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Report to the Government of

BRAZIL

APPLICATION OF SILVICULTURAL METHODS TO SOME OF THE FORESTS OF THE AMAZON

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

ROME, 1961

Report No. 1337 BRA/FO

REPORT

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APPLICATION OF SILVICULTURAL METHODS TO SOME OF THE FORESTS OF THE AMAZON

by

John Pitt

Rome, 1961

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INTRODUCTION

(a) The Problem. Very briefly, the problem is to change a forest with trees of all ages and of many different species only a few of which are of present-day value, into a forest with fewer species but more trees of each which are of value and of about the same age.

In 1951-52 the Food and Agriculture Organization of the United Nations, at the request of the Government of Brazil, sent out a three-man team "to advise the Government on Forest Industry - Sawmilling Operations, Kiln Drying and Training of Personnel; on the modernization of Logging Methods and utilization of Waterways for water logging; on Marketing and Distribution of Timber" FAO Report No. 171 was submitted in October, 1953. (Ref. 4).

In accordance with some of the recommendations of the above Report, the Government of Brazil asked for technical assistance for carrying out a logging training centre and for setting up a sawmill training centre. At some later date assistance was also asked for in silviculture with a view to improving the forest for the future.

For this assignment Mr. C.J.W. Pitt was appointed. He arrived in Brazil on 30 November 1955 and left on 23 September 1960.

(b) Terms of Reference. These were: to advise and assist the Government in the application of silvicultural methods to the Amazon forests for the purpose of developing the rational utilisation of these forests.

(c) Method of Performing Technical Assistance. As all the funds for the work to be performed by the FAO Mission in the Amazon were to come from the Superintendência do Plano de Valorização Econômica da Amazônia (SPVEA) the whole Mission was attached to this body in Belém. The Superintendência did not, however, have any Brazilian technicians in forestry working in the field.

(d) Acknowledgements. Dr. Olimpio dos Santos, Director, Division of Production, Federal Territory of Amapá for help over transport and sometimes for labour, and for the sites for the Fazendinha nursery and trial plots near Macapá.

Dr. R. Butler, General Manager, Indústria e Comércio de Minérios S.A., Pôrto Santana, Amapá, for providing accommodation on numerous occasions at Pôrto Planton and for assistance over transport.

Dr. Joaquim Lopes, Director, Posto Agro-Pecuário de Santarém (locally known as "CBA") for placing part of the forest at the Agricultural Station at the disposal of FAO.

Ilmo. Sr. Mário Guimarães who, as the first administrator of the Sawmill Training Centre at Santarém, rendered valuable assistance on countless occasions.

Dr. Rubens Lima, Director, Instituto Agronômico do Norte ("IAN"), Belém, for providing facilities while visiting Fordlandia and Belterra, for allowing a diameter increment plot to be established at Mucambo in the Institute' grounds and for help provided by the Botanical section of the Institute.

Dr. Murça Pires, in charge of the Botanical Section at IAN, for two short visits to the field and for identifying much botanical material, most of which had been collected by one of his field staff.

Dr. Ricardo Lemos Fröes, Botanist, IAN, for one visit to the field and for help in the herbarium.

Dr. Batista Benito Gabriel Calzavara of IAN for including some plants of Pinus caribeae in his 1959 trial plots.

Dr. Walter Egler, Director, Museo Goeldi, Belém, for occasional seed and help over preparing diagrams for a forestry exhibition.

Dr. Waldemar Cardoso, Chefe, 1st. Inspectorate Regional, Serviço Florestal, for the loan of a machine to make torrões paulista (earth pots) and for occasional visits to two nurseries and some plots in the Bragantina area east of Belém.

Ilmo. Sr. Elias Age, Santarém, for providing facilities for a visit to a Pau rosa factory.

The Conservators of Forests, British Honduras, Jamaica, Trinidad, British Guiana and Surinam, and to the Leader, Tropical Forestry Research Center, Rio Piedras, Puerto Rico, for the facilities provided during brief visits to these countries.

Dr. Armando Navarro Sampaio, Chefe, Serviço Florestal da Companhia Paulista de Estradas de Ferro, Rio Claro, S.P., for seed of eucalyptus species.

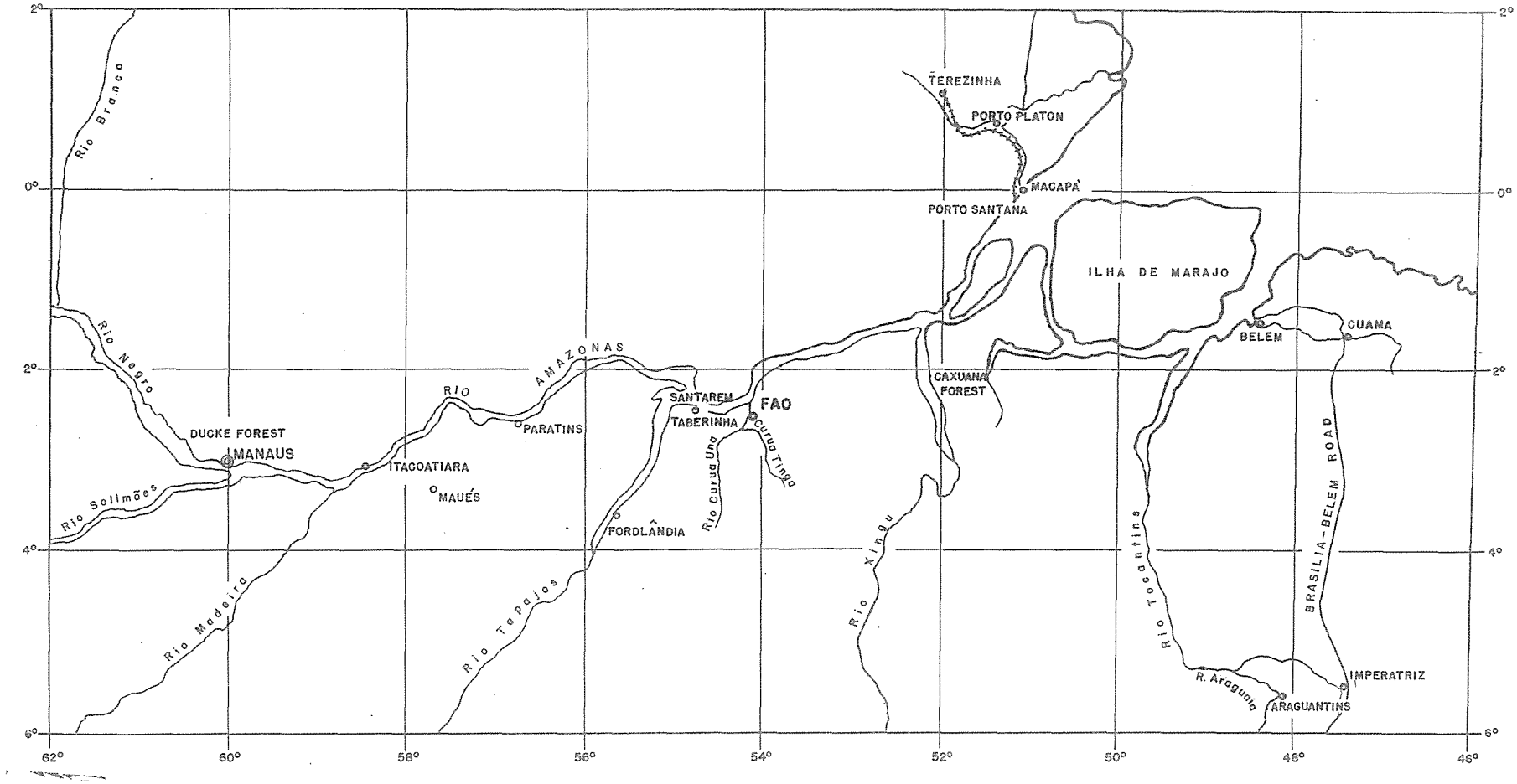
The Director, Serviço Florestal do Estado de São Paulo, for some seed and for mycorrhizal soil.

The Superintendent and staff, especially Dr. Nadir Genu of SPVEA for help generally.

Dr. Francisco Uchos Guerra and then Dr. Osvaldo Vera Cruz for much valuable help in field and office.

Ilmo. Sr. Délcio Seawright Salgado for much patience and efficient secretarial work.

Map I – Situation map lower Amazon region



Mr. H.O. Schaefer, Associate Expert, FAO, for help over some data and for the graphs on pages 23a - e.

(e) Definitions and Names. Technical terms used are explained briefly in Appendix I. Local names are used in the text; botanical equivalents are given in Appendix XIII.

I. SUMMARY OF RECOMMENDATIONS

(i) Major Recommendations

1. It is suggested that, in areas of potential industrial development, it may be economical in the long run to convert an appreciable amount of the very mixed hardwood forests, which take a long time to regenerate, into forests composed of relatively few softer wood quick-growing species whose regeneration can be obtained easily and cheaply by either natural or artificial means (pages 39 and 85). Besides being used for pulpwood, these species would provide cheaper material for plywood, particle board and fiberboard, formwork (shuttering) for concrete, packing cases and much timber for general light constructional purposes.

With regard to natural regeneration attention must be paid to early cleanings to eliminate the slow-growing species, and then to adequate thinnings to keep a comparately wide spacing for the growing desirables - page 39.

2. Further experiments should be laid down with greater degrees of canopy opening than those in hand for diameter increments (page 43) to ascertain the optimum basal area which will give the maximum volume increment in the natural forest - page 42 under "liberation", and page 46.

3. The Curuá Una Centre should be maintained indefinitely and a Forest Reserve created in this area - page 93.

4. Utilization research should be carried out, including use for sleepers, on several of the more common but less well-known species which occur in the Curuá area, and in other parts of the Amazon - page 93.

5. The silvicultural plots at CBA near Santarém should be maintained - page 93.

6. The silvicultural plots Campo Verde near Pôrto Platon should be maintained, if the Territorial Government of Amapá can provide transport for occasional visits; the campos and nursery plots on the equator at Fazendinha should also be maintained - pages 70 and 93.

7. The Silvicultural section of the Instituto Nacional de Pesquisas na Amazônia (INPA), at Manaus, should be gradually expanded, and the technical officer there (Dr. Rubom Valle) sent to Puerto Rico on a short forestry course - pages 75 and 94.

8. The Serviço Florestal should recruit graduate staff (engenheiro-agronomists) to work in the forests, and send them to the Curuá Center for some training - page 94.

9. Silvicultural work on the lines of that already well in hand on the Curuá should be started in the new Caxauna Forest Reserve and along the Brasília-Belém Road, but only after the Chief of the 1st. Regional Inspectorate has visited the Curuá Centre - page 94.

(ii) Other Recommendations of a General Nature

1. Generous financial assistance should be given to any request by FAO for funds for research on the biological control of the shoot borer which attacks various species of the Meliaceae, e.g. Mahogany, Cedro and Andiroba. (page 54).

2. A Forest Reserve should be made in Amapá close to the railway to the manganese mine at Terezinha. (page 66).

3. Forests should be reserved in Mato Grosso and work initiated for their improvement to ensure a future supply of timber close to the more populated regions. (pages 72 and 73).

(iii) Minor Recommendations

These are listed on pages 95 and 96.

II. THE PROBLEM

The composition of the forest can vary, both as regards to species and to numbers of individuals of a species, over quite short distances. See Appendix V. Compartments 5 and 6 are adjoining and 6 and 16 touch at one corner. The figures in this list for compartments 5, 6 and 16 are for areas of approximately 100 hectares; those for the "exploratory survey" of Heinsdijk cover 109 hectares scattered over a very large area between the rivers Tapajós and Xingu. The list on page 21 for the research plots in cpt. 2 shows how the forest varies even in small adjoining blocks of 1 hectare each.

Many of these species are not of present-day value; almost none of the "luxury" species - mahogany, cedro or freijó - is present except for 6 cedro in cpt. 6. Even taking all the ordinary "madeira de lei", these represent only 32 species of the total of 110 referred to on page 21.

The basic problem for the Silviculturist, therefore, is to change the forest from such a heterogeneous mixture of all ages and many species, a large proportion of which are useless, and in which only some stems of the economics are of value, to a forest with a large number of valuable stems of about the same age and of only a few well or reasonably well known species.

When a hundred hectares of forest can yield 2,000 or more stems of a few useful species, even if not in the "luxury" class, instead of about 20 stems (as was the case in one area being exploited by a firm based on Santarém) it is obviously going to be much more economical to exploit this hundred hectares.

The next problem is to recognize the trees. Even more difficult is to recognize the seedlings of the important trees. It is often hard to get good seeds of these species; seed years may be few and far between, and much seed is eaten or quickly rots as soon as it falls.

The next problem is to determine the silvicultural requirements of the important species. Some planting has been done at different times by the Instituto Agronômico do Norte, at Belém, and a little by the Serviço Florestal. There is, however, no Brazilian with professional training in forestry in the Amazon; this is a highly specialised 3 or 4 year degree course, not just nursery work and tree planting as is taught to engenheiro-agronomists under the heading "Silvicultura". Little was known about the best method of planting most species on a large and economical scale and virtually nothing about inducing or even tending natural regeneration of useful species, nor on how to improve the composition and structure of the forest.

Another problem arises over the vastness of the area, the difficulties of communication and the various types of forest which exist.

Another problem is the lack of knowledge about the usefulness of many of the species. The case for improving the forest will depend considerably on the intensity of the exploitation, and this will depend on the amount of the useful species. The present "creaming" of the more accessible forests for such trees as cedro and freijó is highly undesirable; the eyes or jems are being picked out, and, once these are gone, it may well be many years, if at all, before it will be economical to return to exploit some of the remaining useful species.

III. SITUATION AFFECTING THE SOLUTION OF THE PROBLEM OR FACTS BEARING ON IT

1. Natural Features

(i) Climate

Descriptions of the climate in the Amazon Valley have been given in previous FAO Reports - No. 171 (Ref. 4) on pages 77-8, and No. 756 (Ref. 6) on pages 30-32.

Graphs 1 - 3 (pp. 8a - c) are included in this report showing the data available for Belém, Manáus, Macapá, Santarém (IBA), and the Curuá, the SPVEA-FAO Logging and Silviculture Centre fairly near Santarém; the last is for only two seasons, but that for CBA is for 11 years at the Agricultural Station.

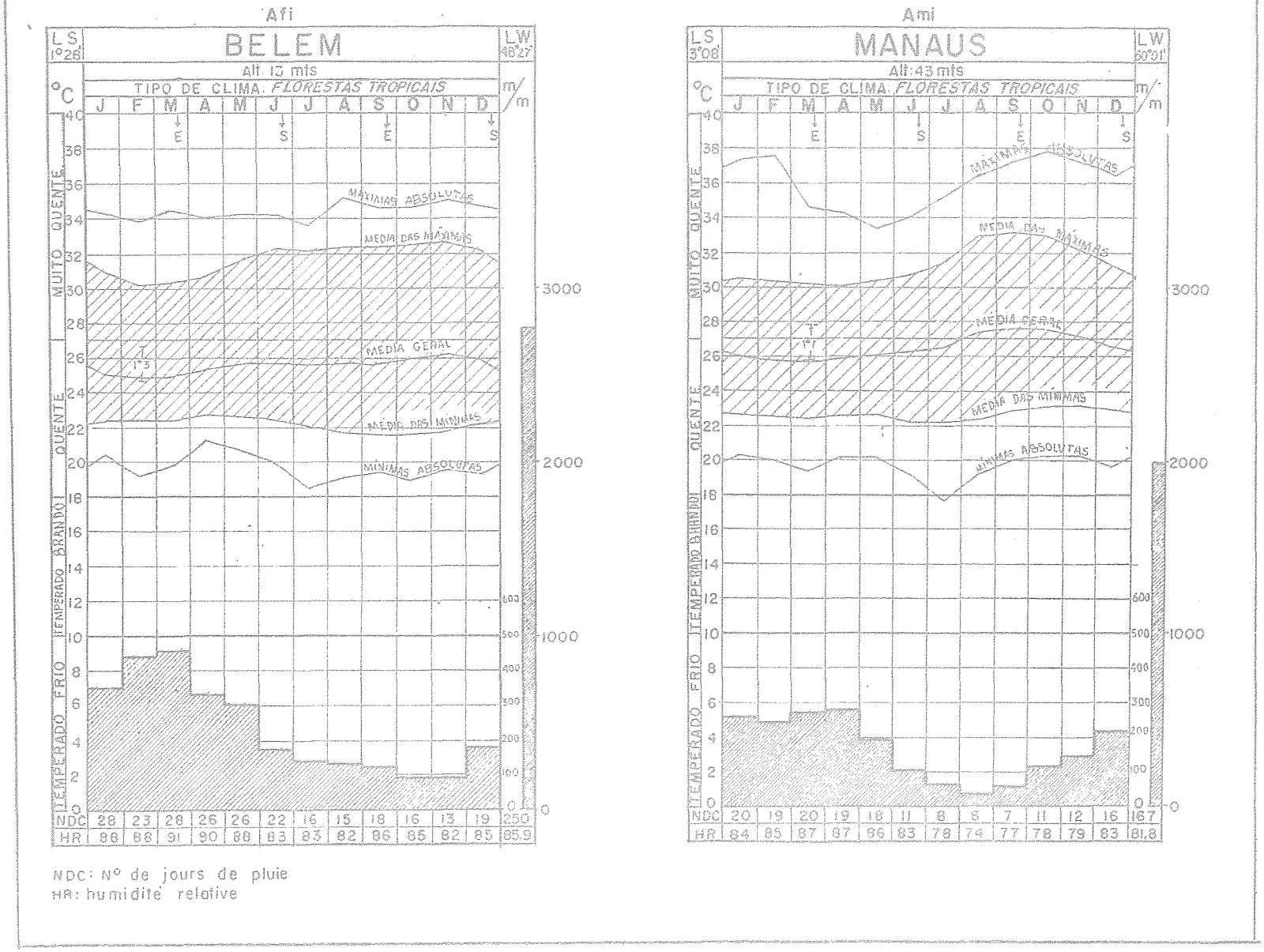
By tropical standards the rainfall for both the Curuá and CBA is surprisingly low. They are both certainly dry during the dry season, and in a low rainfall year ground fires can spread slowly over large areas; this was the case in the dry months of 1958 on the Curuá. In February, 1959 the Mission pedologist found that the subsoil on the Planalto was apparently still quite dry from about 2 m down to 5 m, the deepest that could be reached with the soil auger. Fire can play an important part in some silvicultural operations, as will be seen page 23 in the section on Natural Regeneration After Exploitation (pages 27, 28, 35 and 36).

Monthly rainfall figures unfortunately are not much guide as to when to plant, except for indicating the earliest suitable month - a total of about 100 mm is desirable. In 1958, planting on the Curuá was done under ideal conditions in February, but a dry spell followed and quite a lot of replanting was necessary in April. In 1959, therefore, planting was done in March and was very successful. In 1960, planting would have been successful had it been done early in February. In March, dry sunny spells followed each wet spell when some planting was done, and a fair amount of replanting was necessary in April. The above remarks apply to planting in the open. In enrichment lines planting can be done earlier with success, and also on days when it is not possible to plant in the open. Some successful planting was done near Belém one year in September by the Serviço Florestal, using plants raised in baskets.

In some earlier FAO reports rainfall figures for Santarém have been given with the annual average of 2,312 mm. This is for TAPERINHA on the norther edge of the planalto ESE from Santarém and about half way to the Curuá.

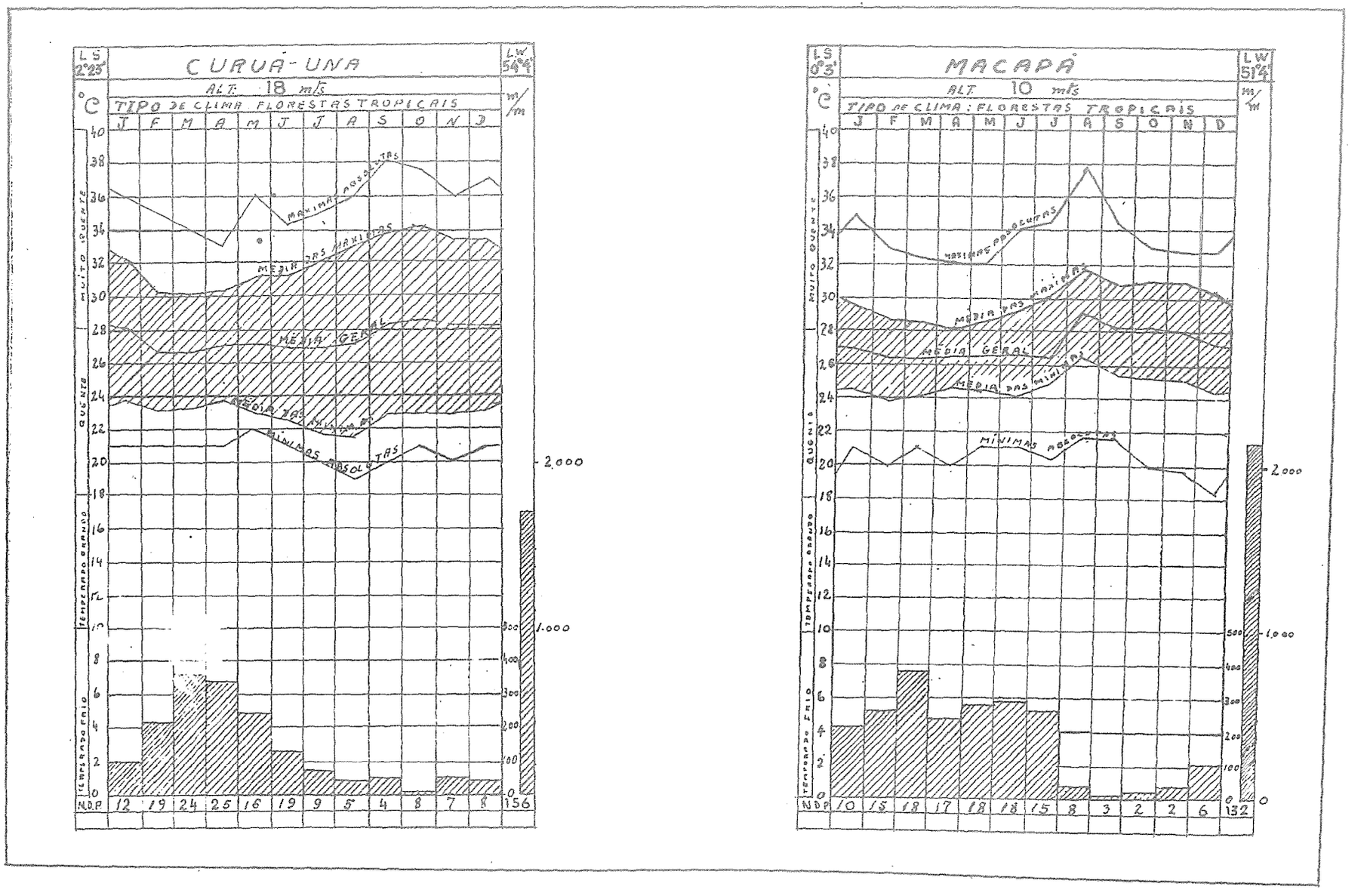
On Graphs 4 - 5 (pp. 8d - e) the monthly rainfall totals have been plotted in mm, and the mean monthly temperatures in degrees centigrade on double the scale. The portion of the graph where the rainfall curve falls below that of the temperature (the shaded area) is said to give some indication of the severity of the dry season. Certainly on the Curuá (Graph 4) the 1958

Graph 1- Outline of the climatic conditions in the tropical forest of Belem and Manaus.

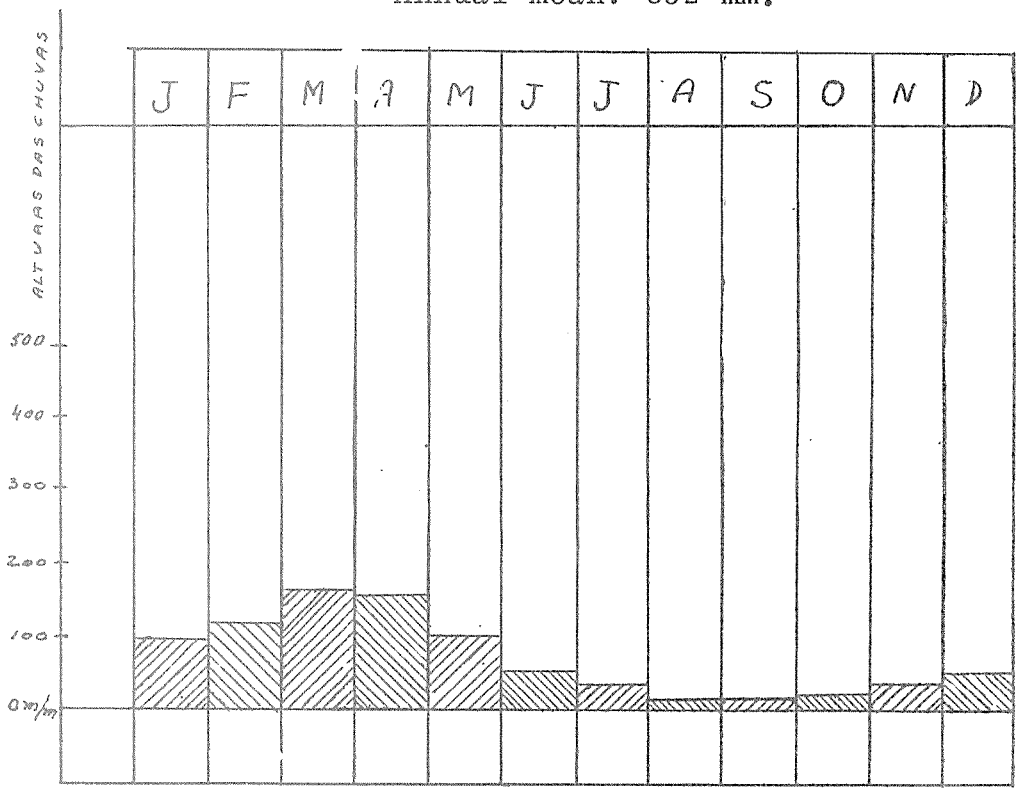


NDC: Nº de jours de pluie
HR: humidité relative

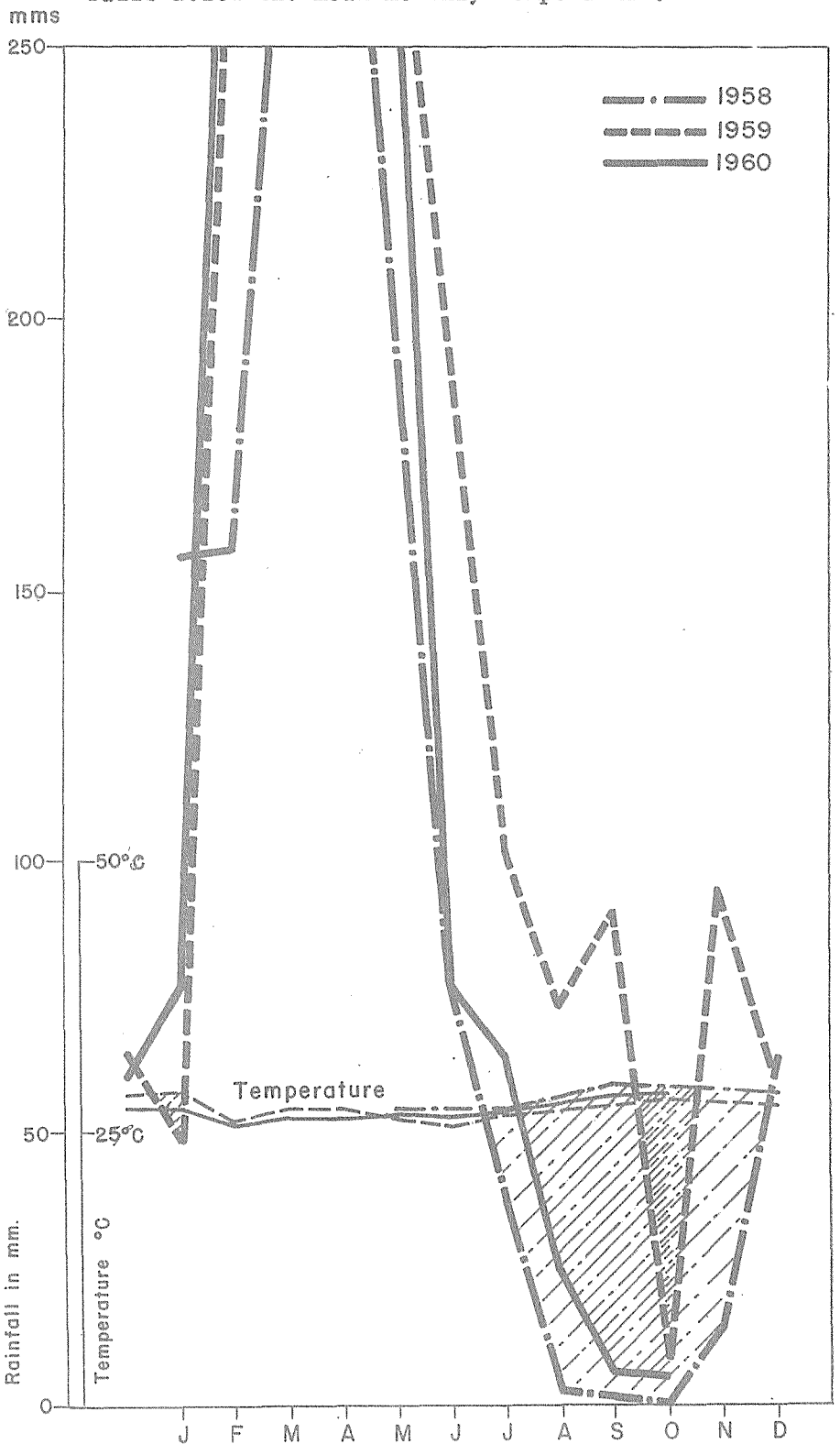
Graph 2- Outline of climatic conditions in the tropical forest of Curva-Una and Macapá.



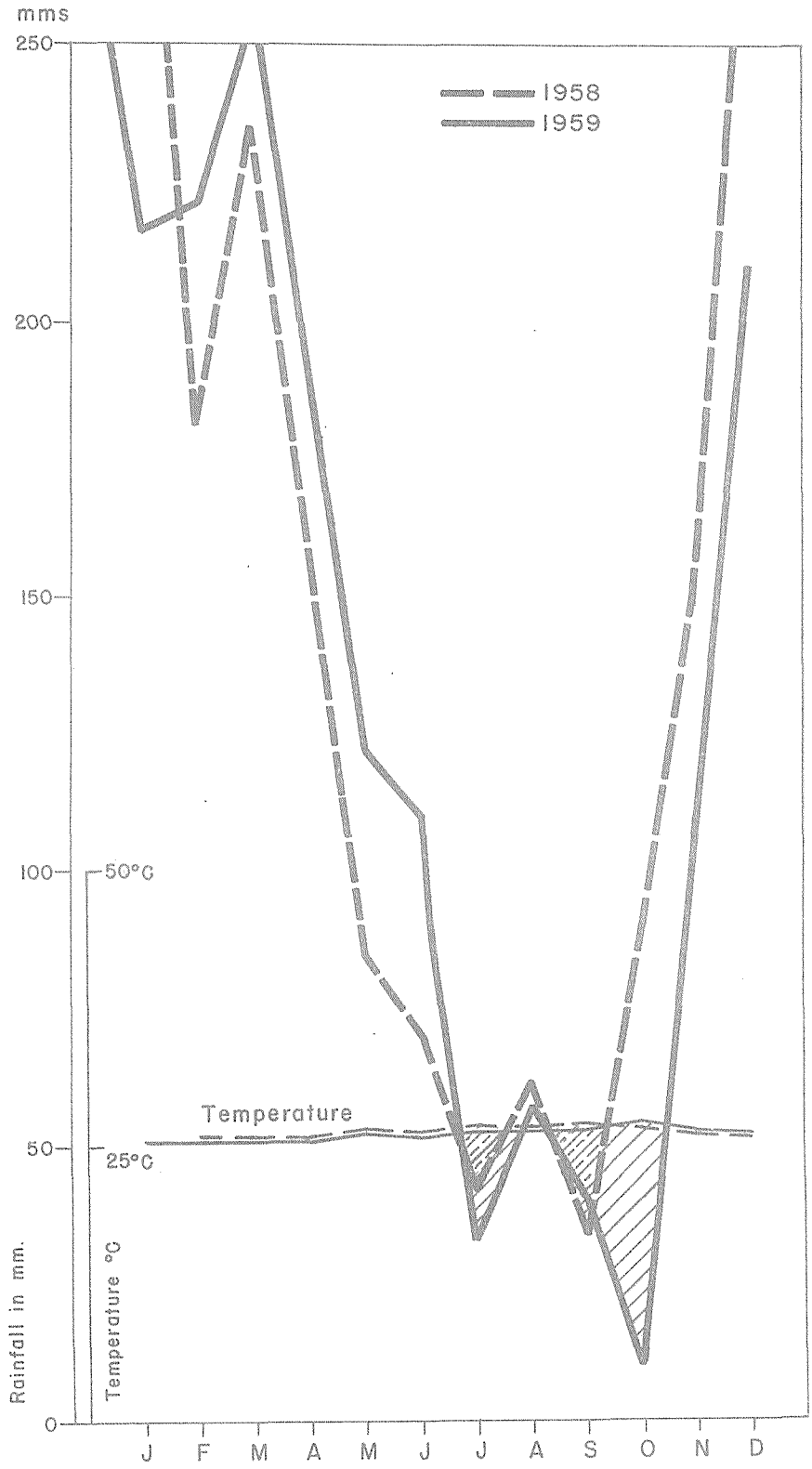
Graph 3- Rainfall in Santarem from 1947 to 1957.
Annual mean: 852 mm.



Graph 4 - Temperature and rainfall of CURUA for the years 1958, 1959 and 1960. Mean monthly temperature 1 cm., 5° C. Rainfall, actual. The "dry" season is represented by the portion where the rainfall curve falls below the mean monthly temperature.



Graph 5 - Temperature and rainfall of MANAUS for the years 1958 and 1959. Mean monthly temperature, 1 cm. 5° C. Rainfall, actual. The "dry" season is represented by the portion where the rainfall curve falls below the mean monthly temperature.



dry season was regarded by the local people as a severe one - there were several ground fires in the forest - while in 1959 it proved very difficult to carry out any burning. Up to October 1960 (the last month for which figures are available) the dry season was quite severe; the graph reflects this.

For Manáus, Graph 5 suggests a much less severe dry season in 1958, but a slightly drier one in 1959. This in fact was said to be the case. The wetter period in August in both 1958 and 1959 is unusual; in Graph 1 it is the driest month.

(ii) Geology

The following "Outline of Geology of Amazônia" was written by G.Mahadevan, a UNESCO geologist who was working with FAO/UNESCO Mission in 1955-56.

> "The main Amazon basin is one of the best known Geo-Synclines of the world. On either side of Rio Amazonas and its main tributaires the Tertiary formations consisting mainly of red mottled and white sandstones grading up into ferruginous sandstones which often are capped by variegated laterites, are met with. This are sometimes covered by quaternary and recent alluvials. On the southern bank of Rio Amazonas, for some distance towards the south, the Tertiary formations are masked by alluvials.
>
> North and south of the Tertiaries from east of Rio Jari, north of Amazonas extending westward to south of Moura on Rio Negro, and from Curuá extending to Rio Abacaxis to the south of Amazonas are narrow bands of palaezoic formations which consist essentially of quarzites, shales and occasionally of limestones. These palaezoic rocks are fringed to the north and south by Archaean rocks which are for the most part granites, gneisses and schists.
>
> The terrain occupied by the Tertiary and Quaternary formations forms high banks rising often to over 40 metres above summer water level. The country is somewhat ondulating. Occasionally, especially towards the eastern parts, the Tertiaries form small hills.
>
> The palaezoic formations give rise to terrain similar to the Tertiaries.
>
> The granitic country gives rise to banks of moderate height, often less then in the Tertiary country. The country is greatly undulating.
>
> One universal feature noted over Amazonas in the extensive lateric soils mixed with decaying vegetation.
>
> There is an intimate relation between the geological formations and the type of forests. This will be definitely brought out in the forest mapping now in progress.

With regard to mineral wealth, the palaezoic formations are known to be petroliferous. The palaezoics occur below the Tertiaries at varying depths in the basin.

Rich deposits of kaolin and other industrial clays are found to occur extensively in the Tertiary and Archaean formations.

The archaeans, more particularly the proterozoics are the home of the most important economic minerals such as manganese, gold, tin, zinc, zircon, monasite, illmonite and other minerals.

One of the richest fields just brought out by recent work is in the southern part of the Rondônia Territory.

Already the mineral wealth of Amapá, Maranhão, and NE Rio Branco are well known.

General Stratigraphic Succession in Amazônia

Age:	Locality:	Description:
Quaternary and recent	Ilha do Marajó, surrounding of Belém and south bank of Amazonas; Rio Branco up to Catrimani.	Laterite sandstones alluvium
Tertiary	On either side of Amazonas and its tributaries.	Sandstones and shales
Mesozoic	Vila Nova – Rio São Manuel Regions of Rio Tapajós and west of Rio Jaci Paraná in Rondônia Territory.	Sandstones, shales and limestones
Palaezoic	Rio Jari–Rio Negro region, north of Tertiaries. Rio Curuá–Rio Abacaxis, south of Tertiaries.	Quartzites shales and limestones
Azoic (Archean	North and south of the above	Granites, diorites, pegmatites, etc.
Azoic (Proterozoic	Fringing the granites, north and south	Gneiss and schists, with intrusives of pegmatites, quartz veins, etc. "

In the Curuá region the road from the riverside camp gradually rises (with one reverse slope) over 5 km to 70 m above the river; there is then a steep "escarpment" rising another 70 m to a planalto. This is absolutely flat for many kilometers eastwards towards the Xingu. The first 5 km is on sand of quaternary origin; this areas is referred to as "Flanco". The "Planalto" is a clay of tertiary origin; there are no lateritic concretions on the planalto except at the edge.

There is no water on this planalto, except in a very few small hollows; it is only near the base of the planalto that the gulleys have any water. The alignment of roads is no problem.

In the Ducke forest near Manaus the picture is very different; here the planalto, called "Chapada" is very much dissected with numerous gulleys, and the sandy soils of the valleys ("baixios") are much wetter and have many permanent streams and rivulets. Road alignments will be more difficult.

Going north or south from the Amazon the rapids ("cachoeiras") and waterfalls are usually first met at the outcrops of the Mesozoic or Palaezoic.

(iii) Soils

In the areas dealt with in this Report the soils fall into two broad physical groups - the sandy soils on the flanco, and the clay soils on the planalto. The planalto carries a much higher volume of timber and is the more promising for forestry development.

The Mission pedologist, Mr. Thomas Day, kindly visited areas in which the silvicultural section was working. He carried out brief soil surveys and sampled a number of typical profiles.

Detailed analyses, and a Note by him on the practical meaning of some of the analyses are given in Appendix III.

(a) Curuá Una

Referring to the planalto soil, where the bulk of work dealt with in this report has been carried out, Mr. Day said:

"These soils are deep, heavy textured (clay), well drained, very strongly acid (pH 4.5-5), and easily penetrated by roots and moisture. They are very old, strongly leached soils with little remaining in the profile beyond silica, hydrated oxides of iron and aluminum, and kaolinite clay.

Like most Amazonian soils the natural fertility is low combined with a problem of phosphate fixation.

One striking difference between the planalto soils in the silvicultural plots on the Curuá and those near CBA at Santarém is the low compaction of the top 1½ to 2 m of the Curuá Una soils. This compaction is sufficiently low so that when digging with a 3-cm diameter auger it can be pushed 2 to 10 cm into the ground by hand once the surface root mat has been pressed. This is probably due to the great amount of soil fauna activity apparent in the areas.

From the viewpoint of a silviculturist this low compaction and high fauna activity might be considered beneficial due to a probable slight increase in fertility but its weakness in supporting loads may create problems for road construction. (in fact it has not.)

The soils are classified as Yellow Latosol."

A detailed analysis is given for profile No. 42 in Appendix III.

The flanco soils were described in the following terms:

"(1) Flanco baixo (profile No. 43)

These plots have soils that are deep, weel drained, very light textured (loamy sand), very strongly acid (pH 4.5-5), and are easily penetrated by roots and moisture. Their light texture, in addition to reducing the natural fertility, also reduces their water holding capacity and thereby makes them somewhat more susceptible to drought. They probably also fix phosphate.

These light textured soils are apparently characteristics of most of the Flanco Baixo of this area.

Soils tentatively classified as Yellow-Red Latosols.

(2) Flanco baixo transition (profile No. 45)

The soils of the Flanco Baixo Transition are similar to those described above except that these are somewhat more heavy textured (sandy loam over sandy clay loam) and therefore apt to be less droughty. This textural change is probably due to the nearness of the more heavy textured Flanco Alto soils (see below) which occupy a small corner of the area originally considered for silvicultural studies.

Classified as Yellow Latosols.

(3) Flanco alto

These soils occupy positions two to three metres higher than the surrounding soils of the Flanco Baixo. In the region seen in the area of the new logging road they exist as rather narrow strips running parallel to the general direction of the river and the base of the planalto. The Flanco Alto soils have many characteristics similar to the soils of the Flanco Baixo in that they are very strongly acid, well drained and easily penetrated by roots and moisture. However, these soils have a slighly heavier texture (sandy loam grading to clay in the lower subsoil) and are strongly concretionary at about 100 to 150 cm depth. Low fertility and phosphate fixation are again present.

The soil is classified as a Yellow Latosol, but is slightly more reddish than the Yellow Latosol in the Low Forest plots to the east.

South of Igarapé Matapi, and outside the area of the silvicultural plots, the soils are more sandy and free of the concretionary material but generally otherwise quite similar to those described above. However, about one kilometer south of the igarapé a small area was found of almost pure quartz sand which is probably a continuation of the intermittant, more or less east-west, strip of "white sand" soils that is found to the south-east of Pôrto Platon.

This "white sand" soil is extremely acid in the top 30 cm (pH 3.5-4) and its fertility level, once the thin organic layer is gone from the surface, would certainly approach zero.

The "white sand" soils are classified as Regosols.

The soils under the poor forest (profile No. 34) are deep, medium textured soils (sandy loam to sandy clay loam), rather easily penetrated by roots and moisture. They give, however, the appearance of having a slight restriction to the free drainage of water through the soil.

The soils are very strongly acid (pH 4.5-5) high in sesquioxides and dominated by kaolinite clay. The natural fertility level is very low on a world scale but may be about average or only slightly below the level of fertility for Amazônian soils.

Phosphate fixation would undoubtedly be a problem that would complicate any fertilizer program.

The reason for the difference in natural forest cover between these plots and those on the High Forest plots further to the west is not presently understood. Perhaps the slightly restricted drainage and an increased soil compaction in these soils may be significant.

The soil is classified as a Yellow Latosol."

(e) Campos, Amapá

Two proposed sites were sampled along the road from Macapá to Pôrto Platon. These are similar to the area with the Fazendinha trial plots on the equator near Macapá (see page 69).

"The soils at Km 87 (profile No. 36) are well drained, deep, rather heavy textured soils (clay loam). Lack of standing water after heavy rains indicates rather easy penetration of water and probably roots. However, numerous worm casts in the form of firm, greyish balls of soil (1-3 cm diam.) suggest the possibility of some

restriction in the downward movement of water. Also, increased compaction when compared with the forest soils of similar appearance add to the idea of reduced penetrability.

The soils are very strongly acid (pH 4.5-5), high in sesquioxides and dominated by kaolinite clay. The natural fertility level is probably very low.

Phosphate fixation would undoubtedly be a problem with any fertilizer program.

The reason for the lack of forest on these soils cannot be stated with any degree of certainty. However, it is difficult to believe on the basis of present information that there is anything inherent in the soil that precludes forest growth. The repeated fires that sweep the campo are undoubtedly a major factor in preventing the re-establishment of forest cover helped by the microclimatic conditions that exist at ground level under a grass cover. There is also a probable factor of reduced fertility caused by the lack of the food gathering ability of trees as compared with grasses. The trees gather fertility elements over a much deeper layer than grasses, and by dropping their litter on the ground help maintain a moderately fertile layer in the surface soil.

The soils are classified as Yellow Latosols and appear to be quite similar to those under the heavy forest cover in the High Forest Plots at Pôrto Platon. It is recognized that a concretionary layer exists in the latter area but this is not felt to be of much significance to plant growth.

The soils of the other areas (km 55.7) (profile No. 39) are deep, well drained, rather heavy textured (clay loam) soils with a thick concretionary layer that often approaches within 20 cm of the surface. These concretions increase in size and concentration with depth, starting with $\frac{1}{4}$ - 1 cm occupying 5 - 20% of the soil mass and increasing to more than 2 cm and 50 - 75% of the soil within 100 cm of the soil surface.

The soils are very strongly acid (pH 4 5-5), high in sesquioxides and dominated by kaolinitic clay. The natural fertility level is probably very low and phosphate fixation would undoubtedly be a problem that would complicate any fertilizer program.

Except for an increase in the contents of concretions in these soils they bear a strong resemblance to those under the heavy forest cover of the High Forest plots at Pôrto Planton.

These soils are classified as concretionary Yellow Latosols."

Classified tentatively as Yellow-Red Latosols.

Although these soils are classified as similar to those of the Flanco Baixo it is at a high level of generalization and I believe that their topographic position, the presence of concretions in the Flanco Alto, and difference in textures are sufficient to consider them as different from the viewpoint of a silviculturist. Also, I am not sure that further investigation in the region would not include one or both soils with the Yellow Latosols, although in this particular area they are doubtless in the Yellow-Red Latosol group.

(b) CBA

These planalto plots are characterized by soils that are deep, heavy textured (clay), extremely acid (pH 4-4.5), well drained and easily penetrated by roots and moisture.

They are very old soils, strongly leached with little remaining beyond quartz, hydrated oxide of iron and aluminum, and kaolinite clay. However, on local standards they are probably of average fertility, although the problem of fixation of phosphate will undoubtedly arise in any fertilizer program.

The soil is classified as a yellow latosol."

For details, see profile No. 40 in Appendix III.

"(c) Santarém (Sawmill Training Center)

Two types of soil were mapped on the 4½ hectare area in these plots.

(1) Shown as EL on map - Deep, well drained, light textured (loamy sand to sandy loam) soil easily penetrated by roots and moisture.

These soils are very strongly acid (pH 4.4-5.0) with the small amount of clay present being probably dominated by kaolinite.

The natural fertility level is low and phosphate fixation would probably cause difficulties in any projected fertilizer program. Due to their light texture the water holding capacity will be low causing the soils to be rather droughty.

The soils are tentatively classified as Brown Latosols.

Included in this mapping unit are two small areas of Yellow Latosols in the south-eastern part of the survey.

These can be recognized by the reddish-yellow color of the subsoil. They are of slightly heavier texture than the soil described above, very strongly acid (pH 4.5-5), dominated by kaolinite, high in sesquioxides, fixed, phosphate, and probably of average fertility on local standards.

(2) Shown as TPB on map. These are Terra Preta soils apparently developing on a Brown Latosol. They are deep, well drained, rather light textured (loamy sand to sandy loam) but with probably a relatively higher amount of organic matter in the top 40 to 50 cm. They are also very easily penetrated by roots and moisture.

The soils are strongly acid (pH 5-5.5) but less acid and probably of higher fertility than the surrounding areas. Among other things this higher fertility will be reflected in a moderate amount of phosphate being available for plant use.

Althought the surface soil has a somewhat higher content of organic matter than other nearby soils of similar texture and therefore has a somewhat higher water holding capacity, the general light texture of the whole profile may cause some droughtiness during periods of low rainfall."

For details, see profile No. 39 in Appendix III.

(d) Pôrto Platon, Amapá

The soils here overlie the basement complex. Two types were found under the good forest - clay with iron concretion (profile No. 33), and a more sandy soil without concretions (profile No. 31). A third type, "white sand" (profile No. 32), supported only very small trees and bush; this vegetation type is referred to as "campina" or "carrasco" at Manáus, but is sometime also called "caatinga". It is likely to be suitable for growing pines, but it is not very extensive in the Pôrto Platon area. It can be picked out easily on air photographs.

"The soil of the High Forest plots are well drained, deep, rather heavy textured soil (clay loam), easily penetrated by roots and moisture.

A layer of iron concretionary fragments underlies most of the area at a depth of 30 to 100 cm. The fragments vary in size from $\frac{1}{2}$ to 20 cm or more and occupy about 7% of the soil mass in the layer in which they occur. This concretionary layer probably varies in thickness from 30 to 60 cm and has little effect on the properties of the soil except to act as dilutant.

The soils are very strongly acid (pH 4.5-5), high in sesquioxides and dominated by kaolinitic clay. The natural fertility level is doubtless very low on a world scale but about average for Amazônia. Application of phosphate fertilizers would undoubtedly show that this soil has a tremendous capacity to "fix" phosphate and thus make it unavailable for plant use.

(iv) Forest Types

There are two main types of forest in the Amazon, (a) swampy and (b) on terra firme.

The main swamp types are the permanent swamp or Igapó and the seasonal swamp or Várzea. Around Manáus however igapó appears to apply to the clear waters which are usually dark or black looking, e.g. Rio Negro, and várzea to the muddy or "white" rivers. The permanent swamps carry rather a poor forest of not very large trees with few of economic value. The seasonal swamps, or tidal swamps near the mouth of the river, carry better forest, with some trees of value such as Ucuuba and Andiroba. Because of the swampy conditions these forests are not suitable for exploitation by mechanical means except above the tidal reaches and then only in the latter part of the dry season.

The main terra firme forests can be divided broadly into,

(a) those on sandy soils of Quaternary origin, referred to here as "Flancc",

(b) those on clay soils of Tertiary origin, referred to as "Planalto"

(c) those forests above the rapids or "cachoeiras" on soils usually developed on much older geological formations. The forests west of Pôrto Platon in Amapá are of this type.

(v) Recognition of Important Species

No local botanist was available to work with the Silvicultural section; one from the Instituto Agronômico do Norte, Belém was already working in the field with the Inventory group. In November, 1956 a botanist made a very short trip to Pôrto Platon. In May 1957 one botanist was able to spend about 10 days in the field in the plots near Santarém on the Curuá. In November 1958 the other botanist was able to make a short visit to the Curuá and was kind enough to arrange for a collector to spend some-time in the field getting material from numbered trees which were being used for diameter increment observations and other for some poisoning experiments. From this collection of over 1000 specimens Dr. Murça Pires was able to provide the names which form by far the greater part of the list given in Appendix XIII.

Whenever material was brought back from the field the botanists at IAN, especially Dr. Murça Pires, very kindly helped in identifying it.

Further valuable help on local names was given by mateiro (tree namer) Correa who has worked for some years with the Inventory group and who joined the staff at the Curuá during 1957.

The number of botanical names for some of the local names shows however that there is still plenty of scope for better collection and itentification.

(vi) Silvicultural Requirements

Information here could only be obtained by observations in the field once the species were recognized. In this respect mateiro Correa was of great assistance.

2. Other Factors affecting Solutions of the Problem

(i) Dispersal of Effort could not be avoided entirely.

(ii) Utilization of Lesser Known Species. Once the Sawmill Training Center at Santarem started it was possible to have some investigations carried out there by supplying logs from the Curuá.

(iii) Finance. Funds were considerably reduced in 1959 which slowed down the progress of the work.

(iv) Staff. No technical staff was provided, but the FAO Mission was able to recruit an engenheiro-agronomist in September, 1956 and to replace him three years later. Both Dr. Francisco Uchoa Guerra and the present assistant, Dr. Oswaldo Vera Cruz have proved apt pupils, and hard workers. Considerable credit is due to both of them for the work they have dome, often under difficult and unpleasant circumstances.

(v) Labour was adequate except sometimes in Amapá.

(vi) Transport. To save a daily 3-hour walk at the Curuá, SPVEA purchased a jeep in the latter part of 1957. This jeep was still giving good service three years later.

(vii) Materials. Such items as were not originally obtainable in Belém, e.g. sprayers and arboricides, were provided by FAO.

(viii) Location of Working Areas. Following on the recommendations in FAO Report No. 171, a FAO Mission for Technical Assistance was established in Belém, in 1953, to work with the Superintendencia do Plano de Valorização Econômica da Amazônia (SPVEA).

The overall concept of the forestry part of the FAO Mission was, briefly,

(a) an Inventory section to carry out exploratory surveys, mainly to find out about the composition of the forest,

(b) a Logging section to carry out mechanical exploitation in a concentrated area,

(c) a Sawmill training section to improve the quality of sawing in the Amazon and to try out many of the lesser known timbers, and

(d) a Silvicultural section to improve the forests for the future.

With only one expert and no local assistant at the start it was clear that dispersal of effort should be avoided and that the main silvicultural effort should be in the same area as the Logging section.

The Inventory section, which had been in the field since May, 1954, had found the highest volume of timber on the planalto. As the Sawmill Training Center was to be at Santarém it was clear both that the logging area should be somewhere near, and that it should work in a planalto area. A suitable site was found on the right bank of the Rio Curuá Una some 105 km by water from Santarém, where the planalto came to within 6 km of the river. The Logging section however was working at the time at Benjamin Constant on the Peruvian Border; it did not move to the Curuá till March, 1957.

Fortunately, the Federal Territory of Amapá, on the north side of the mouth of the river was anxious for some forestry work to be done there. Two members of the Serviço Florestal, Drs. Arthur and Humberto Miranda Bastos were already carrying out an inventory in this area, an area where a deep water port was being developed and about 200 km of railway being built to a large manganese mine. Attention was therefore first turned to Amapá and work on a small scale was started both in the forest beyond the railway construction camp of Pôrto Platon, then the road and railhead, and on poor campos soil near the territorial capital, Macapá.

Investigations in the vicinity of Santarém resulted in a small area (13 ha) of reasonably good high forest being put at FAO's disposal in September, 1956 through the kindness of Dr. Joaquim Lopes, the Director of the Posto Agro-Pecuario (CBA) on the planalto some 14 km from the city. This area was too small for any serious logging but it was suitable for initiating some small scale experiments to study the effect of different degrees of canopy opening on inducing natural regeneration of desirable species. At the same time some work could be done on afforestation trials in the poor secondary growth on the sandy soils in the vicinity of the Sawmill Training Centre by Santarém.

