1982

Soils of the Illawarra region

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Publication Details

This report was originally published as Young, RW, Soils of the Illawarra region, Wollongong Studies in Geography No.10, Department of Geography, University of Wollongong, 1980, 4p.

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Abstract

Because high rainfalls are experienced over the entire IIIawarra region soils here are almost invariably acidic (pH 4 - 6), and have been generally leached of the more mobile elements and compounds. Notwithstanding these common characteristics, there is a considerable complexity of soil types and distribution over the region. This complexity can in part be attributed to variations in the types of rocks on which the soils have weathered. For instance, the volcanic rocks break down to clays, but the sandstones undergo little real chemical alteration. Moreover, even on the sandstones, four or five types of soil can normally be found. It is certainly easy to recognise distinctive catenas, in which soils vary systematically with changes in steepness of slope and freedom of drainage. On the sandstones, for example, deep Yellow Earths on well-drained sites generally give way to organically rich soils in swampy locations further downslope. But not all changes in soil type can be explained in terms of simple catenary relationships. The occurrence of Ferricretes (Laterites) on sandstones is a case in point. Indeed, this example shows that the duration of weathering, changes in the intensity of weathering caused by climatic change, and local variations in the mineral composition of the parent material also are factors which must be considered.

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Department of Geography, University of Wollongong.

SOILS OF THE ILLAWARRA REGION

R. W. YOUNG

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INTRODUCTION

Because high rainfalls are experienced over the entire Illawarra region soils here are almost invariably acidic (pH 4 - 6), and have been generally leached of the more mobile elements and compounds. Notwithstanding these common characteristics, there is a considerable complexity of soil types and distribution over the region. This complexity can in part be attributed to variations in the types of rocks on which the soils have weathered. For instance, the volcanic rocks break down to clays, but the sandstones undergo little real chemical alteration. Moreover, even on the sandstones, four or five types of soil can normally be found. It is certainly easy to recognise distinctive **catenas**, in which soils vary systematically with changes in steepness of slope and freedom of drainage. On the sandstones, for example, deep Yellow Earths on well-drained sites generally give way to organically rich soils in swampy locations further downslope. But not all changes in soil type can be explained in terms of simple catenary relationships. The occurrence of Ferricretes (Laterites) on sandstones is a case in point. Indeed, this example shows that the duration of weathering, changes in the intensity of weathering caused by climatic change, and local variations in the mineral composition of the parent material also are factors which must be considered.

The main problem in writing a brief account of the soils of the Illawarra is that of making some sense of their complexity while at the same time avoiding the trap of attributing certain soils to particular factors, such as climate or slope position, when in fact their origins are poorly understood. I have tried to overcome this problem by describing the assemblages of soils found on the main landscape or terrain units of the region, rather than by working sequentially through the supposed effects of soil-forming factors. In approaching the problem in this way I have tried not only to outline what we know about the relationships among tnese assemblages of soils, but also to highlight what we do not know. The paper considers the processes underlying the formation of the Illawarra's major soil types, and concludes with an examination of man's uses of and impacts on soils in the region.

SOIL LANDSCAPES

1) **Soils of the Sandstone Plateaus:** There are two main sandstone plateaus in this region. The first of these, on the Hawkesbury Sandstone, rises gradually from the Sydney area to terminate abruptly on the Illawarra Escarpment and Cambewarra Range (Figure 1). The second, on the Nowra Sandstone, occupies the very rugged country of the Shoalhaven district. These plateaus have similar patterns of soils. **Skeletal Soils** consisting of small rock fragments and sand, with small amounts of organic material, are widespread on the plateaus. They are found not only on very steep slopes where weathered debris is rapidly eroded, but also on very flat surfaces where the underlying bedrock is extremely resistant to weathering. Where the sandstones have a higher clay content and thus break down more readily, or where the water-table is well below the surface and weathering can as a result extend to considerable depths, **Yellow Earths** are found. Apart from a higher organic and lower clay content near the surface, and red and grey mottling near the water-table, there is little change down a Yellow Earth profile. As the water-table approaches the surface, and as oxidation gives way to reduction as the main form of chemical weathering, Yellow Earths are replaced by **Acid Peat Soils.** Because the high water-table both supports a very dense sedge and shrub vegetation and also retards the decay of organic material, the organic content of soils in the swampy depressions is high, being generally between 10 and 20% and in some places reaching 60%. Most of the sediment in which the organically rich soils have developed has been washed downslope rather than weathered from the underlying rock and the change from organic sediment to solid rock is often very abrupt, though a few centimetres of weathered rock is generally found under these sediments on steeper slopes.

