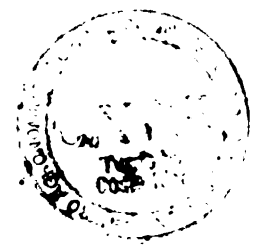
Report on IUFRO Symposium and Workshop on Genetic Improvement and Productivity of Fast Growing Tree Species, held at Aguas de São Pedro, São Paulo, Brazil 25-30th., August 1980. Also on the Associated Tours

D.H. Boshier



CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA, CATIE
Programa de Recursos Naturales Renovables
Turrialba, Costa Rica, 1981

Report on IUFRO Symposium and Workshop on genetic improvement and productivity of fast growing tree species, held at Aguas de São Pedro São Paulo, Brazil 25-30th. August 1980. Also on the associated tours.

Participating IUFRO working parties.

S 2.02-09 Eucalypt provenances.
S 2.03-10 Genetic improvement (Gains) in Eucalypts.
S 2.02-08 Provenances of tropical forest species.
S 2.03-01 Genetic improvements (Gains) in tropical and sub-tropical species.
S 2.02-01 Productivity of short rotation forestry with fast growing eucalypts.
S 1.02-01 Breeding/Fertilization (unofficially)

D.H. Boshier

CATIE, Turrialba, Costa Rica.

CONTENTS PAGE

1. Introduction

This tour was made at the request of Dr. W.G. Dyson, CATIE, and was financed by the Overseas Development Administration (O.D.A.) of the United Kingdom Two papers were presented by the writer at the Symposium:

Stead, J.W. Cordia alliodora (R. & P.) Oken as a plantation species.

Evans, H.B.L. & O.A. Sabido. First year results of the Cordia alliodora provenance trials in Belize.

The tour lasted almost 4 weeks and the itinerary is given below.

16-8-80 Flight San José to Panamá City

17-8-80 Flight Panamá City to São Paulo

18/19-8 Free days.

20-8-80 Start of the tour to the Interior of the State of São Paulo. Visit to the Instituto Florestal de São Paulo. Description of its work programmes and visit to its facilities. Overnight stay in São Paulo.

21-8-80 Visit to Compania Melhoramentos de São Paulo. Tours of plantation and trial plots of (particularly) Araucaria angustifolia, Cunninghamia lanceolata and Cryptomeria japonica. Overnight stay in Piracicaba.

22-8-80 Visit to Duratex S.A. Tours of plantations, seed production areas and progeny trials of Eucalyptus grandis, E. saligna and E. urophylla. Overnight stay at Baurú.

23-8-80 Visit to Companhia Agro Florestal Monte Alegre S.A. - CAFMA. Tours of Pinus caribaea, P. oocarpa and other species and provenance trials. Seed production areas and progeny trials. Overnight stay at Aguas de São Pedro.

24-8-80 Free day

25-8-80 Registration and opening session of the symposium. Presentation of position papers.

26-8-80 Attended the following sessions; Morning: Exploitation, conservation and genetic improvement of Pinus caribaea and P. oocarpa.
Afternoon: Exploitation, conservation and variation of Eucalyptus grandis.
Evening: Exploitation, conservation and improvement of Gmelina and Tectona.

27-8-80 Attended the following sessions; Morning: Exploitation, conservation and variation of other Eucalyptus species.
Afternoon: Selection and breeding methods in Eucalypts.
Evening: Exploitation, conservation and genetic improvement of Araucaria and Agathis.

28-8-80 Attended the following sessions; Morning: Nutrition and physiology of eucalypts. General problems of plantations.
Afternoon: Progress in the selection and improvement of other tropical species.
Evening: Productivity and management of conifer plantations.

29-8-80 Morning: Tour to Champion Papel e Celulose S.A. Mogi-Guaçu, S.P.
Afternoon: Wood quality of fast growing forests (effects of species, provenances and cultural treatments on wood properties).
Evening: Continuation of sessions. Exploitation, conservation and genetic improvement of Pinus caribaea & Pinus oocarpa and progress in selection and genetic improvement of other tropical forest species.

30-8-80 Morning: Closing session with review of the symposium and workshop by Dr. E.C. Franklin. (North Carolina State University).
Meeting of the IUFRO working groups S 2.02-08 and S 2.03.01.
Species, provenance and genetic improvement of tropical species other than eucalypts.

31-8-80 Bus to São Paulo and flight to Vitoria (State of Espíritu Santo).
Overnight stay in Vitoria.

1-9-80 Visit to Aracruz Florestal S.A. Tour of nursery to see mass vegetative propagation techniques and seedling production techniques for eucalypts. Species and provenance tests of eucalypts and pines. Extensive plantings with stock raised by vegetative propagation. Return to Vitoria and overnight stay there.

2-9-80 Visit to Aracruz Florestal S.A. Tours of spacing trials of E. grandis, areas for the production of cuttings. Seed orchards and controlled pollination techniques of E. grandis. Demonstrations of planting and harvesting techniques. Visit to pulp mill and port for pulp shipment. Overnight stay at Linhares.

3-9-80 Visit to Florestal Rio Doce S.A. Tour of Eucalyptus urophylla progeny/provenance trial, spacing trial, seed orchard. Management of natural forest reserve and trial of enrichment planting with indigenous species. Overnight stay at Vitoria.

4-9-80 Flight Vitoria - Rio de Janeiro.

5-9/9/80 Free days.

10-9-80 Flight Rio-Panama. Overnight stay in Panama City.

11-9-80 Flight Panama-Costa Rica.

Rather than listing individual companies and sites that were visited during the tour this report will try to deal with the various points of interest common to several of the companies, including at the same time similar points that were raised by papers at the symposium.

The altitude of sites visited varies from 0-100 m in the coastal area of Espíritu Santo to 600-750 m in São Paulo. Rainfall varies between 1000-1400 mm/yr Temperatures vary between 29°C - 19°C for the mean average max, and mean average minimum in the coastal region of Espíritu Santo and 27°C - 13°C with occasional frost in the parts of São Paulo State which were visited. Detailed data for the individual companies is given in appendix 1. Maps showing the location of the states and companies visited are given in appendix 2.

2. Forestry in South Eastern Brazil

This area as with most areas in the world has undergone severe deforestation particularly in recent years. For example in the state of São Paulo at the time of its founding in 1550 more than 80 per cent of the land is estimated to have been under native forest (some 20 million ha). By 1920, forest still covered more than 40 per cent of the land area but, by 1973, the proportion had been reduced to 8.75 per cent.

Industrial expansion, which began in the 1930's increased dramatically the demand for wood and wood based products. Reafforestation, at first with recently introduced eucalypts and, later with pines, failed to keep pace with this demand. By the 1960's, the native forests of the south and east of Brazil were near to exhaustion and other sources such as the Amazonian forest were too distant for what was a local demand for the economic transport of high-bulk low-unit-value industrial wood. As a result, in 1966, the government introduced fiscal incentives (Lei no. 5.106 and Decreto - Lei no. 1.134) to stimulate reafforestation. In the south-east an estimated 150 million hectares of suitable soil, under 'cerrado' or savanna type vegetation, were available for reafforestation. These soils are generally deep, acidic, yellow-red latosols or oxisols of pH5-6 and are considered to be of medium to low fertility. Although these fiscal incentives have been continously amended since their introduction they have succeeded in stimulating private enterprise in the forestry sector. In the 10 years following 1966 almost 3 million hectares were reafforestated of which 1.5 million were with eucalypts and 1 million with pines. The annual rate of reafforestation is now approximately 350-450,000 ha. The success of these incentives is also illustrated by the fact, that of the seven enterprise visited on the tours, all but one are privately run. Three of the companies were formed after 1966 and two of the others in 1958-59. Large scale plantation forestry in Brazil is thus generally regarded as being only just over 20 years old.

