General Report on Lands of the Wanigela–Cape Vogel Area, Territory of Papua and New Guinea

Comprising papers by H. A. Haantjens, E. A. Fitzpatrick, B. W. Taylor, and J. C. Saunders

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CONTENTS

MAPS

PART I. INTRODUCTION

By H. A. Haantjens*

I. General

This report is the second of a number covering reconnaissance land resources surveys in the Territory of Papua and New Guinea. The objectives of these surveys are to describe, classify, and map the inherent land characteristics of the country—including its surface geology, topography, soils, and vegetation—and broadly assess

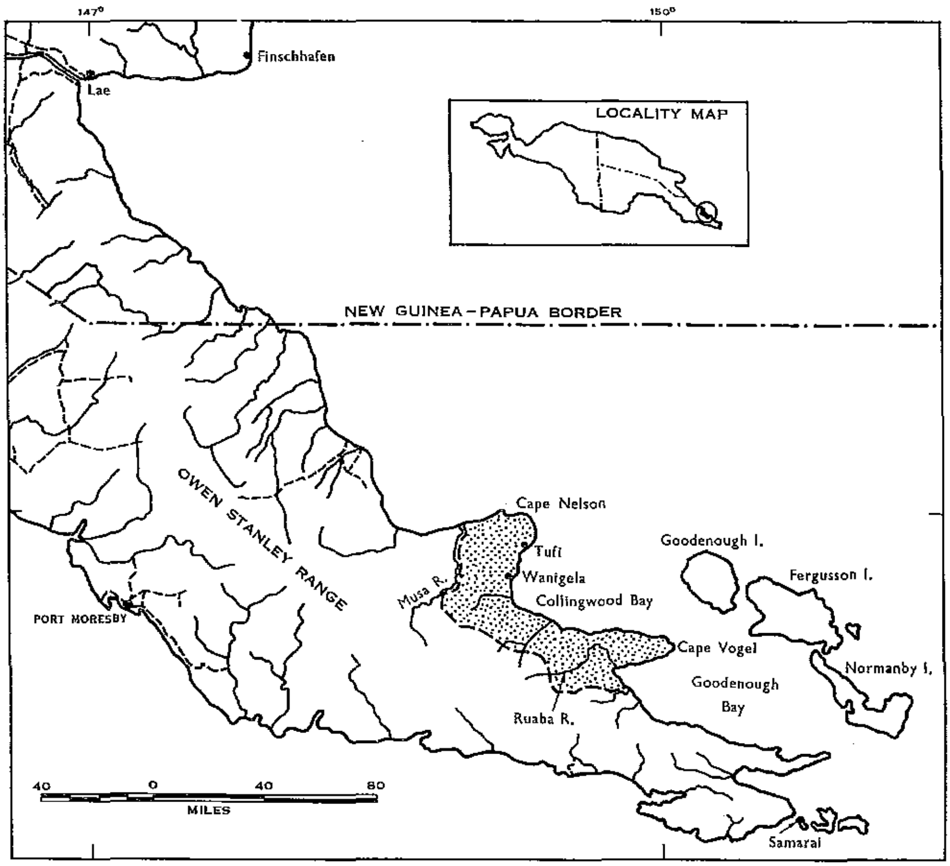

Fig. 1.—Location of the Wanigela–Cape Vogel area.

the land-use potentialities by consideration of these characteristics in relation to the climate, the present land use, and the edaphic requirements of various crops. The concepts on which these surveys are based, notably that of team work by scientists of different disciplines, have been more fully discussed by Christian (1952, 1958).

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The Wanigela–Cape Vogel area covers 1850 sq miles, largely in the Tufi subdistrict of the Northern District, partly in the Baniara subdistrict of the Milne Bay District of the Territory of Papua. Its location between lat. 9°00′ and 9°50′S. and long. 148°50′ and 150°05′E. is shown on Figure 1.

At the time of the field work recent aerial photographs taken by Adastra Airways Pty. Ltd. at a scale of 1 : 40,000 at sea-level were available for Wanigela, Posa Posa Harbour, Cape Vogel, and a small part of Kwagira River map sheets. A large part of the remainder was covered by wartime and post-war trimetrogon runs flown at various heights and in various directions and generally of rather poor quality. Some areas were not covered by aerial photographs. The photo coverage by Adastra Airways was completed shortly after the field work, at scales of 1 : 46,000 and 1 : 50,000 at sea-level.

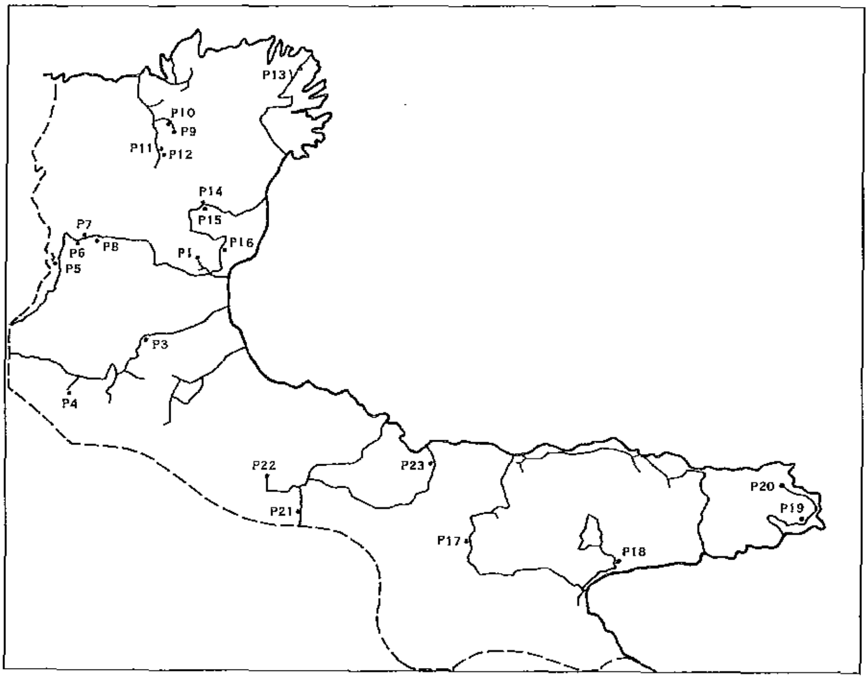

Fig. 2.—Traverses and location of soil samples.

The whole area is covered by wartime military maps at a scale of 1 mile to 1 inch. Except in the higher parts of Cape Nelson sheet these maps are generally of good quality. The base map at a scale of 1 : 250,000 used in this report has been prepared from the recent systematic air photo coverage by the Division of National Mapping, Department of National Development, Canberra.

Field work was carried out during the dry season in July, August, and September 1954. Traverses made during this period are shown in Figure 2. Advantage was taken of the long coastline by the extensive use of a workboat to transport the party from one part of the area to another, thus enabling them to make many short traverses inland or from coast to coast.

The field party consisted of H. A. Haantjens, leader/pedologist, B. W. Taylor, plant ecologist, and J. C. Saunders, forest botanist. A botanical survey was carried out simultaneously, but separately from the main party, by R. D. Hoogland, plant taxonomist. Messrs. W. C. J. Grafen and Q. Anthony of the Department of Native Affairs were seconded to the team for the purposes of general assistance and liaison with the Administration of the Territory of Papua and New Guinea and with the local population. A geological reconnaissance survey of the area was carried out at the same time but independently by J. E. Thompson, resident geologist at Port Moresby of the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. His findings were frequently discussed with members of the team and have contributed materially to the mapping and description of land systems and physical regions in this report. The team did not include a geomorphologist. Consequently a contribution to the geomorphology of the area, normally a part of these reports, is lacking.

II. References

Christian, C. S. (1952).—Regional land surveys. *J. Aust. Inst. Agric. Sci.* **18**: 140–6.

Christian, C. S. (1958).—The concept of land units and land systems. Proc. 9th Pacific Sci. Congr., 1957. Vol. 20. pp. 74–81.

PART II. GENERAL DESCRIPTION OF THE WANIGELA-CAPE VOGEL AREA

By H. A. Haantjens*

I. Climate

Climatic conditions within the area may be described generally as moist tropical with well-defined periods of high and low rainfall coinciding with seasonal alternations in prevailing winds. The wettest part of the year occurs between November and April when winds from between north-west and north-east are dominant. Distinctly drier conditions are associated with south-easterly winds from May to October. Rainfall is known to be strongly governed by differences in the exposure of slopes to the prevailing wind systems, but insufficient data preclude any assessment of the detailed distributional pattern within the area. The existing data suggest that mean annual rainfall ranges from about 70 in. in the sheltered location at the heads of Collingwood Bay and Goodenough Bay to about 130 in. in the exposed localities of the Mt. Victory–Mt. Trafalgar area. Although monthly rainfall data indicate considerable variability, falls of over 4·00 in. per month can be relied upon in all parts of the area during the season of northerly winds. During the drier season, falls of less than 2·00 in. per month are not uncommon. The length and the severity of this drier period increase generally from west to east within the area.

Daily rainfalls of up to 4·00 in. are common throughout the area during the wet season, and these have on occasions exceeded 8·00 in. at the more exposed localities. Throughout the drier part of the year, daily falls are seldom greater than 2·00 in. and in most cases less than 0·5 in. Rainless periods of two weeks are not uncommon at this time of the year, but the passage of a month without some rain is rare.

Both temperature and humidity remain at high levels throughout the year, and there is very little seasonal variation in the mean conditions for both of these elements. Similarly, extremes in temperature or humidity are confined within narrow limits. Temperatures less than 65°F or greater than 96°F have not been observed on the coast. No data are available for inland parts of the area, but in view of the limited altitudinal range and limited distance from the sea, large departures from these conditions are not to be expected.

The climate is characterized by considerable cloudiness throughout the year, especially during the season of northerly winds when spells of continuously overcast weather lasting for several days are common. During the south-easterly season such stratiform cloud conditions are less frequent, and daily development of cumuliform cloud over the land is typical, particularly where normal convection is assisted by local topography.

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In the Mt. Victory–Mt. Trafalgar area the dry period is normally of short duration and less severe than in more sheltered localities to the east. Examination of monthly rainfalls over several years in relation to estimates of evapotranspiration suggests that no serious limitations in plant growth through decline in available soil moisture are to be expected in this part of the area. In the drier area to the south, however, it would appear that some restriction of growth normally would occur, but insufficient data are available to assess these conditions in any detail.

II. Physiography, Soils, and Vegetation

For the purposes of a general description the Wanigela–Cape Vogel area can be conveniently subdivided into five major types of environment: the southern mountains, the central plains, the northern volcanic mountains, the eastern low mountains, hills, and plains, and the coastal flats. By using the references to the land systems, the reader will be able to follow the regional distribution of the features described on the land system map.

(*a*) *Southern Mountains*

The Wanigela–Cape Vogel area is bounded in the south by the northern slopes of the rugged Owen Stanley Range, which rises to over 9000 ft beyond the boundary of the survey area (Plate 1, Fig. 1). These mountains (Maneau land system) are partly characterized by massive frontal slopes with a dense parallel pattern of weakly incised streams and have partly been dissected into large, steep mountain spurs. The metamorphic rocks have locally weathered into shallow acid leached reddish silty clay soils but in many places the slopes are unstable because of landslides and soil creep and are covered with shallow and commonly gravelly brown slope soils. Shallow dark red clay soils of neutral reaction occur on ultrabasic rocks forming a lower part of the range in the south-western corner of the area (Didana land system). These mountains are very largely covered with rain forest (Plate 7, Fig. 1) which merges into lower montane rain forest above 2500 ft.

Normally the boundary between the mountains and the adjacent plains is abrupt (Plate 1, Fig. 2), but in one locality a distinct foothill zone of forested rounded ridges occurs (Budi land system) which has some of the deepest weathered red clay soils in the area.

(*b*) *Central Plains*

North of the mountains stretches a large alluvial plain to the sea (Uiaku land system, Plate 1, Fig. 2). Especially in the upper part the gradient is appreciable and there are several roughly parallel fast-flowing streams which become more sluggish near the coast where the land is locally subject to flooding. The young alluvial soils are mainly rather sandy and commonly stony in the upper part of the plain and medium-textured and poorly drained nearer to the coast. The plains are largely covered by various types of rain forest which differ in structure and composition on well-drained and poorly drained areas, whilst a few large man-made grasslands occur closer to the coast.

A high and somewhat dissected part of the plain near the foot of the mountains (Rakua land system) has rather deep, weathered red-brown clay soils containing some stones and gravel and is covered with a floristically distinct type of rain forest.

Low steep hills of volcanic origin (Sesegara land system) rise above the plain in many places. They have very shallow stony soils and are covered with poorly developed rain forest.

In parts of the plains deposition of alluvial material is continuing today (Wakioka land system). This is mainly evident from the vegetation, which consists of herbaceous communities, woodland, or forest dominated by pioneering species such as *Saccharum spontaneum*, *Casuarina* sp. (Plate 6, Fig. 2), *Octomeles sumatrana*, and others. These areas are also characterized by a poorly defined pattern of small streams with unstable courses and a complete lack of soil formation in the generally calcareous alluvial deposits.

In the west the area is bounded by the forested and generally poorly drained levees and narrow plains along the Musa River (Dove land system).

The lowest parts of the plains are swampy (Tortore land system). They have a vegetation ranging from fluctuating swamp forest through swamp woodland dominated by sago or *Pandanus* to herbaceous swamp communities (Plate 8, Fig. 1). The alluvial soils are commonly finer-textured than those on the higher parts of the plains.

(*c*) *Northern Volcanic Mountains*

The northern part of the area is occupied by the extinct volcano Mt. Trafalgar and the dormant volcano Mt. Victory. The higher areas of Mt. Trafalgar are strongly dissected into mountain spurs (Trafalgar land system, Plate 2, Fig. 1) with undifferentiated brown slope soils or rather shallow, weathered, acid, reddish clay soils. They are almost completely covered with rain forest merging into lower montane rain forest above 2500 ft. The northern foot slopes of Mt. Trafalgar form rolling to hilly plateau-like surfaces separated by deep U-shaped ravines (Bekalama land system, Plate 2, Fig. 2). Because of intensive occupation for shifting cultivation the forest vegetation has been largely replaced by grassland and secondary woody vegetation. The soils are rather shallow weathered red and brown clay soils, locally strewn with boulders of volcanic rock.

In contrast to Mt. Trafalgar, Mt. Victory has generally well-preserved young volcanic land forms. The summit area (Victory land system, Plate 3, Fig. 1) and upper slopes consist of rocky lava domes and more or less dissected lava flows. The lower slopes are slightly concave and broad, although commonly densely dissected (Kwin land system). They are covered with friable brown volcanic ash soils with well-developed dark topsoils, but large areas in the south-western part have more impermeable, mottled soils. Much of the forest in these areas is relatively poor in species and is in a successional stage, having developed after the destruction of the original rain forest during an eruption in the last century. Other areas have a mature, tall rain-forest vegetation. Large areas, predominantly on mottled soils, were once covered by grassland but have been invaded by many shrubs and low trees, apparently as a result of the cessation of the regular burning of the grassland when the population moved out of the area after the eruption.

Several outwash fans of water-transported volcanic sand, gravel, and boulders occur along the margins of Mt. Victory. Older fans (Wanigela land system) have sandy soils with black topsoil and a vegetation of forest and large areas of tall man-made grasslands (Plate 6, Fig. 1). Younger and less stable fans of poorly sorted deposits (Kopwei land system, Plate 3, Fig. 1) have herbaceous and woody pioneering vegetation communities and virtually featureless, commonly gravelly or stony soils.

(*d*) *Eastern Low Mountains, Hills, and Plains*

That part of the area situated roughly east of the Kwagira River is quite distinct from the western part in land forms and soils as well as vegetation. This appears to be mainly due to the influence of the lower rainfall and of the sedimentary rocks, including conglomerate, sandstone, siltstone, marl, and limestone.

Uplifted conglomerate and sandstone bordering the Owen Stanley Range are dissected into very steep, razor-backed low mountain ridges (Tama land system, Plate 3, Fig. 2). North of Tama land system essentially horizontally bedded sediments ranging from fine conglomerate to mudstone (Bewabewa land system) have partly been dissected into intricate patterns of low hills (Plate 4, Fig. 2) and partly form rolling plateau-like surfaces (Plate 5, Fig. 1). On Cape Vogel peninsula the sediments are more strongly tilted and more uplifted, which has resulted in a somewhat higher relief of the irregular hill ridges (Koianaki land system, Plate 4, Fig. 1). This is further accentuated by local higher ridges of volcanic rocks. The areas of coral limestone at Cape Vogel (Tarakaruru land system) comprise low undulating plateaux with few streams, and areas of low rounded hills formed by solution of the limestone. Included is a small area of older limestone with conspicuous cliffs at Castle Hill (Plate 4, Fig. 1).

The slopes on the sedimentary rocks are generally unstable and marred by small slumps and landslides. In combination with the relatively low rainfall this has caused the soils to be very shallow. In Tama land system commonly they are even lithosolic. These soils are dark and very little leached. They vary with the amount of carbonates in the parent rock, ranging from slightly acid and rather poorly structured soils on non-calcareous rocks to black, well-structured, neutral clay soils on limestone. Locally, deeper friable dark red heavy clay soils are found on limestone plains.

Under the influence of the dry conditions the original rain forest was more poorly developed (Plate 5, Fig. 2) and has been largely replaced by short grassland as a result of shifting cultivation. Remnant and secondary forest is mainly restricted to valleys and valley heads and is most common on the calcareous sediments in Koianaki land system and parts of the limestone country.

There are a number of wide alluviated valleys with dark, slowly permeable neutral to weakly alkaline clay soils, mainly covered with relatively poor types of rain forest (Monari land system, Plate 4, Figs. 1 and 2).

(e) *Coastal Flats*

Particularly along the north coast from Sinapa to Tapio there is a narrow belt of tidal flats with various kinds of mangrove communities (Plate 8, Fig. 2). These also occur scattered along the inlets of Cape Vogel. Small areas of low sandy beach ridges (Plate 1, Fig. 1) are associated with the alluvial plains of Uiaku, Wanigela, and Kopwei land systems. They are commonly densely settled and have little natural vegetation.

III. Land-use Potential

There is virtually no land in the area that is suitable for agricultural development without limitations of some kind. However, there are large areas, mainly in the Goropu piedmont and coastal plain and on the lower slopes of Mt. Victory, that appear to have a definite potentiality for intensive development. It is surprising that these areas have the lowest population densities. Because of this they are largely covered by tall rain forest. This would make land-clearing costly but may be turned into an asset if systematic timber exploitation is planned to precede agricultural development.

The potentially productive areas in the Goropu plains comprise Rakua, Uiaku, and Buna land systems. Surface stoniness may limit the possibility of cultivation in many parts of Rakua and Uiaku land systems. In conjunction with deep, well-drained but rather leached, acid soils and a certain amount of dissection by streams, this tends to make the area of Rakua land system primarily suitable for tree crops. In Uiaku land system, land with surface stoniness and rather sandy, calcareous soils may be best utilized for pastures, but other areas appear to be suitable for cultivation and tree crops as well. Poor drainage is a limiting factor in large parts of Uiaku land system near the coast. In most cases drainage improvement would appear to be a simple matter. Such land is judged to be suitable mainly for cultivated crops and pastures. The small areas of Buna land system are densely settled and coconut plantations appear to be the most appropriate form of land utilization.

Favourable conditions for development on Mt. Victory are found in Kwin and Wanigela land systems. The gentle but dissected slopes of Kwin land system, which are locally also rather stony, are primarily suitable for tree crops in areas of friable, well-drained, volcanic soils. There also appear to be considerable areas with slowly permeable, poorly drained soils, which could be best utilized for pastures. Other areas are too strongly dissected for agricultural use, but could be used for forestry. The coarse-textured soils of Wanigela land system also appear to be most suitable for tree crops or pastures, although their use for cultivation cannot be ruled out. The use of low-lying parts of this land system is limited by flood hazards to pastures or dry-season crops.

In developing these areas it will be necessary to provide improved access to the coast. The only present anchorage at Sinapa would need to be much improved. In addition it may be possible, though difficult, to construct a coastal road to Tufi, where an excellent natural harbour exists.

A third area where restricted, though significant, development seems feasible, comprises the valley plains of Monari land system. The slow permeability of the soils makes this land particularly suitable for rice-growing and for a limited range of crops such as sugar-cane, bananas, and possibly cotton. Development of this land could be of much value to this rather densely populated area.

Most of the remaining parts of the area have a low or very low potentiality for development. They include rugged mountains, which should be left under the protection of forest; large hilly areas with poor soils that could probably be partly reafforested (particularly Bekalama land system) or used for extensive grazing; and unstable, stony, or sandy plains that may be used for the exploitation of several large stands of *Casuarina* forest and for extensive grazing. Finally there are rather large areas of swamp, but the sago resources in these appear to be too small and too scattered to warrant commercial exploitation. Some of these swamps could be used for swamp-rice growing or could be drained in major reclamation projects to yield fertile land suitable for cultivation or pastures.

The climate of the western part of the area provides for optimal vegetative growth throughout the year. However, the absence of a marked dry season may interfere with mechanical farm operations, in particular harvesting and weed control. Cloudiness and wetness may delay maturity and reduce the yields of certain crops and favour the spread of virus and fungus diseases. In the eastern part of the area water stress in crops may be experienced between the months of July and October. This drier climate would be more suitable for seasonal mechanized farming. In this area there appear to be appreciable quantities of ground water in the sedimentary rocks to provide ample water for stock and for local supplementary irrigation. Additional water for these purposes could be impounded in reservoirs in many small valleys.

IV. Settlement and Communications

The estimated indigenous population in the area is 14,100*. The overall population density is 7·5 per sq mile, which is below the average for the Territory of Papua and New Guinea. The population is not evenly distributed but is mainly concentrated in a narrow coastal zone. In addition there are inland villages throughout the Cape Vogel peninsula, in the foothills of the Owen Stanley Range south of Tama land system, and in the Rakua–Kwagira River area. There are scattered settlements along the Musa River and at the periphery of Mt. Victory. The large area between the Musa and Rakua Rivers is notably devoid of population.

Indigenous agriculture consists largely of shifting cultivation. The main subsistence crops are taro (*Colocasia esculenta*) in the wetter, western part of the area, and plantains (*Musa* sp., Plate 7, Fig. 2) in the drier, eastern part. Other important crops are cassava (*Manihot utilissima*) and sugar-cane (*Saccharum officinarum*). Coconut groves occur in most villages and are of economic importance along the coast (copra). Some upland rice is grown in valleys in Cape Vogel peninsula.

* This figure is derived from Village Directory, 1960, Department of Native Affairs, Territory of Papua and New Guinea, Port Moresby. Only a rough estimation was possible, as the census districts in the directory do not fully coincide with the boundaries of the area.

In 1954 European settlement was restricted to the Administration settlements (subdistrict headquarters) at Tufi and Baniara, mission stations at Wanigela, Mukawa, and Medino, and trading posts with small coconut plantations near Tufi and at Cape Vogel. One or two cocoa plantations were being developed on the lower slopes of Mt. Victory, near Wanigela.

The concentration of population along a long coastline (Plate 1, Fig. 1) has favoured the use of small ships as the principal means of maintaining communications. The best anchorages are the deep inlets of Cape Nelson, the coral headland of Sinapa on Collingwood Bay, Posa Posa Harbour, Tapio Bay, Larikuku Bay, Tarakaruru River, Medino Bay, and Abuara opposite Baniara Island. Tufi Harbour and Tarakaruru would in particular be suitable for larger vessels. Widespread submerged reefs are a hazard to coastal shipping. Vehicular roads are virtually non-existent and in the whole area Wanigela has the only air strip. This is now suitable for DC3 aircraft. Many good walking tracks link the inland villages with the coast. They are naturally scarce in the thinly populated south and west. There are no navigable rivers.

PART III. PHYSICAL REGIONS* OF THE WANIGELA–CAPE VOGEL AREA

By H. A. HAANTJENS†

I. INTRODUCTION

The Wanigela–Cape Vogel area has been subdivided into six physical regions which are described below. Three of these extend well beyond the limits of the area. Each region has quite distinct characteristics and generally well-defined boundaries which are shown in Figure 3.

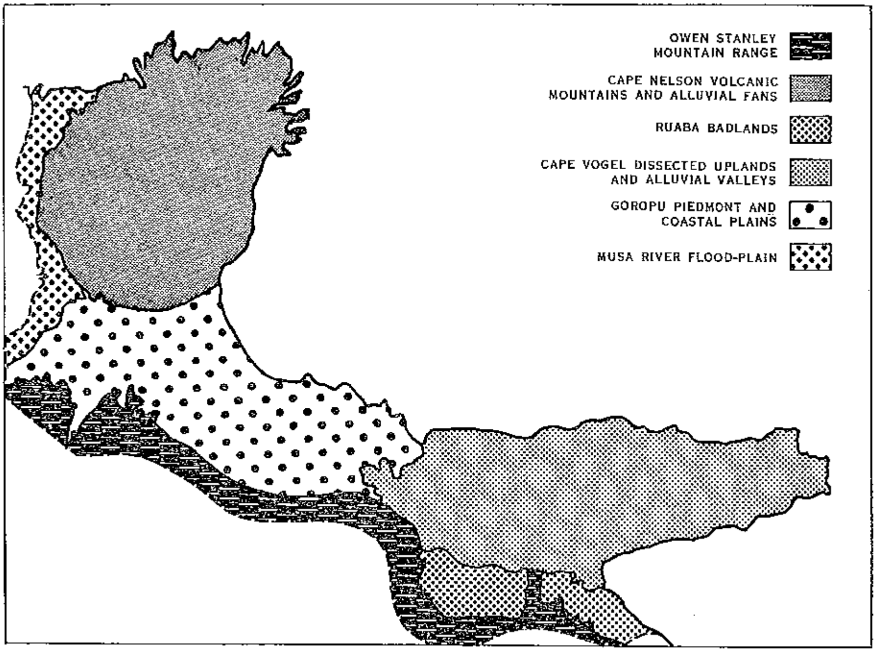

Fig. 3.—Physical regions.

II. OWEN STANLEY MOUNTAIN RANGE

The area is bounded in the south by the northern slopes of this large physical region, which has sharp boundaries with the adjoining regions: a major fault in the western and central parts and unconformable contact with younger, sedimentary rocks in the eastern part. The region includes two geological units: a pre-Tertiary metamorphic block east of Wowo Gap and a plutonic unit west of this gap.

* The physical regions were defined by J. E. Thompson and H. A. Haantjens. This account is partly a condensation of a draft report by J. E. Thompson, Bureau of Mineral Resources, Geology and Geophysics, Canberra, A.C.T.

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The metamorphic block (Plate 1, Fig. 1; Plate 7, Fig. 1) consists of schist and phyllite covered in many areas by low-grade metamorphic calc-silicate rocks. This block, attaining altitudes of over 9000 ft outside the area, is the result of spasmodic tectonic rising and arching accompanied by block faulting. The central part is characterized by a domal structure with a juvenile drainage system of many small parallel streams with very steep gradients. In the eastern and western parts down-cutting by rivers has proceeded much further and has produced a very rugged topography of steep mountain spurs and V-shaped valleys with many landslide scars.

The plutonic unit is aligned with the metamorphic belt. These mountains are less massive in appearance and have a dense pattern of deeply incised streams and more rounded crests attaining a maximum altitude of 4000 ft outside the area. The range consists of ultrabasic rocks and gabbro and appears to be less actively eroding than the metamorphic block.

III. Cape Nelson Volcanic Mountains and Alluvial Fans

The volcanic mountain complex of Mt. Trafalgar (5600 ft) and Mt. Victory (6000 ft) forms an isolated, second major relief element in the area. Although still recognizable in outline and by its radial drainage as a volcano (Plate 2, Fig. 1), Mt. Trafalgar–Topographers Range has long been extinct and is maturely dissected into steep mountain spurs with plateau-like northern and eastern foot slopes dissected by U-shaped gorges (Plate 2, Fig. 2). The range consists of (?)Pleistocene andesitic conglomerate, tuff, and lava. There are no recognizable crater features in the summit area, but a lower dome-shaped feature north-east of the summit could represent a somewhat younger major eruption centre.

Mt. Trafalgar–Topographers Range is separated from the dormant volcano Mt. Victory by a saddle only 1000 ft high. The very rugged summit area of Mt. Victory with a number of large lava domes has been the most recent major eruption centre (Plate 3, Fig. 1). Unconfirmed reports of a devastating eruption about 1880 (Fisher 1957*) are supported by evidence of the successional stage of much of the forest on the higher slopes. The greater part of Mt. Victory consists of broadly concave slopes of andesitic agglomerate and volcanic ash with a youthful dense radial drainage pattern. Young convex lava flows are conspicuous on the south-western slopes and older, strongly dissected lavas occur on the northern slopes. There are some well-preserved adventive cones, notably the crater lake Ridubidubina in the saddle between Mt. Trafalgar and Mt. Victory. Volcanic outwash fans of steep to moderate gradient occur locally along the margins of Mt. Victory. A distinction can be made between stable, older fans with mainly sandy deposits and unstabilized, younger fans of poorly sorted gravel, boulders, and sand (Plate 3, Fig. 1).

