O.F.I. OCCASIONAL PAPERS

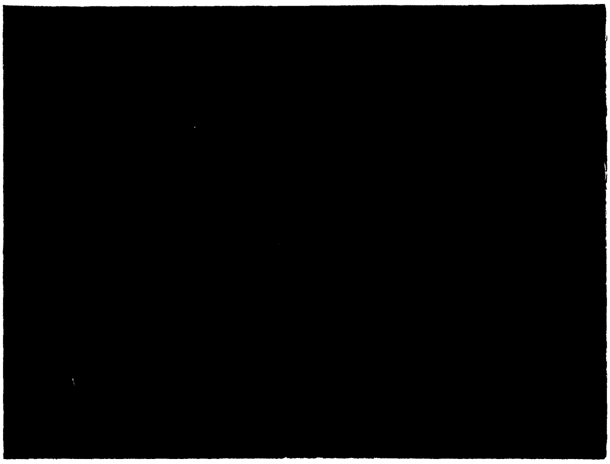
OFI OCCASIONAL PAPERS

No 46
Pulping and Papermaking Properties of three Tropical Pines from Provenance Trials

E R Palmer, R A Plumptre, M S O'Brian, T K Quilter and J Slater

1995

OXFORD FORESTRY INSTITUTE
Department of Plant Sciences
UNIVERSITY OF OXFORD



OFI OCCASIONAL PAPERS

No 46
Pulping and Papermaking Properties
of three Tropical Pines from
Provenance Trials

E R Palmer, R A Plumptre,
M S O'Brian, T K Quilter
and J Slater
1995

ISBN 0 85074 132 7
ISSN 0269 - 5790

Oxford Forestry Institute
Department of Plant Sciences
University of Oxford

PULPING AND PAPERMAKING PROPERTIES OF THREE TROPICAL PINE SPECIES FROM PROVENANCE TRIALS ON TWO SITES IN BRAZIL AND ONE IN SOUTH AFRICA.

by

E.R. Palmer, R.A. Plumptre, M.J. O'Brien, T.K. Quilter and J. Slater

Oxford Forestry Institute
1995

SUMMARY

The Project complements provenance studies of tropical pines reported in detail in Birks and Barnes (1990).

Twelve mm cores were taken at breast height from trees in selected provenance trials and micropulped using approximately 50 gm. samples from 140 trees covering the provenances detailed in Table 1, planted at one or more of the three sites described in Table 2. Tables 23 and 24 summarise the number of trees sampled for each provenance and planting site and show the pulping qualities of the different provenances planted at the three sites, two in Brazil and one in South Africa.

It was only possible to pulp 140 of the 310 trees originally planned and it was consequently only possible to apply limited statistical analysis to the data, particularly for South Africa where data were sparse; however Standard Errors of Means are given for sample (tree) differences in Tables 23 and 24. Instead of "significant differences", the term "meaningful differences" has been used (see Experimental Techniques).

A ranking system was devised to attempt to determine the relative value of different provenances for different sites (pages 6 and 7) considering the major pulp properties.

Within these groupings tear strength tends to be more critical for paper made from these pines than other strength properties and, where other properties are similar, it has been given greater weight in making a final decision on species/provenance suitability for a site.

The objectives of the project were:

1. *To determine differences in pulping and paper making properties between species, varieties and provenances.* This was largely achieved although not within statistically defined limits.

2. *To determine the effect of altitude/temperature on **P. oocarpa and P. patula ssp. tecunumanii** pulp and paper properties.* This was achieved to the extent that the properties of the different provenances for these two species/sub-species were determined. It was difficult to find property differences that appear related to climatic influences (see Tables on pages 7 - 9).

3. *To compare the quality of pulp and paper from low altitude **P. oocarpa** and **P. patula. ssp. tecunumanii**. with **P. caribaea**. grown at low altitude.* This has been achieved to the same extent as 2. above (see Tables on pages 7 - 9).

4. *To determine between-tree differences within provenances and sites in order to assess the possibilities of breeding for better properties.* This has been achieved to the extent that wide between tree differences have been found within species and provenances which indicates that breeding for wood quality for paper making could result in crops of trees with superior qualities for this purpose.

In a study of this nature trade offs are necessary between different properties in order to decide which is the best species/variety/provenance for planting on a specific site and it is difficult to come up with hard and fast conlusions; however, the following recommendations are made as a result of this study, based on pulp properties alone and ignoring other properties such as rate of growth and volume production:

Site	**Characteristics of site**	**Preferred species/provenance**	**Characteristics of species/prov.**
Jari	Low alt. 0 deg. lat. high rainfall	P. caribaea var. bahamensis prov. Andros	Low alt. 24 deg. lat. low rainfall
Agudos	Low alt. 22 deg. lat. medium rainfall	P. patula ssp tecunumanii prov. Rafael	High alt. 13 deg. lat. medium rainfall
Kwambonambi	low alt. 28 deg. lat. medium rainfall	P. patula ssp tec. prov. MPR or Camelias	medium alt. 13-17 deg. lat. medium/high rainfall

It can be seen from the above table that matching provenance source site characteristics with planting site characteristics does not appear to result in the best pulp/paper properties. The additional influence of species characteristics and a large number of other factors need also to be taken into account.

Acknowledgements

The authors acknowledge the help of Dr. R.D. Barnes, OFI, who selected the materials to be sampled, organised their collection and gave much helpful advice during the investigation. We acknowledge, also, the contribution of the late Mr. B. Bayliss, OFI, for collecting the materials in Brazil and Mr. J. Mathur of the Division of Forest Science and Technology, Mtubatuba, South Africa, for collecting the samples in South Africa. They are also grateful to Mrs. Cynthia Bunday, Mrs. Caroline Benfield, Ms. Joely Gibbens and Mrs. Gillian Bendle for their assistance in producing this paper.

The research was funded as project R 4619 in the Forestry Research Programme component of the ODA's Renewable Resources Research Strategy.

CONTENTS

Figures:

Introduction

A large number of provenance trials of the major tropical pines, *Pinus caribaea, P. oocarpa* and *P. patula* spp. *tecunumanii*, have been established in tropical countries. In "Provenance Variation in *Pinus caribaea, P. oocarpa* and *P. patula* spp. *tecunumanii*", (Tropical Forestry Papers No. 21, Oxford Forestry Institute, 1990) Birks and Barnes, report the assessment of eighteen traits; most of these traits were concerned with the growth and form of trees but four reported the density of wood and the composition of pinenes. This investigation is intended to supplement the earlier study by providing information on the pulping and papermaking characteristics of samples from some trials.

The determination of pulping characteristics is important because pulp from softwood species is a major component of strong paper for use in packaging. In 1991 287 million m^3 of coniferous wood was consumed mainly to produce 35 million tonnes unbleached chemical pulp for packaging and 30 million tonnes of mechanical pulp. As a result of the worldwide recession the annual production of pulp has been erratic: despite this consumption of coniferous pulpwood was 14% higher in 1991 than in 1982. Coniferous pulpwood is produced mainly from plantations and new plantations are required for the increased production. The importance of coniferous pulpwood to the forest economy is shown by fact that it is more than a quarter of the total production of coniferous industrial roundwood.

Co-operative studies between the Oxford Forestry Institute and the Natural Resources Institute have established that pulp and paper properties of pines vary considerably between individual trees and provenances. They have shown also, that there are close correlations between micropulping using 50 g samples of wood and full scale laboratory pulping using 800 g of wood. This has made it possible to determine the pulping characteristics of individual trees by taking cores with a 12 mm borer without felling trees.

Species and Provenances Studied

Samples from the following species and provenances were studied.

1. *Pinus caribaea* var. *bahamensis*; Provenance Andros Island, Bahama Islands. Samples of this provenance come from Jari, Brazil and Kwambonambi, South Africa.

2. *P. caribaea* var. *caribaea*; Provenance Los Palacios, Cuba. Samples of this provenance come from Jari, Brazil and Kwambonawbi, South Africa.

3. *P. caribaea* var *hondurensis*; Provenances Guanaja, Honduras and Alamicamba, Nicaragua. Samples of both these provenances come from Jari, Brazil and Kwambonambi, South Africa. Provenances Mountain Pine Ridge, Belize, Culmi, Honduras, Santa Clara, Nicaragua and Poptun, Guatemala. Samples of these four provenances come from Jari, Brazil only.

4. *P. oocarpa*; Provenance Bucarol, Guatemala. Samples of this provenance come from Agudos, Brazil and Kwambonambi, South Africa. Provenance Lagunilla, Guatemala. Samples of this provenance come from Agudos, Brazil.

5. *P. patula* spp. *tecunumanii*; Provenance Camelias, Nicaragua and Mountain Pine Ridge, Belize. Samples of these provenances come from Agudos, Brazil and Kwambonambi, South Africa. Provenance Rafael, Nicaragua. Samples of this provenance came from Agudos, Brazil.

Details of the location and climate of all provenances are given in Table 1.

Sites

Details of the location and climatic conditions of sites where the samples were grown are given in Table 2.

Experimental Techniques

Each provenance was represented by 15 or 14 trees. For the majority of provenances(*P. caribaea* from Jari, *P. caribaea* var *hondurensis* and var *caribaea*, *P. oocarpa* and *P. patula* spp. *tecunumanii* from Kwambonambi) three trees were selected from each of five replicates. For provenances of *P. oocarpa* and *P. patula* spp. *tecunumanii* from Agudos four trees were selected from two replicates and three from another two replicates. For provenances of *P. caribaea* var *bahamensis* from Kwambonambi, two trees were selected from each of seven plots and one tree from an eighth.

The sample taken from each tree consisted of a number of 12 mm. diameter cores, from the periphery to the centre of the tree: the number of cores taken varied so that a minimum of 50 g of dry wood was obtained.

The original intention was to compare differences between trees within a replicate, between replicates of a provenance on a single site, between provenances grown in one location and between the same provenance grown in different locations. In the event, a change in Departmental priorities made it impossible to complete laboratory examination of more than 140 of the 295 samples collected. Because the number of trees examined from each provenance was different it was not possible to make the comparisons between trees within a replicate or between replicates within a provenance. Comparisons were made between trees within a provenance and between average values for each provenance grown in one location.

It was not possible to make a statistical analysis of the difference between provenances, because the number of trees examined from a provenance could be as few as two or as many as 14. Consequently rather than use the team 'significant difference' which has a precise statistical meaning, we have adopted a less precise term 'meaningful difference'. By 'meaningful difference' we mean a difference that is so large that it is likely to affect the use of the species, variety or provenance if it were used in the commercial production of pulp. Whilst the reported values of Standard Deviation and Standard Error of the Mean have been taken into account, our judgement includes experience of the repeatability and importance of the various parameters.

The yield of pulp is very important to industry but it given little weighting in this study because it is imprecise. The Kappa number is a reliable determination and is of considerable importance if the pulp is to be bleached; since the most likely use of these pulps is in unbleached packaging grades of paper, it is given little weighting. The strength characteristics, as determined by micro pulping techniques, have been shown to have a high level of correlation with those determined by large scale laboratory digestions. In our experience the bonding strengths (tensile, burst, fold of most Kraft pulps made from softwood grown in the tropics) are above the minimum required of high quality wrapping and sack papers, but the tearing strength is around or often below the minimum level required. Consequently the tearing strength of pulp is the parameter that it is most important to improve in a programme of selection or breeding to obtain better quality pulp wood; it has, therefore, been given the greatest weight when making recommendations.

Each sample (i.e. each tree) was treated identically in the laboratory. Since there was insufficient wood to determine the moisture content, the samples were stored in an atmosphere of 23°C, 50% Relative humidity until they reached constant weight. The oven-dry weight of wood was then estimated using a factor determined previously using other samples of the same species. Unpublished work at NRI (TPI) and OFI has shown that oven drying alters the pulping characteristics of wood.

Each sample was digested by the kraft (sulphate) process using 17.5% Active Alkali, 25% Sulphidity, 5:1 liquor to wood ratio, 170°C maximum temperature, 1 hour to reach temperature and 4 hours at temperature.

The resultant pulps were stored in an atmosphere of 23°C, 50% Relative Humidity until a constant weight and the oven dry weight calculated (and thus the yield of pulp on wood determined) by using a factor determined previously using pulps from the same species.

20g (oven dry weight) of each pulp was beaten for 5,000 revolutions in a PFI mill, sheets formed by the British Standard Method and tested, after conditioning in an atmosphere of 23°C, 50% Relative Humidity by the appropriate Standard procedures.

In the tables each of the values for physical characteristics of pulp are the average of ten determinations: the figure in italics below the value is the Standard Deviation. The Mean Value for the Provenance is the average of the values for individual trees and the figure in italics below the mean value is the Standard Error of the Mean.

Results and Discussion

1. General

The technique of examining wood cores means that the periphery of the tree (the latest wood) is under-represented and the core (the earliest wood) over represented. This is likely to affect a number of pulp properties; for example the value for tearing strength is likely to be lower and tensile and bursting strengths higher than they would be if the whole tree was pulped. Thus the technique is valuable for ranking samples but is only a general indication of the strengths of pulps that would be obtained by industrial pulping.

The values obtained by pulping and evaluating the pulp obtained for each tree are reported in Tables 3 to 22. The pulping conditions used were expected to yield pulps with a Kappa number (Kappa number is an indirect measurement of the lignin content of the pulp) of 35 to 40 and the beating conditions used to yield a pulp with a freeness about 500

Canadian Standard Freeness. In general this was achieved: the average Kappa number for the pulps obtained from the 140 trees examined was 37.2 and the average freeness value was 497.

Four trees were omitted from the calculation of average values, because some of the values were so far from those expected that they were suspect. The trees omitted were:

a) *P. caribaea* var. *bahamensis* Provenance Andros, Site Kwambonambi Tree No. 58/10. (Table 4). The Freeness value of 150 was exceptionally low. All of the pulp evaluation figures were consistent with a pulp of very low freeness. The results were more like those expected from a hardwood than a softwood.

b) *P. caribaea* var. *caribaea* Provenance Los Palacios Site Kwambonambi Tree No. 1/14. (Table 6). The exceptionably low yield (? pulp lost in a handling error) meant that there was insufficient pulp to test.

c) *P. patula* spp. *tecunumanii* Provenance Camelias Site Kwambonambi Tree 1/23 (Table 14). This tree yielded pulp with a high yield and a very high Kappa number. The pulp had a high freeness, high tearing strength and low bonding strength. If this result is genuine the tree needs further study as obtaining pulps with higher tearing strength is very desirable. The alternative explanation is that a mistake was made in the amount of chemical added to the digester.

d) *P. patula* spp. *tecunumanii* Provenance Mountain Pine Ridge (MPO). Site Agudos Tree 1/4 (Table 15). This tree yielded a pulp with high yield (especially of screenings) and a high Kappa number. It was very difficult to beat. All these findings indicate an undercooked pulp. Either the tree was very difficult to cook or a mistake was made in measuring the chemical added to the digestion.

For only one of these trees (b) is there a reason to suspect laboratory error. For the other three trees laboratory error is possible, but careful examination of the data makes it extremely unlikely. The sampling procedure does not provide sufficient material for a duplicate digestion. Since trees that yield pulp very different from the average pulp quality may be very important in a breeding programme, some means of obtaining further samples must be considered.

2. <u>Difference between trees</u>

The differences between trees were studied only for those provenances grown in Brazil because of the provenances grown in South Africa only two or three trees were examined and such a small sample was unlikely to represent the full range.

For every parameter measured there was a large difference between the highest and lowest value recorded. The average difference between the lowest and the highest yield (expressed as a percentage of the lower figure) was 26% (range for individual provenances 8 to 49); for Kappa number it was 52% (range 20 to 113); for freeness 25% (range 8 to 42); for tensile strength 20% (range 11 to 35); for tearing strength 44% (range 11 to 92); and for bursting strength 20% (range 13 to 34). These values indicate that by selection of superior trees within each provenance for breeding purposes it might be possible to enhance, considerably, the value of the crop.

3. Difference between sites

Plots of trees derived from seven of the provenances investigated have been established in Brazil and South Africa.

a) *Pinus caribaea* var *bahamensis*

The trees grown at Jari in Brazil yielded more pulp with a higher Kappa number than those grown at Kwambonawbi in South Africa. The Brazilian pulp was marginally easier to beat, had a higher tearing strength (+ 27%) and lower tensile (- 13%) and bursting strengths (-9%).

b) *Pinus caribaea* var *caribaea*

The trees grown at Jari in Brazil yielded more pulp with a higher Kappa number. The Brazilian pulp was weaker than the Southern African pulp: tearing strength (-4%), tensile strength (-6%) and bursting strength (-2%).

Apart from the Kappa number the differences were not meaningful.

c) *Pinus caribaea* var *hondurensis*

The trees of both provenances grown at Jari in Brazil yielded more pulp with a higher Kappa number. The Brazilian pulps had higher tearing strength and lower tensile and bursting strengths than the South African pulps. However, the differences were small and only the higher tearing strength of the Brazilian grown trees was meaningful.

d) *Pinus oocarpa*

There was no significant difference in pulp yield and Kappa number of trees grown in Brazil and South Africa. The Brazilian pulps had higher tearing strength (+6%) and lower tensile (-10%) and bursting (-11%) strengths. The difference in tearing strength was probably not meaningful but the lower tensile and bursting strengths were meaningful.

e) *Pinus patula* spp. *tecunumanii*

There was no significant difference in pulp yield of trees grown in Brazil and South Africa. The Brazilian pulps were weaker in all respects than the South African pulps but only the difference in tearing strength (-11%) was meaningful.

4. Differences between provenances

The analysis of differences between species, varieties and provenances is an effort to select the better stock to plant on any given site. The analysis is complex, partly because of the mass of data, partly because the treatment of the different samples and partly because some of the desirable characteristics are negatively correlated.

The mean values of pulp properties for all the provenances grown in Brazil are recorded in Table 23 and for all the provenances grown in South Africa, in Table 24.

