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Studies in Landscape Dynamics in the Cooloola–Noosa River Area, Queensland.

1. Introduction, General Description and Research Approach.

C.H. Thompson and A.W. Moore

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CONTENTS

STUDIES IN LANDSCAPE DYNAMICS IN THE COOLOOLA-NOOSA RIVER AREA, QUEENSLAND.

1. Introduction, soil landscapes and research approach

C.H. Thompson and A.W. Moore
Division of Soils, St Lucia Qld 4067

Abstract

The Cooloola - Noosa River area lies along the coast of southern Queensland, between Noosa Heads and Inskip Point, some 120-180km north of Brisbane. It occupies some 62 000ha and is made up of large sand dunes, coastal plain, river flats, lakes and low sandstone hills, and includes all of the Noosa River catchment upstream of Lake Cootharaba. The sand dunes are typical of the large accumulations of aeolian sands that occur as sandmasses along the Queensland coast; these are the result of several periods of dune-building, and at Cooloola reach elevations of 260m and extned up to 10km inland.

In 1974, the CSIRO Division of Soils commenced a study in landscape dynamics in the area; eight sites were selected for research into the processes affecting the stability of vegetated coastal dunes. The study used a multi-disciplinary team approach and involved seven projects, eight scientists from the Division of Soils, and twelve from other CSIRO Divisions and outside institutions.

This report is the first of a series dealing with various aspects of landscape dynamics in subtropical coastal dunes. It describes the geology, geomorphology, climate and soil landscapes of the area in some detail; discusses a podzol chronosequence in the sand dunes; and presents some information on the impact that man has had on these coastal dunes. The research approach and research disciplines involved are also described.

Eight depositional units are provisionally recognized in the Cooloola sandmass, six of these expressed now as a series of overlapping dune systems of Quaternary age; the four youngest are of parabolic shape, but the older ones have been much modified by erosion so their original form is less certain. Each of the dune systems has characteristic geomorphic components, each with different rates of water erosion and sedimentation which control soil development and soil pattern.

The term soil landscape is defined as a unit with a characteristic drainage net in which similar environmental conditions and processes are associated with each occurrence of the landform components that make up the landscape. Twenty such units are defined in this report, and selected soil profiles from each unit described. *Podzols* are the most common soils in the Cooloola Sandmass, with the depth and intensity of pedological development clearly associated with the relative ages of the dune systems. This chronosequence provides a wide range of sites with marked differences in nutrient supply, vegetation and biological activity, and erosion. The area proved therfore to be very suitable for the investigation of landscape dynamics of coastal dunes in the subtropics.

INTRODUCTION

In 1974, the Brisbane group of the CSIRO Division of Soils initiated a number of research projects in landscape dynamics as part of the Divisional research program on the stability of landscapes. This program is mainly concerned with the movement of water, solutes and solids over land surfaces and through soils, and with environmental processes, both physical and biological, that affect rates of movement. It is also concerned with changes in soil properties with time and under different forms of land use and management because these changes usually influence the movement of water into and through soils.

Within this program, research groups are located in both Brisbane and Canberra. The Brisbane group has been concerned mainly with landscape dynamics of coastal dunes and of hillslopes in coastal river valleys. Most emphasis in the early stages has been placed on research on the coastal dunes because these provide materials in which basic processes can be studied with minimal interference from soil colloids. In addition, processes can be compared in dunes exhibiting varying stages of erosion, weathering and soil development within the same general climatic zone.

The accelerated use of coastal dunes for housing and recreation in the last decade has made it imperative that the processes controlling the dynamics of these landscapes be understood so that management techniques can be designed to cope with instabilities arising from increasing land use. Consequently, investigations were directed towards understanding the processes operating in different native ecosystems on coastal dunes. The aim was to develop experimental techniques and provide base data against which effects of changes in land use or management could be assessed.

The Cooloola - Noosa River area was selected for field experimentation because the sandmass there is made up of several dune systems and soils of different ages and is representative of other large dune systems in southern Queensland (Thompson 1975). It is also similar, albeit to a lesser degree, to large dune systems further north and south along the east coast of Australia (Thompson 1981, 1983) and to some areas overseas, e.g. in northern South America and Africa; Cooloola data should be relevant to these systems.

Early in 1974 eight research sites were selected, seven representing different ecosystems associated with the age sequence of dune systems, and one located on a low sandstone hill in the upper catchment of the Noosa River. Detailed characterization of the sites, principally in terms of their soil, water and biological properties, and measurements of the rates of movement of water, solids and solutes were made at these sites from August 1974 onwards. Subsequently, as the project developed, six supplementary sites were selected to provide particular climatic, soil or biological information, and some 200 additional sites throughout the area have been used to provide data on the distribution of soils, plants, fungi and soil invertebrates.

When the study began, virtually all of the sites selected were in state forest reserves, and tenure for the duration of the experiments was guaranteed by the Queensland Department of Forestry. The network of forest tracks gave adequate access to experimental sites, while management as state forest reserves provided a high measure of protection from wildfires and from disturbance by domestic animals and human activities.

The present paper briefly describes the geomorphology and soil landscapes of the area and sets out the overall research approach. It is the first of a series of divisional reports reporting data collected in the various Cooloola research projects.

LOCATION AND GENERAL DESCRIPTION

The Cooloola - Noosa River area is here defined as the eastern and upper catchments of the Noosa River, the dunes of the Cooloola Sandmass and the low coastal plain flanking the southern shore of Tin Can Inlet. It is a triangular-shaped piece of land, about 65km in length (N-S) and up to 25km wide (E-W), lying along the coast between Noosa Heads and Inskip Point, some 120-180km north of Brisbane (Fig.1).

The southern shore of Tin Can Inlet to Carland Creek thence along the Rainbow Beach road to the crest of the Como Scarp mark the north-western limits of the area. The western boundary runs along the Como Scarp south to the old Como sawmill road, along the old road to Fig Tree Point and down the Noosa River to Noosa Heads, following the western shores of Lakes Cootharaba and Cooroibah.

The total area amounts to some 62,000ha of which 24,000ha are sand dunes, 16,000ha are coastal plain and river flats, 4,000ha are lakes, and 17,000ha are low sandstone hills, mainly west of the Noosa River.

Commercial use of the area began in the 1870s with the logging of native conifers and hardwoods and the introduction of grazing animals. In 1925 most of the area was proclaimed as State Forest Reserve 451 and since then it has been managed to provide a sustained yield from the natural species under a system of controlled logging and protection from wildfires. In 1966, mining leases were granted over some 2,000ha of the peninsula north of the main sandmass from Mudlo Rocks to Inskip Point. Access roads associated with this heavy mineral mining led to the development of the present seaside resort of Rainbow Beach at Mudlo Rocks and to increased use of the beach and coastal dunes for recreation. In December 1975, 23,000ha of the area were gazetted as a national park taking in most of the coastal plain and a large part of the sandmass along both the coastal and inland margins but largely excluding the central high dune areas of tall eucalypt forest and rainforest which remain as state forest.

The present tenure is largely state forest and national park. Relatively small areas, below the Como Scarp and north of Tewantin, have been under private control for many years and used for grazing. Although mining operations have ceased, the peninsula north of Rainbow Beach is held under mining lease. Small areas are used for housing at Rainbow Beach, Teewah and Tewantin, and camping grounds have been established at Lake Freshwater and at Double Island Point. Further small areas at Double Island Point and south of Teewah are held by the Australian Government as lighthouse and airfield reserves respectively.

Brief accounts of the history, geography, and flora and fauna of the area have been provided by Coaldrake (1961), Harrold (1971), Hawkins (1975), Sinclair (1978), and Miller and Coster (1979). Its soils and landscapes have been described previously in broad scale surveys covering more extensive areas of the coast (Coaldrake 1961; Isbell *et al.* 1967; Thompson 1975). The present report is based on additional traversing and deeper drilling aimed at improving the understanding of soil and landscape relationships so as to provide an adequate framework for studies of landscape dynamics in the coastal dunes.

GEOLOGY AND GEOMORPHOLOGY

The Cooloola - Noosa River area is situated in the southern part of the Maryborough Basin (Murphy *et al.* 1976) and is largely drained by the Noosa River and its tributaries. It is made up of six physiographic units (Fig. 1).

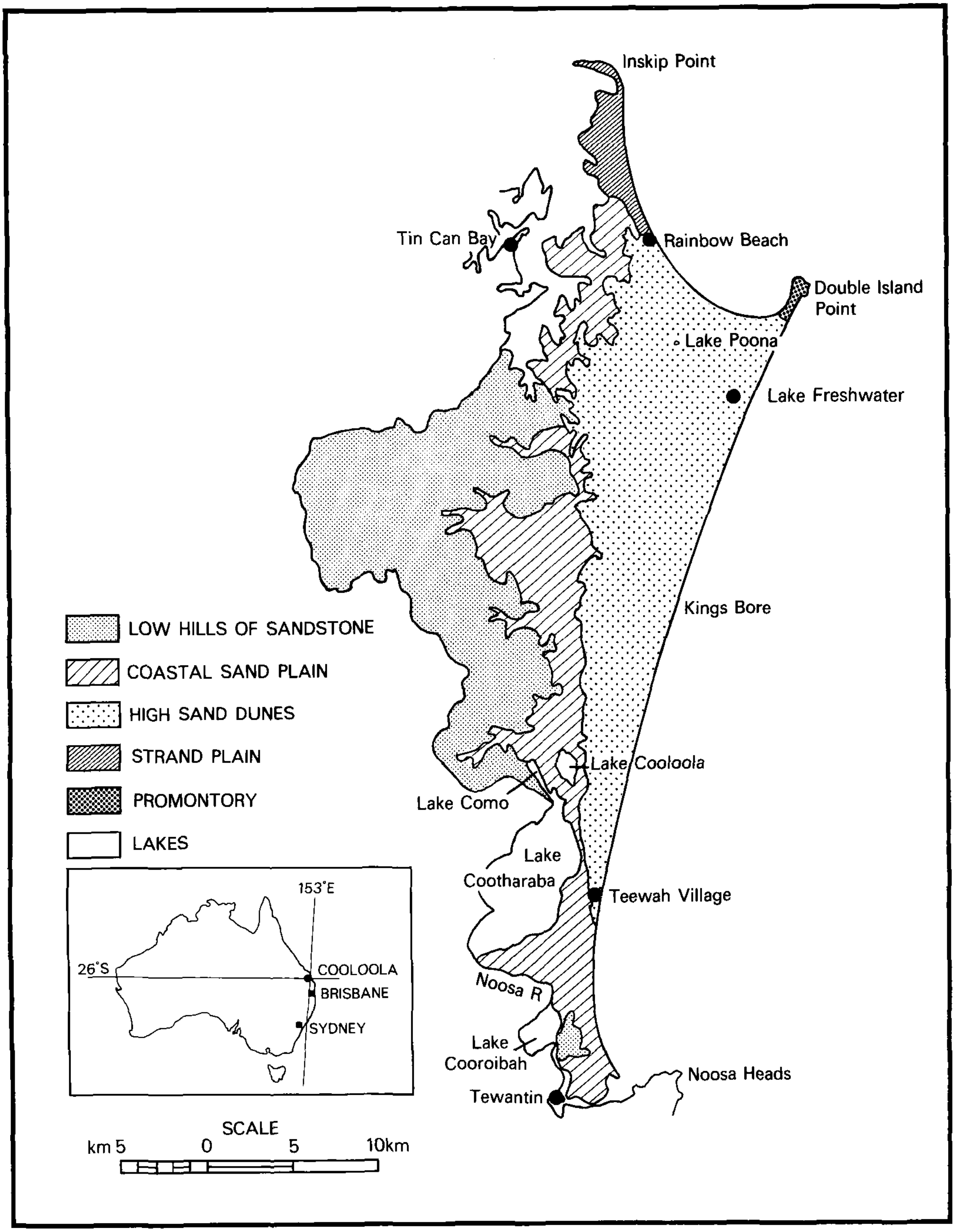


Figure 1. Physiographic units of the Cooloola-Noosa River area.

(1) Low sandstone hills of the river catchment below the Como Scarp (the 'Western Catchment') plus occasional small inliers protruding through the Noosa Plain.

(2) Sand dunes of the Cooloola Sandmass consisting of overlapping dune systems of dominantly quartz sands rising in elevation to as high as 260m above sea level and extending up to 10km inland.

(3) Coastal sand plains, made up of the Noosa Plain adjacent to the Noosa River plus its equivalents that extend to the coast east of Lake Cootharaba and fringe Tin Can Inlet.

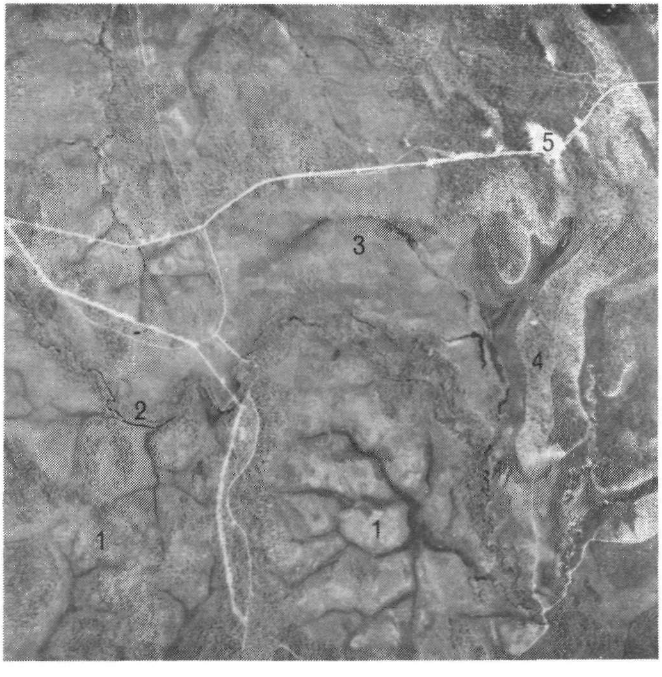
(4) A strand plain of low sand ridges and intervening swales lying parallel to the coast and forming a low peninsula between Rainbow Beach and Inskip Point.

(5) A promontory made up of low hills of aeolianite (calcareous sandstone) and a rocky headland of volcanic rocks (andesite).

(6) Tidal and fresh-water lakes.

Low sandstone hills

The low sandstone hills are cut in the Myrtle Creek sandstone of late Triassic to early Jurassic age (Murphy *et al.* 1976). They are dominantly medium- to coarse-grained, quartzose sandstones with a kaolinitic matrix, but include fine- to medium-grained, sublabile sandstone with siltstone, shale and carbonaceous shale interbeds. Dissection has exposed different beds but all of these have been strongly weathered and are now mantled by a range of soils. The coarse quartzose sandstones with orthoquartzites tend to stand out as cappings and form lag gravels on the higher and steeper hills; the gentler low slopes and broadly convex hills are mostly cut in the sublabile sandstones.



Aerial photo showing: eastern margin of sandstone hills with dendritic drainage net (1), Teewah Creek (2), northern part of Noosa Plain (3), western margin of whale-back sandhills (4) and Mt Bilewilam and quarry for roadbase (5).

Several stages are evident in the dissection of the upper Noosa River catchment and are represented by platforms, cut in the sandstones, with decreasing elevation towards the river. Some of these appear to be mantled by locally-derived sediments.

The sandstones decrease in elevation to the east and pass under the alluvium of the Noosa Plain where local highs of sandstone are exposed as inliers rising through the alluvium just north and east of Lake Cooloola, along the northern shore of Lake Cootharaba, and east of the river near Tewantin. The sandstones also extend below sea level under the Cooloola sandmass and both sandstones and shales have been recorded in bores along the beach and Triassic plant impressions recovered from one sample (Ball 1924). Mount Bilewilam, at the junction of the sandstones and aeolian sands in the central north, is surrounded on three sides and capped by aeolian sands.

An erosion scarp, the Como Scarp (Coaldrake 1961), has been cut into the sandstones by the tributaries of the Noosa River. Its crest, at 60-75m above sea level, defines the river catchment to the north and north-west and separates the drainage systems of the Mary and Noosa Rivers. The escarpment is quite pronounced with moderate to steep slopes spanning elevation differences of 15-30m between its base and crest.

The Noosa River has developed a dendritic drainage pattern between the sandstone hills, characterized by open channels in the third and fourth order streams with gently concave drainage heads forming the first and second order tributaries. The main stream channels are flanked by narrow floodplains which carry comparatively large volumes of water during storm periods. Flood discharge rates from the sandstone hills are high for both Noosa River and Teewah Creek (the main tributary) due to their fan-shaped catchments and to the hard-setting and water-shedding characteristics of some soils and the shallow depths of others.

The swampy drainage lines (first and second order streams) are very important parts of the drainage system. They make significant contributions to base-flow in the open channels through their collection and delivery of seepage waters, while their broadly concave vegetated floors remove much of the sediment from surface flows. Disturbances altering their efficiency in these roles would significantly affect both composition and discharge rates of waters reaching the main river channel.

Sand dunes

The Cooloola sand dunes make up one of the large accumulations of wind-blown sands that occur as islands and mainland deposits along the Queensland coast (Connah 1961; Coaldrake 1962; Thompson 1975; Thompson 1981, 1983). These sandmasses are the result of several different periods of dune-building during which dominantly quartz sands have been blown in from the coast to form overlapping systems of large compound dunes. At Cooloola, these dune systems reach elevations of up to 260m and extend up to 10km inland.

Ball (1924) gave a general description of the Cooloola sandhills and recorded logs of six bores that had been drilled to depths of 15-165m (51-542ft) along the coast during a search for oil. These established that the sandy sediments here overlie Jurassic basement rocks at depths of 23-55m (76-180ft) below high-water mark, that they are interbedded with clay, shale, coarse sand and water-worn pebble beds, and that they contain the remains of plant species that are still common along the Queensland coast. He regarded these underlying sediments as being made up of both wind-blown and estuarine deposits, the latter proven by the occurrence of mangrove (*Ceriops* sp.) material in shale bands exposed at beach level, and by fragments of ***Banksia integrifolia***, ***Casuarina glauca*** and two mangroves (***Ceriops*** sp. and ***Aegisceras*** sp.) recovered from boreholes at depths of 30-37m (100-120ft) below high-water mark. Ball (1924) concluded that the Cooloola sandhills consisted of two different series, both deposited since the Tertiary.

Coaldrake (1960, 1962) also recognized two series, described them in some detail, discussed their origin and age, and gave them formal names, viz. Oceanic Sands and Teewah Sands. The Oceanic Sands were recognized as occurring both above and below the Teewah Sands, which were interpreted as large lenses within the former. Radiocarbon dates from two samples, an organic B horizon of a *humus podzol* and charcoal embedded in sand beneath the *humus podzol*, within the Oceanic Sands but overlying the Teewah Sands at about 76m (250ft) above sea level, gave ages of 30,300±800yr and 39,000±3,000yr B.P. respectively (Coaldrake 1962). Two other radiocarbon dates for samples of wood from near high-water mark, one embedded in sandrock and the other in "brown coal" near high-water mark, showed that both were older than 40,000yr B.P. However, both of these samples are likely to have been contaminated by modern carbon in groundwater issuing at these points; the >40,000yr age should therefore be regarded as minimal. Coaldrake concluded that the dunes had been building intermittently during the Pleistocene and that some of the deposits may in fact be older.

Several different dune systems were observed in the area during reconnaissance soil mapping and it was found that two units were inadequate to accommodate the variations in dune form, degree of erosion and depth of soil weathering evident in the field. Additional informal units were therefore provisionally recognized in a general description of landforms and soils along the coast (Thompson 1975).

Ward *et al.* (1979), in a paper reporting a fossil beach in the sandrock at Rainbow Beach, describe an exposure in the sea cliffs showing contacts between the Teewah Sands, underlying Oceanic Sands and an overlying unidentified unit.

Aerial photo patterns of the overlapping Dune Systems 1—6 in the Cooloola Sandmass; note parabolic shape of dunes in Systems 1—4.

The Cooloola Sandpatch, a large mobile parabolic dune advancing inland through older vegetated dunes and reaching 180m in elevation; coast (1), older vegetated dunes (2), slip–faces (3), trailing arms (4) and dune floor (5).

They concluded, firstly, that the field situation at Rainbow Beach cannot be adequately represented by the two units proposed by Coaldrake (1962) and, secondly, on the basis of correlation between the fossil beach and Gippsland shorelines, that sedimentation here is likely to have begun before 760,000 years ago.

The older a dune system is the longer it may have been exposed to the processes of weathering and erosion that lead to the development of secondary geomorphic features and soil profiles. Such differences were previously used to recognize the four landform and related soil units in the Cooloola dunes (Thompson 1975), of which the 'multi-coloured weakly coherent sands' were approximately equivalent to the Teewah Sands (Coaldrake 1962) and the other three informal units were subdivisions of Coaldrake's Oceanic Sands both above and below the Teewah beds. Subsequent work at Cooloola based on stratigraphic evidence, dune geomorphology, erosional features, and depth and intensity of soil profile development has lead to further subdivisions. Eight separate depositional units are now provisionally recognized, two lying below the Teewah Sand equivalents and five overlying them; however further work is necessary to elucidate the relationship between the Teewah Sand equivalents and the system immediately above them. The Cooloola Sandmass above sea level is now seen as a series of overlapping dune systems of Quaternary age in which the dunes of the four youngest are of parabolic shape.

The term parabolic dune was originally introduced to describe blow-out dunes in Denmark (Steenstrup 1894) and has since been loosely applied to both U- and V-shaped dunes open to the formative winds. This is a normal form for dunes blown into humid vegetated lands, particularly those carrying woodlands and forests. The vegetation on either side of the bare drifting sand traps some sand, thus building characteristic, roughly parallel or converging ridges (the trailing arms) behind the advancing apex. Parabolic dunes have three primary aeolian geomorphic components: the slip-face at the dune apex, trailing arms along each side of the dune with steep external slip-slopes and usually moderate internal slopes, and the concave (in cross-section) dune floor between the trailing arms (Fig. 2). To these may be added inclusions of older dune remnants, occurring as 'islands' or truncated weathering profiles with iron- or organic-cemented pans protruding through the dune floor, and secondary erosional features, such as gully heads, channels, and fans resulting from water erosion of steep external slopes, some internal slopes and parts of the dune floor.

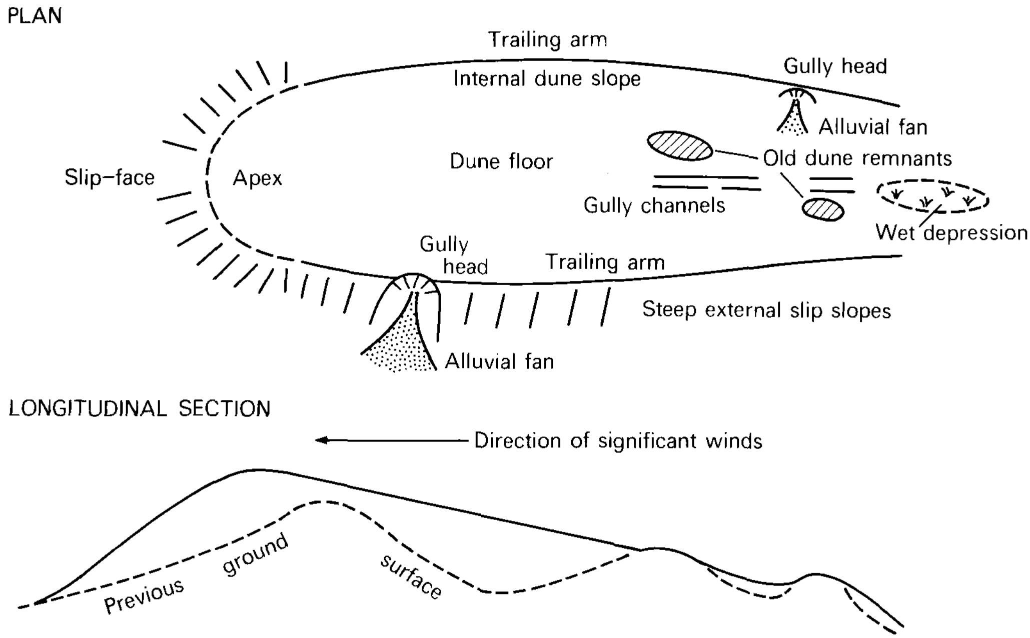


Figure 2. *Geomorphic components of vegetated parabolic sand dunes.*

The youngest four systems (Dune Systems 1, 2, 3 and 4) are clearly made up of U- and V-shaped parabolic dunes open to the formative, predominantly south-east, onshore winds. In the youngest three systems water erosion has not yet breached the perimeter walls of individual dunes, but in the fourth the dune floors have been extensively eroded by water and the trailing arms have been breached in many places.

The next oldest system (Dune System 5) has been much modified by erosion and the original form of its dunes is less certain although the remnant long high ridges and a much-modified apex suggest parabolic shapes also. The approximate equivalents of the Teewah Sands (Coaldrake 1961) recognized here appear to underlie this fifth youngest dune system. This system, referred to here as the Teewah Sand equivalents*, and the dune system immediately below it (Dune System 6) have been so strongly modified by erosion that the initial shape and orientation of the dunes are no longer evident. It is fairly certain that the sandhills making up these systems were higher and much more extensive in the past and have been substantially reduced by erosion. The differences in elevation between exposures of these systems along the western margins of the sandmass and the younger dune systems to the east, the variations in depth of soil weathering on the crests of broad sandhills in the oldest exposed unit (12 to >20m), and the presence of deeply weathered dune sands on the crest of Mount

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* The term Teewah Sand equivalents is used in this report because there is no certainty that the unit we refer to is exactly that envisaged by Coaldrake (1961,1962) although it must be very similar.

Bilewilam and around its margins, all point to substantial erosion over a long period of time.

The Teewah Sand equivalents are extensively exposed in sea cliffs along the coast, outcrop in floors of several dunes in different dune systems and are exposed or near the surface at several localities along the inland flank of the sandmass. It is fairly certain that they underlie most of the present sandmass, make up the largest part of its volume above sea level, and when deposited were much more extensive to the east. Dune System 6, underlying the Teewah Sand equivalents, appears to extend to the coast in several places also. Its relationship to the Teewah Sand equivalents can be seen at a contact between the two, exposed in the sea cliffs at Rainbow Beach (Ward *et al.* 1979).

The oldest of the eight units currently recognized underlies Dune System 6 and is known only from a few exposures along the beach near high-water mark, from the logs of boreholes near Kings Bore, and from a deep auger hole at one inland site. It apparently includes both aeolian and waterlain beds. No surface exposures with soil development have been observed.

