Report No. F3

Report on the Detailed Soil Survey
of the

EXPERIMENTAL AFFORESTATION SITES

by

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Report on the detailed soil survey of the experimental afforestation sites

Contents

Maps

(in end pocket)

Tables

Introduction

This report covers the detailed soil surveys carried out on the experimental afforestation sites as the first priority project by the Forest Department Soil Survey section, after its formation in late 1968.

The bulk of the report is taken up with the description of each of the seven sites (sections 2.2-2.8). It is appreciated that many readers will be interested in only one or two of the sites, so that each site description has been made as self contained as possible. This means that there is a considerable amount of repetition, but this is thought preferable to excessive cross-referencing.

Unless stated otherwise, the classification of the soils of the sites into great soil groups and families is along the lines laid down by the Soil Survey Division of the Department of Agriculture (Sarawak Soil Survey Staff, 1966).

1. Experimental Afforestation Project

1.1 General

The object of Project S4 of the 1966-70 Forest Research Development Plan is to continue the investigation of the possibility of afforestation using fast-growing exotic or indigenous species. The first experimental plots in this investigation were planted at Oya Road in 1965 and, by 1968, 510 plots had been established at seven sites in the state. Tropical pines are the commonest species tested, especially Pinus caribaea of different varieties and provenances, but there are also plots of Araucaria spp. and Eucalyptus deglupta.

The plots can be divided into four groups. Those in the performance trial each consist of 64 trees, planted on a square 8 x 8 grid at intervals of 8 feet. Where planting material was insufficient for plots of this size, arboretum - sized plots were established for observation purposes. These plots each consist of 25 trees planted on a square 5 x 5 grid at intervals of 6 feet.

Following the initial disappointing performance of the earlier plots, a fertiliser trial was begun. This in fact consists of two separate investigations. The first consists of a series of paired arboretum - sized plots, of the same size as the observation plots. One plot of each pair receives full fertiliser treatment and the other is a control. The second investigation is designed to discover which particular plant nutrients are limiting by the 'minus one' subtractive technique. Each subplot in this investigation consists of 9 trees planted on a 3 x 3 square grid at intervals of 6 feet. There are 203 of these subplots laid out in two blocks at Oya Road (see Map 6).

The distribution of the various types of plot is summarised in Table 1.

Table 1

Location of experimental afforestation plots

Site	Number of Plots		
	Performance trial (64 trees)	Arboretum plots (25 trees). Observation and fertiliser trials	Subtractive fertiliser trial (9 trees)
Semengoh	11	14	-
Bt. Temudok	10	17	-
Jakar	-	18	-
Pakan Road	-	18	-
Oya Road	93	76	203
Nyabau	11	14	-
Lambir	1	24	-
Total	126	181	203

1.2 Location and Soils of Sites

The location of the seven sites is shown in Map 1. The sites were chosen to fulfill three conditions:

(a) They should be easily accessible
(b) The land should be under permanent Forest Department control
(c) They should cover as wide a range of Sarawak soil types as possible.

Conditions (a) and (b) are satisfied by the present sites, although new government reserves specifically for silvicultural research had to be created at Bukit Temudok, Jakar, Pakan Road, Oya Road and Lambir. However, for most of them, there was little or no soil survey information so that the extent to which condition (c) was fulfilled was uncertain. Accordingly, when the Forest Department planned its own soil survey section, the detailed soil survey of the sites was given first priority on its programme, as Project SL1 of the 1966-70 Forest Research Development Plan. The section was eventually formed in 1968, and the field work on the sites carried out in 1969 and 1970.

2 Soil Survey of Sites

2.1 Methods

2.1.1 Field

Most of the field work was carried out by the writer and Assistant Forest Officer Abdul Manaf bin Sairi in February - May 1969, with additional short spells in November 1969 (by the writer) and March 1970 (by the writer and A.F.O.s Abdul Manaf bin Sairi and James Dawos Mamit).

The soils were inspected by means of 4 feet augers with 2 inch Edelmann heads. The auger inspections in the plots were located relative to the trees. In the areas beyond the plots the augerings were located at slope - corrected one chain intervals along compass traverses. On the completion of the auger surveys, soil profiles were described and sampled for analysis to illustrate more fully the characteristics of the main soil types found. The descriptions and analyses from these profiles are listed in the Appendix.

2.1.2 Maps

The individual site maps (Maps 2-8) are at a scale of 2 chains to the inch (1:1584). They are based on the plot location maps supplied by the Silvicultural Research section. The contour information for Semengoh, Jakar, Pakan Road and Oya Road has been transferred from large scale (1:10,000 or greater) Land and Survey Department maps. The Lambir site is actually covered by 1:10,000 mapping but the site cannot be tied in satisfactorily

because there are no nearby cadastral boundaries nor is the air photography coverage sufficiently recent. The Bukit Temudok and Nyabau sites are in areas that have not yet been mapped at 1:10,000.

The absence of contour information on the Bukit Temudok, Nyabau and Lambir maps considerably reduces their value. It is the policy of the Department of Agriculture Soil Survey to stipulate the provision of large scale topographical maps as a precondition for detailed and semi-detailed soil surveys. In the light of the experience gained in this survey, such a policy seems unavoidable and should be adopted by the Forest Department.

Large scale aerial photography is available only for the Semengoh and Oya Road sites. The others are covered by the normal Land and Survey Department 1:20,000 - 1:30,000 sorties. These small scale photographs were not used in the preparation of the maps.

The cartographic material used in the preparation of the maps is listed in Table 2.

Table 2

Maps and aerial photographs used

Map No	Site	Base Map	Large Scale Aerial Photographs
1	Location of sites	L. & S. Series 1 3	-
2	Semengoh	L. & S. Topo 1/106 1969	L. & S. 6/68 605
3	Bukit		
3	Bukit Temudok	Silvicultural Research Section plot location map	-
4	Jakar	L. & S. Series 23 Sheet 2/111/14/16	-
5	Pakan Road	L. & S. Series 23 Sheet 1/111/3/2	-
6	Oya Road	L. & S. Topo 2/25 1964	L. & S. 14/68 253
7	Nyabau	Silvicultural Research Section plot location map	-
8	Lambir	-do-	-

2.2 Semengoh

2.2.1 General

The Semengoh site is situated in the south eastern section of the Sg. Semengoh Forest Reserve. The site lies immediately to the west of the Penrissen Road, at about Mile 12, and access from Kuching is extremely easy (see Map 1 and inset to Map 2).

Above 4 acres have been cleared but, so far, only about half of this has been used. There are 11 performance trial (64 trees) plots, 2 arboretum-sized (25 trees) observation plots and 12 arboretum-sized plots as part of a fertiliser trial.

2.2.2 Climate

There are several meteorological stations in the vicinity. Rainfall data for Kuching town goes back to 1876, making this is the oldest rainfall station in the state. There has been a meteorological station at Kuching airport, which is only six miles from the site (see inset to Map 2), for about 17 years. There is also a meteorological station, including an autographic rain gauge, at the Semongok Agricultural Station, less than a mile from the site (see inset to Map 2) but this is a more recent installation and its data covers only 9 years. There is a Forest Department meteorological tower in the Semengoh Arboretum, about ½ mile north of the site, but this installation collects data from different levels within and beneath the canopy of virgin Mixed Dipterocarp Forest, so that they have no direct relevance to conditions on the recently cleared and planted site.

Scott (1964(a)) has described the atomspheric climate of the Agricultural Station in some detail, including data on sunshine and duration of dry spells, and the reader is referred to that report for a fuller description.

Table 3 summarises the rainfall data from Kuching airport and the Semongok Agricultural Station.

Table 3

Rainfall at Kuching Airport and Semongok Agricultural Station

(i) Kuching Airport (16 years to 1968)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	24	23	14	11	11	8	8	8	11	12	12	17	158
Maximum	46	61	24	17	16	13	16	15	16	22	16	24	-
Minimum	8	10	7	4	6	5	1	3	5	6	8	10	-

(ii) Semongok Agricultural Station (9 years to 1968)

Mean	25	26	16	12	10	7	8	8	8	10	12	18	160
Maximum	50	43	25	17	14	12	11	15	12	16	16	26	-
Minimum	16	15	9	8	8	4	3	3	5	6	6	12	-

Figures to the nearest inch.

(from Drainage and Irrigation Department Hydrological Year book 1967-8)

Table shows that the rainfall distribution is markedly seasonal, with the maximum occurring during the Northeast monsoon (November - February). However, even during the drier part of the year, the mean monthly rainfall does not fall below 4 inches, so that the climate is of type 1A (continuously wet) in the classification of Mohr and van Baren (1954). The airport, the Agricultural Station and the site all lie in a belt of low hilly country and there are no local prominences to give rise to exceptional orographic rain, so that the rainfalls listed in Table 3 are thought to be very similar to those prevailing at the site.

There has been a class A evaporation pan in operation at Kuching airport since March 1963. The data up to 1968 from this installation are summarised in Table 4.

Table 4

Evaoporation at Kuching Airport

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	6.6	5.4	5.7	6.0	6.3	6.2	5.8	6.1	6.1	6.0	6.1	5 6	72.6
Maximum	9.7	6.4	7 0	7.0	7.3	7.0	6.0	7.7	6.5	6.5	7.6	6.4	67.2
Minimum	5.2	4.8	4.3	5.0	5.1	5.4	5.0	5.2	5.7	5.2	5.3	4.5	80.1

Figures to the nearest 0.1 inches

(from Drainage and Irrigation Department Hydrological Yearbook 1962-8).

From Table 4 it can be seen that evaporation is relatively invariable, being slightly lower during the wetter months. This pattern is slightly obscured by the exceptionally high evaporation (9.7 inches) in January 1965. This is one of the highest monthly evaporations ever recorded in the state, and it occurred in an exceptional January, when the rainfall was only half the mean, and there were only 19 rainy days. At that time of the year rainless days are rarely cloudless, so that it is surmised that the level of diffuse radiation was very high, accounting for the almost freakish evaporation. The relative uniformity of evaporation rates recorded confirms the finding that variations in the moisture balance at Kuching are largely due to fluctuations in precipitation (Wycherley, 1968).

2.2.3 Soil Parent Material

The site is underlain by the carbonaceous argillaceous sedimentary rocks of the Bau Formation, which are of Cretaceous age (Wilford, 1955) They are dark grey and moderately hard when fresh. They range in character from shale to mudstone, with a common transitional type which has visible micro-laminations but which fractures subconchoidally.

There are thin subordinate layers of fine sandstone throughout the formation but they are not important within the area of the site. There are also thin strata of conglomerate, one of which outcrops on the hill in the southeast part of the site, judging from the frequent occurrence of rounded quartz gravel in the soils. Another outcrop to the west of the site contributes to the gully wash material found in the very minor drainage line along the northwestern boundary (see Profile F1C in Appendix).

The rocks of this Formation have been subject to at least one cycle of fairly intense deformation and folding. Local angles of dip may be quite steep but there is no overall direction of dip.

2.2.4 Topography

The southern part of the site is on the rounded summit of a low hill. This is concordant with other hills in the vicinity and is thought to be a remnant of the '200 foot' Early Pleistocene peneplain. This surface may have been mantled by a thin but extensive ferricrete sheet (Andriesse, 1965), and fragments of ferricrete-coated shale are common in the subsoils over the whole site. The northern slopes of the hill have been dissected by the headwaters of a tributary of Sg. Engkabang. The slopes are steeper in this part of the site and gradients may be as high as 25°.

2.2.5 Original Vegetation

Most of the Semengoh F.R. is covered by old secondary forest, but up till 1953 the south eastern part, including the area of the site, was still under primary Mixed Dipterocarp Forest. In that year a number of taungya

plantation experiments were initiated and the area clear-felled. These experiments have since been allowed to lapse, so that the area reverted to young secondary forest, which was the vegetation that was cleared and burnt before the first plots were planted in 1965.

2.2.6 Previous Soil Survey Coverage

The site is in the area briefly inspected by Dames (1959) although none of his traverses actually cross the site. In his survey he found brownish and reddish-yellow clays, with more or less light grey and red mottling throughout the profile, to be the most widespread soils. This preponderance of the mottled yellow clays is confirmed by the very much more detailed soil surveys of the Semongok Agricultural Station immediately east of the Penrissen Road (Andriesse and Chen, 1962; Scott, 1964 (a)). This soil type is widespread over the outcrop of the Bau Formation argillaceous sediments and is found in the area to the south and west of the Forest Reserve (Andriesse, 1965).

2.2.7 Soils

2.2.7.1 General

The site is entirely covered with heavy textured soils showing an increase in clay content with depth. These soils are subdivided into three mapping units on grounds of colour Two of these mapping units are classified as Red Yellow Podsolic soils, but the third is transitional to the Grey White Podsolic great soil group. The mapping units are described separately below and summarised in Table 5.

2.2.7.2 Mottled Yellow Clay: (Sem)

The dominant soils are the mottled yellow clays. The matrix colour is generally brownish yellow in the upper horizons but becomes redder with depth. The soils are heavy textured throughout, but the clay content invariably increases with depth and apparent clayskins are visible (e.g. Profiles F1A and F1B in Appendix) so that the soils are in the Red Yellow Podsolic great soil group. In the current Sarawak classification these soils are in the Merit family. The high degree of mottling is not usual for this family, and the soils of this area have been separated out at series level as Semongok series (Scott, 1964(a)); Andriesse, 1965).

The intensity and distribution of the mottles varies greatly within the mottled yellow clays but they generally increase with depth. The mottles may be indicative of poor internal profile drainage but the apparently good site drainage and the absence of a correlation between mottling intensity and topographic position suggest that the mottles may be partially inherited from the dark grey parent shale. An unsuccessful attempt to further subdivide the mottled yellow clays on the degree of mottling is reported elsewhere (Baillie, 1970).

2.2.7.3 Unmottled Yellow Clay: Mrt

There are two areas in the southern part of the site which are covered by deep, yellow clays in which any mottles present are only faint and are red or yellow in colour (e.g. Profile F1D). These soils also have a textural B horizon and qualify as Merit family in the current classification, but they have not yet been designated as a separate series. The factors determining the presence or absence of mottling in the heavy textured soils of this whole area are not yet known, but it is possible that the angle of dip of the underlying strata may be steeper in the areas of these unmottled clays thus facilitating more rapid under-drainage.

2.2.7.4 Pale Coloured Clay: Mrt - Krt

There are three small areas of a soil, which is similar in many respects to the mottled yellow clays of Semongok series, except that the matrix colours are much lighter, with light grey, very pale brown and pale yellow the most frequent. Similar soils to this are found on the Agricultural Station and were designated as a variant of Semongok series and were thought to be derived from conglomerate (Scott, 1964(a)). Although similar to the mottled yellow clays, the matrix colours disqualify these soils from the Red Yellow Podsolic great soil group. However the mottles are generally too red and intense in colour to permit the soils to be unequivocally assigned to the Grey White Podsolic great soil group. In Map 2 they are therefore designated as a transitional type between Kerait and Merit families.

Within the site, profile F1C (see Appendix) illustrates this soil type, and rounded quartz pebbles are found in the subsoil, but other profiles in this soil type elsewhere in the Forest Reserve do not have such pebbles. The area in the south east of the site, which has many subsoil rounded pebbles, is covered with the mottled yellow clays and not the pale coloured soils. Because of these anomalies, the pale coloured clays are not thought to be necessarily of conglomeratic origin. It is probable that they are associated with a local facies in the shales, which has a low iron content.

Table 5

Summary of Soil Mapping Units at Semengoh Site

Mapping Unit (see Map 2)	Brief Description	Sarawak Classification			Area (acres)	Representative Profiles (see Appendix)
		Great Soil Group(1)	Family(1)	Series(2)		
(Sem)	Mottled brownish yellow, crumb-fine blocky, clay loam-clay over mottled reddish yellow blocky clay, grading into dark grey, mauve, yellow, and orange soft weathering shale at 30-48 inches.	Red Yellow Podsolic	Merit	Semongok	2.5	F1A, F1B
Mrt	Brownish-reddish yellow crumb-fine blocky clay loam - clay going to reddish yellow blocky clay. At least 48 inches deep.	Red Yellow Podsolic	Merit	-	0.6	F1D
Mrt - Krt	Pale yellow, very pale brown and light grey blocky clay with abundant yellow, red and white mottles, grading into dark grey, mauve, yellow and orange soft weathering shale, or into poorly sorted, pale coloured gully wash	Red Yellow - Grey White Podsolic	Merit - Kerait	Semongok variant	1.1	F1C

Notes

(1) According to current Sarawak classification (Sarawak Soil Survey Staff, 1966)

(2) According to Scott (1964(a)).

2 3 Bukit Temudok

2.3.1 General

The site is situated in a Government Reserve close to the summit of Bukit Temudok and about 4 miles due south of Simanggang (see Map 1 and inset to Map 3) There is a Telecommunications Department mast on the summit of the hill, and the metalled access road to this installation runs through the northeastern corner of the Reserve, so that access is good.

The Reserve was specifically created for silvicultural research (Gazette Notification No.982 of 12.6.1964) and covers about 25 acres, of which only 3 acres have been so far cleared and used. There are 10 performance trial plots (64 trees), 3 arboretum-sized (25 trees) observation plots, and 14 arboretum-sized fertiliser trial plots.

2 3.2 Climate

The nearest medium term meterological Station is at Simanggang, 4 miles away. There is also a rain gauge at the Temudok Agricultural Station, which is about a mile away, at the foot of the hill, but unfortunately this is a recent installation and has available data for only 4 years The rainfall data from these two gauges are summarised in Table 6.

Table 6

Rainfall at Simanggang and Temudok Agricultural Station

(i) Simanggang (32 years to 1968)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	17	12	13	14	12	9	9	9	11	14	15	17	152
Maximum	31	26	23	33	22	15	23	20	38	34	28	29	187
Minimum	7	1	7	3	6	3	1	3	3	6	4	8	108

ii) Temudok Agricultural Station (4 years to 1968)

Mean	18	9	13	12	10	9	7	11	7	11	12	17	135
Maximum	28	17	14	14	13	13	12	16	11	14	16	20	157
Minimum	7	2	10	9	7	7	2	3	4	7	9	12	130

Figures to the nearest inch.

(from Drainage and Irrigation Department Hydrological Yearbooks 1964-8 and Seal (1958)).

From Table 6 it can be seen that the rainfall distribution is less seasonal than for Kuching (see Table 3) In this respect the rainfall pattern is more like that of Central Sarawak, but the depth of precipitation

at Simanggang is greater than usually found at comparable altitudes further east. The climate at both stations falls into class 1A (continuously wet) in the classification of Mohr and van Baren (1954).

It is difficult to estimate how relevant the figures listed in Table 6 are to the rainfall at the actual site. This is because of the complex topographic configuration of the two gauges and the site. Simanggang town is situated in the swamps and presumably receives little or no orographic rain. The gauge at the Agricultural Station is on the landward side, and presumably in the rainshadow, of the isolated mass of Bukit Temudok (see inset to Map 3). This probably explains the lower rainfall there compared with Simanggang. The site itself is almost on the summit of the hill and probably receives additional orographic rainfall, so that it may be a little wetter than Simanggang and considerably wetter than the nearby Agricultural Station. The mean annual rainfall at the site may well be over 170 inches.

There has been a Class A evaporation pan in continuous operation at Simanggang since February 1963. The data from this installation are summarised in Table 7.

Table 7

Evaporation at Simanggang

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	6.0	5.2	5.4	5.6	5.5	5.3	5.5	5.4	5.4	5.9	5.5	5.7	67.1
Maximum	6.5	7.1	6.1	6.3	5.9	5.9	6.4	6.2	6.6	6.9	6.6	7.4	74.7
Minimum	5.6	4.1	5.0	4.9	4.9	4.0	5.1	4.8	4.7	5.0	4.9	5.0	61.2

Figures to the nearest 0.1 inches.

(from Drainage and Irrigation Department Hydrological Yearbooks 1962-8).

Evaporation appears to be slightly lower than at Kuching (see Table 4) but similar to, or slightly greater than, that at Sibu (see Table 14). However the small month-to-month and year-to-year variation is characteristic of all three stations.

2.3.3 Soil Parent Materials

The area is underlain by sedimentary rocks laid down as a post-orogenic shallow water basin deposit, probably in Eocene times. The sandstones forming the Marup and Temudok ridges and the intervening shales that floor the valley of Batang Undup were originally grouped as the Lower Kantu beds in the Plateau series (Haile, 1957). In a more recent geological account of the whole state it is proposed that they be regarded as members of the Silantek Formation, which includes both the Kantu and Silantek beds of Haile (Leichti, 1960).

The site is on the outcrop of the Temudok sandstone. This consists mainly of thick beds of light coloured, crumbly, porous, quartzose sandstone, alternating with subordinate strata of red and grey silty and fine sandy mudstones. These strata dip fairly steeply to the south, so that the outcrops of the various beds run east-west. However colluviation and stream dissection has led to considerable mixture of the soil parent materials so that it is not possible to demarcate the areas of the outcrops of the beds by the texture of the overlying soils. The most extensive soils are of medium texture probably because of this widespread mixture of parent materials from the different strata.

2.3.4 Topography

Bukit Temudok is a lithomorphic feature, formed because of the greater competence of the sandstone compared to the shales to the north and south. It is a promiment, isolated irregular ridge, running parallel to the east-west strike of the rocks. It peters out to the east as the outcrop of the sandstone pinches out and disappears. To the west the outcrop has been eroded and is now buried beneath the peat swamps.

The southwards dip of the sediments is sufficiently shallow (ca 30-60°) to permit cuesta formation, and the site is on the upper dip slope. The northern boundary runs along the crest of the scarp that faces northwards over the lower Undup and Lupar vallies.

Where undissected, the dipslope is of moderate gradient, usually in the range from 15° to 25°. However the slope is dissected by the heads of several minor streams. Some of these do not run directly downwards across the strike, but are constrained by the east-west bands of alternating hard and soft rock to follow oblique courses. Slope gradients are steeper in the vicinity of these streams.

2.3.5 Original Vegetation

The site lies in the broad belt of rolling lowland country in the 1st, 2nd and 3rd Divisions that has been densely populated for a considerable length of time and in which there is virtually no virgin forest remaining. The more accessible land in this belt has been subject to several cycles of shifting cultivation and, as population pressure has increased, the fallows have become progressively shorter in the recent past. The normally recommended 15-20 years fallow is now the exception rather than the rule and fallows of as little as 4 years are known.

On land subject to this type of misuse, the normal secondary succession is disturbed. The fast growing secondary trees such as Macaranga spp. do not appear almost immediately as they normally do after the felling and burning of primary forest. Instead a xeric phase intervenes, in which graminaceous and herbaceous plants are dominant. Lallang (Imperata cylin-

drica) is the most widespread species in this vegetation and, on land that has been really abused, the lallang phase may last several years.

Land on which the succession has been thus altered is known as 'degraded land'. It is assumed that the main causes are deterioration in the soil structure and soil nutrient depletion but, as yet, there is no direct evidence from Sarawak for this.

The Bukit Temudok site is regarded as degraded land, and at the time of clearing the planting area it was covered with young secondary growth in which lallang and resam (Gleichinia linearis) were important components. Lallang is the principal weed in the plots.

2.2.6 Previous Soil Survey Coverage

A brief soil survey of the area was made before the afforestation trials were begun (Wall, 1960). Because the absence of a large scale base map, no attempt was made to demarcate soil boundaries. Two residual-colluvial soils were described; namely a 'yellow loam' and a 'yellow clay loam'. As the descriptions of these soils were taken only from augerings, they have not been included in the Appendix.

2.3.7 Soils

The soils of the site are of the Red Yellow Podsolic type and they are all of basically similar morphology. The common profile form is as follows:

Dark yellowish brown - olive brown, moderate crumb or fine subangular blocky structure and friable consistence.

over Yellowish brown - brownish yellow, weak - moderate fine - medium subangular blocky structure, slightly firm consistence. This horizon generally of slightly heavier texture than the topsoil.

over Brownish yellow - reddish yellow, with or without weak - moderate yellow, reddish yellow and light grey mottling. Weak - moderate medium subangular blocky structure, and firm consistence. This horizon is generally of considerably heavier texture than above and there are often weak - moderate clayskins. This horizon becomes increasingly stony with depth and eventually merges into weathering sandstone or shale.

In the current Sarawak classification (Sarawak Soil Survey Staff, 1966), the Red Yellow Podsolic soils derived from sedimentary rocks are separated into families on grounds of texture. The same criteria are used for the soils of this site, so that the mapping units correspond exactly

to Merit, Bekenu and Nyalau families. The light textured soils (Nyalau family) are further subdivided on depth to weathering rock.

The criteria for separation of these mapping units are summarised in Table 8.

Table 8

Summary of Soil Mapping Units at Bukit Temudok Site

Mapping Unit (see Map 3)	Brief Description	Sarawak Classification		Area (acres)	Representative Profiles (see Appendix)
		Great Soil Group	Family		
Mrt	Yellowish brown and brownish yellow clay loam over reddish yellow slightly mottled clay, with strong clayskins. Moderate depth, with weathering rock at 20 - 48 inches.	Red Yellow Podsolic	Merit	6.3	F2C, F2E
Bkn	Colours similar to above, though subsoil may be brownish, rather than reddish, yellow. Textures are sandy loam - sandy clay loam at surface and sandy clay - clay loam in subsoil. Moderately deep, with weathering rock at 20 - 48"	Red Yellow Podsolic	Bokenu	15.4	F2B
Nyl	Colours similar to above. Textures are loamy sand-sandy loam at surface, going to sandy clay loam in subsoil. Subsoil clayskins generally only weak-moderate. Moderate depth, with weathering rock at 20 - 48".	Red Yellow Podsolic	Nyalau	3.9	F2D
Nyl (s)	As Nyalau, but weathering rock found at 10 - 20".	Red Yellow Podsolic	Nyalau	0.6	-

2.4 Jakar

2.4.1 General

This site is situated in a small Government Reserve that lies immediately to the east of the Sarikei - Saratok main road, about 4 miles west of Jakar bazaar (see Map 1 and inset to Map 4). As it is next to the road, access to the site is good.

