PAPERS

An assessment of China's forest resources

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SUMMARY

China's forest resources have been and continue to be threatened. The analysis of the various reported statistics, while often conflicting, does indicate significant challenges ahead for the forest to supply the material for industrial, non-industrial, fuelwood and conservation objectives. Given forecasted constraints on domestic fibre supply for at least two decades there could be a significant increase demand for logs and forest products from China's trading partners. Overall this paper indicates the challenge in reaching more specific conclusions since there are serious data discrepancies in all major statistical areas. These discrepancies must be addressed before a clear set of land and sustainable development policies can be created.

Keywords: statistics, supply, demand, consumption, production

INTRODUCTION

China's forest resources have and will continue to face significant pressure with the combination of population growth, economic reform and gross domestic product (GDP) growth. Together, these policy and market drivers are leading to an increasing amount of forest products consumption. To gain a better appreciation of the issues it is useful to explore several critical dimensions to better understand the linkages between current and future forest resources and product demand. First, it is fundamentally important to understand the current state of China's forest resource and their contribution to a stable domestic wood supply. Second, it is critical to appreciate the current and projected demands for industrial forest products. Forest products ranked as the first of all commodity imports in 1998 (Kunshan *et al.* 1999) and the imports have risen dramatically since then (Sun 2004). Third, there are pressure on forest land to produce fuelwood, many non-timber forest products, watershed protection, and biodiversity conservation. For example, there remains a significant demand on forest to provide fuelwood in almost every region of China and there are indications that this demand is increasing (Leiwen and O'Neill 2003). Fourth, and finally, there are significant supplies of non-wood fibre materials and agricultural trees that can be used to substitutes for forest resources.

The combination of an uncertain domestic fibre supply for industrial, non-industrial and fuelwood uses combined with a growing demand for many forest products lead senior Chinese analysts to conclude that:

„...one of the present major problems facing forestry in China is that the total amount of forest resources is in-sufficient, resources available for harvesting are almost exhausted, the [forest] structure is unbalanced and the capability for supplying forest products is ra-ther low (Kunshan et al. 1997).

Can the rather gloomy claim[1] made in this statement be substantiated? To address this question we analyze the existing conflicting data on forest resources in the basic statistical categories: forest area, forest growth, forest volume and age, and forest removals (including the Annual Allowable Cut - AAC). We then place these data in the larger context of Chinese forest consumption, production and other fibre sources on the state of the forest resources and its ability to provide fibrous material for both industrial, non-industrial and fuelwood uses.

[1] It was reported that in a forest field assessment nearly 18 % of the forest areas surveyed was being overcut, another 13 % was subject to illegal cutting and over 500,000 ha a year was being deforested (Zhang 2003). Further, many of the slowing growing forest plantations have serious deformity, are of low volume and many are not economically accessible (Jaakko Pöyry 2001). Finally, while there are some fast growing high yielding plantations in China they are not enough. These findings are in sharp contrast to other reports ehich state that forest volume is increasing, forest plantation establishment has been very successful and self-sufficiency well on the way (Zhang 2002; Xu 2002; Government of China 1997).

FOREST AREA

Table 1 summarizes the statistics from various sources to indicate the range of estimates found for the timber forest. The timber forest, which are really the ‚domestic industrial wood supply forest' in China includes both the slow growing and fast growing plantations areas in the statistics. The first complication is attempting to compute the area of forested land as the statistics indicate there is a range.

To calculate the wood supply balance for mainland China a critical statistic is defining not the forest area but the area available for wood supply. Only one study was found which attempted to define this area, Bull *et al.* 1998. China did not report this statistic in the Food and Agriculture Organization (FAO) Forest Resource Assessment 2000 and no government reports were found with a comparable statistic. It seems that the 65.1 million ha reported is likely in the upper range of the estimate of area available for wood supply and if Kunshan *et al.* (1997) are correct in their analysis that area will probably be reduced due to an increase in the protected area by 2010. Further analysis is required to improve the assessment.

TABLE 1 *Timber forest (wood supply forest) in China*

Forested land	Timber forest	Legally protected	Economically inaccessible	Area available for wood supply	Proportion natural	Proportion planned	Base year	Sources
			000 ha					
153632	99395	21835			75244	24151	1988	National Forest Inventory 1998
159000	99400				75200	24100	2001	Jaakko Pöyry 2001
	99400	13004	21288	**65160**			1995	Bull, Mabee and Scharpenberg 1998
163000							2000	FRA 2000
133000							1995	FAO 1995
128000	84928						1997	Kunshan *et al.* 1997
		9000					2000	Kunshan *et al.* 1997
		19000					2010	Kunshan *et al.* 1997
115280	80696						1983	Zhang-Hualing 1998

In Bull *et al*'s (1998) estimates, the legally protected area of 13 million hectares (ha) applies only to the timber forest not to all forested land which other sources seem to be using in providing a statistic on protected forest land. Kunshan *et al.* (1997) forecasted that the protected area would increase from 9 million ha to 19 million ha by 2010.