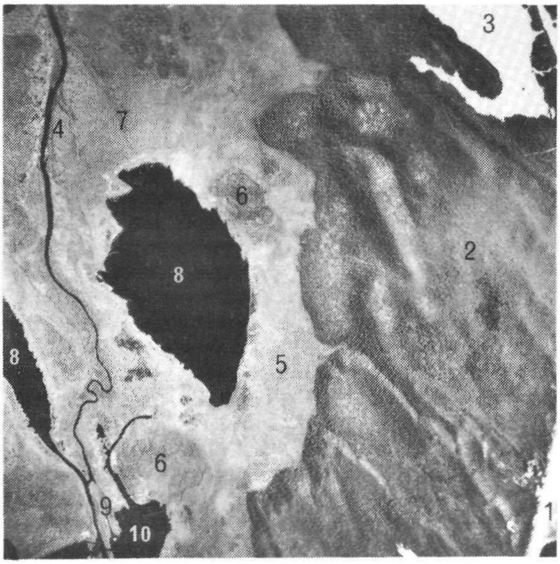
The dune systems can be placed in a relative age sequence using stratigraphic, geomorphic and pedological evidence that show that the sequence must span a considerable period, extending back into the Pleistocene. Absolute ages for individual dune systems have not been established but the radiocarbon dates of Coaldrake (1962) show that some beds are probably greater than 40,000 radiocarbon years old. The radiocarbon date of 30,300±800 B.P. from a sample of the organic pan (Bh horizon) of a "groundwater podzol" (*humus podzol*) 80m (260ft) above the beach (Coaldrake 1962) is an important date. It shows that *humus podzols* developed in this area prior to the last glaciation and that old carbon in these B horizons has persisted through to the present. Unfortunately, it has not been possible to relocate this sample site, so that its precise relationship to the currently recognized dune systems cannot be established. It does, however, provide a minimum date for the formation of *humus podzols* in a dune system younger than the Teewah Sand equivalents and supports Coaldrake's other reported dates in indicating that a large part of the sandmass here is of Pleistocene age. Further support is provided by a date of $43,200^{+4560}_{-2900}$ B.P. obtained from the cellulose fraction of a sample of a tree log lying 6m below the surface of the Noosa Plain where it was embedded in alluvial sands that appear to have been washed out of the sand dunes (C.H. Thompson and H.A. Polach *unpub. data*).

Apex of the mobile Carlo dune showing: saltating sand (1), slip–face (2) and older vegetated dune (3).

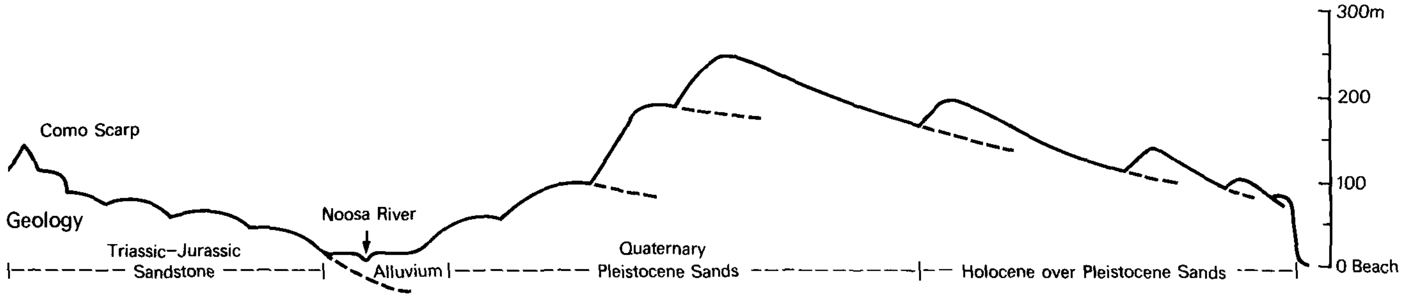
It is also evident that the dunes of the youngest three systems are much less weathered and eroded and therefore are much younger than the dunes in the older systems. The depth of soil weathering is similar to that observed in some of the parabolic dunes of the Outer Barrier at Myall Lakes in New South Wales, where radiocarbon dating has shown the deposits to be of Holocene age (Thom 1965; Thom *et al.* 1978). A radiocarbon dating on a sample of charcoal from the A1 horizon of the soil underlying dune sand at Triangle Cliff, Fraser Island (north of Cooloola), yielded an age of 3,880±105yr B.P. (Grimes 1979). Again, the degree of soil development in the overlying dune sands is very similar to that in the third youngest dune system at Cooloola. The similarity in depths of soil weathering in the younger dunes at Cooloola and those dated at Myall Lakes and Fraser Island strongly suggests similar Holocene ages.

It may be concluded that the relative dune age sequence at Cooloola extends from the Holocene well back into the Pleistocene, that by far the greatest part of the sandmass has accumulated during the Pleistocene and that the Holocene dune systems make up a relatively thin veneer which is generally <50m thick.

Each of the dune systems has a characteristic geomorphic pattern due to the initial size of the dunes, the wind history during its development, the configuration and consistence of the underlying dunes or country rock and the amount of water erosion that has occurred since vegetation cover became established (Thompson 1983). Each system also has a characteristic assemblage of soils associated with the various geomorphic and topographic components of the dunes and their modified remnants. These assemblages are described as soil landscape units in the text, delineated on the accompanying map, and are represented in schematic cross-section in Figure 3. Once the characteristic suite of soils associated with a dune system has been clearly established it can be used to assist in the identification of that dune system in adjacent areas.



Aerial photo showing: coast (1), southern part of Cooloola sandmass (2), the Cooloola Sand patch (3), Noosa River (4), part of Noosa Plain (5), sandstone inliers protruding through alluvium (6), traces of previous river channels (7), delta lakes (8), birdsfoot delta (9) and the northern fringe of Lake Cootharaba (10).



Dune systems				6	5	4	3	2	1
Landforms				Dune remnants	Dune remnants	Parabolic dunes	Parabolic dunes	Parabolic dunes	Parabolic dunes
	Scarp	Low hills	Swampy plain	Whaleback sandhills	High sandridges	Moderately-strongly eroded	Slightly eroded	Weakly eroded	Mobile dunes & sea cliffs
Major soils	*Lithosols & podzolic soils*	*Gleyed & lateritic podzolic soils, soloths & humic gleys*	*Humus podzols & acid peats*	Giant *humus podzols*	Giant *podzols* & giant *humus podzols*	Giant *podzols* & giant *humus podzols*	*Podzols*	*Podzols* & rudimentary *podzols*	Rudimentary *podzols* & *siliceous sands*
Common depth of sola	<1m	<2m	2-4m	12-<25m	10-<18m	8-12m	2-6m	1-2m	<1m
Vegetation	Grassy woodland		Wet heath	Shrubby woodland	Shrubby woodland	Woodland forest & rainforest	Woodland & open forest	Forest	Shrubby woodland

Figure 3. Schematic cross-section showing association of major soils and vegetation formations with dune systems, alluvial plain and sandstone hills.

Coastal sand plains

The Noosa Plain is a flat to very gently undulating sand plain flanking the Noosa River, its tributaries and associated lakes, and extending to the coast east of Lake Cootharaba. It is made up of sandy alluvium, derived from both the sandstone hills and the Cooloola Sandmass, lacustrine sediments downstream of Harrys Hut (Cooloola 028 028*), estuarine deposits along the lower river reaches, and some peat accumulations in the low-lying wet areas of its middle and upper sections.

The two main streams, Noosa River and Teewah Creek, are virtually trenches in the alluvial plain carrying groundwaters seeping out of the sandmass and runoff waters from the sandstone hills, down to Lake Cootharaba. Narrow, weakly-defined floodplains and in places narrow, low levees flank each stream. The Noosa River channel downstream of Teewah Creek junction is comparatively wide and deep, and is virtually an extension of the quiet waters of Lake Cootharaba. During flood periods it carries sediment to the lake where it is building a bird-foot delta at its mouth. Airphotos show the traces of previous river channels which at one time flowed into what is now Lake Cooloola and have since moved progressively westward. An examination of these patterns suggests that Lake Cootharaba at one time probably extended north of Harrys Hut and that both Lake Cooloola and Lake Como owe their existence to the construction of a delta through the northern part of the larger ancestral lake and may therefore be regarded as delta lakes.

Different sections of the Noosa Plain reflect the different processes involved in its development. Downstream of Cooloola 050 070 the impress of delta construction, larger lakes and higher sea levels is fairly obvious. Humic gley soils on the narrow low platforms around the northern and western ends of Lake Como, the western and eastern margins of Lake Cootharaba and the southern part of Lake Cooroibah point to lake levels about 1m higher in the past. Slightly higher levels are implied by the remnants of low sandy shorelines around Lakes Como and Cootharaba. These can probably be correlated with the high sea level shorelines recorded west of Teewah Village (Ward *et al.* 1977).

In the middle section, north of Cooloola 050 070 on the eastern side of the river, the small lateral tributaries have built a series of low-gradient alluvial fans that are interleaved with sediments from the river and Teewah Creek. The present stream channels are weakly entrenched in the older fan deposits. Drilling shows that the sandy alluvium here is more than 10m thick and contains tree logs, charcoal and plant leaves and fruits that have been preserved in the saturated sands. Samples of several different leaves and fruits have been identified by the Queensland Herbarium as representing species common in the present vegetation of the area. However, the radiocarbon date of >40,000 B.P. from the cellulose fraction of the log 6m below the plain surface indicates that these are Pleistocene sediments.

North of Teewah Creek, the plain narrows and the eastern margin extends along drainage lines into the sandmass. Its development here appears to be largely the result of spring sapping of drainage heads and seepage erosion along the sides of the drainage line.

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* Throughout the text, unless otherwise indicated, coordinates refer to the Australian 1:5000 Topographic Survey Transverse Mercator Grid Maps, zone 56J, 9545-I (Wolvi), 9545-III (Laguna Bay), 9545-IV (Cooloola), 9546-II (Kauri Creek) and 9546-III (Wide Bay).

In the north-west (Cooloola 022 217) Teewah Creek has built a low-gradient fan across the plain where the creek emerges from the sandstone hills. The present channel and its floodplain are weakly entrenched in the southern margins of this fan. Drilling has shown that the fan sediments are about 5m thick, overlying *in situ* clay weathered from labile sandstone. Similar fans also occur where the smaller drainage lines join the western margin of the plain and appear to correspond to the older eastern tributary fans in the middle section of the plain.

The Noosa Plain continues to the coast, east of Lake Cootharaba, as a generally flat sand plain with weakly defined depressions, broad low sandy banks and a weakly defined old strandline (Ward *et al.* 1977). A narrow belt of low foredunes overlies the coastal margin of the plain and organic-cemented B horizon remnants of former humus podzols (the sandrock of Ball (1924)) are exposed along the beach, marking a former extension of the plain to the east.

A low coastal plain, equivalent to the Noosa Plain, also lies between the north-western margin of the sand dune systems and Tin Can Inlet. Its character has been determined largely by the drainage waters issuing from the sandmass and by the marine influences of the inlet. Low broad sandy banks representing the degraded margins of the old dune systems and remnants of fans built by streams issuing from them make up the higher southern and inland parts of the plain. The central zone is a generally flat sand plain crossed by broad peat swamps that are fed by seepage waters issuing from the sand dunes. Searys Creek is the only through stream and carries a substantial flow of spring waters from the sand dunes in an open channel to the inlet. Patches of slightly higher sandy sheets and low sandy banks occur sporadically along the coastal margin of the plain and probably represent wind-drifted sand from the intertidal zone. Both sandy and muddy sediments are currently being trapped in the intertidal zone by mangrove communities.

Strand plain

The low peninsula north of Rainbow Beach is dominated by low sand ridges and swales of quartz sands and terminates in the recurved spit known as Inskip Point. Patterns consistent with three periods of recurved spit and parallel sand ridge development are evident on airphotos, recording the growth of the land to the north and east. The series of sand ridges and intervening swales are aligned approximately parallel to the present coastline and are mostly less than 9m in elevation.

Along the coast, a few sharp hillocks of wind-blown sand break the low profile of the foredune and are possibly remnants of apices of small V-shaped dunes that have been recently truncated by the sea. During the past ten years there has been appreciable accumulation of sand along part of this coast near, and south of, the neck of Inskip Point spit.

The western margin of the peninsula is low and generally flat and appears to be mainly of estuarine sediment. This is flanked along the inlet shore by muddy and sandy sediments of the present intertidal zone.

Promontory

A headland of volcanic rocks and three low hills of calcareous sandstones together make up the promontory known as Double Island Point. The rocky headland consists of volcanic lavas, identified as andesite (Ball 1924). Bare rock is exposed around the seaward margins of the headland but the central parts are mantled by brown and yellowish brown quartz sands that in places are more than 6m thick. Along their south-western margin, the lavas are overlain by false-bedded consolidated sands bonded by a calcareous cement derived from included shell fragments (Ball 1924). This aeolianite also outcrops on the lower slopes of the two rounded hills of the promontory neck that connects the headland with the main mass of the Cooloola sand dunes. Although cemented calcareous bands, individually 5-10cm thick, are prominent on the lower slopes, the crests of these hills consist of loose quartz sands to depths of more than 7m. However, some sand beds that are noticeably coarser (higher medium grain size component) than the dune sands of Cooloola generally were found during auger drilling on the hill crests. The relationship between these sands and those imbedded in aeolianite has not been examined.

A sample of the aeolianite analyzed by x-ray fluorescence (J.C. Drinnan *pers. comm.*) contained 15% Ca but only 0.4% Mg; this is consistent with calcium carbonate cement that has been derived from the weathering of shell fragments. However, shelly sands are not being deposited on the adjacent beach at present, so the carbonate must have been derived from older deposits of unknown age.

Quartz sands from the present beach are being blown onto the promontory and have formed a system of low V-shaped dunes that extend across the promontory between the hills of aeolianite. The apices of some of these dunes have been truncated along the northern shoreline leaving the trailing arms as a series of low, approximately parallel ridges separated by dune floors and interdune corridors.

Lakes

Tidal and fresh-water lakes make up about 6% of the area. The Noosa River flows through the two largest lakes, Cootharaba and Cooriobah, both of which are subject to tidal influences. Lakes Cooloola and Como are delta lakes formed by the Noosa River depositing sediment at its entrance to a larger ancestral Lake Cootharaba and are probably Holocene features. Lake Como is connected to Lake Cootharaba by a narrow entrance and is at the margin of the tidal influence. Lake Cooloola is fresh water.

Five small fresh-water lakes, one with clear waters and four with coloured waters (Reeve *et al.* 1984) occur in the sand dunes. Broutha Waterhole and Lake Poona are both on dune floors near the apex of nested, old parabolic dunes and are probably the result of the younger dune reducing free lateral drainage along the older dune floor. Lake Freshwater appears to have a similar origin; a Holocene dune has blocked off an old fluvial valley developed in the Pleistocene dunes. Webber Swamp is an old lake floor with surface water restricted to the northern end. The southern end has been breached by drainage to the Noosa River, while the northern end probably loses water by seepage to tributaries of Cooloola Creek.

CLIMATE

The objective of this section is two-fold. First, it is intended to give a broad picture of the climatic conditions prevailing in the Noosa-Cooloola area and, secondly, an attempt is made to indicate to what extent the period during which we collected data (1974-77) was 'representative' climatically. Very briefly, the climate is subtropical coastal, with hot, moist summers and mild, drier winters. A good general account of the climate of a much larger area, the coastal lowlands from Brisbane to Bundaberg, has been given previously (Coaldrake 1961).

TABLE 1

Monthly and annual climatic data (1892-1974) for Double Island Point Lighthouse (Station No. 40068), latitude 25°56'S, longitude 153°11'E, elevation 77m, 82-yr record (Bureau of Meteorology 1975)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)													
Mean	180	175	174	134	140	125	92	61	56	73	83	135	1428
Medium	140	128	157	111	134	107	75	60	50	53	70	119	1382
Raindays (no.)													
Mean	13	14	17	14	15	12	11	9	9	9	9	11	143
Daily maximum temperature (°C)													
Mean	27.1	27.1	26.3	24.5	22.0	19.9	19.1	20.2	22.1	24.2	25.6	26.7	23.7
86 percentile	29.2	29.2	28.2	26.7	24.2	21.7	21.4	22.3	24.1	26.1	27.8	28.9	
14 percentile	25.0	25.2	24.4	22.8	20.0	18.3	17.1	18.1	20.0	21.8	23.3	24.4	
Daily minimum temperature (°C)													
Mean	22.0	22.0	21.3	19.6	16.9	14.9	13.5	14.4	16.4	18.5	20.0	21.0	18.4
86 percentile	23.8	23.8	23.2	21.4	19.4	17.2	16.0	16.7	18.3	20.0	21.7	22.8	
14 percentile	20.0	20.6	19.7	17.8	14.4	12.6	10.6	12.2	14.4	16.7	18.1	18.9	
Mean relative humidity (%)													
0900hrs	76	79	78	75	75	74	72	70	71	72	73	74	74
1500hrs	74	77	75	72	68	67	64	64	65	68	71	72	70

TABLE 2

Monthly and annual climatic data (1892-1974) for Tewantin (Station No. 40264), latitude 26°24'S, longitude 153°3'E, elevation 9m, 78-yr record (Bureau of Meteorology 1975)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)													
Mean	232	233	241	171	143	118	86	53	69	95	111	157	1709
Median	181	181	204	151	126	82	60	45	52	82	92	145	1650
Raindays (no.)													
Mean	12	13	15	11	11	9	8	7	8	8	9	10	121
Daily maximum temperature (°C)													
Mean	28.5	28.2	28.3	26.1	23.4	21.4	20.6	22.0	23.6	25.5	27.6	27.9	25.3
86 percentile	30.5	30.1	29.7	28.1	25.4	23.3	22.2	24.1	26.2	27.9	31.0	30.6	
14 percentile	26.1	26.4	26.0	24.1	21.2	19.4	18.8	19.9	21.3	23.0	24.4	25.4	
Daily minimum temperature (°C)													
Mean	21.1	21.2	20.1	17.5	14.2	11.8	9.8	11.0	13.1	16.1	18.3	20.1	16.2
86 percentile	23.1	22.8	22.1	19.6	17.8	14.9	14.1	14.4	16.1	18.8	21.6	22.1	
14 percentile	18.9	19.4	18.2	15.4	9.8	8.4	5.7	6.9	9.8	13.1	15.3	17.8	
Mean relative humidity (%)													
0900hrs	70	74	73	75	73	77	74	72	66	66	63	68	71
1500hrs	67	69	65	61	59	59	56	56	56	62	60	67	61

Rainfall

For the Noosa-Cooloola area the annual rainfall median lies between 1200 and 1600mm. The nearest stations with long-term climatic records are those at Double Island Point lighthouse, at the northern end of the area, and Tewantin, some 35km further south. Annual rainfall median and mean for Double Island Point are 1428 and 1382mm respectively (Table 1) and for Tewantin are 1709 and 1650mm (Table 2). Distribution of total annual rainfall values appears to approximate normality (means are only 3-4% higher than medians).

The distribution of monthly rainfall values, however, shows strong positive skewness (means being about 20% higher than medians), i.e. over many years, for any given month, there is a tendency for it to be drier more often than average and wetter less often. Rainfall is strongly summer-dominant, approximately 50% falling during the period January-March inclusive. The greatest number of wet days per month occurs in March (mean for the two stations = 16 days) and is twice that of the lowest month, August (8 days).

Rainfall intensity is important in any consideration of runoff and/or soil movement on slopes. As part of the Representative Basin Program, the Bureau of Meteorology installed four pluviometers in the Teewah Creek catchment in 1972; three were subsequently removed in 1981. In the period April 1972 to December 1976 the highest intensity recorded for a 6-min period was 17.6mm (a rate of 176mm/hr or 7in/hr) in July 1973 at Station No. 40465. Intensities over 6-min intervals often varied widely between the four different sites at any one time, even though the greatest distance between any two is only 3.5km, but daily rainfall showed a higher correlation between sites.

A large amount of rain was received in January 1974 (during which cyclonic rains resulted in the flooding of the Brisbane River); for the four days of the 'flood weekend' (24/1/74 to 28/1/74) 698 and 749mm of rain were received at Stations No. 40464 and No. 40465 respectively. The highest daily rainfall was 313mm at the latter station (on 27/1/74), which approaches the high daily figure of 388mm on 24/1/28 at Inskip, about 20km to the north (Coaldrake 1961). Higher daily totals (with which are associated higher intensities for shorter periods also) are evident for the summer periods than for the winter periods.

For one of the Bureau of Meteorology stations (No.40464) over a two-year period (April 1972-March 1974) there were 198 days when >50mm of rain were received, 118 when >100mm were received, and 60 when >200mm were received. In January 1974 the number of days in these three categories were 24, 20 and 12 respectively. These figures probably give some idea of the frequency of occurrence of surface runoff in the western Noosa River catchment where the soils on the sandstone hills are only moderately deep and many have hardsetting surface horizons. A precise estimate of the water-holding capacity of the soils derived from sandstone is not available, but assuming an average depth of 20cm for the sandy A horizon (which lies over a clay B horizon) and a porespace of 45%, the saturated soil would hold approximately 9cm of water. Thus surface flow could be expected to occur from an initially dry soil for any day when rainfall exceeds 100mm. For soil at field capacity (say 15%), which would often be the case in summer, surface flow would occur after 60mm of rain had been received. However, many of the soils have hardsetting surface horizons and on some slopes, such as that at the sandstone hills research site (R8), runoff would occur from much lower falls.

Temperature and humidity

Daily maximum and minimum temperatures and mean relative humidity at 0900 and 1500hr, on a monthly basis, are shown in Tables 1 and 2 for Double Island

Point and Tewantin respectively. Highest mean daily maxima and minima occur in January and are 28°C and 22°C respectively (values are means for the two stations). The lowest occur in July and are 20°C and 12°C respectively. At Double Island Point there is little change in diurnal variation in the course of the year, it remaining between 5°C and 6°C all year around. However, at Tewantin, which is somewhat removed from the maritime influence, diurnal variation ranges from 7-8°C in December-March to 10-11°C in July-September. Even greater differences could be anticipated further inland, e.g. on the Noosa Plain and in the western Noosa catchment. Frosts may occur here occasionally (Coaldrake 1961).

The Bureau of Meteorology (1975) has chosen to present 14th and 86th percentile values for temperature in its climatic averages tables because these can be interpreted as follows: on the average, the temperature on one day per week remains lower than the 14th percentile and on one day per week rises above the 86th percentile. It happens that these percentiles are close to those (16th and 84th) which are one standard deviation below and above the mean in a normal distribution. An examination of the values in Tables 1 and 2 indicates that the 14th and 86th percentiles are virtually equidistant from monthly means and therefore it is reasonable to assume that monthly temperature values are not skewed (as is the case for rainfall) and that the mean and median coincide.

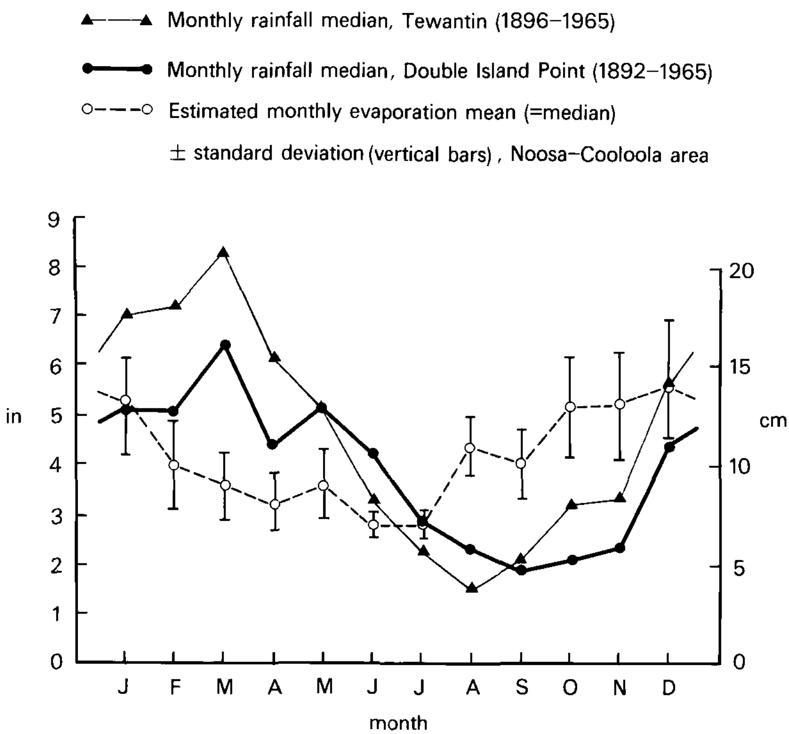


Figure 4. Monthly rainfall medians for Tewantin and Double Island Point, and estimated monthly evaporation mean for the Noosa-Cooloola area.

Evapotranspiration

No empirical evaporation data is available for the Noosa-Cooloola area but an estimate has been made from the maps presented by the Bureau of Meteorology (Anon. 1968). These are based on records from the standard 'Australian sunken tank' at 70 stations around Australia. As for temperature, distribution of evaporation on a monthly basis appears to be normal, and the estimated data shown in Figure 4 can be considered to represent means ± standard deviations or medians and 16th and 84th percentiles.

If monthly evaporation is compared with the corresponding rainfall medians for Double Island Point and Tewantin (Fig. 4) it is evident that, on average, rainfall exceeds evaporation in the period January-June, while the reverse is true for August-November. The months of July and December are in a 'cross-over' situation. Thus the 'drought period of late winter-spring may be quite severe in some years' (Coaldrake 1961), placing the vegetation under water stress and producing conditions conducive to severe bushfires. Consequently prescribed burning in the area is usually carried out by the Department of Forestry and the National Parks and Wildlife Service in May-July.

Wind

Wind direction data for Double Island Point has been presented by Coaldrake (1961) in the form of 'directional wind roses' on a monthly basis (30-yr record). The 'prevailing' wind comes from the south-east; 25 to 50% of observations occur in this quarter, with somewhat more frequent occurrences in the January-May period than in the rest of the year. There are appreciable southerly winds (approximately 25% of observations) and northerly winds (10-25% of observations) for the periods of April-August and September-December respectively. Cyclonic winds result in infrequent, random, catastrophic effects on vegetation.

VEGETATION

The vegetation of the Cooloola - Noosa River area contains more than 750 species (A.G. Harrold *pers. comm.*) occurring in several structural forms ranging from sedgelands and wet heath through various types of woodlands and grassy forests to closed sclerophyll forests and rainforests. Land use and management have further increased the variability by changing the proportions of species occurring locally, by altering both canopy and ground cover and by introducing exotic species. For example, selective logging for both hardwood and rainforest timbers has altered tree canopy cover over much of the area, and prescribed burning to reduce the risk of wildfires has changed both density and composition of the ground cover.

The area has been mapped previously in terms of four landscape units and the vegetation described within six land systems in which eight vegetation classes were recognized (Coaldrake 1961), based on the structural units of Wood and Williams (1960). A general description of the changes in vegetation from the coast inland across the Cooloola sand dunes and the Noosa Plain has also been provided by Harrold (1971). The rainforests (vine scrubs) have received more detailed attention; they have been classified according to structure (Webb 1968) and an extensive species list has been compiled (Webb and Tracey 1975).

None of these studies recognized the different dune systems in the area or the close association between vegetation communities and depth of soil weathering in the dunes, although Coaldrake (1961) depicted several soil and vegetation relationships, mainly associated with differences in drainage. Detailed examination of the soils and vegetation at our research sites plus traverses across the dune systems have shown a close association between vegetation communities and depth of soil weathering (Walker *et al.* 1981) and to landform component, soil drainage and exposure to wind (J. Walker and C.H. Thompson *unpub.. data*). When one of these factors exerts a strong control and remains relatively constant in parts of different soil landscapes similar forms of vegetation usually develop at these sites, e.g. patches of vine scrub in corridors where watertables are below the surface but within reach of deep roots or patches of forest in the old dune systems where erosion has stripped the weathered products so that sesquioxide-coated sands are close to the ground surface.

In this report only general descriptions of the vegetation are given and they are included in the section describing the soil landscapes because of the strong association between vegetation forms and soils. Descriptions are based on detailed examinations of vegetation at the main research sites (J. Walker and M.S. Hopkins *unpub. data*) and from reconnaissance traverses across the Cooloola sand dunes and the Noosa Plain. The structural classes recognized are based on the classifications of Webb (1968) for vine scrub and of Walker and Hopkins (1984) for other vegetation. A summary of the main structural classes, some common species and their relationships to the soil landscapes is given in Table 3. A comprehensive study of vegetation is being made as a contribution towards understanding the stability of coastal dunes and will be published elsewhere.

