TOWARDS A SUSTAINABLE

Paper Cycle

Sub-Study Series

1b Forest Resources and Forestry Practices of Selected World Regions

Wood Resources International Ltd

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Celebrating Twenty Five Years

International Institute for Environment and Development

World Business Council for Sustainable Development

FOREST RESOURCES AND FORESTRY PRACTICES OF SELECTED WORLD REGIONS

WOOD RESOURCES INTERNATIONAL LTD
Reston, Virginia, USA
September 1996

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Preface

IIED is currently undertaking a study of the "Sustainable Paper Cycle" which requires an understanding of the breadth of forestry practices utilized throughout the world. As a result of its on-going work in the area of global timber cost and availability, Wood Resources International Ltd. was asked to prepare brief profiles of 10 key world regions. This document contains these profiles, which address such topics as basic forest resources, forest management practices, current levels of resource utilization, significant environmental issues, and anticipated timber availability.

Profiles were based on published information, and on proprietary data developed by Wood Resources Int., as a result of prior work in each region. IIED selected regions to provide a cross-section of forest ecosystems, resource management philosophies, industry structures, and environmental issues. The regions included in this analysis represent approximately 50% of the world's forested area, and over 50% of global industrial roundwood production. They are:

Australia	Russia
Brazil	Southern Africa
British Columbia, Canada	Sweden/Finland
Germany	Thailand
Indonesia	United States South

It is hoped that this analysis will provide the reader with a perspective of the resources, opportunities, and challenges faced by some of the leading forest product regions of the world.

Wood Resources International Ltd.
November, 1995

Selected Statistics

Region	Total Land Area (Mill. Ha.)	Total Forest Land (Mill. Ha.)	% Forest Cover (%)	Production Forest (Mill. Ha.)	Short/Med. Plantations (Ha.)	1993 Indust. Harvest (Mill. Cum)
Australia	768.2	41.8	5.4	21.0	1,083,300	18.1
Brazil	851.0	560.0	65.8	450.0	4,200,000	138.0
British Columbia	94.8	57.8	61.0	24.0	---	79.2
Germany	*34.9*	*10.5*	*30.1*	*9.4*	*(1)*	*28.0*
Indonesia	193.0	142.0	73.6	65.0	2,200,000	43.0
Russia	2,110.0	760.0	36.0	540.0	---	166.0
Southern Africa	210.8	2.2	1.0	1.6	1,600,000	19.4
Sweden/Finland	72.3	50.6	70.0	43.6	(2)	99.3
Thailand	51.1	12.7	24.9	1.0	2,255,700 (3)	.5
U.S. South	216.3	85.8	39.7	80.7	11,000,000	253.3
Totals	**4,603.4**	**1,723.4**	**37.4**	**1,236.3**	**22,338,997**	**844.8**

(1) An estimated 5 million ha. have been reforested by planting.
(2) An estimated 6-7 million ha. have been reforested by planting.
(3) Including approximately 1.5 million ha. of rubbertree plantations.

Selected Statistics

Region	Projected Timber Availability (Mill. Cum per Year) 1990	2000	2010	2020	Potential Plantation Supply (%) 1990	2020	Key Issues
Australia	19.1	21.8	25.8	29.0	37%	71%	Logging in Native Forests. Strong Envir. Opposition to Expansion of P & P Ind. Chip Export Restrictions.
Brazil *	157.0	155.0	200.0	210.0	43%	76%	Deforestation at 7-8 million Ha. per year. Expansion of Plantations. Charcoal Ind. Wood Consump.
British Col.	81.0	70.0	65.0	72.0	---	---	Declining AAC.
Germany	45.0	52.0	62.0	70.0	---	---	Bio-Diversity. Domestic Harvest Levels. Air Pollution Damage.
Indonesia	57.0	50.0	53.0	58.0	30%	66%	Deforestation at .9-1.3 million Ha. per year. Illegal Logging. Expansion of HTI Plantations.
Russia	500.0	475.0	450.0	450.0	---	---	Environmental Set-Asides. Even-Aged Forest Mgt. Infrastructure.
S. Africa	19.5	22.9	24.9	26.6	100%	100%	Use of Scarce Water Resources. Single Species Plantations.
Sweden/Fin.	130.0	142.0	161.0	173.0	---	---	Bio-Diversity. Forest Health.
Thailand	3.4	2.9	3.9	5.0	100%	100%	Deforestation. Illegal Logging. Resistance to Ind. Plantations.
U.S. South	244.0	271.0	301.0	296.0	13%	34%	Endangered Species Habitat. Wetlands Forest Mgt. Clear-Cutting.

* Excludes fuelwood used for heating and cooking.

Profile of Forest Resources and Forestry Practices

Australia

I. GENERAL STATISTICS

Table 1 - Land & Forest Area

Total Land Area (ha)	768,230,000	
Forest Area (ha)	41,800,000	(5.4%)
Est. Production Forest (ha)	21,000,000	(2.7%)

Table 2 - Forest Land Ownership

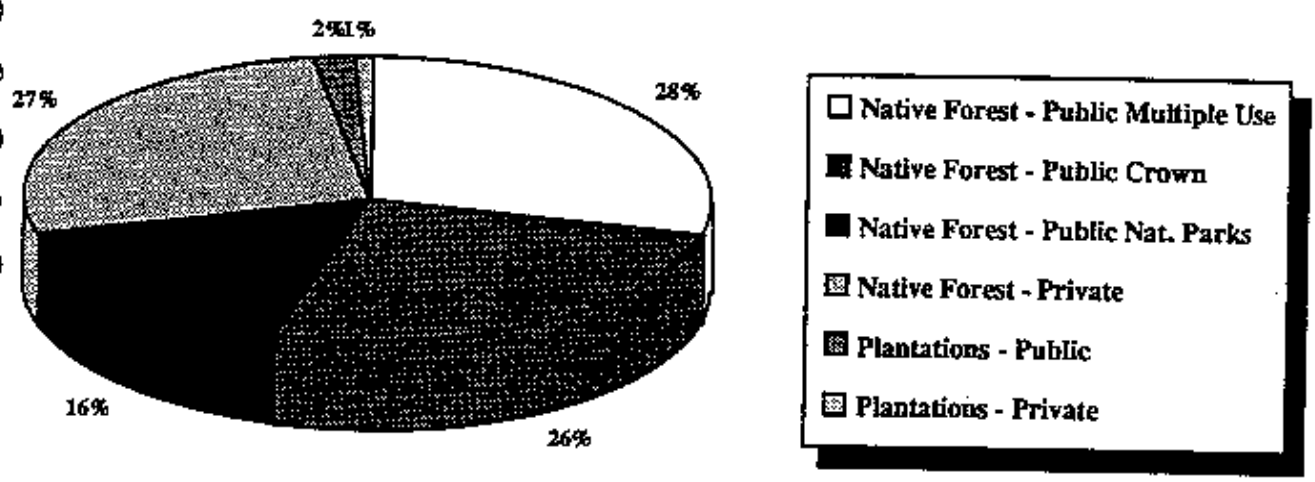
	(%)	(000 Ha)
Native Forests		
Public -- Multiple Use	29.8%	12,135
Public-- Crown	26.3%	10,710
Public -- National Parks & Reserves	16.2%	6,595
Private	27.7%	11,280
Plantations		
Public	1.9%	955
Private	0.8%	128
Total Public	72.7%	30,392
Total Private	27.3%	11,408

Table 3 - Productivity

		Plantations		
	Total	Conifer	Hardwood	Total
Net Annual Growth (million cum)	47.0	10.5	2.0	12.5
MAI per hectare (cum/ha/yr)	3.0	18.0	20.0	---
1993 Harvest (million cum)	18.1	8.0	Neg.	8.0

Area of Industrial Plantations: 1,083,000 hectares

Forest Land Ownership - Australia



II. FOREST RESOURCES

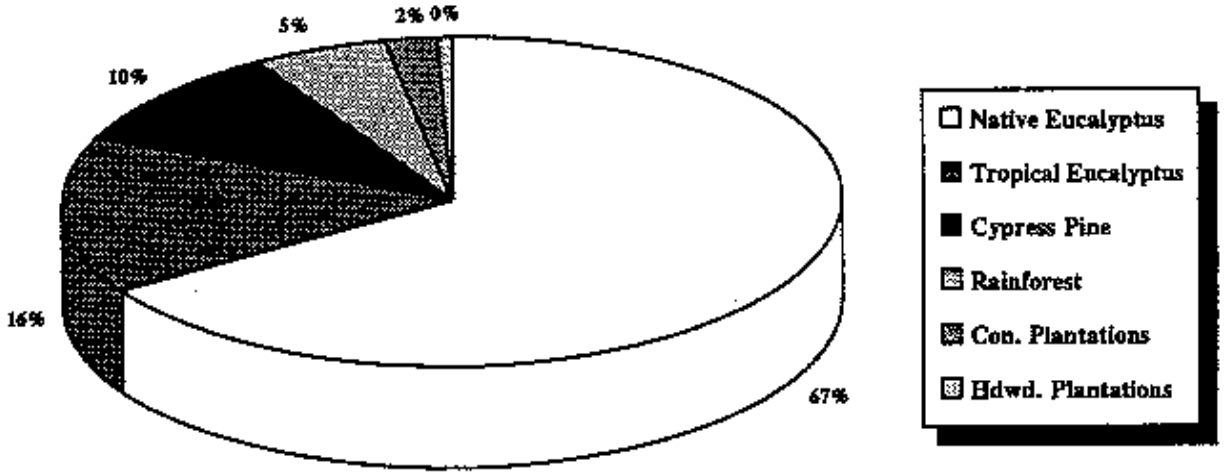
Despite the large size of the country, Australia's 40.7 million hectares of native forests and 1.1 million hectares of plantations cover a relatively small percentage of the total land base (6%). The eastern states of New South Wales, Victoria, and Queensland are the most heavily forested.

Eucalyptus is the predominant forest type, accounting for 34.3 million Ha. of native forest, distributed among moist, mixed and dry areas. Cypress pine (Callitris spp.) occupies approximately 4.2 million hectares, and an assortment of species are found on approximately 2.3 million hectares classified as rainforest. The native forests are 72% owned by the public and 28% owned by private holders. Environmental concerns have essentially removed all but 10 million hectares of public lands from the productive forest land base. In addition to the native forests, Australia has industrial timber plantations established on approximately 1.1 million hectares with a similar ownership pattern.

Table 4 - Forest Types (Species Mix)

	(000 Ha)	(%)
Native Eucalyptus	27,737	66.4%
Tropical Eucalyptus	6,528	15.6%
Cypress Pine	4,167	10.0%
Rainforest	2,287	5.5%
Softwood Plantations	955	2.3%
Hardwood Plantations	128	0.3%
Total	41,802	100.0%

Forest Area by Type - Australia



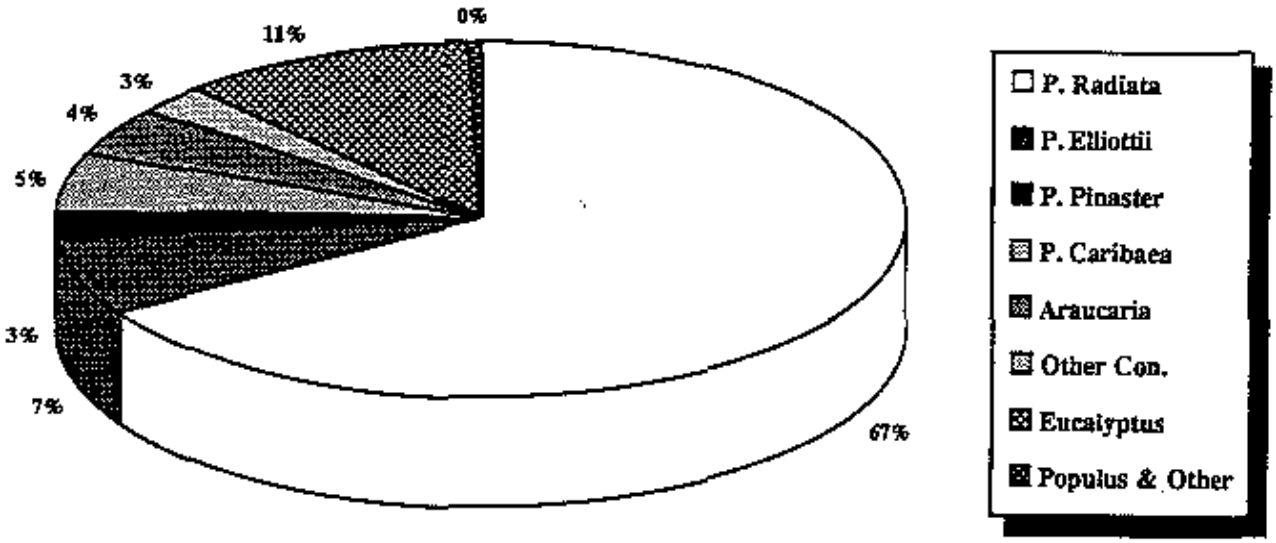
Public lands are classified as either: "Multiple Use Lands," which are largely available for timber production; "Crown Lands," on which some harvesting is permitted but timber is not a principal objective; and lands designated as "National Parks and Reserves," where harvesting is strictly prohibited. Because Australia is a Commonwealth, the states have traditionally been responsible for the management and utilization of the public forest resources. However, the Commonwealth government has exerted greater influence over the past decade as conflicts among the industry, individuals and environmental protection interest groups have intensified.

Although Eucalyptus is native to Australia, it does not grow as rapidly there as in tropical countries where it is often the species of choice for fast-growing plantations. Instead, the majority of Australian plantations are planted with coniferous species. Radiata pine (Pinus radiata) is the most common species grown on Australia's plantations, accounting for 65% of the total plantation area. The area of managed plantations by major species is as follows:

Table 5 - Australia's Industrial Forest Plantations

	(000 ha)	(%)
P. Radiata	715,353	66.1%
P. Elliottii	76,283	7.0%
P. Pinaster	31,731	2.9%
P. Caribaea	57,201	5.3%
Araucaria	46,774	4.3%
Other Softwood	27,550	2.5%
Eucalyptus spp.	123,489	11.4%
Populus spp.	1,277	0.1%
Other Hardwood	3,053	0.3%
Total	1,082,711	100.0%

Plantations by Species



Approximately 80% of Australia's plantations have been established within the past twenty years, suggesting that domestic softwood timber/fiber availability will begin to increase significantly during the next decade and beyond.

III. CURRENT LEVEL OF UTILIZATION

Australia's timber/fiber harvest totaled approximately 18.1 million cubic meters in 1993. Softwood removals accounted for 8 million cubic meters of the total volume. Given the age structure and growth rates of existing plantations, annual softwood availability is currently estimated to be 10.5 million cubic meters, or approximately 2.5 million cubic meters higher than current removals. Based on average growth rates in the native forests that are available for harvest, hardwood availability is theoretically at least 30 million cubic meters, but timber supply from the native forests is determined as much by environmental and political concerns, as by economic considerations. Earlier government projections indicated that a steady supply of hardwood timber of between 12 and 13 million cubic meters was possible throughout the 1990's, but actual hardwood harvests from the native forests are more likely to hover near 10 million cubic meters.

	Native Hardwood	Plantation Conifer
Est. Annual Allowable Cut (million cum)	10.0	10.5
1993 Harvest (million cum)	10.0	8.0
1993 Growth/Drain Ratio	1.00	1.31

Australia runs a sizeable trade deficit in forest products. Imports meet approximately 40% of domestic demand. However, Australia is becoming a significant exporter of certain forest products, the largest share of which are wood chips. In 1994, approximately 5.5 million cubic meters of wood chips were produced and exported, mainly to Japan. Australia accounts for 30% of Japanese imports of wood chips. Chip exports are a contentious political issue. The government has set a policy to restrict chip exports in favor of value-added processing by the year 2000. Although small, exports of Radiata pine are also increasing.

With 1.1 million hectares of existing plantations, and new plantations being established at the rate of 30,000 hectares per year, it is not inconceivable that Australia might become entirely self-sufficient or a net exporter of forest products within 15-20 years.

Table 6 - Production of Wood and Paper Products, 1993

Lumber (000 cum)	3,433
Plywood & Panels (000 cum)	1,387
Wood Pulp (000 tonnes)	1,015
Paper & Paperboard (000 tonnes)	2,131

Allocation of Roundwood Harvest

The proportion of softwood in the total Australian harvests has increased from 24% in 1980, to 55% in 1994. The increase is a direct result of timber maturing from plantations established in the 1960's and 1970's. The Australian timber harvest in 1993/94 totaled 18.1 million cubic meters, of which softwood logs accounted for 8.0 million cubic meters.

Table 7 - Estimated Roundwood Use - 1993

	Hardwood		Coniferous		Total	
	(000 cum)	(%)	(000 cum)	(%)	(000 cum)	(%)
Sawlogs & Veneer Logs	4,181	41.4%	4,720	59.0%	8,901	49.1%
Sleeper Logs	162	1.6%	----	----	162	0.9%
Pulpwood -- Panels	71	0.7%	860	10.8%	931	5.2%
Pulpwood -- Paper/Board	5,424	53.7%	2,120	26.5%	7,544	41.7%
Other	252	2.5%	300	3.8%	552	3.1%
Total	10,090	100.0%	8,000	100.0%	18,090	100.0%

The increase in available plantation timber has made possible larger and more efficient sawmills. Of Australia's 1,405 operating sawmills in 1993, 168 reported processing volumes greater than 15,000 cubic meters per year. This compares with only 40 such mills in 1988. Essentially all of the larger mills process softwood.

While plantations account for less than 3% of Australia's forest area, they provide about one-third of the total harvest. That softwood lumber production increased by 32% between 1991 and 1993 reflects, in part, the effect of increased log supply from plantations.

The industry capacity of reconstituted wood panels, especially medium density fiberboard (MDF), has been increasing over the past few years. Production of MDF, particleboard and hardboard at 18 plants in 1993 totaled 1.4 million cubic meters. About half of the raw material used in panel production comes from sawmill residues and about half from pulpwood.

[redacted]

Australia's 9 pulp mills produced just over 1 million tonnes of wood pulp in 1993, consuming approximately 3.1 million cubic meters of wood fiber. Paper and board production of 21 plants totaled 2.1 million tonnes. Roundwood pulpwood accounted for an estimated 90% of the industry's wood consumption; sawmill residues for the balance. In 1993, 967,000 tonnes of waste paper were used out of a total paper production of 2,131,000 tonnes, resulting in a wastepaper utilization rate of 45.4%.

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

The native Eucalyptus forests of Australia that are classified as production forests, are generally managed on an even-aged basis, and allocated to industry through long-term area or volume based concession agreements. Many stands have repeatedly burned over the years resulting in a very high percentage of cull material, which is generally chipped for the domestic or export woodchip market. As the intent is to totally restock the forest, clear-cutting is the dominant harvest practice. Natural regeneration is generally successful, but may be supplemented by planting.

Net growth on the native Eucalyptus forests is minimal, producing at a rate of only 2 to 5 cubic meters/hectare/year. This is because the native forests have a large component of older stands which add growth very slowly. Regenerated natural forests also grow slowly because of high mortality rates from drought, endemic insects and diseases.

To help compensate for lower supply from native forests, new plantations are being established at the rate of over 30,000 hectares per year. Although there has been some conversion of native forestland to plantations in the past, nearly all plantations are today established on former grass or farmland. Radiata pine plantations are typically managed on a 30-35 year rotation with two commercial thinnings, one taking place between the 10th and 14th years, and the other occurring sometime between the 20th and 25th years. Growth rates average between 15-20 cum/ha/year.

Plantations of Eucalyptus (E. grandis and E. globulus) are being established to augment the fiber supply for the pulp and paper industry. About half of the hardwood plantations are privately owned. These plantations are typically managed on rotations of 10-20 years, using coppice regeneration. Plans call for replacing the root stock after the second rotation with genetically improved varieties, thereby further increasing future yields. Some plantations are opting for a single 15-year rotation. Although variable depending on site, growth rates of 20 cubic meters/hectare/year are currently being realized. The following provides some insight into current plantation management practices, and economics.

Table 8 - Industrial Plantation Parameters
(From Stephens, Hansard, & Dean - ABARE)

	Conifer	Hardwood
Land Costs (US$/Ha)	510	1020
Site Prep & Planting (US$/Ha)	825	940
Annual Maintenance (US$/Ha/Yr)	50	22
Rotation (Yr)	35	20
Annual Yield (Cum/Ha/Yr)	17	18

Site Prep		
Scarification	Yes	Yes
Bedding	Yes	Yes
Initial Stocking Levels (stems/Ha)	1300	1100
Chemical Weed Control	At Planting	At Planting
Chemical Fertilization	At Planting/At Thinning	At Planting
Pruning (yr)	For Sawlogs - 7	No
Thinning (yr)	15,24,30	No

Harvesting systems are mostly conventional motor-manual systems, using chainsaws and cable/grapple skidders to fell and haul logs to roadside landings. Some cable or aerial logging systems are used in the mountainous regions of the southeast Coast and in Tasmania. Harvesting in plantations is increasingly mechanized using either feller-buncher/grapple skidder, or processor/forwarder systems. As in other parts of the world, private contractors dominate harvesting and transportation operations in Australia.

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES

A combative climate exists between Australia's forest industry (and entities dependent on the industry) and a very strong environmental community which has been advocating for prohibitions against logging. Controversies have erupted in several states, usually leading to government agreement to set aside more land for parks or reserves. In an attempt to fashion a compromise between vocal environmental groups and the forest industry, the government brokered a new National Forest Policy Statement which sets out principles supporting both environmental protection and timber production.

Environmental activists are also concerned about monoculture plantations. Issues have been raised about aesthetics, lack of genetic diversity, loss of wildlife habitat, and the impact of large scale agro-forestry projects on traditional rural community life. For its part, the forest industry seeks improved resource security in order to attract investment and become self-sufficient in forest products.

Government logging and forest management concessions are becoming increasingly restrictive and the Commonwealth government is exerting greater influence over forest development issues at the state level. For example, the Australian government uses its authority under environmental and export control laws to require licenses and annual reviews for companies exporting wood chips. Although many argue that Australia's plantations and sawmill residues enable an expanding chip export business, the government intends to ban chip exports after the year 2000, presumably for environmental protection, and to favor secondary manufacturing. Yet, several proposals to construct new pulping facilities have been defeated by opposition from environmental groups. Similar to the United States, the recent electoral cycle brought into power a more pro-business political party. Several new expansions in the forest products industry are once again under consideration, and although a decline in the volume of native Eucalyptus available to the hardwood chip export market is anticipated, the complete shut down of this industry by the end of the current decade is thought to be highly unlikely.

VI. PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020

Heated confrontations over resource use show no signs of abating. Theoretically, Australia is in a position to expand its production of forest products because of investments made in industrial plantations. The

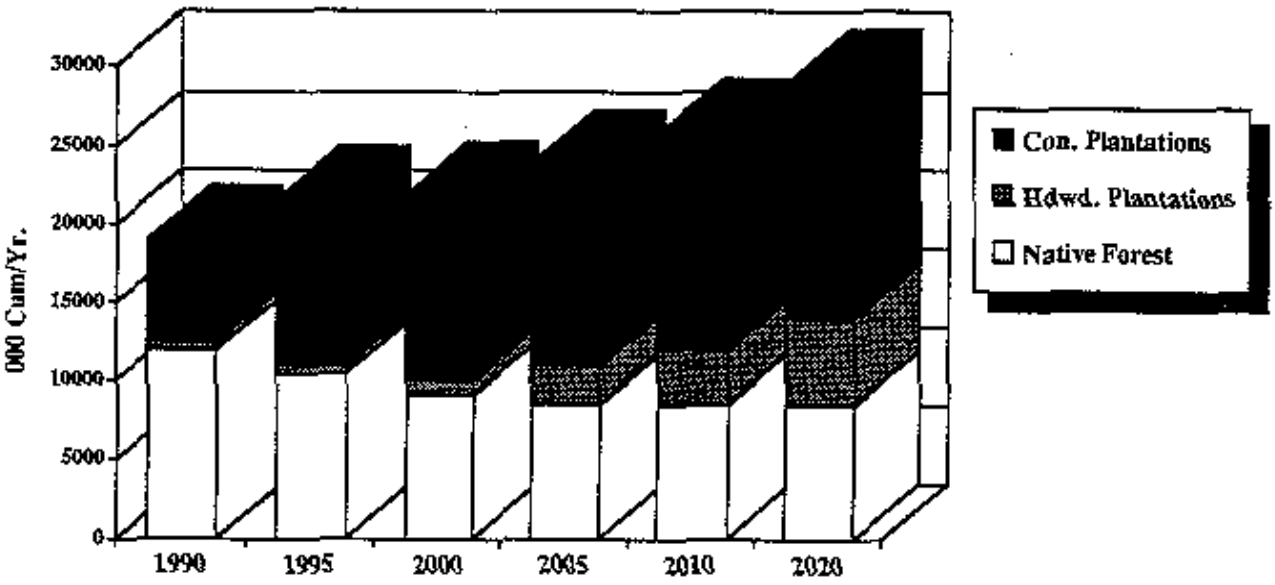
sheer size of the softwood timber inventory maturing over the next twenty years bodes well for the softwood-using industry, but native hardwood output is likely to contract. On the other hand, investments in hardwood plantations are increasing, motivated by a profitable chip export market and the potential for new or expanded pulp capacity.