In Table 2, and as mentioned earlier, the slow growing and fast growing plantation forest can be considered as part of the timber forest (Jaakko Pöyry 2001). A more careful analysis of the statistics is warranted since these plantation areas are frequently and

TABLE 2 *Plantation forest in China*

Gross planted	Industrial plantation	Non-industrial plantation	Slow growing plantations	Fast growing plantation	Fast growing plantation establishment rate - plan	Base year(s)	Sources
			000 ha				
45100						2000	FRA 2000
47000			16300	5100		2001	Jaakko Pöyry 2001
					3830	1980-1987	Kunshan *et al.* 1997
				8324		2000	Xu 2002
				6330	2500	1988-1992	Kunshan *et al.* 1997
34500						1994	Kunshan *et al.* 1997
					500	1998 onward	Kunshan *et al.* 1997
	17519	3854				1995	Brown 2000
				20000		2010	Xu 2002

optimistically described as the future major source of industrial wood supply in China. While this may be a reasonable assumption given the lack of natural forest available for wood supply (discussed later) Table 2 indicates there is a wide range of statistics on the precise area available and the nature, purpose and condition of the forest plantations.

The gross planted area reported for all forested land is around 47 million ha. After a thorough assessment the proportion that is fast growing and high in yield is estimated to be only 5 million ha (Jaakko Pöyry 2001). The plantation area statistic is important in wood supply forecasting since previous estimates of industrial wood supply suggested 17.5 million ha (Brown 2000). If the 16.3 million ha of slow growing plantation is a source of industrial wood supply then Brown's estimate is reasonable. However, as mentioned, there are serious concerns with the viability of the slow growing plantations given the extensive deformity, slow growth, presence of non-commercial species, internal transportation difficulties and prohibitive wood costs (Kunshan *et al.* 1997; Jaakko Pöyry 2001; Roberts 2004). Clearly the assumptions with respect to these slow growing plantations need further analysis.

Accounts by Li and Chen (1992) and Ding and Chen (1995) report a drop in productivity between first and second rotation of about 10 per cent and between second and third rotation up to a further 40 per cent. Ying and Ying (1997) quote higher figures for yield decline... Personal observation suggests that the widespread practices of whole tree harvesting, total removal of all organic matter from a site, and intensive soil cultivation that favors bamboo and grass invasion all contribute substantially to the problem (Evans 2002).

TABLE 3 *Fast growing and slow growing plantations growth rates in China*

	Major species	Fast growth estimates m^3/ha/year	Location	Slow growth estimates m^3/ha/year	Source
Actual	Unknown	3 - 3.5	Hainan Province and Zhanjang Region		Xu 2002
Official	Eucalyptus	18		9	Jaakko Pöyry 2001
Official	Poplar	15		7	Jaakko Pöyry 2001
Official	Masson pine	8		3	Jaakko Pöyry 2001
Official	Chinese fir	10		4	Jaakko Pöyry 2001
Forecast	All species	8 - 10			Jaakko Pöyry 2001

TABLE 4 *Predicated forest growth for all of China*

Forest type	Total growth (000 000 m^3/year)	Source
All forested land	419.1	Kunshan *et al.* 1997 Vergara 1997
Timber forest	219.9	Kunshan *et al.* 1997

Table 2 also shows that the intent of the ‚official' plan was to have vast areas of fast growing plantations. The plan had two major periods 1980-1987 and 1988-1992 and together should have produced 31 million ha by 1992. The plan after 1998 was to slow the area established to 500 thousand ha per year. Again there seems to be a serious discrepancy between the plantation establishment plan and what has actually happened in China. The discrepancies between the planned area and the actual area also need further investigation. Further, there have been noted problems in China's plantations productivity and yield as noted below:

