Explanatory Notes to the Land Limitation and Agricultural Land Use Potential Map of Papua New Guinea

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MAP

Land Limitation and Agricultural Land Use Potential Map of Papua New Guinea (4 sheets)

EXPLANATORY NOTES TO THE LAND LIMITATION AND AGRICULTURAL LAND USE POTENTIAL MAP OF PAPUA NEW GUINEA

By P. BLEEKER*

I. INTRODUCTION

On the eve of the independence of Papua New Guinea it seems appropriate to round off 20 years of land resource surveys by CSIRO (Haantjens 1965*a*, 1968) with the preparation of maps on a national scale dealing with geomorphology, vegetation and soils. Since two soil maps had already been published (Haantjens *et al.* 1967; Bleeker 1974) it was decided to concentrate on the production of a map at 1 : 1 000 000 showing the land limitations that are of particular importance to agriculture. The principal sources of information for this map were the 14 reconnaissance land system surveys (Christian and Stewart 1953; Christian 1958) in the Land Research Series (listed on back cover) covering nearly half of the 470 000 km^2 land mass (Fig. 1). For the remainder of the area much use was made of information obtained from the vegetation map (Paijmans 1975), the geomorphic map (Löffler 1974) and reports available from the Land Utilization Section of the Department of Agriculture, Stock and Fisheries in Port Moresby. In areas of apparently high agricultural potential, aerial photographs and stereo mosaics made up by the Division of Land Use Research were also used.

The purpose of the map is to show the broad distribution of land with respect to terrain, wetness and soil limitations. It should be seen mainly as a general land inventory indicating areas requiring more detailed study. However, the map, together with the maps on vegetation and geomorphology, should also serve other purposes related to natural resources, such as the establishment of national parks, new land settlement areas or road planning and other engineering assessments. Its bias towards commercial plantation-type agriculture is mainly the result of Papua New Guinea's development; in 1972 agricultural products still accounted for approximately 57% of its exports (Anon. 1974). Although this situation has changed with the development of mining ventures such as Bougainville Copper the country will rely heavily, at least for the next decade, on agricultural exports such as coffee, copra, cocoa, rubber, tea (Plate 1, Fig. 1), palm oil, rice (Plate 1, Fig. 2) and pyrethrum (Plate 2, Fig. 1). For this reason descriptions of the mapping units, particularly those showing agricultural potential, are orientated towards soils. The distribution of the mapping units is discussed in relation to the Districts which are shown in Fig. 2. It should be stressed, however, that because of the scale and scarcity of information the assessment of the agricultural capability is based on a limited number of factors and might therefore be somewhat optimistic.

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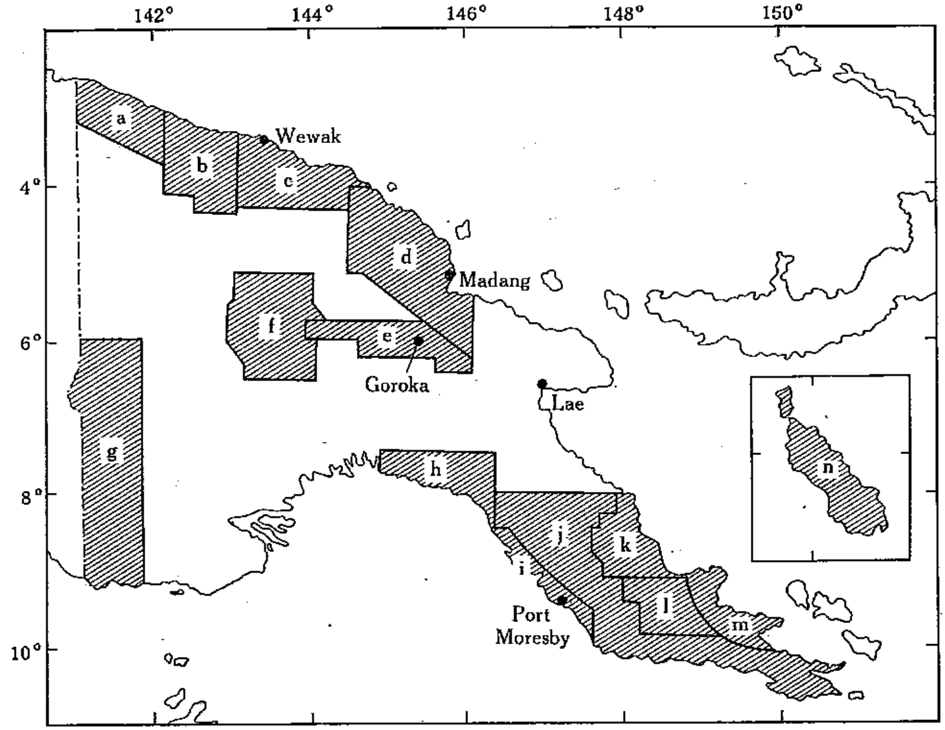


Fig. 1.—Areas covered by surveys of Division of Land Use Research, CSIRO. a, Vanimo; b, Aitape–Ambunti; c, Wewak–Lower Sepik; d, Ramu–Madang; e, Goroka–Mount Hagen; f, Wabag–Tari; g, Morehead–Kiunga; h, Kerema–Vailala; i, Port Moresby–Kairuku; j, Eastern Papua; k, Buna–Kokoda; l, Safia–Pongani; m, Wanigela–Cape Vogel; n, Bougainville and Buka Islands.

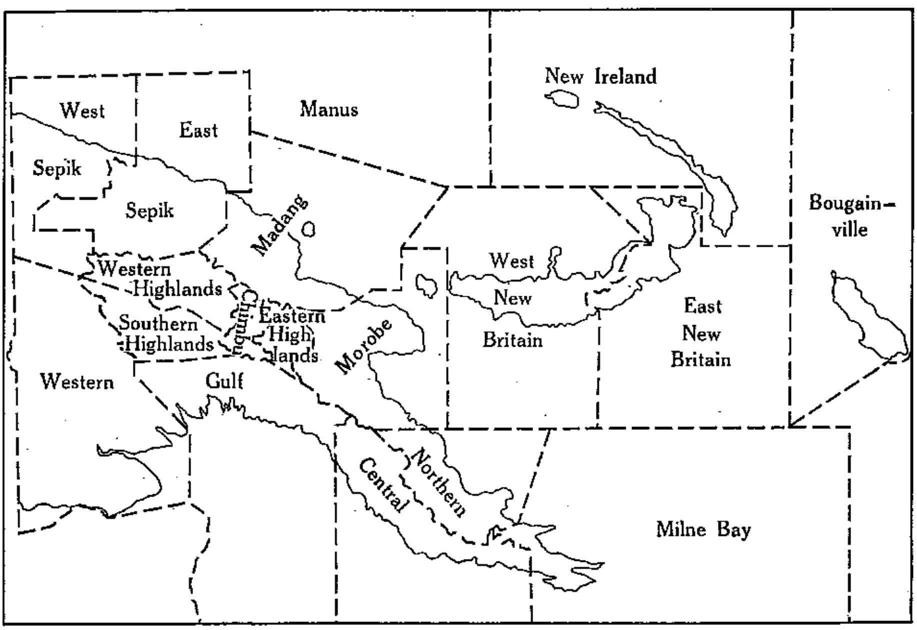


Fig. 2.—Districts of Papua New Guinea.

II. Land Classification and Mapping

Of the 13 land resource reports already published by the Division of Land Use Research, all except one contain data on land use potential in the form of a map, a paper or both. In early reports, small maps mostly at a scale of 1 : 1 000 000 presented generalized groupings of land systems with classes varying from very high to very low agricultural potential. These ratings were assessed on the suitability class of the dominant land unit(s), minor units being ignored. For this assessment the then best-known land capability classification developed by the U.S. Department of Agriculture (USDA) (Klingebiel and Montgomery 1961) was used as a basis. This system was modified slightly for tropical environments by Haantjens (1963) to incorporate tree crops and wet rice cultivation.

The latest survey reports have used a completely different system developed by Haantjens.* The most important features of this system are:

(1) the land is classified separately into four different kinds of agricultural use and is thus much more specific;

(2) each mapping unit as a whole is weighted based on the suitability of each unit according to a sliding scale; and

(3) more than one limitation or hazard will lower the overall capability class more than one single factor.†

This system gives a much better indication of the mean capability of each mapping unit. However, although developed for reconnaissance surveys it is still too detailed for an overall land capability map of Papua New Guinea which is restricted to a limited number of map colours. Haantjens's system also requires a semi-detailed breakdown of the mapping units (e.g. crest, moderate slope, foot slope, valley, etc.) which, with only about half of the country previously covered by land system surveys, would have been an impossible task in the time available.

It was therefore decided to develop a slightly different mapping system which uses the most relevant parts of both Haantjens's and the USDA systems. The main departure from the USDA system is that the land is not classified into one of eight classes, but is simply arranged into classes according to the factor ratings. An explanation of these factor ratings is given in Table 1. Ratings have been ordered, somewhat arbitrarily, from left to right according to the importance of the factor, erodibility (steepness of slope) being considered the most important and soil reaction the least important. The map reference is arranged similarly, but starts with the 'least' important factor and lowest rating (the best land) and the ratings increase gradually further down the reference. Map symbols represent single letters of ratings up to a maximum of four letters. The first (capital) letter indicates the highest and/or most important factor rating of the mapping unit. Map colours are arranged according to the most important (first) factor of a similar rating.

The general overall suitability for arable crops (C), tree crops (T), improved pastures (P) and flooded rice (I) is also given in the map reference. This assessment

* Haantjens, H. A. (1969).—Agricultural land classification for New Guinea land resources surveys, 2nd (revised) Ed. CSIRO Aust. Div. Land Res. Tech. Memo. No. 69/4 (unpublished).

† In other words two hazards in Class 2 and one in Class 3 might give an overall assessment in Class 4, while in the USDA system the land would still be in Class 3.

TABLE 1

EXPLANATION OF FACTOR RATINGS

Factors are rather arbitrarily arranged from the most to the least important (left to right)

Rating	Slope steepness (erodibility) E or e	Flooding and/or inundation hazards F or f	Drainage status D or d	Drought risks M or m	Factor Altitude (m) L or l	Surface rocks and/or stones (%) R or r	Fertility N or n	Salinity S or s	Soil reaction A or a
0	Level or sloping < 2°	No flooding and/or inundation	Well drained	No drought risks	1200	< 1	Apparently relatively fertile	No salinity	Weakly acid to neutral (field pH 6·0–7·0)
1	Slope 2–6°	Occasional seasonal flooding	Imperfectly drained	Possible drying out of upper horizon of profile for short periods	1200–2400	1–2	Appears to have low fertility	Saline (conductivity < 6 mmhos/cm)	Acid or weakly alkaline (field pH 5·0–6·0 or 7·0–7·5)
2	Slope 6–9°	Occasional irregular flooding or inundated for up to 1 month	Poorly drained; easily improved	Profile dries out for indefinite periods	2400–3000	3–7			Alkaline (field pH 7·6–8·5)
3	Slope 9–17°	Inundated for 1–3 months	Very poorly drained; relatively easily improved		> 3000	8–30			Strongly acid (field pH < 5·0)
4	Slope 17–30°	Frequent irregular flooding, or occasional deep devastating flooding, or inundated for 3–6 months	Poorly to very poorly drained; difficult to improve			> 30			Strongly alkaline (field pH > 8·5)
5	Slope > 30°	Permanently or semi-permanently inundated, or subject to very frequent or tidal flooding	Swampy						

is based on general assumptions, such as that tree cropping leads to less erosion than arable cropping on the same kind of land and that arable crops require less well-drained soils than tree crops. Suitability levels are indicated in letter symbols from VH (very high) to N (nil). Since there is such a variety in the environmental conditions of both arable and tree crops these have been further subdivided into four altitudinal classes: 1 = lowland (0–600 m), 2 = mid altitude (600–1200 m), 3 = highland (1200–1800 m) and 4 = high altitude (1800–2400 m). Limitations of scale and the number of mapping units that can be shown have made it impossible to present these classes on the map; they are indicated by subscripts in the map reference. A list of the most common crops grown in Papua New Guinea, with their main ecological aspects, is given in Appendix I. The assessment of the suitability levels according to factor ratings is given in Table 2. Table 3 shows how the *overall* suitability of the mapping units is determined for units with more than one factor rating. It should be stressed that in this assessment economic and social factors such as accessibility, population and land ownership are not considered.

In the map reference only dominant factor ratings can be displayed; 'dominant' is arbitrarily defined as covering an estimated area of >60%. Where no factor rating is dominant in the mapping unit the most important one is given. A shortcoming of this system is that in some cases relatively large total percentages (e.g. 30%) of land with high potential within a mapping unit which as a whole might be unsuitable for agriculture are not shown on the map. However, experience has shown that when this occurs the individual areas are relatively small in size and therefore unsuitable for plantation agriculture. Examples of this are mountain valleys surrounded by steep slopes that are too small to map out individually, or intricate patterns of poorly drained and well-drained land with fertile alluvial soils. Because of the mapping scale small areas of 'uniform' land could seldom be mapped either, as the smallest size of a mapping unit on a map at 1 : 1 000 000 is approximately 4 mm^2, which means that areas of less than 1600 ha (3952 ac) cannot be shown.

III. Assessment of Factors and their Ratings

Most factors shown in Table 1 are relatively easy to determine in the field. In areas where no site data are available vegetation and land form interpretation or measurements from aerial photographs have to be used. Slope steepness (E)* can be measured on aerial photographs by using a stereo dip comparator (van der Bent 1969). Rockiness and stoniness (R) on the surface can be measured adequately in the field only by using percentage charts, although experience has shown that some information can be obtained when rock types are known. For instance, in limestone areas surface stones and rocks are very common on moderate to steep slopes, whilst on mudstones and siltstones they rarely occur. Determination of soil drainage (D) is assessed primarily from the degree and depth of gleying of the soil in the field and

* In this paper slope steepness is equated with erodibility. This is of course a simplification, although in general these two factors will be related. However, erosion rates are known to vary strongly with soil type and/or parent material. For instance, strongly weathered friable clay soils (lateritic soils) in Indonesia are known to be much less susceptible to erosion than quartz-silt rich soils derived from marlstone (van Dijk and Ehrencron 1949).

TABLE 2

ASSESSMENT OF SUITABILITY LEVELS* FOR ARABLE CROPS (C), TREE CROPS (T), IMPROVED PASTURES (P) AND FLOODED RICE (I)† ACCORDING TO FACTOR RATINGS

Rating	Factor: Erodibility	Flooding and/or inundation	Drainage status	Drought risks‡	Altitude (m)‡		Surface rocks and/or stones (%)	Fertility	Salinity	Soil reaction
	E or e	F or f	D or d	M or m	L or l		R or r	N or n	S or s	A or a
0	$C_1T_1P_1I_1$	$C_1T_1P_1I_1$	$C_1T_1P_1I_1$	P_1I_1	0–600	P_1I_1	$C_1T_1P_1I_1$	$C_1T_1P_1I_1$	$C_1T_1P_1I_1$	$C_1T_1P_1I_1$
					600–1200	P_1I_3				
1	$C_2T_1P_1I_5$	$C_2T_2P_2I_2$	$C_2T_3P_1I_1$	P_2I_1	1200–1800	P_1 —	$C_2T_1P_1I_3$	$C_2T_2P_2I_2$	$C_3T_4P_3I_2$	$C_2T_2P_2I_2$
					1800–2400	— T_5P_2—				
2	$C_3T_2P_2$ —	$C_3T_4P_3I_3$	$C_3T_4P_2I_1$	$C_3T_3P_3I_1$		— — P_3 —	$C_3T_2P_2I_5$			$C_3T_3P_2I_2$
3	$C_4T_3P_3$ —	C_4 — P_4I_3	$C_4T_5P_3I_1$			— — P_4 —	$C_4T_3P_3$ —			$C_3T_3P_3I_3$
4	— T_5P_5 —	Flooded C_5 — P_4I_4 Inundated C_5 — P_5I_4	C_5 — P_4I_1				— T_5P_5 —			$C_4T_5P_3I_3$
5	— — — —	— — — I_5	— — P_5I_2							

* Suitability levels are indicated as 1, very high (VH); 2, high (H); 3, moderate (M); 4, low (L); 5, very low (VL); —, nil (N).

† In the assessment of the suitability for flooded rice, problems related to getting the irrigation water onto the land and difficulties in the construction of rice bays are *not* taken into account.

‡ Ratings 0 and 1 for factors M and L are not given for arable and tree crops because these depend strongly on the choice of crop.

in cases of ground water gleying also from the depth of the water-table. However, general drainage indications can also be obtained by extrapolation of vegetation characteristics (see below).

Flooding and inundation (F) are used as separate terms. Flooding is the overflow of moving water which either erodes or deposits material; it generally lasts less than 15 days and usually comes from nearby rivers. The term 'inundation' refers to slowly rising and abating water on the land surface; it does not erode or deposit material and can be caused by rain, rising ground water or spent flood water and it generally lasts more than 15 days. Occasional flooding is defined as the occurrence of a flood once in 1–3 years, frequent flooding when it occurs more often. Deep devastating floods are those over 1 m deep causing much deposition and/or scouring of the land surface. Both flooding and inundation are hazards that are very difficult to assess during a short survey.

TABLE 3

DETERMINATION OF OVERALL SUITABILITY OF MAPPING UNITS FOR ARABLE CROPS (C), TREE CROPS (T), IMPROVED PASTURES (P) OR FLOODED RICE (I) FROM SUITABILITY LEVELS OF INDIVIDUAL FACTOR RATINGS AS DETERMINED IN TABLE 2

Individual suitability	Overall suitability	Individual suitability	Overall suitability
All	1	Three 3, two 2, rest 1	Nil
One 2, rest 1	2	One 4, rest 1	4
Two 2, rest 1	2	One 4, one 2, rest 1	4
Three 2, rest 1	3	One 4, two 2, rest 1	5
Four 2, rest 1	3	One 4, three 2, rest 1	5
Five 2, rest 1	4	One 4, one 3, rest 1	5
One 3, rest 1	3	One 4, one 3, one 2, rest 1	5
One 3, one 2, rest 1	3	One 4, one 3, two 2, rest 1	Nil
One 3, two 2, rest 1	4	One 4, two 3, rest 1	Nil
One 3, three 2, rest 1	4	Two 4, rest 1	Nil
One 3, four 2, rest 1	5	One 5, rest 1	5
Two 3, rest 1	4	One 5, one 2, rest 1	5
Two 3, one 2, rest 1	4	One 5, two 2, rest 1	Nil
Two 3, two 2, rest 1	5	One 5, one 3, rest 1	Nil
Two 3, three 2, rest 1	5	One 5, one 4, rest 1	Nil
Three 3, rest 1	5	Two 5, rest 1	Nil
Three 3, one 2, rest 1	5		

A good general indication of drainage conditions and sometimes also of flooding can often be obtained by extrapolation of vegetation characteristics on aerial photographs when no field data are available. For instance, swamp forest is usually small-crowned, *Melaleuca* swamp forest indicates inundation hazards as well as a monsoonal climate, and sago palm patches indicating swampy conditions are usually also recognizable on aerial photographs. A meander scroll pattern of ridges and swales with alternating forest and grassland indicates frequent flooding. Much information on photo-interpretation of vegetation for land evaluation is given by Paijmans (1970).

Some data on soil reaction (A) and salinity hazards (S) can be obtained also by vegetation extrapolation from aerial photographs. In Papua New Guinea saline soils always occur in mangrove areas and weakly saline soils usually occur in brackish environments characterized by nypa palm vegetation. Both these types of vegetation are usually easily distinguishable on aerial photographs. Soils in the saline environment (mangroves) are also alkaline. Alkaline soils are also often found in areas with seasonal climates (savanna vegetation) on young alluvial deposits. A typical example of this is the Port Moresby–Kairuku area where the alkaline soil reaction has been attributed by Scott (1965) to cyclic salt; the soils show a tendency to increase in acidity away from the coast. However, in the southern part of the Western District, which is also characterized by a seasonal climate, acid to strongly acid soils prevail as a result of deep, strong weathering of Pleistocene sediments (Bleeker 1971). This shows that care should be taken when extrapolating from aerial photographs and that geology and geomorphological processes should also be taken into account. A typical example of this, involving geology and land form history, is given by Haantjens (1967) for the Musa alluvial plain. Here soils occur which are weakly acid to neutral near the surface and alkaline and calcareous at depths below 1 m. Although this could be due to leaching, it can be explained also by alterations in the deposition of calcareous and non-calcareous sediments of the Musa River. This river acquires calcareous deposits from its eastern tributaries above the Musa gorge and non-calcareous material from its western branches. Variations in the rates of denudation of the source areas could therefore alter the nature of the river sediments in the coastal plain.

Field experience has shown that highland soils and soils on recent alluvium and volcanic ash are usually weakly acid. Limestone and coral reef soils are usually weakly acid to neutral in the topsoil with the pH value increasing gradually to neutral or weakly alkaline in the subsoil. Landscapes that are recognizable on aerial photographs as having strongly weathered rocks, such as low accordant ridges, will have acid soils.

Information on fertility (N) is very limited in the land resources reports. Most early reports contain some information on cation exchange capabilities, clay mineralogy and nitrogen levels. In later surveys nutrient levels have been assessed from nitrogen, phosphorus (available) and potassium (available) contents. Because of the limited data only two levels, 'apparently relatively fertile' and 'appears to have low fertility', have been used. However, where available, more detailed information is given in the descriptions of the mapping units. General fertility indications can also be obtained in the field from crop performances in gardens or plantations.

Drought risks (M) can have serious effects on crops, particularly when arable crops are grown. Although most of Papua New Guinea is characterized by high rainfall there are low-rainfall areas with a pronounced seasonal climate. These areas are shown in Fig. 3 (from Ford 1974). In these areas some form of depletion of the soil moisture regime is likely to occur during the dry season, particularly in shallow soils and/or soils with coarse textures. Soil moisture storage and water surplus data for four stations with variable rainfall and seasonality in south-east Papua have been calculated by McAlpine (1973) by a simple weekly water balance model (McAlpine 1970), assuming a 100-mm maximum available soil water storage capacity. Results indicate that weeks with low levels of soil moisture storage, and hence possible plant stress, occur rarely or never at all stations during the wettest quarter of the year, but that during the drier periods soils, in stations with low rainfall and a seasonal distribution, show considerable or even total depletion of moisture. Most soils, however, have available water storage capacities higher than 100 mm and therefore soil water stress is likely to occur only in areas with a low rainfall and seasonal climate. On the other hand, as shown in Appendix I, certain arable and tree crops are better suited to climatic conditions with drier seasons for ripening, flowering, fruiting and harvesting and these areas therefore appear most suitable for these particular crops.

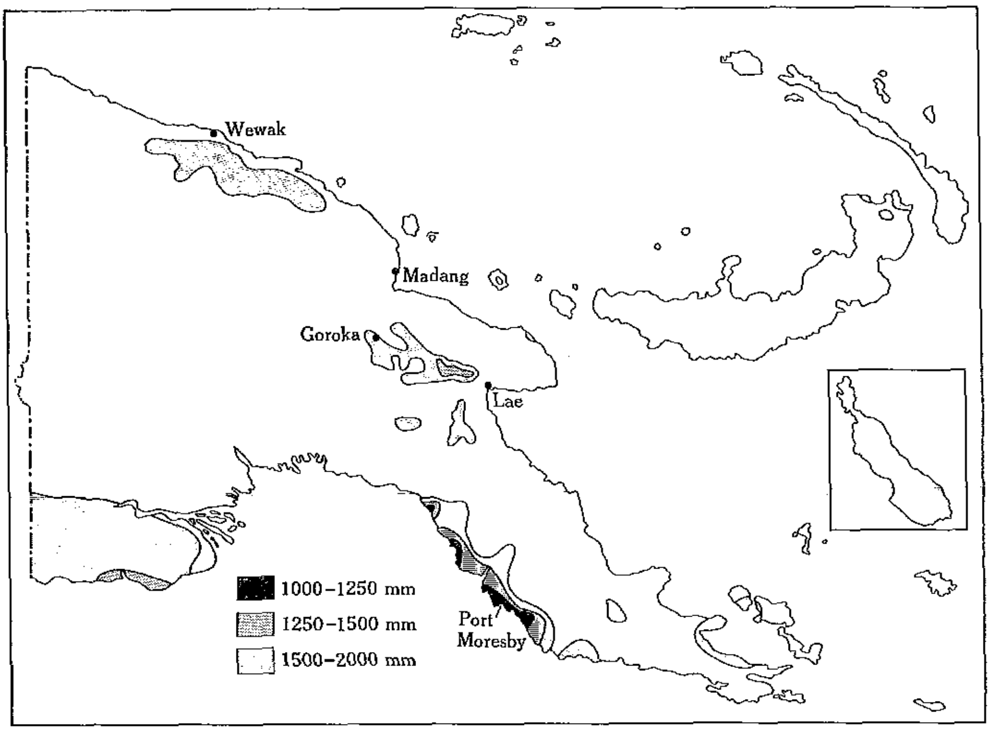


Fig. 3.—Areas with low annual rainfall (after Ford 1974).

Altitude (L) limitations are given because of the effects of temperature and increasing wetness on crops and pasture growth. The 2400-m (8000-ft) contour is considered to be the upper growth limit for arable and tree crops. Whenever possible, a more detailed breakdown is given in the mapping unit descriptions and map reference.

From the above it must be clear that significant information on environmental factors can be obtained solely from air-photo interpretation.

IV. Description of Mapping Units

(a) *Land with No Limitations*

(i) *Map Symbol* O.—This mapping unit covers 4960 km^2. It occurs in many districts but is most common in the Madang, Northern and Central Districts.

It consists of alluvial and ash-covered plains, fans and very gently sloping foot slopes of volcanoes. Tall, large-crowned forest is the most common vegetation, although extensive areas with grassland and secondary vegetation are also found.

A network of relatively narrow alluvial valleys up to 3 km wide and consisting mainly of terraces and minor flood-plains is found in the Madang District. Terraces make up the majority of the valleys and are covered by Recent alluvial soils which are mainly fine- to very fine- over coarse- to medium-textured. Their soil reaction tends to be between 6 and 7 but may be as high as 8 or as low as 5·5. The flood-plains are limited by poor drainage and occasional flooding.

In the Northern District some relatively large areas are found on the fans near Pongani and in the Musa basin, and on volcanic plains in the vicinity of Mt Lamington. The composite alluvial fans near Pongani on the coast are composed of alluvium derived from volcanic rocks, and consist mainly of active and inactive fan slopes. Friable dark brown weakly acid stratified alluvial soils are dominant. On the inactive fan slopes these soils have sandy clay to clay textures and thick dark topsoils and are locally imperfectly drained. Similar soils but with loam to clay loam topsoils over coarse sandy to clayey subsoils occur on the active fan slopes. Coarse textures might well cause slight moisture deficiencies in some of these soils. The Musa basin fans consist mainly of lower and upper fan slopes and have dominantly weakly acid dark brown and brown firm clay soil susually with thick dark topsoils. Parts of the upper slopes are limited by minor erosion hazards due to steeper slopes and also varying amounts of gravel. Active fans also form part of the mapping unit in the Musa basin but these are too gravelly to be suitable for any agricultural use. North of Mt Lamington there is a large dissected volcanic plain, covered by water-transported recent andesitic ash. The plain consists of elongated flat surfaces 80–800 m wide and separated by shallow rounded gullies or by steep-sided stream valleys. Here the soils are neutral weathered brown ash soils, with dark brown to dark yellow-brown firm clay or sandy clay horizons below slightly coarser-textured very dark topsoils. The weathered parent material generally occurs at a depth of 1–1·5 m and is slightly coarser-textured than the B horizon. Similar soils but with mottled subsoils and thicker dark topsoils also occur locally. West of Mt Lamington in the Yodda–Kokoda fault trough valley Recent alluvial plains and 'wedge-shaped' terrace remnants are found. The alluvial plains consist of material derived mainly from the Owen Stanley metamorphics on which medium- and coarse-textured soils have formed. Their soils have a loam to clay topsoil gradually merging into a coarser-textured subsoil or have a sandy loam texture throughout. They are locally stony and on steeper sloping areas are subject to minor erosion hazards. Some moisture deficiencies might also occur in the coarser-textured alluvial soils. The terrace remnants consist of Pleistocene alluvial and colluvial material covered by weathered volcanic ash. They slope very gently to gently and form two clearly defined levels. Ash soils with a very dark friable loam topsoil merging into a clay loam or sandy clay loam subsoil are dominant. The subsoil is dark brown to olive-brown in the upper 60 cm and yellow-brown to light olive-brown in the lower part. These soils have clay minerals dominated by amorphous material and vermiculite with minor kaolinite, quartz and feldspar.

