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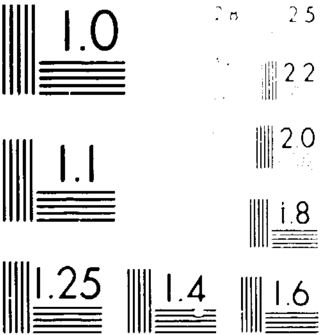

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NATURAL AND MAN-MADE FORESTS AS A SOURCE OF PULP WOOD *

by

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INTRODUCTION

The world total production of pulp in 1978 was almost 126 million tonnes of which 94% (118 million tonnes) was wood pulp (FAO, 1980). In 1977, it was predicted that the demand for papermaking grades of pulp would be 136.2 million tonnes in 1980 and 198.1 million tonnes in 1990. To meet this demand, it was estimated that 504.4 million cubic metres of wood be required in 1980 and 760.4 million cubic metres in 1990, compared with an average consumption in 1973/75 of 429.0 cubic metres. It was estimated that in 1990 a further 206 million cubic metres of wood would be needed for desolving pulps, fibreboard and particle board (FAO, 1977).

The great difficulties of estimating future demand at a time of recession was recognised, and these predictions represent a time lag of some 5 years on the predictions made by Sundelin in 1971. However, pulp production of 123.3 million tonnes in 1978 and 128.9 million tonnes in 1979 indicate that the estimate for 1980, at least, will not be far out (Anon 1980).

These statistics indicate that compared with 1973/5 an extra 75 million cubic metres of wood will be needed in 1980 and an extra 287 million cubic metres in 1990 for papermaking pulp alone. Whilst papermaking pulp is an important and large user of wood, it must be recalled that in 1973/5 the average consumption of wood for paper pulp (429 million cubic metres) was only about a sixth of the total consumption of wood. Since other demands on the wood resources are also increasing and there is pressure on the forest area for other uses (particularly agriculture), the pulp industry is looking to an increased wood supply in an increasingly competitive situation.

At present the production of wood pulp is concentrated in the more developed countries, but these countries not only have a small percentage of the world's forest resources, they are using a very high proportion of their resources. This is illustrated in Tables 1 and 2. It is, therefore, apparent that if the additional wood required for pulp is to be produced, much of it will have to come from less developed countries. It is necessary therefore to consider the best way to produce the quantities of wood required. Alternative strategies are (1) to use the existing natural forest and allow natural regeneration of these forests, or (2) to replace them with man-made forests of selected species.

THE HETEROGENEITY OF MIXED FORESTS

One problem in making industrial use of the mixed forest is the fact that forests are composed of a large number of species with often widely differing characteristics. At the same time is is the heterogeneity that provides one argument for some industrial use. In one forest area which I visited, I was told that fewer than 8 trees per hectare were desirable and valuable timber species. If some use were found for the trees that are at present left standing, it would be easier and cheaper to extract the desirable timber species and the profitability of the whole project would be improved by the value of the otherwise unused timber.

The number of species occurring in any given area varies but it is always large. Recently at the Tropical Products Institute an examination of hardwoods from a South American country was undertaken. The 20 species occurring mostly amounted to 17% of the volume of timber. The remaining 30% of the volume included more than 15 species. A survey for an African country included a table listing the commoner trees and it included 217 species. Australian work in Papua New Guinea found between 100 and 200 species that are likely to be considered for commercial utilization in any one area although in general 30 species would comrise 75% of the total merchantable volume (Higgins, et al, 1973).

In the examination of South American timbers referred to above, only the 6 species which represented about 46% of the standing volume of trees were examined, but since some 10-12% of the standing volume are valuable timber trees the 6 species examined represented a little more than half the mixture that would be available for pulping. Examination of these 6 species showed a great variation in pulping properties. Pulping each species separately, using constant digestion conditions intended to produce a bleachable pulp yielded unbleached pulps with yields between 42% and 44.8% with kappa numbers from 16 to 35. The variation in pulp strength was also large: tensile index in the range 60-92; burst index, 3.5-5.0; and tear index, 7.5-12.4; all measured at 300 Canadian Standard Freeness. Consequently, it is obvious that the required digestion condtions and the quality of pulp obtained will vary with the composition of the mixture of wood species put into the digester. Examinations in other parts of the world have reported equally variable results when examining hardwoods. Twenty-four species from 1 area in Papua New Guinea, pulped by the sulphate process in Australia, had pulp yields between 42.5% and 52.2% with kappa numbers between 18 and 44 (Higgins, et al, 1973). An examination of 130 hardwood species from South America, using constant sulphate digestion conditions and all pulps evaluated at 25 Schopper Riegler, were found to have burst factors from 20-65 and tear factors from 21-168 (Navarro, 1976).