FOREST GROWTH

Since the timber forest is the area where a high proportion of industrial wood would come from, it is essential to have an estimate of forest growth in order to assess the sustainability of supply for producing forest products. Since virtually all of China's forest that is economically viable has now been disturbed, which means the growing stock volume will be drawn down, the focus for calculating sustainable supply will have to be on the growth of the timber forests. For the plantation forests, Table 3 indicates a significant difference between the actual reported growth rates (3-3.5 m^3/ha/year) and the predicted growth rates (8-18 m^3/ha/year). Currently, the major species planted are Masson and exotic pines (*Pinus* spp.), China fir (*Cunninghamia lanceolata*) and Poplar (*Populus* spp.) with currently more focus on Eucalyptus (*Eucalyptus* spp.). For a national growth average Bull *et al.* (1998) reported 2.5 m^3/ha/yr. This is confirmed by Kunshan *et al.* (1997) (Table 4). Dividing the timber forest growth estimate of 219 million m^3 by the estimated 85 million ha of timber forest produces the same result. However, this growth statistic is extremely vague and it is not known if it is a gross annual increment, a mean annual increment, a periodic annual increment or a net annual increment. Whatever the case, it is probably the upper limit of growth with no deduction for various natural and manufacturing losses. Further investigation is warranted given the difference between the official estimates compared with the actual estimates and the significantly greater growth per unit area estimates on all forested land in contrast to the timber forest.

It should also be noted that the growth of the forest on all forested land has virtually no relationship

to the needs of the forest products industry to find available supply of raw material. Furthermore, the growth on the timber forest is almost exclusively in forests which are classified as ‚nearly mature' or younger. This is discussed later in the paper.

TABLE 5 *Total forest volume estimates for China*

Volume (000 000 000 m^3)	Sources
Forested land	
13,0	CCAP and Butterworth 2003
12.6	Government of China 1997
11.2	China National Forest Inventory 1998
10.6 - 11.8	Zhang 2000
10.2	FAO 2001 as cited in Zhu and Taylor 2003
Timber forest	
6.6	Xu, Taylor and Amacher 2003
6.7	Kunshan *et al.* 1997
7.2	China National Forest Inventory 1998
Forest volume available for wood supply	
3.9	Kunshan *et al.* 1997
4.5	Bull *et al.* 1998
3.5	Zhang 1988
2.2	Shi and Xu 2000 (economic wood supply in timber forest)
2.3	Kunshan *et al.* 1999 • volume of nearly mature - 0,9 billion m^3 • volume of mature forest - 1.4 billion m^3 • volume of overmature forest - 1.4 billion m^3 but assume it is not available for wood supply within the timber forest - assume remote and difficult to access or protected
2.9	National Forest Inventory 1994 (prior to logging ban and not accomodating overcutting or illegal logging) • volume accessible - 1.36 billion m^3 • volume to be accessible - 1.63 billion m^3 • volume inaccessible - 0.71 billion m^3

In a forest study of over 28 provinces in China a gloomy picture emerges. Growth rates are being reduced due to short term unsustainable (excessive) logging or under-reforestation of the industrial or natural forest (Xu *et al.* 2003). Both poor logging and poor silvicultural practices have been driven by perverse economic incentives to the forest enterprise managers. They predicted in 1997 that 90 out of 135 state owned enterprises would exhaust the harvestable forest and that most of the 85 state forest enterprises in northeast China would cease to produce timber due to resource depletion (Rozelle *et al.* 1997 as quoted in Xu *et al.* 2003). There is a reported a slight increase in total standing volume (0.46 %) between 1981 and 1997 but this is largely because the volume growing in plantations are included (Xu *et al.* 2003).

FOREST VOLUME AND AGE

Table 5 indicates that there is a very significant difference between the total growing stock for all forested land of 10-13 billion m^3 (Zhang 2000; CCAP and Butterworth 2003; Kunshan *et al.* 1997), the estimate of the commercial growing stock on the timber forest of 6.6 billion m^3, the estimate of the volume on the area available for wood supply of 4.5 billion m^3 (Bull *et al.* 1998) and finally, the netted down volume of 2.2 billion m^3 (Shi and Xu 2000). This significant reduction in standing volume when combined with overcutting and illegal logging statistics (discussed later) should be considered as part of the reduction from 4.5 billion m^3 to 2.2 billion m^3, or if a reduction should be applied to the 2.2 billion m^3. This requires further analysis.

TABLE 6 *Average growing stock in China*

Timber forest		
Non-plantation areas (m^3/ha)	Plantation areas (m^3/ha)	Source
87		Shi and Xu 2000
78	35	Zhang 2003
96		Kunshan *et al.* 1997 Vergara 1997

Kunshan *et al.* (1997) state that most of the over mature forests (1.3 billion m^3) are in the remote and steep mountains areas which are difficult, if not impossible, to access. Therefore the most optimistic scenario is to assume that all of the mature forest (1.4 billion m^3) and the nearly mature forests (0.9 billion m^3) are available for wood supply. This estimate of growing stock of around 2.2 billion m^3 is confirmed in an independent report on the economics of timber supply (Shi and Xu 2000).