IV. Ruaba Badlands

The foothills of the Owen Stanley Range in the eastern part of the area form a small but distinct physiographic region (Plate 3, Fig. 2). They are composed of well-bedded coarse Tertiary sedimentary rocks, which unconformably overlie the

* Fisher, N. H. (1957).—"Catalogue of the Active Volcanoes of the World including Sulfatara Fields." Part V—Melanesia. (Int. Volcanol. Assn.: Naples.)

metamorphic rocks of the Owen Stanley Range but have been rapidly uplifted with the adjoining mountain block and vigorously eroded. In the eastern portion several basic volcanic plugs have pierced and folded the sedimentary rocks. The sharp northern boundary is controlled by recent faulting. The region consists of low mountainous country up to 2400 ft in altitude. It is characterized by intricate, deeply incised dendritic and antecedent drainage and a maze of very steep, razor-backed interfluves with generally unstable slopes.

V. Cape Vogel Dissected Uplands and Alluvial Valleys

This region of intricate but generally low relief extends from Cape Vogel to a few miles east of the Kwagira River. The land forms are strongly controlled by lithology and geological structure. At the tip of Cape Vogel Recent reef limestone, raised in stages to up to 200 ft, has developed a juvenile karst topography. Further west, moderately dipping marine Tertiary sediments have been dissected into rather high steep hills (Plate 4, Fig. 1) with cuestas and hogbacks formed in harder, arenaceous rocks. Areas of massive marl on the north and south flanks have been eroded into fine-textured, disorderly patterns of steep hill ridges with concave slopes. Several occurrences of basic intrusives and hypabyssal rocks stand out as higher, sharper, long ridges in the Cape Vogel peninsula east of the Ruaba River (Plate 4, Fig. 1). Juvenile dissection of gently folded terrestrial Tertiary sediments in the western part of the region has produced extremely intricate patterns of low, convex ridges (Plate 4, Fig. 2) and slightly dissected plateau-like surfaces (Plate 5, Fig. 1), bounded in the north by a low, dissected escarpment. The relief increases again near the western margin of the region. The general altitude of the region is between 400 and 600 ft, with a few higher ridges up to 800 ft including the landmark of Castle Hill capped by older limestone with conspicuous cliffs (Plate 4, Fig. 1).

The hilly parts of the region are interspersed by many wide valleys and basins with low gradients. Most of the alluvium consists of clay (Plate 4, Figs. 1 and 2), but gravelly fans and aprons occur along the foot of the Ruaba badlands region (Plate 3, Fig. 2) and some flood-plains with medium-textured alluvium also occur. An almost continuous zone of mangroves (Plate 8, Fig. 2) fringes the north coast.

VI. Goropu Piedmont and Coastal Plains

This region (Plate 1, Fig. 2) extends from the Cape Vogel uplands to the Musa River flood-plain and the Cape Nelson volcanic mountains. The plains have appreciable gradients and are traversed by numerous subparallel, rather small and fast-flowing rivers, which are moderately incised in the upper part of the plain. Only small areas near the coast appear to be subject to regular flooding.

The region includes a number of distinct morphological elements. The oldest part consists of moderately dissected, higher piedmont terraces. Younger flood-plains, largely of a stable nature, constitute the largest part of the region. The lowest parts of these plains are swampy. Very young, actively aggrading outwash plains (Plate 6, Fig. 2) occur throughout the region, but particularly north of Wowo Gap. Low, dissected hills consisting of (?)Pleistocene basic lava and agglomerate stand out in many places. Recent volcanic extrusives include a distinct lava flow with cone and the small Waiowa volcano, a flat cone with crater lake dating from 1943. Tidal mangrove swamps and local beach ridges (Plate 1, Fig. 1) separate the flood-plains from the sea.

VII. Musa River Flood-plain

The eastern margin of this physical region bounds the Wanigela–Cape Vogel area in the west. It consists of levees and back plains of the Musa River with medium-textured alluvial deposits. The boundary with the Goropu plains and the Cape Nelson volcanic mountains is marked by a fringe of swamp land caused by the blocking of low-lying areas by contrasting sedimentation regimes.

PART IV. LAND SYSTEMS OF THE WANIGELA–CAPE VOGEL AREA

By H. A. HAANTJENS* and B. W. TAYLOR†

I. INTRODUCTION

Land systems may be defined as natural landscapes with a characteristic pattern of rocks, land forms, soils, and vegetation (Haantjens *et al.* 1964‡). The 24 land systems mapped in this area are the result of the interpretation and correlation of data collected by team members in the field, and of the extrapolation of these data by means of air-photo interpretation over the whole of the area.

During the field survey several land systems were superficially examined, whilst in some cases aerial photographs were not available or were of poor quality. Thus not enough data are available to distinguish and describe units in Maneau, Didana, Tama, Budi, Sesegara, Rakua, Tokinawara, Dove, and Ismari land systems. The description of these land systems is in very general terms.

TABLE 1

DEFINITION OF DRAINAGE CLASSES

Drainage Class	Soil Features	Water-table
Excessively drained	Very shallow or very coarse-textured, commonly steep	—
Well drained	Deeper and not excessively coarse-textured, without distinct mottling and without grey colours above 48 in.	Below 6 ft, except for very short periods in some cases
Imperfectly drained	Distinct mottling and grey colours starting between 20 and 48 in.	Normally below 4 ft during dry season
Poorly drained	Distinct mottling and grey colours starting between 9 and 20 in.	Commonly between 28 and 38 in. in dry season
Very poorly drained	Distinct mottling and grey colours starting above 9 in.	Commonly between 12 and 36 in. in dry season
Swampy	Strong gleying throughout, often prominent rusty mottling. Often poorly decomposed plant remains	Permanently near, at, or above ground level

The areas of the land systems were determined on the map with a dot grid with 25 dots per sq cm. The relative areas given for the units are only rough estimates based on field observations and photo-interpretation.

The drainage status of the units is assessed after the soil descriptions. The significance of the terms used is set out in Table 1.

* Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T.

† Formerly Division of Land Research and Regional Survey, CSIRO, Canberra, A.C.T. Present address: F.A.O., Rome.

‡ HAANTJENS, H. A., PATERSON, S. J., TAYLOR, B. W., and STEWART, G. A. (1964).—Land systems of the Buna–Kokoda area. CSIRO Aust. Land Res. Ser. No. 10: 18–44.

Wherever possible, the land systems are illustrated by block diagrams or plans (drawn by Mrs. N. Geier), the latter for land systems with very little relief. Some care should be exercised in the interpretation of these illustrations, for the following reasons:

(1) They are drawn at various scales. To assist the reader, an approximate distance of one mile is indicated and approximate height figures give an idea of the relief. Each diagram should be viewed in relation to these scale indications, otherwise a wrong impression may be created.

(2) It is normally difficult to assign to the units the same relative area in the block diagram as they occupy in the whole of the land system. In general, large units are shown too small, small units too large.

(3) Although every illustration is actually drawn from aerial photographs, the block diagrams are commonly abstract compositions of all the units, each or some having been derived from different photographs.

II. Grouping of Land Systems

The land systems have been placed in six distinct groups (see legend to land system map) to emphasize the broad affinities and differences between them. The groups are based on broad similarities in land forms and/or according to the origin of the land systems.

(*a*) *Erosional Mountains*

This group is characterized by internal relief of over 500 ft and altitude over 2000 ft. The land systems have very steep slopes and V-shaped valleys due to rapid down-cutting by streams. Rain forest is the predominant vegetation except in Tama land system, which is covered by grassland.

(*b*) *Erosional Hills*

In this group internal relief is less than 500 ft and altitude less than 2000 ft. Most hilly areas are characterized by steep, irregular slopes and narrow valleys, and a dense drainage pattern. Plateau-like surfaces occur in Bekalama, Bewabewa, and Tarakaruru land systems. The vegetation is grassland, rain forest, and secondary forest, commonly in complex patterns.

(*c*) *Volcanic Slopes*

Land systems have been placed in this group because of their genetic relationships as parts of the Mt. Victory volcano complex. They range from mountainous areas in the summit, which owe their form to volcanic extrusion rather than to down-cutting by streams, through hilly lava flows, which have more or less preserved their original form, and more or less dissected volcanic slopes to young alluvial fans derived from volcanic deposits. The vegetation is predominantly forest, commonly of a successional nature as a result of past eruptions, with some large areas of grassland.

(*d*) *High Terraces*

The two land systems in this group represent older alluvium, largely deposited as fans at the foot of the mountains. These have subsequently been dissected and are now situated well above the level of the adjoining flood-plains. The vegetation is rain forest in Rakua land system and grassland in Tokinawara land system.

(*e*) *Fluviatile Plains*

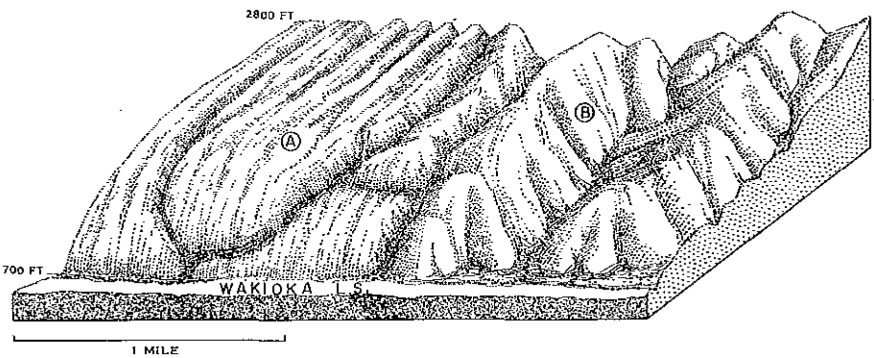
This group comprises young alluvial plains with very low relief. They are partly subject to flooding and in an actively aggrading stage. The vegetation consists largely of rain forest, successional forests, and swamp communities.

(*f*) *Littoral Plains*

These consist of marine deposits such as tidal mangrove flats and beach ridges.

(1) MANEAU LAND SYSTEM (160 SQ MILES)

Very steep, forested, northern slopes of Owen Stanley Range.



Geology.—Phyllite, schist, calc-silicate rocks, and some limestone. Oldest rocks in area, bounded in north by an active fault.

Physical Features.—Northern flank of strongly dissected block-faulted mountains rising from 400 to 3000 ft, but over 9000 ft outside survey area. Central part has a general convex slope dissected into narrow steep ridges by numerous parallel streams (A). Western and eastern parts consist of larger mountain spurs and deep valleys with a subparallel drainage pattern and many landslide scars (B).

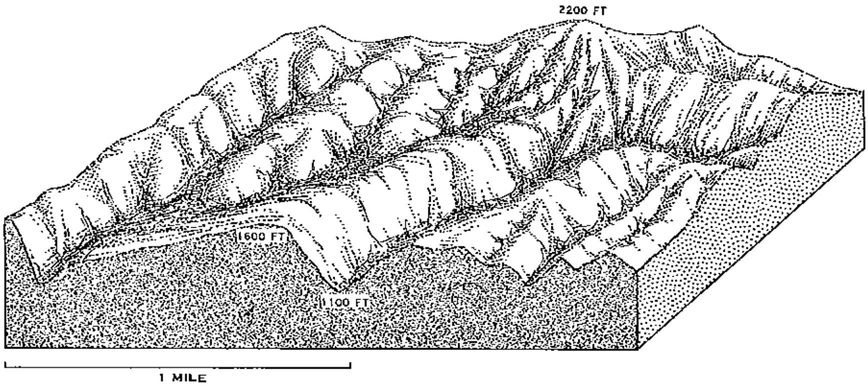
Soils.—Very limited information. Mostly lithosols and shallow slope soils on very steep lower slopes along northern edge and probably on steepest ridges. Shallow yellow-red silty clay soils of Maneau family (strongly weathered red and brown clay soils) observed on less steep higher slopes in central part.

Land Class.—VII–VIIIe, so.

Vegetation.—Mainly rain forest of *Anisoptera kostermansiana–Intsia bijuga–Garcinia* sp. association. In the central part this is locally replaced by garden regrowth and in the eastern part by grassland of *Themeda australis–Alloteropsis semialata* alliance. Above approximately 2000 ft occurs rain forest of the *Lithocarpus* sp.–*Cryptocarya* spp. alliance, which merges into lower montane rain forest above approximately 2500 ft.

(2) Didana Land System (20 sq miles)

Rugged, forested mountain spurs in south-eastern corner of area.



Geology.—Ultrabasic and basic igneous rocks, probably lower Tertiary.

Physical Features.—Massive spurs with rounded, generally broad crests and little-dissected steep slopes rising from 300 to about 2500 ft and up to 4000 ft outside survey area. V-shaped valleys. Internal relief 400–1500 ft. Rather coarse radial to dendritic drainage pattern.

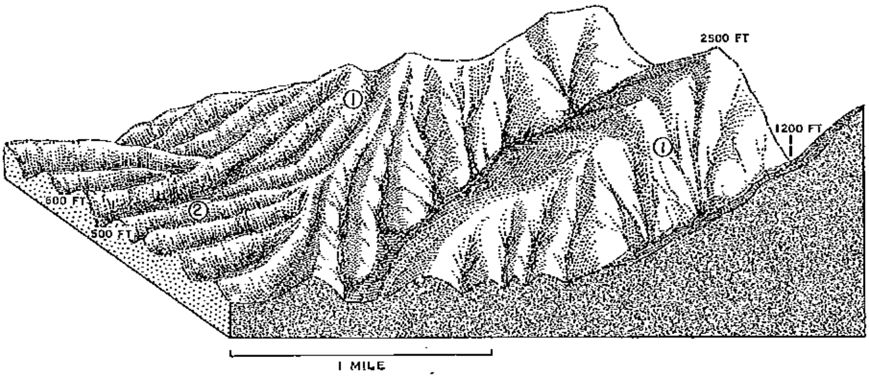
Soils.—Very little information. Shallow dark reddish clay soils of Bereruma family (strongly weathered red and brown clay soils) observed on steep slopes. Probably deeper soils on broad crests.

Land Class.—VI–VIIIe, so.

Vegetation.—Rain forest, mainly of *Lithocarpus* sp.–*Cryptocarya* spp. alliance, also of *Anisoptera kostermansiana–Intsia bijuga–Garcinia* sp. association.

(3) Trafalgar Land System* (100 sq miles)

Rugged forested mountains of the Topographers Range and Mt. Trafalgar.



Geology.—Pleistocene to Recent andesitic lava, conglomerate, and tuff.

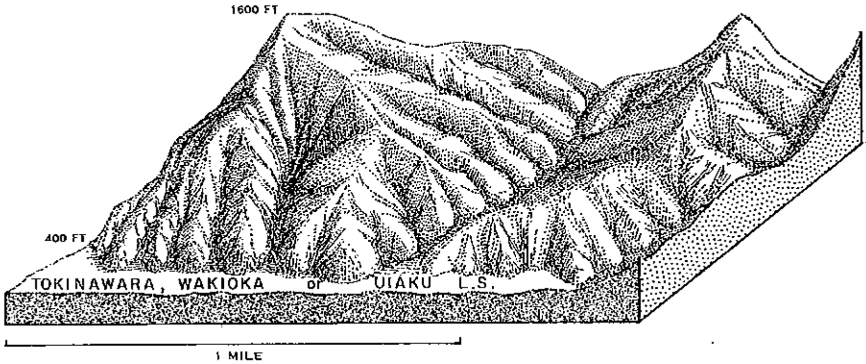
Physical Features.—Maturely dissected, extinct strato volcano. Large barranco valley cutting across main crater area from north to south. Rather coarse, subradial drainage pattern with widening valleys along margins. Rising from sea level to 5600 ft.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Major part of land system	Very steep, sharp, branching mountain spurs with dissected slopes. V-shaped valleys. Relief 400–2000 ft	Mainly rough mountainous land with undifferentiated slope soils. Strongly weathered red and brown clay soils of Oreia family in lower areas with lithosols on steepest slopes. Pockets of moderately to little-weathered ash soils of Boa family on some lower crests in south-west near Mt. Victory. Generally well drained	Mainly VIIIe, some VIIe	Probably lower montane rain forest above 2500 ft. Otherwise mainly rain forest, probably of *Anisoptera kostermansiana–Intsia bijuga* alliance. Mt. Victory blast succession forest, lowland zone, in south-west
2	Small. Western and eastern outer parts of land system	Foot slopes: low, commonly digitate hill ridges with moderate to steep slopes, gentle to moderate crest slopes. Relief 50–200 ft	Strongly weathered red and brown clay soils, mainly of Oreia family, but also of Ilamarora family on lower slopes, where lithosols also occur on narrow ridges. Generally well drained	Mainly VI and VIIe	Secondary forest and regrowth of *Anisoptera kostermansiana–Alstonia scholaris–Rhus taitensis* association. Very small patches of *Themeda* grassland

* This land system has many similarities with Hydrographers land system of the Buna–Kokoda area.

(4) TAMA LAND SYSTEM (90 SQ MILES)

Very steep, strongly dissected, low mountains west of Goodenough Bay. Mainly grassland vegetation.



Geology.—Miocene–Pliocene arenaceous sequence with few interbedded marine mudstones; moderate dip to south-west. Basic shallow intrusives and some extrusives in eastern part. Fault-bounded in the north and west.

Physical Features.—Maturely dissected, block-faulted complex of razor-back mountain ridges with V-shaped valleys. Rather coarse dendritic to subparallel drainage. Rises from 400 to approximately 2400 ft.

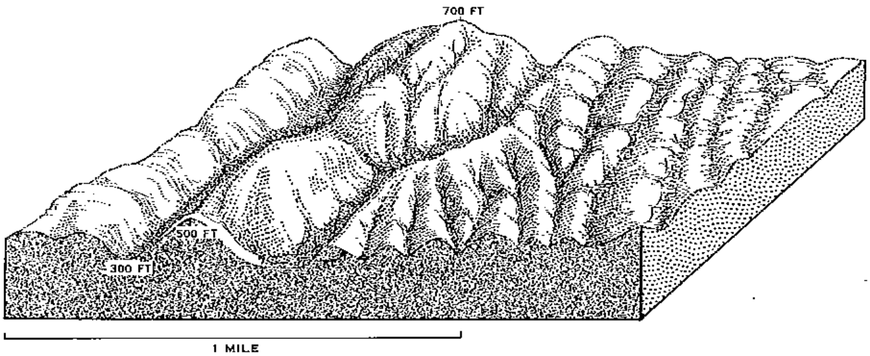
Soils.—Rough mountainous land with mainly lithosols, excessively drained.

Land Class.—Mainly VIIIe, so.

Vegetation.—Mainly grassland of *Themeda australis–Alloteropsis semialata* alliance. Some areas of rain forest and secondary forest of *Anisoptera kostermansiana–Intsia bijuga–Terminalia* spp. association. Minor low forest along streams.

(5) BUDI LAND SYSTEM (20 SQ MILES)

Forested foothills of Owen Stanley Range east of Wakioka River.



Geology.—Calc-silicate metamorphic and some basic and ultrabasic igneous rocks.

Physical Features.—Ridges with gently rounded crests and steep side slopes; also steep hills. Smooth slopes. Very small streams in narrow valleys. Altitude 300–1200 ft.

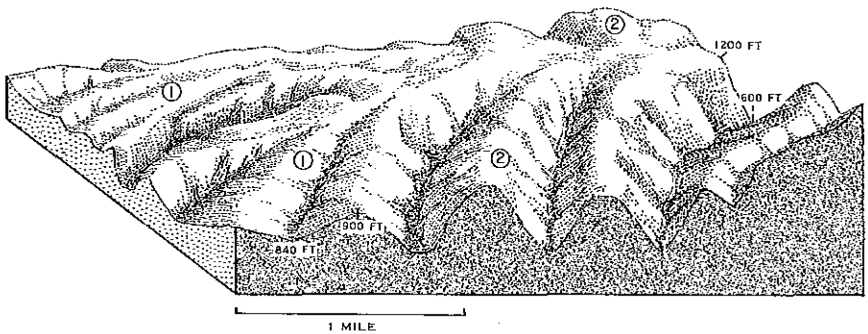
Soils.—Rather deep reddish clay soils of Budi series (strongly weathered red and brown clay soils) observed in the lower part of the land system.

Land Class.—Mainly VIe in lower part, VIIe in upper part.

Vegetation.—Rain forest of *Anisoptera kostermansiana–Intsia bijuga–Garcinia* sp. association.

(6) Bekalama Land System (105 sq miles)

Northern forested lower spurs and dissected foot slopes with grassland in the Mt. Trafalgar–Topographers Range complex.



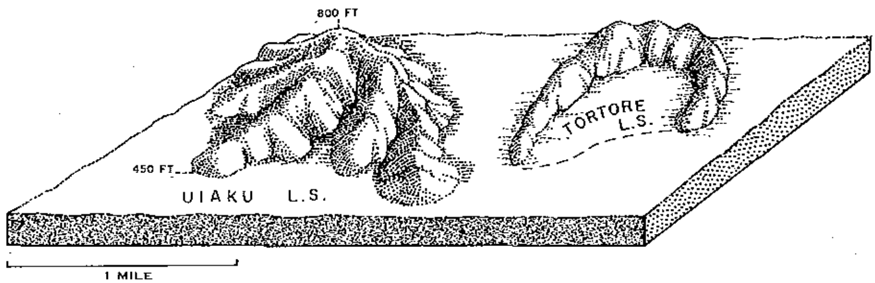
Geology.—(?)Pleistocene andesitic volcanic rocks: conglomerate and breccia, interbedded with tuff.

Physical Features.—Broad gentle volcanic foot slopes with undulating to hilly surfaces, dissected by deep radial gorges, forming drowned valleys along coast. Upper parts more maturely dissected into broad spurs. Rising from sea level to 1400 ft.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Northern part of land system	Rolling surfaces and low rounded hill ridges (normally 6–15° slopes and 30–100 ft relief) with few small streams and separated by U-shaped valleys 100–800 ft deep	Apparently complex pattern of strongly weathered red and brown clay soils of Oreia and Ilamarora families	Mainly VIe,so; valley slopes VIIIe,so	Grassland of *Themeda australis–Alloteropsis semialata* alliance, largely dominated by *Themeda*. Locally regrowth and some secondary forest of *Anisoptera kostermansiana–Alstonia scholaris–Rhus taitensis* association
2	Medium. Highest southern part of land system	Steep-sided, rounded spurs and V-shaped valleys. Relief 200–800 ft	Mainly strongly weathered reddish clay soils of Oreia family, commonly truncated. Probably also Ilamarora family and some lithosols on steepest slopes	Mainly VIIe, so	Secondary forest and regrowth of *Anisoptera kostermansiana–Alstonia scholaris–Rhus taitensis* association. Few areas of *Themeda* grassland on ridge tops

(7) Sesegara Land System (30 sq miles)

Steep, forested hills scattered in plain north of Owen Stanley Range.



Geology.—Pleistocene to Recent basaltic and andesitic agglomerate and lava.

Physical Features.—Isolated, irregular or horseshoe-shaped hills and ridges of volcanic origin. Commonly rounded crests and slightly convex slopes. Altitude 600–1000 ft.

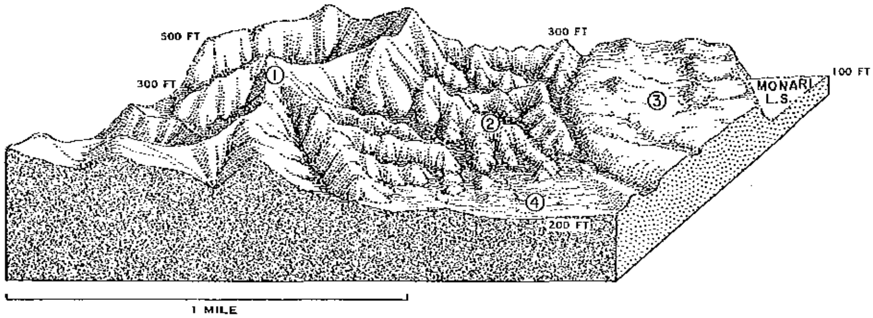
Soils.—Stony land, lithosols, well to excessively drained.

Land Class.—VIIe, so.

Vegetation.—Rain forest of *Anisoptera kostermansiana–Intsia bijuga–Garcinia* sp. association.

(8) Bewabewa Land System (125 sq miles)

Intricately dissected low hills and rolling plateaux at the base of Cape Vogel peninsula. Mainly grassland, but much forest in western part.



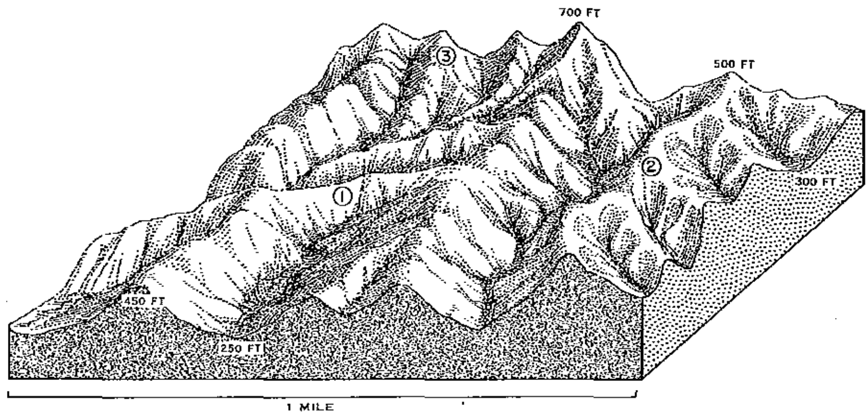
Geology.—Gently folded, Pliocene–Pleistocene terrestrial and minor Miocene–Pliocene marine siltstone, mudstone, and conglomerate, with local tuff.

Physical Features.—Undulating to rolling summit surfaces and foot slopes, and intricate complexes of hill ridges with irregular, steep, and generally convex slopes and a fine-textured dendritic to subparallel drainage pattern. Dissected, low escarpment parallel to north coast. Altitude generally 200–400 ft, up to 600 ft in western part.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Medium. Western and south-western parts of land system	Steep to very steep hill slopes, rounded crests, and narrow valleys. Relief 100–300 ft	Mostly truncated strongly weathered red and brown clay soils of Ukwena family; also shallow dark soils of Podago family; locally strongly eroded profiles of weathered gleyed clay soils (Gurukwaia family) and lithosols. Well to excessively drained	Mainly VIIe, so	Mainly secondary forest and regrowth with little rain forest of *Anisoptera kostermansiana–Intsia bijuga–Terminalia* spp. association. In south and east increasing proportion of grassland of *Themeda australis–Alloteropsis semialata* alliance, with some forest in valleys
2	Medium. Central southern part of land system and along northern edge	Steep to very steep convex hill slopes, rounded crests, and narrow valleys. Relief 50–200 ft. Also dissected escarpment	Dominantly lithosols and shallow dark soils of Podago family. Excessively drained	Mainly VIIe, so	Mainly grassland of *Themeda australis–Alloteropsis semialata* alliance with secondary forest and regrowth of *Anisoptera kostermansiana–Intsia bijuga–Terminalia* spp. association in valleys
3	Medium. Mainly close to north coast, also within big bend of Ruaba River	Undulating to rolling surfaces, with low, sharp emergent hills. Shallow drainage depressions with poorly developed streams. Relief 20–50 ft	Mainly shallow dark soils of Podago family, commonly concretionary: locally gravelly lithosols. Excessively drained. Weathered gleyed soils of Medino family in wet drainage depressions	Mainly VIso	Grassland of *Themeda australis – Alloteropsis semialata* alliance. Minor secondary forest and regrowth along streams
4	Small. Along margins of units 2 and 3	Undulating gentle slopes, up to ½ mile long	Strongly weathered red and brown clay soils of Ukwena family and weathered gleyed soils of Gurukwaia family; commonly truncated. Partly poorly, partly excessively drained	Mainly IVso	Grassland of *Saccharum spontaneum–Imperata cylindrica* alliance on wetter sites, of *Themeda australis–Alloteropsis semialata* alliance on drier sites. Some secondary forest and regrowth of *Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa* association along streams

(9) KOIANAKI LAND SYSTEM (195 SQ MILES)

Intricately dissected low and high hills on Cape Vogel peninsula with a complex pattern of forest and grassland.



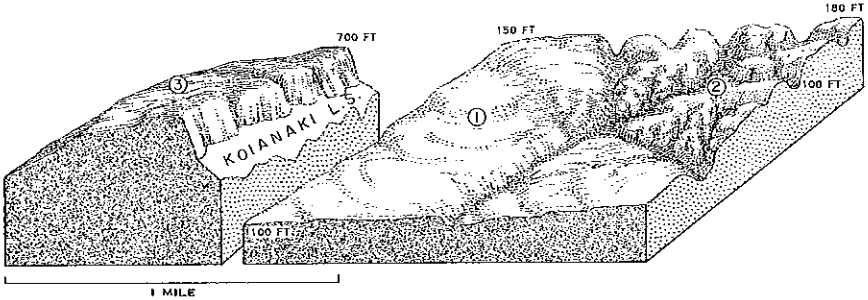
Geology.—Mainly Miocene–Pliocene marine and some Pliocene–Pleistocene terrestrial conglomerate, sandstone, siltstone; Pliocene marl; basic shallow intrusives and some extrusives of Miocene age.