The Australian government has projected a reasonably stable supply of between 12 and 13 million cum per year from native forests, but considerable environmental pressure has removed large areas from the fiber base. Given strong opposition to increased logging, native hardwood production is likely to decline. To compensate for the reduction of timber from native forests, hardwood plantations are being established at a rate of 14,000 hectares per year. By the turn of the century, hardwood plantation fiber should more than offset the decline in production from the native forests.

Table 9 - Projected Timber/Fiber Availability
(thousand cubic meters)

		Plantations		
Year	Native Forest	Hardwood	Conifer	Total
1990	12,000	500	6,550	19,050
1995	10,500	500	10,500	21,500
2000	9,000	1,000	11,800	21,800
2005	8,500	2,500	12,800	23,800
2010	8,500	3,500	13,800	25,800
2020	8,500	5,500	15,000	29,000

Projected Available Timber Supply - Australia



L REFERENCES

gar, W.H., "Australia's Forests - Their Role in our Future", Australian Academy of Science, Canberra, 1981, pp. 21-46.

sia Papermaker, "*Australia: Recovery in Progress*", July, 1994.

ıstralia Manufacturing Council, "Competitiveness of Australian Forest Industries," March, 1990.

ustralian Bureau of Agricultural and Resource Economics. *Quarterly Forest Products Statistics*, 1st Quarter, 1995.

'ayliss, Martin, Editor, Asia Papermaker, "Australia, Downunder on Top - or Just Hanging On", November, 1994.

ıept. of Conservation and Natural Resources, Victoria, "Forest Facts".

elton, Ken. "The Role of *Eucalypt Plantations in Resource Sustainability for the Australian Pulp &* Paper Industry", Commissioner for Management, Forestry Commission of Tasmania, 1990.

Mutton, Dennis. "The Role of Softwood Plantations in Resource Sustainability", Chief Exec., Woods and Forest Dept., South Australia, 1990.

'ulp and Paper Manufacturing Federation of Australia Ltd., "Pulp & Paper, Perspectives", 1991-1993.

lesource Assessment Commission Inquiry into Australia's Forest and Timber Resources, May 1990.

JSDA Foreign Agricultural Service, ATO Reports.

Wood Resources International Ltd., "Wood Resource Quarterly", May 1990, estimates and in-house files.

Profile of Forest Resources and Forestry Practices

Brazil

I. GENERAL STATISTICS

Table 1 - Land & Forest Area

Total Land Area (ha)	851,000,000	
Forest Area (ha)	560,000,000	(66%)
Est. Production Forest (ha)	450,000,000	(53%)

Table 2 - Forest Land Ownership

	(000 ha)	(%)
Native Forests		
Federal/State	487,000	87.0%
Private	66,600	11.9%
Plantations		1.1%
Charcoal Industry	2,300	
Pulp Industry	1,400	
Other Private	2,700	
Total	560,000	100%

Table 3 - Productivity

		Economic Plantations		
	Total	Conifer	Hardwood	Total
Net Annual Growth (million cum)	672	23	65	88
MAI per hectare (cum/ha/yr)	1.2	15	25	21
1993 Harvest (million cum)	300	19	60	79

Area of Industrial Plantations: 6,400,000 hectares

II. FOREST RESOURCES

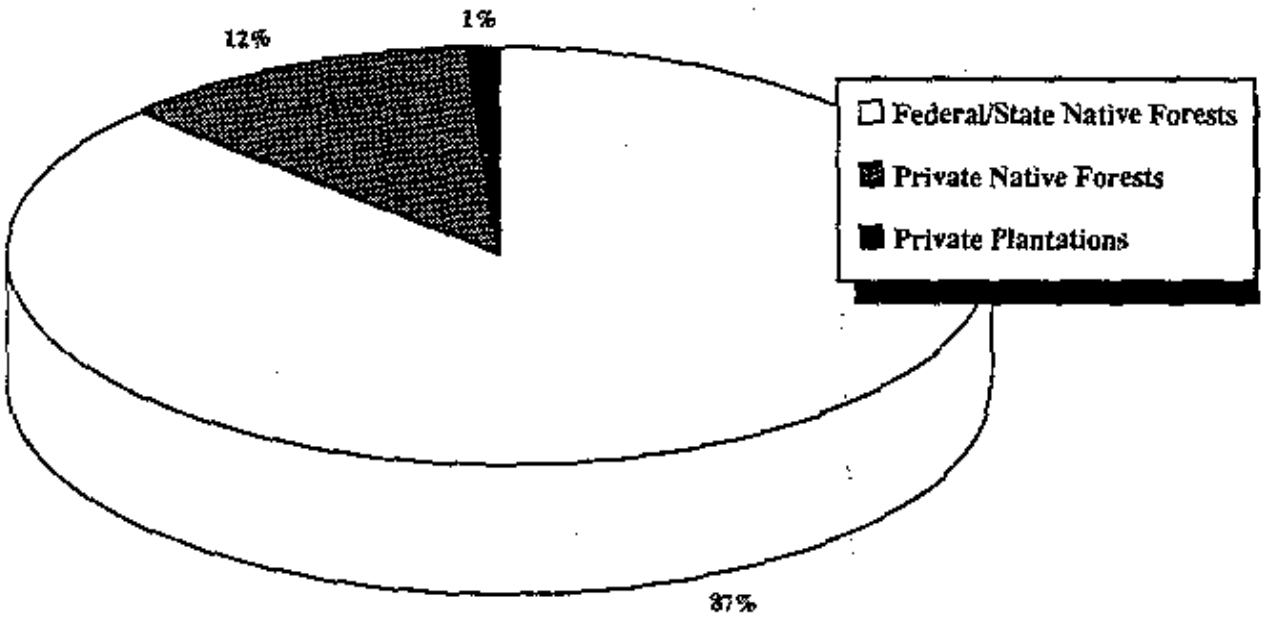
Brazil is the fifth largest country in the world and possesses the largest expanse of tropical forest, the Amazon River Basin. A detailed forest inventory has never been completed, so estimates of the country's total forest area vary depending on definitions and methodology. Most sources place forest cover at approximately 560 million hectares, or roughly two-thirds of Brazil's total land area. The native hardwood forests of the Amazon alone span some 260 million hectares.

The Amazon forests, as well as the forested sections of the southern and eastern regions, contain a diversity of vegetative conditions and forest types. With the exception of about one million hectares of remaining natural Araucaria forests in the southeastern part of the country, virtually all of Brazil's forests are tropical hardwood forest types. Pine and Eucalyptus plantations have been established on 6.4 million hectares. Brazil's pulp and paper industry relies exclusively on these plantations for its raw wood fiber requirements.

A rough estimate of total growing stock in Brazil's forests is 56.1 billion cubic meters, only about 4% of which might be considered commercially important. Most of the standing timber volume is still largely inaccessible in the Amazon region.

The vast majority of Brazil's forest land (87%) is state owned, largely because the government owns the sparsely settled northwestern Amazon region. However, private owners control 71% of the commercially-utilized forest land in the southern and eastern states. The government exerts a tremendous amount of control over land-use and forest management activities on private lands through direct ownership in many steel, mineral, and transportation companies which, in turn, own plantations. The current move to privatize government-run enterprises will result in a major shift to private ownership of many large-scale plantations.

Forest Land Ownership - Brazil

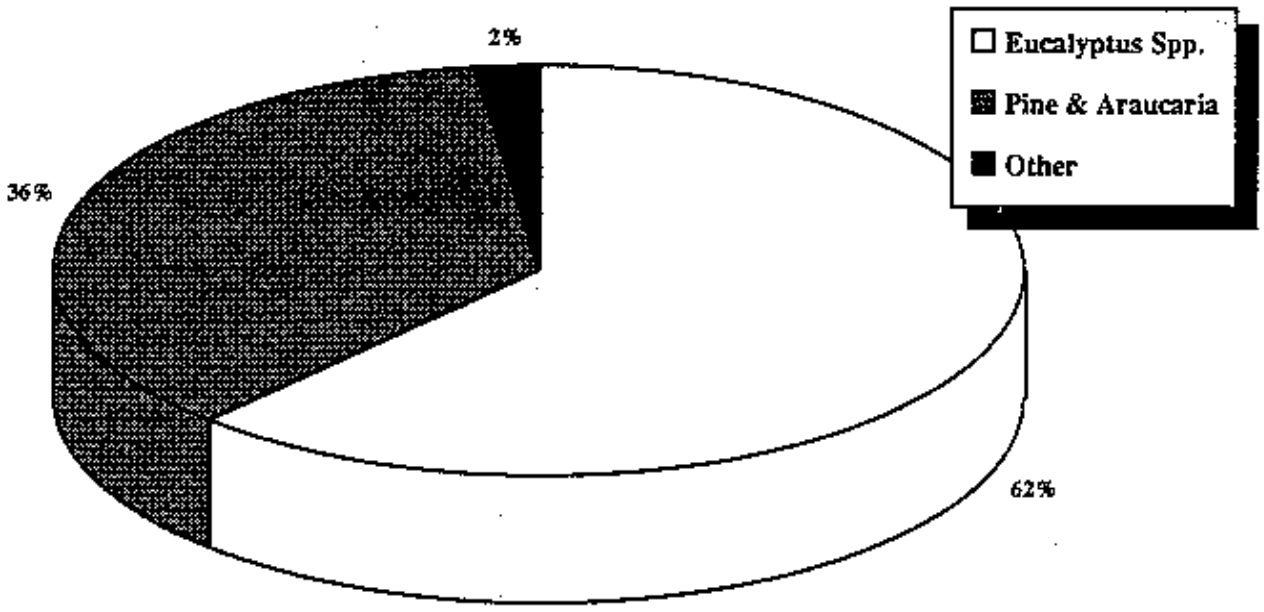


Beginning in 1967, the Brazilian government embarked on an ambitious afforestation program by allowing individuals or companies to invest their tax liability in afforestation projects. According to government statistics, 6.4 million hectares of plantations were established between 1967 and 1987 when the program was phased out. However, not all plantations have proved to be economically viable. The area of economically viable plantations is currently estimated at 4.2 million hectares. About one-third of these plantations were established by steel companies, one-third by pulp and paper enterprises, and one-third by an assortment of solid wood product, non-forest product companies and individuals. The area and species composition of industrial plantations is as follows:

Table 4 - Species Mix (Economically Viable Plantations)

	(000 hectares)	(%)
Eucalyptus spp.	2,600	62%
Pinus and Araucaria	1,500	36%
Gmelina arborea & Others	100	2%
Total	4,200	100%

Plantation Species Distribution - Brazil



III. CURRENT LEVEL OF UTILIZATION

Brazil's total roundwood harvest and consumption was estimated to be 300 million cubic meters in 1993. The use of wood for energy is the single largest use of wood fiber in Brazil, accounting for 237

million cubic meters, or nearly 80% of total consumption. Wood is used for energy in the form of fuelwood (68%) for heating and cooking, or is used to produce charcoal (32%) in the economically important charcoal industry. The charcoal industry provides low-cost energy for steel production, Brazil's largest manufacturing and export industry.

Over 90% of the wood used for fuelwood, and over 70% of the wood used to make charcoal, is logged from the native forests. The heaviest concentration of charcoal production is in the state of Minas Gerais, where years of forest exploitation to provide raw material for the industry has resulted in severe deforestation. Not surprisingly, the largest areas of industrial tree plantations are also located in Minas Gerais. Only 25-30% of the wood fiber used in the charcoal industry currently comes from plantations, but use of plantation wood is rapidly growing as the distances to untapped native forests, and therefore the costs of transport, increase.

The second largest consumer of wood in Brazil is the solid wood industry which consumes an estimated 40 million cubic meters. Sixty percent of this comes from native forests where several thousand small sawmills operate using both selective cuttings from government and private lands, and timber made available from land clearings. Softwood lumber is a smaller, but rapidly growing, segment of the wood industry concentrated in the southern states of Parana and Santa Catarina. Originally founded on native Parana pine (Araucaria angustifolia), the industry has shifted to utilizing planted Loblolly (Pinus taeda) and Slash pine (Pinus elliotti). About 11 million cubic meters of pine sawtimber is processed into lumber by this industry sector.

Hardwood plywood, veneer, and to a lesser extent, softwood plywood and particleboard are also produced in Brazil. Panel producers generally depend on plantations for raw material instead of sawmill residues. Chips and sawdust from sawmills tend to be more valuable as energy wood than as residue for the panel or pulp industry.

In marked contrast to the charcoal and solid wood industries, the pulp and paper industry relies principally on plantations for raw material. Less than 3% of the industry's wood fiber furnish comes from native forests. In 1993, the wood pulp industry utilized an estimated 23 million cubic meters of wood fiber to produce 5.4 million tonnes of wood pulp. Virtually all of the wood fiber furnish utilized by the pulp industry is in roundwood form (only 2% is residues) and consists of 72% hardwood and 28% softwood.

Table 5 - Production of Wood and Paper Products, 1993

Lumber (000 cum)	12,000
Plywood & Panels (000 cum)	2,500
Wood Pulp (000 tons)	5,424
Paper & Paperboard (000 tons)	5,379

Allocation of Roundwood Harvest

Total consumption of timber/fiber in 1993 was estimated at 300 million cubic meters. The following table details sources and allocations of Brazil's harvest:

Table 6 - Estimated Roundwood Use - 1993
(million cubic meters)

	Native Forest	Plantations Hardwood	Plantations Conifer	Total
Fuelwood	150.0	10.0	2.0	162.0
Charcoal Industry	46.0	29.0	---	75.0
Sawmill & Panel Industry	24.0	5.0	11.0	40.0
Pulp Industry	<1.0	16.0	6.0	23.0
Total	221.0	60.0	19.0	300.0
Percentage	74%	20%	6%	100%

Growth rates for industrial plantations in Brazil are among the highest in the world. Some sites with Eucalyptus uro-grandis clones have produced average annual yields as high as 100 cubic meters/hectare. Generally, sustained growth rates for Eucalyptus plantations in Brazil are averaging 25 cubic meters/ hectare/year, and for pine about 15 cubic meters/hectare/year. Applying these growth rates to the areas in plantations produces a sustainable annual available timber/fiber supply of 65 million cubic meters for Eucalyptus, and 23 million cubic meters for pine. Actual timber/fiber availability from pine plantations will likely be higher in the near future because of the preponderance of mature age classes and the use of genetically-improved seedlings in replantings. Assuming no change in dependence on native forests, the Growth/Removal ratio for plantations currently shows a surplus of 5 million cubic meters for Eucalyptus, and 4 million cubic meters for pine.

	Native Forests	Plantations Conifer	Plantations Hardwood
Est. Annual Allowable Cut (mill. cum)	486	23	65
1993 Harvest (mill. cum)	221	19	60
1993 Growth/Drain Ratio	2.20	1.21	1.08

In actuality, if deforestation is to be curbed, then a greater proportion of future industrial roundwood consumption will have to come from plantations. As a result, the government is currently requiring all major wood consumers to achieve self-sufficiency through the use of plantations.

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

Due to the inaccessibility of the topical hardwood forests of Brazil, it is thought that a significant percentage are not currently under formal forest management. Production forest areas are often assigned to local sawmill or panel producers under a concession arrangement, which will stipulate the species and volumes that may be removed from the area on an annual basis. A significant volume of material, however, reaches the open market from illegal logging, and legal and illegal land conversion activities. Some attempts have been made to re-establish the coastal Atlantic rainforest along the south-eastern coast of the country, but marginally successful natural regeneration is the rule for most harvesting activities within the tropical hardwood forests of northern Brazil. By contrast, the industrial plantations are among the most intensively managed in the world.

Eucalyptus plantations, and many pine plantations, are based on rooted cuttings of clonal varieties that have been matched to specific soil and site conditions. Clonal material or seedlings are planted in 3-meter by 3-meter or 2-meter by 3-meter spacing at a stocking level of 1,100 to 1,700 seedlings per hectare. In some cases, plantations have been established on slash and burn clearings which did not necessitate elaborate site preparation. The more intensively managed plantations, however, still involve cultivation, fertilization, chemical weed control and insecticides. Weeding is one of the most costly silvicultural treatments, as is the cost of insect control (specifically leaf-cutting ants).

Pine plantations may be oriented toward either pulpwood or sawlogs. A pulpwood rotation will generally involve initial stocking levels of 1600 stems per Ha. on a 21 year rotation. The stand is thinned at ages 7/8, and 14/15 before final clear-cut felling. A sawlog rotation will begin with 1000 stems/Ha., on a 16-18 year rotation. These stands are pruned at 4, and 8-10 years as necessary. The net result of thinnings within the longer pulpwood rotation is a higher overall yield of pulpwood sized material (as much as 40% of total volume).

Harvesting operations in Brazil still rely primarily on motor-manual, chain-saw/skidder operations. Typically, chainsaws are used to fell, delimb and cut bolts to a standard 2.5 meter length, which are then loaded on trucks or rail cars for hauling. Plantations are clear-cut, while harvesting in native forests primarily consists of selection harvests.

One of the most ambitious forest development projects implemented in Brazil was the Jari project of Daniel Ludwig. In 1967, Ludwig purchased 1.6 million hectares of tropical forest land adjacent to the Jari river in the Amazon river basin. Ludwig's vision was to create an industrial development where fast-growing tree plantations would support large-scale pulp and paper production for export to world markets. Ludwig invested over $1 billion in the project to clear 100,000 hectares, build the necessary infrastructure, and ship a pre-fabricated pulp mill to the site from Japan. For a variety of reasons, Ludwig sold the operation to a consortium of Brazilian companies in 1982. Now called Monte Dourado Forestry Enterprise, the Jari project currently has 75,000 hectares of actively managed plantations supporting a 300,000 metric tonne per year pulp mill. An additional 14,000 hectares is devoted to raising buffalo and other agricultural and mining operations. Species selection for the plantations has benefited from a process of trial and error. After numerous trials with Gmelina arborea, Pinus caribaea, and various Eucalyptus varieties, project managers selected Eucalyptus urophylla and a related hybrid as the preferred species. The Jari plantations are producing on average of 19.6 cubic meters/hectare/year with future rotations expected to yield an average of 27 cubic meters/hectare/year. Brazilian plantation practices and costs vary widely, but are reflected in the following.

Table 7 - Industrial Plantation Parameters

	Conifer (Pulpwood)	Hardwood
Land Costs (US$/Ha)	700	800
Site Prep & Planting (US$/Ha)	350	440
Annual Maintenance (US$/Ha/Yr)	125	60
Rotation (Yr)	21	7
Annual Yield (Cum/Ha/Yr)	15	25

Site Prep		
Scarification	Yes	Yes
Bedding	Yes	Yes
Initial Stocking Levels (stems/Ha)	1600	1350
Chemical Weed Control	At Planting	At Planting
Chemical Insect Control	At Planting/1st 3 yrs.	At Planting/ Every 2 yrs
Chemical Fertilization	No	At Planting
Pruning (yr)	For Sawlogs - 4 & 8	No
Thinning (yr)	7, 15	Cleaning in 2nd/3rd Rot.

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES

Brazil was selected as the site for the United Nations Conference on the Environment and Development in June, 1992, largely because it offers prime examples of the many environmental and development issues facing Third World countries, including deforestation. Approximately 20-30% of its tropical forest cover has been lost.

Since the 1960's, the Brazilian government has encouraged settlement and development of the country's forested interior to relieve the overcrowding and resulting squalor in the more populous eastern areas. Large-scale road-building and homesteading programs enticed people to move west. Small settlements gave way to large ranches. In the south, deforestation resulted from the exploitation of native forests for charcoal and clearing for agriculture. While deforestation has slowed over the past ten years, anywhere from 7 to 8 million hectares of forest continues to be cleared annually.

As previously noted, the charcoal industry is the major industrial wood consuming sector. Brazil has one-third of the world's iron ore reserves and its production of pig iron, steel, and iron alloy is expected to increase. Unless this industry shifts to imported coke and coal, or other energy sources, demand for wood fiber will continue to outstrip the supply from plantations and the current level of native harvests.

While it seems essential for Brazil to rely increasingly on plantations to relieve pressure on the native forests, environmental opposition on grounds of monoculture disadvantages and soil depletion is quite strong in some areas. In order to establish a forest plantation in Brazil, it is necessary to obtain a permit for the conversion of natural vegetation from IBAMA, the federal environmental agency. If the land in question has previously been disturbed by the activities of man (i.e. slash and burn agriculture), there is a good chance that conversion to forest or agricultural use will be approved. However, the conversion of tropical rain forest, or Atlantic rain forest in the latter stages of succession, is generally not permitted. Any new plantation scheme must also retain at least 20% of the area in natural vegetation (50% in the Amazon Legal Area), including streamside riparian zones of at least 30 meters. Although formal state approval is not required to establish plantations, tacit approval is necessary, as state governments through regulation and taxes, can seriously impact the profitability of an unwanted forestry operation.

Should the plantation also involve a primary manufacturing plant, other permits are required, as is a long term supply plan (PIFI) for facilities consuming more than 10,000 cum/year. This plan is intended to demonstrate that the operation will be self-sufficient from plantation forests, and not rely upon native forests for raw materials. According to law, all major consumers of native wood were supposed to have become self-sufficient from plantation forests by 1995. With the exception of the publicly owned steel industry, most have done so.

Although there is opposition to the expansion of plantations in Brazil, more stringent federal and state requirements concerning vegetative conversion activities, and increased ecological diversity within plantations, are expected to permit expansion where the economics can justify the investment. Strongest opposition to plantations seems to be within the more urban areas of the states of Sao Paulo, Espirito Santo, Rio de Janeiro, and Bahia. Plantations cannot compete economically with land uses such as urbanization, recreation, or efficient agriculture, and may therefore be targeted toward areas of less political resistance, and higher economic return.

Issues concerning tarde of tropical hardwood products have also emerged in recent years. A proposal is pending, vehemently opposed by Brazil's forest industry, to include mahogany under the Convention on International Trade in Endangered Species (CITES). Mahogany accounts for better than one-fourth of Brazil's hardwood lumber exports. The industry argues that the value it brings in foreign exchange serves as an incentive to improve management practices.

VI. *PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020*

Notwithstanding strong political and environmental pressure to reduce the heavy reliance on the native hardwood forests, they will continue to be a major source of energy for rural populations well into the next century, and continue to be part of the resource mix for the charcoal, sawmill, and board industries.

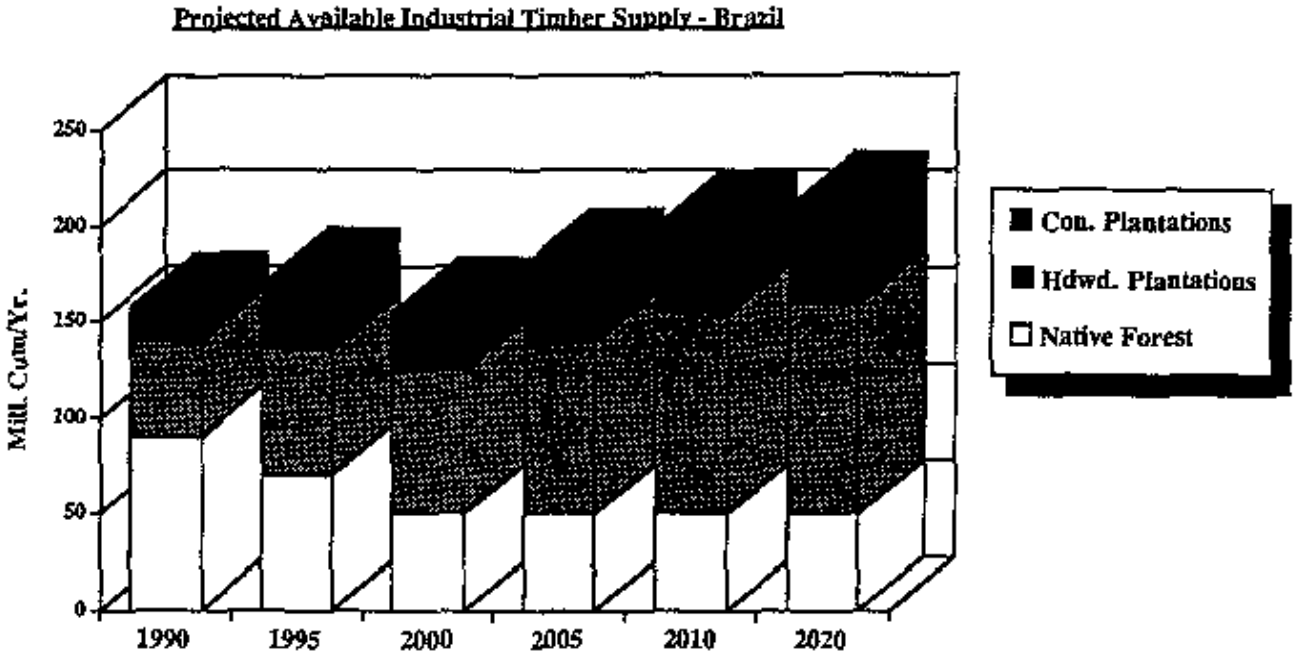
Plantation development has slowed since the major government incentive program was eliminated in 1986 and opposition to monoculture plantations and intensive use of herbicides and insecticides has caused them to be prohibited in some areas. However, unless timber/fiber supply from plantations can be significantly increased to meet growing demand, native forests will continue to be cleared.