The following figures for the projected demand for wood products indicate the size of the demand in the south east which the reafforestation aims to meet (Simoes 1980).

Estimated Demand for Industrial Wood

Year	South East	National	In units of 1000 m^3 round wood
1979	116421.4	236052.5	
1985	145301.7	277277.7	

As more recently the international price for pulp has been higher than the internal Brazilian price, the government has introduced legislation to ensure that a certain quantity of products are retained for the internal market.

The species that have been most used in plantations in the south and south east of Brazil are as shown in the following table.

Principal species used in plantations in the wouth and east of Brazil

States	Parana, Santa Catarina Río Grande do Sul	São Paulo, Espíritu Santo Rio de Janeiro
Species	Pinus elliottii	Pinus caribaea (all 3 varieties)
	Pinus taeda	Pinus oocarpa
	Eucalyptus viminalis	Pinus kesiya
	Araucaria angustifolia	Pinus patula
		Eucalyptus grandis
		Eucalyptus saligna
		Eucalyptus urophylla
		Cupressus lusitanica

Comments in this report are mostly concerned with species in the right hand list, as the more southerly region was not visited on the tours.

Concurrent with this development of forestry in the south and east of the country, has been the development of research programmes usually by each individual company. These programmes have tackled many facets of forestry researc but particular emphasis has been placed on tree improvement. Since 1968 this work has been further developed by an agreement between IPEF (Instituto de Pesquisas e Estudos Florestais, Piracicaba, Sao Paulo State) and a number of private forestry enterprises. The agreement has roughly followed the system of the North-Carolina State University cooperative tree improvement programme. Species, provenance and progeny trials, seed stands and orchards and conservation stands have been established often with replication by several companies. The principal effort is being directed towards the following species: Pinus caribaea, all three varieties, P. oocarpa, Eucalyptus grandis, E. saligna, E. urophylla and the Brazilian 'alba'.

The present situation in Brazil can therefore be summarized as that of a large rapidly developing country with great requirements for wood production of all types. Government policy is aimed at the rapid development of the country without increasing the already large international debt which has been increased by oil price rises. Fiscal incentives have therefore been introduced to stimulate the enormous investment required for such internal production. The result of this is that the majority of forest activities in Brazil are run by private enterprises often with foreign investment.

The poor genetic base of the original species introductions and consequent possibility of large production increases have lead to the inception of tree improvement programmes. The programmes are at varying stages of development such that Brazil now has one of the largest programmes in the world of plantation forestry and associated genetic improvement.

3. Tropical Pine Plantations

3.1. Species Introduction

In the south east of Brazil the principal source of softwood had been the natural forests and a few planted stands of Brazilian "Pine" - Araucaria angustifolia. Near-exhaustion of these stands and the slow growth of planted trees necessitated the use of other species. In the 1940's trials were carried out with Pinus radiata but this proved unsuitable due to the climate being too tropical. Over the last twenty years there have been extensive plantings of tropical pines, firstly of Pinus elliottii and more recently of the higher yielding P. caribaea and P. oocarpa.

The pine plantations and work on pine improvement visited were principally at CAFMA in São Paulo State and to a lesser extent Aracruz Florestal S.A. and Florestas Rio Doce in Espíritu Santo State. CAFMA began in 1958 with the planting of P. elliottii. Growth was poor but species trials indicated that other tropical pines, particularly P. caribaea var. hondurensis, P. caribaea var. caribaea and P. oocarpa, would grow well. Of the 12,000 ha reafforested by this company about 8500 comprise tropical pines. Of these 8.500, 31 per cent are P. oocarpa, P. caribaea var. hondurensis and P. caribaea var. caribaea each represent 27 per cent and the remainder consists of P. caribaea var. bahamensis, P. kesiya, P. strobus var. chiapensis and P. elliottii var. elliottii. The figures below give an idea of the production potential of the different species in this area.

Species	Mean MAI (m^3/ha/yr underbark)
P. elliottii var. elliottii	12
P. patula	18
P. oocarpa	20-23
P. caribaea var. bahamensis	25
P. caribaea var. caribaea	28
P. caribaea var. hondurensis	30

Planting of P. elliottii has stopped but half a million trees have been retained for the production of resin to give an annual production of approximately 1200 tons. This species is included in the tree improvement programme and is under selection for high resin production.

3.2. Improvement Programmes

CAFMA is the largest producer of tropical pine seed in Brazil producing two tons per year. It, and other companies, see the local production of seed for Brazil as being important for two main reasons:

1. In 1978, 18,289 kg of pine seed were used of which 60% was imported (Kageyama 1980a) and assuming a price of $150/kg the annual cost is approximately $3 million. There is therefore both a considerable saving to be made from a local production of seed and also a sizeable market available both for ordinary seed and that of improved genetic quality.

2. It is difficult to be certain of the genetic quality and origen of seed brought on the open market. Suggestions have been made for example that seed described as from the Poptun provenance of P. caribaea is collected from a much larger area than it used to be, to meet an increased demand. Demand, for this provenance has risen sharply in recent years following reports of its good performance in many provenance trials.

A large programme of tree improvement has therefore been developed for tropical pines, principally at CAFMA and also at Aracruz in cooperation with IPEF. It aims to fulfill the normal three main objectives of a programme:

1. Provision of genetically improved seed for future planting.

2. Provision of suitable parent material for future breeding work.

3. Provision of adequate information for future planning decisions.

3.2.1. Provenance Trials

Provenance trials of the major pine species of interest have also been started in recent years. These are principally CFI International Provenance trials of P. caribaea and P. oocarpa. The present breeding programme is based on material from original commercial seed introductions. Thought will therefore have to be given on how promising material from other possibly better provenances can be incorporated into the programme.

3.2.2. Seed Collection Areas (S.C.A.)

Seed collection areas are plantations thinned during normal management by selective thinning to approximately 500 trees/ha, from which seed is collected for immediate sale.

3.2.3. Seed Production Areas (S.P.A.)

Seed Production Areas are selected stands that are thinned more intensively to allow greater crown development. Tree selection at CAFMA is made on the basis of a minimum d.b.h. limit, stand density being reduced to about 3-400 trees/ha in 7 year-old stands and 200/ha in 14 year old stands.

Both SCA and SPA may be certified by IBDF (Brazilian Forestry Institute) under a scheme introduced in 1977 to reduce the importation of seeds. Control of the quality of these areas is in the hands of the Commission of Forest Seed Control and is the first stage in the development of a forest seed certification system in Brazil. The table below gives the total areas for S.C.A.s and S.P.A.s in Brazil certified by IBDF. (Kageyama 1980 a).

Species	Total Area in ha. SPA	SCA
P. oocarpa	465	654
P. kesiya	435	83
P. taeda	172	
P. elliottii var. elliottii	143	
P. caribaea var. hondurensis	1253	750
P. caribaea var. bahamensis	33	17
P. caribaea var. caribaea	154	292

At CAFMA, a fourteen year old stand of P. caribaea var. hondurensis gave 0.01 kg/ha of seed at the time of intensive thinning, while 6 years after opening of the canopy this had risen to 4.53 kg/ha. Similarly with a stand of P. oocarpa annual seed production, before thinning was 0.48 kg/ha and 5 years later 7.06 kg/ha. No comparable figures were available for stands thinned at age 7.