Limited information is available on the Central and Milne Bay Districts which have been covered only by a very broad reconnaissance survey (Blake *et al.* 1973). Two relatively small areas have also been surveyed in more detail by the Land Utilization Section of the Department of Agriculture, Stock and Fisheries.* The mapping unit in these districts consists mainly of well-drained alluvial plains. The largest part (approximately 60–70%) of this plain forms an upper back plain 3–10 m above the main river and has stratified alluvial soils of variable textures usually with thick dark topsoils. Soils are mainly weakly acid to neutral and gravelly horizons are locally common. These gravelly horizons are former deposits of the fast-flowing braided rivers. Lower imperfectly drained back plains cover about 20–30% of the mapping unit and are subject to occasional flooding. The rest of the unit is made up of river channel, both old and recent, associated with poorly drained soils and occasional flooding.

In the West Sepik District this mapping unit consists of fan plains together with minor back plains and levees along streams. Fan plains cover approximately 70% of the area. Both fan plains and levees have strongly stratified but usually very friable loamy alluvial soils. However, textures range from gravelly loam to silty heavy clay in both topsoil and subsoil.

In New Britain the unit has been surveyed extensively by the Land Utilization Section of the Department of Agriculture, Stock and Fisheries (Hartley *et al.* 1967) and a general account of the soils has been provided by F. P. Aland (personal communication). The coastal and alluvial plains mapped in New Britain have been derived from ash deposits of a volcanic belt of which several members are quiescent, but sporadic emissions still occur. Soil development reflects the multiplicity of ash deposits which vary in composition and thickness. Generally the soils are medium-textured and well drained and overlie coarser-textured ash deposits which have a high water-holding capacity. Apparent fertility is moderate but there is a large mineral reserve. Depth of weathering is dependent upon age and some alluvial sorting. Organic manuring is necessary to maintain fertility after removal of the forest cover. Minor inclusions of thin siliceous hardpans may occur but root penetration can be effected if this layer is disturbed physically. Slight inundation and seasonal high water-tables may occur in some areas. The volcanic ash soils of the Cape Hoskins area in New Britain have been described by Bleeker and Parfitt (1974).

No information is available about the areas mapped on Karkar, Long and Umboi Islands, but these are expected to consist of young volcanic ash soils of moderate to high fertility very similar to those soils described for New Britain.

Although considered to be land with a very high agricultural potential, the accessibility and size of the areas are still important considerations in deciding its final capability. The narrow alluvial valleys, for instance in the Madang District, are

* WILLIAMS, B. G., and ALAND, F. P. (1959).—Soil survey report of the Mori–Bamguina area; VAN WIJK, C. L. (1954).—Report on soil survey Kemp Welch River area. (Unpublished.)

not very accessible and have only small terraces. Similarly the Musa basin fans are relatively inaccessible. Large parts of these fans will also disappear under water if the Musa River hydroelectric scheme goes ahead (Haantjens, personal communication 1974). The suitability for flooded rice is expected to be at least one level lower in areas with rapidly permeable soils.

(*b*) *Land with Soils of Low Fertility*

(i) *Map Symbol* Na (*ratings* n_1a_1 *or* n_1).—This mapping unit covers 3210 km^2 and occurs in many areas all over Papua New Guinea (Plate 2, Fig. 2). It is characterized by very gently sloping to almost level stable surfaces such as fans, terraces and volcanic foot slopes on which weathering has produced acid and/or infertile soils.

By far the largest area of this mapping unit is found in the Bougainville District where it comprises volcano–alluvial fans traversed by terraced valleys of streams. These fans, which have a slope of 0·5–2°, consist of dark grey-brown alluvial sand, in which rounded gravel and stones may be present, overlaid by a layer of volcanic ash 30–45 cm thick. This ash layer has a very dark brown humic crumbly fine sandy loam horizon merging into dark brown to dark yellowish brown loamy fine sand. The soils are weakly acid throughout and have a rapid permeability, and the cation exchange capacities indicate that they have low fertility (Scott 1967).

Considerable parts of this mapping unit occur on the alluvial and colluvial fans of the West Sepik District. These fans are all covered by tall forest and assessed to have high to very high forest resources. Although mapped in the same unit, the eastern part of the mapping unit has better drainage conditions than the western part. In the eastern part the slightly dissected alluvial and few colluvial fans are well drained except for some imperfectly drained land on the lower fan surfaces which is probably caused by seepage from the higher surfaces. Strongly developed acid clay to heavy clay soils with coarser-textured friable loam to clay surface soils occur on the eastern fans together with uniform-textured acid clay loam to silty clay soils. They have low to moderate nitrogen and low to very low available phosphorus and potassium contents. In the western part of the mapping unit the soils show a clear tendency to become more developed from south to north away from the mountain front. Farthest from the mountains there are soils similar to those described above for the eastern part of the unit. On the middle fan sectors soils are less strongly developed and less acid and are imperfectly drained because of the slowly permeable subsoils. Soil data from close to the mountains indicate young soils with variable textures and drainage conditions. Low nitrogen and very low available phosphorus and potassium contents are characteristic of these soils. No information is available on the areas mapped near the Green River in the West Sepik District.

In the Northern District the unit is found on plains covered by tall forest but there is also a considerable area consisting of narrow rounded or flat roughly parallel ridges with moderate slopes and shallow soils which are unsuitable for agriculture. Both plains and ridges, however, have similar strongly weathered uniform-textured acid to strongly acid red clay soils with dark brown topsoils 10–15 cm thick. They have low cation exchange capacities in relation to clay content and very low phosphorus contents, while the clay minerals are dominantly kaolinite, gibbsite or halloysite.

South of the Ramu valley in the Madang District (Plate 2, Fig. 2) the unit consists of little-dissected fan and terrace surfaces covered by grassland and built up of cobble and boulder gravel on which strongly weathered red and brown clay soils have formed. The flat upper fan surfaces usually have a dark very friable clay loam topsoil 35–50 cm thick merging into a friable to firm clay subsoil which is often rather stony. More dissected parts of the fans and the terrace surface have a brown friable to firm clay loam topsoil 15–25 cm thick overlying a reddish firm clay to heavy clay topsoil which is 1 m or more thick. The soil reaction in both soils decreases from weakly acid near the surface to acid and strongly acid in the subsoil. The fertility is assessed to be very low to low.

The area mapped near Lae in the Morobe District also consists of fans. However, except for a small area mapped in the Bulu River area approximately 25 km east of Lae,* no information is available on the soils. In this area deep medium-textured friable soils occur with interbedded sandy layers. These soils are well drained, acid to weakly acid and generally have thin topsoils (<10 cm). However, considerable areas also have poorly to very poorly drained soils that are subject to flooding near rivers and have sandy and stony surface layers. Data on fertility (M. F. W. Zijsvelt, personal communication 1974) indicate low to medium nitrogen, low phosphorus and high potassium contents.

In the Chimbu District the unit covers the very gently sloping foot slopes of the volcanoes of Mt Karimui and Mt Soaru at altitudes between 600 and 1200 m, with soils developed on parent material of Pleistocene volcanic origin. On Mt Karimui they are weakly acid uniform-textured loam to sandy loam soils usually with thick dark topsoils and buried A horizons frequently occurring at depths below 40 cm. The Mt Soaru soils have been surveyed by the Land Utilization Section of the Department of Agriculture, Stock and Fisheries.† They have been described as highly leached very deep friable dark brown clays and therefore appear much more weathered than the Mt Karimui soils. Three soils sampled in the Mt Soaru area showed the same characteristics, although their textures were described as sandy clay loam. Soil fertility data of the Bomai (Soaru) soil survey showed a high fertility only in the top few centimetres of the profiles, the subsoils being heavily leached of calcium, magnesium and potassium, while only small amounts of available phosphorus were present. The results of 20 samples taken from topsoils and subsoils in the Mt Karimui area indicate a general high nitrogen content in the topsoil while available phosphorus varies between very low and low and the potassium content is usually between low and moderate in both topsoil and subsoil. The low fertility of these ash soils, which has also been found in other ash-covered areas, is surprising in view of the luxuriant vegetation and 'very good looking' subsistence crops growing on these soils. It seems possible that these crops obtain some plant nutrients from rapidly weathering volcanic glass. The good physical soil condition, especially high friability which enhances rooting, might also be of importance.

No information is available on the areas mapped in New Britain, New Ireland and the Milne Bay District.

* Notes on Bukaua by M. F. W. Zijsvelt (unpublished).

† Soil survey of the Bomai area by A. Hartley and F. P. Aland, June–July 1962 (unpublished).

Generally this land is considered to have a high capability for arable crops, tree crops, improved pastures and flooded rice. An exception is the Chimbu District where the mapping unit occurs mainly at altitudes between 600 and 1200 m and the suitability for flooded rice is considered moderate. The low to very low fertility is the most serious general limitation. Physical soil conditions appear to be good, except for the most western fans in the West Sepik District. Some areas like the Ramu valley and Karimui area are at present inaccessible.

(c) *Slightly Stony and/or Rocky Land*

(i) *Map Symbol* R (*rating* r_1).—This mapping unit covers 1030 km^2 and occurs in the Northern and Milne Bay Districts. It consists of the smooth to undulating foot slopes of Mt Lamington covered by Recent andesitic ash deposits and a large coastal area of very gently sloping to level Recent alluvial plains located in the Collingwood Bay area. Tall large-crowned forest is the most common vegetation.

A flat to undulating plain with many small rounded depressions and small streams forms by far the largest component of this land in the Mt Lamington area. Soils consist of medium-textured brown ash soils with thick dark friable sandy clay loam to clay loam topsoils merging into stratified loamy sand and coarse volcanic sand that locally contains much gravel and stones. Shallow buried topsoils are present in some localities. Vermiculite is the dominant clay mineral with some accessory kaolinite and amorphous material. The soil reaction is generally about 6·0.

Extensive alluvial plains covering both Northern and Milne Bay Districts between Mt Victory and Cape Vogel consist predominantly of stratified coarse-textured soils in the western part and medium-textured soils in the eastern part. The coarse-textured soils have very friable sandy loam to loamy sand topsoils merging into sand and loamy sand subsoils. The medium-textured soils have sandy loam to clay loam textures with occasional layers of sand and clay. Silt loam and silty clay loam are the most common textures, the majority of profiles having rather uniform textures. Very little is known about the fertility of these soils, but they are expected to be moderately fertile. Data for two medium-textured alluvial soils show moderate nitrogen and low exchangeable potassium contents. Soil reaction varies between weakly acid and neutral.

This mapping unit has a very high suitability for tree crops and improved pastures, a high capability for arable crops and moderate capability for flooded rice. The occasional presence of stones on the land is the only limitation in most of the mapping area, and these can be removed without difficulty. The rapidly permeable soils make the land less suitable for growing paddy rice. In the coastal plain stoniness occurs most often along the foot of the mountains. The best land is found in the Mt Lamington area and in the eastern part of the coastal plain. The eastern part is rated slightly higher than the western because stoniness appears less and soils are less susceptible to drying out than those in the west. However, this land might be liable to periods of droughtiness in exceptionally dry years. Both areas appear fairly accessible.

(ii) *Map Symbol* Rna (*ratings* $r_1n_1a_1$).—This mapping unit covers only one area of 70 km^2 located in the Northern District. It consists of forested dissected very gently sloping plains covered by sub-Recent to Pleistocene alluvium. The very limited information indicates strongly weathered soils with dark clay loam topsoils overlying a clayey subsoil which is strong brown in colour in the upper part and red-brown in the lower part. The weathered parent material is a strong brown clay loam. They are acid to strongly acid soils and their low exchange capacities and base saturation indicate a low fertility (Haantjens 1964).

The frequent presence of stones on the surface, which can easily be cleared, is the most serious limitation. The land is considered to have a high to moderate capability for tree crops and pastures, a moderate capability for flooded rice and moderate to low capability for arable crops.

(*d*) *Land at Altitudes between 1200 and 2400 m*

(i) *Map Symbol* La (*ratings* l_1a_1).—This mapping unit covers 270 km^2 in the Western and Southern Highlands Districts. It is composed of dissected valleys and associated colluvial fans with material derived from volcanic ash, lava and greywacke.

In the Southern Highlands most of the unit forms undulating plains up to 2 km wide, mainly between 1200 and 1800 m. Moderately and steeply sloping terrain and terraces also occur as minor components in this landscape. The soils are acid humic brown clay soils generally showing a slight increase in clay content with depth and having well-developed black to very dark grey-brown topsoils. Data on the soils of the Sugu valley (M. F. W. Zijsvelt, personal communication 1974) indicate moderate to low fertility, the nitrogen content being moderate, phosphorus very low and potassium moderate. The valley fill material is underlain by limestone which commonly shows surface depressions as the result of solution and is often also associated with slumping.

In the Western Highlands the unit consists largely of terraces, usually sloping less than 5° but becoming steeper in the headwater sections where the land may also become stony. This land occurs mainly at altitudes between 1800 and 2400 m. The soils are similar to those described above, but appear moderately fertile (Rutherford and Haantjens 1965) and are often somewhat limited by imperfect drainage conditions.

This mapping unit is assessed to have a high capability for arable crops and improved pastures, a high to low capability for tree crops and no capability for flooded rice. However, altitude considerably limits the choice of arable and tree crops, particularly in the Western Highlands District.

(*e*) *Land Subject to Slight Drought Risks*

(i) *Map Symbol* M (*rating* m_1).—This mapping unit covers 1640 km^2 and occurs mainly as a long narrow coastal strip between Madang and Finschhafen in the Morobe and Madang Districts (Plate 3). Two fairly large areas are also found in the Central District. It is restricted to low-rainfall areas with a pronounced dry season and often shallow soils.

In both the Madang and Morobe Districts it consists of a spectacular set of uplifted coral terraces rising over 600 m above sea-level and also of slightly dissected delta fans. The terraces form flat to very gently sloping platforms very variable in width and separated from each other by stepped rocky surfaces. Except for the areas close to Madang and Sialum little information is available on the soils. Shallow soils (rendzinas) consisting of a very black to very dark brown very friable loam to clay loam topsoil 10–30 cm thick overlying limestone or coral detritus occur on the lowest terraces. These soils usually have a weakly acid to neutral soil reaction but may also be alkaline. Higher in the sequence soils become much more developed and deeper as shown by their red to reddish brown clayey very friable B horizons with strong subangular blocky structures (terra rossas). Hard rock is usually encountered at depths between 40 and 60 cm in these soils. On the highest terraces the platforms tend to reach the greatest width reflecting relatively stable periods during the uplift. Imperfectly to poorly drained plastic to very plastic clay to heavy clay soils with thick dark topsoils occur on these terraces. They are weakly acid to neutral and very slowly permeable. The fans form flat to gently undulating surfaces partly dissected by winding narrow creeks. They usually have deep soils with black to very dark grey-brown topsoils overlying gravelly subsoils. They are usually fine-textured, weakly acid and moderately permeable. Vegetation is dominantly grassland.

Well- to imperfectly drained stable alluvial plains with Recent stratified alluvial soils are found in the Central District. Back plains, mainly with medium- and/or fine-textured weakly acid to neutral soils, cover most of this area. The vegetation consists of large-crowned forest which has high timber volumes.

No information is available on the areas mapped in the Bougainville and Milne Bay Districts which comprise uplifted coral reef islands.

Drought risk, together with the fact that shallow soils are frequently found on the lowest coral terraces, are the main limitations for agriculture in this mapping unit, the fertility probably being moderately high. It is assessed to have a very high capability for flooded rice and a high capability for arable crops, tree crops and improved pastures. Areas in the Central District appear to have the highest potential. On the higher coral terraces there appear to be considerable areas with imperfectly to poorly drained soils which are very difficult to improve because of the very slow permeability. Much of this land is at present used for grazing. However, experience has shown (H. Wiederholt, personal communication 1973) that some cattle are lost during the wet season because they become bogged in oversaturated soils. The sharp, jagged limestone outcrops which are very common along the terrace edges are also a serious hazard for grazing cattle. Although the unit is assessed to have a very high capability for flooded rice it should be noted that on the coral terraces irrigation water is relatively scarce and difficult to obtain.

(ii) *Map Symbol* Mn (*ratings* m_1n_1).—This mapping unit covers 1600 km^2. It occurs in many widely scattered areas all over Papua New Guinea but is confined mainly to the Central and Northern Districts. The soil moisture deficiencies characteristic of this mapping unit are induced mainly by a seasonal climate, but are also caused by the sandy nature or shallowness of the soils.

In the Gulf, Central, Milne Bay and both Sepik Districts this mapping unit covers littoral plains consisting of well- to imperfectly drained beach ridges and flat plains often separated by swampy swales. The beach ridges amount to by far the largest area and typically have sandy soils with little or no profile development, although near Malalaua in the Gulf District a beach plain is found covered by a thin veneer (approximately 30–60 cm) of medium-textured alluvium. The beach ridges consist of soils with weakly acid to neutral dark friable sandy loam topsoils and neutral to weakly alkaline sandy subsoils.

Some data on fertility in the West Sepik District indicate that the nitrogen content increases inland and is generally low to very low on the frontal ridges but moderate on most inland ridges. Available phosphorus is generally high but decreases to moderate inland, while potassium is generally low to very low inland. These beach ridges become less pronounced inland and also clearly show more profile development with age, this being reflected in the thickness of the topsoil, browner subsoils and increase in acidity. Because of their sandy nature they have a low fertility. Tall large- to medium-crowned forest covers most of the higher-rainfall areas, while woodland is found in areas with seasonal climates.

In the Northern District north-east of Mt Lamington and in the vicinity of Mt Victory the mapping unit consists of slightly dissected volcanic grass plains with water-transported volcanic sands of andesitic composition. Soil formation is only slight and is restricted to the development of a black very friable topsoil. Soil reaction is weakly acid in the topsoil increasing gradually to neutral with depth. Although these are ash soils, they appear to be of low fertility (see subsection (*b*)(i)).

In both Sepik Districts areas consisting of raised coral reefs occur also, and although they have a different soil reaction they have been included within this unit because they are small. In the most easterly part of the East Sepik District they have been described as having dark to very dark weakly alkaline clay to heavy clay soils 15–60 cm thick. In the West Sepik District, however, the coral platforms near Vanimo have slightly developed dark alkaline coarse-textured soils 50–75 cm thick.

In the Bougainville District the mapping unit consists mainly of coral platforms and less common tidal flats. These coral platforms have shallow greyish brown loamy soils with dark topsoils (rendzinas). Shallow alkaline peaty sands occur on the tidal flats.

No information is available on the soils of the Wau and Bulolo fans in the Morobe District.

Generally the agricultural potential of this mapping unit is assessed to be high for improved pastures and flooded rice and high to moderate for arable crops and tree crops. Areas located in the Northern District with their friable well-structured soils have the highest potential for arable crops and pastures but are less suitable for rice-growing because of their rapid permeability. The beach ridges appear most suitable for coconuts.

(iii) *Map Symbol* Mna (*ratings* $m_1n_1a_{1\ or\ 3}$).—This mapping unit covers 11 360 km^2 and occurs only in the Western District. It consists of gently undulating terrain with characteristic slopes of 1–2°. The main vegetation is monsoon forest and tall mixed savanna. The seasonal climate has led to the formation of texture-contrast soils on fine-textured Pleistocene sediments. The soils consist of loamy sands to silt loams merging into clay loams to clays. They are acid to strongly acid and usually well- but locally imperfectly drained. Pisolitic iron concretions are common.

This mapping unit is assessed to have a high potential for flooded rice and a moderate potential for arable crops, tree crops and improved pastures. Soils appear best suited for flooded rice because of their slowly permeable heavy-textured subsoils.

(iv) *Map Symbol* Mlna (*ratings* $m_1l_1n_1a_1$(.—This mapping unit covers 200 km^2 and occurs only in two relatively small areas, one in the Eastern and the other in the Western Highlands. It consists of terraced and slightly to moderately dissected alluvial fans occurring between 1500 and 1800 m and composed of unconsolidated Pleistocene fluviatile clay, sand and boulder gravel. Flat to gently undulating surfaces with very strongly weathered clay to heavy clay soils form the largest parts of the fans. They have a layer 25–50 cm thick of hard to firm iron concretions close to the surface. The soil reaction is weakly acid in the topsoil, decreasing gradually to strongly acid in the subsoil. The vegetation consists of gardens and garden regrowth.

This land has a moderate capability for arable crops, tree crops and improved pastures, and no capability for flooded rice, but the choice of crops is limited to those suited for highland conditions. The thick concretionary layer occurring close to the surface is expected to limit root penetration and water relations in the profile, thus causing the soils to be droughty. Deep ploughing could probably solve some of these problems.

(*f*) *Land with Imperfectly Drained Soils*

(i) *Map Symbol* D (*rating* d_1).—This mapping unit covers 5300 km^2 in the Sepik, New Ireland, New Britain, Northern, Bougainville, Morobe and Gulf Districts (Plate 4). Vegetation is mainly tall, large-crowned forest but areas with regrowth and gardens are locally common. The unit consists of Recent alluvial plains on the mainland and uplifted coral terraces on the islands.

In the Sepik Districts the unit comprises flood-plains with some terraces. The flood-plains are usually imperfectly drained but also contain well- and poorly drained areas, while the terraces are usually well drained. In the western part of the mapping unit the flood-plains have mainly stratified fine-textured soils with virtually no topsoil. Textures are mainly firm to plastic silty clay or clay and very firm to very plastic heavy clay. In the eastern part the soils are mainly medium-textured with firm to friable clay to silty clay topsoils merging into stratified layers ranging from very friable to firm sandy clay loam or silty clay loam to silty clay or clay. These soils have olive-brown to brown colours typical of recently deposited material.

In the Northern District a large area occurs in the Musa coastal plain. Imperfectly to well-drained alluvial plains consisting largely of prior meander tracts (up to 15 km long and 5 km wide), terraced levees and breakthrough splays occur on the western side of the Musa River. Soils are stratified, generally silty, weakly acid to neutral near the surface and alkaline and calcareous in the subsoil or deeper subsoil. They frequently have rather thick dark topsoils.

The area mapped in the Morobe District east of the Erap River has been surveyed in detail by the Land Utilization Section of the Department of Agriculture, Stock and Fisheries (Holloway *et al.* 1973). It consists mainly of weakly developed medium- to fine-textured soils with a weakly acid to neutral soil reaction.

Apart from Bougainville little or no information is available on the soils of the raised coral terraces in New Britain and New Ireland. A broad survey of the east coast of New Ireland was made by van Wijk (1959) who described the coral soils as red-brown to red clay loams to clays. These soils have somewhat sticky and plastic subsoils and show signs of impeded drainage, particularly during the wet season. In Bougainville (Plate 4) the raised coral terraces form an almost level plateau with some shallow depressions (dolines) and have reddish plastic clay soils locally covered by a 0·5–1 m layer of volcanic ash. These soils consist of reddish brown to dark brown humic clay to clay loam merging into a reddish brown sticky plastic clay with strong brown mottling. They are weakly acid to neutral, becoming weakly alkaline with depth. The ash-covered soils consist of a very dark brown, humic fine sandy loam 10–15 cm thick merging into a dark greyish to yellowish brown fine sandy loam, and between 25 and 50 cm into olive-brown loamy fine sand to fine sand. They are weakly acid.

Another small area consisting of Recent alluvium has been mapped in the south-eastern part of the Gulf District.

This land has a very high capability for improved pastures and flooded rice, a high capability for arable crops and moderate capability for tree crops. Imperfect drainage limits tree crops most seriously, together with the rather poor physical condition of the soils and the fairly high soil reaction, especially in the subsoils of soils on coral limestone. The suitability for flooded rice, although assessed as very high, appears to be limited by the high topographic position and difficulties in obtaining water, particularly on the coral reefs. The best land appears to occur in the Musa coastal plain of the Northern District. Fertility data indicate that both the coral and alluvial soils are fertile, the latter having moderate nitrogen, moderate to high phosphorus and high to very high potassium contents.

(ii) *Map Symbol* Dn (*ratings* d_1n_1).—This mapping unit covers 1980 km^2 and is found only in East and West Sepik, Bougainville and West New Britain Districts. On the mainland it consists mainly of Recent alluvial plains in the West Sepik District but it also includes an area in the East Sepik District with flat to undulating terrace benches and interfluve surfaces. On Bougainville it forms very gently sloping, partly dissected Recent volcano–alluvial fans.

The tall forested alluvial plains of the West Sepik District are made up of a flood-plain, an alluvial plain and one or two terraces. The alluvial plain and the first terrace above it form by far the largest area and they are dominated by imperfectly drained to well-drained soils present in probably about equal proportions, but insufficient information is available for a reliable assessment. They have undeveloped medium- to fine-textured, usually neutral to weakly acid, moderately to slowly permeable soils. Flood-plains are subject to flooding and have alkaline calcareous soils, but they cover only a small percentage of the total area. Fertility data indicate low to moderate nitrogen, low to high available phosphorus and usually high potassium contents.

Terrace benches and interfluve surfaces occurring on Pleistocene alluvium form most of a small area mapped in the East Sepik District. Here strongly developed, usually imperfectly drained but varying between well- and poorly drained acid soils are found. They have coarser-textured very friable sandy loam to firm clay topsoils and very firm to very plastic heavy clay subsoils. Subsoils often show a prominent red, grey and brown mottling. Both interfluve surfaces and terrace benches include areas with moderate slopes. Soil nitrogen contents are moderate to low, available phosphorus very low and potassium shows a strong variation but is usually between moderate and very low. The vegetation is mostly regrowth.

In Bougainville the tall forested fans form very gently sloping plains up to 2 km wide between major streams. Smaller areas consist of gently sloping broad plateaux and narrow to broad ridge crests. The mapping unit is characterized by ash soils which at depths of approximately 0·5–1 m have a compact yellowish brown sand to sandy loam horizon that reduces permeability and causes imperfect drainage. These ash soils have very dark brown to dark brown humic fine sandy loam topsoils, merging between 30 and 45 cm into a thin dark yellowish brown slightly mottled massive loamy fine sand. Between 40 and 60 cm there is an abrupt change to a buried humic massive horizon which is dark brown to brown in colour, has a sandy loam texture and merges into the previously described compact layer which may contain large boulders. The soils have an acid reaction and analytical data indicate a low fertility (Scott 1967).

No information is available on the small area mapped in the West New Britain District.

Generally this land is assessed to have a high capability for arable crops, improved pastures and flooded rice and a moderate capability for tree crops. The overall fertility is low, but shows considerable variation. Soils of the West Sepik area appear best suited to agriculture, as they comprise large areas of well-drained soils and are moderately accessible. However, their fairly high soil reaction somewhat limits tree crops. In the East Sepik the areas with terrace benches and interfluves are largely discontinuous and small in size, and this also limits larger-scale agriculture. The Bougainville areas are moderately accessible.

(*g*) *Land Subject to Occasional Seasonal Flooding*

(i) *Map Symbol* Fl (*ratings* f_1l_1).—This mapping unit covers 70 km^2 in the Eastern Highland District. It consists of narrow flood-plains and discontinuous terraces with Recent alluvial deposits, a pioneering vegetation and gardens. Both flood-plains and lower terraces have undeveloped stratified soils which show a strong variation in texture and drainage. However, limited information indicates that on the flood-plains they are mainly medium- to fine-textured and on the terraces mainly coarse- to medium-textured. Drainage conditions also vary, but the soils appear to be dominantly well drained. Poorly drained, moderately weathered soils with grey, brown and/or red mottled fine-textured subsoils and dark coarser-textured topsoils are found on the highest terraces.

The mapping unit is considered to have a high capability for arable crops, tree crops and improved pastures, and no capability for flooded rice. However, there are considerable areas with impeded drainage, and flooding risks might be more serious than the present assessment indicates. Drainage improvement appears difficult.