Most of the new plantations are being established by the pulp and paper industry to support new or expanded capacity, or for export. The Brazilian pulp and paper industry is expected to expand rapidly over the next 10 to 20 years. By 2005, the area in plantations operated by the pulp and paper industry is expected to increase by 50%. All new capacity will be supported by plantations.

In contrast, the charcoal industry will continue to rely partly on wood fiber from native forests, even though its dependency on plantation wood will increase. The demand for wood fiber from the charcoal industry is expected to remain relatively stable even as the steel industry expands, its energy use shifting away from charcoal, to imported coal and coke.

Table 8 - Projected Timber/Fiber Availability for Industrial Uses (million cubic meters)

		Plantations		
Year	Native Forest	Hardwood	Conifer	Total
1990	90	50	17	157
1995	70	65	35	170
2000	50	75	30	155
2005	50	90	40	180
2010	50	105	45	200
2020	50	110	50	210



VII. REFERENCES

ABECEL - Technical and Economic Indices Concerning Pulp Industry Plantations.

ABRACAVE (Charcoal Industry Association), 1994 Yearbook, Sao Paulo, Brasil.

Associacao Nacional dos Fabricants de Papel e Celulose - "Resource Statistics - 1994", GT-7

Cottle, Laura E., and Gerard F. Schreuder. "Brazil: A Country Profile of the Forests and Forest Industries," CINTRAFOR, Univ. of Washington, Working Paper 27, 1990.

FAO Forestry Paper 112. Forest Resources Assessment 1990: Tropical Countries. Rome.

Machado, Carlos Cordoso; Paulo de Souza, Amaury (Editors), "2nd Annual Symposium Concerning Forest Harvesting and Transportation" (Sic), December, 1995, Bahia, Brasil. (In Portuguese)

McNabb, Ken, Joao Borges, and John Welker, "Jari at 25: An Investment in the Amazon," Journal of Forestry, February, 1994.

Pandey, Devandra. "An Assessment of Tropical Forest Plantation Resources." Uppsala: Swedish Univ. of Ag. Sciences, Dept. of Forest Survey. Oct. 1992.

Sociedade Brasileira de Silvacultura " A Sociedade Brasileira e Seu Patrimonio Florestal", 1990

Suchek, V.I. 1991. "The Role of the Planted Forest in the Pulp & Paper Industry of Brazil," in The Forestry Chronicle, Vol. 67. No. 7.

USDA Foreign Agricultural Service, ATO Reports, "Annual Forest Products Report", October 1994.

US DOC, "Developing Competitive Forest Products: Brazil," Undated Report.

Wood Resources International Ltd., "Wood Resource Quarterly" January 1990, and July 1995, estimates and in-house files.

Profile of Forest Resources and Forestry Practices

British Columbia

I. GENERAL STATISTICS

Table 1 - Land & Forest Area

Total Land Area (ha)	94,780,000	
Forest Area (ha)	57,780,000	(61%)
Est. Production Forest (ha)	24,000,000	(25%)

Table 2 - Forest Land Ownership

	(000 ha)	(%)
Federal/Province	55,780,000	(96.5%)
Private	2,000,000	(3.5%)
Total	57,780,000	(100.0%)

Table 3 - Productivity

	Conifer	Hardwood	Total
Net Annual Growth-AAC (million cum)	78.2	3.0	81.2
MAI per hectare (cum/ha/yr)	2.56	N/A	2.56
1993 Harvest (million cum)	77.8	1.4	79.2

Area of Industrial Plantations: An estimated 2-3 million hectares have been reforested by planting.

II. FOREST RESOURCES

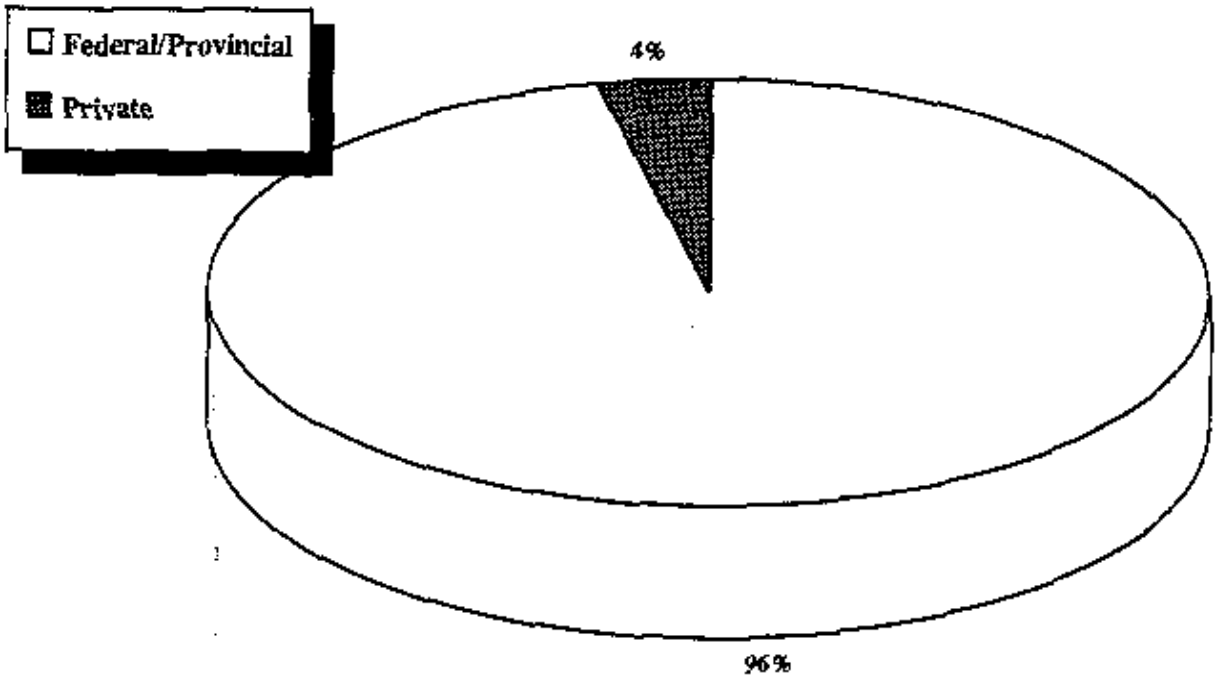
British Columbia holds some of the most extensive old-growth and mature forests in the temperate/boreal zone. While over 60 percent of the Province is covered by forest, less than 50 percent, or 45 million hectares, is classified as stocked, non-reserved productive forest. Of this, 24 million hectares is considered to be economically accessible, and is thus defined as the "current forest harvesting land base." In reality, of the 24 million hectares of this productive forest, only half is considered to be potentially available for harvest at the current time. The remaining area consists of immature and poorly stocked stands potentially suitable for producing fiber in the future.

British Columbia's forests are divided into two distinct zones: coastal and interior. In the coastal forests, hemlock is the predominant species, followed by western red cedar, true firs, Douglas fir and spruce. The main conifer species in the interior, a region which accounts for over 65% of British Columbia's timber harvest, are lodgepole pine, spruce and true firs.

Less than 50% of the 24 million Ha. of economically accessible productive forests in British Columbia can be defined as "original forest", and only a portion classify as "old growth". Due to average rotations in excess of 75 years, and the relatively recent development of the regional forest product industry, most planted and naturally regenerated "second growth" forests have yet to reach maturity. An exact breakdown of land, and forest age classifications for British Columbia is beyond the scope of this profile. However, it is estimated that "original forests" are found on between 40-45 million Ha., including approximately 11 million Ha. of economically productive forests, currently designated for industrial harvesting purposes. Generally immature, second growth forests occupy approximately 15 million Ha., including 12 million Ha. of economically accessible productive forestlands managed for industrial timber production purposes. Other second growth forests are found on private lands, and in recently created reserves. The total area of parks and set-asides, in which no harvesting is permitted, is approximately 11 million Ha.

Ownership of the forest land is almost exclusively public. The British Columbia Provincial Government, or Crown, owns 96.5 percent of the forest land. This includes about 1 percent that is controlled by the Canadian government. Private owners -- either forest industry or non-industrial -- own the remaining 3.5%. An assortment of Native Indian land claims have been filed covering most of the Province. A process has been initiated by which these claims will be heard, but it is likely to be a matter of many years before this issue is resolved.

Forest Land Ownership - British Columbia



Because of climate and topography, the average timber rotation in British Columbia is in excess of 75 years, and the quality of mature standing timber is quite high. The average net annual growth for conifer is approximately 2.6 cubic meters per hectare. According to recent inventories, the standing volume on all forestlands in British Columbia is estimated at 8.6 billion cubic meters. Conifer species account for 96% of standing volume, with hardwood (mostly Populus species), accounting for the balance. The volume of standing timber by volume and species is as follows.

Table 4 - Standing Volume on all Forest Lands by Species

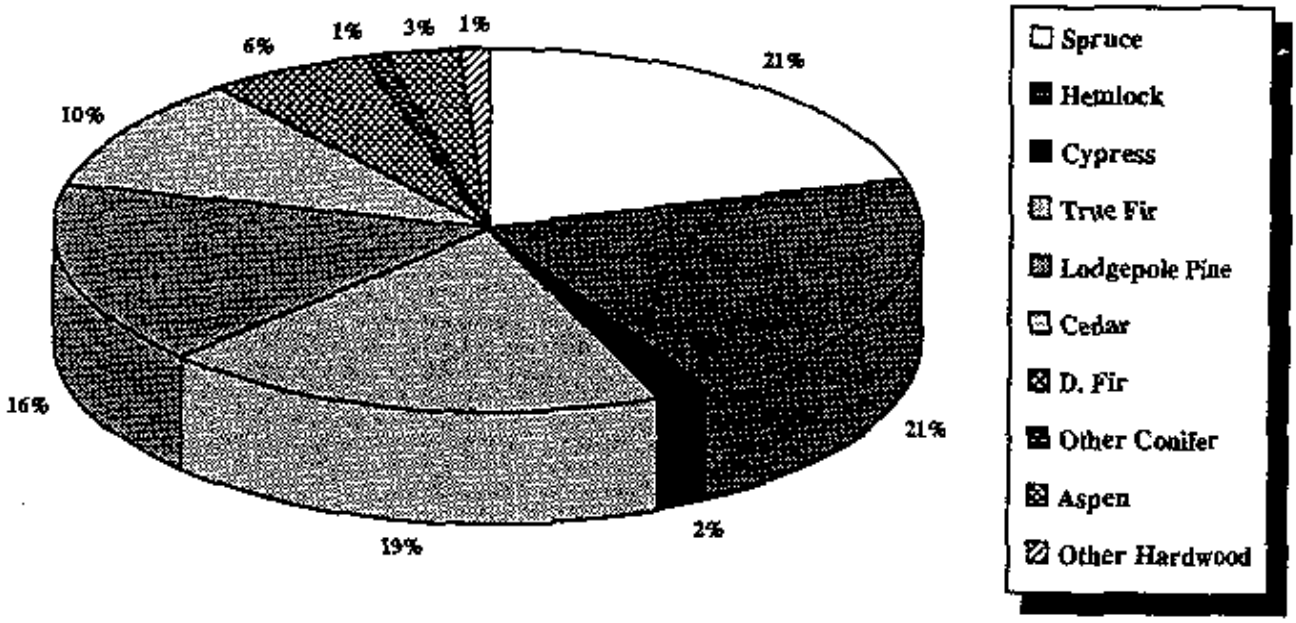
	Coastal		Interior		Total B.C.	
	(mill. cum)	(%)	(mill. cum)	(%)	(mill. cum)	(%)
Spruce	146	4.8%	1,625	29.4%	1,771	20.6%
Hemlock	1,235	40.3%	584	10.6%	1,818	21.2%
True Firs	497	16.2%	1.131	20.5%	1.628	19.0%
Lodgepole Pine	23	0.8%	1,386	25.1%	1,409	16.4%
Red Cedar	703	23.0%	173	3.1%	876	10.2%
Douglas Fir	276	9.0%	260	4.7%	536	6.2%
Cypress	158	5.2%	5	0.1%	163	1.9%
Other Conifer	7	0.2%	55	1.0%	62	0.7%
Total Conifer	3,045	99.5%	5,218	94.4%	8,263	96.2%
Aspen	1	0.1%	227	4.1%	228	2.7%
Cottonwood	4	0.1%	49	0.9%	54	0.6%
Other Hardwoods	11	0.4%	33	0.6%	45	0.5%
Total Hardwoods	16	0.5%	309	5.6%	325	3.8%
Total All Species	3,061	100.0%	3,527	100.0%	8,588	100.0%

III. CURRENT LEVEL OF UTILIZATION

British Columbia's economy is heavily dependent on its forest-based industries. The forest industry accounts for 28 percent of the province's GDP, and 46 percent of total manufacturing shipments. In 1993, British Columbia's forest industries shipped $13.5 billion of products to domestic and export markets. A large share of British Columbia's softwood lumber production is exported to the United States.

The British Columbia Provincial Government divides the Province into 37 timber supply areas and 34 tree license areas. Under provincial law, the Chief Forester is responsible for determining an allowable annual cut (AAC) for each area, and for the Province as a whole. Under terms of the licenses entered into by forest companies, the AAC remains in effect for five years. The law permits operators to vary the harvest by as much as 50 percent in any given year, as long as they remain within 10 percent of the prescribed AAC over a five-year period.

Species Distribution by Volume - British Columbia



A comparison of current AAC's, and 1993 harvests yields the following estimates of Growth/Drain relationships for the Province.

	Conifer	Hardwood
Est. Annual Allowable Cut (mill. cum)	78.2	3.0
1993 Harvest (mill. cum)	77.8	1.4
1993 Growth/Drain Ratio	1.01	2.14

The AAC concept has evolved and changed over time. Originally determined from biological growth and yield data to ensure sustained yield, the AAC has become more policy-driven and is now heavily influenced by ecological and other considerations. As a consequence of pressures to reform forestry practices, and as a result of a major timber supply review still in process, the Ministry of Forests has been lowering the AAC's of licenses scheduled for renewal. Currently, the province has set the conifer AAC at 78.2 million cubic meters: 71.3 million cubic meters for Crown lands and 6.9 million cubic meters for private lands.

The importance of British Columbia's forestry sector cannot be overemphasized. British Columbia accounts for 45 percent of the total Canadian timber harvest and about 6 percent of the world's softwood harvest. The province accounts for 46 percent of Canadian market pulp shipments, 60 percent of the country's lumber production, 18 percent of its newsprint, 30 percent of its total pulp production, and 85 percent of its plywood production. Production of major forest products for 1993 is seen in Table 5.

Table 5 - Production of Wood and Paper Products, 1993

Lumber (000 cum)	33,945
Plywood & Panels (000 cum)	1,523
Wood Pulp (000 tons)	7,041
Paper & Paperboard (000 tons)	3,057

The Province's approximately 270 sawmills and plywood mills are the largest consumer of roundwood, consuming approximately 65 million cubic meters. Production is generally focused on dimension lumber for the North American construction market, with a small percentage of sales into the Pacific Rim and Western Europe.

The 27 pulp and paper mills in the Province secure 80%+ of their wood fiber requirements from sawmill and plywood mill residues. In 1993, approximately 9 million bone dry tons, or 26 million cubic meters, of mill by-products were consumed by the wood pulp industry. Whole tree chips and pulpwood logs account for the balance of the industry's wood fiber requirements -- between 6 and 7 million cum. On a fiber basis, the pulp industry consumed 42% of the wood consumed by the B.C. forest product industry in 1993.

Table 6 - Fiber Consumption by Industry

Pulp/Paper Industry	42%
Solid Wood Industry	51%
Fuelwood	5%
Export& Other	2%

Pulp production totaled 7.0 million tonnes in 1993, while paper production totaled 3.0 million tonnes. Newsprint is the dominant paper grade produced, accounting for 63 percent of paper production. Being distantly removed from major urban centers, British Columbia is geographically ill-positioned to take advantage of recycling. Nevertheless, the industry has been increasing its recovered paper consumption. In 1993, 3.5 million tonnes of recovered paper was consumed by the industry.

Chip supply for wood pulp producers has become an increasingly critical problem as lumber production, and hence availability of sawmill residues, has declined. A "chip crunch" emerged in late 1994, as pulpmills substantially increased operating rates only to find that wood residue supply was not sufficient to meet demand. Producers have been importing pulpwood and chips from Alberta and Alaska, while others have considered the import of wood from the U.S. South, or plantation fiber from South America.

Allocation of Roundwood Harvest

British Columbia accounts for about half of Canada's total timber harvest. In 1993, the timber harvest in British Columbia totaled 79.2 million cubic meters including 72.4 million cum from Crown land, 6.6 million cum from private land, and 0.2 million cum from federal and native reserves. According to B.C. Ministry of Forests data, timber harvesting was conducted on approximately 196,601 hectares of Crown lands and on 24,998 hectares of private lands in 1993.

Over the past decade, annual harvests have declined. During the five-year period 1989-93, B.C. forest industry harvested an average of 78.5 million cubic meters per year, considerably lower than the production peak of 1987 when 90.6 million cubic meters were harvested. Over 90 percent of the harvest is in sawlog or veneer-suitable material, the balance being used for pulpwood or fuelwood.

Many lumber producers, faced with curtailments in log supply from within the Province, have begun to extend their procurement regions into neighboring Provinces. Approximately 2 million cubic meters were imported from Alberta and the Prairie Provinces in 1993. Generally, log exports are permitted

only when a surplus of logs for B.C. milling needs exist. Thus, log exports are minimal; only 1.3 percent of all logs harvested in B.C. were allowed to be exported in 1993.

Table 7 estimates the use of roundwood harvested in 1993 by industry sector.

Table 7 - Estimated Industrial Roundwood Use - 1993
(million cum)

Industry Sector	Conifer	Hardwood	Total
Sawmills	61.0	Neg.	61.0
Plywood & Panels	3.0	1.0	4.0
Pulp Industry	6.7	.4	7.1
Other Uses	7.1	Neg.	7.1
Total	77.8	1.4	79.2

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

Crown and private forests in British Columbia are generally managed on an even-aged, sustained yield basis over rotations between 60-80 years. Traditionally, stands were allowed to naturally regenerate, and were not thinned or chemically treated for the duration of the rotation. Until recently, less than adequate attention was given to reforestation and timber stand improvement activities. As a result, over 1.3 million hectares of productive forest land is considered to have less than satisfactory stocking. Recent legislation requires that these lands be reforested by the year 2000, and that all newly harvested areas be reforested either through planting or natural regeneration. Some 184,823 hectares were planted in 1994, including lands that were unsatisfactorily stocked. Forest type and site conditions allow about half of the harvested areas to be regenerated naturally.

Typical harvesting practices vary between the coast and interior regions. In the coastal region, well over 90 percent of all logging is done using high-lead logging systems appropriate for the higher slopes and larger timber. Conventional tracked or rubber-wheel skidders are typically used for harvesting in the Interior, where log sizes are smaller and the terrain more level.

While clear-cutting is the most prevalent harvesting system, other conventional silvicultural systems such as selection, seed-tree and shelterwood are also used. As environmental pressures increase in sensitive areas, these alternative harvesting systems are being employed more frequently.

Over the past 10 years, more attention has been given to reforestation. Provincial law now requires forest companies to reforest cut-over land within 3 to 5 years after harvest. Planting has increased significantly as have seedling survival rates which now stand at 87 percent, up from 60 percent a decade ago. Although planted forests in British Columbia cannot be considered industrial plantations in the same sense of Eucalyptus plantations in Brazil, or Radiata pine plantations in Chile, the parameters of planted forest management in the British Columbia interior are outlined for comparative purposes.

Table 8 - Industrial Planted Forest Parameters

	Conifer
Land Costs (US$/Ha)	1100
Site Prep & Planting (US$/Ha)	325
Annual Maintenance (US$/Ha/Yr)	N/A
Rotation (Yr)	65-175
Annual Yield (Cum/Ha/Yr)	1.2-4.5
Site Prep	
Scarification	Yes
Bedding	No
Initial Stocking Levels (stems/Ha)	1300-1600
Chemical Weed Control	Yes
Chemical Insect Control	Yes
Chemical Fertilization	Trial Basis, Yr. 10-15
Pruning (yr)	Minimal
Thinning (yr)	Minimal: Pre-Com. Yr. 10-15, Com. Yr. 60-70

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES

Since the late 1980's the land-use and forest management practices of British Columbia have come under considerable scrutiny from many quarters. Among the most vocal, have been Non-Governmental Environmental Organizations such as Greenpeace, which have mounted intensive campaigns to stop harvesting operations on Vancouver Island, and along the B.C. coast. Although species preservation and harvesting methods (clear-cutting) became part of the debate in British Columbia, the principal environmental issue was one of ecosystem preservation; the harvesting and conversion of "original" coastal forest, to planted or naturally regenerated second growth forest.

Much of this debate focused on the Clayqout Sound region of Vancouver Island. This area has been a popular recreational site for those seeking an escape from the more populated southern coast of Vancouver Island. A National Park was created in the 1950's within an area of long-term timber concessions, and private forest industry holdings. As harvesting operations expanded in the region in the 1980's, an on-going dispute between those wanting to preserve "original coastal forests", and logging interests became a national and international conflict. In the early 1990's, the forests in the region were reclassified, increasing the area of preserved forestlands, and the area under "integrated forest management".

At the time, several attempts were made by the Provincial government to create a consensus for management of the area on a basis acceptable to all parties. One such forum was called the Clayqout Scientific Panel. Among its recommendations was the virtual elimination of clear-cutting in the region, and acceptance of forest management based on a "variable retention system". This may be described as a precursor to "landscape" forest management, in that the retention of selected non-timber forest attributes are used to determine the level of timber removals that is acceptable within time and spacial parameters. Some of these concepts have become fundamental to revisions in land-use and forest management policies in the Province, and throughout N. America.

Although the Provincial government responded to the Clayqout Sound controversy, mounting political pressure led to a reassessment of land-use and forest management practices on a Provincial basis. The result has been a series of new policies and programs designed to redefine forest management. Although some have yet to be fully implemented, a review of the primary initiatives is in order.

Commission on Resources and Environment (CORE):

This commission was established in 1992 to review land use strategies on a Provincial basis, and to resolve specific land use conflicts. The Commission focused first on three high conflict areas, including Vancouver Island. Preliminary results from this initial effort included a division of commercial forestland into three classifications, differentiated by the level of forest management intensity permitted.

Protected Areas Strategy

This initiative was also created in 1992 with the intention of doubling the preserved land area in the Province from approximately 6%, to 12%. As of 1994, approximately 60 new set-aside areas have increased the protected land area to approximately 9%.

Forest Practices Act

This legislation, passed in 1993, will create a unified Forest Practices Code for the entire Province, and will establish several new administrative entities responsible for implementing new standards and guidelines, and for enforcement. While the new code standardizes forest management practices, it also expands the regulation of silvicultural activities through new streamside management, bio-diversity, and landscape management regulations, and new standards for silviculture activities in environmentally sensitive areas.

Timber Supply Review

As part of the Forest Act of 1992, a complete review is being undertaken of all 36 Timber Supply Areas (TSA), and 34 Tree Farm Licenses (TFL), in British Columbia to determine the appropriate level of AAC. The process is complex, and incorporates 5 steps leading to a determination by the Chief Forester of a new AAC for each TSA and TFL. In theory, the entire process will be completed for TSA's by the end of 1995, and repeated every 5 years as an on-going adjustment of Provincial timber supply.

Forest Renewal British Columbia

This program was born out of the stumpage increases of 1994 and, if lumber prices remain above US$ 250/thousand board feet, will be funded by industry to a level of approximately $C 400 million per year. These funds are targeted for Land and Resources (50%), Workforce (20%), Environment, Community Stability, and Value-Added Manufacture. There is considerable debate/uncertainty concerning the specifics of the Forest Renewal B.C. program. It has been described as compensation to forest based communities for the mandated reduction of timber supply. The next 3-5 years will determine if this is a fair assessment.

As in other regions of North America, forest health is a perennial concern. Some 13.7 million cubic meters are lost to insects and diseases annually, and another 2.7 million cubic meters are lost to fire. Currently, epidemic infestations of mountain pine beetle and spruce budworm in the interior forests are causing significant damage.

The B.C. industry produces a significant volume of bark and residues which go unutilized. After 1996, environmental regulations will prohibit burning in most areas, so other disposal options are being considered. The feasibility of a wood-fired power plant is being explored. A leading manufacturer, Fletcher Challenge Canada, has announced plans for a new pulp mill that would use sawdust as furnish. It would replace an existing long-fiber mill.