There are two main departures from this widespread catenary pattern on the sandstones. On deep, very well drained sands **Podzols** are occasionally found. They are characterized by a very pronounced contrast in texture beteen the A and B horizons. The A horizon typically consists of bleached quartz sand, with a small amount of organic material in the top few millimetres. The B horizon consists essentially of quartz grains, sometimes with minor iron stains on them, in an organic matrix; the amount of clay in the B horizons of Podzols in this region is generally very small. The contrast in the profile seems primarily to be the result of the downward leaching of organic material and of small amounts of iron and clay, though sheetwash of coarse material from further upslope may contribute to the sandiness of the A horizon. The degree of chemical alteration seems slight.

Only in the scattered outcrops of **Ferricrete** has there been substantial chemical and structural alteration of the parent sandstone. (The term "Ferricrete" has largely replaced the older term "Laterite".) These Ferricretes have been formed by the precipitation of skins rich in iron and aluminium to form nodules or slabby concretions enclosing sand grains and quartz pebbles. Even the nodules which seem at first sight to be very rich in iron generally contain less than 70% Fe_2O_3, while most nodules contain less than 30%. The Al_2O_3 is generally less than 10%, with the remainder of the material in the nodules consisting overwhelmingly of silica. The rock beneath the crusts is, in most cases, highly weathered. The Ferricretes have traditionally been interpreted as evidence of former tropical climates; under humid tropical climates silica is generally leached from the profile while iron and aluminium is retained. In recent years this interpretation has been challenged. It may be that crusts can form as the result of very prolonged weathering under temperate climates like those of the very present day; in the section on alluvial soils I will show that very substantial accumulation of iron has occurred in Pleistocene sediments which were deposited long after the shift from tropical climates in south-eastern Australia took place. Moreover, as has been shown in the Sydney area, and as can be readily demonstrated in the Illawarra as well, Ferricretes seem to develop where there is an abundant supply of iron in the parent sandstones or in adjacent rocks. The possibility that they did form under tropical climates cannot be completely ruled out, but it is certainly not the only hypothesis which can be advanced to explain their occurrence.

2) **Soils on Talus of the Escarpment and Gorges:** Extensive masses of bouldery talus mantle the upper slopes of the Illawarra Escarpment and of the deep gorges like Kangaroo Valley. In this setting the downslope movement of both debris and water plays a major role in soil formation. The surface layers of many of the young debris deposits, which lack any real profile development, can be classified as Skeletal Soils. Others display contrasts between sandy A and clayey B horizons which would normally rate them as **Podzolics,** but the contrast in texture is due to downslope transport rather than to weathering. The texture-contrast soil at the top of Jamberoo Pass, for instance, looks like a normal Red Podzolic. On closer inspection the contrast between the horizons can be seen as the result of sandy debris being carried downslope from an outcrop of Hawkesbury Sandstone onto weathered shales in the Narrabeen Group sediments. In this instance there is no evidence of the migration of clay down through the profile; the significance of this point is discussed in more detail in the next section. Instances like this can be generally recognized by the differences in the rock fragments between the A and B horizons, or by distinct layers of stones