(ii) *Map Symbol* Fd (*ratings* $f_1d_{1\ or\ 2}$).—This mapping unit covers 3380 km^2. Although it occurs in many parts of the country it is concentrated mainly in the Gulf District (Plate 5). It is characterized by Recent stable alluvial plains with stratified alluvial soils subject to wet-season flooding.

In the Gulf and Western Districts the mapping unit consists of soils that are mainly poorly to imperfectly drained, which is reflected in their gleyed and/or mottled subsoils. They are acid to weakly acid and mostly fine-textured. The vegetation consisst of open-forest and large- to medium-crowned forest on plains.

Relatively small areas of this mapping unit are found also in the Sepik Districts. These areas consist of flood-plains but are also characterized by terraces at different levels. This causes a pronounced change in soil reaction from the flood-plains to the upper terraces as a result of increased leaching, with increasing age, first of carbonates and then of exchangeable cations. The soil reaction therefore varies between alkaline and weakly acid, but neutral soils are most common. There is also a strong variation in texture, medium and fine textures being dominant. Generally these soils are imperfectly drained and moderately to slowly permeable, which is reflected in their slightly gleyed and/or mottled subsoils. The vegetation consists mainly of open-forest on plains.

Another small area is found in the Northern District north-east of Mt Lamington. Here poorly drained grass plains are found with sandy soils. These unweathered soils consist of water-transported volcanic ash and have thick topsoils and grey and brown mottled subsoils. Poor drainage is caused by a buried impermeable clay layer found at depths below 2 m. The soils are weakly acid in the topsoil and neutral in the subsoil.

No information is available on the soils of the areas mapped in New Britain and the Morobe Districts. Most of the New Britain soils are expected to be ash-derived, with a weakly acid to neutral soil reaction.

Generally the land of this mapping unit has a high capability for improved pastures and flooded rice, a moderate to high capability for arable crops and a moderate to low capability for tree crops. The best land for arable crops and tree crops occurs in the Sepik District where drainage conditions seem more favourable than in the Gulf and Western Districts.

(iii) *Map Symbol* Fdma (*ratings* $f_1d_1m_1a_{1\ or\ 2}$).—This mapping unit covers 1140 km^2 and is found only in low-rainfall areas with seasonal climates, usually in the Central District.

In the Central District and eastern part of the Gulf District the unit consists of Recent stable alluvial plains which are flooded only for short periods with little or no deposition.* The soils have silty clay to clay textures and are of low permeability. Soil reaction varies between weakly acid and alkaline; neutral and alkaline soils are most common, and weakly acid soils with weakly alkaline subsoils occur only in the most easterly part of the Gulf District. The vegetation consists of grassland and large- to medium-crowned forest.

Another small area occurs along the terraces and flood-plains of the Musa River in the Northern District. Here neutral friable loamy alluvial soils containing much gravel are present. These soils are well drained. The vegetation consists mainly of garden regrowth.

This mapping unit is considered to have a high capability for flooded rice, a moderate capability for arable crops and improved pastures and a low capability for tree crops. However, the area in the Northern District with well-drained neutral soils has a higher capability. Flooded rice appears to be the crop best suited for the Central and Gulf District areas.

(*h*) *Land Subject to Minor Erosion*

(i) *Map Symbol* E (*rating* e_1).—This mapping unit covers 1810 km^2 and is found in the New Britain, Northern, Milne Bay and Morobe Districts.

* It also includes a small area south-east of Port Moresby which is not flooded.

Unfortunately, however, except for New Britain and the Northern District no soil information is available for this mapping unit. The vegetation consists of regrowth and secondary forest.

In New Britain this mapping unit is widespread along the north coast between Rabaul and Talasea and has been surveyed extensively by the Land Utilization Section of the Department of Agriculture, Stock and Fisheries (Graham and Baseden 1956; Hartley *et al.* 1967). It comprises foot slopes and lower slopes of volcanoes, volcanic fans and calderas built up by andesitic volcanic ash layers. The more weathered soils are normally deep, friable and medium-textured, the multiplicity of horizons is less marked and profile textures tend to be uniform. The more recent soils have coarser surface and subsurface horizons and the transition to the weathered buried horizons is generally abrupt. These underlying buried horizons may be derived from basalt flows or andesitic tuffs of earlier eruptional origin or from uplifted marine sediments. Analysis of several representative soils of the Warangoi valley on the Gazelle Peninsula (Graham and Baseden 1956) indicates that these soils have a high nutrient status. The levels of available phosphorus, potassium, calcium, magnesium, total nitrogen and organic matter are substantially greater than those found in most soils, including other volcanic ash soils.

In the Northern District the unit forms part of the gently sloping foot slopes of Mt Lamington volcano which erupted last in 1951, and of Pleistocene to Recent fan deposits located along the eastern part of the Managalase area and in the Musa basin. The foot slopes of Mt Lamington are avalanche slopes covered by recent andesitic ash deposits. Most of the original slopes have been preserved but are deeply dissected by numerous streams. In general they slope 2° in the lower and 4–5° in the upper parts and have weathered brown ash soils which are locally covered by several centimetres of fresh ash. The soils have a dark friable loamy topsoil with a fine subangular blocky structure and merge into a clay loam to sandy clay loam subsoil. They are very similar to the soils occurring on the terrace remnants of the Yodda–Kokoda valley which have been discussed in section IV(*a*). Along the eastern margin of the Managalase area close to Pongani, broad fans form very long gentle slopes and undulating surfaces built up of andesitic basalt lava flows often covered with a thin veneer of fanglomerate and rhyodacite ash. The slopes are usually 0·5–6°, but can be up to 10°. In general, the soils most characteristic of this area can be described as weakly acid brown soils with thick dark topsoils. However, they vary from firm clay soils with sandy loam to sandy clay loam topsoils on the undulating basalt surfaces to medium-textured gravelly alluvial soils on fanglomerate and friable sandy clay ash soils, both of which occur on the slopes. Sparse fertility data indicate that these soils have moderate to high nitrogen contents and high exchangeable potassium contents. Clay minerals are dominantly kaolinite.

Undulating surfaces, sloping 1–5° and forming part of undissected Pleistocene to Recent mudflow fans, are found in the eastern Musa basin. Strong weathering has usually produced deep friable clay soils with neutral dark topsoils merging into red-brown acid and strong brown strongly acid subsoils. In spite of the strong weathering these soils have an above-average fertility, the nitrogen and exchangeable potassium contents both being moderate. Kaolinite is the dominant clay mineral together with some smectite and montmorillonite.

In the Morobe District the mapping unit consists of fan material deposited along the edge of a major fault zone. This area occurs at altitudes between 600 and 1200 m and at present produces tea. It is therefore most suitable for mid-altitude crops.

This mapping unit is considered to have a very high capability for tree crops and improved pastures, a high capability for arable crops and a very low capability for flooded rice. However, some simple measures, such as contour ploughing, should be taken to control erosion when the soil is cultivated. The coarser-textured gravelly alluvial ash soils might also require some measures to conserve soil moisture. The best soils are found on the Gazelle Peninsula, New Britain. The mudflow fans in the eastern Musa basin are relatively inaccessible. However, much more information is necessary before a more reliable assessment can be made.

(ii) *Map Symbol* Ena (*ratings* $e_1n_1a_1$).—This mapping unit covers 170 km^2 in the Central and Milne Bay Districts where it consists of gently to very gently undulating terrain on unconsolidated and consolidated sedimentary rocks. This terrain is dominantly made up of interfluves with flat to very gently undulating crests and side slopes which usually slope less than 5° but can slope up to 30°. The interfluves mainly have texture-contrast soils with very dark grey to brown friable to firm sandy loam to sandy clay loam topsoils overlying a very dark grey, brown or yellowish brown firm sandy clay to heavy clay subsoil. The subsoil often contains iron and manganese concretions. They are generally acid and appear to have a low fertility.

This mapping unit is assessed to have a high capability for tree crops and pastures, a moderate capability for arable crops and a very low capability for flooded rice. At present large areas in the Central District are under rubber cultivation.

(iii) *Map Symbol* Ed (*ratings* e_1d_1).—This mapping unit covers 1620 km^2 and is found in the Milne Bay (Trobriand Islands), Bougainville, New Britain and Manus Districts. It consists of uplifted coral reefs and associated back reef plains. In New Britain the reefs extend a considerable distance inland forming a marine depositional plain of soft calcareous marl and mudstone (Löffler 1974). With the exception of Bougainville no information is available about the soils of areas covering this mapping unit.

In the Bougainville District it comprises very gently to gently sloping plains of uplifted coral lagoon floors which have scattered dolines in the lower areas. Reddish limestone soils (terra rossas) locally covered by ash are dominant in this area. However, the well-preserved condition of the reefs combined with the relatively deep soils (150 cm) suggests that even the terra rossa soils are polygenetic, having received regular additions of volcanic ash (Scott 1967). They consist of a dark reddish brown to dark brown firm crumbly clay to clay loam topsoil of 15–20 cm merging into a reddish brown and yellow-red sticky plastic clay subsoil with faint mottling. They are weakly acid to neutral, becoming weakly alkaline with depth, and have a slow permeability. The ash-covered soils have a black humic and very dark brown to greyish brown humic fine sandy loam topsoil that abruptly overlies a reddish brown massive sticky and plastic clay layer at 30–75 cm. Both the terra rossas and ash-covered soils appear to have moderate fertility.

This land is assessed to have a very high capability for improved pastures, a high capability for arable crops, a moderate capability for tree crops and a very low capability for flooded rice. The terra rossa soils are somewhat difficult to cultivate because of their plastic, sticky and clayey nature which also appears to make them more susceptible to erosion. The areas with the ash-covered soils are therefore best suited to agriculture. Soils in the other districts are also expected to be reddish clay soils (terra rossas) together with shallow soils with dark topsoils (rendzinas).

(*i*) *Land with Alkaline Soils*

(i) *Map Symbol* Ar (*ratings* $a_2r_{1\ or\ 2}$).—This mapping unit covers 110 km^2 and occurs only in the Northern District. It consists of relatively steep alluvial fans and plains located in the eastern Musa basin, mainly at altitudes between 600 and 1200 m. Although slopes of 2–5° occur, most of the land is expected to have slopes of less than 2°. Alkaline calcareous fine sandy and silty stratified alluvial soils which are frequently stony and generally have shallow gravel beds are most common. Most of the land is well drained but considerable areas are poorly drained. The vegetation consists of large- to medium-crowned forest.

Generally the mapping unit is assessed to have a high capability for pastures, a moderate capability for tree crops, a moderate to low capability for arable crops and a moderate to very low capability for flooded rice. However, in this assessment the poorly drained areas, which particularly limit arable and tree crops, are not taken into account.

(*j*) *Land Subject to Moderate Drought Risks*

(i) *Map Symbol* Mn (*ratings* m_2n_1).—This mapping unit covers 740 km^2 and is found mainly along the Upper Markham and Upper Ramu Rivers in the Morobe District, but it extends across the district boundary into the Madang and Eastern Highland Districts. A few small areas occur in the Northern and Central Districts. The unit is confined to areas with strong seasonal and dry climates which combined with coarse-textured and/or gravelly and stony and/or rather shallow soils cause pronounced soil moisture deficiencies.

The soils of the Markham valley have been subject to an extensive study by the Land Utilization Section of the Department of Agriculture, Stock and Fisheries (Holloway *et al.* 1973). The very gently sloping grass-covered fan surfaces along the Upper Ramu River consist mainly of very shallow to deep, medium- to fine-textured well-drained black soils.

Low hills and undulating surfaces consisting of greywacke, siltstone, mudstone and conglomerate occur in the Northern District under eucalypt savanna. Here weakly acid texture-contrast soils with gleyed very plastic clayey subsoils are found. These become temporarily waterlogged after heavy rain.

No information is available about the small area mapped in the Central District.

The mapping unit is considered to have a high capability for flooded rice and a moderate capability for arable crops, tree crops and improved pastures. The suitability for flooded rice might be rather more limited because of the rapid to moderate permeability of the soils. The suitability for arable and tree crops is limited to crops requiring a dry season for flowering, fruiting and/or harvesting.

(ii) *Map Symbol* Mna (*ratings* $m_2n_1a_{1\ or\ 3}$).—This mapping unit covers 210 km^2 and occurs only in the Western District. It consists of broad ridges running east–

west and covered by monsoon forest. The characteristic soils are strongly weathered acid to strongly acid sandy loams to loams, merging into red gravelly loams to gravelly clay loams. They are of very low fertility.

The mapping unit is assessed to have a high capability for flooded rice and a moderate capability for arable crops, tree crops and improved pastures. The suitability for flooded rice could well be lower because of the difficulty of obtaining water for irrigation. The growing of arable and tree crops is limited to crops requiring a dry season for flowering, fruiting and/or harvesting.

(iii) *Map Symbol* Man (*ratings* $m_2a_2n_1$).—This mapping unit covers 700 km^2 and is found only in the Morobe District in the Markham valley west of the Erap River. The land has dominantly grassland and savanna vegetation. It has been surveyed in detail by the Land Utilization Section of the Department of Agriculture, Stock and Fisheries (Holloway *et al.* 1973). The Markham valley consists of a large structural depression filled with sediments that have been shed from the ranges and transported by seasonally fast-flowing rivers. These alluvial fan depositional processes in the valley have resulted in soils with little or no profile development and very variable textures. Medium- to coarse-textured soils often with gravel and/or stones are most common. These soils have an alkaline soil reaction, are base saturated and have high exchange capacities. Exchangeable potassium levels are high while nitrogen levels are marginal and available phosphates are generally inadequate for arable crops. Because of the alkalinity most soils are deficient in trace elements.

Based on a general assessment this mapping unit is considered to have a high capability for flooded rice and a low capability for arable crops, tree crops and improved pastures. A much more detailed assessment of the agricultural capability of the Markham valley is given in the Land Utilization Section report previously mentioned (Holloway *et al.* 1973). The excessively high evaporation rate during the long dry season, resulting in soil moisture deficiency, particularly in the coarser-textured soils, limits the choice of crops. Consequently for continual cropping irrigation will be needed.

(iv) *Map Symbol* Med (*ratings* $m_2e_1d_1$).—This mapping unit of 930 km^2 occurs only in the driest areas of the Central District and forms a narrow fringe along the coast. Most common are texture-contrast soils occurring on interfluves or foot slopes with dolerite, gabbro and various sediments as parent material. The vegetation consists of woodland and savanna. The soils have coarser-textured (sandy loam to sandy clay loam) surface horizons passing abruptly into fine-textured (sandy clay to heavy clay) subsurface horizons. Their soil reaction varies from neutral to weakly alkaline in the topsoils to alkaline in the subsoils. The subsoils frequently contain many carbonate concretions.

This mapping unit is assessed to have a moderate capability for improved pastures, a low capability for arable and tree crops and a very low capability for flooded rice.

(*k*) *Land with Poorly Drained Soils*

(i) *Map Symbol* Dlna (*ratings* $d_2l_1n_1a_1$).—This mapping unit covers 1770 km^2 and is found in the Southern and Western Highlands and the northern part of the Western District (Plate 6). It occurs on a wide variety of land forms including some of the best land in the Highlands. It consists of volcanic ash plains (Plate 6) underlain by Pleistocene volcanic rocks, Recent alluvial plains and Recent alluvial fans.

The ash plains form gently undulating terrain sloping usually less than 3°, but up to 5°, and consist of both poorly and well- to imperfectly drained soils. The poorly drained plains generally have humic olive ash soils with thick well-developed topsoils and slowly permeable clayey subsoils. Well- to imperfectly drained plains are characterized by humic brown clay soils with strongly developed dark topsoils, abruptly overlying brown subsoils and showing a slight increase in clay content with depth. Both the humic olive ash and humic brown clay soils have an acid soil reaction and appear to have low to moderate fertility, the available phosphorus content being very low to low, but the nitrogen content high.

The alluvial fans with slopes of 1–3° consist of colluvial material derived mainly from volcanic ash and they probably also have humic olive ash soils. They appear mainly imperfectly drained but have considerable areas with poorly drained deep dark clay and peat soils.

Alluvial plains are most common in the north-eastern part of the Western Highlands and can be subdivided into upper and lower plains. Very strongly weathered imperfectly drained acid to strongly acid soils with a clayey texture and usually firm to plastic consistency occur on the upper plains. These soils contain large numbers of iron–manganese concretions that cause them to be droughty during periods of low rainfall. The lower plains are poorly to imperfectly drained and have strongly weathered acid to strongly acid grey, red and brown mottled clay soils with well-developed coarser-textured dark topsoils. These soils can also be very rich in iron–manganese concretions. Because of strong weathering the soils have a very low fertility.

Generally this mapping unit is considered to have a moderate capability for improved pastures, a low to very low capability for arable crops and a very low to nil capability for tree crops. However, it includes highland and high-altitude land with variable factors and ratings. Poor drainage is the most serious limitation for agriculture but reclamation appears to be feasible without the need for major works similar to those carried out in the Wahgi valley.

(*l*) *Land Subject to Occasional, Irregular Flooding or Inundation for up to 1 Month*

(i) *Map Symbol* Fd_1 (*ratings* f_2d_1).—This mapping unit covers 1060 km^2 and is found only in the Madang District along the middle Ramu River. It has been covered by a CSIRO reconnaissance survey (Robbins *et al.* 1975), but much more detailed information is available from a report by the Land Utilization Section of the Department of Agriculture, Stock and Fisheries.* The unit consists of flat or very gently sloping flood-plains covered by open forest or grassland. Soils are mainly imperfectly drained and subject to occasional wet-season flooding combined with inundation. Soil textures vary considerably; the rapid texture changes within the soils reflect the stratified nature of the sediments. However, medium- and fine-textured yellowish brown to olive-brown soils are most common. Soil reaction tends to be between

* ZIJSVELT, M. F. W.—Middle Ramu Valley survey 1969–1970 (unpublished).

weakly acid and neutral, but may be acid or alkaline. The fertility of the soils appears to be moderate to high. The nitrogen content is moderate, available phosphorus low to moderate, and potassium high to very high.

The mapping unit is assessed to have a moderate potential for arable crops, improved pastures and flooded rice, and a very low potential for tree crops.

(ii) *Map Symbol* Fd_2 (*ratings* f_2d_2).—This mapping unit covers 1970 km^2 mainly in the Bougainville, Madang and Western Districts, but also includes a few small areas along the south coast of New Britain and in the East Sepik District.

A large area of broad low-lying coastal alluvial plain covered by tall forest occurs in Bougainville. This is built up of Recent volcanic sandy and gravelly alluvium. The soils consist of dark brown humic loamy sand to sand merging into grey mottled sand to loamy sand and grey sand below the water-table. They are subject to irregular and infrequent flooding.

Along the coast in the Madang and East Sepik District the unit forms one continuous area of broad beach ridges covered by grassland, the largest part comprising older ridges with mainly poorly drained old alluvial soils which are inundated during the wet season. Grey-brown mottled soils with thick black to very dark grey sandy loam to sandy clay loam topsoils and sandy subsoils are frequently found. They are moderately permeable and improvement of the drainage appears to be relatively easy.

Another area in the Madang District is found along the Ramu River and except for its slightly more impeded drainage it is similar to the other soils of the Ramu valley area described under section (*l*)(i).

The few field observations available from the Bamu River flood-plains in the Western District indicate dominantly poorly drained weakly acid to neutral stratified alluvial soils of variable texture. The vegetation consists of open plain forest.

No information is available on the areas mapped in New Britain.

The mapping unit is assessed to have a moderate capability for improved pastures and flooded rice and low capability for arable crops. Being located at or close to the coast the areas are relatively accessible.

(*m*) *Land Subject to Moderate Erosion and with Soils of Low Fertility*

(i) *Map Symbol* En (*ratings* e_2n_1).—This mapping unit of 2580 km^2 is found mainly in the Northern District and New Britain. Other smaller areas are mapped in the New Ireland, Bougainville, Central and Morobe Districts.

In the Northern District, the mapping unit covers a wide variety of land forms, rocks and also soils. The largely forested (medium-crowned) lower slopes of Mt Victory volcano consist of long very gentle slopes with moderately weathered acid to weakly acid fine-textured brown ash soils. These soils have very friable and very dark clay loam topsoils, while the subsoils are yellowish brown structureless porous horizons with sandy clay to clay textures. However, stoniness fairly often occurs locally on this land. In the eastern Musa basin there are deeply weathered mudflow fans consisting of undulating surfaces sloping between 5° and 20°. Deep reddish over strong brown weakly acid to neutral friable clay to heavy clay soils are dominant. The vegetation consists of large-crowned forest. The most western part of this mapping unit in the Northern District has mainly gently undulating slopes that form a plateau covered with Pleistocene and Recent basalt lava. Shallow weathering has produced a great variety of dark-coloured basalt and volcanic ash soils. This is the result of the age differences of the flows and the varying degree of admixture with ash. Weakly acid dark brown firm to very plastic heavy clay soils, with weakly acid coarser-textured surface horizons, are common on the rounded crests. The more dissected flows have strongly acid dark red-brown heavy clay soils. Other land forms belonging to this unit are steep to very steep irregular slopes, cones and domes also with very variable soils and locally stony land. A vegetation of regrowth and secondary forest is most usual.

In northern New Britain the largest single occurrence of this unit is on the lower slopes of Mt Ulawun and its outlying cones covered by medium-crowned hill forest. Medium- to coarse-textured volcanic ash soils, in which scoriaceous gravel layers are present at varying depths and thicknesses throughout the soil profile, are the dominant soils. Smaller areas have been mapped east and west of the Kapiura River. The soils appear to be of low fertility. The apparent low fertility of the soils mapped west of the Kapiura River is caused partly by a siliceous hardpan layer occurring within a metre of the surface.

The areas of this mapping unit in Bougainville consist of shallowly dissected Pleistocene volcano–alluvial fans with very short slopes of 8–12°. These fans are built up of volcanic debris covered by ash and have a vegetation of medium-crowned forest. Their soils consist dominantly of brown loams merging into reddish friable clays. They have a weakly acid soil reaction.

Very little information is available on the mapping unit in the New Ireland, Central and Morobe (Umboi Island) Districts and the area mapped along the south coast of the West New Britain District. Soils similar to those described for the north coast of New Britain (above) are expected to occur on Umboi Island. In New Ireland and along the south coast of New Britain the unit consists of uplifted dissected coral reefs and volcanic foot slopes. A reconnaissance soil survey of the east coast of New Ireland was carried out by van Wijk (1959) who mapped the areas covered by this mapping unit as red and brown clays and clay loams over raised coral. In the Central District it forms undulating terrain and low ridges on sedimentary and igneous rocks with characteristic slopes between 5° and 10°. Acid to neutral brown and red clay loam to clay soils, frequently with coarser-textured topsoils, appear to be dominant.

This mapping unit is assessed to have a high capability for tree crops and improved pastures and a moderate capability for arable crops. Within the mapping unit the soils related to volcanic land forms appear to have the highest capability because of their good physical soil conditions, but their rather low fertility is surprising considering their luxuriant vegetation. The scoriaceous gravel layers in the New Britain soils would somewhat limit arable cropping.

(ii) *Map Symbol* Ena (*ratings* $e_2n_1a_{1 \text{ or } 3}$).—This mapping unit covers 32 120 km^2 of which by far the largest part is concentrated in the Western District. However, many other smaller areas occur in the Gulf, Bougainville, East New Britain, West Sepik and Milne Bay Districts.

In the Western District deeply weathered Pleistocene alluvial deposits, intricately dissected into narrow ridges and valleys, are found. The ridges consist mainly of hill slopes having characteristic slopes of 8°, but these can vary between 3° and 15°.

Strong weathering has produced acid to strongly acid red clay loam to clay soils with very low fertility, particularly with respect to available phosphorus. The valleys are very poorly drained to swampy.

In the Gulf District dissected benches and low hills with sediments of varying age are found, with infertile acid to strongly acid soils with finer-textured reddish plastic clayey subsoils. Both the Western and Gulf Districts have a vegetation of small-crowned forest.

The area mapped in Bougainville consists of shallowly dissected Pleistocene to Recent volcano–alluvial fans with very short slopes of 8–12°. These fans are built up of volcanic debris covered by ash and have a medium-crowned forest vegetation. Ash soils with dark humic sandy loam topsoils merging into loamy sand subsoils and having fine sandy lapillitic horizons are the characteristic soils. These soils are acid throughout and have a rapid permeability. One of the outstanding features of these soils is their resistance to erosion.

In the West Sepik District slightly to strongly dissected Pleistocene to Recent fan surfaces and terraces are found, largely covered by secondary vegetation. Differences in age have also produced differences in soils but the most usual are strongly developed acid to strongly acid texture-contrast soils with slightly gleyed firm clay to very plastic heavy clay subsoils and friable loam to clay loam topsoils.

Very little information is available on the soils mapped in the Milne Bay and East New Britain Districts. Irregularly undulating terrain with rounded ridges on basaltic volcanic rocks and red and brown friable clay soils are found in the Milne Bay District. The New Britain soils consist probably of coarse- to medium-textured volcanic ash soils.

The mapping unit is assessed to have a moderate to low capability for tree crops and improved pastures and a low capability for arable crops.

(iii) *Map Symbol* Elna (*ratings* $e_2l_1n_1a_1$).—This mapping unit covers 340 km^2 and occurs only in the Western Highlands and Southern Highlands Districts, mainly at altitudes between 1800 and 2400 m. It consists of long gentle partly dissected foot slopes and fans of alluvial and colluvial origin which are locally covered by Pleistocene ash. Humic brown clay soils are the most usual, with strongly developed friable dark topsoils abruptly overlying dark brown clay to heavy clay subsoils. Generally they show a slight increase in clay content with depth. The soils are acid, well drained and moderately permeable. The vegetation consists of grassland and regrowth.

The unit is assessed to have a moderate capability for improved pastures, a low capability for arable crops and a very low capability for tree crops. The high altitude strongly limits the choice of arable and tree crops.

(iv) *Map Symbol* Emn (*ratings* $e_2m_1n_1$).—This mapping unit covers 230 km^2 and is found only in the Central District. It consists of plains traversed by short rocky ridges with gentle to low-moderate slopes and consisting mostly of tuffs. These are characterized by brown clay soils that are neutral to weakly alkaline at the surface, becoming alkaline with depth due to the calcareous nature of the parent material. The typical vegetation in both Gulf and Central Districts is savanna.

The mapping unit is assessed to have a moderate capability for tree crops and improved pastures and a low capability for arable crops. The choice of arable and tree crops is limited to those adapted to climates with a pronounced dry season.

(v) *Map Symbol* Emna (*ratings* $e_2m_1n_1a_1$).—This mapping unit covers 3980 km^2 and occurs in areas with monsoonal climates, mainly in the Western District but also in the Gulf and Central Districts.

In the Western District the land forms and soils are similar to those described for that district under subsection (*m*)(ii) but the vegetation is dry evergreen forest. In the Gulf and Central Districts the unit consists of low hills with moderate slopes and dissected benches that have strongly weathered acid to strongly acid soils with finer-textured clayey subsoils. The parent material is Miocene and Pliocene sediments, mainly mudstone and siltstone.

The mapping unit is considered to have a moderate to low capability for tree crops and improved pastures, and a low capability for arable crops. However, arable and tree crops requiring seasonal climates should be selected.

(vi) *Map Symbol* Edna (*ratings* $e_2d_{1\ or\ 2}n_1a_1$).—This mapping unit covers 1040 km^2 and is found in the Sepik and Southern Highlands Districts where it continues into the northern part of the Western District (Plate 7). It consists of very low to high hill ridges formed on sedimentary rocks which are often calcareous and frequently show slump features. Gentle to moderately steep hill and dip slopes are the most common and soils vary depending on the type of land form on which they occur.

Strongly developed texture-contrast soils are found on weathered surfaces dissected into very low hill ridges in the south-eastern part of the mapping unit covering both Sepik Districts (Plate 7). These ridges occurring between 0 and 600 m are dominated by secondary vegetation and have acid soils with very plastic to very firm heavy clay subsoils which are predominantly red, brown and grey mottled, and friable loamy topsoils. However, other parts of the mapping unit are characterized by dip slopes (Sepik) and long gentle slopes (Southern Highlands at altitudes between 0 and 1200 m) that show an immature weathering pattern and are covered by medium-crowned hill forest. Both dip slopes and gentle slopes have acid to weakly acid soils slightly to moderately gleyed with firm to very plastic clay to heavy clay subsoils; coarser-textured friable loam to clay surface soils usually prevail.