TABLE 7 *Age classes of the natural (timber) forests*

Age class	% in class 1994	% in class 1998
Young to middle age forest	74	70
Nearly mature forest	10	11
Mature forest	10	11
Over mature forest	6	7

Sources: Forestry Yearbook of China 1994 as quoted in Kunshan *et al.* 1997; National Forest Inventory 1998.

Another alarming statistics is the reported annual reduction in growing stock volume of 253 million m^3 with an annual loss of 271,000 ha in forest area (Kunshan *et al.* 1997). These statistics contrast with other official government reports (e. g., China's National Forest Inventory 1998) which indicate a positive change in volume and area. Again, this discrepancy needs further investigation.

In Table 6 the average growing stock of the forest is relatively low which indicates that the forests are either relatively young or very low in productivity. In

many countries the forest is considered non-commercial if the average growing stock volume is below 100 m^3/ha (Bull *et al.* 1998).

Table 7 presents the most optimistic view on the maturity level of the forest. What the 1994 and 1998 estimates do not account for is the overcutting and the illegal logging of at least the last decade. As mentioned earlier the remaining over mature forest is probably not available for wood supply (Kunshan *et al.* 1997). The mature timber forests are either unevenly distributed with the majority of stands also being in the remote and steep mountainous areas with difficult access or are along the upper reaches of large river systems and therefore are critical to watershed protection (Kunshan *et al.* 1997). From combining the evidence in Table 6 and Table 7 we can see that at a maximum only the nearly mature forest is available for wood supply and that the average volume per hectare is higher but it is still only 110-112 m^3/ha (Kunshan *et al.* 1997, China National Forest Inventory 1998).

TABLE 8 *Summary of annual allowable cut, over cutting and illegal harvesting*

Year	Legally available logged volume from the timber forest (National Forest Protection Program 48 million ha)	Over cutting or illegal logging	AAC (slow growing plantations olny)	AAC (both slow and fast growing plantations)	AAC (including fuelwood, non-industrial and industrial)
	Timber forest (000 000 m^3/yr)				Forested land (000 000 m^3/yr)
Column (1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
1950	20				
1990-1996	63	91-123	52-84	175	
1997	32	87			
1998	29	87			
1999	23	87	53		
2000	14	77	53	130	
2000+	<14		53	100	
2001			42		
2002	12	116	43		223
2003			46		223
2004					223
Sources:	Zhang *et al.* 2000	Xu, Taylor and Amacher 2003; CCAP and Butterworth 2003; Feng 2004; Kunshan *et al.* 1999:83	Jaakko Pöyry 2001; Chinamarket Consulting Company 2004	Kunshan *et al.* 1997; Jaakko Pöyry 2001	CCAP and Butterworth 2003

TABLE 9 *Domestic roundwood removal estimates*

Year	Total annual roudwood removal	Industrial roudwood removal	Non-industrial roundwood	Miscellaneous	Fuelwood - domestic statistics	Reported industrial roundwood production (FAO)	Fuelwood production (FAO)	Total reported roundwood production (FAO)
	Column [2] = [3]+[4]+[5]+[6]	*[3]*	*[4]*	*[5]*	*[6]*	*[7]*	*[8]*	*Column [9] = [7]+[8]*
1988	327					98	181	279
1990-1994	297-298	116-132	64-62	20-18	97-86	90-99	188-204	280-303
1995		105				101	204	305
2001		81				94	191	285
2002	330					93	191	284
2003	354	~116 (illegal) +~46	~75	~20	~97	93	191	284

Sources: Xu, Taylor and Amacher 2003; Jaakko Pöyry 2001; FAOSTAT 2004; Kunshan *et al.* 1997; Zhu and Taylor 2003; Chinamarket Consulting Company 2004.

A more pessimistic scenario is more realistic. Between the first census (1950) and the fourth census (1993) there has been a dramatic loss of 46.62 % of the mature forest. This loss has been accelerated in the last two decades and found in all regions of the country with the lowest rate of loss in the southwest (39 %) to the highest in the east (75 %). To confirm these losses a number of surveys by the National Forestry Bureau were undertaken. They found that in the upper reaches of the Yangtze River there had been a decline in forest cover from 1950 to 1998 from 30-40 % to 10 % while in Sichuan the decline from 1957 to 1993 was from 22 % to 3.3 % (Shi and Xu 2000). Further, Shi and Xu (2000) speculate that in the second largest region of China, the northeast, all mature forest will soon disappear at the current harvest rate. This loss in the mature forest available for wood supply means that the region will have to find alternative sources of roundwood supply. These findings contradict the predictions of other analysts who have assumed that the natural or industrial forest would supply around 77 % of the larger sawlogs and plylogs (or 27 million m^3/year), while plantations would supply 77 % of the smaller logs for panel and pulp production (Jaakko Pöyry 2001:108). Further analysis is required to determine which scenario is more realistic for domestic fibre supply.

