5

Impact of Major Supply Factors

IDENTIFYING SOME OF THE MAJOR FACTORS

The initial phases of the GFSM project developed a quantitative approach to policy analysis (the model as fully described in GFSM Working Paper No. 1) and established a set of base data. The addition of a modelling capability enabled alternative futures to be predicted for each country by varying critical factors that have an impact on wood supply[1]. The variable factors presently incorporated in the model are not an exhaustive collection. Rather they are a subset of a larger set of variables that have been identified as affecting wood supplies, in various studies within the last decade (Table 2). Table 10 lists some of the major factors identified as having the potential to have significant impact on the futures for selected regions. These factors were selected according to their relative importance, their feasibility in modelling and their links with statistics available. In the future a wider range of factors will be incorporated in the modelling framework.

A sustainable forest management (SFM) variable is included in the model because implementation of SFM principles has the potential to affect future

[1] A suite of additional models are already being developed or under way to assist with the Outlook Study process. All of these models will interact in some manner with the data compiled in the GFSM.

Table 10
Selected major factors that influence fibre supply

	Future 1	Future 2	Future 3
Forests disturbed/undisturbed by man			
Sustainable management (as expressed by cutting cycle- periodic or annual)	♦	♦	♦
Land use – deforestation	♦	♦	♦
Land use – legally protected area change	♦	♦	♦
Industrial Plantations			
Afforestation rate	♦	♦	♦
Development gains	♦	♦	♦
Non-wood Fibres			
Non-wood fibre pulping capacity	♦	♦	♦
Recovered Fibres			
Wastepaper recovery rate	♦	♦	♦

wood supplies and because SFM is a central global forest policy issue. (It is also a major theme of the new strategic plan of the FAO Forestry Department). Similarly, land-use change has had probably the most significant impact on forestry production potential in the past 30 years. Land-use change takes place in many forms. In the natural forest, deforestation and the establishment of protected and semi-protected areas have had, and are likely to continue to have, significant impact on the forest available for industrial wood supply. For plantation forests, the rate at which countries establish plantation programmes (afforestation rates), the duration of those programmes and the extent of efforts put into silvicultural and genetic treatments, i.e. development gains, will also have a significant impact on future fibre supply. Non-wood and recovered fibres are also seen as important new sources of fibre. These already play a very significant role in meeting fibre demand and this role will undoubtedly increase in the future.

Finally, there is a very active discussion in the literature on material efficiency and technological change. A variable that explores improvements in material conversion factors and different forest product output per input of standing tree is yet to be incorporated in the modelling capability and is thus not included in Table 10.

SUSTAINABLE FOREST MANAGEMENT IN NATURAL FORESTS

The impact of sustainable forest management on global fibre supply is frequently mentioned in forest policy discussion. In attempting to address this theme, the GFSM model allows the user to adjust the cutting cycle. Adjusting the rate of harvest through this key variable provides a means of simulating SFM from a fibre supply perspective. In the real world, the general expectation is that SFM will necessitate changes in forest rotation ages, particularly in the case of boreal forests, or changes in cutting cycles in the case of tropical and temperate forests. Reviews of the literature in GFSM Working Papers No. 5 and No. 6 support this assertion for the tropical forests.

To demonstrate the impact of SFM on global fibre supply a range of examples and evidence was examined in GFSM Working Paper No. 3. The concept of SFM has been broadened in recent years and, as a result, the objectives of management are shifting emphasis away from predominantly timber production towards a balance with ecological and social sustainability. Conceptualization of SFM has outpaced the development of specific on-the-ground practices that will achieve sustainability, and there are many knowledge gaps to be filled. Yet there are many active efforts, throughout the world, to develop and implement SFM approaches.

Table 11 summarizes a number of examples of volume and cost impacts in applying SFM. In many cases, impact magnitude is based on a single study, so great caution should be exercised in accepting the magnitude of the impacts as being representative. The studies reviewed here, however, consistently showed that there will be reductions in harvest volume, particularly in the short term, and costs can be expected to rise by between 5 percent and 25 percent, on average. There is, however, an expectation that long-term supply will increase through application of SFM (see Working Papers No. 5 and No. 6). In the tropics, the maintenance of site productivity and the retention and prevention of damage to immature stems drive much of this increase. In temperate forests, the longer term increase is expected to be less pronounced and may not be captured without intensified silviculture. Instead, the value of the harvest may rise as more large and high-value products are harvested.