A density of 200 trees/ha would seem to be rather high for maximum crown development and hence the number of cones per tree. A high stocking increases the cost of collecting the same quantity of seed by increasing the number of trees which have to be climbed and hence the time spent in climbing

3.2.4. Selection of Plus Trees

The plantations at CAFMA have been searched for plus trees, selecting principally for volume production and form. The table below gives the number of trees selected and the selection intensity applied. (The selection intensity is thought to be based on the number of trees planted).

Species	Number of plus trees	Selection Intensities
P. oocarpa	250	1:1900
P. caribaea var. hondurensis	200	1:3400
P. caribaea var. caribaea	150	1:6700
P. caribaea var. bahamensis	172	1:2400
P. kesiya	50	1:700
P. strobus var. chiapensis	30	1:100
P. elliottii var. elliottii	50	1:2000

3.2.5. Clonal Banks

The areas at CAFMA in the table below have been established using grafted ramets from the selected mother trees with the following stated objectives:

a) to produce seeds of high genetic quality,

b) to study pollen management and controlled pollination,

c) to study flowering induction,

d) to continue the tree improvement programme

Species	Area	Number of plus trees	Number of ramets
P. oocarpa	28.2 ha	200	7000
P. oocarpa (selected for) (volume only)	4	50	1100
P. oocarpa	1.3	70	350
P. caribaea var. hondurensis	26.6	200	7400
P. caribaea var. hondurensis	1.3	70	350
P. caribaea var. caribaea	3.0	30	300
P. kesiya	23.9	100	6200
P. kesiya	1.3	70	350

With such objectives these clonal banks are in fact what would normally be described as untested first stage clonal seed orchards.

The trees were established at spacings of 6 x 6 m using a top cleft grafting technique in the field with two stock at each position. Grafts for all the P. caribaea and P. oocarpa cuttings are made onto stock of P. caribaea var. hondurensis the reason given being that the latter has a more vigorous root system. The areas are now 5-6 years old and as yet there have been no problems with graft incompatibility. There are at the moment no plans to rogue these banks on the basis of results from progeny tests but rather to use such results as the basis for the establishment of new seed orchards, which would then follow a dynamic orchard scheme with a continous enrichment by new material.

It would seem apparent that there is a need to rogue these clone banks if the maximum improvement in the quality of seed produced is to be obtained. The spacing is sufficiently close to allow removal of one quarter to one half of the ramets, which would permit greater crown development and maintain seed production. The number of clones in the P. oocarpa, P. caribaea var. hondurensis and P. kesiya banks is enough to allow such roguing and still leave a sufficiently large genetic base for further improvement.

Recently both CAFMA and Aracruz, in conjunction with IPEF, have planted units of the Centro de Conservação Genética de Melhoramento de Pinus Tropicais project. The CCGMPT consists of various areas of large untested clonal seed orchards produced from plus trees selected in CAFMA and Aracruz as the table shows.

Species	Area in ha.	Total no. of plus trees	Number of plus trees from CAFMA	Selection intensity at CAFMA
P. caribea var. hondurensis	50	400	200	1:7000
P. caribaea var. bahamensis	50	300	172	1:3000
P. caribaea var. caribaea	50	300	150	1:5000

The ramets were established at 5 x 5 m spacing with the stated objectives of: 1) conservation of genetic material

2) study of orchard management

3) seed production

When asked about the plans for the future of these areas and the other clonal banks, the various people concerned seemed uncertain of the exact role these areas would play. Certainly the CCGMPT does not fit into what is normally understood by an ex-situ gene conservation area where an attempt is made to mantain the natural variability of the populations. It should probably rather be seen as a store of already partially selected material for possible future incorporation into breeding programmes. This problem of how to maintain a species natural variability while still allowing slection was raised by the paper of P.J. Wood and J. Burley (Title unknown) at the symposium. In their paper they proposed a means of simultaneously achieving these aims.

The immediate future, as far as CAFMA is concerned, lies in the production of pine seed of proven quality both for its own use and for sale. For this purpose they have distributed open pollinated seed from their 200 plus trees of both P. caribaea var. hondurensis and P. oocarpa to be used in progeny tests on 16 sites, mostly in the south and east of Brazil. Their aim is also to use controlled pollination in the clone banks to provide seed for further half-sib progeny tests and material for further selection. The proposed mating design is a factorial (N.C.M. II) design which will use pollen from 5 clones to cross with all the other clones as female parents. The open pollinated half-sib progeny test will already have given information on general combining ability (G.C.A.) for roguing of seed orchards. It would therefore appear that if controlled pollinations are to be carried out, they should be designed to obtain more information on specific combining ability (S.C.A.) and to provide suitable material from which to make further selections. The N.C.M. II design cannot supply the latter due to the small number of male parents used which greatly narrows the population base. More suiteable would be some form of partial disconnected diallel design which would give good estimates of S.C.A. and allow a variety of matings to maintain a wide base for further selections.

CAFMA is also developing, in conjunction with Openflora (Duratex group) in Bahia state, a clonal bank of P. caribaea var. hondurensis based on trees selected for vigour and long fibre cellulose. The selections are aimed at providing material for pulpwood production from short rotation plantations.

3.3. Symposium Presentations on Pines

At this stage a few general comments should be included about papers presented at the symposium on tropical pines and in particular the effect of results of the international provenance trials of P. caribaea and P. oocarpa on breeding strategies.

Many reports were given on provenance trials of both P. caribaea and P. oocarpa. The reports and a summary of results in the paper by A. Greaves, indicated that certain provenances were consistent in their relative performances over a range of sites. The most promising P. caribaea provenances were from Alamicamba, Karawala and Brus Lagoon in the coastal lowlands of Nicaragua and Honduras and from Poptun, Culmi and Santa Clara in the higher, drier interior of Guatemala, Honduras and Nicaragua. In the case of P. oocarpa, provenances from Mountain Pine Ridge in Belize, and Yucul, Camelias and Rafael in Nicaragua, grew oustandingly well on most sites.

One of the interesting features of these trials is the good growth of P. oocarpa. The best provenances have sometimes shown greater growth than the best of P. caribaea even in wet tropical areas which would be thought more suited to P. caribaea (Long, A.J. and G.F. Dykstra). The good performances of some of the Nicaraguan provenances in both species would suggest that there will be an increase in demand for seed from these areas. Whereas there are seed collecting centres in all the other Central American countries, there is none in Nicaragua. The country is at the moment ill prepared and will be unable to respond to such a demand. The situation there is perhaps even more critical in view of the increasing pressure from farming leading to the possible disappearance of some of these provenances. For example the P. oocarpa trees that comprised the provenance of "Camelias" have already been felled and so the international provenance trials represent the only sources of this material.

Barnes et al. in their study of the variation and genotype-environment interaction in the international trials of P. caribaea conclude that, "there is unlikely to be any one universally superior provenance of P. caribaea var. hondurensis. There could be circumstances in which the properties of one provenance may be preferable for a special situation, but is more likely that it will be an advantage for most countries to base their commercial and breeding populations on a number of provenances".