Physical Features.—Intricate patterns of finely branching hill ridges with steep, irregular slopes. Sharper, higher ridges of igneous rocks. Fine-textured drainage pattern of small streams. Altitude generally 400–600 ft, but up to 1800 ft.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Major part of land system	Steep to very steep, irregular hill slopes. Rounded crests and narrow valleys. Relief 200–400 ft	Dominantly shallow dark soils of Podago family. Dark soils of heavy texture (Boboni family) in widest valleys. Generally excessively drained	Mainly VIIe, so; some VIe, so	Intricate pattern of grassland of *Themeda australis–Alloteropsis semialata* alliance (commonly on crests and upper slopes) and secondary forest and regrowth of *Anisoptera kostermansiana–Intsia bijuga–Terminalia* spp. association
2	Medium. In northern and southern parts of land system east of Ruaba River	Steep to very steep, concave, irregular hill slopes on marl; sharp crests and narrow valleys. Relief 200–300 ft	Dominantly shallow black structured clay soils of Kanidaba family. Shallow dark soils of Wanaki family on soft marl. Well to excessively drained	VIIe, so	Mainly secondary forest and regrowth of *Anisoptera kostermansiana–Intsia bijuga–Terminalia* spp. association with narrow patches of short *Themeda* grassland along many crests
3	Small. In northern part of land system and one occurrence in south, just east of Ruaba River	Very steep, long hill slopes and sharp crests on igneous rocks. Relief 400–600 ft	Very little information. Probably lithosols and shallow dark soils of Podago family	Mainly VIIIe, so	Grassland of *Themeda australis – Alloteropsis semialata* alliance. Very little secondary forest and regrowth

(10) Tarakaruru Land System (25 sq miles)

Undulating to hilly limestone country with grassland and forest regrowth. Mainly at the tip of Cape Vogel peninsula.



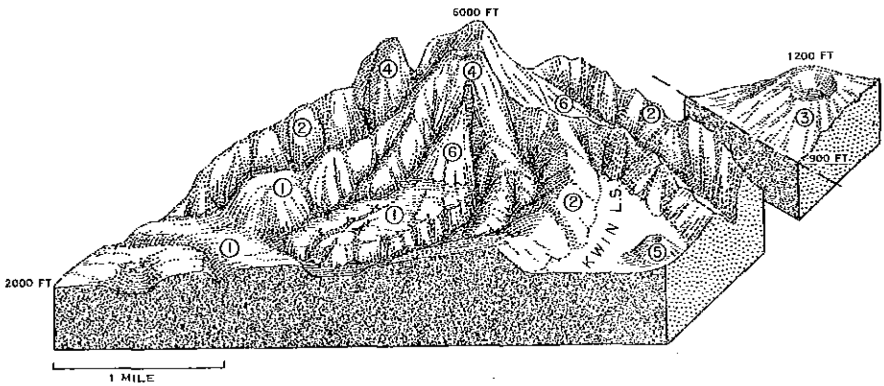
Geology.—Pleistocene to Recent coral limestone; older limestone at Castle Hill.

Physical Features.—Raised coral terraces with conical karst at inland margins. Limestone dip slopes and cliffs at Castle Hill. Few incised streams. Altitude 50–200 ft, but 700 ft at Castle Hill.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Major part of land system	Undulating to rolling very gentle slopes with local short steep slopes and benches	Granular dark red, uniform heavy clay soils of Wabubu family, and shallow black structured clay soils of Ginada family. Many small areas of rock outcrop. Soils of Castle Hill and Gurukwaia families occur in narrow depressions. Well to excessively drained, depending on soil depth	Mainly VIso, st; small areas of IIso, VIIIe, so, st, and VIIIso, st	Grassland of *Themeda australis–Alloteropsis semialata* alliance in east and north, commonly with scattered bushes. Secondary forest and regrowth of *Rhus taitensis–Canarium salomonense–Intsia bijuga* association in western part and in narrow valleys
2	Small. Rather large areas along western edge of land system at Cape Vogel	Low, steep, convex hills, 50–150 ft high, separated by flat-bottomed valleys	Shallow black structured clay soils of Ginada family and rock outcrop. Similar, but deeper soils of Castle Hill family locally in valley bottoms and on steep dissection slopes below main limestone beds. Mostly excessively drained	VIIe, so	Regrowth and secondary forest of *Rhus taitensis–Canarium salomonense–Intsia bijuga* association. Locally *Themeda* grassland
3	Very small. At Castle Hill	Moderately steep, broken slopes and cliffs, up to 300 ft high	Mainly lithosols and rock outcrop. Locally shallow black structured soils of Ginada family. Similar soils of Castle Hill family on lower slopes, below main limestone beds	VIIIso, st	Secondary forest and regrowth of *Rhus taitensis–Canarium salomonense–Intsia bijuga* association, with stands of dry evergreen forest formation on very rocky sites. Very locally *Themeda* grassland

(11) Victory Land System* (50 sq miles)

Summit area, adventive cones, and lava flows of Mt. Victory volcano; volcanic vents in plain north of Owen Stanley Range. Forest vegetation.



Geology.—Recent andesitic and basaltic lava and ash; also agglomerate containing shattered igneous and metamorphic rocks in Waiowa volcano.

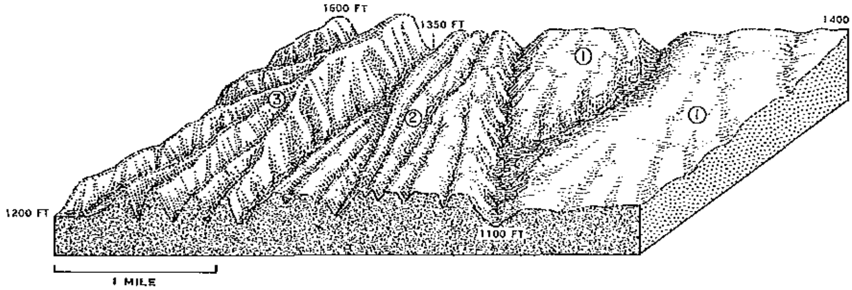
Physical Features.—Mostly well-preserved volcanic land forms of recent eruption centres; tholoids (unit 5), coulée-type lava flows and adventive domes (unit 1), adventive cones with craters (unit 4), strongly dissected older lava flows (unit 2), and low volcanic cone with crater lake, formed during eruption in 1943 (unit 3). Altitude 400–6000 ft. Few streams except in unit 2, which has a radial to subparallel drainage pattern.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	South-western and eastern slopes of Mt. Victory. One occurrence in plain north of Owen Stanley Range	Gently sloping, undulating surfaces with steep, convex side slopes and steeper, broad, strongly convex ridges. Relief 100–300 ft	Mainly lava rock land	Mainly VIIso, st. Side slopes VIIIe, so, st	Mainly Mt. Victory blast succession forest, lowland zone. Most western parts on Mt. Victory and the occurrence in plain are covered with rain forest of *Pometia pinnata–Tristiropsis subangula–Anisoptera kostermansiana* association
2	Medium. Northern and north-western areas on Mt. Victory	Moderately steep to very steep, strongly dissected ridges. Relief 200–800 ft	Very little information. Probably mostly shallow, stony slope soils	Probably VII–VIIIe, so	Mt. Victory blast succession forest, lowland to montane zone
3	Small. Waiowa volcano at foot of Owen Stanley Range	Gullied, gentle, long slopes; shorter moderate to steep slopes towards crater lake	Lava rock land and volcanic ash land	Mainly VIIIso, st	Largely grassland and Waiowa blast succession woodland
4	Small. Three occurrences in summit area of Mt. Victory	Little to strongly dissected, very steep, convex hills, about 1000 ft high	Presumably lava rock land	VIIIe, so, st	Mt. Victory blast succession woodland, montane zone
5	Very small. Locally on lower slopes of Mt. Victory	Steep, 100–300 ft high, smooth or dissected conical hills	Presumably lava rock land and volcanic ash land	Mainly VIIIe, so	Mainly Mt. Victory blast succession forest, lowland to lower montane zone
6	Very small. Locally at base of unit 4	Steep, concave scree slopes	Presumably rubble land	VIIIe, so, st	Mt. Victory blast succession forest, lower montane zone, and almost bare ground

* This land system has many similarities with Lamington land system of the Buna–Kokoda area.

(12) Kwin Land System* (160 sq miles)

Largely forested gentle lower slopes of Mt. Victory volcano with brown volcanic ash soils.



Geology.—Recent andesitic volcanic ash, agglomerate, and lava(?).

Physical Features.—Weakly to strongly dissected, broadly concave lahar–glowing avalanche slopes with a fine-textured, radial drainage pattern. Slopes rise from nearly sea level to about 3000 ft.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Lower parts of land system, except in north	Slightly undulating, long, very gentle slopes with rounded gullies and small streams (relief 10–50 ft). Rather widely spaced bigger streams are 30–100 ft incised	Moderately weathered brown ash soils appear to be dominant: mainly Ambon and Utah families in central and south-eastern sectors, Penari and Boa families in north-eastern sectors. Weathered gleyed soils of Guruguru family appear extensive in south-western sector and of Moiowa family on strongly undulating surfaces (probably lava) in western sector. Land with brown ash soils is well drained, that with gleyed soils imperfectly to poorly drained. Class 1–2 stoniness is common	Much IIe and IIIe, st. Also much III (padi) so; III (padi) so, st; and IV(padi) so, e. Small areas of VI–VIIe	Much rain forest of *Pometia pinnata–Tristiropsis subangula–Anisoptera kostermansiana* association with stands of *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association in upper south-eastern parts. Mt. Victory blast succession forest, lowland zone in north-east. Much regenerating grassland in south-west. Scattered areas of grassland of *Saccharum spontaneum–Imperata cylindrica–Coelorachis rottboellioides* suballiance along western and eastern lower margins
2	Medium. Upper parts of land system, except in north	Gentle to moderate, commonly undulating, long slopes, closely dissected by streams, 30–150 ft incised	Moderately weathered brown ash soils of Ambon and Penari families. Well drained. Commonly class 1–2 stoniness	Much VIe (VIIe on steepest slopes). Smaller areas of IIIe and IIIe, st	Mainly Mt. Victory blast succession forest, lowland zone. Small area of rain forest of *Pometia pinnata–Tristiropsis subangula–Anisoptera kostermansiana* association in south-western sector
3	Medium. Northern part of land system	Steep-sided ridges with rounded, gently to moderately sloping crests and V-shaped valleys. Relief 100–300 ft	Very limited information indicates presence of moderately weathered brown ash soils of Penari and Ambon families; generally well drained	Mainly VIIe	Mainly Mt. Victory blast succession forest, lowland zone. Rain forest of *Pometia pinnata–Tristiropsis subangula–Anisoptera kostermansiana* association in western part. Some regenerating grassland and grassland of *Themeda australis–Alloteropsis semialata* alliance along northern margins

* This land system has many similarities with Hamamutu and Higatura land systems of the Buna–Kokoda area.

(13) Wanigela Land System* (50 sq miles)

Fan-shaped plains with black sandy soils covered with grassland and secondary forest. Associated with Mt. Victory volcano.

No block diagram or plan as relief is very low and distribution of units is largely regional and is reasonably clear from a comparison of descriptions with land system map and grassland boundaries.

Geology.—Recent alluvium of andesitic sand and gravel.

Physical Features.—Stabilized and slightly dissected outwash fans with appreciable gradients. Altitude 25–700 ft. Rather coarse-textured, radial drainage pattern.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Major part of land system	Level to very gently sloping to slightly undulating plains and narrow 6-ft lower terraces along major streams. Slightly dissected by shallow, rounded gullies	Mainly unweathered volcanic sandy soils with black topsoils of Popondetta family. Well to excessively drained	IIso	Mainly grassland of *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance. Also regrowth and secondary forest of *Anisoptera kostermansiana–Pometia pinnata* association
2	Medium to small. Lower parts of land system, extending upward along major streams	Level flood-plains and low terraces. Mostly subject to flooding in wet season	Recent alluvial soils, stratified, mainly medium-textured. Imperfectly to very poorly drained	III–IV (padi)d, f	Regrowth and secondary forest of *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association
3	Small. Narrow upper parts of land system, mainly in Kwin River area	Undulating, gentle slopes with few deeply incised streams	Unweathered volcanic coarse sandy soils with black topsoils of Popondetta family. Well to excessively drained. Class 2–3 stoniness	Mainly Vst	Secondary forest of *Anisoptera kostermansiana–Pometia pinnata* association, Mt. Victory blast succession forest lowland zone near Kwin River, and grassland of *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance

* This land system is very similar to Popondetta land system of the Buna–Kokoda area.

(14) Kopwei Land System (50 sq miles)

Fan-shaped plains with gravelly and stony land and pioneering woody and herbaceous vegetation. Associated with Mt. Victory volcano.

No block diagram or plan as relief is very low and distribution of units is largely regional and is reasonably clear from a comparison of the descriptions with the land system map.

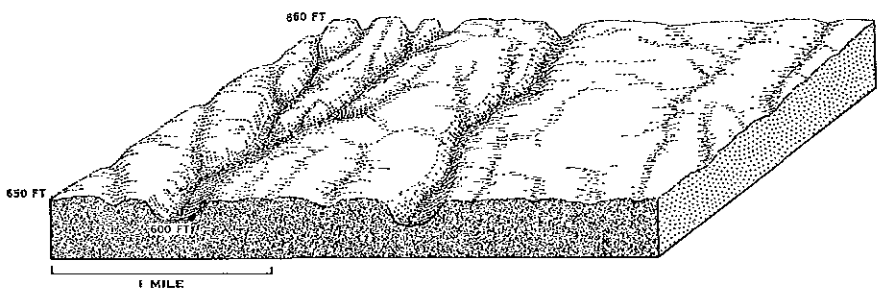
Geology.—Recent alluvium: andesitic gravel, boulders, and sand.

Physical Features.—Unstabilized, very recent outwash fans with appreciable gradients. Altitude generally 0–1000 ft. Little-incised streams with braided, unstable beds, commonly ending in a number of fading distributary channels near the coast.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Major part of land system	Level to very gently sloping, smooth to slightly undulating plains with many wide, shallow, and branching channels. Subject to flooding	Coarse-textured alluvial land, stony land, and river wash. Higher areas excessively drained, low areas poorly drained	Mainly VIIst, so, f. Some VIIIst, f and VIIId, f, so	Complex of mixed succession on low-level distributaries and grassland of *Saccharum spontaneum–Imperata cylindrica–Cymbopogon procerus* suballiance. Large area of secondary woody communities of Mt. Victory blast successions, lowland zone in eastern occurrence of land system
2	Medium. Lowest parts of land system, near coast	Level flood-plains with few, small, shallow streams. Probably subject to flooding	Recent alluvial soils, mainly coarse-textured. Probably also alluvial land. Poorly to very poorly drained	Mostly IV–Vd, f	Regrowth of *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association
3	Small. Narrow upper parts of land system	Gently sloping terraces, closely but shallowly dissected by braiding stream channels. Probably subject to flooding	Rubble land, stony land, river wash. Excessively drained	VIIIst, f	Stream-bed successions

(15) Rakua Land System* (15 sq miles)

Forested, dissected plains with reddish, weathered clay soils, north of Owen Stanley Range.



Geology.—Sub-Recent to Pleistocene alluvium: silt, sand, and gravel derived from schist and calc-silicate rocks.

Physical Features.—Immaturely dissected, very gently sloping, high-level outwash plains, with very steep edges 30–100 ft high, in south and north-west. Subparallel drainage pattern of incised small streams, cutting backwards from the edges, especially in eastern part. Altitude 400–1000 ft.

Soils.—Very limited information indicates predominance of weathered red and brown clay soils of Ma-U family. Commonly class 1 stoniness; well drained.

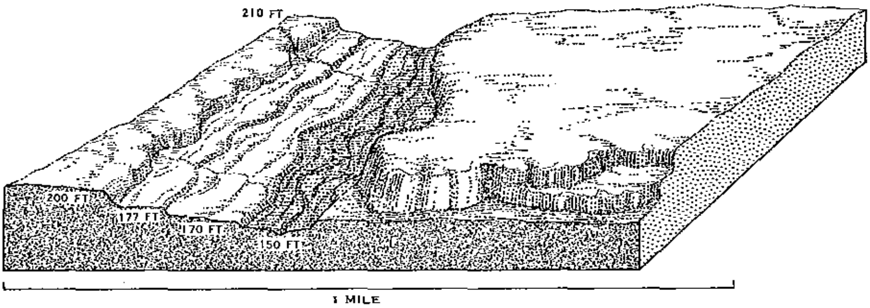
Land Class.—Mainly IIst, so, probably some IIIst, so. Marginal slopes VIe, so.

Vegetation.—Rain forest of *Pometia pinnata–Tristiropsis subangula–Cryptocarya* sp. association.

* This land system is very similar to Ioma land system of the Buna–Kokoda area.

(16) Tokinawara Land System (5 sq miles)

Stony fan terraces with grassland, at foot of Tama land system.



Geology.—Recent fan-glomerates mainly derived from metamorphic and sedimentary rocks.

Physical Features.—Gently undulating fan surfaces with very steep slopes along incised rivers. In eastern part three distinct terrace levels, 20, 27, and 50 ft above river bed. Altitude 100–500 ft.

Soils.—Stony land, excessively drained.

Land Class.—VIIso, st.

Vegetation.—Grassland of *Themeda australis–Alloteropsis semialata* alliance with very small areas of regrowth of *Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa* association along gullies.

(17) Monari Land System (85 sq miles)

Valley plains with dark heavy clay soils, throughout Cape Vogel peninsula.

No block diagram or plan, as relief is very low and distribution of units is largely regional and is reasonably clear from a comparison of the descriptions with the land system map.

Geology.—Recent alluvium: clay and silt, derived locally from sedimentary rocks; minor reef limestone along south coast.

Physical Features.—Alluvial plains in wide valleys with minor terrace formation along streams and locally gently sloping outer margins, due to colluvial influences. Small meandering rivers and commonly intermittent tributary streams. Includes local coastal terraces of coral detritus. Altitude generally 0–200 ft.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Along Ruaba River and more westward	Level to very gently sloping, mostly smooth plains. Few small streams, 5–10 ft incised	Dark soils of heavy texture of Ibiduwa family. Poorly to very poorly drained	Mainly IV–V (padi)d, so	Secondary forest and regrowth of *Terminalia canaliculata–Bischoffia javanica* association with scattered patches of swamp woodland of *Metroxylon sagu* association and grassland of *Imperata cylindrica–Ischaemum barbatum* suballiance. On less poorly drained sites the forest is of *Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa* association with rather large areas of grassland of *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance
2	Medium. East of Ruaba River	Level to gently sloping, mostly slightly undulating plains with few streams approximately 10–15 ft incised. Minor coastal terraces 6–12 ft high	Dark soils of heavy texture of Boboni family. Minor shallow black structured soils of Ginada family on limestone. Imperfectly to poorly drained	Mainly III(padi) so and IV(padi) d, so	Secondary forest and regrowth of *Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa* association and grassland of *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance

(18) Uiaku Land System (295 sq miles)

Extensive, forested alluvial plains from Musa River to Goodenough Bay.

No block diagram or plan, as relief is very low and distribution of units is largely regional and is reasonably clear from a comparison of the descriptions with the land system map and grassland boundaries.

Geology.—Recent alluvium: sand, silt, and clay derived mainly from schists and calc-silicate rocks, locally from basaltic and andesitic igneous rocks, and in the Ruaba River area also from sedimentary rocks.

Physical Features.—Generally well-graded alluvial plains, built up by numerous rivers. Some terrace formation along major rivers in southern part. Moderately dense to sparse, subparallel drainage pattern of small and medium-sized rivers, some of which have slightly braided beds in the southern part of the land system. Altitude 10–1000 ft.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Southern part of land system	Very gently sloping (in south) to level, slightly undulating plains. Major streams 15–30 ft incised in south-west and approximately 10–15 ft elsewhere. Locally well-defined lower river terraces up to 30 chains wide. Includes more steeply sloping, dissected strip along foot of mountains in the east	Recent alluvial soils, predominantly coarse-textured in western, medium-textured in eastern part. Commonly class 1–2 stoniness in upper part, and stony land along foot of mountains. Some volcanic ash land around Waiowa volcano. Well drained	Mainly II–IIIst. Also I. Some IIso on most sandy soils and Vst and VIe, st along foot of mountains	Mainly rain forest of *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association. Some large areas of grassland of *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance and some regenerating grassland south of Sinapa. Waiowa blast succession forest around Waiowa volcano
2	Medium. Northern part of land system	Level flood-plains. Sparse streams 6–10 ft incised. Probably very limited flooding, except in lower reaches of Rakua River	Recent alluvial soils, dominantly medium-textured, some coarse-textured soils along south-western margin. Mainly poorly to very poorly drained, imperfectly drained in southern part	Mainly II–IIId with little IV(padi) d, f	Rain forest and regrowth of *Terminalia canaliculata – Bischoffia javanica* association and of *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association on better-drained sites. Some areas of grassland of *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance, especially in north-eastern part
3	Small. Eastern part of land system	Level alluvial plains and river terraces with few streams up to 10 ft incised. Low river terraces and narrow flood-plain along Ruaba River. Few, low, narrow beach ridges. Regular flooding along Ruaba River, probably much less elsewhere	Recent alluvial soils, mainly medium-textured, locally coarse-textured. Alluvial land and river wash in Ruaba River flood-plain. Some beach deposits, mostly pebbly. Generally well to imperfectly drained, locally very poorly drained	Mainly I and IId. Locally IIId. Some IV(padi) d, f. VII,f,so in Ruaba River flood-plain	Mainly secondary forest and regrowth of *Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa* association. Scattered grassland of *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance. Seral vegetation. Stream-bed successions and seral vegetation leading up to *Planchonia* rain forest in major river flood-plains

(19) Dove Land System* (40 sq miles)

Narrow, forested alluvial plains along Musa River.

No block diagram because of low relief.

Geology.—Recent alluvium: clay, sand, and silt of mixed origin.

Physical Features.—Levee banks and back plains, level, locally some channel microrelief; banks 10–15 ft high along Musa River. Mostly subject to short floods. Altitude 25–200 ft.

Soils.—Recent alluvial soils, medium-textured, well drained along river, poorly drained on back plains. Generally alkaline and calcareous.

Land Class.—Mostly IV(padi)d,f; small areas I.

Vegetation.—Largely secondary forest and some regrowth of *Terminalia canaliculata–Bischoffia javanica* association, with a few small patches of *Saccharum* grassland.

(20) Ismari Land System† (10 sq miles)

Alluvial valley floors associated with Bekalama and Trafalgar land systems.

No block diagram because of low relief.

Geology.—Recent alluvium derived from andesitic volcanic rocks.

Physical Features.—Level flood-plains and river terraces with meandering streams. Altitude 20–200 ft, approximately 800 ft in centre of Trafalgar land system. Locally subject to flooding.

Soils.—Presumably recent alluvial soils, probably medium- and fine-textured, well to imperfectly drained.

Land Class.—Probably II(padi), d and IV(padi), d, f.

Vegetation.—Regrowth and secondary forest, presumably of *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association. Small area of *Octomeles sumatrana* succession in centre of Trafalgar land system. Few areas of grassland, presumably of *Saccharum spontaneum–Imperata cylindrica* alliance in north-western occurrence.

* This land system is very similar to unit 2 of Deunia land system of the Buna–Kokoda area.

† This land system has many similarities with Warisota land system of the Buna–Kokoda area.

(21) WAKIOKA LAND SYSTEM (95 SQ MILES)

Fan-shaped, poorly drained alluvial plains of very recent origin and covered by pioneering forest vegetation. Scattered in plains north of Owen Stanley Range.

No block diagram or map, as relief is very low and distribution of units is largely of a regional nature and is reasonably clear from a comparison of the descriptions with the land system map and grassland boundaries.

Geology.—Recent alluvium: mainly silt and sand, derived from schist and calc-silicate rocks; sand and gravel from sedimentary rocks in eastern parts.

Physical Features.—Very young, unstable outwash fans and plains. Few braiding major rivers with unstable beds in upper parts, locally shallow distributary channels. Altitude 25–600 ft.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Very large. Major part of land system	Almost level flood-plains and distributary swamps. Liable to destructive flooding	Mainly fine sandy alluvial land, with gravel beds along major creeks. Mainly swampy to very poorly drained. Some rubble land along upper courses of major rivers	Mainly VId, f. Some Vd, f. Rubble land VIII, st, f	*Casuarina* sp. succession
2	Small. Inland from Uiaku and in Ruaba River plain	Almost level flood-plains with channel microrelief and slight undulations. Few shallow creeks. Probably little flooding	In west, recent alluvial soils, probably medium-textured. In east, sandy and gravelly alluvial land. Poorly drained in west, well to excessively drained in east	Vd, f in west, VIso in east	Mixed succession on low-level distributaries and some garden regrowth
3	Small. Near Wakioka, Rakua, and Ruaba Rivers	Almost level, slightly undulating plains, partly subject to flooding	Sandy and gravelly alluvial land, stony land, some river wash. Well to excessively drained	Mainly VIso, st	Grassland of *Saccharum spontaneum* – *Imperata cylindrica*–*Cymbopogon procerus* sub-alliance
4	Very small. On both sides of lower Rakua River	Level flood-plains. Probably subject to flooding	Recent alluvial soils, probably medium-textured. Presumably poorly drained	Probably IVd, f	*Octomeles sumatrana* successions

(22) Tortore Land System* (50 sq miles)

Swamps with woody and herbaceous vegetation scattered throughout the area.

No block diagram or plan as relief is very low and distribution of units is not distinct and mostly regional.

Geology.—Recent alluvium: mainly clay and silt of varied derivation.

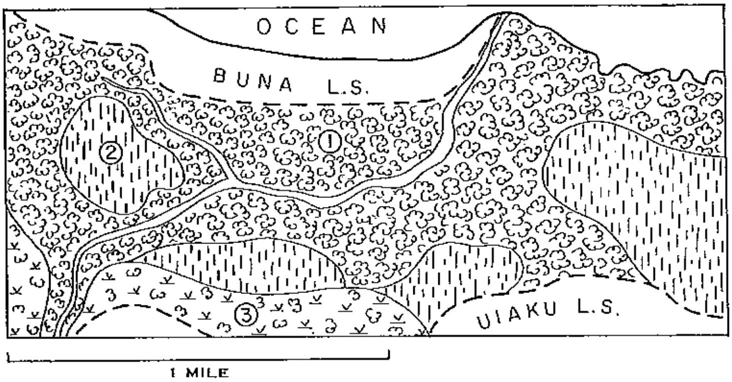
Physical Features.—Distributary swamps (unit 1) and swamps caused by blocking of low-lying areas by contrasting regimes of sedimentation (units 2 and 3). Surface drainage mostly restricted to few small outlet streams. Altitude 10–150 ft.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Predominantly in plain between Musa River and Bewabewa land system	Level plains, probably inundated during wet season, but water-table below surface in dry season	Recent alluvial soils, mostly medium-textured in western part, fine-textured in eastern part. Swampy to locally very poorly drained	VIIp, s	Fluctuating swamp forest of *Bischoffia javanica–Metroxylon sagu* association and fluctuating swamp woodland of *Metroxylon sagu* association
2	Medium. Between Musa River and Mt. Victory	Level plains with water-table at or near surface in dry season	Recent alluvial soils, fine- to medium-textured, swampy	VIIId	Fluctuating swamp forest of *Bischoffia javanica–Pandanus* sp. association and fluctuating swamp woodland of *Pandanus* sp. association
3	Small. East of Musa River, and in Cape Vogel peninsula		Recent alluvial soils, fine-textured, swampy	VIIId	Mainly herbaceous swamp (short grass or sedge and tall grass). Small areas of savannah of *Saccharum spontaneum–Neonauclea* sp. association near the Musa River

* Unit 1 of this land system is very similar to Ambi land system of the Buna–Kokoda area.

(23) Killerton Land System* (60 sq miles)

Mangrove swamps.



Geology.—Recent coastal deposits.

Physical Features.—Tidal flats, inundated by high tide or spring tide; small tidal creeks.

Unit	Relative Area and Distribution	Land Forms	Soils and Drainage Status	Land Class	Vegetation
1	Large. Throughout land system	Level flats	Tidal swamp	VIIId, f	Mangrove forest formation. Narrow zone of mangrove woodland of *Ceriops tagal* association fronting the sea. Very small patches of fluctuating swamp woodland of *Nypa fruticans* association near river mouths in western parts of land system
2	Medium. Landward of or surrounded by unit 1				Mangrove woodland of *Avicennia marina* association
3	Small. At landward margin of land system	Level flats largely above direct tidal influence	Unknown alluvial soils, probably coarse-textured	VIId	Fern–tall tree savannah of *Acrostichum speciosum–Avicennia marina* association, mangrove savannah and mangrove woodland of *Avicennia marina–Bruguiera gymnorrhiza* association

* This land system has been previously described in the Buna–Kokoda area, where it is less extensively developed.

(24) Buna Land System* (8 sq miles)

Local beach ridges.

No block diagram because of low relief.

Geology.—Recent sand and coral detritus.

Physical Features.—Small complexes of low parallel beach ridges, mostly near the mouth of large rivers. Altitude 0–10 ft.

Soils.—Recent alluvial soils: dark sands of mixed mineralogical composition, at Cape Vogel coral and shell sands with dark topsoils. Mostly excessively drained.

Land Class.—IIso.

Vegetation.—Coastal successions (mostly secondary communities) and coconut plantations. Small areas of grassland of *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance.

* This land system has been previously described in the Buna–Kokoda area, where it is more extensively developed.

PART V. CLIMATE OF THE WANIGELA–CAPE VOGEL AREA

By E. A. FITZPATRICK*

I. INTRODUCTION

(a) *Principal Climatic Features*

The climate of the area ranges from a tropical "monsoon" or seasonally dry, humid tropical variety (Köppen 1931 and Thornthwaite 1931 (types *Am* or *BA'w* respectively)) in the driest parts of the area to a tropical "rainforest" or wet tropical type in the more exposed localities of higher rainfall (*Af* or *AA'r* types respectively).