To assist in the selection, tables in which samples are given a numerical rank for pulp yield, Kappa number and the major pulp strength characteristics (tensile, tearing and bursting) were prepared. Except for Kappa number, the highest value is marked '1': for Kappa number, the lowest value is ranked '1', as this is the pulp with the lowest lignin content and that which would be easiest to bleach. The actual values are included in brackets.

a) *Pinus caribaea* var. *hondurensis*

Six provenances growing at Jari, Brazil were examined:

Provenance	**Yield**	**Kappa No.**	**Tensile**	**Tear**	**Burst**
Alamicamba	2 (43.1)	2 (35.5)	3 (81.0)	1 (11.3)	1 (5.30)
Culmi	5 (42.8)	1 (35.3)	1 (83.1)	3 (11.2)	3 (5.25)
Guanaja	2 (43.1)	3 (36.0)	5 (76.9)	4 (10.8)	4 (5.13)
Mountain Pine Ridge	6 (41.2)	4 (37.2)	2 (81.8)	5 (10.5)	2 (5.28)
Poptun	1 (43.9)	6 (41.7)	6 (75.7)	1 (11.3)	6 (4.92)
Santa Clara	4 (43.0)	5 (39.2)	4 (77.0)	6 (10.3)	5 (4.93)

The differences in pulp yield and Kappa were not meaningful. For strength properties the differences between adjacently ranked provenances were not meaningful, but the following differences probably were meaningful: tensile between the trees ranked 1 to 3 and those ranked 4 to 6; burst between trees ranked 1 to 3 and those ranked 5 and 6.

Thus, for growing trees in Jari for use as pulp feed stock the provenances from Alamicamba and Culmi seem preferable.

Only trees from two provenances, growing at Kwambonambi, South Africa, were available for testing. The only difference likely to be meaningful was that the tearing strength of pulps from Guanaja were higher than those from Alamicamba. However, this conclusion must be treated with some reserve as it is based on the examination of a very small number of trees.

b) *Pinus oocarpa*

Two provenances of this species, Bucaral and Lagunilla, growing at Agudos, Brazil, were examined. There was no difference between the mean values recorded.

c) *Pinus patula* spp. *tecunumanii*

Three provenances of this species growing at Agudos, Brazil were examined.

Provenance	Yield	Kappa	Tensile	Tear	Burst
Camelias	3 (45.1)	3 (38.8)	2 (83.2)	3 (9.80)	2 (5.30)
Mountain Pine Ridge	2 (45.4)	1 (35.7)	1 (84.7)	2 (10.21)	1 (5.34)
Rafael	1 (46.2)	2 (36.5)	3 (80.7)	1 (11.1)	3 (5.13)

The differences in yield and Kappa number were not meaningful. The difference of tensile and bursting strength for the first and third ranked provenances were probably significant and the ranking for tearing strength was meaningful. However, the lowest tensile and bursting strengths were well above the level regarded as satisfactory for the manufacture of strong packaging papers. Therefore, tearing strength becomes the most important criterion for selection and trees from the provenance Rafael may be preferred.

Two provenances, Camelias and Mountain Pine Ridge, grown in South Africa, were available for testing. There was hardly any difference between the parameters measured.

5. Differences between species and varieties

a) Grown at Jari Brazil.

On this site the only species growing was *P. caribaea*. The table includes var. *bahamensis*, var. *caribaea* and the two most promising provenances var. *hondurensis*.

	Yield	Kappa	Tensile	Tear	Burst
v. *bahamensis*	1 (44.4)	3 (38.1)	3 (77.3)	1 (13.3)	3 (5.21)
v. *caribaea*	4 (40.0)	4 (39.6)	4 (73.4)	2 (11.9)	4 (4.89)
Alamicamba	2 (43.1)	2 (35.5)	2 (81.0)	3 (11.3)	1 (5.30)
Culmi	3 (42.8)	1 (35.3)	1 (83.1)	4 (11.2)	2 (5.25)

The yield of pulp and its tensile and bursting strengths obtained from *P. caribaea* var. *caribaea* were all meaningfully lower than those obtained from var. *bahamensis* or var. *hondurensis*, its tearing strength was meaningfully lower than that from var. *bahamensis* and higher, but probably not meaningfully higher, than that from var. *hondurensis*.

P. caribaea var. *bahamensis* had the highest pulp yield of all the samples of *P. caribaea*, although the difference was not meaningfully different from the best provenances of var. *hondurensis*; the pulps tensile strength was meaningfully lower than that of pulps from the best provenances of var. *hondurensis*, but higher than that of the lowest ranking provenances; the bursting strength was not meaningfully lower than that of the best provenances of var.

hondurensis. The outstanding feature of pulp from *P. caribaea* var. *bahamensis* was that it had the highest tearing strength of all the samples examined, more than 10% higher than the nearest contender.

For the production of pulpwood *P. caribaea* var. *bahamensis* would be the preferred variety for this site.

b) Grown at Agudos, Brazil

Two provenances of *P. oocarpa* and the three provenances of *P. patula* spp. *tecunumanii* were grown at Agudos.

Species	**Provenance**	**Yield**	**Kappa**	**Tensile**	**Tear**	**Burst**
P. oocarpa	Bucaral	5 (44.3)	3 (38.2)	5 (80.1)	2 (10.2)	5 (5.09)
	Lagunilla	3 (45.1)	5 (39.5)	4 (80.2)	2 (10.2)	3 (5.13)
P. patula spp. *tecunumanii*	Camelias	3 (45.1)	4 (38.8)	2 (83.2)	5 (9.80)	2 (5.30)
	Mountain Pine Ridge	2 (45.4)	1 (35.7)	1 (84.7)	2 (10.2)	1 (5.34)
	Rafael	1 (46.2)	2 36.5)	3 (80.7)	1 (11.1)	3 (5.13)

The preference for this site would be *P. patula* spp. *tecunumanii*, Provenance Rafael for reasons stated in Section 4 c.

c) Grown at Kwambonambi, South Africa

On this site one provenance of each of *P. caribaea* var. *bahamensis*, *P. caribaea* var. *caribaea* and *P. oocarpa* and two provenances of each of *P. caribaea* var *hondurensis* and *P. patula* spp. *tecunumanii* were grown. A ranking table for one provenance of each species is given below:

	Yield	**Kappa**	**Tensile**	**Tear**	**Burst**
P. caribaea var. *bahamensis*	4 (39.9)	1 (25.9)	3 (85.3)	3 (10.5)	1 (5.75)
P. caribaea var. *caribaea*	5 (38.7)	2 (29.3)	5 (77.9)	1 (12.4)	5 (4.99)
P. caribaea var. *hondurensis* Guanaja	3 (41.2)	4 (32.2)	4 (83.1)	5 (9.40)	3 (5.48)
P. oocarpa	1 (43.2)	5 (36.4)	1 (88.7)	4 (9.57)	2 (5.70)
P. patula spp. *tecunumanii* Mountain Pine Ridge	2 (41.8)	3 (31.4)	3 (87.3)	2 (11.4)	4 (5.46)

All of these values were based on the examination of only two or three trees and, therefore, must be treated with some reservation. The best all round selection would be *P. patula* spp. *tecunumanii*, of either provenance. *P. caribaea* var *caribaea* must be considered because of the high tearing strength of its pulp, but the tensile and bursting strengths were very low.

6. <u>Pulp properties related to wood properties</u>

No determinations of wood properties or fibre dimensions were made on the material used for pulping trials, but information on the wood density of closely related material is available, together with data on growth rates and form of trees in 'Provenance Variation in *Pinus caribaea, P. oocarpa* and *P. patula* spp. *tecunumanii* (Birks and Barnes, 1990).

In general, it would be expected that the pulp with a higher tensile strength would be obtained from wood with low density and pulp with high tearing strength from higher density wood.

For the samples of *P. caribaea* studied the relationship between wood density and tearing strength is illustrated in Figure 1 and between wood density and tensile strength in Figure 2. In these figures the initial Capital letter (e.g. J or K) refers to the site where the trees were planted, the next letter (h, b, c) refers to the variety, the next three letters refer to the provenance of seed (Gua etc.) and the final number indicates the number of trees sampled. It is obvious from Figure 1, that the samples yielding the pulps with both the highest and the lowest tearing strength were those with the lowest wood density. However, the interpretation of this simple fact is made more difficult because of the extremes of tearing strength were from different varieties of *P. caribaea* (ala = v. *hondurensis* and = v. *bahamensis*), were grown on different sites (K = Kwambonambi, South Africa, J = Jari Brazil) and the assessment of wood density was on trees 6 to 7 years old and the pulping trials were of trees 15 to 17 years old. The data presented illustrates the dangers of using data obtained for one species or even variety of a species and transferring it to other related species. In Figure 1 *P. caribaea* var *bahamensis* (JbAnd7) and var *caribaea* (JcPal9)) are outliers from the group of var *hondurensis*. It is dangerous, also, to transfer data from one site to another, for example the same provenance of *P. caribaea* var *hondurensis* does not occupy the same relative position when grown in Brazil and South Africa (JhAla12 and KhAla3) and although *P. caribaea* var *bahamensis* yielded pulp with the highest tear when grown at Jari, it ranked only fourth when grown in South Africa (var. *bahamensis* grown in South Africa is not in Figure 1 because data for its density was not available).

As a general rule pulp with high tensile and bursting strength is made with flexible fibres with relatively thin cell walls and, pulp with high tearing strength contains stiffer fibres with thick cell walls. Thin-walled fibres predominate in low density wood and thick-walled fibres in high density wood. Figure 1 shows that there is a tendency for tearing strength to increase with increasing wood density but there is a very wide scatter of individual points. Closer examination indicates that there are several groups. Firstly, the provenances of *P. caribaea* var. *hondurensis* grown at Kwambonambi has the lowest tearing strength, less than 9.4 m Nm^2 g^{-1}. Secondly, the provenances of var. *hondurensis* grown at Jari, with the same wood density range, had tearing strength in the range 10.3 to 11.3 m Nm^2 g^{-1}. Thirdly, the sample of var. *caribaea* grown at Jari had a density of 410 kgm^{-3} and a tearing strength of 11.9 m Nm^2g^{-1}

and the sample grown at Kwambonambi had a wood density of 380 kg m^{-3} and a tearing strength of 12.4 m Nm^2 g^{-1}. Fourthly, a sample of var. *bahamensis* grown at Jari had a wood density of 360 kg m^{-3} and a tearing strength of 13.3 m N^2 g^{-1}.

Figure 2 shows that for all the samples of *P. caribaea* there is a trend for pulp with higher tensile strength to be obtained from wood with lower density. Again, the scatter of individual points is large and there is a clear division due to variety and site.

The most important finding from this analysis is that it is not possible to use data obtained for one variety of a species and assume that other varieties grown on the same site will be the same. Neither is it possible to use data obtained on one site and apply it to the same variety grown on another site.

The illustration of the relationship between tree volume and pulp tearing strength (Figure 3) and tensile strength (Figure 4) shows a similar scatter of points, but confirms that it is not possible to transfer data from one trial to different circumstances.

Figure 5 illustrates the relationship between wood density and tearing strength for samples of *P. occarpa* and *P. patula* spp. *tecunumanii.* Again there is no clear relationship between wood density and tearing strength of pulp for all the samples, but is possible to distinguish some trends by separating species and growing sites.

Figure 6 illustrates the relationship between wood density and tensile strength for *P. oocarpa* and *P. patula* spp. *tecunumanii.* There is a clear trend of higher tensile strength from wood with higher density, but there was a clear division between samples grown in Brazil having a lower tensile strength and higher wood density than those grown in South Africa.

Figure 7 illustrates the relationship between tree volume and tearing strength for *P. oocarpa* and *P. patula* spp. *tecunumanii* and Figure 8 illustrates the relationship between tree volume and tensile strength. There appears to be a clear division between growing sites: samples growing in South Africa were smaller and had a higher tensile strength than the samples grown in Brazil.

Figures 9 and 10 are similar to Figures 1 and 2 plotted as Hi-Lo graphs to show confidence limits around means as given by twice the Standard Errors of the Means. Figures 11 and 12 are similar Hi-Lo graphs for Figures 5 and 6. It should be remembered that standard errors are normally smaller with larger numbers of samples and the sample numbers were small for some provenances. Density is not to scale on Figures 9 - 12. These last four figures reinforce the finding that density has little effect on tear strength but tensile strength decreases slightly with increasing density.

The impossibility of applying data from one investigation to different combinations of species and site were confirmed.

7. Summary and conclusions

1) Trees of *P. caribaea* var. *hondurensis, P. caribaea* var. *caribaea*, and *P. caribaea* var. *hondurensis* (6 provenances) are growing at Jari, Brazil.

   Trees of *P. occarpa* (2 provenances) and *P. patula* spp. *tecumunanii* (3 provenances) are growing at Agudos, Brazil.

   Trees of *P. caribaea* var. *bahamensis, P. caribaea* var. *caribaea, P. caribaea* var. *hondurensis* (2 provenances), *P. oocarpa* and *P. patula* spp. *tecunumanii* (3 provenances) are growing at Kwambonambi, South Africa.

   All of the provenances growing in South Africa were growing also in Brazil.

   Cores were collected from up to fifteen trees from each provenance/site combination to determine the pulping/paper making characteristics of individual trees.

   All of the samples examined were pulped successfully by the kraft (sulphate) process.

2) For the Brazilian grown samples, where between 7 and 14 trees were examined there was considerable variation in all properties of pulp obtained from trees within a provenance. Where it was possible to study the variation between average values for a replicate within a provenance the variation was small. This indicates that there is a possibility of improving the average quality by tree selection.

   For the South African grown samples only two or three trees from each provenance were examined. Consequently, it was not possible to quantify between tree variation.

3) *P. caribaea* var. *bahamensis, P. caribaea* var. *caribaea* and *P. caribaea* var. *hondurensis* (2 provenances) were grown at Jari, Brazil and Kwambonambi, South Africa. *P. caribaea* var. *bahamensis* showed significant differences generally in favour of the Brazilian grown samples; var. *caribaea* showed smaller differences generally in favour of the S. African grown samples; var. *hondurensis*, only the tearing strength showed a meaningful difference in favour of the Brazilian grown samples.

   One provenance of *P. oocarpa* was grown at Agudos, Brazil and Kwambonambi, South Africa. Only the differences in tensile and bursting strengths were probably meaningful, in favour of S. African grown material.

   Two provenances of *P. patula* spp. *tecunumanii* were grown at Agudos, Brazil and Kwambonambi, South Africa. The differences, of which only the tearing strength was probably meaningful, were in favour of South African grown material.

4) *P. caribaea* var. *hondurensis* grown at Jari, Brazil: Alamicamba and Culmi, appeared to yield more desirable pulps. *P. patula* spp. *tecunumanii* grown at Agudos, Brazil: Rafael provenance may be preferred for its higher tearing strength.

   Other differences between provenances grown on the same site were not meaningful.

5) The species or varieties preferred for pulp production would be *P. caribaea* var *bahamensis* at Jari, Brazil, *P. patula* spp. *tecunumanii*, provenance Rafael at Agudos, Brazil, and *P. patula* spp. *tecunumanii*, provenance Mountain Pine Ridge or Camelias at Kwambonambi, South Africa. In South Africa *P. caribaea* var *caribaea* must be considered as yielding pulp with a higher tearing strength than any other species.

6) A very important finding was that it was not possible to use data obtained for one variety of *P. caribaea* to predict the quality of pulp from other varieties growing on the same site. Neither was it possible to use data for any given species, variety and provenance to predict the quality of pulp from the same species, variety and provenance growing in a different site.

In making these recommendations only strength of pulp obtained is considered: all other matters such as rate of growth have not been considered.

References

Birks, J.S. and Barnes, R.D. 1990, Provenance Variation in *Pinus caribaea, P. oocarpa* and *P. patula* spp. *tecunumanii.* Tropical Forestry Papers, Oxford Forestry Institute, University of Oxford No:21. 40 pp.

Greaves, A. 1978. Descriptions of seed sources and collections for provenances of *Pinus caribaea* Tropical Forestry Papers, Commonwealth Forestry Institute, University of Oxford No: 12, 100 pp.

Greaves, A. 1979. Descriptions of seed sources and collections for provenances of *Pinus oocarpa.* Tropical Forestry Papers, Commonwealth Forestry Institute, University of Oxford No: 13, 144 pp.