VI. PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020

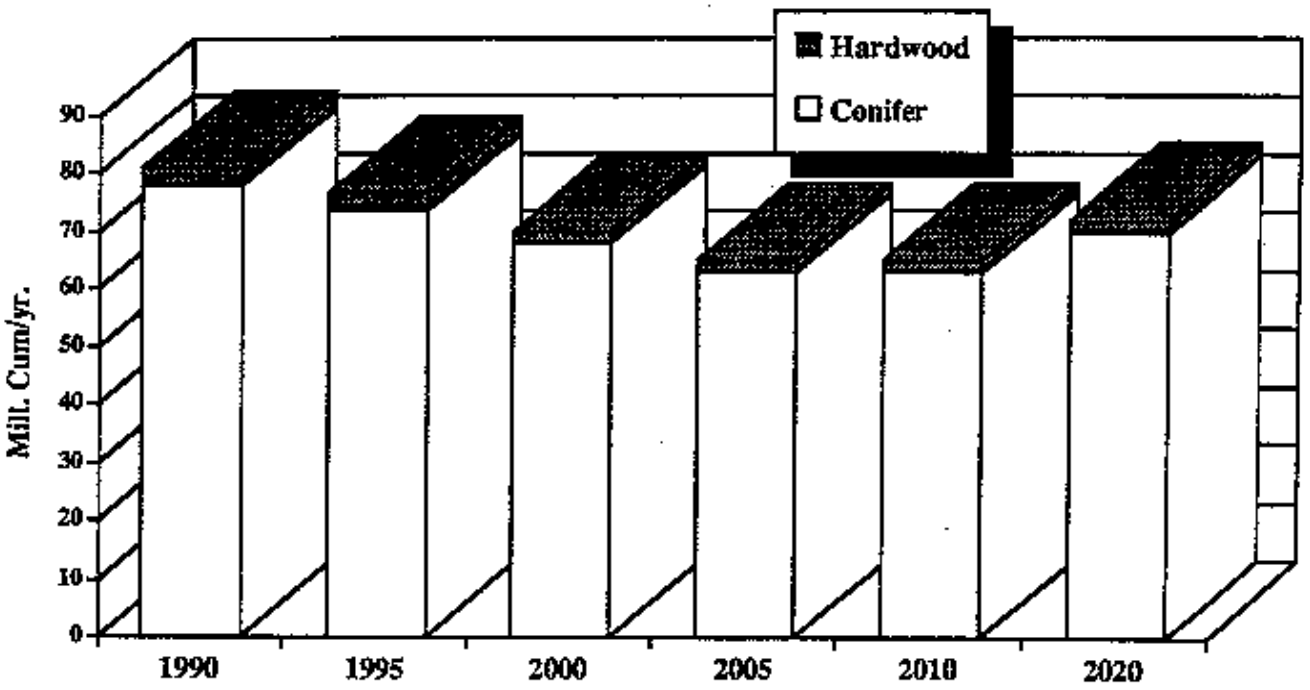
Despite the vast conifer resources of British Columbia, the region's forest industry is projected to undergo a contraction in response to changes in government forest policy. The AAC for the Province is likely to decline by 18 to 20 percent, from nearly 80 million cubic meters to no more than 65-68 million cubic meters by 2015, if not sooner. Under such a scenario, contractions in both the solid wood and pulp industries are inevitable. New Forest Practice Code guidelines for protecting riparian zones and habitat are likely to reduce the AAC even further, by an additional 5-10 percent. Additional land set-asides are also likely to be made. Enhanced management will enable a modest increase in output later in the forecast period.

Unlike other regions where hardwood usage will increase in response to diminishing conifer supply, British Columbia's hardwood resource is limited. However, the use of aspen for bleached kraft pulp and oriented-strand board provides an impetus to further exploit hardwood resources. Hardwood production in 1993 totaled 1.4 million cubic meters. Although hardwood availability will decline, consumption is projected to increase slightly over the forecast period.

Table 9.- Projected Timber/Fiber Availability
(million cubic meters)

Year	Conifer	Hardwood	Total
1990	78.0	3.0	81.0
1995	73.5	3.0	76.5
2000	68.0	2.0	70.0
2005	63.0	2.0	65.0
2010	63.0	2.0	65.0
2020	70.0	2.0	72.0

Projected Available Timber Supply - British Columbia



VII. REFERENCES

British Columbia Ministry of Forests, "British Columbia Forest Practices Code: A Summary of Draft Regulations and Proposed Standards", FS245J, May 1994.

British Columbia Ministry of Forests, "Stumpage Appraisal Information Paper", Jan. 1, 1991.

Canadian Forest Service, "Background Report on Timber Supply in Canada for Canada/U.S. Softwood Lumber Consultations," Unpublished paper. 1995.

Coast Forest and Lumber Association, Coastal Connections", January & March 1995, Vancouver, British Columbia.

Council of Forest Industries of British Columbia. "British Columbia Forest Industry Fact Book - 1994.

Gilfillan, Brian D., "Recent Changes in B.C. Forest Policy: Renaissance or Requiem for Competitiveness?," Council of Forest Industries of British Columbia. Undated.

Government of British Columbia, "British Columbia's Forest Renewal Plan".

H.A. Simons, "The Wood Products Industry in British Columbia, The Next Twenty Years", September 1992.

NLK Consultants, "The Pulp and Paper Sector in British Columbia. The Next Twenty Years," Prepared for Canada-British Columbia Partnership Agreement on Forest Resource Development. 1992.

Pedersen, Larry (Chief Forester - British Columbia Ministry of Forests), "Fibre Supply: Constraint or Opportunity", Presentation, April 1995.

Wood Resources International Ltd., "Wood Resource Quarterly", April 1995, estimates and in-house files.

Profile of Forest Resources and Forestry Practices

Germany

I. GENERAL STATISTICS

Table 1 - Land & Forest Area

	West	East	Total	
Total Land Area (000 ha)	24,412	10,522	34,934	
Forest Area (000 ha)	7,552	2,938	10,490	(30%)
Est. Production Forest (000 ha)	7,490	2,800	9,400	(27%)

Table 2 - Forest Land Ownership

	West		East		Total Germany	
	(000 ha)	(%)	(000 ha)	(%)	(000 ha)	(%)
State	2,266	30%	1,243	42%	3,509	33.5%
Local Entities	1,812	24%	253	9%	2,065	19.7%
Private	3,474	46%	1,442	49%	4,916	46.9%
Total	7,552	100%	2,938	100%	10,490	100.0%

Table 3 - Productivity

	All Forests
	Total
Net Annual Growth (million cum)	61.5
MAI per hectare (cum/ha/yr)	5.9
1993 Harvest (million cum)	28.0

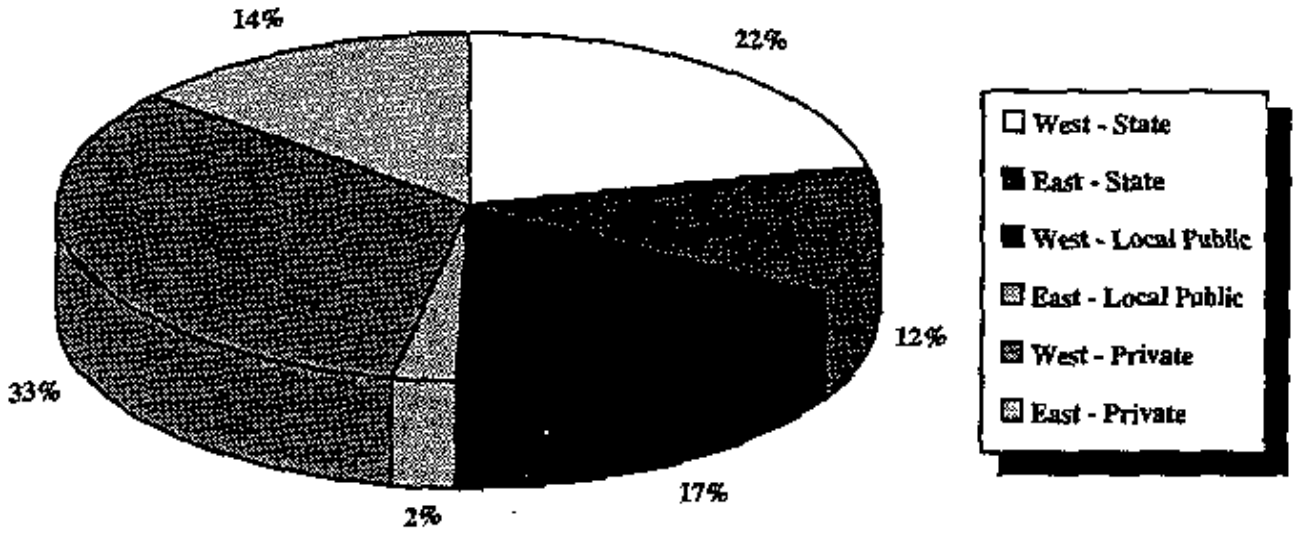
Area of Industrial Plantations: An estimated 5 million hectares have been reforested by planting.

II. FOREST RESOURCES

A forest inventory for a unified Germany is not yet available. Thus, information on the west is more complete than for the east. The government has moved quickly to return appropriated land in eastern Germany to the original owners or their heirs, but ownership disputes will linger for many years. Currently, the 10.5 million hectares of forests of the unified Germany are owned 33% by state governments, 20% by community jurisdictions and 47% by private individuals and entities. Except for forest land on military reservations, the federal government is not a significant forest land owner. Although the intensity

of utilization varies with ownership and other factors, most forests in Germany produce some roundwood on an industrial basis.

Forest Land Ownership - Germany



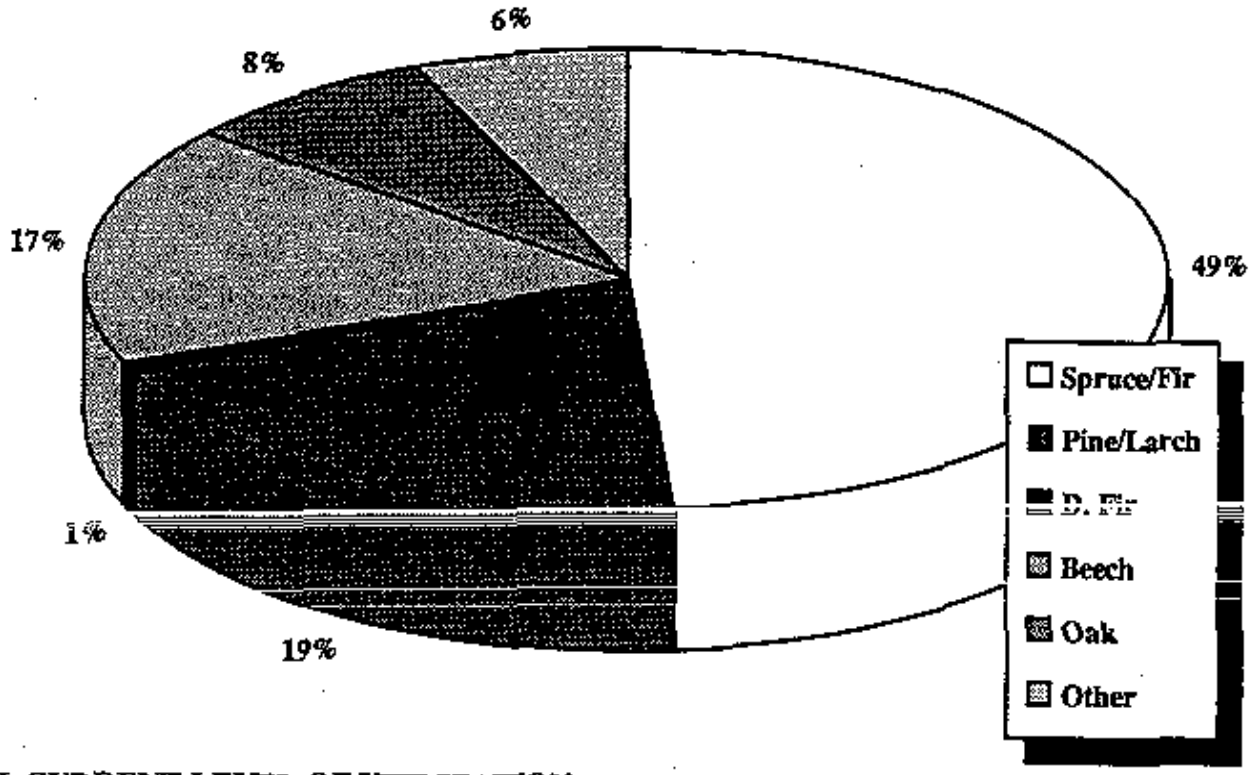
Commercial forests are classified as being either high forests (97%), selection forests (1.5%), coppice forests (1%), or composite forests (<1%). Forest management patterns are fairly uniform throughout western Germany, irrespective of ownership. Growing stock averages 300 cubic meters/hectare in the west. The situation in the east is somewhat different. Average stocking level of the eastern forests is estimated to be 200 cubic meters/hectare. Nevertheless, per hectare inventory is very high in Germany compared with temperate forests in other countries, the result of dense stocking and long rotations.

The most prevalent forest type is spruce/fir, followed by pine/larch, and mixed hardwoods of beech and oak. Douglas fir and other species can also be found. Total growing stock is estimated to be 2.7 billion cubic meters, of which 2.2 billion cubic meters is in the west. The most recent forest inventory covering western Germany shows that the majority of forest stands (58%) are of single-species composition or mixed composition. Only a small percentage (less than 10%) of other species are generally present in mixed forests. Of the forests in western Germany, approximately 17.7% are comprised exclusively of spruce.

Table 4 - Species Distribution by Volume

	East		West		Total Germany	
	(mill. cum)	(%)	(mill. cum)	(%)	(mill. cum)	(%)
Spruce/fir	248	48.4%	1,086	49.0%	1,334	48.9%
Pine/Larch	127	24.8%	402	18.0%	529	19.4%
D. Fir	----	----	19	1.0%	19	.7%
Beech	57	11.1%	407	18.0%	464	17.0%
Oak	33	6.4%	176	8.0%	209	7.7%
Other	46	9.0%	128	6.0%	174	6.4%
Total	511	100.0%	2,218	100.0%	2,729	100.0%

Species Distribution by Volume - Germany



III. CURRENT LEVEL OF UTILIZATION

Timber/fiber yields vary between west and east Germany. The average yield from harvested stands in western Germany is approximately 117.7 cum per hectare, compared with 68.0 cum per hectare in the east. Lower yields in the east are a consequence of poor management practices under the communist government, including high-grading and lack of attention paid to reforestation. Heavy processing of resins has also lowered the quality of 25% of the pine/larch stands in eastern Germany. These trees are no longer of sawlog quality but could be used for chips or other lower value products.

German roundwood harvests totaled 27,958,000 cubic meters in 1993. Actual domestic log consumption was 4 million cubic meters higher because of the utilization of material that was removed from wet storage. In 1990, a severe windstorm blew down 74 million cubic meters of standing timber. About 12.4 million cubic meters of this volume was salvaged and placed in wet storage. This inventory has been slowly drawn down and is now largely depleted. Market prices for timber and wood fiber have been depressed until recently, in part because of the availability of salvaged wood.

The total annual growth in western Germany is estimated to be 61.9 million cubic meters, or an average of 5.9 cubic meters/hectare. Given removals of 28 million cubic meters, there is a very significant surplus of growth over harvest (growth/drain ratio of 2.2:1), and a comfortable margin of annual allowable cut over harvest as seen below.

	Conifer	Hardwood
Est. Annual Cut (million cum)	35.3	12.7
1993 Harvest (million cum)	21.7	6.2
1993 AAC/Drain Ratio	1.63	2.05

Germany is the largest producer of sawnwood in Europe if both conifer and hardwood products are taken into consideration. Conifer lumber production rivals that of Sweden, and hardwood lumber production is the second highest in Europe - behind neighboring France. It is estimated that 75% of domestic demand is met by domestic production, with imports, primarily from Scandinavia, supplying the balance.

The sawmill industry consumed an estimated 21 million cum of roundwood in 1993; 92% of which was conifer. About 2,800 sawmills operate in Germany, 400 in the east and 2,400 in the west. Those in the east tend to be much less efficient, although they are modernizing quickly with investments from established western German companies and foreign investors. Historically, German sawmills have enjoyed a captive market in Germany since most construction work was performed on a custom basis requiring made-to-order sizes. This is beginning to change as European-wide standards begin to have an impact in the market.

The panel industry is also a significant user of roundwood in Germany, consuming over 5 million cubic meters of roundwood in 1993. Production of hardboard, particleboard, and medium density fiberboard also relies heavily on sawmill residues and slabs for raw material supply.

The German paper industry is highly regarded and was once considered the premier paper maker of Europe. However, competition from Scandinavia and other producers has partially eroded this position. The industry is heavily dependent on imported market pulp, and despite surpluses of wood fiber, has decreased its production of wood pulp by as much as 10% since 1990.

The pulp and paper industry uses roundwood for about 60% of its raw wood furnish. Consumption totaled approximately 5 million cubic meters of roundwood in 1993. Pulpwood in Germany is primarily comprised of thinnings, prunings and low-grade logs unsuitable for lumber.

Table 5 - Production of Wood and Paper Products, 1993

Lumber (000 cum)	14,142
Plywood & Panels (000 cum)	8,920
Wood Pulp (000 tonnes)	2,474
Paper & Paperboard (000 tonnes)	13,034

Allocation of Roundwood Harvest

As previously mentioned, the 1993 roundwood harvest in Germany was approximately 28 million cum. Industry consumption was 32 million cum, inclusive of 4 million cum of salvaged material from the 1990 wind storms. About two-thirds of the German harvest is comprised of conifer species, the majority of which is utilized by the sawmill industry to produce construction lumber. Oak and beech are the principal hardwood species harvested.

Table 6 - Estimated Roundwood Use - 1993
(Mill. cum)

Industry Sector	Conifer	Hardwood	Total
Sawmill Industry	19.3	1.7	21.0
Pulp Industry	3.9	1.2	5.1
Panel Industry	2.0	2.9	4.9
Other	.5	.5	1.0
Total	25.7	6.3	32.0

Germany has one of the highest paper recycling rates in the world, having recently reached 54%. For some grades, notably for newsprint and hygiene paper, the recycling rate has more than doubled in four years. The high recycling rate has had a tempering effect on wood demand. According to one source, each 1% increase in the German recycling rate reduces demand for wood by 200,000 cubic meters annually. Further increases in recycling are likely to be much smaller. German law now also requires the recycling of particleboard and fiberboard, and recycling of used furniture is under discussion.

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

Modern silvicultural practice originated in Germany, so German forests have generally been under purposeful management for hundreds of years. Management plans are required of all forest landowners with holdings larger than 30 hectares, with more detailed plans required for holdings greater than 70 hectares. In most cases, even ownerships smaller than 30 hectares are managed in conjunction with neighboring lands. Local foresters are responsible for management activities on state and community forest lands and often for private lands as well. Afforestation and silvicultural practices are heavily subsidized and landowners benefit from generous tax treatment of timber management activities. A well-developed infrastructure of forest roads on both public and private land is maintained by the state.

Plantations do not exist in the same sense as in the United States, the Nordic countries, or in tropical areas. Although German forests are often under-planted prior to a final harvest, they are primarily managed using an uneven-age management approach with rotations that stretch as long as 100-120 years for spruce and pine, 120 years for beech, and 160 years for oak. Somewhat shorter rotations are used for larch and Douglas fir. A typical management regime involves dense initial stocking of 2,500 to 3,000 seedlings per hectare, fertilization and several thinnings over the course of the rotation. The German forestry philosophy favors the production of quality sawtimber over economic considerations, a preference that is reflected in afforestation subsidies that are 33% more generous for hardwood than for conifer, and in rotations that defy economic justification.

Germany's afforestation program is geared toward establishing new forest stands on 10,000 hectares annually, and is targeted at regions with the lowest forest cover. The German government subsidizes the afforestation of land by providing annual payments for 20 years (current rate is approximately $910 per hectare per year). The government pays up to $4,500 per hectare toward stand establishment costs of conifer stands, and up to $6,100 per hectare if a parcel contains at least 75% hardwood. Additionally, incentives in the form of annual payments are available for the conversion of marginal agricultural land to forest use.

It is generally illegal, except in salvage operations, to clear-cut an area larger than 1-2 hectares in Germany. Harvests can generally be described as selection cuts, shelterwood cuts, and group clear-cuts. As a result of the low volume usually produced on a per-hectare basis, the global movement toward mechanization of harvesting operations has not made much headway in Germany. Although there is a strong move toward the use of private contractors, even on State forestlands, the suitability of mechanized equipment is a subject of considerable debate. Systems would have to be tailored to thinnings and selection harvests, on small tracts, and in accordance with strict regulations with respect to soil and aesthetic disturbances.

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES

In 1990, severe wind storms blew down 72 million cubic meters of standing conifer timber -- 3.5% of Germany's total inventory. The wind damage evoked concerns about monoculture forests, particularly single-species stands based on spruce, which tends to be shallow rooted, and susceptible to windthrow. The enormous loss of mature conifer forests supported arguments that harvested areas should be planted with a mix of both conifer and hardwood trees - policies which have generally been embraced by German reforestation subsidy programs. The balance, of course, is to plant commercially acceptable species, in economic stand sizes, while maintaining biological diversity.

Germany also offers a classic example of the plight of industrial forest management in affluent countries. The enormous annual surplus of timber that could be harvested on a sustained yield basis, is not being utilized due to the fact that a significant number of landowners do not depend on timber income for support, and do not wish to initiate harvesting operations. At the same time, Germany continues to be a significant net importer of finished and semi-finished forest products, and significant roundwood based production capacity expansion is unlikely.

The German government issues an annual forest damage report. Significant needle/leaf loss has been observed in 1 of every 4 trees in recent years. Oak damage has been particularly high with 45% of trees affected. Recent studies show 16% of forests in western Germany and as much as 35% of the forests of eastern Germany have been damaged from heavy concentrations of nitrogen in forest soils. Regulations on emissions of industrial air pollutants, particularly sulphur dioxide, are being strengthened. Bark beetle and gypsy moth damage are also problematic in some areas.

VI. PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020

The German forest products industry seems to be going through a transition that is likely to affect how wood fiber and forest products are sold and used in the marketplace, but not likely to alter patterns of forest management and use. German forests, particularly those of eastern Germany, are still relatively young by German standards, and have not yet attained a normalized age class distribution. The move toward the planting of hardwood will begin to impact the species composition of German forests early in the next century.

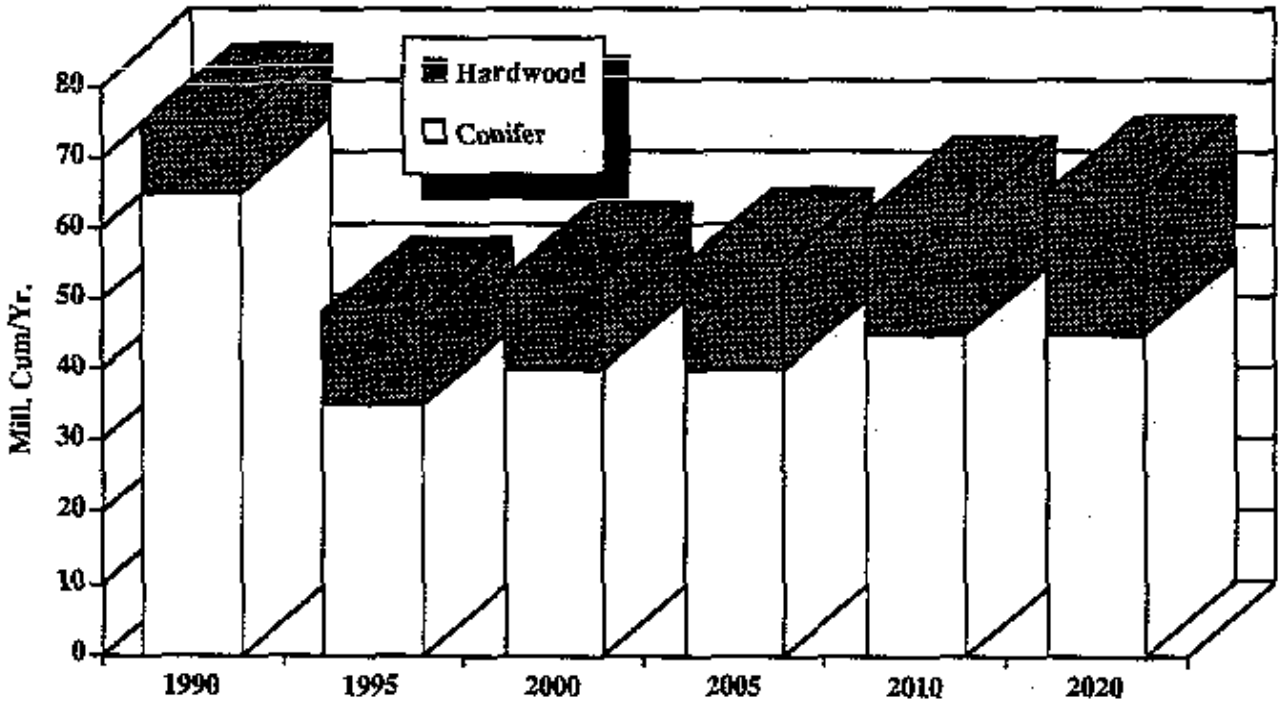
The assimilation of eastern Germany and the ascension of Sweden, Finland and Austria into the European Union will each have some affect on timber and fiber flow. Imports of finished products from Sweden and Finland will likely increase, but total demand on Germany's forest resources is expected to rise only modestly, by a projected average rate of 0.5% per year. As a result, the current surplus of available growth over harvest levels is expected to widen in the years ahead.

