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RECONNAISSANCE SOIL SURVEY  
OF THE  
TEMERLOH - GEMAS REGION  
MALAYA

BY

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MALAYAN SOIL SURVEY REPORT No. 5/1966



Rubber growing on terraced, hillslopes on shale derived soils of the Durian - Malacca

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## INTRODUCTION

This bulletin together with the attached maps is based on field work conducted between 1964 and 1966, and forms part of a project on the mapping of Malayan soils being currently carried out by the Soil Science Division of the Department of Agriculture, States of Malaya. The aim of the project is two-fold. Firstly, and most important, it serves to guide the development intentions of the country, and helps to ensure that agricultural resources are used to a maximum. Under the present rapid pace of rural development during which tremendous efforts are being made to provide land for the landless through government assistance, preparatory surveys such as this are mandatory. The second aim follows logically from the first, and that is to expand and enhance present knowledge of Malayan soils not only for advisory purposes but also in respect to national and international soil classification.

The region covered by this survey is located near the centre of the Malayan peninsula, extending from approximately  $2^{\circ} 35'$  to  $3^{\circ} 30'$  north latitude and  $101^{\circ} 45'$  to  $103^{\circ} 04'$  east longitude (Fig.1). It encloses what is essentially an inverted triangle, the vertices being at Genting Sempak, Kuala Mentiga and Gemas, embracing a total area of approximately 2,400 square miles. It stretches over most of south-central Pahang as well as parts of north-east Negri Sembilan.

The surveying of such a large area of mostly undeveloped forest country within so short a time can only result in a survey report of a schematic - reconnaissance nature, in which the standard of accuracy of the information is extremely variable from place to place. Although accurate and detailed mapping is possible in the developed areas, the same degree of accuracy cannot be obtained under Malayan Forest conditions and ground information has to be supplemented by inferences made from topographical and geological maps where these are available. Therefore, the need for cautious interpretation in the use of these maps cannot be overemphasized, and the data should always be regarded as being provisional in nature. More detailed information is usually necessary before large scale development can proceed with confidence.

FIGURE 1

# MAP OF MALAYA SHOWING POSITION OF AREA SURVEYED



The descriptive soils information, which forms the major portion of the report, includes generalized descriptions of each series recognised or established in the area, and their inter-relationships or associations. To avoid repetition the relative agricultural value of the soils, assessed in terms of the major crops growing or likely to be grown on them, is grouped under the family classification unit that immediately precedes the descriptions of the series in each particular family. Detailed descriptions and analytical data for the major series encountered in the area can be found in the appendix.

### Access

Four principal roads provide motorable access into the western and southern part of the region. These are the Genting Sempak - Temerloh road, the Menchis - Bahau - Gemas road, the Temerloh - Bahau road, and the Kuala Bera road, an extension of which now leads to Kampong Telok. These roads service the principal population centres of the region, Bentong, Temerloh - Mentakab, Triang, Bahau and Gemas, as well as the many tiny kampongs that dot the area. In addition the main East-Coast railway passes north to south through Gemas, Bahau and Mentakab.

The central and eastern portions of the area are considerably less accessible, being serviced only by the P.W.D. road between Pekan and Kuala Chini, and the military road between Ladang Geddes Estate and Fort Iskandar. In the remainder of the area access is possible through the use of navigable rivers, particularly the Sungei Pahang, Sungei Mentiga and Sungei Bera, as well as Tasek Bera, Tasek Chini and Tasek Mentiga. In addition, the landing strip at Bukit Ibam iron mine affords a very rapid means of access into the extreme eastern portion of the region.

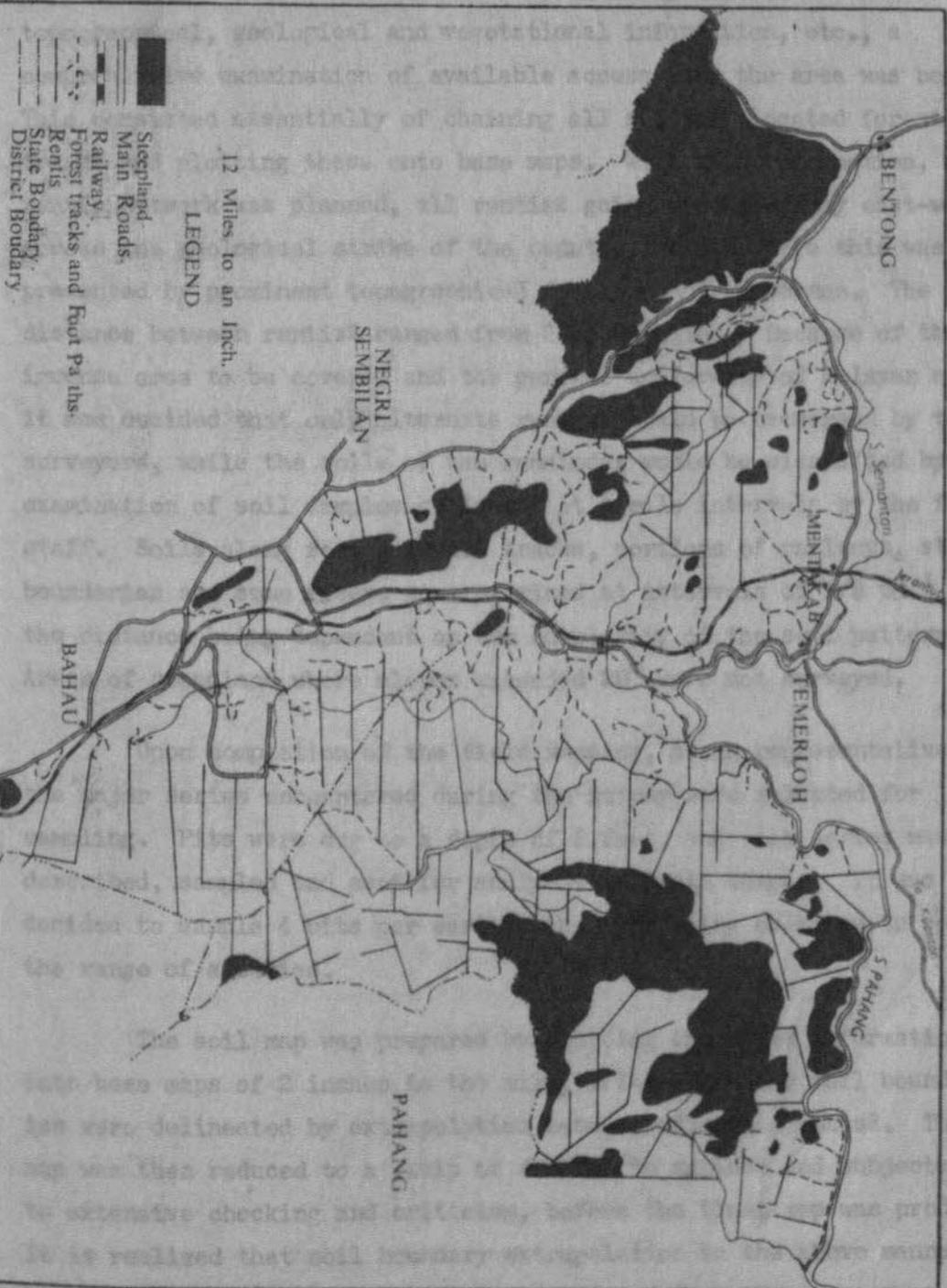
In addition to the established means of access; there are numerous logging tracks and aborigine foot-paths, some of which extend well into the jungle (Fig.2). In the remainder of the region, however, access is possible only by cutting rentis2\*

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\* Rentis is a Malay term for a path cut through the jungle. The plural form is written rentis2.

SKETCH MAP OF TEMERLOH-GEMAS REGION  
SHOWING RENTIS NETWORK.

FIGURE 2



attained to within about  $\frac{1}{4}$  mile is acceptable for this type of reconnaissance survey.

## Method of Survey

The method used in this area was essentially similar to that described by Leamy and Pantou (1906), making use of all units and abbreviations stated therein. After collecting all the available topographical, geological and vegetational information, etc., a comprehensive examination of available access into the area was begun. This consisted essentially of chaining all suitably located forest tracks and plotting these onto base maps. With this information, a rentis network was planned, all rentis<sup>2</sup> going predominantly east-west across the geological strike of the country, except where this was prevented by prominent topographical features and/or swamps. The distance between rentis<sup>2</sup> ranged from 2 to  $2\frac{1}{2}$  miles. Because of the immense area to be covered and the general uniformity of Malayan soils, it was decided that only alternate rentis<sup>2</sup> would be traversed by the surveyors, while the soils of the remainder would be classified by examination of soil samples collected at  $\frac{1}{4}$  mile intervals by the field staff. Soils along roads, forest tracks, portions of railways, state boundaries and some rivers were examined at intervals of  $\frac{1}{8}$  to  $\frac{1}{2}$  mile, the distance being dependant on the complexity of the soil pattern. Areas of steep land where slopes exceeded  $20^{\circ}$  were not surveyed.

Upon completion of the field mapping, areas representative of the major series encountered during the survey were selected for sampling. Pits were dug to a depth of 5 feet, and each series was described, sampled and sent for analysis in Kuala Lumpur. It was decided to sample 4 pits per series, the pits being selected to cover the range of a series.

The soil map was prepared by plotting the field information onto base maps of 2 inches to the mile, after which the soil boundaries were delineated by extrapolation between adjacent rentis<sup>2</sup>. The map was then reduced to a scale of 4 miles to an inch and subjected to extensive checking and criticism, before the final map was produced. It is realized that soil boundary extrapolation in the above manner has certain limitations, but it is considered that the accuracy attained to within about  $\frac{1}{4}$  mile is acceptable for this type of reconnaissance survey.

## Agriculture

Because of the general absence of known mineral deposits and its inland position, the vast majority of the people living in this region earn their livelihood either directly or indirectly from agriculture. Rubber is by far the most important crop of the area, and only minor areas are utilized for padi, vegetables and fruit. Forest exploitation, for the production of timber, is being carried out extensively in the western half of the region, and in several instances agricultural development has followed the timber extraction routes. A few rubber estates and various small holdings, as well as federal and state agricultural development schemes, are located along the major roads and rivers, but the greatest portion of the region is still covered by primary forest.

It is interesting to note that the selection of land for agricultural development in the past appears to have been governed by ready access rather than soil potential, as the greatest portion of agriculturally suitable soils are still undeveloped. It is highly probable that a major land development scheme, possibly of the magnitude of the Jengka Triangle, could be instituted in the region east of Sungei Bera where an extensive area of good quality soils derived from volcanic and arenaceous rocks are located. Another area worthy of consideration is the broad belt of granite derived soils that stretches between Bukit Woh and Bukit Palong. Apart from, and between these two areas, the remaining soils are developed from predominantly argillaceous parent materials, and although they are not suitable for agricultural diversification, they are still capable of producing high yields of rubber under good management. Therefore, it would seem logical to surmise that, barring the discovery and development of a mineral potential, the future prosperity of the region will be largely dependent on controlled development of these forested areas. They represent the region's most valuable natural resource and should not be wasted.

## THE ENVIRONMENT AND SOIL FORMATION

Soil is the collection of natural bodies on the earth's surface, containing living matter, and supporting or capable of supporting plants (Soil Survey Staff, 1960). It includes all horizons differing from the underlying rock material as a result of interactions between climate, vegetation, parent material, relief and time. In various parts of the world certain of these factors tend to dominate the others, with the resultant development of innumerable different types of soils, each reflecting the combined effects of the particular set of genetic factors responsible for its development. Thus in Malaya, we find that climate and parent material (as distinguished from parent rock which may be considered as the unweathered portion of the earth's mantle) are dominant factors. Although a soil also needs time to develop, the effects of this factor are beyond the scope of this report, and therefore will not be discussed further. The other four factors are outlined in greater detail in the following paragraphs.

### Topography and Drainage

The topography of the surveyed area is dominated by three mountain or hill ranges. From west to east, these are the Main Range, the Gunong Benom Range and the Gunong Tahan Range (Richardson, 1947). All of these are highly dissected and well drained, and only the largest, the Main Range, has managed to remain as an integral unit, the others existing as erosional remnants. There are also some large shale and quartzite (mixed with schist) ridges running parallel to the Menchis road. Most of these areas have slopes exceeding  $20^{\circ}$  and have been designated as steep land. The elevation of the steep land boundary varies considerably but, in general, is centered around the 250 foot contour on the plains and around the 500 foot contour along the Main Range.

- 8 -

Between the ranges, and occupying a large tract of terrain in the central portion of the region, is a complex of gently undulating to strongly rolling land dissected by innumerable small streams and rivers. The lowest area in the region is the Sungei Pahang - Tasek Bera drainage complex which is less than 100 feet a.s.l. On either side of this the land rises gently to a general level of 200 - 300 feet a.s.l., but steepland rises up to 4,800 feet (Gunong Besar Hantu 4,799 feet a.s.l.). This area is occupied predominantly by argillaceous sediments which weather to form pale coloured, firm, heavy textured soils. Leamy and Panton (1966) described this area as representing "various stages of dissection of an ancient erosion surface."