The slow permeability, poor physical conditions and slump risk, combined with the other ratings, give this mapping unit only a moderate capability for pastures and a low to very low capability for arable and tree crops.

(*n*) *Moderately Stony to Stony Land*

(i) *Map Symbol* Rm (*ratings* $r_3m_{1\ or\ 2}$).—This mapping unit covers 120 km^2 and occurs only in a few small areas in the Milne Bay District. It consists of undissected terraced grassland fans formed of unconsolidated Recent sediments. The terraces typically have slopes of up to 3°. Their soils consist of coarse-textured gravelly stratified alluvial layers and are excessively drained due to the rapid permeability. They have a neutral soil reaction and stones and boulders are common on the surface.

This mapping unit has a low to moderate capability for improved pastures and a low to very low capability for arable and tree crops.

(*o*) *Very Poorly Drained Land*

(i) *Map Symbol* Dle (*ratings* $d_3l_2e_1$).—This mapping unit covers 260 km^2 and covers a few small areas in the Western Highlands and Central Districts (Plate 8).

The vegetation consists of lower montane forest or alpine grassland, sedges being very common.

In the Western Highlands District it forms a high-altitude volcanic plateau (the Sugarloaf) on andesitic lava (Plate 8).

The small area mapped in the mountains of the Central District consists of undissected fans in an intermontane basin with unconsolidated sediments.

Low temperatures, wetness and frequent frosts combined with poorly drained often peaty soils limit the agricultural potential to a low capability for improved pastures.

(*p*) *Land Subject to Strong Erosion*

(i) *Map Symbol* E (*rating* e_3).—This mapping unit covers 14 130 km^2 and occurs throughout the country on moderately sloping terrain, usually on hill ridges and the lower slopes of volcanoes but also on uplifted dissected coral terraces.

Large areas of hilly terrain are found, particularly in the Sepik Districts, on sedimentary rocks softened by hydration and with slightly to moderately weathered soils. Slumping is very common in these areas. Another fairly large hilly area is found in the Madang District.

On the lower slopes of volcanoes slightly to strongly weathered soils occur depending mainly on the age of the volcano. In the Western and Northern Districts, for instance, the lower slopes of Mt Bosavi and Mt Trafalgar consist of deep strongly weathered brown and/or red clay soils, while in New Britain in the vicinity of Recent volcanoes young ash soils are usually found.

Shallow soils with dark topsoils which might be somewhat stony and/or rocky are expected to occur along the south coast of New Britain on the coral terraces.

Most of this mapping unit is covered by hill forest, but secondary vegetation is also common in more populated areas, especially in the Sepik Districts where some of the original tall forest remains locally.

This mapping unit is assessed to have a moderate capability for tree crops and improved pastures and a low capability for arable crops. Some areas have high timber volumes. Establishment of a National Park has been proposed for the Bosavi area (Schultze-Westrum 1971).

(ii) *Map Symbol* El (*ratings* $e_3l_{1\ or\ 2}$).—This mapping unit covers 3080 km^2 and is confined to high-altitude areas characterized by high-moderate to steep slopes which are covered by volcanic ash and occur mainly in the Western and Southern Highlands Districts. Most common in these areas are humic brown clay soils and humic olive ash soils on the less well-drained sites. The vegetation consists of lower montane forest, grassland and/or regrowth.

This mapping unit is considered to have a moderate (1200–2400 m) and very low (2400–3000 m) capability for improved pastures, a moderate (1200–1800 m) to nil (>1800 m) capability for tree crops, and low (1200–1800 m), very low (1800–2400 m) or nil (2400–3000 m) capability for arable crops. The choice of arable and tree crops is limited.

(iii) *Map Symbol* Edna (*ratings* $e_3d_{1\ or\ 2}n_1a_{1\ or\ 3}$).—This mapping unit covers 410 km^2 and is found in some relatively small areas in East and West Sepik Districts. It consists of low to very low ridges of dissected weathered plains formed of unconsolidated Pleistocene sediments. Slump features are very often found. Slow permeability of the clayey sediments has produced imperfectly to poorly drained soils which are acid to strongly acid.

This land is considered to have a low to very low capability for improved pastures, and a very low to nil capability for arable and tree crops.

(iv) *Map Symbol* Edln (*ratings* $e_3d_{1\ or\ 2}\,l_1n_1$).—This mapping unit covers 310 km^2 and is found only in the Eastern Highlands District at altitudes between 1200 and 1800 m under grassland. It consists of Pleistocene lacustrine deposits forming benched and rounded ridges which show many landslip scars. On the benched ridges (usually poorly drained) slightly to moderately weathered distinct grey and brown mottled plastic clay soils with well-developed dark topsoils occur. The rounded ridges are better drained and characterized by strongly to very strongly weathered firm to plastic clay soils with either large numbers of iron–manganese concretions or red, grey and brown mottled subsoils.

The mapping unit is considered to have a moderate to low capability for improved pastures and a very low to nil capability for arable and tree crops.

(*q*) *Poorly to Very Poorly Drained Land*

(i) *Map Symbol* Dna (*ratings* $d_4n_1a_{1\ or\ 3}$).—This mapping unit covers 2940 km^2 and occurs in the Sepik and Madang Districts. In the Sepik Districts it consists of flat to very gently undulating plains, usually with strongly weathered acid to strongly acid red and grey mottled clay soils. Two fairly large areas are also found in the Madang District. These areas have been included within the mapping unit although the soils are weakly acid and probably also have a higher fertility, as do the Sepik soils. In the western part of the Madang District there is a flat to gently undulating plateau continuing into the East Sepik District. The plateau, which lies more than 10 m above the surrounding flood-plain, is covered by black alluvial clay soils. Another area occurs close to Madang and consists of uplifted coastal plain with mottled plastic clay soils. The vegetation is mainly grassland.

This mapping unit is considered to have a high to moderate capability for flooded rice and a very low capability for improved pastures except for the Madang District where the grazing potential appears to be moderate.

(ii) *Map Symbol* Dlna (*ratings* $d_4l_1n_1a_1$).—This mapping unit covers 370 km^2 and its occurrence is limited to the Western Highlands District between 1200 and 1800 m. It consists largely of fan plains, river terraces and alluvial plains which are all poorly drained. Moderately to strongly weathered soils with prominently red, grey and brown mottled plastic clayey subsoils and very dark coarser-textured topsoils occur on fans and terraces. These soils vary in soil reaction from weakly acid to acid or strongly acid, particularly in the subsoil. The strongly weathered variants contain iron and manganese concretions in variable numbers. Much younger medium- to fine-textured soils occur on the alluvial plains. They are weakly acid and have a uniform sandy clay loam or sandy clay loam to clay over plastic clay to heavy clay texture.

This mapping unit is assessed to have only a very low capability for improved pastures. Poor drainage is caused by the very slow permeability and appears difficult to improve. However, if improved, the mapping unit could attain a high capability for tree and arable crops. Fertility appears to be low, particularly in the strongly weathered concretionary soils.

(iii) *Map Symbol* Dmna (*ratings* $d_4m_1n_1a_1$).—This mapping unit covers 2200 km^2 and is concentrated mainly in the East Sepik District. Relatively small areas occur also in the Northern, Milne Bay and Gulf Districts. It consists of a wide variety of land forms and vegetation and therefore also very different soils, the majority of which are poorly to very poorly drained and subject to drying out of the surface horizons.

In the East Sepik District flat to gently undulating upland grass plains are found, usually with uniform-textured heavy clay soils or soils with finer-textured mottled subsoils.

Most of the unit in the Northern District consists of fan complexes with texture-contrast soils having neutral to weakly alkaline heavy clay subsoils. The fans are covered by small-crowned thin-stemmed forest.

In the Milne Bay District valley plains with weakly acid to neutral dark soils of heavy texture are found with a vegetation of secondary forest.

Beach ridge barriers that are dominated by swales and have undifferentiated weakly acid to alkaline sandy soils occur in the Gulf District under grassland and nypa palm vegetation. These soils are expected also to be weakly saline in the subsoils.

The land is assessed to have a high capability for flooded rice and a very low capability for improved pastures. The pitted land surfaces (Haantjens 1965*b*) occurring in the East Sepik District make grading necessary. The areas most suitable for flooded rice appear to occur in the Milne Bay District.

(iv) *Map Symbol* Df (*ratings* $d_4f_{2\ or\ 3}$).—This mapping unit covers 4420 km^2 and is found in many widely scattered areas on the mainland. In the Western District it consists of areas of non-tidal flats, inundated for 1–3 months each year, with strongly gleyed marine clay to heavy clay soils. These soils are somewhat leached as shown by their soil reaction, which is weakly acid to neutral in the topsoil and alkaline in the subsoil, and they are expected to be weakly saline also. They are usually covered by littoral forest.

In most other areas the mapping unit occurs on unstable flood-plains or back plains liable to flooding and having strongly gleyed alluvial soils with a weakly acid to neutral reaction. In a large area mapped north-west of Kikori along the Kikori River the alluvium forms a thin veneer and overlies limestone at variable depths. Rocks and stones appear to be fairly common on this land, especially upstream of the Kikori River.

In the Northern District the alluvium is derived from volcanic material. Tall forest with an open canopy is the dominant vegetation.

This mapping unit is considered to have a moderate capability for flooded rice, a low to very low capability for improved pastures and a very low to nil capability for arable crops.

(v) *Map Symbol* Dfmn (*ratings* $d_4f_{2\ or\ 3}m_1n_1a_{1\ or\ 3}$).—This mapping unit covers 5410 km^2 and is found in the Western, Central and Milne Bay Districts. By far the largest areas occur in the Western District on plains consisting of Pleistocene sediments and associated with woodland. Here acid to strongly acid texture-contrast soils with clayey red and grey mottled subsoils dominate. Wet-season inundation occurs every year for 1–3 months, followed by drying out of the sandy to loamy topsoils.

Some fairly large areas are also found in the Central District around Marshall Lagoon and the Mori River. They consist of very gently undulating terrain and are mainly interfluves built up of old alluvial sediments. The soils are similar to those in the Western District but also often contain much iron, manganese and quartzite gravel. Dark cracking clay soils occur on the lowest surfaces. The soils of the Central District have been included in this mapping unit although they are not inundated during the wet season. However, their very slowly permeable subsoils cause temporary waterlogging. The vegetation is eucalypt savanna and monsoonal woodland.

Weakly acid to neutral mainly fine-textured alluvial soils which are subject to flooding are expected to occur in the Milne Bay District, but no information is available from this area. Here the vegetation consists of small-crowned forest.

The agricultural potential of this mapping unit is limited to a moderate capability for flooded rice and a very low to nil capability for improved pastures.

(vi) *Map Symbol* Den (*ratings* $d_4e_2n_1$).—This mapping unit covers 1360 km^2 and is found only in the Madang District. It consists of low hilly country formed on Miocene–Pliocene mudstone and sandstone, with slopes usually between 4° and 12°. Weakly acid to neutral plastic mottled clay soils with thick dark topsoils dominate this mapping unit. They probably have a low to moderate fertility. The vegetation consists mostly of secondary forest and garden regrowth.

Impermeable poorly drained soils and moderate slopes limit the agricultural potential of this mapping unit to a very low capability for improved pastures.

(vii) *Map Symbol* Demna (*ratings* $d_4e_2m_1n_1a_1$).—This mapping unit covers 870 km^2 and is confined to the East Sepik District (Plate 9). It forms low hilly terrain characterized by moderate slopes and consisting mainly of Pleistocene mudstone and siltstone. Strongly weathered acid texture-contrast soils with clayey red, brown and grey mottled subsoils and dark topsoils dominate. A strong microrelief is commonly associated with these soils (Haantjens 1965*b*; Lee 1967). The vegetation consists of grassland.

In its present state the agricultural capability is rated as very low for improved pastures.

(*r*) *Land Subject to Frequent Irregular Flooding, Occasional Deep Devastating Flooding or Inundation for 3–4 Months*

(i) *Map Symbol* Fdm (*ratings* $f_4d_1m_1$).—This mapping unit covers 2050 km^2 and is concentrated in areas with pronounced seasonal climates, mainly in the Gulf, Western and Central Districts, but it also includes two small areas in the Morobe District near Lae.

In the Central and Gulf Districts this mapping type is entirely confined to Recent alluvial deposits, usually with an open forest vegetation. The soils are imperfectly to poorly drained and subject to seasonal flooding and inundation, often with deposition of a thin veneer of alluvium during each flood. They have a neutral soil reaction. Little is known about the fertility of the soils, but their cation exchange capacities suggest that they are moderately fertile.

The area, mapped close to the coast in the south-western part of the Western District, has Recent poorly drained soils derived from marine sediments. These soils are weakly acid over weakly alkaline with sandy clay loam topsoils merging into heavy clay subsoils. They are covered by mid-height grassland and are subject to inundation.

No information is available on the soils in the Morobe District.

This mapping unit is considered to have a low capability for flooded rice, a low to very low capability for improved pastures and a very low to nil capability for arable crops.

(ii) *Map Symbol* Fdma (*ratings* $f_4d_1m_1a_{1\ or\ 3}$).—This mapping unit covers 7240 km^2 and is found only in the Western District. It consists of flat plains covered by *Melaleuca* savanna and built up of Pleistocene sediments (Plate 10). The plains are subject to inundation for 3–4 months, whilst in the dry season the sandy to loamy topsoils could well be subject to drying out. The subsoils consist of very slowly permeable red and grey mottled clays. The soils vary between imperfectly and poorly drained and have an acid to strongly acid soil reaction. They have a very low fertility especially in available phosphate which is usually less than 10 p.p.m.

This mapping unit is assessed to have only a low to very low capability for flooded rice.

Some of the areas mapped in the Western District are located within a wildlife sanctuary. A large (1500 km^2) national park has been proposed for the same area (Schultze-Westrum 1971). The wildlife sanctuary contains thousands of deer, wallabies, pigs, wild dogs and many different kinds of bird, including storks, ibis, geese and brolgas. In the rivers crocodiles, turtles, barramundi, sawsharks, prawns and crabs are found.

(iii) *Map Symbol* Fr (*ratings* f_4r_3).—This mapping unit covers 550 km^2 and its occurrence is limited to a few relatively small areas in the Northern District. It consists mostly of alluvial flood-plain terraces and flood-plains covered with coarse-textured frequently stony alluvial soils and open alluvial forest. However, the areas close to Mt Victory and Mt Lamington have plains covered by andesitic eruption products of these volcanoes. They have very low gradients with little-incised usually braided streams which flood frequently and carry pioneering woody and herbaceous vegetation. The suitability is nil for all agricultural land use.

(iv) *Map Symbol* Frm (*ratings* $f_4r_3m_{1\ or\ 2}$).—This mapping unit covers 980 km^2 and is associated with the braided river beds of the Ramu River and its tributaries in the Morobe, Madang and Eastern Highlands Districts. Most of this area consists of channels and gravel banks with coarse-textured stony and gravelly Recent alluvial soils. However, a large part of the area has somewhat better land on the slightly higher stony flood-plain terraces which are rarely flooded. Herbaceous and woody river-bank successions and grassland are the most common vegetation in this mapping unit.

Without improvement this mapping unit is assessed to have no capability for agriculture.

(v) *Map Symbol* Fd (*ratings* f_4d_4).—This mapping unit covers 7970 km^2 and is widespread all over Papua New Guinea (Plate 11). It is characterized by poorly to very poorly drained land frequently subject to flooding and very hard to improve without major reclamation works. The soils consist mainly of medium- to fine-textured stratified alluvium which varies considerably in soil reaction. By far the most common are the weakly acid to neutral soils. However, in the Northern District there are alkaline calcareous soils, derived probably from the eastern tributaries of the Musa River. Alkaline soils occur also along the east bank of the Strickland River in the Western District as a result of the limestone detritus in the river. Similar alkaline soils are probably to be found in the West Sepik District. Open plain forest or small-crowned forest on plains is the most common vegetation.

With the exception of a low capability for flooded rice this land is unsuitable for any type of agriculture.

(*s*) *Land Subject to Very Strong Erosion*

(i) *Map Symbol* E (*rating* e_4).—This mapping unit covers 83 810 km^2 and is the largest mapped. It occurs throughout the massive, rugged, low-altitude mountain areas on a wide variety of rock types and land forms. It supports large forest resources but these can be exploited economically in only a few accessible areas. The main vegetation is medium-crowned forest together with occasional patches of grassland and gardens. Severe erosion hazards because of the steep slopes have led to the dominance of soils consisting of weathered brown clayey regolith material (regosolic brown soils) together with the somewhat more developed brown forest soils and acid brown forest soils (Haantjens 1967). On sediments with high clay contents, such as mudstones, soils are often imperfectly drained even on steep slopes.

Generally this mapping unit is assessed to have a very low capability for tree crops and improved pastures. Except for some grazing it is best left in its natural state. Tourism appears to offer some potential in certain areas.

(ii) *Map Symbol* El (*ratings* e_4l_1).—This mapping unit covers 35 230 km^2 and is found in steeply sloping high-altitude areas throughout the country (Plate 12). Basically it is very similar to (*s*)(i) but shallow stony soils (lithosols) are expected to be somewhat more common. The vegetation consists mainly of lower montane forest with occasional grassland patches.

This mapping unit is assessed to have a very low capability for improved pastures and a very low to nil capability for tree crops.

(iii) *Map Symbol* Er (*ratings* e_4r_3).—This mapping unit covers 31 230 km^2 and is confined mainly to limestone areas, but also includes some land on volcanic rocks. The presence of sink-holes and dolines in many areas is typical, making the terrain extremely inaccessible. Shallow soils with or without dark topsoils (lithosols and rendzinas) dominate. However, deep plastic red clay soils often also occur between rock outcrops. The vegetation consists of small- and medium-crowned forest.

This mapping unit is considered to be unsuitable for agriculture. Subsistence cropping is often confined to infilled dolines. Some of the coral limestone near Kikori in the Gulf District is used successfully for making bricks.

(iv) *Map Symbol* Erma (*ratings* $e_4r_3m_{1\ or\ 2}a_2$).—This mapping unit covers 2280 km^2 and is found only in areas with a pronounced seasonal climate, usually in the coastal strip of the Central District. It has a vegetation of eucalypt savanna. The rock type on which it occurs varies strongly but is on the whole confined to sedimentary rocks such as siltstone, mudstone, sandstone, limestone and chert. However, it also includes areas with gabbro and dolerite. Stony and/or gravelly mainly alkaline shallow soils (lithosols) dominate the crests and steep slopes. Drought risks are likely to be enhanced by the shallow nature of these soils. According to Mabbutt and Scott (1966) the frequent occurrence of lithosols in this mapping area is the result of erosion of the steep hill slopes combined with little weathering; this is consistent with the subhumid climate and the fine texture and chemical stability of the sediments that occur on these slopes.

This mapping unit has no agricultural capability. Some of its unique vegetation could be preserved by establishing a nature reserve.

(*t*) *Swampy Land*

(i) *Map Symbol* Dfl (*ratings* $d_5f_4l_1$).—This mapping unit covers 660 km^2 and is located predominantly in the Western and Southern Highlands Districts. Most of it consists of flood-plains and flood-plain swamps some of which have now been drained successfully (Wahgi valley), and is producing some of Papua New Guinea's high-quality tea (Plate 1, Fig. 1) and coffee. Medium-textured alluvial soils and peat soils dominate. The original vegetation consisted of swamp grasses and sedges. Assessed in its 'original state' this mapping unit has no agricultural capability. However, by improving drainage and establishing protection against overflow it has been converted to first-class land.

(*u*) *Land Subject to Permanent or Semi-Permanent Inundation or Very Frequent Flooding*

(i) *Map Symbol* Fd (*ratings* $f_5d_{4\ or\ 5}$).—This mapping unit covers 56 910 km^2 and occurs in the lowlands along tracts of major rivers such as the Sepik, Fly and Purari (Plate 13). It consists of very poorly drained or swampy flood-plains and swamps covered by swamp forest, swamp woodland, swamp grassland or herbaceous swamp vegetation.

In the frequently flooded areas stratified alluvial soils are found. Variations in texture of these soils can to some extent be related to land form. The river channel will generally have a bed varying from gravel to silt. Gravelly beds and their associated point bars occur in the upper reaches of the river, becoming sandy in the middle and silty in the lower reaches. Where the river-banks are frequently flooded the deposition of silty or sandy bed-loads gives rise to scroll patterns. On the plains away from the rivers the flood waters flow much more slowly, the material deposited becomes finer textured and layering is less obvious. In the back plains and swamps shallow stagnant water supports a relatively abundant plant life, and this causes the formation of peat with the minimum sedimentation of inorganic material. Strongly gleyed alluvial soils and peat soils are therefore dominant in this mapping unit. Their soil reaction, however, varies considerably depending on the area, but soils with a weakly acid to neutral reaction are most common. Acid to strongly acid soils occur in some small areas, for instance north of Lake Murray in the Western District where soils have locally been derived from strongly weathered Pleistocene sediments. Alkaline soils are found in areas where rivers carry material eroded from calcareous deposits.

Although it comprises often very fertile soils this land offers little or no agricultural potential without major improvements, except for a very low capability for flooded rice. However, its forests contain sago, at present one of the main sources of food for the lowland people. Many of the rivers within this mapping unit are very rich in fish. With their abundance in fish and bird life some areas appear very suitable for the establishment of a national park or wildlife sanctuary.

(ii) *Map Symbol* Fdsa (*ratings* $f_5d_5s_1a_{2\ or\ 3}$).—This mapping unit covers 6170 km^2 and occurs usually in narrow fringes along muddy shores or in estuaries (Plate 14). It is strongly related to mangrove vegetation growing in areas under tidal influences. This tidal flooding also gives rise to undeveloped soils of variable texture, but there is in general a clear gradation from coarse to fine on going inland. All soils are strongly gleyed, mottled and saline and have a high alkalinity. The mangrove vegetation plays an important role in stabilizing the soil and possibly increasing aggradation. Raw mangrove peat soils dominate in sheltered areas, for instance near the mouth of the Sepik River. Many soils in the mapping unit are being worked continuously by crabs; the crab mounds, up to 1 m high, are sometimes used for gardening. These mounds are particularly common in the Gulf and Central Districts.

Apart from exploitation of the mangrove forests, which have high timber volumes in some areas, the land has no agricultural potential. At least one area should be set aside as a nature reserve or national park, offering a unique environment.

(*v*) *Land Subject to Severe Erosion*

(i) *Map Symbol* E (*rating* e_5).—This mapping unit covers 46 100 km^2 and is one of the most frequently mapped areas in the country (Plate 15).

It consists of rugged hilly and mountainous terrain, densely dissected by streams and with very steep irregular slopes. However, it also contains much less steep terrain and narrow alluvial valleys. It covers a wide variety of rocks confined mainly to metamorphics and sedimentaries with the exception of limestone. The main vegetation is medium-crowned forest. This great variety of rock type and terrain has resulted in a great variety of soils. Young, little to moderately weathered soils, mostly regosols and acid brown forest soils (Haantjens 1967), are most common.

This mapping unit is considered to have no agricultural capability. Tourism and recreation might offer some potential in selected areas, but access is a major difficulty.

(ii) *Map Symbol* El (*ratings* e_4l_1).—This mapping unit covers 42 020 km^2 and is found in steeply sloping high-altitude areas throughout the central cordillera (Plate 16). It is very similar to (*v*)(i) but shallow stony soils (lithosols) are more common. The vegetation consists mostly of lower montane forest and grassland.

It is unsuitable for any agricultural use.

(iii) *Map Symbol* Erl (*ratings* $e_5r_3l_{1\ or\ 2}$).—This mapping unit covers 9530 km^2 and occurs mainly in the rugged mountains of eastern Papua between altitudes of 1200 and 3000 m (Plate 17). Most of the land consists of very steep mountain ridges sloping between 30° and 45°, with landslides and slumping features occurring often. The main rocks found in this mapping unit are ultrabasic, metamorphic and limestone, the last being confined mainly to the Western Highlands. Shallow soils, usually lithosols and regosols, are dominant together with relatively high percentages of scree material, stones, boulders and rock outcrops. The vegetation consists mainly of lower montane forest and extensive grassland areas.

This mapping unit has no agricultural potential. It should therefore be left in its natural state and used for recreation, wildlife or water supply protection.

(iv) *Map Symbol* Elr (*ratings* $e_5l_3r_3$).—This mapping unit covers 7440 km^2 and is found in the rugged high mountain areas between 3000 and 5000 m which show signs of previous glaciation (Plate 18). Rocks are mainly andesite, granodiorite and metamorphic rocks. Low temperatures, frequent frosts and high rainfall combined with steep, unstable slopes have caused weathering to be very slight. Therefore lithosols and alpine peat soils dominate in this mapping unit. The alpine peat soils are confined mainly to the less steeply sloping terrain. The vegetation consists of montane forest with higher altitudes giving way to alpine grassland and herb fields.

This land has no agricultural capability, but its scenic beauty appears to offer great potential for the tourist industry. Accessibility is a major problem. A national park has already been established in the Mt Wilhelm area, covering the highest mountain in Papua New Guinea.

TABLE 4

DISTRIBUTION OF MAPPING UNITS IN BOUGAINVILLE DISTRICT (NEW GUINEA)

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
Na	n_1a_1 or n_1	1084	11·7	H_1	H_1	H	H
M	m_1	84	0·9	H_1	H_1	H	VH
Mn	m_1n_1	188	2·0	H_1–M_1	H_1–M_1	H	H
D	d_1	208	2·2	H_1	M_1	VH	VH
Dn	d_1n_1	752	8·1	H_1	M_1	H	H
Ed	e_1d_1	356	3·8	H_1	M_1	VH	VL
Fd_2	f_2d_2	668	7·2	L_1	N	M	M
En	e_2n_1	252	2·7	M_1	H_1	H	N
Ena	$e_2n_1a_1$	484	5·2	L_1	M_1	M	N
E	e_3	48	0·5	L_1	M_1	M	N
Fd	f_4d_4	88	1·0	N	N	N	L
E	e_4	608	6·5	N	VL_1	VL	N
Fd	$f_5d_{4\text{ or }5}$	780	8·4	N	N	N	VL
E	e_5	3300	35·5	N	N	N	N
El	e_5l_1	192	2·1	N	N	N	N
Erl	$e_5r_3l_{1\text{ or }2}$	208	2·2	N	N	N	N
		9300	100				

V. DISTRIBUTION OF MAPPING UNITS OVER DISTRICTS

(a) General

In Tables 4–21 the distribution of the mapping units over each of the districts in both Papua and New Guinea is shown. Tables 22–29 show the broad distribution of suitability levels for arable crops, tree crops, improved pastures and flooded rice for each district in square kilometres and percentage area. The calculations in square kilometres are based on a dot area grid, 1 dot being equal to 4 km^2. Areas with very high, high, high to moderate and moderate levels only are discussed.