Table 7 - Projected Timber/Fiber Availability
(million cubic meters)

Year	Hardwood	Conifer	Total
1990	10.0	65.0	75.0*
1995	13.0	35.0	48.0
2000	13.0	40.0	52.0
2005	15.0	40.0	55.0
2010	17.0	45.0	62.0
2020	20.0	45.0	70.0

*Includes 25-30 million cum of timber salvaged from wind storms.

Projected Available Timber Supply - Germany



VII. REFERENCES

Asp, Marina, "Germany", Papermaker, pp. 14-15, Dec./Jan. 1993/1994

Federal Ministry of Food, Agriculture, and Forestry, "Wood Industries" 1989, Bonn.

German Pulp and Paper Association, (Verband Deutscher Papierfabriken), Annual Reports 1990 and 1995.

Schreiber, Prof. Dr. A., "Structural Changes in the Sawmill Industry", Ministry of Food, Agriculture and Forestry, Bonn, 1987.

USDA Foreign Agricultural Service, ATO Reports, "Annual Forest Product Reports", 1988-1994.

Wood Resources International Ltd., "Wood Resource Quarterly", January 1991, estimates and in-house files.

Zentrale Markt-und Preisberichtstelle, "Annual Forest and Wood Product Price Report", 1986.

Profile of Forest Resources and Forestry Practices

Indonesia

I. GENERAL STATISTICS

Table 1 - Land & Forest Area

Total Land Area (ha)	193,000,000	
Forest Area (ha)	142,000,000	(75.0%)
Est. Production Forest (ha)	65,000,000	(33.6%)

Table 2 - Forest Land Ownership

Federal/State	140,000,000	(99.0%)
Private	2,000,000	(1.0%)
Total	142,000,000	(100.0%)

Table 3 - Productivity

	Native Forest	Plantations		Total
		Conifer	Hardwood	
Net Annual Growth (million cum)	63	7	10	80
MAI per hectare (cum/ha/yr)	1.0	15	25	1.73
1993 Harvest (million cum)	30	5	8	43

Area of Industrial Plantations: 2,200,000 hectares

II. FOREST RESOURCES

Indonesia's archipelago stretches over 5,000 kilometers and encompasses 13,000 islands, of which approximately 6,000 are inhabited. Three-quarters of Indonesia's total land area is tropical or mangrove forest. The most significant forests are on the large western islands of Kalimantan, Sumatra, and Java. A wide variety of tropical flora and fauna characterizes Indonesia's tropical and mangrove forests. It is not unusual to find 150 different tree species on a given hectare of land, and it has been estimated that as many as 10,000 different tree species exist in Indonesia. The total standing timber inventory has never been accurately measured, but remains impressive despite many years of exploitation. The western island forests of Sumatra, Java, and Kalimantan support commercially valuable Dipterocarp species such as Meranti (Shorea spp.), Kapur (Dryobalanops spp.), Keruing (Dipterocarpus spp.), and Ramin (Gonystylus bancanus). The eastern island forests (Sulawesi, Irian Jaya) contain a more diverse, and less commercially suited mix of species.

Table 4 - Estimated Distribution of Tropical Hardwood Commercial Species

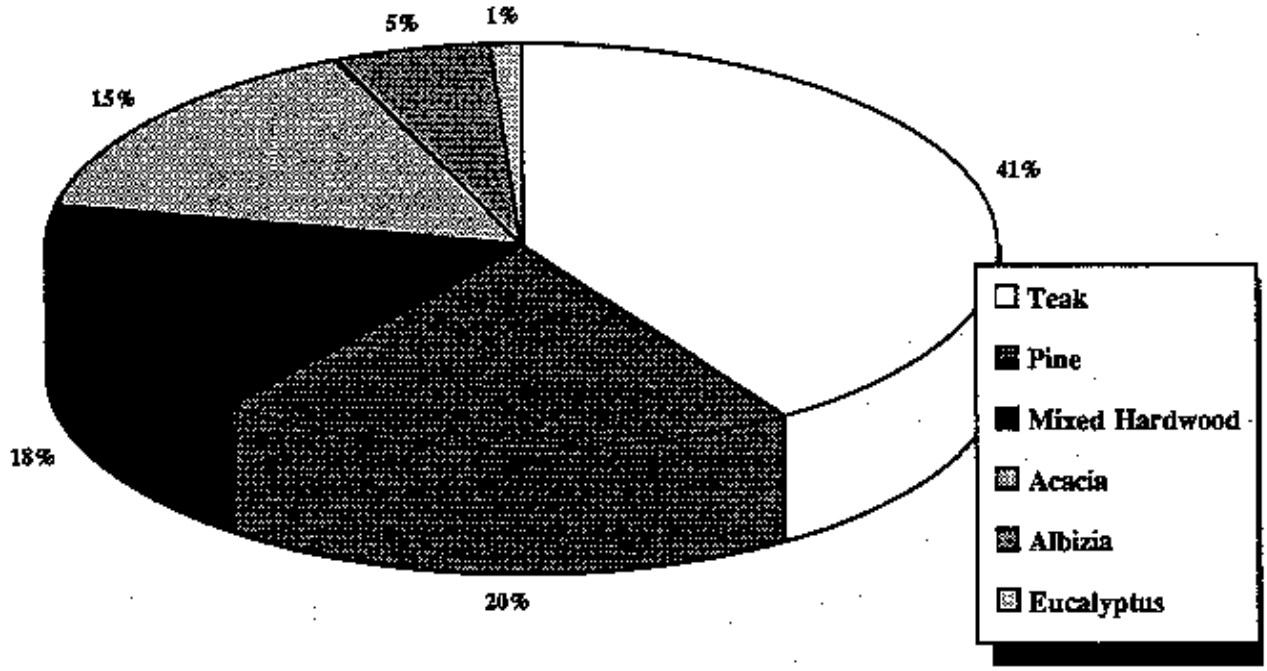
Meranti (Shorea spp.)	36%
Keruing (Dipterocarpus spp.)	5%
Kapur (Dryobalanops spp.)	4%
Ramin (Gonystylus spp.)	2%
Bakau-bakau (mangrove)	1%
Others	53%

Industrial timber plantations have been established on 2.2 million hectares. Over 70% of these are directly owned by the Federal government, and include special use plantations such as Teak and Rubberwood. The balance are immature plantations established within the last 5 years under the new HTI program. A breakdown of industrial plantations by species in Indonesia is shown in Table 5.

Table 5 - Estimated Distribution of Species Within Industrial Plantations

	(hectares)
Teak	915,000
Pine	440,000
Mixed Hardwood	395,000
Acacia	344,000
Albizia	118,000
Eucalyptus	22,000
Total	2,234,000

Industrial Plantations by Species - Indonesia



A national forest inventory is due to be completed in 1996. Currently, official government estimates place Indonesia's forest area at 142 million hectares. With the exception of a few small estates that date back to Dutch colonial days, the forest land is owned by the Indonesian government. However, many local communities claim jurisdiction over specific areas.

The government has classified forest land into five categories: "Protection" forests, "Conservation" forests, "Production" forests, "Limited Production" forests and "Conversion" forests. Slope, soils, vegetation, and commercial potential are the criteria used to classify various forest areas. Forests on slopes greater than 45 degrees are automatically classified as Protection forests and, therefore, are theoretically unavailable for timber production.

From the total forest area of 142 million hectares, approximately 49 million hectares have been set aside as either "Protection" or "Conservation" forests. The government is still in the process of identifying and designating these areas. Approximately 63 million hectares are designated as "Production" and "Limited Production" forests. These are the most important timber producing areas and are made available through concessions. Another 30 million hectares of forest land are classified as "Conversion" forests, meaning they are potentially available for expanding agriculture or other types of non-forest use. Conversion forests are generally poorly stocked, but may contain some commercially valuable timber. They may also be available for conversion to industrial timber plantations. Current timber needs are being met from the Production, Limited Production and Conversion forests.

Table 6 - Indonesia's Forest Land Classifications

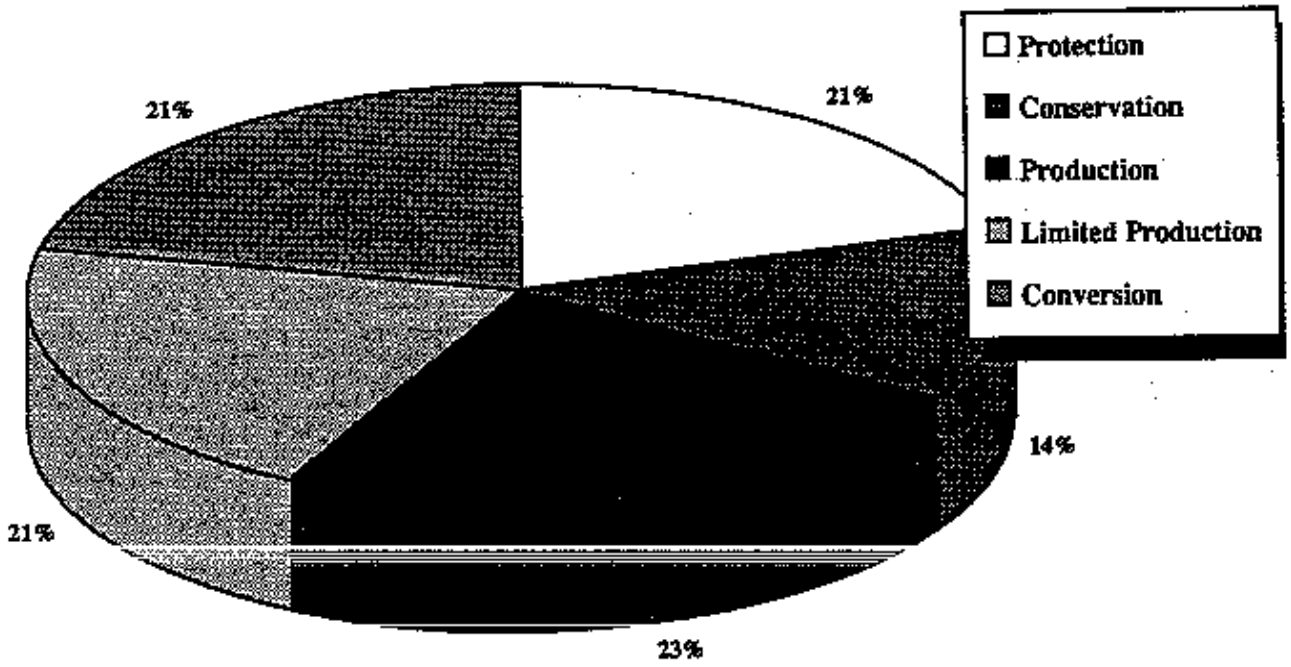
	(mill. ha)	(%)
Protection Forests	29.6	20.8%
Conservation Forests	19.2	13.5%
Production Forests	33.4	23.5%
Limited Production Forests	29.6	20.8%
Conversion Forests	30.2	21.3%
Total	142.0	100.0%

Despite the tremendous growth potential for exotic species, annual growth in Indonesia's native forests is generally very low. The annual growth of commercial species on concession forests is only about 63 million cubic meters, or approximately 1.0 cum/ha/yr. Although annual growth exceeds annual harvest on concession forests, poor management, lack of reforestation, and "high-grading" have reduced the quality of residual stands, and regenerated forests.

III. CURRENT LEVEL OF UTILIZATION

Indonesia has been the focus of global attention because of its history of resource exploitation. Originally a supplier of unprocessed raw material to world markets, Indonesia shifted strategy in the 1970's and 1980's to become an exporter of finished wood products. Exports of forest products totaled $5.5 billion in 1993. The government controls all forest activities through concessions to state enterprises and private forest developers, prescriptive regulations, and export controls.

Forest Land Classification by Area- Indonesia



The Government of Indonesia reported the roundwood harvest at 26.3 million cubic meters for 1993. However, the actual harvest was significantly larger for two reasons. First, this figure does not include fuelwood production, which is substantial. The FAO estimated total production of fuelwood at 146.3 million cubic meters in 1992. Fuelwood use in Indonesia, therefore, dwarfs all other wood consumption. Second, a significant volume of harvested roundwood is either not accurately measured by the government or is harvested illegally. By applying an average recovery factor to reported lumber and plywood production, a derived consumption of 35 million cubic meters can be estimated for the solid wood industry in 1993. Adding timber/fiber used in reconstituted boards, other secondary manufacturing, and wood pulp brings the total to 43 million cubic meters.

	Native Hdwd.	Con. Plantations	Hdwd. Plantations
Est. Annual Allowable Cut (mill. cum)	35.0	7.0	10.0
1993 Harvest (mill cum)	30.0	5.0	8.0
1993 Growth/Drain Ratio	1.17	1.40	1.25

The Production and Limited Production forests are allocated through approximately 580, generally privately held, concessions (called HPH). Typically, concessions permit logging in a defined area for up to 20 years. The concessionaires must provide a 20-year forest management plan, establish integrated wood processing facilities, submit 5-year and annual working plans, pay fees for reforestation and agree to harvest trees in accordance with strict species and diameter specifications. In the past, abuses by concessionaires were relatively common. In recent years, the government has tightened enforcement of its forestry laws and has canceled licenses of abusive concessionaires.

The Indonesian government has targeted the pulp and paper industry for rapid expansion over the next twenty years. In 1993, the industry consisted of 15 pulp mills with an installed capacity of 1.7 million tonnes, and 58 paper and board plants with an installed capacity of 5.3 million tonnes. Capacity has more than doubled in five years. Actual pulp production totaled 1.1 million tonnes in 1993 and paper/board production totaled 2.6 million tonnes. Until 1994, when 3 new wood-based pulp lines came on-stream, only 5 of the country's pulp mills produced wood pulp. Others relied on a variety of fibers including straw, bamboo, bagasse and recycled materials. Indonesia has gone from being a net importer of paper products prior to 1986 to a major world exporter. The biggest operator by far is Sinar Mas, a company that holds nearly half of Indonesia's total pulp and paper capacity. Approximately 5 million cubic meters of wood fiber was consumed by the wood pulp industry in 1993.

The structure of the Indonesian pulp and paper industry is changing as it expands. As many as 42 expansions and new projects are proposed or planned, largely predicated on supply from industrial plantations. Additionally, the government plans to relinquish control of 6 pulp mills currently operating under state enterprises. Production of bleached chemical wood pulp is expected to grow from 630,000 tonnes in 1993, to 3 million tonnes by 2000. Much of this will be sold to markets in China and other Pacific Rim countries. As new, modern mills are constructed, some of the existing smaller pulp mills are likely to close.

To meet future demand for fiber, an aggressive program establishing industrial plantations was undertaken beginning in the 1980's. These plantations, called "HTI" plantations have been established on approximately 948,000 hectares, including 580,000 hectares which support tree species suitable for pulp or solid wood products. Trees to produce rubber, coconut and palm oil, and non-timber products account for the balance. The earliest plantings from the commercial tree plantations will mature in 1996/97, but most of the volume will not be available until early in the next century. The government has indicated a goal to establish 6 million hectares HTI plantations by the year 2000. Because the pulp industry is expanding rapidly -- 4 new pulp lines will come on line during the next five years -- fiber from "Conversion" forests will be required until plantations mature. Fiber procured from these forests totaled an estimated 4 million cubic meters in 1993, but will increase to 10 million cubic meters by 1997 before tapering off . By 2005, plantation-grown wood should increase substantially and provide sufficient volume to meet projected wood pulp requirements.

Approximately 2,700 sawmills operate in Indonesia, but only about 365 are affiliated with concessions and could be considered industrial. To encourage secondary processing, the government banned log exports in 1985 and imposed stiff export taxes on lumber beginning in 1988. Consequently, lumber production fell from a 1988 peak of 10.2 million cubic meters with a large percentage of exports, to 3.0 million cubic meters in 1990 with virtually no exports. Since then, production has increased to about 8.5 million cubic meters, mostly to serve domestic construction and secondary manufacturing markets. The log export ban was later replaced by export taxes to comply with the GATT.

As was the government's intention, the plywood and secondary processing industry experienced dramatic growth after the 1985 log export ban. The number of plywood mills increased from 8 in 1979, with a production 386,000 cubic meters, to 130 mills in 1994, with a production of over 10 million cubic meters. Ninety-five percent of production is exported, mainly to Japan (the largest market), China, Korea, and Europe. One company, Barito Pacific, is believed to control 30% of Indonesia's plywood capacity.

Table 7 - Production of Wood & Paper Products, 1993

Lumber (000 cum)	8,200
Plywood & Panels (000 cum)	10,430
Wood Pulp (000 tons)	1,116
Paper & Paperboard (000 tons)	2,600

Manufacturers of moldings, doors, windows and items as diverse as dowels and picture frames produce 9 million cubic meters of wood products. Blockboard, particleboard, and MDF account for an additional 1.5 million cubic meters of production. There are as many as 10-15 additional particleboard and MDF plants proposed by the end of the decade. Most are being planned by plywood concessionaires facing a prohibition against new investment. These new facilities are expected to use under-utilized manufacturing residues and logging residues.

Hefty tariffs are also theoretically supposed to curtail chip exports, but hardwood chip production and exports have been expanding. About 726,000 oven dried metric tons were exported in 1993 to Japan, Taiwan, and Korea.

Number of Producing Plants

Sawmills	2,700
Plywood & Panels	500
Pulp, Paper & Board	73

Allocation of Roundwood Harvest

Of the 43 million cubic meters of industrial roundwood consumed by the forest products industry in 1993, 26 million cubic meters (60%) was from Production and Limited Production forests. The remaining 40% was harvested from clearings in "conversion" forests, and from rubber plantations (about 20%) and other government owned and operated plantations. The lion's share of the harvest is currently consumed in the plywood and lumber industry, which together accounted for 35 million cubic meters. Tables 8 & 9 estimate the source and use of Indonesia's 1993 roundwood harvest.

Table 8 - Harvest By Land Category, 1993

	(mill. cum)	(%)
HPA Concessions	26.0	60.5%
Conversion Forests	4.0	18.6%
Old Industrial Plantations	4.0	9.3%
Dept of Agriculture	8.0	9.3%
Coop and Other	1.0	2.3%
Total	43.0	100.0%

Table 9 - Estimated Roundwood Use, 1993
(million cum)

Industry Segment	Native Hdwd.	Con. Plantation	Hdwd. Plantation
Plywood	15.0	---	---
Sawmills	9.0	3.0	8.0
Pulp Ind.	3.0	2.0	---
Board Ind.	1.5	---	---
Other	1.5	---	---
Total	30.0	5.0	8.0

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

Concession holders operate using a basic silvicultural philosophy of selective cutting within prescribed minimum diameter standards. The most common logging systems involve the felling of trees by chainsaw, followed by tracked skidding to a landing or roadside. Transport of sawlogs is by truck and river, as most mills built during the 1970's and 1980's were built around waterways. Transport of pulpwood material is exclusively by truck. Theoretically, the system provides for seed trees and replanting where indicated, but in practice most of the commercial timber is removed and little attention is given to the residual stand. Other systems are being tried.

Historically, concession holders were expected to undertake forest inventories and abide by silvicultural guidelines. However, lack of government enforcement meant that silvicultural practices were practically nonexistent and over-cutting was common. Harvesting systems in the production forests are still highly inefficient. The average volume of commercial timber harvested is 50-75 cubic meters per hectare out of a standing volume of approximately 300 cubic meters. As much as 50% of the timber that is felled is left in the woods. The government is attempting to impose more rigorous standards on the concessionaires by requiring that trees felled be a minimum of 50 cm in diameter. The allowable harvests under forest concessions are also being reduced as numerous licenses are renewed or canceled. Currently, the government has fixed the allowable harvest for all of the concessions at 32 million cubic meters annually.

New short-rotation timber plantations, called Hutan Tanaman Industri (HTI), were established in the late 1980's. The HTI's are essentially concessions, generally granted on Conversion forest land, to operate in an area of up to 300,000 hectares for a period of 35 years plus one rotation. Some 6 million hectares of HTI's are planned to augment already existing plantations. As of 1993, HTI plantations had been established on 948,000 hectares using various species. Acacia accounts for the vast majority of plantations (80%); other species being used include Eucalyptus (5%), Albizia and Gmelina (10%), Pine (5%). A typical management regime involves land clearing (using the remaining volume of mixed tropical hardwood for pulp or sawmill production), planting, fertilization and weeding. Rotations of 8 to 10 years are typical for hardwood, 15-18 years for pine. Most of the species will be used for pulp fiber, although Albizia has potential for use as an inner ply for plywood. Hardwoods are being regenerated by coppice, with two rotations planned from the initial root stock.

With average growth rates of 25-30 cum/ha/yr., plantations are expected to yield 250 cum per hectare for hardwood plantations on a 9-year rotation, and 400 cubic meters/hectare on pine plantations with a 16-year rotation. As of July, 1994, Indonesia's timber plantation area, including the new HTI's, totaled approximately 2.2 million hectares. As seen in Table 10, the government is the largest plantation holder.

Table 10 - Indonesia's Timber Plantations (hectares)

Government teak plantations - Java	915,000
Government pine plantations - Java	320,000
Government mixed hardwood plantations- Java	170,000
Government mixed pine\hdwd - Other islands	250,000
HTI Estates - Pulp	430,000
HTI Estate - Solid Wood Products	150,000
Total	2,235,000

Table 11 - Industrial Plantation Parameters

	Hardwood
Land Costs (US$/Ha)	N/A
Site Prep & Planting (US$/Ha)	450
Annual Maintenance (US$/Ha/Yr)	160*
Rotation (Yr)	9
Annual Yield (Cum/Ha/Yr)	25

* Includes a land rental fee of approx. US$ 5/cum due at harvest.

Site Prep	
Scarification	Yes
Bedding	Yes
Initial Stocking Levels (stems/Ha)	1100
Chemical/Mechanical Weed Control	Year 2 and 3
Chemical Insect Control	No
Chemical Fertilization	At Planting/3 months/Yr. 2
Pruning (yr)	No
Thinning (yr)	No

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES

The FAO and World Bank have estimated Indonesia's deforestation rate at between 900,000 and 1.3 million hectares per year. While these estimates are likely to be overstated, deforestation in Indonesia is a significant problem. Although the government has stepped up efforts to regulate forest activity, it has been unable to control deforestation resulting from transmigration policies, subsistence agriculture, and illegal logging.

In the late 1980's, the government placed millions of hectares into protection and conservation classifications, increased enforcement of concession agreements and imposed controls on trade. Exports

of logs have been prohibited since 1985, and exports of lumber are taxed heavily. Since 1986, any forestry development project has been required to conduct an environmental impact assessment. The law also requires concessionaires to allot a minimum of 100 hectares of virgin forests to preserve bio-diversity. Through June, 1992, the government claims to have imposed fines of $20.5 million and revoked 29 concessionaire licenses. The shortfall of these policies, however, was not in their intent, but in their enforcement. In 1993, the government issued a decree requiring concessionaires to establish a security force with the authority to issue citations for violations of forest regulations. Although these efforts have helped measurably, illegal activity is still problematic.

Indonesia has come under increasing pressure from environmental organizations and other governments to stop illegal harvesting activities in native hardwood forest areas, and the purchase of such "illegal wood" by established forest product manufacturing companies. As a consequence, the government of Indonesia has announced it will begin enforcing prohibitions against logging by reducing export quotas by 50% for wood manufacturing companies that violate the prohibition. If illegal procurement continues, quotas may be reduced by 75% . Enforcement is through the quasi-government/quasi-private Association of Wood Panel Producers (APKINDO). However, the track record of self-regulation within the forest concession system is not encouraging.

Of equal importance to some environmental organizations, is the ongoing clearing of cut-over native hardwood forests, for conversion to single-species industrial plantations. "Conversion forests", as these areas are called, consist of native hardwood forests previously harvested for plywood and sawlogs. In theory, all trees less than 50 cm in diameter were left for regeneration purposes. In practive, however, initial harvests were severe, and as little as 100 cum per hectare of immature and cull material remains. The government has assigned these areas, on a 200-300,000 Ha. block basis, to be cleared and replanted with Acacia, Albizia, Pinus, and Eucalyptus species. The residual volume of mixed tropical hardwood (MTH) will support much of the new pulping capacity that will come on-stream in Indonesia until new plantations mature after the year 2000. Until then, Indonesia will remain in the somewhat unenviable position of the world's largest producer of pulp and paper products based on mixed tropical hardwood resources.

Indonesia is also a signing member to the ITTO sustainable forestry program known as Target 2000. This will require a substantially larger oversight role by the Indonesian government with respect to harvesting practices, regeneration and forest management. Enforcement of central government policy throughout this expansive archipelago remains a concern.

VI. PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020

While the Indonesian government has undertaken a number of reforms and enforcement measures designed to improve forest practices throughout the country, conversion of forests to other uses is expected to continue. Unless government policy changes significantly from its current course, Indonesia will lose at least 20 million hectares of forests over the next 25 years.

Through various policies, the government is expected to constrain production of sawnwood and plywood. Demand for timber by these industries is expected to decrease by 25% over the next 20 years. In contrast, increased demand from the country's rapidly growing pulp and paper industry, and the reconstituted board industry, is projected to more than offset this decline. Total timber/fiber demand is projected to increase from 43 million cubic meters in 1993 to 53.5 million cubic meters by 2005, and to

about 60 million cubic meters in 2020. This is in addition to fuelwood demand which is expected to remain relatively constant at 150 million cubic meters per year.