The region surrounding the Bukit Bertangga - Bukit Chini mountain complex is distinctly different from the inland plain just described, in that it is characterized by broad, pediplaned valleys intersected by high, rugged hills, ridges and swamps. There is also evidence of the deposition of deltaic gravels, cobbles and clays in the Tasek Mentiga - Kuala Mentiga region. Deposition of ferruginous shales and sandstones in a continental trough, or possibly a small geosyncline, resulted in the present form of the broad Sungei Jeram Valley.

All the waters in this area, except those of the Sungei Jeram and Sungei Palong, eventually drain into the Sungei Pahang. In most cases, the rivers are quite senile, often possessing old meander scars and oxbows, and are often flanked or fed by local swamps. However, they are relatively fast flowing and often located 10 - 15 feet below the level of recent flood deposits, indicating rejuvenation during relatively recent times.

Due to the proximity of the major rivers and their innumerable tributaries, most of the region is in a mature, well-drained state. However, because of some local obstruction of the

natural drainage pattern and/or partial in-filling of old drainage channels such as occurred in the Tasek Bera and Palong Forest Reserve areas, many local, long, narrow swamps are located throughout the region, but the total extent of these is relatively insignificant to the whole.

An interesting feature in the area is Tasek Bera. Its present status is that of a wide, formerly incised, channel that is slowly being filled with sediments from surrounding hills. It is comprised of a series of marshes separated by many small swamps, but inter-connected by narrow riverlets having relatively fast flowing currents. Vegetation is predominantly rasau mixed with various species of reeds, water lilies and submerged-leaf plants. (See Plate 1). The largest and deepest area of relatively open water is at Tasek Kuin, at the extreme northern end of the lake. The origin



Plate 1. A view of Tasek Bera showing predominately reed vegetation with some rasau. In the background is a small aborigine settlement.

of the lake is open to speculation, but personal opinions are that it was formed by a major river, probably the Sungei Pahang. The shapes of the rivers and swamps surrounding the Tasek indicate a complex drainage history, with the waters, first of all flowing to the south and emptying into the Straits of Malacca via the Sungei Muar (Richardson, 1947), but later switching about and flowing to the north as it does at the present. Some river capture is also evident in this region, the best example of which is the complex capture of the Sungei Palong by a tributary of the Sungei Muar. It is interesting to note that the probable origin of other lakes in this region, Tasek Purun, Tasek Chini and Tasek Mentiga, is also due to the restless meandering of the Sungei Pahang, Tasek Mentiga being incised in a deltaic deposit.

Topography affects the soil by influencing drainage, runoff, infiltration and erosion. In general, erosion appears to keep pace with rock weathering, but on steep slopes it often surpasses it, resulting in exposed rock outcrops and shallow, skeletal soils. Conversely, soils can also affect topography by presenting a surface that is differentially resistant to erosion relative to the surrounding country. Such phenomenon occurs sporadically throughout the region and is evidenced by the presence of numerous steep hills protected by fossil caps of laterite. The biggest area of these is north-west of Triang.

### Geology

According to the Geological Map of Malaya (Geological Survey Staff, 1948) the region to the east of the East Coast Railway, as well as that along the foothills of the Main Range, consists of Triassic quartzites and shales. The broad inland plain between Mentakab and Karak is shown as limestone and calcareous shale of Carboniferous age, with granite outcropping at Bukit Woh, Bukit Poh, and Bukit Palong. Volcanic rocks are indicated in the Sungei Palong and Sungei Serting region, while the main range consists of granite.

During the course of the survey, rock samples were collected from various localities and sent to Geological Survey Headquarters, Ipoh for identification. From this information and that obtained from more recent geological investigations (Alexander, 1961; Operation Bun, unpublished; Inche Jaafar bin Ahmad, geologist, personal communication), it became evident that there are five main sources of parent material in the area. These are briefly described as follows.

Argillaceous rocks cover most of the broad, inland plain west of Tasek Bera, and stretching beyond Temerloh and Gemas. These consist predominantly of shales mixed with minor bands of sandstones and conglomerates, the entire formation being intensely folded and impregnated with quartz veins. The weathered product of such rocks is a heavy textured, predominantly pale colored soil, with coarse structures and firm consistence. The proportion of arenaceous sandstones and conglomerates tends to increase very gradually from west to east, such that in the vicinity of Sungei Bera the lithology is one of predominantly arenaceous rocks interbedded with subordinate bands of shale. Correspondingly, the soils gradually change to more highly colored, sandy, friable types.

Arenaceous rocks over most of the foothills region as well as the country surrounding the Bukit Bertangga - Bukit Chini mountain complex. These consist predominantly of sandstones, quartzites and conglomerates interbedded with minor bands of shales, siltstones and greywackes. Soils developed on these materials are generally sandy, friable, and well drained, with colors varying from reddish yellow to yellow. Where the incidence of interbedded shales becomes greater, the soils correspondingly acquire a heavier texture and a slightly firmer consistence. The Sungei Jeram valley is comprised of siltstones and shales interbedded with conglomerates, quartzites and sandstones, all of which are highly ferruginous, and give rise to reddish, friable, sandy soils when weathered.

Granitic rocks are found in a broad belt stretching between Bukit Woh and Bukit Palong and orientated in a N.N.W. - S.S.E. direction. The composition of the granite is by no means constant, even over quite small areas, and varied from porphyritic biotite granite and biotite granite to a very white, acid granite. The weathering of the latter granite results in a pale colored soil of low fertility, while the weathering of the other granites yields more highly colored and better structured soils, with a higher nutrient status. All the soils are coarse textured and sandy, reflecting the high quartz content of the parent rocks.

The largest areas of volcanic rocks, grouped together as the Pahang Volcanic Series in the earlier geological references (1948), are found in the region east of Kuala Bera and in the Bukit Krisek area, although soils of volcanic origin were also mapped in the Kuala Jempol and the Bukit Kuwap regions. These rocks are of predominantly andesitic composition although some quartz andesites, tracky andesites (Alexander 1961) and rhyolites are also found. Soils developed on these materials are usually reddish yellow in color, very friable, well structured and well rooted. Collectively, they form some of the most favourable agricultural soils in Malaya. Small areas of tuffaceous rocks, mainly rhyolitic in composition, are also scattered sporadically throughout the region, particularly in the area south of Batu Lima Military camp near Mentakab.

The alluvial deposits that are found in this area can be divided into two main types. The recent and sub-recent deposits occur exclusively as fluvial, gently undulating terraces along many of the drainage channels. The other type is "Older Alluvium" (Burton, 1964; Null, Acton and Wong, 1965), the best example of which can be seen on a deep road cut on the Pekan - Kuala Chini road, in the vicinity of Kuala Kinchir. This deposit, which is probably deltaic, consists of

at least two distinct beds of rounded quartz gravel and pebbles, 6 - 8 feet thick, separated by thinner bands of alluvial sands, gravels and clays (see Plate 2). Soils developed on this material

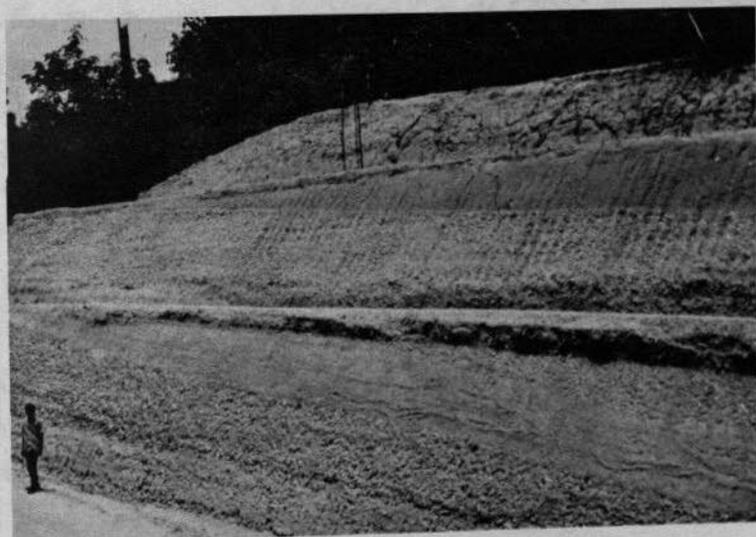


Plate 2. A deltaic, older Alluvial deposit on the Kuala Chini road in which two distinct beds of rounded, quartz pebbles are present. Harimau and Tampoi series are developed on this material

are brownish yellow to strong brown in color, friable, porous, weakly structured, and gritty throughout. Related to these but found only as highly dissected, inland riverine terraces, is another deposit which is characterized by 3 - 4 feet of alluvial materials underlain by 2 - 3 feet of rounded quartz gravels and pebbles. Beneath this there is commonly a thin, somewhat discontinuous, iron-rich hardpan underlain by variegated clay. This material looks somewhat like a weathered granite, but since it occurs at great distances from any possible source of granites, indications are that the material originated from a conglomeratic deposit which may have blanketed the area during some former geological era. With the onset of the

Pleistocene, with its increase in precipitation, periodic drop in sea level and resultant rejuvenation of the rivers, this material was almost completely eroded from the landscape (except for isolated patches appearing on hilltops, etc.) and presently is found mainly as resorted, riverine terrace material. Subsequent erosion has left these terraces as remnants similar in form to other elements of the landscape.

There appears to have been two cycles of rejuvenation and deposition of this material. The sub-recent stage occurs on gently undulating terraces and has been included with Riverine Alluvial soils, to be described later.

### Climate

In Koppen's world classification of climates, cited by Trewartha (1954), Malaya is situated in an Af or Tropical Wet (Rain-Forest) climatic zone, of which the distinctive feature is that the average daily temperature fluctuations are greater than the average seasonal fluctuations. This is accompanied by abundant rainfall in every season. However, the Temerloh - Gemas region, being situated in the central part of the Malayan Peninsula, the figures ranging from 60 - 90 inches per annum. By referring to Fig.3, it is seen that "dry" and "very dry" soil conditions are most common during the months of February, June, July and August. This could possibly account for the high incidence of nodular and fragmental laterite that is found in most of the soils in the area. The principal monsoonal effect is from the north-east during the months of November to January, but even during this period, several consecutive days of rain are rare. The general rainfall pattern is one of localized, tropical thunderstorms of varying intensity and duration, occurring during the late afternoon or early evening, some of which may be of sufficient intensity to damage communications and cause local flooding. A second monsoonal effect, from the south-west, occurs during the months of April to

May but is of much lower intensity than that from the north-east.

During the months of June, July and August it is not uncommon to have short, dry spells of nearly 3 weeks duration, and it is during these times that extremes in temperature are experienced. Normally, however, maximum daily temperatures are invariably in the high 80's to low 90's with a relative humidity approaching 100%.

### Vegetation

Dipterocarp rain forest is the natural vegetation covering the major part of the free draining, upland area. This forest, which is usually dense but not to the point of completely restricting ground movement, is composed of many thousands of tree species, as well as shrubs, herbs and woody climbers. The upper or emergent storey is usually about 100 to 150 feet high and often somewhat discontinuous. The main storey, or second tree layer, occupies a region of about 90 to 100 feet from the ground and forms a continuous canopy except immediately below the large, upper storey trees. The understorey consists of segments of the other two stories together with many other families. Beneath this is a shrub and herb layer which may vary from very thick and dense to open, and which contains young saplings of larger trees, shrub species, palms and some ferns near streams and in moist valleys. There is usually a comparatively poor layer of litter though partially decomposed leaves often cover the forest floor.

According to Wyatt-Smith (1963, Vol.II), there are four main forest types represented in the Temerloh - Gemas region. The most widespread is the Red Meranti - Keruing forest which is characterized by a high percentage in the upper storey of species of the Red Meranti group of Shorea and Dipterocarp. The shrub and sapling layer is usually rather open with palms, mainly Licuala spp., and the woody

scrambler, Agrostistachys spp., often being locally common (see Plate 3).



Plate 3. Red Meranti - Keruing forest on Batu Anam - Malacca - Tavy soils in the region west of Tasek Bera.

In association with the Red Meranti - Keruing forests but comprising an important group by itself, is the Keruing forest. This type commonly occurs on poorer drained soils and in areas which tend to be water-logged during portions of the year. It is characterized by the height of upper storey trees being less than that of the Red Meranti - Keruing forest and by predominance of Dipterocarpus spp. in association with Dryobalanops, Hopea, Shorea, Koompassia and Palagium families.

Balau forests, which are found only in western portions of the region, are characterized by a high percentage of the Balau Heavy Hardwood group of Shorea, of which S.atrinervosa, S.exelliptica and S.maxwelliana are the most common. Diperocarpus spp. and species of the Red Meranti group of Shorea are also frequently present.