It was only in April, 1957 that it was possible to open the main silvicultural centre on the Curuá Una.

IV. ACCOMPLISHMENTS

A. CURUÁ

1. Demarcation and Roads

On the western edge of the "Planalto" some 1800 ha has been laid out in blocks of 1 km^2. A main road connects the area with the camp on the river bank some 6 km to the north-west and continues south-west across the area for another 4 km. There is a main branch road of 1 km to the sawmill site (See Map).

Except along the edge of the planalto, each block is bordered on the east and west sides by cambered lorry extraction roads, and by narrower access roads on the north and south sides.

Road construction, which was done by the FAO Logging Unit, has entailed making:

Main road (9 m wide)	11 km
Extraction roads (also cambered)	22 km
Access roads (some slightly cambered)	22 km

The first 4.5 km from the camp is on sandy soil and has been surfaced with laterite. The main road and extraction roads are now definitely on an "all weather" standard, and the access roads are always passable by jeep, except when closed by tree falls.

2. Inventories

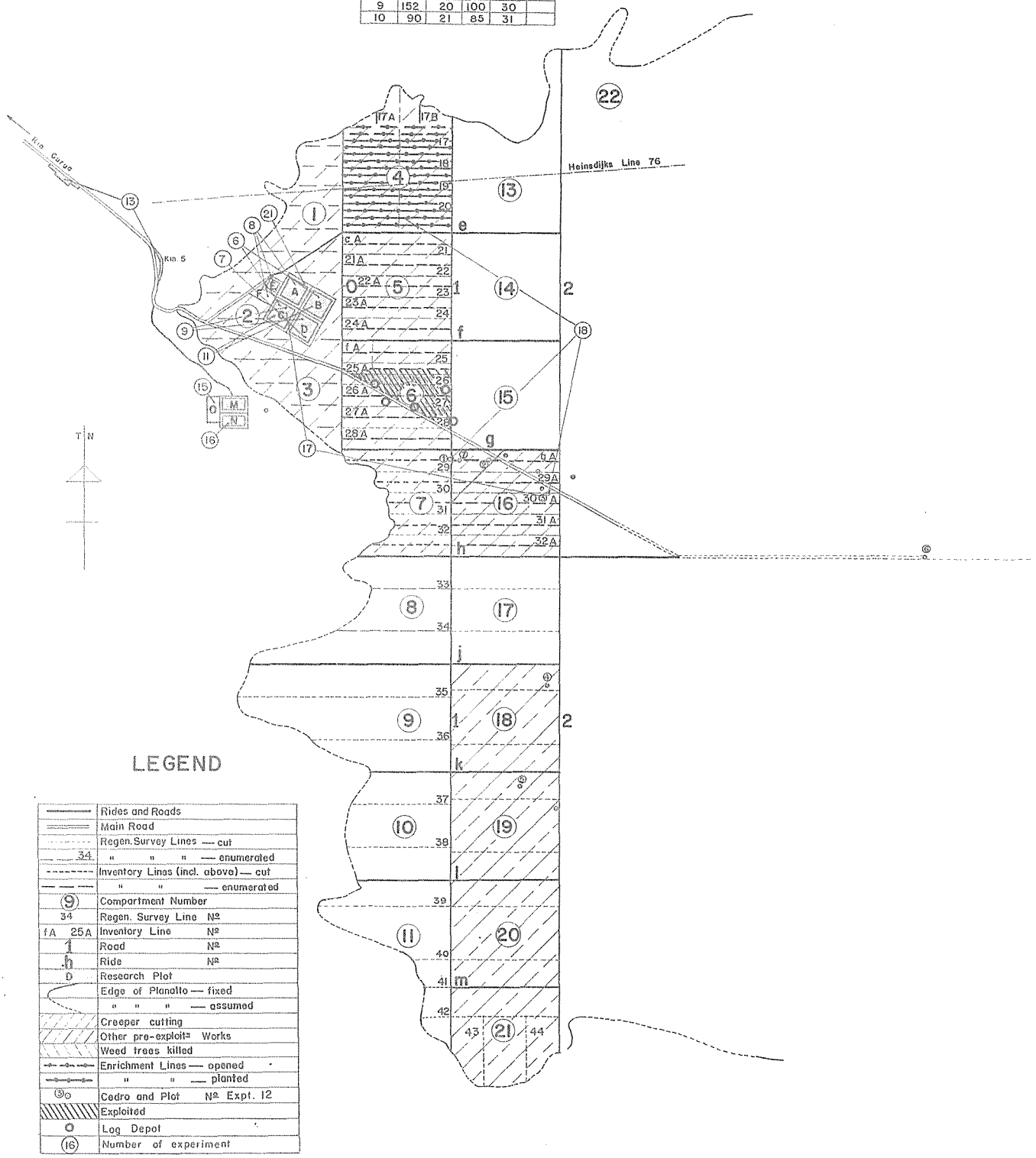
(i) Normal

Prior to carrying out any silvicultural work it was necessary to make a normal inventory of the main research block so that a record of the original composition of the forest would be available. Thirteen hectares were done on the same lines as that carried out by Heinsdijk in his exploratory surveys (Ref. 5), except that the Curuá samples were normally plots of 200 x 50 m, that no tree climber was available to check the estimates of timber height made with the aid of a 5-metre pole, and that the heights and widths of the crowns were not measured. All that was required was to know the original composition of the forest and the approximate standing volume. The minimum diameter was 25 cm at breast height. A form factor of 0.7 was used for calculating volume. There true and overbark.

Map 2 - Curua una forest

0 1 2 Km.

Cpt. No	ha	Cpt. No	ha	Cpt. No	ha
1	80	11	84	22	
2	44	13	104	23	
3	56	14	100	24	
4	115	15	100	25	
5	100	16	98	26	
6	97	17	100	27	
7	64	18	100	28	
8	96	19	100	29	
9	152	20	100	30	
10	90	21	85	31	



LEGEND

	Rides and Roads
	Main Road
	Regen. Survey Lines — cut
34	" " " — enumerated
	Inventory Lines (incl. above) — cut
	" " — enumerated
(9)	Compartment Number
34	Regen. Survey Line Nº
fA 25A	Inventory Line Nº
1	Road Nº
h	Ride Nº
D	Research Plot
	Edge of Planalto — fixed
	" " " — assumed
	Creeper cutting
	Other pre-exploit= Works
	Weed trees killed
	Enrichment Lines — opened
	" " — planted
③o	Cedro and Plot Nº Expt. 12
	Exploited
O	Log Depot
(16)	Number of experiment

The inventory over the 13 ha (plots A, B, C and D1) showed, per hectare:

Plot	Total Volume m^3	Number of Trees	Number of Species
A1	227	102	38
A2	318	125	40
A3	265	113	36
A4	251	112	37
B1	231	111	31
B2	230	98	32
B3	190	109	38
B4	307	146	36
C1	232	96	39
C2	206	94	33
C3	238	114	40
C4	279	110	42
D1	294	128	41
Mean	252	112	37
		Total number of species	110

So as to have a record, for control purposes of the original forest, one plot - D1 - has been set aside as an "INVIOLATE" plot. Two other plots, each of two hectares, have also been marked for this purpose in compartments 1 and 17 in which Dr. Murça Pires, Botanist of the Instituto Agronômico do Norte, Belém, hopes to carry out a detailed botanical survey.

(ii) Linear Regeneration Surveys

In addition to the normal inventory of all trees from class 3 up, i.e. over 25 cm DBH, surveys were made along strips half-chain (10 m), quarter-chain (5 m) and 2 m wide in plots B, C and D1 following the Malayan method (Appendix IV). These are referred to as Linear Regeneration Surveys.

In the half-chain strips 46% of the samples were found to contain desirables between 5 and 55 cm diameter, and in the quarter-chain strips 48% had desirables between saplings over 1.5 m high and poles under 25 cm in diameter. Normally 40% is regarded as an adequate stocking; this is equivalent to 40 trees per hectare. 1960 was too soon to carry out a second survey of these half and quarter-chain strips, which were laid down in 1957. The 2-metre strips have been resurveyed and details are given later under "Natural Regeneration" - page 25.

(iii) Exploitation Inventory

A 100% exploitation inventory, i.e. for logging purposes, was carried out by the Logging section in compartment 6 where all trees of possible timber size - class 5 (minimum diameter 45 cm) and up - were measured. Similar inventories were later made by the Inventory group in compartments 5 and 16 for statistical research purposes - see Smit and Glerum, Ref. 9.

A brief summary of the results, compared with the original exploratory survey of Heinsdijk for this area - his "Planalto II alto" is given below.

	Compt. 5	Compt. 6	Compt. 16	Exp. Survey
Total No. of trees	3,691	3,416	3,161	3,755
Total volume (m^3)	15,747	14,895	16,374	17,504
Number of species	103	103	103	140
Trees per ha	37	35	33	34
Volume per ha (m^3)	157	154	170	161

Details by species are given in Appendix V.

Although the overall results are very close, very considerable variations were found with many species over the short distance (2 km) between compts. 5 and 16, e.g. :

	Compt. 5		Compt. 16	
	No.	Volume (m^3)	No.	Volume (m^3)
Angelim pedra	165	1,442	49	745
Castanheira	69	1,054	172	3,000
Cupiúba	474	1,380	148	557
Louro canela	435	1,799	53	183
Maçaranduba	299	1,316	388	3,271
Mandioqueira	498	2,409	22	120

(iv) Inventory of Small Size Classes

So that some idea could be obtained about the distribution of the small, as well as of the large size classes of the more important species, ten 2-hectare sub-blocks were systematically randomised in compartments 5, 6 and 16 and the number of stems in diameter classes 1 to 4, i.e. from 5 to 45 cm, recorded for some 16 species. The figures obtained for these smaller classes were multiplied by 5 for comparison with those of the larger classes from the 100% Inventory. The distribution of 10 of the most common desirables is shown on Graphs 4-8. The number of stems are for areas of 100 ha. In the inventory summaries classes 11 - 15 and 16 - 20 were grouped together, so only the average for 5 classes can be shown.

Graphs 6 - 8 (pp.23a - c)are for species which are shade tolerant; the curves are steep with high numbers in the smaller size classes. Graphs 9 and 10 (pp.23d - e) (where the number scale is four times that of Graphs 4 - 6)are for species which require more light. Apart from various irregularities the curves are obviously much flatter; in other words, it is only when openings occur that these species get a chance to develop. Taxi pitomba and Taxi branco have been put together as they were sometimes confused in the inventories of the larger classes; the former is much commoner. Taxi preto consists of two species which were not recorded separately in the inventories of the larger size classes; the same applies to Mandioqueira.

In compt. 5 several species have lower numbers in classes 3 or 4 and show an increase in the next few classes. Only Ucuuba and the Taxis show fairly regular distribution curves in all three compartments. In compt. 6 the irregularities are rather similar, but are much less marked in compt. 16.

With regard to the other species, Cupiuba shows the greatest irregularities. It is quite possible that fires - see page 8 ; also, charcoal has been found in some soil borings - have resulted in periodic lightening of the canopy which favours the development of Cupiuba. This can be seen on the edge of the planalto at the south end of road 1 where fire came up from the flanco in 1958.

The absence of some, but not all, of the smaller size classes of Castanheira - 4 and 5 in compts. 5, 2 - 4 in compt. 6 and 3 and 4 in compt. 16 - is of interest; so is the increase in class 10 in all three compartments. Changes in the population of some rodents, which can open the very hard fruits of this species, may be the explanation here.

Angelim pedra shows a very irregular distribution in compts. 5 and 6; it too shows a marked increase around class 10; the curve however is very flat in compt. 16 where there are considerably fewer trees.

Quaruba also shows considerable irregularities in compartments 5 and 6 and is much rarer and the curve flatter in compt. 16.

The shade tolerant species, Maçaranduba, shows an increase in numbers around some of the classes 4 to 7 in each compartment, with a decrease in the preceeding class or two. Louro canela is similar in compt. 5 but has regular curves in 6 and 16.

(v) Silvicultural Inventory

The object of this inventory is to find out whether silvicultural treatment is necessary for any given patch or block of forest or for any compartment. At the same time it gives an idea of the density of desirables large enough for exploitation. This type of inventory is described as "diagnostic sampling" by Dawkins on pages 94-101, Ref. 2. It gives a quantitative estimate of the silvicultural condition of the forest from which can be calculated the stocking of desirables, the competitive state or freedom of the constituents and the stage of the crop in terms of size.

Lines 10 m wide, as in a normal (line) inventory, are taken across the blocks or compartments at intervals of from 5 to 10 chains; the inventory is done in units of 10 m so as to give 100 units to the kilometre or hectare; the inventory is confined to the desirables, and only one is considered in each unit or sub-unit according to the size of the tree. Information is also recorded as to the position of the crown of the desirable in the canopy, whether it is being impeded by other stems, and the number of competing stems on the ground. Brief details are given in Appendix VI, as well as showing how the results are worked out, and the conclusions to be drawn for the silvicultural work that is required. This work of liberation and refining is referred to later, on pages 41 and 42.

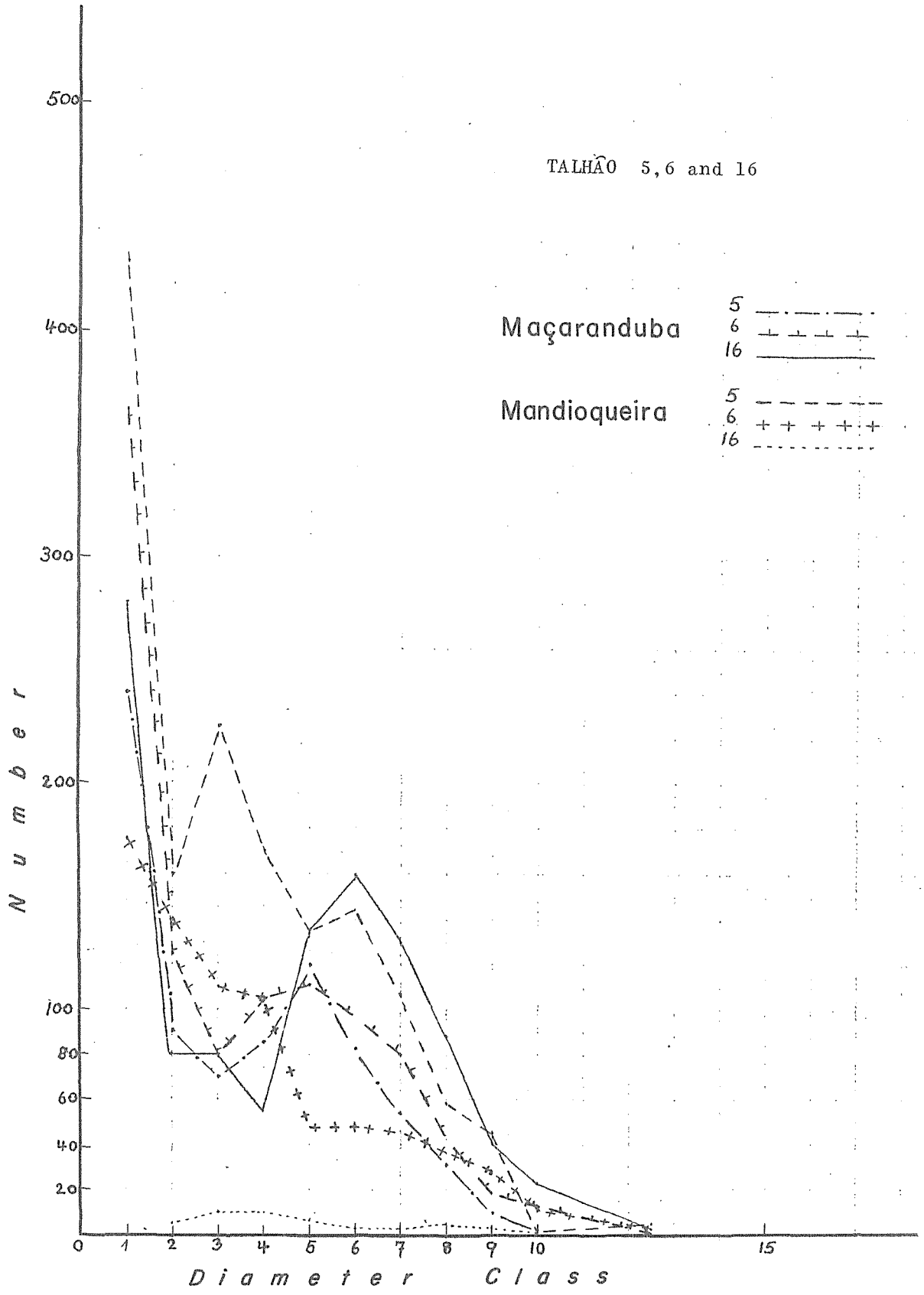
The following comparisons of the different inventories is of interest:

	Compt. 5	Compt. 6
No. of desirables over 45 cm diameter. (Cl. 5 + up) per hectare from 100% inventory	27	18
No. from silviculture inventory (5% of the area)	28	15
No. from normal inventory (4% of area)	26	18

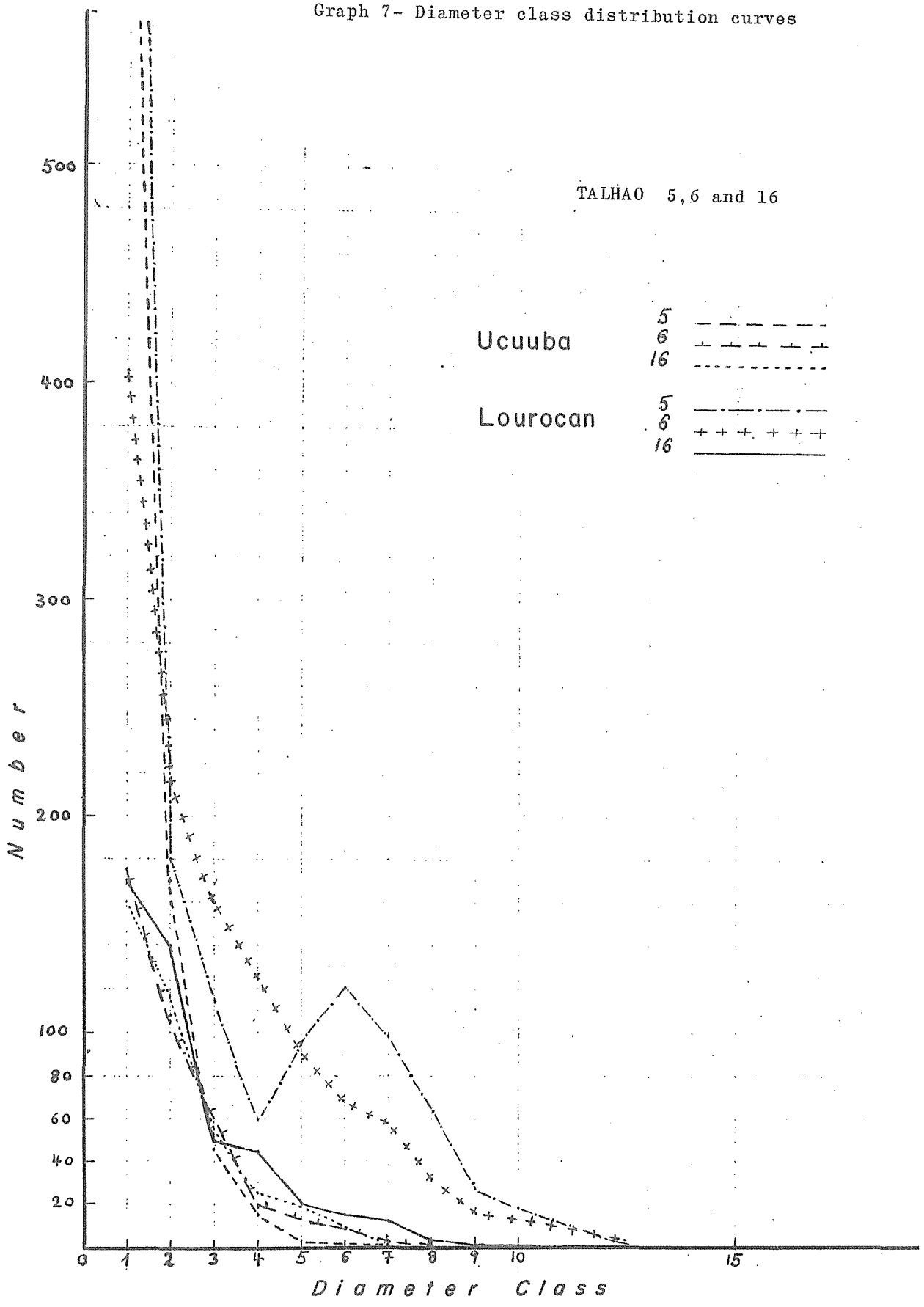
3. Natural Regeneration

In any forest where exploitation is taking place or is to commence, the ideal is to aim at regenerating it by natural means so that the next crop may be better than the one being, or to be, removed. Regeneration by natural means not only saves the expense of nursery work in raising transplants but ensure using species known to be suitable for the particular locality. It is, however, normally a complicated process, as the different species require different conditions for their best development. Research plots are therefore necessary to ascertain what these conditions are. At the same time, however, work can start on a field scale following generally accepted lines; these can be modified in the light of information obtained from the research plots as time progresses.

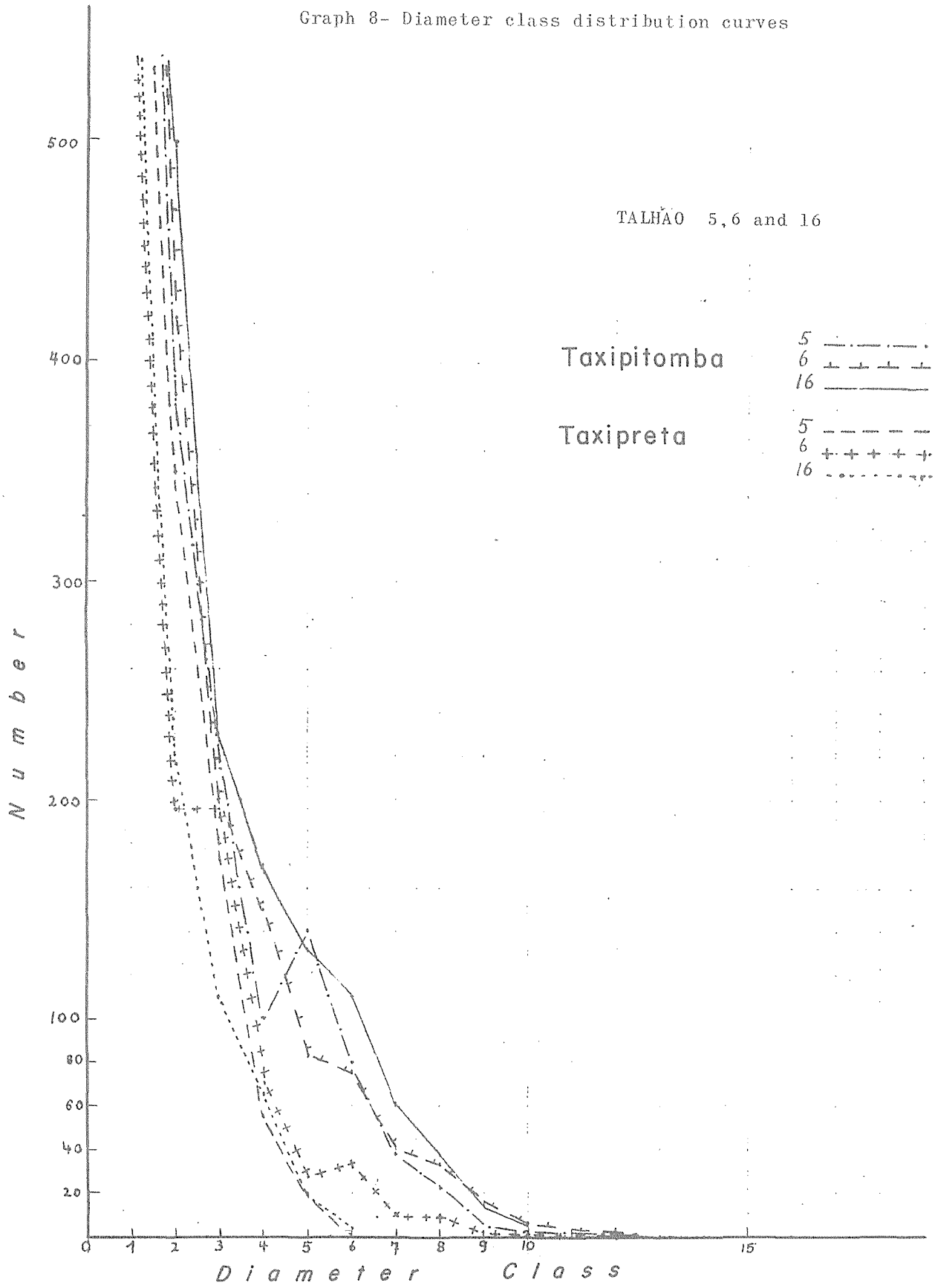
Graph 6- Diameter class distribution curves



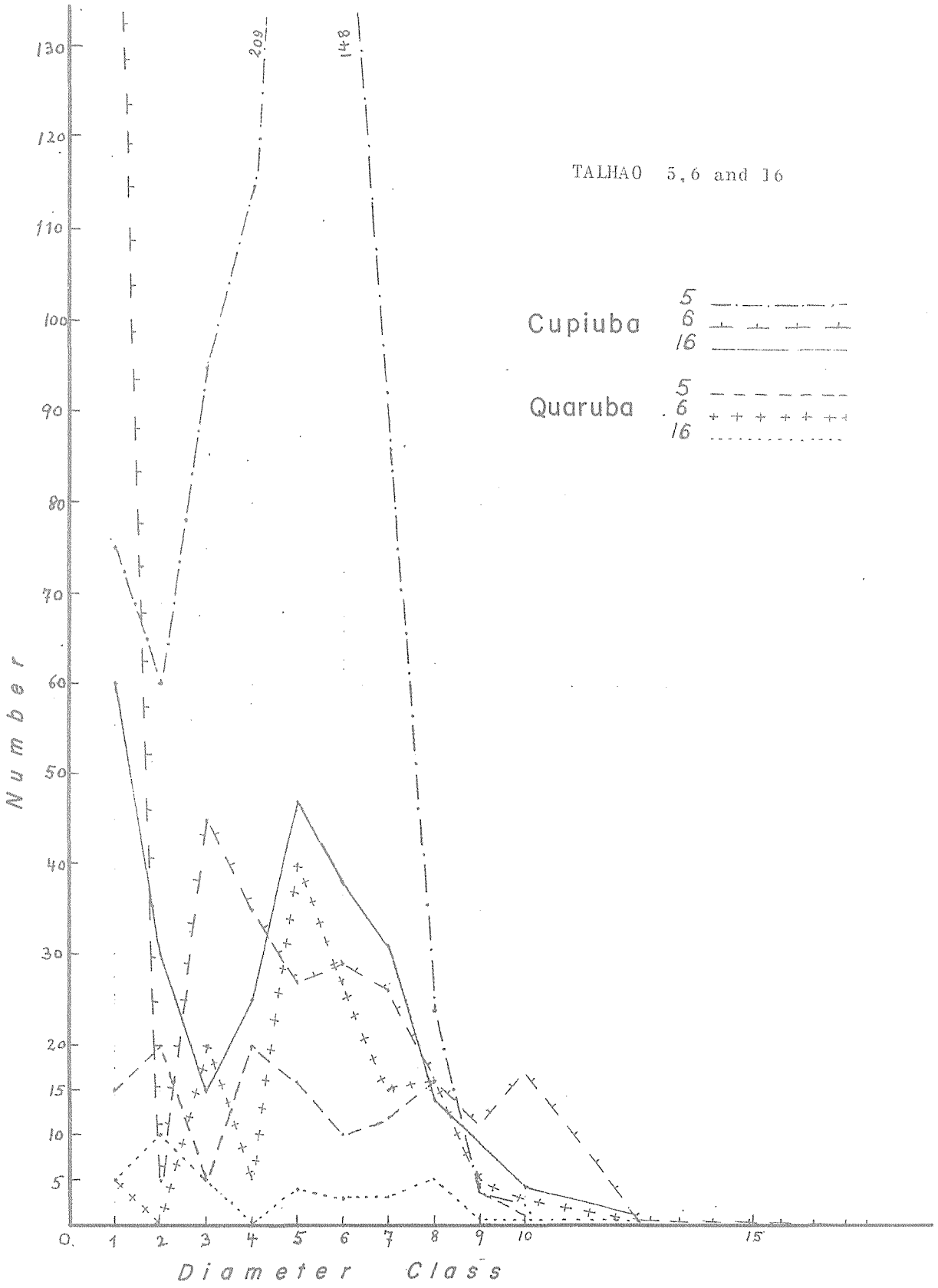
Graph 7- Diameter class distribution curves



Graph 8- Diameter class distribution curves

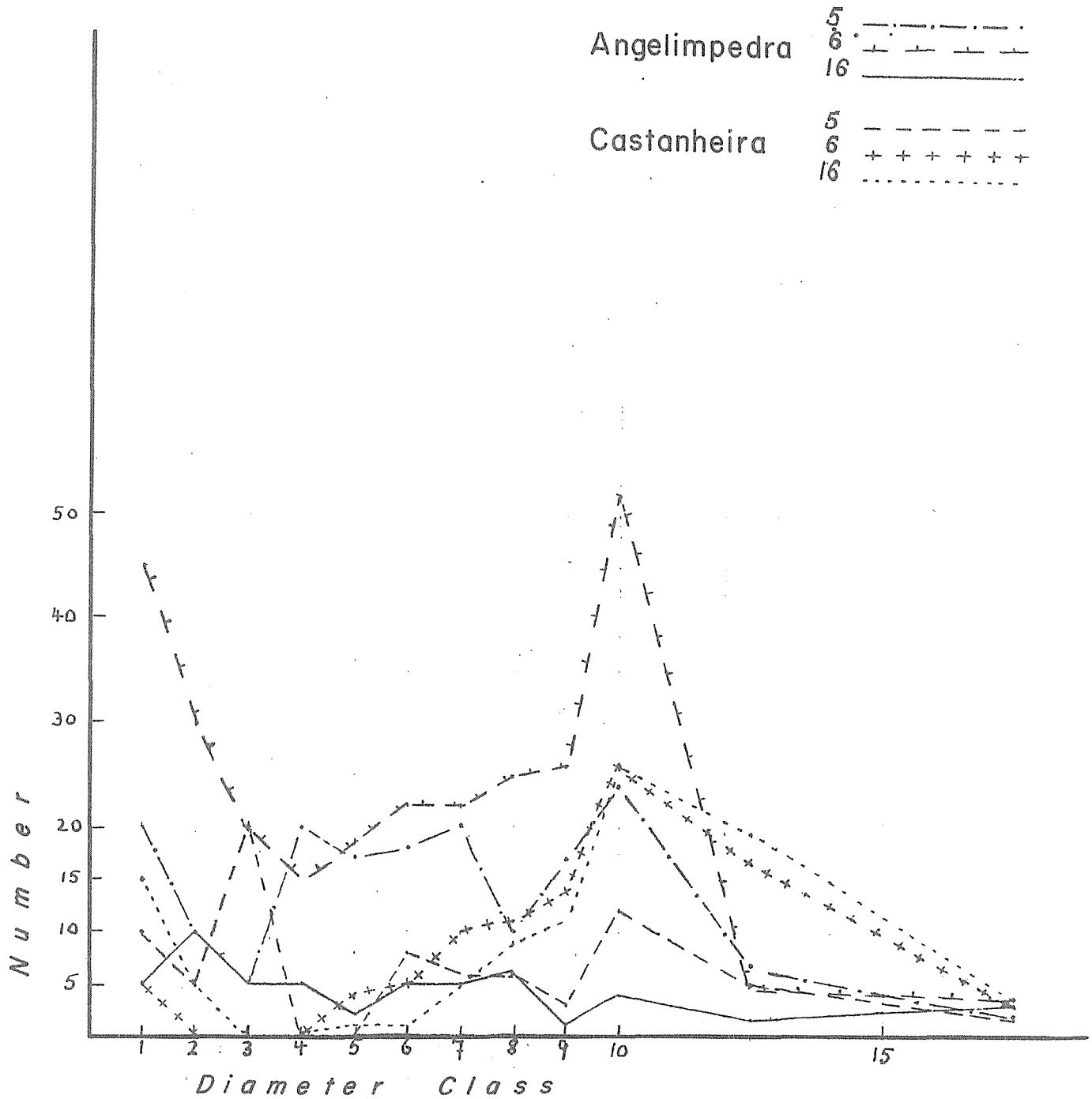


Graph 9- Diameter class distribution curves



Graph 10- Diameter class distribution curves

TALHÃO 5,6 and 16



(i) Research Plots

(a) Inducing natural regeneration before exploitation

Two main plots (B and C) each covering 6.25 ha have been laid down to study the effect of two degrees of canopy opening on inducing natural regeneration of desirables. Five small plots with a total area of over a hectare have been laid down to study that of Guariuba. One of the Cedro plots also includes a study of Angelim da mata. Other plots have been laid down to demonstrate the technique necessary to assist the development of desirables once adequate regeneration has been obtained after clear-felling and burning; there have been some spetacular results here with Cupiúba, and some other species.

One plot - D1 - of one hectare has been set aside as a Control or Inviolate plot.

In all plots creeper cutting is carried out before any other operation is done, as the sooner the creepers die and fall down from the crowns of the large trees the better. Creeper growth however is not dense and does not prevent one getting through the forest quite easily.

In one of the main plots, (B), there was a "light" opening of the canopy; this was achieved by killing, with arboricides (see Appendix VII for details of the technique) or by girdling, about 18 large undesirables per hectere, and doing a selective thinning on the undergrowth. In this last operation all saplings of the Breus, Enviras, Miraúbas, Taxis and Tinteiro round which the thumb and finger met (i.e. up to about 5 cm diam.) were cut.

In the other main plot, (C), there was a fairly "heavy" opening of the canopy. Some 25 large and 43 smaller undesirables trees of the understorey were poisoned per hectare, and all the undergrowth was cut back, except sapling of desirables.

Details of costs in man-days for the various operations are given in Appendix X.

Surveys were then carried out to study the distribution and development of the smaller size classes. The results of the 10 m and 5 m strips have been referred to page 21. Results of the 2 surveys of the 2 m strips are given below. The mean height (in decimetres) is that of the tallest desirables found in each sample or quadrat of 2 m.

Date	Control (D)			Light (B)			Heavy (C)		
	%	No. of Sp.	Mean Ht.	%	No. of Sp.	Mean Ht.	%	No. of Sp.	Mean Ht.
February 1958	38	3	-	26	3	-	22	4	-
October 1959	40	12	5.2	39	13	4.7	64	16	3.9
July 1960	50	9	4.7	63	12	3.2	77	18	5.0

The results are as to be expected - no or little change in the control, some increase in the light opening and a greater increase in the heavier opening. The increase in the number of species between February 1958 and October 1959 is partly due to the fact that in the first sampling the seedlings of a few desirables were not recognized. The decrease in mean heights between October 1959 and July 1960 in D and B can be attributed to the young seedlings which have come in in the extra samples now stocked. In C the increase in mean height is due to the proportion of new samples being much less and to the growth of the earlier seedlings in the other samples being greater due to the more open canopy.

It is advisable to have some better definition of what is meant by a "light" or a "heavy" opening of the canopy. The forest varies very considerably from place to place - witness the differences in volumes and number of trees in the 13 ha covered by the inventory of blocks close together, page 21. Actual measurements of the amount of light coming through are very difficult to make; there will be considerable differences in any one spot depending on the time of day, the amount of cloud and even the time of year, if there is a gap to the north or south. The best guide appears to be by using the basal area of the stems on the plot; this is the area of all stems at breast height. It can be calculated by measuring the girth of each tree and totalling the computed areas. In part of plot C the original basal area was calculated from the inventory figures. In this part of the plot (sub-plots C1 and C2) most of the unpoisoned trees were included in a diameter increment experiment (see page 43) so the basal area of the remaining trees after poisoning could also be calculated. As not many of the trees under 25 cm diameter were poisoned, a comparison of the basal areas before and after poisoning gives a fair indication of the degree of canopy opening.

Using basal areas calculated from girth measurements the following figures were obtained from sub-plots C1 and C2, and for plots D and E at CBA. (see page 61).

	Orig. B.A.	After poisoning
C1 and 2	20.12	11.42
D1	19.62	Control
D and E (CBA)	19.93	10.97
Surround (CBA)	19.05	Control

The figures for basal areas are in m^2 per hectare. These figures, of course, do not include the smaller trees, i.e. those below 25 cm diameter.

A quick method for estimating basal areas is to use a prism of known factor, or to use a relascope - provided the undergrowth is not too dense to see the trees at eye level. For a description of the method see Finch, ref. 3, Appendix II.

Using a prism at the Curué the following basal areas were obtained recently for subplots C1 and C2:

before poisoning 24.76, after 18.5

The increase here would be due to having to include the smaller trees in the prism count.

Using the relascope at CBA the following basal areas were obtained recently for plots D and C:

before poisoning 19.7, after 13.7

A few of the larger poisoned trees at CBA have fallen over, which would explain why the "before poisoning"count is not higher.

Results from the two Curuá plots, (B and C), in inducing regeneration, and from other experiments elsewhere to be described later, show that the more the canopy is opened, especially that of the understorey trees, the more the regeneration comes in, except of a few of the very shade loving species e.g. Maçaranduba. As these are very slow growing they are not really desirables from the point of view of economic forestry. The quicker growing trees are normally the ones which require more light for successful natural regeneration.

The increase in the regeneration of other desirables in some of the cedro plots (page 28) and of the height growth in the "open" plot C, should be noted in this connection.

In the future, therefore, where it is desired to induce natural regeneration or to increase it before exploitation, the canopy should be heavily opened, mainly by poisoning in the understorey and by cutting the undergrowth. Poisoning should be done with a view to reducing the basal area by about 50%, to to about 15 m^2/ha, or about 10 m^2/ha if only the trees over 25 cm diameter are considered.

(b) Natural regeneration following exploitation

Natural regeneration of certain species can also be obtained by the complete removal of the forest, such as might happen if it were to be exploited for wood pulp, and burning the residue, especially if there is a dense tangle of branchwood. This aspect was studied in the surround of a plot, (A), which was clear-felled and burnt for planting trials.

Here, regeneration of Cupiúba, and some other species quickly appeared. The burning was done in November, 1957 and by April 1959 there was sufficient regeneration and development of desirables to justify a cleaning. In June 1959, 59% of the 2 m^2 samples were stocked with plants averaging 9 dm in height; of these 55% were Cupiúba. To study the requirements and development of other desirables, these were given preference over Cupiúba in the cleaning. Some Pau jacaré were kept where there was no accepted desirable. After the cleaning it was found that the area was too heavily stocked and the plants, mainly Cupiúba, were thinned out to a spacing of 1.5 to 2 m. A second cleaning was done in November 1959. Growth results have been

excellent and a survey in June 1960 showed the following compared with a year earlier. A third cleaning was done in August, 1960.

	June 1959	June 1960
% of samples stocked	59	79
% with Cupiúba	55	49
% with other species	4 (3 spp.)	30 (11 spp.)
Mean height Cupiúba (dm)	9	25
Mean height all species (dm)	-	25

Most of the unstocked samples are patches where the fire was intense; here, after 3 years, still very few plants have appeared. Besides killing any seeds present on the ground the fire seems to have sterilised the top soil. However, such patches are capable of growing excellent trees if these are planted, as can be seen in trial plots nearby.

(c) Cedro Plots

In these plots three degrees of canopy opening were aimed at - light, medium and heavy. At the same time in each plot various soil treatments were carried out, with a view to finding the best method of encouraging the regeneration of this rare but very valuable species.

The "light" opening here consisted only of cutting back all saplings (except the few desirables) under 5 cm diameter. In the "medium" opening a number of the understorey trees were poisoned in addition to cutting back the saplings. In the "heavy" opening some of the larger trees as well as more of the understorey ones were poisoned and the saplings cut back.

The soil treatments consisted of,

(1) cleaning or sweeping - to expose the mineral soil,
(2) burning, included the sweepings from (1) and debris from(3),
(3) cultivating,

strips 5 m wide across each plot. A fourth strip was untreated to serve as a control.

Unfortunately, for the next two seasons no seed was borne on the seed tree in each plot. However, much regeneration of other desirables (15 species in all) appeared in the heavy and medium opened plots, but only a little in the light-opened one. Rather than destroy this growth by repeating the soil treatment just prior to the next seedfall, two more plots have been made with medium and heavy canopy opening, but, the soil treatments will not be done till just before the seed fall. This should be about September-October; it is easy to see the fruits as the cedro trees are leafless at this period.

A few cedro seedlings were found in the plots when they were laid down in 1958; these seedlings have been marked with numbered stakes and the heights of the plants are measured periodically. Results to date are:

Date	(1) Heavy	(2) Light	(3) Medium
June 1959 - No. of plants	14	6	16
" " - Mean height(dm)	2.7	1.2	2.1
January 1960 - No. of plants	12	6	16
" " - Mean height(dm)	4.2	1.5	6.1
July 1960 - No. of plants	9	5	17
" " - Mean height(dm)	5	1.6	7.5

The less good growth in the open (heavy) plot is possibly due to the fact that in 1959 the plans in this plot were severely attacked by a white scale insect.

The development of other desirables in the three plots is shown in the following Table:

	Plot 1 (heavy)		Plot 2 (light)		Plot 3 (medium)	
CONTROL	Mar'59	Mar'60	Mar'59	Mar'60	Mar'59	Mar'60
% stocked	40	100	36	56	75	93
No. of species	7	13	7	10	6	13
No. of plants	15	241	14	33	196	287
Mean height (dm)	nr	7.3	nr	2.9	1.8	3.5
CULTIVATED						
% stocked	-	100	-	68	-	95
No. of species	-	9	-	10	-	9
No. of plants	-	354	-	25	-	271
Mean height (dm)	-	7.7	-	2.5	-	5.7
BURNT						
% stocked	-	100	-	40	-	93
No. of species	-	8	-	10	-	8
No. of plants	-	232	-	22	-	144
Mean height (dm)	-	7.9	-	2.6	-	4.3
CLEANED						
% stocked	20	100	32	80	58	83
No. of species	1	6	5	10	4	10
No. of plants	6	*381	11	46	84	*345
Mean height (dm)	1	8.5	5	3.2	2.2	3.3

Notes: % stocked is that of the number of 2 m quadrats with one or more desirables over 10 cm tall.
No. of plants - not more than 20 are counted per quadrat; * before the number shows that some quadrats had more than 20 desirable.
nr Heights not recorded.
Mean height - (in dm) is that of the tallest desirable in each quadrat

The species which have appeared are:

Angelim da mata	Angelim pedra
Breu sucuruba	Cupiúba
Guariuba	Louro amarelo
Louro canela	Maçaranduba
Mandioqueira lisa	Marupá
Morototó	Parapará
Pau d'arco	Tatajuba
Ucuuba	

The increase in numbers of individual plants in the open and medium plot is very marked as is the height growth in the open (heavy)plot.

(d) Other species

Patches have been found of seedlings of two uncommon desirables; as this gregarious seedling is rather rare small plots have been established to study the development of the seedlings to find out why these species do not occur in groups in the natural forest. The seed falls occurred during the earlier part of 1958.

For GUARIUBA two plots have been laid down; one is in C2 where the canopy has been fairly heavily opened to induce natural regeneration (see page 25); in the other a light opening of the canopy was carried out similar to that for cedro. Results to date, compared with planting, are:

	Heavy opening		Light opening	
	Sept'58	May'60	Sept'58	May'60
Natural				
% stocked	80	75	95	75
No. of plants	205(8)	179(9)	188(6)	99
Mean height (dm)	-	4	-	3

Planted

Mean height in Enrichment, 8 months after planting 5

(line Q) Establishment Index 51

" " in Open plot (E) - Planalto - 20 months after planting 13

Establishment Index 35

Note - (1) The number in brackets is the number of samples (out of 20) in which there were more than 20 Guariuba seedlings.

(2) For meaning of Establishment Index, see Appendix I and Appendix VIII.

Under two other seed trees the seedlings have been removed from 20-30 cm round individual plants selected in the centres of 1.5 m equilateral triangles throughout the seeded area. The best of the uprooted seedlings were transplanted in the Nursery to give stock for the trial plots and enrichment lines.

Owing to the low establishment index in the open it would appear that Guariuba seedlings should not be given full light, but that root competition should be reduced as much as possible in enrichment lines. See page 59 for Guariuba at CBA.

For more silvicultural details see GUARIUBA in Appendix IX.

In the case of other species, ANGELIM DA MATA, the one plot is combined with that for cedro - medium opening. Here the growth increment has been rather poor, although seedlings lifted from this area and transplanted in the nursery have grown well in the trial plots, and have also done better in enrichment lines. Results to date, for Angelim da mata, from the "control" strip for the Cedro (3) plot, are:

Date	Aug.'58	Mar.'59	Mar.'60
% stocked	85	50*	62
No. of plants	474(19)	164*	201(1)
Mean height (dm)	not noted	1.2	2.3

For planting the results are:

Mean height, Enrichment line, flanco (N), 20 months after planting 27 dm

Establishment Index 90

" " " " , planalto, 20 months after planting 11 "

Establishment Index 97

" " Open plot, planalto, 20 months after planting 27 "

Establishment Index 75

" " " " , flanco, 20 months after planting 29 "

Establishment Index 55

Note - 1. (*) some seedlings which appeared to be dead after the very dry "summer" of 1958, evidently recovered in 1959; no fall of seed was observed during 1959.
2. No. in brackets after No. of plants in No. of samples with more than 20 seedlings.
3. Growth of natural seedlings, even after a medium opening of the canopy, is poor (1 dm) compared to that of seedlings from the same place after 8 months in the nursery and 10 months in the field (7-15 dm).

It would appear that for the best development of natural regeneration of Angelim da mata the canopy should be very heavily opened wherever a patch of seedlings is found. The seed being light these patches are rather larger than those of Guariuba; they are also less densely stocked.

For more silvicultural details see this species in Appendix IX.

The only other species so far encountered with dense patches of natural regeneration under natural conditions are some BREUS (not B. sucuruba), CAJUAÇU and ROSADINHA. The BREUS are common undesirables of the understorey; they very rarely reach timber size and are regarded as unsuitable for sawing because of a high resin content. CAJUAÇU is rather rare; although a "floater", the logs rot quickly out of the water and the timber is stringy and difficult to finish to a smooth surface, so it is not regarded as a true desirable at present; in other countries, however, it is regarded as being of some value. ROSADINHA is fairly common but unfortunately it is one of the hardest timbers to saw - value 1 against 100 for cedro, i.e. it requires 100 times more saw blades to cut the same surface area of timber. See Appendix XI.

(ii) Field Scale Operations

Natural regeneration operations fall into two phases - pre-exploitation and post-exploitation. The various operations vary in different countries and according to the species. In Nigeria there are about 12 operations starting from 5 years before exploitation up to 5 or 20 years after it.

(a) Pre-exploitation

The standard operation here is creeper cutting. This lets in more light through the canopy and removes the source of one of the commonest and most harmful weeds; many of the twisted stems, particularly in such light-loving trees as Cupiuba are due to having to struggle up through, and often to lift up, a mass of creepers and climbers, especially in the early stages. Creeper cutting a year or more in advance also reduces damage from falling as other trees are not pulled over.

At the same time as creeper cutting young plants of desirables are freed from competing plants by cutting back the latter with a machette. Also, the young growth is cut back over any gregarious patches of seedlings of desirables such as Guariuba or Angelim da mata and these seedlings thinned out; if required the canopy can be further opened by poisoning at this stage (as referred to above, page 27), but it is usual to wait till after exploitation as this in itself may open the canopy sufficiently.

Another pre-exploitation operation may be the poisoning of large undesirables,

(1) to let in more light,

(2) to reduce the amount of seed from weed trees.

A further pre-explotation operation could be some treatment of the ground under seed trees of valuable species as is being tried out for cedro.

At the Curuá, up to September, 1960 creeper cutting has been carried out over 1,029 ha (Compts. 1-7, 16, 18-21) and the freeing of young desirables over 385 ha (Compts. 16, 18-21). The joint operations cost about 2-3 man days per ha and creeper cutting 2 man days. Limitations of staff and funds have prevented the poisoning of large undesirables excepts in the research plots (B and C).

The object of such operations before explotation is to get established a sufficient quantity of young plants of the useful species before the seed trees are removed. This is not being done in the Amazon at present, with the result that some of the best species, e.g. Cedro, Freijó, Mogno (Aguano) are gradually disappearing. It is true that a number of the young plants will be damaged when felling and extraction of the logs takes place; however, some are likely to escape and many of the others, if damaged, will shoot up again.

The degree of pre-exploitation work must depend on both the original composition of the forest and on the species which are to be encouraged for the next crop. The intensity of exploitation is also important. It may be better not to worry too much about the rare but very valuable trees and to aim for some of the less valuable, but still acceptable species, such as Cupiuba, which are fairly common and can be regenerated easily. This should certainly be the policy to be followed in the Curuá area.

Prior to exploitation a detailed logging inventory must be carried out, at least of the larger desirables trees for exploitation (see page 22). This work may be done by the exploiter; in this case he will be concerned only with the trees which are likely to yield him the greatest profit and to leave in the forest many trees which it would also be economical to exploit, and which should be removed for silvicultural reasons. It is no good saying - "Oh, these other trees can be taken out at some later date". Unless they are removed at the same time that the best trees are exploited, when the organization and equipment and roads are all functioning, it will prove very expensive to come back later to remove them. The inventory therefore should be done by the Government who can then encourage the exploiter to take out as much as possible, but at the same time to stop him removing some trees which may be required for seed. For example, if it is desired to have more quick-growing softer timbers such as Parapará, Marupá, Morototó, Quaruba, but which are usually rather rare, then several of these trees should not be felled but retained as seed bearers to insure many more of the species in the next crop.

On the Curuá, the Logging Unit carried out a 100% inventory of all trees over 45 cm diameter in compartment 6, and the Inventory staff did two more compartments, 5 and 16, in a little more detail for statistical purpose (see Ref. 9). All the trees have been numbered and from the records it is easy to select which trees should be felled.

To facilitate the inventory the compartments were divided into strips 100 m wide. Tracks are cleared by tractor along the dividing lines and exploitation is then done strip by strip so as to work systematically through the forest. The old tracks then serve to delimit sub-units for the control of subsequent silvicultural operations. During February to April 1959 exploitation, initiated and controlled by the Silviculturist, was confined to an area of 27 ha. In this area some 217 trees were felled which gave 530 logs (4-6 m long) with a volume of over 800 m^3 suitable for despatch to Santarém. In all 48 different species were cut, several of which were for trial. The preliminary results of the sawing tests on 25 species at Santarém are given in Appendix XI. Seventeen 6" planks of six species were sent to the Instituto Florestal Latino America, Mérida, Venezuela for full scale testing.

(b) Post-exploitation

The operations vary considerably in different parts of the world. As with other things, these operations mush be simple in the early stages in new areas such as the Amazon.

The following operations have been or will carried out by the end of 1960 or early in 1961:

(1) Freeing young advance growth.

(2) Cutting back some young undesirables.

(3) Poisoning to open the understorey in the remaining dense patches of forest not opened by felling operations.

(4) Felling, or burning, large undesirable to open the canopy further.

(5) Burning the larger clumps of crown and branchwood.

(6) Carrying out a regeneration survey.

(7) Cleaning (including creeper cutting) and thinning out the established natural regeneration.

(8) Group planting of quick growing trees in the intensely burnt gaps where regeneration has not appeared.

Over the course of the next few years the following additional operations are likely to be necessary:

(9) More cleanings, including creeper cutting, and further thinning out of established regeneration, natural and artificial. This operation is likely to need repeating on a 5 to 10 year cycle as the new crop gets older.

(10) Further poisoning of remaining understorey trees as regeneration becomes established.

It is too soon yet to predict when the remaining larger trees should be killed; so much will depend on the species desired in the new crop and on their development.

Some of the above operations need describing in more detail.

(1) Freeing young advance growth. This consists of cutting with a machette any small undesirables within a metre or two of good young specimens of desirables. Badly-shaped desirables should be cut back, as well as any damaged by the felling or extraction operations.

(2) Cutting back some young undesirables. At the same time as carrying out operation (1), young plants of some common undesirables, especially those resistant to poisoning, may be cut back to reduce the numbers of these species in the new final crop. It is true that most of the cut back stems will coppice, but they will be just that much behind the desirable. If this regrowth is slashed back again in subsequent cleanings the stumps will soon become weak and gradually die off.

Operations (1) and (2) were carried out over 22 ha of the exploited areas in compartment 6A at a cost of 5 men days per hectare. Young saplings of Abiurana, Mirauba and Uxis, as well as the heavily fluted species Carapanauba, Maraximbé and Pau de remo were cut back in these operations. Besides all being resistant the first three are very hard to saw, and the second three are useless because of the very deep fluting.

(3) Poisoning of understorey trees in dense patches. There will always be some patches of forest, sometimes quite large, in which no trees have been felled. Here the understorey trees of undesirables are poisoned to let in more light to encourage regeneration. Some 1,353 stems of some 71 species were so treated over 22 ha at a cost of 0.85 man-days per hectare, using 136 litres of 4% solution of 1:2 of 2,4-D: 2, 4, 5-T in diesel oil. The larger stems of the more resistant species were frill-girdled before poisoning. In future, operation (4) - see below - will be carried out before the poisoning is done as it will be cheaper and more effective in opening the canopy. However, should the object be to obtain a crop composed mainly of the slower growing more shade-tolerant species such as Maçaranduba, Louros and Ucuuba, the next operation (4) should be much reduced or left out altogether.

(4) Felling or burning large undesirables. These may consist of large trees of useful species which are hollow, overmature or too large to be handled easily for transport or for sawing e.g. Angelim pedra, which can often be burnt down in the dry season; or, they may be of useless species. In both cases the trees are undesirables from the point of view of the future, on account of the space taken up by both their crowns and their roots.