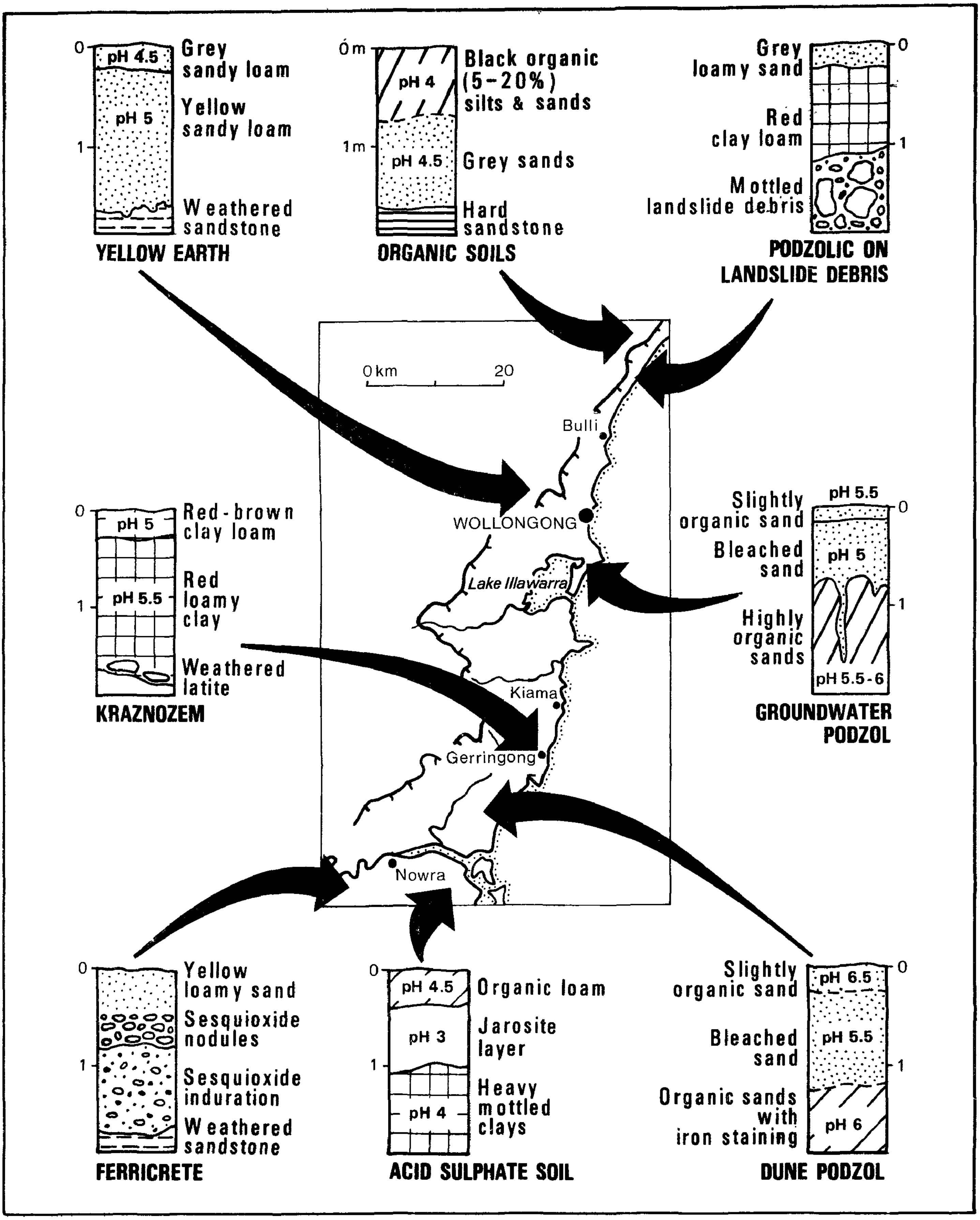

Figure 1: Selected Soil Profiles

within the profile which show where the deposition of the upper layer began.