TABLE 5

DISTRIBUTION OF MAPPING UNITS IN NEW IRELAND DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
Na	n_1a_1 or n_1	84	0·9	H_1	H_1	H	H
D	d_1	656	6·9	H_1	M_1	VH	VH
En	e_1n_1	320	3·4	M_1	H_1	H	N
E	e_3	788	8·3	L_1	M_1	M	N
Fd	f_4d_4	236	2·5	N	N	N	L
E	e_4	3000	31·5	N	$VL_{1,2}$	VL	N
Er	e_4r_3	1268	13·3	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	108	1·1	N	N	N	VL
Fdsa	$f_5d_5s_1a_{2 \text{ or } 4}$	124	1·3	N	N	N	N
E	e_5	1916	20·1	N	N	N	N
El	e_5l_1	1016	10·7	N	N	N	N
		9516	100				

TABLE 6

DISTRIBUTION OF MAPPING UNITS IN EAST NEW BRITAIN DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
O	—	84	0·5	VH_1	VH_1	VH	VH
Na	n_1a_1 or n_1	122	0·7	H_1	H_1	H	H
D	d_1	212	1·1	H_1	M_1	VH	VH
Fd	$f_1d_{1 \text{ or } 2}$	316	1·7	H_1–M_1	M_1–L_1	H	H
E	e_1	560	3·0	H_1	VH_1	VH	VL
Ed	e_1d_1	26	0·1	H_1	M_1	VH	VL
Fd_2	f_2d_2	70	0·4	L_1	N	M	M
En	e_2n_1	192	1·0	M_1	H_1	H	N
Ena	$e_2n_1a_1$	180	1·0	L_1	M_1	M	N
E	e_3	716	3·9	L_1	M_1	M	N
Fd	f_4d_4	226	1·2	N	N	N	L
E	e_4	6688	36·0	N	$VL_{1,2}$	VL	N
Er	e_4r_3	5032	27·1	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	90	0·5	N	N	N	VL
Fdsa	$f_5d_5s_1a_{2 \text{ or } 4}$	18	0·1	N	N	N	N
E	e_5	3842	20·7	N	N	N	N
El	e_5l_1	194	1·0	N	N	N	N
		18 568	100				

TABLE 7

DISTRIBUTION OF MAPPING UNITS IN WEST NEW BRITAIN DISTRICT

Symbol	Rating(s)	Unit area (km²)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
O	—	322	1·9	VH_1	VH_1	VH	VH
Na	n_1a_1 or n_1	94	0·6	H_1	H_1	H	H
D	d_1	314	1·8	H_1	M_1	VH	VH
Dn	d_1n_1	26	0·1	H_1	M_1	H	H
Fd	$f_1d_{1 \text{ or } 2}$	256	1·5	H_1–M_1	M_1–L_1	H	H
E	e_1	388	2·3	H_1	VH_1	VH	VL
Ed	e_1d_1	690	4·0	H_1	M_1	VH	VL
Fd_2	f_2d_2	32	0·2	L_1	N	M	M
En	e_2n_1	748	4·4	M_1	H_1	H	N
E	e_3	1098	6·4	L_1	M_1	M	N
Fd	f_4d_4	884	5·2	N	N	N	L
E	e_4	5878	34·4	N	$VL_{1,2}$	VL	N
Er	e_4r_3	3186	18·7	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	368	2·2	N	N	N	VL
Fdsa	$f_5d_5s_1a_{2 \text{ or } 4}$	88	0·5	N	N	N	N
E	e_5	2666	15·6	N	N	N	N
Lake	—	36	0·2				
		17 074	100				

TABLE 8

DISTRIBUTION OF MAPPING UNITS IN MANUS DISTRICT

Symbol	Rating(s)	Unit area (km²)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
Ed	e_1d_1	228	10·2	H_1	M_1	VH	VL
E	e_3	244	10·9	L_1	M_1	M	N
Er	e_4r_3	1296	58·0	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	312	13·9	N	N	N	VL
E	e_5	156	7·0	N	N	N	N
		2236	100				

TABLE 9

DISTRIBUTION OF MAPPING UNITS IN MOROBE DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture Arable crops	Tree crops	Improved pastures	Flooded rice
O	—	192	0·6	VH_1	VH_1	VH	VH
Na	n_1a_1 or n_1	456	1·3	H_1	H_1	H	H
M	m_1	608	1·8	H_1	H_1	H	VH
Mn	m_1n_1	60	0·2	H_1–M_1	H_1–M_1	H	H
D	d_1	168	0·5	H_1	M_1	VH	VH
Fd	$f_1d_{1 \text{ or } 2}$	132	0·4	H_1–M_1	M_1–L_1	H	H
E	e_1	116	0·3	H_1	VH_1	VH	VL
Mn	m_2n_1	386	1·1	M_1	M_1	M	H
Man	$m_2a_2n_1$	698	2·0	L_1	L_1	L	H
En	e_2n_1	132	0·4	M_1	H_1	H	N
E	e_3	408	1·2	L_1	M_1	M	N
Fdm	$f_4d_{1 \text{ or } 4}m_1$	156	0·5	VL_1–N	N	L–VL	L
Frm	$f_4r_3m_{1 \text{ or } 2}$	596	1·7	N	N	N	N
E	e_4	3864	11·2	N	$VL_{1,2}$	VL	N
El	e_4l_1	2852	8·3	N	VL_3–N	VL	N
Er	e_4r_3	1968	5·7	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	556	1·6	N	N	N	VL
E	e_5	6156	17·9	N	N	N	N
El	e_5l_1	14 088	40·9	N	N	N	N
Erl	$e_5r_3l_{1 \text{ or } 2}$	80	0·2	N	N	N	N
Elr	$e_5l_3r_3$	772	2·2	N	N	N	N
		34 444	100				

TABLE 10

DISTRIBUTION OF MAPPING UNITS IN EASTERN HIGHLANDS DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture Arable crops	Tree crops	Improved pastures	Flooded rice
Mlna	$m_1l_1n_1a_1$	160	1·5	M_3	M_3	M	N
Fl	f_1l_1	68	0·7	H_3	H_3	H	N
Mn	m_2n_1	20	0·2	M_1	M_1	M	H
El	$e_3l_{1 \text{ or } 2}$	64	0·6	L_3–VL_4–N	M_3–N	M–VL	N
Edln	$e_3d_{1 \text{ or } 2}l_1n_1$	308	3·0	VL_3	L_3–VL_3	M–L	N
Frm	$f_3r_3m_{1 \text{ or } 2}$	136	1·3	N	N	N	N
E	e_4	1332	12·8	N	VL_3	VL	N
El	e_4l_1	3500	33·7	N	VL_3–N	VL	N
E	e_5	244	2·3	N	N	N	N
El	e_5l_1	4224	40·6	N	N	N	N
Elr	$e_5l_3r_3$	348	3·3	N	N	N	N
		10 404	100				

TABLE 11

DISTRIBUTION OF MAPPING UNITS IN CHIMBU DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
Na	n_1a_1 or n_1	208	2·9	H_2	H_2	H	M
E	e_3	312	4·3	L_2	M_2	M	N
E	e_4	592	8·3	N	$VL_{1,2}$	VL	N
El	e_4l_1	4940	68·8	N	VL_3–N	VL	N
Er	e_4r_3	328	4·6	N	N	N	N
Dfl	$d_5f_4l_1$	20	0·3	N	N	N	N
El	e_5l_1	484	6·7	N	N	N	N
Elr	$e_5l_3r_3$	292	4·1	N	N	N	N
		7176	100				

TABLE 12

DISTRIBUTION OF MAPPING UNITS IN WESTERN HIGHLANDS DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
La	l_1a_1	204	0·9	$H_{3,4}$	H_3–L_4	H	N
Mlna	$m_1l_1n_1a_1$	40	0·2	M_3	M_3	M	N
Dlna	$d_2l_1n_1a_1$	980	4·2	L_3–VL_4	VL_3–N	M	N
Elna	$e_2l_1n_1a_1$	280	1·2	L_4	VL_4	M	N
Dle	$d_3l_2e_1$	232	1·0	N	N	L	N
El	$e_3l_{1 \text{ or } 2}$	592	2·5	L_3–VL_4–N	M_3–N	M–VL	N
Dlna	$d_4l_1n_1a_1$	368	1·6	N	N	VL	N
E	e_4	2964	12·6	N	$VL_{1,2}$	VL	N
El	e_4l_1	11 116	47·5	N	VL_3–N	VL	N
Er	e_4r_3	1376	5·9	N	N	N	N
Dfl	$d_5f_4l_1$	432	1·8	N	N	N	N
El	e_5l_1	2432	10·4	N	N	N	N
Erl	$e_5r_3l_{1 \text{ or } 2}$	1260	5·4	N	N	N	N
Elr	$e_5l_3r_3$	1136	4·8	N	N	N	N
		23 412	100				

TABLE 13

DISTRIBUTION OF MAPPING UNITS IN WEST SEPIK DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: *Arable* crops	*Tree* crops	*Improved* pastures	Flooded rice
O	—	508	1·4	VH_1	VH_1	VH	VH
Na	n_1a_1 or n_1	596	1·6	H_1	H_1	H	H
Mn	m_1n_1	164	0·4	H_1–M_1	H_1–M_1	H	H
D	d_1	2156	5·9	H_1	M_1	VH	VH
Dn	d_1n_1	996	2·7	H_1	M_1	H	H
Fd	$f_1d_{1\text{ or }2}$	288	0·8	H_1–M_1	M_1–L_1	H	H
Ena	$e_2n_1a_{1\text{ or }3}$	104	0·3	L_1	M_1–L_1	M–L	N
Edna	$e_2d_{1\text{ or }2}n_1a_1$	480	1·3	L_1–VL_1	L_1–VL_1	M	N
E	e_3	3328	9·1	L_1	M_1	M	N
Edna	$e_3d_{1\text{ or }2}n_1a_{1\text{ or }3}$	272	0·7	VL_1–N	VL_1–N	L–VL	N
Dna	$d_4n_1a_{1\text{ or }3}$	2040	5·6	N	N	VL	H–M
Df	$d_4f_{2\text{ or }3}$	240	0·7	VL_1	N	L–VL	M
Fd	f_4d_4	664	1·8	N	N	N	L
E	e_4	9004	24·7	N	VL_1	VL	N
El	e_4l_1	1516	4·2	N	VL_3–N	VL	N
Er	e_4r_3	988	2·7	N	N	N	N
Fd	$f_5d_{4\text{ or }5}$	3088	8·5	N	N	N	VL
Fdsa	$f_5d_5s_1a_{2\text{ or }4}$	24	0·1	N	N	N	N
E	e_5	3920	10·7	N	N	N	N
El	e_5l_1	5156	14·1	N	N	N	N
Erl	$e_5r_3l_{1\text{ or }2}$	280	0·8	N	N	N	N
Elr	$e_5l_3r_3$	704	1·9	N	N	N	N
		36 516	100				

TABLE 14

DISTRIBUTION OF MAPPING UNITS IN EAST SEPIK DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
Mn	m_1n_1	132	0·3	H_1–M_1	H_1–M_1	H	H
D	d_1	1100	2·6	H_1	M_1	VH	VH
Dn	d_1n_1	204	0·5	H_1	M_1	H	H
Fd	$f_1d_{1 \text{ or } 2}$	232	0·6	H_1–M_1	M_1–L_1	H	H
Fd_2	f_2d_2	76	0·2	L_1	N	M	M
Edna	$e_2d_{1 \text{ or } 2}n_1a_1$	264	0·6	L_1–VL_1	L_1–VL_1	M	N
E	e_3	1096	2·6	L_1	M_1	M	N
Edna	$e_3d_{1 \text{ or } 2}n_1$ $a_{1 \text{ or } 3}$	136	0·3	VL_1–N	VL_1–N	L–VL	N
Dna	$d_4n_1a_{1 \text{ or } 3}$	708	1·7	N	N	VL	H–M
Dmna	$d_4m_1n_1a_1$	1696	4·1	N	N	VL	H
Df	$d_4f_{2 \text{ or } 3}$	524	1·3	VL_1	N	L–VL	M
Demna	$d_4e_2m_1n_1a_1$	872	2·1	N	N	VL	N
Fd	f_4d_4	1676	4·0	N	N	N	L
E	e_4	11 860	28·4	N	$VL_{1,2}$	VL	N
El	e_4l_1	1308	3·2	N	VL_3–N	VL	N
Fd	$f_5d_{4 \text{ or } 5}$	18 656	44·7	N	N	N	VL
Fdsa	$f_5d_5s_1$ $a_{2 \text{ or } 4}$	388	0·9	N	N	N	N
E	e_5	580	1·4	N	N	N	N
Elr	$e_5l_3r_3$	216	0·5	N	N	N	N
		41 724	100				

TABLE 15

DISTRIBUTION OF MAPPING UNITS IN MADANG DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
O	—	1212	4·3	VH_1	VH_1	VH	VH
Na	n_1a_1 or n_1	156	0·6	H_1	H_1	H	H
M	m_1	476	1·7	H_1	H_1	H	VH
Fd	$f_1d_{1 \text{ or } 2}$	152	0·5	H_1–M_1	M_1–L_1	H	H
Mn	m_2n_1	168	0·6	M_1	M_1	M	H
Fd_1	f_2d_1	1060	3·8	M_1	VL_1	M	M
Fd_2	f_2d_2	612	2·2	L_1	N	M	M
E	e_3	724	2·6	L_1	M_1	M	N
Dna	$d_4n_1a_{1 \text{ or } 3}$	192	0·7	N	N	VL	H–M
Df	$d_4f_{2 \text{ or } 3}$	108	0·4	VL_1–N	N	L–VL	M
Den	$d_4e_2n_1$	1360	4·9	N	N	VL	N
Frm	$f_4r_3m_{1 \text{ or } 2}$	244	0·9	N	N	N	N
Fd	f_4d_4	1368	4·9	N	N	N	L
E	e_4	10 156	36·3	N	$VL_{1,2}$	VL	N
El	e_4l_1	1924	6·9	N	VL_3–N	VL	N
Er	e_4r_3	200	0·7	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	936	3·3	N	N	N	VL
E	e_5	5012	17·9	N	N	N	N
El	e_5l_1	1200	4·3	N	N	N	N
Elr	$e_5l_3r_3$	604	2·2	N	N	N	N
Lake	—	88	0·3				
		27 952	100				

TABLE 16

DISTRIBUTION OF MAPPING UNITS IN WESTERN DISTRICT (PAPUA)

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
Mna	$m_1n_1a_{1 \text{ or } 3}$	11 360	11·0	M_1	M_1	M	H
Fd	$f_1d_{1 \text{ or } 2}$	136	0·1	H_1–M_1	M_1–L_1	H	H
Mna	$m_2n_1a_{1 \text{ or } 3}$	212	0·2	L_1	L_1	L	L
Dlna	$d_2l_1n_1a_1$	44	tr	L_3–VL_4	VL_3–N	M	N
Fd_2	f_2d_2	508	0·5	L_1	N	M	M
Ena	$e_2n_1a_{1 \text{ or } 3}$	30 064	29·0	L_1	M_1–L_1	M–L	N
Emna	$e_2m_1n_1a_{1 \text{ or } 3}$	3760	3·6	L_1	M_1–L_1	M–L	N
Edna	$e_2d_{1 \text{ or } 2}$ n_1a_1	88	0·1	$L_{1,2}$–$VL_{1,2}$	$L_{1,2}$–$VL_{1,2}$	M	N
E	e_3	2768	2·7	L_1	M_1	M	N
Df	$d_4f_{2 \text{ or } 3}$	932	0·9	VL_1–N	N	L–VL	M
Dfmn	$d_4f_{2 \text{ or } 3}$ $m_1n_1a_{1 \text{ or } 3}$	4852	4·7	N	N	VL–N	M
Fdm	$f_4d_{1 \text{ or } 2}m_1$	572	0·6	VL_1–N	N	L–VL	L
Fdma	$f_4d_{1 \text{ or } 4}$ $m_1a_{1 \text{ or } 3}$	7236	7·0	N	N	N	L–VL
Fd	f_4d_4	1528	1·5	N	N	N	L
E	e_4	7052	6·8	N	$VL_{1,2}$	VL	N
El	e_4l_1	3880	3·8	N	VL_3–N	VL	N
Er	e_4r_3	2304	2·2	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	22 568	21·8	N	N	N	VL
Fdsa	$f_5d_5s_1a_{2 \text{ or } 4}$	1724	1·7	N	N	N	N
E	e_5	12	tr	N	N	N	N
El	e_5l_1	748	0·7	N	N	N	N
Erl	$e_5r_3l_{1 \text{ or } 2}$	228	0·2	N	N	N	N
Elr	$e_5l_3r_3$	476	0·5	N	N	N	N
Lake		452	0·4				
		103 504	100				

TABLE 17

DISTRIBUTION OF MAPPING UNITS IN GULF DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
Mn	m_1n_1	196	0·5	H_1–M_1	H_1–M_1	H	H
D	d_1	32	0·1	H_1	M_1	VH	VH
Fd	$f_1d_{1 \text{ or } 2}$	1724	4·7	H_1–M_1	M_1–L_1	H	H
Fdma	$f_1d_1m_1a_{1 \text{ or } 2}$	256	0·7	M_1	L_1	M	H
Ena	$e_2n_1a_1$	1216	3·3	L_1	M_1	M	N
Emna	$e_2m_1n_1a_1$	212	0·6	L_1	M_1	L	N
E	e_3	1124	3·1	L_1	M_1	M	N
Dmna	$d_4m_1n_1a_1$	68	0·2	N	N	VL	H
Df	d_4f_2	1404	3·9	VL_1	N	L	M
Fdm	$f_4d_{1 \text{ or } 4}m_1$	300	0·8	VL_1–N	N	L–VL	L
Fd	f_4d_4	120	0·3	N	N	N	L
E	e_4	8540	23·4	N	$VL_{1,2}$	VL	N
Er	e_4r_3	7560	20·7	N	N	N	N
Erma	$e_4r_3m_{1 \text{ or } 2}a_2$	252	0·7	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	6124	16·8	N	N	N	VL
Fdsa	$f_5d_5s_1a_{2 \text{ or } 4}$	2460	6·7	N	N	N	N
E	e_5	2132	5·9	N	N	N	N
El	e_5l_1	2592	7·1	N	N	N	N
Erl	$e_5r_3l_{1 \text{ or } 2}$	184	0·5	N	N	N	N
		36 496	100				

TABLE 18

DISTRIBUTION OF MAPPING UNITS IN CENTRAL DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
O	—	986	3·1	VH_1	VH_1	VH	VH
M	m_1	364	1·2	H_1	H_1	H	VH
Mn	m_1n_1	412	1·3	H_1–M_1	H_1–M_1	H	H
Fd	$f_1d_{1\ or\ 2}$	102	0·3	H_1–M_1	M_1–L_1	H	H
Fdma	$f_1d_1m_1a_{1\ or\ 2}$	812	2·6	M_1	L_1	M	H
Ena	$e_1n_1a_1$	72	0·2	M_1	H_1	H	VL
Mn	m_2n_1	36	0·1	M_1	M_1	M	H
Med	$m_2e_1d_1$	928	3·0	L_1	L_1	M	VL
En	e_2n_1	156	0·5	M_1	H_1	H	N
Emn	$e_2m_1n_1$	226	0·7	L_1	M_1	M	N
Emna	$e_2m_1n_1a_1$	6	tr	L_1	M_1	M	N
Dle	$d_3l_2e_1$	24	0·1	N	N	L	N
E	e_3	160	0·5	L_1	M_1	M	N
Df	d_4f_2	160	0·5	VL_1	N	L	M
Dfmn	$d_4f_2m_1n_1$	404	1·3	N	N	VL	M
Fdm	$f_4d_{1\ or\ 2}m_1$	1020	3·2	VL_1–N	N	L–VL	L
Fd	f_4d_4	184	0·6	N	N	N	L
E	e_4	6164	19·6	N	$VL_{1,2}$	VL	N
El	e_4l_1	32	0·1	N	VL_3–N	VL	N
Erma	$e_4r_3m_{1\ or\ 2}a_2$	2028	6·4	N	N	N	N
Fd	$f_5d_{4\ or\ 5}$	1016	3·2	N	N	N	VL
Fdsa	$f_5d_5s_1a_{2\ or\ 4}$	828	2·6	N	N	N	N
E	e_5	5180	16·5	N	N	N	N
El	e_5l_1	5248	16·7	N	N	N	N
Erl	$e_5r_3l_{1\ or\ 2}$	3312	10·5	N	N	N	N
Elr	$e_5l_3r_3$	1604	5·1	N	N	N	N
		31 464	100				

TABLE 19

DISTRIBUTION OF MAPPING UNITS IN MILNE BAY DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
O	—	452	3·1	VH_1	VH_1	VH	VH
Na	n_1a_1 or n_1	44	0·3	H_1	H_1	H	H
R	r_1	112	0·8	H_1	VH_1	VH	M
M	m_1	108	0·7	H_1	H_1	H	VH
Mn	m_1n_1	40	0·3	H_1–M_1	H_1–M_1	H	H
E	e_1	340	2·3	H_1	VH_1	VH	VL
Ena	$e_1n_1a_1$	96	0·6	M_1	H_1	H	VL
Ed	e_1d_1	316	2·1	H_1	M_1	VH	VL
Ena	$e_2n_1a_1$	76	0·5	L_1	M_1	M	N
Rm	$r_3m_{1 \text{ or } 2}$	120	0·8	L_1–VL_1	M_1–VL_1	M–L	N
E	e_3	580	4·0	L_1	M_1	M	N
Dmna	$d_4m_1n_1a_1$	344	2·3	N	N	VL	H
Df	d_4f_2	676	4·6	VL_1	N	L	M
Dfmn	$d_4f_2m_1n_1$	152	1·0	N	N	VL	M
Fd	f_4d_4	120	0·8	N	N	N	L
E	e_4	3304	22·4	N	$VL_{1,2}$	VL	N
Er	e_4r_3	108	0·7	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	20	0·1	N	N	N	VL
Fdsa	$f_5d_5s_1a_{2 \text{ or } 4}$	260	1·8	N	N	N	N
E	e_5	6444	43·7	N	N	N	N
El	e_5l_1	224	1·5	N	N	N	N
Erl	$e_5r_3l_{1 \text{ or } 2}$	820	5·6	N	N	N	N
		14 756	100				

TABLE 20

DISTRIBUTION OF MAPPING UNITS IN NORTHERN DISTRICT

Symbol	Rating(s)	Unit area (km^2)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
O	—	1200	5·2	VH_1	VH_1	VH	VH
Na	n_1a_1 or n_1	368	1·6	H_1	H_1	H	H
R	r_1	920	4·0	H_1	VH_1	VH	M
Rna	$r_1n_1a_1$	68	0·3	M_1–L_1	H_1–M_1	H–M	M–L
Mn	m_1n_1	404	1·8	H_1–M_1	H_1–M_1	H	H
D	d_1	452	2·0	H_1	M_1	VH	VH
Fd	$f_1d_{1 \text{ or } 2}$	40	0·2	H_1–M_1	M_1–L_1	H	H
Fdma	$f_1d_1m_1a_1$	68	0·3	M_1	L_1	M	H
E	e_1	404	1·8	H_1	VH_1	VH	VL
Ar	$a_2r_{1 \text{ or } 2}$	108	0·5	$M_{1,2}$	$M_{1,2}$	H	M–VL
Mn	m_2n_1	132	0·6	M_1	M_1	M	H
En	e_2n_1	780	3·4	M_1	H_1	H	N
E	e_3	1304	5·7	$L_{1,2}$	$M_{1,2}$	M	N
Dmna	$d_4m_1n_1a_1$	92	0·4	N	N	VL	H
Df	d_4f_2	364	1·6	VL_1	N	L	M
Fr	f_4r_3	552	2·4	N	N	N	N
Fd	f_4d_4	824	3·6	N	N	N	L
E	e_4	2072	9·0	N	$VL_{1,2}$	VL	N
El	e_4l_1	260	1·1	N	VL_3–N	VL	N
Er	e_4r_3	116	0·5	N	N	N	N
Fd	$f_5d_{4 \text{ or } 5}$	2080	9·0	N	N	N	VL
Fdsa	$f_5d_5s_1a_{2 \text{ or } 4}$	260	1·1	N	N	N	N
E	e_5	4544	19·8	N	N	N	N
El	e_5l_1	4168	18·1	N	N	N	N
Erl	$e_5r_3l_{1 \text{ or } 2}$	784	3·4	N	N	N	N
Elr	$e_5l_3r_3$	596	2·6	N	N	N	N
		22 960	100				

TABLE 21

DISTRIBUTION OF MAPPING UNITS IN SOUTHERN HIGHLANDS DISTRICT

Symbol	Rating(s)	Unit area (km²)	% of total area	General suitability for agriculture: Arable crops	Tree crops	Improved pastures	Flooded rice
La	l_1a_1	68	0·4	$H_{3,4}$	H_3–L_4	H	N
Dlna	$d_2l_1n_1a_1$	748	4·5	L_3–VL_4	VL_3–N	M	N
Elna	$e_2l_1n_1a_1$	64	0·4	L_4	VL_4	M	N
Edna	$e_2d_{1\text{ or }2}n_1a_1$	204	1·2	$L_{1,2}$–$VL_{1,2}$	$L_{1,2}$–$VL_{1,2}$	M	N
E	e_3	156	0·9	L_1	M_1	M	N
El	$e_3l_{1\text{ or }2}$	1696	10·1	L_3–VL_4–N	M_3–N	M–VL	N
Df	$d_4f_{2\text{ or }3}$	12	0·1	VL_1–N	N	L–VL	M
Fd	f_4d_4	48	0·3	N	N	N	L
E	e_4	728	4·4	N	$VL_{1,2}$	VL	N
El	e_4l_1	3904	23·3	N	VL_3–N	VL	N
Er	e_4r_3	5504	32·9	N	N	N	N
Dfl	$d_5f_4l_1$	204	1·2	N	N	N	N
Fd	$f_4d_{4\text{ or }5}$	212	1·3	N	N	N	VL
El	e_5l_1	56	0·3	N	N	N	N
Erl	$e_5r_3l_{1\text{ or }2}$	2372	14·2	N	N	N	N
Elr	$e_5l_3r_3$	696	4·2	N	N	N	N
Lake	—	52	0·3	N	N	N	N
		16 724	100				

(b) Suitability for Arable Crops

Mean figures of 1·2% of the total area of Papua and 1·0% of New Guinea, or 2640 and 2320 km^2 respectively, are considered to have a very high capability for arable crops (Tables 22 and 23; Fig. 4), but this is very unevenly distributed over the districts. In Papua these areas are found only in the Northern, Central and Milne Bay Districts, while in New Guinea they are concentrated in the Madang, West Sepik, and West New Britain Districts.

Areas with a high capability for arable crops cover 1·5% (3530 km^2) of the total area of Papua and 5·6% (13 400 km^2) of New Guinea. In Papua by far the largest areas occur in the Northern and Milne Bay Districts. In New Guinea the largest areas are found in the West Sepik District, followed by the Bougainville District which also has the highest percentage of land with a high capability for arable crops of all the districts (26·7%).

Areas with high to moderate and moderate capabilities cover 7·5% of Papua (16 930 km^2) and 2·3% (5400 km^2) of the total area of New Guinea. Except for the Southern Highlands they are found in all Districts of Papua, particularly the Western District (6·1% of the total area). The New Guinea areas occur mainly in the Madang and Morobe Districts.

Based on this assessment 10·2% of the total area of Papua and 8·9% of that of New Guinea appear suitable for arable crops.

(c) Suitability for Tree Crops

Mean total figures of 1·9% (4410 km^2) in Papua and 1·4% (3380 km^2) in New Guinea are assessed to have very high capability for tree crops (Tables 24 and 25; Fig. 5). In Papua by far the largest area is located in the Northern District, the other areas occurring in the Central and Milne Bay Districts. The largest areas in New Guinea occur in the Madang District and New Britain.

Areas with a high capability cover a total of 0·9% (1990 km^2) in Papua and 2·4% (5680 km^2) in New Guinea. The largest area in Papua is again found in the Northern District. The largest areas in New Guinea occur mainly in the Bougainville and Morobe Districts.

A total of 9·5% (21 450 km^2) in Papua and 8·0% (19 040 km^2) in New Guinea is considered to have a high to moderate, high to low or moderate capability for tree crops. The very high figures for Papua are due almost solely to the very high percentage of this land in the Western District, with other significant areas occurring in the Gulf and Northern Districts. In New Guinea the areas are more evenly distributed over the districts with the exception of the Highlands Districts. The largest areas occur in the East and West Sepik, New Britain, Bougainville and New Ireland Districts.

These figures indicate that 12·3% of the total land area of Papua and 11·8% of New Guinea might be suitable for tree crops.