Table 1

Details of provenances of *Pinus caribaea* (Greaves 1978) and *P. oocarpa* and *P. patula* spp. *tecunumanii* (Greaves 1979)

Provenance	Country	Code	Latitude	Longtitude	Altitude m	Mean annual rainfall. mm	Mean annual temperature °C
P. caribaea var.*bahamensis*							
Andros Island	Bahamas Islands	AND	24° 53'N	78°07'W	3	1055	25.4
P. caribaea var.*caribaea*							
Los Palacios	Cuba	PAL	22°34'N	83°12'W	50	1477	24.4
P. caribaea var. *hondurensis*							
Guanaja	Honduras	GUA	16°27'N	85°54'W	75	2308	27.1
Alamicamba	Nicaragua	ALA	13°34'N	84°17'W	25	2610	27.3
Mountain Pine Ridge	Belize	MPR	17°00'N	88°55'W	400	1558	23.9
Culmi	Honduras	CUL	15°06'N	85°37'W	550	1325	24.3
Santa Clara	Nicaragua	STA	13°48'N	86°12'W	700	1818	23.4
Poptun	Guatemala	POP	16°21'N	89°25'W	500	1688	24.2
Pinus oocarpa							
Bucaral	Guatemala	BUC	15°01'N	90°09'W	1150	900	21.6
Lagunilla	Guatemala	LAG	14°42'N	89°57'W	1600	936	19.5
Pinus patula spp. *tecunumanii*							
Camelias	Nicaragua	CAM	13°46'N	86°18'W	900	1500	22.4
Mountain Pine Ridge	Belize	MPR	17°00'N	88°55'W	700	2064	21.2
Rafael	Nicaragua	RAF	13°14'N	86°08'W	1200	1366	20.8

Table 2

Location of Sites

Location	Country	Latitutde	Longtitude	Altitude m	Mean annual rainfall mm	Mean annual temperature. °C
Jari	Brazil	0°52'S	52°33'W	80	2500	26.5
Agudos	Brazil	22°22'S	48°32'W	550	1300	20.5
Kwa Mbonambi	South Africa	28°45'S	32°00'E	65	1338	22.0

Table 3

BRAZIL/JARI - CAP 21

Provenance ANDROS - PINUS CARIBAEA VAR BAHAMENSIS

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screen-ings	Total	Kappa No.	Draina-bility CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Fold-ing Endur-ance log_{10}	Air Resist-tance Gurley s	Air Perma-nence	Mois-ture Con-tent %
91041	1	9	39.5	7.3	46.8	36.2	500	4.5	0.70	75.5	3.2	1580	13.4	5.12	1000	2.99	7.2	18	8.6
									0.006	*3.08*	*0.18*	*135*	*0.59*	*0.282*	*224*		*1.35*		
93024		10	34.2	7.5	41.7	41.7	530	4.4	0.70	75.4	3.1	1590	13.0	4.83	702	2.84	4.6	28	13.9
									0.005	*1.88*	*0.25*	*164*	*0.36*	*0.321*	*106*		*0.26*		
93020		13	35.0	7.4	42.5	29.9	510	4.4	0.72	81.2	3.5	1870	13.4	5.56	870	2.93	11.1	11	9.2
									0.006	*5.18*	*0.32*	*270*	*0.64*	*0.356*	*200*		*1.17*		
Mean	1		36.2	7.4	42.8	35.9	513	4.4	0.71	77.4	3.3	1680	13.3	5.17	857	2.92	7.6	19	
93023	4	4	30.3	10.0	40.3	32.0	525	4.4	0.69	79.8	3.1	1650	14.0	5.20	650	2.80	8.0	16	7.9
									0.004	*4.75*	*0.26*	*221*	*0.58*	*0.165*	*204*		*0.86*		
93017		13	33.4	11.0	44.4	33.5	485	4.6	0.74	78.9	3.8	2020	13.4	5.39	1070	3.02	13	9.8	9.3
									0.006	*1.90*	*0.31*	*162*	*0.64*	*0.275*	*262*		*2.22*		
91018		16	33.3	12.1	45.4	48.4	520	4.5	0.73	78.3	3.0	1550	10.1	5.19	790	2.89	11	11	8.4
									0.010	*3.71*	*0.290*	*215*	*0.34*	*0.285*	*172*		*2.05*		
Mean	4		32.3	11.0	43.4	38.0	506	4.5	0.72	79.0	3.3	1740	12.5	5.26	837	2.90	14	12	
91027	5	13	34.2	15.7	49.9	44.8	490	4.7	0.69	72.0	3.9	1870	15.6	5.16	960	2.98	7.1	18	8.4
									0.009	*3.29*	*0.307*	*185*	*0.51*	*0.232*	*146*		*1.42*		
GRAND MEAN	**Mean**	(7 trees)	**34.3**	**10.1**	**44.4**	**38.1**	**509**	**4.5**	**0.71**	**77.3**	**3.4**	**1733**	**13.3**	**5.21**	**863**	**2.92**	**8.86**	**16.0**	9.3
Standard Error of Mean			*1.04*	*1.18*	*1.24*	*2.64*	*6.6*	*0.05*	*0.008*	*1.19*	*0.14*	*69.7*	*0.53*	*0.086*	*59.3*		*1.11*		

Table 4

SOUTH AFRICA

Provenance ANDROS PINUS CARIBAEA VAR BAHAMENSIS

Cook No.	Plot No.	Tree No.	Yield % Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Permanence	Moisture Content %
93046	10	8	35.6	3.0	38.6	26.0	545	4.4	0.74	90.3	2.8	1670	9.75	5.85	809	2.89	16.9	7.5	8.0
									0.007	*3.54*	*0.16*	*95*	*0.312*	*0.481*	*250*		*2.68*		
93044	43	9	38.3	2.9	41.2	25.7	535	4.3	0.73	86.3	3.0	1670	11.16	5.64	999	2.99	10.8	11.8	7.9
									0.007	*4.26*	*0.24*	*212*	*0.760*	*0.389*	*190*		*1.34*		
93047	58	10	34.7	3.4	38.1	22.4	150	9.6	0.83	79.4	2.3	1250	5.48	4.47	155	2.11	>500	<0.2	7.6
									0.005	*5.98*	*0.40*	*273*	*0.269*	*0.191*	*73*				
GRAND MEAN	**(2 trees)**	**(excl. 58/10**	**37.0**	**3.0**	**39.9**	**25.9**	**540**	**4.4**	**0.74**	**85.3**	**2.9**	**1670**	**10.5**	**5.75**	**904**	**2.94**	**13.9**	**9.7**	
Standard Error of Mean			*1.35*	*0.05*	*1.30*	*0.15*	*5.0*	*5.05*	*0.004*	*2.00*	*0.10*	*0*	*0.705*	*0.105*	*95.0*		*3.05*		

Table 5

BRAZIL/JARI - CAP 21

Provenance LOS PALACIOS - PINUS CARIBAEA VAR CARIBAEA

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Permanance	Moisture Content %
93027	1	2	25.0	5.4	30.4	43.0	540	4.3	0.70	81.7	3.0	1680	8.69	5.22	560	2.70	23	5.7	8.0
									0.004	*4.23*	*0.27*	*211*	*0.251*	*0.326*	*250*		*2.7*		
91059		14	39.1	3.5	42.5	28.9	470	4.8	0.71	81.0	2.9	1530	12.0	5.55	1180	3.07	18	7.1	8.3
									0.007	*3.01*	*0.24*	*155*	*0.62*	*0.407*	*171*		*4.5*		
91105	2	1	23.5	8.3	31.8	36.6	450	4.9	0.70	71.5	3.3	1580	13.2	4.81	860	2.92	13	9.9	8.1
									0.007	*2.81*	*0.26*	*162*	*0.53*	*0.29*	*251*		*0.9*		
93021	3	3	34.7	7.9	42.6	41.4	560	4.4	0.69	66.2	3.2	1480	14.7	4.47	700	2.83	3.9	33	7.9
									0.005	*3.15*	*0.36*	*201*	*0.49*	*0.299*	*168*		*0.34*		
91048		6	33.8	7.7	41.5	44.0	495	4.7	0.78	69.0	3.6	1740	8.71	4.63	710	2.82	25	5.0	8.8
									0.008	*1.94*	*0.22*	*145*	*0.589*	*0.264*	*251*		*2.6*		
91093		11	34.2	8.8	43.0	36.9	380	4.9	0.70	74.3	3.2	1560	13.2	4.90	860	2.92	19	6.6	8.2
									0.008	*3.76*	*0.15*	*124*	*0.40*	*0.260*	*221*		*2.6*		
Mean	3		34.2	8.1	41.8	40.6	478	4.7	0.72	69.8	3.3	1593	12.2	4.67	757	2.86	16.0	14.7	
91017	5	7	30.7	14.1	44.8	43.9	460	4.6	0.71	74.5	3.2	1540	11.8	5.08	900	2.94	5.7	22	8.5
									0.009	*3.78*	*0.26*	*195*	*0.35*	*0.272*	*237*		*1.41*		
91100		12	28.7	12.9	41.6	43.0	410	4.9	0.74	70.9	3.7	1800	11.4	4.83	840	2.91	14	9.1	8.1
									0.003	*2.20*	*0.22*	*153*	*0.43*	*0.260*	*210*		*1.9*		
93022		14	30.5	11.3	41.8	38.9	500	4.5	0.65	71.8	2.6	1220	13.6	4.48	510	2.69	4.3	30	7.8
									0.005	*2.71*	*0.20*	*116*	*0.32*	*0.298*	*125*		*0.75*		
Mean	5		30.0	12.8	42.1	41.5	457	4.7	0.70	72.4	3.2	1520	12.3	4.80	750	2.85	8.0	20.2	
Grand Mean		(9 trees)	**31.1**	**8.9**	**40.0**	**39.6**	**475**	**4.7**	**0.71**	**73.4**	**3.2**	**1570**	**11.9**	**4.89**	**791**	**2.87**	**13.9**	**14.2**	
Standard Error of Mean			*1.65*	*1.14*	*1.72*	*1.65*	*19.2*	*0.08*	*0.012*	*1.72*	*0.11*	*56.2*	*0.70*	*0.118*	*66.9*		*2.64*		

Table 6

SOUTH AFRICA

Provenance LOS PALACIOS - PINUS CARIBAEA VAR CARIBAEA

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance $\log_{10}$	Air Resistance Gurley s	Air Permanance	Moisture Content %
3045	1	3	40.8	1.5	42.3	28.9	535	4.4	0.73	83.2	2.6	1400	10.1	5.35	680	2.82	12.6	10.1	8.1
									0.004	*2.12*	*0.17*	*119*	*0.355*	*0.390*	*133*		*3.83*		
3046		14	15.5	7.3	22.8														
3042		21	32.7	2.4	35.1	29.7	430	4.7	0.67	72.5	2.6	1250	14.7	4.62	700	2.84	5.0	25.4	7.8
									0.006	*2.56*	*0.17*	*93*	*0.924*	*0.305*	*123*		*0.60*		
GRAND MEAN	**(2 trees)**		**36.8**	**2.0**	**38.7**	**29.3**	**482**	**4.6**	**0.70**	**77.9**	**2.6**	**1325**	**12.4**	**4.99**	**690**	**2.83**	**8.8**	**17.8**	
Standard Error of Mean			*4.05*	*0.45*	*3.60*	*0.40*	*52.5*	*0.15*	*0.03*	*5.35*	*0*	*75.0*	*2.30*	*0.365*	*10.0*		*3.80*		

Table 7

BRAZIL/JARI -CAP 21

Provenance GUANAJA - PINUS CARIBAEA VAR HONDURENSIS

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Permanence	Moisture Content %
91099	1	6	29.5	10.8	40.3	39.6	510	4.6	0.76	76.9	3.1	1710	9.38	5.08	920	2.95	15	8.6	8.0
									0.010	*3.33*	*0.20*	*168*	*0.47*	*0.270*	*258*		*2.33*		
93016		9	45.0	9.6	54.6	35.0	510	4.5	0.72	78.1	2.9	1480	11.3	5.35	890	2.94	8.5	15	9.3
									0.006	*3.42*	*0.30*	*209*	*0.44*	*0.173*	*212*		*0.95*		
93018		12	30.1	9.1	39.2	35.8	435	4.7	0.72	74.2	3.4	1670	12.9	5.05	700	2.84	18	7.1	8.0
									0.006	*2.40*	*0.23*	*147*	*0.38*	*0.158*	*152*		*2.61*		
Mean	Rep 1		34.9	9.8	44.7	36.8	485	4.6	0.73	76.4	3.1	1620	11.2	5.16	837	2.91	13.8	10.2	8.4
91058	3	3	36.7	7.1	43.8	39.4	470	4.8	0.74	73.8	3.2	1570	10.3	4.56	820	2.90	18	7.0	8.6
									0.006	*3.96*	*0.36*	*225*	*0.60*	*0.365*	*209*		*4.08*		
91064	4	1	36.5	7.0	43.5	35.6	465	4.7	0.72	82.3	3.2	1770	11.4	5.48	1060	3.01	12	11	8.4
									0.007	*3.92*	*0.27*	*225*	*0.39*	*0.327*	*260*		*1.81*		
91024		10	33.4	13.5	46.9	34.8	550	4.7	0.69	66.3	3.3	1455	13.4	4.39	940	2.97	3.5	36	8.3
									0.010	*3.61*	*0.38*	*225*	*0.63*	*0.199*	*127*		*0.65*		
93019		14	32.3	4.3	36.6	32.9	510	4.4	0.79	90.4	2.9	1750	8.30	5.88	810	2.89	67	1.9	7.9
									0.005	*6.89*	*0.36*	*315*	*0.55*	*0.275*	*214*		*6.94*		
Mean	4		34.1	8.3	42.3	34.4	508	4.5	0.73	79.7	3.1	1635	11.0	5.25	937	2.96	27.6	16.3	
92026	5	7	31.6	8.0	39.6	35.1	600	4.4	0.75	73.5	3.3	1590	9.57	5.27	830	2.88	12.3	10	8.1
									0.005	*3.30*	*0.35*	*203*	*0.42*	*0.315*	*342*		*1.29*		
GRAND MEAN		(8 trees)	34.3	8.7	43.1	36.0	506	4.6	0.74	76.9	3.2	1616	10.8	5.13	871	2.92	19.3	12.1	
Standard Error of Mean			*1.78*	*0.98*	*2.00*	*0.82*	*18.3*	*0.05*	*0.011*	*2.51*	*0.07*	*38.7*	*0.62*	*0.171*	*37.9*		*7.06*		

Table 8

SOUTH AFRICA

Provenance GUANAJA - PINUS CARIBAEA VAR HONDURENSIS

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Permanence	Moisture Content %
3032	1	32	31.7	9.8	41.4	31.0	555	4.4	0.80	83.1	3.1	1770	8.46	5.72	960	2.97	40	3.2	8.0
									0.008	*3.85*	*0.30*	*230*	*0.312*	*0.235*	*250*	*0.102*	*4.86*		
3030		12	35.7	3.6	39.3	30.9	550	4.4	0.73	82.6	2.7	1490	9.81	5.20	860	2.92	8.0	15.9	7.8
									0.005	*4.34*	*0.25*	*164*	*0.325*	*0.364*	*198*	*0.101*	*0.98*		
3033	2	36	41.0	1.9	42.8	34.8	565	4.4	0.75	83.5	3.1	1700	9.93	5.52	850	2.91	14.2	8.9	7.5
									0.006	*3.30*	*0.16*	*93*	*0.556*	*0.262*	*259*	*0.134*	*1.46*		
Mean	1 & 2	(3 trees)	36.1	5.1	41.2	32.2	557	4.4	0.76	83.1	3.0	1653	9.40	5.48	890	2.935	20.6	9.3	
Standard Error of Mean			*2.69*	*2.40*	*1.02*	*1.28*	*4.4*	*0*	*0.021*	*0.26*	*0.13*	*84.1*	*0.471*	*0.151*	*35.1*		*9.63*		

Table 9

BRAZIL/JARI CAP 21

Provenance ALAMICAMBA - PINUS CARIBAEA VAR. HONDURENSIS

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endur-ance log_{10}	Air Resist-ance Gurley s	Air Perma-nence	Moisture Content %
92030	1	10	35.0	8.8	43.8	39.3	555	4.5	0.73	79.3	3.0	1600	9.75	5.03	840	2.90	12	10.9	8.1
									0.004	*4.38*	*0.33*	*240*	*0.286*	*0.232*	*242*		*1.92*		
91095		13	30.7	10.4	41.1	35.0	525	4.8	0.73	85.2	3.2	1800	11.7	5.65	1380	3.13	21	6.0	8.2
									0.009	*3.15*	*0.19*	*146*	*0.58*	*0.370*	*315*		*2.24*		
92023	2	10	39.1	6.3	45.5	38.6	520	4.5	0.69	77.0	3.1	1570	12.4	5.03	1100	3.03	6.9	18	7.4
									0.007	*3.32*	*0.29*	*199*	*0.52*	*0.35*	*280*		*1.16*		
91050		13	42.5	2.6	45.1	33.3	530	4.5	0.70	81.1	3.0	1570	12.0	5.58	1100	3.03	7.3	17	8.7
									0.008	*4.88*	*0.27*	*205*	*0.60*	*0.361*	*195*		*2.05*		
91073	3	5	41.2	2.9	44.2	33.6	495	4.7	0.71	80.4	2.7	1420	10.6	5.17	1160	3.05	15	8.3	8.5
									0.007	*3.09*	*0.23*	*155*	*0.50*	*0.279*	*265*		*1.92*		
91043		9	33.9	12.3	46.1	38.9	470	4.7	0.66	82.9	2.5	1350	11.9	5.18	790	2.89	7.9	16	8.4
									0.006	*3.34*	*0.19*	*130*	*0.42*	*0.103*	*197*		*2.24*		
91076		12	39.6	5.5	45.1	39.3	480	4.7	0.73	83.8	2.9	1550	10.6	5.30	1140	3.06	13	9.7	8.4
									0.006	*4.30*	*0.17*	*160*	*0.50*	*0.399*	*230*		*3.72*		
Mean	**3**		**38.2**	**6.9**	**45.1**	**37.3**	**482**	**4.7**	**0.70**	**82.4**	**2.7**	**1440**	**11.0**	**5.22**	**1030**		**12.0**	**11.3**	
91065	4	4	35.2	4.5	39.6	27.1	520	4.8	0.72	87.3	2.8	1590	9.05	5.49	1100	3.02	21	6.1	8.4
									0.009	*3.32*	*0.14*	*145*	*0.50*	*0.298*	*350*		*3.54*		
91062		8	33.5	5.5	39.0	27.8	510	4.6	0.74	77.3	3.3	1690	12.0	5.46	1400	3.13	12	10	8.4
									0.009	*5.19*	*0.43*	*315*	*0.41*	*0.198*	*340*		*1.92*		
91023		16	37.6	8.8	46.4	35.7	510	4.8	0.66	76.5	2.7	1360	12.9	5.00	900	2.95	6.4	20	8.3
									0.010	*2.09*	*0.27*	*165*	*0.54*	*0.286*	*110*		*1.15*		
Mean	**4**		**35.4**	**6.3**	**41.7**	**30.2**	**513**	**4.7**	**0.71**	**80.4**	**2.9**	**1547**	**11.3**	**5.32**	**1130**		**13.1**	**12.0**	
91078	5	11	27.7	7.7	35.3	37.1	475	4.5	0.69	75.9	2.7	1320	11.2	5.01	840	2.92	8.3	15	8.1
									0.008	*3.06*	*0.27*	*167*	*0.28*	*0.220*	*176*		*1.65*		
91026		12	32.8	13.2	46.0	40.8	500	4.7	0.73	85.1	3.2	1730	11.5	5.75	1180	3.06	12	10	8.3
									0.007	*4.14*	*0.22*	*210*	*0.78*	*0.251*	*267*	*3.06*	*0.95*		
GRAND MEAN		(12 trees)	**35.7**	**7.4**	**43.1**	**35.5**	**508**	**4.7**	**0.71**	**81.0**	**2.9**	**1550**	**11.3**	**5.30**	**1078**	**3.01**	**11.9**	**12.3**	
Standard Error of Mean			***1.27***	***1.00***	***1.02***	***1.29***	***7.2***	***0.04***	***0.008***	***1.12***	***0.07***	***44.8***	***0.32***	***0.079***	***58.1***		***1.46***		