In areas that are semi-permanently submerged in mineral-rich fresh water, are found the Lopak or Fresh Alluvial Swamp forests. The structure and floristic composition of these forests varies enormously, depending on the environmental conditions dominant at any particular site. Stilt roots, knee roots, and plank-like buttresses are found on some trees, but these are not a feature of these forests. The most common vegetation types are those dominated by sedges, screw pines, rotans and palms.

Many areas which have been cleared and then abandoned, as well as those caused by the shifting cultivation habits of aborigines, are covered with belukar\*, Lallang (Imperata cylindrica) and Resam (Gleichenia linearis).

#### SOIL CLASSIFICATION

This section, which is purely of academic interest, is included in an attempt to outline the evolution of the classification scheme used in this survey (Leamy, 1966), pertinent parts of which are outlined in Table I. The criteria used in the sub-divisions are briefly described here, but more specific definitions, particularly in lower levels of classification, are found in the next section.

Early attempts in the classification of Malayan soils (Owen, 1951; Panton, 1964) borrowed heavily from terminology used elsewhere in the world, and which in most instances suffered from a strong genetic bias. In the early part of 1966, Leamy (1966, unpublished) proposed a scheme whereby terms that were in common usage were retained in the lower levels, using criteria that pertained more to local conditions (Dudal and Moorman, 1964; World Soil Resources Report 12, 1964), but introducing terms that were defined in the 7th Approximation (Soil Survey Staff, 1960) in the higher levels.

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\* Belukar is a Malay term for secondary vegetation that is growing in areas where the jungle has been cleared but then abandoned.

Table 1. The Structure of the Classifications

ORDER	SUBORDER	GREAT SOIL GROUP	SUBGROUP	FAMILY	SPECIES
OXISOL	ARGOX	RED BROWN OXISOLS NORMARGOX	TYPIC NORMARGOX	KARPOKO KOLAM	SERANGEN Jerangan
				JEMPOI	Katohit Jempoi Jeram Serdang Red Variant Munchong Segamat
	ACROX	YELLOW RED OXISOLS NORMARGOX	ULTIC NORMARGOX TYPIC NORMARGOX	MUNCHONG SEGAMAT	Munchong Segamat
	PETROX	CONCRETIONARY OXISOLS NORMIPETROX	TYPIC NORMIPETROX ULTIC NORMIPETROX	MALACCA TAVY	Malacca Tavy
ULTISOL	UDULT	RED YELLOW ULTISOLS TROPUDULT	TYPIC TROPUDULT	RENGAM SERDANG	Pengam Serdang Kedah
			ACRENTIC TROPUDULT	HARIMAU	Harimanu Tampoi Kawang Kawang Red Variant Tampin
ENTISOL	UDENT	BROWN GREY ULTISOLS PLINTHUDULT	HAPLIC PLINTHUDULT TYPIC PLINTHUDULT	KULAI DURIAN	Durian Bungor
	AQUENT	BROWN GREY ENTISOLS HAPLAQUENT	AQUIC PLINTHUDULT TYPIC HAPLUENT	BATU ANAM TELEMONG	Batu Anam Marang Telemong
		MISCELLANEOUS LAND UNITS		STEEPLAND DEVELOPED LAND MARSH & OPEN WATER LOCAL ALLUVIUM RIVERINE ALLUVIUM INLAND SWAMPS	

Difficulties arose because of the inadequacies of the American system in regards to the Oxisol Order, and because the use of common terminology still carried genetic connotations. However, with Haantjens' (1965) amendments to the definition of Oxisols major difficulties were resolved, and it became possible to prepare an acceptable classification scheme tailored for Malayan soils.

The various soil Orders were developed largely by generalizing on the kinds and relative strengths of processes that tend to give soil its horizons and properties. Each Order was then subdivided into Suborders on the basis of characteristics which seemed to produce classes with the greatest genetic homogeneity. Below this level, genetic considerations were somewhat overlooked, such that in the Great Soil Groups overall morphology of the soil became the dominant factor, while Subgroups were introduced to emphasize the central concept of the Group. At Family level grouping was based mainly on environmental factors.

Thus the classification units refer to the system into which all the soils of the country are divided for easy comparison, such a division being a necessary prerequisite before one can attempt to make general statements of wide application. In general, it is supposed that all soils in a family will react in a similar fashion under cultivation. Beyond this, the system becomes increasingly academic and generally impracticable for the layman.

Mapping Units

The basic unit used for classification during this survey was soil series, this being defined as a collection of soils with similar morphology and developed under similar environmental conditions (including parent materials). Since individual series usually occupied a small area before grading into another, they were usually grouped into an artificial mapping unit called soils association, each

unit being topographically and proportionally similar to other equivalent associations. The association was named by mentioning the series of which it was made up, in chronological order, from the most common to the least common. In practice, a series was not named in the association unless it occupied at least 20% of the total area covered by an individual association.

Another artificial aid used during the survey was soil variant. This was used to distinguish between profiles that were similar in properties to the series from which it derived its name, apart from color. Finally, for the purpose of practical recommendations, the series were grouped into families.

### THE SOILS

#### 1. RED BROWN OXISOLS (NORMARGOX)

These are typically friable to very friable, porous soils possessing weak or absent eluvial A/illuvial B horizon sequences, and colors that are of 7.5YR hue or redder. The clay content of the B horizon is generally between 45% and 75% and acid soluble  $Fe_2O_3$  (6N HCl) between 2.5% and 11% (Leamy, 1966).

##### (a) KAMPONG KOLAM FAMILY

The dominant color of this family is of the 5YR hue, and the soils are commonly friable, porous and well structured. They are not commonly lateritic, although some bands of laterite may be present. These soils are developed from intermediate and acid intermediate igneous rocks and therefore have a relatively higher reserve of plant nutrients. They are suitable for a wide variety of crops, providing that topography is favourable. The following soil series have been

identified in this family within the area surveyed.

### Jerangau Series

This soil occurs on rolling to hilly country (slopes 6 - 20°) and is developed from biotite hornblende granite and granodiorite. It has a heavier texture, slightly stronger colors and more strongly developed structure than soils of the Rengam series with which it occurs in close association. As a unit, Jerangau series is of very minor importance in this region, having been mapped only in the Bukit Tinggi area of west Pahang.

The surface soil is a dark yellowish brown (10YR 4/4) fine sandy clay loam, with friable consistence and moderately developed fine crumb structure. This is underlain by a deep, uniform, fine sandy clay loam to clay loam subsoil, which is reddish yellow to strong brown (7.5YR 6/6 - 5/8) in color and possesses a well developed, medium, subangular blocky structure and medium to weak clayskins. Consistence becomes firmer with depth and texture increasingly coarser. Small, partially weathered fragments of parent material may be present at depth.

### Katong Series

This series, developed on quartz andesite, occurs in association with Segamat series in the area east of Kuala Bera and in the Bukit Krisek region. The surface horizon is yellowish brown (10YR 5/6) in color, clay loam in texture and possesses fine, moderately developed subangular blocky to crumb structures. This grades gradually into a heavy textured, friable, strong brown to reddish yellow (7.5YR 5/6 - 5YR 5/7) subsoil, exhibiting moderately developed subangular blocky structures and moderately to weakly developed clayskins. This soil

commonly occurs on hilly (12 - 20°) terrain, is sometimes lateritic, and usually sandier and grittier than Segamat series. It is of relatively local occurrence.

(b) JEMPOL FAMILY

This family has wide distribution in the eastern portion of the region, particularly in the valleys of the Sungei Jeram and Sungei Chat, as well as in the region of Kuala Jempol. The dominant colors are of 5YR hue and the soils are usually medium textured, friable, porous and moderately to well structured. Although bands of nodular and fragmental laterite are often present, the laterite is usually loosely packed and root penetration is good. Most of the series in this family are still under virgin jungle, except for some small, rubber holdings in the region of Kuala Jempol. In general, these soils are suitable for a wide range of tree crops.

Jempol Series

This soil occupies a small area to the south of Kampong Kuala Jempol. It is developed on sedentary conglomerates and breccias that have been modified by volcanic activity. Topography is rolling to hilly (slopes 6 - 20°). This soil is suitable for oil palm, but most of it is presently under small, rubber holdings.

The surface soil is reddish brown to yellowish red (5YR 4/4 - 4/8) in color, friable, fine sandy clay loam in texture, and possesses fine, well developed crumb structure with moderately developed clayskins. This passes gradually to a yellowish red to red (5YR 4/6 - 2.5YR 4/6) subsoil that is slightly firmer than the surface. Textures are fine sandy clay loam to clay loam, and structures are well

developed, medium, subangular blocky with moderately to well developed clayskins. The soil is porous, moderately gritty and uniform in appearance throughout, although bands of nodular and fragmental laterite and/or angular quartz stonelines may be present at depths of 20 - 40 inches.

### Jeram Series

Jeram series is similar in morphology to Munchong series, except for color, and was originally mapped as Munchong series, red variant. It is very common in the Sungei Jeram valley where it occurs in association with Serdang series, red variant, as well as in the valley of the Sungei Chat and the region immediately west of Bukit Bertangga where it is associated with Bungor soils. Jeram series is developed on ferruginous shales and sandstones, and occurs on rolling to hilly terrain (slopes 6 - 20°). This soil is suitable for a wide range of tree crops.

The surface soil consists of a thin, brown to reddish brown (7.5YR 5/5 - 5YR 5/4) fine sandy clay loam to clay loam, which is friable and porous, and possesses a well developed crumb to fine subangular blocky structure. This passes quickly into a yellowish red to red (5YR 5/6 - 2.5YR 4/6) subsoil, with moderately to well developed subangular blocky structures and weakly expressed clayskins. The subsoil is slightly firmer than the surface and clay loam to clay in texture. The soil exhibits a weak eluvial A/illuvial B horizon sequence, is sometimes weakly mottled and gritty, and often lateritic with the laterite appearing as discontinuous bands of moderate thickness. The greatest proportion of this soil is still under virgin jungle.

Serdang Series, red variant

This series implies a soil that is similar in appearance to Serdang except for color. It occurs in association with Jeram series over a wide range of topography, exclusively in the valley of the Sungai Jeram. Parent materials are ferruginous sandstones. Apart from areas where the soils are extensively lateritic and/or shallow, this series is suitable for a wide range of tree crops including oil palm and fruit.

The surface soils is sandy loam to fine sandy loam in texture, brown to reddish brown (7.5YR 5/5 - 5YR 5/5) in color, very friable and poorly structured. Beneath this is a sandy clay loam, yellowish red to red (5YR 5/6 - 2.5YR 5/5) subsoil, which is friable to very friable in consistence, and possesses moderately well developed subangular blocky structures and moderately developed clayskins. The soil exhibits a well expressed A<sub>c</sub>/B<sub>t</sub> horizon sequence and is sometimes lateritic, the laterite (mostly nodular) appearing as discontinuous bands of moderate thickness. It may also be very weakly mottled and somewhat shallow; fragments of partially weathered parent material are often found within 4 feet of the surface.

(c) MUNCHONG FAMILY

Morphologically, the soils of this family integrate towards the Ultisols in that development of an eluvial A/illuvial B horizon sequence is slightly more distinct, dominant colors are of the 7.5YR hue, and in some places a weakly developed plinthite (variegated clay) horizon is present at depth. Physically, these soils are deep, heavy textured and well structured, but still friable, porous, well drained and well rooted. They are not commonly lateritic, but nodular and fragmental laterite may appear as discontinuous bands.

These soils are suitable for a wide variety of tree crops and should be utilized for agricultural diversification. Only one series is present in this family.

Munchong Series

Munchong series is developed on predominantly argillaceous parent materials that are partly interbedded with sandstones. It commonly occurs on rolling to hilly (slopes 6 - 20°) terrain. It is associated with Serdang series in the region surrounding the Bukit Bertangga - Bukit Chini mountain complex and in a small area to the east of Tasek Bera, but is associated with Bungor series in the Bukit Kertau area as well as in the western part of Bahau Estate.

The surface horizon is a friable, brownish yellow to strong brown (10YR 5/6 - 7.5YR 5/6) sandy clay loam to clay loam, with fine, moderately well developed subangular blocky structures and weak clayskins. This is underlain by a friable, yellowish brown to strong brown (10YR 5/8 - 7.5YR 5/8) clay to sandy clay subsoil, which exhibits fine, moderately to well developed subangular blocky structures with medium clayskins. The soil is usually porous, deep, and uniform in appearance, although it may on occasion be lateritic and somewhat gritty. Some fine, distinct, brownish yellow mottles are often present at depth.

2. YELLOW RED OXISOLS (NORMACROX)

There are soils with deep, uniform, profiles possessing weakly differentiated horizons with diffuse horizon boundaries. Dominant colors are of 5YR and 2.5YR hue, structures are strongly developed, consistences are friable to very friable and pores are abundant throughout. A very weak illuvial B horizon may be present. Clay

content in the oxic horizon is high (normally greater than 70%) and acid soluble  $Fe_2 O_3$  (6N HCl) is usually greater than 18%. These are among the most strongly weathered soils in Malaya (Leamy, 1966).