Table 11
Summary of cost and volume impacts of implementing SFM by region

Region	Country	Case study	Short-term volume reductions	Cost impacts
North America	**West Coast**	Clayoquot Sound	30-40%	8-25% cost increase
North America	**Canada**	White River	10-25%	Increase
North America	**Canada**	Seine River	24%	
Europe	**Sweden**	A. Barklund	6-8%	NA
Asia	**Malaysia**	Sarawak	50%	Increase
Asia	**Malaysia**	Innoprise Corporation	6-8%	5% cost increase
Asia	**Malaysia**	Dermakot	up to 100%	
Asia	**Indonesia**	Indonesian Plan	18.4%	
Asia	**Indonesia**	STREK Project	9 - 15%	Increase
Latin America	**Bolivia**	Chimanes	24 - 57%	35-67% loss in profits to logging contractors
Latin America	**Eastern Amazonia, Brazil**	Paragominas Region	up to 100%	$ 72/ha increase
Latin America	**Brazil**	Precious Woods	24-57%	0% cost increase but assumes more trees as commercial species
Latin America	**Suriname**	CELOS	9%	10-20% cost savings
Latin America	**Costa Rica**			Increase

SFM is primarily a systematic approach to sustaining each component of the forest ecosystem and sustaining interactions between the components. In forests available for wood supply, this means combining wood production with other management objectives, above all, and maintaining ecological capacity through the conservation of plant and animal biological diversity and soil and water conservation. Similar intentions were not specified as clearly in the classic management concept of sustained yield. It is now, however, generally agreed that forest management must systematically address a fuller range of environmental, social and economic issues. Table 12 presents a summary of major differences in management approaches between the two concepts.

Table 12
Contrast of sustained yield and sustainable forest management for temperate forests

SFM	Sustained Yield Forestry
Maintain the productivity of the forest, by avoiding erosion, soil degradation, and impoverishment of the soil ecosystem.	Emphasizes productivity but the tendency is to use agricultural techniques to establish plantations or to use the least-cost regeneration technique.
Use practices that mimic natural disturbances to the extent that is feasible.	No emphasis on the mimicking of natural disturbances. Aesthetic impacts are considered, as well as silvicultural characteristics of species and economics. Where feasible, convert stands of species with low commercial value to high-valued species.
Seek harvesting methods that reduce the level of disturbance in the forest. This has primarily meant that the size of clear-cut areas is being reduced and partial harvesting systems are being used more widely.	Increasing utilization and reducing costs are the primary motivators, subject to social constraints on clear-cut size.
Maintain wildlife populations and maintain species.	Maintaining wildlife and non-timber species was generally considered outside the purview of forest managers and applied biologists were primarily concerned about maintaining populations of game species.
Maintain structural and biological diversity in managed forests.	The agro-industrial ideal was to have uniform rows of same sized, single species trees. Aesthetic considerations and economic costs were primary constraints.

Source: Bull, Williams and Duinker 1996

In practical terms, SFM has to be incorporated into timber yield regulations[2]. The many formulae for yield calculation contain three basic elements: the biological rotation period or the felling cycle, the forest volume increment or growth, and existing growing stock of the forest. Changing management techniques to SFM means a change in the yield calculated. The first change is sometimes applied to the rotation age or felling cycle; it is frequently being made longer. This means that the interventions in the forest are less and the total volume removed from the total forest will change in each felling cycle. So, for example, if the felling cycle is extended from 30 to 50 years for the same forest area then the total average removal per year will also change. The sustainable harvesting volumes to be removed depend on the management strategy.

Growth and growing stock variables have also been given some prominence in the model through the provision of an array of equations. In the case of growth, two equations allow the introduction of a mortality factor of 0.5 and for the growing stock considerable effort was expended to identify the commercial growing stock by forest type which, in the case of the tropical region, is significantly lower than the total growing stock. In future developments of the model there will be more flexibility to allow the simulation of different assumptions with respect to mortality and the volume attributable to commercial species.