(5) Burning of crown and branchwood. Where these exist in dense clumps after felling, or operation (4), fire should be put through them towards the end of the dry season. If left, they hinder the development of most species, provide a lovely trellis for creepers to spread over and make subsequent cleaning operations very difficult for some years to come. If the burn is light regeneration of some species, including desirables, will come in; if it is fierce nothing will come in and the patch should be planted up the next season (operation 8).

Abnormal rains in the dry season prevented light burns in 1959; it was only where the branchwood was very dense that the fire burnt at all, and then it was fairly fierce. Light burns, as were carried out in 1957 in the surround of plot A, have resulted in excellent regeneration as described above (page 27).

(6) Regeneration Survey. During the second year after exploitation linear regeneration surveys (2 m quadrats) should be carried out across the area. Two lines were cut across the exploited part of compartment 6A extended for about 150 m into the unexploited part for the sake of comparison. A summary of the results is shown in Table 1 on page 37. The grouping of the samples into one of five canopy classes was done by three people. The percentage shown for the degree of canopy is approximate. It is interesting to note how the number of stocked samples increases with the degree of canopy opening. The actual number of desirables per sample also increases in the same way.

Other points to note are the difference in species between the more open and more closed groups. The presence of Uccuba in the "open" and "half open" groups is due to advanced growth, present before exploitation - note the number in the "closed" group; it is not a fast grower and could not have reached 0.9 - 1.2 m in a year from seed - it is not growing quickly in the enrichment lines in compartment 4 nor in the open trial plot (E - see Appendix VIII). Madioqueira is not common but is present in the more open samples; its proportion in the final crop could be increased by favouring it in cleanings and thinnings; it is likely to prove a very useful species in view of its easy sawing properties. More recent and larger scale sawing tests than those shown in Appendix XI indicate that both types of Madioqueira are even easier to saw than Cedro, though Mandioqueira lisa is rather liable to twist.

A third regeneration survey line was made 2 months later across another part of the exploited portion of 6A. The results were rather different, as may be seen by comparing Tables 1 and 2. Fewer species had appeared, but the more significant fact was the absence of regeneration in several of the samples in an open area due to the presence of a type of grass-like bamboo "Taboquina" which forms dense thickets about 2 m high. Fortunately it is not common in the Curuá but it could prove a major problem in obtaining natural regeneration; there are a few small patches in the surround of plot A (see page 27). but it is being kept under control by the early cleanings. See page 40 for the treating of areas which the regeneration survey shows to be inadequately stocked, i.e. with less than 40% of the samples with a desirable.

TABLE 1

CURUÁ LINEAR REGENERATION SURVEY (2 m quadrats - plants up to 3 m)

Comporatment 6A - June 1960 - 396 samples

100% FULLY OPEN (72)				75% OPEN (57)				50% HALF OPEN (56)				25% SLIGHTLY OPEN (15)				- CLOSED (195)			
Species	Q	%	Ht.	Species	Q	%	Ht.	Species	Q	%	Ht.	Species	Q	%	Ht.	Species	Q	%	Ht.
Cupiuba	23	32	11 ½	Cupiuba	8	14	9	Parapará	7	12 ½		Ucuuba	5	33	3 ½	Ucuuba	33	17	4 ½
Parapará	18	25	12	Breu suc.	8	14	10	Ucuuba	7	12 ½		Louro can.	2	13	12 ½	Louro can.	12	6	10
Breu suc.	13	18	15	Parapará	7	12	11 ½	Louro can.	6	11						Maçarand.	10	5	11
		75		Ang. pedra	6	11	2	Ang. pedra	3	5						Parapará	5	3	2 ½
8 more		22		Ucuuba	5	9	9	Mand. lisa	3	5						Mand. lisa	4	2	6 ½
		97														Mand. asp.	4	2	8 ½
None		3				60				46				46				35	
				6 more		26		7 more		17		1 more		7		11 more		13	
						86				63				53				48	
				None		14		None		37		None		47		None		52	

CONCLUSIONS - (1) Uccuba, Louros, Maçaranduba and even Mandioqueira are present in fair numbers in the untreated forest as the plants are too tall to have come in since felling in Feb-Apr.1959. If these species are required, only a little opening is necessary; then the YOUNG DESIRABLES MUST BE FRI D.

(2) A MEDIUM OPENING would probably favour more Mandioqueira.

(3) If Cupiuba, Parapara, Breu suc. or Angelim pedra (and Morototó and Piquiá) are required in the final crop, OPEN CANOPY HEAVILY, then (1-2 years later) CLEAN and favour in subsequent "thinni s".

Notes

Q - No. of samples with primary seedling of species shown.

% - Percentage of samples with a primary seedling.

Ht.- Mean height of the seedlings in dm.

TABLE 2

CURUÁ LINEAR REGENERATION SURVEY (2 m quadrats - plants up to 3 m)

Line 27 NE - Compartment 6A - September 1960 - 248 samples

100 % FULLY OPEN (60)				75 % OPEN (22)				50 % HALF OPEN (114)				- CLOSED (52)			
Species	Q	%	Ht.	Species	Q	%	Ht.	Species	Q	%	Ht.	Speciecd	Q	%	Ht.
Cupiuba	21	35	9	Cupiuba	15	68	4.5	Cupiuba	12	10.5	8.5	Cupiuba	15	29	3.5
Breu suc.	9	15	9	Breu suc.	1	4.5	8	Breu suc.	8	7	8.8	Breu suc.	4	8	10.5
Taxi pit.	6	10	2	Parapará	1	4.5	10	Ucuuba	5	4	5.2			37	
				Taxi pit.	1	4.5	11	Taxi pit.	4	3.5	7.2				
		60				82		Guariuba	4	3.5	3.2	3 more	4	8	
								Louro can.	3	2.5	5.3			45	
None				None		18				36		None		55	
								78 more	10	9					
										40					
								None		60					

CONCLUSIONS - (1) Very few of the slower growing shade-tolerant species e.g. Louros, Maçaranduna, Ucuuba are present in this part of the exploited area.

(2) The stocking of desirables is only just adequate in the half-open and closed portions.

(3) There is really little choice for composition of the final crop, it must be mainly Cupiuba, with some Breu sucuruba. The closed patches must be opened to assist growth.

(4) The lower stocking in the fully open samples is due to the presence of a type of small bamboo - "Taboquina" - which forms a thick mat and prevents even Imbauba growing. It is difficult to eliminate, so any trees growing up in it must be assisted in the cleanings to enable a canopy to be formed as soon as possible to suppress this weed.

(7) Weeding or Cleaning and Thinning. Where the above survey shows an adequate number of desirables - normally at least 40% of the samples stocked - the area should be cleaned. This consists of slashing back nearly all useless species, and some desirables when they are too close together. Here, the composition of the final crop can be influenced considerably giving preference to the species, one or more, most desired. Any tree is better than no tree when it comes to early canopy formation, so where the desirable species are rather far apart then some regeneration of useless species must be left to help form a canopy quickly to suppress the weeds and creeper growth. Such plants thus become "desirable" until the canopy is properly closed and they can be removed in a thinning; this is being done with Pau jacaré in plot A (page 27).

Until more information is available from experiments in hand, this cleaning should be done early, i.e. when the leading desirables are between, say, 1.5 and 2 m high. The spacing between the plants left should be between 1 and 1.5 m. This early cleaning gives the remaining young plants a chance to grow up more quickly into strong and healthy saplings. However, it makes it easier for creepers to develop. It is possible that by waiting another year or two, when the plants will be taller more natural selection will have taken place; also, the spacing between the plants left, and the length of time before a second cutting back of shoots from the weed plants, can both be greater. The main disadvantages of waiting are that young plants of useful species may be severely suppressed or killed by the quicker growing weeds, or may become too thin and spindly and fall over when freed in the late first cleaning. This happened with Quaruba in one patch, but not in another, at CBA near Santarém. This is a very important subject on which more observations must be made. Early, and frequent, cleanings undoubtedly give good results. So give the young desirables all possible help by early cleanings. But, if funds are uncertain for subsequent cleanings it is advisable to wait a little longer, say till the 3rd year, before doing the first cleaning. It is partly an economic question of balancing costs against results.

Untrained labourers will have considerable difficulty over the initial spacing in the first cleanings. They can be given a stick to hold at one plant and told to cut back every other plant within the stick's length from it. The stick should be somewhat less than the spacing required, e.g. for 1.5 m, use a stick of about 1 m.

Probably three cleanings, and some thinning, are likely to be necessary in the first five years; subsequently, work should be on a five-year cycle and then ten years depending on the species and age. What is vitally important is to get good crowns developed as early as possible. Research in various parts of the tropics has shown that older trees with small crowns due to insufficient space in the canopy usually do not develop large crowns even if given plenty of growing space; also, the girth increment of trees, which is more important than height for volume production, is closely correlated with the size of the crown.

(8) Group Planting. This is really a special form of "Enrichment planting"(pages 49 50).It is not an operation to be undertaken lightly. It has failed many times in the tropics because of the subsequent difficulty in finding the groups to give them the necessary cleanings. Under the special conditions which pertain to the Curuá, and are likely to be found on other parts of terra firme with clay soils of tertiary origin in the Amazon, group planting may be considered for those patches where the crown and branchwood has been burnt after exploitation and where the fire has been intense and no natural regeneration has appeared during the subsequent rainy season. Experience has shown that weeds, even Imbauba, do not come in for the next 2 or 3 years, but that when suitable trees are planted in such patches they grow rapidly. In the second rainy season after burning therefore these bare patches sould be planted with quick growing trees such as Cupiuba, Parapará, Marupá, Morototó, Tatajuba or exotics such as Gmelina, Terminalis ivorensis or T. superba. Tey are not likely to need weeding in the first couple of years; after that creepers and other weeds are bound to come in. There will be no need to search for the groups at this stage, as the rest of the area will be having a cleaning and these groups should be done automatically at the same time. On grounds of economy, the plants should be widely spaced in the groups, say about 4 or 5 m apart; these distances need not be measured. Also, only one species should be put in in each group, though different groups may have different species. Results in the trial plots (page 50) show that on such sites early growth of the suggested species will be 1.5 to 2 m a year; plants put out in these groups therefore should be 3 or 4 m tall and well able to hold their own against any weed trees which may come in before the first cleaning. By this time the rest of the area where natural regeneration has been obtained will be due for another cleaning and the patches of group plantings will not have to be looked for specially.

4. Treatment of Areas not Adequately Stocked with Natural Regeneration of Desirables

There are several possibilities here; each case must be decided on its merits.

(i) Leave the areas for another year or two in case there is a good seed year of species which are likely to come in with the canopy in its present state, and of which there are seed bearers in the vicinity. The type of seed, light or heavy, is important and also the light conditions under which the seed will germinate and the seedlings develop.

(ii) If the canopy is dense or fairly dense, open it up by poisoning some of the denser-crowned weed trees, particularly in the understorey.

(iii) Enrichment planting may be carried out - see below.

(iv) If the areas are fairly large and not too irregular in shape, they could be felled, burnt and planted.

If the treatment of the area with regard to canopy opening was about the same as in adjoining areas where good regeneration of desirables has been obtained, then it is possible that the poorer areas are of a different soil conditions. These differences should be noted, and mapped, if possible, before exploitation takes place so that they can be given separate treatment. Care, however, should be taken to avoid having several different treatments for small areas with irregular bounderies.

Enrichment planting in lines

Details of this will be discussed below under 7, Artificial Regeneration. It has been mentioned above and should be considered briefly now as a possible alternative where natural regeneration of desirables is not really adequate. It should, however, be avoided unless the areas of inadequate regeneration are really large.

The intensity of the exploitation of the forest is frequently patchy due to the irregular stocking of desirables in the original forest; in some patches, perhaps exploited or perhaps not exploited, adequate natural regeneration of desirables does not appear, anyway in the first year or two. Regeneration is normally regarded as adequate if the line surveys show at least 40% of the quadrats to have one or more plants of desirable species; this corresponds to a stocking of 1000 plants to the hectare.

Where the failed or poor patches are not too small and scattered, lines could be cut through them and planted with suitable desirables; however, it soon becomes difficult to locate these lines for subsequent cleanings; if they are not kept clean and fairly open the plants put out just do not develop and the whole effort is wasted. It is only where the whole area under systematic treatment is fairly small, where the supervision of the work can be intensive, and where the number of patches needing enrichment are not too irregular nor too scattered, that enrichment planting should be considered. Generally, it is better to try one of the other alternatives.

5. Refining and Liberation

Dawkins, (Ref. 2, page 91) and other workers have shown that the natural tropical high forest is "saturated", i.e. that it contains too many stems and that growth is very slow except in the vicinity of fallen trees. The diameter increment plots referred to in the next section should show this in due course in the remeasurements of the controls - the natural forest. Even-aged crops from plantations or natural regeneration have a basal area considerably less than that of the original forest, but a greater potential yield. Tending work therefore should aim at keeping the basal area below the maximum or saturation level. Much work has yet to be done to find out what this level is as it depends on the site, and species. Such measurements as have been made suggest maximum figures of from about 24 to 28 m^2/ha in the good natural forest. Tending operations therefore should aim at reducing the basal area to about 15 to 18 m^2/ha on a cycle, say, of 10 years.

Refining is defined by Dawkins as "The general removal of weeds, defectives and proscripts, whether they are interfering with desirables or not, in the interests of complete utilization of the site by the desired crop". A "proscript" is a species of known or potential value but not required locally for some special reason; e.g. some Taxis may fall into this class at the Curuá because they threaten some of the more useful species.

Liberation is defined by Dawkins as "freeing the desirables from inferior competitors". This means the removal of trees which are impeding the development of the desirables; the term should not be confused with "refining" which refers to improving the composition of the forest as a whole.

One refining operation, of course, is creeper cutting; this has been referred to on page 32.

The cutting of young growth of useless species around good saplings of desirables (page 32) which is done at the same time as creeper cutting is a liberation operation.

So far as the small, medium and large trees are concerned, refining should be done with care. The "weed" of today may be the "desirable" of tomorrow. However, some trees should be removed from the forest to benefit the remainder, and no harm would be done in killing some of the commoner undesirables. The area which could be treated is small compared to the vast extent of the Amazon, so that if in the future a species proved to be economic there would still be plenty of it available from the untreated areas. Species which could be killed in the early years of refining are Abiuranas, Miraubas, Rosadinha, and Uxis, and amongst the understorey the Breus (except B. sucuruba), Enviras and Aquariquarana. Most of these are very hard to saw. Young trees (up to say 20 cm diameter) of such fluted species as Carapanauba, Maraximbé and Pau de remo could also be killed in the refining operation, but it is quite useless trying to poison larger trees of these fluted species. Overmature trees, that is trees which are not likely to give suitable saw logs because of their age, and trees which are too large for economic exploitation, e.g. some Angelim and Piquiás, should also be killed during this refining operation.

In connection with liberation, that is in freeing the crowns of desirables, it is very importat to note that, normally, trees with small crownsdo not respond very much in diameter growth if their crowns are freed. It is only the trees of desirables with larger crowns, therefore, which should be freed; the younger trees in the understorey should be given as much attention as the larger trees so long as they have reasonably good crowns. Trees of desirables with crown forms only in classes 5, 4, and perhaps 3 (perfect, good, tolerable - see page 44), should be considered, but in all five of the crown position classes.

Refining and Liberation for the small, medium and large trees can be carried out together, but after the creeper cutting and freeing of saplings. For the latter only machettes are necessary, but for refining and liberation the trees must be poisoned. Details of the technique are described in Appendix VII. Liberation, however, except for freeing saplings of desirables,

should only be carried out in areas where exploitation is not likely for about ten years or more. If exploitation is carried out sooner the liberated trees are not likely to have had time to benefit.

Creeper cutting should always be done as soon as possible; other refining operations could be carried out shortly before exploitation as they will remove seed bearers of undesirables and will let in light to encourage regeneration.

6. Diameter Increments

From the preceding remarks it is evident that information must be obtained about the response of various species to liberation. For this, permanent plots must be laid down to study the rate of increase of the girth or diameter under different conditions of crown freedom. Opportunity has been taken of the plot where the canopy - plot C - has been heavily opened for natural regeneration studies to measure periodically the girth of the remaining trees. All unpoisoned trees, except those with high buttress, have been marked at 1.5 m from the ground, numbered and the girths measured at two-year intervals. The girths are converted to diameters; the time that will be taken for each tree to pass from one class to the next above will be observed and recorded in due course.

At the same time as the measurements are made the crown position and crown form of the trees are noted. Five classes are used and a number is assigned to each tree at each measurement in accordance with the following tables (vide Dawkins, Ref. 2, pages 44-45).

Crown position

5 Emergent (Emergente). Entirely exposed, free from competition for light, at least within the 90-degree inverted cone in which the crown lies.

4 Upper canopy (Dominante). Exposed in entire vertical plane but in contact with other crowns laterally.

3 Lower canopy (Sub-dominante). Partly exposed and partly shaded vertically by other crowns.

2 Upper Understorey (Sub-bosque alto). Entirely shaded vertically but with some direct side light.

1 Lower Understorey (Sub-bosque baixo). Entirely shaded vertically and laterally by other crowns.

Crown form

The definitions here must be supplemented by the words "for that species".

5 Perfect (Ótima). Of the very best size and development commonly seen, wide, circular in plan, symmetrical.

4 Good (Boa). Very nearly ideal and satisfactory silviculturally, but with some slight defect of symmetry or some dead branch tips.

3 Tolerable (Regular). Just in the satisfactory class, distinctly asymmetrical or thin, but apparently capable of improvement if given more room.

2 Poor (Pobre). Distinctly unsatisfactory with extensive die back, strong asymmetry and few branches, but probably capable of surviving.

1 Very poor (Muito pobre). Definitely suppressed or degenerating, usually badly damaged and probably incapable of putting any growth on the bole.

Beside measuring the girth and noting information about the crown, the timber heights of the boles can be estimated with a 5-metre staff and the volume calculated. Volume tables eliminating the need for estimating the height of bole have been worked out for the Curuá area - see Ref. 9.

As many of the smaller trees belong to species which do not grow to timber size, 60 cm was chosen as the minimum girth for increment measurements.

A control plot in untouched forest (except for creeper cutting) has been laid down in D1, the "inviolate" plot referred to on page 25. The first measurement (after 2 years was made in October, 1960, so it is too soon to start drawing definite conclusions.

It seems however that the Taxis put on the greatest increment, that Cupiuba, Mandioqueira and Quaruba are already responding to the opening of the canopy, but not Maçaranduba and Louro canela; where the crown is already in the upper canopy Louro canela is putting on some increment but Mandioqueira is growing more slowly. From measurements over a period of years, say about 20, it should be possible to get some idea of the diameter growth rates in the natural forest, and from these to estimate the probable age of the trees. More plots should be laid down for this purpose, as other works develop. Two of these girth increment plots will be in the other proposed "inviolate" plots, mentioned on page 24 where Dr. Murça Pires proposes to carry out detailed botanical studies. All the trees there will have been properly identified.

Nothing is really known yet as to what degree of freedom will result in the maximum increase in diameter (or basal area) and therefore in the volume, of the trees which are liberated. In the new plots therefore there should be some in which the canopy is opened to a considerably greater degree than in the existing plots. It is only by having plots with a wide range of degrees of canopy opening, with one or two that are too heavily opened, that it will be possible in due course to say what is the optimum to aim for. This may well vary with different forest types.

7. Artificial Regeneration

This falls into two classes, Enrichment and Plantations. Work in both classes is being done on the Curuá on the two main soil types, the clay of the tertiary planalto, and the sand of the quaternary flanco. Before either operation can be carried out plants must be obtained.

(i) Nursery Work

This raising of the plants is done in a nursery where first the seeds are sown in seed beds and then the small seedlings transplanted to other beds or to some container. Nursery work is an expensive part of the cost of plantations, and the transport of plants from the nursery to the planting site can also be an expensive operation. The object, therefore, should be to raise plants of a type which can be transported easily in large numbers. The simplest type is a small (15–20 cm) transplant which can be lifted from the nursery bed and taken out to the field without a ball of earth round the roots – naked-rooted plants. 500 to 1000 of such plants can be carried in a box by one man; exposure to the air must be avoided as much as possible and this method is suitable, of course, only for wet or dull days.

Some plants do not give good results by the above method; an alternative is to grow larger plants and then reduce the amount of leaves at the time of planting. All the leaves except the leading shoot can be stripped off – such a plant is called a stripling; or, the whole shoot can be cut off about 5 cm above the root collar – such a plant is called a stump. In both cases, and with naked-rooted plants as well, any long roots must be pruned so there is no danger of the roots being bent when planting – "short roots are better than bent roots".

The advantage of striplings is that a tall plant (1–1.5 m) can be obtained on the planting site; this may be important if small plants are likely to be eaten back by animals. A disadvantage is that if a dry spell follows planting, the shoot may die right back or even the plant die altogether.

An advantage of stumps is that they do not suffer badly from a dry spell following planting. Other advantages are that they can be kept quite safely for a day or two in wet sacks, and they have no shoot which can be easily damaged.

If none of these methods gives good results then the seedlings must be transplanted into some container which can be taken to the planting site. In theory the transplant could be taken out with a ball of earth pressed around the roots, but in practice most, if not all, of the soil has fallen away from the roots by the time the plant is put into the planting hole. Ball rooted plants therefore can be regarded as normally having come from some sort of container. These can be of many forms. The common one, as used by most agronomists in the Amazon, is a basket lined with leaves; the size may vary from 10 to 20 cm diameter and from about 15 to 25 cm in height; the baskets often decay rapidly and usually need replacing once or twice in the nursery before the planting season. Results are good but transport is expensive as one man can usually carry only from 5 to 10 plants according to the size of the basket.

Pots or containers can also be made from thin sheets of wood veneer. Here too they sometimes need replacing and are heavy to carry.

Pots can also be made from sheets of galvanized iron (the Queensland "tube") with about 2 cm of each side turned over to form a catch. The most economical size is probably a 15 cm high pot 5 cm in diameter. The advantage of such pots is that they can be used again and again, though it takes a little time to collect them all up after planting a large area.

Pots may also be made of plastic material, with some small holes in the sides for drainage. Here the material can be torn away and the ball of earth with the plant put into the hole; it is not usually easy to get the plant out of the pot, so the pot can be used again, without seriously disturbing the root system.

There are various other containers made from various substances which could be tried out but they are not likely to be easy to get for work in the Amazon.

Another type of pot, but without a containing wall, is well known in the south of Brazil, the torrão paulista. These hexagonal pots, which can be of different sizes according to the type and size of plant being raised, are made in a press from a mixture of clay, sand, manure and perhaps even sawdust. Their preparation and use is well described by Armando Navarro Sampaio (Ref. 8). They are a little heavy to transport and, with the heavy rains and high humidity of the Amazon they may break up. They should be tried out on a larger scale and with varying proportions in the mixture.

Another container is the planting tray or box. This may be made entirely of wood, or only with wooden ends and the sides and bottom made of a sheet of galvanized iron with holes made in it. A convenient size is 40 x 30 cm; for this the two end pieces should be 10 x 30 x 2 cm and the sides and bottom of five pieces 10 x 40 x 1 cm; a gap of 1-2 mm must be left between the bottom pieces for drainage. The box, with about 25-30 transplants, is taken to the actual planting holes and each plant taken out with a cube of earth. When plants are raised in boxes it is very important that the soil be cut between the rows of plants at intervals of 3-4 weeks for 2 to 3 months before planting so that each plant develops a compact root system within its own little cube of soil. The boxes can be used repeatedly, their life depending on the durability of the timber used.

The size of plant is important; sowing and transplanting must be timed so as to give the required size at planting time. In general, plants should be from 10 to 20 cm high, except in the case of striplings and stumps; the former can be up to 1.5 m if the species will stand such treatment; tall plants can be used too for stumps; in any case transplants for stumping should be at least 1 cm thick at ground level; stumps up to 2 cm thick have given good results.

Some plants are accommodating, some are not. Naked rooted plants, striplings, stumps, pots, torrões paulista and boxes have all been used on the Curuá; the best type of plant for each species tried out is mentioned in the silvicultural notes in Appendix IX. Up to date it seems best to use naked rooted plants when possible, then small striplings (30-50 cm) or stumps (from slightly larger plants) and then boxes.

Seed, when collected, should be cleaned at once and dried in the shade. Details about some species are given in Appendix IX. In general, it has been found that most seeds quickly lose their viability, so they should be sown as soon as collected. This sometimes means that the transplants have become rather large by the time the planting season arrives; if the plants can go out as stumps this does not matter, but if they will not do as stumps, e.g. Quaruba or Mädioqueira, the normal container may be rather small or over-crowded for the larger plants. Experiments should be carried out on storing seed, but facilities for this do not exist at a field station such as the Curuá. This is work which should be undertaken by a research institute such as the Instituto Nacional de Pesquisas da Amazônia at Manaus.

Several soils have been tried in the nursery. Besides the normal sandy soil which is rather acid (pH 4.5), black soil (terra preta of pH 5.7), river sand and sawdust have been used with good results. Damping off can be serious; watering the seed beds with a solution of potassium permanganate has made little difference. Any ordinary fungicide should be beneficial. Fertility of transplant beds should be maintained, or improved, by the use of anumal manure or even fertilizers. Ash from the camp kitchen is also being used. Green manure (Crotalaria and Pueraria) were tried on the Curuá but did not do well. Further trials should be made.

Careful records of nursery work should be kept. Details should be noted of the origin and weight of seed sown, the date sown, date of germination, date of transplanting, number transplanted, number of failures replanted and the number of plants put out in the field and where planted. The date of sowing, germination and of transplanting should be shown on a small peg in the nursery on each bed or each group of containers with transplants. A blue pencil is better than red for writing on the pegs. The nurseryman should be literate and should keep a day to day diary of the work he does. This information should be posted monthly to the Nursery Record. A suggested format for this is shown in Appendix XII.

Shade is an important matter in nurseries. It should be such that it can be easily altered according to the weather or the species of plants. The best thing is to have some sort of framework over which slats (ripas) or palm leaves can be quickly placed or removed.

The "hardening off" of plants to be put out in the open is an important point. This should start at least 2 or 3 months before the planting season, and should be in two or three stages so that the plants are in full light at least about 4-6 weeks before being put out in the field.

In the Curuá nursery 55 Amazon, 18 from Minas Gerais and 27 exotic species have been tried. In some cases, generally owing to delays in clearing the seed through Customs, the seed had lost its viability; in a few cases seed germinated but the seedlings soon died off. The following failed to germinate or soon died off:

Local

Amapá	Açacu
Balsamo do Peru	Glicia
Jenipapo	Maparajuba
Matamatá ci	Palheteira

Exotics

Cordia alliodora	Eucalyptus resinifera
Tectona grandis	Terminalia myriocapa

Minas Gerais

Calycophyllum spruceanum	Casuarina cunninghamii
Joannesia principes	Ligustrum japonicum
Lonchocarpus discolor	Myroxylon peruiferum
Platycyamus regnellii	Terminalia catappa
Tipuana speciosa	

Even if only a few plants were raised these plants have been put out in the main trial plot (E) on the Planalto. Up to the 1960 season 44 indigenous and 22 exotic species have been put out here or in other plots to give 204 trial blocks or small plantations (see page 50).

Only good healthy plants should be put out in the field. For naked-rooted, 15 to 20 cm and for ball-rooted stock from 15 to 25 cm is about the best height; slightly larger stock can be used, if the cutting of the roots has been done regularly during the previous 2 or 3 months. Smaller plants should be avoided, unless they are small simply because they are young due to late sowing and transplanting.

It is not necessary to wait for seed before trying out local species. If healthy looking seedlings are found in the forest, these can be lifted carefully and transplanted in the nursery. The work should be done on wet days and during the main rainy season. Seedlings of Guariuba lifted near the end of the rains (June-August) did not take well, but seedlings from the same place lifted the following year in March and April did very much better in the Nursery. If the plants are large (say over 30 cm) they should be stumped, or at least stripped, on being lifted. Care must be taken to keep the roots covered as much as possible.

Species which have been transplanted successfully from the forest to the nursery are Angelim da mata, Angelim pedra, Breu sucuruba, Cupiuba, Guariuba, Mandioqueira lisa, Morototó, Parapará, Pau d'arco, Rosadinha, Taxi pitomba, and Taxi preto fôlha miuda. The only failure has been Quaruba both as a seedling and a stump.

A note of warning must be given here. In general, natural seedlings do NOT do well if taken straight from the forest to the plantation site. They should have a spell in the nursery first to develop a good root system and to be hardened off.

(ii) Direct Sowing

To avoid the cost of nursery work a few species can be established by sowing the seed direct in the planting area. This sowing can be done either in lines or at stake or spots at the required planting distance. For direct sowing the seed should be fairly large, the plant quick growing in the early stage, and the seed abundant and cheap. Even some plants with small seeds such as Eucalyptus citriodora can be established by direct sowing if the weather conditions remain suitable for some time after germination.

For spot-sowing the spot should be well cultivated over a circle of at least 20 cm and to a depth of 15 cm and marked clearly with a stake. Normally, 5 seeds should be sown at each spot in the form of a small cross.

For line-sowing a continuous line should be well cultivated and the seeds sown at intervals of about 3 to 5 times the diameter of the seed; the spacing between the lines should be the same as the normal planting distance.

In both methods the lines or spots must be kept well weeded and the surplus plants pulled up as soon as their leaves start touching each other. This thinning out, especially in line sowings, may have to be done 2 or 3 times in the first year. The surplus plants can sometimes be used, when small, for replanting failures in other spots or further along the lines.

Both methods have been recently demonstrated at the Curuá in an open plot. After 6 months the results were successful with Andiroba (large seed) and Terminalia superba (medium sized seed), but only fairly successful with spot-sowing and unsuccessful in lines with Eucalyptus citriodora (small seed). See page 50 for enrichment by direct sowing.

Small-scale trials should be made with other species with medium to large seeds which can be obtained cheaply in large quantities.

(iii) Enrichment Planting

As the name implies, this entails adding species of more value to the forest than those already there. In special circumstances it may be done in groups, as has been referred to under Natural Regeneration where this has failed to appear in patches where crown and branchwood has been burnt following exploitation (page 27 and page 40). Normally, however, enrichment consists of planting in parallel lines cut through young secondary forest where natural regeneration of desirables has not been adequate. The lines

are usually 20 m apart and the plants usually put out at intervals from 2.5 to 5 m in the lines; this gives a planting density of from 200 to 100 plants per hectare compared to 1,600 in a plantation with a spacing of 2.5 by 2.5 m. The lines should be cleaned to a width of 2-3 m; they should be kept as open as possible overhead, unless the species being planted definitely likes quite a lot of shade. The lines should run east and west so as to get the maximum amount of light from the sun.

Enrichment can be done in old forest, but it is expensive to open the lines adequately and the growth is usually considerably slower than in the open. Compare the periodic annual increment - column 10 in Appendix VIII - for enrichment planting in compartment 4 or plot D with in the open trial plot E.

As no young secondary forest existed on the Curuá planalto, and it would take a few years for any to grow up following a felling, compartment 4 was set aside for enrichment trials and to demonstrate the general technique. 90 ha have now been planted here on a field scale entailing the cutting and opening of 45 km of lines. Some 18 species are on trial and some direct sowing at stake has been tried. Ucuuba, Castanheira and Jacareuba have failed but Andiroba shows some promise for direct sowing.

Along the lines all the undergrowth, except saplings of useful species, is cut back to a width of about 3 m; small trees which can be felled with a few strokes of an axe are then cut. Next, some of the dense-crowned useless understorey species are poisoned and occasionally a large tree when it is giving dense shade. Stakes are put at every 5 m except where a desirable sapling is within 2 m of the spot along the line or within 1 m on either side. Holes are then dug at the stakes. At present the canopy over the lines is not yet sufficiently open in many parts so more poisoning will be carried out later on in the dry season of 1960.

As with ordinary plantation work, failures should be replanted. Normally this should be with the same species unless the results are poor; then another species should be tried. Those species which develop only in the open should not be used for enrichment planting. The more promising species so far used are Andiroba, Angelim da mata, Guariuba, Quaruba and Ucuuba.

(iv) Trial Plots and Plantations

Before plantations on any scale are attempted in a new area small trial plots should be established to give some idea,

(1) of which are the more promising species, and
(2) the best technique for establishing them.

There should be separate plots on each of the main sites likely to be encountered in the area. If the number of plants allow, a species, or type of nursery plant, should be put out in two or three separate blocks in each plot. The size of the blocks does not matter very much, but they should be reasonably uniform as far as the numbers of good plants permit. A useful size is a block of 49 plants (7 x 7); discounting the outside row, which may show an "edge" effect, this leaves 25 plants for subsequent observations and measurements. On the Curuá the blocks are generally 100, 49 or 48 (6 x 8) plants; the smallest has only 4 plants. The plots should be repeated over a

period of years; the conditions in one year may be particularly favourable or unfavourable to the species on trial.

There are two main trial plots, E on the Planalto, and M on the Flanco; the main enrichment area in compt. 4 has been referred to on page 50; in addition there are two more small enrichment plots, D on the Planalto and N on the Flanco, two other plots on the Flanco at 4 and 5 km, and a plot, A1-3, on the Planalto with slightly larger blocks of some of the more promising species. Apart from compt. 4, these plots cover 12 ha. The total number of blocks is 204 with 66 species, 44 of which are Brazilian, mainly Amazonian. Shortage of SPVEA funds in 1959 curtailed explanding the work for the 1960 season.

Apart from the eucalypts, which have to go out as ballrooted plants from some container or other, the normal practice has been to try naked-rooted transplants first. If these do not do well, or if they have become rather large because the seed had to be sown early to avoid loss of viability, striplings or stumps are tried. If all these fail then the transplants have to be raised in some container or other.

Details for each species and type of plant are given in Appendix VIII. Information of special interest is given under the species in Appendix IX. Some interesting comparisons are given below.

Species and type of plants	Age	Estab. Index	Per.An.Inc.* (dm)
Aguano – stripling, Plan.	1	84	9
" – " " (+P)	1	76	11
" – " En.	1	26	NIL
Andiroba – stripling, Plan.	1	94	7
" – " " (+P)	1	88	5
" " En.	1	93	4
Cedro – stripling, Plan.	1	92	6
" – " " (+P)	1	100	10
" – " En.	1	90	4
" – " " Flan.	1	87	4
Cupiuba – stump, Flan.	1	73	14
" – stripling, Flan.	1	62	12
" – " " (+P)	1	69	13
– " Plan.	1	88	14
Euc. citriodora – boxes, Flan.	1	77	36
" " – " " (+P)	1	78	42
" " – " Plan.	1	80	22
" " – pots, Flan.	1	93	37
" " – " " (+P)	1	92	37
Marupá – naked root, Flan.	2	83	21
" – stump "	1	98	13
" – " " (+P)	1	94	13
" – " Plan.	1	96	7
" – " " (+P)	1	100	10
Pinus caribeae – boxes, Flan.	4 mos.	97	3.5
" " – naked root, Flan.	4 "	46	2
" " – " " "	1 yr	71	5
" " – " " " (+P)	1	74	3

* Per.An.Inc. = Periodic Anual Increment
Plan. = Planalto, plot E; (+P) = with fertilizer; En. = Enrichment, compt.4; Flan. = Flanco, plot M.

In the first year these trial plots should be measured for height growth and % survival at the end of the rainy season(4-5 months after planting),and at the end of the first dry season. Subsequent measurements should be only once a year at the end of the dry season. After about the third year for fast-growing species, or later for the slower ones, girth measurements should also be made. Both height and girth measurements should be confined to the taller trees - the largest 20% should be enough to give reliable data. If the blocks are large, i.e. over 100 plants, two or more sampling sub-blocks should be laid down in them.

In all measurements the trees in the outside row, or two rows in the larger blocks, should be ignored, as they may show some "edge" effect due to competition, or lack of it, from the adjoining block.

Mulching has been tried but this proved rather expensive when the weed growth in and around the block was not sufficient to provide the mulch. Also, unmulched plots have not suffered. The broadcast sowing of cover crops however should be encouraged. Crotalaria retusa, C. striata and Pueraria are all doing well. The last may prove a nuisance if it climbs too much over the young plants.

Phosphatic fertilizers are usually regarded as being helpful to the establishment of pines. As some had been obtained for this purpose it was decided to try it with some of the other species as well. In a number of cases the blocks were subdivided and fertilizer (rock phosphate or triple superphosphate) added to part of the block before transplanting. Results so far, however,have not been very conclusive; there were no obvious differences as on the poor campos soil Macapá, page 69. The small numbers of plants and absence of replicated blocks has not permitted a statistical analysis; in any case this work is rather outside the terms of reference of the assignment; such statistical research work should really be done by a forestry research institute,such as it is hoped will be developed at INPA, Manaus.

The quantity of fertilizer used was half a dessert spoonful put in a lump at the bottom of each planting hole. Some comparative results up to November 1960 are given below. There is nothing really conclusive from these preliminary trials.

Species	With P		Without P	
	Estab. Index	Per.An.Inc.*	Estab. Index	Per.An.Inc.*
Andiroba (E)	87	12	94	13
Cedro (E)	98	8	91	7
Cupiuba (M)	56	21	56	21
Eucalyptus citriodora (M)				
pots	87	50	89	50
" " (M) boxes	64	51	69	51
Marupá (E)	93	22	77	21
Pinus caribeae (E)	47	10	49	9
" " (M)	65	11	62	10

(E) is on the Planalto; (M) is on the Flanco.

* Per.An.Inc. = Periodic Annual Increment

Spacing. This is another subject for research. The closer the plants, the quicker the canopy will close, thus reducing the necessity for cleanings. However, it will mean earlier thinnings, and also more plants and therefore a higher initial cost per hectare. The branching habit, or otherwise of the species in question may determine the spacing. So may the object for which the species is being grown; trees required only for poles or for fuelwood may be so spaced that no thinning is necessary. The seriousness of competition from weeds must also be considered; the more the weed competition the closer the spacing should be.

In the earlier stages in a new area and with species about which little is known concerning their silvicultural requirements, it is better to keep to a standard spacing. Later, as the work progresses and more information is gathered about the rate of development of the species the spacing may be altered. At the start all plantation work has been at 2.5 by 2.5 m. This means using 1600 plants a hectare.

From results to date it is suggested that on normal or average terra firme soils, other conditions being equal, the following could be put out at a wider spacing, say 3 by 3 m (1,111 per ha).

Cumaru	Cupiuba
Eucalyptus spp.	Gmelina arborea
Marupá	Parapará
Terminalia ivorensis	Terminalia superba

The following, it is suggested, should be put out at a closer spacing, say 2 x 2 m (2,500 per ha).

Angolim rajado	Copaiba
Cuiarana	Jacareuba
Maçaranduba	

Shade. Some species do not seem to do well in the open. From a study of their natural growth conditions it would seem that these species ought to have some shade, particularly when young. Shade can be provided in various ways; the two commonest are either by planting some other species first at a wide spacing to serve as nurse trees, or by cutting lines through young (2-3 years) secondary growth. Another method is to clear most of the forest but keeping a number of trees scattered over the area; this can be rather expensive and also difficult to carry out. Most of the trees felled will have to be burnt to clear the area for planting, and the heat of the fire may well kill many of the nurse trees; most of the trees in the rain forest are very susceptible to fire.

Nurse trees, at least in the first few years, should be as quick growing as the species they are to protect, and they should not have dense crowns or heavy low branches; a form something like an umbrella is wanted. Two suitable species are Parapará and Morototó; Imbauba would also do, especially as it would die out as the final-crop species develops and overshadows it.

Young secondary growth can often be used to provide shade for species that do not grow well out in the open. It is important to keep the lines well open to reduce root competition and to avoid direct overhead shade. A suitable spacing between the lines is 5 m, centre to centre, with lines cleaned to a width of about 2 m, and the plants put out at 2 to 2.5 m in the lines. As the crop grows up it will become necessary to cut back some of the larger weed trees in the strips originally left to give shade. The planting lines should be cut on a north-south axis so that the strips retained can give the maximum amount of side shade.

Judging by results to date in the open plots, species which are likely to do better with some shade are Acapu, Guariuba, Itauba, Louro canela, Maçaranduba, Mandioqueira áspera, Mandioqueira lisa, Quaruba and the Ucuubas. The meliaceous species, Aguano, Andiroba and Cedro, which suffer from a shoot borer in the open, should also be tried with side shade.

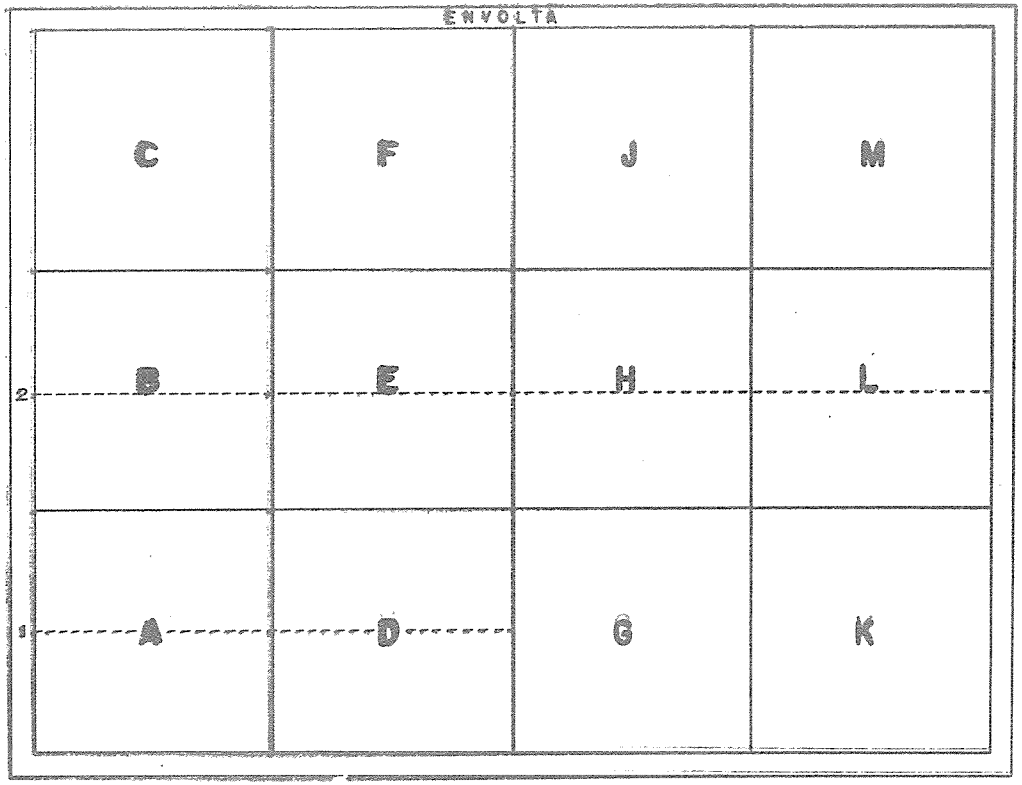
Cedro is already being tried in an alternate mixture with both Parapará or Cupiuba, to see if these quicker growing trees will provide enough shade to discourage the shoot borer, but not seriously slow down the growth of the cedro.

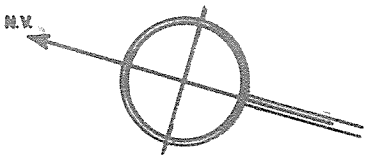
Work has been done in many parts of the tropics on combating this shoot borer, but without much success; if there is too much shade the plants do not seem to be attacked but they grow much more slowly, as can be seen by comparing the periodic annual increment (RPA - column 10 in Appendix VIII).

The most likely solution to the problem probably lies in biological control. This is a matter for entomological experts and should be taken up on an international basis. FAO has already initiated some enquiries in this respect with a view to acquiring funds for work to be done by an Institute of Biological Control with tropical experience. In view of the very much higher value of cedro and mahogany (Aguano) in the Amazon, the Brazilian government should give all the help it can afford to enable this project to develop.

Map 3 – Plan of experimental plots in Santarém

(Each plot measures one hectare)





TRATAMENTOS

COPAGEM BEM ABERTA
COPAGEM MEIO ABERTA
COPAGEM POUCO ABERTA
EXPLORAÇÃO DAS MADEIRAS DE LEI
ENRIQUECIMENTO
LINHAS DE LEVANTAMENTO DA REGENERAÇAO
CRESCIMENTO EM CIRCUNFERÊNCIA

CANTEIROS

A, D, E, F
B, C, H, J
K, L, M
A, B, C,
C, F, J, M
1, 2
ENVOLTA, D, E

0 20 40 60 80 100 m.

CADA CANTEIRO É UM HECTARE

B. COMMISSÃO BRASILEIRA-AMERICANA - CBA

(near Santarém)

During the second half of 1956 a block of 12 ha of forest was made available for experimental work and demonstration purposes, through the kindness of Dr. Joaquim Lopes, Director, Posto Agro-pecuario de Santarém (formerly Commissão Brasileira-Americana - CBA). Part of the area is old or fairly old secondary forest but part of it has not been greatly interfered with except for cutting some trees, e.g. Jarana, for fencing posts. The incidence of the creepers and climbers was much heavier here than in the virgin forest at the Curuá, due to this interference.

The area lies on the Santarém "Planalto" (tertiary clay) and is some 12 km south of the city and about 2 km off the road to Belterra.

1. Demarcation and Roads

The areas is reached by a track of about 300 m from the road from the Agricultural station to a fazenda known as "Andirobal". It has been divided by paths into 12 plots of 1 ha heach and subdivided by lines for survey purposes - see Map 3. A "surround" (envolta) of 10 m wide has been marked out round the plots.

2. Inventories

After creeper cutting in each plot, a normal inventory was carried out of all trees from classes 3 up, i.e. of tress over 25 cm DBH, as was done on the Curuá.

Plot	Total Volume	Number of Trees	Numebr of Species
A	205	142	58
B	179	112	44
C	187	116	46
D	181	115	51
E	212	113	45
F	162	102	41
G	117	121	43
H	76	71	33
J	142	82	33
K	128	123	41
L	208	124	36
M	228	117	36

Total number of species - 98 (Curuá 110 on 13 ha). The above variations reflect the past history of the area.

Half-chain strips (10 m) were run along lines 4, 5, 6 and 7. 70% of the samples were found to contain desirables between 5 and 55 cm diameter. In quarter-chain strips (5 m) along lines 1 and 3 67% of the samples had desirables of sapling or pole size (over 1.5 m tall up to 25 cm diameter).

The figures for the half and quarter-chain strips are rather higher than those for the Curuá - 48% and 46%. Such interference as has taken place in this area in the past would appear to have benefited the regeneration of some of the more useful species, Louros, Parapará and Ucuuba.

The species and percentages of the desirables in two surveys are shown below.

Species	Half-chain	Quarter-chain
Aroeira	1	
Cumaru	2.5	
Cupiuba	2.5	
Freijó branco	15	12
Guariuba	1	
Itauba	-	1
Jarana	1	1
Louros	36	47
Marupá	1	
Morototó	Second.only	
Miratauá	1	
Pau d'arco	1	
Piquiá	Second.only	
Parapará	1	
Quaruba	Second.only	3
Ucuuba	36	36

"Second.only" means thet this species was recorded only as the secondary desirable in one, or more samples. See Appendix IV.

2-metre strips were surveyed along line 2 and part of 1; details are given later under "Natural Regeneration" (pages 57, 58 and 59).

It is too early for a resurvey of the quarter (5 m) and half (10 m) chain strips.

3. Natural Regeneration

(i) Post-exploitation

In the first three plots, A, B and C, about 40 large undesirables per hectare were poisoned in October 1956. In July 1957, the larger desirables were felled, and the following month they were removed by the Logging Unit with its new D6 tractor. These logs were taken to the Sawmill Training Center near Santarém.

This felling and extraction gave a small area where post-exploitation work to further natural regeneration of desirables could be carried out.

The following trees of timber size were felled:

Species	Number of trees	Volume (m^3)
Acapurana*	1	1.1
Cuiarana	1	hollow
Cumaru	3	11.5
Faveira uing*	1	3.3
Faveira fôlha fina*	1	hollow
Freijó branco	2	3.2
Glicia*	1	3.4
Gombeira	1	1.8
Jarana	1	1.4
Jutaí pororoca*	1	2.7
Louro ? preto	3	6.7
Louro sp.	1	1.9
Parapará	2	3
Piquiá	1	5
Quaruba	8	37.1
Quarubarana	3	21.3
Tauari	1	3.9
Taxi branco*	1	1.4
Taxi preto*	1	2.5
Ucuuba	3	9.7
	37	120.9

* These are not yet generally accepted as economics.

In plot A, in which more trees had been felled, a "heavy" opening of the remaining canopy was made by poisoning some 8 dense-crowned understorey trees and by cutting back all the undergrowth except the young desirables. In plot B a lighter opening was made by cutting back some of the undergrowth - those undesirable species with opposite leaves. In the three plots 65 of the large trees which had been poisoned a year earlier, but which were still alive, were repoisoned after exploitation. Plot C was set aside for enrichment planting - see page 60.

Results of 2-metre strip surveys:

Date	Plot A		Plot B	
	%	No. of species	%	No. of species
November 1958		not done	68	8
December 1959	98	14	88	11
October 1960	88	13	98	11

The light decrease in A is probably the result of the last cleaning.

Two cleanings have been carried out in plot A but none yet in B. The object for this is to find out:

(a) whether adequate regeneration can be obtained without the expense of cleanings in the first two years, and,

(b) how much the development of the regeneration is held back by not opening heavily and then cleaning.

There is no doubt that adequate regeneration has now been obtained in both plots. At present the growth of the regeneration in B is equal that of A. When it is freed however (say in 1961 - 1962) it is possible that much of it may be weak and will fall over. During the first cleaning in A in July 1959 there were so many desirables that some were pulled up or cut back where they were interfering with each other; preference was given to species other than the three commoner ones - Louro, Parapará and Ucuuba. Seedlings of 15 desirables species were found in this one hectare.

(ii) Inducing Natural Regeneration before Exploitation

In the next three plots, D, E and F, a "heavy" opening of the canopy was carried out. Some 43 large trees and 68 understorey trees per hectare were poisoned and all the undergrowth except that of desirables was cut back. As with the exploitation plots (A, B, and C), one plot here, F, was set aside for enrichment planting - see page 60.

As at the Curuá, to get an idea of the degree of canopy opening the original basal areas were calculated from the inventory measurements, and that of the unpoisoned trees from measurements for a diameter increment experiment. The agreement with the figures for a similarly poisoned area at the Curuá is remarkably close -

Curuá C1 and 2 - 20.1 reduced to 11.4 m^2/ha (diameter class 3 and up)

CBA D " E - 19.9 " " 11.0 " " " " " "

An estimate of the basal area by using a relascope has been referred to on page 26.

As was to be expected, the regrowth of the undergrowth was fairly vigorous in these quite heavily opened plots. A cleaning was carried out in August 1958 cutting all weeds back to ground level in D; this operation cost 10 man-days for the hectare. In E, only the weeds above waist-height were cut back though, when close to smaller desirables, the smaller weeds were also cut back; this operation cost 4 man-days for the hectare, a considerable saving. Similar cleanings two years later cost 14.5 and 5 man-days respectively.

Results of 2-metre strip surveys:

Date	Plot D		Plot E	
	%	No. of species	%	No. of species
November 1958		not done	60	9
December 1959		" "	86	11
October 1960	94	9	92	9

There is now plenty of regeneration in these two plots, mainly of Louro and Ucuuba. They could be exploited. As this is not practicable, the undestorey should be further opened periodically to assist the development of the established regeneration. Further cleanings will be necessary at 2 or 3 year intervals till the seedlings and saplings are able to form a canopy to suppress the weed growth.

In the next three plots, G.H. and J, a "medium" opening of the canopy was carried out. About 39 large trees and 25 understorey trees (G and J only) per hectare were poisoned and some of the undergrowth cut back - as was done in plot B. As in the previous groups, one plot, J, was set aside for enrichment planting - see page 60.

In the last three plots, K,L and M, a "light" opening of the canopy was carried out. Only about 39 large trees per hectare were poisoned. Nothing was done to the understorey or undergrowth.

Results of 2-metre strip surveys:

Date	Plot H		Plot L	
	%	No. of species	%	No. of species
November 1958	36	6	62	8
December 1959	56	7	62	9
October 1960	79	8	70	8

The stocking in these plots is now quite good but the regeneration of desirables is less and has taken longer to come in than in plots B, D and E; also, the height growth is less.

Over all the plots there is not much difference in the numbers of the more shade tolerant species such as Guariuba and Ucuuba, but there are naturally more of the light demanding ones, such as Parapará and Morototó, in the heavily opened plots.

An interesting feature in all six plots sampled is the amount of Guariuba which has appeared. The fruit is a fairly heavy drupe about the size of a coffee "berry". Only one seed trees is known; it is in the surround on the edge of plot D, and yet young plants are found well distributed over all the sampled plots, as well as being concentrated under the seed tree. Here, they have been thinned out as on the Curuá (page 31).

4. Enrichment Planting

As it was necessary to start enrichment operations early and, as it would take a few years to find out the effect of the different degrees of canopy opening on securing adequate regeneration of desirables, it was assumed at the start that there was not, or would not be, enough natural regeneration in one plot of each of the four different treatments - exploitation and some poisoning, heavy, medium and light canopy openings. Plots C, F, J and M were therefore set aside for enrichment, with the different degrees of canopy opening to be maintained as far as possible.

Lines were cut, ignoring, i.e. also cutting any natural young desirable, through each plot at 10-metre intervals ans plants put out 10 m apart in each line. In plot C (not heavily exploited) 226, and in plot F, 60, small trees overshadowing the lines were poisoned. Plots F, J and M were planted early in 1957, and plot C early in 1958. Replanting of failures has been carried out as far as nursery stocks have allowed.

Results are (November 1960):

Plot	Species	Number	Estab. Index	P.A.I. * (dm)
C	Aguano	3	failed	-
	Andiroba	20	76	9
	Cedro (Ford)	40	83	8
	Cedro (Eq.)	30	31	4
	Jarana	5	55	2
	Piquiá	5	50	6
F	Andiroba	84	80	7
	Cedro (Eq.)	10	64	10
	Terminalia ivorensis	10	55	16
J and M	Andiroba	161	77	4
	Cedro (Eq.)	10	56	6
	Terminalia ivorensis	30	57	5

(Eq.) = Plants (in F and J) or seed came from Ecuador.