TABLE 10 *Annual consumption od fuelwood from all forest sources*

Volume (000 000 m^3 RWE)	Comments	Base year	Source
191		2002	FAOSTAT 2004
191		2000	FAOSTAT 2004
204		1995	Vergara 1997
221		1997	Kunshun *et al.* 1997:15
225	Primary sources unknown	unknown	Kunshun *et al.* 1997; Zhang 1988
252	Includes forest production sites, roadside shrubs, four-sided forests and protection forests	2001	Jaakko Pöyry 2001
3	The total was 3.47 million m^3. Unclear.	2003	State Forest Administration as quoted in Chinamarket Consulting Company 2004
6	SFA forest reference unknown		Kunshun *et al.* 1997:44
86	Unclear of the forest base but might be timber forest (see next table)	1994	Kunshun *et al.* 1997:45
107		1988	Kunshun *et al.* 1997:45

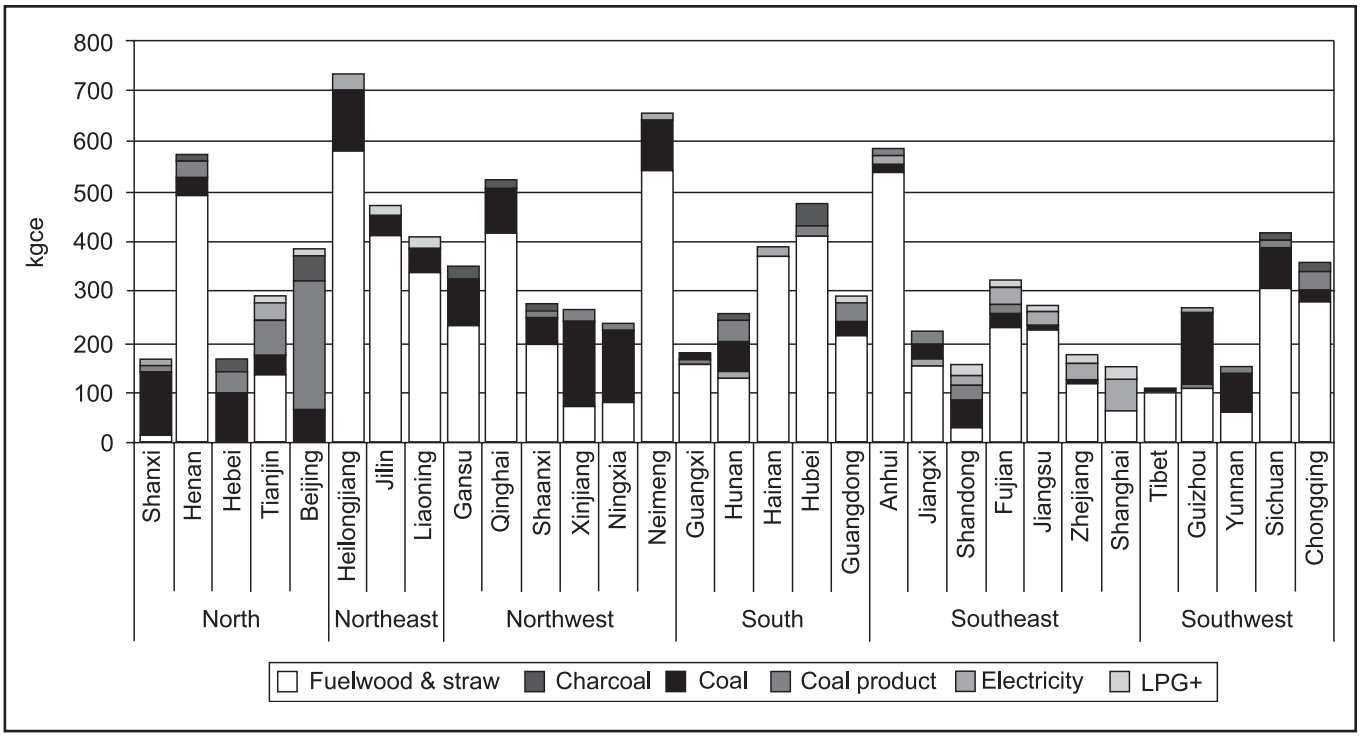
FOREST REMOVALS

Table 8 summarizes the AACs estimates and some of the official projection of harvest levels. In column 2, Zhang *et al.* (2000), although not specifically detailed in their analysis, describe the allowable harvest level on the timber forest only. Due to the logging ban the harvest volume beyond the year 2000 was expected to continue dropping. Column 3, however, shows that there has been a long period of over cutting in the timber forest and in 2003, the ‚illegal logging' volume was 116 million m^3 (Xu *et al.* 2003). This both brings into question the value of the logging ban and recognizes that most, if not all of the illegal logging must be occurring in the small percentage area of the nearly mature or mature forest, or, they are already harvesting the best of the slow growing plantation wood to meet demand. Jaakko Pöyry (2001) estimates the volume of harvest that could be sustained from the current slowing growing plantations is around 50 million m^3/yr and the fast growing plantation around 50 million m^3/yr. For example, in 2003, 72 % of the allowable harvest or 46 million m^3 was from ‚man-made' forest resources, up from 62 % in 2002 (Chinamarket Consulting Study 2004). Again the forecast on the slow growing plantation is the most optimistic view given the serious question on their commercial viability. Since it is reasonable to assume that the current fast growing plantation can grow up to 10m^3/yr the forecasted volume on the current 5 million ha plantation (i. e., 50 million m^3/yr) seems reasonable until further evidence can be collected.

In column 4 the current AAC on the timber forest is probably calculated on the 17 million ha of plantation forest which, as mentioned are growing at approximately 3m^3/ha/yr. Again this seems to confirm that there is no mature or overmature natural forest included. Column 5 summarizes both the historic and the future AAC for all timber forest including both slow growing and fast growing plantations. Column 6 covers the entire area, referred to in official statistics as forest land, and it is likely that the AAC includes fuelwood.[2]