Table 10

SOUTH AFRICA

Provenance ALAMICAMBA - PINUS CARIBAEA VAR HONDURENSIS

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance $\log_{10}$	Air Resistance Gurley s	Air Permanence	Moisture Content %
93048	2	15	20.3	3.8	24.0	23.9	535	4.5	0.76	81.8	2.8	1500	9.14	5.29	930	2.958	19	6.6	7.9
									0.007	*3.85*	*0.28*	*237*	*0.163*	*0.286*	*215*		*2.46*		
93036		31	40.6	2.4	43.0	33.0	600	4.4	0.79	86.7	3.1	1780	8.64	5.59	920	2.962	25	5.0	8.2
									0.008	*4.80*	*0.34*	*292*	*0.399*	*0.366*	*234*		*4.52*		
93035		32	36.2	3.8	40.0	35.3	545	4.4	0.78	88.3	3.1	1770	8.04	5.90	915	3.109	36	3.3	6.8
									0.006	*4.03*	*0.25*	*188*	*0.292*	*0.236*	*214*		*4.74*		
Grand Mean (3 trees)			**32.4**	**3.3**	**35.7**	**30.7**	**560**	**4.4**	**0.78**	**85.6**	**3.0**	**1683**	**8.61**	**5.59**	**922**	**3.030**	**26.7**	**4.0**	
Standard Error of Mean			***6.17***	***0.47***	***5.90***	***3.48***	***20.2***	***0.03***	***0.009***	***1.96***	***0.10***	***91.7***	***0.318***	***0.176***	***4.41***		***4.76***		
Grand Mean (2 trees excl.2/15)			**38.4**	**3.1**	**41.5**	**34.2**	**573**	**4.4**	**0.79**	**87.5**	**3.1**	**1775**	**8.34**	**5.75**	**917**	**3.035**	**30.5**	**2.7**	
Standard Error of Mean			*2.20*	*0.70*	*1.50*	*1.15*	*27.5*	*0*	*0.005*	*0.80*	*0*	*5.0*	*0.300*	*0.155*	*2.50*		*5.15*		

Table 11

BRAZIL/AGUDOS POP 007

Provenance BUCARAL - PINUS OOCARPA

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Permanence	Moisture Content %
91016	1	4	33.6	14.3	47.9	36.8	425	4.7	0.72	74.7	2.6	1270	9.64	4.73	750	2.87	12	10	8.2
									0.007	*4.17*	*0.20*	*160*	*0.336*	*0.202*	*138*		*1.19*		
91086		5	32.0	11.9	44.0	38.4	485	4.7	0.73	88.0	2.8	1500	9.00	5.51	840	2.90	20	6.5	8.0
									0.003	*4.33*	*0.21*	*152*	*0.42*	*0.300*	*288*		*3.87*		
91069		8	33.7	5.6	39.4	34.3	495	4.7	0.73	77.0	3.1	1540	10.6	5.04	920	2.95	9.4	14	8.5
									0.009	*3.14*	*0.31*	*215*	*0.52*	*0.313*	*270*		*0.94*		
Mean	**1**		**33.1**	**10.6**	**43.8**	**36.5**	**468**	4.7	**0.73**	**79.9**	**2.8**	**1437**	**9.75**	**5.09**	**837**	**2.91**	**13.8**	**10.2**	
92029	2	5	32.6	12.7	45.3	37.6	530	4.4	0.74	78.9	2.6	1340	8.82	5.22	805	2.89	17	7.6	8.4
									0.005	*3.92*	*0.36*	*242*	*0.551*	*0.242*	*187*		*1.83*		
91028		7	39.0	7.9	47.0	41.2	530	4.7	0.71	78.5	2.8	1420	11.9	5.23	1040	3.00	6.9	18	8.3
									0.011	*3.13*	*0.218*	*140*	*0.53*	*0.325*	*290*		*1.31*		
91079	3	1	35.0	8.1	43.1	38.1	525	4.7	0.72	83.7	2.8	1490	9.75	5.16	1040	3.01	13	9.5	8.2
									0.009	*3.67*	*0.20*	*147*	*0.36*	*0.310*	*237*		*1.59*		
91055		3	38.1	5.0	43.1	35.0	445	4.7	0.71	74.9	2.6	1280	10.5	4.63	960	2.97	16	7.9	8.5
									0.007	*3.32*	*0.28*	*165*	*0.61*	*0.332*	*227*		*2.22*		
91056		4	35.8	5.6	41.3	30.2	455	4.9	0.74	79.2	2.8	1440	10.5	5.07	1050	3.01	19	6.7	8.4
									0.008	*4.46*	*0.14*	*125*	*0.49*	*0.222*	*250*		*2.57*		
Mean	3		36.3	6.2	42.5	34.4	475	4.8	0.72	79.3	2.7	1403	10.25	4.95	1017	3.00	16	8.0	
92020	4	7	35.0	13.0	48.0	52.1	490	4.7	0.68	85.7	2.4	1300	11.1	5.24	780	2.98	7.5	17	7.5
									0.004	*3.85*	*0.13*	*124*	*0.65*	*0.19*	*233*		*1.19*		
GRAND MEAN	(9 trees)		35.0	9.3	44.3	38.2	487	4.7	0.72	80.1	2.7	1400	10.2	5.09	910	2.95	13.4	10.8	
Standard Error of Mean			*0.79*	*1.22*	*0.99*	*2.02*	*12.8*	*0.04*	*0.006*	*1.57*	*0.07*	*34.3*	*0.33*	*0.090*	*39.9*		*1.62*		

Table 12

SOUTH AFRICA

Provenance - BUCARAL PINUS OOCARPA

			Yield %															
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Draina-bility CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endur-ance log_{10}	Air Resist-ance Gurley s	Air Perma-nence	Moisture Content %
93043	2	12	38.6	5.8	44.4	31.6	515	4.5	0.72	86.9	2.5	1390	11.3	5.48	1020	3.001	8.4	15.1	8.0
									0.005	*4.71*	*0.18*	*159*	*0.89*	*0.204*	*176*		*1.03*		
93034		20	38.5	3.1	41.6	34.1	580	4.4	0.77	88.4	3.1	1830	8.99	5.74	1020	3.003	16.7	7.6	7.9
									0.006	*4.67*	*0.31*	*260*	*0.438*	*0.473*	*152*		*1.36*		
93041		35	40.9	2.7	43.6	43.5	570	4.6	0.76	90.9	2.8	1680	8.43	5.89	1100	3.027	13.7	9.3	8.0
					43.2				*0.007*	*4.89*	*0.21*	*187*	*0.472*	*0.248*	*306*		*1.61*		
GRAND MEAN		(3 trees)	39.3	3.9		36.4	555	4.5	0.75	88.7	2.8	1633	9.57	5.70	1047	3.010	12.9	10.7	
Standard Error of Mean			***0.78***	***0.97***	***0.83***	***3.62***	***20.2***	***0.06***	***0.015***	***1.17***	***0.17***	***129.1***	***0.88***	***0.120***	***26.7***		***2.43***		

Table 13

BRAZIL/AGUDOS - POP 007

Provenance CAMELIAS - PINUS PATULA SPP. TECUNUMANII

			Yield %															
Cook No.	Rep. No.	Tree No.	Screened	Screen-ings	Total	Kappa No.	Draina-bility CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Perma-nence	Moisture Content %
91035	1	6	32.6	12.0	44.6	33.6	470	4.7	0.74	85.1	2.6	1410	8.58	5.38	1010	2.99	17	7.4	8.5
									0.005	*3.93*	*0.18*	*155*	*0.636*	*0.316*	*249*		*3.012*		
91084		7	35.4	7.3	42.7	36.4	485	4.7	0.74	9.71	2.7	1700	8.76	6.13	1110	3.02	21	6.2	8.1
									0.013	*4.13*	*0.24*	*185*	*0.38*	*0.240*	*411*		*3.92*		
91038		8	34.7	10.1	44.8	40.6	465	4.7	0.71	78.3	2.6	1340	9.13	5.06	900	2.95	18	7.2	8.5
									0.003	*3.82*	*0.21*	*160*	*0.501*	*0.169*	*109*		*2.31*		
Mean	1		34.2	9.8	44.0	36.9	473	4.7	0.73	86.8	2.7	1483	8.82	5.52	1007	2.99	19	6.9	
91032	2	3	34.8	12.2	47.0	41.4	505	4.8	0.74	81.1	2.7	1440	9.44	5.20	1150	3.05	11	11	8.7
									0.007	*2.80*	*0.19*	*130*	*0.439*	*0.385*	*308*		*1.96*		
91085		4	35.4	8.2	43.6	37.0	485	4.5	0.71	79.5	2.9	1510	11.0	5.07	1070	3.02	12	11	8.0
									0.008	*6.15*	*0.26*	*197*	*0.45*	*0.23*	*205*		*4.16*		
91054		7	36.6	9.9	46.5	33.9	430	4.9	0.70	82.6	2.5	1300	9.85	5.01	830	2.92	14	9.3	8.3
									0.009	*4.05*	*0.16*	*120*	*0.328*	*0.308*	*128*		*2.65*		
Mean	2		35.6	10.1	45.7	37.4	473	4.7	0.72	81.1	2.7	1417	10.10	5.09	1017	3.00	12	10.4	
91025	3	5	37.9	9.5	47.4	38.1	470	4.8	0.74	92.0	2.6	1505	9.52	5.74	990	2.99	23	5.5	8.3
									0.009	*5.20*	*0.267*	*220*	*0.511*	*0.334*	*197*		*4.97*		
91029		8	35.0	11.6	46.6	47.5	525	4.7	0.70	80.9	2.7	1400	10.0	5.02	830	2.90	8.1	16	8.6
									0.009	*3.46*	*0.17*	*140*	*0.545*	*0.282*	*255*		*1.45*		
91089	4	1	37.9	5.8	43.6	37.8	490	4.8	0.72	78.0	3.0	1510	10.2	5.12	960	2.97	12	10	8.1
									0.007	*3.36*	*0.26*	*166*	*0.47*	*0.25*	*222*		*2.20*		
91096		7	34.3	9.7	44.1	41.3	490	4.7	0.71	77.3	2.26	1310	11.5	5.23	1240	3.09	15	8.6	8.1
									0.011	*2 66*	*0.22*	*139*	*0.37*	*0.42*	*262*		*2.50*		
GRAND MEAN	**(10 trees)**		35.5	9.6	45.1	38.8	482	4.7	0.72	83.2	2.7	1443	9.80	5.30	1009	2.99	15	9.2	
Standard Error of Mean			*0.52*	*.0.66*	*0.52*	*1.31*	*8.0*	*0.03*	*0.006*	*2.07*	*0.05*	*38.1*	*0.29*	*0.116*	*42.9*		*1.47*		

Table 14

SOUTH AFRICA

Provenance CAMELIAS - PINUS PATULA SPP. TECUNUMANII

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Draina-bility CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endur-ance log_{10}	Air Resist-ance Gurley s	Air Perma-nence	Moisture Content %
93037	1	15	43.4	1.1	44.5	30.1	510	4.4	0.73	87.6	2.6	1480	10.8	5.58	900	2.95	11.6	10.9	8.2
									0.004	*4.35*	*0.08*	*113*	*0.50*	*0.231*	*145*	*0.731*	*2.71*		
93038		23	43.3	5.6	48.9	58.9	675	4.4	0.61	69.5	2.7	1250	14.7	4.69	750	2.86	0.8	159	8.4
									0.008	*3.91*	*0.20*	*123*	*1.09*	*0.218*	*234*	*0.141*	*0.09*		
93039		33	43.2	2.0	45.2	30.8	520	4.8	0.72	89.1	2.6	1500	11.4	5.30	880	2.94	10.1	12.6	7.9
									0.008	*4.10*	*0.23*	*164*	*0.47*	*0.244*	*214*	*0.102*	*1.22*		
Mean	1		43.3	2.9	46.2	39.9	568	4.5	0.69	82.1	2.6	1410	12.3	5.19	843	2.913	7.5	60.8	
GRAND MEAN	**(2 trees)**	**Exl. 1/23**	**43.3**	**1.6**	**44.9**	**30.5**	**515**	**4.6**	**0.73**	**88.4**	**2.6**	**1490**	**11.1**	**5.44**	**890**	**2.942**	**10.9**	**11.8**	
Standard Error of Mean			***0.10***	***0.45***	***0.35***	***0.35***	***5.0***	***0.20***	***0.005***	***0.75***	***0***	***10.0***	***0.30***	***0.140***	***10.0***		***0.75***		

Table 15

BRAZIL/AGUDOS POP 007

Provenance MOUNTAIN PINE RIDGE - PINUS PATULA SPP. TECUNUMANII

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance $\log_{10}$	Air Resistance Gurley s	Air Permanence	Moisture Content %
93052	1	1	39.4	5.1	44.5	34.8	510	4.5	0.72	86.8	2.7	1510	10.7	5.42	940	2.97	10.	12.5	8.2
									0.006	*4.03*	*0.23*	*188*	*0.43*	*0.401*	*192*		*1.48*		
92027	-	4	37.4	12.3	49.7	66.4	685	4.4	0.68	80.3	2.8	1460	9.99	5.31	640	2.80	2.4	52.9	8.6
									0.006	*2.98*	*0.18*	*135*	*0.50*	*0.283*	*102*		*0.19*		
91040	-	8	37.5	7.8	45.3	34.9	460	4.7	0.71	84.5	2.6	1940	10.1	5.42	1080	3.02	16	7.8	8.4
									0.004	*3.49*	*0.25*	*180*	*0.46*	*0.358*	*273*		*3.78*		
Mean	**1**	**-**	**38.1**	**8.4**	**46.5**	**45.4**	**552**	**4.5**	**0.70**	**83.9**	**2.7**	**1640**	**10.26**	**5.38**	**887**	**2.928**	**9.5**	**24.4**	
91015	2	2	35.5	11.9	47.5	33.2	420	4.7	0.73	80.6	2.9	1510	10.4	5.12	930	2.96	21	6.2	8.2
									0.006	*2.40*	*0.19*	*140*	*0.31*	*0.281*	*215*		*4.74*		
92032	-	3	36.5	10.3	46.8	36.9	490	4.4	0.69	78.2	2.6	1350	11.0	4.62	670	2.82	11.	11.2	7.9
									0.006	*3.59*	*0.15*	*110*	*0.78*	*0.258*	*115*		*1.75*		
93026	-	6	38.7	5.1	43.8	35.1	545	4.5	0.73	86.8	2.9	1630	10.2	5.54	890	2.88	16.	7.9	7.9
Mean	**2**	**-**	**36.9**	**9.1**	**46.0**	**35.1**	**485**	**4.5**	**0.72**	**81.9**	**2.8**	**1163**	**10.5**	**5.09**	**830**	**2.89**	**16.1**	**8.4**	
91034	3	7	33.8	10.6	44.5	36.0	535	4.5	0.74	87.1	2.8	1550	9.59	5.79	1120	3.04	15	8.2	8.5
									0.005	*2.87*	*0.25*	*180*	*0.46*	*0.393*	*224*		*3.03*		
91042	4	2	36.4	9.1	45.4	38.8	480	4.7	0.72	88.9	2.7	1510	9.66	5.44	890	2.94	18	7.1	8.4
									0.007	*3.26*	*0.17*	*135*	*0.44*	*0.260*	*277*		*2.98*		
Grand Mean (7 trees excl. Tree 1/4)			**36.8**	**8.5**	**45.4**	**35.7**	**491**	**4.6**	**0.72**	**84.7**	**2.7**	**1560**	**10.22**	**5.34**	**931**	**2.95**	**15.4**	**8.7**	
Standard Error of Mean			***0.72***	***1.01***	***0.50***	***0.68***	***16.4***	***0.05***	***0.006***	***1.48***	***0.05***	***69.0***	***0.195***	***0.141***	***55.5***		***1.41***		

Table 16

SOUTH AFRICA

Provenance MOUNTAIN PINE RIDGE - PINUS PATULA SPP. TECUNUMANII

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Permanence	Moisture Content %
3029	2	1	28.7	8.1	36.8	28.2	480	4.4	0.70	79.9	2.7	1390	11.5	5.05	880	2.930	8.1	1.57	7.6
									0.003	*2.78*	*0.19*	*130*	*0.58*	*0.251*	*218*		*1.41*		
3040		21	40.6	3.9	44.5	32.6	535	4.8	0.71	95.3	2.6	1570	11.1	5.79	850	2.927	7.5	16.9	8.1
									0.008	*3.64*	*0.21*	*167*	*0.58*	*0.396*	*115*		*1.14*		
3031		24	40.1	3.9	44.0	33.4	535	4.4	0.70	86.7	2.7	1520	11.6	5.55	810	2.897	7.0	18.1	6.9
									0.005	*5.89*	*0.19*	*169*	*0.75*	*0.394*	*183*		*1.09*		
GRAND MEAN		3	36.5	5.3	41.8	31.4	517	4.5	0.70	87.3	2.7	1493	11.4	5.46	847	2.918	7.5	16.9	
Standard Error of Mean			*3.89*	*1.40*	*2.49*	*1.06*	*18.3*	*0.13*	*0.003*	*4.46*	*0.03*	*53.6*	*0.15*	*0.218*	*20.3*		*0.32*		