[2] It is a value judgement of the authors that yield regulation other than by market forces is necessary. This position is strongly supported in the forestry literature since there are many substantive externalities which a market approach does not deal with in an effective manner.

LAND-USE CHANGE – DEFORESTATION

Deforestation remains a serious policy issue for some forest regions. Table 13 summarizes the deforestation/afforestation rate on a regional basis. There is considerable variation between regions with Central America and the Caribbean reporting the greatest deforestation and Europe the highest afforestation. Given that the forest area change is negative in five out of eight regions, deforestation can be expected to remain a prominent issue in the public policy debate over forests.

Table 13
Average annual change of forest area by region as reported in 1995

Region	Forest area	Annual change	
	1 000 ha	*1 000 ha*	*%*
Asia (39)	474 172	-3 328	-0.7
Oceania (16)	90 695	-91	-0.1
Africa (55)	520 237	-3 748	-0.7
South America	870 594	-4 774	-0.5
Central America & Caribbean (31)	79 443	-1 037	-1.3
North America (2)	457 086	763	0.2
Europe (31)	145 988	389	0.3
Area of the Former USSR (15)	816 167	557	0.1
TOTAL (all countries)	**3 454 382**	**-11 269**	**-0.3**

Source: FAO 1997

A meaningful analysis of changes in the world's forests requires a differentiation between increases or decreases of forest area and the changes in forest condition. That is, both deforestation and forest degradation need to be observed and measured. The most frequently reported parameter is forest cover change. Forest condition, although equally important for wood supply, is less intensively observed and monitored. Future work by FAO will address this issue.

LAND-USE CHANGE – PROTECTED AREA

Figure 16 indicates growth in the total area of forests under legal protection and growth in the number of areas designated *Protected Forests* between 1900 and 1990. From 1970 to 1990 the increase in area under protection is nearly 140 percent. Figure 17 indicates that the average area of protected sites is increasing in size. These figures do not indicate how much of the total area under protection is forested. The rapid rise in the area under protection is a clear indication of the importance of conservation and preservation issues in forest policy.