[2] Adding the 223 million m^3 to the 116 million m^3 of illegal harvest for the year 2003 produces an estimated total domestic timber removal of 339 million m^3 (see next section for comparison).

FIGURE 1 *Per capita energy use of rural households by province.*



REMOVAL STATISTICS

Industrial, non-industrial and fuelwood

Table 9 is an attempt to better understand the total timber harvest removals. It is clear that the there is a lack of consistency, particularly between the domestic reports and what is reported through FAO. In theory, it should be possible to add the industrial, non-industrial, fuelwood and miscellaneous removals to provide a total annual removal. However, in 2003 there are at least three major discrepancies: (1) columns 2 and 9, should be equal but there is 70 million m^3 difference which cannot be explained by any single causal factor; (2) columns 6 and 8, fuelwood, exhibit a 100 million m^3 difference; and (3) column 3, indicates illegal harvesting of 116 million m^3.

The annual roundwood removal includes industrial roundwood, non-industrial roundwood and fuel wood plus other miscellaneous uses (e. g., wood for mushroom cultivation). The FAOSTAT (2004) production statistics are different from other sources but they are

TABLE 11 *Industrial consumption, production and forest products trade in China, 2003, 2002 and 2000*

	Year	Consumption	Production	Imports	Exports	Source
Industrial	2003	172	93	106	27	
Local industrial		75	75			Sun 2004; FAOSTAT 2004
Total		247	168	106	27	
Total comparison	2003	283		123		CTDA as quoted in Chinamarket Consulting Company 2004
Total	2002	185	93	84	8	CCAP and Butterworth 2003; FAOSTAT 2004
Local industrial		75				
Total		260				
Total comparison		*268				CCAP and Butterworth 2003
Industrial	2000	163	96	60	7	Jaakko Pöyry 2001 for imports; FAOSTAT 2004
Local		75				
Total		238				

the reported Chinese official statistics. One could speculate that the production numbers have been reduced from the removals to allow for losses in the forest volume removed into the production process. Chinamarket Consulting Company (2004) indicates that the conversion factor of 57.5 % is appropriate to convert from reported log consumption to log removal from the forest. For example, in 2003 the log consumption was estimated to be 92 million m^3 which would require approximately 160 million m^3 of timber removals. The discrepancy is worth further investigation.

In 2003, the difference between 247 million m^3 and 283 million m^3 is at least partially explained by the difference in import statistics. In 2002, the difference between 260 million m^3 and 268 million m^3 could be due to a change in the estimate of the local industrial consumption. We found no additional data to update the amount consumed and further investigation is required on the local industrial consumption.