(a) SEGAMAT FAMILY

Soils in this family are developed on intermediate and basic igneous rocks, and are usually yellowish red to reddish yellow (5YR 4/6 - 6/8) in color, deep, friable, porous and well structured. Included are soils with laterite concretions if such concretions normally occur below 54 inches, or do not comprise more than 50% of the profile. This family comprises some of the most favourable agricultural soils in Malaya, having a relatively higher nutrient status than other sedentary soils, and excellent physical structure to promote deep root penetration. Such soils are suitable for most upland crops presently grown in Malaya. Only one series is recognised in this family.

Segamat Series

Segamat series is developed on rocks of andesitic composition. In association with Katong series, it occupies a large area east of Kuala Bera as well as in the Bukit Krisek region. Smaller areas are at Bukit Kuwap and a high hill at the eastern border of Lanchang Estate. This latter exposure is recognised as Segamat series, stony phase. In general, this series occurs on rolling terrain (slopes 6 - 12°) but occasionally slopes approach 20°.

The surface horizon is a friable, yellowish red to reddish brown (5YR 4/6 - 2.5YR 4/4) clay, possessing a well developed crumb to very fine subangular blocky structure. It is usually very thin or absent. This is underlain by a deep, uniform, friable, yellowish red to red (5YR 5/6 - 2.5YR 4/6) clay subsoil, which exhibits fine, moderately to well developed subangular blocky structures with

moderately developed clayskins. The soil is very porous and fragments of quartz as well as tiny nodules of laterite are scattered throughout.

As mentioned before, this series constitutes the best agricultural soil that has been found within the surveyed region. However, the high iron content coupled with the relatively drier climate has resulted in local areas that are intensely lateritic. Although the laterite is commonly pisolitic, rather than massive, and therefore root penetration is still possible, crops which lack a vigorous tap root, such as oil palm, Manila Hemp, bananas, etc. could not be expected to produce as well as they would in non-lateritic areas.

### 3. CONCRETIONARY OXISOLS (NORMIPETROX)

These are soils formed on argillaceous or arenaceous sediments on ancient erosion surfaces or dissected remnants thereof. The petric horizon (common term is lateritic horizon) consists of nodular, massive or fragmental laterite, and may be overlain by eluvial and illuvial horizons. It normally occurs within 36 inches of the surface. Variegated clay (plinthite) is usually found at depth beneath the petric horizon (Leamy, 1966).

#### (a) MALACCA FAMILY

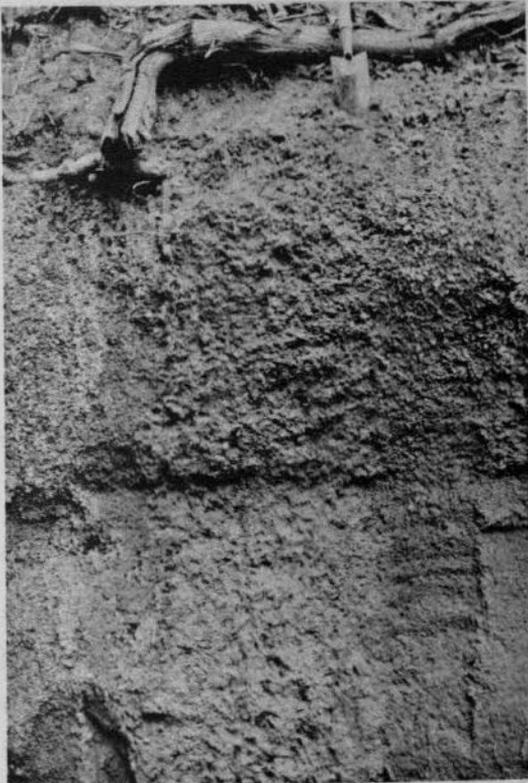
Malacca family is characterised by the presence of a petric horizon appearing within 24 inches of the surface and being greater than 36 inches thick. In this region, the petric horizon is most commonly comprised of nodular and fragmental laterite,  $\frac{1}{4}$  to 2 inches in diameter, but massive boulders of laterite may also be present. As such, the laterite presents an obstacle to root penetration, but not usually to the point of being a total hindrance. Rubber, and even in some cases oil palm, has been successfully cultivated on these soils,

but it is considered that with the present large reserves of more favourable soils, these soils should be reserved for the production of forests.

### Malacca Series

This series occurs in association with all soils mapped in the region, although in most cases the sum total of the exposures constituted less than 20% of any individual area. It is particularly common in the region south-west of Temerloh, in the Ayer Hitam district, in a broad, elongated belt immediately west of Tasek Bera, in the region east of Rompin, and along the eastern border of Palong Forest Reserve. Smaller areas are found in the Tasek Chini region, north of Bukit Kertau, in the eastern portion of the Jeram valley, and in isolated patches east of Tasek Bera. In most cases, Malacca series is associated with Durian, Batu Anam and Tavy soils on hilly (slopes 12 - 20°) terrain where it occurs on hill crests (fossil laterite) with Durian and Batu Anam occurring on side slopes and Tavy on lower slopes and lows. In the eastern and north eastern portion of the region, Malacca is associated also with Serdang, Bungor, and Marang series. An Older Alluvial phase is associated with Kawang soil.

The surface soil, which is often less than one foot in depth, is usually a moderately friable, yellowish brown to strong brown (10YR 6/6 - 7.5YR 5/6) sandy clay loam, with weakly to moderately well developed subangular blocky structures. Beneath this is found a thick horizon of loosely packed nodular and fragmental laterite in which the matrix is strong brown to yellowish red (7.5YR 5/6 - 5YR 5/8) in color, and sandy clay loam to clay in texture (see Plate 4). This horizon may extend to depths of 5 - 8 feet and is often mixed with quartz grit and pebbles indicating that it may have been moved and/or concentrated through erosion. Beneath the laterite horizon is a firm, highly variegated clay (non-hardened plinthite) in which



small pieces of partially weathered shale can often be found.

Plate 4. A Concretionary Oxisol, Malacca series, with nodular laterite to a depth of 5 feet below which is non-hardened plinthite. Location east of Tasek Chini, along road to Good Earth Iron mine.

Although the distribution pattern of Malacca series in this region is highly suggestive of ancient formation and concentration through subsequent erosion, laterite is still being formed during the present. Evidence for this comes from the partially hardened nodules found in mottled horizons of many soils, as well as from recent ground-water laterites (Panton, 1956) sometimes found to occur at the base of hills along the boundary between upland and alluvial soils

(b) TAVY FAMILY

These soils are characterized by the common presence of illuvial B horizons above a petric horizon of nodular and fragmental laterite. The petric horizon is normally deeper than 24 inches and thinner than 36 inches. In many parts of Malaya rubber, and where the laterite band is below 24 inches from the surface, oil palms have been successfully grown on these soils. However, sound management

in soil conservation is required as much as of the land in this family has average slopes exceeding  $20^{\circ}$ .

### Tavy Series

Tavy soils are developed on argillaceous parent materials interbedded with ferruginous sandstones and conglomerates. They occur in close association with Durian series in the region east and south of Kuala Triang, and with Marang and Malacca soils in the area east of Kemayan. In a broad belt west of Tasek Bera, these soils occur with Batu Anam and Malacca series, commonly occupying the lower slope positions in a catenary - tending sequence. Topography is commonly rolling to hilly (slopes  $6 - 20^{\circ}$ ).

The surface soil is yellowish brown to reddish yellow (10YR 5/4 - 7.5YR 7/6) in color, most commonly sandy clay loam in texture, and possesses a weakly to moderately well developed subangular blocky structure and friable consistence. This is underlain by a moderately firm illuvial B horizon that is heavy textured, and exhibits medium, well developed subangular blocky structures with moderately developed clayskins. The color is reddish yellow to brownish yellow (5YR 6/8 - 10YR 6/6). Beneath this, at depths of 20 - 40", is a moderately thick band of closely packed, nodular, lateritic concretions in which the matrix is a yellowish red (5YR 5/8) gritty clay. This in turn is underlain by a firm, highly mottled and iron stained clay. In general, the soil becomes redder and firmer with depth, and is somewhat gritty and porous.

#### 4. RED YELLOW ULTISOLS (TROPUDULT)

These soils have a distinct argillic horizon which may be overlain by an albic horizon, but is separated from it by an abrupt textural change. In some cases moist chroma of the overlying eluvial horizon is the same as that of the argillic horizon (which is usually

6 or more) but the hue is yellower. The colours most commonly dominant in the argillic horizons are 10YR 6/6 and 5YR 5/8. Consistences are friable, structures weak and pores few (Leamy, 1966).

(a) RENGAM FAMILY

Soils of this family are derived from acid igneous rocks. They are friable, porous, moderately well structured and uniform in colour throughout, but an abrupt textural change is present between the Ae and Bt horizons. The great depth to which this soil permits root penetration makes it particularly suitable for tree crops. Rubber, oil palm, fruits and black pepper (Null, Acton and Wong, 1965) could all be successfully grown, but soil conservation practices must be followed as this soil is particularly susceptible to erosion.

Rengam Series

This series is developed from normal granites as well as biotite granite, large boulders of which are often present on the surface. It occurs in association with Tampin series, occupying a broad belt stretching between Bukit Palong and Bukit Woh, as well as a small region to the south of Bukit Senorang, and a tiny patch in Glendale Estate. Topography is commonly rolling (slopes 6 - 12°), but individual slopes may approach 20°. A reddish yellow (5YR 6/6 - 6/8) phase, developed on porphyritic biotite hornblends granite, is also present in the region but is of rather local extent.

The surface soils is a friable, brownish yellow (10YR 5/6 - 6/6) sandy to coarse sandy clay loam, with weakly developed subangular blocky structures and very weakly expressed clayskins. This changes abruptly to a friable, brownish yellow to reddish (10YR 6/8 - 7.5YR 6/8) coarse sandy to gravelly clay, which exhibits moderately well developed, medium, subangular blocky structures with moderately developed clayskins. Beneath this the soil gradually attains a yellowish red to red (5YR 5/8 - 2.5YR 5/8) colour, structures become weaker

and textures slightly lighter. Some prominent red (2.5YR 4/6) mottles and non-hardened plinthite may be present at depth. The most characteristic features of this soil are its porous nature, its coarse textures, the sharp increase of clay with depth, and expressed Ae/Bt horizon sequence. Laterite is not a feature of this soil, although some thin, discontinuous, loosely packed bands are sometimes present in depth.

(b) SERDANG FAMILY

The features of this family are similar to those described for the RENGAM family, except that parent materials are arenaceous, sedimentary rocks. These soils are suitable for rubber, oil palm, and various types of fruits, provided that conservation practices are followed to reduce effects of erosion. Kedah series, however, is too shallow for most crops.

Serdang Series

This series is developed on sandstones, quartzites and/or arenaceous conglomerates, and is very common in the region surrounding the Bukit Bertangga - Bukit Chini mountain complex as well as in the region to the east of Tasek Bera. It is most commonly associated with Bungor and Munchong series although it has also been mapped with Malacca, Kedah and Batu Anam soils. Apart from local areas along the Sungei Pahang that are cultivated for rubber, or those cleared by aborigines, the region covered by this soil is still under forest, most of which is of excellent quality. Topography varies from rolling to hilly (slopes 6 - 20°).

The surface soil is a friable, yellowish brown to brownish yellow (10YR 5/4 - 6/6) sandy to coarse sandy clay loam, with weakly to moderately developed, fine to medium, subangular blocky structures and weakly developed clayskins. This is underlain by a friable, yellowish brown to reddish yellow (10YR 5/6 - 7.5YR 6/8) sandy clay

loam to coarse sandy clay, possessing moderately well developed, medium, subangular blocky structures with moderately developed clayskins. Beneath this the soil changes gradually to a moderately firm, massive, parent material horizon which may be slightly mottled or may contain non-hardened plinthite at depth.

Most of the Serdang series mapped in the region east of Tasek Bera, is distinctly coarser than is usual for this soil. This may be attributable to the predominantly conglomeratic parent material.

### Kedah Series

These are very shallow soils of extremely local distribution. They are associated with Serdang series, and are developed on sandstones and conglomerates on hilly to steep (slopes 12 - 25°) terrain.

Kedah series is a friable, reddish yellow (7.5YR 6/6) sandy clay loam, with weakly developed subangular blocky to crumb structures and weakly expressed clayskins. It exhibits a juvenile type of Ae/Pt horizon sequence, is very porous and loose, and sometimes less than one foot in depth.