It proved impossible to maintain a reliable difference in the degree of canopy opening in plots J and M, so these two are now regarded as having a "light" opening.

* P.A.I. = Periodic Annual Increment

The Cedro plants from a little seed collected at Fordlandia in 1956 continue to do very well (plot C). Efforts to get more seed from here have so far proved fruitless. Cedro from seed from Ecuador is not doing so well. At the Curuá, however, plants from this seed are doing better than plants from local seed, e.g.:

	With P fertilizer		Without	
	Estab. Index	P.A.I.*	Estab. Index	P.A.I.*
Cedro (Ecuador)	92	22	75	17
Cedro (Curuá)	98	8	91	9

Plants from Ecuador seed are also proving more resistant to the shoot borer at the Curuá - see pages 80-81. More trials should be made with plants from Fordlandia seed, even though the seed trees have been badly attacked.

5. Diameter Increments

As explained on page 43 for the Curuá it is necessary to obtain information about the response of various species to liberation. Advantage has been taken of the plots, D and E, where the canopy has been heavily opened for natural regeneration to measure periodically the girth of the remaining trees. At the same time notes are made of the crown prosition and crown form. The control plot in untreated forest is in the surround (1.4 ha).

As at the Curuá, the first remeasurement (after two years) was made in October, 1960, so it is too soon to start drawing definite conclusions. Here, Quaruba of all sizes is putting on good increment, even more than Taxi preto, while Ucuuba is growing about three times faster than on the Curuá. In general the diameter growth is better at CBA.

* P.A.I. = Periodic Annual Increment

C. SANTARÉM

The small plots here are within the limits of the SPVEA-FAO Sawmill Training Centre. The soil is sandy, with some terra preta in the western part. The vegetation is poor secondary bush which has obviously been cleared and cultivated several times in the past. It was an ideal area therefore in which to study the afforestation problem of poor secondary bush near a large centre of population. There could be no question of natural regeneration as all desirables have long since disappeared from the area. Two plots were laid out; one was for line planting through the bush to take advantage of some side shade and one was for trial plots in the open.

1. Nursery

A small nursery was opened here in June, 1956. Apart from raising plants for small local trial plots, some were to be used for enrichment work at CBA, and some were to be available for township planting, if required by the Prefeito. When funds become short in 1959 the nursery was closed, but it was re-opened later in the year for raising eucalypts, some of which were to go to the Curuá, where the nursery results with these species had not been good the previous year.

Seed of 33 different species were sown from 25 of which plants were obtained for trial plots. The following species failes:

Araracanga	Callitris arenosa
Callitris glauca	Eucalyptus paniculata
Eucalyptus propinqua	E. resinifera
Jutaí açu	Pau marfim

2. Line Planting

The lines here were cut 5 m apart and plants put out at 2.5 m in the lines, as the whole area is rather small. Any benefits from shade have been more than counterbalanced by competition from the bush between the lines. Saúva too have caused much damage; had it not been for them results would certainly have been better with Gmelina and Albizzia lebbeck, but neither of these species has done as well as in the open plot where saúva attacks were as bad. Various formicides have been used but the whole area is covered with ant holes. In the 1957 open plot of 3,000 m^2 50 holes were counted from which ants were working. Attacks are less severe now after a three-year war of attrition.

3. Ordinary Trial Plots

In the first year (1957) advantage was taken of a recently cleared but unburnt patch of very young secondary growth (about 1 m high). The new regrowth was cut back and burnt prior to planting. In the following years the plots were extended annually to the south-east in somewhat older secondary growth (about 3-5 m high). Results on the young secondary growth area was replanted in 1958 and again in 1960; whereas plants in the new 1958 plots did well (see below for some results), the same species failed or did very badly in 1957 plots.

Usually, areas of secondary bush, in spite of repeated clearings and burnings for cultivation, are still capable of successful afforestation with such trees as Eucalyptus, even if after a resting period which is too short to give good results with agricultural crops. It would seem however that on these sandy soils of quaternary origin the bush must be allowed a longer resting period for small trees to develop and to reach a height of several metres before being cleared and burnt for afforestation except with Gmelina, and perhaps Teak. The FAO Mission pedologist was unable to find any differences in the soil to account for the poor results in the young secondary bush area.

Saúva caused damage in the earlier years, particularly to Gmelina, which was sometimes defoliated three times a year. The growth of this species would have been about twice as rapid had it not been attacked so often.

Cleanings have to be carried out 2 or 3 times a year in all the plots, but can soon stop in the 1958 plots of Eucalyptus alba and E. camaldulensis where the tree canopy was closing by late 1960. On a large scale it might well be advisable to clean parallel traces with a bulldozer and to plant two rows of trees along each trace. If this cannot be done trials should be made with an arboricide to kill back the regrowth of the bush.

Brief results of the more promising species are given below. More details may be found in Appendix VIII, where results can be compared with those at the Curuá.

Year	Species	Number	Estab. Index	P.A.I.*(dm)
	Line Planting			
1957	Albizzia lebbeck	94	16	2
	Gmelina	60	85	13
	Open Plots			
1957	Albizzia lebbeck	45	41	10
	Gmelina	60	85	13
1958	Eucalyptus alba	90	42	27
	E. camaldulensis	45	29	31
	Marupá	45	62	16
	Teak	45	73	19
1959	Eucalyptus citriodora	300	17	17
	Parapará	75	38	22
1960	Eucalyptus alba	60	87	24
	Eucamaldulensis	60	68	18
	Gmelina		98	7

Pinus caribea will be tried out in 1961.

* P.A.I. = Periodic Annual Increment

The following species have failed or done very badly:

Line planting

Andiroba (1957 and 1958)	Eucalyptus alba
E. camaldulensis	E. tereticornis
Marupá	Schizolobium sp.
Teak	Terminalia ivorensis
Terminalia superba	

Plots in the open

Callitris intratropica	Casuarina cunninghamii
Eucalyptus drepanophylla	Eucalyptus robusta
E. saligna	Schizolobium sp.
Terminalia ivorensis	Terminalia superba

In the light of present information it would not appear to be advisable to attempt large scale afforestation for timber in secondary bush on these quaternary sands. Only quick-growing species for fuel, or possibly for paper pulp, should be planted until more experimental work has been done.

A small fertilizer trial with triple super phosphate was made in the 1958 plots (8 species) but the results were not conclusive. In 1959 a further trial was made on a slightly larger scale with only Eucalyptus camaldulensis and E. cidriodora. Results (November 1960 measurements) are:

Species	Estab. Index	P.A.I. (dm)
Eucalyptus camaldulensis	50	37
" " +P	53	31
" citriodora	17	17
" " +P	41	28

Eucalyptus citriodora does not seem to have done so well here without fertilizer. At the Curuá, however, on the sandy flanco soil plants from the same source as above have shown no response; the P.A.I. with and without fertilizer is 51 dm in each case.

4. Forestry and Erosion Control - Santarém City

At the request of the Prefeito a study was made in April 1956 of the possibility of checking the erosion of some of the city streets by afforestation between the airport and the city.

The following note was submitted in June 1956 to SPVEA, with a copy for the Prefeito:

"FORESTRY AND EROSION CONTROL IN SANTARÉM

The problem of erosion control in Santarém is essentially one of civil engineering, requiring the construction of adequate concrete or brick drains. The amount of the run-off after heavy rain, however, could be reduced if every open space, and part of every yard round every house, is planted with a creeping grass.

2. There is only a small area between the fence of the aerodrome and the southern building limit where trees could be planted; this strip is about 2 km long and 200 m wide. From about half of it the water flows to the west to the "igarapé" IRURÁ, and so does not contribute to the erosion in the town.

3. There was no sign in April, 1956 of any appreciable run-off from the eastern portion, except along an old road leading from the aerodrome. The water which runs away along this road comes from the open spaces around some buildings near the aerodrome gate. Two things can be done here:

(1) plant grass over the open spaces, and

(2) divert the flow from the present channel and direct it westwards to the "igarapé" IRURÁ; this latter would reduce the flow lower down in the town. This diversion will mean an increased flow across the road to the south between where the 38-metre contours cross and re-cross the road. It will be necessary to raise the road a little at this point and to put in a wider culvert.

4. Further along this road to the south it is crossed by the main run-off from the aerodrome. At this point too it is suggested that the road be raised and a large culvert put in. Apart from planting grass over as much as possible of the open spaces around the aerodrome, it is doubtful if anything else can be done to decrease this run-off.

5. So far as tree planting in the strip north-west of the aerodrome is concerned, it would be better to make this area into a park; the trees should be widely spaced (20 or 30 m apart) and each one would need some wire netting round it to protect it from goats. A creeping grass should be planted over the open spaces between the trees and clumps of bushes. The FAO Mission could provide the trees and do the planting, but the Prefeito would have to provide the wire netting to protect the trees. If the Prefeito would like this work to be done he should let the FAO Silviculturist know as soon as possible so that the trees can be reserved for this purpose. The planting could be done about February or March. To make a plantation of trees in this areas would be expensive, as the whole area would need a wire netting fence to protect the trees from goats.

6. With regard to the suggestion for a "Nature Reserve" beyond the aerodrome and to the east of the road to the south, the FAO Silviculturist is willing to help in any way he can."

The suggestions about raising the road for a large culvert (para.3,(2)) and putting in a larger culvert further to the south (para. 4) have been adopted. Nothing has been done with regard to planting grass or tree planting. The conversion of one or two streets into gulleys, large enough to lose a lorry in, continues.

D. AMAPÁ (Federal Territory)

It was possible to make an early start here, thanks to the interest of the Territorial Government. After a short preliminary reconnaissance in December, 1955, a more detailed study was made early in March 1956 and a proposed Forestry Plan was submitted in April. This plan was approved by SPVEA in June, 1956.

Briefly, the plan was in two parts, one for the forest areas and one for the poor degraded campos.

1. Forest Areas

In view of the railway construction from Santana to the site for the manganese mine at Terezinha proposals were confined to the area through which the railway runs west of Pôrto Platon, now generally referred to as "Campo Verde". This is the area where Dr. Arthur Miranda Bastos of the Serviço Florestal was carrying out an inventory - Ref. 7.

(i) Reservation

It was suggested that part of the area near the railway should be made a forest reserve, the location of the boundaries being decided from the results of Dr. Miranda Bastos' inventory survey. The selection and demarcation of one or more areas is the responsibility of the Territorial Government.

(ii) Silviculture

It was proposed that trial plots be established with a view to improving the forest by:

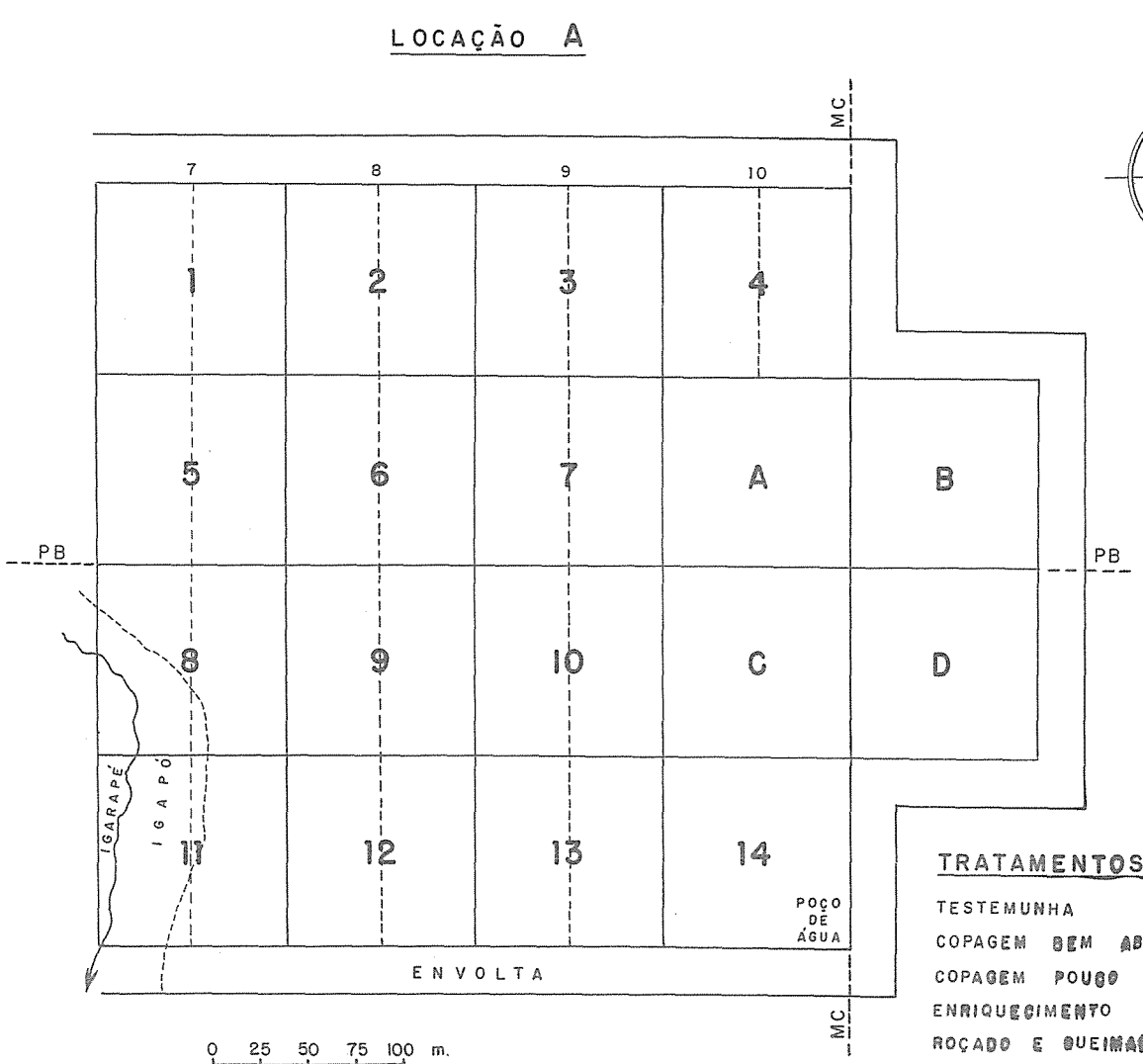
(1) encouraging the natural regeneration of useful timber species,
(2) reducing the number of useless species, and
(3) enrichment planting where natural regeneration is poor or absent.

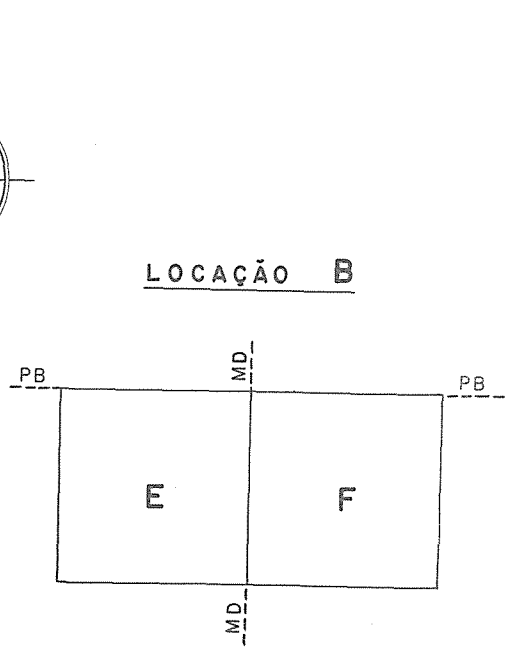
Plots were to be laid out in both good high forest and in poorer forest close to Pôrto Platon.

FAO, with funds from SPVEA, undertook the silvicultural work, transport being provided by the Territorial Government. Six 1-hectare plots were actually demarcated in May 1956 and in August an inventory of 4 ha was made. This inventory showed:

Plot	Total Volume m^3	Number of trees	Number of species
A	219	137	57
B	189	124	46
C	195	112	44
D	237	133	43
Mean	210	126	47
		Total number of species =	78

Map 4 — PLAN OF EXPERIMENTAL PLOTS IN PORTO PLATON





CADA CANTEIRO É UM HECTARE

PICADAS DO INVENTÁRIO DE MIRANDA BASTOS: MC PB MD

TRATAMENTOS

TESTEMUNHA

COPAGEM BEM ABERTA

COPAGEM POUCO ABERTA

ENRIQUECIMENTO

ROÇADO E QUEIMADO

PARCIALMENTE DESTRUIDO PELO I.C.O.M.I.

LINHAS DE LEVANTAMENTO DA REGENERAÇÃO

CANTEIROS

C	
D, F, 1, 2, 5, 6	
B, 9, 10, 12, 13	
A, E, F, 3, 4, 7, 8, 11	
D	
14	
7, 8, 9, 10	

In plot A enrichment lines were opened; in A, B. and D some 64 large undesirables were girdled (poison and sprayers did not arrive till later) and in D the useless undergrowth was cut back. B. and D were to study the development of natural regeneration following light and heavy canopy opening. For the latter 33 understorey trees were poisoned in D in October 1956. C was kept as a control. Creeper cutting was done in A, B and D. Plots E and F were in the poorer forest where lines were cut for enrichment.

It was proposed to extend to 4 ha, each of the plots A, B and D during 1957. However, owing to some misunderstanding ICOMI (the manganese mining company) were allowed to come into this area to establish a farm. By a gentleman's agreement with the managing director of ICOMI, FAO agreed to extend only in a westerly direction. In May, 1957, a further 14 one-hectare plots were laid down and creeper cutting carried out. See Map 4. A block of 3 plots adjoining A and 2 others near the igarapé on the west were for enrichment. One block of 4 plots was for a "heavy" canopy opening and one of 4 for a "light" opening.

(a) Natural regeneration

Half-chain linear regeneration surveys were made in plots A to E in May 1956. They revealed a very low stocking of desirables in the better forest - 25% samples stocked - and only 5% in the poor forest.

Quarter-chain (5 m) strips were surveyed in October 1957. The stocking of the saplings and poles was better, but poorer than at the Curuá or CBA.

	Enrichment	Heavy	Light
Percentage stocked	34	42	37

1960 was too soon to carry out a second survey.

For the "heavy" opening (plots 1, 2, 5 and 6) 32 large and 41 understorey trees of undesirables were poisoned per hectare and the undergrowth cut back, except of desirables. For the "light" opening (plots 9, 10 12 and 13) 19 large undesirables were poisoned per hectare.

Cupiuba is fairly common in the forest and it regenerates readily in the open alongside the roads. As there were 12 Cupiuba trees over 25 cm diameter in plot D it was hoped that some regeneration would appear there following the heavy opening. Practically nothing had come in by mid-1959. However, in plot B, where a fire had come in from clearing work by ICOMI, much Cupiuba regeneration had appeared a year later. In September 1959 the regrowth of the undergrowth in D was cut back, and later the ICOMI farm manager co-operated by trying to burn it; owing to unseasonal rains this burn was not successful, but Cupiuba is now appearing in the few small patches where fires were started. The plot was slashed back again and will be burnt in the latter part of 1960.

In September, 1960 a 2-metre regeneration survey was carried out in the "heavy" (plots 1, 2, 5 and 6) and "light" (plots 9, 10, 11 and 12) opened blocks, three years after the initial treatment. In the heavier opened plot 22% of the samples were stocked with regeneration of desirables and only 16% in the lightly opened plot. These results are much poorer than anything at the Curuá or CBA; they reflect the lower stocking of desirables which was found in the original inventory of the larger trees.

(b) Enrichment planting

In all plots lines were cut 10 m apart and further opened by poisoning; planting was at 10 m in the lines (100 per ha). The take was fairly good in both 1957 (plot A) and in 1958 (plots 3, 4, 7, 8 and 11); some beating up was done in 1959 and was planned for 1960 but transport was not available. By May 1960 many of the plants had died and it was considered advisable not to continue with enrichment work. The lines need more opening first, and, owing to repeated difficulties over transport and sometimes over getting labour, further studies with enrichment planting should be confined to the Curuá, and to work now being started by the forestry section of the Instituto Nacional de Pesquisas da Amazônia at Manaus. Results in plots E and F in the poorer forest are as unsatisfactory.

The species tried were Acapu, Aguano, Anani, Andiroba, Cedro, Cupiuba, Cumaru, Jacareuba, Ucuuba, and Gmelina and Terminalia ivorensis. Details are given in Appendix VIII opposite "PP".

2. Campos Areas

It was thought that these areas, though poor for agricultural crops or even grazing, might be suitable for afforestation; trials were suggested with such species as Pinus caribaea, Gmelina arborea and various Eucalyptus species with interplanting with Leucaena glauca to improve the soil. the first nursery was to be bear Macapá to facilitate control, and later near Pôrto Platon. The trial plots were to be at Matapi and near km 85 and 55 on the road from Macapá. It was suggested that a large areas east and south-east of Pôrto Platon should be earmarked as a possible future reserve for large scale planting, if the trial plots showed promise. It was hoped that some locally recruited staff would be appointed for training - none materialized from the Territory.

The Division of Production kindly made available a nursery site near the Equator at Fazendinha-de-Fora and work started here in June 1956. It soon became apparent that there would be difficulties over transport and labour and before the end of the year it was decided to site the first trial plot close to the nursery. The Division of Production ploughed strips across the plot but were unable to do anything at Matapi. The only other mechanical help they were able to give was to clean the fireline with a tractor in 1959.

(i) Nursery

The nursery was opened in two adjoining sites, one in the open on recently cleared young secondary forest (3-4 m high), and one under older secondary forest (10-12 m high). The open part was for raising plants for the campos trial plots and the shaded part for plants for enrichment planting. Plants were raised in beds for stocks of naked rooted plants, striplings or stumps, and in boxes and pots of galvanized iron. In all 44 species were sown in this nursery from 29 of which plants were obtained for the trial plots or for planting at Pôrto Platon. Mycorrhizal soil for raising Pinus caribaea was introduced from São Paulo and Trinidad, and some young pine seedlings were brought in from the latter. The plants from these seedlings now constitute the main source of mycorrhizal soil for work at the Curuá and at Manáus. Saúva caused some damage at times in the nursery.

The following species failed to germinate or else soon died off before or after transplanting:

Araracanga	Bálsamo do Peru
Callitris arenosa	Callitris glauca
Calophyllum antillum	Cordia alliodora
Eucalyptus saligna	Macacauba
Pau d'arco	Pau marfim
Pinus khasya	Pinus markusii
Taxi	Teak
Terminalia myriocarpa	

(ii) Trial Plots

In the Fazendinha plot planting was done at 2.5 by 2.5 m half of the hole having half a dessert spoon of rock phosphate put in them just before planting; This treatment was repeated with each replanting. The strip-ploughed area was $1\frac{1}{4}$ ha and a further 3/4 ha was subsequently planted, without ploughing, to the east. It very soon became apparent that without P nothing would really grow. Even the Leucaena, which germinated well, soon died in spite of fertilisers, so poor was the soil. Altogether 21 species (5 local) were tried; plots were sometimes duplicated and for some species two or three types of plants were tried. At first some promise was shown with a few Eucalypts, Gmelina and Terminalia, but this was not maintained. If the annual addition of fertiliser is necessary to keep a tree growing quickly, economic afforestation is out of question. Comparison with results at the Curuá or Santarém, even with species whose seed came from the Fazendinha area, show how poor these campos soils are.

In 1958 a small (0.25 ha) plot was put out at km 86; even with fertilizer nothing developed.

(iii) General Recommendations for Campos

In a brief report submitted to SPVEA in April, 1960 it was recommended that no further work should be done on the campos plot, but that it should be protected and kept weeded to see if, after several more years of fire protection, the tress would develop better. It also suggested that if the

Territorial Government whished to initiate more experiments for the improvement of these poor soils it should be on the following lines:

(1) complete protection against fire and cattle,

(2) cultivate strips and sow green manure of various species, with and without fertilisers,

(3) if they do well, plough in the green manures. Up to this stage the direction and supervision of the work whould be the responsibility of a Territorial agronomist. It might take several years to get green manure established to the extent that the soil can be said to have been improved sufficiently for another trial at afforestation,

(4) plant trees, using a fertiliser, e.g. rock phosphate. It is only at this stage that assistance from a silvicurist may be required.

Some results up to January 1960 at Fazendinha compared with other localities are shown in Table 3. Full details are given in Appendix VIII.

In 1959 a few plants of two species of Pine, Pinus caribaea and P. occidentalis, and in 1960 five species of Eucalypts were put out by the nursery, where the previous vegetation was young (3-4 m) secondary growth of forest. Here, on what can be described as still a forest soil, the plants are doing well. Any afforestation therefore in Amapá should be done at present only on areas supporting secondary forest growth - or high forest if the extra expenses of clearing is thought worthwhile.

3. The Future

With the potential development of the Territory due to its mineral resources, the 200 km of railway and port of Santena, and the installation of a hydro-electric scheme at Paredão, it is possible that one day more intensive exploitation of its forests may take place. The plots therefore at Campo Verde beyond Pôrto Platon should be maintained and observations made in them from time to time, as these plots will give some information of value to any experienced professional forester who may be called in to advise the Government on forestry matters. Certainly the Territorial Government would be ill-advised to conclude any sort of forest concession for exploitation on a large scale without consulting a professional forester with tropical experience; by "professional" is meant a man with a university degree in forestry as such.

TABLE 3

COMPARISON OF RESULTS ON AMAPÁ CAMPOS AND SOME OTHER LOCALITIES

Espécie	FAZENDINHA – EQUADOR				OTRAS LICALIDADES				
	viva %	índice sobre-viventes	Idade	R.P.A. (dms)	viva %	índice sobre-viventes	Idade	R.P.A. (dms)	Localidade
Albizzia falcata +	20	20	2	1.2	100	67	2	12.1	Curuá
Eucalyptus alba +	50	29	1.5	2.2	80	65	2	16	Santarém
" +	2	2	1	1	100	70	2	14	+ Curuá
"	12	12	1	1.7	95	91	2	15	"
E. camaldulensis +	37	21	3	4	80	60	2	17	Santarém
"	33	16	3	0.4	94	85	2	9.5	Curuá
E. citriodora +	75	60	3	9.7	80	57	2	9	Santarém
" +	70	54	2.5	6	80	80	1	27	Curuá
"	60	33	2.5	2.1	78	78	1	29	Curuá
E. tereticornis +	10	10	.75	2	88	63	2	7	Santarém
"	10	10	.75	0.8	85	80	2	18	Curuá
Gmelina +	98	98	3	1.5	100	85	3	12	Santarém
"	90	72	3	NIL	100	100	1	13.6	Curuá
Marupá +	59	46	2	1.2	84	71	2	7.5	Santarém
"	60	46	2	0.5	95	83	2	15.3	Curuá
Morototó +	10	8	1.5	NIL	69	28	2	1.6	Curuá
"	3	3	1	1	45	33	2	5.4	Curuá
Parapará +	4	2	2	1	19	10	2	4.3	Santarém
"	4	2	1.5	0.6	97	52	2	14.6	Curuá
Pinus caribaea +	30	30	1	0.7	74	75	1	2.1	+ Curuá
"	28	28	1	0.5	71	71	1	1.4	Curuá
" (viveiro) +	79	79	1	3.9	85		1	2	+ Curuá

+ = com fertilizante

E. MATO GROSSO

In October 1956 a "Processo" in the following terms was received from SPVEA:

"PARECER No. 38/56
Ref. Proc. SPVEA - 15.787

To the Superintendent,

Appreciating the "Preliminary Suggestions for the silvicultural services in the Amazonian Valley", presented by Mr. John Pitt, FAO Forestry Officer, now in Belém with the specific mission of advising and assisting the Government in the application of silvicultural methods for the Amazonian forest, with the purpose to develop the rational utilization of that forest, this Sub-Comission of Natural Resources is quite in accordance with that and recommend its execution as soon as possible.

We also recommend a study of the possibility of extending the services to the Amazonian area of the Mato Grosso State in a zone that is considered available.

This recommendation is due to the necessity to start studies over this transition strip of the Amazonian forest, and to work out, within the present possibilities, a solicitation of the referred State Government in that sense.

This Sub-Commission, when required, will be at the FAO technician's entire disposal to settle together with the Mato Grosso State Representative the indispensible details to the expansion of the referred services.

Sub-Commission of Natural Resources
Belém, 28th September, 1956

(s) NADY BASTOS GENU
President

(s) JOCELYM L. DA ROSA
Member"

In response to this request it was asked whether anyone from Mato Grosso would be available to come to Belém for some training, as it was too far away for work to be done in this State under direct control from Belém. On being assured that one or two engenheiro-agronomists would be available, a 9-day visit was made to Mato Grosso in November 1956; a short Report was submitted to SPVEA in December, 1956.

Trips were made to Cáseres, Rosário Oeaste and to Agua Quente, and teco-teco flights by Cessna to the Pantanal and over Barra dos Bugres and Diamantina. Four main types of forest were seen, (1) Riparian (Vârzea), (2) Good deciduous forest (Cerradão), (3) Semi-evergreen (near Barra dos Bugres) and (4) Savanah (Campos Cerrados). Destruction of many of these forests for agriculture was proceeding space.

Briefly, the main recommendations were:

(1) for the Governor to agree to the policy of setting aside some areas as forest reserves,

(2) when this policy is approved for the local (Cuiabá) branch of SPVEA to recruit an engenheiro-agrônomo to come to Belém for training in silvicultural work,

(3) later, for the FAO Silviculturist to make a longer visit to the State to advise on the selection and demarcation of forest reserves,

(4) when demarcation has started it would be possible to initiate silvicultural works to improve these forests, at the same time as other areas are being selected and reserved.

So far as is known, no action has been taken to check the destruction of the forests, nor to build up future supplies of timber.

F. INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA (INPA) - MANÁUS

At the request of the Brazilian Government, FAO sent out an expert in 1956-57 "to investigate the silvicultural conditions in the Amazon region, to advise the Government on the organization of a research station for tropical forestry in this region and to train national personnel in silvicultural practices".

The Report by Mr. E. Meijer Drees on this assignment has been published by FAO as Report Nos 756 (Pt I) and 1068 (Pt II) under the title:

"Report to the Government of Brazil on the Organization of a Forest Research Centre in the Amazon Region".

Early in 1960 the Director of the Institute asked if help could be given in starting, on a very modest scale, some silvicultural work in the Ducke forest near Manáus. An engenheiro-agronomist was sent to the Curuá for three short spells of training, and two visits have been made to Manáus to advise on the orientation of the work.

The current program includes:

(1) demarcating the limits of the Ducke forest reserve,

(2) opening up a nursery,

(3) some inventory work - in the areas to be clear-felled,

(4) clear-felling of small areas on three different sites, the center part of each area to be used for trial plots.

(5) studing the development of natural regeneration in the surrounds of these trial plots,

(6) laying down of plots on the three main sites to induce natural regeneration by opening the canopy.

(7) carrying out an inventory of the forest, after stratification, i.e. after the limits of the different types have been shown on a map.

(8) enrichment planting on all three main types,

(9) collection of silvicultural information about the more important species,

(10) sawmill trials of possible useful species.

No up-to-date air photographs are available of the area so recourse had to be made to the 1942-44 trimetrogon photographs taken during the war. Fortunately most of the proposed reserve is covered by vertical photographs and the FAO Inventory section have prepared a map on a scale of 1:40,000 showing the stream and drainage channels and the main topographical features. Unfortunately the map maker was not able to recognize on the photographs the limits between the forest on low lying sandy soil ("baixos") and that on the clay slopes ("encostas"). This stratification will have to be carried out in 1961 by an experienced forest interpreter. The edges of the forest on the "planalto" ("chapada") is often very clear however and much of this boundary is shown on the map.

Technical assistance will be necessary at Manáus for some year to come. However, Dr. Rubem Valle, who is in charge of the work there, shows considerable interest and promise. It is recommended that he be sent to Puerto Rico to attend one of the short (three months) training courses there to extend his knowledge of forestry so that he can assume greater responsibility as the Forestry section of the Institute develops.

There has been a Botanical section at INPA and there is some talk of reviving it. The Conselho Nacional de Pequisas already has a Botanical section at the Museu Goeldi in Balém, and there is a good Botanical section under Dr. Murça Pires at IAN, Belém. It would seem a duplication of effort therefore to set up a third Botanical section for Amazônia in Manaus. Rather it would be better to employ assistants in the field, working under the Silvicultural and Agricultural section, who would send their material for identification to Belém.

G. PAU ROSA

The principal recommendations made on page 6 of the "Report to the Government of Brazil on the Forestry Development of the Amazon Valley" FAO Report No. 171 of October, 1953, are divided into:

(1) Proposals which will lead to immediate progress on a practical level, and

(2) Proposals which should be initiated forwith, but whose effect will only be felt later on.

The third proposal in the first category is as follows: "Measures suggested by the Mission as capable of ameliorating the troubles of the Rosewood oil industry should be set in train".

These measures, elaborated on pages 56-58 of the above Report, treat primarily with the actual production of oil. However, the second last paragraph on page 57, begins with a sentence of great significance: "This expansion of output of this industry may have other consequences, the most serious of these being the disappearance of the industry itself for want of raw material".

A visit was made to a pau rosa factory on the Moju river in the Santarém area following which some proposals were submitted to SPVEA in September, 1958. The attention of the Superintendent was called to the need for early action by the Governor of the State of Amazonas, in which most of the pau rosa oil factories are working, to set aside some land for silvicultural studies on the tree - Aniba roseodora - which produces the oil.

After some brief comments on staff and funds, the following proposals were made:

"There appear to be two lines of approach,

(1) encouraging and assisting natural regeneration, and

(2) "compensatory" plantations.

1. Natural Regeneration

This is worth considering only where there is, or was, a reasonable concentration of trees, say about 5 to the hectare, AND, where these localities are accessible. Such localities appear to be very uncommon. They would have to be visited periodically, say at 5 year intervals, over a period of many years. It is a waste of money, and effort, therefore to start in a locality which may become inaccessible some year later when the extract factory moves to another place. Briefly, the work would consist of decreasing the shade over natural regeneration, thinning out these trees as they develop, and thinning out the coppice shoots where these appear on the stumps of felled trees. Gaps between patches of regeneration could be planted with nursery raised trees.

A useful preliminary investigation was made in the Moju area by Dr. Humberto Miranda Bastos in December, 1953 and November, 1954. Unfortunately the factory has ceased working in this particular area (it is 13 km from the river) and it is now virtually impossible to visit it.

2. Plantations

In many parts of the tropics where the yield from a forest is low due to the economic trees being widely scattered, the future supply is being assured by planting the trees in concentrated and accessible localities. Instead of a yield of one tree, or less, from a hectare in the natural forest, the plantation will yield 20, 30, 50 or perhaps even a 100 trees per hectare in the future. If a 100 ha of original averages 1 tree per hectare, the same yield in the future can be obtained from only 1 to 5 ha of plantations. Such plantations are referred to as "compensatory" plantations.

Pau rosa is a very valuable tree. It appears to seed prolifically and the seed to germinate well. It should not be difficult therefore to raise plants in nurseries for establishing plantations in easily accessible localities. Even natural seedlings pulled up carefully in the forest survive transplanting in the rains. The growth too, anyway in the early years in the open, seems to be rapid, averaging about a meter a year.

But a word of warning about plantations. The planting of the trees on the final site is only the beginning of the work; like babies and children, the young trees have to be cared for and looked after every few years if the best yield is to be obtained.

Plantations could be:

(1) either in the open, preferably on land from which a crop of manioc has just been taken, or on cleared young secondary forest, or even cleared high forest (but this would be expensive), or

(2) as "enrichment" planting in secondary or high forest.

In both cases, the work is specialized, particularly the second; also, it has to be carried out over long periods of time.

Industrial concerns exploitating the forest normally have neither the time nor the technical knowledge to carry out large-scale plantings. Experience in many parts of the world has shown that such operations must be done by the Government Forest Service. It is no good making laws or orders that the cutter must replant more trees than he cuts; even if he did plant them, it is very difficult to make him look after them; they will die -"by the will of God".

Compensatory plantations should be the responsibility of the Government. In the Amazon, the FAO Forestry Mission can help. What is necessary is for the Government to decide, (1) on the amount of money to be made available, and therefore the size of the operations, (2) where the plantations should be situated - they must be in localities which are easy to travel to quickly, and should become

Government forest reserves, and, (3) recruit extra staff of young engenheiro-agronomists, to help with the work.

Each separate area should have a program of about 100 to 200 ha a year of enrichment planting or 10 to 20 ha of pure plantations in the open. One agronomist should be able to look after two such areas.

It would appear that suitable localities might be found in Amazonas in the Municipes of Maués, Paritins and Itacoatiara.

At the start, of course, the work will have to be on a smaller scale till the agronomists, the capitães, and the labourers, have learnt what is required."

Following an inquiry by Dr. Raul Antony of the Instituto Nacional de Pesquisas da Amazônia in Manáus some more detailed proposals were made for work by this Institute. These were based on information that most oil is obtained from the smaller branches, and least from the lower part ot the trunk and the roots.

The proposals are as follows:

(a) Propagation:

1. By seed sown in nurseries. Put out the seedlings in:

   (i) beds (canteiros)
   (ii) baskets (paneiros)

   Plants from the beds should be put out in the field as:
   (i) naked rooted - when small (10-20 cm)
   (ii) striplings ("sem fôlhas") - when large (50-100 cm)
   (iii) stumps ("tocos") - " " (100-150 cm)

2. By cuttings

3. By natural seedlings. Put out in the field as (i), (ii) and (iii) above.

Plantations

1. Spacing. Try comparatively close e.g. 2.5 x 2.5 m, and at the probable final spacing e.g. 10 x 10 m.

2. Thinning (for close-planted area). Wait till the canopy is closed; then favour the trees which are likely to give the largest crowns.

Pollarding

1. Natural grown trees. Try pollarding trees of all sizes.

2. Plantation trees. Cut back some young tres (say when 5-6 m high) to 2, 3 and 4 m; then, two or three years later, cut the ends of the branches to encourage a low bushy crown. Repeat after a few years to the taller growing branches.

(b) Light Requirements for Natural Regeneration to develop

Where there are good patches of natural regeneration, try at least two degrees of canopy opening - medium and heavy.

In the medium cut out all shrubs ("arbustos") and kill understorey ("sub-bosque") trees.

In the heavy - as above, and also kill the other large trees standing over the regeneration.

Tree killing - This can be done by girdling ("anelação") the larger trees; the smaller (understorey) trees are likely to fall over if girled. Note girdling is not effective on some species.

Most trees can also be killed by spraying the trunks with arboricides. A 1:2 mixture of 2,4-D and 2,4,4-T in diesel oil is best, using a 3% (by volume) solution for small trees (say up to 15 cm DBH), 4% for medium sized ones (15-30 cm) and 5% for large trees. The solution must NOT be supplied to the bark when wet. Scales of old bark should be scraped off before spraying. Spray a strip about 20 cm (um palmo) wide till the oil just begins to flow down.

With resistant species frill-girdle first, except for small trees. Resistant species appear to be Abiuranas, Breus, Louros, Mirauba, Ucuuba, Uxis and various others with latex. It is useless to treat the larger trees of fluted (sulcadas) species such as Carpanauba, Maraximbé, Pau de remo, Quinarana.

When spraying avoid high pressure in the pulverisadores (this is wasteful); keep the pressure as low as possible.

It is obvious that when the trees are grown in concentrated areas the cost of production of the oil can be greatly reduced; then the industry could face up to competition by synthetics.

It is recommended that the Silvicultural section of INPA should acquire some land near the Itacoatiara - Manáus-road and carry out some work on the above lines.

H. MAHOGANY

The timber of this tree - Swietenia macrophylla -(Aguano or Mogno) is the most valuable that comes from the valley of the Amazon. So far as it is known it does not occur on the more recent geological formations of the Quaternary and Tertiary but only "above the cachoeiras", i.e. on the Cretaceous, Carboniverous, Devonian, and older formations as well as on the basement complex.

A visit was made to the mahogany areas near Araguatins on the Rio Araguaia the main tributary of the Rio Tocantins. This area is really outside the Amazon hyles, and much of the vegetation is deciduous or semi-deciduous, as is mahogamy itself. In the area seen the pH of the soil was from 6 to 7. This probably explains why the plants did not do well in the Macapá and Curuá nurseries - pH 3 to 4.

In the vicinity of Araguatins the mahogany occurs only in the better patches of forest, which appeared to be on soil derived from intrusions of diabase. It was only these patches of forest which were being cleared for shifting cultivation.

The Government is now in the process of creating a large forest reserve in this area; this is a wise precaution in view of its proximity to the Brasilia-Belém road.

Like the other valuable members of the same family, Cedro and Andiroba, mahogany is attacked by a shoot borer when grown in the open (see page 54) When planted in the forest, even in moderately opened enrichment lines it hardly grows at all. The average height of a plot in the open at the Curuá (E) was 1.2 m after 10 months and 2.8 m after 20 months; in the forest in compt. 4, plants of the same age averaged 0.3 m and 0.4 m respectively.

During the earlier part of 1960 the incident of shoot borer attack was not very high compared with cedro in an adjoining plot.

Species	% attacked	
	1st attack February 1960	2nd attack August 1960
Aguano (mahogany)	13	19
Andiroba	4	4
Cedro (local)	40	11
Cedro (ex Ecuador)	4	2

There are only 100 plants in most of these plots. It would however be very unwise to put out large blocks of pure mahogany. Some experiments should now be undertaken with nurse or shade trees, as descriped on page 53.

Mahogany can be established easily with naked rooted plants or striplings, if the weather is good, or with stumps if the plants are larger (80-120 cm or more). Containers were not found to be necessary on the Curuá.

I. INSTITUTO AGRONÔMICO DO NORTE (IAN), BELÉM

1. Girth Increment Plot

Dr. Murça Pires, the botanist of this Institute, had carried out a population study in a patch of high forest near Belém. The two hectares had been divided into 10-metre strips and every tree over 10 cm in diameter numbered and identified. Advantage was taken of this, and, with the kind permission of the Director, Dr. Rubens Lima, the trees were marked at breast height, or above the buttresses if not too high, and the girths measured and recorded. This patch of forest, known as MUCAMBO, is being left intact so that in the course of time some useful information should be available about growth rates under natural conditions.

Recently, an adjoining area has also been marked out and the trees numbered for further botanical study. Girth increments could be extended with advantage to this new area as well.

The original two hectares was first measured for girths in November, 1956. The second re-measurement was carried out in October 1960, but it is too soon to draw definite conclusions.

2. Linear Regeneration Survey

As a training exercise for the first assistant a half-chain survey was carried out in May-June 1956 over the 2 ha of the Mucambo plot. All the sub-plots, i.e. all the 10-m strips were done. This survey showed 45.5% of the samples stocked with 18 different desirables ranging in size from 5 to 45 cm diameter. 15% of the samples had a secondary species. The three common species, Quaruba tinga, Ucuubarana and Acapu, represented 34 of the 45.5% stocked samples. As no silvicultural treatment may be given to this area, it is a little early for a resurvey.

3. Pine Trial Plot

During the past 8 or 10 years various trial plots have been planted in different parts of the grounds of the Institute. Last year, Dr. Calzavara, who is in charge of the plantations, very kindly co-operated and included a block of 200 Pinus caribaea along with several local species and two species of Eucalyptus. The pines were raised at Macapá; the young transplants were brought across and replanted in baskets, as were the other species. The site is typical of the rather poor sandy soil which is common around Belém and the Bragantina area to the east. Comparative rates of growth should give a good idea of the possibilities of this pine in the Belém region. Unfortunately actual measurements are not yet available; it is understood that they are to be published by Dr. Calzavara who is not prepared to supply any data in advance. The pines look healthy; only one has died. The mean height is is probably only a little less than of those on the Curuá (planalto and flanco) put out about a month earlier.

Other species in the same plot as the pine are:

1959 (early)	Acapu	Aguano
	Bracatinga	Cumaru
	Cupiuba	Eucalyptus alba
	Eucalyptus teriticornis	Pau d'arco
1959-1960	Bacuri	Castanheira
	Cedro	Marupá
	Umiri	

In view of Dr. Calzavara's pending publication it would be unethical to comment further on this plot, or on the various other ones in the grounds of the Institute. His kindness in including some pines on behalf of FAO is hereby gratefully acknowledged.

J. EXPLOITATION FOR PULPWOOD

Nothing can be said to have been accomplished here in the field, as such exploitation is quite outside the scope of a section working to a small budget of between one and two million cruzeiros (£2-4,000) a year, when a jeep alone costs about four hundred thousand cruzeiros. However, a general note on the regeneration of the Amazon forests after cutting for pulpwood was submitted to SPVEA in September, 1958 on the following lines, now modified slightly in the light of recent results and observations in the field.

In view of the possible construction of an experimental pulpmill it was considered advisable to enlarge on the very brief proposals made in the Preliminary Suggestions for Silvicultura Work in the Amazon submitted to SPVEA, in March, 1956. The appropriate sentence read:

> "Another possibility worth consideration is to develop the forest into a soft hardwood type with a few quick-growing species under a short rotation for supplying pulpwood."

Each area must be treated on its merits; the details of the work to be done must vary according to the type of forest, and to the natural regrowth which follows operations. The proposals below must be taken as a general guide to be modified as experience is gained.

In a forest type which consists of a large number of species, there are likely to be some species which are not very suitable for pulp; the wood may be too hard, the trees may be too large, or there may be something in the wood which affects the pulp. Therefore, it is probable that a better type of forest for supplying pulpwood be a type consisting of trees of about the same size, and consisting of only a few species which are regarded as most suitable. So far as is known such forests do not exist in the Amazon, but, they can be obtained in one of two different ways.

1. Plantations

The first way is by making plantations with a few good species, immediately after the original forest has been cut for pulpwood. Besides cutting the trees wanted for pulpwood, the following must also be cut:

a) trees of unsuitable species,

b) young trees too small for pulpwood, and,

c) old trees that are too large or otherwise unsuitable.

If there are only a few of these large trees they could be killed by cutting a ring through the bark round the tree, or by poisoning with arboricides.

Then, the whole area will have to be burnt. The felling of as many trees as possible and the burning, is necessary,

a) to clear the ground for planting operations, and

b) to kill the stumps so they will not grow again.

However, the burning will result in the destruction of much of the valuable humus; also, where the ground is sloping, much of the top soil may be eroded.

Several of the trees too large to be cut for pulpwood or otherwise unsuitable, might be quite suitable as timber for a sawmill. The integration of cutting both for pulpwood and for a sawmill is the ideal which should be aimed at wherever possible. It will reduce the work necessary to clean the ground for plantations. It will also reduce considerably the cost of logging and will result in the maximum utilization of the forest.

In any country the establishment of nurseries and the raising of the necessary number of transplants (at least 1,600 per hectare if the planting distance is 2.5 m by 2.5 m in squares) will be a very large undertaking. In the Amazon it will be particularly so as few trained supervisory staff or experienced labourers are available. Also, there is always the danger with plantations of a single species on a large scale (and any undertaking for the economic working of a pulpmill must be on a large scale) of pests and diseases developing and spreading rapidly through the plantations.

2. Natural Regeneration

The second way of obtaining a better pulpwood forest after the original forest has been cut for pulpwood is to encourage the natural regeneration of only the better species for pulp, and to eliminate the unsuitable ones. A Research Institute or a pulp and paper manufacturer should carry out pulping trials on the various quicker growing species and should say which ones are regarded as most suitable. These pulping trials should be carried out immediately, before large-scale felling operations are carried out in the forest. What the silviculturist wants to know is, which of the quicker growing species are good for pulp. He also wants to know which species (slow or fast-growing) are considered to be unsuitable. In fact, any information about the comparative suitability, or unsuitability, of any species will be of value.

A list of the quicker growing species, whose natural regeneration appeas to be abundant and comparatively easy to obtain at the Curuá following the opening of the canopy, was submitted to the Pulp and Paper Section of the Instituto de Pesquisas Tecnológicas, São Paulo, in September, 1960 for them to say which ones are known to be suitable, or unsuitable, for paper making. Small samples (50 kg) of the species which have not been tested were being sent down in November for trial.

The important point now seems to be for the silviculturist to suggest those species which can be established easily by natural regeneration methods and for the paper maker to test these (if not already done) and say which ones are most suitable, and which are useless. The best pulp species can then be encouraged by every suitable means known to silviculture.

The quick-growing species usually are not common in the original forest; therefore, when not common they should not be cut in the first felling, but, should be left as seed trees so as to give as much seed as possible for their natural regeneration.

An operation which should be done before the pulpwood is cut, and several years in advance if possible, is to kill the trees regarded as unsuitable for pulp. This killing can be done more economically by spraying with arboricides than by cutting a ring through the bark round the tree, provided the arboricides can be obtained from the south of Brazil; they are not on sale in Belém.

In places where the killing of unsuitable species is not done before cutting the forest, care must be taken to destroy these unsuitable species as quickly as possible after the felling and removal of the pulpwood. They must not be left alive to go on producing seed.

If some of the trees of the good species are kept to produce seed, and, if the unsuitable species are killed in advance, then, after a forest is cut to produce pulpwood (integrated with timber production) the next crop or generation should contain a very much higher proportion of even-aged trees of the more useful species, as these would be favoured in the earlier cleanings.

The next operation to improve theis new crop is to go through the young regrowth ("capoeira") and cut out any trees growing up which are unsuitable for pulpwood. Also, any trees of limited value should be killed or cut if they are interfering with the growth of more useful species. For this reason, it will be appreciated how important it is for the silviculturist to be kept up to date with any information about the comparative suitability, or unsuitability, for pulp of any species which occur in the Amazon forests.

The cleaning operation described above must be repeated at intervals, usually about every five years.

If the natural regeneration of suitable pulpwood species is absent or only a little is present in the regrowth ("capoeira"), it may be worthwhile to do some enrichment planting. Only time will show to what extent this enrichment planting may be necessary. It should take the form of open line planting in an east-west direction as the softer quicker growing species will not stand much shade.

3. General

Whether there are to be pure plantations or only open line planting, some experimental work should be done on raising the useful species; but, it is necessary for the organization concerned with the production of the pulp to say which species are regarded as the most suitable.

A few words should now be said about the area of the unit on the ground for controlling operations. Whether the forest is to be regenerated naturally or artificially (i.e. by plantations), it should be divided up into some convenient unit ("compartment") to control not only felling and removal of pulpwood, but also silvicultural work. It is suggested that the most convenient unit is a square of 1 km (100 ha), especially where the country is flat; where the ground is very uneven, the main unit boundaries should be the "igarapés". To be able to make a good plan of the compartments good air photographs are essential, especially in uneven country.

Above we have considered the "intensive" or concentrated working of the forest. However, especially in the case of the "várzea" forests, the cutting of trees for pulpwood may be very scattered; only a few trees of only a few useful species might be cut here, and a few there. With such "extensive" working it will not be practical to regenerate the forest as proposed above, i.e. to establish plantations, or to carry out intensive natural regeneration work. All that could be done is to prohibit the cutting of the smallest trees, and to insist that some of the larger trees of the more suitable species are left to produce seed.

The question now arises as to who should do the work proposed above - the Government or the industrial concern who would exploit the forest. It is evident that the work calls for rather specialized knowledge, even if only plantations are to be established. Many people can grow a few trees and plant them, but, when replanting forests cut for pulp very large numbers and areas have to be dealt with. Also, the planting of trees is just the beginning of the work; the trees have to be cared for, failures have to be replanted, and, later on, thinnings have to be carried out.

It is always possible to make a contract in which the industrial concern has to plant the trees, and even to enforce that this work is done. But, it is much more difficult to make them do the work <u>properly</u> and to carry out subsequent tending operations. When other operations, such as enrichment planting and the tending of natural regeneration, are to be done, it is almost impossible to make an industrial concern do this work properly, as it requires very special knowledge.

This treating of the forest, whether plantations, enrichment planting or tending natural regeneration, has to be carried on periodically for many years (15, 20, 30, perhaps even more), before the forest is ready again to be cut for pulp. An industrial concern is not likely to worry about such work to give yields so far in the future. Experience all over the world has shown that in undeveloped areas industrial concerns are not worried about silvicultural operations which are not likely to benefit themselves for many years to come. It is only in well developed countries where much of the forest has already been destroyed, as in parts of the U.S.A.,

Canada, Australia,-and São Paulo-,that industrial concerns will trouble to do the planting for themselves. Again, world experience has shown that in undeveloped areas the replacing of the forest for the future is only successful IF THE WORK IS DONE BY THE GOVERNMENT FOREST SERVICE.

The industrial concern therefore should pay to the Government royalties or fees which will provide the money to finance the replacement of the forest BY THE GOVERNMENT.

If large-scale exploitation of the forest is ever started for pulpwood, i.e. the felling of blocks of several hundred hectares a year, some strips of natural forest should be left round each block to give protection against dessication in the dry season. If the blocks are to be square kilometres, a strip 50 m wide whould be left round each block; these strips will help to retain the forest climate.

K. TRAINING

In August 1957 the Director of the Serviço Florestal asked if the FAO Mission could help over the training of forest personnel. This was agreed to and the Director was to recruit some engenheiro-agronomists in the south and send them up for training. None materialized. For 1958 it was suggested that one or more of the junior local staff in Belén go to the Curuá for training; the principle was agreed to but no one materialized.

Following a visit to Belém in July 1959 by the Director, and a brief one to the Curuá in August by Dr. Arthur Miranda Bastos, both of the Serviço Florestal, it was arranged that the Chief of the 1st Inspectorate from Belém would visit the Curuá. Although he was provided with a ticket he, too, for various reasons, was not able to go. Eventually in March 1960 an assistant went up for a period of over three months. This man worked well, but not much should be expected of him as he had not had even a high school education.

It is a tragedy of the first magnitude that the Serviço Florestal has failed to avail itself much more fully of the opportunities provided by the FAO forestry mission in the Amazon for training Brazilian personnel in tropical forestry. Perhaps they will in 1961.

The short course of training given to a member of the scientific staff of INPA has been referred to on page 74.

L. TIMBER IDENTIFICATION

This is not strictly a silvicultural subject. However, any silviculturist should be able to recognize the logs and timbers of the more important species with which he is dealing. For this reason the Brazilian assistant, Dr. Guerra, was sent to the Instituto de Pesquisas Tecnológicas in São Paulo for a three-week course in 1958 to learn something about the macroscopic identification of the commoner Amazon timbers.