Many of the old and deep talus deposits lower on the escarpment and the gorge walls show much evidence of considerable weathering. The effects of iron and clay movement in these deposits can be seen in the strong red and grey mottling of the clays and silts which surround the boulders, and in the skins of iron and clay which line many fractures and old root channels. The sandy nature of the top soil on many of these old deposits can perhaps be partly attributed to the downward migration of clay through the profile. In some places, however, much of the sandy surface layer seems to have been washed down from further upslope. Indeed entire soils may be buried beneath material moving downslope.

3) **Podzolic Profiles on Shales and Siltstones: Red, Yellow and Grey Podzolic Soils** mantle much of the hill country cut in the shales and siltstones of the Illawarra Coal Measures and the Berry Formation. The clayey B horizon of these soils is easy to explain, for the parent rock is rich in clay. The sandy A horizon is less readily explained. The traditional view is that clay has been lost from the A horizon into the B horizon, but there is little evidence to support such a hypothesis in this region. If migration of this sort had occurred there should be numerous clay skins (**cutans**) lining voids in the B horizon, but there are relatively few of these in the Podzolics. As we have already seen, recent work around Sydney has emphasised the importance of downslope movement of sandy debris in the development of texture contrasts in Podzolic profiles. Movement of this sort is by no means limited to steep slopes like those on the escarpment, and it could account for the sandy topsoil on some of the gentler slopes of the hill country around Berry. But it cannot explain the occurrence of marked texture contrasts between A and B horizons that can be seen on the very crests of some ridges, for there is no higher ground from which the sandy material can have been swept. This brings us to a third possibility; clays in the A horizon may have been destroyed by weathering. Although plausible, this hypothesis is difficult to demonstrate. In short, although Podzolic profiles are widespread, we still have much to learn about the way in which they develop.

4) **Kraznozemic Soils of the Volcanics:** Soils weathered on the volcanic rocks of the region have a high sesquioxide (iron/aluminium) content. They are found on the basalts of the plateau near Robertson, and on the latites (a rock similar to basalt) and sandstones composed of fragments of volcanic rock in the Kiama district. The soils are clayey, show only slight changes in texture down the profile, and are red to chocolate in colour because of the high sesquioxide content. Soils on the hills cut in latite around Berkeley and Albion Park generally consist of a thin loamy A horizon overlying a heavy dark-brown clay containing numerous rock fragments. Similar thin reddish-brown soils occur on many ridges around Kiama. However on well-drained sites in the Kiama and Gerringong areas deep, red **Kraznozems** are the main soils. They typically have clay contents of 60 to 80% throughout the profile, and in some sites reach depths of 3 to 4 metres. Deep Kraznozems and shallow reddish-brown stoney soils are also the main types found on the basalts near Robertson. The effects of slopewash on kraznozemic profiles is well illustrated west of Albion Park at Knight's Hill, on the edge of the plateau, where red clays and loams have been carried down over the silty and sandy soils weathered from the adjacent shales and sandstones.

5) **Soils on Alluvium:** Because of the relative uniformity of parent material, and because there is little deposition of new sediment once a stream has incised below its former floodplain, soils on alluvial terraces often provide excellent illustrations of the effects of duration of weathering on profile development. This is certainly so in the Illawarra region. Here we can identify at least four major stages which, using the terminology of Walker and Coventry (1976), can be called **stratic, cumulic, texture contrast,** and extended **sub-solum.** Sediments of the first stage are so young that the soil-forming processes have not yet obliterated the depositional strata; soils on these sediments are **Alluvial** in the strict sense of the term. In the cumulic stage organic material builds up in the topsoil, and the turning over of sediment by fauna in the soil destroys the depositional laminations. Soils belonging to this stage of development show little contrast down the profile, apart from an organic darkening of the surface layer; they are probably best classified as **Prairie Soils.** As the duration of weathering increases, texture contrasts between horizons become increasingly noticeable, resulting in the development of **Red Podzolics** and **Yellow Podzolics.** The contrast in texture in this instance seems largely to be the product of migration of clays from the A to the B horizon, for examination under the microscope shows numerous cutans lining voids and root channels. With even greater duration of weathering the migration of sesquioxides produces nodules rich in iron or manganese in the B horizon and in the deeper parts of the alluvium beneath the soil (i.e. in the sub-solum). In some places, presumably in very old sediments, the build up of nodules and even iron-rich pinnacles is so great that the sub-solum looks like a weakly developed Ferricrete. The oldest stage in the sequence described here is generally on the highest terrace, and the youngest on the lowest terrace or floodplain. Occasionally, the older sediments have been eroded and younger ones deposited on the truncated remnant.