The Reserve was created especially for silvicultural research (Gazette Notification number 527 of 15/3/66) and covers about 8 acres, of which only about 2 in the northwestern corner have so far been cleared and used. There are 18 arboretum-sized (25 trees) plots, planted in 1967-8. 6 of these are observation plots, the other 12 being part of a fertiliser trial.

2.4.2 Climate

There are two rain guages at Sarikei, about 11 miles from the site. One has been in operation discontinuously since 1936 at the Land Survey Department office. The other has been in continuous operation since 1962 at the P.W.D. waterworks. The figures for both gauges are given in Table 9.

Table 9

Rainfall at Sarikei

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
(i) L. & S Office (21 years to 1968)													
Mean	14	10	12	10	9	6	7	9	10	11	10	13	121
Maximum	22	20	24	19	18	13	13	22	16	19	15	22	145
Minimum	8	3	6	5	4	2	2	4	5	5	6	6	98
(ii) P.W.D. Waterworks (6 years to 1968)													
Mean	15	10	13	10	10	7	8	11	9	11	9	15	128
Maximum	23	16	18	14	16	10	9	22	11	18	14	22	129(1)
Minimum	8	3	10	5	3	3	7	4	7	8	6	10	121(1)

Notes: Figures to the nearest inch.

(1) Figures for 3 completed years only.

(from Drainage and Irrigation Department Hydrological Yearbook, 1968).

The slightly higher means at the waterworks gauge could be due to local spatial variations in the rainfall pattern, or to above average rainfalls in the years since it opened. Careful comparison of the daily records for both stations would be necessary to determine which is the

main factor. Table 9 shows that the rainfall is seasonal, with the highest monthly rainfalls occurring during the Northeast monsoon. However in comparison with West Sarawak (see Tables 3 and 6) the seasonal variation is not strong. The climate falls into Class 1A (continuously wet) in the classification of Mohr and van Baren (1954).

The Jakar site is set in low hilly country whilst both of the Sarikei rain gauges are on the edge of the swamps. Comparison of the Binatang and Pakan rainfall figures (see section 2.5.2 below) suggests that rainfall in the hilly country is higher and may be more reliable than that measured at nearby gauges in the swamps. It is therefore possible that the rainfalls in Table 9 are understimates for that received at the site, even though the gauges are only 11 miles away.

2.4.3 Soil Parent Materials

The site is underlain by rocks of Stage II of the Belaga Formation, although it lies quite close to the conformable boundary between Stages I and II (Wolfenden, 1960). The main difference between the stages is the occurrence of thick beds (up to 300 feet) of greywacke and subgreywacke sandstone in Stage II. The predominant rocks in both stages are dark grey argillaceous sediments. These have been fairly severely folded, probably in more than one cycle of deformation, and steep angles of dip prevail. During deformation, considerable dynamic metamorphism took place and the argillaceous rocks range from mudstone through shale and argillite to phyllite and slate. However only weathered rock was encountered on the site and, in the absence of fresh outcrops, it is not possible to distinguish between these various types, so they are all referred to as shale. The shales consist of widely scattered clastic grains, mostly quartz with subsidiary albite-oligoclase and microperthite, set in a matrix of quartz, sericite, chlorite and fine carbonaceous matter

The massive thick beds of greywacke sandstone that are distinctive of Stage II do not occur on the site, but there are numerous thin beds of sandstone scattered through the dominant shales. These thin beds are also of the greywacke type, consisting of grains of quartz, microcline, microperthite, chert, shale and granite set in a quartz-chlorite-sericite matrix. Both the shales and the sandstones are shot through with quartz veins. There are no traces on the site of the conglomerate that is found elsewhere in Stage II (Wolfenden, 1960).

In the geological account of the whole state, Wolfenden's boundaries and rock types are retained but the nomenclature is altered (Leichti, 1960). Thus Stage I and II become respectively the Layar and Kapit members of the Belaga Formation.

The predominance of medium textured soils and the presence of stone lines indicate that the soil parent materials are not truly sedentary, but have probably been subject to considerable colluvial mixing, so that most of them now have shale and sandstone constituents.

In addition to the residual-colluvial parent materials covering most of the site, there are small areas of alluvium. There is a belt of recent alluvium along the course of the stream in the eastern part of the site. This alluvium is very heterogeneous, with frequent lateral as well as vertical textural changes, but coarse grained material is predominant.

There is a belt of deep, light-coloured coarse and medium textured material along the lower eastern slopes of the hill. This is thought to be an old alluvial terrace deposit. It could be colluvial material, which is either derived from a localised iron-poor facies of the sandstone or which has been bleached by gleying, but the presence of apparently fortuitous, abrupt changes in texture down the profile, and the abundance of coarse and medium rather than fine sand both suggest an alluvial origin.

2.4.4 Topography

The site covers the summit and northern slopes of a low rounded hill and part of the valley of a minor tributary of Sg. Minus (see Map 4). The hill summit is of about 100 feet m.s.l. altitude and is concordant with many others in the area. These summits are probably the remnants of the '200 feet' Tertiary peneplain found throughout lowland Sarawak and on which the Semengoh, Pakan Road and Oya Road sites are also situated. Since Tertiary times this surface has been intensely dissected and slopes are moderately steep and gradients over most of the site are in the 15-25° range.

The material along the lower eastern slopes of the hill are thought to the remnants of an old terrace deposit. However there are no sharp breaks of slope at either the upper or lower edges of this deposit and the terrace topography, if it ever existed, has been eroded and smoothed out beyond recognition.

2.4.5 Original Vegetation

This site, like Bukit Temudok, Pakan Road and Oya Road, lies in the broad belt of degraded land that covers much of the lower parts of the 1st, 2nd and 3rd Divisions. This land has been subject to several cycles of shifting cultivation, with intervening fallows of decreasing length in recent years. The normal secondary succession is altered by this misuse, and lallang (Imperata cylindrica) becomes a serious weed problem (see Section 2.3.5 above).

At the time of clearing the site was covered with young secondary growth of two different ages. The western part of the site was covered with a mixture of lallang and resam and the vegetation is thought to have been 3-5 years old. In the eastern part secondary tree species are established and the vegetation is thought to be 10-20 years old. The plots lie in the western section and lallang is the most important weed.

2.4.6 Previous Soil Survey Coverage

The site lies in the area that was surveyed at reconnaissance level prior to the alignment and construction of the main Kuching - Sibu road, but no report was published.

2.4.7 Soils

2.4.7.1 General

The soils of the hill summit and slopes are mostly covered by medium textured Red Yellow Podsolic soils of Bekenu family. Along the lower slopes, on the eastern flank of the hill there is an area of light and medium textured Grey White Podsolic soils. The alluvium along the stream is dominantly light textured, although lenses of sandy clay and clay are found. The poorly drained soils developed in this alluvium are subdivided on the presence or absence of a thin surface muck layer.

The individual mapping units are described in sections 2.4.7.2-4 below and summarised in Table 10.

2.4.7.2 Yellow Sandy Clay: Bkn

These are the most widespread soils on the site. They are derived from parent material that is a colluvial mixture of shale and sandstone. The profile morphology is as follows:

Dark yellowish brown sandy loam - sandy clay loam topsoil.

over Brownish yellow sandy clay loam with weak - moderate yellow and reddish yellow mottling.

over Brownish or reddish yellow sandy clay or clay loam, with moderate - strong yellow, light grey and yellowish red mottling and strong clay skins. This horizon becomes stonier with depth and gradually merges into soft weathering shale.

These soils are in the Bekenu family of the Red Yellow Podsolic great soil group according to current classification. They are similar to the soils of the same family found on Sites A and B at Oya Road (see section 2.6.7.3 below), but are more strongly mottled than those at the Bukit Temudok or Pakan Road sites. The mottling of these (Jakar) soils increases

down slope, as can be seen by comparing profiles F3A (summit) and F3B (lower slope). The mottling is probably mostly hydromorphic in origin but incomplete weathering of the parent material may also contribute.

2.4.7.3 Grey Sandy Clay Loam: Trb

These soils are developed in the old terrace deposits along the lower eastern slope of the hill. Below a thin, organically darkened, topsoil, matrix colours are of high chroma and low value throughout the profile, light grey and pale yellow being the commonest. Generally the texture becomes heavier with depth, going from loamy sand - sandy loam at the surface to gritty sandy clay loam - sandy clay at depth. Occasionally there are abrupt textural changes to lenses of sandy or loamy sand texture. These are not thought to be pedological features but to be inherited from the parent material.

These soils are classified as members of Triboh family in the Grey White Podsolic great soil group.

2.4.7.4 Gleyed Sandy Alluvial Soils: Tta/Mtu

These soils are developed in the recent coarse textured alluvium in the valley bottom in the eastern part of the site. They are very wet, often almost to the surface. This makes auger inspection difficult, but it is clear that loamy sand - sand clay loam textures predominate. There are sharp vertical textural changes which are inherited from the deposition process. Matrix colours are grey and light grey throughout, but there are usually many yellow, reddish yellow and reddish brown prominent mottles especially along old root channels in the upper horizons.

In the current Sarawak classification these soils come clearly in the Gley great soil group. Those with a muck layer less than 10 inches thick at the surface qualify for Matu family, whereas those with no organic topsoil are in Tatau family.

Table 10

Summary of Soil Mapping Units at Jakar Site

Mapping Unit (see Map 4)	Brief Description	Sarawak Classification		Area (acres)	Representati Profiles (see Appendix
		Great Soil Group	Family		
Bkn	Dark yellowish brown - yellowish brown sandy loam - sandy clay loam, over brownish yellow sandy clay loam merging into reddish yellow sandy clay or clay loam. This horizon becomes stony with depth and merges into weathering rock. Degree of subsoil mottling increases downslope. Moderate depth (weathering rock at 30-48 inches).	Red Yellow Podsolic	Bekenu	6.3	F3A, F3B
Trb	Greyish brown coarse loamy sand-sandy loam over light grey or pale yellow sandy loam, gradually merging in to sandy clay loam of same colours. May be lenses of coarse loamy sand or sand in subsoil. Deep (more than 48 inches).	Grey White Podsolic	Triboh	0.7	-
Tta/Mtu	Very wet gleyed sandy alluvium. May have layers of grit or gritty clay - clay loam in subsoil. Discountinuous thin (less than 10 inches) layer of wet muck at surface.	Gley	Tatau (no muck) Matu (thin surface muck horizon)	1.0	-

2.5 Pakan Road

2.5.1 General

This site is in a Government Reserve that lies to the east of the Pakan feeder road, about 6 miles south of its junction with the main Kuching - Sibu road and about 6 miles north of Pakan bazaar (see Map 1 and inset to Map 5). As the site is adjacent to the road, access is good.

The Reserve was specifically created for silvicultural research (Gazette Notification No. 527 of 15.3.1966) and covers about 10 acres. So far only about 2 acres in the northwestern corner have been cleared and used. 18 arboretum-sized (25 trees) plots were planted in 1967 and 1968. 6 of these are observation plots, the other 12 being part of a fertiliser trial.

2.5.2 Climate

There is a rain gauge at Pakan, about 6 miles from the site, but this is a fairly recent installation and has been in operation for only 7 years. There is a slightly older gauge at Binatang, about 14 miles from the site, from which data for 9 years are available. The rainfall records for both stations are summarised in Table 11.

Table 11

Rainfall at Binatang and Pakan

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
(i) Binatang (9 years to 1968)													
Mean	13	7	11	10	7	7	6	9	9	10	10	12	110
Maximum	23	12	19	14	11	10	12	20	14	16	15	18	-
Minimum	8	2	3	6	2	2	2	2	6	5	6	7	-
(ii) Pakan (6 years to 1968)													
Mean	17	14	16	13	11	7	8	7	12	10	16	14	146
Maximum	21	19	27	21	16	12	14	14	16	12	26	18	166(1)
Minimum	12	11	8	7	5	4	3	1	7	7	11	12	125(1)

Notes: Figures to the nearest inch

(1) Figures for 4 completed years only

(from Drainage and Irrigation Department Hydrological Yearbooks, 1962-8).

It is difficult to come to any definite conclusions from data collected over such short periods, but the suggestion that Pakan is noticeably wetter than Binatang is borne out by comparison of the annual rainfalls for other swamp gauges such as Matu (119 inches mean, from 22 years data) and Daro (107 inches mean, from 13 years data) with Julau (143 inches mean, from 5 years data) which is set in low hilly country like Pakan. As the site is closer to Pakan than Binatang, and as it is also set in the low hilly country, the Pakan, rather than Binatang, rainfall pattern is thought to be that prevailing at the site.

From Table 11 it can be seen that the rainfall is at a maximum during the Northeast monsoon (November - March), but compared with West Sarawak, the seasonality of the rainfall distribution is not marked. In general the climate is similar to that of the nearby Jakar site.

2.5.3 Soil Parent Materials

The geology of this site is very similar to that of the Jakar site. They are both underlain by rocks of Stage II of the Belaga Formation (Wolfenden, 1960), referred to as the Kapit member of the Belaga Formation by Leichti (1960).

The dominant rocks are dark grey argillaceous, steeply dipping, sediments, which may or may not be slightly metamorphosed. These are obviously intercalated by numerous thin beds of greywacke fine sandstone judging by the wide extent of the medium textured soils. For details of the lithology and petrology of these rocks, see Section 2.4.3 above.

As at Jakar, there is no trace of the conglomerate found elsewhere in Stage II, but a considerable amount of angular quartz is encountered in the soils. This quartz is assumed to be derived from the plentiful quartz veins found in this formation (Wolfenden, 1960).

As at Jakar, medium textured soils are widespread and stone lines are common, so it is thought that very little of the soil parent material is truly sedentary, most of it having been subject to at least some colluvial mixing.

This is no alluvium on the site, although there is moderately broad paya just beyond the northwestern boundary.

2.5.4 Topography

The site occupies the summit and the northern and western slopes of a rounded hill, the summit of which is of about 350 feet m.s.l. altitude. The northern slope is dissected by the head of a minor stream (see Map 5). The hill summit is concordant with others in the vicinity and they may possibly be the remnants of a Tertiary peneplain. Intense Quaternary dissection has given moderately steep slopes, and gradients

over most of the site range from 15° to 25°. However the northwestern corner occupied by the plots is flatter than this, with gradients rarely more than 15°

2.5.5 Original Vegetation

The site lies in the same broad belt of degraded land as the Bukit Temudok, Jakar and Oya Road sites. The land has been through several cycles of shifting cultivation and, especially in recent years, the fallows have been of insufficient length. Possibly due to change in the soil, the normal secondary succession is altered, with lallang becoming a serious weed problem.

When acquired by the Forest Department the Reserve was covered with secondary growth of about 3-7 years age, with a high proportion of lallang and resam. Lallang is the main weed in the cleared area around the plots.

2.5.6 Previous Soil Survey Coverage

The site is in the area covered by the Pakan - Durin reconnaissance survey (Scott, 1964 (b)). It lies within a delineation of the Nyalau - Merit compound mapping unit, indicating a cover of Red Yellow Podsolic soils of various textures, in a mixture that was too complex to subdivide at the scale of mapping used (1:100,000).

2.5.7 Soils

2.5.7.1 General

The summit and most of the upper slopes of the hill are covered with deep, yellow, medium textured soils. The lower slopes, including all the area occupied by the present plots, are covered with shallower soils, which are also heavier textured and more mottled than the upslope deep yellow sandy clay loams. The soil mapping units are described separately in sections 2.5.7.2 - 4 and summarised in Table 12.

2.5.7.2 Mottled Sandy Clay: Rpk

These soils occupy the lower slopes of the hill and underly most of the present plots. The profile consists of:

Brown fine sandy loam surface.

over Brownish or reddish yellow, weakly mottled, fine sandy loam to clay loam.

over Stone line of angular quartz, iron concretions and iron-coated fragments of shale and fine sandstone.

over Mixed distinct light red, white, very pale yellow, reddish yellow fine sandy clay - clay. This type of colouring has been aptly described as similar to 'corned beef' (Andriesse, 1967). This horizon gradually merges into weathering shale, usually at 30-48 inches from the surface.

(For details see Profile #3C in Appendix)

These soils can be regarded as the medium textured (Bekenu family) analogue of Lutong series in the Red Yellow Podsolic great soil group. However the presence of common iron concretions in the stone line may qualify them for Rapak family in the Groundwater Laterite great soil group (Sarawak Soil Survey Staff, 1966).

The profile drainage of these soils is suspect, as subsoil mottling and the formation of iron concretions are often indications of intermittent waterlogging. However, in this case, the iron concretions may be relics of ferricrete sheet that formerly capped the pre-dissection erosion surface marked by the concordant hill summits of the area. Similarly the mottling may not be directly due to present-day hydromorphism, but to incomplete weathering of the parent material.

2.5.7.3 Mottled Clay: (Ltn)

At the very foot of the hillslope, bordering the paya that lies immediately northwest of the site, there is a small area of intensely mottled clays. The profile morphology is similar to the mottled sandy clays upslope (see above) but there is no stone line, and the distinct mottling extends upwards almost to the surface. The profile form is:

Grey brown fine sandy loam - fine sandy clay loam with many distinct yellow, red and reddish brown mottles.

over Brownish yellow fine sandy clay - clay with many distinct grey, light grey and reddish yellow mottles.

over Mixed distinct red, yellow, light grey and grey silty clay - clay. This horizon is similar in colour to the 'corned beef' horizon in the mottled sandy clays (see 2.5.7.2 above), but the greys are more conspicuous and the red and yellow colours more muted. These soils are deep and no weathering rock was encountered in the top 48 inches.

These soils are members of Merit family in the Red Yellow Podsolic great soil group. The intense subsoil mottling is similar to that in Semongok series (see section 2.2.7.2 above). In the detailed soil survey of the Oya Road Agricultural Station, similar Belaga Formation analogues of Semongok series were put into Lutong series (Scott, 1964 (c)). The Station is located on the outcrop of the Pelagus member of the Belaga Formation, but the argillaceous rocks in the Kapit and Pelagus members are almost identical, so that the soils formed on them are probably the same.

2.5.7.4 Deep Yellow Sandy Clay Loams: Bkn

These are the most widespread soils on the site and cover the summit and upper and middle slopes of the hill. The profile consists of:

Yellow brown - olive brown sandy loam surface.

over Brownish yellow fine sandy loam which gradually merges into fine sandy clay loam and fine sandy clay. This horizon is very deep (always more than 48 inches) and there only a few, if any, faint reddish yellow mottles.

From the original auger descriptions these soils were classified as belonging to the light-textured Nyalau family in the Red Yellow Podsolic great soil group. However the mechanical analyses of the subsoil samples from Profile F3D show that the soils in this unit are medium-textured and should be classified as members of Bekenu family.

These soils are lighter in texture, deeper and less intensely mottled than the Bekenu family soils on the Jakar and Oya Road sites (see sections 2.4.7.2 and 2.6.7.2).

Table 12

Summary of Soil Mapping Units at Pakan Road Site

Mapping Unit (see Map 5)	Brief Description	Sarawak Classification			Area (acres)	Representative Profile (see Appendix)
		Great Soil Group(1)	Family(1)	Series(2)		
Rpk	Brown sandy loam topsoil, over brownish yellow weakly mottled fine sandy clay loam, over stone line of quartz, iron concretions and shale fragments, over mottled 'corned beef' horizon. This gradually merges with weathering shale at 30 - 48 inches depth.	Red Yellow Podsolic - Groundwater Laterite	Rapak	-	3.8	F3C
(Ltn)	Grey brown mottled fine sandy clay loam topsoil, over strongly mottled brownish yellow fine sandy clay, which gradually merges with light grey, yellow, red 'corned beef' horizon. More than 48 inches deep to weathering rock.	Red Yellow Podsolic	Merit	Lutong	0.2	-
Bkn	Yellowish brown sandy loam topsoil over brownish yellow sandy loam - sandy clay loam, which gradually becomes sandy clay loam - sandy clay at depth. More than 48 inches deep to weathering rock.	Red Yellow Podsolic	Bekenu	-	4.8	F3D

Notes:

(1) According to current Sarawak classification (Sarawak Soil Survey Staff, 1966).

(2) According to Scott (1964(c)).

2.6 Oya Road

2.6.1 General

This is the main centre of the afforestation research programme. There are six separate sites in the 500 acre Government Reserve which was acquired by the Forest Department specifically for this research (Gazette Notification No.527 of 15.3.1966). It lies immediately to the north of the Sibu - Ulu Oya road, fronting on the road from Mile 11½ to Mile 13 (see Map 1 and inset to Map 6). The road from Sibu is being improved and access to the nursery area, and sites A, B and E is very easy. In order to reach sites C, D and F it is necessary to walk, up to ¼ mile in the case of site D.

The plots are grouped as six separate sites in the Reserve, but from Map 6 it can be seen that plots designated as being on the same site may, in fact, be quite widely separated. Thus the arboretum-sized plots of Sites B, D, E and F are not adjacent to the main sites of the same letter, and may be up to ½ mile distant from them.

In all, about three quarters of the total number of performance trial plots, about half of the arboretum-sized (25 trees) plots and all the small subtractive fertiliser trial plots (9 trees) in the Project are situated on the Oya Road sites (see Table 1).

2.6.2 Climate

The nearest medium term meteorological station is at Sibu airport, about 10 miles away. There have been rain gauges at P.W.D. road camps along the Oya Road, but the records from these installations cover such short periods that they are not useful. The rainfall data for Sibu airport is summarised in Table 13.

Table 13

Rainfall at Sibu Airport

(15 years to 1968)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	15	10	12	9	9	7	9	7	10	12	12	15	128
Maximum	23	19	20	20	14	11	16	14	18	21	20	26	164(1)
Minimum	7	3	6	4	4	2	2	2	7	6	7	9	95(1)

Notes:

Figures to the nearest inch

(1) These figures refer to the gauge in Sibu town (after Seal, 1958).

(from Drainage and Irrigation Department Hydrological Yearbook 1967-8).

The rainfall pattern is similar to that of Binatang and Sarikei (see Tables 9 and 11). The depth of rainfall is less and its distribution less seasonal than for the West Sarawak sites (see Tables 3 and 6) but is higher and slightly more seasonal than that recorded at Miri (see Table 21). The climate is in Class 1A (continuously wet) in the system of Mohr and van Baren (1954).

It is probable that the sites receive more rainfall than that recorded at Sibu. Cursory comparison of the rainfalls for the same months at Sibu airport and the P.W.D. road camp at Mile 13½ on the Oya Road, shows that the latter is usually wetter. Unfortunately the records of road camp are not continuous nor of long enough duration for a more definite conclusion. The situation is parallel to that at Bukit Temudok, Jakar, Pakan Road and Lambir, in which the sites are set in hillier country and at higher altitudes than their corresponding medium or long term rainguages. Thus Sibu is on the fringe of the Rajang Delta swamps, whilst the Oya Road Reserve is set in low hills. The Reserve may therefore be expected to receive a certain amount of additonal orographic rainfall that does not fall at Sibu.

There has been a Class A evaporation pan in continuous operation at Sibu airport since April 1963. The data from this installation are summarised in Table 14.

Table 14

Evaporation at Sibu Airport

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	4.9	4.8	5.3	5.6	5.7	5.7	5.7	5.4	5.4	5.4	5.1	5.1	63.9
Maximum	6.1	5.0	6.2	6.1	5.9	6.8	7.3	5.9	5.8	5.9	5.4	5.8	62.2
Minimum	4.4	4.6	4.5	4.8	5 3	5.1	4.9	4.7	5.1	5.0	4.5	4.6	67.0

Figures to the nearest 0.1 inches

(from Drainage and Irrigation Department Hydrological Yearbooks 1962-8)

As in all Sarawak stations, evaporation is relatively invariable and fluctuations in the moisture balance are almost wholly attributable to variations in the rainfall.

2.6.3 Soil Parent Material

The Reserve is underlain by the sedimentary rocks of Stage III of the Belaga Formation (Wolfenden, 1960) referred to as the Pelagus member of the Belaga Formation by Leichti (1960). These are conformable on the Stage II rocks that underlie the Jakar and Pakan Road sites and are lithologically very similar. As in the Stage II outcrop, the dominant rocks are

argillaceous, ranging from mudstone to slate, although shales and argillites are the most common. In the absence of fresh outcrops, these are all called 'shales'. The shales are dark grey in colour when fresh and are intercalated with subordinate thin beds of fine-grained greywacke sandstone.

In addition to these thin beds, there are also massive beds of medium and fine grained greywacke sandstones which may be up to 300 feet thick. The arenaceous rocks, though subordinate, are of more importance in this stage of the formation than in any other and account for about 35% of the total thickness (Leichti, 1960).

Since deposition these rocks have been severely folded and faulted, and vertical or very steep dips are general. As the sandstone is harder than the surrounding shales, the steep dips have given rise to strike ridges, running roughly southeast-northwest.

Within the Reserve there is a clear division between the southern section which is underlain by a succession of the thick massive sandstone beds and intervening mixed shale and thin sandstone beds, and the northern section in which only the shale and subordinate thin beds of fine sandstone are found and the massive sandstone beds are absent (Scott, 1965).

Few of the soils found are thought to be truly sedentary and most of the parent material has been subject to some colluvial movement. However the correspondence of colours in the soil and those of the underlying weathering rocks, as revealed by cuttings along the main road, suggest that colluviation is limited, but it is sufficient to give medium textured soils in areas where there are shale and sandstone outcrops in close proximity.

In Table 15, the parent material of the various sites in the Reserve are classified according to whether shale or sandstone are the dominant components.

Table 15

Parent Material on the Oya Road Sites

Site	Dominant Component of Parent Material
A (both parts)	Sandstone
B (both parts)	Sandstone
C	Sandstone
D (both parts)	Shale
E (main part)	Mixed sandstone and shale
E (fertiliser trial)	Sandstone
F (both parts)	Shale

2.6.4 Topography

The topography of the Reserve has been described by Scott (1965) and he divides the area into the southern half which is underlain by the shales and massive sandstones, and the northern half which is underlain only by shales. In the southern area the steeply dipping massive sandstones originally formed three parallel strike ridges, but these have since been eroded, and now form a series of strike - aligned rounded hills, with summits concordant at 140-160 feet m.s.l. These summits are probably remnants of the '200 feet' peneplain. Gradients on the flanks of these hills may be quite steep, often in 20-30° range. Sites A, B, and C are located on the summits and upper - middle slopes of such hills. The local relief in the southern area is about 80-100 feet, and the intervening vallies are rather broken terrain, underlain by mixed shales and thin - bedded sandstones. Both the main site and the fertiliser trial plots of site E are situated in such terrain.