(d) Suitability for Improved Pastures

Total areas of 2·3% (5210 km^2) of Papua and 4·0% (9500 km^2) of New Guinea are assessed to have a very high capability for improved pastures (Tables 26 and 27; Fig. 6). In Papua the areas are almost the same as those discussed in the previous

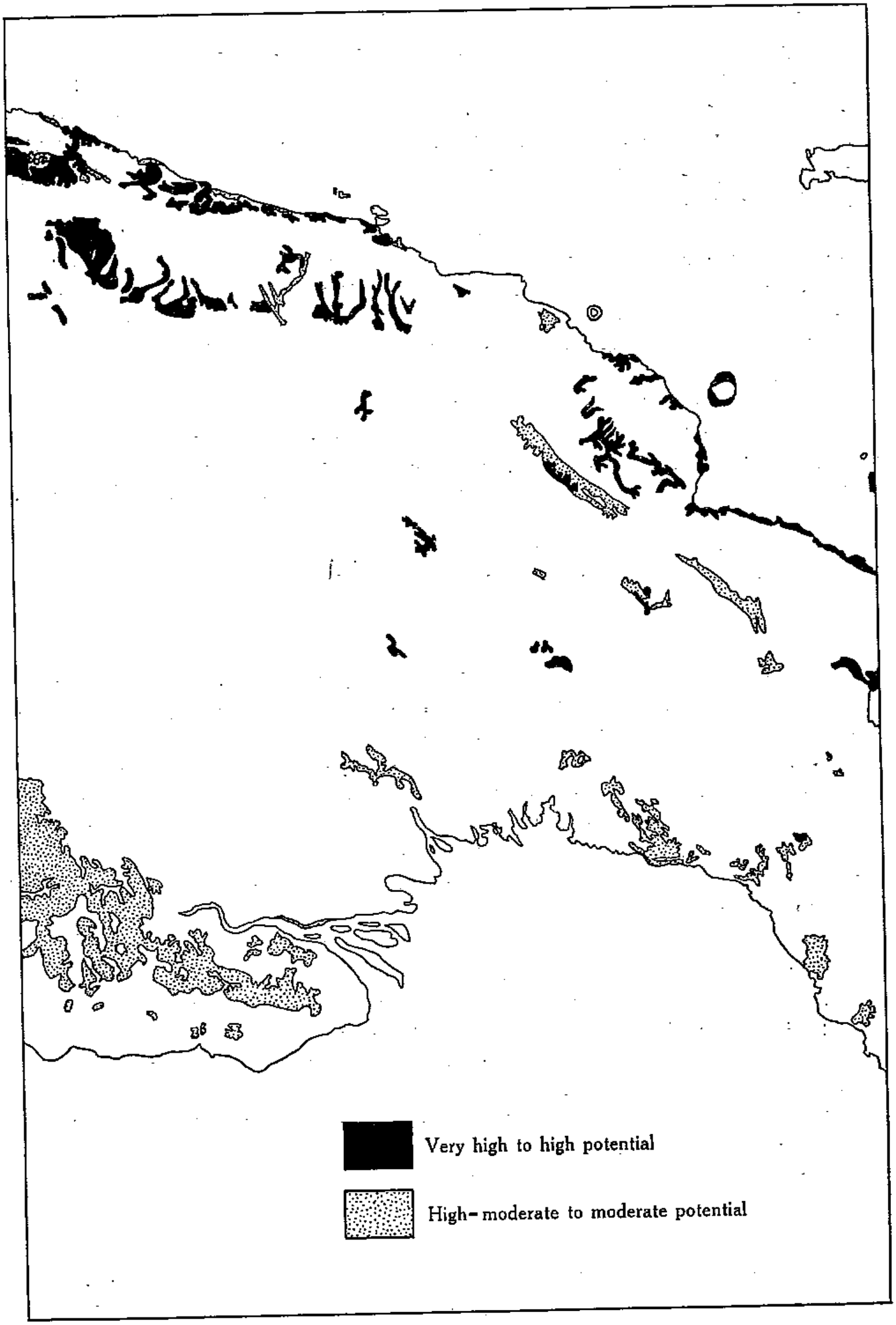


Fig. 4.—Areas with potential for arable crops.

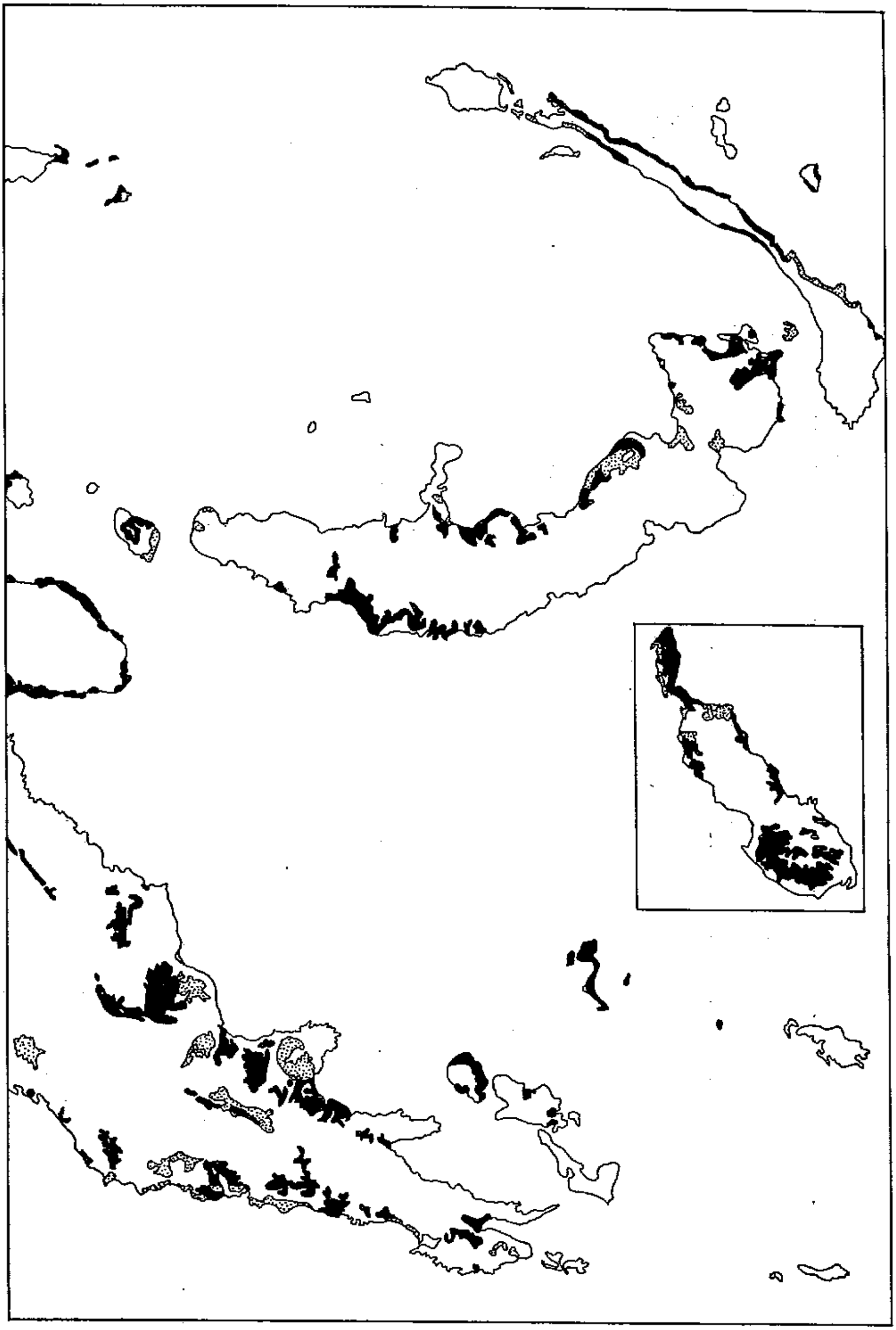


TABLE 22

SUITABILITY FOR ARABLE CROPS (NEW GUINEA)

District	Very high (km²)	Very high (%)	High (km²)	High (%)	High–moderate (km²)	High–moderate (%)	Moderate (km²)	Moderate (%)	Low (km²)	Low (%)	Low–very low (km²)	Low–very low (%)	Very low (km²)	Very low (%)	Very low–nil (km²)	Very low–nil (%)	Nil (km²)	Nil (%)	Total (km²)	Total (%)
Bougainville			2484	26·7	188	2·0	252	2·7	1200	12·9							5176	55·7	9300	100
New Ireland			740	7·8			320	3·4	788	8·3							7668	80·5	9516	100
East New Britain	84	0·5	920	4·9	316	1·7	192	1·0	966	5·3							16 090	86·6	18 568	100
West New Britain	322	1·9	1512	8·8	256	1·5	748	4·4	1130	6·6							13 070	76·6	17 038	99·8
																			(Lake 36	0·2)
Manus			228	10·2					244	10·9							1764	78·9	2236	100
Morobe	192	0·6	1348	3·9	192	0·6	518	1·5	1106	3·2					156	0·4	30 932	89·8	34 444	100
Eastern Highlands			68	0·7			180	1·7			64	0·6	308	3·0			9784	94·0	10 404	100
Chimbu			208	2·9					312	4·3							6656	92·8	7176	100
Western Highlands			204	0·9			40	0·2	280	1·2	1572	6·7					21 316	91·0	23 412	100
West Sepik	508	1·4	3748	10·3	452	1·2			3432	9·4	480	1·3	240	0·7	727	0·7	27 384	75·0	36 516	100
East Sepik			1304	3·1	364	0·9			1172	2·8	264	0·6	524	1·3	136	0·3	37 960	91·0	41 724	100
Madang	1212	4·3	632	2·3	152	0·5	1228	4·4	1336	4·8					108	0·4	23 196	91·0	27 864	99·7
																			(Lake 88	0·3)
Total	2318	1·0	13 396	5·6	1920	0·8	3478	1·5	11 966	5·0	2380	1·0	1072	0·5	672	0·3	200 996	84·3	238 198	100
																			(Lakes 124	tr)

TABLE 23

SUITABILITY FOR ARABLE CROPS (PAPUA)

District	Very high (km²)	Very high (%)	High (km²)	High (%)	High–moderate (km²)	High–moderate (%)	Moderate (km²)	Moderate (%)	Moderate–low (km²)	Moderate–low (%)	Low (km²)	Low (%)	Low–very low (km²)	Low–very low (%)	Very low (km²)	Very low (%)	Very low–nil (km²)	Very low–nil (%)	Nil (km²)	Nil (%)	Total (km²)	Total (%)
Western					136	0·1	11 360	11·0			37 312	36·1	132	0·1			1504	1·5	52 608	50·8	103 052	99·6
																					(Lake 452	0·4)
Gulf			32	0·1	1920	5·2	256	0·7			2552	7·0			1404	3·9	300	0·8	30 032	82·3	36 496	100
Central	986	3·1	364	1·2	514	1·6	1068	3·4			1328	4·2			160	0·5	1020	3·3	26 024	82·7	31 464	100
Milne Bay	452	3·1	920	6·2	40	0·3	96	0·6			656	4·5	120	0·8	676	4·6			11 796	79·9	14 756	100
Northern	1200	5·2	2144	9·4	444	2·0	1088	4·8	68	0·3	1304	5·7			364	1·6			16 348	71·0	22 960	100
Southern Highlands			68	0·4							220	1·3	2648	15·8			12	0·1	13 724	82·1	16 672	99·7
																					(Lake 52	0·3)
Total	2638	1·2	3528	1·5	3054	1·4	13 872	6·1	68	tr	43 368	19·2	2900	1·3	2604	1·2	2836	1·3	150 532	66·6	225 400	99·8
																					(Lakes 504	0·2)

TABLE 24

SUITABILITY FOR TREE CROPS (NEW GUINEA)

District	Capability: Very high (km²)	(%)	High (km²)	(%)	High–moderate (km²)	(%)	High–low (km²)	(%)	Moderate (km²)	(%)	Moderate–low (km²)	(%)	Moderate–nil (km²)	(%)	Low (km²)	(%)	Low–very low (km²)	(%)	Very low (km²)	(%)	Very low–nil (km²)	(%)	Nil (km²)	(%)	Total (km²)	(%)
Bougainville			1420	15·3	188	2·0			1848	19·9									608	6·5			5236	56·3	9300	100
New Ireland			404	4·3					144	15·2									3000	31·5			4668	49·0	9516	100
East New Britain	644	3·5	314	1·7					1134	6·1	316	1·7							6688	36·0			9472	51·0	18 568	100
West New Britain	710	4·2	842	5·0					2128	12·3	256	1·5							5878	34·4			7224	42·4	17 038	99·8
																									(Lake 36	0·2)
Manus									472	21·1													1764	78·9	2236	100
Morobe	308	0·9	1196	3·5	60	0·2			962	2·8	132	0·4			698	2·0			3864	11·2	2852	8·3	24 372	70·7	34 444	100
Eastern Highlands			68	0·7					180	1·7			64	0·6			308	3·0	1332	12·8	3500	33·7	4952	47·5	10 404	100
Chimbu			208	2·9					312	4·3									592	8·3	4940	68·8	1124	15·7	7176	100
Western Highlands							204	0·9	40	0·2			592	2·5					3244	13·8	12 096	51·7	7236	30·9	23 412	100
West Sepik	508	1·4	596	1·6	164	0·4			6480	17·8	392	1·1					480	1·3	9004	24·7	1788	4·9	17 104	46·8	36 516	100
East Sepik					132	0·3			2400	5·7	232	0·6					264	0·6	11 860	28·4	1444	3·5	25 392	60·9	41 724	100
Madang	1212	4·3	632	2·3					892	3·2	152	0·5							11 216	40·1	1924	6·9	11 836	42·4	27 864	99·7
																									(Lake 88	0·3)
Total	3382	1·4	5680	2·4	544	0·2	204	0·1	18 292	7·7	1480	0·6	656	0·3	698	0·3	1052	0·4	57 286	24·1	28 544	12·0	120 380	50·5	238 198	100
																									(Lakes 124	tr)

TABLE
SUITABILITY FOR TREE

District	Very high		High		High–moderate		High–low		Moderate		Moderate–low		Capa- Moderate–very low	
	(km²)	(%)	(km²)	(%)	(km²)	(%)	(km²)	(%)	(km²)	(%)	(km²)	(%)	(km²)	(%)
Western									14 128	13·7	33 960	32·8		
Gulf					196	0·5			2584	7·1	1724	4·7		
Central	986	6·2	592	1·9	412	1·3			428	1·4	102	0·3		
Milne Bay	904	6·2	248	1·6	40	0·3			972	6·6			120	0·8
Northern	2524	11·0	1148	5·0	472	2·1			1996	8·7	40	0·2		
Southern Highlands							68	0·4	156	0·9				
Total	4414	1·9	1988	0·9	1120	0·5	68	tr	20 264	9·0	35 826	15·9	120	tr

25
CROPS (PAPUA)

bility

Moderate–nil (km²)	(%)	Low (km²)	(%)	Low–very low (km²)	(%)	Very low (km²)	(%)	Very low–nil (km²)	(%)	Nil (km²)	(%)	Total (km²)	(%)
		212	0·2	88	tr	7052	6·8	3924	3·8	43 688	42·3	103 052	99·6
												(Lake 452	0·4)
		256	0·7			8540	23·4			23 196	63·6	36 496	100
		1740	5·5			6164	19·6	32	0·1	21 008	66·8	31 464	100
						3304	22·4			9168	62·1	14 756	100
		68	0·3			2072	9·0	260	1·1	14 380	62·6	22 960	100
1696	10·2			204	1·2	792	4·7	4652	27·8	9104	54·5	16 672	99·7
												(Lake 52	0·3)
1696	0·7	2276	1·0	292	0·1	27 924	12·4	8868	3·9	120 544	53·5	225 400	99·8
												(Lakes 504	0·2)

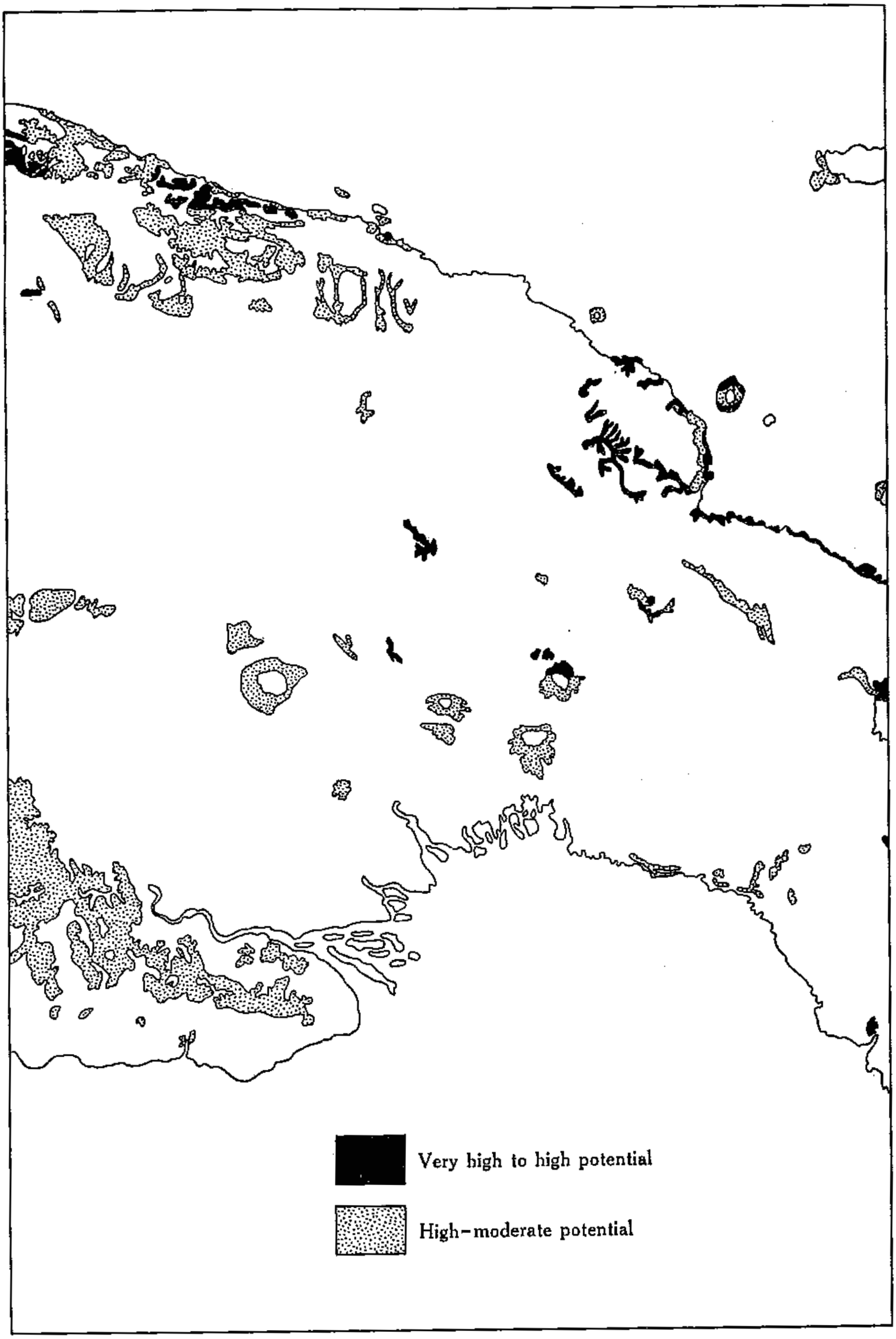
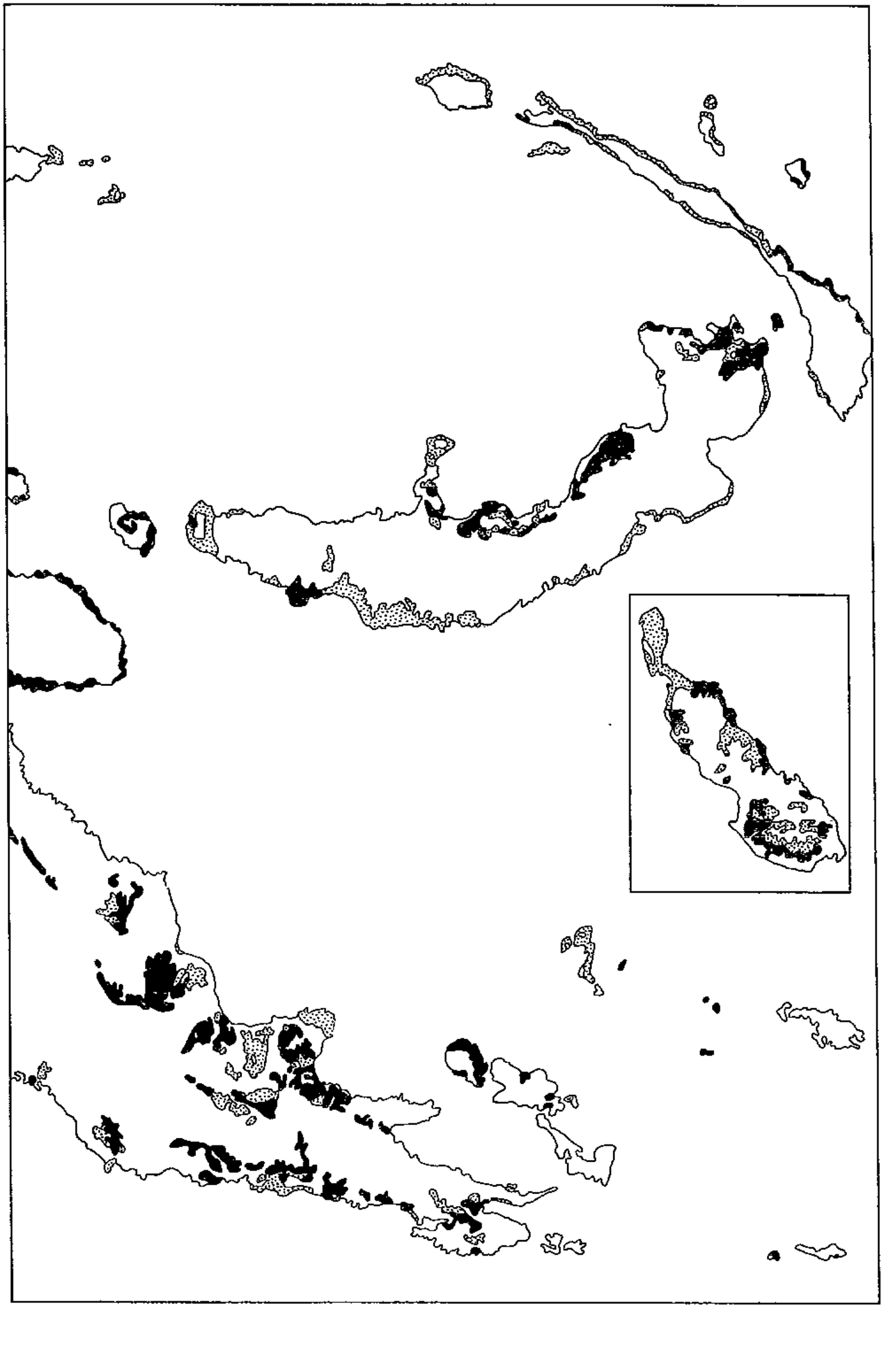


Fig. 5.—Areas with potential for tree crops.



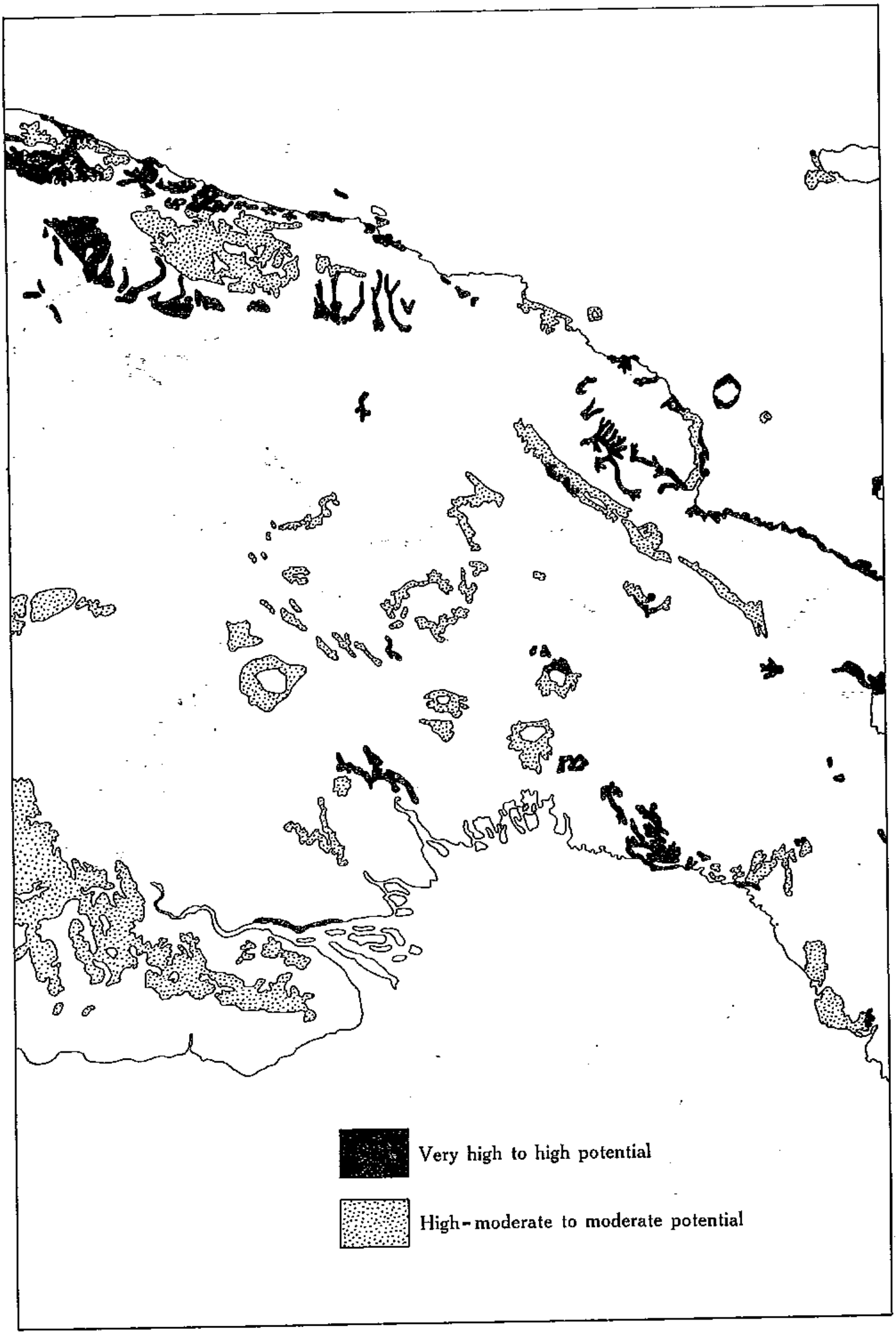


Fig. 6.—Areas with potential for improved pastures.