Owing to low latitudinal position and strong maritime controls, the mean seasonal and mean daily temperature ranges are very small. The extreme temperatures also have very narrow limits, and thus the climate is characteristically monotonous in its temperature regime. The most striking seasonal and spatial contrasts are in winds and in rainfall. The whole of the area experiences a marked maximum in rainfall between November and April. In the most sheltered situations, rainfall is low enough during the months May to October to produce a definitely dry season. However, even within these drier areas this period is not characterized by prolonged rainless weather as is typical over much of northern Australia.

(b) *Principal Climatic Controls*

As elsewhere in Papua–New Guinea, the macrocharacteristics of climate are closely related to seasonal alternation in the prevailing wind systems. Between December and March, winds from compass points between north-west and north-east (monsoons) are dominant. South-easterly winds (trades) prevail between May and October. The transition between these systems normally occurs in April and in late November and early December. These changes are shown diagrammatically in Figure 4, where the wind roses are based upon 25 years of observation at 9.00 a.m. at Cape Nelson. Although some variation from this pattern within the area may be expected owing to local topographical effects, the diagram may be taken as generally representative of the broad seasonal wind conditions.

A striking feature is the persistency of winds during the south-east season. In fact, it is notable that throughout the interval December to March, a fairly large proportion of winds occurs from the south-east even though these are not at that time the dominant winds. The strength of the south-easterly (trade) influence normally diminishes quickly after October, whereas the establishment of this system is spread over several months following April. The peak of this influence is normally reached about August. For winds having a northerly component, the greatest constancy occurs during January and February. Wind velocities at Cape Nelson at 9.00 a.m. average about 10 knots over the period May to September, whereas during January

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and February the mean velocity is only about 3 knots. The transitional months are characterized by light and very variable winds and by the relatively greater importance of purely local convection in the pattern of daily weather.

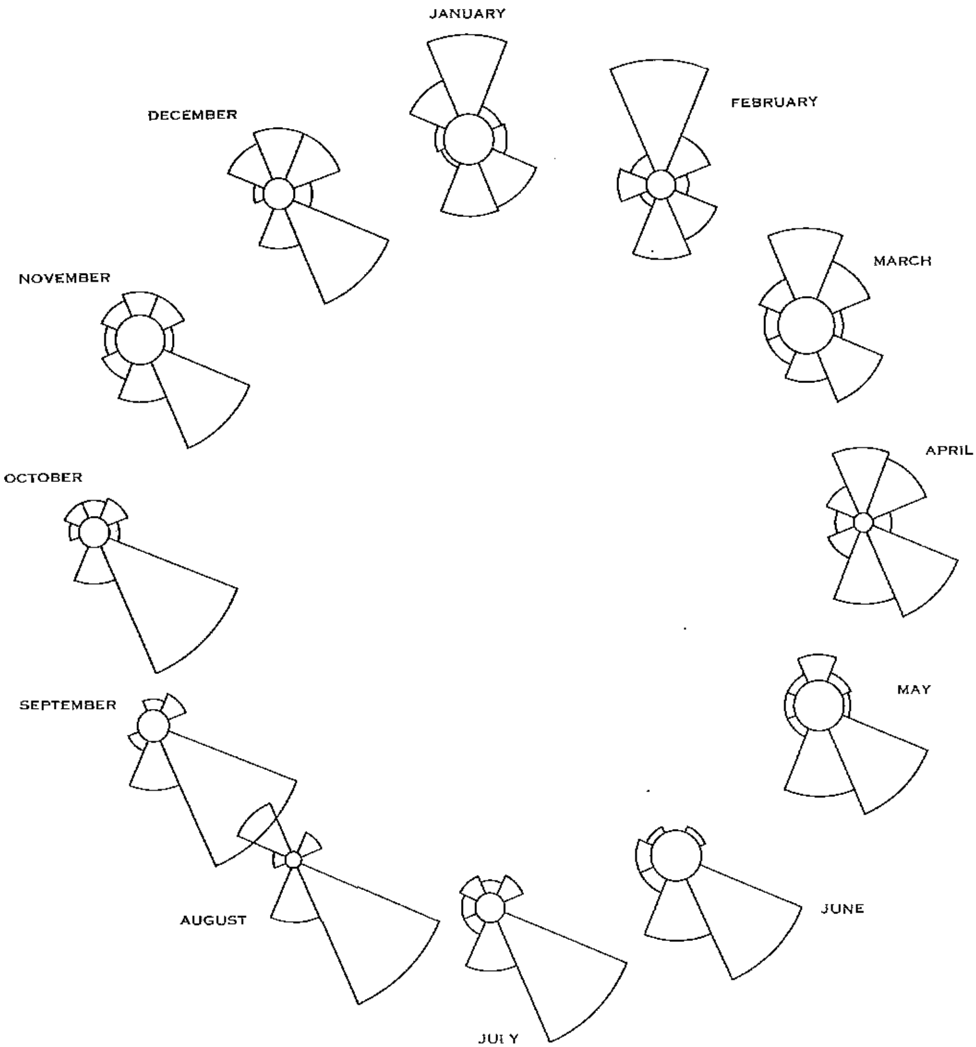

Fig. 4.—Monthly wind roses for Cape Nelson showing the percentage frequency of winds from eight compass point intervals and calm conditions. Data based upon observations at 9.00 a.m. The total area of each of the roses is the same and represents a percentage frequency of 100. Areas of central circles (representing the percentage frequency of calm conditions) and of each of the eight surrounding sectors (representing the percentage frequency of winds from that sector) are proportional.

Through the Solomon Sea area there are marked contrasts in seasonal incidence of rainfall. These are generally related to differences in aspect of the locality with respect to the prevailing wind systems. However, within the limited extent of the

Wanigela–Cape Vogel area highest rainfall is everywhere associated with the season of northerly winds, and distinctly less rainy conditions normally accompany the south-easterlies. These relationships are at least partly explicable by the fact that the area has a leeward position with respect to the high Owen Stanley Range extending to the extreme south-east tip of the New Guinea mainland. The mountainous D'Entrecasteaux Islands also afford some degree of shelter from prevailing winds from a south-east quarter. In contrast the area as a whole is exposed to winds from a northerly quarter, and these have normally had a long run over warm waters of the Bismarck and Solomon Seas. The Mt. Victory–Mt. Trafalgar area is not only most strongly exposed to this northerly influence, but it is also the area least sheltered with respect to south-easterly winds. With orographic conditions also favourable for rain development, this part of the area has considerably higher rainfall throughout the year than the remainder of the area. The greatest degree of sheltering occurs at the heads of Collingwood Bay and Goodenough Bay. These regions are notably drier, particularly during the period of south-easterly influence.

Superimposed on the general wind systems are winds of purely local origin. The data upon which Figure 4 is based do not reveal these effects to any significant degree because at 9.00 a.m. the nocturnal land breeze is dying out and the daytime sea breeze has not yet been established. No data are available to assess the development of local diurnally controlled winds, but it may be expected that land and sea breezes are prominent features in daily weather throughout the area. Under similar conditions elsewhere at these latitudes, the sea breeze generally builds up to a maximum of about 10 knots during mid-afternoon; the nocturnal land breeze normally attains a force only about half that of the sea breeze.

From consideration of topographic relationships within the area, it is to be expected that local katabatic and anabatic circulations (mountain and valley winds) are of some importance.

Although the area lies outside the zone of tropical cyclones, strong squall winds are sometimes experienced. These may attain velocities of up to 40 knots, but they are usually short-lived. They often occur along with heavy rain and thunder during the northerly season and during the transition months. As with the general wind systems and with land and sea breezes, the strength of these squalls is closely related to surrounding topography.

II. General Climatic Characteristics

(*a*) *Rainfall*

Rainfall data are available for only four stations, all situated on the coast. Therefore, no detailed assessment of the areal rainfall pattern is possible, and no attempt is made here to construct an isohyetal map of the area. Mean monthly and annual rainfall conditions at the four stations are shown in Table 2. Since the localities represent both exposed (Cape Nelson and Tufi) and sheltered (Baniara and Wanigela) situations with respect to the controlling seasonal wind systems, it may be concluded that rainfall along the coast varies generally between 70 and 130 in. It is to be expected that annual rainfall increases generally inland, particularly along

TABLE 2

MEAN MONTHLY AND ANNUAL RAINFALL AND HIGHEST AND LOWEST ANNUAL TOTALS ON RECORD AND MEAN NUMBER OF RAIN DAYS FOR FOUR STATIONS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Highest Annual Total on Record	Lowest Annual Total on Record
Baniara (14 yr of records)															
Mean rainfall (in.)	12·0	13·2	11·7	7·7	4·5	3·2	2·5	1·6	2·2	2·0	4·4	6·1	73·7	115·2	45·5
Mean number of rain days	14	13	13	11	9	6	6	5	4	7	8	10	106		
Cape Nelson (25 yr of records)															
Mean rainfall (in.)	16·1	18·9	16·7	12·8	11·1	8·3	5·1	4·0	4·1	8·2	12·4	12·8	130·3	182·2	94·9
Mean number of rain days	18	17	19	18	15	13	11	8	10	9	15	17	170		
Tufi (17 yr of records)															
Mean rainfall (in.)	16·2	19·8	14·5	19·9	10·4	6·5	6·0	3·9	3·8	7·0	13·2	12·3	133·3	165·1	114·1
Mean number of rain days	17	16	16	15	13	12	10	8	8	10	13	14	152		
Wanigela (7 yr of records)															
Mean rainfall (in.)	10·8	10·9	10·1	10·2	6·8	6·8	3·4	2·2	5·2	4·6	9·9	11·9	92·9	109·9	62·3
Mean number of rain days	19	18	16	16	14	13	11	7	11	10	15	20	170		

* Prepared from original records of the Commonwealth Bureau of Meteorology; rain day is considered here as a day with recorded rainfall, i.e. $\geqslant$ 0·01 in.

the exposed slopes in the Mt. Victory–Mt. Trafalgar area and along the north-east-facing slopes of the Owen Stanley Range, which forms the inland boundary of the area. Records are generally too short to obtain any reliable measure of annual rainfall variability, but from the highest and lowest observed annual totals included in Table 2 it would appear that a considerable range can be expected, particularly in the more sheltered areas.

TABLE 3

PERCENTAGE OF MONTHLY RAINFALLS EXCEEDING SPECIFIED AMOUNTS AT FOUR STATIONS*

Amount (in.)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Baniara (14 yr of record)											
⩾0·5	100	100	100	100	91	82	73	68	90	77	91	100
⩾2·0	100	100	95	100	65	73	50	39	33	59	91	95
⩾4·0	87	100	90	87	52	37	32	20	14	18	62	80
⩾8·0	58	81	54	35	22	14	5	10	—	4	29	30
⩾16·0	12	19	18	9	—	—	—	—	—	—	—	—
	Cape Nelson (25 yr of record)											
⩾0·5	100	100	100	100	100	96	83	82	80	90	100	100
⩾2·0	100	100	100	100	100	79	69	44	63	79	97	100
⩾4·0	97	96	100	93	90	69	48	23	42	69	97	97
⩾8·0	87	86	90	83	76	38	31	13	14	52	62	87
⩾16·0	28	48	45	45	17	14	—	3	—	7	21	21
	Tufi (17 yr of record)											
⩾0·5	100	100	100	100	100	100	100	100	100	100	100	100
⩾2·0	100	100	100	100	100	90	55	72	82	100	100	100
⩾4·0	100	100	100	100	100	63	45	27	45	81	100	100
⩾8·0	83	91	83	92	58	27	45	18	—	36	91	72
⩾16·0	50	58	41	67	16	—	9	—	—	—	27	27
	Wanigela (7 yr of record)											
⩾0·5	100	100	100	100	100	100	100	100	100	100	100	100
⩾2·0	100	100	100	100	100	86	85	56	100	71	100	100
⩾4·0	85	100	86	100	85	86	28	28	86	71	86	100
⩾8·0	71	71	43	100	28	43	—	14	—	14	43	71
⩾16·0	17	—	—	72	—	—	—	—	—	—	29	14

* Based upon all available rainfall records.

Throughout the area, the monthly mean rainfalls are highest between November and April. At Tufi, Cape Nelson, and Wanigela there is an apparent abrupt increase in rainfall in November, but at Baniara the increase is more gradual over the November–December period and the very high rainfalls associated with the northerly winds do not occur there until January. At this station mean monthly rainfall declines rapidly after March, and between June and October the monthly means are generally less than 3 in.

Monthly totals from year to year are highly variable as shown by the percentage frequencies in Table 3. It should be noted that the percentages in Table 3 are not strictly comparable between stations and must be viewed with some caution because the span of years covered by the data is short and differs greatly between stations. With the possible exception of Cape Nelson, the period is too short to establish stable percentage frequencies. None the less, Table 3 demonstrates the marked seasonality of rainfall within the area. At all locations monthly falls exceeding 4·00 in. can be relied upon from January to April inclusive, and in the more exposed situations where strong orographic effects are operative (e.g. Cape Nelson and Tufi), very high monthly totals (≥16·00 in.) occur in about 50% of all years. Marked

Table 4

PERCENTAGE OF RAIN DAYS* WITH TOTAL FALLS WITHIN SPECIFIED RANGES FOR THREE STATIONS

Range (in.)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
						Baniara						
0·01–0·24	42	34	39	55	61	47	57	60	50	72	51	35
0·25–0·99	35	37	31	26	30	40	40	35	47	22	34	47
1·00–1·99	16	19	19	9	8	13	—	5	3	4	9	12
2·00–3·99	8	10	8	8	1	—	2	—	—	2	6	5
4·00–7·99	—	—	4	2	—	2	—	—	—	—	—	—
≥8·00	—	—	—	—	—	—	—	—	—	—	—	—
						Tufi						
0·01–0·24	29	26	27	31	38	39	44	46	57	36	30	23
0·25–0·99	31	34	43	31	37	41	37	43	31	44	39	49
1·00–1·99	25	18	21	23	15	17	14	8	6	7	15	23
2·00–3·99	11	17	5	12	10	2	5	3	6	13	9	4
4·00–7·99	4	4	3	2	—	1	—	—	—	—	5	—
≥8·00	—	1	1	1	—	—	—	—	—	—	1	—
						Wanigela						
0·01–0·24	51	44	53	47	46	43	53	70	49	56	46	40
0·25–0·99	30	39	35	27	36	39	43	20	39	32	29	38
1·00–1·99	12	12	9	20	12	13	4	10	11	10	17	13
2·00–3·99	6	5	3	6	4	4	—	—	1	—	7	8
4·00–7·99	2	—	—	—	1	—	—	—	—	2	1	1
≥8·00	—	—	—	—	—	1	—	—	—	—	—	—

* Rainfall ≥0·01 in. considered as a rain day. Percentages are in all cases based upon daily rainfall records for 1955 to 1960 inclusive.

differences occur in the monthly rainfalls received during the south-easterly season. Very high monthly totals are universally uncommon during the period June to October inclusive, but the data for Baniara show that there is a much greater chance of very low monthly totals (less than 0·5 in.) at this time in the coastal zone surrounding Goodenough Bay than elsewhere in the area.

Some indication of seasonal and spatial differences in the character of daily rainfall is given in Table 4. It would appear that throughout the area daily falls of over 4·00 in. are not common even during the January–April period, although falls of over 8·00 in. have occurred at Tufi and Wanigela. The comparative weakness of the rain-producing mechanism during the south-easterly season is demonstrated by the fact that throughout the area generally less than 15% of the daily totals exceed 1·00 in. from May to October inclusive.

As is to be expected, rainfall persistency is much greater during the northerly season than during the south-easterly season. In exposed localities such as Cape Nelson and Tufi, runs of rain days (i.e. $\geqslant 0 \cdot 01$ in.) of a week or more during the wet season are common, and rainless spells of longer than 1 week are infrequent. In the more sheltered localities, Wanigela and Baniara, rainy spells are somewhat shorter and rainless spells somewhat longer. However, areal contrasts in this respect are not marked at this time of year. During the south-easterly season, rainfall usually occurs over intervals of from 1 to 5 days, and rainless spells longer than a fortnight occur quite frequently. The passage of 4 weeks without some rain during the driest part of the year is rare, even at the drier stations, but because falls are often light and ineffectual during this season a succession of weeks with intensifying drought conditions can occur.

(*b*) *Elements Other than Rainfall*

The only extended data relating to elements other than rainfall are for Cape Nelson. Mean monthly and annual conditions are given for this station in Table 5.

Mean minimum temperatures are extremely uniform throughout the year, varying only by a degree or so above and below the annual average of 75·5°F. Reference to daily records indicates that minimum temperatures below 70°F are rare, and that these have never fallen below 65°F. It is to be expected that somewhat lower minimum temperatures would occur with increasing distance inland; however, it is unlikely that significant departures from these levels would occur.

Maximum temperatures show greater variation throughout the year, reflecting the seasonal and diurnal contrasts in radiation. Mean monthly maximum temperatures exceed 85°F at Cape Nelson between October and April. Although distinctly lower mean maxima occur between June and September, these do not fall below 80°F. Daily maxima quite frequently exceed 90° between October and April, but temperatures higher than 96°F have not been recorded. It is to be expected that slightly higher maximum temperatures would occur with increasing distance inland, but the areal differences are not likely to be great in view of strong advection of cooler air that occurs with the daytime sea breeze.

As with temperature, humidity does not change greatly through the year. Average relative humidity at 9·00 a.m. is slightly above 80% from December to July and slightly below this from August to November. The 9·00 a.m. vapour pressures, which are more indicative of absolute atmospheric moisture conditions, are highest between December and April and lowest between July and September.

Cloudiness follows generally the seasonal pattern of rainfall; however, the seasonal contrasts are not as great as might be expected. Even during the dry months, June to October, 9 a.m. cloudiness is about six-tenths. Cloudiness no doubt increases during the daytime period, especially in the Mt. Victory–Mt. Trafalgar area and inland along the slopes of the Owen Stanley Range where convective processes are assisted by orographic conditions.

TABLE 5

MEAN MONTHLY DATA FOR ELEMENTS OTHER THAN RAINFALL AT CAPE NELSON

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature* (°F)													
Mean maximum	88·1	87·0	88·3	86·3	84·6	83·0	82·2	81·6	83·5	85·6	86·9	88·2	85·4
Mean	81·9	81·4	82·1	81·2	80·1	79·1	78·4	78·1	79·2	80·4	81·4	82·2	80·5
Mean minimum	75·7	75·9	75·9	76·2	75·6	75·2	74·6	74·5	75·0	75·2	76·0	76·3	75·5
9 a.m. relative humidity* (%)	82	82	80	82	82	81	81	79	79	79	78	80	80
9 a.m. vapour pressure* (inHg)	0·923	0·917	0·881	0·896	0·869	0·843	0·818	0·794	0·832	0·858	0·872	0·914	0·868
9 a.m. cloudiness* (tenths)	6·8	6·8	6·6	6·4	6·4	6·0	6·1	5·8	6·0	5·7	6·2	6·2	6·2
Total (global) radiation† (cal cm^{-2}/day^{-1})	377	413	384	378	336	334	335	378	423	429	418	404	4609
Evaporation‡ (in.)	5·99	5·31	5·50	4·61	3·99	3·45	3·52	3·69	4·24	5·19	5·84	6·12	57·45

* Obtained from original data held by the Bureau of Meteorology.

† Estimated from 9 a.m. cloudiness and daylength by the method of Budyko (1958).

‡ Estimated evaporation from standard Australian tank from mean maximum temperature, vapour pressure, and daylength by the method of Fitzpatrick (1963).

With only small seasonal changes in day length and in cloudiness, little variation can be expected in total (global) radiation. No data are available from the area for this element, but estimates of mean conditions obtained by the method of Budyko

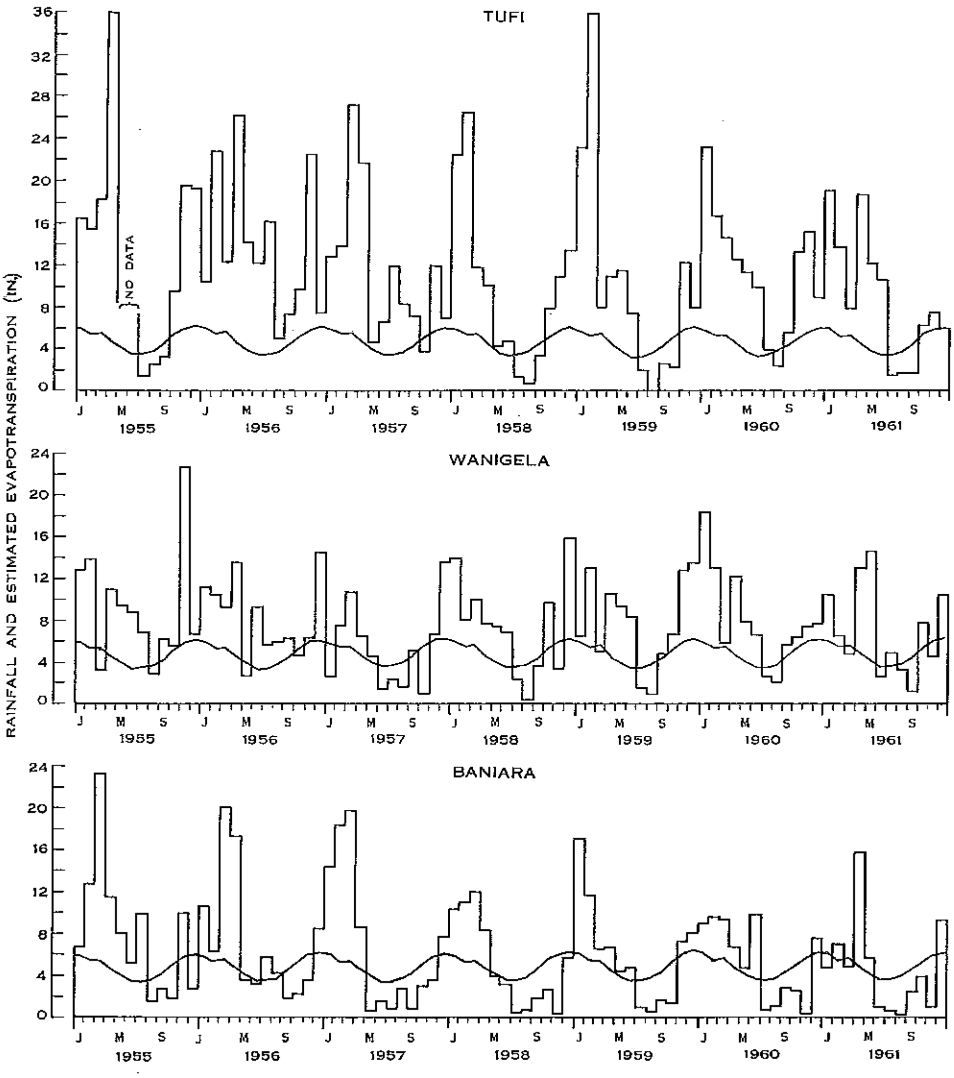

Fig. 5.—Graphs for three stations showing the relationship between monthly rainfalls (histograms) and a recurring potential evapotranspiration (curve). Water requirement is taken to be equal to the mean tank evaporation at Cape Nelson.

(1958) range generally between somewhat more than 330 cal cm^{-2} day^{-1} during the May–July period and somewhat more than 420 cal cm^{-2} day^{-1} between September and November. These estimates are in general agreement with observed levels at Rabaul (Bureau of Meteorology 1963).

No evaporation data are available, but empirical estimates of evaporation from the standard Australian tank based upon mean maximum temperatures, vapour pressure, and day length (Fitzpatrick 1963) range from about 3·5 in. per month from June to August to about 6·0 in. in December and January with an estimated annual amount of about 57 in.

III. Climate, Plant Growth, and Land Use

The area is free from very low temperatures and very long periods with large water deficiencies. It can be expected that even at the highest elevations within the area, temperatures are not low enough to inhibit plant growth to any significant degree. On exposed windward slope positions where rainfall is highest and where intervals between rains are shortest, restrictions in growth through moisture shortages do not appear likely. However, elsewhere within the area, and particularly in the sheltered localities at the heads of Collingwood Bay and Goodenough Bay, occasional limitation in growth through deficient moisture during the south-easterly season seems likely. Data are inadequate to allow any detailed assessment of the water balance, but in Figure 5 the general relationship between monthly rainfalls over seven years at three stations and a recurring evapotranspiration requirement assumed to be equal to the estimated mean tank evaporation (Table 5) is shown. It would appear that rainfall at Tufi does not often fall below this estimated evapotranspiration need, and allowing for the utilization of stored soil moisture reserves, it seems safe to conclude that any restriction of growth would be uncommon and of short duration. However, at both Wanigela and Baniara rainfall has on a number of occasions fallen below the assumed requirement over several months, and even allowing for soil storage, a degree of water stress, depending largely upon prevailing soil and drainage conditions, would seem likely. These assessments are crude in that they make reference only to data over coarse, monthly intervals and neglect temporal variations in evapotranspiration as governed by both meteorological and soil moisture conditions. In the absence of adequate data, a more sophisticated assessment has not been attempted.

Although the presence of a definite period of lesser rainfall may restrict growth to some degree, this feature may be an advantage where some crops are concerned since it affords greater opportunity for successful maturation and harvesting. Such seasonally dry conditions are found only in restricted parts of Papua–New Guinea. It should be noted, however, that even during this period of lower rainfall, cloudiness and humidity remain at high levels, and these features may pose special agronomic problems. The lengthy periods with rainfall which commonly occur during the northerly season may pose some difficulty where crops requiring cultivation are concerned. Also the maintenance of soil fertility under these conditions of high and frequent rainfall is apt to be difficult.

On better-drained land within the area, a land economy based upon grazing would appear practicable from a climatic point of view, but special attention would need to be given to the selection of animals and pasture species most suited to the prevailing warm and humid environmental conditions met with in the area.

IV. Acknowledgments

The author is grateful to Mrs. A. Komarowski, who prepared data and carried out the computations used in this paper.

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PART VI. SOILS OF THE WANIGELA–CAPE VOGEL AREA

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I. INTRODUCTION

The soil profiles examined during this reconnaissance survey have been placed in 10 major soil groups and one group of miscellaneous land types (Table 6). This last group is used in conformity with American soil survey practice (U.S. Department of Agriculture 1951). The others are groups of convenience that appear to suit the local conditions. They are to be considered as morphogenetic units and have been given brief descriptive names. Each group has been subdivided into more narrowly defined taxonomic units that have been called soil families and given locality names, except those of the recent alluvial soil group.

II. DESCRIPTION OF MAJOR SOIL GROUPS AND SOIL FAMILIES

To simplify the descriptions, data on parent rock, land form, and vegetation for each soil family have been summarized in Table 6.

The descriptions of the major soil groups are confined to the characteristics that are typical for the soils as a group, the descriptions of the soil families to those properties that distinguish each family from the others in the same group. The family descriptions are therefore *not* complete and should always be read in conjunction with the group descriptions. Descriptive terms are used in accordance with the U.S. Soil Survey Manual (U.S. Department of Agriculture 1951) and refer to the moist status. This also applies to colour descriptions, which are based on Munsell notations. References to soil depth relate to A plus B horizons, except for the soils on alluvial material (dark soils of heavy texture and recent alluvial soils).

(*a*) *Strongly Weathered Red and Brown Clay Soils*

These leached soils have formed on strongly weathered parent materials. They form a rather heterogeneous group and the following characteristics, although common within the group, are rarely shared by all families. Undisturbed profiles are deeper than 4 ft, but in several families shallow truncated profiles appear to dominate. They are clay soils and the clay content normally increases with depth. The A_1 horizon is generally only poorly to moderately developed. Colours of the B horizon are reddish or strong brown and commonly become redder with depth. The soils are poorly structured but porous, and friable to firm in consistence. They are acid to strongly acid with rather low exchange capacity and base saturation. The exchange complex is commonly dominated by magnesium.

(i) *Budi Family*.—These soils are more than 4 ft deep and have a well-developed dark clay loam A_1 horizon overlying a clay to heavy clay B horizon, brown to red-brown in the upper part and red in the lower part. The C horizon is a reddish silty clay with yellowish mottles of weathered rock fragments.