Table 17

BRAZIL/JARI CAP 21

Provenance MOUNTAIN PINE RIDGE - PINUS CARIBAEA VAR. HONDURENSIS

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Permanence	Moisture Content %
91090		2	35.4	5.1	40.6	32.2	480	4.5	0.73	88.1	2.8	1580	9.02	5.62	900	2.95	22	5.7	8.1
									0.011	*5.10*	*0.18*	*188*	*0.37*	*0.47*	*217*		*1.57*		
91094		7	36.1	2.8	39.0	31.2	470	4.7	0.79	88.2	2.9	1680	7.23	5.52	840	2.91	65	2.0	7.9
									0.009	*3.77*	*0.21*	*180*	*0.25*	*0.31*	*230*		*5.15*		
91033		11	39.6	7.2	46.8	38.3	515	4.6	0.68	67.5	2.7	1300	13.3	4.63	1090	3.02	6.5	20	8.5
									0.008	*2.59*	*0.24*	*125*	*0.54*	*0.36*	*269*		*1.60*		
Mean	1		37.0	5.0	42.1	33.9	**488**	4.6	**0.73**	**81.3**	**2.8**	**1520**	**9.75**	**5.26**	**943**	**2.96**	**31.2**	**9.2**	
91070	2	5	28.3	8.3	36.6	41.7	435	4.7	0.71	79.7	2.7	1370	9.39	4.70	650	2.78	14	9.2	8.7
									0.005	*3.77*	*0.21*	*150*	*0.32*	*0.31*	*240*		*1.96*		
91082		11	34.2	4.9	39.1	36.8	530	4.7	0.74	82.3	2.9	1550	10.4	5.52	920	2.95	24	5.3	8.2
									0.006	*5.62*	*0.26*	*223*	*0.41*	*0.37*	*267*		*9.66*		
91087		16	38.6	7.0	45.6	39.7	535	4.5	0.71	84.8	2.8	1550	11.2	5.72	1160	3.05	8.2	16	8.0
									0.009	*3.13*	*0.14*	*117*	*0.59*	*0.22*	*321*		*1.13*		
Mean	2		33.7	**6.7**	**40.4**	**39.4**	**500**	**4.6**	**0.72**	**82.3**	**2.8**	**1490**	**10.3**	**5.31**	**910**	**2.93**	**12.1**	**10.2**	
91047	3	1	39.5	4.6	44.1	30.6	490	4.7	0.70	79.4	2.9	1510	13.8	5.43	1200	3.07	13	9.7	8.5
									0.008	*2.62*	*0.21*	*155*	*0.69*	*0.24*	*276*		*3.38*		
91097		2	37.2	7.1	44.4	45.1	470	4.9	0.75	85.8	3.4	1940	10.5	5.57	830	2.89	37	3.4	8.4
									0.012	*3.11*	*0.15*	*155*	*0.43*	*0.33*	*299*		*8.37*		
92031	5	5	28.1	6.9	34.9	39.3	510	4.6	0.72	80.2	2.7	1410	9.40	4.84	620	2.78	15.	8.1	8.2
									0.008	*3.00*	*0.13*	*75*	*0.41*	*0.29*	*136*		*1.62*		
GRAND MEAN		(9 trees)	35.2	6.0	41.2	37.2	493	4.7	**0.73**	**81.8**	**2.9**	**1543**	**10.5**	**5.28**	**912**	**2.93**	**22.8**	**8.6**	
Standard Error of Mean			*1.46*	*0.58*	*1.39*	*1.66*	*10.9*	*0.04*	*0.011*	*2.12*	*0.07*	*63.0*	*0.69*	*0.144*	*68.9*		*6.11*		

Table 18

BRAZIL/JARI CAP 21

Provenance CULMI - PINUS CARIBAEA VAR HONDURENSIS

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Performance	Moisture Content %
91088	1	8	34.6	7.2	41.8	37.3	535	4.5	0.67	81.2	2.6	1360	11.3	5.16	910	2.95	5.8	22	8.1
									0.008	*3.64*	*0.26*	*168*	*0.54*	*0.21*	*161*		*1.20*		
92028		10	38.5	7.4	45.9	34.9	505	4.6	0.65	78.5	2.5	1270	15.4	4.77	670	2.81	7.2	18	8.1
									0.007	*3.89*	*0.20*	*120*	*0.89*	*0.176*	*151*		*1.14*		
91039		11	39.4	3.4	42.8	34.4	440	4.9	0.73	80.7	2.8	1450	9.58	5.61	960	2.97	24	5.3	8.5
									0.005	*3.07*	*0.17*	*120*	*0.439*	*0.310*	*204*		*3.74*		
Mean	**1**		**37.5**	**6.0**	**43.5**	**35.5**	**493**	**4.7**	**0.68**	**80.1**	**2.6**	**1360**	**12.1**	**5.18**	**847**	**2.91**	**12.3**	**15.0**	
91071	3	8	36.6	7.4	44.0	27.4	510	4.8	0.69	83.9	2.5	1320	12.3	4.94	1120	3.04	8.1	16	8.5
									0.010	*3.03*	*0.21*	*140*	*0.92*	*0.220*	*250*		*0.82*		
91020		12	37.4	9.0	46.4	37.5	500	4.6	0.66	74.3	2.5	1220	14.2	4.92	940	2.97	5.0	25	8.2
									0.010	*3.16*	*0.19*	*145*	*0.70*	*0.311*	*147*		*0.77*		
91075		13	38.0	6.3	44.3	36.4	495	4.7	0.72	87.2	2.7	1510	10.6	5.33	970	2.97	10	13	8.5
									0.007	*4.51*	*0.15*	*150*	*0.65*	*0.303*	*250*		*1.56*		
Mean	**3**		**37.3**	**7.6**	**44.9**	**33.8**	**502**	**4.7**	**0.69**	**81.8**	**2.6**	**1350**	**12.4**	**5.06**	**1010**	**2.99**	**7.7**	**18**	
91101	4	14	36.4	5.0	41.4	31.5	480	4.7	0.76	86.7	3.0	1750	9.15	5.56	1030	3.01	36	3.5	8.1
									0.005	*3.18*	*0.01*	*123*	*0.46*	*0.23*	*224*		*3.21*		
91091	5	5	27.9	7.6	35.4	33.1	485	4.7	0.74	83.7	2.9	1610	9.43	5.44	930	2.95	19	6.6	
									0.012	*2.74*	*0.20*	*149*	*0.55*	*0.22*	*285*		*2.55*		
91030		10	37.9	5.3	43.2	45.6	495	4.7	0.74	91.4	2.8	1610	8.98	5.56	960	2.96	35	3.4	8.3
									0.007	2.15	0.15	135	0.588	0.369	272		4.91		
GRAND MEAN		**(9 trees)**	**36.3**	**6.5**	**42.8**	**35.3**	**494**	**4.7**	**0.71**	**83.1**	**2.7**	**1460**	**11.2**	**5.25**	**943**	**2.96**	**16.7**	**12.5**	**8.3**
Standard Error of Mean			*1.15*	*0.56*	*1.08*	*1.66*	*8.6*	*0.04*	*0.013*	*1.70*	*0.06*	*59.5*	*0.77*	*0.106*	*40.1*		*4.13*		

Table 19

BRAZIL/JARI - CAP 21

Provenance SANTA CLARA - PINUS CARIBAEA VAR HONDURENSIS

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance $\log_{10}$	Air Resistance Gurley s	Air Permanence	Moisture Content %
91051	1	2	41.5	4.5	46.0	39.0	500	4.6	0.73	81.9	3.0	1600	9.47	5.05	810	2.90	11	12	8.7
									0.007	*2.66*	*0.20*	*150*	*0.380*	*0.301*	*215*		*0.77*		
92019		10	39.8	5.7	45.5	38.4	575	4.5	0.74	86.6	2.9	1640	10.3	5.29	1300	3.10	7.7	17	7.8
									0.007	*3.06*	*0.16*	*142*	*0.75*	*0.23*	*353*		*1.46*		
91081	3	2	36.5	8.9	45.4	39.0	455	4.7	0.74	69.6	2.9	1360	11.7	4.48	910	2.95	11	12	8.3
									0.008	*2.14*	*0.20*	*133*	*0.25*	*0.24*	*147*		*1.74*		
91044		6	33.7	5.4	39.1	23.6	525	4.6	0.75	81.4	3.0	1580	9.87	5.40	1110	3.04	20	6.3	8.5
									0.005	*3.94*	*0.32*	*150*	*0.564*	*0.363*	*190*		*3.87*		
91066	4	3	31.8	7.4	39.2	50.4	460	4.9	0.73	73.3	2.9	1440	10.4	4.60	890	2.92	15	8.6	8.6
									0.008	*5.06*	*0.37*	*240*	*0.40*	*0.189*	*315*		*5.32*		
91061		5	37.8	4.6	42.3	37.1	485	4.7	0.75	80.7	3.1	1680	8.88	5.14	920	2.94	22	5.8	8.4
									0.008	*3.95*	*0.25*	*205*	*0.414*	*0.357*	*288*		*2.92*		
91036		12	35.0	8.3	43.3	38.8	510	4.7	0.72	69.3	3.3	1540	12.0	4.82	1050	3.01	7.3	17	8.5
									0.003	*3.08*	*0.23*	*165*	*0.44*	*0.300*	*269*		*2.04*		
Mean	**4**		**34.9**	**6.8**	**41.6**	**42.1**	**485**	**4.8**	**0.73**	**74.4**	**3.1**	**1553**	**10.4**	**4.85**	**953**	**2.96**	**14.8**	**10.5**	
91021	5	3	34.4	9.0	43.5	47.2	485	4.7	0.75	73.1	3.2	1580	9.40	4.68	760	2.87	14	9.2	8.5
									0.009	*2.52*	*0.24*	*155*	*0.253*	*0.179*	*151*		*2.32*		
GRAND MEAN		**(8 trees)**	**36.3**	**6.7**		**39.2**	**499**		**0.74**	**77.0**	**3.0**	**1553**	**10.3**	**4.93**	**969**	**2.97**	**13.5**	**11.0**	
Standard Error of Mean			*1.15*	*0.67*	*0.96*	*2.80*	*13.6*	*0.04*	*0.004*	*2.28*	*0.05*	*37.2*	*0.39*	*0.119*	*62.3*		*1.90*		

Table 20

BRAZIL/JARI -CAP 21

Provenance POPTUN - PINUS CARIBAEA VAR HONDURENSIS

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Permanence	Moisture Content %
92024	1	1	33.0	8.0	41.0	41.6	525	4.6	0.71	79.0	3.3	1740	11.1	5.19	680	2.80	12	10.6	8.4
									0.006	*3.60*	*0.25*	*183*	*0.49*	*0.266*	*271*		*1.18*		
91014		8	33.4	10.8	44.2	32.9	465	4.7	0.73	78.5	3.3	1660	11.1	5.13	877	2.94	21	6.1	8.3
									0.008	*2.36*	*0.18*	*95*	*0.38*	*0.283*	*212*		*2.33*		
91049		13	36.6	11.1	47.7	47.8	560	4.5	0.69	72.2	2.8	1300	10.0	4.52	780	2.88	8.6	15	8.8
									0.007	*2.10*	*0.10*	*210*	*0.52*	*0.316*	*174*		*1.49*		
Mean	1		34.3	10.0	44.3	40.6	517	4.6	0.71	76.6	3.1	1567	10.7	4.95	779	2.87	13.9	10.6	
91102	2	5	36.3	7.0	43.4	50.0	445	4.9	0.70	75.3	2.6	1290	10.1	4.87	700	2.81	17	7.5	8.2
									0.011	*5.62*	*0.31*	*240*	*0.51*	*0.24*	*327*		*4.93*		
91106		9	37.8	7.2	45.0	43.7	460	4.5	0.69	78.2	2.6	1280	10.4	4.94	740	2.85	11	11	8.1
									0.008	*3.76*	*0.19*	*135*	*0.53*	*0.33*	*228*		*1.02*		
92021	3	9	36.3	10.6	46.9	49.8	540	4.5	0.71	75.6	3.3	1650	11.3	5.24	930	2.94	5.7	22	7.8
									0.006	*3.23*	*0.24*	*178*	*0.46*	*0.20*	*320*		*0.83*		
91057	4	4	32.1	6.1	38.3	31.8	455	4.7	0.72	71.4	3.0	1410	13.3	4.64	990	2.98	10	12	8.5
									0.008	*3.45*	*0.23*	*170*	*0.45*	*0.255*	*299*		2.72		
91053		8	35.4	9.5	44.8	36.1	445	4.8	0.67	75.0	3.1	1490	12.9	4.86	750	2.86	8.7	15	8.5
									0.009	*1.90*	*0.17*	*105*	*0.64*	*0.184*	*198*		*1.68*		
GRAND MEAN		**(8 trees)**	**35.1**	**8.8**	**43.9**	**41.7**	**487**	**4.7**	**0.70**	**75.7**	**3.0**	**1478**	**11.3**	**4.92**	**806**	**.8**	**11.8**	**12.4**	
Standard Error of Mean			***0.72***	***0.69***	***1.08***	***2.61***	***16.6***	***0.05***	***0.007***	***1.00***	***0.11***	***139.7***	***0.44***	***0.091***	***40.0***		***1.76***		

Table 21

BRAZIL/AGUDOS - POP 007

Provenance LAGUNILLA - PINUS OOCARPA

Cook No.	Rep. No.	Tree No.	Yield % Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density $g cm^{-3}$	Tensile Index $N m g^{-1}$	Stretch %	Tensile Energy Absorbed $mJ g^{-1}$	Tear Index $mN m^2 g^{-1}$	Burst Index $kPa m^2 g^{-1}$	Double Folds Number	Folding Endurance $\log_{10}$	Air Resistance Gurley s	Air Permeance	Moisture Content %
91067	1	1	40.2	4.0	44.2	32.2	520	4.5	0.74	77.8	3.0	1560	10.3	5.09	1020	2.98	9.6	13	8.5
									0.009	*4.53*	*0.31*	*230*	*0.43*	*0.407*	*335*		*1.37*		
91037		3	36.8	11.5	48.3	46.0	485	4.5	0.73	80.6	2.8	1460	8.89	5.15	790	2.87	14	8.9	8.6
									0.005	*2.37*	*0.13*	*80*	*0.53*	*0.227*	*233*		*1.62*		
91045		5	35.2	8.4	43.6	39.8	440	4.7	0.73	85.4	2.8	1560	10.1	5.42	1030	3.01	18	7.2	8.6
									0.007	*3.76*	*0.21*	*165*	*0.69*	*0.212*	*181*		*5.27*		
91072		7	33.6	9.9	43.4	40.1	485	4.7	0.73	79.3	3.1	1610	10.3	5.20	1200	3.07	12	11	8.5
									0.007	*2.43*	*0.16*	*105*	*0.57*	*0.265*	*250*		*1.54*		
Mean	1		36.5	8.5	44.9	39.5	483	4.6	0.73	80.8	2.9	1548	9.6	5.21	1010	2.98	13.4	10	
91077	2	3	37.0	9.2	46.2	37.3	495	4.7	0.69	79.5	2.8	1410	11.7	5.10	1110	3.04	7.1	18	8.2
									0.009	*2.09*	*0.17*	*60*	*0.59*	*0.170*	*246*		*1.78*		
91060		5	36.9	7.7	44.6	38.2	535	4.5	0.74	80.5	2.9	1540	9.70	5.28	1100	3.03	12	11	8.4
									0.008	*4.40*	*0.23*	*195*	*0.37*	*0.335*	*284*		*1.69*		
91074		6	28.9	12.0	41.0	34.6	465	4.7	0.73	78.4	3.0	1510	10.6	4.93	990	2.97	17	7.4	7.5
									0.008	*2.81*	*0.20*	*145*	*0.39*	*0.290*	*337*		*6.27*		
91022		7	37.0	10.7	47.8	42.2	465	4.8	0.70	76.3	2.6	1280	10.9	4.83	780	2.87	9.1	14	8.3
									0.008	*2.60*	*0.22*	*135*	*0.48*	*0.196*	*241*		*2.29*		
Mean	2		35.0	9.9	44.9	38.1	490	4.7	0.72	78.7	2.8	1435	10.7	5.04	998	2.98	11.3	12.6	
91031	3	1	41.6	4.8	46.4	43.4	450	4.7	0.73	75.2	2.9	1450	10.3	4.60	800	2.89	14	8.8	8.3
									0.009	*3.87*	*0.35*	*230*	*0.32*	*0.290*	*180*		*3.32*		
91063		5	37.1	7.9	45.0	46.8	490	4.7	0.75	78.9	3.0	1580	8.35	5.05	770	2.87	21	5.9	8.4
									0.007	*2.63*	*0.17*	*145*	*0.15*	*0.261*	*280*		*4.90*		
91052		4	39.3	8.5	47.8	37.4	470	4.7	0.70	50.1	2.7	1410	10.8	5.27	1050	3.00	13	10	8.6
									0.005	*4.68*	*0.22*	*150*	*0.84*	*0.28*	*316*		*2.69*		
Mean	3		39.3	7.1	46.4	42.5	470	4.7	0.73	78.1	2.9	1480	9.8	4.97	873	2.92	16	5.2	
91068	4	3	38.8	7.5	46.3	32.0	505	4.5	0.73	86.1	2.8	1560	9.72	5.55	1300	3.09	11	11	8.4
									0.008	*4.90*	*0.17*	*165*	*0.364*	*0.298*	*410*		*1.53*		
91080		4	32.4	9.3	41.7	49.9	415	5.2	0.73	75.3	3.4	1680	8.80	4.86	780	2.87	25	5.1	8.4
									0.005	*3.03*	*0.25*	*154*	*0.34*	*0.24*	*281*		*4.25*		
91083		7	38.1	7.7	45.7	33.5	455	4.7	0.69	88.7	2.5	1420	11.9	5.46	990	2.98	12	10	8.2
									0.008	*3.27*	*0.24*	*175*	*0.48*	*0.38*	*252*		*3.21*		
Mean	4		36.4	8.2	44.6	38.5	458	4.8	0.72	83.4	2.9	1553	10.1	5.29	1023	2.98	16	8.7	
GRAND MEAN		(14 trees)	36.6	8.5	45.1	39.5	477	4.7	0.72	80.2	2.9	1500	10.2	5.13	979	2.97	13.9	10.1	
Standard Error of Mean			0.88	0.60	0.59	1.50	8.6	0.05	0.005	1.08	0.06	27.6	0.28	0.071	45.9		1.30		