The prospects of producing a uniform pulp seem to depend on attempting to select wood in such a way as to ensure reasonably uniform wood supply. There are technical problems in making such a selection and it might be a costly process. An alternative approach would be to replace the existing heterogenous forest with a uniform man-made forest of a few selected species.

AREA OF FOREST REQUIRED FOR A PULP MILL

It is difficult to illustrate the difference of areas of natural forest and man-made forest to supply the pulp mill because of the number of assumptions that must be made. However, some effort must be made.

Standing volume of wood in tropical forests has been estimated to be between 10 cubic metres per hectare and 300 cubic metres per hectare depending on conditions, but as is shown by the figures reported, in Table 2, around 100 cubic metres per hectare is a reasonable average. Many hardwood species in natural forest have higher wood density than those in plantations, but experience at TPI in evaluating mixed hardwoods is that it is unusual to obtain pulp yields greater than 45%. Consequently, in order to estimate the area required to supply a pulp mill which is producing 165,000 tonnes of pulp per year, it was assumed that the wood density was 600 kg/m^3, the pulp yield 45% and the stocking density 100 cubic metres per hectare. Under these circumstances it would be necessary to clear fell an area of about 6,000 hectares each year. The are would be changed by variation in wood density, by pulp yields, and by the proportion of wood eliminated as unsuitable; however, the range is so wide and so many variables are involved that it is not possible to give a precise figure.

To estimate the total area required further assumptions must be made. Some authorities have stated that the total volume of standing timber is so great that there is no need to make any provision for regeneration of the forest. However, if this is carried into practice the distances over which timber will be transported will be constantly increasing. It is better to assume that the forest will be allowed to regenerate by leaving seed trees standing. Information supplied to TPI has suggested that in some tropical countries it would take 40 years after clear felling before the stocking density of the regenerated forest would reach 100 cubic metres per hectare. This would mean that the total area needed to supply the pulp mill would be approximately 250,000 hectares. However, even this slow rate of growth may be optimistic because other information has suggested that the growth increment of regenerated forest is as low as 0.5 cubic metres per hectare per annum and this would give a stocking density of only 20 cubic metres per hectare after 40 years (Ganguly, 1971).

An alternative form of natural regeneration would be to encourage the growth of the "weed" species that are usually the first to grow after clear felling. This would increase considerably the volume of wood produced in the early years after clearing and would justify cutting over the same area again in a much shorter period, but most of the wood would be of low density (200-300 kg. per cubic metre) and would be so different from the original harvest that some difference in pulping technique and the quality of resulting wood pulp would be inevitable.

Man-made forests show very much greater rates of growth. Species examined at TPI have included <u>Gmelina arborea</u> with growth rates over 30 cubic metres per hectare per annum with wood density around 400 kg per cubic metre and yielding over 50% of unbleached pulp: samples of Eucalyptus species with growthrates in excess of 20 cubic metres per hectare per annum, wood density over 500 kg per cubic metre and pulp yields in excess of 50%; and Pinus species with growth rates of around 25 cubic metres per hectare per annum, wood density around 400 kg per cubic metre and pulp yields of 45-50%. In Table 3 some of these alternatives are set out and indicate that total areas in the region of 20,000 to 30,000 hectares of which some 4-5,000 hectares would be harvested each year, would be able to supply a pulp mill of this size. It is possible that even lower areas would be required if it were practical to plant species such as Leucaena leucocephala which are reported to yield 24-300 cubic metres per hectare per annum of wood with a density of over 500 kg per cubic metre.

The fact that man-made forest would require very much smaller areas than natural forest has a number of other effects. The transport distances will always be shorter: since the same areas will be logged over more frequently it will be possible to establish better roads and in the long-term this must reduce logging costs. Against this must be set the cost of establishing the forest, but especially with hardwoods which will only need to be replanted once in every 5 5 or 6 cutting cycles, this will be a relatively small cost.

HARVEST AND TRANSPORT OF WOOD

The harvesting of plantation timber is normally easier than that for natural forest because of the more uniform size of trees and because the access to the plantations has already been established. However, for land transport the natural forest has the advantage of higher density of logs, which means that a greater weight of wood can be carried at a single load; a maximum load of truck of logs is more often determined by volume than by weight. However, excessively irregularly-shaped logs could nullify this advantage.

HANDLING AND PROCESSING OF WOOD

The removal of bark from wood from natural forests is often more difficult than from plantation wood because the irregular shape of logs makes cleaning more difficult and the higher density makes an extra load for the barking drums. This is a serious disadvantage only where bleached pulps of high brightness are required, because some hard woods have relatively thin bark and this can often be pulped. Woods from plantations are not invariably easily barked, some eucalypts are very difficult to debark especially if the wood has started to dry.