TABLE 3

Summary of soil landscapes, land forms, dominant soils and vegetation in the Cooloola - Noosa River area

Soil landscapes	Landforms	Dominant soils and depth of sola	Vegetation
Mutyi	Seacliffs and exposed adjacent slopes	*SILICEOUS SANDS* Uc1.21 on truncated *PODZOL* remnants	Shrubby woodlands: *Banksia integrifolia* over shrubs <1m tall, severely deformed by wind
	Active mobile dunes	*SILICEOUS SANDS* Uc1.21	Colonizing patches of shrubland: *Pultenaea, Banksia, Acacia, Casuarina* and *Callitris*
	Young V-shaped dunes	Rudimentary *PODZOLS* Uc3.21 (<1m)	Dwarf to low forests and woodlands: *Eucalyptus, Tristania, Callitris, Angophora* and *Acacia*
Chalambar	V-shaped dunes; weak erosion on trailing arms	Young *PODZOLS* Uc2.21 (1-2m) on floors and trailing arms. Rudimentary *PODZOLS* Uc3.21 on trailing arms and slopes. *SILICEOUS SANDS* Uc1.21 on fans	Layered forests 12-19m tall: *Eucalyptus signata, E. intermedia, Angophora woodsiana, Tristania conferta, Causarina torulosa* and *Banksia serrata* over open *Acacia, Leptospermum* and *Xylomelum* understorey; *Themeda, Pteridium* and *Xanthorrhoea macronema* prominent in ground cover
Burwilla	Lobate U-shaped dunes; uneven floors, slight erosion on trailing arms	*PODZOLS* Uc2.21, Uc2.22 (2-6m) on floors. *PODZOLS* (<3m) on trailing arms. Rudimentary *PODZOLS* (<1m) on slopes	Layered woodlands to grassy open forests: *Eucalyptus pilularis*(20-30m) over *Angophora woodsiana* and *Casuarina torulosa* (18-20m) over open *Banksia, Acacia, Casuarina* and *Leptospermum* lower storey. In the eastern part of the soil landscape *E. signata, E.intermida* and *C. torulosa* are very common. *E. signata* has not been observed in the western parts
Warrawonga	Broad U-shaped dune remnants; moderately to strongly eroded trailing arms and floors	Giant *PODZOLS* Uc2.21, Uc2.20 (8-12m) on freely-drained ridges	Woodlands and forests: *Eucalytpus pilularis*(30-50m), *E. intermedia, Tristania conferta, Syncarpia hillii, Casuarina torulosa, Angophora woodsiana* and *Banksia aemula* over open to dense understorey of *Acacia, Leptospermum* and *Casuarina*. Ground cover includes *Pteridium, Themeda, Imperata* and *Xanthorrhoea macronema*
		Giant *HUMUS PODZOLS* Uc2.20 (8-12m) in corridors	Simple or complex notophyll vine forests and microphyll vine forests (20-40m). Also included are minor areas of secondary low mesophyll vine forest with sclerophyll emergents. The main areas of vine forest are in this landscape, minor areas occupy sheltered sites in other soil landscapes

Soil landscapes	Landforms	Dominant soils and depth of sola	Vegetation
Mundu	Large high sandridges; remnants of severely eroded dunes that probably had large open U-shaped form	Giant *PODZOLS* Uc2.22 (10-18m+) on sandridges. Giant *HUMUS PODZOLS* Uc2.33 (10-18m) in corridors	Shrubby layered woodlands (12-20m): *Eucalyptus signata*, *Angophora costata* and *E. intermedia* over *Banksia aemula*, *Acacia flavescens* and *Leptospermum attenuatum* understorey (3-8m). *Xanthorrhoea media* and heath genera are prominent in understorey. *B. aemula* and *Leptospermum* are prominent in corridors
		Iron *PODZOLS* Uc2.21 (1-4m) on some slopes	Open forests (30m): *E. pilularis*, *E. intermedia* and *A. woodsiana* over *B. aemula*, *A. flavescens*, *L. attenuation* and *X. media* in ground cover
Kabali	Low broad whaleback sandhills; very severely eroded remnants of old dunes	Giant *HUMUS PODZOLS* Uc2.20, Uc2.33 (12-25m+) on crests slopes and corridors	Shrubby woodlands (8-12m): *Eucalyptus signata*, *Angophora costata*, *E. intermedia*, *Banksia aemula*, *Acacia flavescens* and *Leptospermum attenuatum* over *Xanthorrhoea johnsonii* and heath genera. Areas of dwarf shrubby woodland (1-3m) where soil depth to B2h is >20m
Double Island Point	Rocky headland with veneer of aeolian sands	*LITHOSOLS - PRAIRIE SOILS* Um6.11, Gn3.41 on andesite. *SILICEOUS SANDS* Uc1.23 varying to >6m	Woodlands: *Banksia integrifolia* and *Pandanus pedunculatus* (3-4 m) over shrubs <1m tall, severely deformed by wind. Some open grassy patches of *Themeda* and *Zoysia*
Bula Kalim	Low hills forming neck of promontory; aeolian sands over aeolianite	*SILICEOUS SANDS* Uc1.22, Uc1.23 (varying to 6m)	Woodlands: *Banksia integrifolia*, *Casuarina equisetifolia*, *Acacia* sp. (4-6m) and shrubs <1m tall on exposed slopes. *B. serrata*, *Tristania conferta* and *C. littoralis* occur on some crests
Tingirri	Narrow foredunes parallel to coast	*SILICEOUS SANDS* Uc1.21 (<1m).	Woodlands: *Banksia integrifolia* and *Causarina equisetifolia* (4-6 m) on dunes, *Melaleuca quinquenervia*, *B. robur* and sedges in swales
Inskip Point	Strand plain of low sandridges and swales parallel to coast; includes sand sheets foredunes and mined areas	*PODZOLS* Uc2.21 (<6m) on sandridges	Layered forests: *Eucalyptus intermedia*, *Tristania conferta*, *E. tessellaris*, *Callitris columellaris* (15-18 m), *Casuarina littoralis* and *Banksia serrata* over softwood scrub species and palms
		HUMUS PODZOLS Uc2.20 in swales	Forests: *M. quinquenervia* (6-8 m) with ground cover of *Imperata*
		SILICEOUS SANDS Uc1.21 (<1m) on foredunes	Woodlands: *B. integrifolia* and *C. equisetifolia* (6-8 m) over shrubs <1m tall, severely deformed by wind
		Anthropic *SILICEOUS SANDS* Uc1.21; areas revegetated after mining	Woodlands: *Acacia concurrens* (8-12 m) with some *A. flavescens*, *A. aulacocarpa*, *C. columellaris* some *Lantana camara*
Smooger Point	Coastal plain, sandy sheets and low sandy banks	*HUMUS PODZOLS* Uc2.33, Uc2.20 (2-4m)	Woodlands: *Melaleuca quinquenervia* with some *Tristania conferta*, *T. suaveolens* and *Eucalyptus intermedia* (8-10 m); in places dense understorey of *Acacia*, *Casuarina littoralis*, *Alphitonia excelsa* and palms
Pirri	Intertidal zone	Saline sands Uc1	Open woodlands to dwarf forests: mangroves including *Avicennia marina* and *Rhizophora stylosa* (2-5 m)
Nilkan	Coastal sand plain	*HUMUS PODZOLS* Uc2.33, Uc2.20 (2-4m) on sandsheets and low sandy banks	Wet heath (generally 1m): *Banksia oblongifolia*, *B. robur*, *Boronia* spp., *Xanthorrhoea resinosa* and sedges usually prominent on sandy sheets
			Shrubby woodlands (5-8m): *B. aemula*, *Acacia* and *Casuarina littoralis* on sandy banks
		PEATY PODZOLS Uc2.33 and *ACID PEATS* O in depressions and wet mounds	Sedgelands (1m): sedges including *Restio* spp. and *Gahnia*, some *B. robur*
Yikiman	Low-gradient fans of sand alluvium washed out of dunes	Giant *HUMUS PODZOLS* Uc2.(33?) (12m) on fan apices. *HUMUS PODZOLS* Uc2.33 (2-4m) along fan margins	Shrubby woodlands: *Eucalyptus signata* (11-14 m), *Banksia aemula*, *Casuarina littoralis* and *Acacia*, some *E. umbra* in places
		PEATY PODZOLS Uc2.33 (2-4m) and *ACID PEATS* O in drainage lines	Sedgelands (1m): sedges including *Restio* spp. and *Gahnia*, some *B. robur*.

Soil landscapes	Landforms	Dominant soils and depth of sola	Vegetation
Noosa River	Floodplains, terraces and low levees of Noosa River and tributaries	*GLEYED PODZOLIC SOILS* Gn2.94 on terraces. *ALLUVIAL SOILS* Uc1.41 on floodplains and some levees	Grassy woodlands: *Eucalyptus signata* (10-14 m), *E. tereticornis*, *E. umbra*, *Tristania suaveolens* and *Casuarina littoralis* with patches of fringing forest including *Syzygium* and *Elaeocarpus* along stream channels
		HUMIC GLEYS Dg5.41 in swampy drainage lines	Layered woodlands: *E. robusta* (14-18 m), *Melaleuca sieberi*, *M. quinquenervia*, *T. suaveolens* and *Banksia robur*
Dibing	Deltaic plain and stranded shore-lines of previously larger lakes	*HUMIC GLEYS* Dy3.11 and gleyed ALLUVIAL SOILS Um6.22 on flats. *SILICEOUS SANDS* Uc1.21, Uc1.22 on sandridges and some levees	Varies from dense forests of *Melaleuca quinquenervia*, with or without *Casuarina glauca* (15-18 m)on flats, to woodlands with *M. quinquenervia* and *Banksia aemula* and to sedgelands in places. Some vine scrub species in places on levees.
Tarangau	Low gradient sandy fans; includes some low, broadly convex sandstone hills	Sandy *YELLOW PODZOLIC SOILS* Gn2.74 (>1.5m) and *PODZOLS* (Uc.3.33) on fans	Open forest: *Eucalyptus grandis*, *E. intermedia* and *Tristania conferta* (2—28 m) as tall emergents above dense vine scrub (8-10m)
		?Sandy *YELLOW PODZOLIC SOILS* . ?Dy5.41 on low sandstone rises	Forests: *E. intermedia*, *T. conferta* (16-20 m) and *Casuarina torulosa*
Pertaringa	Low hills of sandstone	*GLEYED PODZOLIC SOILS* Dg2.41, Dy3.41 and SOLOTHS Dy3.41 on slopes and some crests	Grassy woodlands: *Angophora costata*, *Eucalyptus umbra* (12-15 m), *Casuarina littoralis*, *Banksia oblongifolia*, *Xanthorrhoea resinosa* and *Hakea gibbosa*
		LATERITIC PODZOLIC SOILS Gn2.74/pedal clays on crests and slopes of long platforms	Open grassy forests: *E. signata*, *E. intermedia*, (15-20 m), *A. costata* and *C. littoralis*
		HUMIC GLEYS Dg4.81, Dg2.81 and some *ACID PEATS* O in drainage lines	Woodlands to open woodlands and sedgelands: *Melaleuca quinquenervia* (10-12 m), *M. sieberi*, *B. robusta*, *B. robur* and sedges
Mullens	Steeply-sloping hills of sandstone	*LITHOSOLS* Uc4.1 and podzolic *LITHOSOLS* Uc2.12 on crests and slopes and *RED* and *YELLOW PODZOLIC SOILS* Dr3.41, Dy2.34 on slopes	Open grassy forests to woodlands: *Eucalyptus intermedia*, *E. drepanophylla* and *Tristania conferta* (12-18 m); some *Angophora costata* and *Banksia integrifolia* in places
Como	Steep slopes of sandstone hills	Shallow *YELLOW PODZOLIC* IC *SOILS* Dy3.21 (<80cm), podzolic *LITHOSOLS* (Uc2.12) on slopes	Open grassy forests to forests: *Eucalyptus intermedia*, *Tristania conferta* (12-18 m), *Casuarina torulosa* and *Acacia*

SOIL LANDSCAPES

Definition

A soil landscape is a unit with a characteristic drainage net in which similar environmental conditions and processes are associated with each ccurrence of the landform components that make up the landscape. As used here it is defined as a class of land in which the soils bear a constant relationship to each other because they have formed on a repetitive pattern of landforms developed during the downwearing of a single rock type or single complex of different rocks. Usually only one parent rock and the detrital materials deposited locally from it are involved; however, this mapping unit is sufficiently flexible to accommodate areas of repetitive complex geology in which occurrences of individual rock types are too small to map separately, e.g. outcroppings of narrow strata. A soil landscape has a limited range of topography and a similar drainage pattern throughout. A characteristic pattern in the distribution of native plant communities, associated with the soil/landform/drainage pattern, is usually also evident in each soil landscape. As a result each soil landscape produces a characteristic pattern on air-photos which facilitates its identification and the mapping of its boundaries.

This concept of soil landscape was developed during the mapping of the adjacent Gympie-Cooroy area in 1960-70 (C.H. Thompson *unpub. data*). The concept is more restricted than the landscape unit used by Coaldrake (1961) in mapping ecosystems of the coastal lowlands and is more nearly analogous to that used on North Stradbroke Island (Thompson and Ward 1975). The relationships between the soil landscapes of the present report and the mapping units used in the area previously by Coaldrake (1961), Isbell *et al.* (1967) and Thompson (1975) are shown in Table 4.

TABLE 4

Relationship of soil landscapes to mapping units previously used in the area

Soil landscape units	Coastal landform units (Thompson 1975)	Landscape units (Isbell et al. 1966)	Landscape units* (Coaldrake 1961)
Mutyi	Yellow-brown transgressive dunes and multicoloured weakly-coherent sands	B18	Cooloolah
Chalambar	Yellow-brown transgressive dunes	B18	Cooloolah
Bula Kalim	Yellow-brown transgressive dunes	B18	Cooloolah
Burwilla	High transgressive dunes	B18	Cooloolah
Warrawonga	High transgressive dunes	B18	Cooloolah
Mundu	Low hilly white sandhills	Ca10	Cooloolah
Kabali	Low hilly white sandhills	Ca10	Cooloolah
Yikiman	Low hilly white sandhills	Ca10	Noosa
Inskip Point	Series of beach ridges, foredune, mobile sandsheet complex	B19	Cooloolah
Tingirra	Beach and foredune	Ca12	Noosa
Smooger Point	Coastal sand plain	Z6	Noosa
Nilkan	Coastal sand plain and freshwater swamps	Ca12, Z6	Noosa
Noosa River	Coastal sand plain	Ca12, MB10	Como, Noosa
Dibing	Coastal sand plain	MT3	Cootharaba, Noosa
Tarangau	Coastal sand plain	MT3	Cootharaba
Double Island Point	Low hills of country rock	-	-
Pertaringa	Low hills of country rock	Mb10	Womalah
Mullens	Low hills of country rock	Mb10	Womalah
Como Scarp	Low hills of country rock	Mb10	Womalah
Pirri	-	-	-

* Units are inferred from detailed maps (Coaldrake's Appendix IV) and land system illustrations.

Introduction to soil landscape descriptions

In the Cooloola Sandmass, each of the different dune systems now exposed to weathering and soil formation has been recognized as a separate soil landscape because of differences in initial dune shape, age of groundsurface and subsequent soil weathering and erosion. However, these soil landscapes are not equivalent to the stratigraphic units of geology because they represent surficial materials only and include eroded remnants of older dune systems that have persisted as outcrops or have been exposed by erosion during periods of dune building. In the younger dunes particularly, the soil landscape is a useful geomorphic unit because it includes both the erosional and depositional facets of the new groundsurface developed during the dune-building period and exposed to weathering, soil formation and water erosion after the dune became vegetated.

The degree of soil development and depth of soil weathering in dune sands vary with erosion rates, depth and frequency of wetting and period of exposure. Within a parabolic dune the deepest profiles develop in the almost flat dune floor, near the apex, where erosion is negligible and where there may be minor additions of water and sand by runoff from the adjacent trailing arms. The shallowest profiles are associated with the steepest slopes of gully heads in the external slopes of the dune.

Bare sands on mobile dunes have high rates of water acceptance, but once vegetated the organic-enriched surface horizon can develop a high degree of water repellence. In southern Australia, water repellence in sands has been found to be largely associated with fungal hyphae (Bond and Harris 1964; Bond 1964). Simple water drop tests in the field at Cooloola have shown that large increases in water repellence accompany the increases recorded by Jehne and Thompson (1981) in fungal hyphae in surface samples from colonizing sites through woodlands to dwarf forests on a partly vegetated dune. Similar field tests also show that the surface horizons of the youngest three dune systems (Holocene) mostly have high water repellence but that in the surface horizons of the older dunes (Pleistocene) water repellence is noticeably less. Water repellence is an important feature because it reduces water entry and leads to surface wash on the dune slopes, thereby accelerating erosion and retarding the development of soil profiles.

Soil landscape map

The soil landscapes of the Cooloola - Noosa River area have been identified and mapped on colour airphotos at a scale of 1:25 000, reduced to a publication scale of 1:100 000. Verification of the mapping by soil examination is limited by difficult access in several places and the map is therefore provisional. It should be used with caution, particularly for the area between Lake Como, Cooloola Sandpatch and Teewah Village where the mapping is dependent almost entirely on photo-interpretation.

The soils described in the soil landscapes have been classified according to Stace *et al.* (1968) and these names are used in the following text, with principal profile form nomenclature (Northcote 1979) and provisional placement in U.S. Soil Taxonomy (Soil Survey Staff 1975) given in parenthesis. Most of the profiles on freely-drained dunes are not well catered for in U.S. Soil Taxonomy. The B horizons of the younger soils mostly fail the field, micromorphological or chemical requirements of the spodic B horizon, while the depth to B horizon in the older soils exceeds the depth requirement for Spodsols (Thompson and

Mutyi soil landscape: sea (1), remnants of old dunes carrying *Banksia integrifolia* woodland near the coast (2) and coastal heath in the foreground (3).

Hubble 1980; Brewer and Thompson 1980). As a consequence, most of these soils have had to be placed in the Entisol order despite their clearly developed pedological horizons.

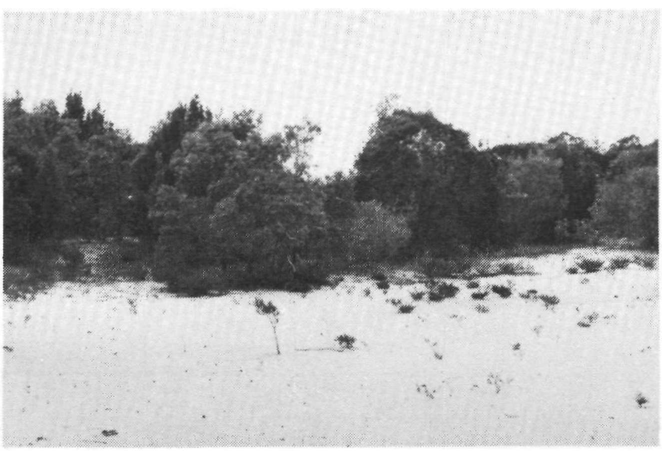
Mutyi soil landscape

This soil landscape is virtually restricted to the coastal margin of the Cooloola Sandmass but it also includes the large mobile dune that extends 3km inland to form the bare sand feature known as the Cooloola Sandpatch. The Mutyi soil landscape is a complex unit dominated by the erosional remnants of old dune systems, mainly Teewah Sand equivalents, with a thin veneer of recently drifted sand; it also includes the youngest system of parabolic dunes, comprising both blowout dunes and invading sand along parts of the coast.

The main landform components are sea cliffs with badland canyons eroded by water and wind, sand ridge bluffs separated by open valleys eroded by wind and water, small mobile or vegetated (stabilized) parabolic dunes and blowout scallops. Local relief is highly variable with the sea cliffs rising almost vertically from high-water mark to elevations of about 100m along much of the coast. Above the sea cliffs, local differences in elevation up to 50m are common between the bluff crests and valley bottoms.

Mutyi soil landscape is exposed to the onshore winds which can reach high intensities during stormy periods, e.g. wind speeds averaging 85km/hr over several one-hour periods were recorded in part of the Mutyi soil landscape during the cyclonic disturbance in February 1981 (P.H. Seguin and D.J. Ross *pers. comm.*). Most trees and shrubs in exposed parts of this unit, other than *Banksia integrifolia* and *Casuarina equisetifolia*, are markedly deformed by the action of wind; wind hedging is a common feature. The wind also carries fierce wildfires inland from the coast and there is much evidence of fire effects. The wind also erodes the dune remnants wherever the vegetative cover is broken. In such cases, it rapidly strips the surface sands down to resistant layers formed by the hardened organic B horizons of old *podzols* or to the ironpans of the Teewah Sand equivalents. Fragments of these ironpans are common at the surface or within the top 50cm of soil over much of the area of dune remnants.

The vegetation is variable because of the differences in soil materials and in exposure to wind and fire. Parts of it have been referred to as coastal scrub, coastal heath or coastal woodland; as a whole it might be regarded as a coastal



Vegetation advancing along a mobile dune in the Mutyi soil landscape: colonizing zone (1), woodland (2) and dwarf forest (3).

shrubby woodland complex. The most common component appears to be *B. integrifolia* shrubby woodland. There are also sizeable areas of shrubland in which species of ***Acacia*, *Banksia*, *Tristania*, *Causarina*** and ***Petalostigma*** are evident. In areas largely protected from the wind, dwarf to low forests have developed in which *Eucalyptus intermedia*, *Tristania conferta*, and in places, *Callitris columellaris* and *Eucalyptus signata* are obvious.

Although juvenile soils dominate the unit, the soil pattern is a complex one that varies with the outcrop of differently coloured sand beds and truncated soils, and with the age and stage of development of vegetation on the young dunes. *Siliceous sands* (Uc1.21) and rudimentary *podzols* (Uc3.21) are the dominant soils. Descriptions of four profiles from Mutyi soil landscape are given below.

Mutyi 1

SILICEOUS SAND (Uc1.22, Quartzipsamment)

Situation: Carlo mobile dune at research site R1
Map ref.: Wide Bay 100 335
Elevation: 115m
Parent material: aeolian quartz sand
Vegetation: none (bare sand)

Horizon	Depth, cm	Soil morphology
C	0-500	Light yellowish brown (10YR6/5)* sand; loose dry; wind-rippled with heavy minerals separated in the ripples. Clear to -
bA_2	500-1200	Very light grey-brown (10YR6/2) sand; A2 horizon of buried giant podzol.

Mutyi 2

SILICEOUS SAND (Uc1.21, Quartzipsamment)

Situation: partly vegetated dune at Kings Bore, research site R11
Map ref.: Cooloola 105 127
Elevation: 75m
Parent material: aeolian quartz sand
Vegetation: dwarf forest; *Eucalytpus intermedia, Callitris columellaris, Casuarina littoralis*

Horizon	Depth, cm	Soil morphology
A1	0-5	Light grey-brown (10YR5/2) sand; loose dry; litter fragments and discrete pieces of organic matter. Diffuse to -

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* Munsell colour notation for moist soil unless otherwise indicated.
\+ Only formal great soil group names (Stace *et al.* 1968) are given in capitals.

C	5-450	Yellowish brown (10YR5/4) sand; loose dry. Clear to -
bA1	450-470	Dark brownish grey (10YR4/1) sand; buried *podzol* A1 horizon. Diffuse to -
bA2	470-500	Off-white (10YR8/2) sand; buried *podzol* A2 horizon.

Mutyi 3

Rudimentary+ *PODZOL* (Uc3.21, Quartzipsamment)

Situation: trailing arm of young vegetated dune at Kings Bore, research site R11
Map ref.: Cooloola 109 128
Elevation: 45m
Parent material: aeolian quartz sand
Vegetation: woodland; *Tristania conferta, Eucalyptus intermedia, Casuarina littoralis, Acacia flavescens*

Horizon	Depth, cm	Soil morphology
A1	0-15	Light grey-brown (10YR4/2), with patches of very light grey-brown (10YR6/2,7/2), sand; loose dry; litter and discrete pieces of organic matter. Diffuse to -
A2	15-30	Light yellowish brown (10YR6/4), with patches of paler (10YR7/3), sand; loose dry. Diffuse to -
Bhir	30-80	Yellowish brown (10YR5/4), with patches of brown (10YR4/4), sand. Diffuse to -
B3	80-100	Light yellowish brown (10YR6/4), with a few patches of yellowish brown (10YR5/4), sand. Diffuse to -
C	100-200	Light yellowish brown (10YR6/4) sand.

Mutyi 4

Rudimentary *PODZOL* (Uc2.21, Quartzipsamment)

Situation: remnant of Teewah Sand equivalents
Map ref.: Cooloola 094 066
Elevation: 45m
Parent material: quartz sands with red sesquioxide coatings
Vegetation: shrubby woodland; *Banksia integrifolia*

Horizon	Depth, cm	Soil morphology
A1	0-10	Grey-brown (10YR4/2) sand; loose dry; diffuse organic matter. Diffuse to -
A2	10-25	Yellowish brown (10YR6/5) sand; loose dry. Diffuse to -
Bir1	25-45	Brownish yellow (10YR6/8) sand; weak coherence, slightly sticky when wet. Gradual to -
Bir2	45-95	Yellowish red (5YR5/8), with patches of red (2.5YR4/6), clayey sand; weak coherence, slightly sticky when wet; some dark red ironpan pieces. Gradual to -
C	95-115	Brownish yellow (7.5YR6/8) and yellow (10YR7/6) clayey sand; some ironpan pieces. Abrupt to -
	115-	Hard ironpan of Teewah Sand equivalents.

Chalambar soil landscape

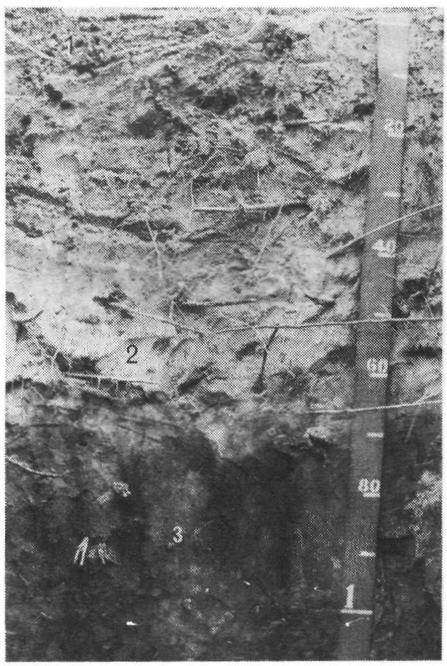
This unit lies along the eastern margin of the sandmass immediately inland from Mutyi soil landscape and in places extending to 2.5km inland. Below the neck of the Double Island Point promontory, dunes of this unit have developed right across the north-eastern shoulder of the sandmass from Laguna Bay to the southern shores of Wide Bay. The dune system forming this unit is dominated by V-shaped dunes with sharp outlines and with little evidence of water erosion showing on the air-photo patterns although small gullies are associated with most external slopes and coastal sections of the dune floors.

The dunes of the Chalambar soil landscape commonly occur at elevations of between 30 and 120m with local relief between dune floors and crests of trailing arms usually <15m but reaching 30m in places. The dunes commonly have single V-shaped apices but in some instances multiple V-shapes have formed along the inland margins. Two forms of apices are apparent; one where the downwind ends of the trailing arms meet in a sharp V that forms the highest part of the dune, the other where the downwind ends of the trailing arms are separated and the dune floor extends right to the slip face in typical 'windrift' form described by Melton (1940). The dunes are generally orientated with the south-east onshore winds and the direction of their advance inland varies between 310° and 340°, as measured on airphotos. The well-preserved sharp outlines, limited erosion and shallow weathering indicate that these dunes are relatively young; they are considered to be Holocene deposits.