In summary, the underlying reasons for the discrepancies between the industrial production statistics presented in Table 11 and the industrial removal statistics presented in Table 10 could be: (1) the removal statistics are gross removals and do not account for losses, there could be at least 25 % to 45 % in losses; (2) there are many small producers who are not part of the statistical system and therefore the production statistics are less than what they should be due to lack of data; (3) the illegally harvested wood is likely not included in production or removal statistics; and (4) the fuelwood removal statistics are inconsistent.

TABLE 12 *Miscellaneous sources of fibre in China for ‚woody' industrial and non-industrial fibre*

Fuelwood forest	Special forest	Economic forest	Protection forest	Four sided trees	Source
		000 000 ha			
4.3	3.4	16.1	16.1 (4.2 planted)		Kunshan *et al.* 1997
4.5	4.0	20.2	21.4	~2 - 2.5	Jaakko Pöyry 2001
		Estimated fuelwood production			
20 million m^3/yr fuelwood	Not producing timber or fuel	Not producing timber or fuel	Producing some fuelwood	20 million m^3/yr fuelwood and poles	Jaakko Pöyry 2001

Table 10 represents a summary of the range of statistics on fuelwood consumption. It is unclear why there are two basic categories of estimates, those which are likely from the FAO and those generated by National Forestry Statistics within China. The FAO derived statistics are in the upper portion of the table and the lower portion are the Chinese government statistics.

The reported statistics, 3 and 6 million m^3, are clearly not reasonable but neither report cited offers an explanation for such a low number. The uncertainty in the statistics is troubling since there is still a very heavy dependence of forests for fuelwood. In 1999, more than 72 % of rural households in China still relied on biomass (fuelwood or agricultural waste) for energy use (Leiwen and O'Neill 2003).

Figure 1 summarizes the per capita energy uses which varies depending on the availability of other cheap energy, the weather patterns and the geography of the area. It was also found that the transition from biomass to modern commercial sources is still at an early stage, and that incomes may have to rise substantially in order for absolute biomass use to fall (Leiwen and O'Neill 2003). In other words the fuelwood usages pressures in rural China will continue into the foreseeable future.

CONSUMPTION, PRODUCTION AND TRADE

Table 11 summarizes for 2002 and 2003 the total industrial consumption in China. The total consumption reported for 2002 is 268 million m^3 (CCAP and Butterworth 2003) and using FAOSTAT data it is possible to produce a very similar statistics 269 million m^3.

Table 12 summarizes some key additional forests which are not forests for industrial uses (i. e., timber forest and fast and slow growing plantations). Fuelwood forests are communal forests grown for firewood and charcoal and over 86 % is considered to be a natural forest (Jaakko Pöyry 2001). Special use forests are for national defence, railway reserves, environmental protection, scientific purposes, scenic and cultural places and nature reserves; most are considered natural forests. Protection forests are for soil and water conservation, sand-dune and desert protection, mangrove forest, farm belts, nature reserves and National Parks. The estimated growing stock in the protection forest is between 1.8 and 2.2 billion m^3 and some fuelwood harvesting is occurring in these forests (Kunshan *et al.* 1997; China National Forest Inventory 1998). Economic forests produce non-wood forest products which are vital to farmers and are also important for soil and water protection. The major tree crops are oilseed, dry fruit, resins, spice and medicines.

Finally four sided trees, which are not considered as forest land, consist of two major *Paulownia* species. They could, in theory, produce 3-4 million m^3 of wood fibre per year. Poplar, which is used in an agroforestry setting, is estimated to produce another 20

million m^3 per year for both industrial and non-industrial uses but the volumes are not included in the official statistics (Jaakko Pöyry 2001).

Table 13 provides a summary of non-wood fibre availability for industrial production processes. These fib-res, many of which are agriculture residues were approximately 429 million tonnes in total in 1994, and with 35-55 % recovery rate, generate 150-236 million tonnes per year of which a significant portion is used for other purposes, especially for energy production in the rural areas of China (Leiwen and O'Neill 2003).

TABLE 13 *Industrial non-wood fibre resources in China*

	Moso bamboo	Bamboo pulp production output - 12 % of material usage	Straw - rice and wheat - residues for pulp output - 40 % usage	Bagasse pulp production output 30 % usage	Reed pulp production 30 % of usage	Other pulp production kenaf, cotton 30 % of usage	Total consumed non-wood pulp	Source
	000 000 ha			000 000 tonnes				
1994	2.7	0.35	8.5	0.35	1.9	1.5	12.6	Zhu *et al.* 1998
1998	2.9							Bull 2004
				000 000 m^3/yr roundwood equivalents				
1994 summary	**5.8**	**0.9**	**22.1**	**0.9**	**4.9**	**3.9**	**32.7**	
Base year				000 000 tonnes				
2000		3.6	9.1	2.5				Zhu 1998
2000		2.0			2.6			Bull 2004
2001							*16.8	Jaakko Pöyry 2001
Forecast								
2010		4.5	20.0	3.8	4.3		4.3	Zhu 1998
2004		5.0						Bull 2004
2010		16.0						Bull 2004

The pulp industry is restructuring in China. There has been a significant shift away from using non-wood fibre in pulp production as indicated by the closure of over 9000 small pulp mills using non-wood fibre (Zhu *et al.* 1998). However, there is still a significant use of non-wood fibres in new manufacturing technologies (Jaakko Pöyry 2001).