Figure 16
Cumulative growth of the world's protected areas

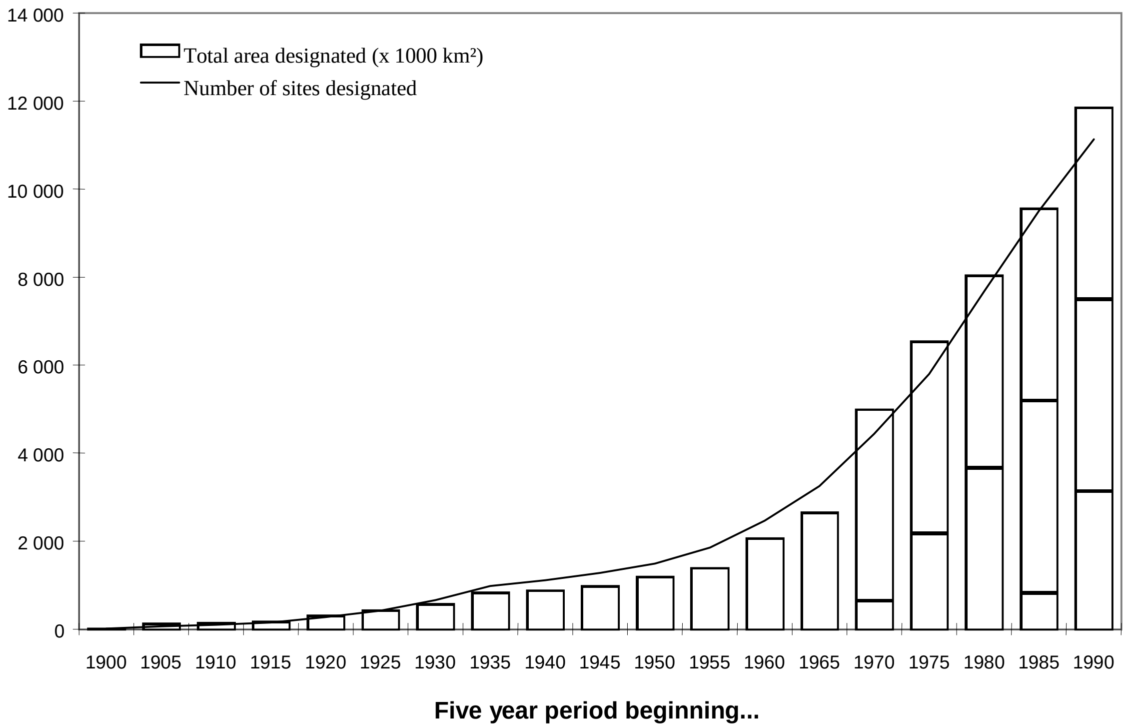

Figure 17
Non-cumulative growth of the world's protected areas

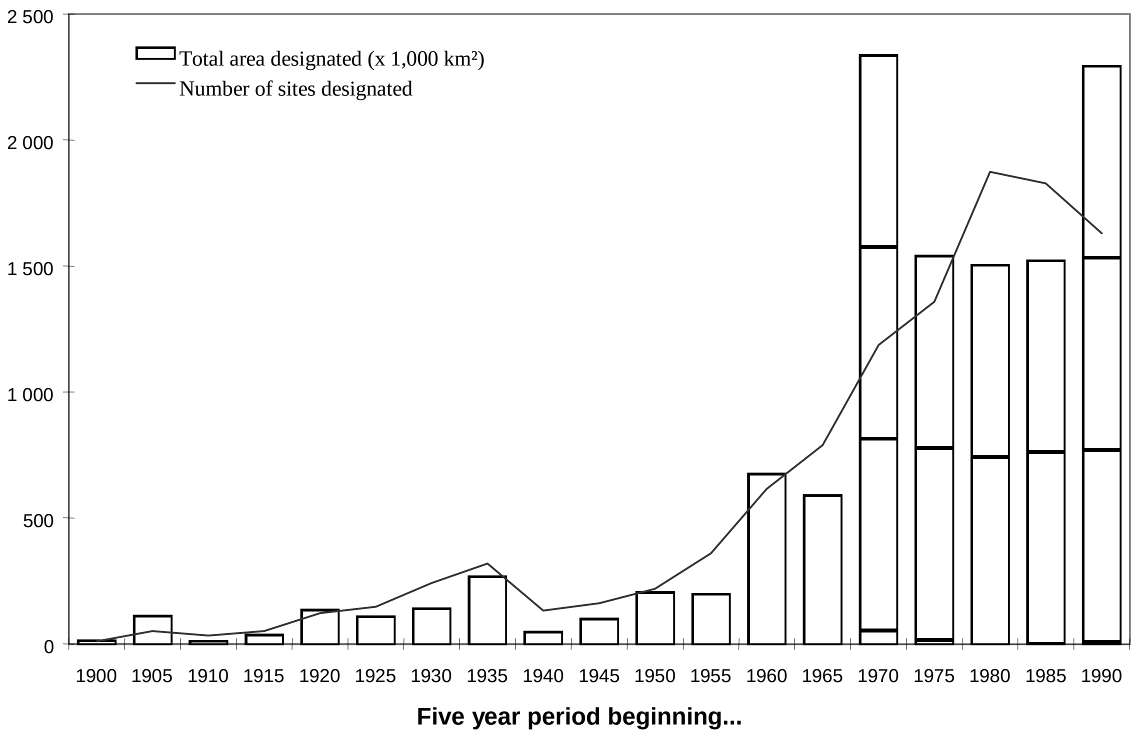

Table 14
Afforestation rate by country (1995)

Country Name	Average Annual Change in Plantation Area	
	(000 ha)	*(% total area)*
Angola	0	0
Argentina	25	3
Australia	20	2
Bangladesh	50	26
Bhutan	0.3	2
Brazil	200	4
Myanmar	3	1
Cameroon	1.6	7
Sri Lanka	10	20
Chile	120	7
People's Republic of China	500	2
Benin	0.8	8
Fiji	1	1
Ghana	1	7
India	500	7
Indonesia	250	5
Japan	0	0
Kenya	1	1
Korea, Republic of	0	0
Malawi	0	0
Malaysia	50	2
Morocco	1	1
New Zealand	50	3
Nicaragua	1	4
Pakistan	50	8
Philippines	44	9
Zimbabwe	5	5
South Africa	24	2
Tanzania, United Republic	1	1
Uganda	0.5	0
Burkina Faso	3	19
Uruguay	20	7
Viet Nam	0	0
Zambia	0	0

Policy makers will continue to debate the appropriate proportion of forest resources to be reserved under legally protected status. Increases in the area under reservation will obviously remove fibre production potential. Consequently, the ability to simulate changes in protected areas for natural forests has been included in the GFSM model.