In places, remnants of older dunes protrude through the trailing arms and, in others, have been exposed in the dune floor during dune building and subsequently covered by a veneer of sand. These older remnants are mainly Teewah Sand equivalents or truncated B horizons of soils associated with Pleistocene dune systems. Small erosion gullies have developed on the external slopes of the trailing arms with their outlets at the apices of small alluvial fans, about 50m in width, that they have formed at the base of the dunes.

The vegetation is typically a layered forest, 12 to 19m in height, in which *Eucalyptus signata* is the prominent tree species although *E.intermedia* and *Angophora woodsiana* are relatively common. Other tree species include *Tristania* *conferta, Casuarina torulosa* and *Banksia serrata*. The understory is open and patchy and includes *Xylomelum pyriforme* and species of *Acacia* and *Leptospermum*. Three years of fire protection result in approximately 90% ground cover in which *Themeda australis, Pteridium esculentum* and *Xanthorrhoea macronema* are prominent. The tree canopies, particularly those of *E. signata* and *A. woodsiana*, are fairly open, and although the canopies are often almost continuous effective cover is only about 60%.

Most of the soils are *podzols* but there are some areas of *siliceous sands* and minor occurrences of *humus podzols*. The *podzols* vary from rudimentary profiles (Uc3.21) on the dune slopes to young profiles (Uc2.21) on crests of trailing arms and dune floors. The latter have soft friable B horizons with accumulations of both organic and iron compounds (Bhir) at depths of 40-70cm and sola thicknesses of <2m. *Siliceous sands* (Uc1.21) occur on the steepest slopes of the gully heads and on the stratified alluvial sands of the small fans. Minor areas of *humus podzols* occur on the dune floors where they are underlain by less permeable bands (older dune remnants) that have facilitated the development of seasonal watertables. Descriptions of three profiles from Chalambar soil landscape are given below.



Left. Forest with *Eucalyptus signata* at research site R2, Chalambar soil landscape. **Right.** Young *podzol* developed in the floor of a System 2 dune at reaseach site R2, Chalambar soil landscape; horizons are A_1 sand with organic fragments (1), A_2 bleached sand (2) and B_2hir sand with accumulations of organic compounds and sesquioxide (3).

Chalambar 1

PODZOL (Uc2.21, Quartzipsamment)

Situation: dune floor at research site R2
Map ref.: Cooloola 125 194
Elevation: 105m
Parent material: aeolian quartz sand
Vegetation: layered forest; *Eucalyptus signata*, *E.intermedia*, *Angophora woodsiana*

Horizon	Depth, cm	Soil morphology
A11	0-5/12	Very light brownish grey (10YR6/1,7/1) sand; loose dry; discrete pieces of organic matter and charcoal. Clear to -
A12	5/12-45	Brownish grey (10YR4/1), grading to light brownish grey (10YR5/1,6/1), sand; loose dry; diffuse organic matter. Diffuse to -
A2	45-55/60	Very light grey-brown (10YR6/1,7/2) sand; loose dry. Clear, slightly uneven to -
Bhir	55/60-75	Brown (10YR4/4), with patches of yellowish brown (7.5YR5/6), sand; barely coherent dry; some tongues of very light brown (10YR6/2) A2. Diffuse to -
Birh	75-110	Yellowish brown (7.5YR5/6), with patches of dark brown (7.5YR4/3), sand; barely coherent dry. Very diffuse to -
B3	110-180	Yellow-brown (10YR6/6), with some dark brown (7.5YR4/3) patches decreasing with depth, sand; loose dry. Very diffuse to -
C	180-270	Pale yellow-brown (2.5Y6/5,10YR7/5) sand; loose dry; some grains of heavy minerals.

Chalambar 2

Rudimentary *PODZOL* (Uc3.21, Quartzipsamment)

Situation: crest of trailing arm of V-shaped dune
Map ref.: Cooloola 126 177
Elevation: 60m
Parent material: aeolian quartz sand
Vegetation: forest; *Eucalyptus signata*, *E.intermedia*

Horizon	Depth, cm	Soil morphology
A11	0-5/8	Light brownish grey (10YR6/1,6/2) sand; loose dry; discrete pieces of organic matter and charcoal. Clear to -
A12	5/8-15	Brownish grey (10YR5/1,4/1) sand; loose dry; diffuse organic matter. Diffuse to -
A2	15-18/20	Light brownish grey (10YR6/1), with patches of very light grey-brown (10YR7/2,8/2), sand; loose dry. Clear to -
Birh	18/20-55	Yellow brown (7.5YR5/6), with a few dark brown (7.5YR4/3) patches, sand; barely coherent dry. Diffuse to -
C	55-300	Pale yellow-brown (10YR7/5) sand; loose dry.

Chalambar 3

SILICEOUS SAND (Uc1.21, Quartzipsamment)

Situation: fan derived from young dune at research site R2
Map ref.: Cooloola 123 194
Elevation: 75m
Parent material: quartz sands, fan alluvium
Vegetation: grassy layered open forest; *Tristania conferta, Eucalyptus signata*

Horizon	Depth, cm	Soil morphology
A11	0-5	Light brownish grey (10YR6/1,7/1) sand; loose dry; discrete pieces of organic matter and charcoal. Clear to -
A12-C	5-20/30	Brownish grey (10YR4/1,4/2) sand; loose dry; diffuse organic matter; patches of yellow- brown (10YR5/4) sand decreasing with depth. Clear to -
bA1	20/30-60	Grey-brown (10YR4/2), with patches of brownish grey (10YR5/1) and light brown (10YR6/3), sand; loose dry. Diffuse to -
bC	60-90/140	Light yellowish brown (10YR6/4,6/3) sand; loose dry. Clear to -
bA1	90/140-160	Dark grey-brown (10YR3/2,4/2) sand; loose dry. Diffuse to -

bC	160-200	Light yellowish brown (10YR6/4,6/3) sand; loose dry.
	200-	Variable number of stratified ground surfaces with developed A1 horizons over C horizon alluvium to depths of 5-9m at which fan alluvium usually overlies pale yellow-brown aeolian sands of the dune base. With depth these overlie dark brownish-grey (10YR3/1) A1 horizons of a buried *podzol* (Uc2.21) formed in the floor of an older dune.

Burwilla soil landscape

This unit is characterized by large parabolic dunes that lie inland of the Chalambar soil landscape. These dunes are broad and open and have gently undulating floors, comparatively low trailing arms and broad U-shaped apices. Their dimensions are 2-4km in length and 1-2km in width, they extend up to 6.5km inland and commonly occur at elevations of 100-180m. Local relief within the dune varies between 15 and 30m.

The apices are broad and open and in some dunes have developed a number of small lobes, particularly along the southern trailing arms. This shape probably results from variations in the direction of onshore winds (between south-east and north-east) during the dune-building phase and to the lack of nearby higher protective areas. The floors are made up of low sandbanks, flats and depressions with a local relief of about 1-15m. Unevenness in dune floors is the result of wind working sand as low transverse ridges along the floors of the dunes during formation and of mild water erosion since they were vegetated. There is some evidence near the coast pointing to reworking of parts of these dunes after the main period of dune formation. Remnants of the next oldest dune system and of the Teewah Sand equivalents protrude through dune floors in places.

The trailing arms are comparatively low. Water erosion on their external slopes has led to the development of gullies and fans, although erosion has not breached the dune walls and the dune outlines on airphotos are sharp and unbroken. The sharp outlines and limited erosion and weathering indicate relatively young dunes; they are considered to be Holocene deposits.

The vegetation ranges from layered woodlands 18-20m tall in which ***Eucalyptus signata***, ***E.intermedia*** and ***Casuarina torulosa*** are common in the eastern sections of the dune floors and trailing arms, to open forests, 30-40m high, on the inland parts of the dune where ***E.pilularis*** is prominent and ***E. signata*** has not been observed. Throughout the dunes, the understory is open and patchy and includes species of ***Banksia***, ***Acacia***, ***Leptospermum*** and ***Casuarina***. With three years of fire protection ground cover increases to about 80% and ***Themeda australis***, ***Pteridium esculentum*** and ***Xanthorrhoea macronema*** are usually evident.

Most of the soils are *podzols* with well developed profiles on dune floors and on the crests of some trailing arms. Rudimentary *podzols* and *siliceous sands* occupy steep dune slopes and some crests where erosion is active. Truncated B horizons of old *podzols* may occur near the surface on parts of the dune floors; at these sites bisequum profiles (Soil Survey Staff 1975) have formed with the younger *podzol* in the newer dune sands although its B horizon may overlap the older deposit. Small areas of *humus podzols* have been observed in depressions in the dune floors and *siliceous sands* and young *podzols* are associated with the alluvial fans. Buried soils have been observed beneath the fan materials. Descriptions of four profiles from Burwilla soil landscape are given below.

Burwilla 1

PODZOL (Uc2.21, Troporthod)

Situation: dune floor, flat area
Map ref.: Cooloola 101 167
Elevation: 150m
Parent material: aeolian quartz sand
Vegetation: layered woodland; *Eucalyptus pilularis, E.intermedia, Angophora woodsiana*

Horizon	Depth, cm	Soil morphology
A11	0-8/10	Very light brownish grey (10YR6/1,7/1) sand; loose dry; discrete pieces of organic matter and charcoal. Clear to -
A12	8/10-50	Dark brownish grey (10YR3/1,4/1) sand; loose dry; diffuse organic matter. Diffuse to -
A13	50-90	Brownish grey (10YR4/1,5/1), grading to light brownish grey (10YR5/1,6/2), sand; loose dry; diffuse organic matter. Diffuse to -
A2	90-96/100	Very light grey-brown (10YR6/2,7/2) sand; loose dry. Clear undulating to -
Bhir	96/100-130	Brown (10YR4/3,4/4), with patches of yellow-brown (10YR5/4), sand; weakly coherent dry; some tongues of A2 in upper part. Grading to -
Birh	130-250	Yellowish brown (7.5YR6/8), with patches of brown (10YR3/3), sand; weakly coherent dry. Diffuse to -
B3	250-350	Light yellow-brown (10YR6/5), with patches of brown (7.5YR4/3) increasing with depth, sand; loose dry. Diffuse to -
C	350-450	Light yellow-brown (10YR6/5,7/5) sand.

Burwilla 2

PODZOL (Uc2.21, Quartzipsamment)

Situation: crest of trailing arm
Map ref.: Cooloola 136 227
Elevation: 100m
Parent material: aeolian quartz sand
Vegetation: layered forest; *Eucalyptus intermedia, Angophora woodsiana, Casuarina torulosa*

Horizon	Depth, cm	Soil morphology
A11	0-6/8	Very light brownish grey (10YR7/1,6/1) sand; loose dry; discrete pieces of organic matter and charcoal. Clear to -
A12	6/8-16	Dark brownish grey (10YR4/1,5/1) sand; loose dry; diffuse organic matter. Diffuse to -
A13	16-30	Light brownish grey (10YR5/1,6/2) sand; loose dry. Clear uneven to -
Bhir	30-80	Brown (10YR4/4) and yellowish brown (10YR5/4) sand; weakly coherent dry. Diffuse to -
B3	80-130	Yellowish brown (10YR6/4), with some patches of brown (7.5YR4/3) increasing with depth, sand; loose dry. Diffuse to -
C	130-450	Yellowish brown (10YR6/4) sand; loose dry; heavy mineral grains evident.

Shallower *PODZOL* profiles and rudimentary forms have been recorded on some trailing arms.

Burwilla 3

Rudimentary *PODZOL* (Uc3.21, Quartzipsamment)

Situation: slipface downslope of dune apex
Map ref.: Cooloola 085 200
Elevation: 140m
Parent material: aeolian quartz sands
Vegetation: layered grassy open forest; *Eucalyptus pilularis*, *Angophora woodsiana*, *Banksia serrata*

Horizon	Depth, cm	Soil morphology
A11	0-2/4	Grey-brown (10YR5/2,5/1) sand; loose dry; discrete pieces of organic matter and charcoal. Clear to -
A1-A2	2/4-30	Grey-brown (10YR5/2), with patches of very light grey-brown (10YR6/2,7/2), sand; loose dry. Gradual and uneven to -
Bir	30-40	Yellow-brown (10YR6/6), with patches of yellowish brown (10YR5/4,5/6), sand; loose dry. Diffuse to -
B3	40-50	Pale yellow (10YR7/5), with yellowish brown (10YR6/6) increasing with depth, sand; loose dry. Diffuse to -

C	50-450	Pale yellow (10YR7/5), with some paler patches, sand.

Burwilla 4

Young *PODZOL* (Uc2.21, Quartzipsamment)

Situation: fan alluvium washed out of dune slope at research site R5
Map ref.: Cooloola 084 200
Elevation: 130m
Parent material: sand alluvium from dune slope
Vegetation: grassy layered open forest; *Eucalyptus pilularis*, *E. intermedia*

Horizon	Depth, cm	Soil morphology
A1	0-20	Light brownish grey (10YR6/1,5/1) sand; loose dry; discrete pieces of organic matter and charcoal. Very diffuse to -
A2	20-80	Very light grey-brown (10YR7/2,7/3), with patches of light yellowish brown (10YR6/4), sand, loose dry. Clear to -
Bir	80-100	Yellowish brown (10YR6/6), with paler patches, sand; loose dry. Diffuse to -
C	100-150	Patchy very light grey-brown (10YR7/2) and light brown (10YR6/3) sand. Clear to -
bA1	150-180	Brownish grey (10YR5/1,6/1) sand; some charcoal. Diffuse to -
bA2	180-210	Very light grey-brown (10YR6/2) sand. Diffuse to -
bBhir	210-600	Brown (10YR4/3) and light yellowish brown (10YR6/4) sand; overlying other buried soils to depths >6m.

Horizon thicknesses and depths to buried soils appear to be very variable on these fans.

Warrawonga soil landscape

This unit comprises remnants of very large parabolic dunes that were blown across the sandmass to form the present high and generally central ridges that make up much of the present topographic divide. Remnants of individual dunes are 3-5km long, 1-2km wide and extend to 7km inland. They commonly reach elevations of 180-250m and have local relief, between crests of trailing arms and bottoms of eroded dune floors, of up to 60m. Parts of the initial dune floors have survived near the apices of some dunes and these have concave surfaces with relatively gentle slopes to the adjacent trailing arms and local relief of

<20m. The gentle slopes may be partly due to water erosion reducing the height of the nearby trailing arms and depositing some sand across the dune floors.

Elsewhere, the dune floors have been extensively and deeply eroded by water to form deep, and often steep-sided, valleys extending towards the coast between the dune arms. These have cut through the initial floors of the dunes of the Warrawonga soil landscape into organic B horizons of older soils on underlying dune remnants and into ironpans of the Teewah Sand equivalents. Watertables within 12m of the surface commonly occur along the lower sideslopes and valley bottoms. Where drainage is restricted by organic-pans or ironpans near the surface ephemeral swamps and some perched lakes have developed. In places erosion has breached the trailing arms leaving isolated high areas of what were originally continuous sandridges. It is also apparent that in some places more than one dune followed the same course during the period of aeolian deposition leading to nested dunes that have since been similarly eroded.

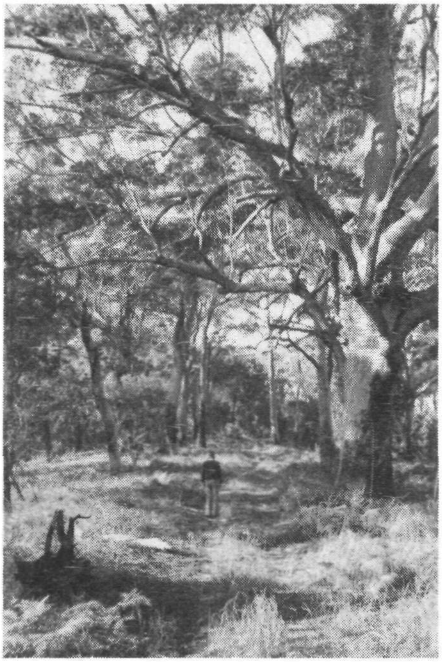
The higher parts of the dune remnants form the topographic divide between deep erosion valleys that run generally south-east to the coast and similar ones that have been cut in the underlying dunes (Dune System 5) and the Teewah Sand equivalents and which radiate to the north and west. Along the eastern margins of the sandmass younger dunes (Dune Systems 2 and 3) have invaded these deep erosion valleys, cutting off their access to the coast and in places filling them with younger sand deposits. Because of the deep weathering, extensive erosion and invasion by younger sands, the dunes of Dune System 4 are regarded as Pleistocene deposits.

The vegetation on the trailing arms ranges from very tall layered woodlands to forests, 30-50m high, in which *Eucalyptus pilularis*, *E.intermedia*, *Tristania conferta* and *Casuarina torulosa* are common trees. A few large trees of *Syncarpia hillii* occur in places. The lower storey varies from open to moderately dense, depending on past management, and includes *Acacia* spp., *Banksia aemula*, *B.integrifolia* and *Leptospermum* spp.; *Themeda australis*, *Pteridium esculentum* and *Xanthorrhoea macronema* occur in the ground cover.

Backhousia myrtifolia is a common understory plant on the middle to lower internal slopes of the trailing arms where there is usually a fairly narrow transition to rainforest on the dune floors. The rainforests vary from simple to complex notophyll vine forests, 20-40m tall, and contain numerous species (Webb and Tracey 1975). Large trees of *T.conferta* are common emergents in the rainforest margins.

All the soils examined on the trailing arms and steep external dune slopes were *podzols* or giant *podzols*, sometimes overlying older soil horizons formed on remnants of earlier dunes. Soils on the dune floors under rainforest were found to have humus dominant B horizons characteristic of *humus podzols* developed under the influence of watertables. Several holes were drilled into saturated zones in or below the B horizon.

Near the coast flanking the southern shore of Wide Bay, a thin veneer of aeolian yellow-brown sand (20-120cm thick) has been deposited over soil profiles that are otherwise similar to those of the Warrawonga soil landscape; these areas have been provisionally included in the unit. The areas mapped in this landscape between Cooloola Sandpatch and Teewah Village have been determined by photo-interpretation only and should be regarded as provisional. Some of the areas appear to have been reworked by the wind and these are indicated on the map. Descriptions of three profiles from Warrawonga soil landscape are given below.



Left. Layered woodland with *Eucalyptus pilularis,* on the trailing arm of a System 4 dune in the Warrawonga soil landscape. **Right.** Giant *podzol* exposed at top of seacliffs eroded into the Warrawonga soil landscape: veneer of young coastal sand (1). A_1 horizon (2), thick bleached A_2 (3), thick B_2hir accumulation of organic compounds and sesquioxides in vertical streaks (4) and pipes of A_2 horizons penetrating B_2hir (5).

Warrawonga 1

Giant ***PODZOL*** (Uc2.22, Quartzipsamment)

Situation: near dune apex just north of Ramsay Scrub
Map ref.: Cooloola 076 113
Elevation: 190m
Parent material: aeolian quartz sand
Vegetation: forest; ***Eucalyptus pilularis, E.intermedia,*** much ***Tristania conferta*** regrowth

Horizon	Depth, cm	Soil morphology
A11	0-6	Very light brownish grey (10YR6/1,7/1) sand; loose dry; discrete pieces of organic matter and charcoal. Clear to -
A12	6-70	Dark brownish grey (10YR3/1 grading to 4/1 with depth) sand; loose dry; much diffuse organic matter. Diffuse to -

A13	70-150	Light brownish grey (10YR5/1 grading to 6/1) sand; loose dry; diffuse organic matter. Diffuse to -
A2	150-510	Very light grey-brown (10YR6/2,7/2) sand; loose dry. Very uneven to -
B1	510-550	Very light grey-brown (10YR7/2), with patches of very dark brown (10YR2/2,3/3) and yellowish brown (10YR5/8), sand; a mix of A2 pipes penetrating the top of the B horizon with humate and iron accumulation. Diffuse to -
Bhir	550-680	Dark brown (7.5YR3/2,3/3), with patches of yellowish brown (7.5YR5/8), sand with humate and iron accumulation; friable to firm moist; no evidence of pan development.

Warrawonga 2

Deep *PODZOL* (Uc2.22, Quartsipsamment)

Situation: crest of trailing arm at research site R5
Map ref.: Cooloola 091 199
Elevation: 200m
Parent material: aeolian quartz sand
Vegetation: layered woodland; ***Eucalyptus pilularis, E.intermedia, Casuarina torulosa, Banksia integrifolia, B.aemula***

Horizon	Depth, cm	Soil morphology
A11	0-10	Very light brownish grey (10YR6/1,5/1) sand; loose dry; discrete pieces of organic matter and charcoal. Clear to -
A12	10-60	Dark brownish grey (10YR3/1 grading to 4/1) sand; loose dry; much diffuse organic matter. Very diffuse to -
A13	60-120	Light brownish grey (10YR5/1 grading to 6/1) sand; loose dry; diffuse organic matter decreasing with depth. Diffuse to -
A2	120-270	Very light grey-brown to off-white (10YR7/2, 8/2) sand; loose dry. Very uneven to -
B1	270-300	Off-white (10YR8/2), with patches of dark brown (10YR3/3) and yellowish brown (7.5YR5/8), sand; a mix of A2 pipes and top of B horizon with humate and iron accumulation. Diffuse to -

Bhir	300-480	Dark brown (10YR3/3,4/4) and yellow-brown (7.5YR5/8,5/6), with patches of black (10YR2/1), sand with humate and iron accumulation; friable to firm moist; no evidence of pan development. Very diffuse to -
B3	480-700	Yellowish brown (10YR6/6,6/5), with patches of brown (10YR4/4) decreasing with depth, sand; loose dry. Very diffuse to -
C	700-780	Light yellow-brown (10YR6/4,7/5) sand; loose dry.

Warrawonga 3

Giant *HUMUS PODZOL* (Uc2.20, Quartzipsamment)

Situation: dune floor south of Broutha Waterhole
Map ref.: Cooloola 097 227
Elevation: 170m
Parent material: aeolian quartz sand
Vegetation: simple notophyll vine scrub; includes *Ficus watkinsiana, Agathis robusta*

Horizon	Depth, cm	Soil morphology
A11	0-5	Very light brownish grey (10YR6/1,7/1) sand; loose dry; discrete organic fragments and charcoal. Clear to -
A12	5-60	Dark brownish grey (10YR3/1 grading to 4/1) sand; loose dry; much diffuse organic matter decreasing with depth. Very diffuse to -
A13	60-100	Light brownish grey (10YR5/1 grading to 6/2) sand; loose dry; diffuse organic matter decreasing with depth. Diffuse to -
A2	100-870	Off-white (10YR8/2,9/2) sand; loose dry; occasional threads of yellowish brown root stain. Clear to -
Bh	870-900	Dark brownish grey to black (10YR3/1,2/1) sand with humate; soft and wet grading into watertable.

Mundu soil landscape

This unit is made up of large high sandridges, that form much of the western 'wall' of the high dunes of the Cooloola sandmass at elevations of 100-160m. The unit mostly lies inland of the Warrawonga soil landscape although a few small areas also occur in the middle of the sandmass and near the coast and apparently represent isolated highs that have been surrounded by younger dunes. In the western section, the sandridges are separated by deep erosion valleys (see p. 43) with narrow floors 40-60m below the ridge crests. Most of the permanent creeks flowing out of the sandmass to the west and north-west originate in these valleys and are fed by 'white water' springs issuing at the drainage heads and bv lateral seepage of coloured waters (Reeve and Fergus 1983; Reeve *et al.* 1984). The valley sideslopes do not appear to be as steep as those of the eroded Warrawonga soil landscape and have probably been smoothed through the movement of surface sand by raindrop impact through the open vegetation (Bridge and Ross 1983; Bridge *et al.* 1984).

The dunes that constitute the Mundu soil landscape have been strongly modified by water erosion since deposition. This has destroyed most of the original dune form and all of the remnants appear to have been reduced in elevation. Consequently there are few indications of the initial dune form and orientation, although the long sandridges and remnants resembling much-modified apices suggest large parabolic dune shapes. These dunes appear to have over-run an eroded landscape in the Teewah Sand equivalents but recognition of them as dune sands separate from the underlying Teewah Sand equivalents is provisional. It is based largely on the shape of some remnants and on differences in soil profiles formed in each material. No clear stratigraphic contact has yet been found between the two and it is possible that the overlying dune sands are in fact surficial beds of the Teewah Sand equivalents. The valleys are deeply eroded into the Teewah Sand equivalents and most sideslopes of the sand ridges appear to be cut in these materials. The Mundu soil landscape as currently mapped includes soil formed in both materials and in colluvium derived from them and the unit must therefore be regarded as provisional.

The vegetation is typically a shrubby layered woodland, 12-20m tall, in which *Eucalyptus signata* and *Angophora costata* are prominent trees. *Banksia aemula, Acacia flavescens* and *Leptospermum attenuatum* are common in the second storey and the ground cover is dominated by *Xanthorrhoea media*. There are also some areas of taller open forest that include *E.pilularis* and *E. intermedia;* these appear to be associated with slopes where the underlying Teewah Sand equivalents are near the surface. Small patches of rainforest around the drainage heads of some streams are also included.

The soils are dominantly giant *podzols* and giant *humus podzols* with some areas of iron *podzols* formed in iron-rich beds of the Teewah Sand equivalents where these have been exposed by erosion. Descriptions of four profiles from Mundu soil landscape are given below.

Mundu 1

Giant *PODZOL* (Uc2.22, Quartzipsamment)

Situation: crest of sandridge at research site R6
Map ref.: Cooloola 079 224
Elevation: 120m
Parent material: aeolian quartz sands of Dune System 5
Vegetation: shrubby woodland; *Eucalyptus signata, Banksia aemula, Acacia flavescens, Xanthorrhoea media*

Horizon	Depth, cm	Soil morphology
A11	0-10	Very light brownish grey (10YR7/1,6/1) sand; loose dry; organic fragments and charcoal. Clear to -

A12	10-50	Brownish grey (10YR4/1), with light grey-brown (10YR5/2) patches, sand; loose dry; diffuse organic matter. Diffuse to -
A13	50-90	Light brownish grey (10YR5/1 grading to 6/1) sand; loose dry; diffuse organic matter decreasing. Very diffuse to -
A21	90-1140	Off-white (10YR8/1,9/1) sand; loose dry; occasional yellowish brown rootline stain. Diffuse to -
A22	1140-1170	Off-white to cream (10YR8/2) sand; loose dry. Clear uneven to -
Bhir1	1170-1190	Off-white (10YR8/2), dark brown (10YR3/3,2/2) and yellowish brown (10YR5/4) sand with humate and iron; mixed material from A2 pipes and B2 pan. Diffuse to -
Bhir2	1190-1320	Yellowish brown (7.5YR6/6), with patches of brown (10YR4/4) dark brown (10YR3/3) and black (10YR2/1), sand with accumulated humate and iron; some off-white (10YR8/2) A2 pipe material in places; occasional thin (<5mm) dark ironpans through the dark humate material. Horizon appears to be massive and firm but not cemented; it also appears to be penetrated by pipes of A2 material. Abrupt to -
	1400-	Reddish brown (5YR5/6) sand with ironpan (interpreted as Teewah Sand equivalent).