The present assistant, Dr. Osvaldo Vera Cruz, went on a similar course of four weeks in October, 1960.

Punched cards have been made and work is in hand in preparing a key. The preparation and distribution of sets of these punched cards should be a definite step forward towards the better identification of the local timbers.

Profiting from his course at São Paulo, Dr. Guerra, who is now the Adminstrator at the Centre at Santarém, is able to instruct the trainees in timber identification with the aid of a hand lens.

V. APPRAISAL OF ACCOMPLISHMENTS

The span of life of the different trees in the forest may be anything from 20 or 30 years up to perhaps 200 or 300 or more. In the very short period of less than 5 years therefore it is impossible to expect a complete answer to the problem. However, as has been shown in the previous section, much information of value has been collected and a sound basis laid for the application on a larger scale of silvicultural methods to the forests, at least on the planalto, for developing the rational utilization of these forests. Many and varied operations have been demonstrated, and some cost figures, in man-days, collected - See Appendix X. Considerably more time however must elapse before total costs can be evaluated against the final results.

The scope of the work is almost unlimited, once funds and personnel are made available. The work should certainly be extended to a várzea area, as soon as the Inventory section has got some data from it. The igapó and flanco types are likely to be less productive, though some growth results from plantation trial plots at the Curuá on the latter are somewhat spectacular, at least in the early years. These sandy soils which lie between the rivers and the planalto in the Tapajós-Xingu region, sometimes in quite broad belts, may be capable of growing good pine (pinus caribaea) which would provide a much better furnish for pulp than the existing forest. Owing to the sandy nature of the soil extraction could be done during much of the rainy season; in fact in the dry season it may be more difficult to get out the timber unless lateritic gravel ("piçarra") or something else is put down to improve the surface.

The duration of the work is indefinite. For how long technical assistance should continue will depend on how soon a government department begins to take an active interest in the work and to participate in its actual execution. There is no doubt that planalto forests such as occur at the Curuá can,

(1) yield a good quantity of timber of acceptable species,

(2) be regenerated naturally, and with more stems of fewer desirable species,

(3) have the future composition of the next crop determined to a considerable extent in the cleanings of the natural regeneration during the first few years following exploitation, and

(4) be converted to good plantations after clear-felling and burning if a much greater quantity of more valuable species is required (compensatory plantations).

The last also applies to the flanco forests.

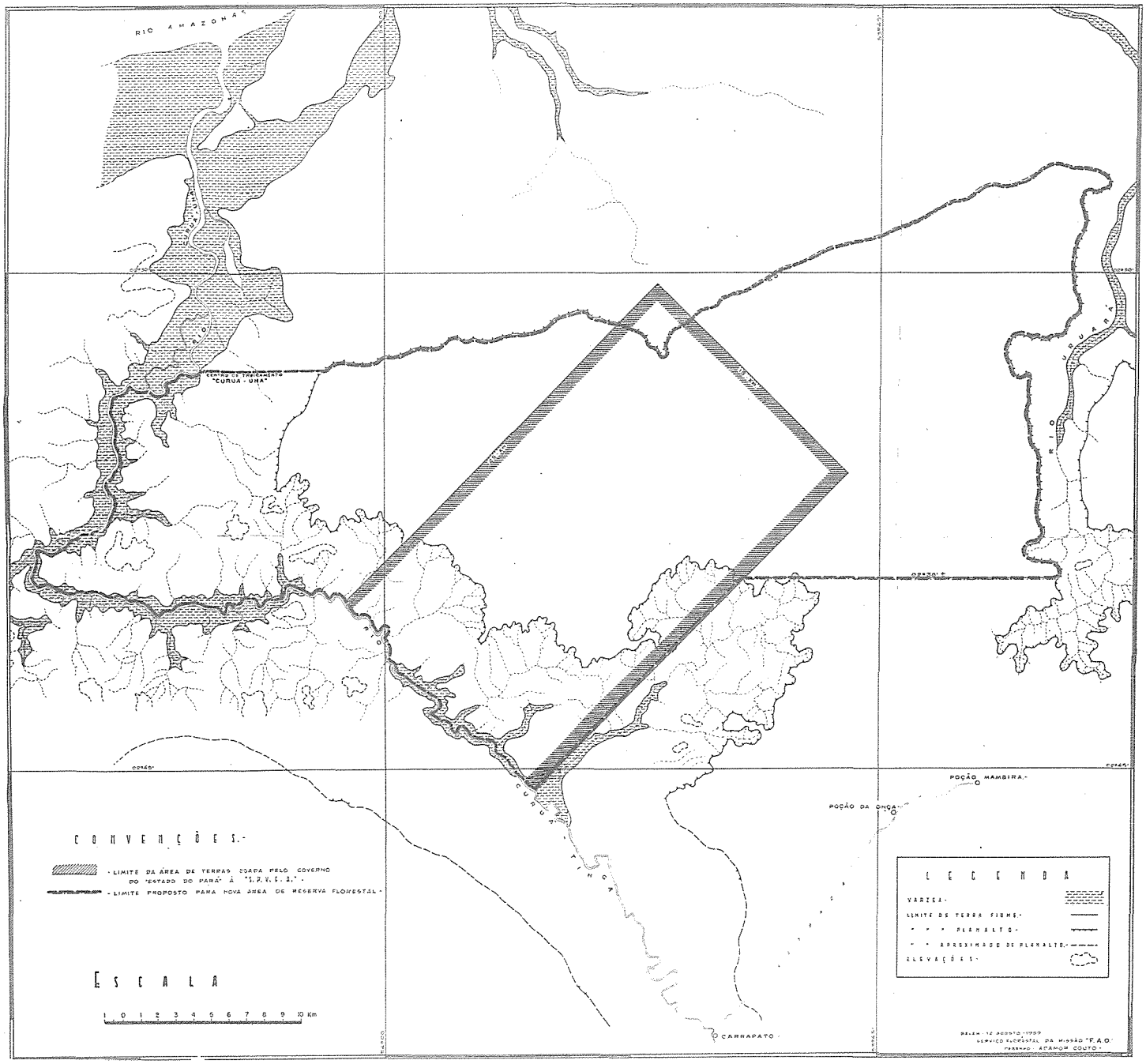
Quick economic returns must not be expected from silvicultural work. God, through the forces of nature, grows the trees. All that silviculture can do is to speed up the time by reducing competition to the minimum, to improve the quality of the individual trees and to improve the composition of the forest.

Professor Aubreville the well-known French colonial forester, who visited Brazil in 1957, made the following statement at the Fourth World Forestry Congress in India in 1954:

> "In a general way one can state that these tropical countries which spend a part of their present financial resources on the improvement of their forests will create for themselves in the future considerable riches which will contribute to the improved standard of living of the population."

With the technical assistance of FAO and funds provided by SPVEA, Brazil has made a small start in improving some of the Amazon forests. Now is the time to go ahead on a somewhat larger scale.

Map 5 - Proposed area of new forestry reserve



VI. RECOMMENDATIONS FOR FUTHER ACTION TO BE TAKEN BY THE GOVERNMENT

1. Curuá Una Centre

In view of the valuable results already being obtained, of the long-term research projects already in hand, the good riverside camp, the excellent road system and the comparative accessibility (2 ½ hours by air from Belém to Santarém, and then 6 hours by launch) this center should be maintained indefinitely.

SPVEA, through the Brazilian Government has asked for FAO to continue in this area anyway to the end of 1962. It would be premature to make specific recommendations now about 1963 onwards; much will depend on what the Serviço Florestal does during 1961 and 1962.

What is clear, however, is that the area of planalto and flanco east of the Curuá camp and north of the Rio Curuatinga to the eastern edge of the area originally put at the disposal of SPVEA for work by FAO should be made into a government Forest Reserve. A proposal to this effect has already been submitted by SPVEA. Explotation in this area should be encouraged and controlled so that silvicultural methods can continue to be applied for improving the forests for the future. A map showing the area proposed is attached - Map 5.

Utilization research, including studies of which species are suitable for railway sleepers, should also be carried out. This could lead to a more intensive exploitation of the forests, as several of the more common undesirables, e.g. Mirauba, may prove suitable. A yield of sleepers, as well as of timber, besides reducing the overhead costs per ton of forest produce obtained, or per hectare of forest exploited, would also result in a greater opening of the canopy, which, as has already been shown is more favourable to the natural regeneration of the exploited area.

2. CBA - Santarém

As a complement to the Curuá, the research plots here should also be maintained. They contain several species which are not found at the Curuá, in particular Jarana.

3. Amapá

Provided the government of this Federal Territory can provide transport when required to visit and work at Pôrto Platon - a few days once or twice a year - the forest plots at Campo Verde should be maintained. The campos and nursery plots at Fazendinha on the equator should be maintained - this means mainly protection from fire. They can always be visited by taxis if government transport is not available.

4. Instituto Nacional de Pesquizas na Amazônia - (INPA) - Manáus

Adequate funds should be provided for the gradual development of the Silvicultural section here. The question of botanical work being done in Belém has been mentioned on page 75; it would be better, and less expensive, to have two field assistants at Manáus working to Belém than one botanist in Manáus.

Dr. Rubens Valle should be sent to Puerto Rico for one of the three-month forestry courses there, so as to give him a better idea of what tropical forestry really is.

An experienced tropical forester should be made available to visit Manáus periodically over, say, at least the next five years to advise on the development of the work in the Ducke forest in the light of results being obtained. After such a period the Silvicultural section of the Institute could probably take over the Curuá and CBA plots, if the Serviço Florestal has still done nothing about them.

5. The Serviço Florestal

(i) Staff

(a) Some engenheiro-agronomists should be recruited immediately who are willing to work in the Amazon forests. They may have to be paid more. Geologists for Petrobrás get well paid; cannot similar inducements be offered to agronomists?

(b) Advantage should be taken now of the SPVEA/FAO work on the Curuá for these men to receive some training in forestry. It is likely to be at least four years before any Brazilian-trained forester from the new National Forest School will be available; even these men will not be adequately qualified for work in the Amazon unless they have done some of their field training at the Curuá.

(ii) Caxuana Forest Reserve

A large forest reserve has recently been created in this area, east the Rio Xingú. See page 80 of FAO Report No. 949, Ref. 5. According to the Decreto No. 3,076 some silvicultural work is to be carried out here. The foreman, or assistant, referred to on page 89 who has had a little field training at the Curuá centre, has not the basic education, still less the scientific, to initiate work here. Before any work is initiated in this area the Chief of the 1st. Regional Inspectorate, which has its headquarters in Belém, should visit the Curuá to see for himself the lines on which work in the Caxuana area should be done.

(iii) Brasilia-Belém Road

The Serviço Florestal are acquiring a few square kilometres along this orad in the vicinity of km 70 south of the Rio Guamá, for experimental work. Here too, before any silvicultural work is initiated, the Chief of the Inspectorate should visit the Curuá Centre. Additional plots should be laid out in each of the other forest types which the FAO Inventory section are finding along this road; there may be four or five.

6. Exploitation for Pulpwood

The silvicultural implications of such large-scale exploitation have been referred to on pages 84 to 88. They are still on general lines. Little is known about the suitability of many of the Amazon timbers as a furnish for wood pulp. Technically, it is said that a mixed furnish from all species will provide suitable pulp, but it has yet to be proved economic. Amongst other things which do not appear to be known is the cost of producing the raw material. How much will it cost to fell so many hectares of forest how many m^3 of pulpwood will be produced (inventory figures show only the stem volumes; no date are available for branch wood and for top pieces too small for timber) and, how much will it cost to carry the pulpwood billets so many kilometres to the factory?

This is basic information which the Government should be able to supply if it wished a commercial concern to set up a large wood pulp factory in the Amazon region. It is information which could be obtained at little reasonable cost, and in an area where the silvicultural implications could be studied.

7. Minor Recommendations

1. Resurvey of Linear Regeneration Survey 10 m and 5 m strips, Curuá, CBA and Pôrto Platon (pages 22,56 and 67) at 5 year intervals.

2. Heavier opening of the canopy about 5 years (?) before exploitation to induce or increase the natural regeneration of desirables; reduce basal area to below 15 m^2/ha (or 10 m^2 if only trees in class 3 and up, i.e. over 25 cm diameter, are measured) - (page 27).

3. Give plenty of light to any seedling regeneration of Cedro (pages 28-29).

4. Assist gregarious patches of natural regeneration of Guariuba (page 30) and Angelim da mata (page 31).

5. Pre-exploitation operations - refining and liberation (page 41).

6. Post-exploitation operations to favour development of regeneration-cleanings, periodic poisoning of remaining trees as regeneration develops (page 34).

7. Maintainance of and need for more diameter increment plots (pages 43 and 44).

8. Direct-sowing trials (page 49).

9. Measurements of establishment index, height and diameter growth in trial plots (page 52).

10. Spacing trials for plantations (page 53).

11. Shade or Nurse trees to assist species which appear not to like full light (page 53).

12. At CBA continue observations and diameter measurements (pages 55-61).

13. Clean plot B in 1961 or 1962 (page 58), and open understorey further in plots D and E (page 59).

14. Try bulldozing traces for planting in poor young capoeira on sandy soils (page 63).

15. Protection and observation of "campos" trial plots, Fazendinha near Macapá (page 69).

16. Pau rosa work by INPA (page 79).

A P P E N D I C E S

to the

REPORT

on

APPLICATION OF SILVICULTURAL METHODS TO SOME

OF THE FORESTS OF THE AMAZON

A P P E N D I C E S

APPENDIX I

D E F I N I T I O N S

It is advisable to explain briefly a number of terms and expressions which appear in this report. The Portuguese equivalent, as used in the Amazon, is given in brackets.

Basal area (Área basal) - The area of the cross section of the stems of the trees at breast height.

Cleaning (Limpeza) - Cutting back, normally, to near ground level of all undesirable plants including creepers, which can be cut with a few strokes of a machette.

Compartment (Talhão) - A block or unit of forest demarcated for purposes of control.

Defective (Defectivo) - An unsound stem of a desirable species but which is of little or no use because of some defect such as a bad twist or a hollow.

Desirable (Desejável) - A species which is required for carrying out the objects of management; normally it is a species of timber value (economic - madeira de lei) but it may be a weed species retained temporarily to help close the canopy to suppress creepers and other weeds.

Diameter class (Classe do diâmetro) - The number for each class represents the mean diameter in decimeters at breast height, e.g. Class 4 includes all trees with diameters greater than 35 cm and less than 45 cm. Class 1 is sometimes sub-divided in 1A (5-10 cm) and 1B (10-15 cm). Normally, the girth is measured in the field and converted to diameter by using a table.

Economic (Madeira de lei) - A species of known commercial value. An economic species is desirable, but a desirable may not always be an economic.

Emergent (Emergente) - A tree whose crown is completely exposed, free from competition for light.

Enrichment planting (Enriquecimento) - Putting out in lines, or occasionally in groups, plants of species which are of greater value than of the surrounding forest.

Establishment Index (Índice de sobreviventes) - The percentage of the total number of plants used (original planting plus replanting of failure) still alive. This give a better idea than the percentage stocking or the success, or otherwise, of the species.

Form factor — (Fator forma) - The factor used to allow for the taper of the trunk, when calculating the volume from the basal area and height of trunk. Normally 0.7 is used.

Hardening off — (Aclimatação) - The process of reducing shade, and water, so that the plants in the nursery may become accustomed to the conditions they will have when planted out.

Impeder — (Impedidora) - A tree which is hindering the development of a better tree.

Índice de sobreviventes - See "Establishment Index".

Liberation — (Remoção da concorrência) - The freeing of desirables from inferior competitors by the removal of impeders.

Madeira de Lei - See "Economic".

Mature — (Adults) - A tree of exploitable size and age, which will not increase in value but has not yet started to decrease (die back or become rotten). Normally, trees between classes 5 and 10 or 11.

Nurse trees — (Árvores coadjuvantes) - Trees which are put in at a wide spacing with the primary object of providing some shade to trees of another mor useful species which will be planted between the original rows and which will eventually form the final crop. The nurse trees may, or may not, give an intermediate yield.

Overmature — (Caduca) - A tree which is deteriorating in value or is too large to exploit, normally over class 11.

P.A.I. — (Rendimento periódico anual - R.P.A.) - The periodic annual increment. In the case of height measurements it is calculated normally by deducting the original height of the plants from the mean height of the tallest 20% of the trees in the plot, or sampling sub-plot, and then dividing by the age.

Pole — (Árvore pequena) - A small tree normally in diameter class 1A, 1B, or 2 (i.e. 5-25 cm diameter).

Proscript — (Proscrita) - A species of possible value, but not required locally; elsewhere, it may be a desirable.

Refine — (Refinamento) - The removal of weeds, defectives and proscripts, whether they are interfering with desirables or not, in the interests of complete utilization by the desired crop.

Ride — (Estrada de acesso) - A small road (jeepable) usually along the boundary of a compartment.

R.P.M. - See "P.A.I."

Sapling (Vara e' Varinha) - A young tree larger than a seedling (over 1.5 m) and less than 5 cm in diameter. A 'varinha' is between 1.5 and 3 m high.

Seedling - natural (Muda nativa) - A plant up to 1.5 m high developed from seed in the forest; plants under 5 or 10 cms are usually not counted as so many of them soon die off.

Seedling - nursery (Mudinha) - A plant, usually up to 15 cm, developed from seed sown in the nursery and before it is transplanted.

Stripling (Muda sem fôlhas) - A nursery transplant from which all the leaves, except the youngest, have been removed; usually between 30 and 150 cm high.

Stump (Tôco) - A nursery transplant from which the shoot has been cut off leaving about only 5 - 10 cm of stem. Plants should be at least 1 cm thick before stumping.

Sustained Yield (Rendimento regular) - A reasonably constant yield which can be expected year after year or period after period for an indefinite number of years.

Transplant (Muda) - A nursery seedling after removal from the seed bed and planting in another bed or some container.

Undesirable (Indesejável) - A species which does not promote the objects of management; the term includes Defectives, Impeders and Proscripts.

Weed (Planta inútil) - A species of no known value, which can be a potential source of hinderance to desirables; it may be a creeper, climber or tree as well as herbe or grass.

Weeding - See "Cleaning".

APPENDIX II

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APPENDIX III

SOIL ANALYSIS SUPPLEMENT TO 1957 SOIL REPORTS FOR SILVICULTURE PLOTS

Amapá, Santarém, Rio Curuá Una - October, 1958

by Thomas H. Day, Soil Specialist

General comments on the practical meaning of some analyses

1. Carbon/Nitrogen Ratio (C/N)

This is the relative proportion by weight of organic carbon to nitrogen in the soil. It is a measure of the nitrogen potential of the soil organic matter, a low C/N indicating organic matter rich in nitrogen.

The ratio is of practical importance especially in two ways:

(1) A given soil under a given set of conditions has a more or less constant C/N. If organic matter is added with a higher than normal C/N there will be competition for the available N until the balance is reestablished. As growing plants do not have the competitive strength of the soil MICRO-ORGANISMS this means a temporary shortage of N available for plant growth.

(2) In attempting to build up the organic matter content of a soil the nitrogen content must be considered because a stable increase in organic matter content cannot be accomplished without a proportional increase in N content.

It might also be added, parenthetically, that to attempt to lift the quantity of soil organic matter much above the natural level is generally a difficult and costly business.

1. Soil pH

The soil pH is, of course, a measure of its acidity. The pH determined using KCL is usually lower than that determined with water because of a reaction between the salt and the soil colloid.

3. SiO_2, Al_2O_3, Fe_2O_3 and their ratios

These figures offer a good clue to the type of clay found in the soil. Where the SiO_2/Al_2O_3 is about 2 there is a good possibility of Kaolinite or one of its close relatives being the dominant clay mineral. A number much below that indicates an increasing proportion of aluminium oxide. A number much above 2 probably indicates the presents of montmorillonite, illite or their relatives.

The practical significance of the presence of these clays is shown in the Exchange Complex, the Index of Structure, the Moisture Equivalent, and the "available P_2O_5 (Truog)

The ratio SiO_2/Al_2O_3 as well as $SiO_2/Al_2O_3 + Fe_2O_3$ are somewhat useful in soil classification and nomenclature.

4. P_2O_5 (Attacked by H_2SO_4)

This is an attempt to measure the total phosphate in the soil. The units are in percent in contrast to the "available" phosphate (Truog) which is parts per hundred thousand.

An approximate but useful factor is 4 x P_2O_5 in p.p.h.t. = P in p.p.m.

In general it can be said that the value of total phosphate is least in acid soils that are high in iron and aluminum oxides, and Kaolinite clay - which closely describes most Amazonian soils.

The limited analyses so far made on Amazonian soils indicates a general variation in "total" phosphate between 0.01 and 0.05%. For some of the more fertile soils in temperate zones the variation would be between 0.05 and 0.1%

Although the differences here between tropical and temperate soils is rather substantial it is even further increased by a greatly reduced availability often found in tropical soils.

5. "Available" P_2O_5(Truog)

This is an attempt to measure by laboratory analysis the amount of phosphate available to plants. The method used has given reasonable correlation in field checks with soils of the Temperate Regions but the accuracy with Amazonian soils has yet to be proved. It must be said, however, that the very low levels of "available" phosphorus found thus far do not conflict with what might logically be assumed to be true.

6. Exchangeable Cations.

These are the cations absorbed on the clay particals, the dominant ones being generally Ca, Mg, K, Na, and H. The symbol "S" is the milli-equivalent sum of all the cations except hydrogen. "T" is an approximation of the total absorption capacity of the soil. "S" plus hydrogen equals "T". And "V" is the percent of the exchange capacity occupied by the metallic ions.

The exchangeable cations and the exchange capacity of the soil are an important part of the fertility of the soil. A high "V" indicates a good availability of the plant food elements held in the exchange complex. "S" indicates the amount of these elements held and, as a generalization, can be said to approximate the amount available for plant use. "T" is a rough measure of the fertility capacity of a soil with the better temperate zone soils having a capacity of perhaps 20 or more milliequivalents per 100 gr of soil.

7. Mechanical analyses

This is the separation of the soil into the various sized units to determine its texture.

8. Index of structure

This is a measure of the stability of the strctural units of the soil. A high index indicates a more stable soil, i.e. a soil more resistant to erosion and one more resistant to structural breakdown from cultivation.

9. Moisture equivalent

The moisture equivalent is a laboratory estimation of the moisture holding capacity of the soil.

Comments on the soil analyses made for silviculture plots

1. Amapá

The soil analyses received do not give any basis for changing or adding to the original reports. (see pages 14 - 16 Report).

2. Santarém, Saw Mill Training Center

a) Terra Preta soil (TPB on map) - Generally the phosphate content of the Terra Preta soils is higher than for the normal soils of the region but the extremely high phosphate level in the sample analysed is probably quite exceptional. It would be very surprising if the same level was maintained over the whole area mapped as Terra Preta. There should be no immediate problem of phosphate shortage, however.

The organic matter content is much lower than anticipated. The cause of the black soil color is not known.

The level of plant food available in the exchange complex is low similar to other soils in the region. However, the percent saturation ("V") of the exchange complex is many times what it generally is with normal regional soils. This results in a higher pH and greater availability of the plant food elements held in the complex. The higher pH, the greater availability of the metallic ions, and the large amount of phosphorus present should make for much more favorable growing conditions than generally found in the region.

The water holding capacity of the soils is quite low and droughtiness will probably be a problem during the dry season.

b) HL on map - No analyses made on this soil. Analyses made on other related soils show little need to change or add to the discussion already submitted. (see pages 13 - 14 Report).

3. Silviculture plots on Curuá Una river and those on planalto near CBA.

Soil analyses revealed little beyond that already suggested in the original reports. The Flanco Baixo soils - pp. 11 - 13 -Report- are somewhat more sandy than originally thought, which would make them quite droughty and very low in natural fertility. But beyond that little of practical interpretation can be added.

4. Terra Preta at Curuá Una campsite

Similar to the Terra Preta at the Santarém Sawmill Training Center this soil has a much higher level of phosphate than would normally be expected in soils of the region - although much lower than the Santarém Terra Preta. Organic matter, nitrogen, exchangeable bases (metallic ions in the exchange complex) are at the normal regional low level. However, the percent of base saturation ("V") is many times greater than normal making for a higher pH and a much greater availability of the plant food ions held in the exchange complex. All these together give a much more favorable condition for plant growth, although fertilizers will probably be necessary to maintain good production with any program of long-term cropping.

Fertilizer recommendations

The making of specific fertilizer recommendations solely on the basis of laboratory analyses of the soil ranks with crystal gazing and astrology as a science. Where creditable recommendations are made from laboratory tests there is a mass of field data correlated with previous analyses which allows a skilled man to interpret the numbers obtained from the laboratory into reasonable estimations of desirable fertilizer applications.

However, although laboratory analyses have many limitations they do give a "first approximation" of the needs of the soil as well as many of its characteristics.

Regarding the soils analysed for the silviculture plots some generalizations can be made from the tests conducted:

Excepting the Terra Preta all the soils are very low in natural fertility, very strongly acid, and probably have ability to tie-up large amounts of phosphate in a form difficult for plants to use. This latter factor will vary directly with the clay content of the soil. Also, in any intensive cropping program minor element deficiencies are likely to occur. And, short-lived crops such as vegetables are more apt to show deficiencies than long-lived perennials like trees. In addition, it should be noted that beyond the actual mineral fertility of the soil other factors such as soil temperatures and moisture relations are perhaps of equal importance and may actually be of critical importance in any attempts to establish trees on open, savannah areas.

In answer to the request for fertilizer recommendations for ICOMI the following is added:

It must be clearly understood that any fertilizer recommendation made under the present conditions is at best a rough estimate. Types of crops, different methods of soil management, and systems of fertilizer application can have a tremendous influence on the effectiveness of fertilizers added. Also, a shortage of some element (including the microelements) can cause an apparent lack of response to a fertilizer application that can be completely misleading.

Another point is that these soils are weakly buffered, i.e. applications of fertilizers and soil amendments can have a relatively great effect. As a result of this the nutritional balance can be easily upset and misinterpretations made from fertilizer trials. For example, some calcium is no doubt desirable on these soils, but if it is applied in excess a nutritional imbalance may result which can cause an apparent potassium shortage. This can be complicated by the fact that Superphosphate (16% calcium) may, when added under some conditions, give a depressing effect on production. Such results can easily lead to the misimterpretation that excess phosphorus is causing a drop in production whereas it is, in reality, in very short supply and too much calcium is what is causing the difficulty.

With this background of points of caution and it being understood that many other complications may also be involved I make the following recommendation:

In general about 50 kg N, 200 kg P_2O_5, and 100 kg of K_2O per hectare would be a good starting point.

If legumes are grown in a rotation or in a pasture the amount of N can be reduced.

The rather heavy application of P_2O_5 is recommended because of the probably severe shortage of P as well as the strong phosphate fixing power of the soil. Localized application will greatly increase the effectiveness of phosphate applications.

Later if deficiencies are still noted, some micronutrient applications might be tried like Zn, Cu, B, and Mo. Sulfur might also be in short supply, but if Superphosphate is used as the phosphorus carrier it should supply the necessary S.

The high acidity of the soils suggests the use of lime. If pastures or green manure crops are grown which contain legumes, about two tons per hectere of lime would be a good estimate of need. For vegetables and other field crops perhaps only one ton per hectare. In the latter case I would leave part of the field without lime application to see what effect, if any, is taking place.

Whereas the presence in the soil of sufficient mineral nutrients is necessary, the maintenance of a good physical condition of the soil is also a requirement. I, therefore, suggest some method be used to maintain the organic matter level in the soil through the addition of animal manures, good crops rotations, or the turning under of green cover (green manure). This will help with both the availability of minerals present and the maintenance of good physical conditions for plant growth.

Again I caution against the acceptance of these recommendations as being optimum. They are, I believe, as good as can be made considering the present dearth of information. But as experience is gained there will, no doubt, be changes.

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 31 — Sample Nos: 17,18,19
Municipality: — State: Ter. of Amapá
Location: Pôrto Platon - M.B. Line M.M. 500 m — S. of the Matapí
Classification: Red Yellow Latosol — Igarapé
Analyses by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20-2mm	Fine Earth <2mm	BULK DENSITY Apparent	Real
29,892	A1	0-10					
29,893	A_2	10-30					
29,894	B_2	80-100					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P O Truog (mg/100g)
29,892	1.34	0.12	11.2	4.0	3.2	1.3
29,893	0.82	0.08	10.3	4.6	3.7	1.0
29,894	0.23	0.03	7.7	4.7	3.8	1.0

Lab. No.	ATTACKED BY H_2SO_4 d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	SiO_2 / Al_2O_3 Ki	SiO_2 / $Al_2O_3+Fe_2O_3$ Kr
29,892	Nd	Nd	Nd	Nd	0.02	-	-
29,893	9.93	9.19	2.33	Nd	0.03	1.84	1.58
29,894	11.47	10.79	2.53	Nd	0.03	1.81	1.57

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	100S/T (V)
29,892					0.5	7.1	7.3	
29,893					0.5	5.0	5.1	
29,894					0.5	2.1	2.2	

Lab. No.	MECHANICAL ANALYSIS (Int.Sys) NaOH dispersion - Size in mm Coarse sand 2.0-0.20	Fine sand 0.20-0.02	Silt 0.02-0.002	Clay below 0.002	Silt-U.S. 0.05-0.002 mm	Index of Structure	Moisture equivalent
29,892	62.2	19.7	3.5	14.6		77	8.8
29,893	52.3	25.4	3.6	18.7		52	11.8
29,894	51.2	18.8	1.3	28.7		99	14.2

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No: 32 — Sample Nos.: 20,21,22
Location: Pôrto Platon - km S of Igarapé Matapi on line MC — Terr. of Amapá
Classification: Regosol (white sand)
Analises by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20-2mm	Fine Earth <2mm	BULK DENSITY Apparent	BULK DENSITY Real
29,895		0-5					
29,896		5-25					
29,897		70-100					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P2O5 Truog (mg/100g)
29,895	7.42	0.42	17.7	3.1	2.0	5.0
29,896	1.17	0.07	16.7	3.7	2.2	1.1
29,897	0.04	0.01	4.0	5.5	3.9	1.2

Lab. No.	ATTACKED BY H_2SO_4 d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	SiO_2 / Al_2O_3 Ki	SiO_2 / $Al_2O_3+Fe_2O_3$ Kr
29,895					0.02		
29,896					0.01		
29,897					0.01		

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^{+}	Na^{++}	S	H^{+}	T	100S/T (V)
29,895					3.3	38.1	41.4	
29,896					0.5	5.0	5.3	
29,897					0.5	0.4	0.5	

Lab. No.	MECHANICAL ANALYSES (Int.Sys). NaOH dispersion - Size in mm Coarse sand 2.0-0.20	Fine sand 0.20-0.02	Silt 0.02-0.002	Clay below 0.002	Silt-U.S. 0.05-0.002 mm	Index of Structure	Moisture equivalent
29,895	64.6	26.1	7.8	1.5		67	22.9
29,896	79.9	16.5	1.3	2.3		91	4.3
29,897	83.1	15.4	0.4	1.1		82	1.4

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 33 — Sample Nos: 23,24,25,26,27
Location: Pôrto Platon - 100 m west M. Bastos' lines — Terr. of Amapá
Classification: Red Yellow Latosol — MC-PB
Analyses by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20-2mm	Fine Earth <2mm	BULK DENSITY Apparent	BULK DENSITY Real
29,898	A_1	0-10					
29,899	A_3	10-25					
29,900	B_1	25-40					
29,901	B_{21}	40-70					
29,902	B_{22}	70-120					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P O Truog (mg/100g)
29,898	2.63	0.24	11.0	4.1	3.4	1.1
29,899	1.53	0.14	10.9	4.4	3.7	1.1
29,900	1.00	0.12	8.3	4.6	3.9	1.0
29,901	0.57	0.07	8.1	5.0	4.1	1.0
29,902	0.47	0.06	7.8	5.1	4.8	1.0

Lab. No.	ATTACKED BY H_2SO_4 d= 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	SiO_2 Al_2O_3 Ki	SiO_2 $Al_2O_3+Fe_2O_3$ Kr
29,898	24.34	22.10	9.36	-	0.05	1.87	1.47
29,899	26.46	24.69	10.46	-	0.03	1.82	1.43
29,900	-	-	-	-	0.03	-	-
29,901	28.65	26.84	10.82	-	0.03	1.81	1.44
29,902	-	-	-	-	0.04	-	-

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	100S T (V)
29,898					0.5	12.1	12.3	
29,899					0.5	8.1	8.3	
29,900					0.5	5.6	5.7	
29,901					0.5	3.3	3.5	
29,902					0.5	2.2	2.3	

Lab. No.	MECHANICAL ANALYSES (Int.Sys). NaOH dispersion - Size in mm Coarse sand 2.0-0.20	Fine sand 0.20-0.02	Silt 0.02-0.002	Clay below 0.002	Silt-U.S. 0.05-0.002 mm	Index of Structure	Moisture Equivalent
29,898	15.5	8.3	12.0	64.2		67	30.4
29,899	16.9	0.4	10.5	72.2		65	30.9
29,900	8.5	4.6	7.3	79.6		99	31.4
29,901	9.4	4.0	5.8	80.8		100	31.9
29,902	8.9	4.1	5.3	81.7		100	33.1

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 34
Location: Pôrto Platon - 20 m west of line M.D.
Classification: Yellow Latosol
Analyses by: Inst. de Química Agrícola

Sample Nos: 28, 29
Terr. of Amapá 1,750 m south of Road in Pitt's plot E.
Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20–2mm	Fine Earth <2mm	BULK DENSITY Apparent	BULK DENSITY Real
29,903		2–25					
29,904		75–95					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) EC1 n.	P P2O5 Truog (mg/100g)
29,903	0.76	0.07	10.9	4.5	4.1	1.0
29,904	0.21	0.03	7.0	5.3	4.4	1.0

Lab. No.	ATTACKED BY H_2SO_4 d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	$\frac{SiO_2}{Al_2O_3}$ Ki	$\frac{SiO_2}{Al_2O_3+Fe_2O_3}$ Kr
29,903	11.22	10.47	2.33		0.02	1.82	1.60
29,904	17.86	16.19	3.25		0.02	1.88	1.66

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	100S/T (V)
29,903					0.5	4.3	4.5	
29,904					0.5	2.4	2.6	

Lab. No.	MECHANICAL ANALYSES (Int.Sys). NaOH dispersion – Size in mm Coarse sand 2.0–0.20	Fine sand 0.20–0.02	Silt 0.02–0.002	Clay below 0.002	Silt-U.S. 0.05–0.002 mm	Index of Structure	Moisture Equivalent
29,903	49.5	20.5	4.5	22.5		55	13.4
29.904	29.0	16.2	3.2	41.6		100	19.0

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 36 — Sample Nos: 30,31,32,33
Location: Pôrto Platon - km 87 - Macapá Road — Terr. of Amapá
Classification: Red Yellow Latosol
Analyses by: Inst. de Química Agrícola — Data of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20-2mm	Fine Earth <2mm	BULK DENSITY Apparent	BULK DENSITY Real
29,905	A_1	0-10					
29,906	AB	10-30					
29,907	B_{21}	30-90					
29,908	B_{22}	90-140					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P_2O_5 Truog (mg/100g)
29,905	1.64	0.12	13.7	4.7	4.0	1.0
29,906	0.83	0.07	11.9	5.1	4.2	1.0
29,907	0.30	0.04	7.5	5.7	4.8	1.0
29,908	0.26	0.04	6.5	5.6	4.9	1.0

Lab. No.	ATTACKED BY H_2SO_4 d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	SiO_2 / Al_2O_3 Ki	SiO_2 / $Al_2O_3+Fe_2O_3$ Kr
29,905	-	-	-		0.02	-	
29,906	-	-	-		0.03		
29,907	-	-	-		0.03		
29,908	26.79	24.55	3.83		0.03	1.86	1.69

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	100S/T (V)
29,905					0.5	6.2	6.5	
29,906					0.5	3.4	3.6	
29,907					0.5	1.2	1.4	
29,908					0.5	1.2	1.3	

Lab. No.	MECHANICAL ANALYSES (Int. Sys). NaOH dispersion - Size in mm Coarse sand 2.0-0.20	Fine sand 0.20-0.02	Silt 0.02-0.002	Clay below 0.002	Silt-U.S. 0.05-0.002	Index of Structure	Moisture equivalent
29,905	24.0	22.9	12.1	41.0		100	22.9
29,906	25.5	19.0	9.3	46.2		69	23.0
29,907	21.5	14.3	10.3	53.9		100	25.6
29,908	18.9	13.3	9.9	57.9		100	28.1

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 37 — Sample Nos: 34, 35, 36
Location: Pôrto Platon - Rd - Km 55 -7, Macapá — Terr. of Amapá
Classification: Red Yellow Latosol
Analyses by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20-2mm	Fine Earth <2mm	BULK DENSITY Apparent	BULK DENSITY Real
29,909	A1	0-15					
29,910	B_{21}	25-60					
29,911	B_{22}	60-120					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KO1 n.	P O Truog (mg/100g)
29,909	1.14	0.09	12.7	4.9	4.1	1.0
29,910	0.42	0.04	10.5	5.2	4.4	1.0
29,911	0.34	0.03	11.3	5.4	4.7	1.0

Lab. No.	ATTACKED BY H_2SO_4 d - 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	SiO_2 / Al_2O_3 Ki	SiO_2 / $Al_2O_3+Fe_2O_3$ Kr
29,909	-	-	-		0.03	-	-
29,910	21.09	19.44	6.02		0.03	1.84	1.54
29,911	-	-	-		0.03	-	-

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	100S/T (V)
29,909					0.5	4.4	4.5	
29,910					0.5	1.8	1.9	
29,911					0.5	1.7	1.9	

Lab. No.	MECHANICAL ANALYSES (Int.Sys) NaOH dispersion - Size in mm Coarse sand 2.0-0.20	Fine sand 0.20-0.02	Silt 0.02-0.002	Clay below 0.002	Silt-U.S. 0.05-0.002 mm	Index of structure	Moisture equivalent
29,909	22.6	26.1	9.3	42.0		62	21.0
29,910	18.2	22.5	8.1	51.2		99	23.1
29,911	14.7	16.4	5.8	63.1		100	27.2

SOIL ANALYSES

Soil Section of FAO Missiom to the Amazon

Field Profile No. 39 — Sample Nos.: 1, 2, 3, 4
Municipality: Santarém — State: Pará
Location: Sawmilling Training Centre. Silviculture Plots.
Classification: Terra Preta sôbre brown Latosol
Analyses by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20-2mm	Fine Earth <2mm	BULK DENSITY Apparent	Real
30,061	A_1	0-35					
30,062	AB	35-70					
30,063	B_{21}	70-100					
30,064	B_{22}	100-160					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P O Truog (mg/100g)
30,061	1.66	0.13	12.8	5.6	4.7	98.8
30,062	0.66	0.04	16.5	5.6	4.6	43.1
30,063	0.41	0.03	13.7	5.7	4.6	31.2
30,064	0.38	0.03	12.7	5.5	4.3	18.0

Lab. No.	ATTACKED BY H_2SO_4 d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	$\frac{SiO_2}{Al_2O_3}$ Ki	$\frac{SiO_2}{Al_2O_3+Fe_2O_3}$ Kr
30,061	4.28	3.94	1.33		0.37	1.85	1.52
30,062	4.67	4.29	1.32		0.18	1.85	1.54
30,063	5.24	3.97	1.31		0.14	2.24	1.85
30,064	5.68	5.29	1.51		0.14	1.82	1.54

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	$\frac{100S}{T}$ (V)
30,061	3.97	0.43	0.08	0.04	4.52	5.14	9.66	47
30,062	2.32	0.30	0.10	0.03	2.75	3.60	6.35	44
30,063	1.71	0.48	0.05	0.01	2.25	1.96	4.21	55
30,064	1.13	0.42	0.05	0.01	1.61	2.25	3.86	41

Lab. No.	MECHANICAL ANALYSES (Int. Sys). NaOH dispersion - Size in mm Coarse sand 2.0-0.20	Fine sand 0.20-0.02	Silt 0.02-0002	Clay below 0.002	Silt-U.S. 0.05-0.002 mm	Index of structure	Moisture equivalent
30,061	63.9	21.2	5.8	9.1		55	11.5
30,062	65.7	21.9	1.8	10.6		41	7.9
30,063	65.7	21.1	1.6	11.6		38	7.6
30,064	66.1	20.0	1.2	12.7		39	7.7

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 40 — Sample Nos: 1, 2, 3, 4, 5
Municipality: Santarém — State: Pará
Location: Pitt's Planalto Plots, near CBA, SE side of Plot E4
Classification: Yellow Latosol
Analyses by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20-2mm	Fine Earth <2mm	BULK DENSITY Apparent	BULK DENSITY Real
30,065	A_{11}	0-20					
30,066	A_{12}	20-40					
30,067	AB	40-60					
30,068	B_{21}	60-90					
30,069	B_{22}	90-120					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P O Truog (mg/100g)
30,065	3.48	0.32	10.9	3.9	3.6	2.1
30,066	1.98	0.17	11.6	4.1	3.7	1.1
30,067	1.11	0.10	11.1	4.2	3.8	1.0
30,068	0.76	0.07	10.9	4.2	3.6	1.0
30,069	0.51	0.66	8.5	4.1	3.7	1.0

Lab. No.	ATTACKED BY H_2SO_4 d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	$\frac{SiO_2}{Al_2O_3}$ Ki	$\frac{SiO_2}{Al_2O_3+Fe_2O_3}$ Kr
30,065	34.25	28.55	5.00		0.05	2.04	1.83
30,066	35.10	29.36	5.40		0.04	0.03	1.82
30,067	36.60	31.05	5.35		0.04	2.00	1.81
30,068	37.05	32.22	5.54		0.04	1.95	1.76
30,069	37.22	33.51	5.34		0.04	1.89	1.71

Lab. No.	EXCHANGEABLE (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	$\frac{100S}{T}$ (V)
30,065					0.83	17.13	17.96	4.6
30,066					0.62	10.66	11.28	5.6
30,067					0.52	6.79	7.31	7.1
30,068					0.45	4.71	5.16	8.7
30,069					0.31	3.52	3.83	8.2

Lab. No.	MECHANICAL ANALYSES (Int. Sys.) NaOH dispersion - Size in mm Coarse sand 2.0-0.20	Fine sand 0.20-0.02	Silt 0.02-0.002	Clay below 0.002	Silt-U.S. 0.05-0.002 mm	Index of Structure	Moisture equivalent
30,065	4.4	4.9	8.3	82.4		71	38.8
30,066	3.9	2.6	8.4	85.1		70	37.1
30,067	2.5	2.3	7.3	87.9		100	35.6
30,068	1.7	5.3	5.2	87.8		100	34.5
30,069	2.6	8.8	6.9	81.7		100	34.2

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 41 — Sample Nos: 1, 2, 3, 4
Municipality: Santarém — State: Pará
Location: Curuá Una Logging Training Center River Camp
Classification: Terra Preta sôbre Yellow Latosol
Analyses by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20–2mm	Fine Earth <2mm	BULK DENSITY Apparent	BULK DENSITY Real
30,070	$A_{12}A_{13}$	2–30					
30,071	AB	30–60					
30,072	B_{21}	60–150					
30,073	B_{22}	150–170					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P O Truog (mg/100g)
30,070	0.97	0.08	12.1	5.6	4.5	3.2
30,071	0.44	0.03	14.6	5.1	4.0	7.0
30,072	0.28	0.02	14.0	4.9	3.7	6.7
30,073	0.15	0.01	15.0	4.7	3.6	7.4

Lab. No.	ATTACKED BY H_2SO_4 d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	SiO_2 / Al_2O_3 Ki	SiO_2 / $Al_2O_3+Fe_2O_3$ Kr
30,070	5.50	5.19	1.42	–	0.06	1.80	1.53
30,071	7.54	7.52	1.75	–	0.07	1.71	1.49
30,072	8.43	8.02	1.74	–	0.07	1.79	1.57
30,073	9.14	8.58	2.17		0.07	1.81	1.56

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	100S/T (V)
30,070					3.18	2.87	6.05	52.5
30,071					1.32	2.09	3.41	38.5
30,072					0.87	1.63	2.50	34.8
30,073					0.54	1.18	1.72	33.9

Lab. No.	MECHANICAL ANALYSES (Int. Sys.) NaOH dispersion – Size in mm Coarse sand 2.0–0.20	Fine sand 0.20–0.02	Silt 0.02–0.002	Clay below 0.002	Silt–U.S. 0.05–0.002 mm	Index of structure	Moisture equivalent
30,070	54.2	30.7	3.6	11.5		74	8.2
30,071	59.9	21.3	0.2	18.6		49	8.8
30,072	57.4	21.7	1.0	19.9		52	8.8
30,073	54.3	24.0	0.3	21.4		54	8.8

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 42 — Sample Nos: 1, 2, 3, 4
Municipality: Santarém — State: Pará
Location: Curuá Una - Center of Pitt's Planalto Plots
Classification: Yellow Latosol
Analyses by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel > 20mm	Gravel 20-2mm	Fine Earth <2mm	BULK DENSITY Apparent	BULK DENSITY Real
30,074	A_1	0-30					
30,075	AB	30-45					
30,076	$B_{21}(1)$	45-90					
30,077	$B_{21}(2)$	90-130					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P O Truog (mg/100)
30,074	3.56	0.26	13.7	4.4	3.8	1.1
30,075	1.23	0.09	13.7	4.6	3.8	1.0
30,076	0.83	0.06	13.8	4.7	3.8	1.0
30,077	0.56	0.04	14.0	4.9	3.9	1.0

Lab. No.	ATTACKED BY $H_2S O_4$ d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	$\frac{SiO_2}{Al_2O_3}$ Ki	$\frac{SiO_2}{Al_2O_3+Fe_2O_3}$ Kr
30,074	32.35	30.24	5.28	–	0.03	1.82	1.64
30,075	36.14	32.16	5.58	–	0.03	1.91	1.72
30,076	35.77	32.06	5.55	–	0.03	1.90	1.71
30,077	36.47	32.47	5.65	–	0.03	1.91	1.72

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	$\frac{100S}{T}$ (V)
30,074					0.74	14.81	15.55	4.7
30,075					0.52	6.46	6.98	7.4
30,076					0.52	4.29	4.81	11
30,077					0.51	2.55	3.06	16

Lab. No.	MECHANICAL ANALYSES (Int.Sys) NaOH dispersion - Size in mm Coarse sand 2.0-0.20	Fine sand 0.20-0.02	Silt 0,02-0.002	Clay below 0.002	Silt-U.S. 0.05-0.002 mm	Index struofure	Moisture equivalent
30,074	6.0	6.6	13.9	73.5		75	42.5
30,075	3.5	5.8	6.7	84.0		59	36.9
30,076	3.5	4.2	4.3	88.0		96	35.8
30,077	3.3	6.6	6.2	83.9		100	34.0

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 43 — Sample Nos: 1, 2, 3
Municipality: Santarém — State: Pará
Location: Curuá Una - Pitt's flanco baixo Plot I
Classification: Yellow Latosol
Analyses by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20-2mm	Fine Earth >2mm	BULK DENSITY Apparent	BULK DENSITY Real
30,078	A_{12}	2-30					
30,079	AB	30-80					
30,080	B_{21}	80-140					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P O Truog (mg/100g)
30,078	1.27	0.10	12.7	4.3	3.6	1.1
30,079	0.68	0.05	13.6	4.7	3.7	1.1
30,080	0.34	0.02	17.0	4.5	3.6	1.0

Lab. No.	ATTACKED BY $H_2S O_4$ d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	SiO_2/Al_2O_3 Ki	$SiO_2/(Al_2O_3+_{Kr}Fe_2O_3)$
30,078	9.75	8.87	2.03	-	0.02	1.87	1.63
30,079	10.79	10.25	2.13	-	0.02	1.79	1.58
30,080	11.57	10.73	2.22	-	0.02	1.83	1.62

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	100S/T (V)
30,078					0.81	5.83	6.64	12
30,079					0.51	3.71	4.22	12
30,080					0.55	1.85	2.40	23

Lab. No.	MECHANICAL ANALYSES (Int.Sys) NaOH dispersion - Size in mm Coarse sand 2.0-020	Fine sand 0.20-0.02	Silt 0.02-0002	Clay below 0.002	Silt-U.S. 0.05-0.002 mm	Index of structure	Moisture equivalent
30,078	32.7	45.2	0.8	21.3		70	14.2
30,079	47.2	26.5	2.2	24.1		52	14.5
30,080	40.3	30.8	0.4	28.5		53	13.3

SOIL ANALYSES

Soil Section of FAO Mission to the Amazon

Field Profile No. 45 — Sample Nos: 1, 2, 3, 4
Municipality: Santarém — State: Pará
Location: Curuá Una - Flanco baixo (Froes) Pitt's proposed Plott II
Classification: Yellow Latosol
Analyses by: Inst. de Química Agrícola — Date of Analyses: 8/8/58

Lab. No.	HORIZON Symbol	HORIZON Depth	AIR DRY SAMPLE (%) Gravel >20mm	Gravel 20-2mm	Fine Eart <2mm	BULK DENSITY Apparent	Real
30,081	A_{11}	0-15					
30,082	A_{12}	15-35					
30,083	AB	35-75					
30,084	B_2	75-160					

Lab. No.	C (%)	N (%)	C/N	pH (1:1) Water	pH (1:1) KCl n.	P O Truog (mg/100g)
30,081	0.65	0.04	16.3	4.5	3.3	1.8
30,082	0.86	0.05	17.2	5.0	3.9	1.0
30,083	0.50	0.02	25.0	5.3	4.1	1.0
30,084	0.22	0.01	22.0	5.1	4.0	1.0

Lab. No.	ATTACKED BY H_2SO_4 d = 1.47 (%) SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	SiO_2 / Al_2O_3 Ki	SiO_2 / $Al_2O_3+Fe_2O_3$ Kr
30,081	1.45	1.41	0.80	-	0.01	1.75	1.29
30,082	2.55	2.65	1.42	-	0.02	1.63	1.22
30,083	2.74	2.87	1.41	-	0.02	1.63	1.24
30,084	3.18	3.38	1.61	-	0.02	1.60	1.23

Lab. No.	EXCHANGEABLE CATIONS (me/100g) Ca^{++}	Mg^{++}	K^+	Na^{++}	S	H^+	T	100S/T (V)
30,081					0.34	2.25	2.59	13
30,082					0.45	4.13	4.58	10
30,083					0.50	2.35	2.85	17
30,084					0.40	0.66	1.06	36

Lab. No.	MECHANICAL ANALYSES (Int. Sys.) NaOH dispersion - Size in mm Coarse sand 2.0-0.20	Fine sand 0.20-0.02	Silt 0.02-0.002	Clay below 0.002	Silt-U.S. 0.05-0.002 mm	Index of structure	Moisture equivalent
30,081	84.2	11.8	0.9	3.1		74	3.1
30,082	71.9	20.9	0.2	7.0		77	6.4
30,083	72.9	20.3	0.6	6.2		52	4.7
30,084	58.4	31.4	0.2	10.0		54	4.7

APPENDIX IV

LINEAR REGENERATION SURVEY

This is a method developed in Malaya for enumerating or sampling regeneration in the dense re-growth following the opening of the canopy. The size of the sample is varied according to the size of the plants being sampled. The method can equally well be used to sample the amount of regeneration induced by partial canopy opening prior to exploitation, or the amount of advance growth and small and medium size classes present at any particular time.

The method is fully described by Barnard (Ref. 1).

Briefly, it consists of cutting one or more lines through the area to be sampled and noting the number of samples stocked with desirable species. The size of the sample varies; converting to the metric system for use in the Amazon the size is 2 m by 2 m for seedlings, 5 m to 5 m (quarter-chain) for saplings and small poles, or 10 m by 10 m (half-chain) for poles and small trees.

The size classes have been modified to fit in with those used by the Inventory group.

Size Classes to be Recorded in Each Class of Sampling

Sampling Class	Size Classes	Name of Class
2 x 2 m	up to 1.5 m tall	Muda
Quarter-chain	1.5 to 3 m tall	Varinha
	3 m tall to 5 cm diameter	Vara
	5–10 cm	1A
	10–15 cm	1B
Half-chain	5–10 cm diameter	1A
	10–15 " "	1B
	15–25 " "	2
	25–35 " "	3
	35–45 " "	4
	45–55 " "	5

In each sample, of whatever size, the best stem of a desirable is noted by name and size, provided it is likely (with some liberation if necessary) to grow into an acceptable timber tree. This is referred to as the chosen, or "primary", tree or seedling. If there is another good desirable it is also recorded as a "secondary" tree or seedling.

The samples are marked out on the ground by laying a chain along the line and using 3 poles of 2 or 5 m to give the 2 m squares or quarter-chain squares on one side of it. In the case of half-chain sampling it was found quicker to mark the corners of the 10 by 10 m squares in advance with debarked saplings, using 5 m poles laid out at every 10 m at right angles to, and on both sides of the chain.

The object of the sampling is to obtain the percentage number of samples stoked with desirables, and therefore an idea of the percentage.

Sampling Class	Size of Sample	Area
2 x 2 m	4 m^2	1/2500 ha
Quarter-chain	25 "	1/400 ha
Half-chain	100 "	1/100 ha

A half-chain sample with a medium sized tree is regarded as likely to have developed from one out of four quarter-chain samples with poles, which in turn are regarded as having developed from twenty five samples with seedlings.

A percentage of 40 samples stocked is normally regarded as satisfactory in any sampling class.

This 40% means that 1000 stocked samples out of 2,500 samples of 2 x 2 m (or one hectare) are likely to give 160 stocked samples out of 400 quarter-chain samples, which in turn are likely to give 40 stocked samples out of 100 half-chain samples, or, in other words, 40 medium sized desirables per ha. At maturity with, say, a diameter in class 8 (75-85 cm) this would be about 20 timber trees per ha - surely a very good yield for any tropical forest. Not more than 20 seedlings are recorded in any one sample.

To get some ideas of the rate of growth of the regeneration the height of the primary seedling is noted (in decimeters) after its name; for this height measuring one of the 2-m poles is marked in units of decimeters. If desired, the regeneration of all desirable species may be recorded.

For the quarter-chain sampling a diameter gauge is used with two notches cut in it, 5 in 10 cm wide accordingly, and two marks made on the 5 cm notch side to indicate 15 cm.