Table 22

BRAZIL/AGUDOS POP 007

Provenance RAFAEL - PINUS PATULA SPP. TECUNUMANII

			Yield %																
Cook No.	Rep. No.	Tree No.	Screened	Screenings	Total	Kappa No.	Drainability CSF	Drainage Time s	Density gcm^{-3}	Tensile Index Nmg^{-1}	*Stretch* %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds Number	Folding Endurance log_{10}	Air Resistance Gurley s	Air Permanence	Moisture Content %
92033	1	6	36.7	10.0	48.8	41.2	515	4.6	0.72	80.0	2.8	1490	9.72	4.75	840	2.92	13	10.1	8.0
									0.006	*3.60*	*0.20*	*146*	*0.341*	*0.170*	*139*		*1.57*		
91103	2	2	36.6	6.6	43.2	34.6	490	4.7	0.72	77.5	2.7	1390	11.0	5.07	1090	3.02	14	9.0	8.1
									0.010	*3.91*	*0.12*	*122*	*0.40*	*0.31*	*326*		*1.47*		
91046		3	39.0	7.5	46.4	33.9	450	4.7	0.68	76.7	2.4	1160	11.6	4.69	810	2.89	13	9.8	8.4
									0.008	*3.23*	*0.17*	*135*	*1.03*	*0.486*	*237*		*3.37*		
91104		4	38.4	5.6	44.0	34.0	500	4.7	0.68	82.4	2.6	1370	12.1	5.54	1050	3.01	13	9.6	8.1
									0.012	*3.96*	*0.15*	*135*	*0.59*	*0.28*	*241*		*1.06*		
91098		5	41.3	5.3	46.6	37.0	520	4.7	0.73	82.5	2.8	1490	10.03	5.10	1070	3.02	10	12	7.9
									0.011	*1.83*	*0.18*	*127*	*0.49*	*0.21*	*283*		*1.78*		
Mean	**2**		**38.8**	**6.25**	**45.0**	**34.9**	**490**	**4.7**	**0.703**	**79.8**	**2.6**	**1352**	**11.25**	**5.10**	**1005**	**2.98**	**12.5**	**10.1**	
91092	3	5	38.2	6.3	44.5	32.3	430	4.7	0.72	83.3	2.5	1340	11.4	5.37	980	2.98	26	4.9	8.1
									0.006	*3.32*	*0.27*	*178*	*0.45*	*0.27*	*209*		*2.43*		
92022		7	36.4	7.7	44.1	37.3	470	5.0	0.75	84.8	3.1	1680	10.4	5.52	1080	3.00	25	5.1	7.3
									0.005	*3.39*	*0.26*	*198*	*0.36*	*0.30*	*369*		4.66		
92025	4	7	39.5	7.0	46.5	36.2	500	4.4	0.69	75.4	2.7	1350	12.5	4.76	810	2.90	7.4	17.2	8.1
									0.004	*3.49*	*0.16*	*140*	*0.69*	*0.251*	*138*		*1.31*		
91019		8	30.3	21.1	51.4	42.0	445	4.7	0.72	83.4	2.6	1410	10.5	5.36	1060	3.02	18	7.1	8.3
									0.007	*3.12*	*0.12*	*90*	*0.31*	*0.388*	*121*		*5.19*		
GRAND MEAN		**(9 trees)**	**37.4**	**8.6**	**46.2**	**36.5**	**480**	**4.7**	**0.71**	**80.7**	**2.7**	**1409**	**11.1**	**5.13**	**977**	**2.97**	**15.4**	**9.4**	
Standard Error of Mean			***1.03***	***1.65***	***0.88***	***1.10***	***10.8***	***0.05***	***0.008***	***1.13***	***0.07***	***46.9***	***0.31***	***0.112***	***40.6***		***2.13***		

Table 23

Samples grown in Brazil - Mean Values for each Provenance

Species	Provenance	Site	No.of Trees	Total Yield %	Kappa Number	Drainability CSF	Density Grm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds number	Air Resistance Gurley
Pinus caribaea* var. *bahamensis	Andros	Jari	7	44.4 *1.24*	38.1 *2.64*	509 *6.6*	0.71 *0.008*	77.3 *1.19*	3.4 *0.14*	1733 *69.7*	13.3 *0.53*	5.21 *0.086*	863 *59.3*	8.86 *1.107*
Pinus carribaea* var. *caribaea	Los Palacios	Jari	9	40.0 *1.72*	39.6 *1.65*	475 *19.2*	0.71 *0.012*	73.4 *1.72*	3.2 *0.11*	1570 *56.2*	11.9 *0.70*	4.89 *0.118*	791 *66.9*	13.9 *2.640*
Pinus caribaea* var.*hondurensis	Guanaja	Jari	8	43.1 *2.00*	36.0 *0.82*	506 *18.3*	0.74 *0.011*	76.9 *2.51*	3.2 *0.07*	1616 *38.7*	10.8 *0.62*	5.13 *0.171*	871 *37.9*	19.3 *7.06*
	Alamicamba	Jari	12	43.1 *1.02*	35.5 *1.29*	508 *7.2*	0.71 *0.008*	81.0 *1.12*	2.9 *0.07*	1550 *44.8*	11.3 *0.32*	5.30 *0.079*	1078 *58.1*	11.9 *1.46*
	M.P.R. *	Jari	9	41.2 *1.39*	37.2 *1.66*	493 *10.9*	0.73 *0.011*	81.8 *2.12*	2.9 *0.07*	1543 *63.0*	10.5 *0.69*	5.28 *0.144*	912 *68.9*	22.8 *6.11*
	Culmi	Jari	9	42.8 *1.08*	35.3 *1.66*	494 *8.6*	0.71 *0.013*	83.1 *1.70*	2.7 *0.06*	1460 *59.5*	11.2 *0.77*	5.25 *0.106*	943 *40.1*	16.7 *4.13*
	Santa Clara	Jari	8	43.0 *0.96*	39.2 *2.80*	499 *13.6*	0.74 *0.004*	77.0 *2.28*	3.0 *0.05*	1553 *37.2*	10.3 *0.39*	4.93 *0.119*	969 *62.3*	13.5 *1.90*
	Poptun	Jari	8	43.9 *1.08*	41.7 *2.61*	487 *16.6*	0.70 *0.007*	75.7 *1.00*	3.0 *0.11*	1352 *139.7*	11.3 *0.44*	4.92 *0.091*	806 *40.0*	11.8 *1.76*
Pinus oocarpa	Bucaral	Agudos	9	44.3 *0.99*	38.2 *2.02*	487 *12.8*	0.72 *0.006*	80.1 *1.57*	2.7 *0.66*	1400 *34.3*	10.2 *0.33*	5.09 *0.090*	910 *39.9*	13.4 *1.62*
	Lagunilla	Agudos	14	45.1 *0.59*	39.5 *1.50*	477 *8.6*	0.72 *0.005*	80.2 *1.08*	2.9 *0.06*	1500 *27.6*	10.2 *0.28*	5.13 *0.071*	979 *45.9*	13.9 *1.30*
Pinus patula* spp. *tecunumanii	Camelias	Agudos	10	45.1 *0.52*	38.8 *1.31*	482 *8.0*	0.72 *0.006*	83.2 *2.07*	2.7 *0.05*	1443 *38.1*	9.8 *0.29*	5.30 *0.116*	1009 *42.9*	1.50 *1.47*
	M.P.R. *	Agudos	7	45.4 *0.50*	35.7 *0.68*	491 *16.4*	0.72 *0.006*	84.7 *1.48*	2.7 *0.05*	1570 *69.0*	10.2 *0.20*	5.34 *0.141*	931 *55.5*	15.4 *1.41*
	Rafael	Agudos	9	46.2 *0.88*	36.5 *1.10*	480 *10.8*	0.71 *0.008*	80.7 *1.13*	2.7 *0.07*	1409 *46.9*	11.1 *0.31*	5.13 *0.112*	977 *40.6*	15.4 *2.13*

Note: All figures in italics are the Standard Error of Mean

Table 24

Samples grown in South Africa - Mean Values for each Provenance

Species	Provenance	Site	No. of Trees	Total Yield %	Kappa Number	Drainability CSF	Density Grm^{-3}	Tensile Index Nmg^{-1}	Stretch %	Tensile Energy Absorbed mJg^{-1}	Tear Index mNm^2g^{-1}	Burst Index $kPam^2g^{-1}$	Double Folds number	Air Resistance Gurley
Pinus caribaea var.*bahamensis*	Andros	Kwambonambi	2	39.9	25.9	540	0.74	88.3	2.9	1670	10.5	5.75	904	13.9
				1.30	*0.15*	*5.0*	*0.004*	*2.00*	*0.10*	*0*	*0.71*	*0.105*	*95.0*	*3.05*
Pinus caribaea var.*caribaea*	Los Palacios	Kwambonambi	2	38.7	29.3	482	0.70	77.9	2.6	1325	12.4	4.99	690	8.8
				3.60	*0.40*	*52.5*	*0.030*	*5.35*	*0*	*75.0*	*2.30*	*0.365*	*10.0*	*3.80*
Pinus caribaea var. *hondurensis*	Guanaja	Kwambonambi	3	41.2	32.2	557	0.76	83.1	3.0	1653	9.40	5.48	890	20.6
				1.02	*1.28*	*4.4*	*0.021*	*0.26*	*0.13*	*84.1*	*0.47*	*0.151*	*35.1*	*9.63*
	Alamicamba	Kwambonambi	3	35.7	30.7	560	0.78	85.6	3.0	1683	8.61	5.59	922	26.7
				5.90	*3.48*	*20.2*	*0.009*	*1.96*	*0.10*	*91.7*	*0.32*	*0.176*	*4.4*	*4.76*
Pinus oocarpa	Bucaral	Kwambonambi	3	43.2	36.4	555	0.75	88.7	2.8	1633	9.57	5.70	1047	12.9
				0.83	*3.62*	*20.2*	*0.015*	*1.17*	*0.17*	*129.1*	*0.878*	*0.120*	*26.7*	*2.43*
Pinus patula spp. *tecunumanii*	Camelias	Kwambonambi	2	44.9	30.5	515	0.73	88.4	2.6	1490	11.1	5.44	890	10.9
				0.35	*0.35*	*5.0*	*0.005*	*0.75*	*0*	*10.0*	*0.30*	*0.140*	*10.0*	*0.75*
	M.P.R.*	Kwambonambi	3	41.8	31.4	517	0.70	87.3	2.7	1493	11.4	5.46	847	7.5
				2.49	*1.06*	*18.3*	*0.003*	*4.46*	*0.03*	*53.6*	*0.15*	*0.218*	*20.3*	*0.32*

M.P.R. = Mountain Pine Ridge. Note: All figures in italics are the Standard Error of the Mean.