6) **Soils on Coastal Sediments:** Most of the coastal sediments are young dune and beach sands which show little sign of soil development. Soils on dunes close to the beaches consist of sands with minor organic accumulation in the top few centimetres. Those well back from the beaches, however, often have the bleached A horizon and the organic and iron concentration in the B horizon which is typical of Podzols on well-drained sands in coastal Australia. On the small remnants of Pleistocene sands at Bass Point and Kemblawarra there are **Groundwater (or Humus) Podzols** in which a bleached A horizon a metre or so thick overlies a massive organic B horizon. These very deep Podzols are the product of a long period of weathering, during which organic material accumulated near the water-table. **Acid Sulphate Soils** have developed on some old estuarine deposits in the region, especially those in the delta of the Shoalhaven River. These soils form when the old sediments are drained or exposed on the surface. Sulphides formed under reducing conditions are then oxidised to form sulphates, and in the process sulphuric acid is released which causes the soils to become extremely acidic (pH 2 to 4). These soils commonly display yellow stains of **jarosite** ("cat clay"), which is a ferric sulphate produced by the oxidation.

SOILS AND LANDUSE

By far the most striking illustration of the effect of soil quality on landuse in the Illawarra region is the virtually complete shunning of the sandstones and coastal sands by agriculturalists and pastoralists. With the exception of the small area of orcharding on the more silty beds of the Hawkesbury Sandstone at Darkes Forest (due west of Stanwell Park), the two main sandstone plateaus of the region have not been farmed. By contrast even the smallest patches of basalt capping the sandstones have at some time been cleared for grazing. Farm lands on the coastal lowland also end abruptly on the edge of the deep coastal sand deposits. Not only are the sandy soils poor, but because they have little clay to hold any nutrients added to them, fertilising them is a costly business with very short-term benefits.

Acid Sulphate Soils, especially those near the mouth of the Shoalhaven, have caused problems when drained during programmes of flood mitigation and agricultural expansion. Their great acidity is not easily counteracted, and they are often completely devoid of vegetation.

With the exception of the sandstones, coastal sands and the Skeletal Soils on very steep slopes, most soils in the region have been farmed at some time. The most sought after soils have been the Kraznozems and the Prairie and Alluvial Soils along the small coastal streams. In the case of the latter, however, a good nearby water supply was an added attraction. With the decline in agriculture over the last few decades, especially near the edge of the urban area, soils of marginal quality have gone out of production. Indeed, the spread of the city and its suburbs, and more recently the growth and spread of towns like Kiama and Gerringong, has resulted in the loss of quite good agricultural land.

As the urban areas have expanded the main constraint exerted by soils on landuse has gradually switched from their chemical to their physical properties. Slope stability is now a major problem in parts of urban Illawarra, and that problem can be related to the mechanical strength of the soils and the weathered rock beneath them. Aspects of that problem have already been considered in an earlier issue of this series (Young, 1980).

Although changes in landscape undoubtedly were accompanied by erosion of soil, the details of that impact are far from clear. Human modification of the region's soils probably began more than 20,000 years ago with the burning of the vegetative cover by the aboriginal people. However any impact the aborigines did have was greatly exceeded by that caused when the forests were cleared during European settlement of the region. Evidence of gullying and of sheet erosion is widespread, but soil erosion in this region did not reach anything approaching the degree of damage suffered in many other parts of the country. This is because the region was given over largely to intensive grazing which required a good grass cover on the land throughout the year. Probably the main impact of farming on soil degradation has occurred in the headwaters of the Macquarie Rivulet where the deep kraznozems on the basalts are ploughed every year.