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TABLE 6

RELATIONSHIPS OF SOIL FAMILIES TO ENVIRONMENTAL FACTORS

Major Soil Group and Soil Family	Parent Rock	Land Form*	Vegetation†
Strongly weathered red and brown clay soils			
Budi	Calc-silicate metamorphic rocks	Rounded steep hill ridges with broad crests	Rain forest(8)
Ma-U	Alluvium, derived from schist and calc-silicate rocks	Very gentle, moderately dissected slopes	Rain forest(4)
Oreia	Andesitic conglomerate, breccia, and tuff	Steep spurs and rolling surfaces with gentle to moderate slopes	Secondary forest and regrowth(7) and grassland(*e*)
Ukwena	Sandstone, siltstone, mudstone, and some fine conglomerate	Undulating to rolling surfaces with gentle slopes; locally steep hill slopes	Grassland(*e*); also secondary forest and regrowth(9)
Ilamarora	Andesitic conglomerate, breccia, and tuff	Rolling surfaces with moderate slopes and steep spurs	Grassland; also regrowth and secondary forest(7)
Maneau	Calc-silicate metamorphic rocks, phyllite, schist	Steep to very steep mountain slopes	Rain forest(8, 11)
Bereruma	Ultrabasic igneous rocks	Steep to very steep mountain slopes	Rain forest(8)
Granular dark red uniform heavy clay soils			
Wabubu	Coral limestone	Undulating surfaces with very gentle to gentle slopes	Grassland(*e*) with shrubs; also secondary forest and regrowth(10)
Weathered gleyed soils			
Moiowa	Andesitic lava(?)	Undulating to rolling surfaces with gentle to moderate slopes	Grassland(*a*); also rain forest(5)
Gurukwaia	Siltstone and mudstone	Gentle to moderate lower slopes, locally crests	Grassland (mainly *b*, also *e*); locally regrowth and secondary forest(10)
Guruguru	Andesitic conglomerate and ash	Very gentle to gentle, broad undulating slopes	Regenerating grassland and grassland(*b*); locally rain forest(5)
Medino	Colluvium, derived from terrestrial sedimentary rocks	Level to very gently sloping drainage depressions	Regrowth(9)
Moderately weathered brown ash soils			
Ambon	Andesitic ash and agglomerate	Gentle to moderate, commonly dissected slopes; also steep ridges	Rain forest(5) and blast area succession forest
Utah	Andesitic ash and agglomerate	Gentle, undulating slopes	Rain forest(5)
Boa	Andesitic ash	Gentle, undulating slopes	Blast area succession forest
Penari	Andesitic ash	Gentle to moderate slopes commonly dissected; also steep ridges	Rain forest(5) and blast area succession forest

TABLE 6 (*Continued*)

Major Soil Group and Soil Family	Parent Rock	Land Form*	Vegetation†
Unweathered volcanic sandy soils with black topsoils			
Popondetta	Sandy andesitic alluvium	Level to gently sloping plains, slightly dissected	Grassland(*a*) and rain forest and regrowth(*b*)
Shallow dark soils			
Podago	Siltstone, sandstone, fine conglomerate; also basic shallow intrusives and extrusives	Steep to very steep hill slopes; also undulating to rolling plateau-like surfaces	Grassland(*e*), locally regrowth and secondary forest(9)
Wanaki	Soft marl and mudstone	Moderate to steep hill slopes, broken by landslide benches	Complex of grassland(*e*) and secondary forest(9)
Shallow black structured clay soils			
Ginada	Limestone	Broken, undulating to rolling surfaces with gentle to moderate slopes; steep convex hills; small reef surfaces	Regrowth and secondary forest(10) and grassland(*e*)
Castle Hill	Calcareous sediments with limestone	Lower, steep dissection slopes and valley bottoms	Regrowth and secondary forest(10)
Kanidaba	Hard marl	Steep to very steep, concave hill slopes	Secondary forest and regrowth(9), some grassland(*e*) on crests
Dark soils of heavy texture			
Boboni	Fine-textured alluvium derived from marl and marine sedimentary rocks	Slightly undulating, level to very gently sloping valley plains above flood level	Secondary forest and regrowth(3). Locally large areas of grassland(*a*)
Ibiduwa	Fine-textured alluvium derived from terrestrial sedimentary rocks	Smooth to slightly undulating, level to very gently sloping valley plains	Secondary forest and regrowth(1,3). Locally large areas of grassland(*a*, *c*)
Recent alluvial soils			
Sandy soils	Recent alluvium	Level to very gently sloping plains and slightly undulating low beach ridges	Rain forest, secondary forest and regrowth (mainly 2). Some coastal successions and grassland(*a*)
Coral sandy soils	Coral and shell detritus	Slightly undulating beach ridges	Coastal successions and grassland(*a*)
Medium-textured soils	Recent alluvium	Level to very gently sloping plains and level swamps	Rain forest and some regrowth (mainly 2, some 1 and 3). Very locally grassland (*a*, little *b*), fluctuating swamp forest and woodland
Plastic clay soils	Recent alluvium	Level swamps	Fluctuating swamp forest and woodland and herbaceous swamp

TABLE 6 (*Continued*)

Major Soil Group and Soil Family	Parent Rock	Land Form*	Vegetation†
Lithosols and shallow slope soils	Various types of consolidated rock	Very steep to precipitous slopes; narrow crests	Rain forest(7, 8) and grassland(*e*)
Miscellaneous land types			
Rock outcrop	Limestone	Cliffs and hillocks	Sparse shrubs
Rough mountainous land	Sedimentary and igneous rocks	Very steep to precipitous slopes of sharp mountain ridges	Grassland(*e*); rain forest (unidentified); some lower montane rain forest
Lava rock land	Andesitic and basaltic lava	Steep, more or less dissected domes and cones; lava flows with gently sloping, undulating surfaces and steep, convex side slopes	Blast area succession forest; some rain forest(5)
Volcanic ash land	Andesitic volcanic ash	Very gentle to moderate slopes	Woody and herbaceous blast area successions
Rubble land	Recent gravel	Broken plains	Stream-bed successions
Stony land	Recent and sub-Recent unsorted alluvium; basaltic and andesitic agglomerate and lava	Very gentle to gentle, slightly undulating slopes; steep to very steep hill slopes	Grassland(*d*) and seral vegetation; rain forest (2, 8)
River wash	Recent alluvium	Higher parts of stream beds of mostly braided rivers	Stream-bed successions
Alluvial land	Recent alluvium	Smooth to slightly undulating, level plains	Successions on flood deposits, predominantly woody and commonly dominated by *Casuarina* sp.
Tidal swamp	Marine mud and sand	Littoral flats	Mangrove forest and woodland

* Level, $<1°$; very gentle, 1–3°; gentle, 3–7°; moderately steep, 7–12°; steep, 12–22°; very steep, 22–35°; precipitous, 35–60°; cliffs, $>60°$.

† (1) *Terminalia canaliculata–Bischoffia javanica* alliance; (2) *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association; (3) *Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa* association; (4) *Pometia pinnata–Tristiropsis subangula–Cryptocarya* sp. association; (5) *Pometia pinnata–Tristiropsis subangula–Anisoptera kostermansiana* association; (6) *Anisoptera kostermansiana–Pometia pinnata* association; (7) *Anisoptera kostermansiana–Alstonia scholaris–Rhus taitensis* association; (8) *Anisoptera kostermansiana–Intsia bijuga–Garcinia* sp. association; (9) *Anisoptera kostermansiana–Intsia bijuga–Terminalia* spp. association; (10) *Rhus taitensis–Canarium salomonense–Intsia bijuga* association; (11) *Lithocarpus* sp.–*Cryptocarya* spp. alliance. (*a*) *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance; (*b*) *Saccharum spontaneum–Imperata cylindrica–Coelorachis rottboellioides* suballiance; (*c*) *Imperata cylindrica–Ischaemum barbatum* suballiance; (*d*) *Saccharum spontaneum–Imperata cylindrica–Cymbopogon procerus* suballiance; (*e*) *Themeda australis–Alloteropsis semialata* alliance.

(ii) *Ma-U Family.**—These soils are 3–4 ft deep with a moderately developed, dark clay loam A_1 horizon overlying a clay B horizon, strong brown in the upper part and red-brown in the lower part. The C horizon is a strong brown friable light clay and continues beyond 4 ft depth. The soils contain some subangular stones and gravel.

(iii) *Oreia Family.**—These soils are 2–3 ft deep and have variably developed clay loam to clay A_1 horizons. The B horizon is a red-brown clay which merges gradually into the C horizon of brownish silty clay loam with multicoloured mottles of weathered soft and harder rock fragments.

(iv) *Ukwena Family.*—These soils are 2–3 ft deep. They have a poorly to moderately developed clay loam A_1 horizon overlying a red-brown clay to heavy clay B horizon, which is much firmer and more plastic than is normal in this group and has faint yellow mottles of weathered rock fragments and harder fragments. The underlying C horizon is a strongly mottled firm clay or silty clay.

(v) *Ilamarora Family.**—These soils are 1–3 ft deep with a very poorly to moderately developed dark loamy A_1 horizon. The B horizon is a brown to dark yellow-brown clay loam, which merges into a similarly coloured, more silty C horizon with mottles of weathered rock fragments and harder fragments.

(vi) *Maneau Family.**—These soils are 1–2 ft deep with very poorly developed loamy A_1 horizons, overlying yellow-brown and with depth strong brown silty clay B horizons, which merge gradually into a more yellow silty loam C horizon with pink and black mottles of weathered rock fragments and harder fragments.

(vii) *Bereruma Family.**—These soils are dark red-brown clay loam to light clay soils, 12–18 in. deep, with a granular to subangular blocky structure in the surface soil. The soil material contains many hard rock fragments and merges into a C horizon of reddish and brownish mottled, completely weathered rock. The soils are unusual for this group in having a neutral reaction and high base saturation.

(*b*) *Granular Dark Red Uniform Heavy Clay Soils*

(i) *Wabubu Family.**—These are dark red-brown, and at depth dark red, heavy clay soils of remarkable friability. This consistence appears to be due to a fine granular and, at depth, very fine angular blocky structure. The dark A_1 horizon is normally thin. The soils are of variable depth (10–36 in.) and rest abruptly on limestone, whilst limestone floaters occur throughout the profile. Noteworthy in the analytical data are the high clay content, which gradually increases with depth, and the high base saturation in relation to pH, both of which decrease gradually with depth.

(*c*) *Weathered Gleyed Soils*

These leached soils are formed on moderately to strongly weathered parent material of apparently low permeability. They have moderately to well-developed dark to very dark A_1 horizons, notably coarser in texture than the strongly mottled and commonly dominantly grey clay B horizon, which is massive and generally very plastic even in the moist state. Iron concretions are common in the lower A_1 and the B horizons. The soils are moderately to weakly acid.

* Analytical data are available in Appendix I.

(i) *Moiowa Family.*—These soils are more than 4 ft deep and characterized by a thin, strong brown B_1 horizon with many faint mottles between the A_1 horizon and the strongly red, brown, and grey mottled B_{2g} horizon.

(ii) *Gurukwaia Family.*—These 2–3 ft deep soils commonly have many iron concretions in the A_1 horizon. The B_{2g} horizon has a light grey to pale brown matrix with many brown, red, and/or black mottles. The C horizon consists of mottled soft weathered rock with veins of light grey clay.

(iii) *Guruguru Family.**—These soils are 2–3 ft deep and are characterized by a sharp though highly irregular transition at a depth of 8–15 in. between the friable sandy loam to sandy clay loam A_1 horizon and very plastic to extremely firm sandy clay to clay B_{2g} horizon. This horizon is grey in colour with distinct brown mottles and whitish speckles and merges gradually into a similar, but more sandy C horizon, which is strongly whitish-speckled and contains more or less weathered gravel and stones.

(iv) *Medino Family.*—These are rather anomalous wet soils of a colluvial nature, with a thin slightly peaty and gleyed sandy clay loam A_{1g} horizon overlying dark brown-grey and grey plastic sandy clay loam and clay layers with brown mottles and locally iron concretions, ferruginous rock fragments, and gravel.

(*d*) *Moderately Weathered Brown Ash Soils*

These soils are characterized by very friable, well-developed, very dark clay loam A_1 horizons and moderately deep to deep profiles. The B horizons are dark yellow-brown to yellow-brown, structureless, but porous and commonly speckled by dark minerals. They are commonly rather brittle and merge gradually into similar but sandier and slightly lighter-coloured C horizons of considerable depth, which gradually merge into fresh sandy volcanic ash. The soils are weakly acid in reaction.

(i) *Ambon Family.**—These soils are 3–4 ft deep and have a sandy clay to clay texture in the B horizon and a very gradual transition to the sandy clay loam C horizon. Some stones occur commonly throughout the profile.

(ii) *Utah Family.**—These soils are approximately 3 ft deep and have a clay B horizon, which merges rather rapidly into sandy clay loam and sandy loam C horizons. The B horizon is faintly and the C horizon distinctly brown, grey, and black mottled.

(iii) *Boa Family.*—These soils are more than 4 ft deep and have polygenetic profiles. The upper profile consists of loam to sandy clay loam, with a very dark to black A_1 horizon overlying a dark brown B horizon. This profile is underlain at a depth of 27 to 38 in. by a very dark brown to black buried A_1 horizon. A sample of the buried A_1 horizon yielded 6% organic carbon and the very high C/N ratio of 28, indicative of strong carbonization of the original organic matter.

(iv) *Penari Family.**—These soils are 1–2 ft deep and have a generally very strongly developed, very dark brown to black, loam to sandy clay loam A_1 horizon, overlying friable brown sandy loam and with depth grey-brown or olive-brown loamy sand C horizons. Some profiles have a thin dark brown sandy clay loam B horizon between the A_1 and C_1 horizons. The subsoils are strongly black speckled with dark minerals.

* Analytical data are available in Appendix I.

(*e*) *Unweathered Volcanic Sandy Soils with Black Topsoils*

(i) *Popondetta Family*.—These soils have a well-developed, mostly black, very friable, crumbly loam to sandy loam A_1 horizon. This merges clearly into brown-grey D layers of stratified, loose andesitic sand, loamy sand, or gravelly sandy loam. The chemical properties are likely to be similar to those given for this family in the Buna–Kokoda area (Haantjens 1964).

(*f*) *Shallow Dark Soils*

These soils have formed on moderately to little-weathered parent material. They have well-developed, very dark, but poorly structured and firm to plastic sandy clay loam to clay A_1 horizons, which commonly contain black and brown concretions or ferruginous rock fragments. The A_1 horizon either directly overlies a C_2 horizon of partly weathered sedimentary rock, or there are also thin transitionary gleyed B_{2g} and/or C_{1g} horizons with ferruginous rock fragments. The soils are weakly acid and appear to be little leached, having high base saturation.

(i) *Podago Family*.*—These soils are generally 6–12 in. deep with hard weathered sandstone, siltstone, or mudstone underlying the A_1 horizon. In some profiles a thin mottled plastic sandy clay to clay C_{1g} horizon is present.

(ii) *Wanaki Family*.—These soils are 12–18 in. deep and have a thin, dark, mottled plastic clay to heavy clay B_{2g} horizon, overlying a light greyish, distinctly mottled, very plastic clay C_{1g} horizon, approximately 1 ft thick. The C_2 horizon consists of light grey, angularly fragmented, soft marl with brown and black fragment faces.

(*g*) *Shallow Black Structured Clay Soils*

These soils are characterized by a black to very dark grey A_1 horizon with a strongly developed medium subangular blocky structure, gradually weakening with depth. The surface soil can have a medium to coarse granular structure. The texture is clay or heavy clay and the soils are neutral in reaction and fully saturated.

(i) *Ginada Family*.*—These soils are 6–12 in. deep and either they are directly underlain by hard coral limestone or there is a thin, massive, very dark grey C horizon with many disintegrated and fresh limestone fragments. Limestone gravel and stones also occur in the A_1 horizon and there is much rock outcrop.

(ii) *Castle Hill Family*.—These soils are 2–3 ft deep and have a dark brown or dark grey, plastic clay or heavy clay B horizon, commonly containing some weathered rock fragments. In one profile this horizon merged into yellowish weathered sandstone containing free carbonate. Small limestone blocks occur locally in and on the soil.

(iii) *Kanidaba Family*.—These soils are 6–12 in. deep, light to medium clays, abruptly underlain by firm to hard, whitish or yellowish, slightly weathered marl.

(*h*) *Dark Soils of Heavy Texture*

These are more than 4 ft deep and essentially alluvial soils with little profile development. They are plastic clay soils. The A_1 horizon is very dark and has a well-

* Analytical data are available in Appendix I.

developed subangular blocky structure in its upper part. The massive subsoil is dark grey to grey-brown and normally distinctly brown and black mottled. Small amounts of black iron concretions and weathered rock fragments are commonly present throughout the soil.

(i) *Boboni Family.*—These soils have a well-developed A_1 horizon. The clay subsoils are commonly *not* mottled and can contain low amounts of weathered limestone. In two profiles buried A_1 horizons were observed in the subsoil. The soils are neutral to weakly alkaline in reaction and fully saturated.

(ii) *Ibiduwa Family.**—These soils have a poorly to moderately developed A_1 horizon. The subsoil is silty clay to heavy clay. The soils are weakly acid to neutral in reaction, but fully saturated.

(*i*) *Recent Alluvial Soils*

These soils consist of alluvial deposits that have remained essentially unmodified by pedogenetic processes. Soil formation is restricted to slight to moderate development of an A_1 horizon, a certain amount of mixing by biological action, and varying degrees of gleying due to periodically or permanently high water-tables. Texture varies greatly, not only between different soils but commonly also within the same profile, owing to stratification of the deposits.

(i) *Sandy Soils.*—These soils have very friable sandy loam to loamy sand topsoils, and subsoils of sand and loamy sand with occasional layers of sandy loam.

(ii) *Coral Sandy Soils.*—These soils have a moderately developed very dark loamy sand A_1 horizon, overlying whitish coarse sand of coral and shell fragments.

(iii) *Medium-textured Soils.**—These soils range in texture from sandy loam to clay loam with occasional layers of sand or clay. Silt loam and silty clay loam are the most common texture classes. The majority of profiles have rather uniform textures or become gradually or suddenly coarser in texture with depth. Some profiles become gradually or suddenly finer in texture and internal drainage is impeded when this change in texture is considerable.

(iv) *Clay Soils.*—These soils have uniform clay textures. All profiles observed are wet, plastic, and strongly gleyed. At one site a thin peaty A_0 horizon was observed.

(*j*) *Lithosols and Shallow Slope Soils*

The term lithosol has been applied to soils shallower than 6 in. and overlying consolidated weathered rock. Such soils are generally dark and consist essentially of a thin A_1 horizon. They commonly contain rock fragments and are associated with rock outcrop.

Shallow slope soils are undifferentiated brown soils consisting of weathered regolithic material. They commonly contain rock fragments, which may be aligned in bands or zones.

* Analytical data are available in Appendix I.

(*k*) *Miscellaneous Land Types*

This group comprises surface materials and land types of various kinds with very poorly developed soils that cannot be classified as alluvial soils.

(i) *Rock Outcrop.*—Small areas of outcropping hard limestone.

(ii) *Rough Mountainous Land.*—Vegetated, very steeply sloping land with narrow V-shaped valleys and sharp divides. High proportion of lithosolic soils.

(iii) *Lava Rock Land.*—Normally forested, very bouldery, strongly convex or dissected, recent and older lava flows and lava domes.

(iv) *Volcanic Ash Land.*—Land covered by normally much more than 6 in. of recent volcanic ash or gravel.

(v) *Rubble Land.*—Level land of which the surface is covered for more than 90% by boulders, stones, and gravel.

(vi) *Stony Land.*—Land with 15 to 90% stones and boulders on and in the surface soil.

(vii) *River Wash.*—Scarcely vegetated, shifting gravel bars, sand bars, or mud bars in river beds, normally emerging above water-level.

(viii) *Alluvial Land.*—Normally vegetated very young river and fan deposits; sand or gravel, rarely silt loam; mostly liable to flooding and subject to changes caused by shifting of river channels; variable drainage status; mostly calcareous in Wakioka land system.

(ix) *Tidal Swamp.*—Land inundated with salty or brackish water at high tide and covered by mangroves. Normally sands with layers of organic mud.

III. Soils and Land Systems

The distribution of the various kinds of soils in the land systems is shown in Table 7. In most cases there are very specific correlations between the land systems and the individual soil families.

The paucity of climatic data prevents any detailed correlation with kinds of soil. In general terms it can be stated that the soils in Tama, Bewabewa, Koianaki, Tarakaruru, Tokinawara, and Monari land systems have developed under a significantly drier climate than those in the remainder of the area. The soils restricted to this drier zone are the granular dark red uniform heavy clay soils, the shallow dark soils, the shallow black structured clay soils, the dark soils of heavy texture, as well as the Gurukwaia and Medino families of the weathered gleyed soils.

The strongly weathered soils are generally restricted to well-drained and generally forested mountain and hill land systems and the old, high terraces of Rakua land system, which are located in the wetter, western part of the area. As a group these soils occur on many rock types, but the individual families are each restricted to one particular type of parent material. The land surfaces on which these soils have formed appear to be essentially of late Pleistocene age (Haantjens 1964). The families with best-developed profiles (Budi, Ma-U) occur on the most gentle slopes. All these features suggest that this group of soils represents the zonal trend in soil formation, at least in the wetter part of the area.

TABLE 7

DISTRIBUTION OF SOIL FAMILIES IN LAND SYSTEMS

Occurrence of soil families is indicated as: *D* (dominant, >50%), S (subdominant, 15–50%), and m (minor, <15%)

Major Soil Group and Soil Family	Erosional Mountains				Erosional Hills						Volcanic Slopes				High Terraces		Fluviatile Plains						Littoral Plains	
	Maneau	Didana	Trafalgar	Tama	Budi	Bekalama	Sesegara	Bewabewa	Koianaki	Tarakaruru	Victory	Kwin	Wanigela	Kopwei	Rakua	Tokinawara	Monari	Uiaku	Dove	Ismari	Wakioka	Tortore	Killerton	Buna
Strongly weathered red and brown clay soils																								
Budi					*D*																			
Ma-U															*D*									
Oreia			S			*D*																		
Ukwena								m																
Ilamarora			m			S																		
Maneau	S																							
Bereruma		*D*																						
Granular dark red uniform heavy clay soils																								
Wabubu										S														
Weathered gleyed soils																								
Moiowa												m												
Gurukwaia								m		m														
Guruguru												S												
Medino								m																
Moderately weathered brown ash soils																								
Ambon												S												
Utah												m												
Boa			m									m												
Penari												S												
Unweathered volcanic sandy soils with black topsoils																								
Popondetta													*D*											

Shallow dark soils																						
Podago							*D*	*D*														
Wanaki								m														
Shallow black structured clay soils																						
Ginada									*D*													
Castle Hill									m													
Kanidaba								S														
Dark soils of heavy texture																						
Boboni								m							S							
Ibiduwa															*D*							
Recent alluvial soils																						
Sandy soils													S			m						*D*
Coral sandy soils																						S
Medium-textured soils												S				*D*	*D*	*D*	m	*D*		
Plastic clay soils																				S		
Lithosols and shallow slope soils	*D*	m	m		m	S	m	m	m													
Miscellaneous land types																						
Rock outcrop									m													
Rough mountainous land			*D*	*D*																		
Lava rock land										*D*												
Volcanic ash land										m						m						
Rubble land										m			m									
Stony land						S							S	*D*		m			m			
River wash													m			m			m			
Alluvial land													S			m			*D*			
Tidal swamp																					*D*	

The soil families on steeply sloping land probably have naturally shallow profiles, but the rather shallow soils of Oreia and Ilamarora families occurring on moderate slopes probably have been truncated as a result of long, intensive use for shifting cultivation, which has also led to the formation of extensive man-made grasslands. In the mountainous Maneau and Trafalgar land systems the strongly weathered red and brown clay soils are associated with lithosols, shallow slope soils, and rough mountainous land.

The granular dark red uniform heavy clay soils of Wabubu family are restricted to the limestone plains of Tarakaruru land system. They are distinguished from the weathered red and brown clay soils by their uniform very high clay content, well-developed structure and great friability, high base saturation, and irregular depth. They appear to be typical terra rossa. They are associated with the shallow, black, structured clay soils of Ginada family, but the distribution pattern of these two families is not fully understood. Wabubu family is always found on fairly level terrain. Steep slopes always have black soils, but these were also found on sites where red soils could be expected.

The weathered gleyed soils are less weathered than those of the two previous groups. They occur in land systems with gentle slopes on slowly permeable parent materials. These are mainly mudstones for Gurukwaia family in Bewabewa and Tarakaruru land systems (in the latter only locally exposed below the limestone beds) and probably older laharic mud flows for Guruguru family and older lava for Moiowa family in Kwin land system. It is not known whether the markedly coarser texture of the upper horizons of Guruguru family is due to eluviation or the result of younger ash deposits on a weathered clayey substratum. The limited field evidence points to the former. It is interesting to note that the weathered gleyed soils in Kwin land system are rather selectively associated with grassland or regenerating grassland. It is possible that the poor physical properties of these soils promoted a rapid conversion into grassland after forest clearing and retarded the process of forest regeneration after the regular burning of the grassland had ceased.

The moderately weathered brown ash soils are virtually confined to Kwin land system. Their occurrence in Trafalgar land system is restricted to locally preserved ash deposits from Mt. Victory. These soils can be considered as intermediate stages and variations in soil formation on Recent and sub-Recent volcanic ash and agglomerate on the broad lower slopes of Mt. Victory. This process of soil formation is assumed to lead ultimately to the development of strongly weathered, reddish soils. None of the brown ash soil families has yet reached this final stage. Ambon family includes the apparently most strongly weathered soils of the group, with Penari family as a clearly less mature counterpart. Whether this is purely a matter of age or whether other factors, such as the nature and texture of the parent material and the altitude, also play a role is not clear. Utah family is similar to Ambon family in weathering status, but clearly more poorly drained. As there are no signs of slow permeability or of poor external drainage, it is possible that the excessive wetness of these soils is due to water perched on a slowly permeable substratum. The Boa family with its buried A_1 horizon is most frequently found in the higher parts of the land system, where the more rapid rate of organic accumulation increases the chance of well-developed organic horizons being preserved below younger ash deposits. Also, such sequences of ash showers are likely to be better developed in areas near the crater zone. Soils of Boa and Penari families are locally covered by up to 15 in. of rather fresh ash, enriched with organic matter and of sandy loam to fine sandy loam texture. Such spots are within the area covered by Mt. Victory blast succession forest. This suggests that this ash was deposited during the last eruption of Mt. Victory about 1880.

The stable, older outwash fans of Wanigela land system, which are associated with Mt. Victory, are largely covered by the unweathered volcanic sandy soils with black topsoils of Popondetta family, in which profile development is virtually restricted to the formation of a well-developed black A_1 horizon. On the less stable youngest outwash fans of Kopwei land system very little soil formation has occurred. They have been mainly mapped as rubble land, stony land, alluvial land, and river wash.

The soils of the summit area of Mt. Victory and a number of older and recent lava flows, all grouped together in Victory land system, have been little investigated. Soil formation in these areas appears to be minimal and most of it has been mapped as lava rock land, volcanic ash land, and rubble land. The same applies to Waiowa volcano and a lava flow in the alluvial plain, which were included in Victory land system.

The shallow dark soils (in particular those of Podago family) strongly dominate the soil pattern on the Tertiary sedimentary rocks of the hilly Bewabewa and Koianaki land systems in the drier, eastern part of the area. Although these soils are largely covered with man-made grassland, they are probably not the result of severe truncation during an era of intensive occupation. It is more likely that these soils are inherently shallow and that this feature, together with the rather pronounced dry season, has been responsible for the rapid transformation of the generally poor forest into grassland. The shallowness of these soils may be caused by the instability of the slopes on the sedimentary rocks, which are strongly affected by slumping (Plate 4, Fig. 2). Furthermore, the dense, rather impermeable nature of the sediments may retard their weathering, especially in this area of relatively low rainfall. Extremely shallow, lithosolic soils related to Podago family are found on the very steep slopes of Tama land system. This area has been mapped as rough mountainous land. Soils of Wanaki family have developed on soft marls and are transitionary in character to the weathered gleyed soils.

The shallow, dark, structured clay soils are also confined to the drier, eastern part of the area where they occur on calcareous sedimentary rocks and limestone in Koianaki and Tarakaruru land systems. The distribution of Ginada family has already been discussed in connection with the granular dark red uniform heavy clay soils. The other families occur on marl and calcareous sandstone and are somewhat transitional to the shallow dark soils.

The dark soils of heavy texture are virtually confined to Monari land system and again are a component of the distinct soil pattern in the drier, eastern part of the area. Developed in fine-textured alluvium in well-graded valleys these soils are not flooded or rarely flooded and have weakly developed profile characteristics associated with dark cracking clays. Boboni family is more alkaline and has more clearly defined dark upper horizons and a more strongly developed structure than Ibiduwa family. This difference is probably largely due to the derivation of the parent material of Boboni family from calcareous marine sedimentary rocks as opposed to terrestrial rocks in Ibiduwa family. Slightly greater maturity may be a contributing factor, as the Boboni soils generally occur somewhat higher above stream levels than the Ibiduwa soils.

The recent alluvial soils occupy most young alluvial plains (Uiaku, Dove, Ismari, and Tortore land systems) and beach ridges (Buna land system). They are also important in the lower parts of the volcanic outwash fans (Wanigela and Kopwei land systems). These soils are mostly medium-textured, sandy soils being important only in the most recent fans (Kopwei land system) and on beach ridges (Buna land system and in some parts of Uiaku land system), and clay soils only in the lowest, swampy parts of the flood-plains (Tortore land system). The soils are likely to belong to different mineralogical provinces, but no investigations were carried out to support this. The soils in Wanigela, Kopwei, and Ismari land systems are presumably derived from andesitic material. Those in Dove land system are probably of mixed composition, having been deposited by a river with a large and heterogeneous catchment. Those in Uiaku, Wakioka, and Tortore land systems are mainly derived from calc-silicate rocks, phyllite, and schist, but from sedimentary rocks in the eastern part. Many soils in Uiaku, Dove, and Wakioka land systems are calcareous on freshly deposited sediments. With the high rainfall in this part of the area the carbonates are rapidly leached downward, but they are commonly still present in the subsoils. Some profiles have calcareous surface horizons overlying non-calcareous subsoils. This is taken as evidence of recent deposition over slightly older, leached alluvial soils. This feature is particularly common in the very young, active-depositional plains of Wakioka land system, where most of these unstabilized deposits have been mapped as alluvial land rather than as alluvial soils.

IV. References

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PART VII. VEGETATION OF THE WANIGELA–CAPE VOGEL AREA

By B. W. TAYLOR*

I. GENERAL DESCRIPTION AND DISTRIBUTION OF VEGETATION TYPES

The distribution of the vegetation communities in the land systems is shown in Table 8.

The vegetation of the area is influenced primarily by climatic factors, drainage conditions, landscape dynamics, and the activities of man. Slopes and soil conditions appear to have a secondary effect, reflected mainly by differences in floristic composition within the larger structural vegetation units.