For the half-chain sampling a tape is used to measure the girth of the larger poles and the small trees and the diameter class filled in later from tables.

The dominance of the chosen tree (column "dom") in quarter- and half-chain sampling is marked according to the table given on page 27 for crown position.

The presence of creepers or climbers is recorded under Observations.

Examples of field sheets and of summaries are given below.

MEIO/QUARTO - CORRENTE - QUADRADO - AMOSTRAS

Situação: C U R U Á — Linha No. : 18

Leitura da Bússola: 90 — Data: 9/9/57

Feito por: GUERRA — Talhão No. 5

Amostra No.	Nome	Dom.	Cir.	Diam.	OBSERVAÇÕES
	(MEIO - CORRENTE)				
95	Cupiuba	3	131	4	
	Maçarand.	2	82	3	Mudas da Maç.
96	-				
97	Louro canela	4	163	5	
98	Mand. lisa	1	-	1B	
99	-				
100	Ang. pedra	3	113	4	
	Guariuba	2	78	2	Poucas mudas Ang. mata
	(QUARTO - CORRENTE) (lado esquerdo - norte)				
194	Mand. asp.			Vh	
195	-				
196	Louro canela			1B	
	Ucuuba			V	
197	-				
198	Maçarand.			V	
199	Cupiuba			1B	
	Para			1A	
200	Ang. ped.			1B	
	Ucuuba			Vh	

NOTE: Five out of seven quarter-chain samples are stocked, three of which have a secondary species.

REGENERAÇÃO AMOSTRAS i.e. (2 x 2 m)

Situação: C U R U A C Linha No.: 6

Leitura da Bússola: 210 Data: 6/8/60

Feito por: VERA CRUZ Lado da Linha: OESTE (direita)

Amostra No.	Nome da Muda	Quant.	OBSERVAÇÕES
90	-		Maçarand. peq. 1
91	Ang. da mata (7)	2	(this means one seedling recently germinated i.e. under 5cm tall)
	Ucuuba	3	
92	Ucuuba (5)	2	
	Cupiuba	2	
93	Guariuba (5)	3	Guariuba peq. 1
	Ucuuba	2	Maçarand. peq. 3
94	Ang. pedra (6)	1	
	Guariuba	2	
95	Ang. pedra (3)	3	
	Maçarand.	1	
96	-		
97	Ucuuba (3)	4	Mand. asp. peq. 2
98	Piquiá (6)	1	
	Maçarand.	2	
99	-		
100	Cupiuba (4)	4	

NOTE: On this page there are 8 stocked samples, 6 with a secondary species.
The height of the tallest primary in each sample is given in brackets in dms.

ANALISE DE AMOSTRAS DE MEIA-CORRENTE

Local: C U R U Á

Talhão: 4

Tipo da floresta: Planalto II alto

Linhas: 17 - 20

Data: 8 - 10/8/57

Feito por: GUERRA

Comprimento das linhas cortadas : 4 kms

Homens-dias: 8

Total da área examinada: 100 has

Número das amostras: 400

Área das amostras: 4 has

	Primeira						Segunda					
N o m e	Total	1	2	3	4	5	Total	1	2	3	4	5
Ang. da mata	4		1		2	1						
Ang. pedra	12	1		4	4	3	5	2	1		1	
Cupiuba	35	7	10	8	6	4	17	6	3	4	2	2
Guariuba	12	2	1	3	4	2	7	2	1	3	1	
Louro canela	24	3	4	4	7	6	9	4	3	1		1
Maçarand.	17	8	4	3	2	1	7	2	2		2	1
Mand. lisa	22	9	5	6	2		8	3	2	2	1	
Mand. asp.	23	8	6	4	3	2	7	2	3	2		
Piquiá	8	2		3	2	1	1			1		
Ucuuba	35	12	9	7	4	2	19	6	4	3	4	2
TOTAIS	192	52	40	42	36	22	80	27	20	16	11	6
%	48	13	10	10	9	5	20	7	5	4	3	1

This shows an adequate stocking fairly well distributed as to size classes and as to species.

ANALISE DE AMOSTRAS DE QUATRO-CORRENTE

Local: C U R U Á — Talhão: 5

Tipo da Floresta: Planalto II alto — Linhas: 21, 22, 23, 24

Data: 12-17/8/57 — Feito por: FRANCISCO

Comprimento das linhas cortadas : 4.04 kms

Homens-dias: 17 — Total da área examinada: 100 has

Número das amostras: 808 — Área das amostras: 2.5 has

	Primeira					Segunda				
N o m e	Total	Vh	V	IA	IB	Total	Vh	V	IA	IB
Ang. da mata	2	1	1							
Cupiuba	10	2	6	1	1					
Cumaru	3		3			1	1			
Louro can.	320	122	160	18	20	69	51	18		
Maçar.	94	45	49							
Maparajuba	13	5	6	2						
Parapara	3	2	1			1	1			
Ucuuba	95	57	25	5	8	28	21	7		
TOTAIS	540	234	251	26	29	99	74	25		
%	67	29	31	3	4	12	9	3		

This shows adequate stocking but confined to the most shade tolerant and slower growing species; some opening of the canopy, especially in the understorey, would be advisable to accelerate their growth.

ANÁLISE DE AMOSTRAS DE REGENERAÇÃO

Local: C U R U Á — Talhão: C

Tipo da floresta: Plananlto II alto — Linhas: 6

Data: 5-6/8/60 — Feito por: VERA CRUZ

Comprimento das linhas medidas: 200 ms

Homens-dias: 2 — Total área examinada: 4 has

Número das amostras: 100 — Área das amostras: 0.04 has

Nome	Com Primeras Mudas					Amostras com mudas secundárias
	Altura média (dms)	Totais	Quantidade			
			1	2-20	+ 20	
Ang. da mata	7	6	4	2		2
Ang. pedra	5	4	3	1		3
Cupiuba	8	15	10	5		7
Guariuba	4	4	2	2		8
Maçaranduba		4	2	2		2
Mand. lisa	4	7	5	2		9
Mand. asp.	3	7	5	2		4
Parapara	6	3	2	1		
Piquiá	4	2	2			
Ucuuba	4	15	8	7		9
TOTAIS		67	43	24		44
%		67%	43%	24%		44%

This shows adequate stocking; 37% are of the shade tolerant species and 30% of the ones which have come in because of the canopy opening. The plot could now be exploited.

APPENDIX V

LIST OF TREES AND VOLUMES FOR A 100% ENUMERATION OF THE THREE COMPARTMENTS OF THE CURUÁ-UNA FOREST, COMPARED WITH HEINSDIJK'S INVENTORY (FAO Report No. 601) FOR THIS TYPE OF FOREST "PLANALTO II ALTO"

(Lista dos árvores e dos volumes de uma enumeração 100% de três talhões na floresta de Curuá-Una, comparados com o inventário de Heinsdijk (Relatório de FAO, No. 601) sôbre êste tipo de floresta: Planalto II alto"

CURUÁ-UNA

Nome	T.5 (100 ha)		T.6 (97 ha)		T.16 (97 ha)		Inventário de Heinsdijk (Planalto II alto) (109 ha)	
	Quantidade	Volume	Quantidade	Volume	Quantidade	Volume	Quant.	Volume
Abiorana			5	7				
Ab. branca	14	36	31	89	43	131	227	768
Ab. casca grossa			1	2	115	322	66	240
Ab. cutite	10	23	6	13	7	32	17	77
Ab. goiabinha							19	50
Ab. matamatá							11	28
Ab. sêca	1	2			4	10	6	21
Ab. ucuuba	22	69	6	46	22	74	99	397
Acapu							454	1,101
Acapurana							8	18
Açoita cavalo	1	3	4	16	4	20	6	20
Amapá	17	71	5	27	14	59	11	158
Amarelinho	4	8	1	2	3	7	2	5
Amora			1	2				
Anani	4	11	7	18	3	22	3	13
Andira	2	21						
Angelim			1	5				
Ang. da mata	16	139	10	65	14	121	1	14
Andiroba							140	494
Ang. pedra	165	1,442	217	1,856	49	745	30	423
Ang. rajado							3	37
Araracanga	36	187	20	132	1	3	1	5
Araticiú							2	3
Aroeira	2	8	22	160	19	115	52	455
Axixá	5	15	5	9	7	19	4	10
Axuá	1	3			2	2	4	7
Bacabinha	2	4						
Belantinha							6	18
Breu branco							20	34
Breu manga	2	4	5	25	16	42	27	56
Breu preto	4	8	28	51	104	288	231	501
Breu sucuruba	14	59	8	18	8	51	11	49
Buicu							1	4

Nome	T.5		T.6		T.16		Planalto II alto	
	Q.	V.	Q.	V.	Q.	V.	Q.	V.
Cajaçu	22	108	18	106	12	63	13	76
Capitiú	2	8			9	46	9	87
Caqui					5	15	4	11
Caripé	33	71	164	451	18	46	77	245
Caroara	1	2	1	2	11	39	4	17
Castanheira	69	1,054	160	2,283	172	3,000	75	1,356
Caxingubarana	1	2	3	5	12	34	3	17
Caucho							1	1
Cedro					6	31	12	225
Coataquiçaua	1	8	1	1	1	2		
Copaíba					1	2	9	80
Copaibarana	1	2					1	2
Croton							6	32
Cuiarana	46	161	41	170	89	435	32	187
Cumaru	40	187	29	135	7	39	18	102
Cumaté							8	24
Cupiuba	476	1.380	135	611	148	557	68	309
Env. ata braba			1	2				
Env. branca			1	1	2	4	1	4
Env. preta	2	4	6	12	11	29	11	29
Env. X					9	22	10	34
Faeira	1	5	24	119			2	6
Fav. arara tuc.	3	15	20	86	43	178	6	43
Fav. barba tim.	2	4			1	3	11	58
Fav. bolacha	19	62	15	48	2	13	38	294
Fav. bolota	5	15	4	9	3	23	2	8
Fav. f. fina	34	98	55	152	90	378	77	347
Fav. mapaxiqui	3	24	4	9	7	20	11	33
Fav. marimari							6	15
Fav. parkia	4	12						
Fav. uing	22	81	16	44	24	178	33	192
Freijó							19	97
Freijó branco	1	2			3	7	25	81
Glícia	3	9	7	22	8	31	7	14
Gombeira	2	6	1	1	7	26	13	47
Goiabinha							1	2
Guabiraba							2	5
Guariuba	35	149	51	282	33	143	2	15
Imbaúba			1	4				
Imbaubarana					1	2	11	27
Ingá	9	23	8	20	20	64	42	100
Ingarana	4	11	4	12	16	60	12	43
Itaúba	26	110	13	51	16	84	19	79
Jacareuba							4	41
Janitá			2	47	2	6		
Jarana							57	324
Jatauba							3	6
Jatoá							4	13
João mole	7	15	6	17	3	9	9	25
Jutaí açu	12	70	13	100	10	117	24	265
Jutaí miri			1	3	13	70	9	50
Jutaí pororoca	5	14	8	15	4	12	9	18
Jutairana	1	3					5	17

Nome	T.5		T.6		T.16		Planalto II alto	
	Q.	V.	Q.	V.	Q.	V.	Q.	V.
Louro			5	19				
" amarelo	9	22	23	57	17	36	21	107
" branco	9	23	14	55	17	36	72	236
" canela	435	1,799	286	951	53	183		
" cânfora			1	3				
" chumbo			5	32				
" cumaru							2	14
" preto			7	21	1	2	35	148
Macacaúba					4	19		
Macaco escorrega			1	1				
Maçaranduba	299	1,316	375	1,416	588	3,271	272	1,710
Macucu	4	96	11	60	5	13		
Mamorana	1	5	6	22	7	30	12	68
Mandioqueira	498	2,409	230	1,078	22	120		
Maparajuba	37	134	37	96	29	113	28	147
Marupá	2	6	4	9	12	38	4	16
Maramatá branco							48	122
" ci	17	40	20	44	5	13	2	4
" verm.			1	9				
" preto	27	121	12	57	13	49	8	30
Melancieira							3	15
Miraúba	231	543	183	325	175	406	24	64
Molongó	2	7						
Moracea							9	24
Morototó	9	37	4	12	9	32	15	67
Muirajuçara	2	10			2	14	2	7
Muirapiranga					1	4	2	6
Muirapixuna	3	9	9	14	70	239	50	84
Muiratauá					5	21	12	104
Murta	1	3					1	3
Muruci			1	1			4	8
Mururé	14	48	14	41	49	187	15	81
Mututi	1	3	2	3	2	6	6	26
Murupita							4	14
Olacacea	4	15			3	9	20	54
Papo de mutum			3	6			1	2
Parapará	1	1	2	3	13	42	27	91
Parinari	2	5	2	3	2	8		
Pau branco	18	47	12	33	10	40	8	29
Pau d'arco			24	23	15	100	30	191
Pau jacaré	20	58	4	10	7	33	16	53
Pau para tudo	4	10					3	5
Pau santo					8	25	12	42
Paxiubarana			1	1				
Pente de macaco	4	9			7	18	37	119
Piquiá	41	362	31	271	33	402	23	243
Piquierana			1	3			4	60
Pracuuba	13	34	15	29	2	9		
Preciosa	17	45	20	74	26	83	8	39
Puruí			1	2			1	3

Nome	T.5		T.6		T.16		Planalto II alto	
	Q.	V.	Q.	V.	Q.	V.	Q.	V.
Quaruba	59	324	118	509	21	145	71	595
Quarubarana	38	191	22	94	26	188	32	314
Quaruba rosa	17	73	11	34	6	32		
Quinarana	1	3	4	9	1	2	50	95
Rosadinha	93	191	131	305	51	111	52	173
Sapucaia	34	160	18	116	38	254	33	219
Seringa itauba	41	188	14	48			1	5
Sorva	3	6	6	11			12	58
Sucupira	30	127	8	27	16	54	11	47
Sucuuba	2	5					1	6
Sumaúma							3	22
Tatajuba					10	70	10	81
Tatapiririca	2	4			2	5	2	5
Tamanqueira							1	2
Taruma	1	1						
Tauari	28	150	26	150	36	210	59	408
Taxi			1	5				
" branco	27	85	44	109	28	88	1	4
" pitomba	259	933	244	713	300	1,279	53	209
" preto	22	54	91	266	58	180	155	635
Tento	12	44	4	8	4	14	5	37
Tinteiro	1	2						
Ucuuba	4	14	27	81	30	88	36	152
Ucuubarana							21	115
Urucurana	2	3					8	28
Uruazeiro							2	5
Urucu da mata							11	21
Uxi	20	60	58	191	23	83	5	17
Uxirana	54	147	36	108	47	119	10	26
TOTAL	3,691	15,747	3,416	14,895	3,161	16,374	3,755	17,504
No. de espécies	103		103		103		140	
No. por ha.	37	158	35	154	33	170	34	161

NOTA:

As espécies sulcadas, como Aquariquara, Carapanaúba, Maraximbé e Pau de remo, não se mediram nos talhões 5 e 16.

The Aquariquara, Carapanaúba, Maraximbé e Pau de remo species were not measured in compartments 5 and 16.

APPENDIX VI

SILVICULTURAL INVENTORY

This type of inventory, referred to on p. 24 *, is done to find out whether silvicultural treatment is necessary. The inventory lines should be from 100 to 200 m apart depending on the intensity of sampling required (10-5%). Each line is marked with numbered pegs at 10 m (half-chain) intervals giving 100 samples to the kilometer or hectare. 5 m poles are laid out on the ground at right angles to the first two pegs on both sides of the line so as to give a sample plot of 10 x 10 m; by moving forward the two rear poles to the next peg the next sample is marked out.

The most promising tree of a desirable species - the "Leading Desirable" (LD) - is selected and recorded according to its size - see a sample inventory sheet below.

5+ is for trees in class 5 or up, i.e. with a girth of 142 cm or more at breast height.

4-2 is for trees with girths between 141 and 47 cm.

1 is for trees under 47 cm in girth and over 5 cm diameter.

In addition the following information is recorded:

(1) the number of competing stems (concor. de pés) which equal or exceed the LD in girth,

(2) The crown position (copa) of the LD, using the scale given on p. 43 - Report.

(3) whether impeded or threatened by any undesirables "U" in the plot, by climbers (if these have not already been cut - use the letter "C" if climbers are present), or a combination of these.

If the LD is below class 5 another is selected in the half plot the other side of the line, and the above details again recorded. There are thus two sub-plots of 10 x 5 m, i.e. 1/200 ha.

If either LD is below class 2 another is selected in the other unoccupied quarter-plot of 5 x 5 m, i.e. 1/400 ha.

If any LD is below class 1, i.e. a sapling (vara) less than 5 cm diameter, as measured with a gauge, the remaining desirables in the quarter-plot are counted up to five and all are recorded in the "Observations" column by abbreviations of the local names.

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* Report

For interpretation of the inventory see "Table of Effective Stocking" below for compartments 5 and 16 at the Curuá.

Impeded Crowns Those which require attention are the ones which are being impeded by undesirables or climbers, i.e. with a U or C in the "Imped." column. Dawkins suggests that if a stand shows more than 75% freedom no crown tending is necessary at the moment.

Competing Stems Usually only those samples in which there are two or more competing stems are counted and recorded in the "Concor. de Pés." column. Dawkins suggests that if a stand has more than 25% of the stems with competition some reduction of the basal area is necessary.

For more details about this type of inventory, which is usually called Diagnostic Sampling, see Dawkins (Ref.2) pp. 94-101.

INVENTÁRIO DA SILVICULTURA

Talhão: 16 — C U R U Á Linha: 2-9 A (cont.)

Teitura da Bússola: 270 Data: 26/7/60

Feito por: VERA CRUZ

Amos.	N o m e	Classe de diâmetro 5 + 142 e+ circ.	4 - 2 141-47 circ.	1 menos 47 cm	Concor. de Pés	Copa	Imped.	Obs. (Varas)
89	—							
90	—							Cup. Para
91	—							Cup. 3' para, B. suc.
92	Maçar.	1.75			—	5	—	
93	—							B. suc. T. pit.
94	—							
95	Taxi pit.			1A	2	2	U	
96	Taxi branco		105		—	4	—	T. pit.
97	Muiracatiara	159		—	—	5	—	
98	Maçar. Itauba		121	1B	—	4	—	
99	—							Maç. T. pit.
100	Louro can.			1B	1	2	—	
	Ucuuba			1B	2	2	U	Para 2'
	Cupiuba			1A	2	1	UD	B. suc.

Note: (1) The circumferences in cm are recorded in the field under the appropriate diameter class, except class I where the 5 and 10 cm gauge is used.

(2) The number of "varas" are those in an otherwise unstocked whole or sub-sample.

TABLE OF EFFECTIVE STOCKING - CPT. 5 CURUA

(bringing all figures to the standard of 1/100 ha)

	No. of Plots by PLOT SIZES					STOCKING p.ha	
	1/2000	1/400	1/200	1/100	ha	Effective	Cumulative
Total No. of Plots				500			
.·. area of sample					5		
No. of plots stocked with trees all 5 and up				142 ÷	5	= 28.4	28
.·. lacking 5				358			
No. of plots with trees Cls 2 - 4			137 ÷ 2 =	68 ÷	5	= 13.6	42
.·. lacking 2 - 4				290			
No. of plots with trees Cl. 1A and B		194 ÷ 4	=	48 ÷	5	= 9.6	52
.·. lacking 1A and B				242			
Saplings counted	644 ÷ 20		=	32 ÷	5	= 6.4	58
.·. Entirely unstocked				210 ÷	5	= 42	

This stand has 42 stems p. ha of Cl. 2 and up (28 of Cl. 4 and up).

.·. as over 40% stocked with desirables, trees under Cl. 2 may be ignored for silvicultural treatment.

Impeded growns, Cl. 2 and up - 32 out of 279, i.e. 11.5%, or 88.5% freedom.

.·. as over 75% freedom, NO treatment required.

Competing stems, Cl. 2 and up - 21, i.e. 7.5%

.·. as less than 25%, NO treatment required.

TABLE OF EFFECTIVE STOCKING - CPT. 16 - CURUÁ

(bringing all figures to the standarda of 1/100 ha)

	No. of Plots by PLOT SIZES					STOCKING p.ha	
	1/2000	1/400	1/200	1/100	ha	Effective	Cumulative
Total No. of Plots				500			
∴ area of sample					5		
No. of Plots stocked with tress Cl.5 and up				75	÷ 5 = 15		
∴ lacking 5				425			
No. of plots stocked with tress Cl. 2 - 4			87 ÷ 2	43	÷ 5 = 8.6		23.6
∴ lacking Cl.2 - 4				382			
No. of plots stocked with trees Cl. 1A and B		124 ÷ 4		31	÷ 5 = 6.2		29.8
∴ lacking 1A and B				351			
saplings counted	528 ÷ 20			26	÷ 5 = 5.2		35
∴ Entirely unstocked				325 325	÷ 5 = 65		

This stand has 23.6 stems p.ha of Cl. 2 and up (15 of Cl. 5 and up)

∴ as less than 40% stocked with desirables, trees under Cl.2 must receive assistance, i.e. liberation

Impeded crowns, Cl. 2 and up. 50 out of 162, i.e. 31%, or 69% freedom.

∴ as less than 75% are free some liberation treatment is required.

Completing stems Cl.2 and up. 81, i.e. 50%

∴ as more than 25% some refining treatment is required.

APPENDIX VII

THE USE OF ARBORICIDES

The advantage of arboricides is that an undesirable tree can be "removed" without having to cut it down, thereby causing damage in its fall and encumbering the forest floor with its branches. Poisoned trees die slowly and their branches fall one by one when dead; if the stem does fall over after a year or two, the few dead branches left do little damage.

Girdling can be quite effective on some species but it takes longer to do and, except for the large trees, the others are likely to fall over in a wind when still alive.

There are various chemicals which can be used to kill trees. Arsenic is one of them; this is simple to use and effective, but it is poisonous to humans. The most popular are the butyl esters of 2.4-D and 2.4, 5-T; the former is considerably cheaper, but it is less effective. A mixture of the two is probably the best. In Uganda, where Dawkins did much of the early work, a mixture of D to T in the proportion of 2 to 1 in a 3% solution in heavy diesel oil is used. This hasn been found to be too weak in the Amazon. The normal technique now is to use a 4% solution of D to T in the proportion of 1 to 2 (not 2 to 1), and to frill - girdle (q.v.) the more resistant species before spraying. Only light diesel oil is available in the Amazon.

The size of tree is rather important. If only small trees, up to say 15 cm in diameter, are being treated, a 3% solution will suffice to give a kill of about 70-80% after a year or so. If only large trees, say over 45 cms diameter, are being treated, a 5% solution should be used and the kill will take a little longer.

The standard sprayer is the Vermorel "Florex" which is sold in England as the "Cooper Pegler No.5 Handsprayer" with a C.P. low-volume nozzle; it has a built-in fine filter. Other sprayers can be used but they should be of the hand type with a capacity of 2 to 3 litres. Larger sprayers which have to be carried on the back are somewhat cumberosome when making one's way through the undergrowth.

It is important to keep everything as clean as possible. A filter cloth must always be used when refilling the sprayer, and the gauge filter in the nozzle must be cleaned at the end of each day's work. It is also important to keep checking on the various screws and screw pins, as these tend to work lose and can be easily lost. It is advisable to have a few spare sprayers, say a 25 to 33% reserve, so that no time may be lost in the field if a fault dovelops. Some spare washers are also an essential, and spare complete nozzle units are advisable.

One officer selecting the trees to be poisoned can keep 3 to 4 spraymen busy; there should be one or two extra men with small axes for frill girdling and one or more carrying cans of the solution and provided with a funnel and filter cloth.

The frill, on the resistant species, is made by cutting into the bark at an angle of about 30 degrees from the vertical and slightly opening the cut all the way round.

The pressure in the sprayer should be as low as possible, but enough to give a liquid fan impinging on the tree about half a meter away. A mist cloud must be avoided - it is very wasteful.

A completely overlapping belt of at least 20 cm depth must be sprayed right round the tree. The wetting is adequate when the liquid begins to run. It is wasteful to use more.

Spraying should not be done when the bark is wet unless every stem is to be frilled (and this takes extra time). With frills, however, a little less spray may be used.

With large old trees, the rough loose scales of bark should be scraped off before spraying.

Heavily fluted trees such as Carapanaúba, Pau de remo, Maraximbé, Quinarana and Aquariquara are all very resistant, except when very small (up to 10 cm), and should not be sprayed - it is just a waste of time, though occasionally one will die.

Trees with a latex, resin or gum tend to be more resistant and should be frilled all the way round first.

A controlled experiment with numbered trees and three different concentrations was laid down in September, 1958. The concentrations were:

(1) 4% 2.4, 5-T plus some 2 : 1 of D : T (about 5% in all)

(2) 3% 2.4, 5-T

(3) 4% of 1 : 2 of D : T

All three were applied in separate plots to, (a) the dominants and (b) the understorey trees. After 20 months the results were:

Percentage DEAD

No. of months	(a) Dominants			(b) Understorey		
	(1)	(2)	(3)	(1)	(2)	(3)
3	32	-	1	51	17	16
7	44	7	5	69	46	44
13	59	25	36	86	73	71
20	61	26	36	88	75	81

Percentage ALIVE

No. of months	(a) Dominants			(b) Understorey		
	(1)	(2)	(3)	(1)	(2)	(3)
3	56	79	91	41	57	73
7	44	79	78	22	43	44
13	28	40	36	12	13	19
20	34*	30	40*	7	11	11

The difference between the "dead" and "alive" figures are for the trees classed as "dying".

* The alight increases here are for "dying" trees which have recovered, anyway, to some extent.

Note: NO frill-girdling was done here.

In January 1959, a girdling experiment was laid down for comparison; a ring about 5 cm deep was cut into 70 dominant trees of 29 different species, including one or two of the main desirables. Some desirables were also poisoned in the September 1959 treatments. The reason for also treating some desirables is that it may be found that logs from such trees killed 2 or 3 ahead of felling may float - as is the case with teak in Burma.

Results from girdling were:

No. of months	% Dead	% Alive
3	1	81
9	31	43
17	47	24

In the spraying experiment 93 dominants and 243 understorey trees were treated.

Labour costs were:

Man-days	Spraying	Girdling
per hectare	1.17	0.83
per 100 trees	0.35	1.2

There is no point in giving the cost of the arboricides used, as this varies according to the exchange rate for cruzeiros. The price of diesel oil has varied too since the work was started. Consumption of diesel oil over several experiments, including the above, averaged about 15 litres per 100 trees.

Arboricides in mid-1960 in Belém, ex São Paulo by air, cost:

2, 4, 5-T	Drum of 5 gallons	Cr$11,500
	Crate of 6 tins of 1 gallon each	" 14,200
2,4-D	Drum of 5 gallons	" 5,300
	Crate of 6 tins of 1 gallon each	" 6,900

All the above work was done without any frill-girdling before spraying.

In June and July, 1959 some more poisoning was done at C.B.A. and the Curuá to open the canopy further in parts of some plots where there were still denser patches. The resistant species, which were well known by then, were frilled before spraying. Results 11 months later were:

	% Dead	% Alive
C.B.A. (17 trees)	65	18
Curuá C (54 trees)	43	39

Accurate costs cannot be given for this work as some of the trees still alive from previous treatments were retreated at the same time.

In November, 1959 some 1353 undesirable trees in the understorey in the denser unexploited patches of cpt. 6A (the area exploited early in 1958) were poisoned to open the canopy to encourage regeneration (operation (3) on p. 35*). The resistant species were frilled first.

This work cost 0.85 man days per hectare and 10 litres of diesel were used per 100 trees. The patches treated covered probably less than half of the whole area. This was a normal post-exploitation operation so the treated trees were not numbered and marked for control purposes.

The lists below show the more resistant trees. It must be remembered however that the smaller the tree the less resistant it usually is. Bark thickness may not matter; one of the thinest barked trees - Mirauba - is fairly resistant.

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* Report

Very Resistant

Spraying	Frill and Spray (only 11 months)	Girdling
Axixá	Amapá	Cuiarana
Balantinha	Cuiarana	Cumaru
Breu sucuruba	Enviras	João mole
Cuiarana	Glicia	Pau branco
Cupiuba	João mole	Piquiá
Maparajuba		Sapucaia
Mututi		
Parinari		
Uxi		

Fairly Resistant

Spraying	Frill and Spray (only 11 months)	Girdling
Abiuranas	Abiuranas	Cupiuba
Amapá	Rosadinha	Miraúba
Angelim pedra	Taxis	Pau jacaré
Breus		
Enviras		
most Faveiras		
Muirapixuna		
Miraúba		
Rosadinha		
Quaruba		
Uxirana		

Foliage sprays

2.4-D, being less expensive, can also be used to kill young growth by spraying directly on the leaves. In this respect it is useful for cleaning along enrichment lines, but great care must be taken not to spray the enrichment plants. The work should be done when there is no wind. It could also be used to keep open planting lines cut through young secondary growth (p. 53 - Report).

APPENDIX VIII

ESTABLISHMENT INDICES AND PERIODIC ANNUAL INCREMENTS

- Tabela de sobreviventes e crescimento -

Explanation of terms used in the following table of results.

Note: In the first column of the tables 'Localidade' vernacular names (See Appendix XIII) are used for the local species, and botanical names for the exotics.

Localidade:

PP — Porto Platon (ou Campo Verde) em Amapá.
Floresta virgem alta em solo argiloso derivado da rocha matriz.

Porto Platon (or Campo Verde) in Amapá.
Virgin forest on clay soil derived from the basement complex.

Faz. — O canteiro no Equador, Fazendinha; perto de Macapá, originalmente arado em faixas. Campos em argila laterítica pobre (terciário).

The plot on the Equator, Fazendinha; near Macapá; originally ploughed in strips. Campos on degraded lateritic clay (tertiary).

Faz.(N.C.) — Uma área adjacente que não foi cultivada.

An adjoining area which was not cultivated.

Faz.Nur — Uma área de capoeira perto do Viveiro, no Equador (argila terciária)

An area of young secondary forest by the Nursery on the Equator (tert. clay).

Sant. — Centro de Treinamento da FAO, perto de Santarém. Vegetação secundária em solo arenoso pobre (quaternário).

FAO Sawmill Training Centro, near Santarém. Secondary bush on poor sandy soil (quaternary).

E_L — Linhas de enriquecimento.

Enrichment lines.

'57 — Ano de plantio ao ar livre; área desmatada e queimada.

Year of planting in open; area cleared and burnt.

CBA — Floresta alta (parte secundária) perto a Estação agrícola, uns 12 kms ao sul de Santarém. Planalto, argila terciaria.

High forest (part secondary) near the Agricultural Station some 12 km south Santarém. Planalto, tertiary clay.

CBA C — Explorado, linhas de enriquecimento grandemente abertas.
F — Linhas de enriquecimento, copa grandemente aberta.
J e M — Linhas de enriquecimento, copa levemente aberta.

C — Exploited, heavily opened enrichment lines.
F — Enrichment lines, canopy heavily opened.
J and M — Enrichment lines, canopy lightly opened.

Curuá or Cur. — Centro de FAO na margem direita de Rio Curuá Una, uns 105 kms de Santarém por rio. TODOS os canteiros aqui estavan sob floresta virgem.

FAO Centre on right bank of Rio Curuá Una some 105 km by river Santarém. ALL plots here were under virgin forest.

Km4 — Canteiro à margem da estrada - solo arenoso pobre.

Roadside plot - poor sandy soil.

Km5 — Canteiro à margem da estrada - melhor solo arenoso na base de planalto.
Roadside plot - better sandy soil at base of planalto.

A,E — Canteiros perto da serraria, no planalto (argila terciária) - derrubados e queimados.

Plots by sawmill on the Planalto (tertiary clay) - clear-felled and burnt.

D — Canteiro au sul de A - Enriquecimento.

Plot south of A - Enrichment.

4(PP) — Talhão 4, Planalto - Enriquecimento. (PP)-Linha plantada.

M. — Canteiro no Flanco - solo arenoso (quaternário) derrubado e queimado.

Plot on Flanco - sandy soil (quaternary) - clear-felled and burnt.

N — Canteiro no Flanco, ao lado de M - Enriquecimento.

Plot on Flanco beside M - Enrichment.

Tipo da muda

RN Raizes nuas; normalmente pequenos transplantes de viveiro.

Naked rooted; normally small nursery transplants.

Sem fol. Mudas sem folhas - transplantes maiores do viveiro dos quais as folhas, exceto as mais novas, foram removidas. As raizes mais compridas são podadas.

Striplings - larger nursery transplants from which the leaves, except the youngest ones, have been removed; the longer roots are pruned.

Tocos Tocos - transplantes maiores do viveiro con os brotos cortados cêrca de 5 cm acima do coleto. As raizes mais compridas podadas.

Stumps - larger nursery transplants with the stems cut off about 5 cm above the root collar; the longer roots are pruned.

Caixa Estoque de mudas com torrão, provinda de caixas.

Ball-planted stock from boxes.

Vaso Estoque de mudas de vasos feitos de ferro galvanizado.

Ball-planted stock from pots made from sheets of galvanized iron.

Torr.Paul. Torrão paulista - transplantes cultivados em vasos de terra hexagonais.

Torrão paulista - transplants raised in hexagonal earth pots.

Sem.em linhas Semeadura directa em linhas.

Direct sowing in lines.

Sem.em covas Semeadura directa em covas.

Direct sowing at stake.

Col.6 Quantidade total usada Êste é, o total das colunas 2 o 5, esta constando do número de plantas usadas no replantio.

This is the total of columns 2 and 5, the latter being the number of plants used for beating up.

Col. 7 Indice sobreviventes Êste é a percentagem do total de plantas usadas que ainda estão vivas na idade mostrada na coluna 8. Êste índice dá uma idéia melhor que a percentagem de plantas vivas (col. 4) das espécies fáceis de se estabelecerem. Quanto mais perto o índice estiver de 100 mais fácil é estabelecer-se o tipo de planta usada nas condições do canteiro em questão.

This is the percentage of the total number of plants used which are still alive at the age shown in column 8. This index gives a much better idea than the percentage of plants alive (col.4) of the ease, or otherwise, of establishing the species. The closer the index is to 100 the easier it is establish the type of plant used in the conditions of the plot in question.

Col. 9 Altura média (dms) Esta é a altura média de 20% das árvores mais altas no canteiro ou linha de enriquecimento, em decímetros. A menos que haja apenas muito poucas plantas num canteiro, as árvores na fileira exterior não são medidas.

This is the mean height in decimetres of the tallest 20% of the trees in the plot or enrichment line. Unless there are only very few plants in a plot, trees in the outside row are not measured.

Col.10 Rendimento periódico anual é o incremento periódico anual, calculado deduzindo-se a altura original (col.1) da média da altura, dividindo-se pela idade.

This is the Periodic anual increment, calculated by deducting the original height (col.1) from the mean height and dividing by the age.

\+ Significa que P_2O_5, ou fosforita ou triplo super fosfato, foi adicionado ao buraco antes do plantio - mais ou menos metade de uma colher de sobremesa por buraco. O P_2O_5 foi adicionado de novo no replantio.

Means that P_2O_5, either rock phosphate -(fos)- or triple super phosphate - TSP - was added to the hole before planting - about half a dessert spoonful per hole. P_2O_5 was again added on beating up.

TABLE FOR APPENDIX VIII

Nome e Localidade	Tipo da Muda	1 Altura (dms)	2 Quantidade plantada	3 Quantidade viva	4 viva %	5 Quantidade replantada	6 =2+5 Quantidade total usada	7 = 3+100/6 Indice sobreviventes	8 Idade	9 Altura media (dms)	10 = 9-1/8 R.P.A
Acapu PP	Sem.fol.	2	10	5	50	-	10	50	1.5	2.6	0.4
CuruaD	"	5	25	21	84	-	25	84	0.7	8	4
" E	"	4	48	4	8	-	48	8	0.7	4	NIL
" 4	(Y)"	4	192	131	68	-	192	68	0.7	4	NIL
Aguano PP	Sem.fol.	1.4	100	68	68	30	130	52	1.5	2.3	0.6
CuruaD	"	2	95	45	47	80	175	26	2	2	NIL
" E+	"	1.7	50	48	96	12	62	77	1.7	30	16
" E	"	1.7	50	49	98	15	65	75	1.7	26	14
" 4	(NN)"	2	154	21	14	-	154	14	1.7	4	1
Albizzia Faz.	+ RN	1	80	13	16	87	167	8	2.7	5	1.5
falcata "	"	1	75	1	1	43	138	1	2	6	2.5
Curua Km4	"	1	12	9	75	10	22	41	2.7	44	16
" " 5	Sem.fol.	1	21	14	67	8	29	50	2.7	78	28
Albizzia Sant.E.	"	10	90	25	28	70	160	16	3.7	17	2
lebbeck "'57	"	4	45	23	50	11	56	41	3.7	42	10
Curua Km5	Caixa	1	6	6	100	3	9	67	1.7	7	3.5
" E'59	Sem.fol.	2	12	12	100	-	12	100	1.7	35	20
" E'60	"	1	100	85	85	-	100	85	0.7	2	1
" M +	Caixa	2	12	11	92	-	12	92	1.7	52	30
" M	"	2	18	18	100	-	18	100	1.7	44	25
Anani PP	Sem.fol.	1.1	80	39	49	-	80	49	1.5	1.7	0.4
Curua E	RN	2	8	2	25	-	8	25	1.7	7	3
Andiroba PPA	Sem.fol	3.7	70	63	92	16	86	73	2.5	6.2	1
PP E+F	"	3.7	139	134	96	14	153	88	2.5	4.7	0.4
Sant.E	"	3.5	120	21	17	230	350	6	1.7	7	2
CBA F	"	3	84	76	91	11	95	80	3.7	28	7
" J +M	"	3	161	149	93	10	194	77	3.7	18	4
" C	"	3	20	20	100	6	26	76	2.7	28	9
Curua A	Sem.em linhas	-	125 ms	x	x	-	x	x	0.7	5	7
" A	" " covas	-	50	49	98	-	50	98	0.7	4	6
" E +	Sem.fol.	5	50	50	100	7	57	87	1.7	25	12
" E	"	5	50	50	100	3	53	94	1.7	27	13
" 4('58)	Semear.	-	793	159	20	-	793	20	2.5	12	5
" 4('59)	"fol.(20)5		182	180	99	13	195	92	1.7	11	3.5
" 4('60)	Semear.(F)	-	192	162	85	-	192	85	0.6	5	8

Nome e Localidade	Tipo da Muda	1 Altura (dms)	2 Quantidade plantada	3 Quantidade viva	4 viva %	5 Quantidade replantada	6=2+5 Quantidade total usada	7 = 3 x 100 / 6 Indice sobreviventes	8 Idade	9 Altura média (dms)	10= 9 - 1 / 8 R.P.A.
Ang.da mata											
Cur. E	Sem.fol.	6	50	47	94	12	62	75	1.7	27	12
(H.excelsum)M	"	5	80	60	75	34	114	52	1.7	28	13
Cur. M	"	5	120	96	80	49	169	57	1.7	30	15
" N	"	5	40	37	93	1	41	90	1.7	27	13
" 4(59)(KK)	"	4	158	158	100	5	173	97	1.7	11	5
" 4(60)(U)	"	3.5	185	176	95	-	185	95	0.7	5	2
(1)=H.petraeum E	RN	0.5	48	29	60	-	48	60	0.7	2	2
" Ang.pedra											
Cur.E	Sem.fol.	4	100	80	80	23	123	65	0.7	7	4
" M	"	6	100	48	48	25	125	38	0.7	7	1.5
"4(S)	"	2.5	188	127	67	-	188	67	0.7	4	2
" Ang.rajado											
Cur.E	Sem.fol.	2	50	49	98	7	57	86	1.7	14	7
Apuleia praecox E	"	1	9	8	90	-	9	90	0.7	9	11
Cabiuna E	"	4	90	89	99	11	101	88	0.7	11	10
M	"	4	100	86	86	6	106	86	0.7	11	10
Cajuaçu E	"	6	40	28	70	19	59	48	0.7	9	4
Calophyllum antillum Cur.E	RN	4	4	4	100	-	4	100	1.7	21	10
Castanheira Cur.E	"	1	9	8	90	-	9	90	0.7	4	4
Casuarina Faz + caixa cunningham.		1	110	10	9	-	110	9	3.7	18	5
Faz	"	1	110	3	3	-	110	3	2.5	3.6	1
Cedro(Ecua.)PP	Sem.fol.	3	50	36	72	22	72	50	1.5	5	1.4
CPA C	"	3	30	16	-	22	52	31	2.7	15	4
" F	"	4	10	7	70	1	11	64	3.7	40	10
" T	"	4	10	9	90	6	16	56	3.7	27	6
Cur.E + tocos		0.5	23	21	92	-	23	92	1.7	38	22
E	"	0.5	24	18	75	-	24	75	1.7	30	17
Cedro(Fond.)C	Sem.fol.	4	40	38	95	6	46	83	2.7	26	8
Cedro(Cur.)E	"	3	50	49	98	-	50	98	1.7	17	8
F	"	3	50	49	98	4	54	91	1.7	15	7
N	"	3	39	34	87	4	43	77	1.7	10	4
4('59)(JJ)tocos		0.5	131	112	85	26	157	72	1.7	10	4
4('60)(N)	RN	0.7	188	38	20	-	188	20	0.7	1	0.5
(+Cup + Para)A3	"	1	200	142	71	6	206	69	0.7	3	3
(+Para)A3	"	1	200	158	79	6	206	77	0.7	3	3
M	"	1	48	27	56	2	50	54	0.7	4	4
Cedro rosa Cur.E	"	1	24	19	79	-	24	79	0.7	3	3

Nome e Localidade	Tipo da Muda	1 Altura (dms)	2 Quantidade plantada	3 Quantidade viva	4 viva %	5 Quantidade replantada	6= 2 + 5 Quantidade total usada	7 = 3 x 100 / 6 Indice sobreviventes	8 Idade	9 Altura média (dms)	10= 9 - 1 / 8 R.P.A.
Copaíba Cur.E	RN	2	50	49	98	18	68	72	1.7	9	4
M +	"	2	40	26	65	17	57	46	1.7	14	7
M	"	2	60	46	76	39	99	46	1.7	7	3
N	"	2	39	30	77	8	47	64	1.7	9	4
A (QQ)	"	2	153	143	93	25	178	80	1.7	5	2
Cuiarana Cur.E	"	1	49	36	72	8	57	63	0.7	2	1.5
M M	"	1	48	36	73	7	55	65	0.7	3	3
Cumaru PP	Sem.fol.	2	10	7	70	-	10	70	3	3.8	0.6
Cur.D	"	2	40	38	95	-	40	95	2.7	12	4
E	"	9	20	12	60	4	24	50	1.7	27	10
N	"	6	39	30	77	-	39	77	1.7	10	2
Cupiuba PP(E)	"	2.5	11	8	72	10	21	38	2.5	5	1
Cur.km5	tocos	0.5	87	87	100	25	112	77	1.7	33	19
A	Sem.fol.	4	150	90	60	125	275	33	0.7	4	NIL
(+Cedro + Para)A	"	4	200	10	5	-	200	5	0.7	3	-1.5
"	Sem.fol.	3	50	46	92	9	59	78	1.7	39	21
M +	"	4	100	87	87	56	156	56	1.7	40	21
M	"	4	120	109	91	77	197	56	1.7	40	21
Eucalyptus											
alba Faz (NC)+	caixa	1.5	50	failed.		Replanted with E.citriodora					
" (NC)+	"	1.5	20	11	55	34	54		2.7	14	5
" "	"	1.5	20	8	40	19	39	20	1.5	not measured	
" "	"	1.5	50	failed.		Replanted with E.citriodora					
" (60)+	"	2	49	17	35	-	49	35	0.7	7	7
" Nur	"	2	14	2	14	-	14	14	0.7	13	6
Sant.58	"	3	90	54	60	40	130	42	2.7	77	27
60	"	1.5	60	52	87	-	60	87	0.7	18	24
Cur. km4	"	3	25	24	96	3	28	86	2.7	55	19
" 5	"	3	27	failed		49	76		"sauva"		
E	"	2	100	95	95	-	100	95	0.7	23	30
M	"	1	100	95	95	-	100	95	0.7	32	44
A	"	2	200	188	94	-	200	94	0.7	28	37
A	Torr.Paul.	1	25	19	76	-	25	76	0.7	31	43
E.botayoides											
E	caixa	2	25	24	96	-	25	96	0.7	29	40
E.camaldulensis											
Faz.+	"	1.5	30	20	67	47	77	26	3.7	24	6
"	"	1.5	30	10	33	32	62	16	3	1.9	0.4
"(NC)	"	1.5	13	6	40	16	29	20	2.5	2.3	0.8
"(60)	"	1.5	30	18	60	-	30	60	0.7	3.5	3
" Nur	"	2	14	3	21	-	14	21	0.7	5	4
Sant.58	"	2	45	20	45	24	69	29	2.7	85	31
" 59 +	"	2	30	20	67	8	38	53	1.7	55	31
" "	"	2	30	19	64	8	38	50	1.7	65	37
" 60	"	1.5	60	39	65	-	60	65	0.7	14	18

Nome da Localidade	Tipo da Muda	1 Altura (dms)	2 Quantidade plantada	3 Quantidade viva	4 viva %	5 Quantidade replantada	6=2+5 Quantidade total usada	7 = 3 x 100 / 6 Indice sobreviventes	8 Idade	9 Altura média (dms)	10 = 9 - 1 / 8 R.P.A.
(cont.)											
E.camaldulensis	caixa										
Cur.km4	"	2	24	7	29	5	29	23	2.7	25	9
A	"	1	100	97	97	-	100	97	0.7	29	40
A	Torr.Paul.	1	25	19	76	-	25	76	0.7	30	41
E	caixa	1	100	88	88	-	100	88	0.7	23	32
M	"	1	100	92	92	-	100	92	0.7	25	34
E.citriodora											
Faz.57+	"	2	140	34	85	22	62	55	3.7	58	15
" "	"	2	40	24	60	32	72	33	2.5	5.8	2.1
"(NC)+57	"	2	50	35	70	15	65	54	2.5	16	6
" " 57	"	2	50	35	70	91	141	25	2.5	2.7	0.6
" " +59	"	1	39	16	40	48	87	40	2.7	2.5	2
" " 59	"	1	34	15	45	17	51	29	0.7	1.8	1.1
" " +60	"	2	60	killed		-	60	by fire			
"Nur 60	"	2	14	4	29	-	14	29	0.7	12	15
Sant '58	"	3	134	77	57	41	175	44	2.7	49	17
" 59+	"	2	150	90	60	52	202	41	1.7	50	28
" 59	"	2	150	40	26	87	237	17	1.7	31	17
" 60	"	2	60	13	22	-	60	22	0.7	9	10
Cur.M+	vasos	4	105	98	93	8	113	87	1.7	90	50
M	"	4	105	100	95	7	112	89	1.7	90	50
M+	caixa	3	120	93	78	26	146	64	1.7	90	51
M	"	3	120	103	86	28	148	69	1.7	90	51
E	"	2	50	48	96	10	60	80	1.7	70	40
A	sem.en linhas	-	125 ms.	x	x	-	x	x	0.7	6	8.5
A	" " covas	-	50	38	76	-	50	76	0.7	13	20
E.deglupta											
Faz(NC)+	caixa	1	30	3	10	-	30	10	0.7	2	1.8
"	"	1	30	-	-	-	30	F	0.7	-	-
Cur. E	"	1	25	25	100	2	27	92	1.7	65	38
E.drepano-phylla Faz +	"	1.5	10	6	60	-	10	60	3.7	54	14
"	"	1.5	10	3	30	-	10	30	2.5	3.3	1
E.grandis											
Cur.E	"	3	25	24	96	-	25	96	0.7	26	33
"	"	2.5	45	36	80	-	45	80	0.7	21	26
E.maculata											
Sant'60	"	1	50	0	0	-	50	0	0.7	failed	
Cur.E	"	1	18	16	89	4	22	73	0.7	17	23
"	"	1	30	13	43	-	30	43	0.7	17	23
E.maidenii											
Faz.Nur	"	1	14	2	14	-	14	14	0.7	3	3
" +	"	1	50	5	10	-	50	10	0.7	2	1.5
Cur.E	"	1	25	17	68	11	36	47	0.7	15	20
E.robusta											
Faz +	"	1	10	2	20	3	12	15	3.7	burnt back	
"	"	1	10	1	10	4	14	7	2.5	4	1.2

Nome e Localidade	Tipo da Muda	1 Altura (dms)	2 Quantidade plantada	3 Quantidade viva	4 viva %	5 Quantidade replantada	6=2+5 Quantidade total usada	7 = 3 x 100 / 6 Indice sobreviventes	8 Idade	9 Altura média (dms)	10 = 9 - 1 / 8 R.P.A
(cont.)											
E.saligna	Cur.E. caixa	2	25	25	100	1	26	97	1.7	90	52
A	"	1	100	97	97	-	100	97	0.7	26	36
A	Torr.Paul.	1	25	23	92	-	25	92	0.7	30	41
M	caixa	2	100	96	96	-	100	96	0.7	28	38
E.tereticornis											
Faz. NC +	"	1.5	20	2	10	-	20	10	0.7	2.6	2
" "	"	1.5	20	2	10	-	20	10	0.7	1.6	0.2
Faz.Nur	"	2	14	1	7	-	14	7	0.7	6	5
" (60)+	"	2	60	11	18	-	60	18	0.7	5	4
Sant 58	"	2	45	31	69	22	67	46	2.7	39	14
" 60	"	2	60	3	5	-	60	5	0.7	6	6
Cur.km4	"	3	21	6	28	7	28	21	2.7	55	19
" A	Torr.Paul.	1	25	25	100	-	25	100	0.7	33	46
" E	caixa	2	100	99	99	-	100	99	0.7	23	30
" M	"	3	100	97	97	-	100	97	0.7	26	32
Faveira bolacha											
Cur.E	Sem.fol.	10	16	15	94	-	16	94	1.7	31	12
Gmelina arborea											
PP (E+F)	tocos	0.5	20	17	85	19	39	43	2.5	3.9	1.4
Faz. +	Sem.fol.	7	150	144	92	-	150	92	burnt	back	
(Ghana)	"	7	150	135	90	49	189	72	3	5.8	-0.4
Sant.En.	"	12	60	54	90	14	74	72	3.7	36	7
" '57	"	7	60	60	100	10	70	85	3.7	54	13
" '60	"	2	89	87	97	-	89	98	0.7	7	7
Cur.A	"	2	181	176	97	-	181	97	0.7	11	13
E	"	3	100	99	99	-	100	99	0.7	10	10
M +	tocos	0.5	25	25	100	-	25	100	1.7	39	23
M	"	0.5	25	25	100	-	25	100	1.7	36	21
(Paq.) E +	"	0.5	12	12	100	-	12	100	1.7	26	15
E	"	0.5	12	12	100	-	12	100	1.7	25	14
(Ghana) M	Sem.fol.	3	100	100	100	-	100	100	0.7	17	20
Grevillea banksii E	RN	2	52	48	93	5	57	85	0.7	13	16
M	"	2	48	36	75	18	66	55	0.7	11	13
Guariúba											
(Cur.) D	Sem.fol.	8	23	27	74	-	23	74	0.7	8	NIL
E	"	3	50	29	58	33	83	35	1.7	13	6
4 (Q)	"	3	195	99	51	-	195	51	0.7	5	3
(CBA) 4 (18)	"	2.5	190	165	87	-	190	87	0.7	3	0.7
Itauba Cur.Km5	RN	1	25	25	25	7	32	100	2.7	19	7
D	"	1	94	85	91	49	143	60	2.7	7	2
E+	Sem.fol.	5	20	13	65	21	41	32	1.7	12	4
E	"	5	20	11	55	22	42	26	1.7	7	1
Jacareuba											
PP	"	2.7	40	25	62	-	40	62	0.7	3.5	1
Cur. E	RN.	2	55	55	100	7	62	89	1.7	21	11
4 (HH)	"	2	152	131	86	33	185	71	1.7	4	1

Nome e Localidade	Tipo da Muda	1 Altura (dms)	2 Quantidade plantada	3 Quantidade viva	4 viva %	5 Quantidade replantada	6=2+5 Quantidade total usada	7 = 3 x 100 / 6 Indice sobreviventes	8 Idade	9 Altura média (dms)	10 = 9-1 / 8 R.P.A.
Jarana CBA C	RN	2	6	6	100	5	11	55	2.7	7	2
Cur. E	"	1	10	9	90	3	13	68	1.7	14	8
4 (SS)	RN e Sem. om covas	1	>90	18	20	90	>180	10	1.7	6	3
Louro branco (CBA)											
Cur. E	RN	2	25	8	32	36	53	15	1.7	8	3.5
(") E	"	2	30	11	35	37	67	16	1.7	7	3
Maçaranduba											
Cur. E	"	0.5	48	45	94	-	48	94	0 7	1	0.7
Maesopsis amenii Cur.E	Sem.fol.	3	12	9	75	1	13	68	1.7	38	21
Mandioqueira											
lisa Cur. D	"	12	47	3	6	-	47	6	0.7	9	- 4
E	"	10	50	4	8	-	50	8	0.7	8	- 2
E	tocos	0.5	47	3	6	-	47	6	0.7	8	10
4 (W)	Sem fol.	8	187	39	21	-	187	21	0.7	8	NIL
Marupá											
Faz.Cur.+	RN	1	100	51	51	29	129	40	2.7	12	4
"	"	1	100	60	60	32	132	46	2	1.5	0.2
" NC +	"	1	40	30	75	29	69	44	1.5	1.7	0.6
" "	"	1	40	32	80	26	66	46	1.5	2.4	1.3
Sant En.	"	1	30	0	0	22	52	0	failed		
" '58	"	1	45	33	73	8	53	62	2.7	43	16
Cur.km4	"	1	98	94	95	101	179	52	2.7	53	19
km5	"	1	202	173	86	34	236	74	2.7	68	25
Cur. E+	tocos	0.5	25	25	100	2	27	93	1.7	38	22
E	"	0.5	25	21	84	2	27	77	1.7	37	21
M+	"	0.5	150	?	?	18	168	?	1.7	?	?
M	"	0.5	150	?	?	8	158	?	1.7	?	?
N	"	0.5	39	35	90	3	42	83	1.7	29	17
Morototo											
Faz.NC +	RN	1.5	80	5	6	109	189	6	2.7	11	3.5
"	"	1.5	90	3	3	33	123	2	1.5	3.2	1
Cur.km4	"	1.5	99	88	88	179	278	32	2.7	12	4
"5	"e Sem.fol.	1	102	83	83	90	192	43	2.7	35	13
Nauclea diderichii Cur.E	vasos	1	6	4	67	1	7	57	1.7	5	2.5
Parapara											
Faz. +	RN	0.5	100	4	4	90	210	2	2	2.5	1
"	"	0.5	100	4	4	105	205	2	1.5	1.2	0.5
Sant '58	"	2	75	9	12	107	192	5	2.7	29	10
'59	Sem fol.	4	75	41	87	33	108	38	1.7	41	22
Cur.km4	RN	2	100	99	99	123	233	42	2.7	45	16
km5	RN e sem fol.	2	96	96	100	86	182	52	2.7	66	24