In the shale area in the northern half of the area, there are no rocks hard enough to give lithomorphic positive features and the topography is only gently undulating. Summit altitudes range from 50 to 80 feet m.s.l., local relief is rarely more than 40 feet and slope gradients are usually less than 5°, always less than 10°. Site D occupies the summit and upper slopes of an interfluve in this type of terrain. The main part of site F lies on the gently graded lower slopes in the broad shale-floored valley between the northern two lines of sandstone hills and is much more similar to site D than to any of the others.

2.6.5 Original Vegetation

There is no virgin, or even very old secondary, forest left in the Reserve and the whole area is regarded as degraded land (see section 2.3.5). The Reserve lies in the almost continuous stretch of such land that covers most of the lower lying parts of the 1st, 2nd and 3rd Divisions and which also includes the Bukit Temudok, Jakar and Pakan Road sites.

Much of the Reserve is covered with low lallang - resam scrub with few secondary tree species emerging. Lallang is the commonest weed on the planted sites.

2.6.6 Previous Soil Survey Coverage

The Reserve lies in the area that was covered by the broad reconnaissance soil survey that was carried out prior to the final alignment and construction of the Oya Road (Grant, 1960). The vicinity of the Reserve was described as being predominantly underlain by shale, and consisting of low, moderately steep hills, covered with Red Yellow Podsolic and allied Skeletal soils of medium to heavy textures.

Before the experimental sites were chosen, a semi-detailed soil survey of the whole Reservewas carried out by Scott (1965). He described and mapped the hill soils as being a mixture of Red Yellow Podsolic, Grey White Podsolic and Upland Gley soils, whilst the relatively broad vallies in the northern section are filled with Lowland Gley and fairly shallow peat soils. For details the reader is referred to the original report and maps.

2.6.7 Soils

2.6.7.1 General

This report is only concerned with the soils of the sites actually planted. No soils beyond the boundaries of the present plots were inspected and for a description of the soils of the whole Reserve, the reader is referred to the report of the original semi-detailed soil survey (Scott, 1965), the boundaries of which are, by and large, confirmed in the present more detailed survey. In the accompanying map (Map 6) no attempt is made to extrapolate the soil boundaries beyond the site limits.

In general the sites on the steeper hills are covered with well drained Red Yellow Podsolic soils, generally of light to medium texture. Those on the flatter areas are covered with a mixture of Red Yellow Podsolics, Grey White Podsolics and intergrades between them. These soils are usually of heavier texture than the Red Yellow Podsolics on the steeper hills.

The soil mapping units used in Map 6 are described individually below and summarised in Table 17. When more detail of the soils morphological and chemical characteristics is required, reference should be made to the relevant profile descriptions in the Appendix. The profiles described and sampled by I.M. Scott in the semi-detailed survey (1965) are included for ease of reference and are preceded by an 'S'. Those described and sampled by the writer in the course of this survey are preceded by an 'F'.

2.6.7.2 Reddish Yellow Sandy Clay Loam. Nyl

These are the most widespread soils on the steep sandstone hills and are the predominant soils on sites A, B and C. The profile consists of:

Yellowish brown sandy loam topsoil.

over Brownish yellow sandy loam, which is increasingly yellow and reddish yellow mottled with depth.

over Reddish or brownish yellow sandy clay loam with common yellow and reddish yellow mottles and medium - strong clayskins. This horizon becomes increasingly stony with depth, but weathering sandstone is not found in top 48 inches.

(For details, see Profiles S 713-9; S 720-8, S 746-51 and F3BA in Appendix)

These soils are in the Nyalau family of the Red Yellow Podsolic great soil group. They are morphologically similar to the soils of the same family found on the Bukit Temudok and Lambir sites, although developed on different parent materials.

They are found especially on the upper slopes of the hills and are clearly derived from parent materials in which the shale component is minimal. The mottling is thought to be due to localised incomplete weathering and not hydromorphism, so that the soils are deemed to be well drained.

2.6.7.3 Reddish Yellow Sandy Clays: Bkn

These soils are also found on the slopes of the steep sandstone hills and occur on sites A, B and C. The profile morphology is very similar to that of the reddish yellow sandy clay loams, but textures are heavier. Thus the typical profile is as follows:

Yellowish or olive brown sandy loam or sandy clay loam topsoil.

over Brownish yellow sandy clay loam with weak-moderate reddish yellow mottling.

over Reddish yellow sandy clay; more mottled and stony than above.

These soils come in Bekenu family in the Red Yellow Podsolic great soil group in the current Sarawak classification. The medium textured Red Yellow Podsolic soils on the Agricultural Station, to the east of the Reserve, were classified as Likau series. However these do not correspond exactly with the soils of this mapping unit, as the colours are generally less red and the mottling less marked (Scott, 1964 (c)). The soils of this mapping unit are similar to those Bekenu family soils on the Bukit Temudok and Jakar sites, but more mottled and shallower than those at Pakan Road.

They are derived from parent materials which are a mixture of shale and sandstone components. They are thought to be well drained.

2.6.7.4 Reddish Yellow Clays: Mrt

These soils are only found on a small, steep, lower slope area on site A. The profile morphology is similar to those of the reddish yellow sandy clay loams and sandy clays, except that reddish colours in the subsoil are more marked. Thus a profile is typically as follows:

Yellowish brown sandy clay - clay loam topsoil.

over Brownish yellow or reddish yellow clay loam - clay with moderate yellow and reddish yellow mottling

over Reddish yellow clay with strong - moderate light red, yellowish red and yellow mottling and strong clayskins. Increasingly stony with depth, and may merge into weathering shale by 48 inches.

These soils are in the Merit family of the Red Yellow Podsolic great soil group in the current Sarawak classification. They are similar to the slightly mottled Merit family soils on the Semengoh and Bukit Temudok sites. They are derived from parent material in which shale is the dominant constituent. However the sandy clay surface textures and fragments of sandstone in the subsoil show that the parent material is mixed.

2.6.7.5 Mottled Red, White and Yellow Clays: (Ltn)

These soils are found only on site D (both the main site and the fertiliser trial arboretum-sized plots). The profile morphology is similar to that of reddish yellow clays (Mrt) described above but yellow and white colours are much more prominent in the subsoil. A typical profile is as follows:

Olive brown sandy clay loam topsoil.

over Brownish yellow sandy clay with strong yellow and pale yellow mottling

over Moderately thick stone line - mostly angular quartz but also iron-coated shale and iron concretions.

over Mixed distinct light red, yellowish red, pale yellow, and white 'corned beef' clay - silty clay.

(For details, see Profile F3BD in Appendix)

These soils are in the Merit family of Red Yellow Podsolic great soil group, but the stronger mottling and the possibility of poor drainage distinguish them from the reddish yellow clays in the same family on site A. The difference between these two soils is analogous to that between the Semongok series and the unmottled Merit family soils on the Semengoh site (see 2.2.7.2-3 above). The strongly mottled clay found in the north west corner of the Pakan Road site (see 2.2.4.7 above) is very similar to the soils of this mapping unit. These Belaga Formation analogues of Semongok series were put into Lutong series when they were found on the Oya Road Agricultural Station (Scott, 1964 (c)).

These soils occur on much gentler slopes than the reddish yellow clays of site A, so that the mottling may be due to imperfect site drainage. However in the analogous situation on the Semengoh site, where the mottled and unmottled soils are adjacent, it is not possible to attribute the mottling wholly to poor drainage, and differences in the degree of

weathering of the parent material also play a role. Similarly, in the Oya Road Merit family soils, the strong mottling in Lutong series may be partly due to the fact that weathering is less advanced than in the relatively unmottled soils on site A.

2.6.7.6 Light Grey Silty Clays: (Bnd)

These soils cover large parts of the northern half of the Reserve and are found on sites D, E and F The profile consists of:

Dark greyish brown loam topsoil.

over Light grey, pale yellow, or very pale brown silty loam - loam with few yellow, very light grey mottles.

over Colours as above, except that yellow and brownish mottles may increase. Silty clay loam - silty clay. This horizon continues to below 48 inches.

(e.g. Profiles S705-12, S 738-45 in Appendix)

These soils were put into Bandang series in the Semadoh family of the Gley soil group by Scott (1965). It is arguable that the placement in a great soil group that is hydromorphic by definition assumes that the pale colours are due to poor profile drainage. However in placing these soils in Kerait family of the Grey White Podsolic group there is the implicit assumption that the pale colours are caused by low iron contents in the parent material. Until more chemical and mineralogical work has been done this conflict cannot be resolved. However Bandang series is a useful mapping unit and is retained, despite the doubt surrounding its position in the higher taxa.

These soils are found in all slope positions in low undulating terrain, on gradients as steep as 10°. The parent material is predominantly derived from shale, but the subsoils have high very fine sand and silt contents so that the soils are probably not of wholly argillaceous origin.

2.6.7.7 Light Grey Sandy Loam: Srt

These soils cover parts of site E and a very small area in the fertiliser trial plots on site B. The profile consists of:

Deep greyish brown sandy loam topsoil.

over Light grey, pale yellow or very pale brown sandy loam.

over Colours as above with weak yellow, reddish yellow mottling, sandy loam - sandy clay loam. Texture usually sandy loam to at least 48 inches.

(e.g. Profile F3BB in Appendix)

These soils are in Saratok family in the Grey White Podsolic great soil group in the current Sarawak classification. The pale colours are assumed to be due to low iron contents in the predominantly arenaceous parent material. The coarse texture and the moderately steep slope gradients rule out poor drainage as a major influence on soil formation.

2.6.8 Intergrades between Red Yellow and Grey White Podsolic soils:

(Ltn - Bnd)

Bkn - Krt

Nyl - Krt

Nyl - Srt

In addition to the six mapping units so far described, which fall clearly into either the Red Yellow or Grey White Podsolic great soil groups, there are four mapping units which are intergrades between them. These are common on the undulating terrain of sites D, E and F, and small areas are also found on sites B and C.

In some of these soils, the reddish yellow and light grey matrix colours are intimately mixed throughout the profile and there are no distinct colour changes with depth. In others the reddish and brownish yellow colours may predominate at the top, gradually giving way to the pale yellow and light grey with depth (Profile F3BC is of this type - see Appendix) or vice versa so that the profiles appear to be of a 'Red Yellow over Grey White Podsolic' or a 'Grey White over Red Yellow Podsolic' type. These changes are probably due to a combination of the juxtaposition of the 'normal' and 'low iron' strata in the underlying rock and the degree of colluvial mixing. These various profile types are distributed is such an intricate pattern that no attempt is made to separate them.

As in the Red Yellow Podsolic and Grey White Podsolic great soil groups, these intergrades are separated according to subsoil texture. There are three textural subdivisions of the Red Yellow Podsolics and two of the Grey White Podsolics, but unfortunately none of the differentiae coincide, so that four subdivisions of the intergrades are possible. These are summarised in Table 16.

Table 16

Textural subdivision of the Oya Road Red Yellow-Grey White Podsolic intergrades

Mapping Unit	Subsoil texture (above 48 inches)	Occurrence
(Ltn - Bnd)	Clay, silty clay, silty clay loam	Sites D, F (Fertiliser trial)
Bkn - Krt	Sandy clay	Sites B, E, F
Nyl - Krt	Sandy clay loam	Site E
Nyl - Srt	Sandy loam	Sites C, E (Fertiliser trial)

2.6.7.9 Gleyed Alluvial Soils: Bjt

The sites were originally located so as not to take in any significant areas of valley bottom land, but it is impossible to avoid all the minor gullies, and small areas of gully wash alluvium are found on sites A, B and D. This material is predominantly heavy textured but sharp textural discontinuities due to the exigencies of deposition occur, and subsoil bands and lenses of coarser textured material are common.

The profile is poorly drained, with grey colours and rust mottling extending almost to the surface. There may be a thin (less than 3 inches) muck layer at surface but this is not usual. The soils are generally unaugerably wet by 24 inches.

These soils are mostly in the Bijat family of the Gley great soil group but those soils with a thin muck surface layer qualify for Sebandi family.

Table 17

Summary of Soil Mapping Units at Oya Road Sites

Mapping Unit (see Map 6)	Brief Description	Sarawak Classification			Occurrence (Sites)	Representative Profiles (see Appendix)
		Great Soil Group[1]	Family[1]	Series		
Nyl	Yellowish brown sandy loam, over brownish yellow slightly yellow mottled sandy loam, over brownish or reddish yellow sandy clay loam with moderate mottling and clayskins, becoming increasingly stony with depth.	Red Yellow Podsolic	Nyalau	-	A, B, C	S 713-19 S 720- 8 S 746-51 F3BA
Bkn	Yellowish brown sandy loam - sandy clay loam, over brownish yellow slightly mottled sandy clay loam, over brownish or reddish yellow sandy clay with moderate mottling and clayskins.	Red Yellow Podsolic	Bekenu	? Likau[2]	A, B, C	-
Mrt	Yellowish brown clay loam, over brownish yellow clay loam - clay with moderate yellow, reddish yellow mottling, over reddish yellow clay with moderate-strong light red, yellowish red, yellow mottling and clayskins.	Red Yellow Podsolic	Merit	-	A	-
(Ltn)	Olive brown sandy clay loam, over brownish yellow strongly mottled sandy clay, over quartz stone line, over mixed light red, yellowish red, white 'corned beef' clay - silty clay	Red Yellow Podsolic	Merit	Lutong[2]	D, E, F	F3BD
(Bnd)	Dark greyish brown loam, over deep light grey, pale yellow or very pale brown silty loam - loam which goes to silty clay - silty clay loam at depth. Moderately yellow mottled throughout.	**Grey White Podsolic or Gley**	Kerait or Semadoh	Bandang[3]	D, E, F	S 705-12 S 738-45

Table 17 (contd.)

Srt	Dark greyish brown sandy loam, over deep light grey, pale yellow or very pale brown sandy loam, which may be weakly yellow and reddish yellow mottled.	Grey White Podsolic	Saratok	-	B, E	F3BB
(Ltn-Bnd)	Greyish brown loam - sandy clay loam, over mixed reddish yellow brownish yellow, very pale brown and light grey sandy clay - silty clay going to clay - silty clay at depth.	Intergrade Red Yellow Podsolic - Grey White Podsolic	Merit - Kerait	-	D, F	-
Bkn-Krt	Greyish brown sandy clay loam, over mixed reddish and brownish yellow, very pale brown and light grey sandy clay loam going to sandy clay at depth.	Intergrade Red Yellow Podsolic - Grey White Podsolic	Bekenu - Kerait	-	B, E, F	F3BC
Nyl-Krt	Greyish brown sandy loam, over mixed reddish and brownish yellow, very pale brown and light grey sandy clay loam.	Intergrade Red Yellow Podsolic - Grey White Podsolic	Nyalau - Kerait	-	E	-
Nyl-Srt	Greyish brown sandy loam, over mixed reddish and brownish yellow, very pale brown and light grey sandy loam.	Intergrade Red Yellow Podsolic - Grey White Podsolic	Nyalau - Saratok	-	C, E	-
Bjt	Wet, gleyed, heavy textured alluvial soil.	Gley	Bijat	-	A, B, D	-

Notes:

(1) According to the current Sarawak classification (Sarawak Soil Survey Staff, 1966).

(2) According to Scott (1964 (c)).

(3) According to Scott (1965).

2.7 Nyabau

2.7.1 General

This site lies in the southern part of the Similajau Forest Reserve. It is close to the true left (south) bank of Sg. Sebatang, about ½ mile from the mouth (see Map 1 and inset to Map 7). Access is by boat from Bintulu and in good weather the journey takes less than an hour. However the trip involves going round from Kuala Bintulu to Kuala Sebatang on the open sea, which means access is not possible by small boat during bad weather.

About 4 acres have been cleared for plots, but only about half of this has been so far used. There are 10 normal size performance trial plots (64 trees). In addition there is one performance trial plot (Plot 11) which is planted with 64 trees of Eucalyptus deglupta but at a planting interval of 12, rather than the normal 8, feet. There are 2 arboretum-sized (25 trees) observation plots and 12 arboretum-sized fertiliser trial plots.

2.7.2 Climate

The only long term meteorological station in the vicinity is 6 miles away at Bintulu, where there has been a rain gauge in discontinuous operation since 1915. There is also an autographic rain gauge at the Nyabau dam, which is less than 2 miles from the site, but this is a fairly recent installation and has available data for only 5 years. The rainfalls at the Bintulu and Nyabau gauges are summarised in Table 18.

Table 18

Rainfall at Bintulu and Nyabau dam

(i) Bintulu (46 years to 1968)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	15	11	11	10	10	11	9	11	12	16	16	18	151
Maximum	50	32	26	20	19	21	22	21	27	41	25	36	202(1)
Minimum	4	1	3	3	2	2	1	1	5	7	10	3	122(1)

(ii) Nyabau dam (5 years to 1968)

Mean	21	9	8	10	9	11	12	11	10	13	16	19	149
Maximum	50	18	11	16	15	17	19	16	14	21	24	29	-
Minimum	9	3	5	7	1	8	4	5	6	6	11	14	-

Notes: Figures to the nearest inch.

(1) These figures refer to 31 completed years only.

(from Drainage and Irrigation Department Hydrological Yearbooks (1962-8) and Seal (1958)).

The two stations are clearly very similar, as the high January mean for Nyabau is caused by the exceptionally heavy rainfall in January 1963. The distribution is slightly seasonal, with the maximum occurring during the North East monsoon, but the effect is less marked than for the stations in West and Central Sarawak. The climate is of the type 1A (continuously wet)in the classification of Mohr and van Baren (1954).

The rainfall at the site is probably very similar to those at Bintulu and Nyabau as they are all in topographically similar situations.

There has been a Class A evaporation pan in operation at Bintulu since April 1963. The data from this installation are summarised in Table 19.

Table 19

Evaporation at Bintulu

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	5.9	5.1	6.0	6.4	6.0	6.1	5.9	6.2	6.1	5.9	5.9	5.7	71.3
Maximum	6.5	5.7	6.8	7.0	6.9	6.5	6.5	6.8	6.2	6.6	6.5	6.0	73.6
Minimum	5.6	4.8	5.3	5.8	5.0	5.6	5.4	5.4	5.8	5.3	5.4	5.4	69.5

Figures to the nearest 0.1 inches

(from Drainage and Irrigation Department Hydrological Yearbooks 1962-68).

From Table 19 it can be seen that evaporation is relatively invariable during the year and from year to year. Fluctuations in the moisture balance are almost entirely due to variations in the rainfall.

2.7.3 Soil Parent Materials

Because of the economic possibilities of its coal, oil, glass sand and heavy mineral beach sands, the Bintulu area has been visited fairly often by geological parties, the first recorded being in 1913. Much of the earlier work was incorporated into the report of the reconnaissance geological survey of the Upper Rajang and adjacent areas (Kirk, 1957). Although his general mapping scale was only 1:250,000, Kirk investigated the coastal region from Tanjong Kidurong to Tanjong Batu (see inset to Map 7) in detail because of his interest in the ilmenite-zircon beach sands. The site is therefore covered by a 1:40,000 map (Kirk, 1957 p.144). However the boundaries in the area of the site on this map are extremely indefinite, and the site is tentatively mapped as recent alluvial mud and silt deposits.

In a more recent detailed geological study of the Bintulu area (Kho, 1968), the site did not come within the area of the general survey, which was mapped at a final scale of 1:50,000. However the same report includes an assessment of the glass sand potential of the area, illustrated by detailed (ca 1:14,000) map of the deposits in the vicinity of the site. According to this map, the site is situated on the old raised beach sand deposits. This accords with the topography, vegetation and soils (see 2.7.4-7 below).

These sands consist of almost pure quartz. Total chemical analysis shows that the sand has an exceptionally high silica content (99.5%+ in all samples) (Kho, 1968) and the only rather high iron and titanium contents chemically disqualify the samples from being graded as highest quality glass sand (Kirk, 1957). The other drawback with the samples is the excessive proportion of fine sand and silt size grains. The mechanical analyses of 4 samples taken in the area south of Sg. Sebatang are listed in Table 20.

Table 20

Mechanical analyses of Sebatang area raised beach sand samples

Grain size (microns)	>833	833-495	495-246	246-175	175-147	147 >
USDA(1) fraction (approximate equivalent)	Coarse very coarse sand	Coarse sand	Medium sand	Fine sand	Fine sand	Fine sand, silt and clay
Sample number (as in Kho, 1968)						
5	-	1	49	21	9	19
6	1	1	39	13	12	34
7	-	3	37	25	24	18
8	-	-	70	17	6	6

Notes: Figures to the nearest 1%

(1) USDA fractions are those given in the 7th Approximation (Soil Survey Staff, 1960).

Analyses by Central Glass Co., Osaka, 1964, (quoted in Kho, 1968).

The sands vary in thickness from 1 to 20 feet. They generally overlie heavier textured deposits, which often have very high silt contents (Kirk, 1957). Over most of the site it is not possible to estimate the thickness of the sand because of the impenetrable humus pan, but in Profile F4C there is sand to a depth of more than 10 feet.

2.7.4 Topography

The site occupies the top of an old raised beach deposit and there is no overall gradient, but there are considerable surface irrgularities, especially in the south eastern corner. The raised beach is about 30 feet above present mean sea level. There is series of raised beaches and wave cut rock benches at this level in the area and they are thought to have been formed during a mid-Pleistocene trangression of the sea from well below its present level. Since their deposition, the sea has regressed in at least two stages, leaving another terrace at 6-10 feet above present mean sea level (Kho, 1968).

2.7.5 Original Vegetation

The site was covered in Kerangas forest prior to clearing. This type of forest is very typical of podsolised soils on siliceous parent materials. It is characterised on aerial photographs by an even, small-crowned canopy, which is usually 80-100 feet high. Common indicator tree species are Casuarina sumatrana, Agathis alba and Dacrydium becarii var. subelatum (Wood and Beckett, 1961).

2.7.6 Previous Soil Survey Coverage

The site is in the area covered by the Bintulu - Labang reconnaissance soil survey (Wall, 1963). It was mapped as being covered by podsols of the Miri and Buso families. No field investigations were carried out in the vicinity of the Sebatang and the mapping was done by aerial photograph interpretation.

In an earlier generalised account of the soils of the Bintulu area (Wood and Beckett, 1961), no mapping was attempted but several profile pits were dug in kerangas forest, including one near the true left (south) bank of Sg. Sebatang, to the west of the site. Unfortunately the description and analyses from this profile pit are not included in the published account.

2.7.7 Soils

2.7.7.1 General

The aerial photograph interpretation of Wall (1963) is confirmed by field observation, and the site is entirely covered by soils of the Podsol great soil group. They are subdivided according to the degree of development of the humic B horizon. The mapping units are described individually in sections 2.7.7.2-3 and summarised in Table 21.

2.2.7.2 Podsols with Indurated Humic Pan: Mri

These are the more extensive soils on the site and underlie all the present plots.

The general profile morphology is as follows:

Thick litter layer (up to 16 inches).

over Dark greyish brown moist medium sand.

over Light grey - white, wet medium sand with many brown and pale brown streaks, especially on vertical crack faces.

over Hard, impenetrable, dark brown - dark reddish brown indurated sand.

(see Profile F4D in Appendix)

The indurated humic pan occurs at variable depth but, on the site, it is usually more than 20 inches below the beginning of the mineral profile. Because of its extreme induration, it was not possible to determine if the humic pan had been formed at,or just above,a boundary with heavier textured and less permeable material. However this is generally the case in podsols in lowland Sarawak (Andriesse, 1969). In an exposure of this soil along Sg. Sebatang, the humic pan is more than 4 feet thick. Although the white sand just above the pan was saturated, the bottom of the humic pan and the pale yellow sandy clay loam beneath it were only moist.

These soils are in Miri family in the Podsol great soil group according to the current Sarawak classification. Profile No.3 of Wood and Beckett (1961) is of this type, although the humic pan is very much deeper.

2.2.7.3 Podsols with Non-indurated Humic Pan: Bso

These soils are found in the eastern part of the site. Their profile morphology is very similar to that of the indurated pan podsols, except that the white and light grey sand is less wet, and the humic pan is thinner and not indurated sufficiently to prevent auger penetration. Beneath the humic pan there is a deep layer of the raised beach sand. For details of the profile morphology, see Profile F4C in the Appendix.

These soils are classified as members of Buso family in the current Sarawak classification. Profile description No.5 of Wood and Beckett (1961) is of this type.

Table 21

Summary of soil mapping units at Nyabau site

Mapping Units (see Map 7)	Brief Description	Sarawak Classification		Area (acres)	Representative Profile (see Appendix)
		Great Soil Group	Family		
Mri	Thick (up to 16 inches) litter layer, over thin grey brown sandy topsoil, over wet white, light grey medium sand, abruptly over thick, very indurated, dark brown humic pan	Podsol	Miri	3.2	F4D
Bso	Thick litter layer, over thin grey brown sandy topsoil, over light grey and white moist sand, over thin - medium friable humic pan, over deep (60 inches+) pale yellow and white sand.	Podsol	Buso	1.1	F4C

2.8 Lambir

2.8.1 General

The site lies in the 600 acres Government Reserve that was created especially for silvicultural research (Gazette Notification No.1306 of 13.6.69). The Reserve lies on either side of the Bakam feeder road, stretching from Mile 3 to Mile 4½. The site is situated to the north of the road at 4th Mile (see Map 1 and inset to Map 8) and, as it is immediately adjacent to the road, access is good.

About 3½ acres have been cleared but only about 1½ of these have been so far used. There is one performance trial plot (64 trees) planted with Eucalyptus deglupta, 12 arboretum-sized (25 trees) observation plots and 12 arboretum-sized fertiliser trial plots.

2.8.2 Climate

The nearest medium term meteorological station is at the old Lutong airport which is about 12 miles away. There were rainfall gauges at the P.W.D. road camps at 7th and 9th miles on the main Miri - Niah road, which were closer to the site, but the records from them cover only 2 or 3 years and are therefore not used.

The rainfall at Lutong airport is summarised in Table 22.