Mundu 2

Giant *PODZOL* (Uc2.22, Quartzipsamment)

Situation: crest of sandridge south-west of Ramsay Scrub
Map ref.: Cooloola 065 095
Elevation: 130m
Parent material: Teewah Sand equivalents
Vegetation: shrubby woodland; ***Eucalyptus signata, Banksia aemula, Xanthorrhoea media***

Horizon	Depth, cm	Soil morphology
A11	0-12	Very light brownish grey (10YR7/1,6/1) sand; loose dry; organic fragments and charcoal. Clear to -
A12	12-70	Brownish grey (10YR4/1,5/1) sand; loose dry; diffuse organic matter. Very diffuse to -
A13	70-90	Light brownish grey (10YR6/1 grading to 7/1) sand; loose dry. Diffuse to -

A2	90-970	Off-white (10YR9/1,8/1) sand; loose dry. Uneven to -
Bhir	970-1100	Off-white (10YR8/2), with yellowish brown (7.5YR5/8) and some dark brown (7.5YR3/2), sand with iron and humate accumulation; pipey B horizon in which large pipes of A2 penetrate yellowish-brown sands and there is a thin band of humate between the two. Fragments of reddish brown ironpan are interpreted as indicating Teewah Sand equivalents.

Mundu 3

Iron *PODZOL* (Uc2.21, Quartzipsamment)

Situation: slope of sandridge north of Frankis Gulch
Map ref.: Cooloola 083 189
Elevation: 100m
Parent material: Teewah Sand equivalents
Vegetation: open forest; ***Eucalyptus pilularis***, ***E.intermedia***,, ***Tristania conferta***, ***Casuarina littoralis***, ***Banksia integrifolia***, ***Acacia flavescens***

Horizon	Depth, cm	Soil morphology
A11	0-3	Very light brownish grey (10YR6/1,7/1) sand; loose dry; organic fragments and charcoal. Clear to -
A12	3-20	Dark brownish grey (10YR4/1) sand; loose dry; diffuse organic matter. Diffuse to -
A2	20-25	Light grey-brown (10YR6/2) and light brown (10YR6/4) sand; loose dry. Gradual to -
B1	25-45	Yellowish brown (10YR5/4), with a few dark brown (6.5YR9/3) patches, sand with some humate patches; weakly coherent dry. Diffuse to -
Birh	45-90	Yellowish brown (7.5YR5/6,5/8), with some dark brown (7.5YR4/3) patches, iron-rich sands with some humate patches; weakly coherent dry. Diffuse to -
Bir	90-138	Reddish yellow (5YR5/8) clayey sand; massive, porous sands with bridging between sand grains (sandy fabric). Very abrupt to -

D	138-140	Dark reddish brown ironpan of Teewah Sand equivalents.
	140-170	Reddish yellow (5YR5/8 grading to yellow 10YR7/6) sand; loose dry. Very abrupt to -
	470-480	Dark reddish brown ironpan with small lenses of reddish yellow clayey sand.

Mundu 4

Giant *HUMUS PODZOL* (Uc2, Quartzipsamment)

Situation: lower slope of sandridge at research site R6
Map ref.: Cooloola 077 223
Elevation: 80m
Parent material: colluvial sands derived from Dune System 5 and Teewah Sand equivalents
Vegetation: shrubby woodland; *Eucalyptus signata, Angophora costata, Banksia aemula, Leptospermum* spp.

Horizon	Depth, cm	Soil morphology
A11	0-4	Very light brownish grey (10YR7/1,6/1) sand; loose dry; organic fragments and charcoal. Clear to -
A12	4-40	Brownish grey (10YR4/1) sand; loose dry; diffuse organic matter. Diffuse to -
A13	40-90	Very light brownish grey (10YR6/1 grading to 7/1) sand; loose dry. Diffuse to -
A21	90-1400	Off-white (10YR8/2,9/1) sand; loose dry; occasional light brown stain from fine roots. Diffuse to -
A22	1400-1450	Off-white (10YR8/1,9/1) sand; saturated (falls from sand auger); top of watertable presumably perched on organic-pan Bh horizon as exposed lower down in drainage line.

Kabali soil landscape

This unit comprises the low, whaleback sandhills of the western and northern margins of the sandmass where it joins the coastal plain. These sandhills have broad convex crests that reach elevations of 30-80m, and smooth sideslopes of 5-15° to open valleys drained by shallow, spring-fed streams.

The crests of these sandhills are lower, the sideslopes are less steep and the valley bottoms are more open than those of the adjoining Mundu soil landscape. It appears that this is largely the result of water erosion that over a long period has destroyed the original shape of these dunes and markedly reduced their initial height. Much of this erosion has probably been accomplished by raindrop splash (Bridge and Ross 1983; Bridge *et al.* 1984), slowly moving sand grains downhill from the crests and slopes of the dunes to form deep colluvial aprons in the interdune corridors. Some of this sand has been carried away by the running streams and deposited as low gradient sandy fans on the adjacent Noosa Plain.

No evidence has been found to suggest that the initial deposition of these sands was not by aeolian means. Sieve analyses of sands from this unit show very similar grain-size distributions to samples from the other dune systems but with slightly greater amounts of <140mm material (Ross 1977). Exploratory examination under a scanning electron microscope (M.P. Green *pers. comm.*) has shown that the quartz grains are more strongly weathered than those of adjacent dune systems. This suggests that the sands are of similar origin and that the differences in dune shape and degree of grain weathering are most likely due to exposure to erosion and leaching over a long period.

The whaleback sandhills extend to the coast at Rainbow Beach where a section in the seacliffs (Ward *et al.* 1979) shows that they underlie the Teewah Sand equivalents. Their distribution along the western side of the sandmass is generally at lower elevations than observed exposures of the Teewah Sand equivalents also and this suggests a similar relationship elsewhere in the sandmass.

The vegetation is typically shrubby woodland, 8-12m tall, in which *Eucalyptus signata* and *Angophora costata* are prominent trees; *Banksia aemula, Acacia flavescens, Casuarina littoralis* and *Leptospermum attenuatum* are common in the second storey and shrubs, 1-3m tall, form an open ground cover in which *Xanthorrhoea johnsonii* are common. Included in the unit are a few small patches of rainforest around the drainage heads of small streams.

Some areas of dwarf shrubby woodland, 1-3m tall, are included in which *E. signata, B.aemula* and *E.intermedia* are commonly the tallest plants above an open shrub cover. This dwarf vegetation has been found to be associated with areas where soil depth to B horizon exceeds 20m.

Soil depth in these sandhills is determined by the period of subaerial weathering, degree of erosion at the crests and the amount of colluvial accumulation along the lower slopes. On the crests, soil depth to B horizon has been found to vary from 12 to >23m but no sites protected from erosion have yet been found. Watertables, apparently perched on cemented organic B horizons, are common beneath the lower slopes and corridors and generally prevent deep auger sampling of these materials. Cemented B horizons with water seeping from the sand above them are frequently exposed in eroded gully walls along the floors of the corridors and are presumed to extend laterally under adjacent lower slopes, similar to the relationship depicted for the Cooloola Land System by Coaldrake (1961). Even the soils on the broad crests of the sandhills have been found to have seasonal watertables at depth. As a result, all of the soils examined have been classified as giant *humus podzols* and their B2h horizons vary from soft organic accumulations to hard cemented organic pans. Descriptions of four profiles from Kabali soil landscape are given below.

Kabali 1

Giant *HUMUS PODZOL* (Uc2.21, Quartzipsamment)

Situation: crest of sandhill at research site R7
Map ref.: Cooloola 074 220
Elevation: 75m
Parent material: aeolian quartz sands of Dune System 6
Vegetation: shrubby woodland; *Eucalyptus signata, Angophora costata, Banksia aemula, Acacia flavescens, Xanthorrhoea johnsonii*

Horizon	Depth, cm	Soil morphology
A11	0-3	Very light brownish grey (10YR6/1,7/1) sand; loose dry; organic fragments and charcoal. Clear to -
A12	3-30	Dark brownish grey (10YR4/1,3/1) sand; loose dry; diffuse organic matter. Diffuse to -
A13	30-70	Light brownish grey (10YR5/1 grading to 6/1) sand; loose dry; diffuse organic matter decreasing with depth. Diffuse to -
A21	70-840	Off-white (10YR8/1,9/1) sand; loose dry. Diffuse to -
A22	840-1190	Off-white (10YR8/1,9/1), with a few yellowish (7.5YR7/4) spots, sand; loose dry. Clear to -
Bh	1190-1200	Brown (10YR4/3) sand; soft moist; diffuse organic matter. Abrupt to -
D	1200-1350	Yellow-brown (7.5YR5/6) sandy clay loam; massive, very firm moist; fragments of very thin ironpan, grading into banded red-brown (2.5YR3/6) and pale brown (10YR7/4) coherent sands and clayey sands; appears to contain some iron-enriched nodules.

Kabali 2

Giant *HUMUS PODZOL* (Uc2, Quartzipsamment)

Situation: crest of sandhill
Map ref.: Cooloola 062 203
Elevation: 65m
Parent material: aeolian quartz sands of Dune System 6
Vegetation: dwarf shrubby woodland; *Eucalyptus signata, Banksia aemula, Acacia flavescens, Xanthorroea johnsonii*

Horizon	Depth, cm	Soil morphology
A11	0-5	Off-white (10YR8/1,9/1), with light grey-brown (10YR5/2) patches, sand; loose dry; organic fragments and charcoal. Clear to -
A12	5-20	Grey-brown (10YR4/2,5/2) sand; loose dry; diffuse organic matter. Diffuse to -
A13	20-45	Light grey-brown (10YR6/2 grading to 7/2) sand; loose dry; diffuse organic matter decreasing with depth. Very diffuse to -

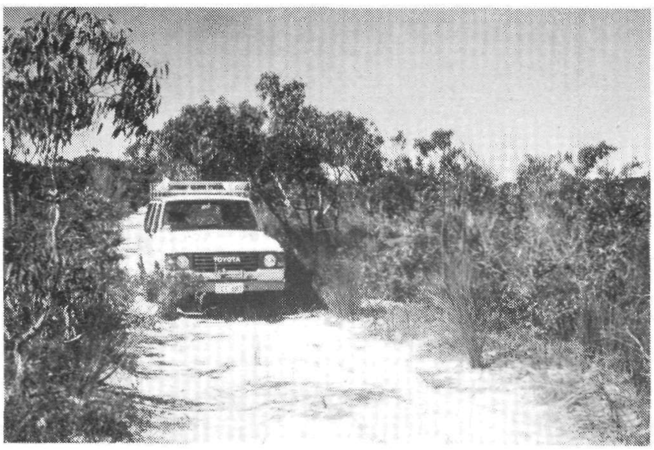
A21	45-2100	Off-white (10YR8/1,9/1) sand; loose dry. Diffuse to -
A22	2100-2150	Off-white (10YR8/1) sand; wet (water prevented further augering - interpreted as seasonal watertable perched on B horizon).

Kabali 3

Giant *HUMUS PODZOL* (Uc2.33, Quartzipsamment)

Situation: crest of sandhill near Camp Milo
Map ref.: Wide Bay 074 244
Elevation: 70m
Parent material: aeolian quartz sands of Dune System 6
Vegetation: shrubby woodland; ***Eucalyptus signata, Banksia aemula, Casuarina littoralis, Leptospermum attenuatum, Xanthorrhoea johnsonii***

Horizon	Depth, cm	Soil morphology
A11	0-5	Very light brownish grey (10YR6/1,7/1) sand; loose dry; organic fragments and charcoal. Clear to -
A12	5-30	Dark brownish grey (10YR4/1,5/1) sand; loose dry; diffuse organic matter. Diffuse to -
A13	30-75	Very pale grey-brown (10YR5/2 grading to 7/2) sand; diffuse organic matter decreasing with depth. Very diffuse to -
A21	75-900	Off-white (10YR8/1,9/1) sand; loose dry. Diffuse to -



Dwarf shrubby woodland in which *Eucalyptus signata, Banksia aemula* and *Xanthorrhoea johnsonii* are prominent, Kabaii soil landscape.

A22	900-1110	Off-white with creamy tinge (10YR8/2) sand; loose dry. Clear to -
B1	1110-1121	Light grey-brown (10YR5/2), with dark brownish grey (10YR3/1) and off-white patches, clayey sand; massive and firm moist. Clear to -
Bh	1121-1300	Black (10YR2/1) grading to dark brown (7.5YR3/2) organic sand hardpan; grading into wet grey-brown sands below 13m (note: watertable perched above organic sand hardpan and permanent watertables in grey-brown sands below hardpan).

Kabali 4

Giant *HUMUS PODZOL* (Uc2, Quartzipsamment)

Situation: corridor between sandridges at research site R7
Map ref.: Cooloola 076 221
Elevation: 55m
Parent material: sandy colluvium derived from Dune System 6 and Teewah Sand equivalents
Vegetation: shrubby woodland; *Banksia aemula, Eucalyptus signata, Leptospermum flavescens, L. attenuatum*

Horizon	Depth, cm	Soil morphology
A0	1-0	Leaf litter, mainly from *B. aemula*.
A11	0-44	Very light brownish grey (10YR6/1,5/1) sand; loose dry; organic fragments and charcoal. Clear to -
A12	4-40	Dark brownish grey (10YR4/1,3/1) sand; loose dry; diffuse organic matter. Diffuse to -
A13	40-60	Light brownish grey (10YR5/1 grading to 7/1) sand; loose dry; diffuse organic matter decreasing with depth. Very diffuse to -
A21	60-130	Off-white (10YR9/1) sand; loose dry. Diffuse to -
A22	130-500	Off-white (10YR9/1) sand; saturated (interpreted as perched watertable above organic sand hardpan exposed in gully further along corridor).

Double Island Point soil landscape

This unit is restricted to the rocky headland at Double Island Point and consists of volcanic lava (andesite) with in places an overlying veneer of aeolian sands that show some evidence of periodic accumulation.

Most of the area is covered by ***Banksia integrifolia*** woodland with some ***Pandanus*** sp. and with ***Themeda australis*** and ***Zoysia macrantha*** in the ground cover.

Soil data are limited. *Lithosols* and intergrades to *prairie soils* have developed on ledges of andesite on the hillslopes and on mixed andesite and aeolian sands on some ridges; most slopes have outcrops of andesite. Descriptions of two profiles from Double Island Point soil landscape are given below.

Double Island Point 1

LITHOSOL (Um6.11, Ustorthent)

Situation: steep slope with rock outcrop
Map ref.: Wide Bay 190 316
Elevation: 80m
Parent material: andesite
Vegetation: woodland; ***Banksia integrifolia, Pandanus*** sp., ***Themeda australis***

Horizon	Depth, cm	Soil morphology
A11	0-8	Black (10YR2/1) organic loam; strong fine crumb structure; friable moist. Gradual to -
A12	8-10/15	Very dark brown (10YR2/2) organic loam to clay loam; strong fine subangular blocky structure; friable moist; slight gravel and stone. Abrupt to -
R	10/15-	Hard andesite.

Double Island Point 2

LITHOSOL - PRAIRIE SOIL intergrade (?Gn3.41, ?Haplustoll)

Situation: crest of spur with outcropping boulders
Map ref.: Wide Bay 190 311
Elevation: 45m
Parent material: andesite with some aeolian sand additions
Vegetation: woodland; ***Banksia integrifolia, Pandanus*** sp.

Horizon	Depth, cm	Soil morphology
A1	0-20	Very dark brown fine (10YR2/2) sandy loam; moderate crumb grading to subangular blocky structure; much diffuse organic matter; field pH is 6. Diffuse to -
B	20-40	Very dark brownish grey (10YR3/1) fine sandy clay loam; weak blocky structure; firm moist; field pH is 6. Abrupt to -
	40-	Andesite boulders.

Giant *humus podzol* at Rainbow Beach exposed in sea cliffs cut in a remnant of Dune System 6.

Bula Kalim soil landscape

This unit is restricted to the three low hills that stand out along the neck of the Double Island Point promontory and which have cemented bands of aeolianite exposed along their lower and middle slopes. The most north-easterly of these hills is in places underlain by andesite. The three hills are separated by both mobile and recently vegetated young dunes that have advanced across the low areas of the promontory. The three hills reach elevations of 85-107m and have steep sideslopes, particularly where they have been truncated by the sea along the Wide Bay frontage.

The vegetation is mainly *Banksia integrifolia* woodland, with several *Acacia* spp. and *Casuarina equisetifolia* on the exposed slopes. *B.serrata, Tristania conferta* and *C.littoralis* have been observed on the hill crests.

Soil data are limited and a reconnaissance of the south-western low hill shows that the soils of the upper slopes and crests are siliceous sands with no evidence of calcium carbonate cementation to depths of 7.5m. Descriptions of two profiles from Bula Kalim soil landscape are given below.

Bula Kalim 1

SILICEOUS SAND (Uc1.22, Quartzipsamment)

Situation: lower internal slopes (5°) of trailing arm of parabolic dune
Map ref.: Wide Bay 174 298
Elevation: 90m
Parent material: aeolian quartz sands
Vegetation: woodland; *Banksia serrata, Tristania conferta, Casuarina littoralis, Acacia* spp.

Horizon	Depth, cm	Soil morphology
A1	0-20	Patchy grey-brown (10YR4/2) and light brown (10YR5/3) sand; loose dry; fragmentary and diffuse organic matter; water-repellent sands. Diffuse to -
C	20-140	Yellow-brown (1OYR5/6) sand; loose dry; a few pieces of charcoal at 80cm. Clear to -
	140-260	Yellowish brown (7.5YR6/8) sand; loose dry; some heavy minerals and charcoal. Clear to -
	260-590	Yellow-brown (10YR5/8) sand; medium-grained, noticeably coarser than other dune sands. Gradual to -
	590-740	Pale yellow-brown (10YR7/5) sand, finer-grained than overlying bed; some yellowish brown (7.5YR4/6) patches.

Field pH is between 6 and 7 throughout the profile; there is no evidence of calcium carbonate cementation.

Bula Kalim 2

SILICEOUS SAND (Uc1.23, Quartzipsamment)

Situation: ridge crest above aeolianite outcrop
Map ref.: Wide Bay 180 304
Elevation: 40m
Parent material: aeolian quartz sands, probably calcareous before leaching
Vegetation: woodland; *Banksia integrifolia, Causarina equisetifolia, Themeda australis*

Horizon	Depth, cm	Soil morphology
A1	0-20	Grey-brown (10YR4/2,4/3) sand; loose dry; fragmentary and diffuse organic matter. Diffuse to -
	20-80	Dark brown (10YR3/4) sand; loose dry. Diffuse to -
	80-220	Yellowish brown (7.5YR5/8) medium-grained sand. Diffuse to -
	220-300	Yellow-brown (10YR6/6) sand; some heavy minerals.

Field pH is 7.5 at 80cm with no evidence of calcium carbonate cementation although aeolianite was recorded at 1m depth in a hole nearby.

Tingiri soil landscape

This unit is restricted to the narrow belt of foredunes that form the coastline from the mouth of the Noosa River north to near Teewah Village. These foredunes reach elevations of about 6m and in many places have been broken by wind erosion. The southern section has been mined for heavy minerals and revegetated using a limited number of native species. A similar belt of foredunes forms the coastline between Rainbow Beach and Inskip Point as a continuation of the strand plain there but these have been included in the Inskip Point mapping unit.

The foredunes carry a woodland of *Banksia integrifolia* and *Casuarina equisetifolia;* thickets of *Melaleuca quinquenervia* over *B. robur* and sedges occupy the wet depressions.

Soil data are limited. Siliceous sands are associated with the foredunes and humus podzols with the wet depressions. The foredunes in the northern half of the unit are underlain by *humus podzols* of the Nilkan soil landscape (see p. 65); the organic hardpan of truncated *humus podzols* is exposed as sandrock along this part of the beach. A description of one profile from Tingiri soil landscape is given below.

Tingiri 1

SILICEOUS SAND (Uc1.21, Quartzipsamment)

Situation: foredune
Map ref.: Laguna Bay 253 304*
Elevation: about 6m
Parent material: aeolian quartz sand blown from intertidal zone
Vegetation: woodland; *Casuarina equisetifolia*

Horizon	Depth, cm	Soil morphology
A1	0-5	Grey-brown (10YR5/2) sand; some charcoal and fragmentary organic matter. Clear to -
C	5-200	Light brown (10YR6/3,6/4) sand; some heavy minerals.

Inskip Point soil landscape

This unit comprises the foredune, low sandridges, swales and sand sheets that together make up the low strand plain that extends from Rainbow Beach to Inskip Point. The sandridges are mostly 5-8m in elevation and are aligned approximately parallel to the present coastline; three periods of development are evident in photo-patterns. Sandridges associated with the two older strandlines have been mined for heavy minerals. Mining has more or less levelled these areas and they have been revegetated using selected native species.

The natural vegetation of the area grades from *Casuarina equisetifolia* and *Banksia integrifolia* woodland near the coast to *Eucalyptus intermedia* forest, 15-20m tall, about 0.5km inland. Common forest species on the sandridges

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* Military 1-mile Series, Languna Bay (1:63 360) 2nd ed., 1942.

include *E.intermedia, Tristania conferta, Callitris columellaris, E.tesselaris, Casuarina littoralis* and *B. serrata* ; some softwood scrub species such as *Alphitonia excelsa, Dodonaea triquetra,* several *Acacia* spp. and a palm (*Livistona* sp.) usually occur in the understorey. *Melaleuca quinquenervia* occurs in the swales where it may form dense almost pure stands above an open *Imperata cyclindrica* ground cover.

The revegetated mined areas are dominated by *Acacia concurrens* woodland and only a few other species are represented. These include *A.flavescens, A. aulococarpa, Callitris columellaris, Dodonaea triquetra* and *Lantana camara.*

Soil data are limited to the old coastal sandridges, foredune and mined area. *Podzols* have developed on the older sandridges, *humus podzols* in the swales, and *siliceous sands* on the foredunes. The mined areas with topsoil replacement have profiles similar to *siliceous sands,* although in places there is some evidence of a small amount of remobilization of iron since revegetation. Descriptions of three profiles of Inskip Point soil landscape are given below.

Inskip Point 1

PODZOL (Uc2.21, Quartzipsamment)

Situation: low sandridge about 0.5km inland
Map ref.: Wide Bay 073 391
Elevation: about 8m with 1.5m local relief between ridge and swale
Parent material: marine and aeolian quartz sands
Vegetation: forest (15-18m); *Eucalyptus intermedia, Tristania conferta, Banksia serrata, Acacia flavescens*

Horizon	Depth, cm	Soil morphology
A00	10-7	Mixed leaf litter and twigs.
A0	7-0	Dark reddish brown (5YR3/2) decomposed litter.
A11	0-10	Patchy light brownish grey (10YR6/1) and brownish grey (10YR5/1) sand; organic fragments. Clear to -
A12	10-60	Very dark brownish grey (10YR3/1) sand; diffuse organic matter. Diffuse to -
A13	60-120	Brownish grey (10YR4/1) grading to light grey-brown (10YR5/2,6/2) sand; diffuse organic matter decreasing with depth. Diffuse to -
A2	120-220	Brownish white (10YR7/3,8/3) sand. Clear to -
Bh	220-300	Brown (10YR5/3,4/3) sand; loose dry. Gradual to -
Bhir	300-350	Yellowish brown (7.5YR5/6) and patches of brown (10YR4/3) sand; loose dry. Diffuse to -

B3	350-400	Yellow-brown (10YR6/5), with some brown (10YR5/3) patches decreasing with depth, sand; loose dry. Diffuse to -
C	400-450	Pale yellow-brown (10YR7/5) sand; watertable at 450cm.

Inskip Point 2

SILICEOUS SAND (Uc1.21, Quartzipsamment)

Situation: frontal dune
Map ref.: Wide Bay 081 376
Elevation: 5-8m
Parent material: marine and aeolian quartz sands
Vegetation: woodland; *Casuarina equisetifolia, Banksia integrifolia*

Horizon	Depth, cm	Soil morphology
A1	0-20	Light grey-brown (10YR5/2) sand; fragmentary and diffuse organic matter. Diffuse to -
C	20-60	Pale yellow-brown (10YR6/5) sand; loose dry. Clear to -
D	60-110	Light grey-brown (10YR6/2) sand; some organic fragments (interpreted as older ground surface buried by aeolian sands blown in from the beach).

Inskip Point 3

Anthropic *SILICEOUS SAND* (Uc1.21, Quartzipsamment)

Situation: revegetated mined area
Map ref.: Wide Bay 066 419
Elevation: about 4m
Parent material: mined quartz sands with overlay of topsoil removed from *podzols* in the area before mining
Vegetation: woodland (4-6m); *Acacia concurrens* with some *A.flavescens, A.aulacocarpa, Persoonia* sp., *Lantana camara* and *Callitris* seedlings.

Horizon	Depth, cm	Soil morphology
A11	0-4	Light brownish grey (10YR6/1,7/1) sand; organic fragments. Clear to -
A12	4-18	Brownish grey (10YR4/1) sand; diffuse organic matter. Clear to -
C	18-150	Pale yellow-brown (10YR7/5) sand; loose dry.

Thickness of topsoil is quite variable (from 3 to >30cm).

Smooger Point soil landscape

This unit is restricted to the areas of sandy sheets and low sandy banks that occur at intervals along the southern shores of Tin Can Inlet. These areas are slightly higher than the adjoining coastal plain but their elevation is generally <10m. Watertables commonly occur within 1.5m of the surface.

The woodland vegetation reflects the drainage conditions and teatree (*Melaleuca quinquenervia)* is usually present. Other trees observed include *Tristania suaveolens*, *T.conferta*, *Eucalyptus intermedia* and *E.signata*. In some areas there is a dense understory of *Acacia* spp. with some *Casuarina littoralis*, *Banksia integrifolia*, *Alphitonia excelsa* and occasional palms (*Livingstona* sp.).

The soil parent materials are probably sandy marine alluvium overlain by sands blown from the intertidal zone of Tin Can Inlet. Soil data are limited; *humus podzols* appear to be the dominant soils. Descriptions of two profiles from Smooger Point soil landscape are given below.

Smooger Point 1

HUMUS PODZOL (Uc2.33, Tropohumod)

Situation: crest of low broad beach ridge
Map ref.: Wide Bay 048 306
Elevation: about 5m
Parent material: marine and aeolian sands
Vegetation: layered woodland; *Melaleuca quinquenervia*, *Tristania conferta*, *Acacia* spp.

Horizon	Depth, cm	Soil morphology
A11	0-3	Light brownish grey (10YR6/1,5/1) sand; organic fragments and charcoal. Clear to -
A12	3-30	Very dark brownish grey (10YR3/1,3/0) sand; diffuse organic matter; many roots. Diffuse to -
A13	30-60	Brownish grey (10YR5/1 grading to 7/1) sand; diffuse organic matter decreasing with depth. Diffuse to -
A2	60-110	Off-white (10YR8/1,8/2) sand. Clear to -
Bh1	110-115	Very dark brownish grey (10YR3/1) sand; organic matter; friable and slightly sticky wet. Clear to -
Bh2	115-130	Black (10YR2/1,2/0) organic sandpan; very firm moist. Gradual to -
B2hir	130-150	Brown (7.5YR4/4), with very dark brown (7.5YR2/2) patches, sand with iron (?) and organic accumulation. Watertable at 150cm.

Smooger Point 2

HUMUS PODZOL (Uc2.20, Tropohumod)

Situation: generally flat sand sheet
Map ref.: Wide Bay 028 287
Elevation: <5m
Parent material: marine and aeolian sandy sediments
Vegetation: layered woodland; *Melaleuca quinquenervia, Banksia integrifolia, Casuarina littoralis, Acacia* spp.