Lowland rain forest is the natural vegetation type throughout the area below 2500 ft, except in swamps and unstable areas. This tall, dense, tropical forest is very rich in species. It has been subdivided into 11 associations on the basis of structural and floristic differences. On the poorly drained parts of Monari, Uiaku, and Dove land systems the rain forest is low with a dense understorey and many gaps in the canopy, which consists of generally small-crowned trees with few emergents. The better-drained parts of the plains of Wanigela, Kopwei, Monari, Uiaku, and Ismari land systems have a tall forest with a closed but irregular canopy with variable crown sizes and many emergents. There is a great difference in species composition between the forest in Monari and the other land systems. This is probably due to the different climatic and soil conditions. The rain forest in the upland areas of Kwin, Wanigela, and Rakua land systems and all the hilly and mountainous land systems (Plate 7, Fig. 1) is generally characterized by a dense, even-crowned canopy. The many floristic differences in the upland forest are commonly related to particular land systems or groups of systems. Hill forest in the Cape Vogel peninsula appears to be more poorly developed, owing to the combined effect of shallow soils and lower rainfall. In extreme conditions, on rocky limestone slopes, dry evergreen forest occurs (Plate 5, Fig. 2). Above 2500 ft the rain forest of the hills merges into lower montane rain forest, which is lower in height, has different and fewer species, and a denser ground layer.

Structurally and floristically more simple communities appear when the drainage conditions are exceptionally poor. The greater part of the freshwater swamps of Tortore land system is covered by swamp forest and swamp woodland in which sago palms and *Pandanus* are prominent. The most swampy parts have various kinds of herbaceous communities (Plate 8, Fig. 1). The tidal flats of Killerton land system are occupied by various mangrove communities (Plate 8, Fig. 2) which commonly occur in definite zones.

Various types of successional vegetation occur on unstable sites. The most important are successions on flood deposits, ranging from herbaceous communities (Plate 3, Fig. 1) to forests that are commonly dominated by a single species, such as *Casuarina* sp. (Plate 6, Fig. 2) or *Octomeles sumatrana*. This vegetation occurs on the

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TABLE 8

DISTRIBUTION OF VEGETATION COMMUNITIES IN LAND SYSTEMS

Occurrence of communities is indicated as: *D* (dominant, >50%), S (subdominant, 15–50%), and m (minor, <15%)

	Formation and Association or Alliance	Erosional Mountains				Erosional Hills						Volcanic Slopes				High Terraces		Fluviatile Plains						Littoral Plains	
		Maneau	Didana	Trafalgar	Tama	Budi	Bekalama	Sesegara	Bewabewa	Koianaki	Tarakaruru	Victory	Kwin	Wanigela	Kopwei	Rakua	Tokinawara	Monari	Uiaku	Dove	Ismari	Wakioka	Tortore	Killerton	Buna*
Climax communities	Rain forest																								
	Terminalia canaliculata–Bischoffia javanica																	S	S	*D*					
	Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris												m	S	S				*D*		*D*				
	Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa								m								m	S	m						
	Pometia pinnata–Tristiropsis subangula–Cryptocarya sp.															*D*									
	Pometia pinnata–Tristiropsis subangula–Anisoptera kostermansiana											m	S												
	Anisoptera kostermansiana–Pometia pinnata													S											
	Anisoptera kostermansiana–Alstonia scholaris–Rhus taitensis			S			S																		
	Anisoptera kostermansiana–Intsia bijuga–Garcinia sp.	*D*	S	*D*		*D*		*D*																	
	Anisoptera kostermansiana–Intsia bijuga–Terminalia spp.				m				S	S															
	Rhus taitensis–Canarium salomonense–Intsia bijuga										S														
	Lithocarpus sp.–*Cryptocarya* spp.	m	*D*																						
	Lower montane rain forest	m		S																					
	Dry evergreen forest								m																
	Mangrove forest																							S	

	Fluctuating swamp forest																		S		
	Mangrove woodland																			S	
	Fluctuating swamp woodland													m					S		
	Savannah																		m		
	Fern–tall tree savannah																			m	
	Mangrove savannah																			m	
	Herbaceous swamp																		S		
Disclimax and seral communities	Grassland																				
	Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus					m					D			S	m	m	m				S
	Saccharum spontaneum–Imperata cylindrica–Coelorachis rottboellioides									m											
	Imperata cylindrica–Ischaemum barbatum													m							
	Saccharum spontaneum–Imperata cylindrica–Cymbopogon procerus											S						m			
	Themeda australis–Alloteropsis semialata	m	m	D	D	D	D	D					D								
	Regenerating grassland									S					m						
	Successions on flood deposits																				
	Casuarina sp. successions																	D			
	Octomeles sumatrana successions																m	m			
	Mixed successions											S						S			
	Stream-bed successions											m			m						
	Coastal successions																				S
	Successions on volcanic blast areas																				
	Waiowa blast successions								m												
	Mt. Victory blast successions								D	S		S									

*The remainder of this land system is occupied by settlements and coconut plantations.

unstable outwash plains of Kopwei and Wakioka land systems. The eruption of Mt. Victory, which according to reports took place about 1880, has resulted in a large area of successional forest in Victory, Kwin, and Kopwei land systems. A smaller area of younger stages of successional vegetation is found on and around Waiowa volcano (Victory and Uiaku land systems), which erupted in 1943. Its boundary is shown on the land system map accompanying this report.

The pattern of natural vegetation described above has been disturbed by man in many places. Clearing of forest for shifting cultivation has resulted in the formation of various stages of garden regrowth (Plate 2, Fig. 2) and secondary forest, particularly in Bekalama, Bewabewa, Koianaki, Taraķaruru, Wanigela, and parts of Monari, Uiaku, Dove, and Ismari land systems. When shifting cultivation is often repeated in areas of regrowth, this can be converted by fire to grassland, which is subsequently maintained as a disclimax vegetation by regular burning (Plate 6, Fig. 1). The distribution of these grasslands is shown in a generalized way on the land system map. They are particularly widespread in the drier, eastern part of the area (Tama, Bewabewa, Koianaki, Tarakaruru, and Tokinawara land systems; Plate 4, Figs. 1 and 2; Plate 5, Fig. 1) as a result of the combined effects of the marked seasonality in rainfall, poor soils, and dense population. Extensive grasslands also occur on the northern foot slopes of Mt. Trafalgar (Bekalama land system) and the volcanic outwash fans of Wanigela and Kopwei land systems. In Bekalama and Wanigela land systems this has probably been caused by intensive gardening in the past on infertile or sandy soils, and in Kopwei land system by burning of poor successional vegetation on gravelly fan deposits. When burning of grassland ceases, a process of forest regeneration is initiated. The largest areas of such regenerating grassland occur in Kwin land system on the lower slopes of Mt. Victory. Burning was probably discontinued after the 1880 eruption, when the population fled from the mountain slopes. If this is so, the tree growth on these former grasslands is poor compared with that of the successional forest of the blast area. This could be partly due to the poor physical properties of the soils in the regenerating grassland areas.

II. Classification

The classification of vegetation adopted in this report consists firstly in the recognition of the status of the community, i.e. whether climax or seral. Seral communities are described as a series of successional stages. The climax vegetation has been subdivided into structural units, termed formations (Beard 1944). The formations are subdivided into alliances and associations, on the basis of floristic composition (Beadle and Costin 1952). In rain forest the associations are usually determined by the differences in the most abundant species in the dominant layer, but occasionally by radical differences in the list of rarer species. Alliances are groups of related associations.

Where tree species have not yet been identified and a specific name is not available, native names are quoted in the text. These names are predominantly in the Onjob language, Koreaf village, near Wanigela. Other names quoted are from a Cape Vogel language, Boga Boga village, denoted by *v*, Minafea language, Kabubu village on Cape Nelson, denoted by *m*, and Orokaiva language, Mumuni village, near Popondetta, denoted by *o*.

III. Climax Communities

(a) *Rain Forest Formation*

Rain forest is an evergreen hygrophilous forest, at least 100 ft high, usually higher, and has three or four layers of trees. It is rich in thick-stemmed lianes and in woody as well as herbaceous epiphytes.

(i) Terminalia canaliculata–Bischoffia javanica *Alliance*.—Only one association has been placed in this alliance.

(1) Terminalia canaliculata–Bischoffia javanica *Association*.—In this association mature forest is of frequent occurrence and is usually about 110 ft high. *Bischoffia javanica* and *Terminalia canaliculata* are the most common species and usually total at least 20% of the trees in the dominant layer. Other common species in the dominant layer are *Ficus* sp. ("kimabu", *v*), *Planchonia timorensis*, *Neonauclea* sp. ("kaforna"), *Syzygium* spp., and *Dysoxylum* spp. Secondary communities are infrequent; common species are *Macaranga aleuritoides* and *Ficus calopilina* in young stages and *Ficus* sp. ("fipo"), *Artocarpus altilis*, *Sterculia* sp. ("torfi"), and *Endospermum myrmecophilum* in later regrowth stages.

(ii) Pometia pinnata *Alliance*.—Five associations have been placed in this alliance. These are all of very mixed floristic composition with no tendency to single species dominance. Many species are common to all five associations with *Pometia pinnata* the most abundant.

(1) Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris *Association*.— In this association there are numerous stands of mature forest and these range in height from 120 to 160 ft. Common species are *Pometia pinnata*, *Tetrameles nudiflora*, *Alstonia scholaris*, *Ficus* spp., *Palaquium* sp., *Canarium* spp., *Dysoxylum* spp., *Syzygium* sp., *Terminalia* sp. ("hearo", *o*), *Pterocymbium beccarii*, *Octomeles sumatrana*, and *Pterocarpus indicus*. In a secondary forest a few species may be locally dominant, notably *Pometia pinnata*. Species prominent in advanced regrowth stages are *Endospermum myrmecophilum*, *Elaeocarpus* sp. ("raroku"), *Ficus subcuneata*, and *Terminalia canaliculata*.

(2) Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa *Association*.—Mature stands of this association are very rare and the community commonly encountered is a secondary forest or advanced regrowth community generally less than 80 ft in height which has only two tree layers. Common species in the secondary forest are *Planchonia timorensis*, *Anisoptera kostermansiana*, *Terminalia microcarpa*, *Terminalia* spp. ("kauwaipe", *v*, and "mapamapa", *v*), *Syzygium* sp. ("mokomokapa", *v*), *Bischoffia javanica*, *Cordia dichotoma*, *Maniltoa* sp., and *Alstonia scholaris*. Common regrowth species are *Serianthes kanehirae*, *Ficus* sp. ("fipo"), *Kleinhovia hospita*, and *Alstonia spectabilis*, in advanced stages, and *Ficus calopilina*, *Artocarpus altilis*, *Canarium acutifolium*, and *Macaranga* sp. ("hiyatum") in young stages.

(3) Pometia pinnata–Tristiropsis subangula–Cryptocarya *Sp. Association*.— This association is closely related to the *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association. No secondary communities of this association occur, all the

stands encountered were mature forest ranging from 120 to 160 ft in height. The more common species include *Pometia pinnata*, *Tristiropsis subangula*, *Dracontomelum* sp., four species of *Cryptocarya*, *Alstonia scholaris*, *Ficus* spp., *Dysoxylum* sp. ("iyaningau"), and *Canarium schlechteri*.

(4) Pometia pinnata–Tristiropsis subangula–Anisoptera kostermansiana *Association.*—Most of the stands of this association are mature forest 100 to 150 ft in height, with *Pometia pinnata*, *Tristiropsis subangula*, *Anisoptera kostermansiana*, *Ficus* spp., *Intsia bijuga*, *Syzygium* sp. ("itareuk"), *Planchonia timorensis*, *Cedrela toona*, *Terminalia* sp. ("gau"), *Litsea* sp. ("waure"), *Dracontomelum* sp. ("imbur"), and *Dysoxylum* sp. ("iyaningau") common. Advanced garden regrowth is common but young stages are now rare. Species common in advanced regrowth include *Terminalia* sp., *Ficus* sp. ("fipo"), *Sterculia* sp. ("torfi"), *Artocarpus altilis*, *Endospermum myrmecophilum*, and *Pimeleodendron amboinicum*.

(5) Anisoptera kostermansiana–Pometia pinnata *Association.*—This association consists largely of secondary communities. Common species are *Alstonia spectabilis*, *Terminalia* sp., *Artocarpus altilis*, *Endospermum myrmecophilum*, and *Celtis* sp. ("domoila"). Species characteristic of mature forest which are common in these secondary communities include *Anisoptera kostermansiana* and *Pometia pinnata* as well as the less frequent *Alstonia scholaris*, *Dracontomelum* sp. ("dundum"), *Dysoxylum* spp., and *Syzygium* sp.

(iii) Anisoptera kostermansiana–Intsia bijuga *Alliance.*—Four associations have been placed in this alliance. A large group of species is common to all four associations.

(1) Anisoptera kostermansiana–Alstonia scholaris–Rhus taitensis *Association.*—Secondary forest of this association covers extensive areas, while mature forest which is generally less than 100 ft in height is rare. Important species include *Anisoptera kostermansiana*, *Rhus taitensis*, *Intsia bijuga*, and *Pterocarpus indicus*, which are often locally abundant, and *Alstonia scholaris*, *Ficus* spp., *Canarium acutifolium*, and *Ganophyllum falcatum*, which consistently occur but are not locally abundant. Advanced regrowth also covers large areas, common species being *Albizia falcata*, *Ervatamia punctulata*, and *Endospermum myrmecophilum*. Species prominent in young regrowth are *Ficus wassa*, *Ficus* sp. ("euta"), and *Macaranga tanarius*.

(2) Anisoptera kostermansiana–Intsia bijuga–Garcinia *Sp. Association.*—This association consists solely of mature forest. There is no indication that any part of its area has ever been gardened. The canopy layer averages approximately 120 ft but occasionally exceeds 140 ft. Four species are common, *Anisoptera kostermansiana*, *Intsia bijuga*, *Garcinia* sp. ("fisi"), *Canarium acutifolium*, and *C. salomonense*. These species account for half the number of trees in the dominant layer in most stands. However, numerous other species occur in the dominant layer including strangling *Ficus* spp. ("dunara"), *Evodia* sp. ("isilau"), *Syzygium* sp. ("sosolope"), and *Tristiropsis subangula*. Species common in the second tree layer include *Garcinia* sp. ("fisi") and *Pandanus* sp. ("im").

(3) Anisoptera kostermansiana–Intsia bijuga–Terminalia *Spp. Association.*—In this association secondary forest is of widespread occurrence, most stands being

less than 80 ft in height and having only two tree layers. However, rare stands of more mature secondary forest have three tree layers and reach a height of up to 120 ft. *Anisoptera kostermansiana* and *Intsia bijuga* are the most common species in the secondary forest and normally account for from 20 to 100% of the dominant trees in any one stand. Other species which are locally abundant are *Terminalia* spp. ("mapamapa", *v*, and "kauma", *v*), *Terminalia macadamii*, *Rhus taitensis*, *Canarium* sp. ("karowe"), and *Serianthes kanehirae*. *Canarium* sp. ("arofila"), *Maniltoa* sp. ("didimana"), cf. *Dysoxylum* sp. ("morupe", *v*), and several species of Myristicaceae are of widespread occurrence but are never locally abundant. A fan palm and *Pandanus* sp. are conspicuous in the lower tree layer. The only stand examined in Tama land system differed slightly in composition, common species being *Intsia bijuga*, *Terminalia* spp., and cf. *Calophyllum* sp. ("kapakopua", *v*), and a species of bamboo was conspicuous in the lower storey. In the more mature secondary forest *Anisoptera kostermansiana* and *Intsia bijuga* are not as abundant as in the typical stands, but are still common; other important species of tall trees include *Terminalia* spp. ("edzanonte", *v*, and "mapamapa", *v*), cf. *Hopea papuana*, and strangling *Ficus* spp. ("dunara").

(4) Rhus taitensis–Canarium salomonense–Intsia bijuga *Association*.—Most stands of this association are two-tree-layered secondary forest 70 ft high, but some stands have three tree layers. This forest varies considerably from site to site and in most stands two or three species are predominant. These species include *Rhus taitensis*, *Canarium salomonense*, *Maniltoa* sp. ("didimani"), *Mangifera* sp. ("ware"), *Buchanania* sp. ("poduma", *v*), and *Terminalia* sp. ("mapamapa", *v*). Other common species which are locally abundant include *Intsia bijuga*, *Alstonia spectabilis*, *Sterculia* sp. ("torfi"), *Palaquium* sp. ("kwortowa"), and *Ervatamia punctulata*. Conspicuous species confined to the lower tree layer include a fine-leafed *Pandanus* sp. ("misimisika", *v*) and *Barringtonia* sp. ("butuna", *v*). Species common in young stands of regrowth include *Macaranga* sp. ("kikorbe"), *Bridelia* spp., *Glochidion* spp., *Pandanus* spp., and *Timonius* sp. ("zaloga").

(iv) Lithocarpus *Sp.*–Cryptocarya *Spp. Alliance*.—Because only a few stands were examined, no attempt can be made to recognize associations within the alliance. Mature forest covers the greatest area and is from 100 to 140 ft in height, but there is a gradual drop in height with increased altitude. At approximately 2500 ft elevation there is a gradual transition to lower montane rain forest. Species recorded from mature stands include *Lithocarpus* sp., *Cryptocarya* spp., *Ficus* spp., *Litsea* sp. ("nonuwa"), and *Mangifera* sp. Species recorded from advanced regrowth include *Albizia falcata* and *Endospermum myrmecophilum*.

(*b*) *Lower Montane Rain Forest Formation*

This formation is a two-tree-layered rain forest of evergreen trees with leaves predominantly simple. The only climax community seen with this structure was at 2500 ft in the Owen Stanley Range. The forest is of a very mixed composition with *Lithocarpus* sp. common. As only one stand was examined and this was secondary forest, no attempt at floristic classification can be made.

(*c*) *Dry Evergreen Forest Formation*

This formation is a two-tree-layered evergreen forest, approximately 70 ft in height. The leaves are predominantly simple and xeromorphic. A group of secondary communities has been tentatively placed in this formation. The floristic composition of these communities is similar to that of the *Rhus taitensis–Canarium salomonense–Intsia bijuga* association of rain forest. The most abundant species is *Mangifera* sp. ("ware"), while *Rhus taitensis, Canarium salomonense, Intsia bijuga,* strangling *Ficus* spp. ("dunara"), and *Alstonia spectabilis* are common.

(*d*) *Mangrove Forest Formation*

This formation has normally a single layer of tall evergreen trees, 50–80 ft in height, with buttresses, prop roots, and pneumatophores common. In some stands a dense lower layer of shrubs or small trees is present. The ground layer is sparse and consists solely of tree seedlings. Three associations have been recognized which occur as parallel zones.

(i) Heritiera littoralis *Association.*—The association occupies a narrow zone on the landward edge of mangrove forest. *Heritiera littoralis* is abundant but a few other mangrove species occur, notably *Xylocarpus* sp., *Bruguiera gymnorrhiza,* and *Rhizophora mucronata.*

(ii) Bruguiera gymnorrhiza *Association.*—This community is found as a broad belt seaward of the *Heritiera littoralis* association. *Bruguiera gymnorrhiza* is abundant but other mangrove species occur, notably *Rhizophora mucronata.*

(iii) Rhizophora mucronata *Association.*—This association occurs in a wide band seaward of the *Bruguiera gymnorrhiza* association. *Rhizophora mucronata* is abundant; other species occurring include *Rhizophora apiculata* and *Bruguiera cylindrica.*

(*e*) *Fluctuating Swamp Forest Formation*

Fluctuating swamp forest has two tree layers. The upper layer, usually between 70 and 100 ft high, is composed of evergreen trees with predominantly simple leaves. The lower layer, 20–40 ft high, often consists of tall monocotyledons. Lianes are rare but epiphytes may be common. Buttressing is not marked and pneumatophores are rare. Two associations of this formation have been recognized.

(i) Bischoffia javanica–Metroxylon sagu *Association.*—Trees in the dominant layer belong to many species but usually 50% are *Bischoffia javanica.* Other important species are *Palaquium* sp. ("kwartowa"), *Terminalia canaliculata,* and *Alstonia scholaris.* The ground layer is composed predominantly of the sago palm, *Metroxylon sagu,* but other species occur, notably species of Myristicaceae and *Ficus* spp.

(ii) Bischoffia javanica–Pandanus *Sp. Association.*—This community is very similar to the *Bischoffia javanica–Metroxylon sagu* association. There are slight differences in the species present in the upper layer, but *Bischoffia javanica* is still abundant. The lower tree layer is composed largely of *Pandanus* sp. and *Metroxylon sagu.*

(*f*) *Mangrove Woodland Formation*

Mangrove woodland consists of a single-layered community of evergreen woodland trees. Buttressing is not common but prop roots and pneumatophores are abundant. Three associations are recognized.

(i) Ceriops tagal *Association.*—This association occurs as a narrow belt between the open sea and mangrove forest. The community consists of an almost pure stand of *Ceriops tagal* with occasional trees of *Rhizophora mucronata.*

(ii) Avicennia marina *Association.*—This association consists of a pure stand of *Avicennia marina.* The association is usually a closed woodland, 20–40 ft high, but in its most reduced form the association consists of scattered trees less than 20 ft in height, the intervening ground being bare.

(iii) Avicennia marina–Bruguiera gymnorrhiza *Association.*—This association consists of a closed woodland 20–30 ft in height. The most common species in the canopy layer are *Avicennia marina* and *Bruguiera gymnorrhiza.* The ground layer is moderately dense, approximately 3 ft high, and consists almost entirely of the fern *Acrostichum speciosum.*

(*g*) *Fluctuating Swamp Woodland Formation*

This formation is a single-layered community, consisting largely of tall monocotyledons. There are no shrub and ground layers. Three associations are recognized.

(i) Metroxylon sagu *Association.*—This association consists of an almost pure stand of the palm *Metroxylon sagu,* 20–40 ft in height. Other species which occur include *Ficus* spp., *Planchonella densinervia,* and *Planchonia timorensis.*

(ii) Pandanus *Sp. Association.*—This association consists of a pure stand of *Pandanus* sp. Transitionary stages between this community and the *Metroxylon sagu* association occur but are rare. They consist of a mixed stand of *Pandanus* sp. and *Metroxylon sagu.*

(iii) Nypa fruticans *Association.*—This association is very similar in appearance to the *Metroxylon sagu* association but lower, rarely exceeding 20 ft in height. The association consists of a pure stand of the palm *Nypa fruticans.*

(*h*) *Savannah Formation*

Savannah has a dense herbaceous ground layer with scattered trees 20–40 ft in height. It is very similar in structure to some of the disclimax grasslands in the area. Only one association in the formation has been recognized.

(i) Saccharum spontaneum–Neonauclea *Sp. Association.*—The association has a dense ground layer identical with the *Saccharum spontaneum* association described below. The scattered trees are largely *Neonauclea* sp.

(*i*) *Fern–Tall Tree Savannah Formation*

This formation consists of scattered tall trees up to 100 ft in height, and scattered smaller trees generally 20–40 ft high. The ground layer is dense and consists predominantly of ferns 4–6 ft high and scattered bushes 6–10 ft high. Only one association has been recognized.

(i) Acrostichum speciosum–Parinari corymbosum *Association*.—The tall trees are predominantly of one species, *Parinari corymbosum*. The smaller trees belong to many species including *Hibiscus tiliaceus* and *Dolichandrone spathacea*. The ground layer consists largely of *Acrostichum speciosum*, *A. aureum*, and bushes of *Acanthus ilicifolius*.

(*j*) *Mangrove Savannah Formation*

Mangrove savannah has a dense ground layer of ferns with scattered small trees; pneumatophores and prop roots are common. Only one association is recognized.

(i) Acrostichum speciosum–Avicennia marina *Association*.—This association has a ground layer consisting of *Acrostichum speciosum* and *A. aureum*, 2–6 ft in height. The scattered trees, approximately 20–30 ft in height, belong mainly to three species, *Avicennia marina*, *Rhizophora apiculata*, and Indet. ("gae", *m*).

(*k*) *Herbaceous Swamp Formation*

Herbaceous swamp is a single-layered community of herbaceous hydrophytes. Three main types of herbaceous swamp are recognized.

(i) *Herbaceous Swamp* (*Sedge*).—This community is extremely dense and 6–12 ft in height. In most stands *Thoracostachyum sumatranum* and *Hanguana malayana* are co-dominants but in a stand of herbaceous swamp south of Medino both species occur in pure stands. Other species are rare and include several Cyperaceae and grasses.

(ii) *Herbaceous Swamp* (*Tall Grass*).—This community is dominated by the grass *Phragmites karka* 10–14 ft high, but several other grass species, twining plants, and small trees are present. This community, occurring on sandy soils with fluctuating water-table, is probably a climax community but is very similar to some seral stages in Kopwei and Wakioka land systems.

(iii) *Herbaceous Swamp* (*Short Grass*).—The third type of herbaceous swamp is dominated by cf. *Saccharum spontaneum* 3 ft high, forming a pure stand.

IV. Disclimax and Seral Communities

(*a*) *Grassland*

Two alliances of disclimax grassland, the *Saccharum spontaneum–Imperata cylindrica* alliance and the *Themeda australis–Alloteropsis semialata* alliance, are recognized in the Wanigela–Cape Vogel area. The first of the alliances has been subdivided into four related suballiances. These grassland areas were originally covered by forest. They are the result of intensive native gardening and are being maintained by annual hunting fires. Each alliance and suballiance consists of a series of associations, the particular association present being dependent on the effect of the burning, the taller association occurring where the effect is less intense. Many factors can be correlated with the distribution of the associations through their effect on the severity of burning, thus tall associations in the series tend to be found in areas of higher rainfall, in depressions or other low-lying areas, in grass stands of small size particularly if distant from native settlement, and on deep or more fertile soils, particularly those of finer texture. The short associations tend to be found on well to excessively drained sites, on eroded and shallow soils, and in areas with a marked dry season, particularly in areas subject to frequent burning due to the proximity of villages.

(i) Saccharum spontaneum–Imperata cylindrica *Alliance*.—Four suballiances are recognized in this alliance.

(1) Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus *Suballiance*.—Mature stands of this suballiance are 6–12 ft in height before burning and very densely packed. After burning, blackened stems remain but the underground rhizomes are unharmed and the community rapidly regenerates. The dominant species in the majority of stands is *Saccharum spontaneum*, but in areas where the effect of burning is more intense the shorter grasses *Imperata cylindrica* and *Ophiuros exaltatus* may enter the community as co-dominants or may completely replace *Saccharum spontaneum*. In tall stands associated species are rare but they are of common occurrence in shorter stands. The most important of the associated species are the grasses, *Sorghum nitidum*, *Apluda mutica*, *Coelorachis rottboellioides*, and many species of Compositae, Cyperaceae, Leguminosae, and Euphorbiaceae, but no one species is particularly common. Small shrubs may be locally common, important species being *Desmodium heterocarpum*, *Bridelia* sp., *Melastoma malabathricum*, and *Crotalaria* spp. Scattered trees are generally present in stands of this suballiance, three species being common, *Nauclea orientalis*, *Antidesma ghaesembilla*, and *Albizia procera*, but many other tree species also occur.

(2) Saccharum spontaneum–Imperata cylindrica–Coelorachis rottboellioides *Suballiance*.—This community is very similar to the preceding suballiance, differing largely in the replacement of *Ophiuros exaltatus* by *Coelorachis rottboellioides* and in the fact that the shorter stages in the series of associations cover more extensive areas.

(3) Imperata cylindrica–Ischaemum barbatum *Suballiance*.—This community ranges in height from 2 to 6 ft and is mainly densely packed. The dominant species are *Saccharum spontaneum*, *Imperata cylindrica*, *Ischaemum barbatum*, *Alloteropsis semialata*, and in a few areas *Phragmites karka*. Associated herbaceous species are abundant, the most common being *Polygonum* sp., *Crinum asiaticum*, *Helminthostachys zeylanica*, Cyperaceae, Leguminosae, and Euphorbiaceae. Trees may be present, *Nauclea orientalis* being the most common species. This suballiance occurs on sites which were apparently once covered by stands of the *Saccharum spontaneum–Imperata cylindrica–Ophiuros exaltatus* suballiance. These sites are now flooded frequently but dry out and are regularly burnt each year.

(4) Saccharum spontaneum–Imperata cylindrica–Cymbopogon procerus *Suballiance*.—This community is 6–12 ft high but is somewhat open in structure. Most stands are dominated by *Saccharum spontaneum* but a few areas are dominated by *Imperata cylindrica*. Other species of tall grasses are *Cymbopogon procerus* and *Hymenachne amplexicaulis*. No other herbaceous species are common but many species occur, largely Leguminosae, Compositae, and a few grasses, notably *Ischaemum barbatum*. Shrubs are common, particularly *Crotalaria mucronata*. Scattered trees occur, the most abundant being *Timonius timon*. Other common tree species are *Nauclea orientalis*, *Antidesma ghaesembilla*, and *Albizia procera*, as well as many

species common in successions on recent alluvium. If burning is temporarily discontinued these trees soon dominate the succession and suppress the grass layer, as has happened over a large area to the south of Aku village.

(ii) Themeda australis–Alloteropsis semialata *Alliance*.—The different associations of this alliance have a continuous cover of grass before the annual burning and range in height from 2 to over 6 ft. However, regrowth after burning is usually slow and the community is generally open for several months. The sequence of dominants in the alliance with increasing severity of burning is *Saccharum spontaneum, Coelorachis rottboellioides* or *Ophiuros exaltatus, Imperata cylindrica, Themeda australis*, and *Alloteropsis semialata*. On any large stand two or more of these species may occur as local dominants.