Such a conclusion, if borne out by more detailed studies in progress has important implications for many programmes. Many organizations such as the companies visited in Brazil, have started large improvement programmes with material selected from original commercial introductions. In Brazil wide ranging provenances trials had not been carried out until recently. The conclusion by Barnes et al suggests however that it will be possible to continue with such programmes without having to start agin from a better population base. This is provided that additons of selected material from other good provenances are made as results from the trials become available.

4. Plantations of other Conifer Species

The Companhia Melhoramentos de São Paulo founded in 1890 produces pulp and paper and specialises in high quality paper for industrial and other purposes. It uses primarly conifers and has three areas of forest; two in the state of São Paulo and one in Minas Gerais. The latter is the largest area and is of approximately 11,000 ha planted mostly with P. patula. The site visited was at Caieras about 35 km from Sao Paulo city, with over a half of the 4,400 ha being in conifers. The three main species grown are Cryptomeria japonica, Cupressus lusitanica and Cunninghamia lanceolata. The latter two are used primarily to provide pulp for the fine quality papers.

Large scale planting at Caieras did not begin until 1927 when it was principally with Araucaria angustifolia. Later in the 1940's-50 eucalypts, principally Eucalyptus saligna, were planted and coppiced on 7 year rotations for pulp-wood. The present area of eucalypts (45%) is being reduced by destumping and replanting with the three main species and in future Eucalypts will only be grown in small areas as fire breaks.

The species are quite carefully matched to site quality and the plantation is composed of relatively small units of each species. The Cupressus lusitanica, which has a superficial root system, is planted on shallow soils and the other two species on the deeper soils.

Production is not entirely aimed at pulp. Cryptomeria wood is used for construction purposes and when felling cypress stands the logs are separated at the felling site into 2 m lengths for pulp and 4.5 m for saw logs. The diameter limits are 7 cm minimum for pulp and 12 cm for sawlogs (underbark) and a chipsaw is used for conversion of the logs, allowing such low limits for saw logs.

One advantage of Cunninghamia lanceolata as a plantation species is its ability to coppice. The two best sprouts are selected after 18 months and resprouting may be so vigorous as to necessitate selecting 3 more times. Stands at a felling age of 24 years were quoted as giving MAIs upward of 30 m^3/ha/yr.

5. Eucalypts

The companies visited that mainly grow eucalypts are Duratex S.A. (São Paulo), Champion Papel e Celulose, S.A. (São Paulo) and Aracruz Florestal, S.A. (Espíritu Santo). The production at Duratex is aimed mainly at supplying material for their hardboard mills whereas that of the other two is exclusively for pulp. The principal species planted are:

	Duratex	Champion	Aracruz
E. grandis	58%	40%	80%
E. saligna	38%	40%	15%
E. urophylla	3%	19%	5%

5.1. Species Introductions

The most important early introductions of eucalypts to Brazil were made at the Botanical Garden of Rio Claro in the state of São Paulo in 1919. A number of species were introduced including what was then known as E. alba and has since been renamed as E. urophylla. The E. 'alba' seed appears to have come from one tree in the Botanical Garden in Djakarta. This tree is thought to have originated from seed from the natural stands of E. urophylla on Flores Island in Indonesia.

The first extensive plantings of eucalypts in Brazil were made using seed collected from the Rio Claro introductions, principally from the plots of E.'alba'. The resultant stands have however shown a high degree of variability in many characters suggesting the presence of hybrids. The E. 'alba' was planted next to plots of E. tereticornis and E. saligna and the fact that it flowers there for ten months of the year would make hybridization highly possible.

Examination of the plot layout at Rio Claro has given an indication of which of the combinations are difficult or impossible and having examined plantations Pryor identified most of the hybrid mixture as being hybrids of E. urophylla x E. tereticornis and E. urophylla x E. robusta. Such plantations of the Brazilian 'alba' seen on the tours show such characteristics of uncontrolled hybridization with variation in bark colour, pattern and texture, leaf shape, etc. (Martin, B. and C. Cossalter 1975, De Castro Pasztor 1977, Pryor, L.D. 1971).

The poor nature and potential of the material available in the past (Brazilian 'alba')is evidentfrom the MAIs that were being obtained at the rotation age of 7 years. In 1967, companies such as Champion were obtaining $15m^3$/ha/year overbark, which with intensive silvicultural treatment, such as soil preparation and fertilization, could be raised to $21m^3$/ha/yr. New introductions were made in 1968 by Champion and Duratex (at the suggestion of L.D.Pryor) of E. grandis from Coff's Harbour, N.S.W., Australia which on similar 7 year rotations gave MAIs of $35m^3$/ha/yr. New introductions of other species were made around this time many giving greater yields than the Brazilian 'alba' e.g. E. urophylla $30m^3$/ha/yr, E. saligna $25m^3$/ha/yr. The plantations at Duratex, who started planting about 1970, are therefore based mainly on new introductions particularly of the Coff's Harbour E. grandis.

Champion, being an older company, had originally established most of its plantations with seed of Rio Claro origin. This resulted in large areas of low yielding plantations and so the company is now conducting a programme for the reform of these areas. After clear felling coppicing is prevented by herbicides, or succesive debudding and new seedlings stock is planted between the stumps. The seed is obtained from seed production areas of their new introductions of E.grandis It was calculated that an increase of $10.5m^3$/ha/yr in MAI would be necessary to justify such a programme economically. At an average increase of $13.5m^3$/ha/yr this goal has easily been achieved.

The first plantings at Aracruz were of E. grandis, E. saligna and E. 'alba' with seed from commercial plantings obtained from the original Rio Claro introductions. These plantations showed great variation, containing some trees

of high quality and vigour, others with the opposite. Its commercial scale plantings after 1974 were made using seed from South Africa (coast of Natal) and Zimbabwe as the best seed available in the quantities required.

5.2. Improvement Programmes

The majority of companies have realised the probable poor quality of this original material and its limitations for future improvement. This is particularly so because the original introductions appear to have been made with seed from only one tree. In the last 5-10 years they have attempted to broaden the genetic base from which they work and identify the most suitable natural populations to use by conducting more detailed species, provenance and progeny trials.

5.2.1. Provenance Trials

The natural range of E. grandis is large, running on the east cost of Australia from 33° latitude south in Central N.S.W. to 17° latitude south in northern Queensland. The most planted provenance in the area visited in São Paulo is that of Coff's Harbour which is at a latitude of 30° south. Figures from a eucalyptus species and provenance arboretum and an arboretum of 13 E. grandis provenances, both at Aracruz in Espirito Santo indicate that while the Coff's Harbour provenance shows good growth, that of Atherton at 17°08' latitude, 145°37' longitude shows the best performance. Trees of the Atherton provenance are superior in volume production stem form and resistance to the canker caused by Diaporthe cubensis. Seed collections have therefore been made by the company from plus trees selected in the Atherton area to use as a base for the breeding programme. The seed is now being tested in a half-sib progeny trial which is 2.5 years old. Some selections have already been made of best trees within good families to produce seed orchards by grafting.

Duratex and Champion however, seem to have neglected the need for adequate provenance trials. Champion appear not to have carried out such work and are developing a breeding programme based on their introductions of the Coff's Harbour provenance. Duratex have conducted a small provenance trial of E. grandis but included only four provenances all from northern N.S.W. Of these Kyogle at 28° 37' latitude south gave the best growth and Coff's Harbour was only third. Their conclusion was that a simple choice of provenance may bring about highly significant gains in forest production. Duratex is however still basing its improvement programme on material selected from plantations of Coff's Harbour origin and currently has no plans to introduce new material. As São Paulo is at about 22°latitude south it seems possible that provenances from further north in Queensland may show even better performance.