Horizon	Depth, cm	Soil morphology
A1	0-10	Brownish grey (10YR5/1) sand; diffuse and fragmentary organic matter. Diffuse to -
A2	10-30	Light grey-brown (10YR5/2,6/2) sand. Sharp to -
	30-70	Light brown (10YR5/3), mottled with yellow-brown (10YR5/6), clayey sand. Clear to -
Bh	70-80	Black (10YR2/1) organic sand; friable and slightly sticky wet. Clear to -
D	80-110	Dark brown (7.5YR4/2) sandy loam; perched watertable at 80cm. Gradual to -
	110-150	Very light grey-brown (10YR7/2) sandy clay.

Pirri soil landscape

This unit is restricted to the intertidal zone along the southern shore of Tin Can Inlet. The vegetation varies from low open woodland to dwarf forest 5-8m tall. Eight mangrove species have been recorded here (Dredge *et al.* 1977) with *Avicennia marina* and *Rhizophora stylosa* being most common in the areas examined during the present survey.

The parent materials of the soils are marine sands and organic residues. Soil data are limited; the soil profiles examined do not fit any of the Australian great soil groups and the term saline sands is used provisionally. A description of one profile from Pirri soil landscape is given below.

Pirri 1

Saline sand (Uc1, Aquent)

Situation: intertidal zone under mangroves
Map ref.: Wide Bay 054 432
Elevation: intertidal zone about mean sea level
Parent material: marine sands and organic residues
Vegetation: forest; *Rhizophora stylosa, Avicennia marina*

Horizon	Depth, cm	Soil morphology
	0-25	Dark brown (7.5YR4/2,3/2) clayey fine sand; fine mangrove root mass; low-tide watertable at 2cm. Gradual to -
	25-110	Brownish grey (10YR4/1) clayey fine sand; many large and fine mangrove roots. Clear to -
	110-150	Grey (5Y5/1) clayey sand grading to sand.

Field pH is 8.0 throughout profile.

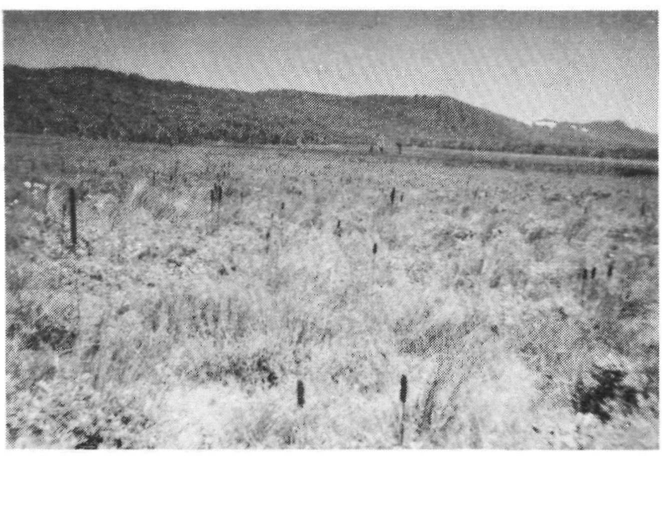
Nilkan soil landscape

This unit is made up of the Noosa Plain and the open coastal plain fringing Tin Can Inlet. These are flat to gently undulating coastal plains generally <20m in elevation. Most of the area is seasonally wet with perched watertables at or near the surface following rain.

The parent materials of the soils are mainly sandy alluvium derived from the sandstone hills and the Cooloola sand dunes but include some lacustrine and estuarine deposits and peat accumulations in some areas. Sandstone underlies these sediments and in places is covered only by a thin veneer where it contributes to the soil profile and affects the local moisture regime.

The middle to lower reaches of the Noosa River, Teewah Creek and Searys Creek are shallowly entrenched in different parts of these plains, but elsewhere surface drainage is sluggish and water moves through swampy depressions to these streams.

The vegetation largely reflects the drainage status. The greater part of the area is covered by heath <1m high in which ***Banksia oblongifolia, B. robur, Boronia*** spp. and ***Xanthorrhoea resinosa*** are prominent. ***B. robur, Gahnia sieberana*** and ***Restio*** spp. mark the more poorly drained areas. Over much of the area, the plain is treeless due to high watertables but where drainage is better, e.g. along the banks of stream channels and on remnants of some lateral sandy fans, low shrubby woodlands, 5-8m tall, occur with ***B. aemula, Eucalyptus signata, E. umbra, Casuarina littoralis*** and ***Acacia*** spp. as common low trees.



Wet heath with *Banksia oblongifola* and *Xanthorrhoea resinosa* on the Noosa Plain, Nilkan soil landscape; western margin of Cooloola Sand–mass in background.

The soils also reflect the poor drainage. *Humus podzols* with organic hardpans 1-2m below the surface are the dominant soils. These grade into *peaty podzols* as the drainage becomes poorer and into *acid peats* in the wetter depressions. *Acid peats* are also associated with the mound peat area near the Rainbow Beach road crossing of Searys Creek. Descriptions of five profiles from Nilkan soil landscape are given below.

Nilkan 1

HUMUS PODZOL (Uc2.33, Tropohumod)

Situation: sand plain behind foredunes
Map ref.: Laguna Bay 251 274*
Elevation: about 4m
Parent material: quartz sands, probably of marine origin
Vegetation: woodland; *Melaleuca quinquenervia, Banksia robur*

Horizon	Depth, cm	Soil morphology
A11	0-20	Very dark brownish grey (10YR3/1), with speckling of white quartz grains, loamy sand. Diffuse to -
A12	20-30	Brownish grey (10YR5/1) sand; diffuse organic matter decreasing with depth. Diffuse to -
A2	30-60	Off-white (10YR8/2,9/2), with a few brownish grey (10YR4/1,6/1) patches, sand. Sharp to -
Bh1	60-80	Black (10YR2/1) organic sand; soft and friable grading to firm pan in lower part. Gradual to -
Bh2	80-110	Very dark reddish brown (5YR2/2) organic sandpan; firm pan becoming softer with depth.

Nilkan 2

PEATY PODZOL (Uc2.33, Tropaquod)

Situation: low-lying part of plain, profile on mound in swamp hummock microrelief
Map ref.: Cooloola 049 088
Elevation: <.5m
Parent material: decomposing plant residues and sandy alluvium
Vegetation: sedgeland; *Banksia robur, Xanthorrhoea resinosa, Leptospermum* sp. and sedges are prominent

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* Military 1-mile Series, Laguna Bay (1:63 360) 2nd ed., 1942.

Horizon	Depth, cm	Soil morphology
0	0-30	Very dark brownish grey fibrous peat speckled with white quartz grains. Diffuse to -
A1	30-50	Very dark brown (10YR2/2) peaty loam to clay loam; many plant roots. Diffuse to -
A2	50-100	Very light brownish grey (10YR5/1 grading to 6/2) sand; perched watertable. Clear to -
Bh	100-140	Very dark brown and black (10YR2/2,2/1) organic sand; massive and firm continuing below 140cm.

Nilkan 3

ACID PEAT (O, Tropohemist)

Situation: crest of mound peat near road crossing Searys Creek
Map ref.: Wide Bay 069 268
Elevation: 25m
Parent material: decomposing plant residues
Vegetation: sedgeland; *Restio* spp., some *Gahnia sieberana* and occasional *Leptospermum* spp.

Horizon	Depth, cm	Soil morphology
	0-45	Very dark brown (7.5YR2/2) fibrous peat; saturated, watertable within 10cm of surface of mounds. Diffuse to -
	45-100	Black (10YR2/1) decomposed organic matter; saturated. Clear to -
	100-150	Light grey-brown (10YR5/2) sand; wet, drilling below 150cm prevented by watertable.

Nilkan 4

GLEYED PODZOLIC SOIL (?Dg2.81, Albaqualf)

Situation: very slightly elevated portion of Noosa Plain
Map ref.: Cooloola 040 186
Elevation: about 12m
Parent material: sandy alluvium overlying feldspathic sandstone
Vegetation: dwarf shrubby woodland; *Eucalyptus umbra*, *Hakea gibbosa*, *Persoonia* sp., *Acacia* spp., *Banksia oblongifolia*, *Xanthorrhoea resinosa*

Horizon	Depth, cm	Soil morphology
A11	0-20	Dark grey-brown (10YR3/2) loamy sand; massive, hardsetting dry; diffuse organic matter. Diffuse to -

A12	20-40	Grey-brown (10YR4/2) sand; diffuse organic matter decreasing with depth. Diffuse to -
A2	40-75	Very pale brown (10YR6/2,7/2) bleached sand; some rusty yellow rootlines and spots. Clear to -
Bg	75-100	Very light grey (5Y7/1,8/1), with faint yellowish mottling, sandy medium clay; no evidence of pedality in auger sample; trace of water-worn gravels; clay subsoil is essentially similar to that weathered from sandstone on nearby lower hillslopes and is interpreted as having been derived from sandstone.

Yikiman soil landscape

This unit comprises the remnants of old large fans of sands washed out from the sand dunes and deposited along the margins of the coastal plain. The present drainage lines are incised in these old fans to depths of 1-3m. The fan surfaces have very gentle slopes to the coastal plain and in many places the junction is barely perceptible.

The vegetation is a shrubby woodland in which *Eucalyptus signata* and *Banksia aemula* are very common species; *E.umbra* occurs in places. The present drainage lines are generally swampy and carry sedgelands in which *B. robur* is usually present.

The soils of the fan remnants are *humus podzols* with giant profiles on the apex and higher parts of the fans and shallower profiles around the fan margins where watertables are closer to the surface. *Peaty podzols* and *acid peats* occur in the drainage lines. Descriptions of three profiles from Yikiman soil landscape are given below.

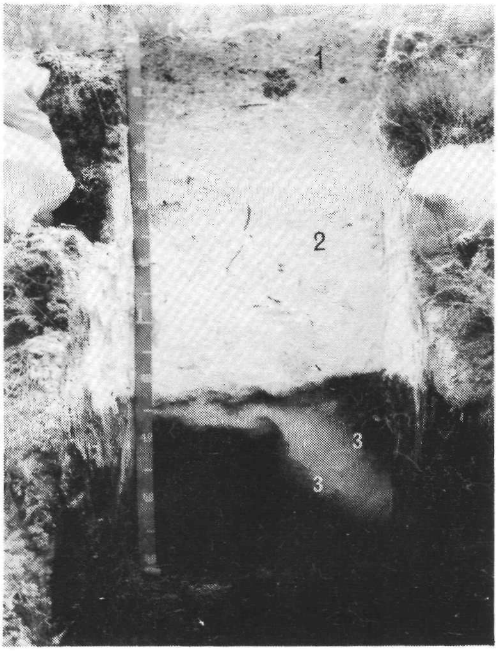
Yikiman 1

Giant *HUMUS PODZOL* (Uc2, Quartzipsamment)

Situation: remnant of old fan
Map ref.: Cooloola 058 101
Elevation: about 30m
Parent material: quartz sand alluvium
Vegetation: shrubby woodland; *Eucalyptus signata, Banksia aemula, Xanthorrhoea* sp.

Horizon	Depth, cm	Soil morphology
A11	0-5	Very light brownish grey (10YR6/1,7/1) sand; loose dry; charcoal and fragments of organic matter. Clear to -
A12	5-30	Brownish grey (10YR4/1,4/2) sand; loose dry; diffuse organic matter. Diffuse to -

A13	30-60	Light grey-brown (10YR5/2 grading to 6/2) sand; loose dry; diffuse organic matter decreasing with depth. Diffuse to -
A21	60-920	Off-white (10YR8/1,9/1) sand; loose dry; occasional root staining. Diffuse to -
A22	920-1000	Off-white (10YR8/2,7/2) sand; saturated, watertable at 920cm (interpreted as watertable perched on organic pan).



Humus podzol in sandy fan alluvium at research site R10, Yikiman soil landscape; horizons are A_1(1), A_2 of bleached sand (2), Bh sand with accumulation of organic compounds (3).

Yikiman 2

HUMUS PODZOL (Uc2.33, Tropohumod)

Situation: gently sloping fan at research site R10
Map ref.: Cooloola 041 176
Elevation: 8m
Parent material: interleaved sandy alluvium from dunes and sandstone
Vegetation: shrubby woodland; *Banksia aemula, Eucalyptus signata, Casuarina littoralis*

Horizon	Depth, cm	Soil morphology
A11	0-4	Very light brownish grey (10YR6/1,7/1) sand; loose dry; organic fragments and charcoal. Clear to -

A12	4-15	Very dark brownish grey (10YR3/1,4/1) sand; massive, weakly coherent dry; diffuse organic matter. Diffuse to -
A13	15-60	Light grey-brown (10YR4/2,5/2 grading to 7/2) sand; loose dry; diffuse organic matter decreasing with depth. Diffuse to -
A2	60-120	Off-white (10YR8/1,8/2) sand; perched watertable. Abrupt to -
Bh1	120-140	Black (10YR2/1,3/1) organic sand; friable moist. Clear to -
Bh2	140-198	Black (10YR2/1) organic sand hardpan; hard and cemented dry. Abrupt to -
C	198-208	Grey-brown (10YR4/2,3/2) sand; loose dry; sandy alluvium overlying stratified sandy alluvium and buried soil horizons.

Yikiman 3

PEATY PODZOL (Uc2.20, Tropoquod)

Situation: swampy drainage line
Map ref.: Cooloola 065 166
Elevation: about 30m
Parent material: organic residues and quartz sand alluvium
Vegetation: sedgeland; some *Banksia robur* and *Leptospermum liversidgei*

Horizon	Depth, cm	Soil morphology
A0	20-0	Black (10YR2/1) peat with some white sand; many roots in the upper part. Gradual to -
A1	0-30	Black (10YR2/1) peaty sand; massive, weakly coherent. Diffuse to -
A2	30-80	Light grey-brown (10YR5/2,6/2) sand; saturated, watertable at 30cm. Clear to -
Bh	80-110	Very dark brown (7.5YR2/2) organic sand; weakly coherent but no evidence of pan.

Noosa River soil landscape

This soil landscape consists of narrow floodplains, terraces and low levees of the Noosa River and its tributaries upstream of a rather arbitrary boundary (near Cooloola 050 070) based on air-photo patterns. The narrow floodplains are broken by many erosion channels and sandy banks, the result of frequent flooding. In contrast, the terraces have very gentle slopes that in many places grade almost imperceptibly into the open plain.

Most of the area carries a grassy woodland in which *Eucalyptus signata, E. tereticornis, E.umbra, E.bancroftii* and *Tristania sauveolens* are fairly common species. The channels of the main streams are lined in places with fringing forests that include *Elaeocarpus reticulatus, Syzygium coolminianum* and *Eucalyptus spp.*, or woodland of *E. umbra, Banksia aemula*, and *Melaleuca quinquenervia*. Small patches of dense *Melaleuca* forest, wet sclerophyll forest and sedgeland also occur.

Gleyed podzolic soils on the gently sloping terraces are probably dominant, *alluvial soils* associated with narrow floodplains, and *humic gleys* and *humus podzols* occur in the swampy drainage lines. Descriptions of three profiles from Noosa River soil landscape are given below.

Noosa River 1

GLEYED PODZOLIC SOIL (Gn2.94, ?Haplaquept)

Situation: terrace of Noosa River, probably over-topped by high floods
Map ref.: Cooloola 000 176
Elevation: about 20m
Parent material: sandy alluvium derived from sandstone
Vegetation: grassy woodland; *Eucalyptus signata, E.umbra, E. intermedia, Casuarina littoralis*

Horizon	Depth, cm	Soil morphology
A1	0-10	Dark grey-brown (10YR4/2) fine sandy loam; massive, hardsetting dry. Gradual to -
A2	10-25	Light brown (10YR5/3), with very light grey-brown (10YR7/3) patches, fine sandy loam; massive, earthy fabric. Gradual to -
B1	25-50	Light yellowish brown (2.5Y5/4), with very light grey-brown (10YR7/3) patches, fine sandy clay loam. Gradual to -
B21	50-70	Mottled light grey (2.5Y7/1) and yellow-brown (10YR5/4,5/6), with some reddish brown (5YR4/4) patches, silty clay. Diffuse to -
B22	70-130	Mottled light grey (2.5Y7/1) and yellowish brown (10YR5/8) silty medium clay; no evidence of pedality in augered material.

Noosa River 2

ALLUVIAL SOIL (Uc1.41, Quartzipsamment)

Situation: narrow floodplain of the Noosa River
Map ref.: Cooloola 001 178
Elevation: about 20m
Parent material: sandy alluvium derived from sandstone
Vegetation: grassy woodland; *Eucalyptus signata, E.tereticornis, E.umbra, Tristania sauveolens*

Horizon	Depth, cm	Soil morphology
A1	0-10	Grey-brown (10YR5/2,5/1) loamy fine sand; massive, hardsetting dry. Diffuse to -
C	10-50	Pale yellowish brown (10YR6/4,6/3) fine sand; weakly coherent. Gradual to -
C	50-150	Pale yellowish brown (10YR6/4), with very light grey-brown (10YR7/2) patches, fine sand; river alluvium continuing below 150cm.

Noosa River 3

HUMIC GLEY (Dg4.51, Umbraqualf)

Situation: swampy drainage line
Map ref.: Wolvi 962 123
Elevation: about 25m
Parent material: sandy alluvium and organic residues
Vegetation: layered woodland; *Eucalyptus robusta, Melaleuca sieberi, M. quinquenervia, Tristania sauveolens* and *Banksia robur* over dense sedge ground cover

Horizon	Depth, cm	Soil morphology
A11	0-20	Very dark brown (10YR2/2) fibrous organic clay loam; many roots. Diffuse to -
A12	20-60	Very dark brown (10YR2/2) organic clay loam; saturated, watertable at 20cm. Diffuse to -
A13	60-70	Dark brownish grey (10YR4/1,4/2) organic clay loam; saturated. Abrupt to -
Bg	70-100	Light grey (10YR7/1), with some yellow-brown (10YR5/8) mottles, medium heavy clay; no evidence of pedality.

Dibing soil landscape

This unit takes in the low country along the Noosa River downstream of Cooloola 050 070 and marginal to Lakes Cooloola, Como, Cootharaba and Cooriobah. It is essentially the deltaic plain of the Noosa River plus the former shorelines and lands that were inundated when the lake levels were higher than at present. As mapped it extends around the eastern margins of Lakes Cootharaba and Cooriobah to the river mouth and so includes some estuarine sediments. The country is generally flat with elevations of <5m; it includes broad swampy depressions, very low sandridges of stranded shorelines and low sandy levees. Most of the area is seasonally wet with watertables at or close to the surface for long periods in most years.

The vegetation varies from forest to sedgeland depending on the drainage condition and texture of the soil. The river levees usually carry an open forest in which *Eucalyptus signata* and *Banksia aemula* are common species and a number of vine scrub species also occur. The open forest of the levees grades into woodlands and sedgelands east of the river. Dense forests of *Melaleuca quinquenervia* occur along many of the shallow depressions and grade into woodlands and then sedgelands on the lake margins. *Causarina glauca* occurs along the lake margins and with *M.quinquenervia* forms a dense forest on Kinaba Island.

The limited soil data indicate that *humic gleys* and gleyed *alluvial soils* on flats and depressions are the most common soils. *Siliceous sands* and, in places, *humus podzols* occupy the lower sandridges and sandy levee deposits. *Peaty podzols* have also been recorded in some areas around the lake margins. Descriptions of three profiles from Dibing soil landscape are given below.

Dibing 1

HUMIC GLEY (Dy3.11, Umbraqualf)

Situation: gently sloping flat adjacent to Lake Como
Map ref.: Cooloola 015 021
Elevation: <5m
Parent material: lacustrine sediments
Vegetation: woodland; *Melaleuca quinquenervia, Tristania sauveolens*

Horizon	Depth, cm	Soil morphology
A1	0-20	Very dark brownish grey (10YR2/1,3/1) loam; moderate subangular blocky structure. Clear to -
Bg	20-50	Brownish grey (2.5Y5/2), mottled with yellowish brown (10YR5/8), medium clay; moderate coarse prismatic structure breaking to blocky peds 1-2cm size; dark brownish grey (10YR4/1) cutans on some ped faces. Abrupt to -
	50-54	Stoneline of quartz and sandstone gravel, some sesquioxide nodules. Abrupt to -
D	54-100	Very light grey (2.5Y7/1), mottled with yellow-brown (10YR6/8), stiff heavy clay.

Dibing 2

Gleyed *ALLUVIAL SOIL* (Um6.22, ?Aquent)

Situation: wet flats of Kinaba Island
Map ref.: Cooloola 028 983
Elevation: about 1m
Parent material: lacustrine sediments
Vegetation: forest; *Causarina glauca, Melaleuca quinquenervia*

Horizon	Depth, cm	Soil morphology
A00	10-2	Dry litter; leaves and twigs from mainly *C. glauca*.
A0	2-0	Very dark brown (7.5YR2/2) decomposed litter; moist.
A11	0-8	Dark brown (7.5YR3/2) silt loam; moderate crumb and subangular blocky structure. Gradual to -
A12	8-15	Grey-brown (10YR4/2), with some rusty flecks, silty clay loam; moderate subangular blocky structure, pedality decreasing with depth. Gradual to -
C1	15-45	Light grey-brown (10YR5/2) silty clay loam; saturated, watertable at 15cm. Gradual to -
	45-150	Very light grey-brown (10YR7/2) medium-grained sand.

Dibing 3

SILICEOUS SAND (Uc1.22 on clay D, Quartzipsamment)

Situation: low sandridge of old shoreline just north of Lake Como
Map ref.: Cooloola 015 022
Elevation: about 5m
Parent material: quartz sands
Vegetation: woodland; *Eucalyptus tereticornis, Banksia integrifolia, Acacia* spp.

Horizon	Depth, cm	Soil morphology
A1	0-40	Dark grey-brown (10YR3/2 grading to 4/2) sand; medium-grained; loose dry. Diffuse to -
C	40-90	Yellow-brown (7.5YR7/6) sand; loose dry.
	90-94	Stoneline of sandstone and quartz gravels, some sesquioxide nodules. Abrupt to -
D	94-120	Yellowish-brown (10YR5/6), mottled with reddish brown and light grey, medium clay; moderate blocky structure.

Tarangau soil landscape

This unit comprises the gently undulating area of low-gradient sandy fans and broadly-convex sandstone hills that extend north-west from Lake Como to the Como Scarp. Elevations are generally <20m over most of the unit but reach about 50m at the base of the scarp.

The fans carry open forest with *Eucalyptus grandis, E.intermedia* and *Tristania conferta* as tall emergents above fairly dense vine scrub, 8-10m high, in which palms (*Livistona* sp.) are usually present. Tall forest in which *E. intermedia, T.conferta* and *Casuarina torulosa* are common occurs on the sandstone hills. Small areas of dense *Melaleuca quinquenervia* forest occupy some narrow drainage lines.

Soil data are limited. Sandy *yellow podzolic soils* on the higher parts of the gently undulating fans are probably dominant. A feature of these soils are their thick (30-50cm) fine sandy loam A1 horizons. *Podzols* with hardpan B horizons occupy adjacent but slightly lower sites in the fans and *yellow podzolic soils* with clay subsoils grading into sandstone within a metre depth occupy some of the low hillslopes. Descriptions of two profiles from Tarangau soil landscape are given below.

Tarangau 1

YELLOW PODZOLIC SOIL (Gn2.74, ?Paleustult)

Situation: higher part of low-gradient fan
Map ref.: Wolvi 000 015
Elevation: <20m
Parent material: sandy alluvium derived largely from sandstone
Vegetation: open forest; *Eucalyptus grandis, E.intermedia, Tristania conferta,* over dense vine scrub 8m tall

Horizon	Depth, cm	Soil morphology
A11	0-30	Dark grey-brown (10YR4/2,3/2) fine sandy loam; moderate subangular blocky structure. Diffuse to -
A12	30-50	Grey-brown (10YR5/2,4/2), with pale yellowish brown (2.5Y6/4) patches, fine sandy loam; massive, earthy fabric. Diffuse to -
A2	50-75	Pale yellowish brown (2.5Y6/4), bleached dry, clayey sand. Diffuse to -
B1	75-100	Yellow-brown (10YR6/8), with some yellowish brown (6.5YR5/8) mottles, sandy clay loam; massive, earthy fabric; low amounts of lateritic nodules. Diffuse to -
B2	100-140	Yellow-brown (10YR6/8), with some reddish brown (5YR4/4) mottles, sandy clay; massive, earthy fabric; low amounts of lateritic nodules 1-2cm size.

Tarangau 2

PODZOL (Uc3.33, Troporthod)

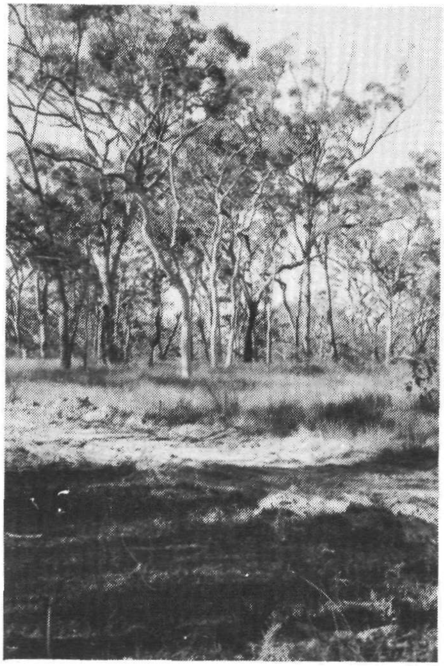
Situation: low-gradient fan
Map ref.: Wolvi 961 008
Elevation: 20m
Parent material: sandy alluvium derived mainly from sandstones
Vegetation: open forest; *Eucalyptus grandis, Tristania conferta* over dense vine scrub 8m tall

Horizon	Depth, cm	Soil morphology
A00	3-0	Mixed leaf litter.
A11	0-40	Very dark brownish grey (10YR3/1), with white speckle of quartz grains, loamy sand; diffuse and fragmentary organic matter. Diffuse to -
A12+A2	40-60	Dark brownish grey (10YR4/1,5/1), with some pale grey-brown (10YR6/2,7/2) bleached patches, sand; diffuse organic matter decreasing with depth. Abrupt to -
Bhir1	60-80	Dark brown (6.5YR2/2), with brown (7.5YR5/8) and reddish brown (5YR4/8) patches, organic hardpan; very hard dry. Gradual to -
Bhir2	80-100	Brown (7.5YR4/4) clayey sand; massive, weak pan. Gradual to -
C	100-120	Yellow-brown (10YR6/8), with reddish brown (5YR4/4) mottles, sandy clay loam; massive, earthy fabric similar to the B2 horizon of adjacent yellow podzolic soils.

Pertaringa soil landscape

This unit covers a relatively large area and includes the low hilly sandstone country of the western catchment of the upper Noosa River, the upper Teewah Creek catchment, the low hills between the old Como sawmill and Fig Tree Point, and the area east of Carland Creek between the Rainbow Beach road and Tin Can Inlet. Most of the area consists of low sandstone ridges that are made up of convex rises and long, gently sloping platforms, with gentle to moderate sideslopes to shallow valleys with dendritic drainage pattern. Elevations are generally less than 60m and local relief less than 20m. Small areas of higher hills with steeper slopes and surface stone (Mullens soil landscape) have been included where they are too small to delineate separately.

The vegetation on sites with free to moderate drainage varies from grassy woodland to open grassy forest over most of the area; there are a few small areas of forest. Common species include *Eucalyptus signata, E.drepanophylla, E. gummifera* and *Angophora costata*. The seasonally wet slopes carry woodlands to open woodlands that include species such as *E. umbra, Melaleuca quinquenervia, Banksia oblongifolia, Hakea gibbosa* and *Leptospermum* spp.