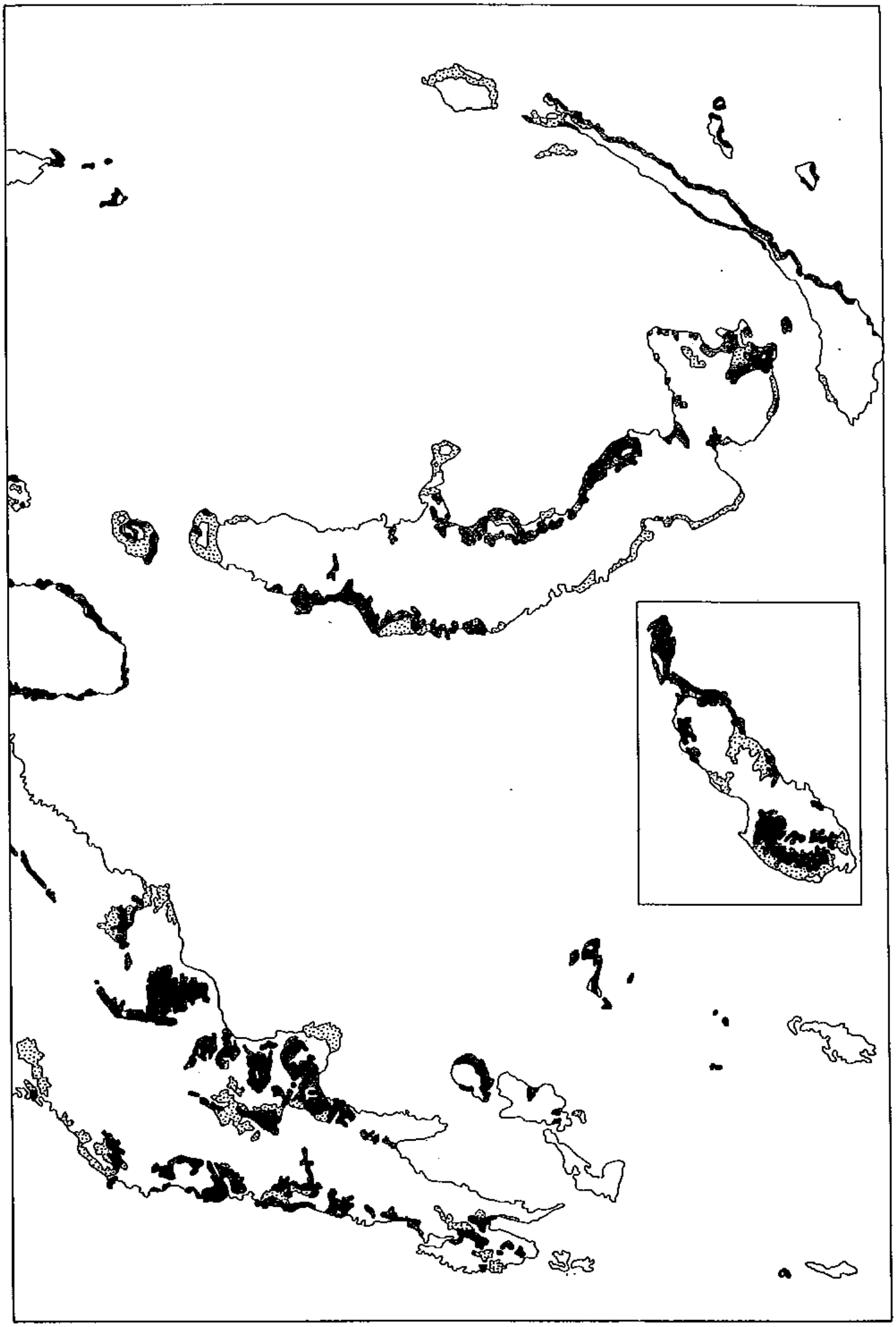


TABLE 26

SUITABILITY FOR IMPROVED PASTURES (NEW GUINEA)

District	Very high (km²)	Very high (%)	High (km²)	High (%)	Moderate (km²)	Moderate (%)	Moderate–low (km²)	Moderate–low (%)	Moderate–very low (km²)	Moderate–very low (%)	Capability Low (km²)	Capability Low (%)	Low–very low (km²)	Low–very low (%)	Very low (km²)	Very low (%)	Nil (km²)	Nil (%)	Totals (km²)	Totals (%)
Bougainville	564	6·1	2360	25·4	1200	12·9									608	6·5	4568	49·1	9300	100
New Ireland	656	6·9	404	4·3	788	8·3									3000	31·5	4668	49·0	9516	100
East New Britain	882	4·7	630	3·4	966	5·3									6688	36·0	9402	50·6	18 568	100
West New Britain	1714	10·1	1124	6·6	1130	6·6									5878	34·4	7192	42·1	17 038	99·8
																			(Lake 36	0·2)
Manus	228	10·2			244	10·9											1764	78·9	2236	100
Morobe	476	1·4	1388	4·1	794	2·3					698	2·0	156	0·4	6716	19·5	24 216	70·3	34 444	100
Eastern Highlands			68	0·6	180	1·7	308	3·0	64	0·6					4832	46·5	4952	47·6	10 404	100
Chimbu			208	2·9	312	4·3									5532	77·1	1124	15·7	7176	100
Western Highlands			204	0·9	1300	5·6			592	2·5	232	1·0			14 448	61·7	6636	28·3	23 412	100
West Sepik	2664	7·3	2044	5·5	3808	10·4	104	0·3					512	1·4	12 560	34·5	14 824	40·6	36 516	100
East Sepik	1100	2·6	568	1·4	1436	3·4							660	1·6	16 444	39·4	21 516	51·6	41 724	100
Madang	1212	4·3	784	2·8	2564	9·2							108	0·4	13 632	48·8	9564	34·2	27 864	99·7
																			(Lake 88	0·3)
Total	9496	4·0	9782	4·1	14 722	6·2	412	0·2	656	0·3	930	0·4	1436	0·4	90 338	37·9	110 426	46·3	238 198	100
																			(Lakes 124	tr)

TABLE 27

SUITABILITY FOR IMPROVED PASTURES (PAPUA)

District	Very high (km²)	Very high (%)	High (km²)	High (%)	High–moderate (km²)	High–moderate (%)	Moderate (km²)	Moderate (%)	Moderate–low (km²)	Moderate–low (%)	Moderate–very low (km²)	Moderate–very low (%)	Capability Low (km²)	Capability Low (%)	Low–very low (km²)	Low–very low (%)	Very low (km²)	Very low (%)	Very low–nil (km²)	Very low–nil (%)	Nil (km²)	Nil (%)	Totals (km²)	Totals (%)
Western			136	0·1			14 768	14·3	33 824	32·6			212	0·2	1504	1·5	10 932	10·6	4852	4·7	36 824	36·6	103 052	99·6
																							(Lake 452	0·4)
Gulf	32	0·1	1920	5·2			2596	7·1					1616	4·5	300	0·8	8608	23·6			21 424	58·7	36 496	100
Central	986	3·1	1106	3·5			2168	6·9					184	0·6	1020	3·2	6600	21·0			19 400	61·7	31 464	100
Milne Bay	1220	8·3	288	1·9			656	4·5	120	0·8			676	4·6			3800	25·7			7996	54·2	14 756	100
Northern	2976	13·0	1700	7·5	68	0·3	1504	6·6					364	1·6			2424	10·5			13 924	60·5	22 960	100
Southern Highlands			68	0·4			1172	7·0			1696	10·1			12	0·1	4632	27·7			9092	54·4	16 672	99·7
																							(Lake 52	0·3)
Total	5214	2·3	5218	2·3	68	tr	22 864	10·1	33 944	15·0	1696	0·8	3052	1·4	2836	1·3	36 996	16·4	4852	2·1	108 660	43·1	225 400	99·8
																							(Lakes 504	0·2)

section (very high capability for tree crops), except that the values are on the whole slightly higher. In New Guinea the largest areas occur in the Sepik, New Britain and Madang Districts.

Areas with a high pasture capability cover a total of 2·3% (5220 km^2) of Papua and 4·1% (9780 km^2) of New Guinea. The largest Papuan areas occur in the Gulf, Northern and Central Districts. In New Guinea they are found mainly in the Bougainville and West Sepik Districts.

Areas with a moderate capability for improved pastures cover 10·1% (22 860 km^2) of Papua and 6·2% (14 720 km^2) of the total area of New Guinea. In Papua most of this land is concentrated in the Western District with other areas in the Gulf, Central, Northern and Southern Highlands Districts. In New Guinea these areas are more evenly distributed over the districts, although expressed as percentages they still vary between 1·7% of the area of the Eastern Highlands and 12·9% of the total area of the Bougainville District.

These figures indicate totals of 14·7% of Papua and 14·3% of New Guinea which could be suitable for pastures.

(*e*) *Suitability for Flooded Rice*

Total areas of 1·6% (3590 km^2) of Papua and 3·5% (8300 km^2) of New Guinea are assessed to have a very high capability for flooded rice (Tables 28 and 29; Fig. 7). In Papua the largest areas are found in the Northern and Central Districts while in New Guinea they occur mainly in the West Sepik and Madang Districts.

Areas with a high capability cover 7·4% (16 630 km^2) of Papua and 4·0% (9460 km^2) of New Guinea. The largest areas occur in the Western District covering over 10 000 km^2 or almost 70% of the total area with this suitability in Papua. The most significant occurrences in New Guinea are located in the East and West Sepik, Bougainville and Morobe Districts.

Areas with a high to moderate and/or moderate capability total 4·7% (16 850 km^2) of Papua and 2·7% (6530 km^2) of the total area of New Guinea. In Papua most of this land, like other areas with a high capability, is located in the Western District. In New Guinea the largest occurrences are found in both East and West Sepik and Madang Districts.

In total these figures show that 13·7% of the total area of Papua and 10·2% of New Guinea might be suitable for flooded rice-growing.

(*f*) *Relationships between Population Densities and Mapping Units*

Table 30 and Fig. 8 show the district populations and population densities per square kilometre. Because of the dominant subsistence agricultural land use (Plate 19) in Papua New Guinea it can be expected that the distribution of population will be related to environmental factors. In other words, the highest population densities should be found in areas with favourable climates and fertile well-drained soils, and free of endemic diseases. Fig. 8 clearly shows that the highest population densities occur in the Highlands Districts, Maprik–Lumi area, Gazelle Peninsula, Trobriand Islands and Bougainville. A comparison of Fig. 8 with Figs 4 and 5 shows that with a few exceptions there is very little correlation between population density and

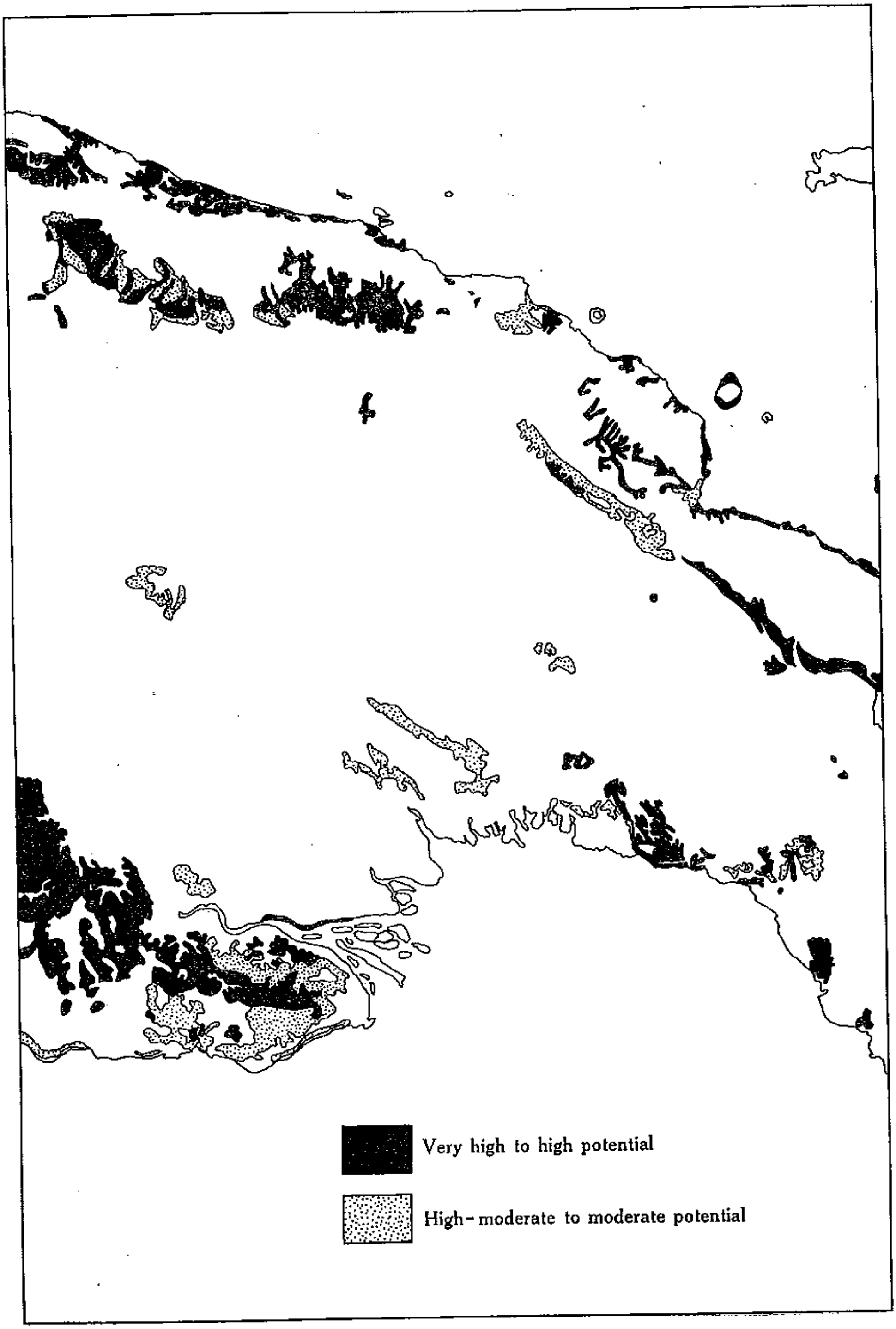


Fig. 7.—Areas with potential for flooded rice.

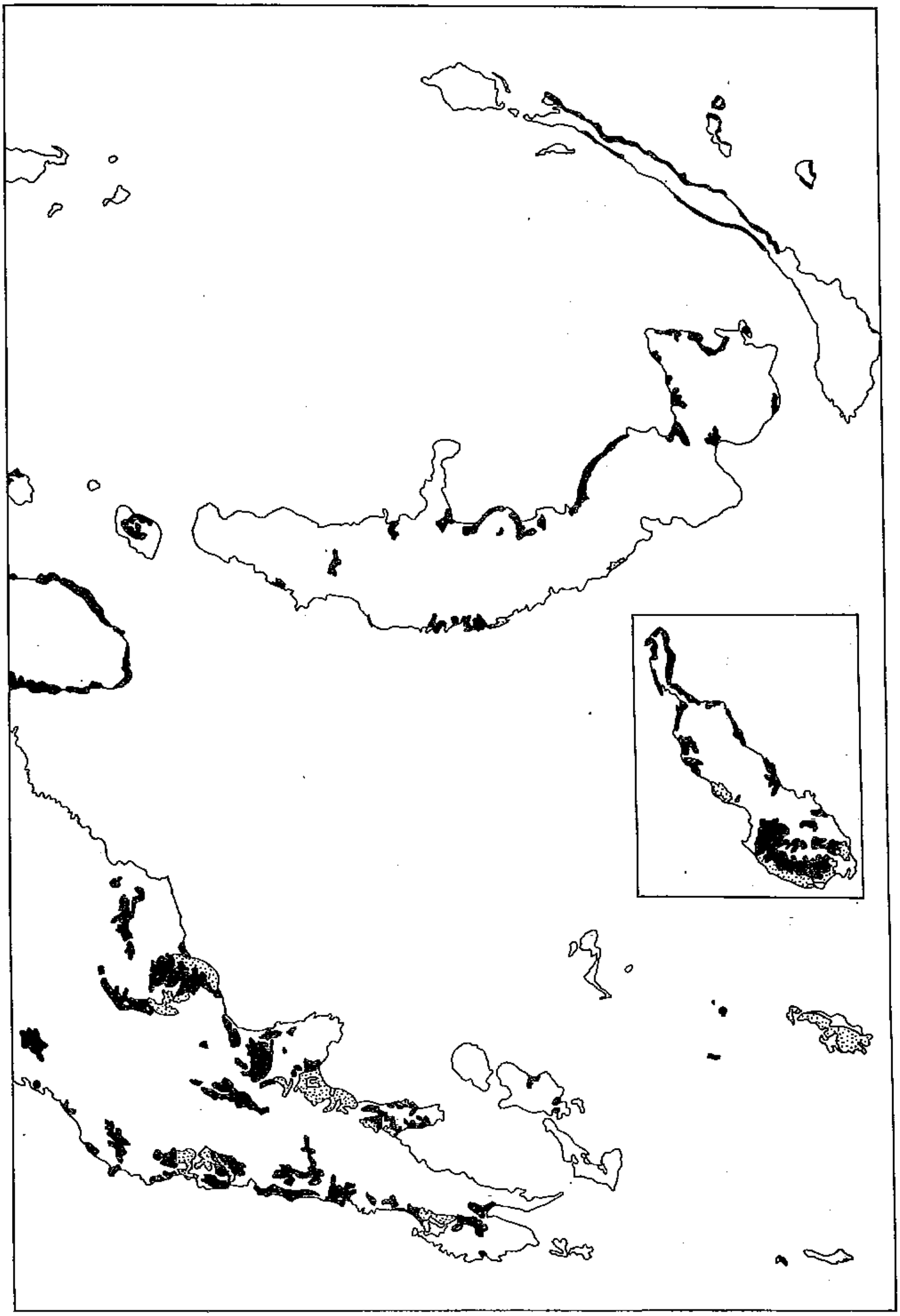


TABLE 28

SUITABILITY FOR FLOODED RICE (NEW GUINEA)

District	Capability: Very high (km²)	(%)	High (km²)	(%)	High–moderate (km²)	(%)	Moderate (km²)	(%)	Low (km²)	(%)	Very low (km²)	(%)	Nil (km²)	(%)	Total (km²)	(%)
Bougainville	292	3·1	2024	21·8			668	7·2	88	1·0	1136	12·2	5092	54·7	9300	100
New Ireland	656	6·9	84	0·9					236	2·5	108	1·1	8432	88·6	9516	100
East New Britain	296	1·6	438	2·4			70	0·4	226	1·2	676	3·6	6862	90·8	8568	100
West New Britain	636	3·7	376	2·2			32	0·2	884	5·2	1446	8·5	13 664	80·0	17 038	99·8
															(Lake 36	0·2)
Manus											540	24·1	1696	75·9	2236	100
Morobe	968	2·8	1732	5·0					156	0·5	672	1·9	30 916	89·8	34 444	100
Eastern Highlands			20	0·2									10 384	99·8	10 404	100
Chimbu							208	2·9					6968	97·1	7176	100
Western Highlands													23 412	100	23 412	100
West Sepik	2664	7·3	2044	5·6	2040	5·6	240	0·7	664	1·8	3088	8·4	25 776	70·6	36 516	100
East Sepik	1100	2·6	2264	5·4	708	1·7	600	1·5	1676	4·0	18 656	44·7	16 720	40·1	41 724	100
Madang	1688	6·0	476	1·7	192	0·7	1780	6·4	1368	4·9	936	3·3	21 424	76·7	27 864	99·7
															(Lake 88	0·3)
Total	8300	3·5	9458	4·0	2940	1·2	3598	1·5	5298	2·2	27 258	11·5	181 346	76·1	238 198	100
															(Lakes 124	tr)

TABLE 29

SUITABILITY FOR FLOODED RICE (PAPUA)

District	Capability: Very high (km²)	(%)	High (km²)	(%)	High–moderate (km²)	(%)	Moderate (km²)	(%)	Moderate–low (km²)	(%)	Moderate–very low (km²)	(%)	Low (km²)	(%)	Low–very low (km²)	(%)	Very low (km²)	(%)	Nil (km²)	(%)	Totals (km²)	(%)
Western			11 496	11·1	212	0·2	6292	6·1					2100	2·0	7236	7·0	22 568	21·8	53 148	51·4	103 052	99·6
																					(Lake 452	0·4)
Gulf	32	0·1	2244	6·1			1404	3·9					420	1·1			6124	16·8	26 272	72·0	36 496	100
Central	1350	4·3	1362	4·3			564	1·8					1204	3·8			2016	6·4	24 968	79·4	31 464	100
Milne Bay	560	3·8	428	2·9			940	6·4					120	0·8			772	5·2	11 936	80·9	14 756	100
Northern	1652	7·2	1104	4·8			1284	5·6	68	0·3	108	0·5	824	3·6			2484	10·8	15 436	67·2	22 960	100
Southern Highlands							12	0·1					48	0·3			212	1·3	16 400	98·0	16 672	99·7
																					(Lake 52	0·3)
Total	3594	1·6	16 634	7·4	212	0·1	10 496	4·6	68	tr	108	0·1	4716	2·1	7236	3·2	34 176	15·1	148 160	65·6	225 400	99·8
																					(Lakes 504	0·2)

suitability of land for agriculture. The indications are therefore much stronger that the high population densities of the Highlands are the result of the better climate and the almost non-existence of diseases such as malaria and tuberculosis. A comparison of Fig. 8 with Fig. 3 (low-rainfall areas) indicates in addition that the highest population densities occur in the lower-rainfall areas with a seasonal rainfall distribution. There are, however, notable exceptions such as the southern part of the Western District and the Cape Vogel area. Brookfield and Hart (1971) have pointed out that malaria might be a significant factor influencing the population distribution.

TABLE 30

PAPUA NEW GUINEA—POPULATION AND DENSITY OF DISTRICTS*

District	Population	Population density per km^2
Bougainville	78 066	8·4
New Ireland	53 467	5·6
East New Britain	99 846	5·4
West New Britain	62 015	3·6
Manus	23 250	10·4
Morobe	238 363	6·9
Eastern Highlands	253 666	24·4
Chimbu	190 102	26·5
Western Highlands	344 772	14·7
West Sepik	102 118	2·8
East Sepik	207 219	5·0
Madang	192 380	6·9
Western	67 644	0·7
Gulf	71 268	2·0
Central	166 921	5·3
Milne Bay	111 211	7·5
Northern	62 695	2·7
Southern Highlands	206 879	12·4

* Population figures obtained from Papua New Guinea Annual Report (Anon. 1974). Density per km^2 calculated from dot grid totals of each district.

However, again there are exceptions such as the Maprik area, which has a high incidence of malaria. The Gazelle Peninsula and Trobriand Islands appear to be less malarial than other low land areas. Brookfield and Hart (1971) suggest that in the Gazelle Peninsula this might be ascribed to the presence of highly permeable ash soils and a regular rainfall, but they rightly indicate that very similar areas along the north coast of New Britain are thinly populated. The subject is extremely complex and it is very difficult to draw generalized conclusions about the factors which influence the population distribution.

The population of Papua New Guinea is almost certainly increasing, but the rate is not known (van der Kaa 1972). If the population continues to grow this might have serious implications for the Highlands District if no alternative non-agricultural sources of income can be found. Population pressures and the introduction of cash crops, for which the best land is often used, have already resulted in a marked decrease

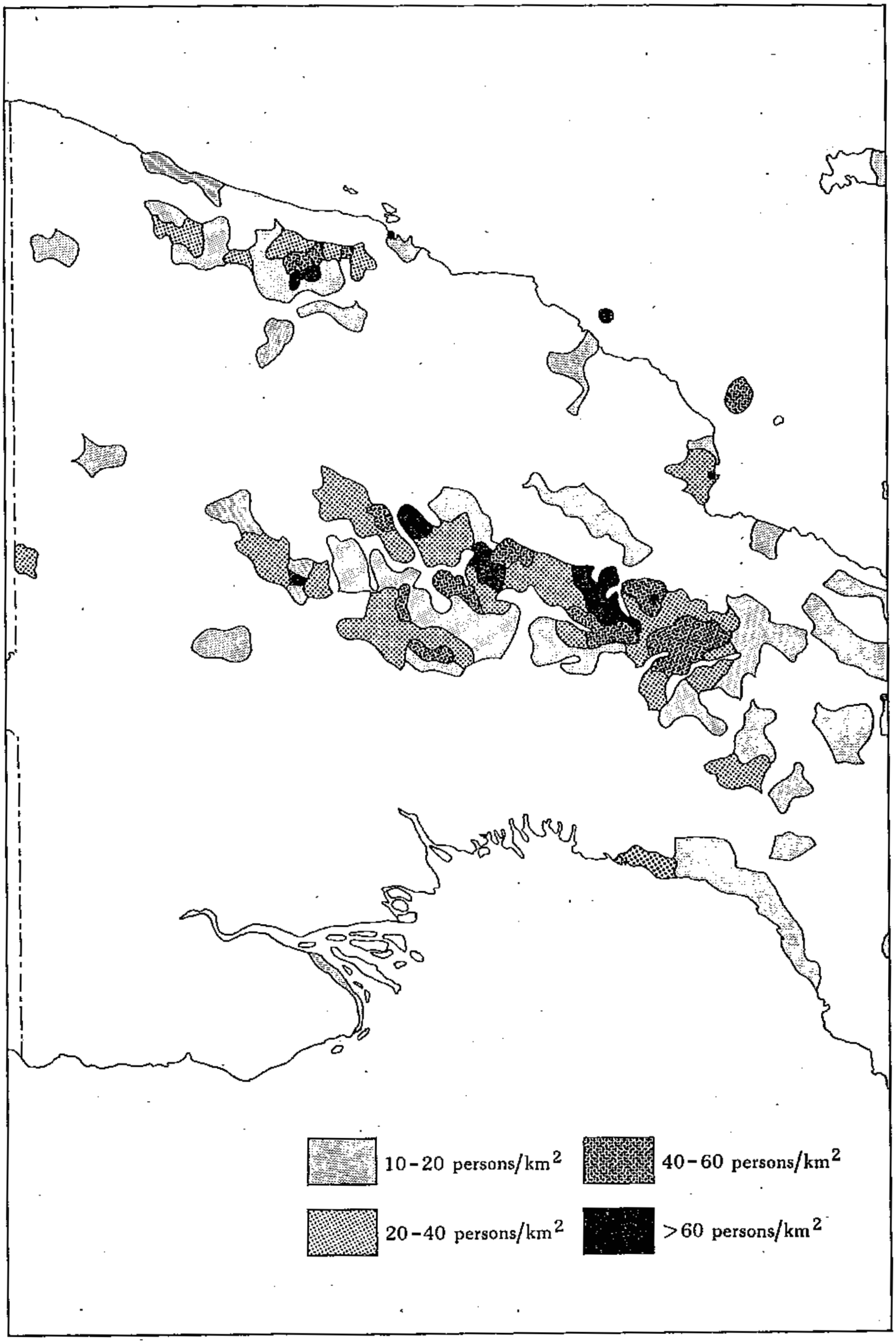
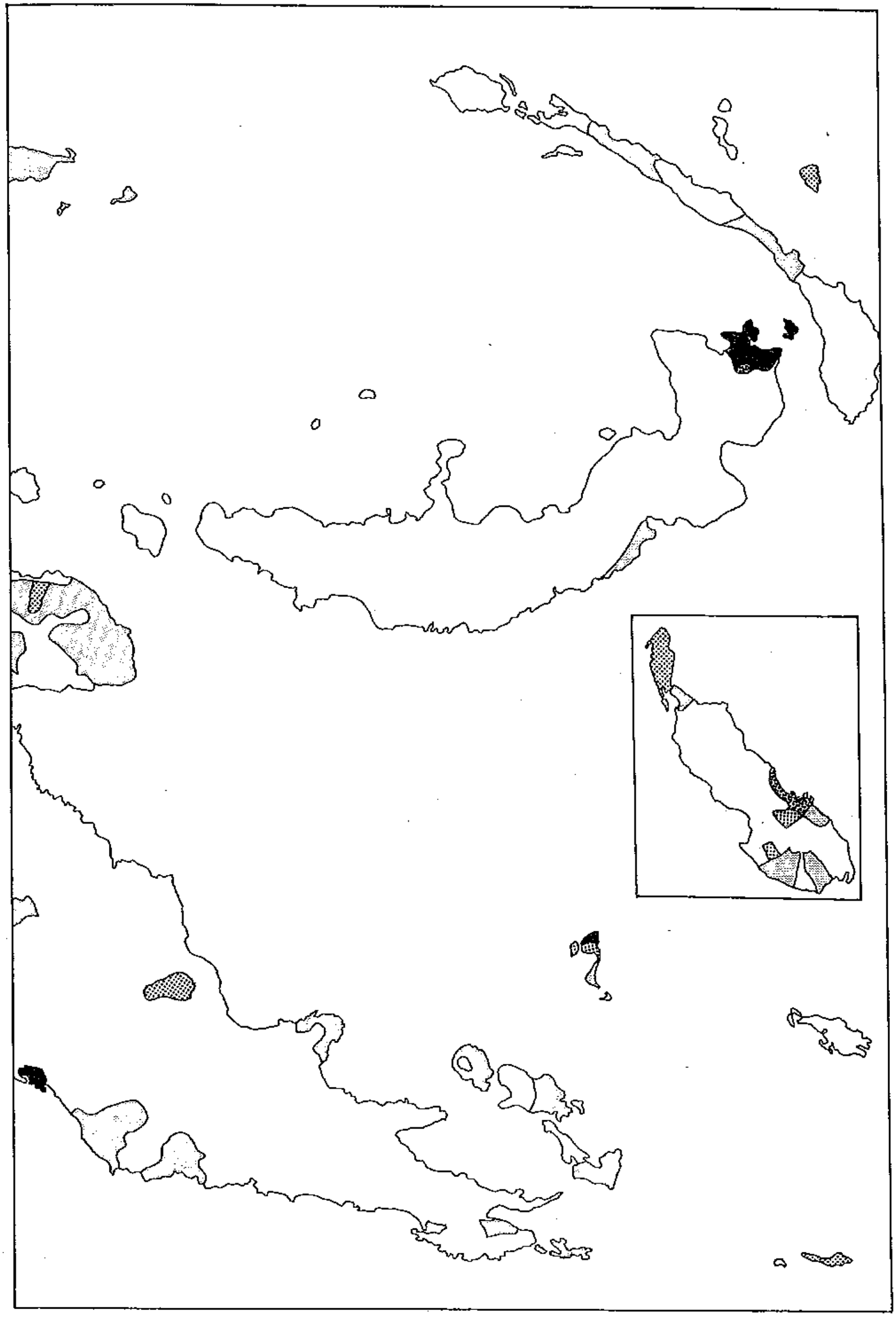


Fig. 8.—Areas with high population densities (after Ford 1974).



of the shifting cultivation rotation cycle. This has affected crop yields and has increased the rate of erosion of the subsistence gardens usually found on sloping terrain sometimes with slopes of over 40°. It is fortunate that, as shown in the figures and tables, other areas have excellent resources combined with very low population densities, and these might offer excellent possibilities for resettlement schemes for the Highlands people.