Chipping of wood from natural forest can cause difficulties because of its hardness, higher density and the presence in some samples of high contents of abrasive materials such as silica, leadsto higher power consumption and greater wear on chipper knives. In addition, irregular size and shape of wood from natural forest make it more likely that this material would need some pre-treatment, such as splitting, before chipping; by contrast, the more uniform plantation material would be grown on a rotation and eliminate this requirement.

COMPARISON OF WOOD FOR MIXED FOREST AND PLANTATIONS

The most obvious difference between wood from natural hardwood forests and from plantations is the density. As might be expected from a forest containing well over 100 species, the prospects are that the wood density will vary widely and values from under 200 kg per cubic metre to over 1,000 kg per cubic metre have been quoted. In our experience at TPI, the wood available for exploitation tends towards the upper end of the range, because the low density trees are usually the first to be re-established when a forest area is cleared but they are short-lived and easily suppressed when the more robust and more dense trees become established.

Thus the mean density of a sample of wood from South America was 735 kg per cubic metre with values in the range of 423-920 kg per cubic metre. This is one respect in which mixed forests from differing parts of the world differ; mixed samples from various localities in Papua New Guinea had densities of between 431 and 498 kg per cubic metre (Higgins, et al, 1973). By contrast with this variation in the natural forest, it is possible to select species to grow in plantations with fairly uniform densities in the range of 400-550 kg per cubic metre.

The main difference in chemical composition between woods from natural forest and plantations is that the former tend to have higher ash content and the ash contains more silica.

The mixed hardwoods also tend to be harder. At TPI we have not been able to quantify this factor, but we did have much more difficulty in sawing and chipping samples from natural forest in South America than in any plantation species we have examined. These factors are important not only in chipping as mentioned above but also in digestion because the higher ash content, and again the high silica content, make the efficient operation of the recovery system more difficult.

COMPARISON OF PULPS FROM MIXED HARDWOODS AND OTHER PULP WOODS

Ease of Digestion

In work at TPI a mixture was prepared from 6 species of wood in the proportion they were found in the forest. This mixture was pulped by the sulphate process, and the digestion conditions and pulps obtained were compared with those of 2 hardwoods often used for pulping and for some hardwood species grown in plantations in the tropics. The results shown in Table 4, indicate that a mixed hardwoods needed more severe digestion conditions in terms of chemical change and digestion time. The mixed tropical hardwood needed longer digestion time principally because it was more difficult for the cooking liquor to penetrate the samples; when the temperature was raised rapidly to that required for digestion, there was an excessive amount of screening rejects (Palmer and Gibbs, 1978).

Investigations were made in Brazil to compare mixed hardwoods from the Amazon area with plantation grown eucalypts, and also in Australia, where hardwoods from Papua New Guinea were compared with eucalypts used commercially in Australia. They also reported that the mixed hardwoods needed more severe pulping conditions (Correa, et al, 1974; Higgins et al, 1973).

Yield of Pulp

Investigations at TPI have shown that at constant kapa number the yield of pulp from mixed tropical hardwoods was lower than that from temperate hardwoods and from most hardwoods grown in plantations in the tropics. The difference can be as much as 5 or 6% (dry pulp on dry wood). Again these findings agree with those of investigations in Brazil and Australia.

Quality of Pulp

In order to compare the quality of pulps from mixed tropical hardwoods with that from temperate grown hardwoods and from hardwood species grown in plantations in the tropics Table 4 gives some strength characteristics compared on the basis of pulp from United States Southern pines as 100. The pulps from mixed tropical hardwoods were more difficult to beat, whilst those from plantations were the same or easier. The tensile and bursting strength of the pulps from mixed tropical hardwoods were lower, whilst those of the pulps from plantation-grown species were equal or higher. The tearing strength of pulps from both tropical and United States mixed hardwoods were equal, whilst the pulps from the plantation-grown species had a lower tearing strength.

These results indicate that the only technical advantage pulps from mixed hardwood species have over pulp from hardwoods grown in plantations in the tropics are higher tearing strength and higher bulk of pulp sheet. Again these results are in general agreement with those reported in Brazil and Australia.

Cost of Wood

An argument made frequently for the use of mixed forest is the importance of utilizing all this "free" cellulose. However, this is a doubtful argument. In its favour is the fact that to establish plantations, land must be acquired, cleared and planted. All of this involves capital cost and interest charges with no return until the first rotation is felled. Also, with natural regeneration there are no replanting costs.