Grassy woodland with *Angophora costata* and *Eucalyptus umbra* on a low sandstone hill at research site R8, Pertaringa soil landscape.

Open forests of *M.quinquenervia*, with some *E.robusta* and with *B.robur* prominent in the ground cover occur along the drainage lines and wet heath is associated with some swampy areas.

A range of soils have developed as a result of variations in the composition of the parent sandstones or their derivatives and differences in the stage of dissection or drainage condition. The most common soils on the sandstone hills appear to be *gleyed podzolic soils, soloths* and *lateritic podzolic soils*.

The *gleyed podzolic soils* usually have clay subsoils at shallow depths and are associated with the lower and middle slopes but extend upslope onto some of the saddles. There is usually a sharp boundary between sandy loam surface horizons and the clay subsoils which have prismatic or coarse blocky structure. The soils are mostly <70cm deep to the underlying medium-grained sandstone. The *lateritic podzolic soils* occupy the crests and upper slopes of the gently sloping platforms or dissected remnants of them. They have earthy profiles with gradational texture increase in the upper part of the profile and overlie pedal clays usually at depths of 80-120cm; lateritic nodules and in some cases quartz gravels occur in the lower part of the earth profile above the pedal clays. These soils appear to have formed in sandy alluvium overlying sandstone and as a rule the thickness of earthy profile is greater on the younger platforms closest to the river. No *lateritic podzolic soils* were observed on the low sandstone hills south-east of the old Como sawmill.

Humic gley soils have developed in the sandy alluvium of most of the depression lines but occupy a smaller aggregate area than any of the above soils and are really an extension of the Noosa River soil landscape. Minor areas of other soils occur, e.g. some areas of sandy *yellow podzolic soils* with earthy gradational profiles that appear to have weathered from medium-grained sandstone in place, shallow *podzols* associated with the quartzose sandstone capping on some hillcrests, *humus podzols* on small areas of very sandy alluvium, and *acid peats* in some swampy areas. Descriptions of five profiles from Pertaringa soil landscape are given below.

Pertaringa 1

GLEYED PODZOLIC SOIL (Dg2.41, ?Glossaqualf)

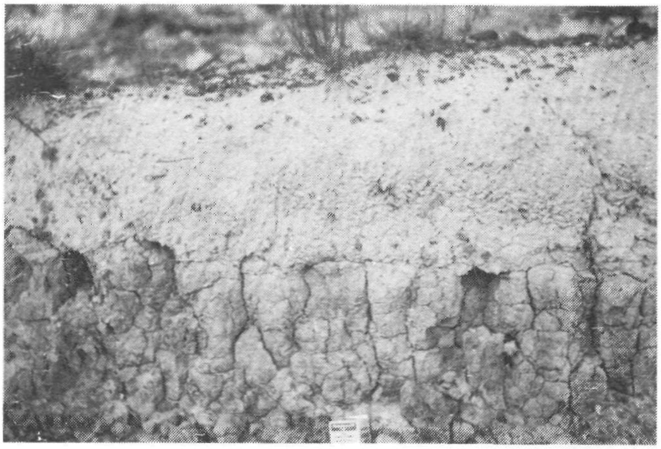
Situation: lower slope of low sandstone hill
Map ref.: Wolvi 922 211
Elevation: 50m
Parent material: medium-grained sandstone with interbedded shale bands
Vegetation: grassy woodland; *Eucalyptus umbra* with a little *E. intermedia; Banksia oblongifolia, Xanthorrhoea resinosa* and sedges are prominent in the ground cover

Horizon	Depth, cm	Soil morphology
A1	0-15	Brownish grey (10YR5/1) sandy loam; massive, hardsetting dry. Gradual to -
A2	15-30	Light grey-brown (10YR6/2,7/2), bleached dry, some rusty flecks, sandy loam; low amounts of gravel. Clear to -
Bg1	30-100	Light grey (5Y7/1,8/1), with brownish grey (10YR6/1) and yellow-brown (10YR5/6) mottles, sandy medium clay; strong coarse blocky structure; some bluish (5GY6/1) patches on ped faces; some pockets of light grey-brown sandy loam associated with fresh-water crayfish burrows. Diffuse to -
Bg2	100-120	Very light grey (5Y8/1), with reddish (5YR4/6) and yellowish (7.5YR5/6) mottles, sandy medium clay with pockets of weathered sandstone.
C	120-	Strongly weathered sandstone.

Pertaringa 2

SOLOTH (Dy3.41, Haplustalf)

Situation: crest of low sandstone hill at research site R8
Map ref.: Wolvi 967 124
Elevation: 50m
Parent material: medium-grained sandstone
Vegetation: grassy woodland; *Angophora costata, Eucalyptus umbra* with occasional *E. intermedia, Casuarina littoralis* and *Themeda australis* ground cover



Soloth on medium–grained sandstone, Pertaringa soil landscape; horizons are thin sandy loam A_1 (1), bleached clayey sand A_2 (2) and B_2 clay with prismatic structure (3).

Horizon	Depth, cm	Soil morphology
A1	0-5	Brownish grey (10YR4/1), with grey-brown (10YR5/2) patches, sandy loam; massive, hardsetting dry. Clear to -
A2	5-13	Pale brown (10YR5/3,6/3), bleached dry, with rusty flecks, clayey sand; moderate amounts of iron-impregnated sandstone gravel. Abrupt and uneven to -
B2	13-50	Yellowish brown (10YR5/4), mottled with pale brown (10YR6/3), medium clay; strong prismatic structure; peds 10x10x15cm breaking to blocky 5cm peds; brownish grey (10YR4/1) on ped faces. Diffuse to -
C	50-	Brown (10YR5/3), with yellowish mottling, weathered sandstone.

Pertaringa 3

LATERITIC PODZOLIC SOIL (Gn2.74 over pedal clay, ?Paleustult)

Situation: crest of gently sloping platform underlain by sandstone
Map ref.: Cooloola 013 182
Elevation: 30m
Parent material: (?) old sandy alluvium overlying medium-grained sandstone
Vegetation: open grassy forest; *Eucalyptus signata, E.intermedia,* occasional *E.umbra,* lower storey includes *Casuarina littoralis, Leptospermum attenuatum, Persoonia* spp., *Banksia oblongifolia*

Horizon	Depth, cm	Soil morphology
A1	0-10	Grey-brown (10YR4/2) and brownish grey (10YR5/1) sandy loam; massive, hardsetting dry. Gradual to -
A2	10-40	Light yellowish brown (10YR6/4) sandy loam; massive, earthy fabric. Diffuse to -
B1	40-80	Yellow-brown (10YR6/8) sandy clay loam; massive, earthy fabric. Diffuse to -
B2	80-100	Yellow-brown (10YR5/8), with reddish yellow (5YR5/8) mottles, sandy clay; massive, earthy fabric; low amounts of lateritic nodules particularly at 95-100cm. Clear to -
D	100-125	Yellow-brown (10YR5/8), mottled with red (2.5YR4/6) and pale yellow-grey (2.5Y7/4), medium clay; moderate blocky structure, peds 8-10mm (interpreted as truncated remnant of lateritic weathering profile in medium-grained sandstones as seen elsewhere in the coastal lowlands).

Pertaringa 4

HUMIC GLEY (Dg4.81, Albaqualf)

Situation: narrow drainage line with swamp hummock microrelief
Map ref.: Wolvi 979 143
Elevation: about 20m
Parent material: sandy alluvium derived from sandstone
Vegetation: woodland; *Eucalyptus bancroftii*, *Melaleuca quinquenervia*, dense wet heath understorey that includes *Banksia robur* and *Leptospermum* spp.

Horizon	Depth, cm	Soil morphology
A11	0-40	Very dark brownish grey (10YR3/1,2/1) organic loam; moderate subangular blocky structure. Gradual to -
A12	40-65	brownish grey (10YR3/1 grading to 4/1) loamy sand; apedal. Diffuse to -
A13	65-80	Brownish grey (10YR4/1 grading to 5/1,6/1) sand; with diffuse organic matter decreasing with depth. Diffuse to -
A2	80-110	Very light grey-brown (10YR6/2,7/2) sand; saturated, perched watertable. Abrupt to -

Bg	110-125	Very light brownish grey (10YR7/1), with yellow-brown (10YR6/8) mottles, sandy medium clay; no evidence of pedality; continuing below 125cm.

Pertaringa 5

PODZOL (Uc2.31, Troporthod)

Situation: crest of low sandstone rise
Map ref.: Cooloola 025 201
Elevation: 45m
Parent material: coarse quartzose sandstone capping medium-grained sandstone
Vegetation: shrubby woodland; ***Eucalyptus signata*** and ***E.umbra***, , with dense understorey of ***Leptospermum*** spp., ***Xylomelum pyriforme*** and ***Acacia flavescens***

Horizon	Depth, cm	Soil morphology
A11	0-20	Very dark brownish (10YR3/1), speckled with white quartz grains, loamy sand; low amounts of fine quartz grit. Diffuse to -
A12	20-45	Dark brownish grey (10YR4/1) grading to brownish grey (10YR4/1,6/1) sand; diffuse organic matter decreasing with depth; slight quartz grit. Diffuse to -
A2	45-60	Very light brownish grey (10YR7/2,7/1) sand; slight quartz grit. Abrupt uneven to -
Bhir	60-80	Yellow-brown (10YR6/6), mottled with pale brown (10YR6/3,7/3) and dark brown (7.5YR4/2,10YR4/3), light sandy clay loam; massive hardpan; slight quartz grit. Gradual to -
B3	80-100	Light yellow-brown (10YR6/4) sandy clay; massive, earthy fabric; friable to firm moist; moderate amounts of reddish yellow (5YR5/8) and brown sesquioxide nodules. Diffuse to -
	100-	Weathered medium-grained sandstone.

Mullens soil landscape

This unit comprises the small residual sandstone hills that rise above the low hilly western catchment of the Noosa River. These hills have narrow crests with elevations of 60-170m, moderate to steep slopes of 15-30° and a local relief usually in excess of 50m. They may be capped by coarse quartzose sandstones and have medium-grained sandstones and shales exposed on the lower slopes. Boulder outcrops and surface stone are a feature of most crests and the slopes are usually mantled by lag gravels.

The vegetation varies from grassy woodland to open grassy forest in which *Eucalyptus intermedia* and *E.drepanophylla* are common species and some *Tristania conferta, Angophora costata* and *Banksia integrifolia* are often present. The soils are shallow and stony and quite variable depending on the underlying strata. *Lithosols* and podzolic *lithosols* appear to be dominant and occur in complexes with shallow, earthy *yellow podzolic soils* in some areas. Both *red* and *yellow podzolic soils* have also been observed on lower slopes and in places are associated with shale bands interbedded with the sandstone. Descriptions of three profiles from Mullens soil landscape are given below.

Mullens 1

Podzolic *LITHOSOL* (Uc2.12, Ustorthent)

Situation: slope (22°) of sandstone hill
Map ref.: Wolvi 930 149
Elevation: 90m
Parent material: quartzose sandstone
Vegetation: open grassy forest; *Eucalyptus intermedia, E.drepanophylla, Tristania conferta, Angophora costata*

Horizon	Depth, cm	Soil morphology
A1	0-15	Grey-brown (10YR4/2), with brownish grey (10YR4/1) patches, loamy sand; some surface gravel and stones; hardsetting dry. Gradual to -
A2	15-30	Light grey-brown (10YR6/3,7/3) bleached loamy sand; some weathered sandstone gravel. Clear uneven to -
C	30-	Weathered sandstone.

Mullens 2

YELLOW PODZOLIC SOIL (Gn2.34, ?Ustochrept)

Situation: upper slope of sandstone knoll
Map ref.: Wolvi 983 152
Elevation: about 50m
Parent material: medium-grained sandstone
Vegetation: grassy woodland; *Eucalyptus signata, E.intermedia, Banksia integrifolia, Tristania conferta*

Horizon	Depth, cm	Soil morphology
A1	0-15	Dark brownish grey (10YR3/1) loamy sand; much surface gravel and stone. Gradual to -
A2	15-40	Light grey-brown (10YR5/2,6/2) bleached loamy sand; much sandstone gravel and stone. Diffuse to -

B2	40-70	Yellow-brown (10YR6/8) clayey sand to sandy clay loam; massive, earthy fabric; much gravel and stone. Gradual to -
C	70-	Weathered sandstone.

Mullens 3

RED PODZOLIC SOIL (Dr3.41, Haplustalf)

Situation: upper slope of sandstone hill
Map ref.: Wolvi 897 221
Elevation: 160m
Parent material: quartzose sandstone interbedded with shale
Vegetation: grassy forest

Horizon	Depth, cm	Soil morphology
A1	0-5	Dark brownish grey (10YR4/1,3/1) coarse sandy loam; hardsetting dry; gravel and stone 2-30cm size form a surface mulch. Gradual to -
A2	5-15	Pale brown (10YR5/4,dry7/4) bleached sandy loam; some sandstone gravel. Clear to -
B2	15-25	Red-brown (5YR4/6), mottled with yellowish brown (10YR5/4), medium clay; strong blocky structure, peds 2-5cm; hard dry. Gradual to -
B3	25-35	Mottled reddish brown (5YR5/6) and yellowish brown (10YR6/4) light medium clay; some shale fragments. Gradual to -
C	35-	Grey shale.

Surface horizons are interpreted as being derived from sandstone and the subsoil from shale.

Como Scarp soil landscape

This unit is confined to the moderate to steep slopes of an erosion scarp that defines the western limits of the Noosa River catchment. It is cut mainly in medium-grained sandstones; crest elevations vary from 60 to 80m.

The vegetation varies from open grassy forest along the northern and central parts of the scarp to forest in the southern sector, south-west of Tarangau property. Common tree species include *Eucalyptus intermedia, Tristania conferta* and *Casuarina torulosa*.

Soil data are limited. The soils are shallow, generally <60cm to weathered sandstone; boulder outcrop and surface stone are less obvious than in Mullens soil landscape. Shallow *yellow podzolic soils* and *podzolic lithosols* appear to be the most common soils but some areas of shallow *red podzolic soils* have also been observed. A description of one profile from Como Scarp soil landscape is given below.

Como Scarp 1

YELLOW PODZOLIC SOIL (Dy3.21, Haplustalf)

Situation: steep slope of erosion scarp
Map ref.: Wolvi 960 306
Elevation: about 70m
Parent material: medium-grained sandstone
Vegetation: forest; *Eucalyptus intermedia, Tristania conferta, Casuarina torulosa*

Horizon	Depth, cm	Soil morphology
A1	0-12	Dark grey-brown (10YR3/2) sandy loam; hardsetting dry. Gradual to -
A2	12-24	Light brown (10YR5/3), with brownish grey (10YR5/1) patches, sandy loam. Clear to -
B2	24-42	Mottled pale olive (2.5Y6/3) and yellowish brown (7.5YR5/8) sandy medium clay; strong blocky structure with grey-brown (10YR4/2) cutans on ped faces. Diffuse to -
	42-	Soft weathered medium-grained sandstone.

THE PODZOL CHRONOSEQUENCE

Although the Cooloola Sandmass is made up of overlapping dune systems deposited one above the other, sizeable areas of six of the dune systems were not covered by successive phases of dune building. These areas appear to have been continuously exposed to subaerial weathering since their deposition and they form a large part of the present groundsurface. These dunes can be placed in a relative age sequence by using geomorphic and stratigraphic evidence and differences in degree of erosion and weathering, but no absolute ages have been determined for the individual systems at Cooloola. However, the few geochronometric dates available from materials embedded in some of these sands (Coaldrake 1962) and from similar dunes elsewhere along the coast (Thom and Chappel 1975; Marshall and Thom 1976; Grimes 1979) together with differences in the degree of erosion evident in the dunes, indicate that the present groundsurface must include both Holocene and Pleistocene dunes. From the available evidence (see pp. 10-15) it can also be deduced that the oldest dunes must extend back to at least the last interglacial period and are probably older (Thompson 1981). Where exposed, these form a time sequence in which the aeolian sands have been weathered to form a range of soils with the depth and intensity of pedological development clearly associated with the relative age of the dune systems.

Time sequences are useful in extending man's view of changes that occur in soils and biolgoical systems as weathering proceeds, provided that the parent materials are relatively constant throughout the sequence and variations in climate and drainage have not produced marked distortions in the weathering trends (Jenny 1980).

Although there is no certainty that the sands were identical in each of the dune-building phases at Cooloola, there is strong evidence that they were very similar. Examinations of weathered and unweathered sands from the different dune systems show that they are all well-sorted, with similar modal grain sizes between 180 and 250μm (Ross 1977) although under the scanning electron microscope sands from the oldest system show some evidence of greater weathering (M.P. Green *pers. comm.*). The sand grains are mostly quartz with usually <2% of other minerals, mainly ilmenite, rutile, zircon, monazite and feldspar. There is no evidence of sea-shell fragments except for rare pieces in some of the youngest dunes and a few shells on the surface elsewhere that have been distributed by man.

The sands of the currently mobile dunes are varying shades of yellow-brown due to thin sesquioxide coatings around the quartz grains. Unweathered sands have been recovered from all but the oldest dune system and have been found to have similar coatings and colours. All the evidence points to aeolian sands of similar grain size and composition forming each of the dune systems in the age sequence. In addition, the sands of the apices and adjacent trailing arms are >30m thick, except in the youngest system, which ensures the pedological unity of the weathering column. For studies of weathering and soil development these dunes provide a parent material that can be regarded as essentially constant both in depth and across the different dune systems. Mineralogically, it is a simple parent material in which subaerial weathering is largely confined to the removal of the sesquioxide coatings from the sand grains and transportation of the constituent compounds to greater depths or out of the system.

The climate at Cooloola is determined by its location on the coast and by both the tropical and temperate weather systems that bring summer rains to northern Australia and winter rains to the south. It lies in the overlap zone between these two systems and as a consequence may have escaped extreme variations in rainfall during the Quaternary. It has been suggested that northerly movement of the southern anticyclone system during a glacial period would probably increase the winter rainfall component to such areas and thereby compensate for loss of summer rainfall (Coaldrake 1968).

It is perhaps significant that there is no evidence at Cooloola of dune forms characteristic of regional areas of bare sand, such as might be expected to develop if the rainfall became too low to support vegetation. In fact, the youngest four dune systems consist of parabolic dunes and there is some evidence that the dunes of the next oldest system initially had parabolic form also. The parabolic shape with trailing arms extending upwind is characteristic of blowout dunes developed in vegetated areas and of sands blown into forest and woodland areas from a coastal source. These shapes imply that the dunes at Cooloola have supported a vegetation cover continuously since at least before the deposition of the youngest four systems and probably for a much longer period. In addition, there has been extensive fluviatile erosion in dunes regarded as being of Pleistocene age and no evidence of regional reworking by wind since then. Also, the occurrence of giant *podzols* on high exposed areas of the older dune systems is in itself proof that these have been vegetated since soil profile development began at these sites otherwise the deep soil profiles would have been destroyed. This shows that local climates during the last glaciation and probably for a considerable time before that have been sufficiently favourable to support vegetation on these dunes.

Although higher rainfall than that pertaining at present will have led to higher watertables, the thickness of permeable sands in each of the systems, their elevation of 50-260m above sea level and the hilly ridge and corridor topography have ensured that the ridge situations have remained well-drained in all except perhaps the oldest dune system. Variations in climate since the oldest dunes were deposited will have accelerated or retarded the annual weathering rates and so will have increased or reduced the degree of difference evident between different dune systems. However, there is little evidence to show that these variations were of sufficient magnitude to distort the weathering trend at freely-drained sites.

Soil development in the dunes begins with the first colonizing plants and proceeds under a vegetative cover. It consists of the mobilization of the sesquioxide coatings on the sand grains, together with organic compounds derived from the vegetation and soil organisms and their translocation to lower depths in the dune sands.

At freely-drained sites this leads to the development of *podzol* profiles in which the sands of the A1 and A2 horizons have been stripped of sesquioxide coatings and those of the B horizons have received additions of iron, aluminium and organic compounds (Brewer and Thompson 1980). With increasing age, the organic compounds and sesquioxides in the top of the B horizons are remobilized and moved to deeper positions. This eventually leads to a marked increase in the thickness of the bleached A2 relative to that of A1 and B horizons and to the formation of giant profiles in which the vertical dimensions are limited only by the thickness of freely-drained sand and prevailing rates of erosion.

A comparison of the soils at similar geomorphic sites in each of the dune systems shows a close association between the depth and degree of soil development and the relative age of the dune system (Fig. 5), the extremes being soils with rudimentary horizon development restricted to the surface 1m in the youngest dunes and giant forms on the oldest dunes where depth to B horizon can exceed 22m.

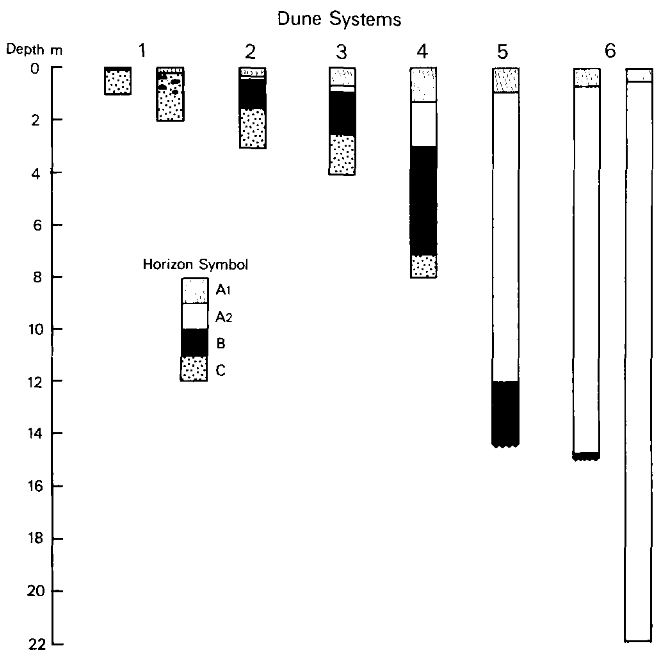


Figure 5. Examples of *podzol* profile development on trailing arm crests (dune systems 1-4) and ridge crests (dune systems 5 and 6).

Because the parent materials and weathering trends are relatively constant and there is little variation in the present climate across the sandmass, the *podzol* chronosequence at Cooloola provides a wide range of sites with marked differences in the degree of weathering, podzol development, erosion, nutrient supply, vegetation and biological activity in coastal sand dunes. The area therefore proved to be a most suitable site for the investigation of landscape dynamics of coastal dunes in the subtropics.

LAND USE – IMPACT OF MAN ON SAND DUNES

Ecosystems on sand dunes are naturally fragile because of the continual struggle to obtain nutrients and water from a medium that has a poor capacity to supply elements essential to plant growth and in which the physical properties allow soil water conditions to oscillate rapidly between saturation and drought. As a consequence most vegetation communities, and indirectly the soil fauna dependent upon them, are in a relatively delicate, dynamic equilibrium susceptible to environmental changes that affect nutrient and moisture supply.

Similarly, the rate of erosion on dune slopes is largely determined by the amount of cover on the soil surface protecting it from raindrop impact (Bridge *et al.* 1984). This means that changes in the amount of litter, grass and shrub understorey, and tree canopy will affect the rates of erosion.

The impact of both Aboriginal and European man on the sand dunes has derived mostly from their influence on canopy and surface cover, through timber-cutting and burning and through the removal or addition of various elements required for plant growth. Although trampling by domestic livestock accelerates erosion, the introduction of exotic species does not appear to have had markedly deterimental effects. However, these are likely to pose a much greater threat as nearby urban populations and recreational use of the area both increase.

According to Tindale (1974), the Aboriginal people of the Noosa River were known as the Dulingbara; their territory is shown as the coastal land north of Noosa Heads, including the southern third of Fraser Island, and extending some 30km inland. It is uncertain whether the Dulingbara were a separate tribe or had affiliations with the Kabi Kabi to the west or with the Batjala tribe to the north. In presenting vocabularies for four tribes from south-eastern Queensland, Watson (1944) regarded the area as part of the Kabi Kabi territory.

Water erosion has exposed roots of a living tree (*Angophora woodsiana*) on the steep external slope of a dune, Chalambar soil landscape.

A number of Kabi Kabi words from Watson (1944) have been used as soil landscape names in the present report.

Although few Aboriginal middens were observed along the Cooloola coast during soil mapping, there is ample evidence of Aboriginal occupation throughout the sand dunes, particularly near the coast and south of Tin Can Inlet. Stone artifacts, consisting of pebbles, waste flakes, core stones and occasional flaked tools such as choppers and scrapers, occur as lag gravels on the surfaces of deflated areas in the floors of mobile dunes. Occasional pieces have also been observed on the surface of vegetated dunes that have been freshly burnt.

In addition, seashells appear to be scattered throughout the dunes. Because these shells are now pitted and incorporated in the top 5cm of soil, and the conical types have broken 'nipped' apices, they are attributed to Aboriginal activity. The most common shell is that of *Plebidonax deltoides** (pipi) which today is plentiful along the sandy surf beaches of Cooloola, but *Saccostrea cucullata* (oyster) and *Pyrazus ebeninus* (Hercules club) shells were probably brought from the mangrove areas fringing Tin Can Inlet. All three shells are also common in coastal middens elsewhere in southern Queensland.

Although there is little documented evidence from this area, we can assume that the firestick was used by Aborigines here as freely as by Aborigines elsewhere in Australia (Blainey 1976), resulting in the accidental and/or deliberate burning of the vegetation whenever it would carry a fire. As elsewhere, this would encourage the development of grassy woodlands and open forests on the dune ridges and retard the advance of rainforest up the dune slopes from the moist corridors.

However, the population density and the permanency of Aboriginal occupation is unknown and ideas about burning are mostly conjectural. In the Cooloola area, burning seems to have been less frequent or at a lower intensity than was the case during the first 50 years of European settlement, judging from the evidence of fire destruction and damage to the native conifers during this period (Hawkins 1975).

Loss of surface cover as a result of burning accelerates water erosion of the dune slopes (Bridge *et al.* 1984); therefore fires associated with Aboriginal occupation must have increased the rate of dune degradation through both nutrient loss to the atmosphere and erosion. It is also popularly believed that many of the small blowout dunes along the coast appeared following disturbance of plant cover by the Aborigines. While there is no proof of this, the concentration of artifacts in these areas show that they were favoured camping grounds and human occupation certainly must have reduced the surface cover and thereby accelerated wind erosion at these sites.

On the credit side, the addition of human wastes and the translocation of seashells would have brought to the older dune systems small, but possibly significant, amounts of nutrients in short supply, principally phosphorus and calcium. These additions perhaps partly compensated for the loss of these elements resulting from burning. (X-ray fluorescence analysis of pipi shells from Cooloola show that they contain about 15% calcium (J.C. Drinnan *pers. comm.*).)

European use of the dunes began about 1870 when timber cutters entered the area for the rich stands of *Agathis robusta* (kauri pine), *Araucaria cunninghamii* (hoop pine) and *Gmelina leichardtii* (white beech) in the vine forests (Hawkins 1975). The timber was cut and hauled by bullock teams to Tin Can Inlet and then rafted or taken by punt to Maryborough for milling. By

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* Provisional identification following Coleman (1975).

1873, the timber industry in the area had grown to the extend of using a locally constructed locomotive running on a tramway of wooden rails to shift logs to Tin Can Inlet (Buettel 1977); the tramway was later extended to service both Broutha and Thannae Scrubs. The increased demand for timber also led to cutting in some of the hardwood stands of *Eucalyptus pilularis* (blackbutt) and *Syncarpia hillii* (turpentine) in the area.