FIGURE 1 Pinus caribaea

Tear against Density

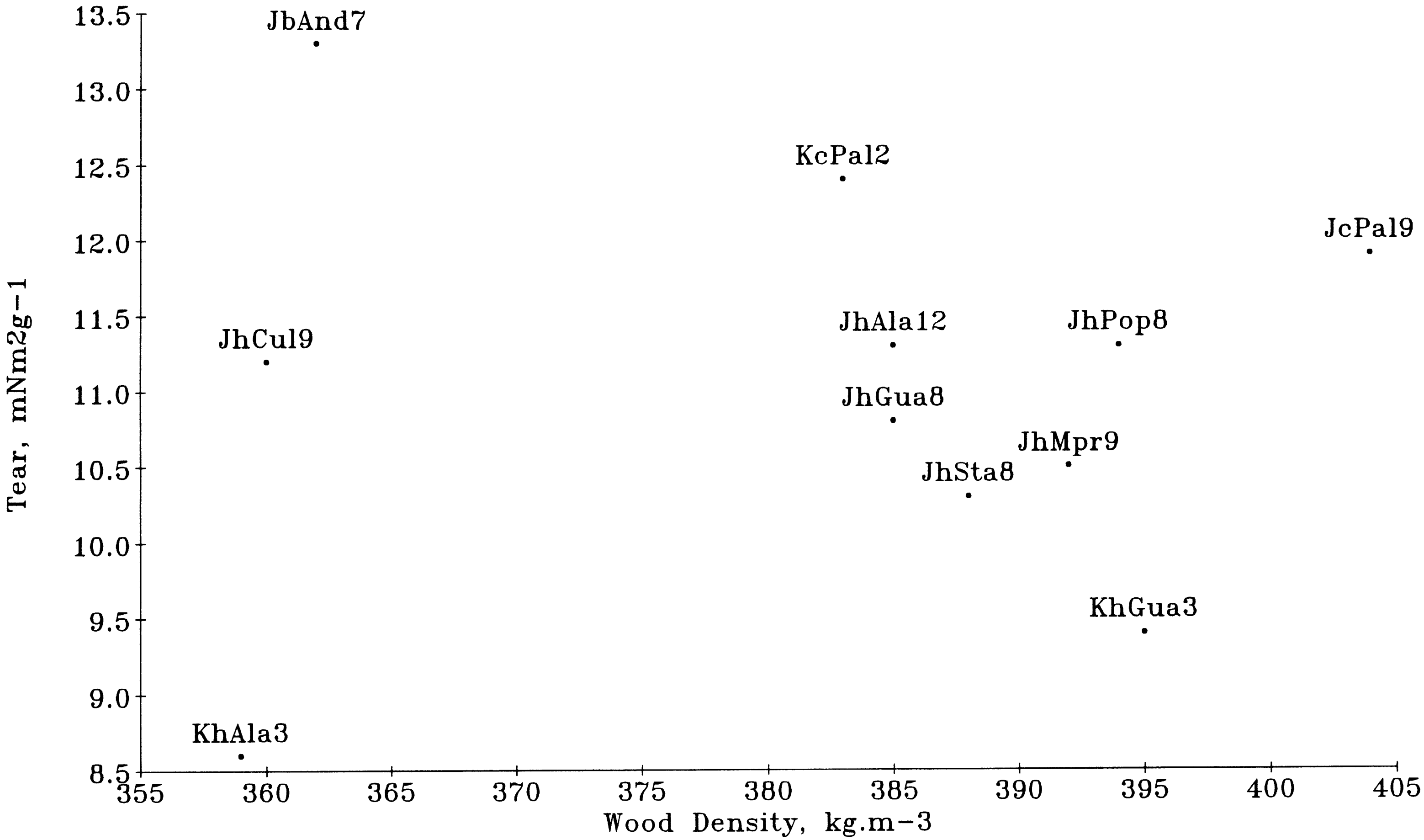


FIGURE 2 Pinus caribaea

Tensile strength against Density

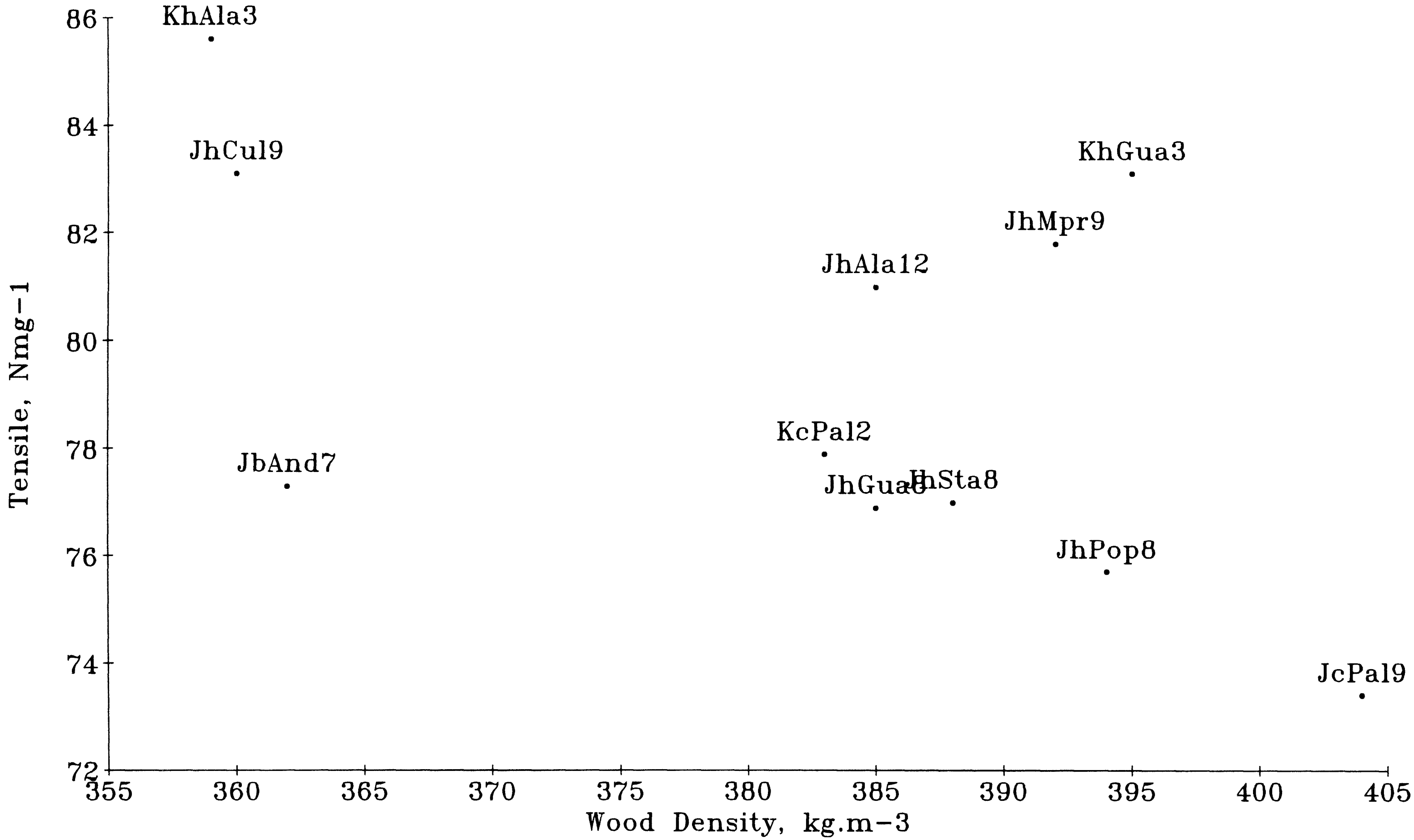


FIGURE 3 Pinus caribaea

Tear against Tree Volume

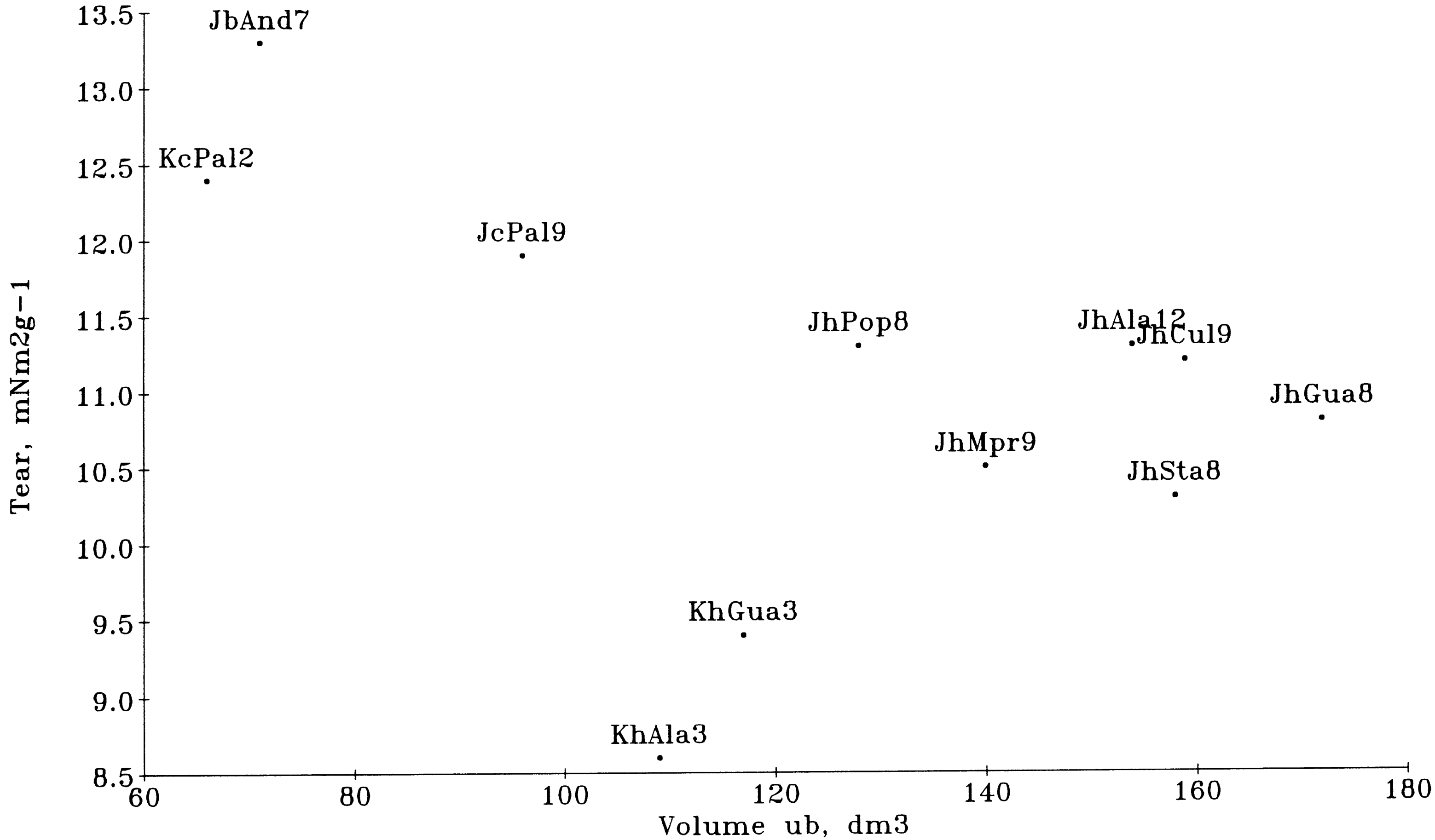


FIGURE 4 Pinus caribaea

Tensile against Tree Volume

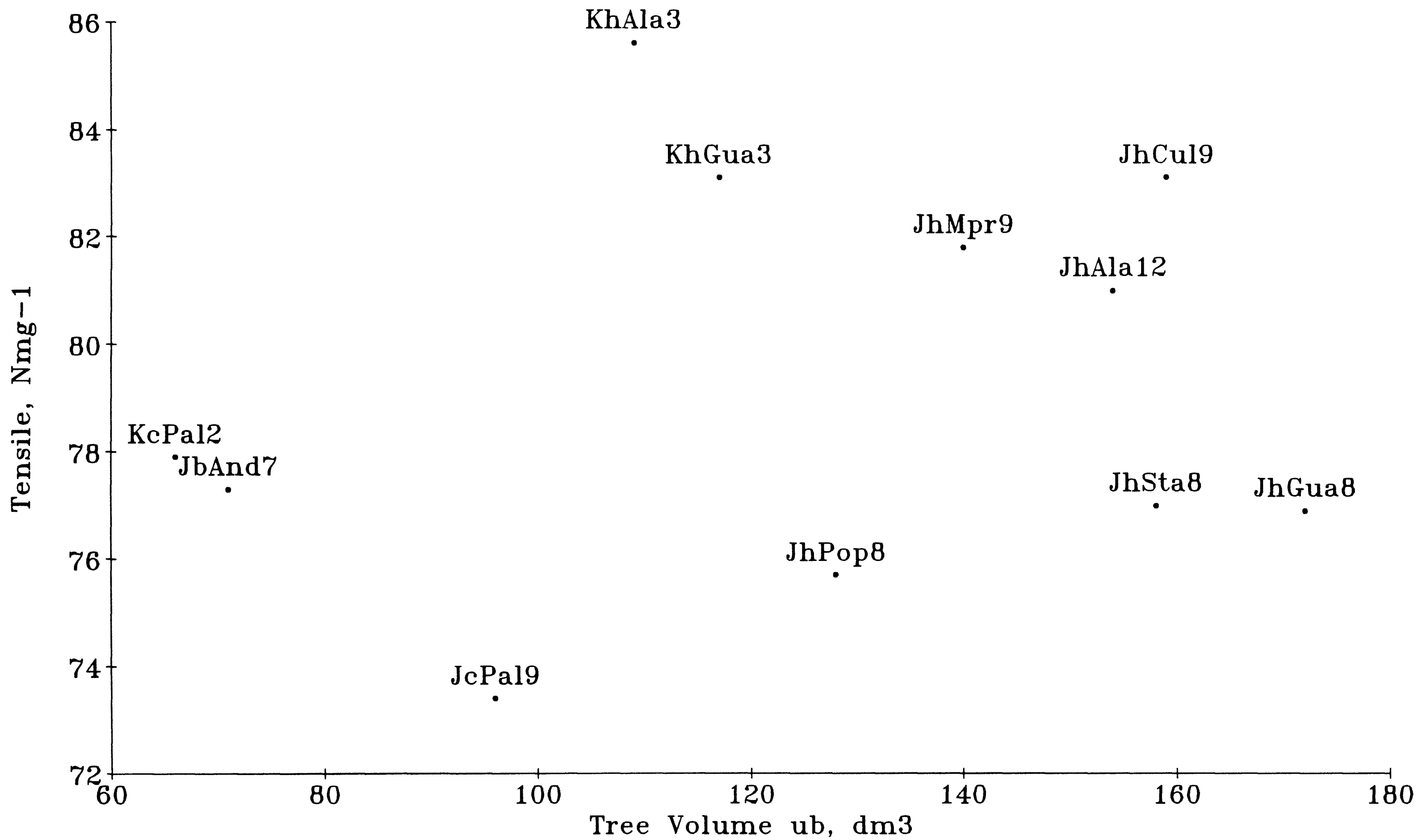


FIGURE 5 P. ooc. & P. pat. ssp tec.

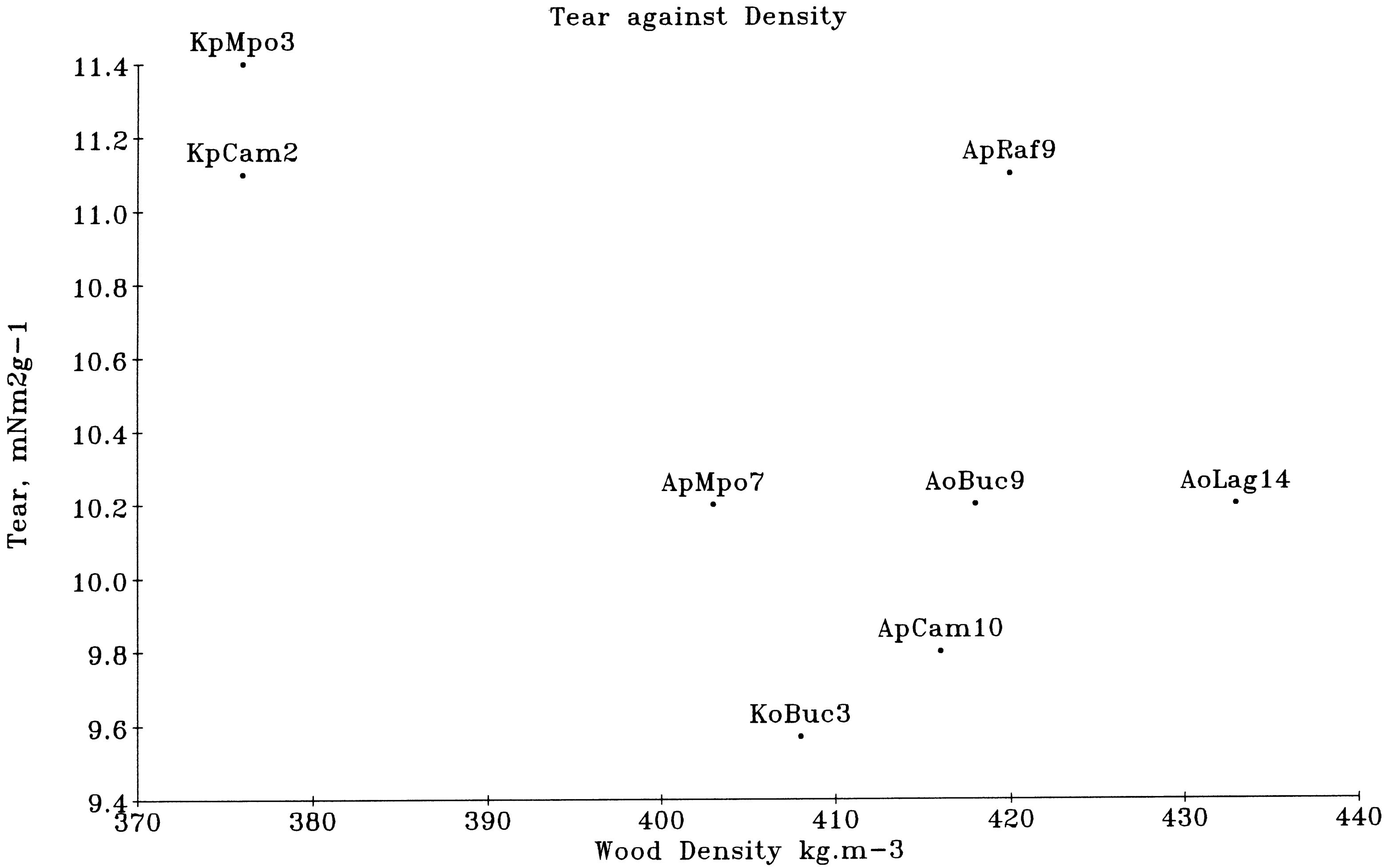


FIGURE 6 P. ooc. & P. pat. ssp. tec.

Tensile against Density

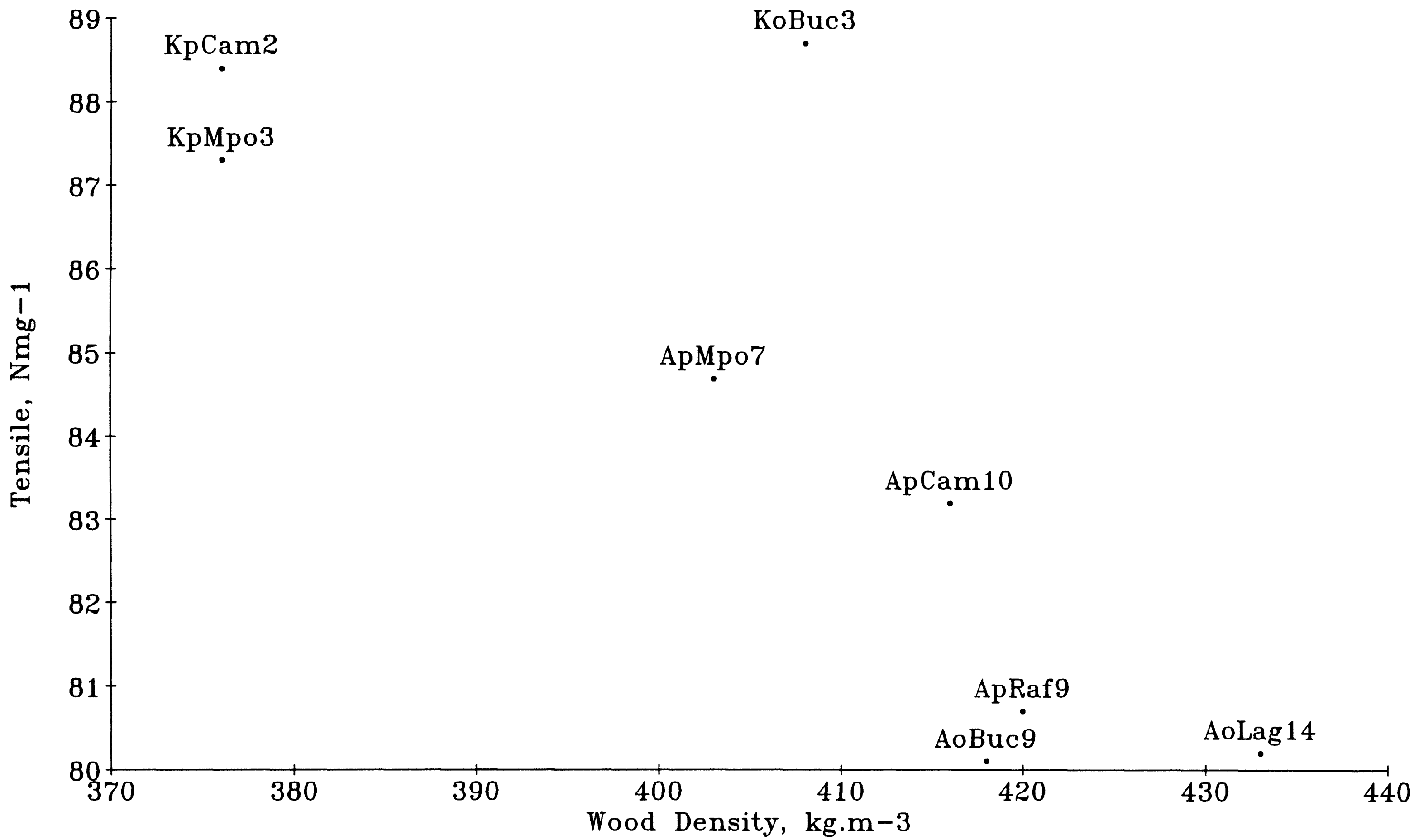


FIGURE 7 P. ooc. & P. pat. ssp. tec.