### (c) HARIMAU FAMILY

Soils in this family are developed on Older Alluvial deposits that are probably of Pleistocene age. Various field criteria are available to aid in the identification of these deposits (Null, Acton and Wong, 1965), but the most useful is the presence of bedded, rounded, quartz pebbles immediately beneath the solum and/or evidence of stratification within the profile. In these soils horizonation is not as distinct as it is in the RENGAM or SERDANG families, and neither albic horizons nor abrupt textural changes occur, except where these are the result of deposition. These soils are strongly impoverished of weatherable minerals, and analysis have indicated major element

deficiencies. In addition manganese deficiency has been found in similar soils in Johore, and other trace element deficiencies are suspect. Rubber, however, is being successfully cultivated in a narrow belt bordering the Sungei Pahang. For these reasons future land use should be directed towards rubber, with oil palm being a questionable alternative.

### Harimau Series

This soil is developed on what are probably deltaic sands, gravels and clays of Pleistocene age. Topography ranges from undulating to hilly (slopes 2 - 20°) and correspondingly, external drainage varies from good to poor. In association with Tampoi series, this soil occupies a small area in the region between the Sungei Pahang and Tasek Mentiga, most of which is still under virgin jungle. It is separated from the Sungei Pahang by a thin strip of recent alluvium.

This series consists of a light yellowish brown (10YR 6/5), sandy clay loam surface soil, that is underlain by a brownish yellow to yellowish brown (10YR 6/6 - 5/8) sandy clay loam subsoil. Structures are weakly to moderately well developed with moderately developed clayskins, and the soil is friable, porous, slightly mottled, and distinctly gritty throughout. At depths of 60 - 80 inches there is usually a sharp contact with bedded, rounded, quartz pebbles, which are often mixed with fragmental and nodular laterite. This soil is similar in morphology to Kawang series, and is probably related to it, but is separated from Kawang on the basis of differences in mode of deposition.

### Tampoi Series

Tampoi series is closely associated with Harimau soils in the region north of Tasek Mentiga. It is most often found on undulating to rolling (Slopes 2 - 12°) topography, while Harimau occurs on more hilly terrain. Its mode of origin is similar to that of Harimau.

The surface soils consists of a thin, friable, yellowish brown (10YR 4/4) sandy loam, with poorly to moderately developed crumb structure. This is underlain by a reddish yellow to strong brown (7.5YR 6/8 - 5/8) sandy loam to sandy clay loam subsoil, possessing weakly developed subangular blocky structures and weakly to moderately developed clayskins. In general the soil exhibits weak horizon differentiation and a very porous and loose nature. Rounded quartz pebbles mixed with nodular laterite commonly occur at depths of 10 - 15 feet.

### Kawang Series

This is the only new series that has been mapped in this region. Its name is taken from Sungei Kawang Estate where it was first recognised. This soil occurs on a highly dissected (slopes 12 - 25°) upper terrace along the Sungei Pahang as well as along most of its major tributaries, with a distribution pattern that is highly suggestive of extensive past erosion. Where topography is undulating (slopes 2 - 6°), the deposit is considered to be of sub-recent age and is included with Riverine Alluvial soils. In most cases, Kawang series is associated with an intensely lateritic soil which was mapped as Malacca, Older Alluvial phase.

The surface soil is a friable, yellowish brown (10YR 5/4 - 5/6) sandy loam to sandy clay loam, possessing poorly to moderately well developed, fine, subangular blocky structures and weakly developed clayskins. Beneath this is a friable, brownish yellow to reddish yellow (10YR 6/8 - 7.5YR 4/4) subsoil, which is sandy clay loam to gravelly clay in texture, and exhibits a fine to medium, moderately to well developed subangular blocky structure with weakly to moderately well developed clayskins. The soil is distinctly gritty throughout with the grit sometimes concentrated in a thin band occurring within 3 feet of the surface. Below this is a thick layer of well rounded quartz pebbles lying in an argillaceous matrix of quartz grit and clay. This commonly overlies a thin, discontinuous, iron-rich hard pan which in turn overlies a firm, variegated clay. The entire deposit is generally less than 5 - 8 feet deep.

#### Kawang Series, Red Variant

This soil occurs as an old, highly dissected, riverine terrace in the region east of Kuala Bera, bordering a large area of soils that are derived from andesite. In most cases it appears to overlie a truncated sedentary soil that is similar to Segamat in appearance. Morphologically, this soil is very similar to Kawang series except for the matrix color being yellowish red to red (5YR 5/8 - 2.5YR 4/8), this being due to the fact that the source of this material was probably derived largely from andesite. The rounded pebbles that are found at depth are usually exclusively quartz, but occasionally one finds the odd rounded pebble of relatively fresh andesite. This series is associated with an intensely lateritic soil that was mapped as Malacca series, Older Alluvial phase.

The soil is yellowish red to red (5YR 5/8 - 2.5YR 4/8) in color, friable, vesicular, and moderately well structured with moderately developed clayskins. It is distinctly gritty throughout the profile, the grit being of various sizes and sub-rounded to rounded in shape. Below this is a layer of well rounded quartz pebbles lying in an argillaceous matrix of quartz grit and clay, below which is a truncated, andesite derived soil of similar color.

## 5. YELLOW GREY ULTISOLS (PLINTHUDULT)

Most plinthudults are characterised by non-hardened plinthite (variegated clay) which forms a continuous phase within 48 inches of the surface. They all have a textural B horizon which in most cases qualifies as an argillic horizon, and which is often overlain by an albic horizon, the two being separated by an abrupt textural change. Dominant subsoil colors range from yellow to light grey, and clay content from about 40% to 80%, with most figures in the 60 - 80% range. Consistences vary from friable to very firm, and structures are typically moderately developed tending to be coarse and in some cases prismatic. The soils are not commonly very porous, horizon boundaries are distinct, and concretionary, lateritic horizons occur in some soils (Leamy, 1966)

### (a) KULAI FAMILY

Soils of this family are formed on very acid igneous rocks and show a minimal development of both argillic and plinthite horizons. Subsoil colors vary from yellow to grey, consistences from friable to firm and in most cases there is a strongly developed textural B horizon. Although the reserve nutrient status of these soils is relatively low, they have been used for both rubber and oil palm in various parts of Johore with considerable success. Judicial management practices, however, must be rigidly applied. Of the various soils that are grouped into this family, only Tampin series is present in this area. This soil occurs exclusively under virgin jungle, except

for a small area in Glendale Estate on which rubber is cultivated.

### Tampin Series

This series is developed from a very acid granite, and occurs mostly in a broad belt stretching between Bukit Woh and Bukit Palong. Smaller areas are present in the Bukit Senorang region and in Gendale Estate. It is associated with Rengam series on undulating to rolling (slopes 2 - 12°) terrain, and tends to occupy the lower slope position in a catenary - tending sequence.

The surface soil is a friable, very pale brown to yellow (10YR 7/3 - 7/6) sandy to gravelly clay loam, with poorly developed, fine to medium, subangular blocky structures and weakly expressed clayskins. This is overlain by a pale brown to olive yellow (10YR 6/3 - 2.5Y 6/6) subsoil, which is sandy clay to gravelly clay in texture, friable in consistence and possesses weakly to moderately developed, medium, subangular blocky structures and moderately developed clayskins. This soil possesses a strongly expressed Ae/Bt horizon sequence, is commonly weakly mottled at depths greater than 40 inches, and exhibits a distinct increase of clay with depth. It is well rooted, sometimes micaceous, and distinctly gritty throughout.

### (b) DURIAN FAMILY

These soils commonly have an argillic horizon overlain by a weakly developed eluvial horizon, but do not possess all the criteria for an abrupt textural change. Non-hardened plinthite normally occurs within 48 inches of the surface. Concretionary horizons may be present but are normally thinner than 18 inches, although they may on occasion be as thick as 35 inches. In the past these soils were used mostly for rubber, but present evidence indicates that they are probably suitable for oil palm.

foothills to the Main Range, it is associated with Durian and Malacca soils. In various other parts of the area, it occurs with Batu Anam, Malacca and Marang series on rolling (slopes 6 - 12°) topography

The surface soil is a friable, light yellowish brown to reddish yellow (10YR 6/4 - 7.5YR 6/8) fine sandy clay loam, with moderately well developed, fine to medium, subangular blocky structures and weakly developed clayskins. This is underlain by a friable, brownish yellow to reddish yellow (10YR 6/6 - 7.5YR 6/8) clay subsoil, which possesses moderately to well developed, medium, subangular blocky structures with moderately well developed clayskins. The soil is rather porous and characteristically exhibits a faint, diffuse type of mottling giving the overall profile a faint, splotchy appearance. It becomes firmer and redder with depth, often contains a considerable amount of quartz grit, and is sometimes lateritic, the laterite appearing as a band at depths of 15 - 30 inches and up to 20 inches thick. It may also possess distinct, angular quartz stonelines.

(c) BATU ANAM FAMILY

Soils of this family are characterized by the presence of an argillic horizon which is overlain by an albic horizon and underlain by non-hardened plinthite. Although the soils are moderately well drained, mottles are present throughout the profile. Dominant subsoil colors are pale yellow to light grey and thin concretionary horizons, normally less than 12 inches thick, may occur. The nutrient status is below normal for Malayan soils, but rubber is being successfully cultivated in many areas. However, before large scale planting with oil palm is attempted, test plots should be conducted to determine the practicability of this crops on these soils

Batu Anam Series

Batu Anam series is developed on an iron-poor siliceous shale, which accounts for its pale color and firm consistence. It is most

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commonly associated with Durian and Malacca series on undulating to hilly topography (slopes 2 - 20°), these associations occupying vast tracts of land in the inland plain that stretches between Temerloh and Gemas. In other parts of the area it is associated with Marang, Bungor, Tavy and/or Serdang series on topography that is generally undulating to rolling (slopes 2 - 12°), but in which individual slopes may approach 20°.

The surface soil is a moderately firm, light yellowish brown to pale yellow (10YR 6/4 - 2.5Y 7/4) clay loam to clay, which possesses well developed, medium to coarse, subangular blocky structures with weakly to moderately developed clayskins. This passes abruptly into a firm to very firm, very pale brown to yellow (10YR 7/4 - 2.5Y 7/6) heavy clay subsoil, which is highly mottled, and possesses a well developed, coarse, jagged prismatic breaking to coarse, subangular blocky structure. Clayskins are extremely well developed. This is underlain by a highly mottled zone of non-hardened plinthite. The soil is usually rather shallow, exhibits a well defined Ae/Bt horizon sequence, and is commonly lateritic. The laterite appears as a continuous band of closely packed, nodular and fragmental concretions at depths of 15 - 30 inches and up to 24 inches thick. Fragments of partially weathered shale are often found at depths greater than 3 feet.

### Marang Series

This soil is developed on sandy shale and/or interbedded shales and sandstones. In the region east of Komayan it is found also on a low, conglomeratic ridge, the conglomerate being made up of well rounded pebbles of shale, quartzite and sandstone. This series is very common in south-central portions of the area surveyed, particularly in the Palong Forest Reserve and in the region east and north of Bahau. It is most commonly associated with Batu Anam and Bungor soils on rolling topography (slopes 6 - 12°), but occurs with Malacca and Tavy soils on

steeper slopes. In the valley of the Sungai Mentiga it is associated with Serdang series.

The surface soil is a friable, light yellowish brown to pale yellow (10YR 6/4 - 2.5Y 7/4) sandy to fine sandy clay loam, which possesses weakly developed, fine to medium, subangular blocky structures and very weakly expressed clayskins. This is underlain by a friable, very pale brown to yellow (10YR 7/8 - 2.5Y 7/6) sandy to fine sandy clay subsoil, which is weakly mottled and exhibits moderately well developed, fine to medium, subangular blocky structure and moderately developed clayskins. To this point the soil is porous, moderately well rooted, slightly mottled, and exhibits a well expressed Ae/Bt horizon sequence. Beneath this, at depths varying from 2 - 5 feet, there is commonly a very sharp unconformity, the soil changing to a firm, highly mottled, but still well structured clay which is light grey to pale yellow (2.5Y 7/0 - 7/8) incolor. Some tiny nodules of hard and soft laterite are common in this horizon and rooting is very poor. A thin, angular quartz stoneline is often present at the boundary of the unconformity, and small fragments of quartz are common throughout the soil.

## 6. BROWN ENTISOLS (HAPLUDENT)

The brown Entisols are characterised by a complete lack of genetic horizons (although depositional bands of different textures are quite common), and colors that are dominantly brown. The normal horizon sequence is Ah/AC/C, textures are sandy and silty, consistences very friable and friable, and structures are weakly developed. They are confined to the floodplains of the larger rivers and streams, mainly well inland from the coast (Leamy, 1966).

### (a) TELEMONG FAMILY

These soils represent the central concept of Brown Entisols. They are immature, sandy, friable, well drained soils which occur in

positions that are subject to periodic addition due to flooding. The nutrient status of these soils is variable, depending exclusively on the depositional history of the site. In general they may be utilized for most tropical upland crops including rubber, oil palm, fruit, tobacco, and vegetables, provided that external drainage is favourable. The total area occupied by these soils, however, is very small.