Nome e Localidade	Tipo da Muda	1 Altura (dms)	2 Quantidade plantada	3 Quantidade viva	4 viva %	5 Quantidade replantada	6 =2+5 Quantidade total usada	7 = 3x100/6 Indice sobre viventes	8 Idade	9 Altura média (dms)	10= 9-1/8 R.P.A.
(cont.)											
Parapara A3	tocos	0.5	150	135	90	2	152	89	0.7	7	9
(+cedro) "	"	0.5	200	174	87	3	203	86	0.7	6	8
(+"+cup.)"	Sem.fol.	6	185	117	79	-	185	79	0.7	9	4
E	tocos	0.5	48	48	100	9	57	85	1.7	41	24
M+	"	0.5	28	23	83	19	47	49	1.7	44	26
M	"	0.5	21	21	100	9	30	70	1.7	41	24
M(60)	"	0.5	36	35	97	-	36	97	0.7	9	12
M(60)	Sem.fol.	6	36	32	89	5	41	78	0.7	9	4
Pau d'arco E	"	3	48	47	98	-	48	98	0.7	7	6
Paineira E	RN	1	9	7	78	-	9	78	0.7	2	1.5
Pinus caribaea											
Faz +	caixa	1	189	65	34	136	325	20	1.7	2	0.6
"	"	1	195	56	28	-	195	28	1	1.5	0.7
" +	RN	1	189	148	78	110	299	49	1.7	5	2.3
"	"	1	200	76	38	18	218	35	1	1.2	0.2
Faz.Nur.	caixa	1	48	36	75	9	57	63	1.7	15	8
Cur.Km4+	"	1	18	5	28	10	28	18	1.7	5	2.3
('59) E+	RN	1	49	48	98	53	102	47	1.7	18	10
" E	RN e "	1	50	48	96	48	98	49	1.7	17	9
" M+(TSP)	RN	1	100	95	95	45	145	65	1.7	19	11
" M+(fos)	"	1	21	17	81	6	27	63	1.7	16	9
" M	"	1	80	75	94	41	121	62	1.7	18	10
('60) A1+(fos)	caixa	1	200	198	99	4	204	97	0.7	5	6
" A2+(TSP)	RN	1	400	253	63	65	465	54	0.7	3	3
" A2+(fos)	"	1	400	261	65	65	465	56	0.7	4	4
" A2	"	1	800	486	61	130	930	52	0.7	2	1.5
" M +(fos)	"	2	100	67	67	47	147	45	0.7	4	3
" M	"	2	100	54	54	48	148	36	0.7	2	NIL
" M +(fos)	caixa	2	100	97	97	-	100	97	0.7	4	3
" M	"	2	100	99	99	-	100	97	0.7	5	4
P.occidentalis											
Faz. +	RN e "	1	200	16	8	29	229	7	1	1.1	0.1
" Nur.	caixa	1	48	3	6	7	55	5	1.7	9	5
Faz	RN	1	200	18	9	30	230	8	1	1.1	0.1
P.merkusii											
Cur.A+(fos)	caixa	1	200	184	92	-	200	92	0.7	1	NIL
A+(fos)	RN	1	200	106	53	10	210	51	0.7	0.5	-0.7
E+(fos)	caixa	1	50	48	96	-	50	96	0.7	1	NIL
E	"	1	50	48	96	1	51	95	0.7	1	NIL
E+(fos)	RN	1	50	31	62	11	61	51	0.7	1	NIL
E	"	1	50	34	68	11	61	55	0.7	1	NIL
M+(fos)	caixa	1	50	33	66	-	50	66	0.7	1	NIL
M	"	1	50	35	70	-	50	70	0.7	1	NIL
M+(fos)	RN	1	50	9	18	7	57	16	0.7	0.5	-0.7
M	"	1	50	1	2	7	57	1	0.7	0.5	-0.7
Piquiá CBA C	Sem.fol.	3	5	4	80	3	8	50	2.7	20	6
Cur.D	"	4	16	3	19	6	22	14	2.7	18	6
E	"	5	16	11	69	6	22	50	1.7	32	16

Nome e Localidade	Tipo da Muda	1 Altura (dms)	2 Quantidade plantada	3 Quantidade viva	4 viva %	5 Quantidade replantada	6=2+5 Quantidade total usada	7 = 3x100/6 Indice sobreviventes	8 Idade	9 Altura média (dms)	10= 9-1/8 R.P.A.
Quaruba Cur.D	RN	2	17	16	94	1	18	89	1.7	9	4
E+	"	2	45	16	36	87	132	12	1.7	25	14
E	"	2	54	15	28	100	154	10	1.7	20	11
4 (GG)	"	2	162	151	93	5	167	91	1.7	11	5
Santa Barbara											
E	"	1	9	9	100	-	9	100	0.7	2	1.5
Schizolobium excelsum E	Sem.fol.	2	6	5	83	-	6	83	0.7	12	14
Sobrasil E	RN	1	49	22	44	-	49	44	0.7	9	11
M	"	1	60	0	0	-	60		failed		
Sapucaia E	Sem.fol.	7	6	5	83	-	6	83	0.7	6	-1.5
Tatajuba E	caixa	2	49	49	100	-	49	100	0.7	17	21
E	Sem.fol.	4	49	48	98	4	53	91	0.7	17	19
M	vasos	2	48	43	90	-	48	90	0.7	10	11
M	RN	4	48	43	90	4	52	83	0.7	7	4
4(M)	misturada	1.3	194	153	79	-	194	79	0.7	4	4
Tectona grandis Sant.'58	tocos	0.5	45	33	73	-	45	73	2.7	51	19
Terminalia ivorensis PP	"	0.5	21	16	75	5	26	62	2.5	3.3	1.1
Faz.(57)+	Sem.fol.	6	50	22	44	9	59	37	3.7	burnt	
"	"	6	50	49	98	7	57	86	3	8	1.1
(vice P.occidentalis)											
Faz.+(60)	Sem.fol.	2	115	killed		-	115		by fire		
Faz.Nur	"	2	44	44	100	-	44	100	0.7	12	14
CBA F	"	5	10	6	60	1	11	55	3.7	65	16
J + M	"	5	30	18	60	2	32	57	3.7	24	5
Cur.A1	RN	2	200	190	95	23	223	85	0.7	6	6
E	"	3	100	98	98	-	100	98	0.7	7	6
M	"	2	100	99	99	-	100	99	0.7	8	10
Sant.60	"	1.5	59	0	0	-	59	0	0.7	failed	
Terminalia superba A1	Sem.em linhas	-	125 ms	x	x	-	x	x	0.7	5	7
A1	" "covas	-	50	41	82	-	50	82	0.7	5	7
E	RN	1	100	45	45	6	106	42	0.7	4	4
M	"	1	100	64	64	7	107	60	0.7	5	6
A1	"	1	300	208	69	23	323	65	0.7	5	7
Sant.60	"	1	142	0	0	-	142	0	0.7	failed	
Ucuuba PP	Sem.fol.	2.5	170	147	85	80	25	59	1.5	5	1.8
Cur.D	"	2	33	27	82	33	66	41	1.7	11	5
(CBA) E	"	6	48	42	87	13	61	68	1.7	14	5
(Cur.)E	"	4	48	18	38	-	48	38	1.7	15	7
(Igapo) E	"	4.5	48	45	93	1	50	91	1.7	12	4
(CBA + ") 4(z)	"	5	148	137	92	14	162	85	1.7	7	1
Ucuubarana											
E	"	2.5	48	36	75	13	61	59	1.7	11	5

APPENDIX IX

SILVICULTURAL NOTES ON THE PRINCIPAL TERRA-FIRME SPECIES

These Notes summarise, by species, the information which has been collected to date on some 44 of the more important desirables which occur on the terra-firme soils. Unless otherwise stated the information was collected on the Curuá.

There are several gaps. It is hoped that these will be filled in in the course of the next few years. The collection of this information is really part of the duties of the Silvicultural section of I.N.P.A. in Manáus.

Explanatory Notes

Size of Seed

This is only approximate

Very small	under 1 mm	e.g. Cupiuba, Tatajuba
Small	1-5 mm	Cedro, Morototó (frts)
Medium	5-20 mm	Marupá, Parapará, Maçaranduba
Large	20-50 mm	Ucuuba, Castanheira, Anani
Very large	over 50 mm	Andiroba, Piquiá, Acapu

Rate of Growth

For natural regeneration (NR) three figures or ranges are given, viz. "NR. 10-6, 5, 2". The first is average growth (in dm) in the open or under a well opened canopy (100-75% open); the second is under a partly opened canopy (50-25%); the third is under closed canopy.

The figures represent the average annual growth in decimeters and must be taken as an indication rather than an exact figure; several are based on only a few observations.

For artificial regeneration (AR) two figures or ranges are given, viz. "AR. 13-10,4-3". The first is for growth (in dm) in the open, and the second for that in enrichment lines.

Where there is none, or no reliable information, a ? is used between the commas.

Types of bark

This is for mature trees; younger trees are often less scaly or less fissured.

Colour of blaze

This is for a fresh blaze. When two colours are given, the second is for the inner bark by the cambium.

SILVICULTURAL CHARACTERISTICS

Local Name – ACAPU

Botanical Name – Vouacapoua americana Ducke

Family – Papilionaceae

Dates of Flowering and Fruiting – Fls. Jan-Feb. '56 Curuá – Frt. June 1959 Curuá

Type of Fruit – Legume, single seeded

Type of Seed – Very large, oval

No. per 100 gr – About 5-8

Viability – Short

Frequency of Seed years – Possibly annual

Germinative capacity – Good when fresh

Time to germinate – 9-10 days

Conditions for, and type of, germination: Hypogeal; shade

Pretreatment of Seed (if necessary): No

Type of root of seedling – Tap

Rate of growth – Slow – AR NIL, 4-nil

Habitat – Understorey on Planalto; widely distributed

Shade tolerance – Tolerant, probably very

Time of leaf – Fall

Natural Regeneration – requirement: Shade

Artificial Regeneration – best type of plant – ? Striplings; not tried as stumps. Does not to well in the open (I.A.N., Castanhal, Curuá E). Suitable for enrichment; should be tried with side shade. Fruit falls at wrong time for direct sowing.

Type of bark – Smooth hor. lines

Type of timber – Hard, dark brown

Colour of blaze – Light brown; hollows in stem

Observations – Not found singly – seed not widely dispersed.

SILVICULTURAL CHARACTERISTICS

Local Name – AGUANO, MOGNO

Botanical Name – Swietenia macrophylla (L.) Jacq.

Family – Meliaceae

Dates of Flowering and Fruiting – Frts. June-July (Tocantins)

Type of Fruit – Capsule

Type of Seed – Medium, winged

No. per 100 gr – 150-200

Viability – Fairly short; remained good after 4 months in refrigerator in vegetable compartment

Frequency of Seed years – Probably annual

Germinative capacity – High when fresh

Time to germinate – 16, 20-30 days

Conditions for, and type of, germination – Hypogeal; not too wet

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Tap; a few fibrous branches

Rate of growth – Fast, in open; very slow in forest – AR 16-14, 1-nil

Habitat – Semi-deciduous forest (Babasu palm); not a true rain forest species; appears to prefer less acid soils (pH6-7)

Shade tolerance – Not very

Time of leaf fall – End of dry season; deciduous for some weeks

Artificial Regeneration – best type of plant: Stumps or striplings; probably best established with a nurse tree because of shoot borer attacks; not suitable for poor soils

Type of bark – Scaly

Type of Timber – Soft; floats

Observations – At João Caelho (Serv.Flor.) appeared to recover quickly from borer and to send up a single new shoot (not branching as Cedro and Andiroba did at Fordlândia). Not heavily attacked at Curuá in first year (19%).

SILVICULTURAL CHARACTERISTICS

Local Name	–	AMAPÁ (doce)
Botanical Name	–	Brosmium paraense Hub.
Family	–	Moraceae
Dates of Flowering and Fruiting	–	Pink fls. Caruá Sept. '58
Type of Fruit	–	Berry, about 5 cm
Type of Seed	–	Medium, flat
Frequency of Seed years	–	? annual
Germinative capacity	–	Nil – Curuá
Rate of growth	–	Probably fairly slow
Habitat	–	Terra firme; a dominant or emergent
Shade tolerance	–	Tolerant
Type of bark	–	Roughish; lenticels
Type of Timber	–	Soft
Colour of blaze (and latex)	–	Light brn., much latex (? sweet)
Observations	–	There are at least two main species, Amapa doce and Amapa amargo depending on whether the latex is sweet or bitter; the latter is probably Parahacornia amapá (Apocyn.)

SILVICULTURAL CHARACTERISTICS

Local Name - A N A N I

Botanical Name - Symphonia globulifera L. or Moronobea coccinea

Family - Guttiferae

Dates of Flowering and Fruiting - Frts. April-May '57 Macapá

Type of fruit - ? Capsule

Type of Seed - Medium roundish

Viability - Fair if seed dried

Germinative capacity - Good (fresh)

Time to germinate - 1 - 2 weeks; 5 months when seed dried and kept 2 months.

Conditions for, and type of germination - Hypogeal. Likes plenty of moisture.

Pretreatment of Seed (if necessary) - No, for immediate sowing; Advisable to wash clean and dry for keeping.

Rate of growth - Slow
NR ?,3,? AR 3,?

Habitat - Primarily swamps, igapó but does occur on terra firme on planalto; gets up into the upperstorey.

Shade tolerance - Tolerant

Type of bark - Fissures, thin and shallow. Type of Timber - Medium heavy

Colour of blaze (and latex) - Lt.brn; yellow sticky latex

Observations - Characterised by stilroots, rather like Rhizophora (mangrove)
The varzea species is probably Symphonia and that on the terra firme is probably Moronobea. There may be a third species.

SILVICULTURAL CHARACTERISTICS

Local Name - A N D I R O B A

Botanical Name - Carapa guianensis aubl.

Family - Meliaceae

Type of fruit - Capsule, 4-locules; frt.size of tennis balls; 6-8 seeds

Type of seed - Very large No.per100 grs. v. few.

Viability - Poor

Frequency of seed years - Annual

Germinative capacity - Good when fresh, goes off quickly (? 1 month)

Time to germinate - 5 - 17 days

Conditions for and type of germination - Hypogeal

Pretreatment of seed - No

Type of root of seedling - Fibrous

Rate of growth - Fast in open, fair in shade
AR 12, 5-4

Habitat - Swamps, varzea and igapó, but also found on terra firme, usually somewhat concentrated.

Shade tolerance - Fairly tolerant

Natural Regeneration - requirements - Probably shade

Artificial Regeneration - best type of plant - Direct sowing as soon as seed falls, coverwell; striplings, transplanting unnecessary in nursery. Attacked heavily by shoot borer in open - Fordlândia.

Type of bark - Scaly; long irregular Type of Timber - Medium-soft; floats

Colour of blaze - Red-pink

Observations - Not such a good timber as Mahogony or Cedro, but well worth encouraging as it appears a little more tolerant of shade and easy to establish.

SILVICULTURAL CHARACTERISTICS

Local Name ANGELIM DA MATA

Botanical Name - Hymenolobium excelsum Ducke

Family - Papilionaceae

Dates of flowering and fruiting - Seed fell Curuá '58

Type of fruit - Legume 1-seeded; fruit-slightly winged

Type of seed - Medium, flat

Frequency of seed years - Not annual

Germinative capacity - Fairly good

Time to germinate - 12 days

Pretreatment of seed - No

Type of root of seedling - Fibrous (not much); tap root develops after few months; sometimes had nodules (5x10 mm)

Rate of growth - NR 15,?,2. AR 15-12, 13-5
Fairly fast in open; very slow where canopy not open

Habitat - Planalto and Flanco; an emergent; rare

Shade tolerance - Fairly tolerant, but stands full light

Natural regeneration requirements - Shade not essential; appears along road sides; abundant in forest under seed trees; appears in exploited areas.

Artificial Regeneration - best type of plant. Naked rooted or small striplings; not tried as stumps. Probably suitable for enrichment if lines well opened.

Type of bark - Scaly, rough (lenticels)

Type of Timber - Hard; not fully tested but said to be better than Angelim pedra.

Colour of blaze - Brown to pink brn; little dk red gum.

Observations - A species of some silvicultural promise; natural seedlings transplant fairly well in the nursery and these take well later in the field in the open or in enrichment lines. There is another species, H. petraeum which is very rare at the Curuá; there may be a third.

SILVICULTURAL CHARACTERISTICS

Local Name - ANGELIM PEDRA

Botanical Name - Dinizia excelsa Ducke

Family - Minosaceae

Dates of flowering and fruiting - Frts. Apr-May, Curuá '59

Type of fruit - Legume - few seeds

Type of seed - Medium, flat No.per 100 grs. ? 200

Frequency of seed years - Probably annual

Germinative capacity - Fairly good

Time to germinate - 8 days

Conditions for and type of germination - Epigeal; light

Pretreatment - No

Type of root of seedling - Tap, few fibrous branches

Rate of growth - Not very fast
NR 3, 1.5, 1.2 AR 4-1.5, 2

Habitat - Terra firme on planalto or where some clay mixed with sand on flanco. One of the principal emergents.

Shade tolerance - Not tolerant

Time of leaf fall - Middle of rainy season

Natural Regeneration requirements - Light; appears on sides of roads where soil disturbed and in exploited areas.

Artificial Regneration - best type of plant. Only small striplings tried Small natural seedlings transplant fairly well in the nursery.

Type of bark - Scaly, large (15-20 cms) Type of timber; Hard; light brown with some dark boarder patches.

Colour of blaze - Mottled, brown to pink brown.

Observations - One of the largest of the planalto trees with a spreading crown and not very straight stem. Large and overmature trees can usually be burnt down near the end of the dry season; the stem may burn for a month and the roots for two months.

SILVICULTURAL CHARACTERISTICS

Local Name	-	ANGELIM RAJADO
Botanical Name	-	Pithecolobium racemosum Ducke
Family	-	Mimosaceae
Dates of Flowering and Fruiting	-	Fls. Aug. '58 C.B.A.
Type of Fruit	-	Legume
Type of Seed	-	Small
Pretreatment of Seed (if necessary)		No
Rate of growth	-	Slow
Habitat	-	An understorey tree at the Curuá, not reaching timber size
Shade tolerant	-	Tolerant
Artificial Regeneration - best type of plant:		Only tried as small striplings; took well
Type of Timber	-	Heavy; varigated
Observations	-	The plants put out in the Curuá trial plot were transplants from self-sown seedlings from a shade tree in the nursery.

SILVICULTURAL CHARACTERISTICS

Local Name – ARARACANGA

Botanical Name – Aspidosperma alba (Vahl) R.Ben.

Family – Apocynaceae

Dates of Flowering and Fruiting – Frt. Nov. '59 Curuá

Type of Fruit – Folliole

Type of Seed – Medium, flat, winged

No. of seed per 100 gr: ? 10–15 seeds

Time to germinate – 26 days

Pretreatment of Seed (if necessary) No

Rate of growth – Probably slow

Habitat – Uncommon on the Planalto; in the upperstorey

Shade tolerance – ? fairly

Natural Regeneration – requirements: ? light; some seedling have appeared on the roadside where there are a couple of seed trees.

Artificial Regeneration – best type of plant: Not yet tried

Type of bark – Few scales

Colour of blaze – Pink-brn; brittle; latex not obvious

Observations – Bark turns pink after abrasions.

SILVICULTURAL CHARACTERISTICS

Local Name	-	AROEIRA (or MUIRACATIARA)
Botanical Name	-	Astronium lecointei Ducke, A. cf ulei Matt.
Family	-	Anacardiaceae
Habitat	-	One of the tallest, but small crowned, trees on the Planalto. Uncommon.
Shade tolerance	-	? fair

Artificial Regeneration - best type of plant: seed not yet collected.

Type of Timber	-	Fairly heavy; generally varigated
Observations	-	The log is susceptible to cerambycid attack, especially on the lower side when not barked. Probably has the tallest clean bole of any tree in the planalto forest.

SILVICULTURAL CHARACTERISTICS

Local Name – BREU - BRANCO, MANGA AND PRETO

Botanical Name – Protium - about 6 species

Family – Burseraceae

Dates of Flowering and Fruiting – B. branco fls. Oct. Curuá

Type of Fruit – Follicle

Type of Seed – Medium; roundish

Frequency of Seed years – Probably scattered

Germinative capacity – Probably good

Conditions for, and type of, germination: Shade

Pretreatment of Seed (if necessary): No

Rate of growth – Slow, in the forest

Habitat – One of the commonest groups in the understorey of the Planalto.

Shade tolerance – Very

Natural Regeneration – requirement: Shade; occurs in gregarious patches.

Artificial Regeneration – best type of plant: Not tried

Type of bark – Rough; sm. scales on B. manga

Type of Timber – Not good. Strong resin smell

Observations – Probably the most important group of weed trees owing their dense crowns and abundant regeneration. Some Breu preto have been determined as Tetragastris or Trattinickia; probably the leaves came from another tree.

SILVICULTURAL CHARACTERISTICS

Local Name	–	BREU SUCURUBA
Botanical Name	–	Tetragastis altissima (Aubl) Suart. or Trattiniekia burserifolia Mart.
Family	–	Burseraceae
Frequency of Seed years	–	Occasional
Germinative capacity	–	Evidently good

Condition for, and type of, germination: Light

Pretreatment of Seed (if necessary): No

Type of root of seedling	–	Tap root
Rate of growth	–	Fast - NR 10-6, 6-5,2
Habitat	–	Occasional on the Curuá planalto; a fairly large tree in the upperstorey
Shade tolerance	–	Probable only fairly

Natural Regeneration – requirements: Light

Artificial Regeneration – best type of plant: Probably stumps; large natural seedlings (0.5–1m) transplanted fairly well in the nursery as stumps in Apr. '60

Type of bark	–	Rough
Observations	–	Came in quite abundantly in the open natural regeneration plots early in 1960 and in the more open exploited area, Curuá.

SILVICULTURAL CHARACTERISTICS

Local Name – CAJUAÇU

Botanical Name – Anacardium giganteum Hanc and Engl.

Family – Anacardiaceae

Dates of Flowering and Fruiting – Fl. buds Apr. '59; Frts. Sept.'57 Apr. '59, Sept. '60

Type of Fruit – Fleshy receptacle (edible) with seed (nut) outside

Type of Seed – Large, curved and tapered

Frequency of Seed years – Irregular – ? 3 years

Time to germinate – 6 days

Pretreatment of Seed (if necessary): No

Type of root of seedling – Tap

Rate of growth – Medium – AR 4, ?

Habitat – Uncommon, co-dominant; nice clean straight bole

Shade tolerance – Tolerant

Natural Regeneration – requirements: Abundant under seed trees

Artificial Regeneration – best type of plant: Striplings did not take well in 1960; try as stumps

Type of bark – Smooth

Type of Timber – Soft, woolly; floats

SILVICULTURAL CHARACTERISTICS

Local Name	–	CASTANHEIRA
Botanical Name	–	Bertholletia excelsa HBK
Family	–	Lecythidaceae
Dates of Flowering and Fruiting	–	Fls. Jan-Feb, Curuá – Frts. fall a year later
Type of Fruit	–	Hard shell, size of croquet ball; does not open normally
Type of Seed	–	Large – "Brazil nut"
Viability	–	Fairly good
Frequency of Seed years	–	Generally annually; none 1960 on Curuá
Germinative capacity	–	Fair
Time to germinate	–	Ages (months)
Pretreatment of Seed (if necessary):		Possibly some stratification
Type of root of seedling	–	Tap
Rate of growth	–	Slow to fairly slow – AR 4,?
Habitat	–	The finest and one of the largest of the emergents on the planalto; very straight stem. Fairly common
Shade tolerance	–	Not very
Natural Regeneration – requirements:		Some animal to open the fruit, but not to eat all the seeds; needs light
Artificial Regeneration – best type of plant:		Only small striplings tried. Grows well in the open at I.A.N. Belém
Type of bark	–	Fissured deep fibrous
Type of Timber	–	Not too hard; sometimes has irregular zone of black"gum"
Colour of claze	–	Lt. brown
Observations	–	Although the timber is quite nice for floors, tables, etc.,the law does not allow the tree to be felled because of its value as a nut producer. It is therefore really an agricultural crop and, as it is being grown and studied at the I.A.N., Belém little attention has been devoted to raising it on the Curuá.

SILVICULTURAL CHARACTERISTICS

Local Name – CEDRO

Botanical Name – Cedrela odorata L.

Family – Meliaceae

Dates of Flowering and Fruiting – Fls. probably about March-Apr.
Frts. open and/or fall about Oct.-Nov.

Type of Fruit – Capsule

Type of Seed – Small , winged

No. per 100 gr. – 250-300

Viability – Not very long (? one month)

Frequency of Seed years – Irregular ? 2-3 years and not all same year

Germinative capacity – Fairly good

Time to germinate – 8-20 days

Condition for, and type of, germination: Hypogeal

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Fibrous

Rate of growth – Fairly fast in open – NR ? 5.4,0.4 AR 8-7,4-3

Habitat – A very rare tree of the upperstorey on the Planalto

Shade tolerance – Not

Time of leaf fall – July-Aug., generally leafless till about Feb.

Natural Regeneration – requirements: Light, freedom from competition

Artificial Regeneration – best type of plant: Small naked rooted (15 cm) or large stumps (1.5-2 cm); not good for enrichment unless line very open; probably will do best with a shade tree because of shoot borer attack

Type of bark: Fissues deep; red-brn. Type of Timber: Fairly soft; floats

Colour of blaze – Red, white streaks

Observations – Almost the only tree exploited from higher up the Curuá. In view of its high value and comparative ease to plant out, experimental work with this species should have top priority, especially on planting with shade trees

SILVICULTURAL CHARACTERISTICS

Local Name – CUIARANA

Botanical Name – Terminalia amazonica (Gmel) Exell and T. tanibouca Smith

Family – Combretaceae

Dates of Flowering and Fruiting – Frts. June '59 Curuá

Type of Fruit – Drupe

Type of Seed – Frt. sown; medium

No. per 100 gr – 100 (dry frts.)

Frequency of Seed years – Sporadic

Germinative capacity – Fairly good

Time to germinate – 4 ½ months

Conditions for, and type of, germination: Epigeal; wet clean soil

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Fibrous

Rate of growth – Slow – AR 3-1.5, ?

Habitat – An occasional tree in the upperstorey, Planalto

Shade tolerance – – Not very

Natural Regeneration – requirements: Light; appeared where water stood in pools on logging track

Artificial Regeneration – best type of plant: Only small naked rooted stock tried

Type of bark – Roughish; fibrous

Type of Timber – Fairly heavy, yellow or green-brown

Observation – There are two species at the Curuá, one with very small leaves.

SILVICULTURAL CHARACTERISTICS

Local Name – CUMARU

Botanical Name – Coumarouna odorata Aubl.

Family – Papilionaceae

Dates of Flowering and Fruiting – Frts. Dec. '58 and June '59 Curuá

Type of Fruit – Fleshy drupe, 1-seeded

Type of Seed – Medium, elongated

Frequency of Seed years – Probably most years

Germinative capacity – High

Time to germinate – 11 days

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Tap, with fibrous laterals

Rate of growth – Moderately fast, in open – AR 10, 4-2

Habitat – A large tree with a short bole, both on the planalto and flanco

Shade tolerance – Fairly tolerant

Natural Regeneration – requirements: Some light; suckers if roots injured

Artificial Regeneration – best type of plant: Probably small striplings or large stumps

Type of bark – Smooth; very few scales

Type of Timber – Very hard

Colour of blaze – Orange cream and dark brn.-speckled; some red sap.

Observations – It is cultivated as an agricultural crop at I.A.N., Belém for the seeds ("tonka bean") for oil; also, as the timber is so hard, little attention has been given to this species on the Curuá.

SILVICULTURAL CHARACTERISTICS

Local Name – CUPIUBA

Botanical Name – Goupia glabra Aubl.

Family – Celastraceae

Dates of Flowering and Fruiting – Fls. buds Apr. Curuá, May Porto Platon
Frts. Aug. '59, Nov.-Dec. '59 Curuá

Type of Fruit – Small black berry (3 mm)

Type of Seed – Very small

Viability – Good after 5 months

Frequency of Seed years – Probably annual

Germinative capacity – Fairly good

Time to germinate – 1 – 1½ months when fresh; 2½ – 3 months after 5 months

Conditions for, and type of, germination – Epigeal; light clean soil

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Fibrous, few

Rate of growth – Fast; NR,10-7,4,2 – AR,21-19. Not suitable for enrichment

Habitat – An upperstorey tree on both the Planalto and Flanco

Shade tolerance – Not tolerant

Natural Regeneration – requirements: Light; seed should be able to reach the mineral soil. Will come up after a light burn

Artificial Regeneration – best type of plant: Stumps are likely to do better than striplings; small naked rooted plants will take but only if conditions remain good after planting.

Type of bark: Scaly

Type of Timber: Fairly heavy

Colour of blaze – Brn. speckled

Observations – Sapwood attacked by ambrosia beetles. A species with great possibilities; timber is of general use; natural regeneration is easy to obtain by opening the canopy and exposing the mineral soil (light burn). With adequate cleanings when young to keep crowns free and supress creepers the stems should be much straighter and the number per hectare very much higher than in the virgin forest.

SILVICULTURAL CHARACTERISTICS

Local Name	–	GUARIUBA
Botanical Name	–	Clarisia racemosa R et P.
Family	–	Moraceae
Dates of Flowering and Fruiting	–	Frts. Curuá about Mar-Apr. '58 C.B.A. June '59
Type of Fruit	–	Drupe, 1-seeded; dioecious
Type of Seed	–	Medium
No. per 100 gr	–	104
Viability	–	Fair
Frequency of Seed years	–	Irregular
Germinative capacity	–	Good
Time to germinate	–	1 month
Conditions for, and type of, germination	–	Epigeal
Pretreatment of Seed (if necessary)	–	No
Type of root of seedling	–	Tap; orange bark
Rate of growth	–	Slow – NR 3,2,1 – AR 6, 3-1
Habitat	–	A rare tree in the lower part of the upperstorey on the Planalto; fairly large bole
Shade tolerance	–	Very tolerant
Time of leaf fall	–	Aug. '58
Artificial Regeneration – best type of plant:		Striplings (small-50cm) do fairly well in forest; poorer in open. Stumps should be tried from larger sized transplants.
Type of bark	–	Rough; red when scraped; hor. lenticels.
Type of Timber	–	Heavy; yellow brown.
Colour of blaze (and latex)		Orange-red; pale yellow; thick latex
Observations	–	Masses of seedlings found under seeds trees (4 at Curuá and 1 at C.B.A.); also scattered through forests – ? by birds; adult trees however only rare; never found in a group.

SILVICULTURAL CHARACTERISTICS

Local Name	–	ITAUBA
Botanical Name	–	Mezilarus itauba (Muisn) Taub. ex Mex.
Family	–	Lauraceae
Type of Fruit	–	Drupe
Type of Seed	–	Medium, oval
No. per 100 gr	–	220
Viability	–	Not good
Frequency of Seed years	–	Irregular
Germinative capacity	–	Fair
Time to germinate	–	4.5 - 5.5 weeks

Conditions for, and type of, germination - Hypogeal

Pretreatment of Seed (if necessary) No

Type of root of seedling	–	Tap, few fibrous laterals
Rate of growth	–	Slow - AR 7-4, 2
Habitat	–	Rare large tree on Planalto; also on Flanco but with a short bole
Shade tolerance	–	? very tolerant; not too happy in the open
Artificial Regeneration	–	best type of plant: Small naked rooted; did well at km 5, Curuá; striplings a year older took badly (Curuá E); try as stumps at 2 years.
Type of bark	–	Scaly, vert. brn
Type of Timber	–	Hard; durable
Colour of blaze	–	Pink-brn; speckled
Observations	–	Very slow in enrichment lines (Curuá D3), considerably faster in open at km5

SILVICULTURAL CHARACTERISTICS

Local Name	-	JACAREUBA
Botanical Name	-	Calophyllum brasiliense Camb.
Family	-	Guttiferae
Type of Seed	-	Medium, round
Viability	-	Almost NIL after over 9 months
Germinative capacity	-	6 weeks, 4 months after 9 months storage

Pretreatment of Seed (if necessary) - No

Type of root of seedling	-	Tap; some fibrous rootlets
Rate of growth	-	Slow in forest, better in open (Curuá E) AR 11,1
Habitat	-	A varzea species, but young plants doing well in open on Planalto
Shade tolerance	-	Tolerant

Artificial Regeneration - best type of plant: Only small striplings tried; took well even in open.

Colour of blaze (and latex) Orange latex

SILVICULTURAL CHARACTERISTICS

Local Name – JARANA

Botanical Name – Eschweilera jarana (Hub.) Ducke

Family – Lacythidaceae

Dates of Flowering and Fruiting – Apr. '58, Nov-Dec. '59 C.B.A.

Type of Fruit – Follicle - few seeds

Type of Seed – Very large-up to tennis balls size

No. per 100 gr – 1.2

Viability – Fair; good in soil

Frequency of Seed years – Irregular

Germinative capacity – Fair

Time to germinate – 1-8 months, some 13-16 months in Sant.Nursery

Conditions for, and type of, germination - Hypogeal

Pretreatment of Seed (if necessary) - No

Typer of root of seedling – Tap; does not transplant easily

Rate of growth – Slow - NR 7, 3, ? AR 8, 3

Habitat – Occasional tree on Planalto; sub-dominant, but some in upperstorey

Shade tolerance – Tolerant; not doing well in open, Curuá E

Natural Regeneration - requirements - Shade

Artificial Regeneration - best type of plant: Sow seeds direct and cover well against rodents

Typer of bark – Fissures deep; fibrous

Type of Timber – Hard, durable

Colour of blaze – Light brn.; yellowish

SILVICULTURAL CHARACTERISTICS

Local Name – JUTAI-AÇU or JATOBA (Belém)

Botanical Name – Hymenaea coubaril L.

Family – Caesalpinaceae

Dates of Flowering and Fruiting – Frts.C.B.A. Oct '56

Type of Fruit – Legume

Type of Seed – Large; some flesh

Viability – Fair; good in soil

Frequency of Seed years – ? 2-3

Germinative capacity – Low

Time to germinate – 6-8 months

Condition for, and type of, germination – Epigeal

Pretreatment of Seed (if necessary) – Clean and dry before sowing

Rate of growth – Slow

Habitat – In upperstorey on Planalto

Shade tolerance – ? fairly tolerant

Artificial Regeneration – best type of plant: Not yet tried

Type of bark – Roughish; very hard

Colour of blaze – Red brn. or red

SILVICULTURAL CHARACTERISTICS

Local Name – LOURO CANELA

Botanical Name – Ocotea caniculata (Rich) Mz

Family – Lauraceae

Dates of Flowering and Fruiting – Frts. July '57 and '59

Type of Fruit – Drupe

Type of Seed – Medium

No. per 100 gr – About 100

Viability – Poor

Frequency of Seed years – ? 2 years

Germinative capacity – Fair

Time to germinate – 2 – 3 months

Conditions for, and type of, germination – Hypogeal

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Fibrous

Rate of growth – Slow – NR 5, ?, 1.5 – AR 3, ?

Habitat – A sub-dominant tree on the Planalto

Shade tolerance – Very tolerant

Natural Regeneration – requirements: Shade

Artificial Regeneration – best type of plant: Small striplings have not taken well in the open; not tried for enrichment as slow growing

Type of bark – Scaly; hor. lines and lenticels

Type of Timber – Brown, pleasant smell

Colour of blaze – Red-brn.

SILVICULTURAL CHARACTERISTICS

Local Name – MACACAÚBA

Botanical Name – Platymiscium uleii Huber and other spp.

Family – Papilionaceae

Dates of Flowering and Fruiting – Seed, Museo Goeldi, Belém in Apr.-May

Type of Fruit – Legume, 1-seeded, small wings

Type of Seed – Medium, flat

Viability – Not good

Frequency of Seed years – Possibly annually

Germinative capacity – ? fair

Conditions for, and type of, germination – Epigeal; not known, failed in nurseries but does well under seed tree in Belém. Try leaving on top of soil and in fruits.

Pretreatment of Seed (if necessary) – ?

Type of root of seedling – Tap

Rate of growth – Slow

Habitat – Varzea, normally

Shade tolerance – Probably tolerant

Artificial Regeneration – best type of plant – In Curuá nursery for trial in 1961; seedlings taken from under seed tree in Belém.

Type of bark – Roughish; cream

Type of Timber – Red brown; streaky popular for furniture but heavy

Colour of blaze – Yellow soon turning brn.

Observations – Probably the most popular furniture timber in Belém; also used now for parquet flooring. Efforts should be made to grow this tree on the Planalto; there is one plot of it at I.A.N. Belém, on sandy terra firme soil.

SILVICULTURAL CHARACTERISTICS

Local Name – MAÇARANDUBA

Botanical Name – Manilkara huberi Standl.

Family – Sapotaceae

Dates of Flowering and Fruiting – Fls. Aug. '58 Curuá – Frts. Nov-Feb '58-59

Type of Fruit – Berry – 2-3 seeds

Type of Seed – Medium; flattish

No. per 100 gr – 167

Viability – Fair

Frequency of Seed years – Probably 2-3

Germinative capacity – Fairly good

Time to germinate – 2 months and continuing up to over 6

Conditions for, and type of, germination – Did best on sand, Curuá

Pretreatment of Seed (if necessary) – No

Rate of growth – Very slow – AR 0.7,?

Habitat – A slender emergent on Planalto, and Flanco "alto"

Shade tolerance – Very tolerant

Natural Regeneration – requirements – Shade

Artificial Regeneration – best type of plant: Only tried as small naked rooted plants, which took very well.

Type of bark – Fissure – deep

Type of Timber – Hard, dark red-brn.

Colour of Blaze (and latex) Dark red; white latex

Observations – A durable timber used for constructions also for shingles; appears to be relatively evenly and widely distributed in all size classes.

SILVICULTURAL CHARACTERISTICS

Local Name	–	MANDIOQUEIRA ASPERA (or ESCAMOSA) previously called "QUARUBA"
Botanical Name	–	Quales sp. probably Q. paraense Ducke or homosepela
Family	–	Vochysiaceae

Dates of Flowering and Fruiting – Fls. Jan-Mar. '60, Curuá

Type of Fruit	–	Capsule 3 locules
Type of Seed	–	Medium; small wing
Frequency of Seed years	–	Irregular

Conditions for, and type of, germination – Shade

Rate of growth	–	Slow
Habitat	–	A well-shaped dominant of the Planalto
Shade tolerance	–	Tolerant; appears not to like full light when young
Time of leaf	–	Fall

Natural Regeneration – requirement: Shade

Artificial Regeneration – best type of plant: Not yet tried

Type of bark	–	Rough or scaly
Type of Timber	–	Red brown; with some occasional fine white streaks
Colour of blaze	–	Dark brown
Observations	–	Quite definitely a different species from Mand. lisa – bark, fruit, seedlings, young leaves and timber are all different. A species of considerable promise; with a nice timber very easy to saw. Regeneration much less common than that of Mandioqueira lisa.

SILVICULTURAL CHARACTERISTICS

Local Name – MANDIOQUEIRA LISA

Botanical Name – Quales sp., probably Q. albiflora Warm, or Q. acuminata

Family – Vochysiaceae

Dates of Flowering and Fruiting – Grn. frts. Feb. '59; ripe Apr. '59

Type of Fruit – Capsule 3-locules

Type of Seed – Small, small wing

Viability – Probably fair

Frequency of Seed years – ? irregular but seeded in 1958 and 1959 Curuá

Germinative capacity – Fair

Time to germinate – 4 weeks

Condition for, and type of, germination – Epigeal, shade (some anyway)

Treatment of Seed (if necessary) – No

Type of root of seedling – Fibrous; small ones trahsplant well to nursery

Rate of growth – Slow – NR 10, 4, 2 AR ?, NIL

Habitat – A well-shaped dominant of the Planalto

Shade tolerance – Tolerant; appears not to like full light when young

Natural Regeneration – requirements: Shade

Artificial Regeneration – best type of plant: Ball – should be raised in a container; failed as stumps and striplings in open, though striplings took fairly well in enrichment lines; they died back in the dry season

Type of bark – Smooth; lenticels

Type of Timber – Yellow-brown

Colour of blaze – Very dark brown

Observations – Saws very easily but tends to twist

SILVICULTURAL CHARACTERISTICS

Local Name – MARUPÁ

Botanical Name – Simaruba amara Aubl.

Family – Simarubaceae

Type of Fruit – Drupe

Type of Seed – Medium; oval

Frequency of Seed years – One known in five years

Germinative capacity – Fairly good

Time to germinate – 15 days

Conditions for, and type of, germination – Epigeal

Tratment of Seed (if necessary) – No

Type of root of seedling – Fibrous when small (15 cm), then marked tap root

Rate of growth – Fast – NR ?, 2.5, 2 – AR 25-16, 17 (Curuá plot N)

Habitat – A "secondary"species (capoeira) on both Planálto and Flanco; very rare in virgin forest

Shade tolerance – Not tolerant

Natural Regeneration – requirements: Open or light shade

Artificial Regeneration – best type of plant: Small (15 cm) naked rooted stock, or stumps from large (1-1.5 m) trasplants.

Type of bark – Smoothish, very small vert. fissures

Type of Timber – Very light; floats

Colour of blaze – Orange

Observations – A species to be encouraged owing to its ease of establishment, fast growth and general usefulness as a light soft hardwood. Growing slowly, but doing better than Morototó and Parapará in the Macapá trial plot on poor campos.

SILVICULTURAL CHARACTERISTICS

Local Name	–	MOROTOTÓ
Botanical Name	–	Didymopanax morototoni (Aubl) D. et P.
Family	–	Araliaceae
Dates of Flowering and Fruiting	–	Frts. June '57 Macapá, Aug. '58 Curuá
Type of Fruit	–	? Shizocarp
Type of Seed	–	Small flat; fruit sown
No. per 100 gr.	–	5,900
Viability	–	Fair
Frenquency of Seed years	–	? almost annual
Germinative capacity	–	Fairly good
Time to germinate	–	5-6 weeks
Conditions for, and type of, germination	–	Epigeal; light
Type of root of seedling	–	Fibrous
Rate of growth	–	Medium to fairly fast – NR 15-10, ?, 4-1.5 AR 13-5, not suitable for enrichment
Habitat	–	A slender rare tree in the upperstorey on the Planalto, and on Flanco; a constituent of secondary forest
Shade tolerance	–	Not tolerant
Natural Regeneration – requirements	–	Light
Artificial Regeneration – best type of plant		Probably medium sized (50-70 cm) striplings (well stripped) or stumps from larger transplants.
Type of bark	–	Smooth; fine vert. lines
Type of Timber	–	Very light; floats
Colour of blaze	–	Orange; white streaks
Observations	–	A species to be emcouraged; might be a useful shade tree; stems would probably be straighter when grown with less competition.

SILVICULTURAL CHARACTERISTICS

Local Name – PARAPARÁ (CARAURA near Belém)

Botanical Name – Jacaranda copaia (Aubl) D.

Family – Bignoniaceae

Date of Flowering and Fruiting – Fls. Aug. '58 Curuá; Seed Mar. '59 Curuá

Type of Fruit – Follicle

Type of Seed – Medium; very flat, winged

Viability – Fair

Frequency of Seed years – Perhaps annual

Germinative capacity – High

Time to germinate – 10-35 days

Conditions for, and type of, germination – Light

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Tap

Rate of growth – Very fast – NR 10-7, 3, 1.3 – AR 26-16, not suitable for enrichment

Habitat – An occasional to rare tree in upperstorey of Planalto and Flanco; often common in secondary growth

Shade tolerance – Not very tolerant

Natural Regeneration – requirements – Light

Artificial Regeneration – best type of plant: Stump; but striplings take fairly well

Type of bark – Fissures, thin and shallow

Type of Timber – Very light; floats

Colour of blaze – Brown

Observations – A species to be encouraged because of its ease of establishment both natural and artificial and rapid growth

SILVICULTURAL CHARACTERISTICS

Local Name – PAU AMARELO

Botanical Name – Euxylophora paraensis Hub.

Family – Rutaceae

Dates of Flowering and Fruiting – Seed Feb. '60 Brasilia Road

Conditions for, and type of, germination – ? shade

Rate of growth – Probably slow

Habitat – Occasional on clay soils, east of R. Tocantins

Shade tolerance – Probably tolerant

Type of bark – Scales; square; gen. some horizontal lines

Type of Timber – Yellow; hard

Colour of blaze – Yellow; yellow-brn; speckled

SILVICULTURAL CHARACTERISTICS

Local Name	–	PAU D'ARCO
Botanical Name	–	Tabebuia avelanedea, T. serratifolia (Vahl) (mauve) and Nichols (yell.)
Family	–	Bignoniaceae
Date of Flowering and Fruiting	–	Fls. – yellow June '58 and '60; mauve Aug. '58. Frts. opened about Oct. (yell.)
Type of Fruit	–	Follicle
Type of Seed	–	Medium, flat, winged
Viability	–	Fair
Frequency of Seed years	–	? annual
Germinative capacity	–	Fair
Time to germinate	–	18 days
Conditions for, and type of, germination	–	Fair amount of light
Pretreatment of Seed (if necessary)	–	No
Rate of growth	–	Medium – NR 6, ? , ?
Habitat	–	A very large and tall but rare tree on the Planalto; also on Flanco
Shade tolerance	–	Not very
Natural Regeneration – requirements	–	Some degree of canopy opening necessary
Artificial Regeneration – best type of plant		Not yet tried; stripped natural seedlings (25–40 cm) transplanted well to nursery
Type of bark	–	Fissures, thin and shallow
Type of Timber	–	Hard
Colour of blaze	–	Dark brn., orange

SILVICULTURAL CHARACTERISTICS

Local Name	–	PAU ROSA
Botanical Name	–	Aniba rosaeodora Ducke
Family	–	Lauraceae
Type of Fruit	–	Drupe
Type of Seed	–	Fairly large; oval

Conditions for, and type of, germination – Some light

Pretreatment of Seed (if necessary) – No

Rate of growth	–	Probably slow
Habitat	–	A sub-dominant tree on clay soil, rarely east of R. Tapajós
Shade tolerance	–	Probably not very

Natural Regeneration – requirements – Fairly open

Artificial Regeneration – best type of plant: Not yet tried

Observations	–	This is the tree which yields the valuable pau rosa oil. It should be tried in plantations – see p. 76 – Report.

SILVICULTURAL CHARACTERISTICS

Local Name	–	PIQUIÁ
Botanical Name	–	Caryocar villosum Pers.
Family	–	Caryocaraceae
Dates of Flowering and Fruiting	–	Fls. aug-Sept. yellow – Frts fall Jan. '56; Mar. '60
Type of Fruit	–	Drupe, large 8 – 10 cm
Type of Seed	–	Very large; kidney shape
Viability	–	Good
Frequency of Seed years	–	Probably annual
Germinative capacity	–	Fair
Time to germinate	–	5–6 weeks
Conditions for, and type of, germination	–	Epigeal
Pretreatment of Seed (if necessary)	–	No need to open stone to get out kernel
Rate of growth	–	Medium – NR 10, 6, ? – AR 16, 6
Habitat	–	Short-boled large-crowned dominant on the Planalto
Shade tolerance	–	Not very
Time of leaf fall	–	June, CBA '59; Aug. Curuá '59
Natural Regeneration – requirements	–	Some light; fire probably assists opening of stone
Artificial Regeneration – best type of plant		Only small stripling tried; these take well
Type of bark	–	Fissures, thin; flaky, brittle
Type of Timber	–	Tough and heavy
Colour of blaze	–	Dark to light brown
Observations	–	A valuable timber for heavy construction and for ships' rafters and rails; valuable edible fruit (after boiling).

SILVICULTURAL CHARACTERISTICS

Local Name – QUARUBA

Botanical Name – Vochysia maxima Ducke

Family – Vochysiaceae

Dates of Flowering and Fruiting – Fls. Dec. '57, Curuá – Seed collected Apr. '58

Type of Fruit – Capsule 3-locules

Type of Seed – Small; small wing

Frequency of Seed years – Occasional; only 1 over 5 years

Germinative capacity – Fairly good

Time to germinate – 12 days

Conditions for, and type of, germination – Epigeal

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Fibrous

Rate of growth – Medium – NR 15-12, 5,2 – AR 14-11, 5-4

Habitat – A nice straight tree in the upper canopy, planalto

Shade tolerance – Good

Natural Regeneration – requirements – Some light; seed should reach bare soil.

Artificial Regeneration – best type of plant: Probably potted; stumps and striplings did not take well at the Curuá. Does not seem to like full light. Probably a good enrichment species.

Type of bark – Fissures, deep; grey brn.

Type of Timber – Soft; like Cedar; floats

Colour of blaze – Choc.brn.; red; little orange gum

Observations – Natural regeneration should be kept well thinned, otherwise tends to fall over if dense patches thinned. Young stems, e.g. 2-3 cm diam., do not coppice.

SILVICULTURAL CHARACTERISTICS

Local Name – QUARUBA TINGA

Botanical Name – Vochysia guianensis

Family – Vochysiaceae

Dates of Flowering and Fruiting – Fls. July '56, Aug. '60 Belém

Type of Fruit – Capsule 3-locules

Type of Seed – Small; small wing

Frequency of Seed years – ? 4 years

Germinative capacity – Probably good

Conditions for, and type of, germination – Epigeal

Pretreatment of Seed (if necessary) – No

Rate of growth – Slow

Habitat – An upper canopy tree in the forests around Belém

Shade tolerance – Very tolerant when young

Artificial Regeneration – best type of plant: Probably potted; will grow in the open

Type of bark – Thin pink scales

Observations – Does quite well on the poor sandy soil round Belém; produces a thick leaf litter and suppress grass. A possible shade tree for Mahogany, Cedar and Andiroba.

SILVICULTURAL CHARACTERISTICS

Local Name – TATAJUBA

Botanical Name – Bagasa guianensis Aubl.

Family – Moraceae

Dates of Flowering and Fruiting – Fls. – ? Aug.-Sept. '58 Curuá
Frts. Nov. '58 – Jan '59.

Type of Fruit – Berry large 3-4 cm; dioecious

Type of Seed – Very small

Viability – Fair

Frequency of Seed years – ?

Germinative capacity – Fairly good

Time to germinate – 3-4 weeks

Conditions for, and type of, germination – Hypogeal

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Tap

Rate of growth – Rapid – NR 10-9, ?, ? – AR 21-11, 4

Habitat – A rare tree in the upper canopy of the Planalto

Shade tolerance – Not tolerant

Time of leaf fall – July-Aug. '58

Natural Regeneration – requirements: Light; seedlings which appeared in Cedro plot (3) – medium opening – grew slowly in the first year and then died off; doing well in Cedro (1) – heavy opening

Artificial Regeneration – best type of plant: Small striplings and potted stock both took well

Type of bark – Scaly; narrow vert.

Type of Timber – Yellow brown

Colour of blaze – Choc. brn.; light brn; copious white latex

Observations – The quickest growing tree (out of Umiri, Cumaru, Cupiuba and others) on poor sandy soil near Belém. Showing considerable promise in first year both on Planalto and Flanco at the Curuá. Logs badly attacked by cerambycid beetle. A tree to be encouraged as its timber (yellow going brown on exposure) seems to be quite good; debarking should decrease susceptibility to borers.

SILVICULTURAL CHARACTERISTICS

Local Name – TAUARI

Botanical Name – Couratari macrosperma, A. C. Sm., C. pulchra Sand., C. tenuicarpa

Family – Lecythidaceae

Dates of Flowering and Fruiting – Fls. mauve Curuá July '58; CBA July '59

Type of Fruit – ? capsule – "plug" falling out

Type of Seed – Medium, winged

Germinative capacity – Apparently fairly good

Conditions for, and type of, germination – Epigeal; stem winged below cotyledons

Pretreatment of Seed (if necessary) – No

Rate of growth – Probably slow

Habitat – An upperstorey tree with large tall buttress on the Planalto

Shade tolerance – Tolerant

Time of leaf fall – July, just before flowering

Natural Regeneration – requirements – Some shade

Artificial Regeneration – best type of plant: Not yet tried

Type of bark – Fissures, deep; fibrous; sometime scaly

Colour of blaze – Light brown

SILVICULTURAL CHARACTERISTICS

Local Name	–	TAXI PITOMBA
Botanical Name	–	Sclerolobium cf. paniculatum Vog.
Family	–	Caesalpiniaceae
Dates of Flowering and Fruiting	–	Fls. Sept-Oct. '59 Curuá – Frts. Dec-Jan '60
Type of Fruit	–	Legume 1-seeded
Type of Seed	–	Medium, flat
Viability	–	Fairly good
Frequency of Seed years	–	1 observed in 5 years. ? only once in a lifetime

Conditions for, and type of, germination - Epigeal

Pretreatment of Seed (if necessary) - No

Type of root of seedling - Tap

Habitat	–	An upper canopy tree on the Planalto; common
Shade tolerance	–	Fairly tolerant

Artificial Regeneration - best type of plant: To be tried 1960-61

Type of bark	–	Roughish
Colour of blaze	–	Red-brn.
Observations	–	After seeding the trees are said to die. Certainly some died back on the Curuá. Possibly a pioneer species in openings.