INDUSTRIAL PLANTATIONS – AFFORESTATION RATE

Table 14 summarizes the planned afforestation rates reported by country in terms of area and percent. There is frequently a significant difference between planned and actual afforestation rates but for the purposes of this study the planned rates are used as a starting point. Recent performance of countries should be reviewed to determine the reliability of these rates for modelling purposes.

Table 14 also indicates the countries where plantation programmes are established but where active afforestation is not yet reported. These appear as having low to no afforestation rates. So, for example, Japan has significant areas in plantations but they are not expanding at the present time.

Since the growth on plantations is so much higher than on natural forests policy developments which promote the use of plantations will have a significant impact on the plantation rate.

INDUSTRIAL PLANTATIONS – DEVELOPMENT GAINS

Development gains, particularly in industrial plantations, are another key factor in analysing potential fibre supply. These development gains include both silvicultural and genetic gains. Naturally biotechnology will also play an important role in the future but a proper evaluation of biotechnology's role in the future is presently beyond the resources of the GFSM project.

GFSM Working Paper No. 2 provides a partial survey of studies published on factors affecting productivity in tropical forest plantations. The paper provides only a start to what would be a long and complicated process of database construction to identify reference material on the subject. In general, it can be concluded that a good tree improvement programme (starting with species/provenance matching to site) can usually result in considerable gain in wood yields from tropical forest plantations. Optimal nursery and silvicultural practices (including those discussed in GFSM Working Paper No 2: seed pre-treatment, application of nitrogen-fixing soil micro-organisms, optimal spacing for defined end use, selection of adequate site, fertilization, and irrigation) can considerably increase such gains further.

Quantification of possible increases in plantation yield for a particular site, species or provenance is difficult. The data presented in Table 15 should be treated very carefully. The gains reported cannot be expected to be reproduced within the same range at a different geographic location and under different climatic and edaphic conditions. Moreover, it is nearly impossible to predict the interrelations of different factors involved that can affect plantation productivity. Percentage gains as a result of silviculture and tree improvement operations, as reviewed in this study, are widely variable. Incorporating the wide range of such data into a model for prediction of future gains is a challenging task.

Despite these cautions it is, nonetheless, worthwhile considering the results in a forecasting exercise. The statistics presented in Table 15 indicate the range of increases expected in development gains and this range could be used as a rough guide to determine the variable to apply in simulating alternative futures.

Table 15
Potential increases from development (genetic & silvicultural) gains

Genus	Country	Gain (%)					
Treatment		DBH	MAI	BA	V	H	Y
Acacia							
Spp./Prov. Matching	P.R. China	8-728			107-129		
	Thailand	229-1107					
	Fiji	157					
	Indonesia		59-242				
	Pakistan	41-257					
	Sri Lanka	56-247					
Spacing	Malaysia		222				
	Thailand		11-52				
Symbiotic Associations	Senegal					8-50	
	Philippines	192				70-210	