### Telemong Series

This series is developed on recent, riverine levees or terraces along the major and semi-major rivers. It is most commonly associated with Local Alluvial and Riverine Alluvium, occupying the better drained positions on flat to undulating (slopes 0 - 6°) topography. It is also associated with Akob series, but only in small, local areas.

The surface soil is a friable, yellowish brown to light yellowish brown (10YR 5/4 - 6/4) sandy loam to fine sandy clay loam, which possesses weakly developed subangular blocky to crumb structures. The subsoil is a friable, yellowish brown to strong brown (10YR 5/6 - 7.5YR 5/6) sandy to fine sandy clay loam, with moderately developed, medium, subangular blocky structures and weakly developed clayskins. The soil is commonly porous, well drained and well rooted, and may on occasion be somewhat gritty and slightly micaceous. Some very light, reddish yellow mottles are sometimes visible at depths of 4 to 6 feet, but these are never a conspicuous feature of the profile.

### 7. BROWN GREY ENTISOLS (HAPLAQUENT)

These are heavy textured, recent soils developed on riverine and marine alluvium, but where the marine influence does not dominate soil characteristics. Dominant colors are browns and greys, and profiles are typically mottled to considerable depth. Horizons are weakly expressed and a typical sequence is Ap/ABg/BCg/Cr. Consistences

are firm and structures are weak or absent (Teamy, 1966).

(a) BRIAH FAMILY

Soils of this family occur on recent riverine alluvium in poorly drained locations, on coastal plains and on inland river floodplains. They are subject to constant water table fluctuations, the water table varying from very near the surface to 3 feet, depending on local conditions. Owing to their tendency towards water logging during the wet season, these soils are not generally suitable for tree crops but have considerable possibilities for annual food crops. Where irrigation water is available, these soils are best suited for wet padi. Only Akob series is present in this area.

Akob Series

This series occurs in the Batu Kikir region in association with local alluvium, as well as in small hollows immediately behind better drained, river levees on which Telemong or Local Alluvium is developed. It is common to find that Kampong houses have been built on Telemong or Local Alluvium soils, which are slightly raised, behind which are shallow depressions of Akob series on which padi is grown.

The surface soils is pale brown (10YR 6/3) in color, moderately friable, and possesses a well developed crumb structure. This passes gradually into a firm, very pale brown to white (10YR 7/3 - 8/2) sandy clay, which is very intensely mottled and exhibits a weakly to moderately developed subangular blocky structure. Below this light grey blotching commences and at greater depth this becomes the dominant color. In areas where this soil is used for wet padi for extended periods, an inverted gley may become established, whereby the surface colors become bluish grey owing to complete reduction. This feature, however, will disappear rapidly when the unundation water is removed.

## 8. MISCELLANEOUS LAND UNITS

In rapid schematic - reconnaissance soil surveys it is seldom necessary to do more than delimit the boundaries of certain landscape types which are easily recognised and which are mostly of fairly low agricultural potential (Leamy and Panton, 1966). In some cases the soil distribution pattern is too complex for surveys of this type, in others, the physical barriers are too great to permit adequate ground coverage. Therefore, to economize on both time and money, such areas are often excluded from detailed observation and efforts are concentrated on more favourable regions. Consequently, such areas can be adequately defined, but descriptions are necessarily sparse.

### Steepland

This unit is defined as land occurring above the steepland boundary, the boundary being a line separating land with average slopes less than  $20^{\circ}$ , and topographically suitable for tree-crop agriculture, from land having average slopes exceeding  $20^{\circ}$  and better suited to permanent forest. Most steepland soils are developed from shales, sandstones, quartzites and granites and are known to be suitable media for the growth of various crops. However, the presence of skeletal profiles and the severe erosion that can be expected after clearing suggest that such areas should be left for forest and game reserves.

### Disturbed Land

This land includes soils which have been extensively disturbed by open-cast tin mining and are of questionable agricultural potential. Only one such area, immediately east of Kampong Menchis, is found in this region. In this survey this unit does not include population centres, since all centres are relatively small.

## Fresh Water Marsh and Open Water

This unit is introduced to designate large areas of open water which are wholly or partially covered with herbaceous plants. This distinguishes such areas from Inland Swamp which consists of naturally wooded areas, all or most of which are covered with water much of the time (Soil Survey Staff, 1951). The open water areas of Tasek Bera, Tasek Chini and Tasek Mentiga offer possibilities as tourist attractions, and fish and game reserves.

## Local Alluvium

These are soils which are very diverse in properties and characteristics but are all developed along drainage channels in positions that are subject to periodic addition due to flooding. They are all of recent age and are neither well drained nor organic in nature, the well drained members being mapped as Telemong while the organic soils were called Inland Swamp. They are most commonly associated with Telemong and/or sub-recent Riverine Alluvium, and occupy the lowest or most recent terrace while Riverine Alluvium occupies the intermediate terrace. They are suitable for a wide variety of tree crops but are usually of local extent.

## Riverine Alluvium

This unit embraces a wide group of soils all of which possess the common property of occupying a terrace that would be intermediate in age between Kawang series and Local Alluvium - Telemong. These soils are of variable composition, usually yellow to strong brown (10YR 7/6 - 7.5YR 6/6) in color, friable in consistence, and exhibit weak structural development and clayskins. They are commonly slightly mottled, gritty and micaceous. Topography is undulating (slopes 2 - 6°) and moderately dissected. Included in this unit is a deposit which exhibits all the characteristics of Kawang series, but its position and topography strongly suggests it to be of sub-recent age. The

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extent of these soils is very limited, but they are suited for a wide variety of crops.

### Inland Swamp

This is essentially a topographical or vegetational unit used to indicate the presence of organic and/or muck soils that are found in many old drainage channels. Such soils occur under naturally woody vegetation in areas which are affected by very poor or impeded external drainage, and therefore are covered with water much of the time. Except for local areas which may be used for padi, these soils possess a very low agricultural potential.

### SOIL SUITABILITY CLASSIFICATION

The soils of the Temerloh - Gemas region have been grouped into soil suitability classes, generally following the scheme outlined by Wong (1966, unpublished). This scheme is necessarily broad in approach since it is based primarily on field observations obtained during the course of reconnaissance surveys, concentrating on such characteristics as would limit the agricultural development potential of an area. In erecting this classification certain assumptions have been made, the most important of which is that plant nutrient deficiencies which characterize most Malayan soils, will be corrected by fertilizer application. However, where laboratory analysis have shown soils to have acute major and minor nutrient deficiencies, and since this condition is considered to be more difficult to diagnose and correct than the normal, these are included as a limitation. It should be kept in mind that this scheme is aimed primarily at assessing suitability of soils for rubber and oil palm and does not contain sufficient detail to predict satisfactorily for crops with special requirements.

The limitations to agricultural development which have been

found to occur in the Temerloh - Gemas region are listed as follows:

### Very Serious Limitations

-- These are limitations to development which are extremely difficult to correct, which severely reduce the productivity of the soil, or which result in severe damage to the land under development.

1. Slopes steeper than  $20^{\circ}$
2. Massive or densely packed, thick laterite at or very close to the surface.
3. Land disturbed by mining.

### Serious Limitations

These are development impediments which are quite difficult to correct, or which reduce the productivity of the soil, or which require special techniques to be overcome.

1. Acute nutrient deficiencies, including trace element as well as major element deficiencies.
2. Very poor and poor drainage.
3. Moderately steep slopes ( $12^{\circ}$  -  $20^{\circ}$ ).
4. Massive or densely packed, thick laterite within 2 feet of the surface.
5. Strong compaction.
6. Sand texture throughout.

### Minor Limitations

These impediments are relatively easy to correct, or only slightly reduce the productivity of the soil, or only slightly restrict the range of crops which could be grown.

1. Susceptibility to flooding.

2. Weak structures within the top 4 feet.
3. Imperfect to moderate drainage.
4. Weak or moderate compaction.

On the basis of the above all the soils of this region have been grouped into five classes, all of which are shown on the legend accompanying the soil map. For greater ease in interpretation a soil suitability map is also included. It should be noted that although a soil series generally falls into one or other of the five classes, it may also fall into two or more classes since it may occur under variable topographical, etc., conditions. In the same way, when grading soil, areas, associations between series become important since some soils may possess limitations which others do not, but these limitations may be of sufficient magnitude to down-grade the entire area. For these reasons, and because existing topographical maps were found to be somewhat inadequate, the classes as found in the legend most commonly represent the authors' personal opinions on individual areas. The scheme as outlined above was used only as a guide.

SUMMARY AND CONCLUSIONS

The reconnaissance survey of the Temerloh - Gemas region was undertaken to obtain a rapid assesement of the soil pattern in both developed and undeveloped areas. The primary objective was to collect and present data from which sound land use planning could be projected, as well as to enhance present soil knowledge in what was previously a pedologically virgin area. For ease in interpreting this data soil areas were divided into five suitability classes and separate recommendations were made for each (see soil legend). In

addition a soil suitability map, which supplements the soil map, was prepared. A summary of approximate acreages occupied by soils in each class is given below.

Table 2:      SUMMATION OF ACREAGE IN SOIL SUITABILITY CLASSES

Class 1	179,800 acres
Class 2	171,800 "
Class 3	545,300 "
Class 4	233,700 "
Class 5	411,600 "
Total	1,542,200 "

According to present day opinion Class 1 and 2 soils are of above average agricultural potential while Class 3 soils should only be used for crops which have a wide range of soil tolerance. Soils of Classes 4 and 5 should be reserved for either productive or protective forests. From this it is seen that approximately 40% of the area surveyed is comprised of land which is unsuitable for agriculture and should be used for other purposes. The remainder of the area is topographically and pedologically suitable for agricultural development, but only about 20% of the total is suitable for agricultural diversification, the remainder being best suited for crops such as rubber. Areas of steep land, where average slopes exceed 20°, should be left undisturbed, while larger areas of open water offer possibilities as tourist, and fish and game reserves.

As is common in most parts of Malaya, past land development in this region was more influenced by available access than by soil potentials, resulting in a situation whereby the greatest portion of agriculturally suitable soils is still undeveloped. The largest single area of these lies to the east of Sungei Bera and Tasek Bera, stretching south to the Johore border, and surrounding the Bukit Bertangga -

Bukit Chini mountain complex. It is probable that a major land development scheme, possibly of the magnitude of the Jongka Triangle, could be instituted in this region. Another area which offers very good possibilities is the broad belt of granitic and mixed sedimentary soils, which passes through the centre of Kemosul Forest Reserve and stretches between Bukit Woh and Bukit Palong. Apart from, and between these two areas, the remaining soils are developed from predominantly argillaceous parent materials, and although they are not suitable for agricultural diversification, they are still capable of producing high yields of rubber. However, development should not be attempted in areas that are extensively lateritic. Lack of available access would probably be the greatest physical barrier to immediate agricultural development in this region.

In conclusion, it may be surmised that soil is probably the most valuable natural resource present in the Temerloh - Gemas region. If used wisely and to its maximum, it could bring prosperity and well-being to a multitude of people.

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APPENDIX I

Profile Descriptions and Chemical Analysis of Major Series

Batu Anam Series

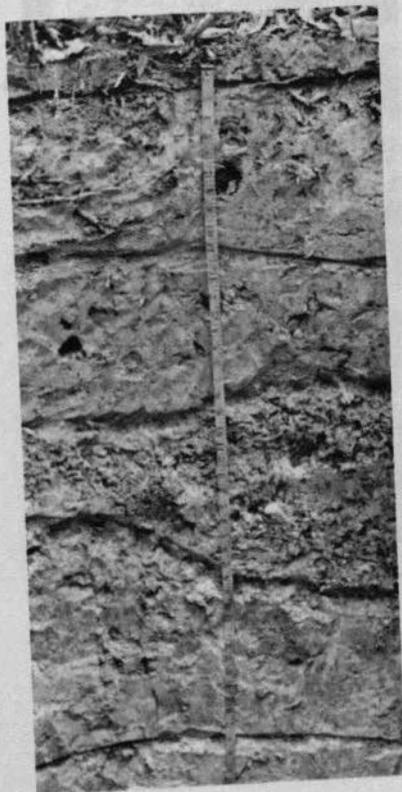
Location: Lanchang Estate, Map Sheet 3C/9, Grid position 214346

Topography: 16° slope in hilly terrain

Vegetation: Very old rubber

Parent material: Shale

Great Soil Group: Yellow Grey Ultisols



- Ah - 0-2"; light brownish gray to pale brown (10YR 6/2.5) very fine sandy clay loam; friable; fine, well developed granular to subangular blocky structure; patchy clay-skins; abundant pore; well rooted; boundary distinct.
- Ae - 2-11"; very pale brown to yellow (10YR 7/4) clay matrix with very pale brown (10YR 7/5) ped face; firm; medium to coarse, strongly developed subangular blocky structure; patchy clayskins; many pores; well rooted; boundary indistinct.
- Bt - 11-20"; reddish yellow (7.5YR 7/6) heavy clay matrix with pink (7.5YR 7/4) ped face; few mottles; very firm; coarse, well developed subangular blocky structure; very few stones and concretions fairly well rooted; boundary distinct.
- Bcn - 20-23"; very pale brown (10YR 7/4) heavy clay; medium to coarse, strongly developed subangular blocky structure, discontinuous to continuous clayskins; many pores; much nodular and fragmental laterite; poorly rooted; boundary distinct.
- Btg - 32-44"; white (10YR 8/1) heavy clay matrix with very pale brown (10YR 7/4) ped face; very firm; coarse, well developed prismatic to subangular blocky structure; strong cutans; few to many pores; very poorly rooted; boundary indistinct.
- C - 44"+; white (2.5Y 8/1) heavy clay matrix with white (2.5Y 8/2) ped face; many, fine, prominent, dark yellowish brown (10YR 4/4) mottles; very firm; coarse, weakly, developed prismatic to subangular blocky structure; patchy clayskins; few pores; very few roots.

