at half-ebb.

PLATE 2

Terrain model of portion of the Coastal Lowlands east of Gympie, showing
1 Massive sandhills of oceanic sand overlying Teewah sand.
2 Low lying oceanic sands (heath downs and swamps).
3 Low rolling hills.
4 Rolling hills.
5 Steep ridges.
6 The Como Scarp; partly indicated by white line.
7 Rugged mountainous belt west of the Coastal Lowlands.

PLATE 3

Fig. 1.—Upper horizons of a “mound soil” on Fraser Island. Original ground level is at the top of the peg which is marked in inches. Note the sparseness of the raw litter and the dense mat of living roots which show especially on the sides of the pit.

Fig. 2.—Upper portion of a deep valley peat showing the penetration of fibrous roots and humification of the decomposing organic matter which in this case is almost complete at a depth of 18 in. The whitish sand below the tarpaulin is typical of that surrounding these peats. The measuring stick is marked in inches.

Fig. 3.—The edge of an area of plains peat which extends to the right of the photograph for approximately 800 yd. The foreground, background and left centre of the photograph are all occupied by siliceous sandhills. The line of trees at left centre marks the edge of the peat which extends upslope through a height of 5-6 ft.

PLATE 4

Fig. 1.—General view of mound peat at Wide Bay 267707. The person on the right is standing on peat with water at the surface, the person on the left is standing on dry siliceous sand.

Fig. 2.—An edge of the mound peat shown in Plate 4, Figure 1, showing the original level sandy floor with the humified and fibrous peat sloping up from it. Water is trickling down the face of the pit at the right hand side.

Fig. 3.—Aerial photograph (from a height of 200 ft) of a whorled hummock formation; hummocks are light-coloured and trenches are dark-coloured. Ground inspection of this area showed a fall of not more than 2 ft across the photograph and the slope could not be measured with an Abney level.
ECOSYSTEM OF WALLUM COUNTRY, QUEENSLAND

PLATE 5

Fig. 1.—Grassy forest. The tree layer in this photograph contains seven species of *Eucalyptus*. The ground layer is predominantly *Themeda australis* and *Imperata cylindrica*. Toolara podzolic soil.

Fig. 2.—Layered forest showing the shrub layers suppressing the ground layer which is still visible in left foreground. Two fires in five years would change this community to one resembling that in Plate 5, Figure 1. Toolara podzolic soil.

PLATE 6

Fig. 1.—Dry sclerophyll forest on the deep siliceous sand of Fraser Island (regosol). The principal tree species in this photograph are *Tristania conferta*, *Eucalyptus resinifera*, and *Syncarpius hillii*. This area is on a Forest Reserve protected from fires.

Fig. 2.—Dry sclerophyll forest analogous to that in Plate 6, Figure 1, after burning. Note total destruction of the shrub layers. Regosol.

PLATE 7

Fig. 1.—Low layered forest with the shrub layer beginning to assume prominence over the ground layer which is composed largely of sedges and *Xanthorrhoea hastile*. Principal tree species are *Melaleuca quinquenervia* and *Eucalyptus acmenioides*. Tinana podzolic gley.

Fig. 2.—Low sclerophyll shrub woodland (“Wallum” community); the trees are all *Banksia aemula*. The remainder of the community is a typical forb heath with three years' growth since the last fire. Ground-water podzol.

PLATE 8

Fig. 1.—Tall woodland with *Eucalyptus micrantha* and *E. acmenioides*. The ground layer is predominantly *Ptilanthelium deusta* and *Xanthorrhoea media*. Tinana podzolic gley.

Fig. 2.—Low woodland with *Casuarina luehmannii*, *Eucalyptus exserta*, and *Angophora lanceolata* in the tree layer. Ground layer of grasses, sedges, and *Xanthorrhoea hastile*. Solodic soil.

PLATE 9

Fig. 1.—Layered woodland with *E. acmenioides*, *E. micrantha*, *E. intermedia*, and *E. seeana* var. *constricta* in the tree layer. *Banksia oblongifolia* is the most obvious species in the low shrub layer while the sedge *Ptilanthelium deusta* is predominant in the ground layer. *Xanthorrhoea hastile* in foreground. Grasses are a minor constituent of this community. Tinana podzolic gley.

Fig. 2.—Forb heath and tree forb heath (*Melaleuca quinquenervia*) on a ground-water podzol. Note absence of young trees. The slender shrub in the foreground is *Callistemon pachyphyllus* which is constantly retarded by fires in areas such as this. The fallen tree by the figure is a windthrow.
Fig. 1.—Shrub savannah with *Eucalyptus acmenioides* and *Melaleuca quinquenervia* in the tree layer. Shrub layer still recovering from fire about one year before. Gley soil.

Fig. 2.—Beach dune succession on Bribie Island.
1 *Cakile maritima* on low berm.
2 *Spinifex hirsutus, Ipomea pes-caprae* on first stabilized dune.
3 Invasion by *Casuarina equisetifolia*.