Table 22

Rainfall at Lutong airport

(25 years till 1968)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	13	7	6	6	8	10	8	10	12	12	13	12	111
Maximum	68	20	12	14	12	24	16	24	20	22	21	23	168
Minimum	2	1	3	0	2	1	0	2	5	9	2	6	94

Figures to the nearest inch.

(from Drainage and Irrigation Department Hydrological Yearbook, 1968 and Seal (1958)).

From Table 22 it can be seen that the Lambir site probably experiences a drier and less seasonal climate than any of the others. However it should be noted that the site is situated on the seaward foot hills of the Lambir range, so that it may receive a significant amount of localised orographic rain which does not fall at Lutong. Until there is a raingauge established at the site, the quantity and reliability of this additional rainfall will remain uncertain.

As a corollary of its lower rainfall, Miri experiences more sunshine than stations in central and West Sarawak (Seal, 1958). There has been a Class A evaporation pan in continuous operation at the new Miri airport since 1963 and, predictably, the evaporation is slightly higher than for any other evaporation pan in Sarawak. The evaporation data for Miri are summarised in Table 23.

Table 23

Evaporation at Miri

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean	5.3	5.7	6.4	6.7	6.7	6.6	6.6	6.7	6.3	6.1	5.7	5.6	74.2
Maximum	6.6	6.7	7.1	7.5	7.4	7.5	7.4	7.1	6.7	6.3	6.3	6.0	80.9
Minimum	4.9	4.9	5.9	6.1	5.8	6.0	6.2	6.2	5.1	5.6	4.9	4.8	71.0

Notes: Figures to the nearest 0.1 inches.
(from Drainage and Irrigation Department Hydrological Yearbooks 1962-8).

2.8.3 Soil Parent Material

The site is underlain by rocks of the Tukau or Lower Miri Formations (Wilford, 1961). These are very similar and cannot be distinguished in the absence of fresh outcrops. They consist of interlayered sandstones, shales and lignites. There are no outcrops on the site, but nearby road cuttings and the preponderance of light textured soils show that the sandstones are locally dominant. These are soft and poorly consolidated, yellow or grey coloured when fresh, and mostly fine or medium-grained. The subordinate shales are yellow and bluish grey and are not found in beds of thickness greater than 2 feet. There are no traces in the vicinity of the site of the lignitic members, nor of the conglomeratic sandstone noted elsewhere in the Tukau formation (Wilford, 1961).

These rocks are thought to have been deposited on the south western shoulder of the north west Borneo Geosyncline during Late Miocene - Pliocene times (Tf - Tgh). Since deposition the rocks of the region have been subject to moderate folding. The site is situated on the southern flank of the Liku syncline and the beds dip gently northwards at angles of 10-20°.

A prominent feature of these rocks is the abundance of interlayer sheets of ferricrete. These may be up 2 inches thick and are harder and less permeable than the surrounding rocks, especially when the latter are weathered. There are also fragments of 'pipestone', which is the local name given to old root channels that have been petrified by concentric

ferricrete deposition. As pieces of pipestone are exposed in cuttings, embedded in rocks up to 40 feet below the present land surface, it is clear that they are not of recent formation, and probably date from the time when the rocks were being deposited in shallow, brackish water. In such conditions the precipitation of ferric oxides and hydroxides road root channels, with their immediate surroundings of positive redox potentials, is not suprising and rust-coloured root channels are common features in most poorly drained soils. However, if the interlayer ferricrete sheets were also precipitated during the deposition of the sediments, it is less obvious what initiated their formation.

2.8.4 Topography

The Reserve lies in the northern foothills of the Lambir range. The hill summits are low (up to 350 feet above mean sea level) but the topography is fairly rugged because of the high density of drainage lines and their deep dissection. The drainage is generally eastwards, i.e. parallel to the strike of the underlying rocks, but the pattern appears to be dendritic and not subject to strong lithological control.

The site is situated on the crest and upper slopes of a north-south aligned ridge. The crest is very narrow and is marked by the tractor path on Map 8. The upper slopes are moderately steep, with gradients in the 20-30° range.

Landslips are a common feature in the Reserve and in the Lambir Development Scheme to the east, but there are none on the site. These landslips are thought to be caused by a combination of very intense precipitation, high surface soil infiltration rates, the presence of sub-surface layers of markedly lower permeability, and poor soil cohesion. The coarse-textured surface horizons become saturated and slip during heavy rain if there is a subsoil horizon of heavier texture or a layer of impermeable sheet ferricrete. Many of the landslips visible on the post - 1963 aerial photography are thought to have been formed during the exceptional rainfall in the 1962-3 landas. It is interesting that these slips occurred in areas under non-exploited Mixed Dipterocarp Forest as well as in areas of secondary growth and shifting cultivation. For more detailed discussion of these landslips, see Wall (1965). If large scale afforestation planting should ever take place in this area and if coincided with exceptionally heavy rains, landslips would be a possible hazard.

2.8.5 Original Vegetation

Until 1964 the whole area was part of the Lambir Forest Reserve and was under largely undisturbed Mixed Dipterocarp Forest. By the 2nd excision (Gazette Notification No.L.N.46 of 2.3.1964), the Lambir Forest Reserve was restricted to the area the proposed Lambir Hills National Park. Part

of the excised area, including all of what is now the Silviculture Reserve was exploited under licence by Yong Khaw Timber Co. The site itself was clear-felled early in 1967.

2.8.6 Previous Soil Survey Coverage

The site lies in a delineation of the compound Nyalau/Bekenu mapping unit in the Bekenu-Niah-Suai reconnaissance soil survey (Wall, 1962 and 1966) indicating a cover of Red Yellow Podsolic soils of light and medium textured.

Part of the Lambir Development Scheme, about 1 mile to the east of the site, has been mapped at semi-detailed level (Wall, 1965). In that area, the upper and middle hill slopes are covered almost entirely with Red Yellow Podsolic soils, which range from Merit family (heavy texture) through Bekenu family (medium texture) to Nylau family (light texture), according the relative proportions of the shale and sandstone in the parent material.

2.8.7 Soils

The site is entirely covered with light textured Red Yellow Podsolic soils. The basic profile morphology is as follows:

Discontinuous thin litter and ash layer.

over Yellowish brown, often mottled grey, friable, crumb.

over Yellow or brownish yellow with faint reddish yellow mottles, weak subangular blocky.

over Reddish yellow with common distinct yellow and light - grey mottles. Texture heavier than above horizon, weak subangular blocky with strong clayskins. This horizon becomes increasingly stony with depth and gradually merges into soft weathering sandstone, generally at depths of 30-48 inches.

These soils are classified as members of Nyalau family in the Red Yellow Podsolic great soil group. They are subdivided into Nyalau and Peninjau series on subsoil texture. In Nyalau series the topsoil is generally sandy loam, going to sandy clay loam in the subsoil. Peninjau series soils are lighter textured, with loamy sand topsoils and subsoils that are not heavier than sandy loam. In both series the sand fractions are predominantly medium-grained.

The soil mapping units are summarised in Table 24.

Table 24

Summary of soil mapping units at Lambir site

Mapping Unit (see Map 8)	Brief Description	Sarawak Classification			Area (acres)	Representative Profile (see Appendix)
		Great Soil Group(1)	Family(1)	Series(2)		
(Nyl)	Yellowish brown sandy loam, over brownish yellow faintly mottled sandy loam, over reddish yellow distinctly mottled sandy clay loam with strong clayskins. This horizon increasingly stony with depth and merges into weathering sandstone at 30 - 48 inches.	Red Yellow Podsolic	Nyalau	Nylau	3.4	F4A F4B
(Pnj)	Colours as above, but topsoil texture is loamy sand and subsoil not heavier than sandy loam.	Red Yellow Podsolic	Nyalau	Peninjau	0.3	-

Notes:

(1) According to the current Sarawak classification (Sarawak Soil Survey Staff, 1966)

(2) According to Wall (1966)

3. Range Covered by Sites

3.1 Climate

The climate of Sarawak is uniform and is characterised by even warm temperatures, high rainfall and high relative humidities. Temperature varies so little from month to month and from station to station that it can be treated as a constant for the whole state, except for high montane areas, so that any subdivision into climatic types can be defined primarily in terms of the quantity and seasonal distribution of the rainfall.

The generalised mean annual rainfall map of the country, compiled by the Department of Civil Aviation (1961), shows that over 80% of the country receives between 120 and 160 inches rainfall per annum. Only limited areas in the 5th Division and the Rejang delta receive less than this and areas in the 1st Division and along the Kalimantan border in the 3rd and 4th Division receive more. Thus the sites, which vary between 160 inches (Semengoh) and 115-120 inches (Lambir), cover most of the range.

The effect of the Northeast monsoon decreases towards the north and east and the rainfall distribution within the year is most seasonal in West Sarawak and most even in the 5th Division (Seal, 1958). However the pattern appears to be complex, with great local variations, and until medium and long term records for more stations are available, it is not possible to be more precise. The sites probably cover the range fairly well with Semengoh having the most seasonal and Lambir having the most even distribution.

3.2 Geology

The rocks of Sarawak can be roughly divided into 6 formations. The igneous rocks are treated as one formation, irrespective of age or composition, because of their relative unimportance. The remaining five formations are sedimentary rocks, subdivided according to age. The approximate areas of the outcrops of the rocks of each formation are listed in Table 25, together with distribution of the sites.

Table 25

Geological Distribution of Sites

Formation	Area of outcrop as % of State	Site
Quaternary sediments	16	1 Nyabau
Tertiary - Neogene sediments	28	1 Lambir
Tertiary - Palaeogene sediments	38	4 Jakar, Pakan Road, Oya Road, Bukit Temudok
Upper Cretaceous sediments	11	-
Pre-Upper Cretaceous sediments	4	1 Semengoh
Igneous	4	-

(from Sarawak Annual Report, 1959)

If the location of further sites were to be decided only on geological grounds, then the outcrops of the Neogene and Upper Cretaceous sediments should be favoured. However it is not known whether age differences between otherwise similar sedimentary rocks are pedogentically or edaphically significant, so that the imbalance in the present geological distribution of sites may not be at all important.

3.3 Topography

The state can be roughly divided into 5 major landscape types. These are the coastal swamps, the raised beaches, the interior vallies, the rolling hilly country and the rugged mountainous area of the interior.

The coastal swamps, both peat and tidal, and the raised beaches occur as a discontinuous fringe of variable width along the coast. The alluvial areas of the interior vallies are not extensive, but may be of considerable local agricultural importance.

Most of the interior of the country is hilly or mountainous, the relief becoming greater and the slopes steeper away from the coast. This area is arbitrarily divided into the rolling hills of the pericoastal areas and the steep mountainous land of the interior, but the boundary between them is very gradual. The rolling hilly country consists mostly of the intensely dissected remnants of the 200-350 feet peneplain. Where rocks of unusual hardness outcrop, positive lithogenic features such as Bukit Temudok stick out of this landscape. The mountainous interior rises to altitudes of more than 2000 feet and slopes steeper than 30° are common. The summits generally appear concordant and may be the remnants of a Tertiary erosion surface.

Until the current 1:50,000 topographic survey of the state is complete, estimates of the extent of each landscape type are inevitably tentative. The figures in Table 26 below are taken from the estimates of Dames (1962) and the Sarawak Soil Survey Staff (1969).

Table 26

Topographic Distribution of Sites

Landform	Area as % of State		Site
Coastal swamps	13		-
Raised beaches	1	1	Nyabau
Interior vallies	3		-
Rolling hilly country	20-25	6	Semengoh
			Bukit Temudok
			Jakar
			Pakan Road
			Oya Road
			Lambir
Steep mountainous country	60-65		-

Table 26 shows that there is a strong imbalance in the topographic distribution of the current sites. The emphasis on the rolling hilly country is, in fact, slightly exaggerated as the Bukit Temudok site is an area which is considerably higher and more rugged than the surrounding rolling terrain. However Bukit Temudok is an isolated lithogenic feature and is not typical of the mountainous country of the interior.

3.4 Vegetation and Land use

It is not yet known if the type of vegetation or land use prior to planting has any effect on the performance of the planted trees. If such an effect is found by analysis of the performance of the trees on the current plots, the figures in Table 27 will be of interest. The areas of the land use and vegetation types are taken from the Lands and Surveys Department's planimetric estimates of 1966.

Table 27

Land use and Distribution of Sites

Land use or Vegetation type	Area as % of State	Sites
Settlement and permanent crops (including wet padi)	4	-
Swamp forest (coastal and peat)	13	-
Kerangas forest	3	1 Nyabau
Hill padi land and secondary forest	20	4 Bukit Temudok, Jakar, Pakan Road, Oya Road
Hill forest	60	2 Semengoh, Lambir.

Strictly speaking the Semengoh site was covered with secondary forest at the time of planting, but it had only been cleared and burnt once.

The swamp forests are discounted for this type of afforestation, so that it is clear from Table 27 that the major imbalance in the distribution of the present sites is that the secondary forest is overrepresented and there are insufficient sites on land previously covered by virgin hill forest. This emphasis on the degraded land of the lowland parts of the 1st, 2nd and 3rd Divisions is intentional as this land is largely unproductive, even for hill padi, and an alternative, profitable use for it would be most welcome.

3.5 Soils

By the end of 1968, over 32% of the state had been covered by reconnaissance soil surveys. From this base and by aerial photograph interpretation, a soil map covering the whole state at a scale of 1:500,000 was prepared and published (Sarawak Soil Survey Staff, 1968). The area of each of the 12 simple mapping units used was measured by the grid-count method and the results are summarised in Table 28 below. Where compound units were mapped, the area covered was split equally between the component simple units.

Table 28

Great Soil Groups and Distribution of Sites

Mapping Unit		Area as % of State (1)	Sites (2)
1	Skeletal soils	1	-
2	Brown Forest and associated skeletal soils	Tr	-
3	Lateritic and associated skeletal soils	1	-
4	Shallow Red Yellow Podsolic and associated skeletal soils	63	-
5	Red Yellow Podsolic soils, generally moderately deep	14	6 Semengoh Bukit Temudok Jakar Pakan Road Oya Road Lambir
6	Grey White Podsolic soils	1	1 Oya Road
7	Podsols	1	1 Nyabau
8	Gley soils	3	1 Oya Road
9	Saline gley soils	2	-
10	Shallow peat soils)	11	-
11	Deep peat soils)		-
12	Recent alluvial soils	1	-

Notes:

(1) To the nearest 1%.

(2) Very small areas not covered by current plots are ignored.

From Table 28 it is clear that the current plots are disproportionately concentrated on the deeper Red Yellow Podsolic soils, at the expense of the more extensive shallow and stony Red Yellow Podsolic and associated skeletal soils. This imbalance stems from that shown in the topographic distribution. The deeper Red Yellow Podsolics are the dominant soils of the rolling hilly country, whereas the shallower soils are dominant in the more rugged interior.

The only other extensive soil type without coverage by the present sites are the deep peats. This is intentional as it is not anticipated that afforestation of these areas with the exotic species under test will be necessary or successful.

4. Conclusions

As mentioned above, the concentration of the present plots in the low hilly zone, with its predominantly secondary vegetation and deep Red Yellow Podsolic soils, is intentional. This type of land has several practical advantages for bulk cellulose production. It is easier to clear, termite infestation and damage is less likely, and it is more accessible. At present it is used for shifting cultivation of declining productivity, and an alternative and profitable use would be most welcome.

However this land is highly encumbered with customary rights and, increasingly, title deeds. If bulk cellulose production proves economically feasible it may be necessary to consider supplementing lowland plantations with areas in the rugged interior. Land pressure and encumberance is much less in these areas.

The present plots can give no indication of the potential and problems of afforestation with fast growing species on the steep slopes and shallow soils that predominate in the interior. If further research into this type of afforestation is to be given high priority by the Forest Department, the siting of some plots in the rugged interior should be considered. At present there are no suitable areas under permanent Forest Department control that are readily accessible to the Silvicultural Research Section, which is based in Sibu.

Appendix

Soil Profile Descriptions and Analyses

The profiles listed below are described along the lines laid down in the Soil Survey Manual (Soil Survey Staff, 1951). The Munsell System is used for the soil colours, which were determined in the field moisture condition at the time of sampling and description. The chemical and mechanical analyses were carried out at the laboratory of the Department of Agriculture's Research Centre at Semongok, using the methods described in Sim (1965).

In Table 29 the profiles are listed by sites. Those preceded by an 'F' were described and sampled by the writer in the the course of this survey. Those preceded by an 'S' were described and sampled by I.M. Scott in 1965.

Table 29

Soil Profiles Distribution

Map Number	Site	Profile	Mapping Unit
2	Semengoh	F1A	(Sem)
		F1B	(Sem)
		F1C	Mrt
		F1D	Mrt-Krt
3	Bukit Temudok	F2B	Bkn
		F2C	Mrt
		F2D	Nyl
		F2E	Mrt
4	Jakar	F3A	Bkn
		F3B	Bkn
5	Pakan Road	F3C	Bkn
		F3D	
6	Oya Road	S705-12	(Bnd)
		S713-20	Nyl
		S721-28	Nyl
		S738-45	(Bnd)
		S746-51	Nyl
		F3BA	Nyl
		F3BB	Srt
		F3BC	Bkn-Krt
		F3BD	(Ltn)
7	Nyabau	F4C	Bso
		F4D	Mri
8	Lambir	F4A	(Nyl)
		F4B	(Nyl)

Profile F1A

Mapping Unit: Mottled yellow clay: (Sem)

Sarawak classification: G.S.G. Red Yellow Podsolic — Family Merit — Series Semongok

Location: Between plots 3 and 4 in pine plantation (see Map 4).
Topography: Upper slope (gradient 14°) of low rounded hill.
Parent material: Bau Formation shale
Vegetation: Lallang (Imperata cylindrica).

¼-0 Litter.

0-2 25Y 4/4 (olive brown) sandy clay, moderate coarse granular, moist-wet, friable, but very slightly sticky and plastic, many roots, much charcoal.

Clear regular boundary

2-5 25Y 4/4 (olive brown) and many medium distinct 25Y N5/(grey), 25Y 7/6 (yellow), 10YR 6/6 (brownish yellow) mottles, clay loam, moderate medium subangular blocky with moderate discontinuous clayskins, moist, firm, slightly porous, many roots, much charcoal.

Clear wavy boundary

5-13 10YR 6/6 (brownish yellow) and many medium-coarse 25Y 7/4 (pale yellow) and few medium distinct 75YR 5/8 (strong brown) mottles, clay loam, weak coarse subangular blocky with strong continuous 75YR 5/4 (brown) and 10YR 5/6 (brown) clayskins, moist, firm, roots common.

Diffuse boundary

13-25 As above but texture is clay and roots decrease to few.

25-38 Mixed 5YR 6/8 (reddish yellow), 7.5YR 7/8 (reddish yellow) and 2.5Y 8/4 (pale yellow) with a few medium distinct 25Y N6/ (grey) mottles, clay, moderate weak fine subangular blocky with weak discontinuous clay skins, moist, firm, scattered fine angular quartz grit, few roots.

Gradual wavy boundary

38-50 As above but in addition to the fine angular quartz, there are also rounded quartz pebbles of up to 4" diameter. From 44-50 inches there also fragments of dark red and yellow brown medium sandstone. No roots

Gradual regular boundary

50-60+ Mixed 5YR 6/8 (reddish yellow), 10YR (brownish yellow), 7.5YR 6/8 (reddish yellow) and 2.5 N7/ (light grey), clay with patches of 2.5Y 7/8 (yellow) and 10R 5/4 (weak red) sandy clay, structureless - massive, moist, firm, plastic, slightly sticky, scattered fine angular quartz grit, no roots.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 2	4.7	2.5	0.18	170	420	750	1590	9.6	4.6	5.2	36.7	15.8	35.8	Sandy clay
2	2 - 4	4.8	1.7	0.12	120	210	930	1830	10.1	3.2	3.8	33.6	20.7	33.4	Clay loam
3	7 -10	4.7	0.4	0.05	100	60	1190	2120	13.6	3.3	4.6	35.5	25.5	33.2	Clay loam
4	16-20	4.9	0.2	0.05	100	110	1140	2450	14.7	2.6	3.3	31.0	18.1	46.4	Clay
5	30-34	4.8	0.1	0.06	130	110	1680	3420	18.3	1.7	2.1	21.5	18.9	60.1	Clay
6	54-58	4.7	0.1	0.09	180	110	2310	6110	26.7	5.3	1.2	6.4	20.2	69.4	Clay

	Exchangeable me./100gms Ca	Mg	K	Na
Sample 1	1.1	1.1	0.2	0.1
2	0.7	0.5	0.2	0.1
3	0.2	0.7	0.1	0.1
4	0.1	0.6	0.1	-
5	0.4	0.2	0.1	0.1
6	0.3	0.3	0.2	-

Profile F1B

Mapping Unit. Mottled yellow clay: (Sem)

Sarawak classification	G.S.G.	Family	Series
	Red Yellow Podsolic	Merit	Semongok

Location: Between plots 7 and 11 in pine plantation (see Map 4).
Topography: Upper slope (gradient 6°) on low rounded hill
Parent material: Bau Formation shale.
Vegetation: Lallang (Imperata cylindrica)

0-1 2.5YR 3/2 (very dark greyish brown), clay loam, moderate medium crumb, moist, friable, many roots, much charcoal.

Clear regular boundary

1-3 2.5YR 4/2 (dark greyish brown) and many medium distinct 2.5Y 7/4 (pale yellow), 7.5YR 6/8 (reddish yellow) mottles, clay, weak medium subangular blocky with very weak discontinuous clay skins, moist, firm, few roots, occasional charcoal.

Clear wavy boundary

3-11 10YR 6/8 (brownish yellow) and many medium distinct 2.5Y 7/4 (pale yellow) and 2.5Y 7/2 (light grey) mottles, clay, strong-moderate coarse subangular blocky with moderate discontinuous clay skins, moist, firm, roots rare

Diffuse boundary

11-22 7.5YR 6/6 (reddish yellow) and many medium distinct 5Y 7/1 (light grey) and 5Y 8/3 (pale yellow) mottles, clay, moderate medium-coarse subangular blocky with strong continuous yellow clay skins, moist, very firm, roots rare.

Diffuse boundary

22-32 Mixed 5YR 6/8 (reddish yellow), 2.5Y 8/4 (pale yellow) and 2.5Y 7/2 (light grey), clay, very weak coarse subangular blocky, moist, firm, no roots, scattered fine angular quartz grit, many stones of dark red shale

Clear wavy boundary

32-52+ Fragments of soft and slightly dark brown and dusky red hard shale and fine sandstone set in mixed 7.5R 5/8 (red), 10YR 5/1 (grey), 10YR 7/1 (light grey), 10YR 7/6 (brownish yellow) and 10YR 8/6 (yellow), clay, structureless - massive, moist, firm, no roots.

Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
0 - 2	4.5	7.7	0.47	310	680	1300	1910	11.0	5.2	4.0	19.8	33.9	43.8	Clay
1 - 3	4.5	3.2	0.25	180	220	1180	2190	12.8	3.0	1.6	17.8	31.7	45.2	Clay
5 - 9	4.6	0.8	0.10	150	180	1540	2580	15.2	0.5	0.5	20.9	25.6	54.7	Clay
13-18	4.6	0.4	0.05	150	Tr	1400	2940	18.4	1.4	2.2	18.7	31.3	54.5	Clay
26-30	4.7	0.3	0.12	150	110	1950	3900	22.0	1.1	0.6	12.3	13.1	69.8	Clay
40-44	4.6	0.3	0.08	170	220	2730	4780	21.8	3.3	0.8	7.1	24.4	67.5	Clay
48-52	4.6	0.3	0.07	260	220	2430	5590	21.8	0.5	0.3	6.8	7.7	89.2	Clay

	Exchangeable me./100gms Ca	Mg	K	Na
Sample 1	2.6	1.7	0.3	0.1
2	0.8	0.8	0.2	0.1
3	0 2	0.6	0.2	0.1
4	0.1	0.4	0.2	0.1
5	0.1	0.4	0.2	0.1
6	0.1	0.4	0.2	0.1
7	0.1	0.4	0.2	0.1

Profile F1C

Mapping Unit: Pale coloured mottled clay: (Mrt - Krt)

Sarawak classification:	G.S.G.	Family	Series
	Red Yellow - Grey White Podsolic	Merit-Kerait	Semongok variant

Location: North west corner of cleared area in pine plantation (see Map 4)
Topography: Bank of upper part of dry gully (gully gradient 9°).
Parent material: Gully wash derived from Bau Formation shale
Vegetation: Secondary growth

0-2 10YR 5/4 (yellow brown), gritty fine sandy clay loam, moderate fine crumb, moist, friable, many roots, common angular quartose coarse sand-fine grit.

Clear regular boundary

2-6 10YR 6/3 (pale brown) and many fine distinct 10YR 6/4 (light yellow brown) and 10YR 6/8 (brownish yellow) mottles, clay, moderate fine angular blocky with strong continuous pale brown clay skins, moist, slightly firm, slightly porous ped interiors, frequent angular quartz grit.

Gradual wavy boundary

6-14 10YR 7/4 (very pale brown) and many medium distinct 7.5YR 6/8 (reddish yellow) and 2.5Y 6/2 (light brownish grey) mottles, clay, moderate-weak medium subangular blocky with strong continuous 10YR 5/3 (brown) clay skins, moist, firm, common roots, common angular and rounded quartz pebbles (up to ½" diam.).

Gradual wavy boundary

14-28 Mixed 10YR 7/3 (very pale brown), 2.5Y 7/2 (light grey), 5YR 6/8 (reddish yellow) and few medium distinct 2.5YR 5/6 (red), 7.5YR 7/8 (reddish yellow) mottles, gritty clay, weak coarse subangular blocky with moderate continuous 10YR 6/4 (light yellow brown) clay skins, moist, firm, grit is angular and rounded quartz, few roots.