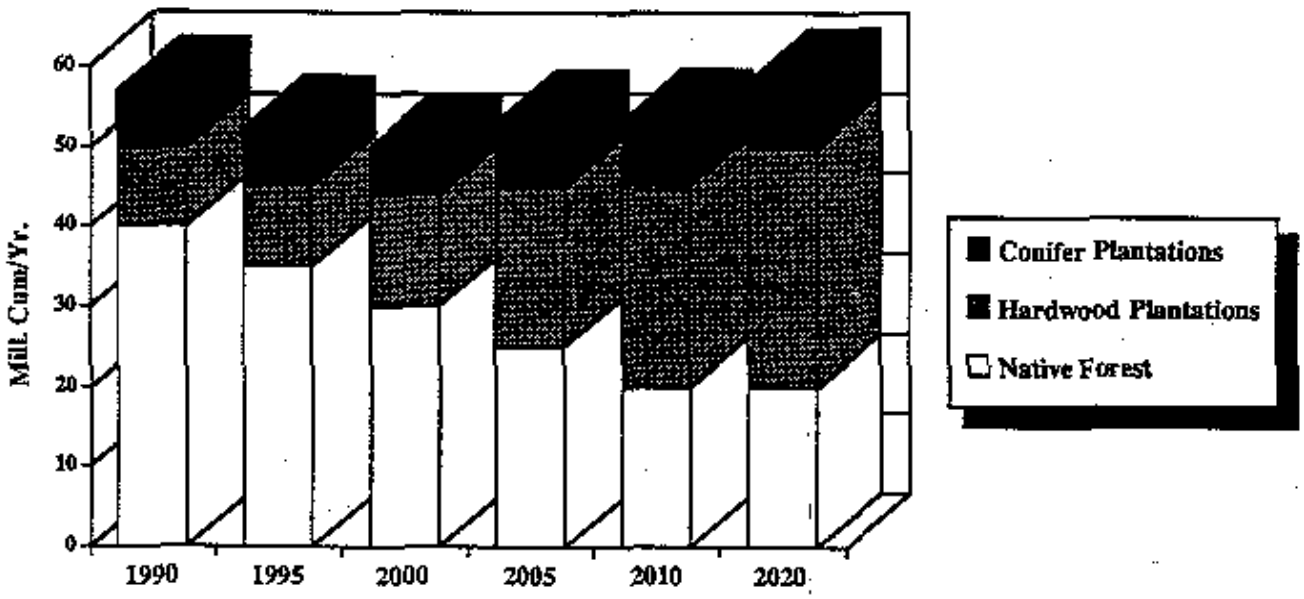
Annual pulp manufacturing capacity is projected to expand to 4.5 million tonnes, up from just 630,000 tonnes in 1993. To supply this capacity, the industry will require 13 million cubic meters of wood fiber by 1997, and as much as 20 million cubic meters by 2005, up from 5.0 million cum in 1993. Fiber for reconstituted board is projected to grow from 1.5 million cubic meters in 1993 to 3.5 million cubic meters by 2005.

Once mature, HTI plantations will produce a surplus of fiber despite the expansion in pulp manufacturing. Thus, Indonesia may become a major supplier of chips to the Pacific Rim, provided current export policies are relaxed.

Table 12 - Projected Timber/Fiber Availability
(million cubic meters)

		Plantations		
Year	Native Forest	Hardwood	Conifer	Total
1990	40	10	7	57
1995	35	10	7	52
2000	30	14	6	50
2005	25	20	8	53
2010	20	25	8	53
2020	20	30	8	58

Projected Available Timber Supply - Indonesia



VII. REFERENCES

Asia Pacific Papermaker, " Indonesia: A Changing Climate", pp. 22-23, July, 1994

Asia Pacific Papermaker, "Serang: Integration All The Way", September 1993

FAO - Directorate General of Forest Utilization - Ministry of Forestry, Govt. of Indonesia, "Situation and Outlook of the Forestry Sector of Indonesia", Jakarta, September 1990, UTF/INS/065/INS.

FAO Forestry Paper 112. Forest Resources Assessment 1990: Tropical Countries. Rome

Government of Indonesia, Ministry of Forestry, Forestry Statistics, 1989/1990, Jakarta, 1991.

Government of Indonesia, Ministry of Forestry, "Forestry Indonesia 1991/1992", Jakarta, 1993.

Government of Indonesia, Ministry of Forestry, "Indonesian Forests in Brief"

Government of Indonesia, Ministry of Forestry, "Progress Toward Sustainable Management of Tropical Forests, Target Year 2000", Prepared for 13th ITTC Session, Yokohama, Japan, Nov. 1992

Hagler, Robert W., "Indonesia --Restructuring Pacific Rim Markets," Asia Pacific Papermaker, June, 1993.

Indonesian Pulp & Paper Association, "Indonesian Paper Trade Directory 1991", Jakarta, 1991.

Lockyer, Ross, "A New Era", Asia Pacific Forest Industries, January 1990.

Ngadiono, "Equilibrium Projection of Pulp Industry and Wood Raw Material in Pelita 6, 7, and 8", PT Aji Buana Asri, Bogor, Indonesia, July 1994.

Perum Perhutani, "Sustained Yield Forest Management in Indonesia", Jakarta, 1992.

Pulp and Paper International, "Sinar Mas: Growth Won't Stop at Home", pp. 21-22, August, 1993.

USDA Foreign Agricultural Service, ATO Reports, "Annual Forest Product Reports" 1992, 1993, 1994.

Wong, Alfred, "Forest Resource of Indonesia", Arboken Inc., Paper presented at Pacific Paper Expo, Vancouver, B.C. Canada, November 6, 1990

Wood Resources International Ltd., "Wood Resource Quarterly", January 1993 , estimates and in-house files.

Profile of Forest Resources and Forestry Practices

Russia

I. GENERAL STATISTICS

Table 1 - Land and Forest Area

Total Land Area (000 ha)	2,111,000	
Forest Area (000 ha)	760,000	(36%)
Est. Production Forest (ha)	540,000	(26%)

Table 2 - Forest Land Ownership

Public 100%

National Forest Service	94%
State Agricultural Enterprises	4%
Ministry of Environment	1%
Other Public	1%
Total	100%

Table 3 - Productivity

All Forests

	Conifer	Hardwood
Net Annual Growth (mill. cum)	570	270
MAI per hectare (cum/ha/year)	1.3	1.4
1993 Harvest (mill cum)	107	59

II. FOREST RESOURCES

The forests of Russia contain approximately 22% of the world's forested area. The expansive conifer forests of Siberia and the Far East, which account for 78% of the forest area of Russia, contain nearly 50% of the total world coniferous forested area. The total area of forest in Russia is estimated at 760 million hectares, or approximately 36% of the total land area of the country -- 600 million hectares, or 79%, is classified as conifer, with the balance classified as deciduous, or hardwood, forest.

At the current time, the forests of Russia are divided into three groups based on their ecological and conservation requirements.

Group I:	Forests set-aside for soil or water conservation or other protective purposes. No industrial harvesting operations are permitted, although thinning operations may be carried out in some regions to enhance forest health.
Group II:	Restricted forests where only salvage harvesting operations may occur.
Group III:	Forests primarily managed for industrial roundwood production.

Nearly 30% of the total forest area of Russia is classified in either Group I or II, and therefore is generally not available for industrial harvesting operations. As seen in Table 4, a greater percentage of hardwood forests are protected than conifer.

Table 4 - Classification of Forest Lands in Russia
(million hectares)

Group	Total	Conifer	Hardwood
I	167	125	42
II	53	30	24
III	540	453	86

The total volume of timber in Russia is estimated to be 80.7 billion cum. Approximately 63%, or 51 billion cum, is considered to be suitable for commercial use. As in much of the northern boreal forest, a limited number of species account for much of the volume. Russian conifer forests are predominantly larch, pine and spruce. While larch is virtually absent from European Russia, it accounts for more than 50% of the conifer inventory in Siberia. The three varieties considered commercially important are Sukachev Larch, Siberian Larch, and Gmelina Larch. Pine is the dominant species in Western Siberia, accounting for 50% of the forest resources in that region. Scots Pine and Crimean Pine are the two most prominent species. Spruce and fir are the dominant conifer species in the European part of Russia, accounting for 68% of the total conifer inventory in this part of Russia.

Hardwood forests are generally comprised of birch and aspen, which are the dominant deciduous species in Russia, and together account for almost 80% of the total deciduous inventory. Other temperate, generally high-density hardwoods, such as oak, ash, and beech make up the remaining volume. The distribution of forest species by volume in Russia is seen in Table 5.

Classification of Russian Forests

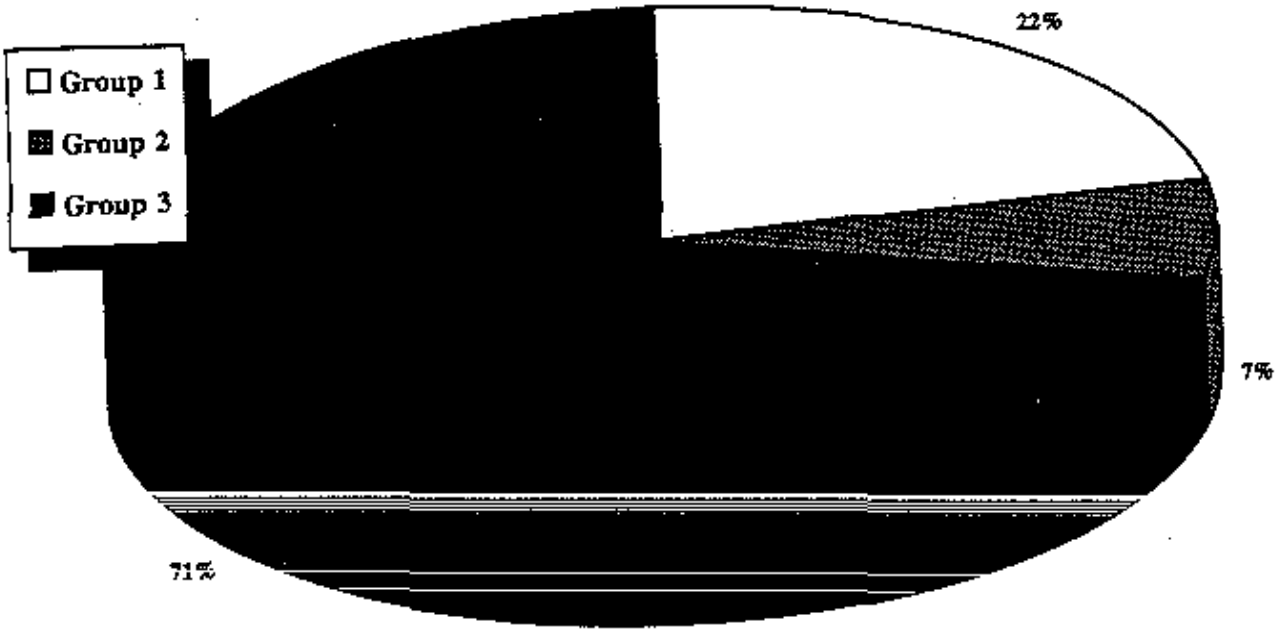


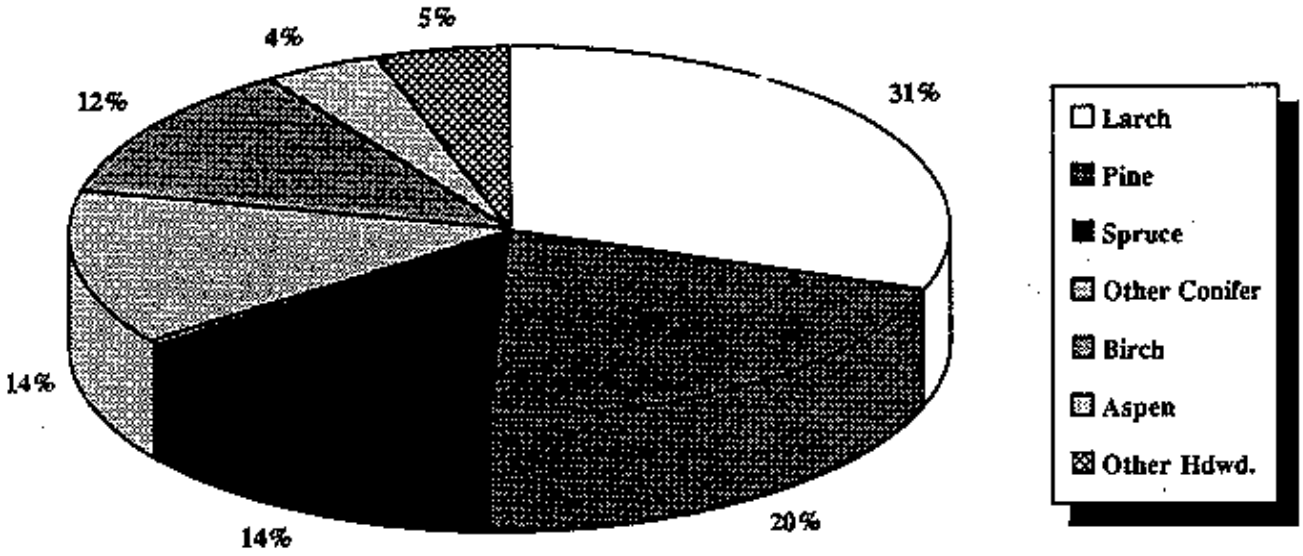
Table 5 - Distribution of Species by Volume

Conifer		Non-Conifer	
Larch	30.7	Birch	12.0
Pine	20.3	Aspen	3.9
Spruce	14.0	High-density	2.4
Other	14.1	Other	2.6
Total	79.1	Total	20.9

The uneven development of Russia has shaped the current age-class distribution of its forest resources. Only about 20% of the forest land in European Russia is classified as middle-aged or mature. In contrast, the Asian region has large areas of mature and over-mature timber. It is estimated that at least 60% of the forest land in Asian Russia can be classified as mature or over-mature. As a result of over-mature Siberian forests, conifers have a generally older age-class structure than hardwood forests, many of which have regenerated in European Russia on farmland abandoned during the collectivization process of the 1930's. An estimated age-class distribution of Russian forests is as follows:

Age Class	Conifer (%)	Hardwood (%)
Young	5	4
Premature	24	29
Middle Age	13	14
Mature	58	52
Total	100	100

Distribution of Species by Volume - Russia



III. CURRENT LEVEL OF UTILIZATION

Annual growth for the total forest area of Russia has been estimated at 840 million cum, of which just over 15%, or 140 million is found in western, or European Russia. The dislocation of Russian supply and demand is exemplified by the fact that although European Russia supports 15% of annual growth, it provided nearly 60% of the 1993 annual harvest. Harvests have declined drastically during the last five years, as a result of idled manufacturing capacity, and loss of markets for forests products, primarily in eastern Europe. Since 1988, the total harvest has fallen from approximately 325 million cum, to an estimated 1993 level of 166 million cum - nearly 30% of which was for fuelwood purposes. With an industrial roundwood harvest of only 118 million cum, Russia's forest product industry is today not much larger than that of British Columbia.

Just over 64% of the 1993 harvest was of conifer species; a percentage considerably lower than during the 1980's, when conifer harvests represented between 72% and 74% of the total. A gross division of the 1993 roundwood harvest is as follows (in million cum).

	Conifer	Hardwood	Total
Industrial Roundwood	86	32	118
Fuelwood	21	27	48
Total Removals	107	59	166

The extent of the harvest potential for Russia can only be estimated due to changing forest classifications, and limited knowledge of potential yields from more intensive forest management. The following is based on our 1995 assessment of Annual Allowable Cut - reflecting an assumption that in the near term, 60% of annual growth will at least be theoretically available for industrial utilization.

	Conifer	Hardwood
Est. Annual Allowable Cut (mill. cum)	300	200
1993 Harvest (mill. cum)	107	59
1993 AAC/Drain Ratio	2.80	3.39

The forest industry in Russia is an important sector, accounting for about 12% of all industrial facilities in the country. There are an estimated 33,000 enterprises operating in forest harvesting and production of forest products. According to Roslesprom, the Russian Forest Products Association, approximately 85% of the timber industry has been transformed to non-governmental enterprises, generally in the form of joint-ventures. As of September 1995, 65% of the logging industry had been privatized, and as much as 95% of the solid wood and pulp industry was also privatized. Most public companies in this sector are privatized through management or employee buy-outs, rather than through foreign investment.

In 1993, there were almost 700 sawmills in Russia with a production capacity of 140 million cum. Since the late 1980's, Russian sawnwood production has declined from 83 million cum, to approximately 30 million cum in 1993. A total of 50 pulp mills also operate in Russia. Most wood pulping capacity is located in the European and Ural regions of Russia, with only about 27% based in Siberia and the Far East. Between 1988 and 1993 wood pulp production in Russia declined by almost 50%, to an estimated output level of 5.3 million tonnes. The pulp industry utilizes as much as 20 million cum of roundwood, supplemented by 5-6 million cum of sawmill residual chips.

As with all sub-sectors within the forest industry, plywood production dramatically decreased between 1988 and 1993. Estimated production in 1993 was 1.1 million cum, down from 2.3 million cum in 1989. General production levels for major forest products is seen in Table 6.

Table 6 - Production of Wood and Paper Products, 1993

Lumber (000 cum)	30,000
Plywood & Panels (000 cum)	1,100
Wood Pulp (000 tonnes)	5,354
Paper & Paperboard (000 tonnes)	4,825

Allocation of Roundwood Harvest

By working backwards through solid wood and pulp production levels, it is possible to estimate 1993 demand for roundwood in Russia, and a likely allocation of the 118 million cum industrial harvest.

Table 7 - Estimated Roundwood Use - 1993

Sawmill Industry	60.0
Plywood Industry	3.0
Pulp Industry	20.0
Other Industrial Uses	35.0
Total	118.0

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

The management of forests in Russia has traditionally been of extremely low intensity, and often nonexistent. Conifer stands along developed transportation networks and close to populated areas have in many cases been systematically overcut. This is especially true for the southern part of Siberia, the Far East, and the region west of Moscow. With few incentives or penalties, the improvement of forest resources, through silvicultural investments, has been minimal. Recent increases in the cost of labor and investments in forest enterprises, has led to the harvesting of primarily "high value" stands, thereby further reducing the quality of regeneration forests.

Where forest management is practiced, the following regime is typical. Stands are naturally regenerated (an estimated 70% of cut-over areas in 1993 were neither seeded, or replanted), followed by a series of commercial thinnings. The practice of natural regeneration in much of European Russia has resulted in hardwood or mixed stands replacing the conifer forests that once dominated the region. Rotations range between 90-140 years for conifer, and 50-70 years for hardwood. The volume of wood obtained from thinnings has decreased from 24.1 million cum in 1992 to an estimated 18.5 million cum in 1994. The contribution to total delivered timber supply from this source is much higher in the European region where the transportation network and markets are more developed.

Timber is generally harvested in Russia on a "diameter -cut" basis. However, many harvests resemble clear-cuts in that smaller trees and the understory are destroyed in the operation, and most trees are felled to determine their merchantability. The most common harvesting systems remain motor-manual systems, although tracked feller-bunchers and feller-forwarders are also used, particularly in seasonally difficult terrain. Wood is transported by both truck and rail. However, the percentage of rail transport has declined significantly in recent years as the true costs of long distance transport have become recognized.

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES*

Several forest management issues dominate environmental concerns in Russia with respect to forestry and the forest product industry. These include ecosystem preservation, even-aged forest management, boreal forest regeneration, and the impact of air pollution on forest health.

Perhaps the most pressing environmental issue that will face Russia in the years ahead is to determine what percentage of its huge, original coniferous forest should be set-aside, and thereby protected from industrial exploitation. Approximately 130 million Ha., or 17% of the productive forestland, is classified as Group 1 forest, for the purpose of protecting specific environmental values. This percentage has increased from approximately 13% in 1966, and is exemplified by recent set-asides in eastern Russia, where harvesting in nearly all of the Korean Pine forests of the Russian Far East was prohibited to provide a safe-haven for the Ussuri, or Siberian Tiger. As a result of this, and other environmental set-asides, the annual allowable harvest for this region fell from approximately 55 million cum per year, to 37 million cum per year. The 1993 harvest from this same region was estimated at 16 million cum. As Russia begins to develop its interior infrastructure, and society continues to voice environmental concerns, it is anticipated that the area of protected, Group I forests will modestly expand.

* Much of this section is paraphrased from personal correspondence with Dr. Charles Backman & Prof. Anatoly Shvidenko of the Siberian Forest Study, IIASA, Laxenburg, Austria, November 1995.

A second issue of concern is that of clear-cutting and even-aged management. In order to economically justify the infrastructural costs of harvesting in Russia, it is often necessary to obtain large volumes of raw material for a given level of investment. During the last decade, approximately 90% of final harvests in Russia were clear-cuts. In late 1993, the Federal Service of Forest Management adopted new final felling regulations that attempt to significantly expand the use of selection and partial cuts in the final felling operation. The use of alternative final harvesting methods will be further encouraged by the increasing availability of mechanized thinning equipment from Scandinavia, greater scrutiny of forest operations by local authorities, and a shift in responsibility for forest regeneration to forest leaseholders. Nevertheless, calls for "clear-cut free" forest products will be virtually impossible for Russian manufacturers to produce in the near term, and could negatively impact their access to vitally important European markets. Although thinnings will provide an increasing volume of raw material to the forest products industry of Russia, it is not possible to rebuild this industry on thinnings alone.

A third, and related forest management issue is the question of successful natural regeneration within the taiga zones of central Siberia. The national inventory of 1988 identified as much as 5.5% of the State forest area as burnt or dead forests (3.7%), un-regenerated clear-cuts (1.2%), and grassy glades (.6%). It is generally believed that in the absence of fire, natural regeneration is sufficient to re-establish healthy forest stands, albeit with an increased presence of hardwood species. However, reoccurring wildfires make natural regeneration impossible, and can result in northern (green) desertification. To insure adequate regeneration, it is necessary to 1) improve forest fire protection, 2) better protect regeneration during harvesting operations, and 3) continue to plant inadequately stocked or fire areas.

Finally, Russia is a major consumer of coal for energy purposes, and has well documented problems with air pollution. Work done by Nilsson *et alia (IIASA, 1992)*, showed that the within the European part of Russia, air pollution could reduce potential harvest levels by as much as 10%. Other than genetic selection of species that are more pollution tolerant, forest managers have limited responsive options. The solution lies in alternative energy sources, and pollution control technologies.

VI. PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020

Russia can be segregated into two distinct geographical regions with very different conditions at present, and in the future. In the European region, where the majority of the population, consumption, and forest products manufacturing facilities are situated, there is only modest opportunity for expansion of harvest levels in the future. Conversely, Siberia, with a low population, very limited manufacturing capacity, and poor infrastructure has more abundant forest resources. Development in this region will be driven mainly by cultivating export markets in the Pacific Rim, while the European region will be driven by greater internal consumption and increasingly limited timber resources.

Although the trend of declining harvest levels is expected to continue in the very short term, there is great potential for increased Russian harvests in the future. The maximum annual allowable cut (AAC) within the next 20 years has been estimated at 620 million cubic meters. This represents a theoretical maximum, but is indicative of the great potential for increased harvests, particularly for conifer species in the Asian regions of Russia. Although harvesting can be increased in European Russia in the short term (5-10 years), nearly 90% of incremental supply over the next 20 years will be found in Siberia. Actual harvests from this region, of course, may be considerably lower than are possible, depending on the speed and success of investments in the forest industry. Restrictions due to environmental concerns, particularly in the European part of Russia and the Far East, and the lack of developed transportation networks in Siberia, are other obstacles in reaching the annual allowable harvest levels.

Projections of future harvests in Russia are very difficult to estimate, both due to unreliable and inconsistent inventory data, and due to the uncertainties in political, economical and social changes which will occur over the next 20 years. Forest management practices and environmental constraints will also decide the growth and health of the Russian forests, and the availability of commercial timber in the future. Some of the issues that will affect future harvest levels are:

Forest health: Air pollution, drought stress, and fungal and insect attacks are affecting growth and quality of the timber in some regions.

Forest fires: There are an estimated 1-2 million hectares burnt every year.

Land set-asides: The conservation movement, especially in the Far East, is pressuring for setting aside forest land to protect endangered species habitat.

Uneven age classes: There is a large share of mature and over-mature forests in Russia, especially in the East.

Future harvests will be of a somewhat different species mix than today. The deciduous share of 35% today, will move toward 45% of total harvest in the decades ahead. Larch will claim a much larger share of the cut in coming decades, while the spruce and pine volumes will suffer a decline. Opportunities exist for increased harvests of hardwood species, particularly birch and aspen from forests in the west.