Table 13 also indicates that the bamboo production potential is already significant and growing with a potential before the planned expansion of area to produce at least 5.8 million m^3 per year of fibre for various forest products. The bamboo use in pulp is fairly modest compared to other uses and when combined with straw, bagasse and reed, plus other agricultural residues met approximately 50 % of the domestic pulp requirements (Zhu *et al.* 1998).

FORECASTS

Table 14 is a summary of some possible future fibre availability forecasts. In all cases, the demand (as indicated by consumption estimates) will outstrip supply for industrial products. One study predicted a gap in commercial timber supply of 75 million m^3 annually (Zhu 2001). Another study predicted that the commercial timber supply would be around 100 million m^3 annually from the timber forest and plantations (Jaakko Pöyry 2001). In both these studies the non-industrial forests were not included and it is not clear what proportion of the fibre was used for different purposes.

Perhaps the most serious problem facing China is that these scenarios ignore the short-term problems which seem to be facing the country. Since various statistics and studies presented in this paper indicate a lack of mature and older wood, poor management and a host of other challenges there could well be a shortage of fibre in all forest listed in Table 14 for up to two decades. Further, the industrial removal data for 2002-2003 is in the range of 230 to 250 million m^3 and so the scenarios reflect the optimistic view that somewhere fibre will be found to supply the age class gaps discussed in the paper.

There are suggestions that there will be a decline in the output of non-wood or agricultural waste for pulp (Zhu *et al.* 1998) but most agree there will be an increase in bamboo production (Bull 2004).

While the growth statistics suggest production of 220 million m^3 from timber forest this assumes appropriate silvicultural practice, an end to deforestation and no loss of land to permanent land conversion. Finally, since the fuelwood statistics are so confusing, no attempt was made in this paper to integrate a forecast of these statistics.

CONCLUSION

The analysis of the various reported statistics, while often conflicting, highlights significant challenges ahead for the Chinese forest resources to supply the material for industrial, non-industrial, fuelwood and conservation objectives.

In general, the statistics indicate that the natural forest appears to have changed dramatically in the last two decades. It appears that most of the remaining natural forest is very young. There has been, and continues to be, significant illegal logging and overcutting activities which is further depleting the meager commercial growing stock. And, the use of forest for fuelwood shows no signs of declining.

The plantation forests of China do not yet provide a significant level of the fibre supply required. The slower growing plantation forest seem to be a disappointment since the growth rates are slow, there are plenty of deformities in the stems, and declines in yield with subsequent rotations are evident. Their contribution to future domestic supply needs requires further analysis. The faster growing plantation are also surrounded by a host of complex policy issues which could well constrain their development and expansion. These include labor productivity, property rights, competing uses for the land, environmental limitations, costs of land and other fixed costs.

The future of the use of non-wood fibre material remains open to debate. While there have been a significant number of non-wood fibre mills shut down in order to protect water, non-wood fibre may still prove to be important in the future.

The demand for forest products is growing rapidly in virtually all product categories. Given forecasted constraints on domestic supply for at least two decades there could be a significant increase in demand for logs and forest products from China's trading partners.

The forecasts indicate significant challenges ahead for the forest sector in China even when considering the most optimistic scenarios. Overall this paper highlights the need to provide more specific conclusions since there are serious data discrepancies in all major statistical areas. These discrepancies must be addressed before a clear set of land and sustainable development policies can be created.

TABLE 14 *Long run future fibre availability scenarios*

Fibre source	Scenario #1 (current management)	Scenario #2 (optimistic)	Scenario #2 (very optimistic)
		000 000 m^3	
Timber forest	12	33	63
Plantations (slow growing)	20	51	85
Plantations (fast growing)	40	41	51
Non-industrial	63	63	80
Miscellaneous	12	12	12
Total roundwood fibre	**147**	**200**	**291**
Non-wood (agricultural)	20	32	32
Non-wood (bamboo)	9	6	9
Total non-wood	**29**	**38**	**41**

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