These examples and the earlier ones mentioned with the pines emphasise a point that was also shown many times at the symposium; that is the need for full provenance trials sampling all the natural range of a species if the maximum possible production is to be attained. Much effort may be wasted by starting an improvement programme from the wrong base population. Brazilian experience also stresses the importance of the continuation of the programme of provenance trials

of various species on a number of sites here in Costa Rica. These trials were started in recent years by CATIE and noted by R.H. Kemp in "Report on a visit to the Tropical Agricultural Research and Training Centre (CATIE)" in July 1977, as being important.

5.2.2. Seed Production Areas

Both Champion and Duratex are involved in the cooperative programme with IPEF and have similar seed improvement programmes. Seed production areas have been developed by these companies from selected good stands of E. grandis, E saligna and E. urophylla. The SPAs are formed by an initial thinning to remove 70% of the trees at age four years and another, two years later, to leave approximately 200 trees/ha, that is 10% of the original population. This still seemed to give too high a stocking, does not allow full crown development and, as with the pine seed production areas, the cost of collection must be much higher than it need be. Selections in these stands are made on the basis of diameter measurements. de Freitas et al (1980) quoted diameter differentials obtained by selection at the 1st. thinning of SPAs of E. grandis at 4 years of age, as follows:

	mean dbh of original population in cm	mean dbh of selected population in cm
SPA I	11.1	13.69
SPA II	9.15	10.85

One fifth of the trees are used each year for seed collection with yields of 10-15 Kg/ha (250-350 g/tree).

Champion has an area of 120 ha given over to such SPAs which produces 1800 Kg/yr and is sufficient for their present needs. For eucalyptus species, this is a very large quantity of seed and, assuming viability of 2-400 seeds/g, would produce twice the number of plants needed annually in Brazil. My first comment on the quantity of seed used is that seed collected from plantations of Rio Claro hybrids has a very low viability. The second is that Brazilian nursery practice seemed to be wasteful, especially in the proportion of seedlings that were pricked out. M. Ferreira, in a paper presented at the symposium, estimated the requirement for seed at 1 kg for every 10 ha planted with the availability of more expensive seed of improved quality the companies will have to improve their nursery practices, if seed cost is not to prove an unnecessary burden and full advantage is to be taken of the new seed.

5.2.3. Special Seed Production Areas

A study has been started at Champion, in collaboration with IPEF, to investigate the effect of selection intensity and pollination conditions on the quality of E. grandis seed. The experiment will compare plots raised from six kinds of seed.

1) Seed from SPA (SI 1:10)
2) Seed from trees in commercial plantations without selection
3) Seed from trees in commercial plantations (SI 1:10)
4) Seed from isolated plus trees (SI 1:5000)
5) Seed from plus trees from commercial area (SI 1:5000)
6) Seed from special seed production area (SI 1:5000 for ♀ , 1:10 for ♂)

The special seed production area has been developed to give increased gain to commercial seed over that obtained from the seed production areas (Kageyama 1980 b.). Kageyama suggests that they will give an intermediate position in gain between an S.P.A. and a clonal seed orchard with production of good quality seed in a short period of time. However such a system can not easily produce large quantities of commercial seed at the intensity of selection suggested. Yields will be at the most 0.1 Kg/ha and the cost of collection will be increased considerably. At 7 months of age no significant differences had appeared between the mean heights of the treatments.

5.2.4. Selection of Plus Trees

Champion and Duratex have both proceeded with the selection of plus trees in their plantations. At Champion for E. grandis the selection intensity achieved was 1:5000, using growth form and phytosanitary aspects as bases for selection At Duratex the selection intensity was less — 1: 1600. Open-pollinated, half-sib progeny trials have then been planted to test these plus trees and the results will be used to decide which clones are included in new seed orchards. First results of a trial at Duratex which include plus trees of their own, plus trees from Champion, selections from Rio Claro and commercial controls from Champion and from South Africa, already point to the possibilities for improvement by selective breeding. They also indicate the relatively poor performance of seed collected from selected trees at Rio Claro.

5.2.5. Seed Orchards

An orchard has been established at Aracruz based on plus trees of E. grandis. This was established at a spacing of 8 x 8 m and when visited the trees had large low crowns with large quantities of seed. The stocking however was only about 60% and crown growth was best where the surrounding trees were missing, which suggests that a spacing of greater than 10 x 10 m could be used. Champion and Duratex have failed to establish seed orchards based on their existing plus tree selections which are now being progeny tested. As a result, if they wait until they have results from these tests, there will be a considerable delay before they are able to produce seed of proven quality. The establishment of clonal seed orchards, which can later be rogued, is the easiest solution to this type of problem .

5.2.6 Interspecific Hybridisation

Various hybrid crosses have been made at Aracruz although as yet no morphological work has been done to show hybrid characters. The crosses attempted so far by controlled pollination have been E. grandis x E. pellita, x E. urophylla and E. urophylla x E. pellita. E. pellita shows very good resistance to the canker caused by Diaporthe cubensis and it is hoped to combine both good growth and resistance in the hybrid.

Champion has also conducted work on interspecific hybrids; E. grandis x E. pellita, x E. urophylla, x E. robusta x E. saligna. At 32 months the x E saligna showed greater height growth than pure E. grandis and the highest wood basic density was shown by the x E. urophylla at 0.502 g/cm .

The E. grandis x E. robusta hybrid is intended for plantations on marginal sites with hydromorphic soils where E. grandis grows poorly. This work also lacks morphological studies to show hybrid characters.

Aracruz were also testing the possibility of producing a E. grandis x E. urophylla hybrid in a seed orchard by open pollination. This is done by selecting the most highly self incompatible tree from a number of E. grandis plus trees. This tree is then grafted onto root stock in the orchard beside grafts of a number of plus trees of E. urophylla in the ratio 1:1. Seed will be collected only from the E. grandis grafts. The aim of this is to produce hybrids in which selections can be made and vegetatively propagated. The use of more E. grandis clones either in isolated two tree groupus of E. grandis and E. urophylla or multiclonal grafts as suggested by Hodgson (1976), would however give greater possibilities of combinations and numbers of trees within which to select for good hybrids:

Too much work on hybridisation would seem unwise at present while there is so much potential for improvement by use of the breeding populations they already have.

5.2.7 Vegetative Propagation

Of the present 10,000 ha/yr of planting at Aracruz, 6,000 ha is planted by using rooted cuttings. In the next few years as production capacity for cuttings increases, all plantings of material of Rio Claro origen will be by rooted cuttings and only pure species will be planted from seedling stock. The use of vegetative propagation will be to produce immediate gains by selection within the company's older more variable plantations. This is one part of a two sided approach to its improvement programme. Its own collections of E. grandis from Atherton are intended to provide a base for future long term improvement.