Diffuse boundary

28-42 7.5YR N7/ (light grey) and many medium distinct 10YR 6/4 (light yellow brown) and few fine prominent 5YR 7/8 (reddish yellow) mottles, few discontinuous patches with common medium distinct 2.5YR 5/6 (red), 7.5YR 6/8 (reddish yellow) mottles, clay, massive - very weak coarse subangular blocky with weak discontinuous 10YR 6/3 (very pale brown) clay skins, moist, very firm, slightly plastic but not sticky, scattered fine angular and rounded quartz grit no roots

Diffuse boundary

42-66+ Very heterogeneous gully wash material. Variation lateral as well as vertical Mixed 7.5YR 6/8 (reddish yellow) 2.5YR 5/6 (red), 10YR 7/1 (light grey), 10YR 6/3 (pale brown), 10YR 7/4 (very pale brown), texture varies clay - sandy clay loam - silty clay - fine sandy clay, structureless-massive, moist, very firm, plastic, slightly sticky, no roots.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 2	4.6	3.6	0.26	150	220	1370	2010	12.7	9.7	9.9	30.8	25.7	29.1	Sand clay loam
2	2 - 6	4.5	1.5	0.16	110	220	1430	2550	17.5	7.7	8.1	20.8	20.2	41.5	Clay
3	8 -12	4.7	0.5	0.08	90	100	1850	2990	20.2	5.4	6.5	21.8	20.2	46.9	Clay
4	18-22	4.7	0.2	0.05	70	110	2470	3430	24.5	5.8	7.9	22.0	15.5	46.1	Clay
5	33-37	4.8	0.3	0.05	60	100	2130	3350	21.8	6.1	8.0	22.5	21.1	43.5	Clay
6	46-50	4.7	0.3	0.04	60	100	1830	3060	23.1	5.4	8.2	28.3	19.6	38.9	Clay loam
7	62-66	4.4	0.4	0.04	60	100	1250	2340	20.0	3.3	7.1	29.3	18.9	40.0	Clay

Sample	Exchangeable me./100gms Ca	Mg.	K	Na
1	1.2	1.4	0.2	0.1
2	0.4	1.9	0.1	0.1
3	0.3	0.4	0.1	0.1
4	0.1	0.5	0.1	0.1
5	0.2	0.1	0.1	0.1
6	0.1	0.4	0.1	0.1
7	0.1	0.7	0.1	0.1

Profile F1D

Mapping Unit: Unmottled yellow clay: Mrt

Sarawak classification:	G.S.G.	Family	Series
	Red Yellow Podsolic	Merit	-

Location South west corner of cleared area in pine plantation (see Map 4).
Topography: Rounded summit of low hill (gradient ca 2°).
Parent material: Bau Formation shale.
Vegetation: Secondary growth - mostly lallang and resam.

1-0 Litter.

0-3 10YR 3/3 (dark brown), clay, moderate medium granular, moist, friable, abundant roots, scattered fine angular quartz grit.

Clear regular boundary

3-15 10YR 7/8 (yellow) and many fine faint 7.5YR hue (reddish yellow) mottles, clay, moderate medium subangular blocky with strong continuous 10YR 5/3 (brown) clayskins, moist, firm, roots common, scattered angular quartz stones.

Diffuse boundary

15-32 7.5YR 7/8 (reddish yellow) and common medium fine faint yellow and yellowish red mottles, clay, weak coarse subangular blocky with moderate continuous 10YR 6/4 (brownish yellow) clay skins, moist, firm, plastic, slightly sticky.

Gradual wavy boundary

35-45 7.5YR 6/8 (reddish yellow) and many medium distinct 5YR 6/8 (reddish yellow) and 2.5Y 7/4 (pale yellow) mottles, clay, weak coarse subangular blocky with moderate continuous 10YR 6/6 (brownish yellow) clayskins, moist, firm, plastic but not sticky, few roots, scattered fine angular quartz grit.

Diffuse boundary

45-68+ Mixed 7.5YR 6/8 (reddish yellow) and 10YR 7/8 (yellow) and many medium prominent 2.5Y 7/4 (pale yellow) and few fine very faint white mottles, clay, structureless-massive, moist, firm, sticky, plastic, no roots, scattered angular quartz grit.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 2	4.2	8.8	0.45	140	410	1490	1810	14.3	4.9	5.8	15.7	17.3	42.7	Clay
2	7 -11	4.5	1.2	0.12	80	120	1810	2840	20.8	5.6	5.9	19.7	15.7	52.9	Clay
3	22-26	4.6	0.6	0.07	70	Tr	2210	1120	20.6	5.5	5.8	19.8	14 5	53.9	Clay
4	36-40	5.0	0.3	0.06	80	50	2100	3160	25 3	4.6	5 5	17.9	13.8	58.0	Clay
5	48-52	4.9	0.3	0.05	70	220	2040	3670	28.4	4 4	5.1	18.3	6.7	60.3	Clay
6	64-68	4.9	0.2	0.05	80	20	2230	4120	30.2	3.9	3.8	16.1	14.6	61.0	Clay

Sample No.	Exchangeable me./100gms Ca	Mg	K	Na
1	0.2	1.8	0.4	0.1
2	0.1	0.4	0.1	0.1
3	0.1	0.5	0.1	0.1
4	0.1	0.4	0.1	0.1
5	0.1	0.8	0.1	0.1
6	0.1	0.8	0.1	0.2

Profile F2B

Mapping unit: Bkn (Map 3)

Sarawak classification:	G.S.G.	Family	Series
	Red Yellow Podsolic	Bekenu	-

Location: Road cutting between Bukit Temudok site and Telecommunications mast (see Map 3).

Topography: Summit of Bukit Temudok cuesta (gradient ca 15°).

Parent material: Temudok sandstone.

Vegetation: Secondary growth, including lallang and resam.

0-2 2.5Y 4/4 (olive brown), fine sandy clay loam, weak fine subangular blocky, moist, friable, many roots.

Gradual wavy boundary

2-5 Mixed 10YR 6/6 (brownish yellow) and 2.5Y 5/6 (light olive brown), fine sandy clay loam, moderate medium subangular blocky, moist, slightly firm, many roots, scattered charcoal.

Gradual wavy boundary

5-25 10YR 6/8 (brownish yellow) with few yellowish red patches of weathering sandstone, fine sandy clay loam, weak-moderate coarse subangular blocky with moderate continuous clayskins, moist, firm, many roots, scattered charcoal.

Diffuse boundary

25-38 10YR 6/8 (brownish yellow) with 10YR 5/6 (yellowish brown) in old root channels and few reddish brown mottles, fine sandy clay (fine sandy clay loam in old root channels), moderate-weak coarse subangular blocky with weak clayskins, moist, firm, few roots, scattered charcoal.

Clear slightly wavy boundary

38+ Hard medium sandstone, red weathering colours but white, yellow where fresh.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 2	4.4	2.0	0.17	160	310	820	1340	10.4	2.4	4.2	45.9	23.0	25.6	Sandy clay loam
2	2 - 5	4.6	1.1	0.10	120	110	750	1340	9.7	0.5	0.5	49.8	20.2	27.9	Sandy clay loam
3	14-18	4.8	0.5	0.05	100	190	760	1330	12.1	-	0.5	49.8	23.6	30.1	Sandy clay loam
4	28-32	4.8	0.2	0.05	110	210	950	1760	14.2	0.3	0.5	48.0	2.1	52.2	Sandy clay

	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
Sample 1	0.3	0.5	0.2	0.1	14.2
2	0.5	0.2	0.1	0.1	12.0
3	0.3	0.3	0.1	Tr	10.1
4	0.3	0.3	0.1	Tr	10.3

Profile F2C

Mapping unit: Mrt (Map 3)

Sarawak classification: G.S.G. Red Yellow Podsolic; Family Merit; Series -

Location: Between Performance Trial plots Nos. 7 and 4 on Bukit Temudok site (see Map 3).

Topography: Upper dipslope of Bukit Temudok cuesta (gradient ca 15°).

Parent material: Temudok sandstone and shale

Vegetation: Lallang (Imperata cylindrica).

0-2 10YR 5/6 (yellowish brown), fine sandy clay loam, moderate medium crumb-granular, moist, slightly firm, porous many roots.

Gradual wavy boundary

2-5 Mixed 10YR 5/6 (yellowish brown) and 10YR 6/8 (brownish yellow), fine sandy clay loam, moderate medium subangular blocky, moist, friable slightly - firm, porous, many roots.

Clear wavy boundary

5-9 10YR 6/8 (brownish yellow) with common fine faint pale yellow and grey mottles, fine sandy clay loam, weak medium - coarse subangular blocky, moist, firm, slightly proous, many roots, scattered charcoal.

Gradual regular boundary

9-21 10YR 6/8 (brownish yellow) with common fine distinct pale yellow mottles, fine sandy clay, moderate coarse subangular blocky with moderate clay-skins, moist, firm, many roots, much fine charcoal.

Diffuse boundary

21-38 10YR 6/8 (brownish yellow) with few fine faint yellowish red mottles, clay, weak coarse subangular blocky with moderate clayskins, moist, firm, few roots, scattered charcoal.

Gradual wavy boundary

38-50 10YR 6/8 (brownish yellow) with many medium distinct 2.5YR 5/8 (red) and many coarse distinct light grey mottles, clay, weak coarse subangular blocky, moist, firm, few roots, many stones - weathering shale.

Diffuse boundary

50-60+ As above, but proportion weathering shale increases. Weathering shale is mostly dark grey, with patches of light grey and red.

Sample No.	Depth (inches)	pH H_2O	% Org C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 2	4.8	3.0	0.29	200	320	1420	2690	10.6	1.6	1.3	34.7	34.5	30.5	Clay loam
2	2 - 5	4.7	2.0	0.21	163	430	1220	2610	11.0	3.7	2.7	28.5	35.7	32.5	Clay loam
3	5 - 9	4.7	0.9	0.12	120	430	1160	2740	11.8	0.5	1.1	31.5	28.9	36.8	Clay loam
4	14-17	4.9	0.9	0.08	100	110	1680	3010	13.3	0.3	0.5	29.9	30.8	40.0	Clay loam - clay
5	29-32	4.9	0.3	0.13	100	220	1320	3290	15.2	0.6	0.6	25.8	28.5	46.3	Clay
6	42-46	4.9	0.3	0.07	120	220	1680	4330	17.7	3.1	1.1	24.3	32.5	41.7	Clay
7	50-53	4.8	0.2	0.05	110	110	1800	4080	15.0	4.8	8.1	58.7	28.5	34.7	Weathering rock

Sample	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
1	1.6	1.6	0.6	0.1	22.7
2	0.5	0.5	0.3	0.1	20.2
3	0.6	0.2	0.2	0.1	18.7
4	0.2	0.9	0 1	Tr	19.0
5	0.4	0.3	0.2	Tr	21.4
6	0.3	0.4	0.2	Tr	27.8
7	0.9	0.1	0.2	Tr	24.1

Profile F2D

Mapping unit: Nyl (Map 3) G.S.G. Family Series
Sarawak classification: Red Yellow Podsolic Nyalau -
Location: Chain 7 on western rentis at Bukit Temudok site (see Map 3).
Topography: Upper dipslope (gradient 30°).
Parent material: Temudok sandstone and shale.
Vegetation: Secondary growth, including much resam and young trees of simpor and geronggang.

½-0 Litter of resam stems and leaves, etc.

0-3 2.5Y 4/4 (olive brown), fine sandy loam, weak fine subangular blocky, moist, friable, porous, many roots, much bleached coarse sand.

Gradual regular boundary

3-8 10YR 5/6 (yellowish brown), fine sandy loam, weak fine subangular blocky, moist, friable, porous, many roots, much bleached coarse sand.

Gradual slightly wavy boundary

8-23 10YR 6/8 (brownish yellow), sandy loam, weak medium subangular blocky with very weak discontinuous clayskins, moist, slightly firm, slightly porous, roots common, scattered small, subangular, soft stones of 7.5YR 3/8 (strong brown), reddish brown and yellow fine sandstone.

Clear regular boundary

23-38 10YR 5/8 (yellowish brown), sandy loam to sandy clay loam, structure masked by stones, with weak continuous clayskins [10YR 7/6 (yellow)] against the stones, moist, slightly firm, slightly porous, roots common, abundant soft to hard fragments of red, light grey, yellow and pale yellow fine sandstone, and many slightly hard fragments grey, dark grey, pale brown and red shale.

Gradual irregular boundary

38-47+ As above, but the proportion of stones increases

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 3	4.2	1.7	0.15	110	180	360	680	3.0	0.1	1.1	63.6	18.9	14.8	Sandy loam
2	4 - 7	4.6	0.9	0.09	80	160	360	840	3.2	0.4	3.3	67.8	14.6	13.6	Sandy loam
3	14-17	4.8	0.4	0.06	60	120	230	780	3.7	0.3	2.4	68.8	14.7	16.9	Sandy loam
4	29-32	5.1	0.3	0.04	100	200	140	2510	7.0	1.4	2.2	59.0	23.9	20.3	Sandy clay loam
5	43-47	5.2	0.2	0.08	140	190	690	3210	6.5	2.6	1.7	50.3	35.1	18.0	Stony loam

	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
Sample 1	0.4	0.2	0.1	0.1	10.8
2	0.2	0.2	Tr	0.1	7.8
3	0.2	Tr	Tr	0.1	7.3
4	Tr	0.8	Tr	0.1	9.7
5	Tr	Tr	Tr	0.1	10.5

Profile F2E

Mapping unit: Bkn (Map 3).

Sarawak classification: G.S.G. Red Yellow Podsolic; Family Merit; Series -

Location: Chain 9 on central rentis on Bukit Temudok site (Map 3).

Topography: Midslope of dissected dipslope (gradient 19°).

Parent material: Temudok shale and sandstone.

Vegetation: Young secondary growth with much lallang (Imperata cylindrica).

0-3 10YR 4/4 (dark yellowish brown) with few fine faint 10YR 5/6 (yellow brown) mottles, silty clay loam, moderate fine subangular blocky, moist, slightly firm, slightly porous, few fine pieces of sandstone, many roots, scattered charcoal.

Gradual slightly wavy boundary

3-5 Mixed 10YR 5/8 (yellowish brown) and 10YR 4/4 (dark yellowish brown) with common fine faint 7.5YR 5/8 (strong brown) mottles, silty clay loam, moderate fine subangular blocky with weak discontinuous clayskins, moist, slightly firm, slightly porous, many roots, few fine pieces of sandstone, common charcoal.

Gradual regular boundary

5-18 10YR 6/8 (brownish yellow) with few fine faint yellow and 7.5YR 6/6 (reddish yellow) mottles, clay, moderate medium subangular blocky with strong continuous clayskins [7.5YR 7/8 (reddish yellow)], moist, firm, porous, roots common, few hard stones of 2.5YR 4/4 (reddish brown), yellowish red and yellow fine sandstone.

Diffuse boundary

18-32 7.5YR 7/8 (reddish yellow) with few medium faint 2.5YR 5/8 (red) and few fine faint light grey mottles, clay, moderate medium subangular blocky with strong continuous clayskins [7.5YR 6/8 (reddish yellow)], moist, firm, slightly porous, roots rare, few small fragments of soft hard purple, light grey and red shale.

Gradual slightly wavy boundary

32-37 10YR 6/8 (brownish yellow), clay, structure masked by stones, weak clayskins against stones, moist, slightly firm, slightly porous, roots rare, many soft to slightly hard fragments of light grey, reddish brown, strong brown, reddish yellow and orange shale.

Gradual irregular boundary

37-43+ As above, but the proportion of stones increases.

Sample No.	Depth (inches)	pH H_2O	% Org C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 3	4.4	1.9	0.34	190	500	1010	1910	9.7	0.4	0.8	13.9	39.7	36.8	Clay loam
2	3 - 5	4.2	1.0	0.22	150	400	1620	2700	10.7	1.2	0.7	17.4	40.2	39.2	Clay loam
3	10-13	4.8	0.5	0.11	110	280	1720	2360	10.9	0.3	0.3	23.0	37.0	45.6	Clay
4	23-27	4.8	0.4	0.10	110	1040	900	1950	4.6	4.6	1.5	18.1	35.3	44.2	Clay
5	33-36	4.9	0.7	0.09	100	360	1180	3830	13.4	1.3	0.9	16.1	33.7	50.5	Clay
6	41-43	5.1	0.3	0.10	140	430	1860	3690	14.6	5.7	2.0	14.0	39.1	42.0	Stony clay

	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
Sample 1	1.3	1.2	0.4	0.2	24.9
2	0.6	1.1	0.1	0.1	17.1
3	0.2	0.2	0.1	0.1	20.0
4	Tr	0.2	0.1	0.1	19.7
5	Tr	0.2	Tr	Tr	23.6
6	Tr	0.2	0.1	0.1	24.1

Profile F3A

Mapping unit: Bkn (Map 4)

Sarawak classification:	G.S.G.	Family	Series
	Red Yellow Podsolic	Bekenu	-

Location: Road cutting close to observation plot No.5 at Jakar site (see Map 4).
Topography: Summit of low rounded hill (gradient ca 5°).
Parent material: Mixed shale, fine sandstone and vein quartz from Kapit member of Belaga Formation.
Vegetation: Lallang (Imperata cylindrica).

0-3 10YR 4/4 (dark yellowish brown), fine sandy loam, weak fine crumb (tending to single grain), slightly moist, friable, roots abundant.

Gradual regular boundary

3-14 10YR 6/6 (brownish yellow), fine sandy clay loam, weak - moderate coarse subangular blocky with very weak clayskins, moist, firm, many roots, scattered quartz grit.

Gradual regular boundary

14-38 10YR 6/8 (brownish yellow) with few medium faint pale yellow and yellowish red mottles, fine sandy clay loam, weak to moderate coarse subangular blocky with strong continuous [10YR 7/6 (yellow)] clayskins, moist, firm, few roots, scattered quartz grit

Clear wavy boundary

38-48 Mixed 10YR 6/6 (brownish yellow) and 5YR 6/8 (reddish yellow) with many 5YR 7/4 (pink) mottles, fine sandy clay loam - fine sandy clay, very weak coarse subangular blocky with strong - moderate clayskins, moist, firm, few roots, slightly porous, scattered quartz grit.

Clear wavy boundary

48-61 Stone line of quartz grit, dark red fine sandstone and yellowish red shale set in 7.5YR 6/8 (reddish yellow), fine sandy clay, clayskins next to stones, moist, firm, no roots.

Clear slightly wavy boundary

61-69 Large, fairly hard stones of yellow, red and purple fine sandstone; clayskins next to stones, much quartz grit.

Clear regular boundary

69-79 Mixed pale yellow, brownish yellow, reddish yellow and yellowish red, fine sandy clay, very weak coarse subangular blocky, moist, firm, no roots, much soft (sugary) quartz.

Gradual wavy boundary

79-89 Mixed 2.5Y 7/6 (yellow), yellowish red, reddish yellow, red pale yellow and white, sandy clay, moderate coarse subangular blocky with few clayskins, moist, firm, no roots, scattered quartz grit and stones.

Diffuse boundary

89-94+ Slightly hard purple, reddish yellow and yellowish red weathering shale.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 3	4.5	2.0	0.14	120	210	1120	2800	7.6	2.6	5.7	49.8	16.7	26.3	Sandy clay loam
2	7 -10	4.7	0.6	0.06	90	210	1350	2820	9.1	0.9	4.0	50.3	15.2	29.0	" " "
3	24-28	5.0	0.2	0.03	80	210	1420	3600	11.7	1.0	3.1	46.4	16.1	35.0	Sandy clay loam - sandy clay
4	41-44	5.0	0.1	0.03	90	210	1500	4160	14.9	1.0	3.1	42.1	19.0	40.2	Sandy clay
5	72-76	5.1	0.1	0.03	70	100	1420	3080	13.5	8.7	7.2	35.2	19.3	33.8	Sandy clay
6	82-86	5.1	0.1	0.03	80	190	1740	6280	14.0	3.1	3.3	40.2	22.0	40.7	Clay
7	89-93	5.0	0	0.04	100	210	1800	7860	14.2	1.8	2.3	21.7	29.0	48.2	Weathering shale

Sample	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
1	0.4	0.1	0.2	Tr	14.4
2	0.3	0.1	0.1	0.1	13.3
3	0.4	0.1	0.1	Tr	7.0
4	0.2	0.2	0.1	Tr	7.6
5	0.2	0.1	0.1	Tr	6.3
6	0.3	0.1	0.1	Tr	14.3
7	0.1	0.4	0.1	Tr	15.4

Profile F3B

Mapping unit: Bkn (Map 4)

Sarawak classification: G.S.G. Red Yellow Podsolic; Family Bekenu; Series -

Location: Close to fertilizer trial plot No.1 at Jakar site (see Map 4).

Topography: Lower slope of low rounded hill (gradient 22°).

Parent material: Mixed shale and fine sandstone from Kapit member of Belaga Formation.

Vegetation: Lallang (Imperata cylindrica).

0-2 2.5YR 4/4 (olive brown), fine sandy loam, moderate very fine subangular blocky, moist, slightly firm (to friable), porous, roots abundant, much charcoal.

Gradual regular boundary

2-6 10YR 5/4 (yellowish brown), fine sandy loam, moderate fine subangular blocky with weak clayskins moist, slightly firm, slightly porous, many roots, common charcoal.

Abrupt wavy boundary

6-11 10YR 7/6 (yellow) with many medium distinct brownish yellow, reddish yellow, yellowish red, and light brownish grey mottles, fine sandy clay loam, moderate medium subangular blocky with moderate ⌈10YR 6/6 (brownish yellow)⌋ clayskins, moist, firm, ped interiors porous, many roots, common charcoal, scattered quartz grit.

Gradual wavy boundary

11-19 7.5YR 6/8 (reddish yellow) with many medium distinct 2.5Y 7/2 (light grey) and few yellowish red mottles, fine sandy clay loam, weak coarse subangular blocky with strong ⌈5YR 6/6 (reddish yellow)⌋ clayskins, moist, firm, ped interiors porous few roots, scattered quartz grit.

Clear wavy boundary

19-25 5YR 6/8 (reddish yellow) with many medium distinct 5Y 7/4 (pale yellow) and 5Y 7/1 (light grey), mottles fine medium sandy clay loam, weak coarse subangular block with strong ⌈10YR 8/6 (yellow)⌋ clayskins, moist, firm, few roots, scattered fine quartz.

Clear wavy boundary

25-28 10YR 8/6 (yellow) with many medium distinct 2.5YR 5/6 (red) mottles, clay loam, very weak very coarse subangular blocky (tending to massive) with strong ⌈2.5Y 7/4 (pale yellow)⌋ clayskins, moist, firm, non porous very few roots, abundant quartz grit.

Clear wavy boundary

28-47+ Mixed 2.5Y 7/6 (yellow), 7.5YR 7/6 (reddish yellow) and 10R 3/4 (dusky red) fine sandy clay, massive with moderate (pale yellow) clayskins against stones, moist, firm, few roots, common soft - slightly hard weathering shale.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 2	4.8	1.2	0.12	130	210	860	2510	5.0	0.5	8.0	56.8	19.1	19.3	Sandy loam
2	2 - 6	4.6	0.9	0.09	110	150	890	3120	5.6	4.1	7.7	53.7	17.1	20.6	Sandy loam - Sandy clay loam
3	7 -10	4.8	0.3	0.04	80	370	880	4080	6.8	1.5	4.9	51.4	12.6	32.0	" " "
4	13-17	4.8	0.1	0.04	90	250	1080	4080	7.1	1.5	4.6	49.1	17.7	31.3	" " "
5	20-24	4.9	0.1	0.05	80	210	1110	4840	8.4	1.9	3.7	43.9	20.6	34.4	" " "
6	25-28	4.9	0.2	0.05	100	210	1180	5570	13.3	9.3	5.2	33.1	20.0	36.1	Sandy clay
7	32-36	5.0	0.1	0.06	120	200	920	6340	16.7	4.9	3.6	18.5	39.7	35.5	Clay loam
8	42-47	4.9	0.1	0.01	120	110	1000	8360	12.8	5.7	3.1	11.0	44.6	34.5	Silty clay loam

	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
Sample 1	0.7	0.8	0.2	Tr	13.3
2	0.4	0.1	0.1	Tr	7.9
3	0.3	0.1	0.1	Tr	5.8
4	0.3	0.3	Tr	Tr	6.4
5	0.3	0.6	0.1	Tr	6.2
6	0.1	0.4	0.1	Tr	5.7
7	0.2	0.3	0.1	Tr	10.3
8	0.3	0.1	0.1	0.1	7.3

Profile F3C

Mapping unit: Rpk (Map 5) G.S.G. Family Series

Sarawak classification: Red Yellow Podsolic - Groundwater Laterite — Merit-Rapak — -

Location: Between fertiliser trial plot No.10 and observation plot No.5 at Pakan Road site (see Map 5).

Topography: Lower slope of low rounded hill (gradient 11°).

Parent material: Shale, fine sandstone and vein quartz from Kapit member of Belaga Formation.

Vegetation: Lallang (Imperata cylindrica).

0-2 10YR 5/4 (yellowish brown), fine sandy loam, moderate fine subangular blocky with moderate discontinuous clayskins, moist, slightly firm, porous, roots abundant, much charcoal.

Clear regular boundary

2-6 10YR 5/4 (yellowish brown) with many medium fine 10YR 6/6 (brownish yellow) and grey mottles, fine sandy clay loam, medium fine subangular blocky with strong continuous clayskins, moist,firm, slightly porous, many roots, much charcoal, few quartz stones.

Clear wavy boundary

6-11 10YR 6/8 (brownish yellow) with many medium distinct, 10YR 7/8 (yellow) and few medium distinct 10YR 6/8 (reddish yellow) and few coarse distinct 2.5Y 7/4 (pale yellow) mottles, fine sandy loam, weak medium subangular blocky with weak clayskins, moist, very firm, common roots, scattered quartz grit, slightly porous.

Clear wavy boundary

11-14 Colours as above, stony clay loam, structure masked by stones, moderate clayskins, moist, very firm, few roots, slightly porous, abundant stones are quartz, iron concretions and dark red shale fragments.

Gradual very wavy boundary

14-19 Mixed 2.5YR 5/6 (yellowish red), 5YR 6/8 (both reddish yellow), and 10YR 8/8 (yellow), stony clay, weak moderate subangular blocky with strong [7.5YR 6/6 (reddish yellow)] clayskins moist, firm, few roots, non-porous, abundant stones are quartz, iron concretions and dark red shale fragments.

Clear wavy boundary

19-32 Colours as above, plus 10YR 5/8 (red), clay, weak coarse subangular blocky with moderate [10YR 6/3 (pale brown)] clayskins moist, firm, slightly porous, few roots.