AVERAGE CHEMICAL ANALYSIS FROM FOUR REPRESENTATIVE PROFILES

Horizon	% clay / .002mm	% silt .002-.02 mm.	% fine sand .02-.2mm	% coarse sand .2-2mm	% gravel 2-10mm	pH	C.E.C. me/100 gm	% Sat <sup>n</sup>	% Fe <sub>2</sub> O <sub>3</sub> (6N HCl)	% C	% N	Easily Soluble	
												P p.p.m.	K p.p.m.
Ah	47	23	22	7	-	4.4	11.7	9	1.52	2.03	0.16	38	88
Ae	54	22	19	5	-	4.7	7.3	7	2.10	0.54	0.07	27	44
Bt	58	19	11	3	1.8	4.7	8.4	6	3.94	0.27	0.05	18	23
Btg	74	18	7	2	1.0	4.7	8.8	5	2.63	0.18	0.04	12	15
C	71	19	10	1	-	4.8	7.7	5	2.01	0.15	0.03	9	14

Bungor Series

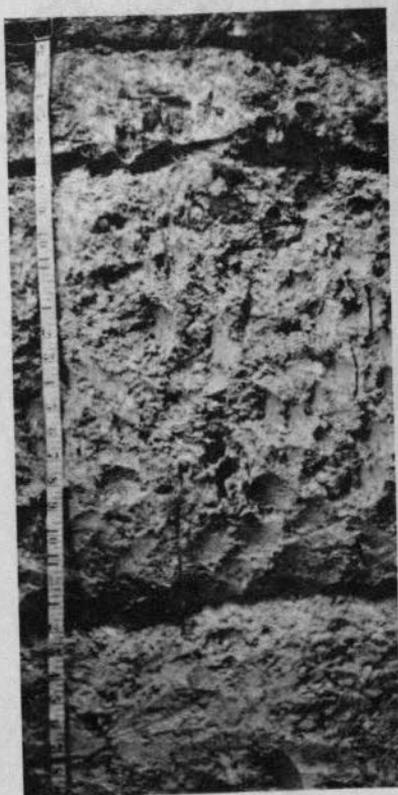
Location: Along trail from Kg. Pelangai to Kg. Chemomoi. Map sheet 3C/13, Grid position: 272077

Topography: 8° slope in rolling terrain

Vegetation: Primary jungle

Parent material: Shale and Sandstone

Great Soil Group: Yellow Grey Ultisols



- Ah - 0-2"; yellowish brown (10YR 5/4) fine sandy loam; friable; medium, well developed granular to subangular blocky structure; many pores; many roots; boundary distinct.
- Ae - 2-7"; brownish yellow (10YR 6/6) fine sandy clay loam; friable; fine, moderately well developed subangular blocky structure; patchy clayskins; abundant pores; some quartz grit; many roots; boundary distinct.
- Bt - 7-26"; brownish yellow to reddish yellow (8.7YR 6/8) clay; friable; fine to medium, strongly developed subangular blocky structure; discontinuous clayskins; many to abundant pores; some quartz grit; well rooted; boundary indistinct.

Btgj- 26-50"; brownish yellow to reddish yellow (8.7YR 6/8) clay; friable; fine to medium, moderately well developed angular blocky structure; discontinuous clayskins; many to abundant pores; some quartz grit; poorly rooted; boundary distinct.

Bitj- 50"+; reddish yellow (7.5YR 6/6) clay matrix; many, medium, distinct, yellow (2.5Y 7/6) mottles; friable to firm, fine moderately well developed angular blocky structure; patchy clayskins; many pores; some quartz grit; few roots.

AVERAGE CHEMICAL ANALYSIS FROM THREE REPRESENTATIVE PROFILES

Horizon	% clay /_.002mm	% silt .002-.02 mm	% fine sand .02-.2mm	% coarse sand .02-2mm	% gravel 2-10mm	pH	C.E.C. me/100 gm	% Sat <sup>n</sup>	% Fe <sub>2</sub> O <sub>3</sub> (6N HCl)	% C	% N	Easily Soluble	
												P p.p.m.	K p.p.m.
Ah	41	16	37	8.0	-	4.3	13.7	4.5	2.07	9.73	.12	136	41
Ae	44	17	34	6.2	-	4.4	8.4	3.5	2.32	0.65	.06	120	21
Bt	53	18	29	5.8	-	4.6	7.8	4.3	2.87	0.34	.04	64	8
Btt	57	12	29	5.0	-	4.5	6.9	6.0	3.14	0.22	.02	24	7

Durian Series

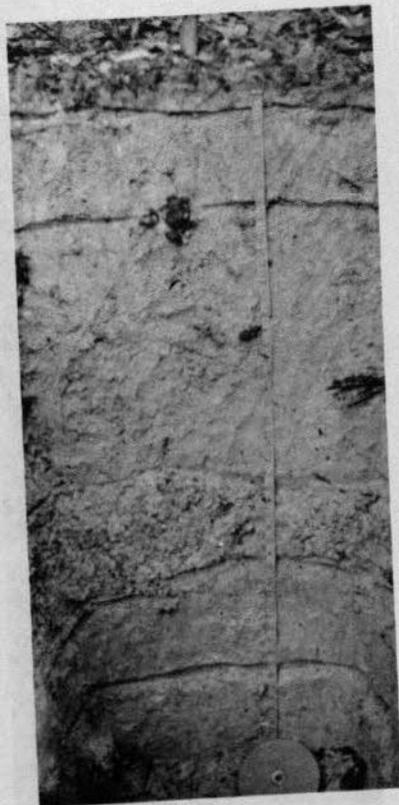
Location: Jambu Rias forest track, Map sheet 3C/9, Grid position 193313

Topography: 2° slope in rolling terrain

Vegetation: Secondary jungle

Parent material: Shale

Great Soil Group: Yellow Grey Ultisols



Ah - 0-2"; pale brown (10YR 6/3) very fine sandy clay loam; friable; medium, moderately developed subangular blocky to granular structure; many pores; well rooted; boundary distinct.

Ae - 2-8"; yellow (10YR 7/6) clay loam to clay; friable to firm; medium, moderately developed subangular blocky structure; discontinuous clayskins; many pores; fairly well rooted; boundary distinct.

Bt - 8-27"; matrix reddish yellow (7.5YR 6/6) clay with few mottles; ped face yellow (10YR 7/5); firm medium to coarse, well developed subangular blocky structure; continuous clayskins; many pores; some quartz grit; moderately well rooted; boundary distinct.

Bcn - 27-33"; reddish yellow (5YR 7/8) clay with few mottles; firm; much fragmental and nodular laterite; poorly rooted; boundary distinct.

Bti - 33-41" very pale brown (10YR 7/3) clay with many, large, prominent, reddish yellow (5YR 7/6) mottles; firm; medium, moderately developed subangular blocky structure; discontinuous clayskins; few pores; much quartz grit; few roots; boundary distinct.

BC - 44"+; very pale brown (10YR 7/4) clay with many, large, distinct, reddish yellow (7.5YR 7/6) mottles; medium, fine, moderately developed subangular blocky structure; patchy clayskins; few pores; some quartz grit; few roots.

AVERAGE CHEMICAL ANALYSIS FROM FOUR REPRESENTATIVE PROFILES

Horizon	% clay / <math>_{0.002}</math>mm	% silt <math>_{0.002-0.02}</math> mm	% fine sand <math>_{0.02-0.2}</math>mm	% coarse sand <math>_{0.2-2}</math>mm	% gravel 2-10mm	pH	C.E.C. me/100 gm	% Sat <sup>n</sup>	% Fe <sub>2</sub> O <sub>3</sub> (6N HCl)	% C	% N	Easily Soluble	
												P p.p.m.	K p.p.m.
Ah	48	19	20	11	6.4	4.4	10.1	10	1.29	1.81	0.14	60	90
Ae	54	19	18	8	1.1	4.5	10.0	5	1.71	0.56	0.07	27	54
Bt	64	18	15	7	0.2	4.6	8.3	5	2.32	0.27	0.03	14	49
Bcn	69	15	10	7	18.7	4.6	10.0	4	2.14	0.33	0.05	17	30
Bti	74	13	8	5	2.6	4.7	11.2	3	2.72	0.25	0.04	12	21
C	76	16	7	2	0.5	4.7	11.4	3	2.68	0.18	0.04	11	20

Kamang Series

Location: Beyond Kg. Jawi Jawi, Map sheet 3C/13, Grid position 302022

Topography: Rolling terrain

Vegetation: Rubber

Parent material: Riverine Alluvium

Great Soil Group: Red Yellow Ultisols



- Ah - 0-5<sup>m</sup>; dark grayish brown (10YR 4/2) sandy loam; friable fine, moderately well developed subangular blocky structure; many pores; much quartz grit; well rooted; boundary distinct.
- Ae - 5-11<sup>m</sup>; yellowish brown (10YR 5/4) sandy clay loam; friable; fine, weakly developed subangular blocky structure; many pores; much quartz grit; well rooted; boundary diffuse.
- Btg - 11-20<sup>m</sup>; yellowish brown (10YR5/5) coarse sandy clay loam; friable; fine, moderately well developed subangular blocky structure; patchy clayskins; abundant pores; much quartz grit; well rooted; boundary distinct.
- C - 20<sup>m</sup>+; reddish yellow (7.5YR 6/6) clay; friable to firm; abundant, well rounded, clear as well as smoky quartz pebbles; some nodular laterite; few roots.

AVERAGE CHEMICAL ANALYSIS FROM FOUR REPRESENTATIVE PROFILES

Horizon	% clay /_.002mm	% silt .002-.02 mm	% fine sand .02-2mm	% coarse sand .2-2mm	% gravel 2-10mm	pH	C.E.C. me/100 gm	% Sat <sup>n</sup>	% Fe <sub>2</sub> O <sub>3</sub> (6N FCY)	% C	% N	Easily Soluble	
												P p.p.m.	K p.p.m.
Ah	34	10	32	26	1.0	4.7	13.0	9	1.00	1.72	0.15	150	68
Ae	38	9	28	27	4.6	4.7	8.8	6	1.54	0.56	0.07	65	26
Btg	50	8	19	26	13.6	4.7	8.8	10	1.96	0.41	0.04	51	16
C	46	8	20	31	24.8	4.7	6.0	5	3.77	0.21	0.03	56	11



Munchong Series

Location: Bahau Estate, Map sheet 3C/13, Grid position 521556

Topography: 2° slope in rolling terrain

Vegetation: Mature rubber

Parent material: Sandstone and Shale

Great Soil Group: Red Brown Oxisols



- Ah - 0-3"; brown to strong brown (7.5YR 5/5) sandy clay loam; friable; fine, strongly developed subangular blocky structure; abundant pores; much quartz grit; well rooted; boundary distinct.
- Aej - 3-12"; reddish yellow (7.5YR 6/6) clay; friable; weakly developed subangular blocky structure; patchy to discontinuous clayskins; abundant pores; many roots; boundary diffuse.
- Bt - 12-26"; yellowish brown to brownish yellow (7.5YR 5.5/8) clay; friable; fine to medium, strongly developed subangular blocky structure; almost continuous clayskins; abundant pores; much quartz grit; well rooted; boundary diffuse.
- Btj - 26-40"; brownish yellow (7.5YR 6/8) clay; friable; fine, moderately well developed subangular blocky structure; discontinuous clayskins; abundant pores; much quartz grit; moderately well rooted; boundary distinct.
- BC - 40"+; reddish yellow (5YR 6/8) clay matrix with few, fine, distinct, brownish yellow (10YR 6/6) mottles; friable; fine, weakly developed subangular blocky structure; abundant pores; some quartz grit and soft laterite; poorly rooted.