At the moment, Aracruz has facilities for the production of 2.25 million cuttings every 40 days and this will soon be increased to 3.5 million. The cuttings originate from 150 plus trees selected in the stands of Rio Claro origen. The trees are than felled and cuttings taken from the one month old coppice shoots, each stump producing 3-400 cuttings. To produce clonal material on the scale that is needed these cuttings are planted out and then felled, after 1.5-2 years growth, to produce more cuttings. By this method approximately 20-30 ha are needed to provide sufficient cuttings for the yearly planting programme. At a cost of 1.3 cruzeiros ($0.02)/ rooted cutting the company says that costs are cheaper than for the production of seedlings.

Various reports were given at the symposium on the use of rooted cuttings. and it seems likely that their use will increase in the next few years. This is particularly so with species in which the low viability of seed or poor seed production limits their wider use. For example, E. dunnii is a species which has shown good growth in trials in São Paulo and has the useful attribute of frost resistance, but, which can't be grown on a commercial scale because of its poor seed production. Another possibility is presented by Araucaria spp where seed storage is difficult.

5.3 Canker Studies

Work is being carried out on susceptibility to a stem canker of Eucalyptus by the fungus Diaporthe cubensis. This fungus is indigenous to Brazil and, according to the experience of Duratex, causes stem cankers on trees more than 6 m tall, and may kill 20-30% of the crop before felling at age 7 years. At Duratex, canker free trees were selected in stands where the canker was very common and open-pollinated seed collected from these trees was used to plant a half-sib progeny test. At 12 months of age, 33% of the progenies showed disease symptons though there was great variability in the degree of symptons. A clonal bank was also established by top cleft grafting to facilitate the conservation of genetic material, controlled pollination studies and the establishment of a seed orchard. It is hoped that trees raised from the orchard seed will combine high productivity with resistance to the canker. The bank was planted at a spacing of 5 x 2.5 m and at the same age the incidence of canker was much lower than in the concurrent progeny test established at their usual commercial spacings of 3 x 1.5 m. It may be, that at such close spacings there is considerable competition and suppression of some stems, which predispose the trees to attack by the fungus. Also the spacing of this stand is far too close for maximum seed production and will therefore have to be rogued to about one eigth of its present stocking. This indicates the kind of saving that can be made if seed orchards are established at or near to their final spacings.

The approach at Aracruz to this problem is slightly different. Firstly they are studying the susceptibility of different eucalyptus species and provenances to the fungus and secondly are trying to produce potentially resistant interspecific hybrids. The former is however at the moment only a preliminary investigation there not being sufficient provenances of E. grandis in the test to indicate adequately any pattern of resistance in this species. First results show that the Atherton provenance has the lowest incidence of canker, 10-20%, whereas up to 50% of stems may be attacked in the Gympie and Bellthorpe provenances and 70% in the Jinna provenances. Provenances from higher latitudes seem to be more susceptible than provenances from lower latitudes. If this is the case, careful site selection will be needed for E. grandis in Brazil. The hybrids tried are those mentioned in section 5.2.6.

Besides work on the selection of resistant provenances and individuals, it would appear that the problem of the canker also needs more work on its sivicultural aspects and possibilities of control.

5.4 Coppiccing Studies

Several of the companies are investigating the ability of the eucalypt stools to coppice and production levels after succesive cuts. Problems with the death of cut stumps varied from company to company. Champion found that death can be as high as 40% whereas at Duratex it was between 15-20%. This they gave as the reason for the falls in yield at succesive rotations falling from 30-25-20 m^3/ha/yr. Aracruz

indicated that stump death could be as high 50% in some areas and that survival would be one of the characters they would be selecting for in future generations. Studies done at Champion indicated that E. grandis is particularly sensitive to the time of cutting in sandy soils. By cutting in November survival was 100%, instead of the 60% when cutting in May. Duratex also found that it was related to the height of cutting. By altering their cutting height from the normal of 5 cm to 10-15 cm. gains of 10-15% in survival could be obtained.

Champion have also looked at the planting of seedlings to replace dead stumps. Using larger than normal seedlings (50cm) and cutting the coppice at the time of transplanting, after two years growth there is no significant difference between the coppice or seedling growth.

5.5 Pests

One area in which research is probably needed is that of potentially damaging pests and possible means of their control. At the moment the plantations are generally free of pest problems apart from the Atta ant which causes defoliation particularly in the cerrado soil areas. There are three species involved; Atta sexdens rubofilosa Atta laevigata, Acromyrex octospinosa and control is affected by fumigation with Methyl bromide, or by "Mirex". Application of aldrin to planting holes ensures that termites of the genera Syntermes and Anophotermes are not a problem.

The possibility of some native insect problem developing, or an accidental introduction of a pest from Australia , is however real. The lack of such infestations at the moment should not give confidence for the future as extensive plantings of these species are less than 20 years old. Whilst Aracruz was doing work on the identification of insects found in the plantations it would seem also necessary for some work to be done on Australian pests that could possibly cause problems in Brazil. The scale of investment in this part of Brazil is now so large that a serious pest outbreak would have a disastrous effect and leave a great shortage of material.

5.6 Management Practices

All of the companies visited are working on 7 year coppice rotations with yields o 250 - 350 m^3/ha at felling. Duratex are looking at the possibility of a coppice with standards system leaving 160 trees at felling to mature to saw log size and be felled at the second rotation cut. The aim of this is to produce both wood for their hardboard mills and saw logs for other markets.

Aracruz are also using the lop and top, which is chipped in the forest by mobile chippers and then burnt in the pulp mill, to provide over 70% of the fuel for the mill. The indications were that such a policy is at the moment mainly political, when anything that reduces dependence on oil imports is highly favoured. The question is how long can what is virtually whole tree harvesting continue. Cromer et al. in a paper presented at the symposium indicated that a high proportion of a trees nutrients are held in the leaves and branches. In an unfertilized plot 60% of the biomass was in the stemwood and 13% in the leaves. Total nitrogen and phosphorous content in the stemwood and bark was about 30-35% whereas in the leaves it was 50-58%, Harvesting all but a few of the leaves, as this system appeared to be doing, will therefore remove about 75% of the trees NP content from the site. While the reason for such harvesting can be understood, it would seem that there is a need

for research by Aracruz to determine what effect this system is having and its likely future consequences.

Planting by the larger companies is carried out throughout the year by the use of watering at the time of planting. One hundred grams of fertilizer (generally NPK 10:28:6 + Boron) is applied to each tree at planting time.

6. Instituto Florestal São Paulo

This is part of the Agriculture and Supply Secretariat of São Paulo state and is one of the four institutes that come under the coordination of the natural resource section. It began as the Botanic Garden in 1896 changing in 1911 to the state forest service until 1970, when its present structure was arranged. Its responsibilities are as follows:

1. Forest research in the areas of development, silviculture, management, inventory, forest mechanization, ecology, parasitology and forest entomology, forest products and wild fauna.

2. Management of state reserves and state parks aiming at their preservation and use for educational, scientific and leisure purposes.