Diffuse boundary

32-46+ Mixed 10YR 8/6 (yellow), 2.5Y 8/2 (white) and 10R 4/8 (red), with yellowish red and reddish yellow mottles, silty clay, weak coarse subangular blocky with strong [10YR 7/4 (very pale brown)] clayskins, moist, firm, few roots, reddish yellow and red patches show shale laminations, very slightly porous.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 2	4.9	1.5	0.13	110	240	510	3070	9.3	1.0	3.6	44.1	26.6	22.1	Loam
2	2 - 6	4.8	1.2	0.11	110	100	500	3100	5.5	5.7	4.1	46.6	24.9	20.8	Sandy clay loam
3	7 -10	4.9	0.4	0.09	110	40	610	3580	5.8	2.6	1.9	41.8	29.4	24.7	Loam
4	11-14	5.2	0.3	0.05	90	100	630	4630	8.4	3.6	1.5	36.7	28.9	31.4	Clay loam
5	15-18	4.9	0.3	0.05	90	110	1050	5800	12.7	2.1	1.1	28.3	28.6	44.0	Clay
6	23-27	5.1	0.3	0.06	100	120	1220	7400	18.1	0.6	0.6	19.0	32.6	55.4	Clay
7	37-40	5.1	0.2	0.07	100	230	800	9450	19.2	1.6	0.6	9.8	48.0	42.9	Silty clay
8	43-46	4.9	0.2	0.06	90	210	900	7350	16.5	0.6	0.5	12.7	41.6	44.7	Silty clay

Sample	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
1	0.1	0.5	0.2	Tr	14.7
2	0.4	0.6	0.1	0.1	6.6
3	0.2	0.3	0.1	Tr	5.0
4	0.2	0.5	0.1	Tr	4.7
5	0.1	0.4	0.1	0.1	9.6
6	0.2	0.5	0.1	0.1	14.9
7	0.1	0.3	0.1	Tr	5.6
8	0.1	0.1	0.1	Tr	5.6

Profile F3D

Mapping unit: Kkn (Map 5)

Sarawak classification:	G.S.G.	Family	Series
	Red Yellow Podsolic	Bekenu	-

Location: 8 chains from road along northern boundary of Pakan Road site (see Map 5).

Topography: Midslope of low rounded hill (gradient 25°).

Parent material: Mixed shale and sandstone from Kapit member of Belaga Formation.

Vegetation: Secondary growth with much lallang and resam.

0-2 2.5Y 4/4 (olive brown) with few brownish yellow mottles, fine sandy clay loam, moderate fine subangular blocky, moist, friable, slightly porous, abundant roots, scattered charcoal.

Gradual regular boundary

2-7 10YR 5/4 (yellowish brown) with few faint 10YR 6/6 (brownish yellow) mottles, fine sandy clay loam, moderate fine subangular blocky, moist, friable, slightly porous, common roots, scattered charcoal.

Clear wavy boundary

7-14 10YR 6/8 (brownish yellow), fine sandy clay loam, weak medium subangular blocky with weak ⌊ 10YR 7/4 (very pale brown) ⌋ clayskins, moist, slightly firm, few roots, scattered quartz grit.

Gradual regular boundary

14-38 10YR 6/8 (brownish yellow) with few fine faint reddish yellow mottles, fine sandy clay loam, moderate medium subangular blocky, with moderate ⌊ 2.5Y 7/6 (yellow) ⌋ clayskins, moist, firm, few roots.

Diffuse boundary

38-75 10YR 6/8 (brownish yellow) with few fine faint reddish yellow mottles, fine sandy clay, weak coarse subangular blocky with moderate discontinuous ⌊ 2.5Y 7/4 (pale yellow) ⌋ clayskins, moist, firm, few roots, scattered quartz grit.

Clear wavy boundary

75+ Many stones of quartz, red shale and soft black iron concretions, set in material as above.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract: P ppm	Ca ppm	Mg ppm	K ppm	Group III %	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 2	4.8	2.3	0.19	100	110	820	2400	9.8	3.4	5.8	51.6	17.8	25.2	Sandy clay loam
2	3 - 6	4.9	2.0	0.17	90	150	990	2380	9.6	1.6	5.3	48.1	15.0	26.4	" " "
3	9 -12	5.1	1.0	0.09	100	100	920	2860	11.2	0.6	3.9	47.1	16.6	26.0	" " "
4	24-28	5.2	0.3	0.04	50	190	880	2980	11.8	2.0	4.4	50.3	12.6	31.6	" " "
5	50-54	5.3	0.2	0.03	50	100	1120	3870	17.0	1.3	3.1	43.6	14.6	38.4	Sandy clay
6	72-75	5.2	0.2	0.03	70	210	1250	3790	17.0	2.6	2.4	39.9	14.8	41.1	Clay

Sample	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
1	0.2	0.6	0.2	Tr	11.6
2	0.1	0.3	0.1	Tr	18.6
3	0.1	0.4	0.1	Tr	15.1
4	0.1	0.5	0.1	Tr	5.2
5	0.1	0.1	0.1	0.1	5.1
6	0.2	0.4	0.1	Tr	5.4

Profile S713-20

Mapping unit: Nyl (Map 6)

Sarawak classification: G.S.G. Red Yellow Podsolic; Family Nyalau; Series -

Location: Between performance trial plots 14 and 15 on main site B, Oya Road (see map 6).

Topography: Upper slope of low rounded hill (gradient ca 20°).

Parent material: Belaga Formation (Pelagus member) fine sandstone.

Vegetation: Lallang beneath planted pines.

0-2 10YR 2/3 (very dark greyish brown), fine sandy loam, very weak fine granular, moist, very friable, porous. abundant roots.

Gradual regular boundary

2-6 Mixed very dark greyish brown, yellowish brown and very dark grey, fine sandy loam, very weak medium grandular, moist, friable, porous, many roots.

Gradual wavy boundary

2-10 10YR 5/8 (yellowish brown) with greyish brown staining down root channels, and few fine faint light yellowish brown mottles, fine sandy loam, structureless, moist, friable, porous, few roots.

Gradual wavy boundary

10-17 10YR 5/8 (light yellowish brown) with greyish brown staining down root channels, fine sandy clay loam, structureless, moist, friable, porous, few roots.

Gradual wavy boundary

17-39 10YR 5/8 (light yellowish brown), fine sandy clay loam, structureless moist, friable, porous, few roots.

Gradual wavy boundary

39-50 As above except that texture lightens to fine sandy loam.

Gradual wavy boundary

50-58+ 7.5YR 7/8 (strong brown) with many medium faint reddish yellow mottles, sandy clay loam, structureless, moist, friable, porous, roots absent.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
713	0 - 2	4.3	2.0	0.16	90	200	300	900	4.7	3.4	7.6	45.4	18.7	14.3	Sandy loam
714	2 - 6	4.6	1.4	0.09	70	100	300	800	4.6	5.4	9.8	44.7	19.2	14.7	Sandy loam
715	6 -10	4.5	0.5	0.04	40	100	200	900	4.8	3.5	11.4	49.6	21.0	15.4	Sandy loam
716	10-17	4.7	0.3	0.02	50	100	400	800	7.2	5.5	8.6	46.5	19.2	18.1	Sandy loam
717	17-30	4.8	0.2	0.01	40	100	400	900	7.6	4.9	8.5	45.5	19.3	20.3	Sandy clay loam
718	30-39	4.9	0.1	0.01	30	100	400	1000	7.4	4.9	8.7	44.8	19.6	20.1	Sandy clay loam
719	39-50	4.8	0.1	0.01	45	100	300	1200	7.7	3.0	9.8	46.1	23.2	19.2	Sandy loam
720	50-58	4.2	0.1	0.01	30	100	200	1200	9.5	3.1	10.0	45.7	20.8	20.4	Sandy clay loam

Profile S.721-28

Mapping unit: Nyl (Map 6)

Sarawak classification: G.S.G. Red Yellow Podsolic — Family Nyalau — Series -

Location: Between performance trial plots 2 and 3 on main site A, Oya Road (see Map 6).

Topography: Midslope of low rounded hill (gradient ca 20-25°).

Parent material: Belaga Formation (Pelagus member) fine sandstone.

Vegetation: Lallang and resam.

0-3 10YR 3/2 (very dark greyish brown), fine sandy loam, very weak medium subangular blocky, moist, friable, porous, abundant roots.

Clear regular boundary

3-11 10YR 5/6 (yellowish brown) with brown staining in root channels, fine sandy loam, very weak coarse subangular blocky, moist, friable, porous, many roots

Gradual regular boundary

11-20 10YR 5/8 (yellowish brown), fine sandy loam, very weak coarse subangular blocky, moist, friable, porous, many roots.

Gradual regular boundary

20-31 As above except texture is fine sandy clay loam and roots are only few

Gradual regular boundary

31-40 As above but consistence is firm.

Gradual regular boundary

40-48 10YR 5/8 - 6/8 (yellowish brown - brownish yellow), sandy clay loam, structureless - massive, moist, friable, porous, roots rare.

Gradual regular boundary

48-56 10YR 5/8 (yellowish brown) with many fine - medium distinct light yellowish brown mottles, and few fine faint pink stains, sandy clay loam, structureless, moist, friable, porous.

Gradual wavy boundary

56-72+ 10YR 5/8 (yellowish brown) with many medium - coarse distinct red and many fine - medium faint light yellowish brown mottles, sandy clay loam, structureless, moist, friable, porous, few roots.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract					% of fine earth					Texture
					P ppm	Ca ppm	Mg ppm	K ppm	Group III%	Coarse sand	Medium sand	Fine sand	Silt	Clay	
721	0 - 3	4.3	1.9	0.01	90	200	300	900	5.1	4.1	9.7	43.5	21.3	16.2	Sandy loam
722	3 -11	4.5	0.6	0.06	60	200	400	1200	6.2	3.2	10.7	45.9	22.0	16.1	Sandy loam
723	11-20	4.5	0.3	0.03	50	200	400	1400	7.2	2.3	12.4	44.9	21.1	19.7	Sandy loam
724	20-31	4.4	0.2	0.02	50	200	400	1300	7.6	4.0	9.7	45.4	20.7	20.3	Sandy loam
725	31-40	4.5	0.2	0.01	40	100	400	1300	7.7	2.5	10.1	45.5	19.7	21.0	Sandy clay loam
726	40-48	4.6	0.1	0.01	40	100	600	1700	8.0	3.1	11.6	43.5	20.6	21.8	" " "
727	48-56	4.3	0.1	0.01	50	100	400	1700	8.8	2.7	10.7	41.7	21.2	22.0	" " "
728	56-72	5.4	0.2	0.02	50	100	500	2400	8.6	2.9	10.7	41.4	21.2	23.2	" " "

Profile S.738-45

Mapping unit: (Bnd) (Map 6)

Sarawak classification: G.S.G. Grey White Podsolic or Gley; Family Kerait or Semadoh; Series Bandang

Location: Between performance trial plots 1 and 4 on main site F, Oya Road (see Map 6).

Topography: Lower slope (gradient 4°).

Parent material: Belaga Formation (Pelagus member) shale

Vegetation: Lallang (Imperata cylindrica)

0-2 10YR 4/2 (dark greyish brown), silty loam, very weak fine granular, moist, friable, porous, abundant roots.

Clear regular boundary

2-6 10YR 5/2 (greyish brown), silty loam, weak coarse subangular blocky, moist, friable, porous, many roots

Clear broken boundary

6-7/10 Discontinuous horizon with intervening material from above down root channels. 10YR 7/2 (light grey), silty loam, weak coarse subangular blocky, moist, friable, porous, few roots.

Gradual irregular boundary

7/10-14/18 10YR 6/1 (light grey) with many fine distinct pale brown and yellow mottles and few medium distinct mauve patches, silty loam, very weak coarse subangular blocky, moist, friable, porous, few roots.

Gradual wavy boundary

14/18-18/25 5Y 7/1 (light grey) with many medium distinct pale brown mottles and many coarse distinct rusty root channels, silty loam, structureless, moist, firm, roots rare.

Gradual wavy boundary

18/25-22/31 5Y 7/1 (light grey) with many coarse distinct pale brown and yellow mottles and few medium distinct rusty root channels, silty loam, structureless, moist, firm, roots rare.

Gradual irregular boundary

22/31-32/45 5Y 7/1 (light grey) with many medium faint very pale brown mottles and some dark brown staining down root channels, silty clay loam, structureless, moist, firm, roots rare.

Gradual irregular boundary

32/45-54+ 5Y 7/2 (light grey) with few fine very faint very pale brown mottles, silty clay, structure etc. as above.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract					% of fine earth					Texture
					P ppm	Ca ppm	Mg ppm	K ppm	Group III%	Coarse sand	Medium sand	Fine sand	Silt	Clay	
738	0 - 2	4.0	2.4	0.18	100	200	200	1400	1.7	0.3	2.1	27.9	53.1	12.4	Silty loam
739	2 - 6	4.3	1.4	0.13	80	300	400	1600	2.3	0.7	2.7	28.6	54.6	12.8	Silty loam
740	6-7/10	4.4	0.7	0.06	70	100	400	2000	2.9	1.0	2.7	30.1	52.5	14.1	Silty loam
741	7/10-14/18	4.4	0.3	0.03	60	100	200	1600	3.0	0.8	2.3	27.3	54.4	14.2	Silty loam
742	14/18-18/25	4.1	0.1	0.06	70	100	500	2600	4.3	0.6	1.6	25.1	53.5	20.3	Silty loam
743	18/25-22/31	4.2	0.1	0.07	90	200	700	3400	6.3	0.4	1.4	21.8	50.6	26.6	Silty loam
744	22/31-32/45	4.2	0.4	0.06	110	200	400	5300	9.3	0.1	0.4	13.8	48.0	38.1	Silty clay loam
745	32/45-54	4.1	0.3	0.06	110	200	400	7200	11.4	0.2	0.8	8.4	49.8	43.0	Silty clay loam

Profile S.746-51

Mapping unit: Nyl (Map 6)

	G.S.G.	Family	Series
Sarawak classification:	Red Yellow Podsolic	Nyalau	-

Location: Between performance trial plots 3 and 4 in site C, Oya Road, (see map 6).

Topography: Mid slope of low rounded hill (gradient ca 20°).

Parent material: Belaga Formation (Pelagus member) fine sandstone.

Vegetation: Lallang (Imperata Cylindrica).

0-2 10YR 2/2 (very dark brown), sandy clay loam, structureless, moist, friable, porous, abundant roots.

Gradual wavy boundary

2-7 10YR 5/6 (yellowish brown) with few medium distinct yellow and pale brown mottles, sandy clay loam, weak coarse subangular blocky, moist, friable, porous, many roots.

Clear wavy boundary

7-16 10YR 5/8 (yellowish brown), sandy clay loam, very weak medium subangular blocky, moist, friable, porous, few roots.

16-45+ 10YR 5/8 (yellowish brown) with light yellowish brown staining down main cracks, sandy clay loam, weak coarse subangular blocky, moist, friable, many roots.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
746	0 - 2	4.4	3.9	0.11	140	400	200	1000	7.4	1.0	5.7	42.3	22.4	20.5	Sandy clay loam
747	2 - 7	4.3	1.2	0.09	80	200	200	1000	8.9	1.2	5.5	45.1	23.3	23.1	" " "
748	7 -16	4.2	0.4	0.06	70	100	400	1100	11.2	1.4	7.4	41.1	23.3	25.1	" " "
749	16-24	4.1	0.2	0.04	70	200	300	1200	10.9	1.3	5.7	44.5	23.2	26.3	" " "
750	24-29	4.2	0.2	0.03	70	200	200	1200	11.4	1.1	5.7	40.1	22.0	29.1	" " "
751	29-45	4.3	0.1	0.01	70	200	500	1500	12.4	1.1	5.0	40.0	23.0	29.6	" " "

Profile F3BA

Mapping unit: Nyl (Map 6)

	G.S.G.	Family	Series
Sarawak classification:	Red Yellow Podsolic	Nyalau	-

Location: Site B subtractive fertiliser trial at Oya Road (see Map 6).
Topography: Upper slope of low rounded hill (gradient ca 10°).
Parent material: Belaga Formation (Pelagus member) sandstone.
Vegetation: Planted pines with much lallang (Imperata cylindrica).

0-3 10YR 3/2 (very dark greyish brown), fine medium sandy loam, moderate medium crumb - fine subangular blocky, moist, friable, porous, many roots, much charcoal.

Clear regular boundary

3-6 Mixed distinct 10YR 7/4 (very pale brown) and 10YR 4/2 (dark greyish brown) with many medium faint 10YR 3/2 (very dark greyish brown) and common medium distinct 10YR 7/1 (light grey) mottles, medium sandy loam, moderate - strong fine subangular blocky, moist, slightly firm, porous, many roots.

Abrupt slightly wavy boundary

6-12 Mixed distinct 10YR 7/4 (very pale brown), 7.5YR 7/8 (reddish yellow), 2.5Y 8/2 (white), 2.5Y N7/ (light grey) and 7.5YR 6/6 (reddish yellow), sandy loam - sandy clay loam, weak medium subangular blocky, moist, slightly firm, slightly porous, common roots.

Diffuse boundary

12-29 2.5Y 8/6 (yellow) with many fine distinct 2.5Y N7/ (light grey), 7.5 YR 7/8 (reddish yellow) and few fine prominent 5YR 6/6 (reddish yellow) mottles, sandy clay loam - sandy loam, very weak medium subangular blocky, moist, slightly firm, slightly porous, few roots.

Diffuse boundary

29-52 Mixed distinct 2.5Y 8/4 (pale yellow), 10YR 7/1 (light grey) and 7.5YR 7/8 (reddish yellow) with common fine prominent 2.5YR 5/8 (red) mottles, sandy clay loam, weak medium - coarse subangular blocky with weak discontinuous clayskins [10YR 7/4 (very pale brown)] along old root channels, moist, firm, slightly plastic, non sticky, non porous, few roots.

Clear regular boundary

52-65+ Mixed faint 2.5Y 7/2 (light grey) and 10YR 7/4 (very pale brown) with common fine reddish brown rusty root channels, sandy clay loam, weak coarse subangular blocky, moist, firm, plastic, slightly sticky, no roots, common fine hard subangular fragments of 2.5YR 6/6 (light red) and 2.5YR 4/8 (red) iron - stained sandstone.

N.B. From 43 to 65+ inches part of this profile is occupied by a boulder of hard reddish yellow, red and strong brown medium sandstone.

Profile F3BA (contd.)

mple o.	Depth (Inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract					% of fine earth					Texture
					P ppm	Ca ppm	Mg ppm	K ppm	Group III%	Coarse sand	Medium sand	Fine sand	Silt	Clay	
1	0 - 3	4.2	1.8	0.12	70	90	480	760	3.0	1.4	6.3	64.3	15.4	11.6	Sandy loam
2	3 - 5	4.7	0.8	0.08	50	Tr	460	630	2.7	0.7	4.8	66.8	16.0	11.7	" "
3	7 -10	4.6	0.2	0.03	30	Tr	530	890	3.8	0.6	4.7	68.9	11.9	14.2	" "
4	19-22	4.8	0.1	0.03	40	Tr	660	1360	5.3	0.4	3.6	67.8	12.4	17.7	" "
5	35-38	5.0	0.1	0.04	50	Tr	1040	2860	8.1	0.7	2.5	61.6	10.6	26.0	Sandy clay loam
6	56-60	4.8	0.1	0.12	40	Tr	1130	2480	8.1	0.7	2.4	60.8	14.8	26.2	-ditto-

	Exchangeable me./100gms.				
	Ca	Mg	K	Na	CEC
Sample 1	0.8	0.6	0.1	0.1	9.7
2	0.3	Tr	0.1	0.1	5.3
3	0.2	Tr	0.1	0.1	14.0
4	0.5	Tr	Tr	0.1	4.5
5	0.2	Tr	Tr	0.1	4.7
6	0.2	Tr	Tr	0.1	5.2

Profile F3BB

Mapping unit: Srt (Map 6) G.S.G. Family Series
Sarawak classification: Grey White Podsolic Saratok -
Location: Between plots 3 and 4 on arboretum site E at Cya Road (see Map 6).
Topography: Mid-upper slope of low rounded hill (gradient ca 10°).
Parent material: Belaga Formation (Pelagus member) sandstone.
Vegetation: Planted pines with much resam (Gleichinia linearis) and shrub sized secondary trees e.g. Simpor.

0-9 10YR 5/2 (greyish brown) with common medium distinct 10YR 6/3 (pale brown) and 10YR 7/2 (light grey) mottles, sandy loam, moderate fine-medium subangular blocky, moist, friable, but very slightly indurated, porous, many roots with a concentration of large tree roots at 7-9 inches, much charcoal, much bleached coarse quartz sand.

Clear slightly wavy boundary

9-21 Mixed faint 10YR 7/1 (light grey), 10YR 8/3 (very pale brown) and 2.5Y 8/4 (pale yellow) with many fine distinct 10YR 6/4 (light yellowish brown) mottles, sandy loam, weak medium - coarse subangular blocky, moist, friable, porous, common roots and many old root channels (often light yellowish brown stained but some dark brown), common charcoal.

Diffuse boundary

21-50 Mixed faint 2.5Y N7/ (light grey) and 2.5Y N8/ (white) with common medium faint 2.5Y 7/2 (light grey), many fine faint distinct 10YR 7/4 (very pale brown) and 10YR 6/4 (light yellowish brown) and few fine prominent, 7.5YR 7/6 (reddish yellow) mottles, sandy loam, weak coarse subangular blocky with weak discontinuous clayskins (10YR 7/2 (light grey)) and brown to dark brown humus coatings below 44 inches, moist, friable, slightly porous, few roots but many old root channels (often filled with light yellowish brown - brown material), scattered charcoal.

Gradual diffuse boundary

50-65+ Colours as above plus few fine prominent 10YR 8/6 (yellow) mottles, sandy clay loam, weak coarse subangular blocky with rare discontinuous clayskins but much organic staining on ped faces (10Y 4/3 (brown to dark brown) and 10YR 6/4 (light yellowish brown)), moist, firm, non porous, rare roots and few old stained root channels, rare charcoal.

Sample No.	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III %	% of fine earth Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
	0 - 3	4.1	1.2	0.09	40	20	370	4130	1.1	1.8	7.1	66.8	15.6	13.5	Sandy loam
	6 - 9	4.5	1.0	0.07	50	50	350	630	2.1	3.6	11.6	63.2	15.7	10.9	Sandy loam
	13-17	5.0	0.4	0.03	30	20	450	700	3.6	0.7	8.5	67.6	14.0	12.4	Sandy loam
	31-34	4.8	0.2	0.05	30	10	520	1010	3.2	0.7	6.7	67.9	16.1	14.1	Sandy loam
	45-48	4.9	0.1	0.02	40	Tr	680	2030	5.0	1.1	8.5	66.1	14.0	18.2	Sandy loam
	61-65	5.0	0.1	0.03	50	Tr	980	3440	6.5	1.9	5.5	60.8	17.0	22.6	Sandy clay loam

Sample No.	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
1	0.5	Tr	0.1	0.1	2.3
2	0.4	Tr	0.1	0.1	6.2
3	0.2	Tr	Tr	0.1	4.0
4	0.2	Tr	Tr	0.1	3.7
5	0.2	Tr	Tr	0.1	3.5
6	0.2	Tr	Tr	0.1	4.0

Profile F3BD

Mapping unit: (Ltn) (Map 6)

Sarawak classification: G.S.G. Red Yellow Podsolic — Family Merit — Series Lutong

Location: Between performance trial plots 11 and 12 on main site E at Oya Road (see Map 6).

Topography: Upper slope of low, gently sloping hill (gradient ca 4°).

Parent material: Belaga Formation (Pelagus member) shale.

Vegetation: Planted pines with much lallang and resam.

0-6/8 2.5Y 5/2 (greyish brown) with common medium distinct 10YR 6/4 (light yellowish brown) and 2.5Y 7/4 (pale yellow) mottles, clay loam - silty clay loam, moderate fine subangular blocky, moist, friable - slightly firm, slightly plastic, non sticky, porous, many roots and few old root channels with faint brownish yellow and reddish brown staining, much charcoal.

Clear wavy boundary

6/8-8/12 Mixed 2.5Y 7/4 (pale yellow), 5Y 7/3 (pale yellow), 5YR 6/6 (reddish yellow), and 5Y 7/4 (light grey), silty clay loam, weak fine subangular blocky - massive, moist, firm, slightly plastic, non sticky, porous - slightly porous, common roots, rare charcoal, common medium sized black very hard iron concretions, especially in lower part of horizon.

Clear irregular boundary

8/12-12/16 2.5YR 6/8 (light red) with many fine distinct 2.5Y 8/4 (pale yellow) and 2.5YR 5/6 (red) mottles, gritty clay, structure masked by grit, moist, very firm, slightly plastic, non sticky, non porous, rare roots, grit is iron concretions as above and hard angular fragments of iron-stained shale.

Clear irregular boundary

12/16-27 Mixed 7.5YR 6/8 (reddish yellow), 2.5YR 5/8 (red), 2.5Y 7/6 (yellow) and 2.5Y N7/ (light grey), silty clay - clay, massive - very weak very coarse prismatic with strong continuous pale brown clayskins on vertical crack faces, moist, firm, plastic, slightly sticky, non porous, rare roots, few old root channels with yellowish brown staining.

Diffuse boundary

27-54+ Mixed streaky 2.5Y 7/8 (yellow), 2.5Y N7/ (light grey) and 5YR 6/8 (reddish yellow) (streaks appear laminar especially below 48 inches), silty clay - clay, massive with few vertical cracks, clayskins as above and not seen below 36 inches, moist, very firm, plastic, slightly sticky, non porous, no roots.