The associated species vary considerably for the different associations. Tall associations are poor in associated species although somewhat richer than the taller stands of the *Saccharum spontaneum–Imperata cylindrica* alliance. Associations dominated by short grasses are much richer floristically: common associated species include the grasses *Sorghum nitidum, Eragrostis elongata, Eragrostis* cf. *brownii, Capillipedium parviflorum, Heteropogon contortus*, and *Ischaemum barbatum*, and numerous species of Cyperaceae, Leguminosae, Compositae, Euphorbiaceae, and Labiatae. Shrub species, notably *Desmodium heterocarpum* and *Melastoma malabathricum*, are common. Four tree species are often found as scattered individuals, *Timonius timon, Antidesma ghaesembilla, Nauclea orientalis*, and *Albizia procera*. Other tree species are common and in most cases these are species abundant in the surrounding gallery forest.

(*b*) *Regenerating Grassland*

The term regenerating grassland is used to cover all stages of the successions leading from disclimax grassland to rain forest, as a result of the cessation of burning. The majority of stands observed ranged from 30 to 45 ft in height but the tallest stand is over 75 ft.

In the shorter stands of the succession there is a single tree layer of moderate density. This tree layer is of a mixed composition, common species consisting of those trees characteristically found in grassland, species characteristic of garden regrowth, and some species characteristic of mature forest. The ground layer is moderately dense and consists largely of ferns, Cyperaceae, and Zingiberaceae with occasional plants of *Imperata cylindrica* and *Saccharum spontaneum*. In taller stands of regenerating grassland two tree layers are present. Here the typical grassland trees are rare, and are found largely in the lower tree layer. The most common species are species characteristic of advanced garden regrowth but a few species of mature forest are present.

When aerial photographs taken in 1942 and 1954 were compared no changes in pattern, height, and density of these regenerating grasslands could be discerned. Even those stands which were found by ground examination to be only 30 ft high appeared the same on both photographs, and thus their growth in height during the last 12 years must be less than 15 ft. This rate is extremely slow as garden regrowth on apparently comparable sites reaches a height of 30 ft in considerably less than 3 years.

(c) *Plant Successions on Flood Deposits*

Four groups of successions have been recognized on very recent river flood deposits. These are the *Casuarina* sp. successions, the *Octomeles sumatrana* successions, mixed successions on low-level distributaries, and a group of successions on stream beds.

(i) Casuarina *Sp. Successions*.—Following the formation of swampy alluvial fans by destructive floods, a low scrub growth rapidly springs up consisting largely of *Pandanus* sp., *Metroxylon sagu*, and tree seedlings. A high proportion of these young trees are *Casuarina* sp. nov. aff. *cunninghamiana*, which has a rapid growth rate and dominates the community. Other tree species form a second tree layer, important species being *Tetrameles nudiflora*, *Evodia* sp., and other species originally present in the area. The growth of *Casuarina* sp. continues until a height of over 160 ft is reached. At this stage most stands have three well-marked tree layers, at 160 ft, 100 ft, and 30 ft, and an ill-defined layer from 50 to 80 ft. The tallest layer consists solely of *Casuarina* sp., the other layers are of very mixed composition similar to the *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association, although *Pometia pinnata* is of rare occurrence. *Casuarina* sp. is very rare in these lower layers and it is apparent that the community will change to a mixed forest on the death of the trees in the dominant layer. The layer of *Pandanus* sp. and *Metroxylon sagu* present in the pioneer community persists until new stream beds have been cut and the drainage has improved. In most areas this layer disappears before the community has reached a height of 60 ft but may persist for a longer period.

Little information can be given on the rate of development of this succession. *Casuarina* sp. has a growth rate probably as rapid as *Octomeles sumatrana*, in which case the succession could reach a height of 160 ft in less than 100 years. No information is available on the life span of *Casuarina* sp. and it is not possible to estimate the time necessary for the development of mixed forest.

(ii) Octomeles sumatrana *Successions*.—Following destruction of the original vegetation by depositional floods, a mass of hydrophilous species regenerates with *Saccharum spontaneum* dominant in most stands, but in some sites *Pandanus* sp. or *Metroxylon sagu* is dominant. Seedlings of *Octomeles sumatrana* as well as other tree species are present in this pioneer community and *O. sumatrana* rapidly becomes dominant and grows to a height of over 150 ft. In this mature community the associated species are largely the same as those found in mature *Casuarina* sp. communities. It is expected that the dominance of *Octomeles sumatrana* does not persist for longer than 150 years, after which the community changes to a typical stand of the *Pometia pinnata* alliance.

(iii) *Mixed Successions of Low-level Distributaries*.—These successions mostly lead up to the climax of *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association. Differences between the successions are largely associated with drainage conditions. Areas flooded for long periods are colonized by a mass of many herbaceous species. Other areas which are occasionally flooded but which are seasonally very dry because of the coarse nature of the deposits are colonized by tall grasses, *Phragmites karka* on the poorly-drained and *Saccharum spontaneum* on the better-drained sites. These grasses reach a height of 12 ft and are gradually invaded by tree species, including *Parinari corymbosum*, *Glochidion* sp., *Nauclea orientalis*, *Albizia falcata*, and many species common in the *Pometia pinnata–Tetrameles nudiflora–Alstonia scholaris* association. Following the establishment of a closed tree layer further growth is generally rapid. Herbaceous stages of this succession are readily converted by burning into grassland of the *Saccharum spontaneum–Imperata cylindrica–Themeda intermedia* suballiance, but if burning is discontinued the succession is resumed.

(iv) *Stream Bed Successions*.—Several distinct successions occur on stream beds in the Wanigela–Cape Vogel area. Several streams draining Mt. Victory have a moderately steep course with a wide boulder-strewn bed. Coarse sand occurs between these boulders and in small sand banks. The stream usually covers only a portion of the bed but frequently changes position and a fresh succession is initiated along its old course. Grasses are prominent as early colonists on such sites, particularly *Saccharum spontaneum* and *Pennisetum macrostachyum*. Other pioneer species include many Cyperaceae and Compositae, the shrubs *Crotalaria mucronata* and *Cassia alata*, and tree species *Ficus* spp., *Leucosyke* sp. ("aejaeja"), *Pipturus argenteus*, *Euroschinus papuanus*, *Albizia falcata*, *Elaeocarpus* spp., *Pterocarpus indicus*, and *Octomeles sumatrana*.

In the streams crossing the alluvial plain north of the Owen Stanley Range, sand banks are rare. In successions on these areas *Casuarina* sp. is a primary colonist and usually dominates all stages. Other pioneer species are of minor importance.

(*d*) *Coastal Successions*

Two main groups of successions occur on coastal deposits.

(i) Ipomoea pes-caprae–Barringtonia asiatica *Succession*.—This succession normally occupies a belt 20 yd wide behind sandy beaches. The pioneer community is herbaceous with *Ipomoea pes-caprae* and *Ischaemum muticum* dominant. This is succeeded by a woody community up to 70 ft high. Tree species common in this community include *Barringtonia asiatica*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Thespesia populnea*, *Intsia bijuga*, and *Pterocarpus indicus*. This woody community is often destroyed by native gardening and a secondary succession is initiated.

(ii) Casuarina equisetifolia *Succession*.—This succession develops on recent river deltas. The primary colonist is *Casuarina equisetifolia*, which can develop to a height of over 70 ft. Such stands are rare, however, as development is usually prevented by native gardening.

(*e*) *Plant Successions on Volcanic Blast Areas*

(i) *Waiowa Blast Successions*.—Several distinct communities are found in the blast area of Waiowa volcano, which was formed in 1943. The greater part of the volcano is covered by an open community with the grasses *Saccharum spontaneum* and *Imperata cylindrica* dominant. On the lower slopes this community is invaded by a few species of small trees, *Euroschinus papuanus*, *Terminalia canaliculata*, *Pipturus argenteus*, and *Casuarina* sp. nov. aff. *cunninghamiana*. In small depressions these species form a low woodland with a dense ground layer of ferns and grasses, and with other tree species rare. A second woodland, up to 25 ft high, is found on the many small dry gullies which drain radially down the crater wall. In this woodland *Casuarina* sp. makes up over 80% of the dominant trees; other tree species present are *Euroschinus papuanus*, *Terminalia canaliculata*, *Octomeles sumatrana*, *Ficus pungens*, and *Pipturus argenteus*. The ground layer is very sparse but climbers are frequent.

The vegetation on the lahar deposits consists of grassland, up to 14 ft high, which is dominated by *Saccharum spontaneum* and in which small trees rarely occur. In addition, numerous small areas are still devoid of vegetation.

The largest part of the blast area is on the alluvial plain and is covered by an open forest community 60 ft in height. Up to 80% of the dominant trees are *Octomeles sumatrana*. Other species recorded include *Casuarina papuana*, *Nauclea orientalis*, *Albizia falcata*, *Dysoxylum* sp., *Alstonia spectabilis*, *Vitex cofassus*, and *Ficus* sp. ("fipo"). The dense ground layer consists of *Saccharum spontaneum*, *Imperata cylindrica*, and many fern species.

(ii) *Mt. Victory Blast Successions*.—Three main zones, a lowland zone below 2200 ft, a lower montane zone between 2200 and 3000 ft, and a montane zone above 3000 ft elevation, are recognized in the seral vegetation which followed the eruption of Mt. Victory in the last century.

The greater part of the lowland zone is covered by rain forest which in most stands exceeds 150 ft in height. *Octomeles sumatrana* and *Albizia falcata* are the most abundant species in the dominant layer and *Endospermum myrmecophilum*, *Artocarpus altilis*, *Elaeocarpus* sp. ("roroke"), *Tetrameles nudiflora*, *Canarium* spp., and *Ficus* spp. are common. These species are also common in the lower tree layer, in which *Octomeles sumatrana* and *Albizia falcata* are, however, rare. Many species of Myristicaceae, Palmae, Pandanaceae, *Macaranga* spp., *Ficus* spp., and *Litsea* sp. ("waure") are also common in this layer.

In one portion of the lowland zone (Wanigela land system) *Octomeles sumatrana* and *Albizia falcata* are not common and the predominant species are *Pometia pinnata* and *Tristiropsis subangula*. This area probably suffered less from the eruption than areas now dominated by *Octomeles sumatrana*. Areas of the lowland zone covered by lahar deposits carry forest ranging from 30 to 130 ft in height generally with only one or two tree layers and with a floristic composition very similar to the communities dominated by *Octomeles sumatrana* and *Albizia falcata*.

In the lower montane zone the vegetation is a two-tree-layered submontane rain forest, 90–120 ft high. The dominant species have been provisionally identified as one of the Dipterocarpaceae and *Syzygium* sp. The montane zone is covered by a two-tree-layered community from 20 to 40 ft in height. Occasionally there is only one tree layer present. The trees branch low and their trunks are completely covered by moss. This formation continues up to the maximum elevation examined at approximately 4000 ft.

V. References

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PART VIII. LAND-USE POTENTIAL OF THE WANIGELA–CAPE VOGEL AREA

By H. A. HAANTJENS*

I. SYSTEM OF LAND CLASSIFICATION

The system of land classification used in this report is adopted from the standard land classification system of the United States Soil Conservation Service.† Only minor alterations are made to suit the New Guinea environment.

In this classification scheme all land is grouped into eight land classes, denoted by Roman figures, which indicate the level of suitability of the land for different types of crop production. Each class except class I is subdivided into a number of subclasses, denoted by letter symbols, indicating the nature of the limiting factors because of which the land is placed in a particular land class. One of the modifications used in this report is that when the land-use potential is limited by two or more such factors, the most important one is given first, but the land class is determined by the combined effect of all factors listed.

The land classes and subclasses should not be considered as productivity or fertility classes in a narrow sense. For instance, yield levels of class I land, which is not subject to any limitations in land use, may be lower than those of class III land after the hazards limiting its use have been overcome by appropriate special measures.

The land classification in this area has been carried out on the basis of the units into which each land system is subdivided. The land classes and subclasses are indicated by their symbols and are included in the descriptions of the units in the land systems in Part IV.

II. LIMITATION OF THE ASSESSMENT

As the assessment has been based on very limited field investigations, it is possible that land will have to be transferred to other classes in some cases. Furthermore, the assessment is carried out on the basis of present-day agricultural practices and possibilities. Any major changes in such practices and possibilities in the future are likely to affect the classification, which should be revised in the light of the new concepts. However, it is unlikely that the subclass letter symbols will have to be changed, as there is little doubt about the nature of the limiting factors in the assessment in this report. Any development should be preceded by more detailed surveys and field trials and its economic viability should be assessed.

III. DESCRIPTION OF LAND CLASSES AND SUBCLASSES

Land classes I–IV are all suitable for cultivation, but in decreasing order, class IV being marginal for this form of land use. Land classes V–VIII are *not* suitable for cultivation.

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† A manual on conservation of soil and water. U.S.D.A. Soil Conserv. Serv. Agric. Handb. No. 61, 1954.

Class I land can be cultivated safely with ordinary farming methods. It is nearly level, has deep productive soils, is well drained and not subject to damaging floods. It is suited to most types of land use, including paddy rice growing, although this form of land use would involve special measures for water supply.

Class II land has some limitations. It requires simple special practices to maintain or reach optimal productivity under cultivation. Class II land can generally be used without special limitations for other types of land use, but tree crops require special measures where drainage is imperfect. Some areas are suitable for paddy rice growing.

Subclass IIe.—Susceptibility of this land to erosion requires simple control measures, under cultivation. These measures may be contour planting, strip cropping, short rotations with legumes or cover crops, mulching, simple terracing, etc.

Subclass IIst.—This land is sufficiently stony to interfere with the cultivation of row crops, but stones can be cleared without undue effort.

Subclass IIso.—This land has either very infertile soils or sandy soils with low moisture-holding capacity. The improvement and maintenance of soil productivity require more than normal attention and care.

Subclass IIst, so.—This land combines the limiting factors of subclasses IIst and IIso.

Subclass IId.—This land requires drainage improvement to reach optimum productivity, especially for tree crops and arable crops, but this can be achieved by simple means such as a small number of drainage trenches.

Subclass II (padi) d.—This land is very similar to subclass IId land, but its topography and soil are particularly suitable for paddy rice cultivation with simple water control measures.

Class III land requires intensive special measures to improve and maintain its productivity under cultivation. In many cases class III land can be used without special limitation for other forms of land use, but when the land is imperfectly drained, intensive measures are required for tree crops. Some areas are particularly suitable for paddy rice growing, but not very suitable for most tree crops.

Subclass IIIe.—The degree of erodability requires intensive erosion control measures when the land is cultivated, such as frequent rotation with grasses or legumes and intensive terracing. Very erosion-susceptible crops should not be grown.

Subclass IIIst.—This land is too stony for row crops and the removal of stones requires a major effort.

Subclass IIIe, st.—This land combines the limiting factors of subclasses IIIe and IIIst.

Subclass IIIso.—The soils are of moderately low to low fertility and very sandy with very low moisture-holding capacity. The improvement and maintenance of the productivity of this land when cultivated require intensive special measures such as frequent rotations with grasses and legumes, mulching, and frequent application of fertilizers. The choice of crops is limited by the low availability of moisture.

Subclass IIIst, so.—This land combines stoniness of class II or III with soil deficiencies of class II.

Subclass III (padi) so.—The soils are fine-textured, slowly permeable, very plastic, and difficult to till. This land is particularly suitable for pastures or paddy rice growing with simple terracing and water control measures. It is not very suitable for most tree crops.

Subclass III (padi) so, st.—This is very similar to subclass III (padi) so land but has the stoniness of class II.

Subclass IIId.—This land requires much-improved drainage by intensive measures such as the establishment of a network of drainage ditches, tile drainage, or, locally, mechanical disposal of excess water, especially for tree crops and arable crops.

Subclass III (padi) d, f.—Flood control on this poorly drained land appears possible by relatively simple means, such as low stop banks and improvement of natural drainage channels. Its low topography and fine-textured soils make it particularly suitable for paddy rice growing with simple water control measures, but less suitable for tree crops.

Class IV land is best maintained in perennial vegetation but can be cultivated occasionally or for a limited number of crops if handled with great care.

Subclass IVso.—This land has infertile soils which appear to be alternately waterlogged and suffering from water stress. It is suitable for grazing but can be cultivated only occasionally for a limited range of crops. It is only marginal for tree crops.

Subclass IVd, f.—This land is poorly drained and liable to flooding. Flood control and improvement of drainage are difficult to implement. It can be used for cultivation only during a short period of the year and the choice of crops is therefore limited. This land is unsuitable for tree crops. Pastures or forestry are the types of land use best adapted to this land.

Subclass IV (padi) d, f.—This is similar to subclass IVd, f land, but has fine-textured soils which could be used for paddy rice growing.

Subclass IV (padi) so, e.—This is land with the erodability of class II or III and with fine-textured, slowly permeable, very plastic soils. Its suitability for cultivation and tree crops is very limited, but it is suitable for pastures or terraced paddy rice growing with simple water supply measures.

Subclass IV (padi) d, so.—This land is poorly drained and has fine-textured, slowly permeable, very plastic soils. It can be used for cultivation during a short period of the year but is particularly suited to paddy rice growing with simple water supply measures. It is also suitable for grazing and forestry.

Class V land is nearly level, not subject to erosion, and has productive soils, but it is unsuitable for cultivation because of other factors. It is productive grazing or forestry land and is in some cases suitable for tree crops or paddy rice cultivation.

Subclass Vd, f.—This land is poorly or very poorly drained and subject to serious flooding. Flood control and drainage are not feasible. The land is also stony in some places. It is unsuitable for tree crops, but suitable for pastures or forestry.

Subclass Vst.—This land is too stony for cultivation and the stones are too numerous to be removed. It is moderately suitable for grazing and tree crops and very suitable for forestry.

Subclass V (padi) d, so.—This land is poorly or very poorly drained and has fine-textured, slowly permeable, very plastic soils. Improvement of drainage is very difficult. This land is particularly suitable for paddy rice growing with simple water supply measures. It is also suitable for grazing but less suitable for forestry.

Class VI land is subject to moderate limitations for pastures or forestry. Some subclasses are also moderately suitable for tree crops.

Subclass VIe.—This land has such erosion hazards that it is suited to pastures or forest only under careful management. It is also suitable for tree crops, provided measures are taken to prevent erosion.

Subclass VIso.—The soils are too shallow and infertile for tree crops. The land is only moderately suitable for pastures or for forestry.

Subclass VIe, so.—The combination of moderately steep slopes and shallow or very infertile soils makes this land suitable for pastures or forestry with only moderate limitations, but it is only marginal for tree crops.

Subclass VIe, st.—A combination of erosion hazards and stoniness makes this land suitable only for tree crops and forestry and moderately suitable for pastures.

Subclass VIso, st.—The combination of very sandy or very shallow, infertile soils and too many stones to be removed makes this land only moderately suitable for pastures. It is unsatisfactory land for tree crops but is suitable for forestry without many limitations.

Subclass VId, f.—This poorly drained land carries a serious risk of damaging floods. Although the drainage can be improved by simple means, the land is suitable only for rather extensive grazing and for forestry.

Class VII land is subject to severe limitations for pastures or forestry. One subclass can also be used for tree crops.

Subclass VIIe.—The limitations of this subclass are similar in nature but more severe than those of subclass VIe. It is very difficult land to manage, even for forestry.

Subclass VIIe, so.—The combination of steep slopes and very shallow or very infertile soils makes this land unsuitable for tree crops and severely limits its suitability for pastures and forestry.

Subclass VIIso, st.—The combination of very shallow and very sandy or very infertile soils and excessive stoniness makes this land suitable only for extensive grazing or forestry.

Subclass VIIst, so, f.—The combination of very coarse-textured infertile soils, a high degree of stoniness, and flooding prevents the use of this land other than for extensive grazing and forestry.

Subclass VIId.—This land is very poorly drained. The ground water is probably brackish. Drainage cannot easily be improved. The land is of poor quality and can be used only for extensive grazing.

Subclass VIIf, so.—This land is subject to frequent flooding and has poor, coarse-textured soils. It can be used for seasonal extensive grazing, but seems little suitable for forestry.

Subclass VIIp, s.—This is swampy land, which is difficult to reclaim and is suitable only for sago or paddy rice grown under primitive irrigation conditions.

Class VIII land has such unfavourable characteristics as to be unsuited to cultivation, tree crops, grazing, or forestry. In many cases it is important for watershed protection. Some of this land is covered by good forest, but its exploitation would be very difficult. Class VIII land has also been subdivided into subclasses according to the nature of the limiting factors, but these subclasses are merely of academic interest and do not require further explanation and definition.

IV. Regional Land-use Potential

The assessment as described and applied in the foregoing gives as detailed a picture of the land-use potential of the area as can be expected from this type of survey. However, it does not provide the reader with a general outline which would enable him to visualize the broad land-use potentialities in the area as a whole. To give this kind of information the land systems have been grouped into four categories of land-use potential, each subdivided according to general land form characteristics (Table 9). These land-use groups are shown on an inset map on the accompanying land system map. The boundaries are generalized because of the small scale.

(*a*) *Land with Moderately High Land-use Potential*

(i) *Uplands*.—This comprises level land with deep but rather infertile soils, which are commonly somewhat stony. It is locally broken by incised streams. It carries good natural forest and is primarily suitable for tree crops, but some areas could also be used for cultivation and the land is suitable for pastures.

(ii) *Plains*.—This is level land with fertile deep soils which are, however, poorly drained in low-lying areas and partly subject to flooding. Much of the land is primarily suitable for cultivation or pastures, the higher parts also for tree crops that are adapted to neutral or calcareous soils. Locally, stoniness could render cultivation difficult. Many lower-lying areas should be suitable for paddy rice and land subject to flooding is probably best used for pastures or forestry. Large areas are covered with good natural forest.

(*b*) *Land with Moderate Land-use Potential*

(i) *Hills*.—This small area with rather steep slopes but deep, though rather infertile, soils is suitable for tree crops or grazing, but not for cultivation. It is covered with good natural forest.

(ii) *Uplands*.—These volcanic slopes have areas of good, deep soils, suitable for cultivation with appropriate measures to control erosion. Such land is very suitable for tree crops. Large areas have slowly permeable soils, unsuitable for tree crops and only marginal for cultivation. This land should be good pasture land and some could be used for paddy rice growing with simple terracing. Stoniness would be an obstacle to cultivation in many parts of this subgroup. Large-scale agricultural operations and communications around Mt. Victory would be difficult in view of the broken nature of many of the volcanic slopes. The north-western part is so dissected that it could be used only for forestry. Large areas of good natural forest exist in the area.

TABLE 9

GROUPING OF LAND SYSTEMS INTO LAND-USE GROUPS WITH THEIR PRINCIPAL CHARACTERISTICS

Land-use Groups				Component Land Systems	Principal Land Classes
Level of Agricultural Potential	Approx. Area (sq miles)		Nature of Terrain		
Moderately high	380	15	Uplands	Rakua	II, III
		365	Plains	Wanigela, Uiaku, Ismari, Buna	I, II, III, IV (mostly complex)
Moderate	305	20	Hills	Budi	VI (erosion hazards only)
		160	Uplands	Kwin	Mixture of II, III, IV, VI
		125	Plains	Monari, Dove	IV or mixture of III, IV, and V
Low	400	255	Hills	Bekalama, Bewabewa, Tarakaruru	VI–VII
		145	Plains	Kopwei, Wakioka	Mixture of IV–VIII or V and VI
Very low or nil	660	420	Mountains	Maneau, Didana, Trafalgar, Tama, Victory plus small part of Sesegara	VII, VIII
		225	Hills	Sesegara, Koianaki plus small part of Victory	VII
		5	Uplands	Tokinawara	VII
		110	Swamps	Tortore, Killerton	VII–VIII

(iii) *Plains*.—Cultivation of this level land is possible only for a limited range of crops or during a limited period of the year, because of the slowly permeable, poorly drained clay soils in Monari land system and because of poor drainage and flood hazards in Dove land system. There appears to be scope for paddy rice growing, particularly in Monari land system. Planting of tree crops is not recommended, except on the higher parts of Dove land system. All this land should be suitable for grazing.

(c) *Land with Low Land-use Potential*

(i) *Hills*.—Shallow and locally infertile soils and steep slopes are the principal limitations in this area and generally rule out cultivation and tree crops. Small level areas in Tarakaruru land system have better soils but commonly too much rock outcrop. Most of this land could be used only for extensive grazing, with possibilities for more intensive grassland management on flatter areas. There is very little good natural forest and reafforestation would present problems where the soils are very shallow. Careful management is needed to protect associated valley land in Monari land system against flooding.

(ii) *Plains*.—The land-use potential of this land is low because of very coarse-textured soils and/or very poor drainage and the risk of damaging depositional floods. Land use would appear to be restricted to extensive grazing and forestry, although forest establishment may locally present problems. Rather large areas of tall *Casuarina* sp. forest are present in Wakioka land system.

(d) *Land with Very Low or No Land-use Potential*

(i) *Mountains*.—Probably 80% of this land has no potential for development, because of the rugged nature of the terrain. The remainder, mainly along the margins, may offer some possibilities for forest exploitation. Most of the land is covered by rather poor forest and the maintenance of a protective vegetation cover is essential, as this group includes the most important catchment areas. Disturbance could easily lead to increased flooding and silting in the potentially valuable lowlands.

(ii) *Hills*.—Land of this subgroup is characterized by steep slopes and very shallow or stony soils, which make it unsuitable for anything except extensive grazing. There are only small areas of natural forest and these are of poor quality. Reafforestation to protect associated valley land and for local timber and fuel supply would be of value in Koianaki land system, but might be difficult to achieve.

(iii) *Uplands*.—This very small area is mostly level, but has such poor, stony soils that it is suitable only for extensive grazing. Reafforestation might be possible.

(iv) *Swamps*.—The freshwater swamps of Tortore land system are partly unsuitable for any form of land use and partly suitable only for the cultivation of swamp rice with natural basin flooding. Rather small and scattered areas are rich in sago. It might be possible to reclaim parts of the swamps in major projects. This would produce fertile land suitable for cultivated crops and pastures. The brackish-water swamps of Killerton land system are unsuitable for any land use other than the exploitation of the mangrove forests.

PART IX. FOREST RESOURCES OF THE WANIGELA–CAPE VOGEL AREA

By J. C. SAUNDERS* and B. W. TAYLOR†

I. INTRODUCTION

The aim of this Part is to indicate areas of potentially important forest in the Wanigela–Cape Vogel area. Stocking rates quoted are only approximate and have been obtained by a comparison of assessments on areas of crown-land at Wanigela, Sinapa, and Kwagira, made by the Department of Forests of the Territory of Papua and New Guinea, with assessments made in the field during ecological investigations. The results have been extrapolated by means of air-photo interpretation. The forested areas are concentrated mainly in the Cape Nelson–Wanigela–Kwagira River region, with isolated areas on Cape Vogel. They are shown on the accompanying forest resources map.

II. CLASSIFICATION OF FOREST TYPES

(a) *Grouping of Forested and Non-forested Land*

For forestry purposes the area has been classified into three broad groups, productive forest on gentle topography, productive forest on steep or rugged topography, and other areas.

(i) *Productive Forest on Gentle Topography*.—This forest has a minimum stocking rate of 3000 super ft per acre of commercial timber, and is situated on flat or gently sloping land where the general slope is not greater than 12° and dissection is only slight to moderate. The total area in this group is approximately 630 sq miles.

(ii) *Productive Forest on Steep or Rugged Topography*.—This forest has a minimum stocking rate of 3000 super ft per acre of commercial timber and is situated in areas with a general slope of more than 12° or on severely dissected areas. This group covers an area of 320 sq miles.

(iii) *Other Areas*.—These include all forested and unforested land not included in (i) and (ii). The timbered regions of this group usually represent secondary forest and advanced regrowth stages of the forest types described in Section III, and swamp forest. Many such forests are capable of yielding supplies of timber for local consumption.

(b) *Floristic Classification of Productive Forests*

The productive forests in the area have been classified floristically into types and subtypes and in the descriptions of the types and subtypes reference has been made to the above group or groups in which they occur.

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The following floristic types and subtypes have been recognized:

(*a*) *Pometia pinnata* mixed forest
- (i) With a high stocking rate
- (ii) With a low stocking rate
- (iii) *Pometia pinnata–Tristiropsis subangula* forest

(*b*) *Terminalia canaliculata–Bischoffia javanica* forest

(*c*) *Anisoptera kostermansiana–Intsia bijuga* forest

(*d*) *Casuarina* sp. forest
- (i) Pure stands
- (ii) Mixed stands
- (iii) Immature stands

(*e*) *Octomeles sumatrana* forest
- (i) Mature stands
- (ii) Immature stands

(*f*) *Octomeles sumatrana–Albizia falcata* forest
- (i) *Octomeles sumatrana–Albizia falcata* dominant stands
- (ii) Mixed stands

(*g*) *Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa* forest

(*h*) *Anisoptera kostermansiana–Alstonia scholaris–Rhus taitensis* forest

(*i*) *Lithocarpus* sp.–*Cryptocarya* sp. forest

(*j*) Mangrove forest

III. Description of Productive Forest Types

(*a*) Pometia pinnata *Mixed Forest*

All areas of this type are on gentle topography.