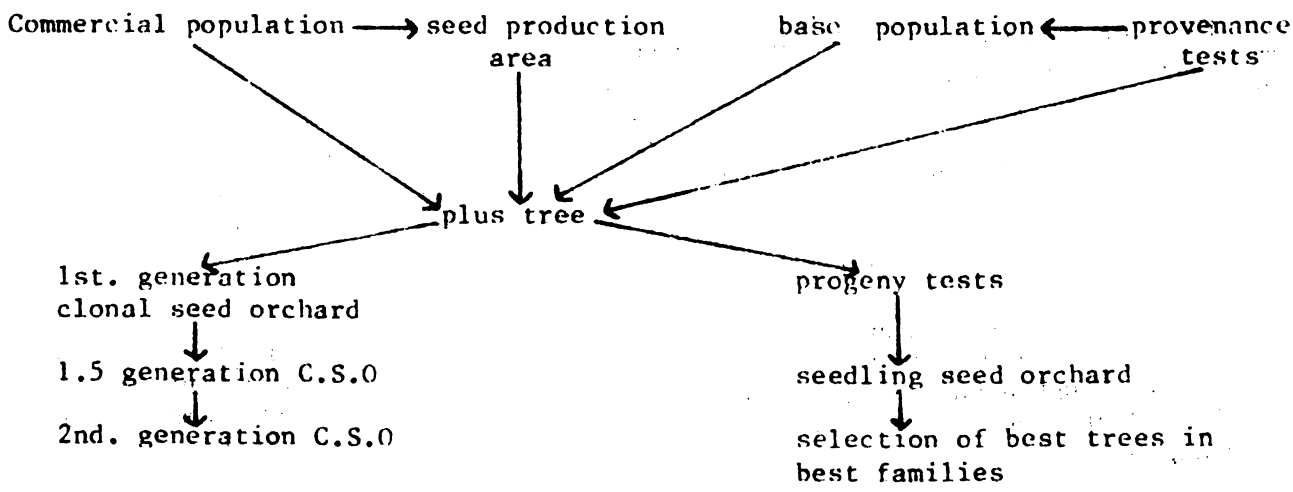
3. Management of the forests cultivated on state grounds, aiming at their rational exploitation and sustained production.

4. Production of improved forest seeds, forest seedlings and ornamental plants. Under its administration it has 57,000 ha of forests and experimental plots, 136,000 ha of forest reserves and 564,000 ha of state parks.

The main aims of the institutes tree improvement programme are stated as being:

1. The selling of seeds on the open market,
2. The maintenance of a germplasm bank,
3. The development of specific techniques e.g. electrophoresis of isoenzymes.
4. Genetic improvement of species receiving little attention from other institutions e.g. Araucaria angustifolia, Eucalyptus tereticornis.
5. Cooperation with other state, federal and international institutions.

A diagram showing the planned development of the genetic programme is given below.



In 1980 the programme is at the stage of the first generation seed orchards and progeny tests. The commercial populations are those that were planted using seed from original introductions while the provenance tests reflect the need to assess first of all the populations that will perform best. Due to the great demand for seed the eucalyptus provenance trials are being heavily thinned at four years old to provide seed production areas. This could possibly make accurate assessments of these trials difficult when the general rotation age in use is seven years. The seed production areas of pine species are a result of provenance trials thinned normal up to the commercial rotation age, the first thinning occurring at seven years.

The work on electrophoresis of isoenzymes is being carried out on material of 21 provenances of E. grandis by which they hope to be able to identify the provenances. Such a technique could be useful in trying to distinguish some of the provenances in the Brazilian "alba" and so characterize it more easily.

7. Cooperative Tree Improvement Programmes

Various cooperative tree improvement programmes are in existence in the world and appear to have been of benefit to all concerned. Most cooperatives have arisen from the need for secure sources of seed as large plantation programmes are developed. To a small organization the possibility of technical assistance and research informatio from a variety of sites can be particularly attractive. The general advantages and problems of such cooperation have been well outlined by J.P. Van Buijtenen (1975).

One session at the symposium was devoted to cooperation on a national, regional and international basis. Various reports were given on programmes already in operation and on the establishment of new ones. One was given on the possibilities of the establishment of a programme for the global coordination of the exchange of information and genetic material of tropical lowland conifers. (Palmberg 1980).

Also reported on was CAMCORE (Central America and Mexico Coniferous Resources Cooperative) which has recently been established and is based at the North Carolina State University. This involves six North American and Latin American forest industries and the university, with the host countries as honorary members. (Guatemala is a full member). The stated goal is "to preserve", test and utilize the coniferous resources of Central America and Mexico for the purpose of improving the productivity of forest lands in the tropics and sub-tropics (Gallegos et al 1980). The programme will begin in Guatemala in 1981 and have two simultaneous phases; a) Preservation Phase- establishment of banks (of seed origen) on individual cooperator's land and in the host country, to preserve material of known provenances, b) Testing Phase- includes establishment of progeny trials.

IPEF (Instituto de Pesquisas e Estudos Florestais) is based at the University of São Paulo, Piracicaba, São Paulo state. Four technical staff work full time for IPEF but considerable technical assistance is also provided by cooperation with the Forestry Department of the University. Some 29 forestry companies are members of the IPEF cooperative and represent a wide range of climates from those in the south to those in the north of the country. Each company pays the same monthly quota ($500.00 in 1979) and membership is aided by tax concessesions such that the cost to individual companies is small.

The cooperative is run by an Administrative Board consisting of a scientific director and six representatives of the member companies. The tree improvement programme, though a main feature, is only part of the research programme. The other main fields of investigation are silviculture, forest products, forest economics and management, forest protection. It also aims to help in the training of new staff

and the dissemination of information by a variety of publications.

It was clear that the value of the IPEF programme varied from company to company. CAFMA and Champion appeared to depend considerably on IPEF for technical assistance. Aracruz, though a member of the cooperative, has clearly placed a large investment in its own research. In this case it appears that the cooperative is unable to provide assistance on the scale that Aracruz requires.

The possibility of CATIE carrying out tree improvement programmes in the near future raises the question as to what form these could take. Large scale plantation programmes requiring secure supplies of seed have not yet started in Central America. As a result the regional demand for seed and the consequent financial interest to form such a cooperative has not yet arisen. Any improvement programme started by CATIE will have to rely on the interest and cooperation of individuals and small interests.

It seems certain that in the next 20-30 years all countries in Central America will be forced to develope large scale plantations as shortfalls in wood production become apparent due to rising internal demands. Costa Rica estimates that its existing forests can only sustain the internal demand for saw wood for 30 years more. From 2010 it will have to import an estimated one million m^3/yr of timber to meet its demands (Plan Nacional de Desarrollo Forestal 1979-1982). The usefulness of CATIE starting an improvement programme is thus apparent particularly when one considers the lead in times involved and the probability of a sudden, large demand.

3. The Symposium

The sessions were listed as below and in the tour itinerary.

26/8/80 Afternoon: Silviculture and yield in fast-growing forests.

27/8/80 Morning: Response of eucalypt plantations to fertilizers

Afternoon: Development of short rotation ecosystems.

28/8/80 Morning : Cooperation-National, regional and international.

Afternoon: Management of eucalypts for seed production, hybridization and vegetative propagation.

352 people from 29 countries attended of whom 251 were from Brazil. Some 250 papers were presented, summaries of the majority being given in a special edition of Silvicultura (N°16). The proceedings will be published by the Sociedade Braziliera de Silvicultura.

Sessions on pines and eucalyptus were the most heavily attended reflecting the interests of those attending from Brazil. In contrast the sessions on other tropical forest species were poorly attended. The papers presented there however emphasise that there is great potential for growth with various species many of which are little known. In this respect CATIE can play a role in increasing knowledge, particularly of Cordia alliodora.