Sample	Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
1	0 - 4	3.8	0.8	-	110	50	420	1270	2.2	0.6	0.9	42.5	45.1	14.6	Loam
2	6 - 9	4.8	0.3	-	100	10	510	1360	2.9	1.2	0.8	40.5	63.7	2.2	Silt loam
3	10-14	5.0	0.2	-	120	10	930	2270	7.4	4.3	0.6	30.4	41.6	28.3	Clay loam
4	20-23	4.6	0.2	-	140	10	1590	3880	11.1	0.3	0.4	20.1	36.3	47.7	Clay
5	30-34	4.7	0.1	-	130	Tr	2000	6050	19.8	Tr	0.1	8.4	30.4	60.4	Clay
6	50-54	4.7	0.1	-	110	Tr	2170	6770	11.5	Tr	0.1	10.5	41.2	49.0	Clay

Sample	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
1	0.4	Tr	Tr	0.1	8.0
2	0.6	0.1	Tr	0.1	4.6
3	1.0	0.2	Tr	0.1	6.5
4	1.9	0.1	Tr	0.1	8.4
5	1.7	0.1	0.1	0.1	9.9
6	1.7	0.2	0.1	0.1	10.9

Profile F4A

Mapping unit: (Ny1) (Map 8)

	G.S.G.	Family	Series
Sarawak classification:	Red Yellow Podsolic	Nyalau	Nyalau

Location: Close to plot 8 on Lambir site (see Map 8).
Topography: Upper slope (gradient 20 - 25°).
Parent material: Miri/Tukau Formation soft fine sandstone.
Vegetation: Originally Mixed Dipterocarp Forest - now thick secondary growth.

0-2 2.5Y 7/4 (pale yellow) with many medium distinct 7.5YR N3/ (very dark grey) and few fine faint 10YR 6/3 (pale brown) mottles, sandy loam, moderate medium granular with very weak discontinuous clayskins [10YR 7/4 (very pale brown)], moist, friable, slightly porous, many roots.

Gradual regular boundary

2-5 2.5Y 7/4 (pale yellow) with many medium distinct 10YR N3/ (very dark grey) and few fine faint 7.5YR 5/8 (strong brown), 10YR 6/3 (pale brown) mottles, sandy loam - sandy clay loam, weak fine subangular blocky with weak discontinuous clayskins [10YR 7/4 (very pale brown)], moist, firm, slightly porous, many roots.

Diffuse boundary

5-19 2.5Y 8/4 (pale yellow) with few fine faint 5Y 7/3 (pale yellow), 2.5Y 6/2 (light brownish grey) mottles, sandy clay loam, weak fine subangular blocky with weak discontinuous clayskins [10YR 6/3 (pale brown)], moist, firm, porous, few roots.

Gradual regular boundary

19-34 2.5Y 8/4 (pale yellow) with few fine faint 2.5Y N7/ (light grey) and 2.5Y 6/4 (light yellowish brown) mottles, sandy clay loam, moderate medium subangular blocky with moderate continuous clayskins [10YR 7/4 (very pale brown)], moist, firm, very slightly porous, few roots, common old root channels filled with mixed 2.5YR 6/2 (dark grey) and 10YR 5/2 (greyish brown) sandy loam.

Gradual wavy boundary

34-42 10YR 8/6 (yellow) with few fine faint 7.5YR 5/8 (strong brown) and 2.5Y N7/ (light grey) mottles and few faint rusty root channels, sandy clay loam, moderate medium subangular blocky with weak continuous clayskins [2.5Y 7/4 (pale yellow)], moist, firm, slightly porous, roots absent.

Gradual wavy boundary

42-62 10YR 6/8 (brownish yellow) with common medium distinct 2.5YR N7/ (light grey) and few fine faint 7.5YR 5/8 (strong brown) mottles, sandy clay loam, weak medium subangular blocky with weak discontinuous clayskins [2.5Y 7/4 (pale yellow)], moist, firm, slightly porous, roots absent, common stones of slightly hard pale yellow, dark red and dark reddish brown iron-stained sandstone.

Gradual regular boundary

62-74+ 2.5Y 7/4 (pale yellow) with common medium distinct 7.5YR N7/ (light grey) and 10YR 6/8 (yellowish brown) mottles, sandy clay loam - sandy clay, weak moderate subangular blocky with weak discontinuous clayskins [10YR 7/4 (pale brown)], moist, firm, non-porous, roots absent, many stones of hard dark brown pipestone and slightly hard - hard strong brown, reddish yellow and weak red iron-stained sandstone.

Profile F4A (contd.)

Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
0 - 2	4.4	1.3	0.09	60	60	610	1930	3.8	0.1	2.5	67.1	16.7	14.5	Sandy loam
2 - 5	4.4	0.8	0.08	75	80	660	2220	3.5	0.4	1.9	66.3	16.9	14.5	Sandy loam
10-12	4.5	0.5	0.05	60	61	730	2360	3.9	0.2	2.0	63.1	15.5	17.0	Sandy loam
26-28	4.7	0.2	0.04	60	61	856	3100	5.1	0.1	1.7	60.0	16.9	22.1	Sandy clay loam
37-39	4.7	0.1	0.04	80	80	1020	3050	5.1	0.2	1.4	59.2	14.0	23.7	-ditto-
50-52	4.7	0.1	0.04	90	60	1160	4320	8.1	1.1	1.7	52.5	15.2	30.9	-ditto-
70-73	4.6	0.1	0.06	110	60	1470	4500	8.2	5.2	2.0	40.4	19.1	32.6	-ditto-

	Exchangeable me./100gms.				
	Ca	Mg	K	Na	CEC
Sample 1	3.1	4.5	0.1	Tr	5.0
2	0.2	0.3	0.1	Tr	4.4
3	0.1	0.1	0.1	Tr	4.2
4	0.1	0.1	0.1	Tr	4.0
5	0.2	0.1	0.1	Tr	9.2
6	0.3	0.1	Tr	Tr	5.3
7	0.1	0.1	0.1	Tr	10.4

Profile F4B

Mapping unit: (Nyl) (Map 8)

Sarawak classification:	G.S.G.	Family	Series
	Red Yellow Podsolic	Nyalau	Nyalau

Location: Between plots 9 and 10 on Lambir site.
Topography: Upper slope (gradient 25 - 30°).
Parent material: Miri/Tukau Formation soft fine sandstone.
Vegetation: Originally Mixed Dipterocarp Forest - now thick secondary growth.

0-3 10YR 6/4 (light yellowish brown) with many medium distinct 10YR 5/2 (greyish brown), 10YR 6/2 (dark greyish brown) and many medium faint 10YR 5/6 (yellowish brown) mottles, sandy clay loam, moderate fine subangular blocky, moist, friable, porous, abundant roots, much bleached coarse angular quartz grit.

Clear-regular wavy boundary

3-12 10YR 6/6 (brownish yellow) with common fine very faint 10YR 8/6 and 10YR 8/8 (yellow) mottles, sandy clay loam - sandy loam, weak medium subangular blocky breaking to moderate fine crumb, clayskins on worm/root channels [7.5YR 7/6 (reddish yellow)], moist, friable, many roots, patches of coarse sand in old worm channels.

Gradual regular boundary

12-27 Mixed faint 10YR 7/8 (yellow) and 2.5Y 7/6 (yellow) with common fine distinct 7.5YR 7/8 (reddish yellow) and 2.5Y 8/4 (pale yellow) mottles, sandy loam to sandy clay loam, weak medium subangular blocky with moderate - weak discontinuous clayskins [10YR 7/6, 7/8 (yellow)], moist, slightly firm, few roots.

Diffuse regular boundary

27-38 7.5YR 7/8 (reddish yellow) with many fine faint 5YR 6/8 (reddish yellow), 2.5Y N7/ (light grey) and many medium faint 2.5Y 8/4 (pale yellow), 2.5Y 6/6 (yellow) mottles, sandy loam - sandy clay loam, moderate medium subangular blocky with strong continuous clayskins [7.5YR 7/8 (reddish yellow)], moist, firm, ped interiors slightly porous, few roots.

Gradual wavy boundary

38-49 Mixed distinct 5YR 6/8 (reddish yellow) and 2.5Y 7/4 (pale yellow) with many distinct 2.5Y 7/2 (light grey) mottles, sandy clay loam, structureless - massive (to very weak coarse subangular blocky), moist, firm, very slightly porous, no roots.

Diffuse boundary

49-64+ Mixed distinct 5Y 8/3 (pale yellow), 2.5Y 7/2 (light grey) and 5YR 6/8 (reddish yellow), sandy clay loam - sandy loam, structureless - massive, moist, firm, non porous, no roots.

Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
0 - 3	4.2	2.4	0.14	80	60	650	1700	3.6	0.2	2.1	61.6	17.1	17.9	Sandy loam
6 - 9	4.3	1.0	0.07	80	60	830	1940	4.8	0.6	2.2	60.1	14.6	20.3	Sandy clay loam
18-22	4.6	0.1	0.04	60	160	730	1930	4.6	0.2	2.4	62.9	15.3	18.3	Sandy loam
31-34	4.6	0.1	0.04	70	60	980	2600	6.4	0.1	1.7	57.3	13.9	24.7	Sandy clay loam
42-46	4.6	0.1	0.04	80	60	1100	2610	6.8	0.1	2.3	55.4	15.2	27.4	-ditto-
62-64	4.5	0.1	0.05	70	60	1260	3210	6.9	0.5	1.6	54.6	16.1	28.4	-ditto-

	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
Sample 1	0.2	0.4	0.1	Tr	9.1
2	0.2	0.1	0.1	Tr	8.1
3	0.1	0.1	Tr	Tr	7.3
4	0.1	0.1	Tr	Tr	8.4
5	Tr	0.1	Tr	Tr	7.9
6	0.1	0.1	Tr	Tr	8.7

Profile F4C

Mapping unit: Bso (Map 7)

Sarawak classification:	G.S.G.	Family	Series
	Podsol	Buso	-

Location: Western, unplanted section of Nyabau site (see Map 7).
Topography: Flat raised beach, with slight micro-relief.
Parent material: Quaternary raised beach deposit.
Vegetation: Originally kerangas forest.

0-0 2.5YR 3/4 (dark reddish brown) litter, roots still clear but leaf laminae completely disintegrated. Abundant large tree roots; layer of wood ash at 1-2 inches, rare bleached coarse sand grains.

Clear regular boundary

0-2 7.5YR 4/2 (brown to dark brown), sandy loam - sand, structureless - single grain, very moist, loose, roots abundant, much bleached grit.

Gradual regular boundary

2-8 2.5Y N4/ (dark grey) with many medium to fine very faint patches 2.5Y N6/ (grey) and few fine faint reddish brown, and orange (along root channel) mottles, sand, very weak medium subangular blocky breaking to give single grain, moist - wet, friable, very porous, many roots.

Clear wavy boundary

8-9/11 Mixed faint 10YR 2/2 (very dark brown) and 10YR 4/3, 10YR 5/3 (brown brown to dark brown), loamy sand, moderate-weak medium angular blocky, moist - wet, friable, hard (indurated), many roots, very porous.

Clear irregular boundary

9/11-17/20 2.5Y 7/4 (pale yellow) with few distinct streaks of 7.5Y 4/4 (dark brown) and patches of orange, yellow and reddish brown, sandy loam - sandy clay loam, moderate medium subangular blocky, iron staining along ped faces (especially horizontal surfaces), moist, slightly firm - friable, but darker patches are slightly brittle, roots rare.

Clear irregular boundary

17/20-26/30 2.5Y 8/4 (pale yellow) with many medium faint 2.5Y 7/2 (light grey), 2.5Y 8/6 (yellow) orange, reddish brown, dark brown patches, fine sandy clay loam, weak - moderate medium subangular blocky, moist, firm, non porous, roots absent.

Gradual irregular boundary

26/30-39 5Y 8/2 (white) with abundant patches 10YR 2/2 (very dark brown) especially on vertical ped faces and many fine faint distinct yellow, reddish yellow, orange, brown, reddish brown mottles along old root channels sandy clay loam - sandy loam, weak medium subangular blocky tending to massive, moist, firm, slightly porous, roots absent but many old root channels.

Clear regular boundary

39-46 2.5Y 7/4 (pale yellow) with many medium faint distinct 2.5Y 7/8 (yellow), 7.5YR 7/8 (reddish yellow) and few reddish brown mottles, sand - loamy sand, single grain, moist, friable, roots absent.

Gradual regular boundary

46-56 5Y 8/3 (pale yellow) with many medium very faint 5Y 8/2 (white) and 5Y 8/6 (yellow) mottles, sand, single grain, moist, loose, roots absent.

Diffuse boundary

56-74+ Mixed 5Y 8/1, and 5Y 8/2 (white) with few patches of 5Y 8/3 (pale yellow) sand, structureless - single grain, moist, loose, no roots. This horizon continues to 120 inches + (auger).

Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III %	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
6 - 0	3.5	35.4	0.93	90	380	350	310	0.7	-	-	-	-	-	Peat
0 - 2	4.5	6.5	0.25	70	60	90	Tr	0.6	0.7	1.9	69.4	12.1	12.9	Sandy loam
4 - 6	4.6	1.2	0.04	90	60	60	Tr	0.5	0.2	2.0	80.1	11.3	4.9	Loamy sand
8 -10	4.3	3.3	0.08	80	60	180	250	1.1	0.5	2.5	70.0	17.0	9.0	Sandy loam
13-16	5.1	0.9	0.04	80	60	650	1120	7.1	2.3	3.8	59.6	14.9	12.8	Sandy loam
21-25	4.9	0.4	0.04	80	60	410	1800	8.5	0.1	1.3	56.3	15.6	24.9	Sandy clay loam
32-35	4.8	0.1	0.03	60	60	1160	2130	8.7	Tr	1.1	64.7	9.8	25.4	Sandy clay loam
41-44	5.0	Tr	0.03	40	60	780	1520	4.8	0.1	1.3	77.9	6.3	14.8	Sandy loam
50-52	5.2	0.1	0.02	30	60	560	1130	3.3	Tr	0.7	84.4	3.9	11.9	Loamy sand
71-74	5.7	Tr	0.02	10	100	113	400	1.0	0	0.2	96.8	2.8	1.7	Sand

	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
Sample 1	1.5	1.6	0.8	0.3	10.0
2	1.6	3.0	0.4	0.1	18.7
3	0.5	0.1	1.1	Tr	5.7
4	0.1	0.1	0.8	Tr	11.9
5	0.1	0.2	Tr	Tr	8.2
6	0.1	Tr	Tr	Tr	6.7
7	0.1	0.1	Tr	Tr	7.4
8	0.1	Tr	Tr	Tr	5.7
9	0.1	Tr	Tr	Tr	5.1
10	Tr	Tr	Tr	Tr	1.5

Profile F4D

Mapping unit: Mri (Map 7)

Sarawak classification:	G.S.G.	Family	Series
	Podsol	Miri	-

Location: Between performance trial plots 4 and 5 on Nyabau site (see Map 7).
Topography: Raised beach with marked microrelief.
Parent material: Quaternary raised beach deposit.
Vegetation: Originally kerangas forest.

0-0 Dark reddish brown litter.

0-5 5YR 4/2 (dark reddish grey) and many bleached [7.5YR N7/ (light grey)] coarse sand grains, sand, structureless - single grain, moist - wet, soft, few roots.

Gradual slightly wavy boundary

5-10 Mixed distinct 10YR 6/2 (light brownish grey) and 7.5YR 5/2 (brown) with many bleached [2.5Y N8/ (white)] coarse sand grains, sand, structureless - single grain, wet - moist, soft, rare roots.

Clear regular boundary

10-17 Mixed distinct 2.5Y N8/ (white) and 2.5Y 6/2 (light brownish grey) with few fine faint 2.5Y 5/2 (greyish brown) mottles and streaks of dark organic matter in old root channels, sand, structureless - single grain, wet - moist, soft, roots absent.

Gradual wavy boundary

17-21 Mixed distinct 2.5Y N8/ (white), 10YR 6/3 (pale brown), 2.5Y 6/6 (olive yellow) and 2.5Y 5/4 (light olive brown), sand, structureless - single grain, wet, soft, roots absent.

Clear wavy boundary

21-30+ Mixed faint 7.5YR N2/ (black) and 10YR 4/2 (very dark grey), sand, structureless - massive, wet, hard (indurated), roots absent.

This horizon is too wet and too hard for the pit to be deepened.

Depth (inches)	pH H_2O	% Org. C	% Total N	Conc. HCl Extract P ppm	Ca ppm	Mg ppm	K ppm	Group III%	% of fine earth: Coarse sand	Medium sand	Fine sand	Silt	Clay	Texture
3 - 0	3.2	40.9	0.54	180	1110	1360	Tr	1.2	-	-	-	-	-	Peat
0 - 4	4.3	1.4	0.05	Tr	60	60	Tr	0.7	0.4	24.6	70.0	2.6	3.5	Sand
6 - 9	5.6	0.2	0.01	20	60	60	Tr	0.7	0.5	14.4	82.9	1.1	2.9	Sand
12-15	5.7	0.1	0.01	Tr	60	Tr	Tr	0.7	0.5	19.5	78.1	1.4	5.1	Sand
18-20	5.4	0.1	0.01	20	280	310	Tr	0.8	0.3	14.6	78.6	5.9	3.2	Sand
24-30	3.8	3.5	0.04	Tr	60	Tr	Tr	0.6	0.9	25.0	64.8	0.9	9.6	Loamy sand/ sand

Sample	Exchangeable me./100gms. Ca	Mg	K	Na	CEC
1	1.4	10.4	0.4	0.1	85.7
2	Tr	0.3	Tr	0.1	3.4
3	Tr	Tr	Tr	Tr	0.1
4	Tr	Tr	Tr	Tr	0.6
5	Tr	Tr	Tr	Tr	0.1
6	Tr	Tr	Tr	0.1	14.8

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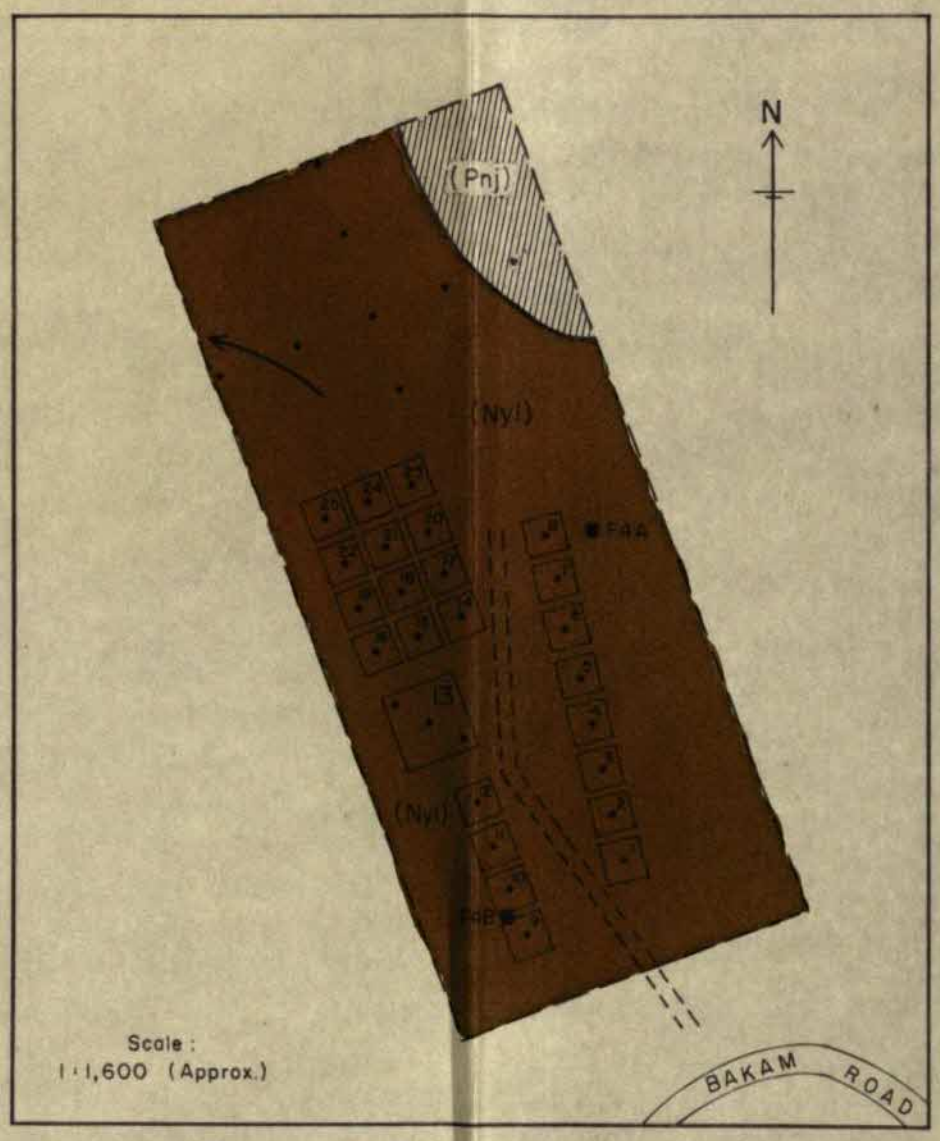
LAMBIR

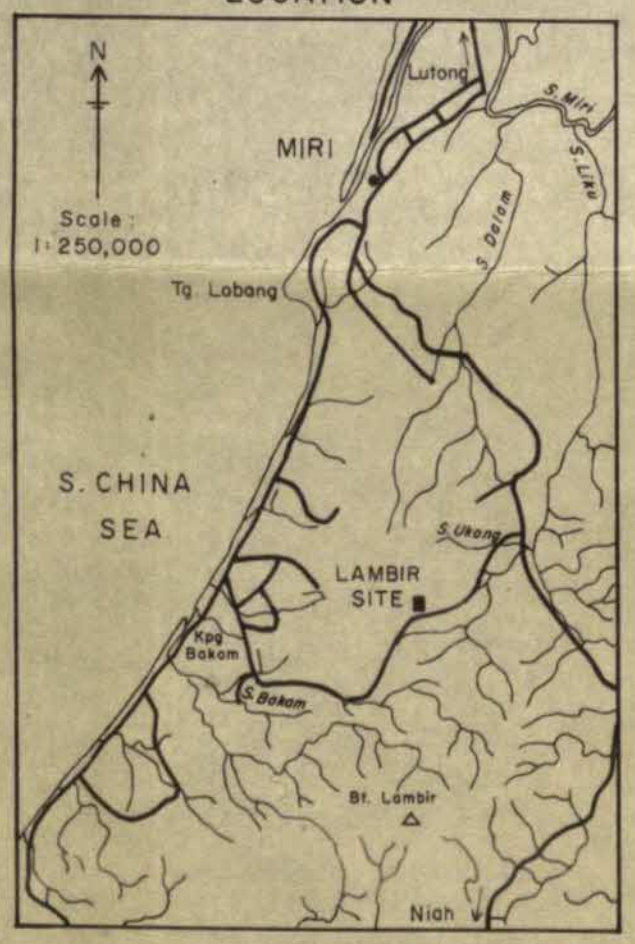


LEGEND

- Boundary of cleared area.
- Road.
- Tractor path.
- Drainage line.
- Performance trial plot (64 trees).
- Arboretum plot (25 trees).
- Soil auger inspection.
- ■ F4A Described and sampled soil profile pit.

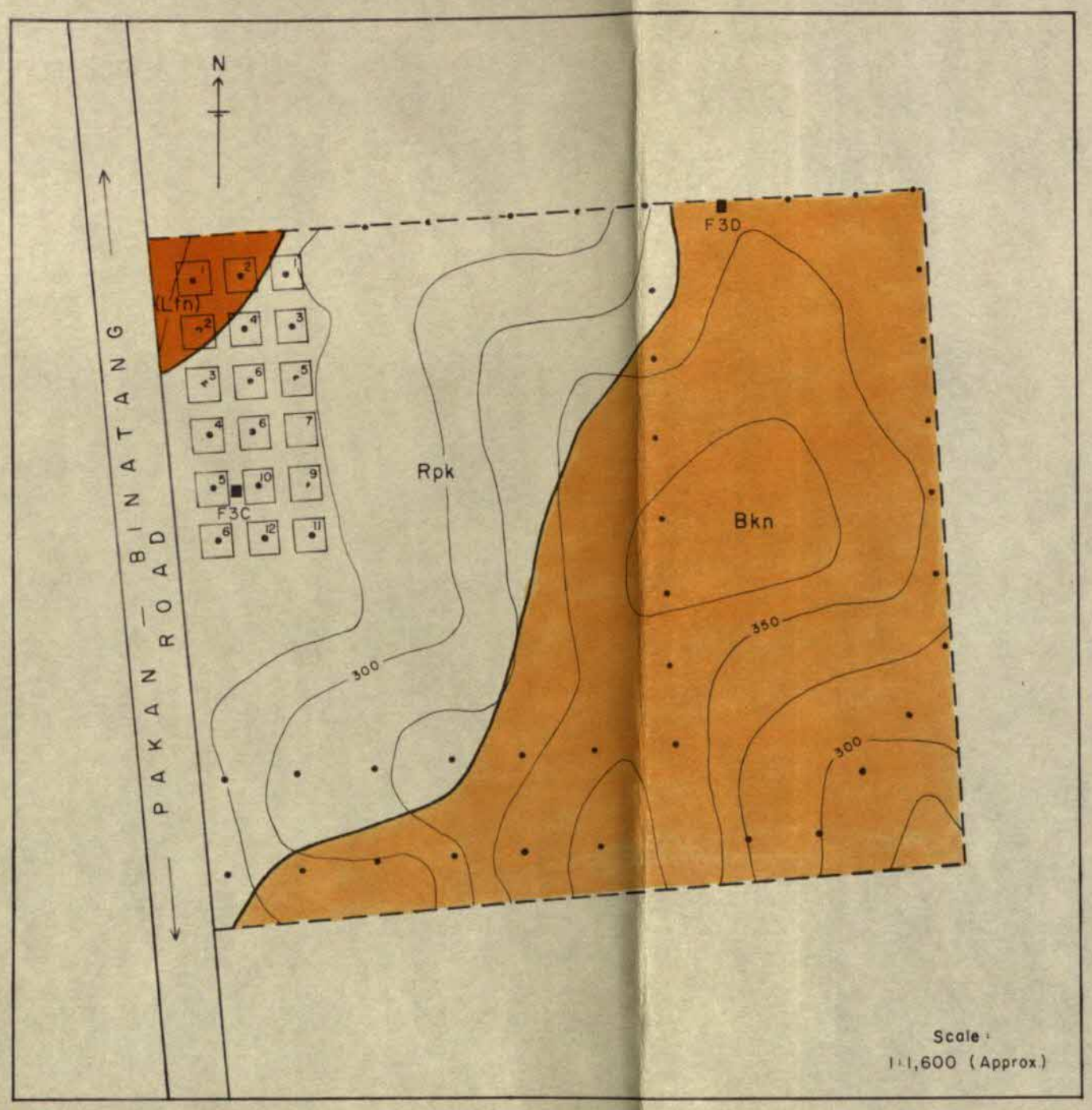
SOIL MAPPING UNITS	
(Nyl)	Brownish yellow - yellow sandy loam over reddish yellow sandy clay loam.
(Pnj)	Brownish yellow loamy sand - sandy loam over reddish yellow sandy loam.