(i) *With a High Stocking Rate*.—This subtype covers extensive areas of the alluvial plain flanking the Owen Stanley Range and of the lower slopes of Mt. Victory, totalling 230 sq miles. It is a mature forest with a canopy level at about 150 ft and a high stocking rate, approximately 8000 to 10,000 super ft per acre. *Pometia pinnata* is the most common species present and probably amounts to 10–20% of the commercial timber. Other species with relatively high stocking rates are *Tetrameles nudiflora*, *Syzygium* spp., *Terminalia* spp., *Tristiropsis subangula*, *Dracontomelum* sp., *Anisoptera kostermansiana*, *Intsia bijuga*, *Canarium* spp., *Alstonia scholaris*, *Planchonia timorensis*, *Pterocymbium beccarii*, *Pterocarpus indicus*, *Celtis* sp., *Ficus* spp., *Litsea* sp., *Elaeocarpus* sp., and *Sterculia* sp., and there are numerous other species present in small quantities.

(ii) *With a Low Stocking Rate*.—This subtype is also situated on the alluvial plain flanking the Owen Stanley Range and is adjacent to the forest with high stocking rate. It has a similar floristic composition, but is less dense because of the effects of native gardening. The stocking rate is far smaller than that of the main type, but is still high enough to be classified as a commercial productive forest. The area of this subtype is 25 sq miles, with an estimated stocking rate of 3000–3500 super ft per acre.

(iii) Pometia pinnata–Tristiropsis subangula *Forest*.—This subtype covers part of the blast area, 10 sq miles, on the south-eastern slopes of Mt. Victory. The stocking rate is high, about 10,000–12,000 super ft per acre, and the canopy level varies from 100 ft to 150 ft. *Pometia pinnata* and *Tristiropsis subangula* comprise over 20% of individual trees present and the other common species are *Albizia falcata*, *Endospermum medullosum*, *Elaeocarpus* sp., *Artocarpus altilis*, *Tetrameles nudiflora*, *Pterocymbium beccarii*, *Litsea* sp., *Canarium* spp., and *Ficus* spp.

(*b*) Terminalia canaliculata–Bischoffia javanica *Forest*

This forest type on gentle topography generally occupies rather poorly drained alluvial deposits usually bordering swamp communities. It normally has indefinite boundaries but its approximate area is 80 sq miles. The canopy level averages 110 ft and the stocking rate is about 6000–8000 super ft per acre. Floristically the type contains up to 20% of *Terminalia canaliculata* and/or *Bischoffia javanica*. Other common species include *Neonauclea* sp., *Planchonia timorensis*, *Dysoxylum* spp., *Syzygium* spp., and *Ficus* spp., together with many other species in smaller quantities. The topographically low position and poor drainage probably make access difficult during the wet season.

(*c*) Anisoptera kostermansiana–Intsia bijuga *Forest*

This forest on gentle topography covers an area of hilly country south of Baiawa village and is also found on the numerous small hills arising from the alluvial plain flanking the Owen Stanley Range. The area at the western end of Cape Vogel is about 10 sq miles, with a stocking rate of 3000–5000 super ft per acre, whereas the small hills on the alluvial plain carry 35 sq miles of forest with a stocking rate of 5000–6000 super ft per acre. The canopy level is generally at 110–120 ft and approximately 30–50% of the upper layer consists of *Anisoptera kostermansiana* and *Intsia bijuga*. Numerous other species are present, the most common being *Tristiropsis* sp., *Syzygium* sp., *Ficus* spp., and *Canarium* sp.

(*d*) Casuarina *Sp. Forest*

This type is found on recent alluvial fans in the upper part of the alluvial plain flanking the Owen Stanley Range and in the blast area of Waiowa volcano. Although it occurs on gentle topography, some areas may be liable to damaging floods.

(i) *Pure Stands*.—The total area of this subtype is approximately 5 sq miles with a stocking rate of more than 15,000 super ft per acre. *Casuarina* sp. nov. aff. *cunninghamiana* predominates, accounting for 80% or more of the timber present, and although the girths of individual trees are never very large, the general height attained is in excess of 160 ft and the stands are dense. Many other species, attaining a height of 120–150 ft, occur but are relatively rare. They include *Tetrameles nudiflora*, *Evodia* sp., *Pometia* sp., *Litsea* sp., *Alstonia* sp., *Vitex cofassus*, and *Tristiropsis subangula*.

(ii) *Mixed Stands*.—The total area of this subtype is approximately 30 sq miles with a stocking rate of 8000–10,000 super ft per acre. The canopy level of the forest is about 150 ft and *Casuarina* sp. comprises 10–80% of the timber present. Other species mentioned in the description of the pure stands are common and amount to a considerable proportion of the timber present.

(iii) *Immature Stands.*—These forests cover an area of 40 sq miles and at present they are non-commercial. If not disturbed by disastrous floods before maturity, they should develop into good commercial forest as the areas are not used for native agriculture. For this reason they are included in the productive forest group.

(*e*) Octomeles sumatrana *Forest*

All areas of this type occur on gentle topography.

(i) *Mature Stands.*—This subtype occupies only a small area, less than 1 sq mile, on the lower part of the alluvial plain flanking the Owen Stanley Range. It has a very high stocking rate, 15,000 super ft per acre, and over 60% of timber present is *Octomeles sumatrana*. Numerous other species, similar to those listed under the *Pometia pinnata* mixed forest type, are present. Access within the area during the wet season may be affected because of poor drainage.

(ii) *Immature Stands.*—An area of 10 sq miles of this subtype occurs on the blast area of Waiowa volcano. The forest is 60 ft high, and is dominated by *Octomeles sumatrana*. Providing it is allowed to mature, the forest is expected to be productive within 50 years' time and up to 90% of the timber present will consist of *Octomeles sumatrana*.

(*f*) Octomeles sumatrana–Albizia falcata *Forest*

Because this type is found on the blast area of Mt. Victory, a relatively small number of species of mill size are present, but this number is probably in excess of 10. A high percentage of these are rapidly growing species.

(i) Octomeles sumatrana–Albizia falcata *Dominant Stands.*—Of this subtype, approximately 15 sq miles on gentle topography and 15 sq miles on rugged topography are present on the blast area on the lower slopes of Mt. Victory. The level of the canopy is over 150 ft and the stocking rate is about 12,000–15,000 super ft per acre. *Octomeles sumatrana* and *Albizia falcata* comprise 50% of the stand. The other species present include *Endospermum medullosum*, *Elaeocarpus* sp., *Artocarpus altilis*, *Tetrameles nudiflora*, *Pterocymbium beccarii*, *Litsea* sp., *Canarium* sp., and *Ficus* spp.

(ii) *Mixed Stands.*—Areas covered by this subtype are fairly extensive. There are approximately 70 sq miles on gentle topography and about 25 sq miles on rugged topography on the southern and western lower slopes of Mt. Victory. The subtype has a stocking rate of about 10,000–12,000 super ft per acre and the canopy level is at 150 ft. The species present are similar to the *Octomeles sumatrana–Albizia falcata* subtype but *Octomeles sumatrana* and *Albizia falcata* comprise less than 20% of the individual trees present.

(*g*) Planchonia timorensis–Pterocarpus indicus–Terminalia microcarpa *Forest*

This forest is found on Cape Vogel on flat or gently sloping alluvium in the river valleys. It covers an area of 30 sq miles and has a stocking rate of 3000–4000 super ft per acre. The canopy level averages 70 ft and the main species present are

Planchonia timorensis, *Pterocarpus indicus*, and *Terminalia microcarpa*. Other species present include *Intsia bijuga*, *Anisoptera kostermansiana*, *Terminalia* spp., *Syzygium* sp., *Bischoffia javanica*, *Cordia dichotoma*, *Maniltoa* sp., *Alstonia scholaris*, *Serianthes kanehirae*, and *Ficus* sp. Access may be affected by flooding during the wet season.

(*h*) Anisoptera kostermansiana–Alstonia scholaris–Rhus taitensis *Forest*

Approximately 95 sq miles of this type, which has a stocking rate of 6000–8000 super ft per acre, is found on the steep and rugged slopes of Mt. Trafalgar. The canopy level is slightly over 100 ft in height. *Anisoptera kostermansiana*, *Rhus taitensis*, and *Pterocarpus indicus* are often locally abundant and other species, *Alstonia scholaris*, *Ficus* spp., *Canarium* spp., and *Ganophyllum falcatum*, though never locally abundant, are consistently present.

(*i*) Lithocarpus *Sp.*–Cryptocarya *Sp. Forest*

This type is found on the Owen Stanley Range, normally at higher altitudes. Only small areas have been investigated and very little is known about the floristic composition. A conservative estimate of its stocking rate would be about 3000 super ft per acre. It is found only on steep or rugged topography and covers an area of 185 sq miles within the area mapped.

(*j*) *Mangrove Forest*

The total area of this type is approximately 40 sq miles but most of this area is occupied by scattered small stands. It has a stocking rate of about 3000 super ft per acre and the canopy rarely exceeds 80 ft in height. The main species present are *Bruguiera* spp. and *Rhizophora* spp. but *Heritiera littoralis* and *Xylocarpus granatum* also occur. Although this forest occurs on flat land, access to these tidal flats is commonly difficult.

APPENDIX I

Analytical Data of Soil Families, arranged in Alphabetical Order*

Soil Family and Profile Number	Depth (in.)	Coarse Sand (2000-200μ) (%)	Fine Sand (200-20μ) (%)	Silt (20-2μ) (%)	Clay (<2μ) (%)	Organic Matter† (%)	Nitrogen (%)	C/N Ratio	P-HCl (%)	pH	Exchangeable Cations: C.E.C.‡ (m-equiv. %)	Ca (m-equiv. %)	Mg (m-equiv. %)	K (m-equiv. %)	Na (m-equiv. %)	Saturation (%)
Ambon (P8)	0–11	12	32	22	31	4	0·18	13	0·03	5·8	13	4·3	3·4	0·5	0·3	65
	17–33	10	19	15	55	1·5	0·07	12	0·04	5·8	13	3·9	4·1	0·3	0·4	67
	33–42+	15	29	14	40				0·07	6·0	13	4·4	4·4	0·2	0·6	73
Bereruma (P4)	0–12	14	24	32	29	11	0·47	14	0·04	6·8	30	7·1	20	0·6	0·3	94
	18–30	16	24	23	36					7·5						
Ginada (P20)	3–7	2	11	15	71	9	0·29	18	0·06	6·6	61	60	2·8	0·3	0·3	100
Guruguru (P6)	0–8	17	43	17	18	4	0·17	13·5	0·03	5·8	9·5	3·4	1·1	0·2	0·2	52
	8–23	11	33	12	45				0·01	6·4	16	4·6	8·8	0·2	0·2	87
(P16)	15–20	15	24	17	44		0·04		0·01	5·9	15	7·9	4·9	0·2	0·3	91
Ibiduwa (P18)	0–5	2	10	23	61	11	0·34	12	0·05	6·5	67	43	24	1·6	1·0	100
	5·18	1	9	20	69		0·09		0·02	6·4	70	41	32	0·5	1·0	100
	18–24+	2	7	23	67					6·5						
Ilamarora (P9)	0–5	15	39	25	21		0·24		0·07	5·7						
	9–16	5	18	23	51				0·05	5·7						
	21–30+	7	22	27	44				0·06	5·3						
Maneau (P21)	1–6	29		21	49	6	0·29	12·5	0·04	4·6	15	1·2	1·5	0·4	1·3	30
	6–14	10	23	30	37		0·06		0·02	4·6	28	0·3	1·3	0·2	0·6	9
	14–26	10	27	33	34					4·6						
	26–36+	6	27	36	31				0·02	4·8						
Ma-U (P22)	0–4	8	27	21	42	9·5	0·53	10·5	0·09	6·0	15	6·1	5·7	0·7	0·5	87
	4–9	5	22	22	49	4·5	0·29	10	0·08	5·4	6	0·9	2·4	0·3	0·4	70
	9–22	5	19	19	57		0·15		0·08	5·4	3	0·8	1·3	0·2	0·3	79
	22–38	4	23	15	58		0·07		0·06	5·3	2	0·8	0·8	0·2	0·2	100
	38–44+	6	27	16	51					5·3						
Oreia (P10)	0–8	44		21	32	8	0·34	13·5	0·06	5·6	13	3·1	2·8	0·5	0·3	53
	8–17	5	15	23	56	4	0·14	16	0·04	5·3	9	1·1	0·7	0·2	0·3	25
	22–36	1	14	27	58		0·06		0·04	5·3	4·5	0·7	0·3	0·2	0·3	33
	33–46+	3	20	31	46				0·04	5·4						

(P13)	2–7	9	10	18	58	8	0·26	18	0·06	5·4	11	1·9	2·5	0·5	0·4	48
	7–15	8	11	22	58	3	0·11	17	0·05	5·3	8	0·7	0·3	0·3	0·3	19
	15–30	2	13	29	56				0·04	5·4	6·5	0·6	0·2	0·2	0·3	20
	30–39	2	18	33	46					5·3						
	39–43+	5	31	32	32				0·04	5·3						
Penari (P11)	0–8	14	42	32	10		0·27		0·07	5·8						
	8–13	10	40	29	20				0·04	5·7						
	15–28	16	44	22	18				0·01	5·9						
(P15)	0–9	17	35	17	17	9	0·46	11·5	0·09	5·9	12	5·4	2·4	0·5	0·4	72
	9–18	16	48	19	10	7	0·34	12·5	0·07	5·7	6·5	1·7	0·7	0·2	0·4	46
	18–34	36	50	8	6		0·18		0·05	5·6	3	1·2	0·2	0·2	0·4	62
	34–44+	29	50	13	5				0·01	5·5						
Podago (P23)	0–6	21	21	21	27	6	0·23	15·5	0·10	6·1	27	15	9·8	0·6	0·2	95
Utah (P1)	0–2	15	30	15	29	10	0·48	12·5	0·05	6·1	22	14	5·4	0·3	0·2	91
	2–12	16	33	18	33	3	0·17	9·5	0·03	5·8	12	4·2	4·3	0·1	0·2	74
	12–23	15	22	18	42	1	0·06	10	0·02	5·6	10	2·9	5·7	0·1	0·4	91
	23–35	19	26	17	37				0·02	5·6	9	1·2	6·4	0·1	0·6	95
	35–60	25	35	19	20					6·2						
	70–80+	29	44	14	11					6·6						
Wabubu (P19)	0–4	4	9	18	67	10	0·38	15·5	0·08	5·8	22	12	5·6	0·6	0·4	86
	4–8	3	11	13	72	6·5	0·23	16·5	0·07	5·5	14	6·2	3·0	0·3	0·3	69
	8–12	3	9	11	77				0·07	5·4	11	5·0	1·8	0·2	0·2	65
	12–30	1	3	3	94				0·06	5·6						
Medium-textured	0–12	3	44	24	22	5	0·29	11	0·10	7·2	21	20	2·4	0·2	0·3	100
alluvial soils (P3)	12–24	4	66	18	12	1	0·06	8	0·06	7·6§	7	6·2	1·1	0·1	0·2	100
	31–38	2	33	43	18				0·10	8·5§	9			0·05	0·5	100
	42–48+	2	61	12	9					8·9§						
(P17)	0–6	51		24	24	5	0·24	12	0·10	6·5	29	25	6·0	0·3	0·3	100
	6–23	1	60	21	14				0·07	6·8	23	18	6·5	0·2	0·3	100
	30–36+	3	52	23	22					7·0						

* Carried out by Division of Soils, Adelaide, under supervision of J. T. Hutton.

† Percentage organic carbon multiplied by 1·7.

‡ Direct determination.

§ Contains free $CaCO_3$.

INDEX TO LAND SYSTEMS, SOIL FAMILIES, AND VEGETATION COMMUNITIES

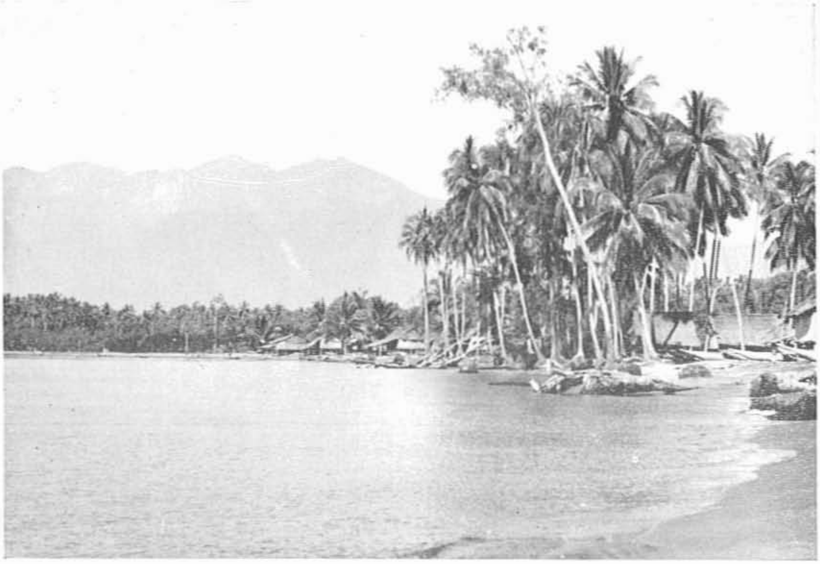

Fig. 1.—Like many other parts of New Guinea the Wanigela–Cape Vogel area is characterized by great contrasts in relief. Only the lower parts of the Owen Stanley Range, consisting mainly of metamorphic rocks, are included in the area. Mt. Suckling in the background is 12,000 ft. The indigenous population is largely concentrated in a narrow zone along the coast. Many villages with coconut groves are situated on the low beach ridges of Buna land system.

Fig. 2.—The largest areas suitable for agricultural development (Uiaku land system) occur in the densely forested alluvial plains between the Owen Stanley Range and the coast. This land is commonly rather stony near the foot of the mountains and poorly drained near the coast. Patches of grassland in the coastal zone indicate past intensive occupation by shifting cultivation.

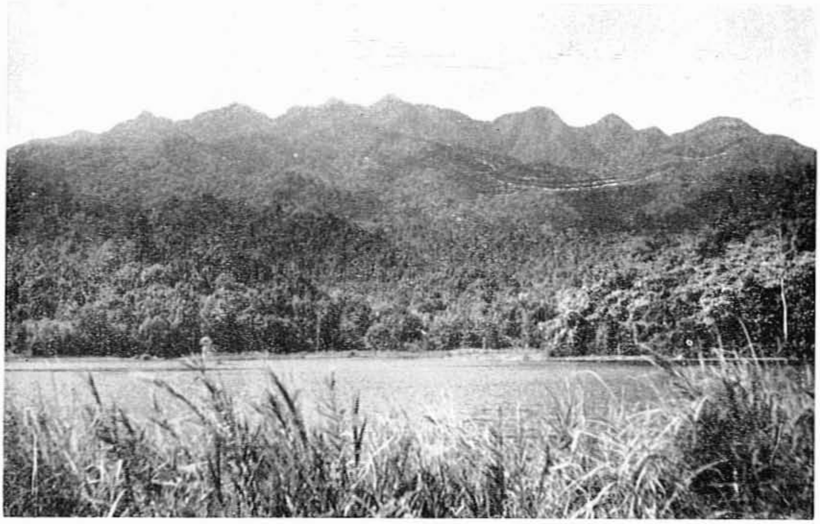

Fig. 1.—Mt. Trafalgar (5600 ft), a strongly dissected extinct volcano, forms a major relief element in the northern part of the area. This extremely rugged terrain (Trafalgar land system) is virtually unsuitable for development and should be left under its protective forest cover as a major catchment area. Lake Mogana was formed by the blocking of a valley by outwash fan deposits from the dormant volcano Mt. Victory.

Fig. 2.—The northern foot slopes of Mt. Trafalgar (Bekalama land system) consist of agglomerate and tuff and form undulating to hilly interfluves separated by deep, U-shaped valleys. Their lower parts are drowned and form some of the best natural harbours in the area. Although the soils are poor, the interfluves are rather densely populated and the forest vegetation has been largely replaced by garden regrowth and grassland.

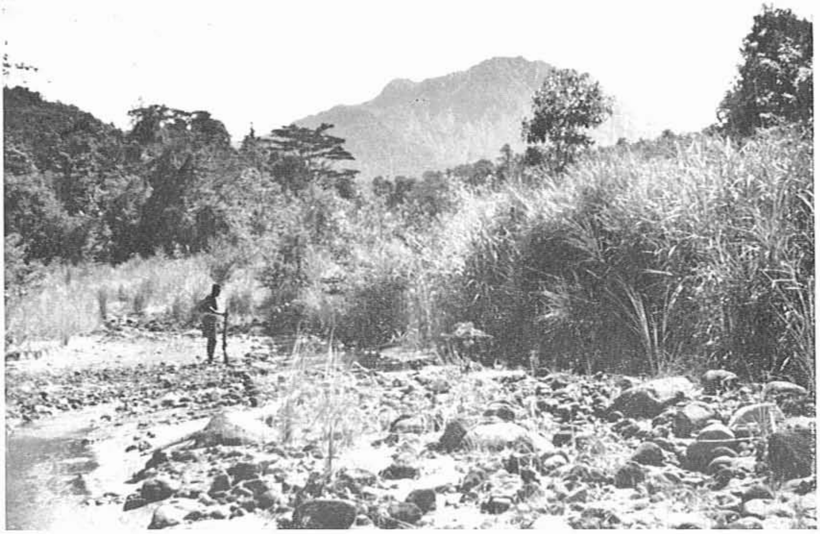

Fig. 1.—South-west of Mt. Trafalgar the dormant volcano Mt. Victory rises to 6000 ft. The summit (Victory land system) consists largely of volcanic domes and lava flows. Wedged between the two mountains are young unstable outwash fans of Kopwei land system. They comprise much stony land and alluvial land covered by pioneering successional vegetation, locally dominated by cane grass (*Saccharum spontaneum*).

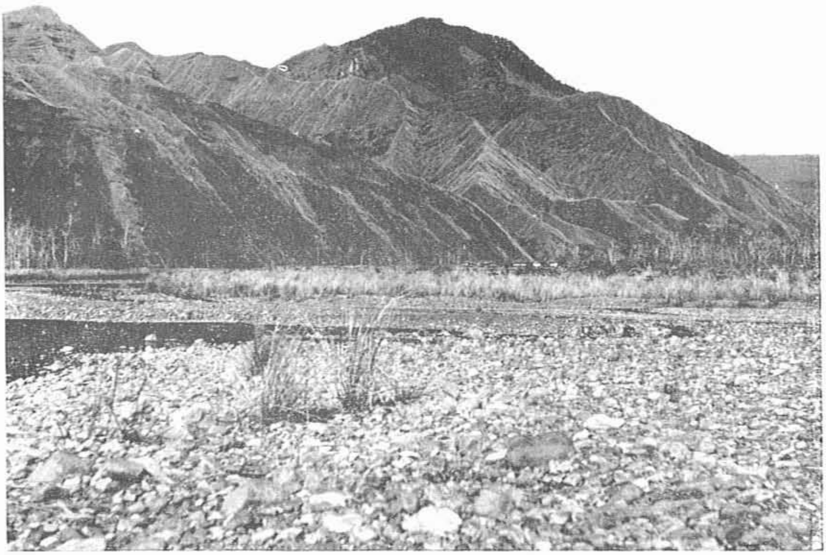

Fig. 2.—Tama land system comprises the highest (up to 2400 ft) and most rugged part of the Tertiary sedimentary sequence in the eastern, drier part of the area. The tilted and strongly bedded coarse sediments have been dissected into razor-backed ridges. Shifting cultivation on the very shallow soils has led to a rapid conversion of the forest to poor *Themeda* grassland. Gravelly outwash fans mapped as part of Wakioka land system occur north of the sharp, fault-controlled boundary of Tama land system, particularly where the Ruaba River emerges from its gorge through the mountains.

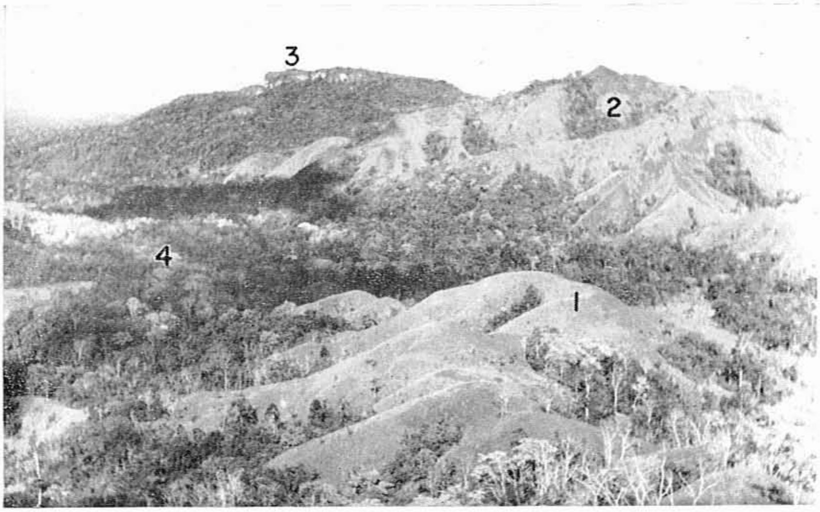

Fig. 1.—Gently dipping Tertiary marine sediments have been dissected into the hilly land forms of Koianaki land system on Cape Vogel peninsula (1). Shifting cultivation on shallow soils and under a relatively dry climate has produced a complex vegetation pattern of *Themeda* grassland and forest remnants in narrow valleys and folds of the terrain. Many trees are deciduous. Basic shallow intrusive rocks now stand out as sharper, higher ridges (2). Limestone of Tarakaruru land system forms the conspicuous cliffs of Castle Hill (3). The wider valleys of Monari land system have dark soils of heavy texture and are mostly covered by rain forest (4).

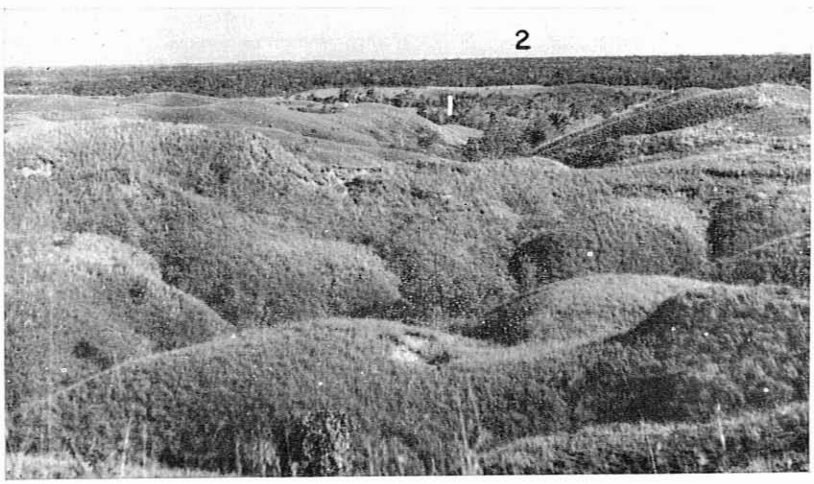

Fig. 2.—Subhorizontal Tertiary terrestrial sediments of Bewabewa land system at the base of Cape Vogel peninsula have been partly dissected into very complex, low convex hills. Numerous small landslides are evidence of the instability of the slopes and the soils are consequently very shallow. Behind a narrow zone of gentle foot slopes with deeper, strongly weathered soils (1) stretches a forested alluvial plain of Monari land system (2).

Fig. 1.—In contrast to Koianaki land system, rather large plateau-like surfaces have been preserved on the subhorizontal sedimentary rocks of Bewabewa land system. These surfaces have been stripped and have shallow soils and poor vegetation similar to those on the more dissected parts of the land system. Depressions commonly have poorly developed stream channels and are poorly drained, with a woodland vegetation.

Fig. 2.—The rain forest in the drier, eastern part of the area is generally more poorly developed than in the wetter, western part. In extreme cases, such as on rocky limestone slopes, dry evergreen forest takes its place (Tarakaruru land system).

Fig. 1.—Repeated use of land for shifting cultivation may result in the formation of grassland. This is subsequently maintained as a disclimax vegetation by regular burning during the drier season. Grass fires are lit to hunt out small animals as well as for the fun of it. The tall cane grasslands of Wanigela land system at the foot of Mt. Victory are commonly dotted by low, fire-resistant trees.

Fig. 2.—Large and small unstable outwash fans occur in the alluvial plains north of the Owen Stanley Range (Wakioka land system). Stream channels are commonly poorly developed and of an ephemeral nature. *Casuarina* sp. is the most important pioneering tree species. Several stands, much taller than those on this photograph, could be worth exploitation.

Fig. 1.—Tall, dense rain forest is the major vegetation type west of Cape Vogel peninsula. Forest of the *Anisoptera kostermansiana–Intsia bijuga–Garcinia* sp. association covers the lower slopes of the Owen Stanley Range (Maneau land system). At approximately 2500 ft this merges into lower montane rain forest.

Fig. 2.—Indigenous agriculture consists of shifting cultivation. Plantains are the main subsistence crop in the drier Cape Vogel area. Their cultivation involves longer periods of land occupation than that of taro, the principal crop in the remainder of the area. These banana trees grow on very stony limestone land in Tarakaruru land system.

Fig. 1.—Freshwater swamps with mineral soils occur throughout the area, particularly in the western alluvial plains. The vegetation is generally swamp forest or swamp woodland with much sago or *Pandanus*, but the most poorly drained aspects are covered with various types of herbaceous swamp vegetation, of which this sedge swamp in an embayment on Cape Vogel is an example.

Fig. 2.—Mangrove forest and woodland form an almost continuous though narrow zone along the coast from Mt. Victory to Cape Vogel, whilst isolated patches occur along the indented coastline of Cape Nelson. Three different associations of mangroves commonly form clearly defined zones in the wider parts of the mangrove belt.