In the field of tropical pines, particularly P.caribaea and P. oocarpa, and the eucalypts much more is known and many reports were given on breeding programmes for these. With the event of vegetative propagation in the eucalypts and its investigation in pines it is clear that work is far ahead of that for other tropical species. This point was raised at a meeting of the working party on Species, provenance and genetic improvement of tropical species with the exception of the eucalypts. It was suggested that the state of knowledge in the tropical pines

was so far ahead of that in other species that if continuation of these advances is to occur it might be necessary to make a separate group for it. This it was argued would allow further advances to be made without detriment to much needed work on the other tropical species. The general consensus at the end was that rather than split up the group future meetings should deal with more specialised matters and that there should be a greater number of smaller meetings.

Dr. E C. Franklin mentioned these possibilities in his summary of the symposium. He also mentioned the following points. That the need for full species and provenance testing had been emphasised and must be the most important stage in selection and improvement. That before any work is started a fully detailed programme must first of all be worked out. This should list the possible alternative and projected gains.

He mentioned that basic density and wood quality are important factors which should be assessed in a programme as soon as is feasible. As a programme develops, emphasis must be placed on quality rather than gross yield, looking for uniformity of wood properties both within plots and trees. Also at the moment too little emphasis is given at an early stage to disease an insect problems.

He highlighted vegetative propagation as being the newest and most exciting prospect in the improvement of eucalypts and pines. He then forecasted that the next major step would be the broad scale application of tissue culture. The use of cloning however brings with it certain requirements for improvement programmes ; 1) It does not remove the need for sexual programmes using genetic recombination. 2) Clones must be proven in proper clonal tests and not presume on the basis of ortet performance. (Something that didn't seem to have been adequately done at Aracruz. 3) The genetic base must not be narrowed too much. The potential gains are high but so are the risks and a programme must aim to optimize gains whilst minimising risks.

Finally he pointed out that the role of the forest geneticist is to assess the available variability for utilization as soon as is possible and that because variability is much greater than in animal or in annual crop breeding, the same techniques are not necessarily applicable.

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Appendix 1

Geographical and Climatic Data of sites visited

Cía Melhoramentos de São Paulo - Caieiras
23°24'latitude south 46°44'longitude west
Altitude 780 m
Monthly mean temp 17.6°C
Mean annual precipitation 1,459 mm
Soils considered medium to low fertility
Topography Hilly
Geology Pre-Devonian - shale zone with granitic instrusions

Duratex S.A. Rio Claro
22°43'-22°51' latitude south 48°44'-49°00' longitude west
Altitude 600-740 m
Mean max temp 27.3°C
" min " 13.0°C
Absolute min temp -2.6°C
Mean annual precipitation 1,200 mm
Climate CWA Koeppen
Topography Slightly wavy
Soil Mainly latosol yellow-red with low fertility and pH ranging from 5-6. Depth greater than 2 m.

Cía. Agro-Florestal Monte Alegre - Agudos
22°20'-22°29' latitude south 48°51'-48°49'latitude west
Monthly mean temp 18-23.6°C
Annual mean temp 21.1°C
Mean annual precipitation 1300 mm
Climate Mesothermic CWA Koeppen
Soils Sandy dark red latosol and small area of sandy yellow latosol.

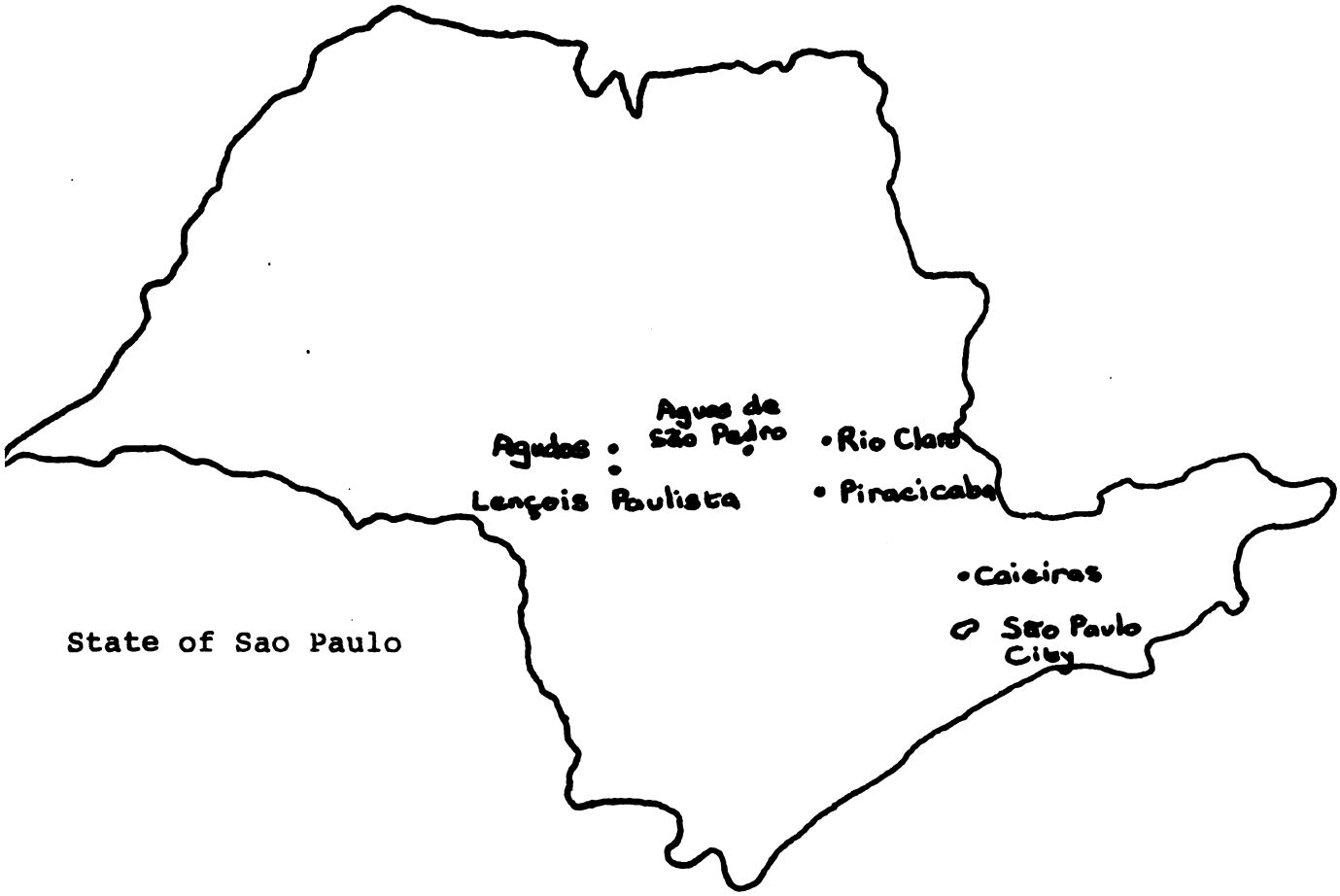
Aracruz Florestal S.A. - Aracruz
19°48' latitude south 40°17' longitude west
Altitude 5-50 m
Mean annual temp 23 6°C
Mean Max temp 29.2°C
Mean Min temp 19.1°C
Mean annual precipitation 1,364 mm
Mean annual relative humidity 80%
Topography Flat
Soil Oxisol - Red-Yellow-clayey (predominance of Kaolinite)

Appendix 2

Map of Brazil showing the location of the two states visited.

Scale 1: 30 million

Maps showing the location of sites visited. Scale 1:5 million



State of Sao Paulo

State of Espíritu Santo