A rough quantitative measure of the impact of European settlement can be gauged from the growth of the deltas where Macquarie Rivulet and Duck Creek enter Lake Illawarra. The modern deltas began to form about 6500 years ago when the sea reached its present level and drowned the lower part of the valley, forming the lake. Since then the deltas have filled in about 10% of the area of the lake, but during the last 120 years sedimentation has increased to a rate 6 times greater than the long-term average rate. Indeed, after tapering off slightly during the 1940s and 1950s, it increased again sharply during the 1970s and 1980s (Figures 2 and 3); this last upturn seems to be linked to the marked urban expansion that has occurred in the lower parts of the Macquarie Rivulet catchment during the last few decades (Young, 1976, 14-15). The disruption of vegetation and soil during construction work, together with the increased runoff of water from established built-up areas, certainly boost the amount of sediment fed into the streams.

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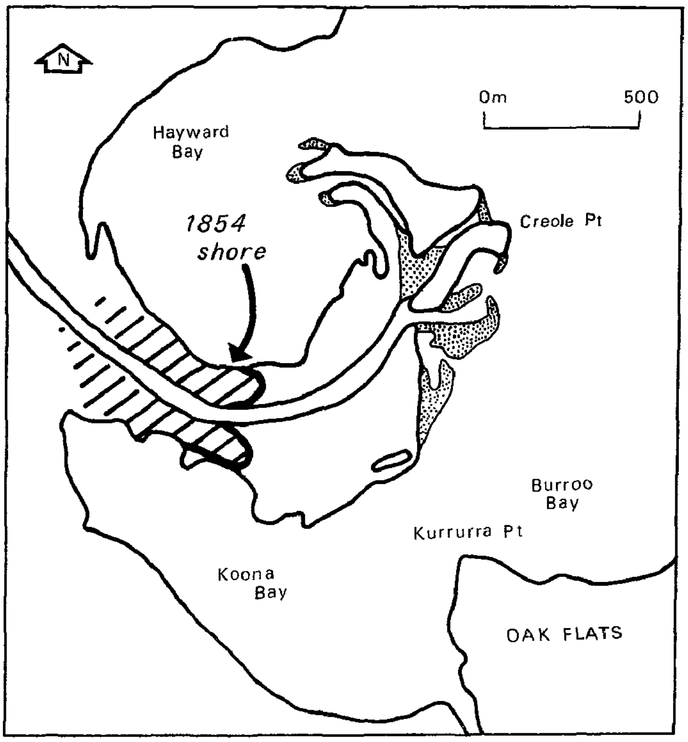

Figure 2: Macquarie Rivulet Delta

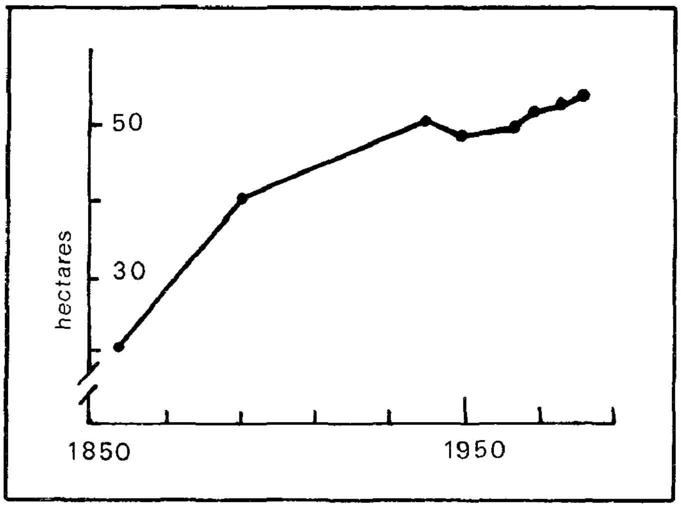

Figure 3: Growth of the Delta

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For 1983, a further four papers in the series are envisaged.

Department of Geography, The University of Wollongong, 1982.