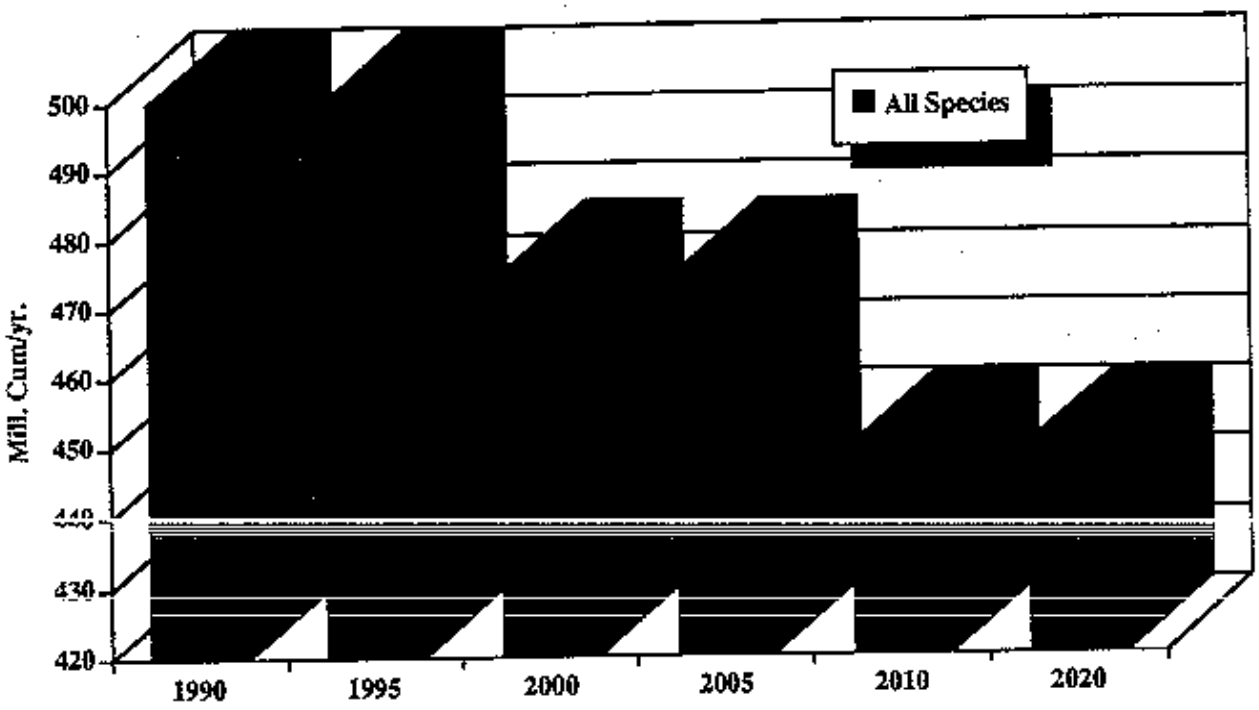
The following estimates timber availability (rather than harvest) in Russia over the next 25 years. Our general assessment is that gains in available timber supply through better utilization of harvested material, and more intensive management of production forests will almost offset an anticipated further reduction in Group III, or production forest area. By 2015, the share of the total harvest originating from Siberia will have increased to an estimated 65%, from a 1993 level of 40%.

Table 7 - Projected Timber/Fiber Availability
(million cubic meters)

All Forests

1990	500.0
1995	500.0
2000	475.0
2005	475.0
2010	450.0
2020	450.0

Projected Available Timber Supply - Russia



VII. REFERENCES

Backman, C., 1994. The Russian Forest Resource Physical Accessibility by Economic Region. Working Paper 94-126. IIASA. Laxenburg, Austria.

Backman, C. & T. Waggener, 1994. The Russian Forestry Sector Outlook and Export Potential for Unprocessed Logs and Primary Forest Products. CINTRAFOR, Seattle, WA

Backman, C. & T. Waggener, 1990. Soviet Forest at the Crossroads: Emerging Trends at a Time of Economic and Political Reform. CINTRAFOR, Seattle, WA

CIS Pulp and Paper Fact Book, 1995. Pulp and Paper International, Miller Freeman.

Nilsson, S. et.al. 1994. Siberian Forestry. Working Paper 94-08. IIASA. Laxenburg, Austria

Nilsson, S. et.al. "The Forest Resources of the Former European USSR", IIASA, Laxenburg, Austria, 1992

Nipieilesprom, (JSC Research & Design Institute on Economics, Production Management and Information of Forestry, Pulp & Paper, and Woodworking Industries), Dr. Nikolai A. Burdin, Director, Moscow.

USDA Foreign Agricultural Service, "Annual Forest Products Report", 1995

Profile of the Forest Resources and Forestry Practices

South Africa and Zimbabwe

I. GENERAL STATISTICS

Table 1 - Land & Forest Area

	South Africa	Zimb. & Swaz.	Total	
Total Land Area (ha)	170,000,000	40,812,300	210,812,300	
Forest Area (ha)	1,700,000	535,000	2,235,000	(1%)
Est. Production Forest (ha)	1,400,000	200,000	1,600,000	(.8%)

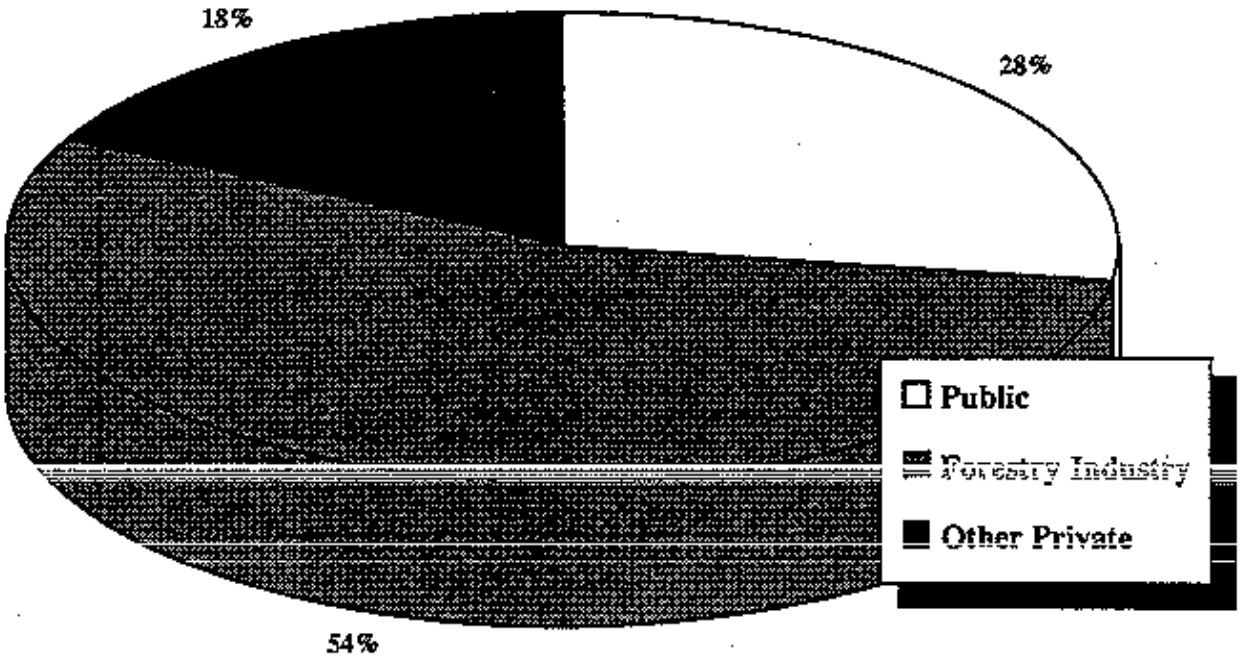
Table 2 - Production Forest Land Ownership

	South Africa (000 ha)	Zimb. & Swaz. (000 ha)	Total (000 ha)	(%)
Public	440	Min.	440	27.5%
Forest Industry	710	170	880	55.0%
Other Private	250	30	280	17.5%
Total	1,400	200	1,600	100.0%

Table 3 - Productivity

	Native Forest	Con. Plantation	Hdwd. Plantation
South Africa			
Net Annual Growth (000 cum)	950	9,300	8,500
MAI per hectare (cum/ha/yr)	1.5	15	22
1993 Harvest (000 cum)	5	8,200	8,800
Zimbabwe & Swaziland			
Net Annual Growth (000 cum)	350	1,700	550
MAI per hectare (cum/ha/yr)	1.0	10	15
1993 Harvest (000 cum)	400	1,600	420

Forest Land Ownership - Southern Africa



Total Southern Africa

Net Annual Growth (000 cum)	1,300	11,000	9,050
MAI per hectare (cum/ha/yr)	1.4	14	21
1993 Harvest (000 cum)	405	9,800	9,220

Area of Industrial Plantations: 1,600,000 hectares

II. FOREST RESOURCES

For the purpose of this profile work, we have defined "southern Africa" as including the countries of South Africa, Zimbabwe, and Swaziland. By far the most important country with respect to both supply and demand of forest products is the Republic of South Africa, which unless otherwise noted, will include the independent homeland regions of Transkei, Venda, and Ciskei.

The total forest area in South Africa is estimated at 1.7 million Ha. This includes a plantation area of approximately 1.3 million Ha. within the Republic of South Africa proper (RSA), and 75,000 Ha. within the independent homeland regions of Transkei, Venda, and Ciskei. Native forests, primarily Podocarpus species, account for just over 300,000 Ha. of the total, and are strictly protected for all except salvage harvesting. The total forest area of Zimbabwe and Swaziland is estimated at 535,000 Ha., of which 200,000 consists of industrial plantations. The native forests of Zimbabwe are better defined as forested savannah, and are utilized primarily for fuelwood, and cottage rural industries.

The industrial plantation forests of southern Africa total approximately 1.6 million Ha. Conifer species account for approximately 55% of the total, and hardwood, 45%. More specifically, the area of industrial plantations by major species group is as follows:

Table 4 - Industrial Plantations by Species Group (000 ha)

	S. Africa	Zimb.	Swaz.	Total	(%)
Pinus Patula	270	50	50	370	23.1%
Other Pine	335	25	20	380	23.8%
Other Conifer	125	---	---	125	7.8%
Eucalyptus Spp.	550	25	15	590	36.9%
Acacia Mearn.	105	15	--	120	7.5%
Other Hardwood	15	---	---	15	.9%
Total	1,400	115	85	1,600	100.0%

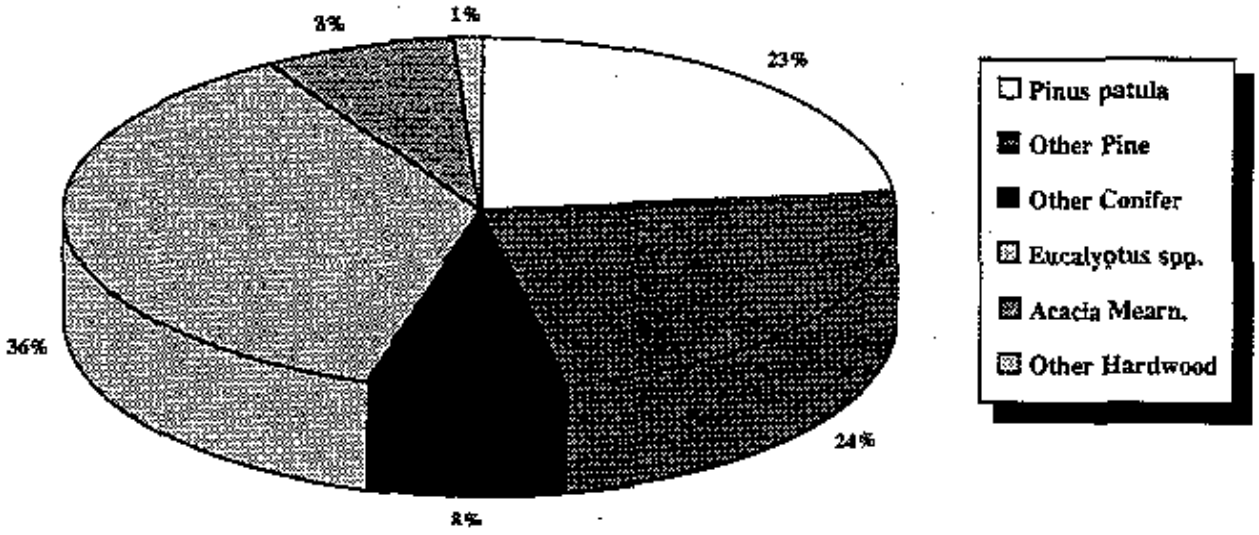
The forest products industry is the largest single owner of industrial forestland in southern Africa, with an estimated ownership of 55%. In the RSA, private forest holdings are dominated by Sappi (approx. 280,000 Ha.), Mondi (approx. 270,000 Ha.), and HL&H (approx. 160,000 Ha.). Major corporate holders in Zimbabwe include Hunyani Paper, Borders, and Wattle Co. Much of the plantation forests of Swaziland is controlled by Usutu Pulp Co., and Piggs Peak.

Public control of plantations in the RSA is concentrated in the quasi-governmental forestry organization called South African Forestry Corporation Ltd. (SAFCOL), which was created by the partial privatization of the former forest service. The forest service of Zimbabwe also controls both plantation, and native forest areas.

A unique feature of the plantations of the RSA is that they are established with the intention of producing a particular end-product. As a result, the 1.3 million ha. RSA plantation resource can be categorized by management objective as follows (000 ha.)

	Conifer	Eucalyptus	Acacia	Other
Sawlogs	408.2	31.4	0.0	1.8
Pulpwood	245.0	215.6	67.3	.6
Mining Timber	0.0	243.7	25.9	0.0
Poles	6.6	22.9	1.4	0.0
Other	8.0	7.3	9.2	6.5
Total	667.8	520.9	103.8	8.9

Industrial Plantations by Species - Southern Africa



II. CURRENT LEVEL OF UTILIZATION

The total harvest for southern Africa was estimated for 1993 at nearly 20 million cum. Industrial removals from native hardwood forests in South Africa are limited to salvage operations, and have averaged approximately 5000 cubic meters per year over the past 30-40 years. These removals support "cottage industry" production of traditional wood products and furniture. Although the native forests of Zimbabwe are heavily utilized for rural fuel purposes, and an estimate is included in this work to reflect this demand, no similar estimate is available for South Africa or Swaziland. Therefore, removals generally reflect removals of plantation roundwood for industrial purposes.

By far the largest users of roundwood are the pulp and sawmill industries of South Africa, which accounted for nearly 90% of removals in 1993. The South African forest product industry consists of approximately 200 manufacturing plants, including 130 sawmill and veneer operations. The total production of major forest products in 1993 for the entire region is estimated below.

Table 5 - Production of Wood and Paper Products, 1993

Lumber (000 cum)	2,145
Plywood & Panels (000 cum)	437
Wood Pulp (000 tonnes)	2,293
Paper & Paperboard (000 tonnes)	1,941

Growth rates throughout southern Africa are extremely dependent on site conditions - specifically on rainfall, which is the constraining factor to significant expansion of the plantation resource. In the RSA, annual growth rates for conifer plantations range between 14-16 cum/ha/year on 25 year rotations. Hardwood growth rates range between 10-12 cum/ha/year for Acacia (Wattle), to as much as 40 cum/ha/year for Eucalyptus on good sites. The average is between 20-25 cum/ha/year on 9-12 year rotations. It is assumed that growth rates in Swaziland are very similar to those of the RSA, but that averages in Zimbabwe are as much as 25% lower, due to generally drier conditions.

By combining average growth estimates, and harvest levels, it is possible to estimate growth/drain relationships for the various forest types within southern Africa as follows.

	Native Forest	Con. Plantations	Hdwd. Plantations
Est. Annual Allowable Cut (000 cum)	1,300	11,000	9,050
1993 Harvest (000 cum)	405	9,800	9,220
1993 Growth/Drain Ratio	3.20	1.12	.98

Allocation of Roundwood Harvest

The total consumption of roundwood in southern Africa for 1993 was estimated at 19.4 million cum. Use, by industry sector, is estimated as follows.

Table 6 - Estimated Industrial Roundwood Use - 1993

Industry Sector	Conifer (000 Cum)	Hardwood (000 Cum)
Sawmill, Veneer Mills	4,400	480
Pulpmills	5,200	4,520
Export Chip Industry	0	1,300
Mining Timber	0	2,540
Poles	100	280
Other	100	100
Total	9,800	9,220

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

There is only a minimal amount of native forest that remains in southern Africa today. Some is managed as ecological "preserves", in an attempt to retain some of the original habitat conditions that existed prior to colonization. Other areas are extensively managed for fuel and local wood requirements. In all countries, native forests are effectively "reserved" from industrial exploitation, and do not contribute to the wood requirement of local forest product industries.

As previously mentioned, 1.6 million hectares of industrial plantations supply nearly all of the wood required by industry. Land used for plantations is generally marginal agricultural land, scrub forestland, savannah, or grasslands. The management of pine plantations in Zimbabwe is generally based on a 25-30 year sawlog rotation. Initial stocking levels are estimated at 1400 stems per hectare, with pruning between the ages of 6 and 8. Commercial thinnings may take place at ages 14 and 20, before a clear-cut harvest. Hardwood (most of which is Eucalyptus) is managed for pulpwood or poles on either a 10 or 20 year rotation. Initial stocking is estimated at 1700 stems per hectare, and the final clear-cut harvest will yield an average of 15-20 cum/ha/year.

Management of industrial plantations in South Africa is similar. Conifer plantations may follow either a sawlog or pulpwood regime. Eucalyptus is generally managed for mining timber or pulpwood. Eucalyptus grandis remains the most common plantation species in South Africa, accounting for over 33% of all industrial plantations currently in existence. Recently, there have been attempts to increase the use of alternative Eucalyptus species such as Euc. Nitens, which has shown better growth rates, and improved density characteristics. Conifer plantations will probably remain focused on exotic Pinus species such as patula and elliottii. The following summarizes plantation management economics, and practices in South Africa.

Table 7 - Industrial Plantation Parameters (South Africa)

	Conifer Logs	Conifer Pulp	Eucalyptus
Land Costs (US$/Ha)	600	600	600
Site Prep & Planting (US$/Ha)	390	390	720
Annual Maintenance (US$/Ha/Yr)	50	50	87
Rotation (Yr)	25	18	9
Annual Yield (Cum/Ha/Yr)	15	15	22
Site Prep			
Scarification	Yes	Yes	Yes
Bedding	No	No	Yes
Initial Stocking Levels (stems/Ha)	1400	1700	1300
Chemical/Manual Weed Control	At Planting & 2-3	At Planting & 2-3	At Planting & 2-3
Chemical Fertilization	At Planting	At Planting	At Planting
Pruning (yr)	5-8 yrs	No	No
Thinning (yr)	9,14,18	No	No

The final harvest for industrial plantations in southern Africa is generally a clear-cut harvest. The dominant harvesting system is motor-manual consisting of chainsaw felling and bucking, skidding or forwarding by farm tractor, skidder, or small forwarder, and loading by hand or grapple loader. To minimize soil compaction and erosion problems in the highlands of northeast South Africa, a small percentage of high-lead and winch systems are utilized.

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES

Perhaps the most contentious forest resource related issue in this arid region is the conservation, and allocation of water. New plantations must generally obtain permits, as water used by plantation forests is viewed as water unavailable for agricultural or industrial development purposes. This is particularly relevant to year-round water consuming species such as Eucalyptus.

South Africa also has several endangered bird species such as the Blue Swallow, and Wattle Crane, which do not generally inhabit industrial plantation ecosystems. Also, there are wetland areas along the southeast coast of the region which may become unavailable for forest development, and set-aside for ecosystem preservation purposes.

Finally, despite the fact that the greatest threat to forest resources in southern Africa is fire, the region is dependent on a very small number of plantation species, and is therefore relatively more susceptible to large-scale insect, disease, or meteorological phenomena than regions supporting a more diverse forest resource.

The impact of these environmental concerns on the current and anticipated forest resources of southern Africa is expected to be minimal. The concept of plantation forests is widely accepted, and generally viewed as being in the best interest of the region by protecting watersheds, providing employment, and reducing the region's dependence on imported manufactured products, and its demands on native forest resources. Although a plantation resource of 2.0 million Ha. has been proposed for the region, expansion will likely be constrained by water/rainfall availability. The nature of plantations, however, will change as owners utilize a wider variety of Eucalyptus species, incorporate native forest areas where possible, and reduce the size of management units, in order to construct more diverse forest ecosystems.

VI. PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020

Because forest plantations in South Africa are generally managed for specific end-uses, knowledge of the age-class distribution permits a reasonably accurate projection of the volume of wood that will reach maturity under a specific set of forest area, growth, and demand assumptions. A model has been created under the auspices of the South African Forest Owners Association to project timber supply based on high, average and low yield assumptions.

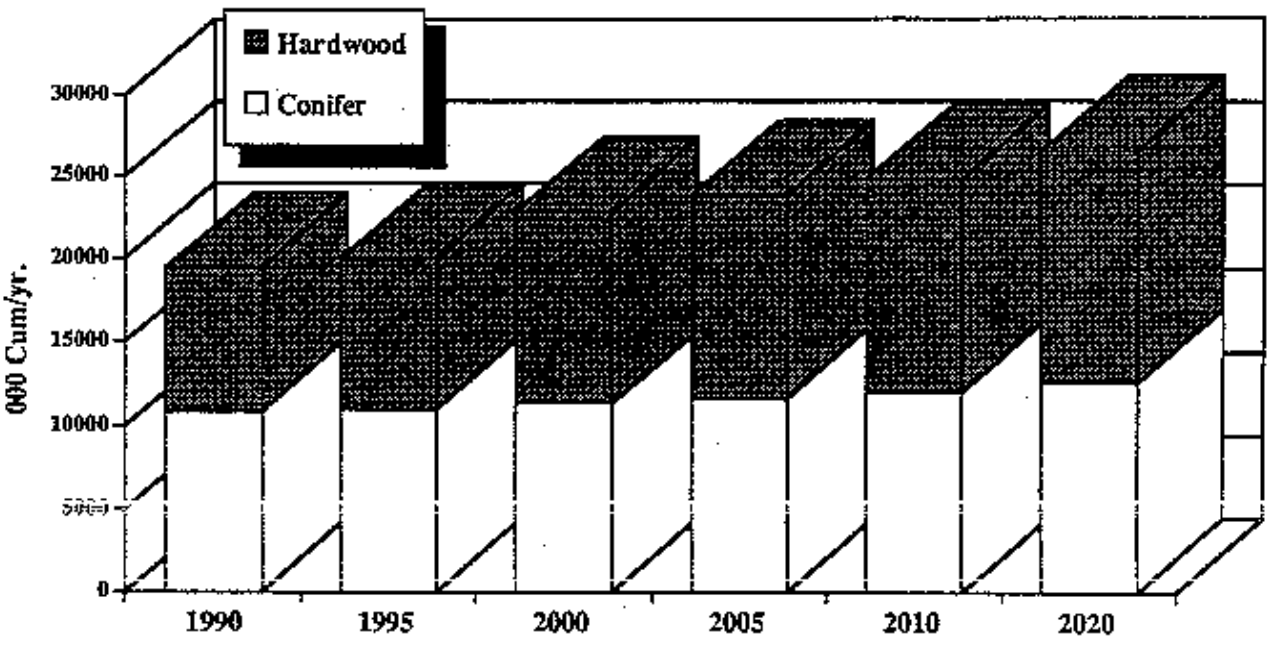
Until the recent drought, it was generally assumed that better selection of growing stock, and the matching of species to micro-climatic conditions would increase the yield of timber on a cum per hectare basis. However, the drought has reduced the annual increment of wood by as much as 20-25% through dieback and mortality. As a result, the model's low yield assumptions are deemed to be much more realistic at the current time.

The other assumptions on which this model is based - that there will be very little change in the overall area of industrial plantations in South Africa, and that demand will continue to grow at a modest pace - are thought to be very reasonable over a 15-25 year time horizon. It is likewise anticipated that although there will be minimal expansion of the plantation resources of Zimbabwe and Swaziland, current plantations will be re-forested, and sustainably managed over a 15-25 year time horizon. The following projections of current and anticipated timber availability (in thousand cum/year) are based in part on the Forest Owners Association model, supplemented to reflect additional volumes available from other countries of southern Africa.

Table 8 - Projected Industrial Timber/Fiber Availability
(thousand cubic meters)

Year	Con. Plantations	Hdwd. Plantations	Total
1990	10800	8650	19450
1995	11000	9050	20050
2000	11300	11550	22850
2005	11700	12150	23850
2010	12100	12750	24850
2020	12600	13950	26550

Projected Available Industrial Timber Supply - Southern Africa



VII. REFERENCES

South African Department for Environmental Affairs - Forestry Branch, "Commercial Timber Resources and Roundwood Processing in South Africa", 1989/1990.

South African Dept. of Forestry, " Forestry in South Africa", 1980.

South African Forest Owners Association, "Forestry and Forest Products Industry Facts", 1990.

South African Forest Owners Association, "Long Term Supply & Demand Forecast for Roundwood in the RSA and T.B.V.C. States", November, 1990.

South African Lumber Manufacturers Association, Annual Report.

South African Timber Growers Association. Annual Statistics.

U.N. Food and Agriculture Organization (FAO), "Yearbook of Forest Products 1982-1993", Rome. 1995

U.S. Department of Agriculture - Foreign Agricultural Service, "Annual Forest Products Report"

Wood Resources International Ltd., "Wood Resource Quarterly", October 1991, estimates and in-house files.