VI. Acknowledgments

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VII. References

Anon. (1974).—Papua New Guinea Report 1972–73. (Australian Government Publishing Service: Canberra.)

van der Bent, E. Th. (1969).—Dip estimation for photogeology. *Photogramm. Eng.* **35**, 1225–7.

Blake, D. H., Paijmans, K., McAlpine, J. R., and Saunders, J. C. (1973).—Land-form types and vegetation of Eastern Papua. CSIRO Aust. Land Res. Ser. No. 32.

Bleeker, P. (1971).—Soils of the Morehead–Kiunga area. CSIRO Aust. Land Res. Ser. No. 29, 69–87.

Bleeker, P. (1974).—A soil map of Papua New Guinea. *In* 'Papua New Guinea Resource Atlas'. (Ed. Edgar Ford.) (Jacaranda Press: Milton, Qld.)

Bleeker, P., and Parfitt, R. L. (1974).—Volcanic ash and its clay mineralogy at Cape Hoskins, New Britain, Papua New Guinea. *Geoderma* **11**, 123–35.

Brookfield, H. C., and Hart, D. (1971).—'Melanesia. A Geographical Interpretation of an Island World.' (Methuen: London.)

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

Christian, C. S., and Stewart, G. A. (1953).—General report on survey of Katherine–Darwin region 1946. CSIRO Aust. Land Res. Ser. No. 1.

van Dijk, G. W., and Ehrencron, V. K. R. (1949).—The different rate of erosion within two adjacent basins in Java. Gen. Agric. Exp. Stn, Buitenzorg, Java, Commun. No. 84, 1–11.

Ford, E. (Ed.) (1974).—'Papua New Guinea Resource Atlas.' (Jacaranda Press: Milton, Qld.)

Graham, G. K., and Baseden, S. C. (1956).—Investigation of soils of the Warangoi Valley. *Papua New Guinea Agric. J.* **10**, 73–81.

Haantjens, H. A. (1963).—Land capability classification in reconnaissance surveys in Papua and New Guinea. *J. Aust. Inst. Agric. Sci.* **29**, 104–7.

Haantjens, H. A. (1964).—Soils of the Wanigela–Cape Vogel area. CSIRO Aust. Land Res. Ser. No. 12, 55–68.

Haantjens, H. A. (1965*a*).—Practical aspects of land system surveys in New Guinea. *J. Trop. Geogr.* **21**, 12–20.

Haantjens, H. A. (1965*b*).—Morphology and origin of patterned ground in a humid tropical lowland area, New Guinea. *Aust. J. Soil Res.* **3**, 111–29.

Haantjens, H. A. (1967).—Pedology of the Safia–Pongani area. CSIRO Aust. Land Res. Ser. No. 17, 98–141.

HAANTJENS, H. A. (1968).—The relevance for engineering of principles, limitations and developments in land system surveys in New Guinea. Proc. 4th Conf. Aust. Road Res. Bd. Vol. 4, pp. 1593–612.

HAANTJENS, H. A., REYNDERS, J. J., MOUTHAAN, W. L. P. J., and VAN BAREN, F. A. (1967).—Major soil groups of New Guinea and their distribution. R. Trop. Inst., Amsterdam, Commun. No. 55.

HARTLEY, A. C., ALAND, F. P., and SEARLE, P. G. E. (1967).—Soil survey of West New Britain. The Balima–Tiauru area. Dep. Agric. Stock Fish., Port Moresby, Soil Survey Rep. No. 1.

HOLLOWAY, R. S., ZIJSVELT, M. F. W., KNIGHT, M. J., BRIGATTI, J. M., LEGGER, D., STRONG, B. W., ALAND, F. P., BLACKBURN, K. J., and HOLZKNECHT, H. A. (1973).—Land resources and agricultural potential of the Markham valley. Dep. Agric. Stock Fish., Port Moresby, Res. Bull. No. 10.

VAN DER KAA, D. J. (1972).—Population. *In* 'Encyclopaedia of Papua and New Guinea'. (Melbourne Univ. Press in assocn with Univ. of Papua and New Guinea.)

KLINGEBIEL, A. A., and MONTGOMERY, P. H. (1961).—Land capability classification. USDA Agric. Handb. No. 210.

LEE, K. E. (1967).—Microrelief features in a humid tropical lowland area, New Guinea, and their relation to earthworm activity. *Aust. J. Soil Res.* **5**, 263–74.

LÖFFLER, E. (1974).—Explanatory notes to the geomorphological map of Papua New Guinea. CSIRO Aust. Land Res. Ser. No. 33.

MABBUTT, J. A., and SCOTT, R. M. (1966).—Periodicity of morphogenesis and soil formation in a savannah landscape near Port Moresby, Papua. *Z. Geomorphol.* **B10**, 69–89.

MCALPINE, J. R. (1970).—Estimating pasture growth periods and droughts from simple water balance models. Proc. 11th Int. Grassl. Congr., pp. 484–7.

MCALPINE, J. R. (1973).—A climatic classification for Eastern Papua. CSIRO Aust. Land Res. Ser. No. 32, 50–61.

PAIJMANS, K. (1970).—Land evaluation by air photo interpretation and field sampling in Australian New Guinea. *Photogrammetria* **26**, 77–100.

PAIJMANS, K. (1975).—A vegetation map of Papua New Guinea. CSIRO Aust. Land Res. Ser. No. 35.

PURSEGLOVE, J. W. (1968).—'Tropical Crops. Dicotyledons', Bks 1 and 2. (Longmans: London.)

PURSEGLOVE, J. W. (1972).—'Tropical crops. Monocotyledons', Bks 1 and 2. (Longmans: London.)

ROBBINS, R. G., HAANTJENS, H. A., MABBUTT, J. A., PULLEN, R., REINER, E., SAUNDERS, J. C., and SHORT, KAREN (1975).—Lands of the Ramu–Madang area, Papua New Guinea. CSIRO Aust. Land Res. Ser. No. 37 (in press).

RUTHERFORD, G. K., and HAANTJENS, H. A. (1965).—Soils of the Wabag–Tari area. CSIRO Aust. Land Res. Ser. No. 15, 85–99.

SCHULTZE-WESTRUM, T. G. (1971).—Conservation in Papua New Guinea. Final Report on the 1970 World Wildlife Fund Mission.

SCOTT, R. M. (1965).—Soils of the Port Moresby–Kairuku area. CSIRO Aust. Land Res. Ser. No. 14, 129–45.

SCOTT, R. M. (1967).—Land use capability of Bougainville and Buka Islands. CSIRO Aust. Land Res. Ser. No. 20, 168–73.

VAN WIJK, C. L. (1959).—Reconnaissance soil survey—east coast New Ireland. *Papua New Guinea Agric. J.* **11**, 95–100.

APPENDIX I

Ecological Aspects of some Crops Grown in Papua New Guinea

(Crops arranged in alphabetical order. Source: Purseglove 1968, 1972)

Crop	Altitude (m)	Mean temp. (°C)	Rainfall (mm)	Soils	Comments
Avocado	0–1500	21–32	1500–3000	Well drained; pH 5·0–7·0. Various textures, but loams preferred	Very sensitive to poor drainage. Liable to wind damage
Banana	0–1500	21–32	1500–3000	Well drained; pH 5·0–7·0. Various textures	Evenly distributed rainfall preferable. Fungal diseases limit some varieties in wetter areas
Cardamom	600–1000	16–26	2000–3000	Well drained; pH 5·5–6·5. Various textures, but loams preferred	Preferably grown under rain forest shade
Cashew	0–800	24–32	1000–1500	Well drained; pH 4·5–6·5. Sandy soils most suitable	Often grows on hill slopes too dry and stony for other crops
Cassava	0–1800	20–32	1000–5000	Well drained; pH 5·0–7·0. Coarse and medium textures	Tolerant of drought. Will produce crop on exhausted soils unsuitable for any other production
Castor	0–1800	20–32	1000–1500	Well drained; pH 5·0–7·0. Coarse and medium textures	Needs drier period for ripening of fruit. Heavy rainfall should be avoided
Citrus	0–1800	18–32	1000–3000	Well to imperfectly drained; pH 5·0–8·0. Various textures, but loams preferred	Climate too humid or too wet, not suitable because of pests. Limes and pomelos grow best at low altitudes, other varieties best at high altitudes
Cocoa	0–600	21–32	1500–4000	Well drained; pH 5·5–6·5. Best well-structured soil with medium to coarse textures	Evenly distributed rainfall most suitable
Coconut	0–600	21–32	1500–4000	Well to imperfectly drained; pH 5·0–8·0. Various textures	Tolerates saline conditions. Preferably long dry season
Coffee (arabica)	1000–1800	15–24	1500–3000	Well drained; pH 5·5–6·5. Various textures, but loams preferred	Usually grown under shade. Intolerant of water-logging
Coffee (robusta)	0–1000	21–32	1500–3000	Well to imperfectly drained; pH 5·0–6·5. Various textures	Usually grown under shade

Kapok	0–400	22–32	1000–3000	Well drained; pH 5·5–6·5. Deep permeable medium-textured soils	Drier periods needed for flowering and fruiting
Maize	0–1800	18–32	1000–3000	Well drained; pH 5·5–7·0. Deep permeable soils, various textures	Preferably drier periods for ripening and harvesting
Mango	0–1200	24–32	1000–2500	Well to poorly drained; pH 5·5–7·5. Various textures	Prefers seasonal climates with marked dry seasons. Even shallow slowly permeable soils produce mangoes
Mint	0–500	21–32	2000–4000	Well to imperfectly drained; pH 5·5–7·0. Various textures	Grows in both seasonal and non-seasonal climates
Nutmeg	0–400	24–32	2000–3500	Well-drained; pH 5·5–6·5. Medium-textured soils	Wild species grow in Papua New Guinea. Rainfall should preferably be fairly evenly distributed
Oil palm	0–600	21–32	> 2000	Well to imperfectly drained; pH 4·0–7·0. Various textures	At least 5 hr sunshine per day desirable and an evenly distributed rainfall. In Papua New Guinea best areas on volcanic ash soils
Papaw	0–1500	24–32	1500–4000	Well drained; pH 6·0–7·0. Coarse to medium textures	
Passionfruit	0–1800	18–32	1000–2000	Well to imperfectly drained; pH 5·0–7·0. Heavy-textured soils should be avoided	There are highland and lowland varieties. Only the highland variety is produced commercially
Peanut	0–1800	15–32	1000–3000	Well drained; pH 5·0–6·5. Coarse- to medium-textured, friable to loose soils	Dry season for ripening and harvesting desirable
Pepper	0–600	24–32	2500–4000	Well drained; pH 5·5–7·0. Various textures	Non-seasonal climates desirable
Pineapple	0–1500	20–30	1000–2500	Well drained; pH 5·0–6·5. Coarse and medium textures	Tolerant to drought (special water storage cells)
Pyrethrum	1800–2700	14–22	1000–2500	Well to imperfectly drained; pH 5·0–7·0. Various textures	Cool temperatures stimulate flowering and increase pyrethrum content
Rice (flooded)	0–800	20–32	1000–4000	Well to very poorly drained; pH 5·5–6·5 (dry soil), 7·0–7·5 (flooded soil). Medium to fine textures	Water quality (irrigation) extremely important. Two crops per year desirable

APPENDIX I (*Continued*)

Crop	Altitude (m)	Mean temp. (°C)	Rainfall (mm)	Soils	Comments
Rice (upland)	0–800	20–32	1200–4000	Well to imperfectly drained; pH 5·5–6·5. Medium to fine textures	Yields generally less than flooded rice
Rubber	0–600	23–32	2000–4000	Well to imperfectly drained; pH 4·0–8·0 (5·0–6·0 optimum). Various textures	Areas with seasonal climates not ideal. Tolerates relatively poor soils and is less susceptible to poor drainage than oil palm and coconut. Not too much morning rain
Sorghum	0–1800	18–32	1000–2500	Well drained; pH 5·5–7·5. Various textures	Prefers dry season. Requires phosphate fertilizers
Soya bean	0–1800	15–32	1000–2000	Well drained; pH 5·0–6·5. Coarse to medium textures	Prefers climate with pronounced dry season for ripening
Sugar-cane	0–300	24–32	1500–3000	Well to imperfectly drained; pH 5·0–7·5. Prefers heavy soils	Needs dry season for harvesting and ripening of crop
Sweet potato	0–2700	22–32	1000–3000	Well to imperfectly drained; pH 5·0–6·5. Various textures	Well-distributed rainfall. Frost-free growing period
Taro	0–1500	21–32	1000–4000	Well to poorly drained; pH 5·0–7·0. Various textures	Requires relatively fertile soils
Tea	600–1800	14–32	2000–3000	Well drained; pH 4·5–6·0. Deep permeable various-textured soils	Prefers evenly distributed rainfall. In highlands at present grown on reclaimed peat swamps
Tobacco	0–1500	20–28	1000–1500	Well drained; pH 5·0–6·5. Various textures	Needs drier period for ripening and harvesting. Very sensitive to variations in soil that affect flavour and aroma
Vanilla	0–800	18–32	2000–3000	Well drained; pH 5·5–7·0. Various textures, but prefers light friable soils	Needs growing under shade trees. Prefers evenly distributed rainfall
Yam	0–1500	21–32	1000–4000	Well to imperfectly drained; pH 5·0–7·0. Various textures	Tolerant of drought and stony soils

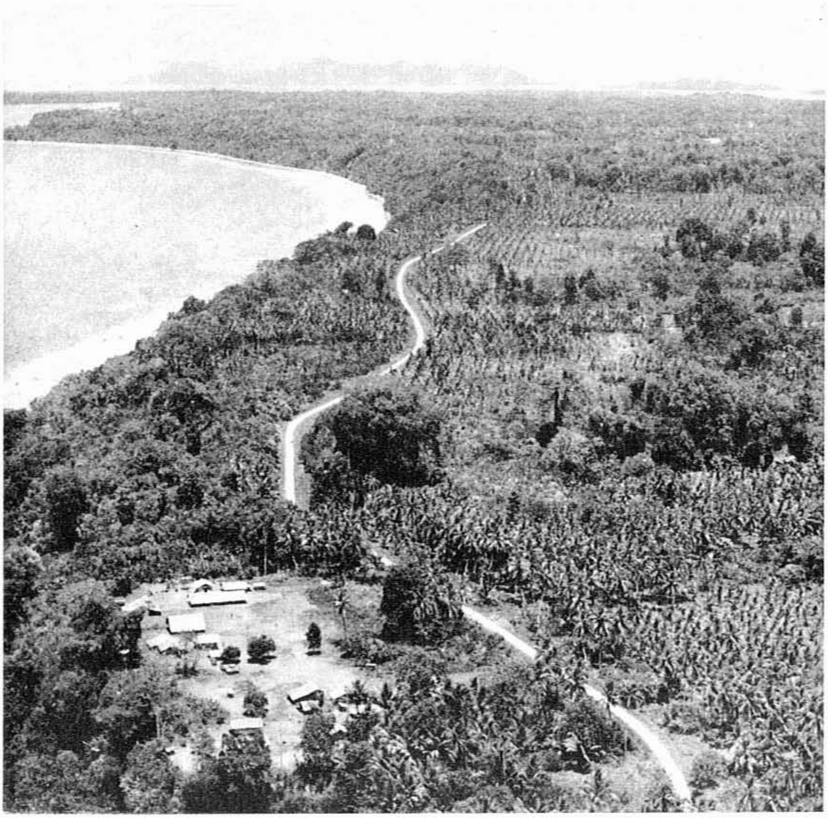
Fig. 1.—Tea is gradually becoming an important export product. Several large estates have been started by expatriate owners in the Wahgi valley and on the fan plains of the Western Highlands District where the climate has proved very favourable for the growth of tea. Some indigenous farmers have now also commenced growing tea on small plots of their gardens. Papua New Guinea's tea production was planned to reach approximately 7000 tonnes by 1974/75. (Photograph courtesy Papua New Guinea Department of Information and Extension Services.)

Fig. 2.—At present very little rice is produced in Papua New Guinea and the country has to spend large amounts on imports. However, there are several large areas which offer good prospects for rice production. This photograph shows experiments with flooded rice at Bubia Agricultural Research Centre near Lae. (Photograph courtesy Papua New Guinea Department of Information and Extension Services.)

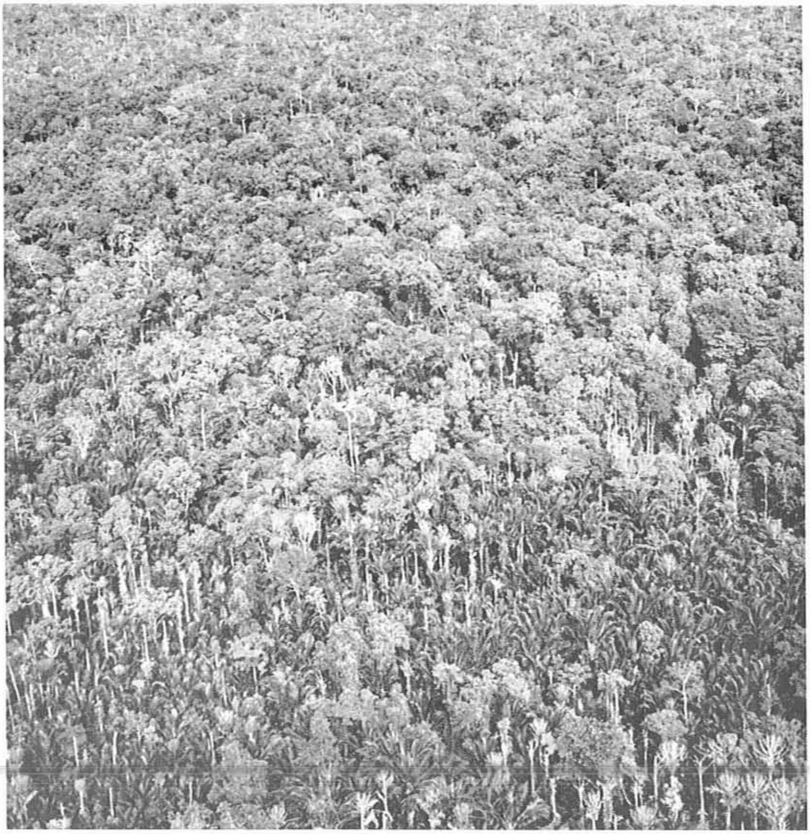
Fig. 1.—Pyrethrum is the only crop suitable for high-altitude areas between 1800 and 2700 m. It was introduced in the late 1950s as a possible cash crop but has been only moderately successful because of fluctuating prices and difficulties in transporting it to the processing mill. (Photograph courtesy Papua New Guinea Department of Information and Extension Services.)

Fig. 2.—Na (ratings n_1a_1 or n_1). Looking down on the slightly dissected fan surfaces on the southern side of the Ramu River which have strongly weathered red and brown clay soils. The vegetation is mainly alluvial forest and grassland. This land has a high capability for agriculture.

M (rating m_1). Uplifted coral terraces occur in a long narrow strip along the north coast of the Huon Peninsula. The rate of uplift of these terraces has been calculated at approximately 3 m per 1000 years. They form flat to very gently sloping platforms separated from each other by stepped rocky surfaces. Soils show a strong variation from the lowest to the highest terraces, rendzinas occurring on the lower, terra rossas on the middle and heavy plastic sticky clay soils on the upper terraces.



D (rating d_1). Buka Island and the northern coast of Bougainville are largely made up of an upwarped Pleistocene coral reef. This view of the east coast of Buka Island shows the characteristic densely cultivated pattern of coconut plantations, gardens and regrowth on the red sticky plastic clay soils. After coffee, copra is the second largest export commodity of Papua New Guinea.



Fd (ratings $f_1d_{1 \text{ or } 2}$). Recent stable alluvial plains subject to wet-season flooding and with undeveloped stratified alluvial soils occur throughout the country. In this photograph, taken in the Gulf District, imperfectly to poorly drained land with medium-crowned forest is shown together with swampy sago patches in the foreground. This land appears best suited for flooded rice.

Dlna (ratings $d_2l_1n_1a_1$). Gently undulating ash plains are common in the Highlands. These plains are both poorly and well to imperfectly drained. The better-drained parts include some of the best land in the Highlands and are intensively used for almost permanent sweet potato cultivation. Garden preparation involves complete tillage and heaping of the tilled soil into mounds usually 2·5 m in diameter, 0·5 m high and 1–1·5 m apart. Compost is added to the centre of the mounds which are planted either wholly with sweet potato or with lesser amounts of other crops. Land selected for gardening is generally under *Miscanthus* grassland. Most gardens are fenced by cordylines and casuarinas that are specifically planted for this purpose. Some casuarina groves can be seen on the top right-hand side of this picture.

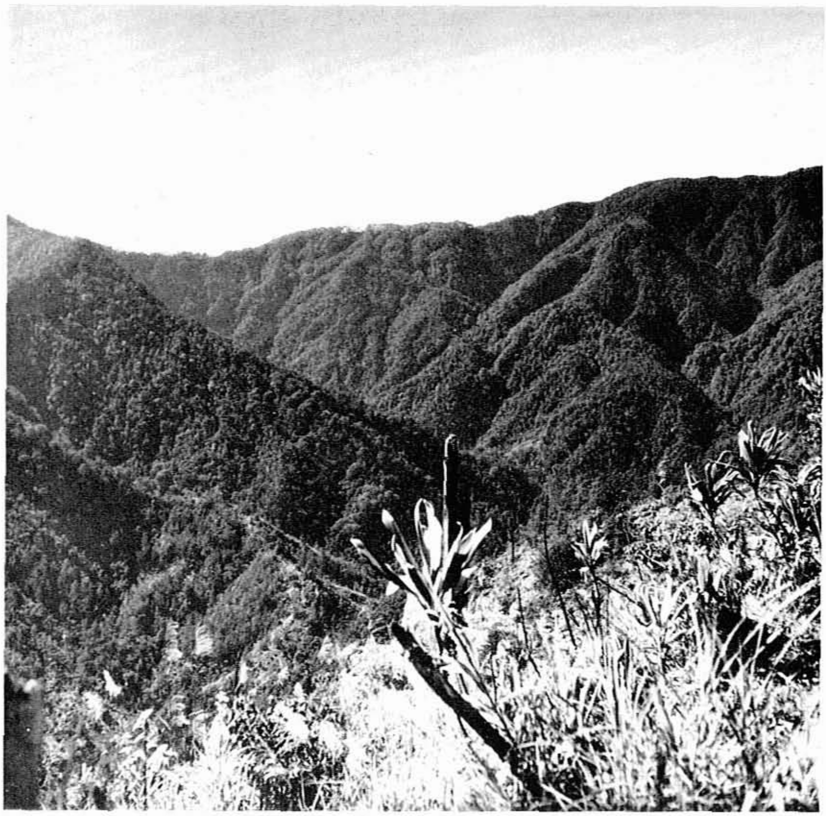
Edna (ratings e_2d_1 or $_2n_1a_1$). Low accordant hill ridges with sharp crests and slumped side slopes are common in the Sepik Districts. They have formed on sedimentary rocks and are covered by mid-height grassland with remnants of forest with sago in the understorey in the valleys. These areas are best suited for grazing.

Dle (ratings $d_3l_2e_1$). High-altitude volcanic plateaux cover small areas of the Highlands. This view shows the Sugarloaf area in the Western Highlands. Because of the high altitude and cold air drainage much of this country carries alpine or lower montane grassland.

Demna (ratings $d_4e_2m_1n_1a_1$). Low hilly terrain with moderate slopes on Pleistocene sediments and with poorly drained, strongly weathered texture-contrast soils is found in the East Sepik District. A strong microrelief is associated with this landscape and is thought to have been caused by earthworm activity.

Fdma (ratings $f_4d_1m_1a_{1 \text{ or } 3}$). Poorly drained sedge–grassland flats which become inundated during the wet season are characteristic of the Western District. A typical feature of these flats is termitaria that reach heights of more than 3 m. A rim of low, thin-stemmed *Melaleuca–Banksia–Grevillea* savanna commonly occurs between sedge–grassland on the flats and tall mixed savanna on the better-drained surrounding slightly undulating terrain. Imperfectly to poorly drained texture-contrast soils with heavy plastic red and grey mottled subsoils are the typical soils for these flats.

Fd (ratings f_4d_4). The alluvial flood-plain of the lower Ramu River has large areas of frequently flooded poorly to very poorly drained land. This photograph shows a general view of the meandering river with its scrolls, levees, back plains and oxbows.



El (ratings e_4l_1). Steeply sloping mountainous terrain at altitudes between 2100 and 2400 m is covered mainly by lower montane forest. In this photograph the rugged mountains of the Kubor Range in the Western Highlands are shown.

Fd (ratings $f_5d_{4 \text{ or } 5}$). Swampy or very poorly drained flood-plains subject to frequent flooding are most common along the major rivers. This aerial photograph shows the fan-shaped scroll complexes made up of interlocking groups of meander scrolls and abandoned meanders along the Strickland River. Extensive back swamps, partly shown in the top left and bottom right corners, flank the scroll complexes. (Photograph is Crown Copyright and has been made available by courtesy of the Director of National Mapping, Canberra.)

Fdsa (ratings $f_5d_5s_1a_{2 \text{ or } 3}$). Swampy low-lying mangrove flats subject to tidal flooding occur frequently in deltas. They are most common in the Gulf and Central District. Mound-building crabs play an important role in accretion in this environment. The crab mounds are of conical shape and the largest are 1·5 m high with 2·5 m basal diameter. The mounds are abundant adjacent to tidal channels, decreasing rapidly in numbers away from the channels. Man's ingenuity has resulted in the use of the crab mounds for gardens. This photograph, taken at high tide, shows bananas, sweet potatoes, sugar-cane and coconuts planted on the mounds.

E (rating e_4). One of the most common mapping units is mountainous and hilly terrain with dominant slopes of 30° or more. The knife-edged ridges and spurs with V-shaped valleys shown here occur near Rabaraba in the Milne Bay District on sedimentary rocks.

El (ratings e_4l_1) and Frm (ratings $f_4r_3m_{1 \text{ or } 2}$). The deeply dissected slopes of the Saruwaged Mountains are broken by trunk streams. On entering the Markham valley they have thrown up large fans consisting of coarse gravelly material.

Erl ($e_4r_3l_1$). The active volcano Mt Bagana in Bougainville consists mainly of very steep debris slopes and lava flows devoid of any vegetation. Steam is still being emitted. Nuées ardentes were produced by Mt Bagana in 1950 and 1952. The lava flows display a surface composed entirely of angular blocks and rubble.

Elr (ratings $e_5l_3r_3$). Very steep slopes at altitudes between 3000 and 5000 m combined with high rainfall, low temperatures and occasional frosts have caused weathering to be slight. This photograph shows a view from the summit ridge of Mt Wilhelm into a glacial valley with stepped cirque lakes and moraines. The vegetation is sparse at this altitude and on the summit is limited to rock crevices. Lower down, alpine grassland and montane rain forest occur.

The bush-fallow or shifting cultivation is the most practised form of indigenous agriculture in Papua New Guinea. Its main purpose is to restore the plant nutrients to the soil during the long fallow period. In the lowlands, a clearing is cut, usually only 0·2–0·5 ha in size, by felling the small trees and ring-barking the larger ones. The cut material is left to dry out and is then burnt. This burn is never complete and leaves tree stumps and many logs. Crops are planted haphazardly, mainly with the digging stick making a small hole for each plant and sometimes roughly loosening the soil around the hole. Food crops shown in this photograph are taro, bananas and sugar-cane.