Genus / Treatment	Country	Gain (%) DBH	MAI	BA	V	H	Y
Eucalyptus							
Spp./Prov. Matching	P.R. China	212					
	Thailand	41-63					
	Sri Lanka	147					
	Israel		700				
	Nigeria		239				
	Australia/Tasm.	8-517					
	Brazil		82				
Spacing	PNG			41			
	India	89	17-1445				
	Australia	59-82					133
	Thailand				729		
	Ethiopia		34				
Genetic Improvement	Brazil		78		25-178		
	South Africa				8-60		
	India		400		463		
Teak							
Spp./Prov. Matching	India	32				15-33	
Genetic Improvement	India	144				102	
Fertilization/Irrigation	PNG					1 138	
	Puerto Rico						60
	India	93-176	57-121			13-4348	
Site Quality	El Salvador et al.		1 600				
	Liberia					260-350	
	Benin					161	
	Bangladesh	45-54					
	Thailand				502		
	India					150	
Pinus							
Spp./Prov. Matching	Kenya	26			150		
	India	0-175					
	Thailand		283				
	Malawi			174-379			
	Tanzania	92					
	Zimbabwe	28					
	Nigeria	37					
	Zimbabwe	28					
	Nigeria	37					
	Rep. Korea				53-67		
	New Zealand				20-30		
	various tropical	21-64			75-400	26-31	
Genetic Improvement	various				5-46		
	Korea				57-100		
	Australia		17-18	11-22	9-53		
	Zimbabwe				17-37		
	var. East Africa				11		
Fertilization	Indonesia					25-100	
	New Zealand				19		
	Australia	4-10					
	PNG					452-820	
	P.R.China					30	
	New Zealand				46-288		
	Madagascar					83	
	Swaziland					29	

Note: Spp./Prov. matching means matching species/provenances to site. See also note on next page.

Note: The percentage of volume (V) or VUB (volume under bark), or VOB (volume over bark)), MAI (mean annual increment), DBH (diameter at breast height), BA (basal area), H (height) or yield (Y) gain is calculated by comparing the additional volume of wood (or other parameter) resulting from the genetic or silvicultural improvement (e.g. fertilization, provenance selection, site selection, spacing selection) with a base value. For example, an additional 1 m^3/ha of wood under a tree improvement programme, as compared to a volume yield of 10 m^3/ha from an unimproved source, would be a 10% gain. The basis for comparison can be either an unimproved situation (e.g. unfertilized plantation, local seed source), or the poorest performer in the study.

NON-WOOD AND RECOVERED FIBRE

Currently, wood is the major raw material input to the global pulp and paper industry. Significant levels of non-wood fibres are used in a handful of countries, most notably in the People's Republic of China, India, and several other Asian countries, but there are also stronger indications of interest in the fibre, particularly in North America. At present, the most common non-wood fibre is straw (Table 16). This material accounts for 46 percent of total non-wood fibre consumption, followed by bagasse (14%) and bamboo (6%) (Atchison 1995). Other non-wood fibres, such as cotton, hemp, sisal, and kenaf, are also becoming more important in the manufacture of pulp and paper.

Non-wood species currently used only sporadically in the pulp and paper industry are likely to become more important, as collection and targeted production of non-wood fibre expand beyond the present focus in East Asia, to a more global scale.

Table 16
Non-wood pulping capacities by region

	Total papermaking pulp capacities *(thousand metric tons)*			
Raw materials	1985	1988	1990	1993
Straw	6 166	5 260	7 623	9 566
Bagasse	2 339	2 267	2 646	2 984
Bamboo	1 545	1 674	1 468	1 316
Miscellaneous (cotton, reeds, sisal, jute, hemp, abaca, kenaf, flax)	3 302	6 366	6 870	6 870
Total papermaking non-wood capacity	**13 352**	**15 567**	**18 607**	**20 736**
Total paper and paperboard production	**178 558**	**225 887**	**238 939**	**250 359**
Percentage non-wood	7.4%	6.9%	7.8%	8.3%

Source: GFSM Working Paper No. 4.

Table 17 indicates that currently all regions except North America are consuming more wastepaper than they are recovering. The North American region has consistently been the largest supplier of this material, and maintains a dominant player status in world exports of wastepaper. Of the other regions, the Asia-Pacific has the largest demand for wastepaper. Europe, Africa, Latin America and the former USSR each have a lower level of demand that probably could be serviced through reserves of wastepaper from previous years or from slight increases in national recovery levels in the countries of these regions.

Table 17
Wastepaper recovery levels by region

Region	Wastepaper recovery	Recovery of total production	Wastepaper consumption	Ratio of Recovery:consumption
	('000 tons)	*(%)*	*('000 tons)*	*(x:1)*
Europe	31 923	46	32 297	0.99
Asia-Pacific	35 603	40	40 946	0.87
North America	41 999	45	34 427	1.22
Latin America	4354	31	5853	0.74
Africa	901	23	924	0.98
Former USSR	40	2	629	0.06
Total	**114 820**		**115 076**	

Source: GFSM Working Paper No. 4