SILVICULTURAL CHARACTERISTICS

Local Name – TAXI PRETO (fôlha graûda)

Botanical Name – Tachingalia myrmecophyla Ducke

Family – Caesalpiniaceae

Dates of Flowering and Fruiting – Fls. early '59 Curuá – Ftrs. falling May-June '59

Type of Fruit – Legume, 1-seeded

Type of Seed – Medium, flat

Viability – Fairly good

Frequency of Seed years – ? Once in a lifetime; 1 seen in 5 years

Germinative capacity – Fairly good

Time to germinate – Weeks to months

Conditions for, and type of, germination – Epigeal

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Tap

Habitat – An upper canopy tree on the Planalto; fairly common

Shade tolerance – Tolerant

Natural Regeneration – requirements – Seeds will germinate on top of leaf litter.

Artificial Regeneration – best type of plant: To be tried 1960-61

Type of bark – Roughish; irreg. vert. marks

Colour of blaze – Choc. brn.; streaky

Observations – Heavy seeding Curuá May-June '59. Locals said trees would then die; some did; others died back and may not have recovered had there not been good wet spells of 2-3 days with 70 to 90 mm of rain in Aug., Sept. and November (the dry months – only 16 mm fell in the 4 months Aug.-Nov. in 1958). May be a floater.

SILVICULTURAL CHARACTERISTICS

Local Name	--	TAXI PRETO (fôlha miúda)
Botanical Name	--	Sclerolobium micropetalum Ducke
Family	--	Caesalpiniaceae
Type of Fruit	--	Legume 1-seeded
Habitat	--	Reaches the upper canopy on the Planalto but has a smaller bole than the large-leafed Taxi preto
Shade tolerance	--	Tolerant
Type of bark	--	Roughish; irreg. vert. marks
Colour of blaze (and latex)	--	Choc. brn.; streaky
Observations	--	May be a floater. Previously lumped together with the large-leafed Taxi preto.

SILVICULTURAL CHARACTERISTICS

Local Name – UCUUBA

Botanical Name – Virola sebifera Aubl., V. mellioni (Benoist),A.C.

Family – Myristicaceae

Dates of Flowering and Fruiting – Frts. Curuá Nov. '57; CBA Jan. '58 Dec. '59

Type of Fruit – Follicle 1-seeded with fleshy red aril

Type of Seed – Large; oval

Viability – Not good

Frequency of Seed years – About 2 years

Germinative capacity – Fairly good

Time to germinate – 3-4 weeks to 2 months

Conditions for, and type of, germination – Epigeal; can be sown on top of the soil

Pretreatment of Seed (if necessary) – No

Type of root of seedling – Tap; food fibrous laterals

Rate of growth – Slow – NR 6-5, 4, 3 – AR 7-4, 1

Habitat – An occasional but common upperstorey tree of the Planalto

Shade tolerance – Very tolerant

Natural Regeneration – requirements – Shade, probably distributed by birds; responds to canopy opening.

Artificial Regeneration – best type of plant: Small striplings took well; requires some shade for best growth

Type of bark – Small fissures, hard

Type of Timber – Soft; floats

Colour of blaze (and latex) – Light brn.; red-brn. or clear deep red sap.

SILVICULTURAL CHARACTERISTICS

Local Name	–	UMIRI
Botanical Name	–	Humiria balsamifera, Aubl., H. floribunda Mart.
Family	–	Humiridaceae
Rate of growth	–	Fast, near Belém
Habitat	–	On poorer soils (sandy) near Belém, and in Amapá (clay)
Shade tolerance	–	Probably not tolerant
Observations	–	Produces a heavy leaf litter and soon suppresses the grass. Probably a good tree as a soil improver, and/or a nurse. Doing well in a plantation near Marituba, Belém, established by the Serviço Florestal for the Bragança railway for sleepers and fuel.

APPENDIX X

COSTS OF OPERATIONS

(in man-days)

Many of the figures below are based on small-scale operations, often with untrained labour. They represent maximum rather than average figures. Some operations depend on the intensity of the work, e.g. the number of trees poisoned or girdled per hectare, or the amount of selective underbrushing.

On a field scale with experienced labour the operations normally should not exceed the figure given in brackets. With inventories much depends on whether lines have to be cut or if old ones can be followed.

Operation	Man-days per ha
Linear Regeneration Surveys	
Inventory, Normal	3-7 (p. km) (3-4)
" (in blocks)	1.5-2 (p.km)
Silvicultural	0.6-2
Size classes 1-4	3-3.2 (p.km) (2.5)
	0.4-0.6 (0.5)
Natural Regeneration	
Pre-exploitation	
Creeper cutting and freeing advance growth	2-4 (2)
Underbrushing (selective)	1-14 (1-8)
Girdling	1-4
Poisoning (light opening)	0.4-1.4 (1)
" (heavy opening)	0.7-2.3 (2)
Repoisoning	0.5-1.5
Inspections (counting deaths)	0.25-0.5
Post-exploitation (after clear-felling and burning	
First cleaning (at 16 months)	18
First "thinning" (at 18 ")	6
Second cleaning (at 24 ")	30
Third " (at 32 ")	14
Post-exploitation (after heavy selection felling)	
Freeing advance growth	5-17 (12)
Poisoning	0.85
Enrichment	
Line cutting	1-5 (p.km) (1)
Cleaning	1 "
Widening	0.8-10 " (4)
Poisoning	0.8-1.4 " (1)
Pitting	1-3 " (1)
Planting	1.4-4.4 " (1)
Beating up	1-1.5 "
Height measuring	0.6-1 " (0.5)

(cont.)

Operation	Men-days per ha	
Plantations		
Underbrushing	4-12	(5)
Felling desirables	8.3-25	
Clear-felling remainder	18.7-36	
" " all trees (one operation)	28	(20)
" " (staggered) (Note 1)	31-40	(30)
Burning (sometimes with firelines)	1.3-4.2	
Collecting and reburning large branches and stems (Note 2)	20-60	
Staking and pitting (Note 3)	2.5-10	(2)
Planting (Note 4)	4.5-7.5	(4-6)
Beating up	3-6	
Height measuring	1-3	(1)
Sowing cover crops	1	(1)
Cleaning and mulching (Note 5)	8-70	(5)
Girth Increment Plots		
Numbering trees	3	
Measuring	1.3-1.5	

Notes: (1) To try to avoid the cost of reburning in 1960 ("encoivaramento") the largest trees only were felled in May, the medium and smaller trees in July and poles and undergrowth which remained were cut in September. If everything is cut early the leaves all fall and the fire does not take so well. Large trees might well be felled a year ahead. This method proved very successful in one plot (Curua F-31 man-days per ha) and fairly successful in another (Curua O-40 man-days per ha).

(2) This "encoivaramento" should be avoided as it is very expensive; staggered fellings starting with the large trees (see above note) may be the answer.

(3) Staking is unnecessary unless the weed growth is likely to be rapid; the figure (2) man-days is without staking.

(4) Planting costs on a large scale will vary considerably according to the type of nursery plants; naked rooted transplants, striplings or stumps will cost less to plant than to transplants from containers.

(5) Subsequent experience has shown that mulching is not necessary at the Curuá, even on the sandy soil, especially if cover crops are sown.

APPENDIX XI

PRELIMINARY QUALITY OBSERVATION OF 25 SPECIES FROM CURUÁ

Vernacular name	Specific Gravity	Cutting Property	Colour	Observations
Abiurana branca	x) 0.87	3.4	medium brown	Sapwood pale susceptible to insect attack, should be cut off; heartwood without figuring. Even for sleepers very difficult to cut.
Abiurana casca grossa	x) 0.88	7.1	pale yellow	Very bad smell, susceptible to fungi attack, mould and sap stain. Much easier to cut than ABER but also quite difficult.
Acapu	0.94-1.15	(10)	dark-chocolate brown	Well-known timber for parquets; even dark brown
Açoita cavalo	0.61	(50)	yellowish-brown	Smells like pickled fish; used for sandals and rifle-stocks though without figuring. Not difficult to cut.
Amapá	0.6	(80)	dark yellow	Unpleasant fish smell when fresh. Good timber for general carpentry though not attractive. easy to cut.
Angelim pedra	0.7	30	reddish-brown	Good for construction and sleepers. Upon exposure very nice dark red colour. Surprisingly not difficult to cut.
Araracanga	0.83-1.05	(55)	canary yellow	Construction civil and naval, sleepers, probably suitable for parquets because of nice colour.
Caju-açu	x) 0.5	(120-150)	dirty yellow	Smells like mouldy bread; tearing and lifting fibres by cutting; very easy to cut. Suitable for concrete shuttering and for boxes.
Caraipé	x) 1.1-1.2	0.3	violet-brown	Not durable; quite easy to split and not very difficult to cut with axe, burns well when green. Impossible to cut longitudinally.
Cuiarana	0.82	19.2	olive-yellow	Resembles freijó but planes without figure. Heavy carpentry and construction. Quite good to cut, better than shown by the one evaluated saw.
Cupiúba	0.88	(55)	medium reddish-brown	Unpleasant smell; easy to work, good for construction.
Faeira	x) 0.8	(30)	tabak-brown	When fresh nice red colour; planes without figure heavy but quite good to cut. Suitable for construction and sleepers. Try quarter-sawn.
Guariuba	0.7	(60)	cinnamon-brown	When fresh nice yellow; for carpentry and canoes
Jutai-açu	0.85	16.1	brown	In British Guiana known as "locust"; good export timber, sapwood must be cut off, therefore only big logs are economic, estimated cutting in 45% - much better than shown by the one evaluated saw.
Louro canela	x) 0.76	(55)	medium brown	Very pleasant smell though not distincly canela.
Madioqueira áspera	x) 0.84	(80)	yellow medium brown	) When cutting we did not find much difference
" escamosa	x) 0.76	96.5	tabak-medium brown	) between them, all seem to be good timber for
" lisa	0.7	(90)	violet medium brown	) carpentry, though not attractive. Last one twists) on drying.
Morototó	0.53	19.1	pale yellow	Susceptible to stain and insect attack; the estimated cutting property much higher than 2 evaluated saws-approx. 100.
Mururé	0.69	(80)	orange-medium brown	Our specific gravity is only 0.54, probably not durable; suitable for carpentry, easy to cut.
Rosadinha	x) 1.10	(1)	rosa-brown	Very susceptible to fungi (mould) attack; very difficult to cut.
Seringueira itaúba	x) 0.6	(60)	whitish-yellow	Probably very good timber for carpentry; susceptible to fungi attact. Good for cutting.
Taxi branco	x) 0.69	(80)	medium brown	Nice carpentry timber.
Taxi preto da mata	0.79	(40)	dirty-yellow	Probably useful general carpentry timber.
Tauari	0.51	(90)	pale rose-brown	Probably a very good carpentry timber.

Explanatory notes:

x) = specific gravity not available in any bibliography, but determined approx. in C.T. Santarém

( ) = around cutting property means, this only estimated, as only a few logs were cut.

CUTTING PROPERTY - Cedro is taken as the standard, with a figure of 100 m^2. This is equivalent to cutting 276 m^2 with one saw, the mean of a large number of obervations.

A "Cutting Property" of 1 means that the same saw would cut only 1 m^2 compared to 100 for cedro.

Sgd. V.C. Hasek
Santarém, 5.1.1960

APPENDIX XII

RECORDS

In any forestry operation it is most important that careful records be kept of both the work done and of the cost (labour in man-days), as well as of the results and of any comments or observations.

Records are required for:

1. Seed
2. Nursery
3. Experiments
4. Plantations
5. General forest work

Seed Register

This is, of course, kept in the main office. It should show, on a separate page for each species, both local and botanical names, and the number of seeds per 100 gr; in columns should be shown the date of receipt, origin of seed, amount received and balance in stock; it should also show the date of issue, to whom or which nursery, the amount issued and again the balance.

The basis for many of the other Records must be daily notes made in the field by responsible members of the field staff. Two types of notes are normally sufficient:

(1) Nursery Diary
(2) Analysis of Labour

Nursery Diary

This should be written up daily, in duplicate, so that about once a month the top sheets can be removed and sent (or taken) to the main office, while the copies remain in the nursery or nearby field office.

Information should be recorded daily on the work done (one line or even one or two words is generally enough), and also on:

(i) Date and weight of seed sown.
(ii) Date of germination (also giving the date of sowing).
(iii) Date and number of seedlings transplanted; and if into beds or containers; this too should refer back to the date of sowing, as seed may be sown in two or three batches during the season.
(iv) Date and number of replacing transplants which have died; this should be referred back to both the date of sowing of the seedlings used and the date of the original transplanting. This replacing should be done once a week or once a fortnight for a month or two.
(v) Date of root cutting in transplant beds or boxes.
(vi) Date, number and type of transplants taken to the field for final planting.

If the dates of sowing, germination and transplanting are written on name pegs in the nursery beds there should be no confusion if there are 2 or 3 batches of seedlings and transplants. (See p. 47 - Report)

Nursery Register

This should be posted up monthly from the Diary. Transplanting, which will normally be done on several days, can be totalled for the month to give one entry for the dates shown. Replanting of deaths of the transplants should not be recorded in the "transplant" column, but in the "observations" column, as this work does not increase the number of transplants; it merely aims at keeping the beds or containers as fully stocked as possible.

A suggested form for the Nursery Register is shown on p. 113; below is given a suggested form for recording nursery expenditure month by month.

MONTHLY RECORD OF NURSERY COSTS 19..

Month	Work done	Man-days	Cost	Running total

Note: (1) Man-days should show actual number worked, taken from the Analysis of Labour (see below).

(2) Cost should include payments for Sundays and holidays.

(3) The cost of any material e.g. fencing wires or fertilisers should be included.

VIVEIRO: _____ ESTAÇÃO: _____ CAPITÃO: _____

ESPÉCIES	Origim da Sementes	SEMEADURA			TRANSPLANTES		PLANTIO DEFINITIVO			N. de perdas Mortas ou destruídas	OBSERVAÇÕES Quantidade aproveitada
		Quant.	Data	Data da Germ.	Quant.	Data	Quant.	Data	Local do Plantio		

Notes (1) The "season" (Estação) is taken as from the beginning of the year, so far as sowings are concerned, till after the following planting season, i.e. about February-April the following year.

This means that information about final planting, though done the following year, is shown on the sheet where the sowing and transplanting has been recorded. The season therefore will be shown as "1959-60"; this means that the information is for sowing and transplanting in 1959 and final planting in 1960.

(2) After the planting season, i.e. about April on the Curuá, the remaining plants which are worthile keeping are usually replanted, if scattered over a bed, perhaps sometimes being stumped in the process, and are transferred in the Register to the next season. A note is made under "Observations" for the sowing season of the amount transferred, and the name, number or transplants and date entered on the sheet for the next season. In the "sowing" (Semeadura) columns an entry is made "transferred from 19.."

(3) Sowings should be entered in chronological order. If a second sowing is likely to follow within a month or so a space may be left for it. If much seed is sown and transplanting is likely to spread over 2 or 3 months, leave a couple of lines before the next entry.

Analysis of Labour

It is most important that the number of man-days spent on each operation should be recorded daily in the field office. On a sheet for each month there should be a line for each day and columns for each operation; the last column should show the total number of labourers who worked that day. By totalling each column the number of man-days spent on each operation can be obtained for posting the various registers. It sometimes happens that a gang may work on two jobs in one day; in this case the number should be divided in proportion to the time spent on each, in whole numbers as far as is reasonable.

A suggested form for this Analysis of Labour is given below:

Place ..... Month ..... 19..

Day	Nursery	Creeper cutting cpt.	Cleaning plot...	Planting plot....	L.R.S. Inventory plot	Refining Cpt.....	Collecting seed (name)	....	Sick	TOTAL
1										
2										
3										
.										
.										
.										
.										
.										
31										
TOTAL										

Experiment Register

No experiment is worthwhile doing unless it can be described and the results recorded. The Register must consist of a number of forms, though not all forms are required for each experiment. The following forms are in use:

1. Situation Map - This must show the site of the experiment in relation to the nearest town or village or some other well-known reference point. It can usually be traced from an existing map.

2. Plot Map - This is on a much larger scale and shows the actual boundaries, and any subdivisions of the plot, if any.

3. Plot Chart or List of Trees etc. - This is on a still larger scale to show the position of each tree, if required, or gives such details as names and numbers of trees (e.g. for diameter increments).

4. Description of Experiment - This should show information under the following heads:

(1) Object of Experiment
(2) Species
(3) Date of Formation
(4) Area
(5) Situation - brief description as to how to find and recognise the plot
(6) Climate - (i) Altitude, (ii) Rainfall (iii) Temperature, (iv) General remarks.
(7) (i) Geology, (ii) Soil, (iii) Humus
(8) Slope and aspect
(9) Drainage
(10) Animal factors
(11) Type of vegetation
(12) Initial Condition of Plot (i) Overwood, (ii) Underwood, (iii) Undergrowth (iv) Ground Flora, (v) Regeneration of principal species, (vi) Remarks
(13) Method of Demarcation
(14) Method of numbering and marking (if any)
(15) Details of work done at first formation, species, numbers of plants, type and size are recorded here
(16) Details of Treatment to be applied
(17) Probable Seasons of Inspection
(18) Remarks

5. Subsequent History - All work done subsequent to the formation of the plot, and any observations or comments should be recorded here. Each entry must be signed and dated. e.g.

Form 5

SUBSEQUENT HISTORY OF EXPERIMENTAL PLOT No. ..

Date and signature	Particulars

6. Detailed Record of Measurements or Observations

This form must vary according to the requirements. The field sheets on regeneration surveys and inventories should be filed here (see forms in App. IV, pages 27 and 28).

7. Summary of Measurements or Observations

This form too will vary according to requirements. The Analyses of regeneration surveys should be filed here (App. IV, pages 29, 30, 31) Average height measurements and percentage survivals in trial plots should be shown here, along with numbers of plants used to replant failure.

8. Labour and Costs - Information recorded here is obtained from the monthly Analysis of Labour sheets.

Form 8

LABOUR AND COSTS

EXPERIMENTAL PLOT No. ...

Date	Work done	Area or distance	Man-days	M.D. per ha/km

9. Other Information - e.g. Details of soil analyses.

When the work becomes more advanced and Sample Plots for yields, etc. are laid down, more special forms are required. Work in the Amazon is still too much in the early stages for these forms to be described here. Anyone interested should refer to the British Forestry Commission Bulletin No. 31 "Code of Sample Plot Proceedure", H.M. Stationary Office, London, 1959.

Plantation Register

This register has not yet been introduced as the work so far has been on a small scale. Once the experimental stage is passed and plantations are established on a field scale a separate register must be opened for the plantations.

The following forms are recommended:

1. Description - e.g.

Form 1

DESCRIPTION OF PLANTATION

Year ..... Compartment No. .... Area .....ha

(1) Species, number of plants and spacing
(2) Past history of Compartment
(3) Vegetation Type
(4) Preparation Treatment
(5) Notes on Establishment (Planting)
(6) Prescription for subsequent Treatment
(7) Subsequent Notes and Observations (to be signed and dated)

2. Details of Operations - e.g.

Form 2

DETAILS OF OPERATIONS

Compartment No. ... Year of Formation ..... Area ..... ha

Date	Work done	Area(or distance)	Man-days	M.D. per ha	Running Total per ha

3. Details of Production - This will only be required later.e.g.

Form 3

DETAILS OF PRODUCTION

Compartment No. ... Year of Formation ..... Area ..... ha

Date	Type of Yield	Quantity	Area	Yield per ha	Value	Value p. ha	Remarks

Compartment Register

The Plantation Register is really part of this, but it is usually convenient to keep it separate just for Plantations, and to record other information, e.g. details of exploitation and natural regeneration operations, in the Compartment Register.

The following forms have been introduced at Curuá:

Form 1

1. Description and Prescriptions

(1) Name of forest, or locality
(2) Compartment No.
(3) Area
(4) Sub-division (if any)
(5) Type of forest
(6) Soil
(7) Date demarcated: (i) boundaries, (ii) internal lines or roads.
(8) Linear Regeneration Surveys: (i) lines numbered, (ii) intensity of survey, (iii) date (Summary and Details - if needed - should be filed as form 4)
(9) Inventories: (i) type, (ii) lines numbered, (iii) intensity of survey, (iv) date. (Summary and Details - if needed - should be filed as form 5)
(10) Previous history (if any)
(11) Observations
(12) Proposed Prescriptions

2. Control Register - e.g.

Form 2

CONTROL REGISTER

Compartment No. ..

Month	Work done	Area	Man-days	Man-days per ha

3. Observations and Comments - e.g.

Form 3

OBSERVATIONS AND COMMENTS

Compartment No. ..

Date and Signature	Particulars

NOTE

All Records should be in some sort of durable cover, and of such a type that extra sheets can be added easily at any time.

THEY SHOULD NOT BE TAKEN OUT INTO THE FIELD

Measurements or other data should be recorded on field sheets and the information posted to the Registers in the office.

APPENDIX XIII

LISTS OF LOCAL-BOTANICAL AND BOTANICAL-LOCAL NAMES OF TREES IN THE FAO AREAS, CURUÁ-UNA and C.B.A., SANTARÉM

These lists, compiled by Mr. John Pitt, FAO silviculturist, are based mainly on determinations made by Dr. Murça Pires, botanist, I.A.N., Belém, on material collected by his field assistant Raimundo from numbered trees in some research plots (Expts. 9, 18 and 19). The local names were given by mateiro Corres who worked with FAO Inventory party in this region and is still with FAO at the Curuá. Small wood specimens were collected at the same time as the botanical material (Dec. 1958-Jan. 1959); these have helped considerably in some cases where a mistake was made in the collection of the botanical material. There is obviously still some confusion over some local names, e.g. the Breus and Faveiras.

Some names are based on material collected from felling operations at the Curuá.

Where no botanical material has been collected the botanical names are taken from the list given in Heinsdijk's Inventory Report FAO No. 601 or were supplied by Dr. Murça Pires.

NOTES

(1) These names occur in Heinsdijk's Report FAO No. 601, paragraphs 50-59, in the forest type "Planalto II alto"; they have not been encountered so far at the Curuá or Santarem.

(2) Caqui is not a common name. Kaki is a Japanese name known in the south (São Paolo) for an edible fruit of this genus.

(3) These are not common names; however they are used by workers with the FAO Mission in default of any other name.

(4) Some confusion still exists in the recognition of some of Faveiras.

o

Listas de nomes Locais-Botânicos e Botânicos-Locais de Árvores nas áreas da Missão FAO: Curuá-Una e C.B.A., Santarém

Estas listas baseiam-se, principalmente, na classificação gentilmente feita pelo Dr. Murça Pires, botânico do I.A.N. em Belém, com material coletado pelo seu assistente, Raimundo, de árvores numeradas em alguns dos canteiros de pesquisas (Experimentos 9, 18 e 19). Os nomes locais foram dados pelo mateiro Correa, que trabalhou no grupo de inventário florestal da FAO nessa região, encontrando-se, atualmente, ainda trabalhando para a FAO, no Centro de Curuá. Pequenos espécimes de madeira foram coletados na mesma ocasião que o material botânico (Dez. 1958-Jan. 1959; aquêles têm ajudado consideràvelmente em alguns casos onde foi feito um êrro na coleta do material botânico. Ainda há, òbviamente, alguma confusão acêrca de alguns nomes locais, p.e. os Breus e as Faveiras.

Alguns nomes baseiam-se no material coletado quando das operações de derruba no Curuá.

Onde nenhum material botânico foi coletado, os nomes botânicos são tirados da lista que se encontra no Relatório do Inventário de Heinsdijk, FAO No. 601, ou foram fornecidos pelo Dr. Murça Pires.

OBSERVAÇÕES

(1) Êstes nomes occorem no Relatório de Heinsdijk, FAO 601, parágrafos 50-59, no tipo de floresta "Planalto II alto" ate agora não foram encontrados no Curuá ou Santarém.

(2) Caqui não é um nome regional. Kaki é un nome japonês empregado no Sul (São Paulo) para uma fruta comestivel dêste gênero.

(3) Êstes nomes não são regionais; entretanto, são usados pelos trabalhadores da Missão FAO por falta de outro.

(4) Alguma confusão ainda existe na identificação de alumas das Faveiras.

LISTA DOS NOMES LOCAIS-BOTÂNICOS DAS ÁRVORES NAS AREAS DA FAO; CURUÁ-UNA E C.B.A., SANTARÉM

-A-

Abiurana	Pouteria spp.
Abiurana branca	Pouteria sp.
Abiurana casca grossa	Pouteria sp.
Abiurana cutite	Pouteria cf. macrophylla P. spp.
Abiurana goiabinha	Pouteria cladantha P. cf. torta P. cf. virescens
Abiurana matamátá (1) (provâvelmente)	Pouteria sp.
Abiurana sêca	Pouteria sp.
Abiurana ucuuba	Pouteria cladantha P. cf. gutta
Açacú	Hura crepitans
Acapu	Vouacapoua americana
Acapurana	Cassia apoucouita
Açoita cavalo	Luhea sp.
Aguano	Swietania macrophylla
Amapá	Brosmium affn. amplicoma B. paraense
(Rapé de Índio)	Olmedioperebea sclerophylla Parahacornia amapa Pogonophora schomburgkiana
Amarelinho	Moronobea coccinea
Anani	Symphonia globulifera
Andira (1) (provàvelmente)	Hymenolobium petraeum
Andiroba	Carapa guianensis
Angelim da mata (normalmente) (às vezes)	Hymenolobium excelsum H. petraeum
Angelim pedra	Dinizia excelsa
Angelim rajado	Pithecolobium racemosum
Aquariquara (normalmente) (às vezes)	Minquartia guianensis Geissospermum cf. vellosii
Aquariquarana (normalmente) (às vezes)	Lindackeria cf. maynensis L. sp. afn. pauciflora
Araracanga	Aspidosperma alba A. cf. verruculosa
Arataciú	Sagotia racemosa
Aroeira	Astronium lecointei A. cf. ulei
Ata brava	Ver Envira ata brava
Axixá	Sterculia pilosa
Axuá	Saccoglotis cf. guianensis S. sp.

-B-

Bacabinha quina		Ferdinandusa cf. paxii
Balantinha	(1)	Ecclinusa abreviata
Bacuri		Platonia insignis
Breu branco		Protium divaricatum v. trijugum
		P. giganteum
		P. heptaphyllum
		P. nodulosum
		P. sagotianum
		Tetragastris altissima
Breu manga		Protium divaricatum v. trijugum
		P. giganteum
		P. heptaphyllum
		P. nodulosum
		P. sagotianum
		Tetragastris altissima
Breu preto		Protium divaricatum v. trijugum
		P. giganteum
		P. heptaphyllum
		P. nodulosum
		P. cf. opacum
		P. puncticulatum
		P. sagotianum
		Tetragastris altissima
		Trattinickia burserifolia
Breu sucuruba		Tetragastris altissima
		Trattinickia burserifolia
Buiçu	(1)	Ormosia coutinhoi

-C-

Cajauçu		Anacardium giganteum
Camaã		Casearia spruceana
Capitiu		Siparuna guianensis
Caqui	(2)	Diospiros praetermissa
Carapanauba		Aspidosperma auriculata
Caripé		Licania hostmannii
		L. cf. incana
		L. micrantha
		L. cf. stahelli
	(às vezes)	Hirtella cf. praealta
Caroara		Brosmium cf.longifolium
Casca grossa		Ver Abiurana casca grossa
Castanheiro		Bertholletia excelsa
Cauaçu		Couepia sp.
Caucho	(1)	Castillea ulei
Caxingubarana (casca cortada amarela; leite - creme)		Brosium cf. longifolium
		B. cf. pauciflora
		B. velutinum
		Helicostylis sp.
(casca cortada, verm. marron;leito marron claro)		Ogcodeia sp.
Cedro		Cedrela odorata

Cedrorana (no C.B.A.)	Ver Quaruba
Chimarris (3)	Ver Pau de remo
Coataquiçaua	Peltogyne cf. paniculata
Conario (3)	Connarus angustifolius
Copaíba	Copaifera spp.
Copaibarana	Epurea schomburgkiana
Croton (1)	Croton matauzensis
Cuiarana (ou Tanimbuca)	Buckenavia var. capitata
	Terminalia amazonica
	T. tanibouca
Cumaru	Coumarouna odorata
Cumaté	Saccoglottis
Cupiuba	Goupia glabra
Cupuí	Theobroma subincanum
	-D-
Desconhecida (? Moela de mutum)	Pera bicolor
	Quiina pteridophylla
	-E-
Envira amarela	Xylopia benthamii
Envira ata brava	Rollinia annonoides
Envira branca	Guatteria amazonica
Envira preta	Bocagiopsis cf. multiflora
	Gualteria cf. poeppigiana
	Rollinia exsucca
Envira surucucu	Duguetia surinamensis
	D. cf. flagellaris
Envira X (3)	Xylopia amazonica
	X. cf. nitida
Erva de rato	Psycotrea sp.
	-F-
Facheiro	Derris spruceana
Faeira	Roupala afn. montana
Faveira arera tucupi (4)	Parkia multijuga
	Pithecolobium decandrum
Faveira barbatimão	Stryphnodendrum cf. pulcherrimum
Faveira bolacha	Vatairea guianensis
Faveira bolota	Parkia pendula
Faveira dura	Pithecolobium ou ? Enterolobium
Faveira fôlha fina	Piptadania suaveolens
Faveira marmari (1)	Cassia spruceana
Faveira mapuxiqui (às vezes)	Pithecolobium decandrum
(normalmente)	Stryphnodendrum cf. pulcherrimum
Faveira orelha de negro	Enterolobium cf. maximum
Faveira parkia	Parkia oppositifolia
Faveira uing (3)	Ver Fav. dura
Freijó	Cordia goeldiana
Freijó branco (1)	C. cf. nadophila

-G-

Glícia		Glycidendron amazonicum
Goiabinha		Calycolpus cf. glaber
		Eugenia cf. brachypoda
Gombeira		Alexa cf. wackenheimii
		Andira macrothyrsa
		Swertzia aptera
Guabiraba		Eugenia conjuncta
Guariuba		Clarisia racemosa (syn. C. nitida)

-I-

Imbáuba		Cecropia cf. obtusa
Imbaubarana		Pourouma velutina
Ingá		Ingá cf. alba
		I. cf. capitata
		I. cf. fagifolia
		I. cf. heterophylla
		I. cf. rubiginosa
Ingarana		Pithecolobium latifolium
Itaúba		Mezilarus itauba
		M. lindaviana
Itaubarana		Trichilia sp.
		Cascaria silvestri

-J-

Janita		Brosmium cf. velutimum
Jacareúba	(1)	Callophyllum brasiliense
Jarana		Eschweilera cf. jarana
Jataúba		Ver Jatoá
Jatoá		Guarea sp.
João mole		Neea cf. oppositifolia
Jutaí açu		Hymenaea cf. coubaril
Jutaí mirim		H. parvifolia
Jutaí pororoca		Dialium guianense
Jutairana		Cynometra hostmanniana

-L-

Lacre		Visma cf. cayennensis
Louro	(normalmente)	Ocotea spp.
Louro amarelo	(normalmente)	Aniba cf. burchellii
		Ocotea sp.
Lauro branco		Aniba sp.
		A. cf. burchellii
		Ocotes spp.
Louro canela		Aniba sp.
		Licaria cf. americana
	(normalmente)	Ocotea cf. canaliculata
Louro chumbo		Ver Louro canela
Louro cumaru		Ver Louro canela
Louro preto		Ocotea sp.

-M-

Macacaúba	Platymiscium trinitatis
Macaco escorrega	Capirona hyberiana
Maçaranduba	Manilkara huberi
Macucu (normalmente)	Hirtella cf. praealta
	Licania cf. heteromorpha
	L. cf. opetala
	L. cf. paniculata
	L. cf. parvifructa
	L. cf. stahelli
(fôlha graúda e sapupemas curtas)	Casearia singularis
Mamorana	Bombax longipedicellatum
	B. paraensis
Mandioqueira (normalmente lisa)	Qualea spp.
(áspera ou escamosa; muitas vezes chamada Quaruba)	Q. sp. cf. paraensis, homosepala
Mandioqueira (lisa)	Q. sp. cf. albiflora, acuminata
Maparajuba	Manilkara amazonica
Maraximbé	Emmotum fagifolium
Marupá	Simaruba amara
Matamatá branco	Eschweilera sp.
(às vezes)	E. cf. sagotiana
Matamatá ci (3)	Eschweilera cf. sagotiana
Matamatá preto	Lecythis sp.
	Eschweilera cf. collina
Melancieira (1)	Alexa grandifolia
Mirapucu	Talvez Miconia sp.
Miraúba	Mouriria cf. brevipes
	M. cf. calocarpa
	M. cf. plaschaertii
	M. spp.
Mogno	Swietenia macrophylla
Molongó	Ambelania acida
	Lacmelia arborescens
	Malouetia cf. duckei
Moraceae	Ver Caroara, Caxinguberana ou Janitá
Morototó	Didymopanax morotoni
Muiracatiara	Ver Aroeira
Muirajuçara	Rauwolfia pentaphylla
Muirapiranga	Brosmium paraense
Muirapixuna	Cassia scleroxylon
Muiratauá	Apuleia molaris
Muiratinga	Ver Paxiubarana
Murici	Byrsonima cf. arugo
(raramente)	Ternstroemia cf. dentata
Murta	Eugenia cf. patrisii
	E. sp.
	Myrica cf. fallax
Murupita	Sapium sp.
Mururé	Trymatococcus cf. amazonicus
Mututi	Pterocarpus rohrii

-O-

Olacacia (3)	Olacaceae
	Chaunochiton kappleri
Orelha de negro	Enterolobium cf. maximum

-P-

Papo de mutum	Touroulia, Quiina ou Lacunaria spp.
Paraparará	Jacaranda copaia
Parinari	Parinari sp.
Pau amarelo	Euxylophora paraensis
Pau branco	Chaunochiton kappleri
	Ilex innundata
	Leonia cf. glycocarpa
	Maytenus sp.
Pau d'arco amarelo	Tabebuia serratifolia
roxo	T. avelanedae
Pau de remo	Chimarrhis turbinata
Pau jacaré	Laetia procera
Pau marfim	Agonandra brasiliensis
Pau para tudo	Simaba cedron
Pau rosa	Aniba rosaeodora
Pau santo (1)	Zollernia paraensis
Paxiubarana (Muiratinga)	Olmediophaena obliqua
	Tuvomita cf. grata
Pente de macaco	Apeiba cf. aspera
Piquiá	Caryocar villosum
Piquiarana (1)	C. glabrum
Pitomba	Sapindaceae
Pitombarana	Leonia cf. cymosa
	Matayba cf. arborescens
	Sapindaceae
Pracaúba	Trichilia spp.
Preciosa	Aniba cf. canellil
Puruí	Amajona monteiroi
	Duroia cf. sprucei

-Q-

Quaruba	Vochysia maxima
	V. sp.
(às vezes)	Qualea - Ver Mandioqueira
Quarubarana	Erisma uncinatum
Quaruba rosa	Vochysia revoluta
	V. cf. surinamensis
Quinarana	Geissospermum cf. vellosii

-R-

Rapé de índio	Ver Amapá
Rosadinha	Pouteria cladantha
	P. melinonii
	P. venulosa
	P. sp.

-S-

Sapucaia		Lecythis paraensis
		L. usitata
Seringa itaúba		Hevea guianensis
Sorva		Couma guianensis
		Macoubea cf. sprucei
Sucupira		Bowdichia nitida
Sucuuba		Plumiera sp.
Sumaúna	(1)	Ceiba pentandra

-T-

Tamanqueira		Fagara sp.
Tanimbuca		Ver Cuiarana
Tarumá		Vitex trifolia
Tatajuba		Bagassa guianensis
Tatapiririca		Prunus myrtiflora
Tauari		Couratari macrosperma
		C. pulchra
	(fôlha miúda)	C. tenuicarpa
Taxi branco		Sclerolobium ? sp. nova
		S. sp.
	(raramente)	S. micropetalum
Taxi pitomba		Sclerolobium cf. paniculatum
		S. ? sp. nova
		S. sp.
		Tachigalea cf. myrmecophila
Taxi preto	(fôlha miúda)	Sclerolobium micropetalum
	(raramente)	S. ? sp. nova
	(raramente)	S. sp.
	(normalmente)	Tachigalea cf. myrmecophila
		T. paniculata
Tento		Ormosia cf. paraensis
Tinteiro	(raramente)	Bellucia cf. axinanthera
		Miconia cf. minutiflora
		M. cf. ruficalyx
		M. cf. surinamensis
		M. sp.
Toboquina		Oliyra latifolia
Trichilia		Trichilia cf. acariacantha
		T. cf. lecointei

-U-

Ucuuba	(pubescente)	Virola cusplidata
		V. cf. melinonii
	(pubescente)	V. multinervea
		V. cf. sebifera
Ucuubarana		Iryanthera sp.
		Osteophloem platyspermum
Umiri		Humiria balsamifera
Uruazeiro	(1)	Cordia sp.
Urucu da mata	(1)	Bixa arborea
Urucurana		Conceveiba cf. guianensis
		Conceveibastrum cf. martianum
		Hebepetalum humiriifolium
Uxi		Saccoplottis sp.
Uxicurua		?Saccoplottis sp.
Uxirana		Saccoglottis amazonica
		Vantanea cupularis

LISTA DOS NOMES BOTÂNICOS-LOCAIS DAS ÁRVORES NAS AREAS DA FAO; CURUÁ-UNA E C.B.A., SANTARÉM

-A-

Agonandra brasiliensis Miers	Pau marfim
Alexa grandifolia Ducke	Melancieira
A. cf. wackenheimii R.Ben	Gombeira
Amajona monteiroi Standl.	Purui
Ambelania acida Aubl.	Molongó
Anacardium giganteum Hanc.et Engl.	Cajuaçu
Aniba cf. burchellii Kost.	Louro amarelo
	Louro branco
A. cf.canellil (HBK) Mez.	Preciosa
A. cf. rosaeodora Ducke	Pau rosa
A. sp.	Louro branco
	Louro canela
Andira macrofhyrsa Ducke	Gombeira
Apeiba cf. aspera Aubl.	Pente de macaco
Apuleia molaris Benth.	Muirataúá
Aspidosperma alba (Vahl.) R.Ben	Araraganga
A. auriculata Mgf.	Carapanauba
A. cf. verruculosa M. Arg.	Araracanga
Astromium lecointei Ducke	Aroeira (= Muiracatiara)
A. cf. ulei Maltick	Aroeira

-B-

Bagassa guianensis Aubl.	Tatajuba
Bellucia cf. axinanthera	Tinteiro
Bertholletia excelsa HBK	Castanheira
Bixa arborea Hub.	Urucu da mata
Bocageopsis cf. multiflora (Mart) Fries	Envira preta
Bombax longipedicellatum	Mamorana
B. paraensis Ducke	
Bowdichia nitida Benth	Sucupira
Brosmium affn. amplicoma Ducke	Amapá
B. cf. longifolium Ducke	Caroara
	Caxingubarana (casca cortada amarela; leite creme)
B. paraense Hub.	Amapá ou Muirapiranga
B. cf. pauciflora Ducke	Caxingubarana
B. cf. volutimum (Blake)Ducke	Caxingubarana
	Janita
Buchanavia var.capitata (Vahl)Eich?	Cuiarana
Byrsonima amazonia Oris	Murici
B. cf. arugo Sagot	

-C-

Callophyllum brasiliensi Camb	Jacaraúba
Calycolpus cf. glaber (Bth)Beg.	Goiabinha
Capirona hyberiana Ducke	Macaco escorrega
Carapa guaianensis Aubl.	Andiroba
Caryocar glabrum (Aubl) Pers.	Piquiarana
C. villosum Pers.	Piquiá
Casearia silvestri Sw.	Itaubarana
C.singularis Eichl.	Macucu (fôlha grande et sapupemas curtas)
C. spruceana Benth	Camaã
Castilloa ulei Warb.	Caucho
Cassia apoucouita Aubl.	Acapurana
C. scleroxylon Ducke	Muirapixuna
C. spruceana Benth	Faveira marimari
Cecropia cf. obtusa Trec.	Imbaúba
Cedrela odorata L.	Cedro
Ceiba pentandra Gaerta	Sumaúma
Chaunochiton kappleri (Sagot)Ducke	Olacacia
	Pau branco
Chimarris turbinata D.C.	Pau de remo ou Chimarris (3)
Clarisia racemosa R. et P. (syn. C. nitida)	Guariúba
Coccoloba sp. Lam.	Caúaçu
Connarum angustifolium (Rdlk)Shell	Conário (3)
Copaifera spp. Ducke, Hayne, Magno	Copaiba
Cordia goeldiana Hub.	Freijó
C. cf. naidophila Johnst.	Freijó branco
C. sp.	Uruazeiro
Couma guianensis Aubl.	Sorva
Coumarouna odorata Aubl.	Cumaru
Couratari macrosperma A.C. Sm.	Tauari
C. pulchra Sandw.	Tauari
C. tenuicarpa A.C. Smith	Tauari (fôlha miúda)
Conceiveba cf. guianensis Aubl.	Urucurana
Conceveibastrum cf. martianum P. et Hoff	Urucurana
Croton matauzensis Aubl.	Croton
Cynometra hostmaniana Tul.	Jutairana

-D-

Derris spruceana Benth	Facheiro
Dialium guianense (Aubl.)Sandw.	Jutaí pororoca
Didymopanax morototoni (Aubl.) Dne. et Pl.	Morototó
Dinizia excelsa Ducke	Angelim pedra
Diospyros praetermissa Sand.	Caqui (2)
Duguetia cf. flagellaris	Envira surucucu
D. surinamensis Fries	Envira surucucu
Durois cf. spruceí Rusby	Puruí

-E-

Ecclinusa abreviata Ducke	Balantinha
Emmotum fagifolium Desv.	Maraximbó
Enterolobium cf. maximum Ducke	Faveira orelha de negro
E. schomburghii Benth	Faveira dura (nosca)
Epurea schomburgkiana Benth	Copaibarana
Erisma uncinatum Warm	Quarubarana
Eschweilera cf. collina Eyma.	Matamatá preto
E. cf. jarana (Hub.) Ducke	Jarana
E. cf. sagotiana	Matamatá ci (3)
	Matamatá branco (às vezes)
E. sp.	Matamatá branco
Eugenia cf. brachypoda DC.	Goiabinha
E. conjuncta Amshoff	Guabiraba
E. cf. patrisii Vahl.	Murta
E. sp.	Murta
Euxylophora paraensis Hub.	Pau amarelo

-F-

Fagara sp.	Tamanqueira
Ferdinandusa cf. paxii Winkl.	Bacabinha quina

-G-

Geissospermum cf. vellosii Allemad.	Quinarana
	Aquariquara (às vezes)
Glycidendron amazonicum Ducke	Glícia
Goupia glabra Aubl.	Cupiubá
Guarea sp.	Jatoá; Jataúba
Guatteria amazonica	Envira branca
G. cf. poeppigiana Mart.	Envira preta

-H-

Hebepetalum humirifolium (PL) Bth.	Urucurana
Helicostylis sp.	Caxingubarana
Hevea guianensis Aubl.	Seringa itaúba
Hirtella cf. praealta Sagot.	Macucu (normalmente)
	Caripé (às vezes)
Humiria balsamifera Aubl.	Umiri
Hura crepitans L.	Açacú
Hymatanthus sucuuba (Spn.)Woodson	Sucuuba
Hymenaea cf. courbaril L.	Jutaí açu
H. parviflora Huber	Jutaí mirim
Hymenolobium excelsum Ducke	Angelim da mata
H. petraeum Ducke	Angelim da mata
	Andira (raramente)

-I-

Ilex innundata Poepp	Pau branco
Inga cf. alba Willd	Ingá
O. cf. capitata Desv.	Ingá
I. fagifolia Willd.	Ingá
I. cf. heterophylla Willd.	Ingá
I. cf. rubiginosa (Rich.)	Ingá

-J-

Jacaranda copaia (Aubl.) D.	Parapará

-L-

Lacmelia arborescens (M.Arg.)Mgf.	Molongó
Lacunaria sp. Ducke	Papo de mutum
Laetia procera Eichl	Pau jacaré
Lecythia paraensis Hub.	Sapucaia
L. usitata Miers	Sapucaia
L. sp.	Matamatá preto
Leonia cymosa Mart.	Pitombarana
L. cf. plycocarpa P. et E.	Pau branco
Licania cf. heteromorpha Bth.	Macucu
L. hostmannii Fr.	Caripé
L. cf. incana Aubl.	Caripé
L. micrantha Mig.	Caripé
L. cf. apetala (E.Mey) Fr.	Macucu
L. cf. paniculata Fansh et Mag.	Macucu
L. cf. parvifructa Fansh et Mag.	Macucu
L. stahelli Kleinh.	Caripé Macucu
Licaria cf. americana (Nees)Kost	Louro canela
Lindackeria cf. maynensis P.et E.	Aquariquarana (normalmente)
L. sp. afn. pouciflora	Aquariquarana (às vezes)
Luhea st. Willd.	Açoita cavalo

-M-

Malouetia cf. duckei Mgf.	Molongó
Manilkara amazonica (Huber)	Maparajuba
M. huberi Standl.	Maçaranduba
Macoubea cf. sprucei (M.Arg.)Mgf.	Sorva
Matayba cf. arborescens Rdlk.	Pitombarana
Maytenus sp.	Pau branco
Mezilarus itauba (Meisgn.)Taub.ex Mez.	Itaúba
M. lindaviana Sch. et Mez.	Itaúba
Miconia cf. minutiflora (Bompl.)DC.	Tinteiro
M. cf. ruficalyx Glearon	Tinteiro
M. cf. surinamensis Glearon	Tinteiro
M. sp.	Tinteiro
	Mirapucu (raramente)
Minquartia guianensis Aubl.	Aquariquaro (normalmente)
Moraceae Ducke	Caroara, Caxingubarana ou Janitá
Moronobea coccinea	Anani

Mouriria cf. brevipes	Miraúba
M. cf. calocarpa Ducke	Miraúba
M. sp. plaschaertii Pulle	Miraúba
M. spp.	Miraúba
Myrica cf. fallax (Rich.) DC	Murta

-N-

Neea cf. oppositifolia R. et P.	João mole

-O-

Ocotea canaliculata (Rich.) Mz.	Louro canela (normalmente) Louro chumbo (às vezes) Louro cumaru (às vezes)
O. sp.	Louro amarelo
O. spp.	Louro branco
O. spp.	Louro preto
O. spp.	Louros
Ogcodeia sp.	Caxingubarana (casco cortada verm.) (marrom; leite marrom claro)
Olacaceae Klots	Olacácia (3)
Olyra latifolia	Taboquina
Olmediophaena obliqua (Hub.)Ducke	Paxiubarana (=Muiratinga)
Omedioperebea sclerophylla Ducke	Amapá (= Rapé do índio)
Ormosia coutinhoi Ducke	Buiçu
O. cf. paraensis Ducke	Tento
Osteophloem platyspermum (A.DC)Werb	Uccubarana

-P-

Parahacornia amapa (Hub.)Ducke	Amapá
Parkia multijuga Benth	Faveira arara tucupi
P. oppositifolia Bth.	Faveira parkia
P. pendula Ducke	Faveira bolota
Parinari sp. Huber	Parinari
Peltogybe cf. paniculata Bth.	Coataquiçaua
Pera bicolor	desconecida
Piptadenia suaveolens Miq.	Faveira fôlha fina
Pithecolobium decandrum Ducke	Faveira arara tucupi (4) Faveira mapuxiqui
P. latifolium (L.) Benth	Ingarana
P. racemosum Ducke	Angelim rajado
P. sp. Benth	Faveira dura ou Faveira uing (3)
Platonia insignis Mart.	Bacuri
Platymiscium trinitatis Huber	Macacauba
Plumeira sp.	Sucuuba
Pogonophora schomburgkiana Miers.	Amarelinho
Pourouma velutina Mart.	Imbaunaraba
Pouteria cladantha Standl.	Abiurana goiabinha Abiurana ucuuba Rosadinha
P. cf. gutta (Ducke) Baehni	Abiurana ucuuba
P. macrophylla Eyma	Abiurana cutite
P. melinonii (Engl.) Baehni	Rosadinha

Pouteria cf. torta (Mart.) Rdlk	Abiurana goiabinha
P. venulosa (Mart.et Eichl)Baehni	Rosadinha
P. cf. virescens Baehni	Abiurana goiabinha
P. spp.	Abiurana (várias)
P. sp.	Abiurana branca
P. sp.	Abiurana casca grossa ou Casca grossa
P. spp.	Abiurana cutite
P. sp.	Abiurana matamatá
P. sp.	Abiurana sêca
P. sp.	Rosadinha
Protium divaricatum Engl. v. trijugum Swart	Breu branco
	Breu manga
	Breu preto
P. giganteum Engl.	Breu branco
	Breu manga
	Breu preto
P. heptaphyllum (Aubl.) March.	Breu branco
	Breu manga
	Breu preto
P. nodulosum Swart.	Breu branco
	Breu manga
	Breu preto
P. cf. opacum Swart.	Breu preto
P. puncticulatum Machs.	Breu preto
P. sagotianum March.	Breu branco
	Breu manga
	Breu preto
Prunus myrtiflora Urb.	Tatapiririca
Psycotrea sp.	Erva de rato
Pterocarpus rohrii	Mutiti

-Q-

Qualea sp. cf. paraensis, Ducke homosepela	Mandioqueira (áspera ou escamosa, frequentemente chamada Quaruba)
Q. sp. cf. albiflora Warm, acuminata	Mandioqueira (lisa)
Q. spp.	Mandioqueira (normalmente lisa)
Quiina pteridophylla (Rudlk)Pires	desconocida (= Molea de mutum)
Q. sp.	Papo de mutum

-R-

Rollinia anonoides R.E. Fries	Envira ata brava ou Ata brava
R. exsucca DC.	Envira preta
Rauwolfia paraensis Ducke	Muirajuçara
R. pentaphylla	
Roupala afn. montana	Faeira

-S-

Saccoglottis amazonica Benth	Uxirana
S. cf. guianensis Aubl	Axuá
S. sp.	Axuá
S. sp.	Uxi ou Cumaté
Sagotia racemosa Baillon	Araticiú
Sapium sp.	Murupita
Sapindaceae	Pitomba
	Pitombarana
Sclerolobium micropetalum Ducke	Taxi preto (fôlha miúda) (normalmente)
	Taxi branco (raramente)
S. cf. paniculata Vog.	Taxi pitomba
S. ? sp. nova P. et F.	Taxi branco
	Taxi pitomba
	Taxi preto (raramente)
S. sp.	Taxi branco
	Taxi pitomba
	Taxi preto (raramente)
Simaba cedron Planch.	Pau para tudo
Simaruba amara Aubl.	Marupá
Siparuna guianensis Aubl.	Capitiú
Sterculia pilosa Ducke	Axixá
Stryphnodendron cf.pulcherrimum (Willd)Hochn	Faveira mapuxiqui (normalmente
	Faveira barba timão (às vezes)
Swartzia aptera DC.	Gombeira
Symphonia globulifera L.	Anani
Swietania macrophylla (L) Jacq.	Aguano, Mogno

-T-

Tabebuia avelanedae(L.et G.)Standl.	Pau d'arco (roxo)
T. serratifolia (Vahl.) Nichols	Pau d'arco (amarelo)
Tachigalea cf.myrmecophila Ducke	Taxi preto (normalmente)
	Taxi pitomba
T. paniculata Aubl.	Taxi preto
Terminalia amazonica (Gmel)Exell	Cuiarana ou Tanimbouca
T. tanibouca Smith	Cuiarana ou Tanimbouca
Ternstroemia cf. dentata (Aubl.)	Murici (raramente)
Tetragastris altissima (Aubl.)Swert.	Breu branco
	Breu manga
	Breu preto
	Breu sucuruba (normalmente)
Theobroma subincanum M.	Cupuí
Touroulia sp.	Papo de mutum
Trattinickia burserifolia Mart.	Breu preto
	Breu sucuruba (normalmente)
Trichilia cf. acariacantha Harms.	Trichilia
T. lecointei Ducke	Trichilia
T. sp.	Itaubarana
	Pracaúba
Trymatococcus cf. amazonicus P.et. E.	Mururé
Tuvomita cf. grata Sandw.	Paxiubarana

-V-

Vantanea cupularis Hub.	Uxirana
Vataires guianensis Aubl.	Faveira bolacha
Virola cuspidata Benth	Uccuba(pubescente)
V. cf. melinoni (Benoist) AC.	Uccuba
V. multinerva Ducke	Ucuuba (pubescente)
V. cf. sebifera Aubl.	Ucuuba
Visma cf. cayenensis Choir	Lacre
Vitex triflora Vahl.	Taruma
Vochysia guianensis Aubl.	Quarubatinga
V. maxima Ducke	Quaruba Cedrorana (às vezes no C.B.A.)
V. revoluta Ducke	Quaruba rosa
V. cf. surinamensis Stafl.	Quaruba rosa
V. sp.	Quaruba
Vouacapoua americana Ducke	Acapu

-X-

Xylopia amazonica Fries	Envira X (3)
X. benthamii Rob. Fries	Envira amarela
X. cf. nitida Dun.	Envira X (3)

-Z-

Zollernia paraensis Hub.	Pau santo

APPENDIX XIV

LIST OF RESEARCH PLOTS

Campos Trial Plots, Fazendinha, Macapá

Natural Regeneration and Enrichment, Porto Platon

Natural Regeneration and Enrichment, C.B.A.

Line Planting, Santarém

Trial Plots, Santarém

Natural Regeneration, Planalto, Curuá

Enrichment Planting, Planalto, Curuá

Trial Plots, Planalto, Curuá

Girth Increments, Planalto, Curuá

Girth Increments, I.A.N., Belém

Tree Killing - Arboricides, Porto Platon, C.B.A., Curuá

Cedro Regeneration, Planalto, Curuá

Roadside Planting, Km 4 and 5, Flanco, Curuá

Campos Trial Plots, Km 56, Macapá - Porto Platon

Trial Plots, Flanco, Curuá

Enrichment Planting, Flanco, Curuá

Guariuba Regeneration, Planalto, Curuá

Tree Killing - Arboricides and Girdling, Planalto, Curuá

Girth Increments, C.B.A.

Trial Plot, Pines, I.A.N., Belém.

The position of the Curuá plots is shown on the Curuá map (Map No. 2)