Against this argument are several case studies carried out for FAO in Africa which indicate that the cost of pulp wood grown in plantations (measured by volume) delivered at a pulp mill will be less than that of mixed hardwoods; the cost of the more difficult harvesting, together with the need to exploit a larger area, more than compensated for the cost of establishing plantations (Streyffert, 1968). In the case of hardwood plantations, the cost of the second and subsequent crops is reduced by the fact that regrowth (at least for a number of species) is by coppice growth, not replanting. It would be necessary to study specific proposals to establish that the cost of plantation wood delivered to the mill is less than that of natural forest wood. However, the number of studies showing that 85-90% of the cost of wood delivered to the mill is the cost of harvesting and transport, makes it likely that the conclusions reached in African case studies hold widely in tropical countries.

CONCLUSIONS

This comparison of the relative merits of using wood from natural forest and man-made forest as a raw material in the manufacture of pulp and paper shows that the balance of the cost and technical advantages lies with the man-made forest. In order to raise some of the capital for plantations it will be necessary to use the mixed forest. It is possible to produce pulp from this, but this pulp will be of lower quality and probably higher cost, though this may be regarded as an acceptable short-term commercial risk. Other uses that do not involve the high capital investment of a pulp mill might be considered; unfortunately it is difficult to think of alternative uses that would consume the large quantity of wood required for a pulp mill without high capital cost.

TABLE 1

REGIONS PRODUCING WOODPULP COMPARED WITH FOREST AREA

			Proportion of pulp manufactured %	Proportion of total forest area %	Proportion of accessible forest area %
North America			52.3	19	20
	USA	36.0			
	Canada	16.3			
Europe (excluding USSR)			24.3	3	7
	Sweden	7.3			
	Finland	5.1			
Asia			10.1	14	17
	Japan	7.5			
USSR			8.0	19	23
Latin America			3.0	22	17
	Brazil	1.7			
Oceania			1.4	2	1
	New Zealand	0.9			
Africa			1.0	21	15
	South Africa	0.7			
All Developing Countries			6.0		

TABLE 2

EXPLOITED FORESTS

	Proportion of accessible forests explored %	Growing stock in exploited forests m^3/ha
North America	77	83
Europe (excluding USSR)	99	76
Asia	74	102
USSR	83	94
Latin America	25	103
Oceania	85	59
Africa	38	74

TABLE 3

AREA OF PLANTATION TO SUPPLY A 165,000 TONNE/ANNUM PULP MILL

RATE OF GROWTH, m^3 /ha/ann	7				15				30				100			
WOOD DENSITY, kg/m^3	400		500		400		500		400		500		400		500	
PULP YIELD, WT. OF OVENDRY PULP / WT. OF OVENDRY WOOD	45	50	45	50	45	50	45	50	45	50	45	50	45	50	45	50
ROTATION YEARS	10	10	10	10	7	7	7	7	7	7	7	7	3	3	3	3
PLANTATION AREA REQUIRED HA x 100	131	118	105	94	61	56	49	44	31	28	25	22	9	8	7	7

TABLE 4

COMPARISON OF DIGESTION CONDITIONS AND PULP STRENGTHS (USA MIXED HARDWOODS = 100)

ALL COOKS: 25% SULPHIDITY, 170°C MAXIMUM TEMPERATURE AND 5:1 LIQUOR TO WOOD RATIO

Digestion conditions	Tropical mixed hard woods		Mixed USA hard-woods	Beech	Eucolyptus Saligna	Eucalyptus Camaldulensis	Gmelina arborea Highest yield	Gmelina arborea Lowest yield
Active alkali as Na_2 on ovendry wood %	17.5	20	15	15	15	15	15	15
Time to reach maximum temperature, hours	2	2	1	1	1	1	1	1
Time at maximum temperature, hours	2	2	2	2	2	2	2	2
YIELD OF PULP								
Oven dry digested pulp, per cent oven dry wood	46.7	45.4	49.4	49.8	51.7	46.6	51.9	46.4
Oven dry screened pulp, per cent oven dry wood	46.0	45.2	47.8	45.2	51.0	45.7	51.5	46.0
Oven dry screenings, per cent oven dry wood	0.7	0.2	1.6	4.6	0.7	0.9	0.4	0.4
Kappa Number	28.4	24.6	27.6	23.2	23.7	28.3	25.5	34.7
PULP STRENGTH AT 300 CSF								
Beating Time in P.f.l. mill	127	130	100	113	102	67	96	104
Tensile Strength	81	78	100	90	105	99	110	108
Bursting Strengh	68	52	100	87	104	92	111	104
Tearing Strength	99	103	100	79	89	87	90	100