Tear against Tree Volume

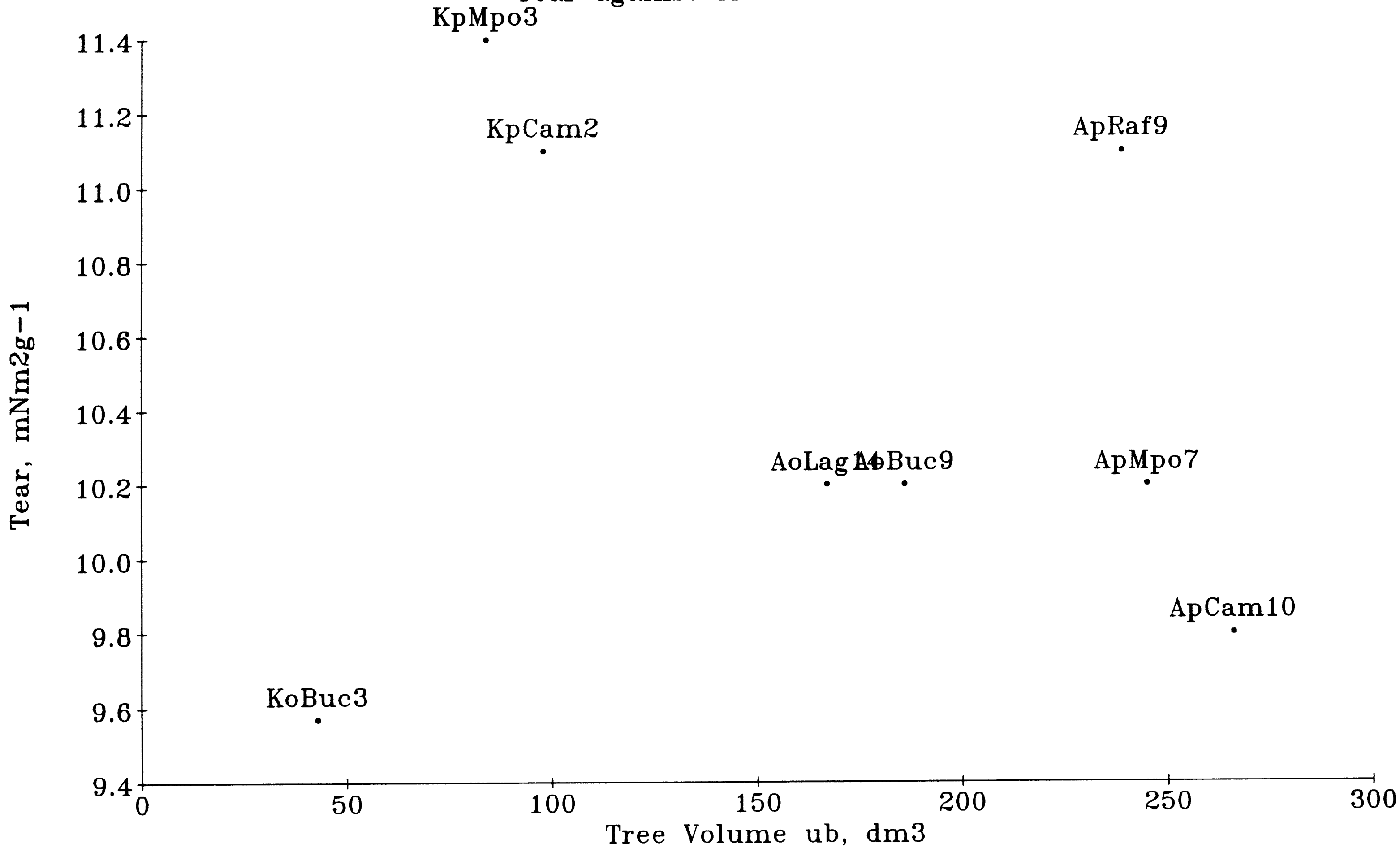


FIGURE 8 P. ooc. & P. pat. ssp. tec.

Tensile against Tree Volume

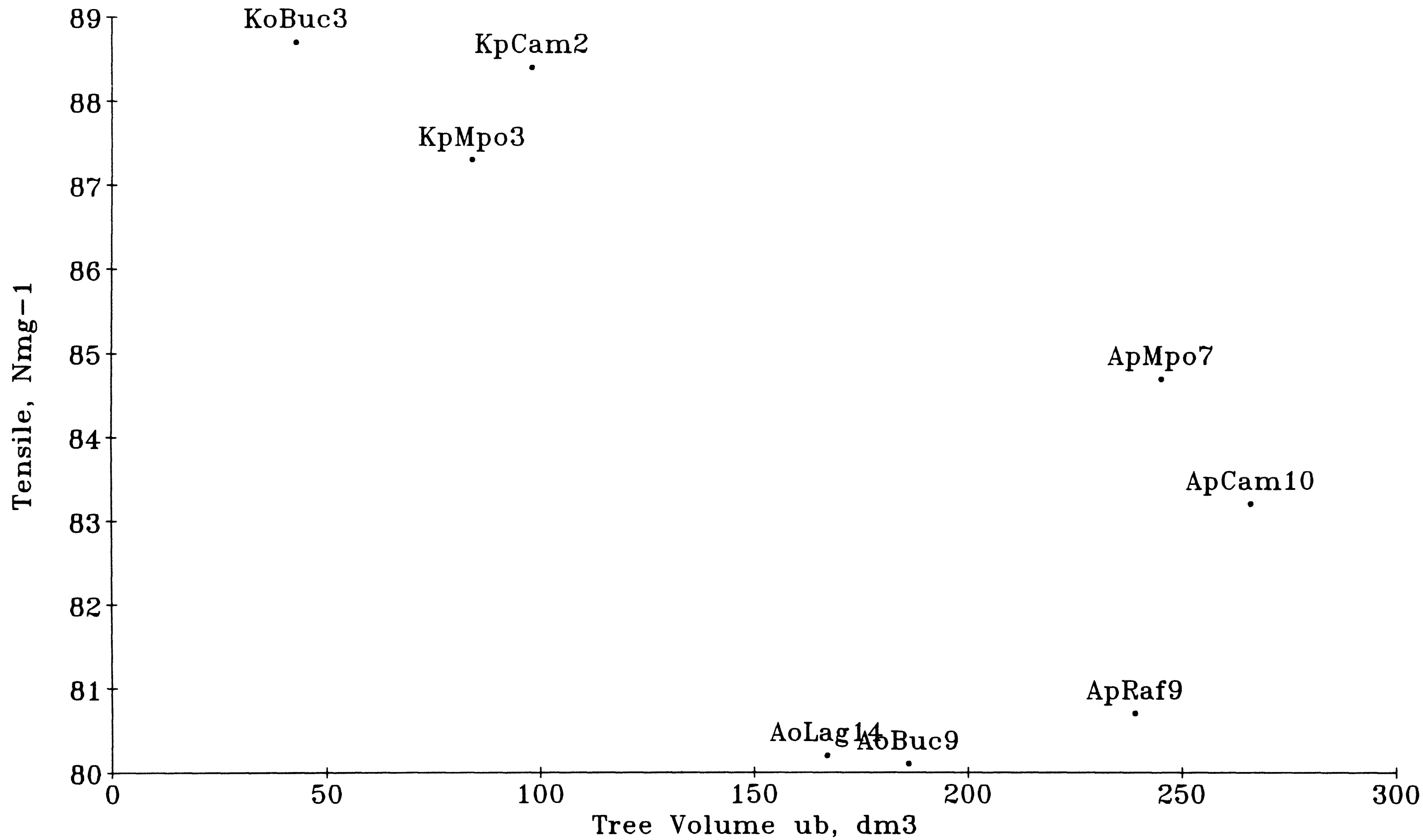


FIGURE 9 Tear Variation P. caribaea

Hi-Lo Graph 2xSE of Mean

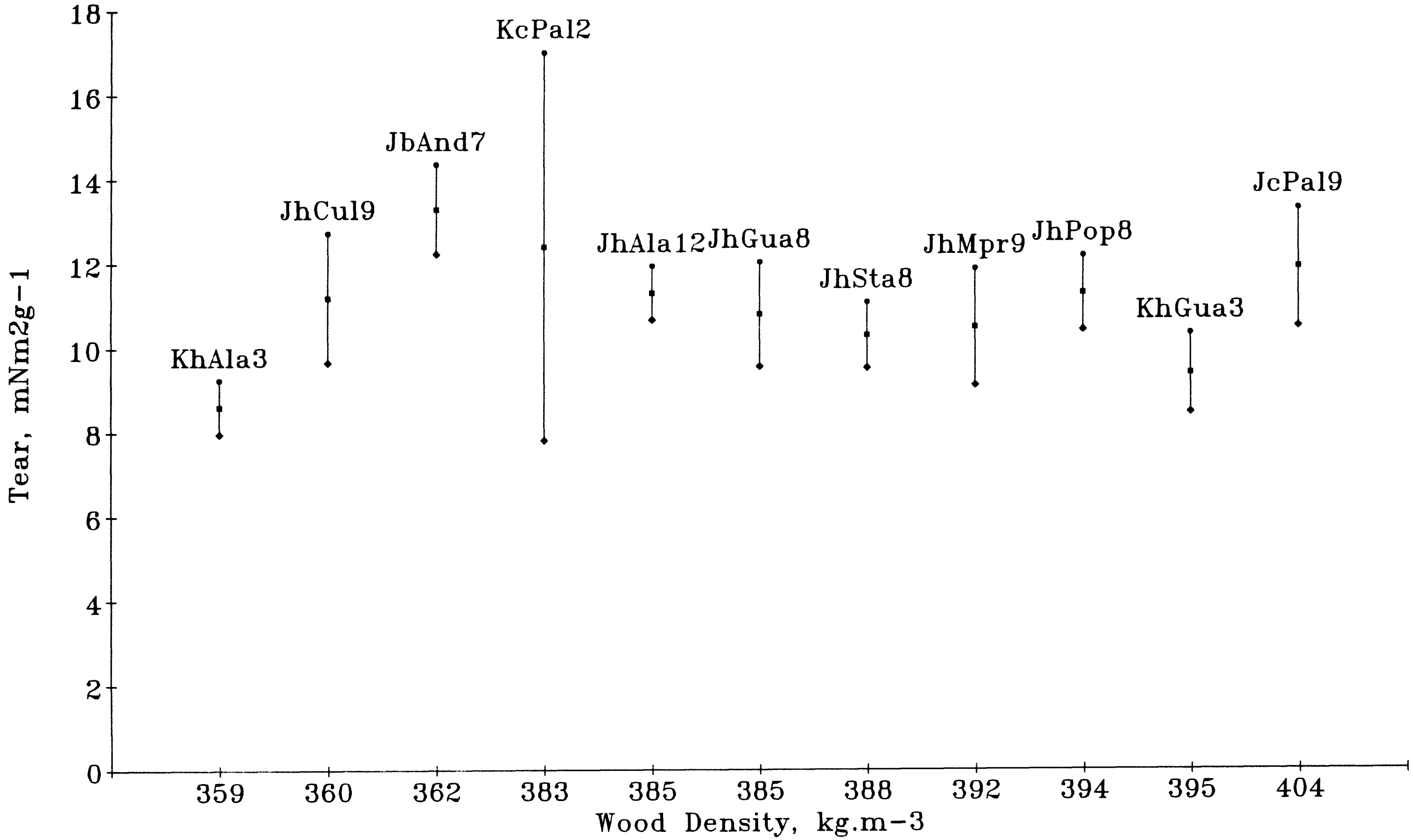


FIGURE 10 Tensile Variation P. caribaea

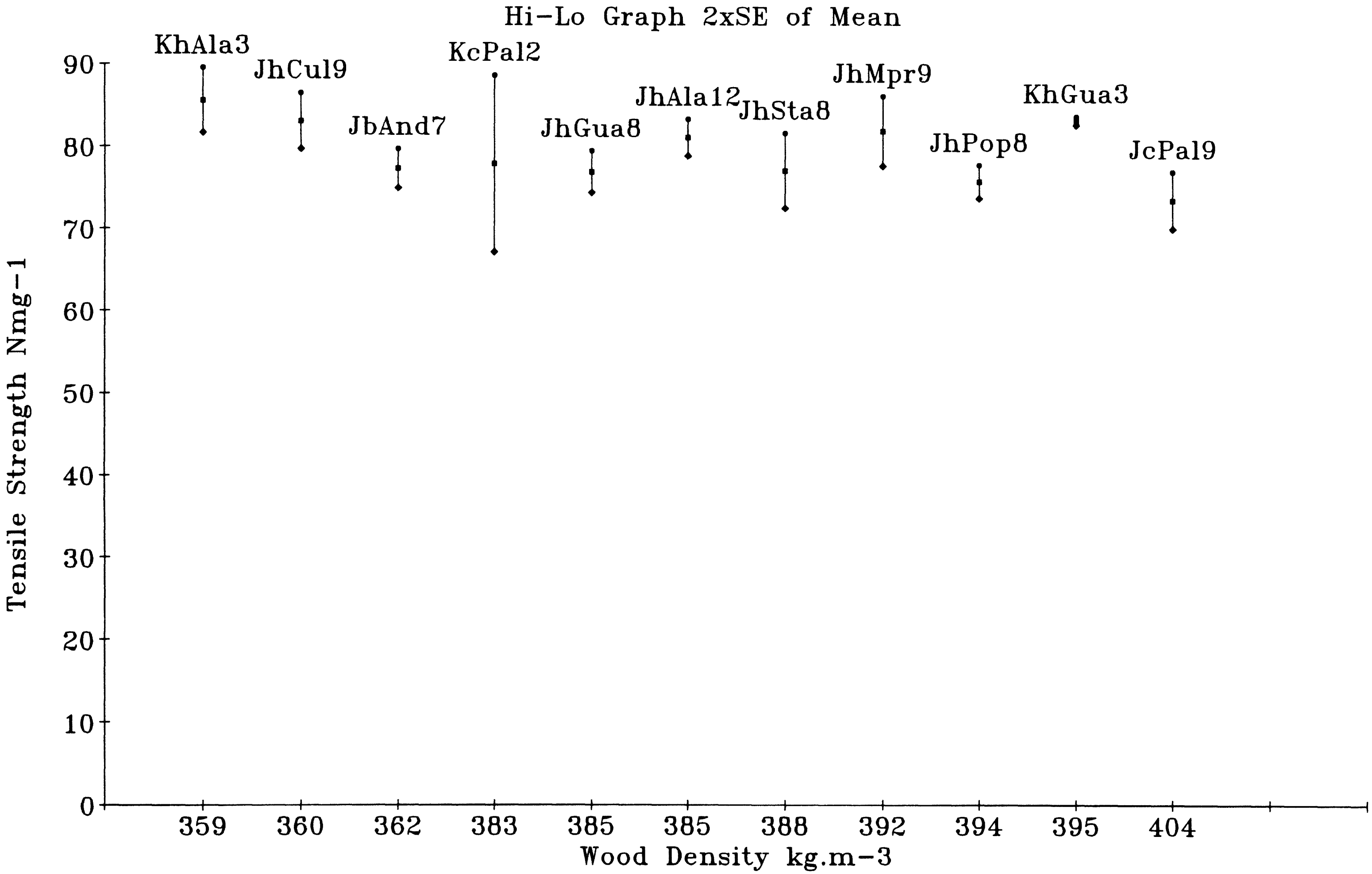


FIGURE 11 Tear Var., P. ooc. & P. pat.

Hi-Lo Graph 2xSE of Mean

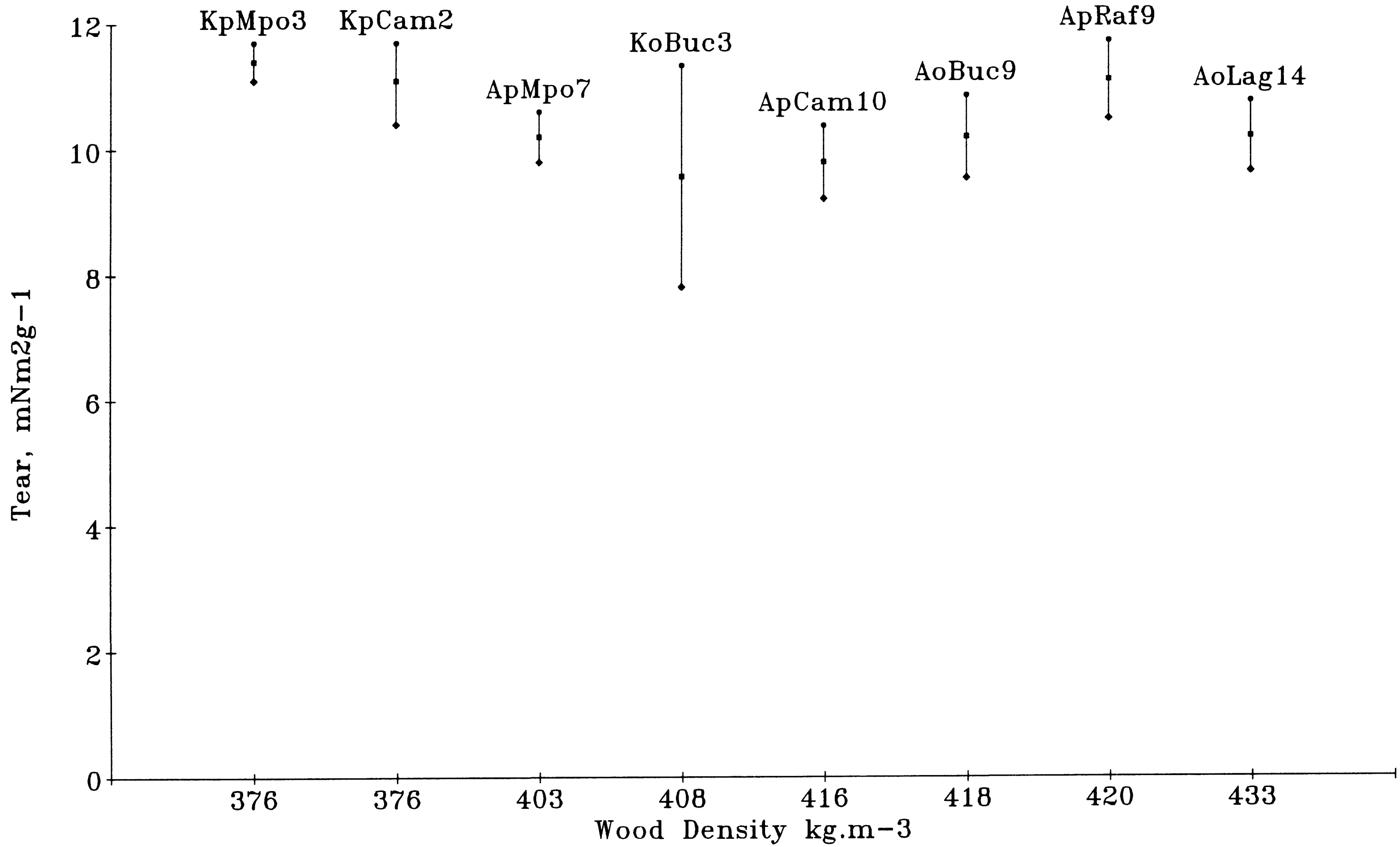


FIGURE 12 Tens. Var., P. ooc. & P. pat.

Hi-Lo Graph 2xSE of Mean