LOCATION



F.D.S.S. Map 17 Soil Survey Drawing No. 236 Plot location information supplied by Silvicultural Research Section, Forest Department. Compiled by I.C. Baillie Drawn by Salbiah

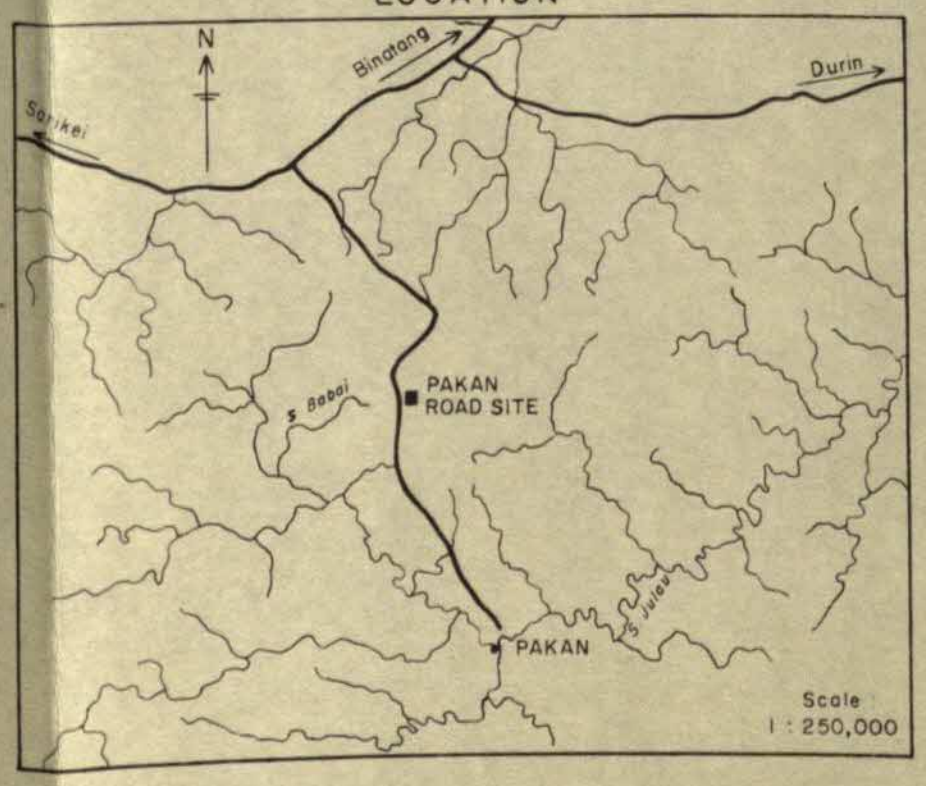
PAKAN ROAD



LEGEND

- Boundary of Reserve.
- Road.
- 350 — Form line (feet).
- 13 — Arboretum plot (25 trees).
- • Soil auger inspection.
- ■ F3D — Described and sampled soil profile pit.

LOCATION

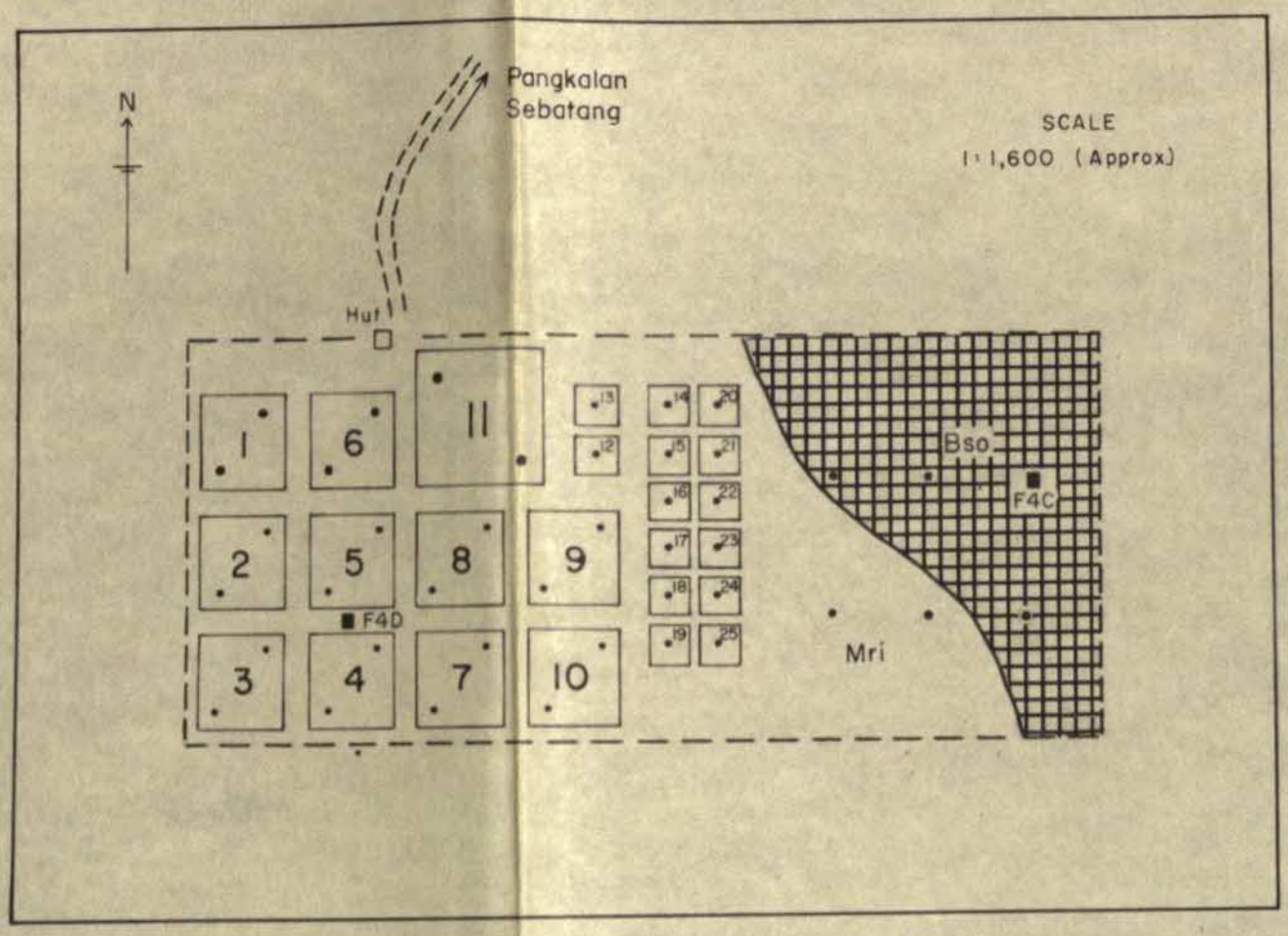


SOIL MAPPING UNITS

Rpk	Mottled brownish yellow sandy loam - sandy clay loam, over red, yellow and white 'corned beef' clay horizon, usually with stone line of rounded quartz gravel and black iron concretions at boundary. Moderately deep (24 - 48 inches to weathering shale).
(Ltn)	Colours similar to above, but texture is clay throughout. No stone line above 'corned beef' horizon. Deep (more than 48 inches).
Bkn	Unmottled brownish yellow sandy clay loam going to sandy clay or clay at depth. Deep (48+ inches to weathering rock).

F.D.S.S Map 14 Soil Survey Drawing No. 233
Base on Land & Survey Series 23 sheet 1/III/3/2.
Plot location information supplied by Silvicultural Research Section, Forest Department.
Compiled by I.C. Baillie Drawn by Saibion

NYABAU



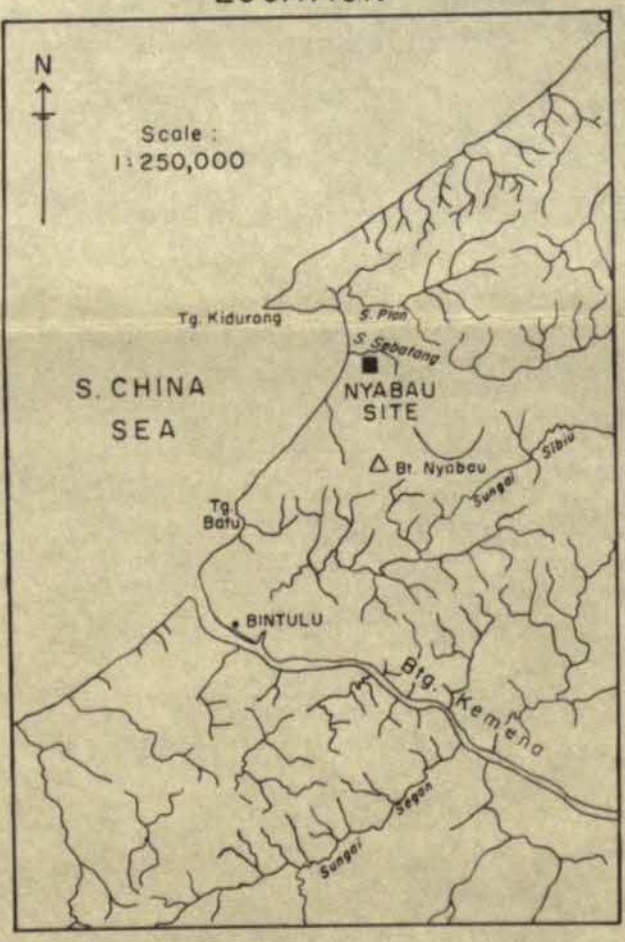
LEGEND

– – – –	Boundary of cleared area.
= = = = =	Footpath.
II	Performance trial plot (64 trees).
7	Performance trial plot (64 trees).
13	Arboretum plot (25 trees).
•	Soil auger inspection.
■ F4C	Described and sampled soil profile pit.

SOIL MAPPING UNITS

	Brief Description
Mri	Thick litter over thin organic coloured topsoil. Light grey or white wet sandy subsoil horizon overlies indurated and unaugerable brown humus pan.
Bso	Similar profile to Miri, but white sand less wet and humus pan less indurated – can be augered. Pan overlies deep, pale yellow sand.

LOCATION



F.D.S.S. Map 16 | Soil Survey Drawing No. 235 | Plot location information supplied by Silvicultural Research Section, Forest Department. | Compiled by I.C. Baillie | Drawn by Salbiah

BUKIT TEMUDOK

LEGEND

- Boundary of Forest Department area.
- Road.
- Drainage line.
- 13 — Performance trial plot (64 trees).
- 13 — Arboretum and fertilizer trials plot (25 trees).
- Soil auger inspection.
- F2C — Soil profile pit.

SOIL MAPPING UNITS

Mrt	Clay loam over clay subsoil. Brownish or reddish yellow throughout. Generally moderately deep (weathering rock begins at 20 - 48 inches).
Bkn	Fine sandy loam or sandy clayloam over fine sandy clay subsoil. Brownish or reddish yellow throughout. Generally moderately deep (weathering rock begins at 20 - 48 inches).
Nyl	Fine sandy loam or loamy sand over fine sandy clay loam or sandy loam subsoil. Brownish or reddish yellow throughout. Generally moderately deep (weathering begins at 20 - 40 inches)
Nyl (s)	Brownish yellow fine sandy loam or loamy sand over fine sandy clay loam. Shallow (weathering rock begins at 10 - 20 inches)

LOCATION

F.D.S.S. Map 2

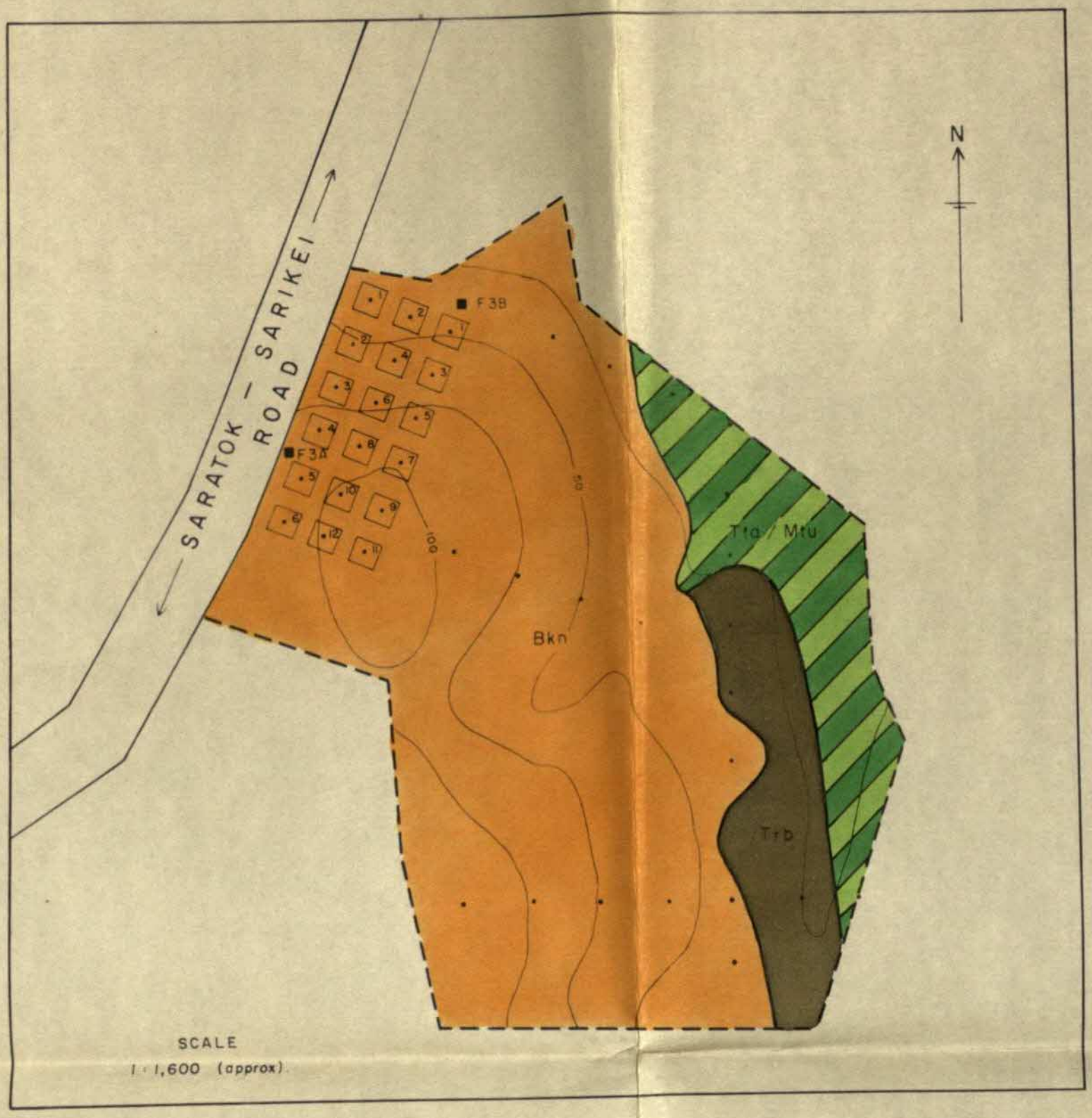
Soil Survey Drawing No. 231

Plot location information supplied by Silvicultural Research Section, Forest Department

Compiled by I.C. Baillie

Printed by Surprint

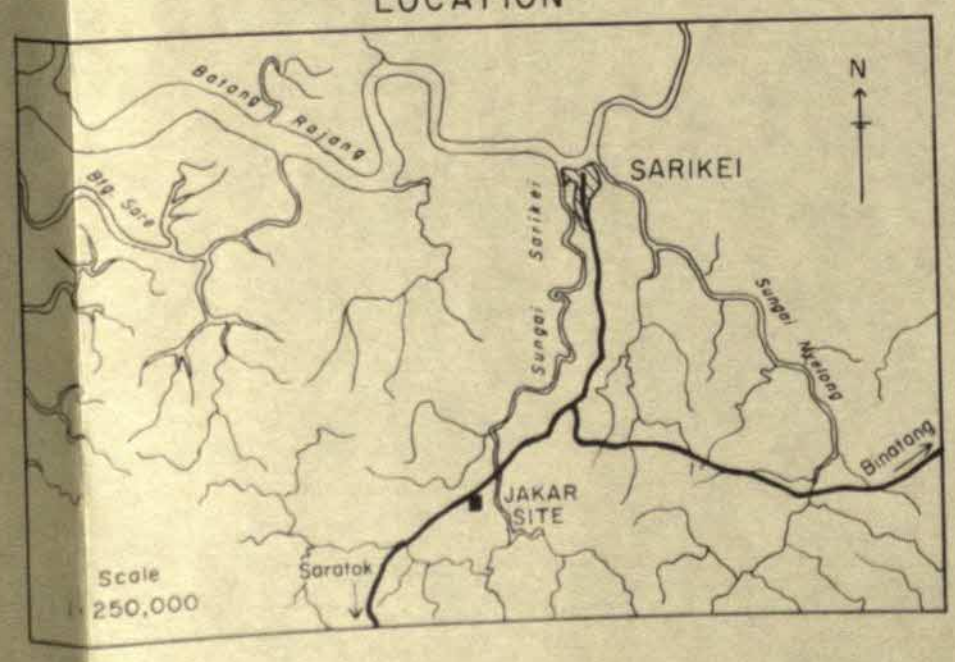
JAKAR



LEGEND

- Boundary of Reserve.
- Road
- 100 Form line (feet).
- Arboretum plot (25 trees).
- Soil auger inspection.
- F3A Described and sampled soil profile pit.

LOCATION



SOIL MAPPING UNITS

	Brief Description
Bkn	Reddish yellow and brownish yellow soils. Sandy loam at surface grading to sandy clay at depth. Weathering rock often begins 30 – 48 inches.
Trb	Pale yellow, light grey or white colours predominant throughout profile. Texture increases from sand at surface to sandy loam or sandy clay loam at depth. Deeper than 48 inches.
Tra/Mtu	Wet gleyed soils formed on sandy alluvium in valley bottom. May (Matu) or may not (Tatau) have muck layer (less than 10 inches thick) at surface.

F.D.S.S. Map 15

Soil Survey Drawing No. 232

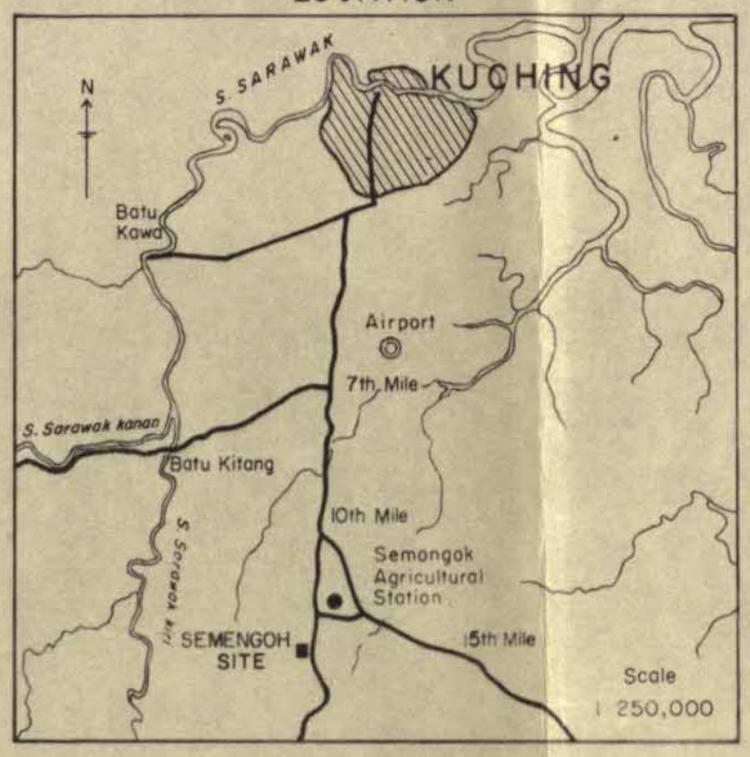
Base on Land & Survey Series 23 sheet 2/111/4/16.
Plot location information supplied by Silvicultural Research Section, Forest Department.

Compiled by I. C. Baillie

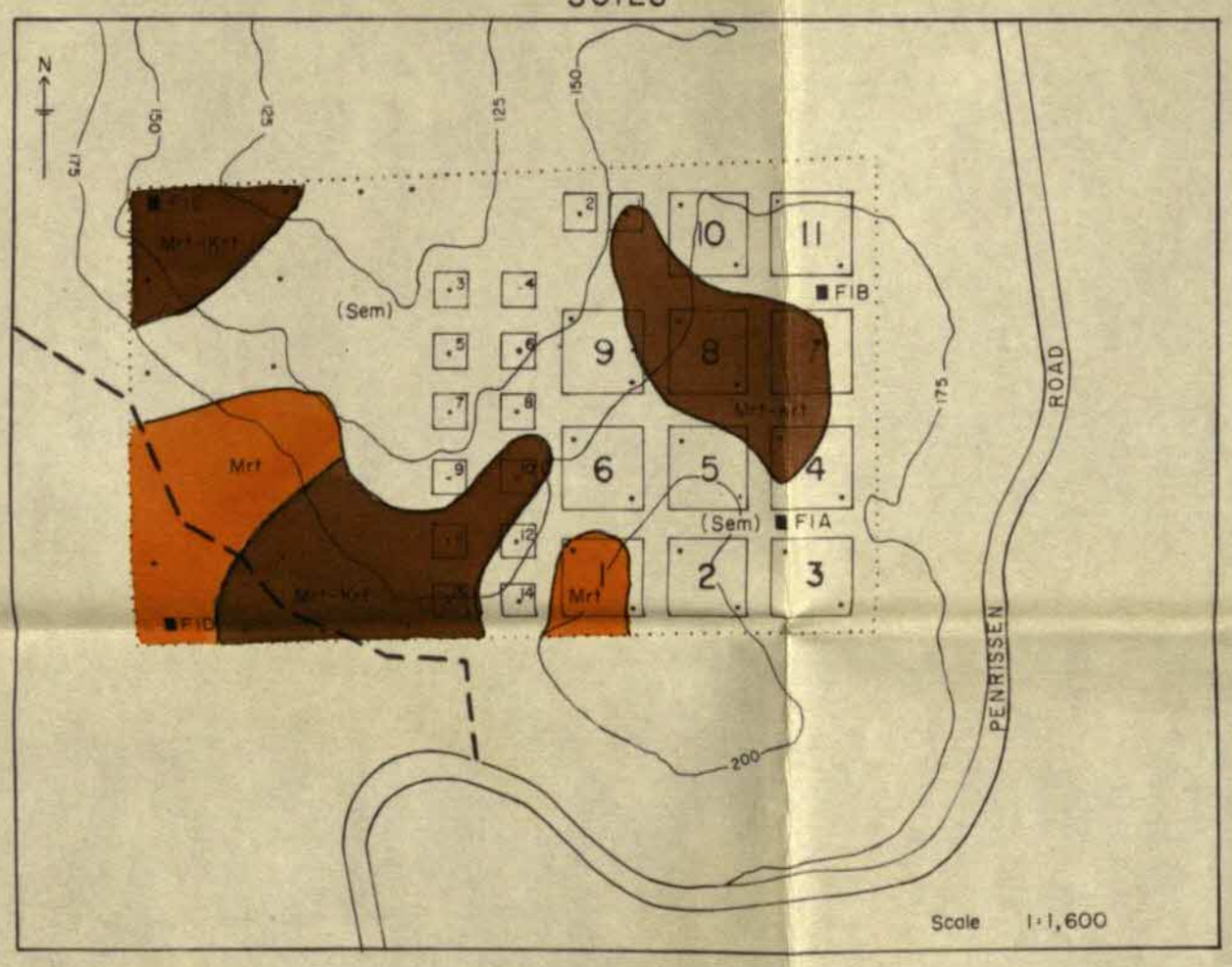
Drawn by Salbiah

SEMENGOH

LOCATION



SOILS



SOIL MAPPING UNITS

(Sem)	Mottled reddish yellow and brownish yellow clays.
Mrf - Krf	Mottled pale and very pale brown and light grey clays.
Mrf	Unmottled reddish yellow and brownish yellow clay.

LEGEND

—150—	Contour.
———	Road.
— —	Foot path.
.....	Boundary of cleared area (and survey area).
7	Performance Trial plot (64 trees).
7	Fertilizer Trial plot (25 trees).
•	Soil auger inspection.
■ FIA	Described and sampled soil profile pit.

F.D.S.S. Map II Soil Survey Drawing No. 230 Base map from Land & Survey Topo 1/106, 1969 Compiled by I.C. Baillie Drawn by Satbiah

LOCATION OF EXPERIMENTAL AFFORESTATION SITES

SCALE 1:2,000,000

0 20 40 60 80 100 MILES

N

—+—+— State Border

———— Divisional Boundary

■ Experimental Afforestation Site

SOUTH CHINA SEA

INDONESIAN BORNEO

BRUNEI

BRUNEI

Miri

LAMBIR

FIFTH DIVISION

FOURTH DIVISION

Baram

Belaga

Tinjar

NYABAU

Baram

Sibu

OYA ROAD

THIRD DIVISION

Rejang

Balleh

JAKAR

PAKAN ROAD

Batang Lupar

Kuching

SEMENGOH

FIRST DIVISION

SECOND DIVISION

Simanggang

BUKIT TEMUDOK

F.D.S.S. Map 10 Soil Survey Drawing No. 229 Based on Land & Survey Dept. Series No. 15 Compiled by J.C. Baillie Drawn by Saibin