AVERAGE CHEMICAL ANALYSIS FROM THREE REPRESENTATIVE PROFILES

Horizon	% clay /_.002mm	% silt .002-.02 mm	% fine sand .02-.2mm	% coarse sand .2-2mm	% gravel 2-10mm	pH	C.E.C. me/100 gm	% Sat <sup>n</sup>	% Fe <sub>2</sub> O <sub>3</sub> (6N FCT)	% C	% N	Easily Soluble	
												P p.p.m.	K p.p.m.
Ah	38	12	27	24	-	4.5	9.5	10	2.40	1.10	0.07	83	27
Aej	48	11	21	19	-	4.6	6.8	5	3.73	0.55	0.05	43	18
Btj	58	12	17	14	-	4.7	6.9	5	4.99	0.35	0.04	27	3
BC	60	7	14	18	-	4.9	6.8	4	6.14	0.24	0.02	20	-

Renqam Series

Location: Main forest track starting from Kemayan to Menchis, Map sheet 3C/14, Grid position 372045

Topography: Rolling terrain

Vegetation: Primary jungle

Parent material: Hornblende Biotite Granite

Great Soil Group: Yellow Ultisols



- Ah - 0-3"; dark brown (10YR 4/3) coarse sandy loam to coarse sandy clay loam; friable; medium, moderately well developed granular structure; patchy clayskins; abundant pores; much quartz grit; well rooted; boundary distinct.
- Ae - 3-12"; strong brown (7.5YR 5/6) gravelly clay loam; friable; medium, moderately well developed subangular blocky structure; patchy clayskins; abundant pores; much quartz grit; many roots; boundary distinct.
- Bt - 12-29"; yellowish red to reddish yellow (5YR 5.5/8) gravelly clay; friable; medium, moderately well developed subangular blocky structure; almost continuous clayskins; many pores; much rounded quartz grit; moderately rooted; boundary indistinct.

- Bti- 29-44"; yellowish brown (5YR 5/8) gravelly clay; friable; medium, weakly developed subangular blocky structure; discontinuous clayskins; many pores; few channels; much sub-rounded quartz grit; few roots; boundary distinct.
- Cm - 44"+; red to light red (2.5YR 5.5/8) gravelly clay matrix; many, coarse, prominent; red (2.5YR 4/6) mottles; friable; weakly developed subangular blocky structure; patchy clayskins; many pores; much sub-rounded quartz grit; few roots.

AVERAGE CHEMICAL ANALYSIS FROM FOUR REPRESENTATIVE PROFILES

Horizon	% clay / <math>_{<math>0.002\text{mm}</math></math>	% silt <math>_{0.002-0.02\text{mm}</math>	% fine sand <math>_{0.02-2\text{mm}</math>	% coarse sand <math>_{0.02-2\text{mm}</math>	% gravel 2-10mm	pH	C.E.C. me/100 mm	% Sat <sup>n</sup>	% Fe <sub>2</sub> O <sub>3</sub> (GN ACT)	% C	% N	Easily Soluble	
												P p.p.m.	K p.p.m.
Ah	28	11	28	34	2.1	4.6	8.5	10	1.59	1.41	0.11	53	78
Ae	35	11	23	30	6.6	4.7	6.1	7	2.31	0.44	0.04	45	31
Bt	50	10	18	25	14.8	4.7	5.8	6	3.51	0.34	0.03	38	21
Btij	53	10	15	24	22.8	4.8	6.1	6	3.52	0.27	0.02	30	14
BC	58	8	13	23	29.4	4.8	6.0	7	3.77	0.18	0.02	26	8

Sogamat Series

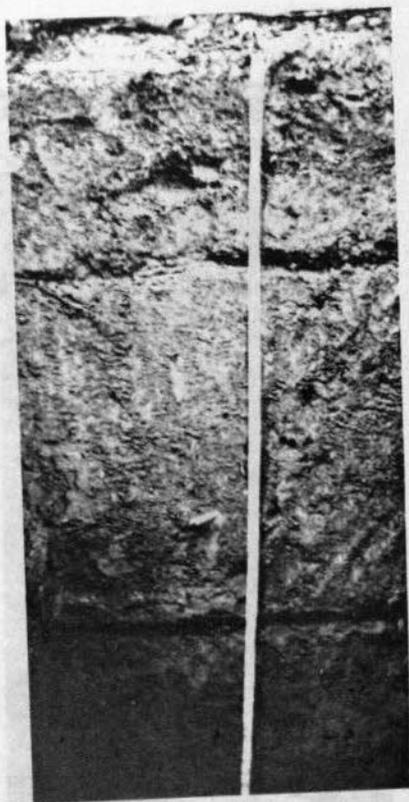
Location: Along track beyond Kuala Bera, Map sheet 3C/11, Grid position 694261

Topography: 3° slope in rolling to hilly terrain

Vegetation: Disturbed primary jungle

Parent material: Andesite

Great Soil Group: Yellow Red Oxisols



BA - 0-13"; reddish brown to red (2.5YR 4/5) clay; friable; fine, moderately to strongly developed subangular blocky structure; very weak clayskins; abundant pores; well rooted; boundary indistinct.

Btj - 13-38"; dark reddish brown to dark red (2.5YR 3/6) clay; friable; fine, strongly developed subangular blocky structure; patchy to discontinuous clayskins; abundant pores; some tiny laterite nodules and quartz grit; well rooted; boundary indistinct.

BC - 38"+; dark reddish brown to dark red (2.5YR 3/6) clay; friable; fine, moderately well developed subangular blocky structure; patchy clayskins; many to abundant pores; some tiny laterite nodules and quartz grit; moderately well rooted.

AVERAGE CHEMICAL ANALYSIS FROM FOUR REPRESENTATIVE PROFILES

Horizon	% Clay / 0.002mm	% silt .002-.02 mm	% fine sand .02-.2mm	% coarse sand .2-2mm	% gravel 2-10mm	pH	C.E.C. me/100 gm	% Sat <sup>n</sup>	% Fe <sub>2</sub> O <sub>3</sub> (6N FCT)	% C	% N	Easily Soluble	
												P p.p.m.	K p.p.m.
Ah	82	7	7	2	-	4.7	17.3	15	18.03	3.06	0.26	65	215
BA	89	5	3	2	-	4.9	11.3	7	23.92	1.25	0.14	49	66
Btj	91	4	3	1	0.6	5.0	7.3	11	24.16	0.62	0.06	32	34
BC	99	2	2	1	0.2	4.7	6.7	12	24.32	0.35	0.04	21	26

Serdang Series

Location: Along forest path about 20 chains east of Tasek Bera, Map sheet 3C/15,

Grid position 813883

Topography: 8° slope in rolling terrain

Vegetation: Belukar

Parent material: Conglomerates

Great Soil Group : Yellow Ultisols



- Ah - 0-5<sup>in</sup>; grayish brown (10YR 5/2) sandy loam; friable; fine, moderately well developed subangular blocky to crumb structure; abundant pores; very much quartz grit; well rooted; boundary diffuse.
- Ae - 5-16<sup>in</sup>; brownish yellow (10YR 6/6) sandy clay loam; friable; fine, to medium, moderately well developed subangular blocky structure; very weakly developed clayskins; much quartz grit; well rooted; boundary diffuse.
- Bt - 16-42<sup>in</sup>; reddish yellow (7.5YR 6/6) sandy clay loam to sandy clay; friable; medium, moderately well developed subangular blocky structure; discontinuous clayskins; abundant pores; moderately well rooted; boundary distinct.
- BC - 42<sup>in</sup>+; reddish yellow (7.5YR 6/6) sandy clay loam; coarse, weakly developed subangular blocky to massive structure; patchy clayskins; many pores; weakly mottled; poorly rooted.

AVERAGE CHEMICAL ANALYSIS FROM FIVE REPRESENTATIVE PROFILES

Horizon	% clay / <math>_{<math>0.002\text{mm}</math></math>	% silt <math>.002-.02\text{mm}</math>	% fine sand <math>.22-.2\text{mm}</math>	% coarse sand <math>0-2\text{mm}</math>	% gravel <math>2-10\text{mm}</math>	pH	C.E.C. me/100 gm	% Sat <sup>n</sup>	% Fe <sub>2</sub> O <sub>3</sub> (6N HCl)	% C	% N	Easily Soluble	
												P p.p.m.	K p.p.m.
Ah	24	12	34	44	-	4.7	9.3	7	1.49	1.55	0.12	21	51
Ae	30	12	31	30	0.2	4.8	6.2	5	1.53	0.42	0.07	16	22
Bt	44	10	25	30	3.9	4.9	6.6	6	1.71	0.28	0.02	13	9
Bc	50	10	20	24	2.7	5.2	7.3	5	2.74	0.20	0.02	11	6

Tampin Series

Location: Main road north Ayer Hitam Junction, Map sheet 3G/2, Grid position 463737

Topography: 2° slope in rolling country

Vegetation: Disturbed primary jungle

Parent material: Acid Granite

Great Soil Group: Yellow Grey Ultisols



- Ah - 0-3"; dark brown (10YR 4/3) gravelly loam; friable; fine, weakly developed subangular blocky to crumb structure; many pores; much quartz grit; very well rooted; boundary distinct.
- Ae - 3-18"; very pale brown (10YR 7.5/3) gravelly clay loam to gravelly clay with few mottles; friable; fine, weakly developed subangular blocky structure; patchy to discontinuous clayskins; abundant pores; much quartz grit; many roots; boundary indistinct.
- Btgj - 18-36"; very pale brown (10YR 7/4) gravelly clay matrix with very diffuse mottles; friable; medium, weakly developed subangular blocky structure; discontinuous clayskins; abundant pores; much sub-rounded quartz grit; moderately well rooted; boundary distinct.
- Bti - 36"+; pink (7.5YR 7/4) gravelly clay matrix; few, medium, faint, pinkish white (7.5YR 8/2) mottles; friable; medium, weakly developed subangular blocky structure; discontinuous to almost continuous clayskins; many pores; much sub-rounded quartz grit; poorly rooted.

AVERAGE CHEMICAL ANALYSIS FROM THREE REPRESENTATIVE PROFILES

Horizon	% clay / .002mm	% silt .002-.02 mm	% fine sand .02-.2mm	% coarse sand .2-2mm	% gravel 2-10mm	pH	C.E.C. me.100 gm	% Sat <sup>n</sup>	% Fe <sub>2</sub> O <sub>3</sub> (6N ACT)	% C	% N	Easily Soluble	
												P p.p.m.	K p.p.m.
Ah	23	9	32	4	5.5	5.0	7.8	15	0.55	1.24	0.10	20	88
Ae	28	13	25	36	5.7	5.1	5.6	9	0.54	0.35	0.03	14	42
Bt	42	9	21	31	10.1	5.0	6.1	7	0.69	0.22	0.02	13	37
Btgj	49	8	17	28	8.1	5.0	6.6	6	0.81	0.17	0.02	11	25
Cu	48	10	20	24	2.2	5.0	7.0	6	0.81	0.15	0.02	11	21

APPENDIX 2

Soil Sampling Sites

<u>Soil</u>	<u>Grid Reference</u>	<u>Soil</u>	<u>Grid Reference</u>
Batu Anam	3C/9, 153318	Munchong	3C/13, 162079
	3C/9, 214346		3C/13, 521556
	3C/14, 493953		3G/2, 567573
	3G/3, 662669	/	
Bungor	3C/9, 176508	Rengam	3C/14, 315048
	3C/13, 272077*		3C/14, 372045
	3C/16, 149072		3C/14, 052863
			3G/2, 431705
Durian	3C/9, 193313	Serdang	3C/12, 145319
	3C/10, 346354		3C/15, 810056
	3C/10, 493160		3C/15, 813833
	3C/15, 633971		3C/15, 816832
			3C/15, 841806
Kawang	3C/9, 175367*	Segamat	3C/11, 650395
	3C/10, 570135		3C/11, 668257
	3C/11, 682284		3C/11, 694261
	3C/13, 302022		3G/3, 842783
Marang	3C/14, 543954	Tampin	3C/14, 380032
	3G/3, 645689		3C/14, 424012
	3G/3, 669693		3G/2, 463737
	3G/7, 499677		

\* Type Locations

### APPENDIX 3

#### Laboratory Analysis

Soil samples from 39 pits, representing ten major soil series, were analysed in the laboratory.

Mechanical analysis was done by the Bouyoucous Hydrometer method using Tetron as a dispersant.

A glass electrode was used for pH determination.

Cation exchange capacity was determined by leaching with 0.1N. barium chloride and titrating with N/50 versenate. Percentage base saturation was calculated as a function of the total cations present in the leachate.

The determination for iron was carried out by extracting with 6N hydrochloric acid for 8 hours after ignition at 450°C. for 2 hrs. Only one profile per series was analysed for iron.

Carbon was analysed by the Walkley -- Black method and nitrogen by the micro-Kjeldahl method. A mixture of selenium, copper sulphate and potassium sulphate was used as a catalyst.

Phosphorus figures were obtained by leaching with a solution of 2N sodium chloride and 0.2N hydrochloric acid and extraction with 0.1N sodium hydroxide, followed by digestion on a steam bath. Color was developed using chloromolybdate acid solution and stannous chloride.

Values for potassium were determined by extraction in N/2 acetic acid followed by estimation in a Lange flame photometer.