From 1880 to 1924 large amounts of both softwood and hardwood logs were cut in the area for milling in Maryborough or at Cootharaba on the western side of Lake Cootharaba. During this period the area was also used for grazing, with frequent burning being the only form of management. Two areas totalling about 1300ha were selected in the Ramsay Scrub area in 1877 and were apparently used for timber-getting and grazing since no evidence of clearing for cultivated crops has been found (Hawkins 1975). Both blocks were later surrendered to the Crown. In 1924 a timber survey showed that most of the accessible kauri and hoop pine had been cut, there had been heavy selective cutting in the hardwood forests, and there was abundant evidence of both heavy grazing and frequent fires (Hawkins 1975). The fires had penetrated many of the vine scrub areas injuring both kauri and hoop pine and had killed much of the *Callitris columellaris* (cypress pine) along the coast and were therefore of greater severity than experienced before European settlement.

In 1925, an area of 27,033ha was proclaimed as State Forest 451 covering the parishes of Cooloola and Womalah. Since then logging has been controlled, a system of firebreaks has been developed to protect the main timber stands from wildfires, and regeneration of some native timber species has occurred.

The first 50 years of European settlement must have had a substantial effect on the dunes. Movement of sand down the dune slopes would have been increased dramatically following the loss of surface cover, due to the increased frequency and/or intensity of fires, by the reduction in canopy cover following logging, and direct disturbance of the soil surface by bullock teams hauling logs and by grazing animals. A loss of nutrients, significant in relation to the low total levels in these dunes, would also have been associated with the removal of logs and grazing animals from the area and through increased burning. Again on the credit side there was a small return in human wastes and sea shells carried into the dunes by the early timber cutters.

Since 1930, the Queensland Department of Forestry has implemented a management strategy based on controlled logging determined by estimates of

Logged *Eucalyptus pilularis* in indigenous hardwood forest on a dune slope, Warrawonga soil land-scape.

sustained yield of millable timber from the different kinds of indigneous forest. Tree marking and silvicultural techniques involving the retention of seed trees, removal of large mature (including defective) trees and thinning to a prescribed density, have been practised in the main timber stands of the area (Hawkins 1975). Some areas of *Eucalyptus pilularis* (blackbutt) forest, skirting the rainforest areas near Lake Freshwater and further north in the Searys/Cameron logging area, have been partially cleared and burnt to encourage blackbutt regeneration. In addition, two small areas of rainforest, one in Cameron Scrub and one in Ramsay Scrub, were cleared and planted to indigenous or exotic conifers or to native hardwoods as experimental plantations.

Forestry management has also provided general protection from wild fires by a system of firebreaks and by prescribed burning during the autumn or early winter to reduce fuel loads. Prescribed burning about once in three years appears to have reduced both the frequency and intensity of fires compared with those experienced in the area following European settlement. With forest management much of the damage inflicted by the early timber cutters has become less obvious, as both the vegetation and the soil surfaces have adjusted to the less demanding form of exploitation. Over much of the area, rate of degradation of the dunes has gradually decreased so that it probably approaches that of geological (natural) erosion. However, rates have been accelerated in those areas that have been periodically disturbed by logging operations, silvicultural treatments such as thinning and enrichment planting, and areas leased to grazing.

From 1966 to the mid-1970s, sand mining extracted heavy minerals (rutile, zircon, monazite and ilmenite) from part of the strand plain north of Rainbow Beach, the intertidal zone between Kings Bore and Double Island Point and the foredunes north of the mouth of the Noosa River.

Aerial view of Rainbow Beach (1), sand mining area (2) in Inskip Point soil landscape, coloured sands and sea cliffs (3) and Carlo mobile dune (4), 1970 (Photo: Brisbane Courier–Mail).

The mining operation on the beach was limited to excavation below high-water mark of small amounts of sand at any one time, with the ore being transported by truck to a treatment plant at the mouth of Freshwater Creek. Here the heavy minerals were removed and the sand tailings backloaded to near their place of origin. Although only a small area was mined at any one time the beach between it and the treatment plant was subjected to traffic by heavily laden trucks. One obvious residual effect of the mining is the accumulation of ilmenite on the beach at the site of the treatment plant.

Dredges were used in mining the strand plain and foredunes. The vegetation in the mine path was bulldozed and burnt, a layer of topsoil was pushed into storage heaps, and the underlying sands to a depth of several metres were passed through a dredge to recover the heavy minerals. The operation mixed the sands to the depth of mining, destroying both the soil profiles and their biological systems. After mining, the sand tailings were mostly covered with the stockpiled topsoil and planted to a limited number of native species, among which *Acacia concurrens* is predominant in the area north of Rainbow Beach.

The spreading of topsoil was very uneven, varying from virtually nothing to thicknesses of 50cm or more adjacent to parts of the mining road to Bullock Point. This appears to have markedly affected growth of the vegetation, with dense cover developing on areas with thick topsoil overlays and very sparse cover where the topsoil is thin or lacking.

The main observable effects of mining have been the disappearance of the initial sandridge and swale topography and the disturbance of soil profiles and their biological systems including the natural vegetation. While varying density of plant cover has been achieved in the rehabilitation program, it is limited to a few species and natural recolonization by other species from the adjacent natural forest appears to be very slow. As a consequence the marked differences in structure and floristics between vegetation on the mined area and that of the undisturbed natural forest will persist for a long time and will be reflected in the diversity and populations of other biota inhabiting these areas.

During the establishment phase, and subsequently where the vegetative cover is thin, there has been accelerated erosion of sand due to raindrop impact but such movement is localized and there appears to be negligible loss from the system as a whole.

An examination of the soils in the mined areas has shown marked variability in the thickness of topsoil and its colour, the latter determined largely by its organic matter content. In a few places there is some indication of remobilization of iron and the beginning of podzol development since the topsoil was replaced some ten years ago. However, this appears to be both limited and variable and much less pronounced than that recorded in the Myall Lakes area, N.S.W. (Paton *et al.* 1976).

Urban development at Rainbow Beach began in 1966 with the access road and housing associated with the sand mining industry and has been extended by the increasing demand for coastal recreation since then. The obvious effects of housing are the reduction or removal of native vegetation, the introduction of exotic plant species, and the remoulding of dune surfaces for roads and drainage systems or to achieve more favourable gradients for houses. Less obvious are the changes resulting from wetter soil water regimes, the addition of fertilizers to garden areas and the introduction of domestic animals.

Changes in insolation, food supply and soil water regimes following marked modification of the native vegetation have led to changes in the diversity and populations of soil biota in the area, e.g. different ant species in the town area and adjoining woodland (P.J.M. Greenslade and C.H. Thompson *unpub. data*). Accelerated erosion due to raindrop impact has led to the local redistribution of sand in areas of reduced vegetation cover and is clearly evident in new housing developments where the native vegetation has been removed leaving a bare soil surface. Changes have also occurred in the composition of the groundwater. Where this issues as springs along the beach below the settlement, it has been found to have noticeably higher levels of nitrate and potassium and slightly higher contents of phosphorus than groundwater from elsewhere in the sandmass (Reeve *et al.* 1984), implying contamination from the urban development.

Few exotic plant species appear to be widespread in the areas of native vegetation at Cooloola; this is probably due partly to the area's isolation from urban and agricultural activities and partly to the very low inherent fertility of the soils which would reduce the chances of survival for many species. *Baccharis halimifolia*(groundsel) is widely distributed along the coastal margins of the sandmass mainly in the Mutji soil landscape and in the mined area south of Teewah Village. *Lantana camara* occurs throughout the revegetated mined areas north of Rainbow Beach, along tracks through the rainforest areas and in places along the coast to the south. A potential menace to the area is *Chrysanthemoides monilifera* (boneseed) which has been observed on foredunes and areas adjacent to the mined area north of Rainbow Beach. It is an aggressive species with the potential to become widespread throughout the sandmass. Urban development will inevitably bring a pool of other exotic species to the sand dune margins; some of these may also invade the native forests.

The development of Teewah Village has taken place largely within the existing vegetation cover and without the provision of most basic community utilities such as formed roads, electricity supply, town water and drainage systems. Accelerated erosion is evident along the sand tracks servicing the settlement but other effects of utilization are less obvious; however, in the long term they must be very similar to those of the more sophisticated development at Rainbow Beach.

Prior to 1966, recreational use of the Cooloola area was largely confined to the activities of fishermen, both amateur and commercial, along the beach between Noosa Heads and Inskip Point. There was some camping along the beach, particularly in the Double Island Point, Freshwater and Mudlo Rocks areas, and a few illegal holiday shacks had been constructed to house fishing parties and families on holidays. In addition, limited use was being made of the Noosa River, north of Lake Cootharaba, for fresh-water fishing, canoeing and bushwalking. However, since the middle 1960s the sealed access road to Rainbow Beach, the increased availability of four-wheel-drive vehicles and the marked accent on recreation in coastal areas have led to greatly increased recreational use and pressures on the sand dunes at Cooloola.

The effects of recreational use are two-fold: those associated with camping areas and disposal of wastes, and those associated with vehicular traffic. The early camping areas had no sanitary facilities, so rubbish, wastes and fish remains were mostly left exposed around the camp sites or covered by a thin veneer of sand. The National Parks and Wildlife Service has provided controlled camping grounds near Lake Freshwater and at Double Island Point, where water is supplied and sanitation and rubbish disposal facilities are provided. These camping areas experience heavy use at weekends and during holiday periods and the effects on the sand dunes, locally, will be similar to those experienced in urban developments, i.e. increased erosion where the surface cover is broken and some contamination of local groundwater. However, the retention of a large part of the native vegetation should reduce the impact on the soil biota.

Increased vehicular traffic imposes two kinds of pressures. The first relates to the beach which has become the main highway from Tewantin to Double Island Point and from Rainbow Beach south to Double Island Point and north to Inskip Point. The effects of this traffic on the ecology of the beaches, e.g. on the sand-burrowing molluscs such as pipis, appears to be unknown and may warrant study. Secondly, vehicles are used to travel along bush tracks through the dunes and to assail steep dune slopes for amusement. While the tracks can carry limited traffic, the disturbance of sand and the formation of wheel tracks lead to increased local erosion. Some of the steeper tracks down dune slopes, e.g. the track down the dune slope south of Lake Freshwater, have had to be closed to all vehicular traffic because of severe erosion.

There is no doubt that the ecosystems on these coastal dunes are fragile and will need to be used with care if we wish to avoid marked changes occurring in them. On the other hand, it should not be forgotten that the ecosystems associated with the young dunes for the most part have a great capacity to recover following superficial disturbances that cause only limited destruction of native vegetation. Most of the erosion that occurs is a local redistribution of the dune sands; there is virtually no loss of solids from the sandmass, apart from that along the sea cliffs where the sea is carrying the debris away, and suspended colloid and solution losses are low.

Geological erosion is slowly remoulding and reducing these dune systems to lower elevations with gentler slopes, and man's use has so far slightly increased the rate of these processes. Management for different kinds of land use needs to recognize the limits of use that can be tolerated so that the community can still derive maximum benefit from the area without degrading the biological systems that are dependent on the present soils and stages of weathering developed in these dunes. This will not be easy because the tolerance levels of these ecosystems are mostly unknown. Management should proceed cautiously, keeping disturbance to both vegetation structure and groundcover to a low level, because there is evidence that marked changes in either will increase local erosion and induce changes to biological diversity and size of populations.

RESEARCH APPROACH

In this section we try to indicate very briefly how Soils Division staff became involved in research in the coastal sandmasses and the procedures used for running a substantial, strongly field-oriented, program over several years.

Initiation of the program

It is probably true nowadays that choice of land use is largely a socially dependent, rather than socially determinant, activity and that hard data are unlikely to play a major role in this type of decision making. This is not nearly so true, however, in the case of land management. Whether it be agriculture, forestry, national parks or other forms of land use that are under consideration, it is necessary to know in some detail what it is we have to work with (the resources) and what is going on in these resources (weathering and ecological processes). As CSIRO research scientists, we see a need to provide information about natural resources and the processes that determine their development and persistence. It is not our role to make management decisions, but rather to provide base data and to indicate what are the likely consequences of particular management practices.

The work of much of the Brisbane group of Soils Division can be described very broadly by the term 'landscape dynamics'. The aim of landscape dynamics research is to provide an understanding of the environmental factors controlling rates of movement of water, solutes and solids over and through soils and landscapes, and to establish reference data against which the effects of changing use can be judged.

Our involvement in work in the coastal sandmasses began in the latter part of 1972 when the then chief of the Division proposed that research into 'the relationship between (landscape) instability and the various factors likely to be associated with it' be initiated in Brisbane. This was endorsed by the CSIRO Queensland State Committee and the CSIRO Executive, although the support offered was moral rather than material. This is of significance because it placed constraints on both the type and amount of research that was possible.

Staff discussions began around mid-1973 and led to the formulation of a broad outline of research in landscape dynamics for the ensuing 7-10 years, and to the initiation in 1974 of a number of projects in the coastal sandmasses. All staff, both professional and technical, were invited to participate in these discussions and most of them contributed.

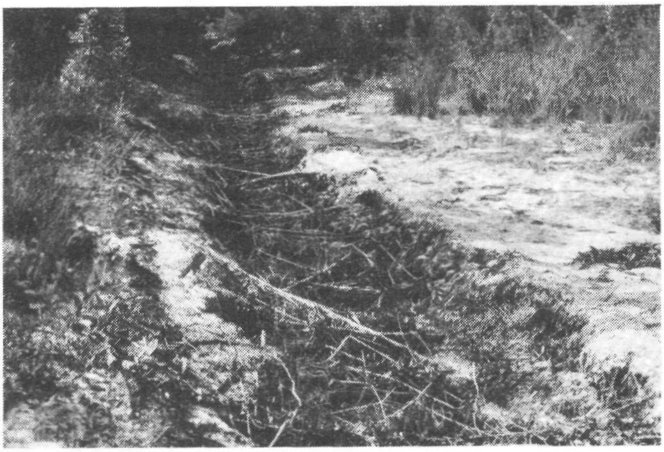
'Landscape dynamics' was the theme around which discussion and eventually new research projects developed. It was visualized that as resources (people, money, services) within the group become available following the termination of existing projects, they would be channelled where possible into this research area. In fact, this did occur to quite a considerable degree. Some reorientation of attitudes and thinking was necessary and we had, of course, to take cognizance of the skills that were (and were not) available in the group.

Further discussion meetings were held between mid-1973 and mid-1974 and during that period the School of Australian Environmental Studies, Griffith University, received a two-year extramural grant from CSIRO for hydrological work in this area.

Given our 'charter' and the various constraints operating, it became apparent that our overall research program should follow along the lines outlined below.

(1) A team approach, involving cooperative research, was considered to be desirable for looking at landscape dynamics because a wide range of disciplinary skills would be needed. While we had appropriate expertise in the areas of pedology, geomorphology, physics and chemistry, gaps were evident in our ranks when it came to hydrology and biology in particular, and it was obvious that it would be necessary to look outside the group for assistance in these areas. This was forthcoming in a number of instances in the work at Cooloola.

(2) In general, it was felt that it was undesirable to spread our limited resources over too large a geographical area and that, insofar as possible, most of the field work should be restricted to within 100-250km of Brisbane.



Water erosion along wheel tracks resulting from heavy rain during a cyclone in 1974, Yikiman soil landscape.

(3) The major part of our research should be directed towards understanding processes. However, a knowledge of 'soils in the landscape' is vital to provide a framework for other research activities. Thus a by-product would be the continued production of resource inventories (e.g. soil, geological and vegetation maps) as required by our research needs.

(4) Largely by a process of elimination, taking into account physical, sociological and political factors, it was decided that much of our work in the next 5-8 years should be carried out in three 'outdoor laboratories'. The first was Narayen Research Station (near Mundubbera) because in 1973 we were already committed to working there. The second was the coastal sandmasses, mainly between North Stradbroke Island and Bundaberg, and the third was the Lockyer Valley-Darling Downs area.

The projects

The second outcome of our discussions was the initiation of several projects in the coastal sandmasses. Formal proposals for these were submitted in May, 1974, and incorporated into the Divisional Research Program for 1974-75. Fortuitously in July, 1974, the Royal Society of Queensland held a symposium on 'Stradbroke Island' and two contributions based on work in the coastal areas prior to this time were delivered at that meeting (Thompson 1975; Thompson and Ward 1975).

Seven projects were set up at that time. One was concerned with geological, pedological and geochemical investigations in the coastal fringe, with emphasis on Fraser Island (W.T. Ward and I.P. Little). The six remaining projects were centered on the Cooloola - Noosa River area because it is closer to Brisbane and more accessible. A wide range of research activities was covered at Cooloola and these, along with the resources brought to bear on them, are shown in Table 5. It is worth noting that project 6, which covered instrumentation, automatic recording and data processing, was obviously of benefit to research other than this particular program.

As indicated above, we managed to fill some of the gaps in expertise with help from people outside the Soils Division group. Regional hydrology was investigated by J.R. Forth of Griffith University and on the biological side assistance was forthcoming from the Division of Water and Land Resources, Canberra (plant ecology), Queensland Department of Primary Industries (botany), Division of Tropical Crops and Pastures (mycology), two private individuals (botany and mycology), Division of Soils, Adelaide (ants), University of Queensland and Queensland Institute of Technology (earthworms), Division of Entomology (termites), and South Australian Museum (springtails). In addition, assistance of a specialist nature was provided by Division of Soils, Canberra (micromorphology) and Australian National University (carbon-dating).

Research management and logistics

Planning was largely completed by mid-1974 and we began installing instruments and taking measurements in August of that year. The hydrologist took up his appointment in October and began field work immediately. Installation of equipment continued at a high pitch through to the end of 1974.

The measurement techniques used in the field have been described by Ross *et al.* (1984) and Table 6 indicates what equipment was installed at each of the 15 research sites. In addition, a large amount of soil, water and vegetation sampling and observation was carried out.

This period of intense field activity was a striking example of highly motivated teamwork on the part of both professional and technical staff. While

TABLE 5

Research activities, scientific disciplines and personnel involved in the study of landscape dynamics in the Cooloola-Noosa River area

		CSIRO BRISBANE SOILS GROUP								COLLABORATORS													
		PEDOLOGY	PHYSICS			CHEMISTRY				HYDROLOGY	BIOLOGY										MICRO-MORPH	RADIO CARBON LAB.
Project No.	Research Activities	THOMPSON, C.H.	BRIDGE, B.J.	ROSS, P.J.	PREBBLE, R.E.	FERGUS, I.F.	REEVE, R.	SKJEMSTAD, J.O.	DRINNAN, J.C.	FORTH, J.R. [1]	WALKER, J. [2]	HOPKINS, M.S. [2]	McDONALD, W.J.F. [3]	HARROLD, A.G. [4]	GREENSLADE, P.J.M. [5]	GREENSLADE, P. [6]	DYNE, G. [7]	MILLER, L. [8]	JEHNE, W. [9]	ABERDEEN, J.E.C. [4]	BREWER, R. [10]	POLACH, H.A. [11]
1	SOIL RESOURCES	☆	●					●	●												●	●
2	ECOLOGY	☆				●					●	●	●	●	●	●	●	●	●	●		
3	ELEMENT DYNAMICS					☆	●	●	●	●												
4	EROSIONAL PROCESSES	●	☆		●																	
5	a WATER QUALITY	●				●	☆	●														
	b WATER RESOURCES		●				●			☆												
6	INSTRUMENTATION		●	☆	●	●	●															

☆ PROJECT LEADERS

● COOPERATORS

1. SA ENG. & WATER SUPPLY DEPT. (formerly GRIFFITH UNIVERSITY) BRISBANE
2. CSIRO WATER & LAND RESOURCES
3. BOTANY BRANCH, DPI, QLD
4. UNAFFILIATED
5. CSIRO SOILS, ADELAIDE
6. SOUTH AUSTRALIAN MUSEUM
7. QIT (formerly UNIV. QLD), BRISBANE
8. CSIRO ENTOMOLOGY, CANBERRA
9. CSIRO SOILS (formerly TROPICAL CROPS & PASTURES), BRISBANE
10. CSIRO SOILS, CANBERRA
11. ANU RADIOCARBON LAB., CANBERRA

TECHNICIANS

CLARK, S.F.
DELLAWAY, E.J.
PITT, W.R.
ROSS, D.J.
SEGUIN, P.H.
SMITH, K.J.
WILLIAMS, D.J.
****

LIASON

THOMPSON, C.H.
****

SERVICE M'MENT

FERGUS, I.F.
****

RESEARCH M'MENT

MOORE, A.W.
****

TABLE 6

Instrumentation installed at research sites in the Cooloola - Noosa River area

Research site	Soil landscape	Location[1]	Pluviometers	Atmospheric accession towers	Wells	Anemometers	Temperature sensors	Sand traps	Litter traps
R1	Mutyi	NS 098335						+	
R2	Chalambar	NS 125194	+	+		+	+	+	+
R3	Burwilla	NS 103189	+		++		+	+	++
R4	Burwilla	NS 085199	+				+	+ [2]	
R5	Warrawonga	NS 086208					+	+	++
R6	Mundu	NS 077223					+	+	+
R7	Kabali	NS 075222	+	+	++		+	+	+
R8	Pertaringa	MS 965124	+ [3]				+	+	
R9	Nilkan	NS 022217	+	+	+ [4]				
R10	Yikiman	NS 041176			++				
R11	Mutyi	NS 106126					+++		
R12	Mutyi	NS 131187		++		+			
R13	Burwilla	NS 120206		+					
R14	Toolara[5]	MS 896227		+					
R15	Noosa River	MS 985167							

1. *In grid zone 56J, Universal Transverse Mercator Grid, Maps 9545-I (Wolvi) and 9545-IV (Cooloola).*

2. Also equipment for measuring stemflow and surface wash.

3. Bureau of Meteorology pluviometer no. 40467.

4. Cased bores.

5. Undescribed landscape of the low hilly sandstone plateau above the Como Scarp.

the bulk of the work fell on the shoulders of 10 or so people, all of the 25 members of Soils Division staff made at least one trip to the field.

As far as possible field work for all projects was integrated operationally. This made it possible to carry out a large and varied field program for approximately three years with relatively limited resources. However this was only achieved by the nomination of a 'service manager' (I.F. Fergus) who was responsible for day-to-day allocation of personnel, vehicles and other resources, and for coordinating field trips when sampling and measurements were required for several of the projects.

Liaison with organizations and persons outside the group and the development of collaborative ecological projects was also handled largely by a single person (C.H. Thompson). This included contact with our 'hosts', the Queensland Department of Forestry and the National Parks and Wildlife Service, because all the research sites were located in state forest reserves or Cooloola National Park. The field staff of these organizations were very cooperative and helpful, although a few short-lived crises arose when annual prescribed burns were carried out in areas where the research sites were located.

These logistic and liaison duties were performed by the two persons concerned in addition to full research programs of their own. On the other hand, overall management of the whole program was the responsibility of A.W. Moore who was not directly involved in any of the research projects.

Conclusion

When any activity, including research, runs smoothly and successfully, it is tempting to try to see it as a model that could be used in other situations. If a careful analysis is made, however, one cannot be too sanguine about this approach. Research management, like most management, contains a large opportunistic component. Good research management consists of taking advantage of the opportunities that arise periodically.

In the particular case of the Cooloola program the happy coincidence of a number of factors provided an environment in which the program was able to flourish. These factors were as follows. (1) At the time there was a need for information about landscape dynamics in the coastal areas of south-east Queensland that were beset with ever-increasing problems of land use and land management. (2) The scientists and technicians in Brisbane were old enough to have a substantial, broad background of experience in environmental sciences, but young enough to handle a considerable amount of hard physical labour. (3) Most of these people were personally compatible. (4) Most of the scientists were in a position that enabled them to initiate new projects at that particular time. (5) Most of the scientists responded positively to the cooperative, consensus type of research management that was decided upon. (6) As the program developed the accumulation of resource and process data produced by several disciplines working in one area proved an attractive inducement for collaboration from scientists in other disciplines.

The success of a research program may be judged by its contributions to science and the community. The Cooloola program has produced a considerable amount of data and new information about the dynamics of vegetated coastal dunes in the subtropics. This includes new information on the development and weathering of dunes, soil formation, importance of water erosion in vegetated dunes, development of black (organic enriched) and white groundwaters, rates of element accession from the atmosphere and the relationship between stages of forest succession and soil weathering. In addition, it has led to the development of simple instrumentation and reliable automatic recorders for measuring some environmental processes, while the biological projects have found several species of earthworms, termites, springtails and ants that are new to science.

Much of the data has been made available through published papers, conference papers, poster displays and consultation. The program is expected to produce 30-40 publications, about half of which have been published or are in press.

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APPENDIX

List of plant genera and species mentioned in the text

Scientific name	Common name	Scientific name	Common name
Acacia		*Ficus*	
aulacocarpa	hickory wattle	*watkinsiana*	strangler fig
concurrens	Brisbane black wattle	*Gahnia*	
flavescens	-	*sieberana*	saw sedge
Aegaceras	a mangrove	*Gmelina*	
Agathis		*leichardtii*	white beech
robusta	kauri pine	*Hakea*	
Alphitonia		*gibbosa*	wallum hakea
excelsa	red ash	*Imperata*	
Angophora	apple	*cylindrica*	blady grass
costata	rusty gum	*Lantana*	
woodsiana	smudgee	*camara*	lantana
Araucaria		*Leptospermum*	
cunninghamii	hoop pine	*attenuatum*	wild may
Avicennia		*liversidgei*	swamp may
marina	grey mangrove	*flavescens*	
Baccharis		*Livistona*	cabbage-tree palm
halimifolia	groundsel	*Melaleuca*	
Backhousia	carrol	*quinquenervia*	paper-barked teatree
Banksia		• *sieberi*	narrow-leafed teatree
aemula	wallum banksia	*Pandanus*	
integrifolia	coastal banksia	*sp.*	pandanus palm,
oblongifolia	dwarf banksia		screw palm
robur	broad-leaved banksia	*Persoonia*	geebung
serrata	red honeysuckle	*Petalostigma*	quinine bush
Boronia	boronia	*Pteridium*	
Callitris		*esculentum*	bracken fern
columellaris	cypress pine	*Pultenaea*	bush pea
Casuarina		*Restio*	cord rush
equisetifolia	coastal sheoak,	*Rhizophora*	
	horsetail oak	*stylosa*	red mangrove
glauca	swamp sheoak	*Syncarpia*	
littoralis	black sheoak	*hillii*	satinay, turpentine
torulosa	forest sheoak	*Syzygium*	
Ceriops	a mangrove	*coolminianum*	lillypilly
Chrysanthemoides	boneseed	*Themeda*	
Dodonaea	hop bush	*australis*	kangaroo grass
Elaeocarpus	blueberry ash	*Tristania*	
Eucalyptus		*conferta*	brush box
bancroftii	Bancrofts gum	*suaveolens*	swamp box
drepanophylla	grey ironbark	*Xanthorrhoea*	
grandis	flooded gum	*johnsonii*	
gummifera	red bloodwood	*macronema*	bottle-brush
intermedia	pink bloodwood		grasstree
pilularis	blackbutt	*media*	grasstree
robusta	swamp mahogany	*resinosa*	swamp grasstree
signata	scribbly gum	*Xylomelum*	
tereticornis	Queensland blue gum	*pyriforme*	woody pear
tesselaris	carbeen	*Zoysia*	
umbra	broad-leafed white	*micrantha*	coastal couch grass
	maghogany		