Profile of Forest Resources and Forestry Practices

Sweden/Finland

I. GENERAL STATISTICS

Table 1 - Land & Forest Area

	Sweden	Finland	Total	
Total Land Area (ha)	41,823,000	30,462,000	72,285,000	
Forest Area (ha)	24,437,000	26,200,000	50,637,000	(70%)
Est. Production Forest (ha)	23,700,000	19,900,000	43,600,000	(60%)

Table 2 - Forest Land Ownership

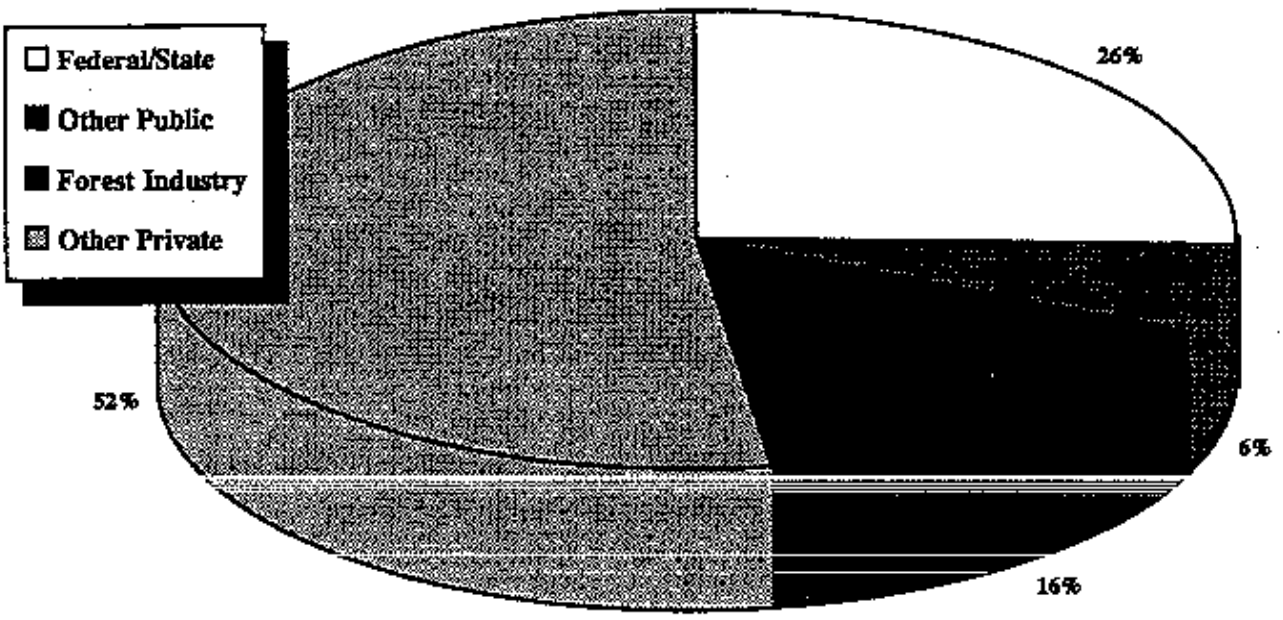
	Sweden		Finland		Total	
	(000 ha)	(%)	(000 ha)	(%)	(000 ha)	(%)
Federal/State	4,448	18%	8,800	33%	13,248	26%
Other Public	2,004	8%	1,200	5%	3,204	6%
Forest Industry	5,792	24%	2,000	8%	7,792	16%
Other Private	12,170	50%	14,200	54%	26,370	52%
Total	24,414	100%	26,200	100%	50,614	100%

Table 3 - Productivity

	Sweden	Finland
Net Annual Growth (million cum u.b.)	86.0	70.0
MAI per hectare (cum/ha/yr)	4.2	3.5
1993 Harvest (million cum u.b.)	56.3	43.0

Area of Industrial Plantations: An estimated 6-7 million hectares have been reforested by planting.

Forest Land Ownership - Sweden/Finland



II. FOREST RESOURCES

Forest have long played an important role in Scandinavian society and forest management has a history that can be traced back a century or longer. Early reforestation laws in Sweden date back to 1574, while more recent laws requiring the re-establishment of a clear-cut area date to 1903. Finnish forest policy is geared toward the closely-linked goals of improving the forest resource, and insuring the availability of export income. Setting forest policy has been a specific function of the Finnish government since before the first Forestry Act of 1928.

The economies of both Sweden and Finland depend heavily on their respective forest products sectors, and both countries are net exporters of forest products, primarily to the rest of Europe. Approximately 80% of the manufactured forest products of each country are directed toward the export market. Both countries are heavily forested, although forests account for a slightly larger share of the total land area in Finland (70%) than in Sweden (58%). The percentage of forest land has remained relatively constant in both countries throughout this century.

Two-thirds of Sweden, and a greater proportion of Finland, are located within the northern boreal forest type, while the southern part of each country supports mixed conifer/hardwood forests. The predominant species in both countries are Norway Spruce (Picea abies) and Scots Pine (Pinus sylvestris), which comprise about an equal share of the total growing stock of both countries. European birch and other hardwoods (aspen, beech, oak, and alder) account for about 18% of the total inventory in the region. Lodgepole pine (Pinus contorta), exotic to the area, has been planted in northern Sweden, and covered an estimated area of 13,000 hectares in 1993.

Although age classes are generally well-distributed, the growing stock inventory of both countries has a relatively high percentage of mature trees in large diameter classes (>25 cm). Net annual growth is estimated at 86 million cubic meters (under bark) in Sweden, and 70 million cubic meters in Finland. Growth exceeds drain in the two countries by over 50%, so their respective inventories continue to increase significantly.

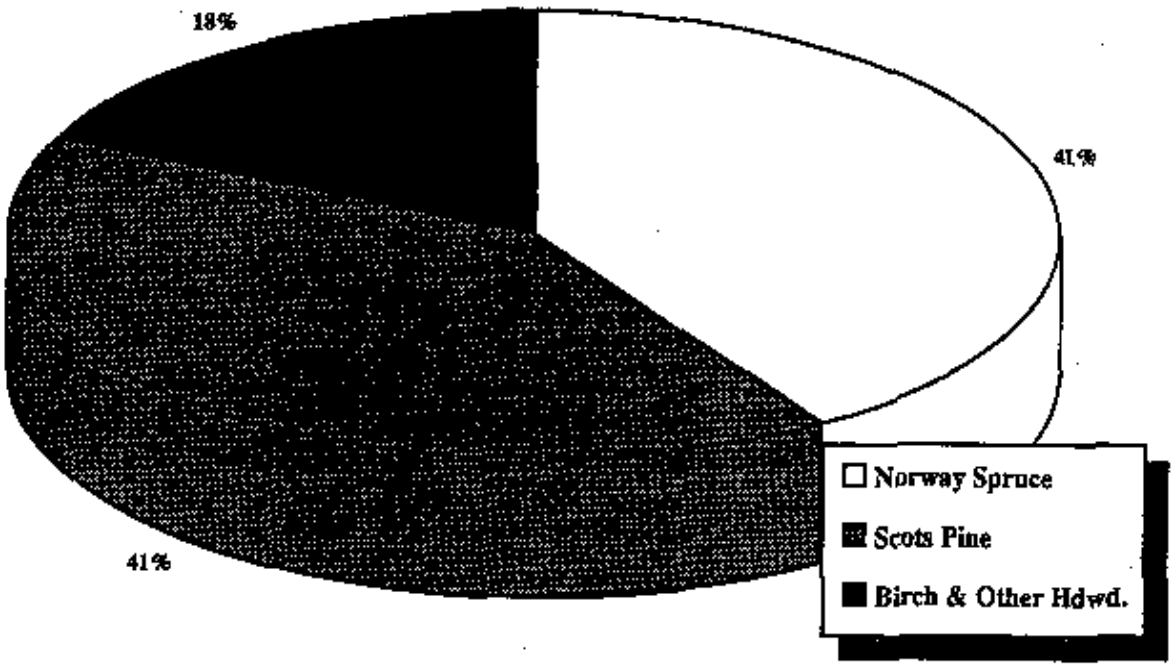
Table 4 - Species Distribution by Volume
(Billion cum)

	Sweden		Finland		Sweden/Finland	
Norway Spruce	1.244	44%	.690	37%	1.934	41%
Scots Pine	1.077	39%	.845	45%	1.922	41%
Birch & Other Hardwoods	.475	17%	.340	18%	0.815	18%
Total	2.796	100%	1.875	100%	4.671	100%

Private ownership dominates the forest land base in both Sweden and Finland. The forest industry owns a larger proportion of forest land in Sweden (24%) than in Finland (8%). Overall, farmers and other nonindustrial owners control the majority of forest land in both countries.

Landowner and forest management associations, organized in many cases as cooperatives, figure prominently in both countries. They are particularly strong in Finland where there is a close link between local county boards of forestry that oversee and enforce forest management regulations, and the 370 forest owners' associations. Through these associations and their umbrella group, the Central Union of Agricultural Producers (MTK), landowners negotiate timber prices and contracts for forest management services.

Species Distribution by Volume - Sweden/Finland



III. CURRENT LEVEL OF UTILIZATION

Compared to many other countries, timber/fiber costs tend to be high in Sweden and Finland because of high growing costs, and the structure of the marketplace. However, relative uniformity of species and quality of raw material, coupled with highly efficient processing plants, have enabled both countries to develop very competitive export-oriented industries.

Although fiber cost has historically been high, timber/fiber supply does not appear to be a constraint on sustainable, or in fact expanded, production of forest products in Sweden and Finland. A high proportion of the forest land and inventory -- between 20 and 25% -- are in mature stands that could be harvested, and both countries enjoy a comfortable excess in growth over harvest. Infrastructure is not a problem; extensive road networks traverse the region and processing mills have easy geographical access to timber/fiber supplies.

Because of the natural species distribution, the lion's share of the production is based on conifer species. A very small hardwood industry produces lumber and dimension products. In 1993, the volume of industrial roundwood harvested in Sweden was approximately 56.3 million cubic meters (underbark), supplemented by about 7.5 million cubic meters of imported logs, pulpwood, and chips. Finland's domestic fiber supply in 1993 was approximately 43 million cubic meters, plus 6.1 million cubic meters of imports. Imports of chips, pulpwood and non-coniferous logs represent, in part, trade between the two countries, but primarily wood fiber coming from Russia, Estonia, Latvia, and other parts of Europe. Imports of pulpwood and chips from South America have increased since 1994.

Comparison of domestic harvests with current net annual increment, yields the following estimates of Growth/Drain relationships for both countries.

	Conifer		Hardwood	
	Finland	Sweden	Finland	Sweden
Net Annual Increment (mill. cum u.b.)	56.0	72.0	14.0	14.0
1993 Harvest (mill. cum u.b.)	37.0	50.0	6.0	6.0
1993 Growth/Drain Ratio	1.51	1.44	2.33	2.33

The forest products industry in Sweden and Finland is comprised of several thousand sawmills, including approximately 300 which might be considered large, about 70 plywood and panel mills, and 200 plants producing pulp, paper, and board products. Several thousand other secondary manufacturers of wood products operate in each country.

Number of Producing Plants

	Sweden	Finland
Sawmills	2,483	4,171
Plywood & Panels	19	52
Pulp, Paper & Board	108	91

Both countries have a very high domestic wastepaper recovery rate. However, wastepaper utilization relative to production is low because both Sweden and Finland are such large net exporters of pulp and

paper products. The two countries are net importers of wastepaper, but less than 10% of the total fiber furnish is recovered paper.

Traditionally, Sweden and Finland enjoyed easy access to European markets. With their entry into the European Union (EU) on January 1, 1995, they now have a direct voice in EU policy and standards development, and can directly participate in deliberations concerning certification and eco-labeling issues. With the inclusion of Sweden and Finland, the EU has gone from being only 40% self-sufficient in wood supply, to over 70% self-sufficient. The two countries account for 65.1% of EU pulp production and 29.5% of EU paper and paperboard production.

Table 5 - Production of Wood and Paper Products, 1993

	Sweden	Finland
Lumber (000 cum)	13,400	8,300
Plywood & Panels (000 cum)	752	1,145
Wood Pulp (000 tonnes)	10,074	9,339
Paper & Paperboard (000 tonnes)	8,781	9,990

Approximately 70% of chips produced at sawmills go to pulp mills, 12% go to particleboard, and 2% go to fiberboard. Approximately 5% is exported, and the balance is used for fuel. Taking into consideration chip consumption, the pulp industry is the dominant consumer of wood fiber in both countries.

Table 6 - Net Timber/Fiber Consumption

	Sweden	Finland
Pulp Industry	65.5%	62.0%
Solid Wood Industry	25.9%	18.0%
Export	1.7%	2.0%
Fuelwood	6.9%	18.0%

Allocation of Roundwood Harvest

The total volume of roundwood harvest by both countries in 1993 was approximately 100 million cum under bark. The use of this material by industry sector is estimated in Tables 7 and 8.

Table 7 - Estimated Roundwood Use in Finland, 1993
(Million cum)

Industry Sector	Pine	Spruce	Hardwood
Sawmill & Plywood	7.3	9.4	.9
Pulp Industry	7.7	7.5	4.0
Other Industrial Use	3.0	2.1	1.1
Totals	18.0	19.0	6.0

Table 7 - Estimated Roundwood Use in Sweden, 1993
(Million cum)

Industry Sector	Pine	Spruce	Hardwood
Sawmill & Plywood	17.8	9.5	.5
Pulp Industry	11.6	8.8	5.5
Other Industrial Use	1.4	.9	---
Totals	30.8	19.2	6.0

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

Most Swedish and Finnish forests are under some form of management. While specific policies differ between the two countries, reforestation of cut-over land is compulsory and landowners are either required to develop forest management plans, or provided with very strong economic and other incentives to do so. In Finland, setting forest policy has been a specific function of government since before the country's first Forestry Act of 1928. County boards of forestry supervise forestry maintenance, including planning and improvement work on private as well as public lands. Approximately 70% of harvested areas are replanted, while 30% are naturally regenerated. In Sweden, about 155,400 hectares are planted annually with indigenous species, most often with the same species that was removed.

Rotations tend to be long, ranging from 90 years in southern Sweden and Finland, to 140 years in the northern zones. In the extreme southern portion of Sweden, rotation ages can be as short as 70 years, during which time trees grow to an average of 30 meters in height and 30 cm in diameter. In the northern climate, corresponding figures would be 15 meters in height and 20 cm in diameter at 140 years. After soil scarification, stands are often planted at a rate of 2000 stems per hectare. Under such regimes, as many as one pre-commercial, and five commercial thinnings are made between years 30 and 70, before a final clear-cut, seed-tree, or shelterwood harvest. Net annual growth per hectare averages about 3.5 cubic meters in Finland and 4.2 cubic meters in Sweden.

In Sweden, the use of herbicides for weeding was abolished by law in 1980, with only limited exceptions. Some fertilization is used in larger scale operations, but the practice has lessened in recent years. Fertilized hectares have declined from 125,000 in 1987, to 30,000 last year.

Clear-cutting is the generally accepted practice for final harvesting. Because of terrain, high labor costs, and even-aged forest management, mechanized harvesting systems dominate harvesting operations. A single or double-grip harvester, matched with rubber-tired, or tracked forwarder is the most common harvesting system used in Scandinavia today.

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES

Government influence on forest regeneration and forest management has a long history in both Sweden and Finland. Both countries have recently revised forest-related laws to promote sustainability.

In Sweden, a 1994 update to the Forestry Act recognized biological diversity along with timber production as goals for forest management. The law establishes guidelines and performance standards for forest management activities. Based on a New Forestry Policy approved in 1993, the Act proposes a new management strategy for Swedish forests that will encourage both timber production and environmental objective to be met, in principle, on every hectare of forest. This "multiple use" approach could reduce the requirement for expanded set-asides and protected areas (2.8% of forest land in Sweden is currently reserved).

Larger forest owners are also developing long-term nature conservation strategies which try to mimic the natural ecological process, and re-create a more diverse forest environment. This is often referred to as "ecological landscape planning", and involves leaving unmanaged areas within a larger forest landscape, often linked by corridors to create a matrix of varying forest conditions.

The Swedish National Board of Forestry (NBF) under the Ministry of Agriculture is the agency responsible for enforcing the Act, and is itself organized into 24 county forestry boards. The law requires a landowner to submit plans detailing conservation measures he will take at the time of final harvest, and encourages the development of a normalized forest age-class distribution by restricting the harvest of timber prior to economic maturity. The law also prohibits broadleaved forests in southern Sweden from being converted into other forest types. As might be expected, regulations governing larger holdings are more rigorous than for small, privately held parcels.

The limited number of forest species naturally found in the forest of both Finland and Sweden has been the focus of environmental concern for many years. The vast majority of stands are comprised of spruce, pine, and birch. The need to promote bio-diversity where possible, has received considerable attention in law and in practice, and as exemplified in the Swedish Forestry Act, has become a cornerstone of Scandinavian forest practices. Although Finland has yet to put some of these concepts into formal legislation, it is expected to do so through revisions in the current Forestry Act which is scheduled to come into effect in 1997.

Acid rain and other pollutants have been identified as possible causes for pine and spruce die-back, which has become endemic in both Sweden and Finland. A major concern is the acidification of forest soils, particularly in southern regions of each country, where soil pH has been slowly decreasing for several years. Widespread liming has been proposed as a possible solution in Sweden. In recent years, as much as 15% of the forest land in southern Finland, and 24% in the north, has exhibited stress conditions due to acid rain or other causes thought to be related to air pollution.

In 1992, the forest industry, trade unions, forest owners and the church (a minor owner) agreed on a "Declaration of Intent" to protect bio-diversity and environmental values. The voluntary principles enunciated included commitments to consider non-timber values in normal practices, use nontraditional silvicultural procedures when possible, and support the government purchase of more nature reserves.

Formally joining the EU has brought the need to conform with certain European-wide standards and practices. For example, EU standards concerning the maximum weight of vehicles are more stringent than those in Scandinavia, because the frozen northern roads tend to support heavier loads. However, being part of the EU provides Sweden and Finland with an opportunity to participate in policy-making concerning eco-labeling and forest certification. Several countries, including Sweden and Finland, are attempting to establish a mechanism within the EU to coordinate forest policy.

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Although the final harvest of most forests in Scandinavia remains a clear-cut harvest, an increasing volume of wood is being obtained from commercial thinning operations. Thinnings in Sweden currently provide as much as 30% of domestic timber supply, up from 20% in the early 1980's. Although clear-cutting for final harvest is accepted, and even encouraged in forest management legislation, the adoption of "landscape forest management" will reduce the size of clear-cuts in the future. It is unclear at this point how these changes in forest management policy, and fiber sourcing, might compliment embryonic calls for "CCF" (clear-cut free) pulp and paper products.

VI. PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020

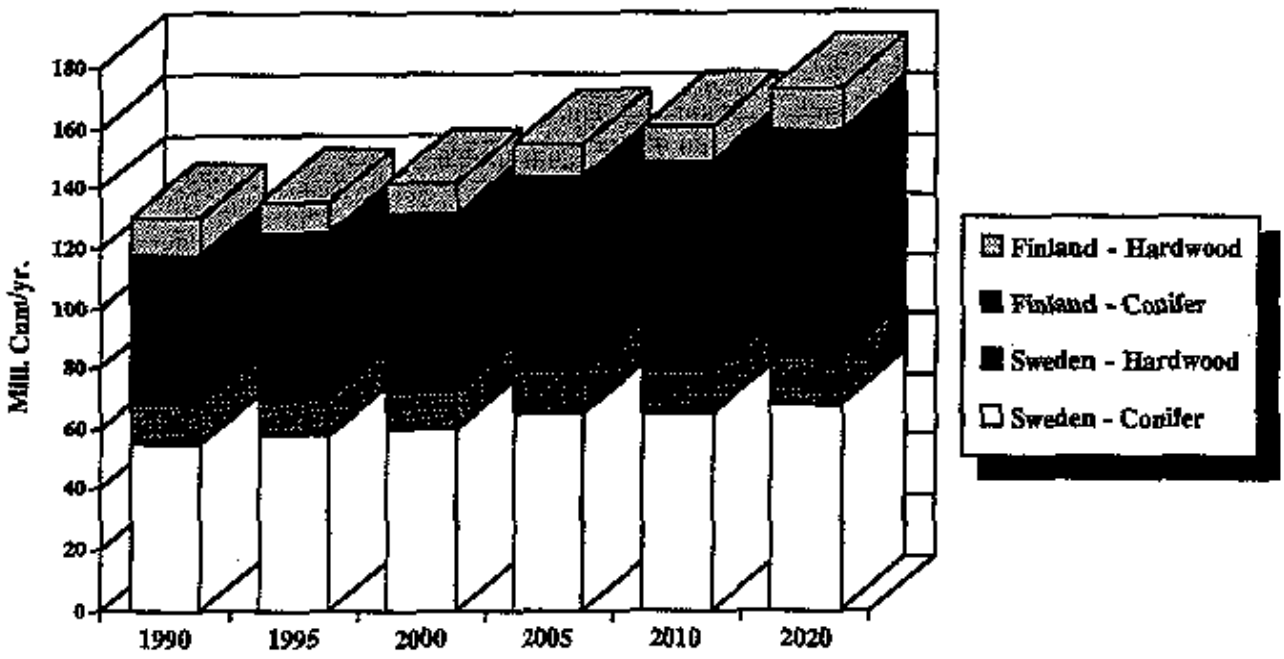
A significant increase in growth rates and large surplus in inventory provide Scandinavia with significant expansion opportunities, though environmental pressures will keep annual roundwood consumption substantially below calculated sustained yield. Considerable debate also surrounds the impact of acid rain on the Scandinavian forests. Dramatic increases in growth rates are attributed to a temporary fertilization effect from acid rain; but higher stress and mortality have also been measured. Because fiber and capital costs for new plant and equipment are high, and nonindustrial landowners in Sweden are demonstrating an increasing reluctance to harvest timber, expansion in Sweden's forest products industry will be more restrained than in Finland.

The following projections show potentially available conifer and hardwood supply from Sweden and Finland, over a 25 year forecast period. All projections are in cum under bark, and reflect our best estimates concerning the percentage of sustainable supply that might actually be available for industrial purposes.

Table 9 - Projected Timber/Fiber Availability
(million cubic meters u.b.)

Year	Sweden		Finland		Total	
	Con.	Hdwd.	Con.	Hdwd.	Con.	Hdwd.
1990	55.0	13.0	50.0	12.0	105.0	25.0
1995	58.0	12.0	55.0	10.0	113.0	22.0
2000	60.0	12.0	60.0	10.0	120.0	22.0
2005	65.0	14.0	65.0	11.0	130.0	25.0
2010	65.0	14.0	70.0	12.0	135.0	26.0
2020	68.0	16.0	75.0	14.0	143.0	30.0

Projected Available Timber Supply - Sweden/Finland



VII. REFERENCES

Finnish Forestry Association, "Annual Ring", 1995.

Finnish Forestry Association, "The Representation of the Revised Forest 2000 Program".

Finnish Forest Industries Association, "Facts and Figures, 1995"

Finnish Forest Research Institute, "Forest Finland", Helsinki, June 1995.

Finland Ministry of Agriculture and Forestry, "Finland and Forests", Undated.

Forsstrom, Anders, "Ups and Downs", International Papermaker, May, 1995.

Grey, Gene W. "Finland: Forestry and Technology," Journal of Forestry, July 1988.

Hakkila, Pentti, "Procurement of Timber for the Finnish Forest Industries", Finnish Forest Research Institute, Research Paper 557, Vantaa 1995.

Sennblad, Gotthard, and Ulf Sundberg, "Private Forestry in Sweden," Royal College of Forestry, Garpenberg, Sweden. Undated.

Sweden National Board of Forestry, "The Forestry Act," "Sweden's New Forest Policy," Jönköping 1995.

Sweden National Board of Forestry, "Statistical Yearbook 1995", Jönköping 1995.

Swedish Pulp and Paper Association, "Plain Facts on the Swedish Forests and their Products." 1992.

Swedish Pulp and Paper Association, "The Forest Cycle - Piece by Piece", Stockholm, April 1993.

Swedish Pulp and Paper Association, "Sweden's Forest Industry", 1989 and 1990.

USDA Foreign Agricultural Service, ATO Reports, "Annual Forest Product Report", 1988-1994.

Wood Resources International Ltd., "Wood Resource Quarterly", July and October 1989, estimates and in-house files.

Profile of Forest Resources and Forestry Practices

Thailand

I. GENERAL STATISTICS

Table 1 - Land & Forest Area

Total Land Area (ha)	51,089,000	
Forest Area (ha)	12,735,000	(25%)
Est. Production Forest (ha)	1,000,000	(2%)

Table 2 - Forest Land Ownership

Federal/State	Nearly 100%
Private	Minimal

Table 3 - Productivity

	Native Forest	Fiber Plantations
Mean Annual Increment (000 cum)	Not Applicable	500*
MAI per hectare (cum/ha/yr)	4-5	20-25
1993 Harvest (000 cum)	120	400

* Exclusive of rubberwood

Area of Industrial Plantations: 760,000 hectares - of which approximately 370,000 are thought to be for non-industrial purposes.

II. FOREST RESOURCES

Thailand was once a preeminent timber producer, known worldwide for high quality teak and other furniture-grade tropical woods. However, deforestation has been a persistent problem due to population growth, rampant and uncontrolled agricultural development, voracious logging, and the building of dams and other public works projects.

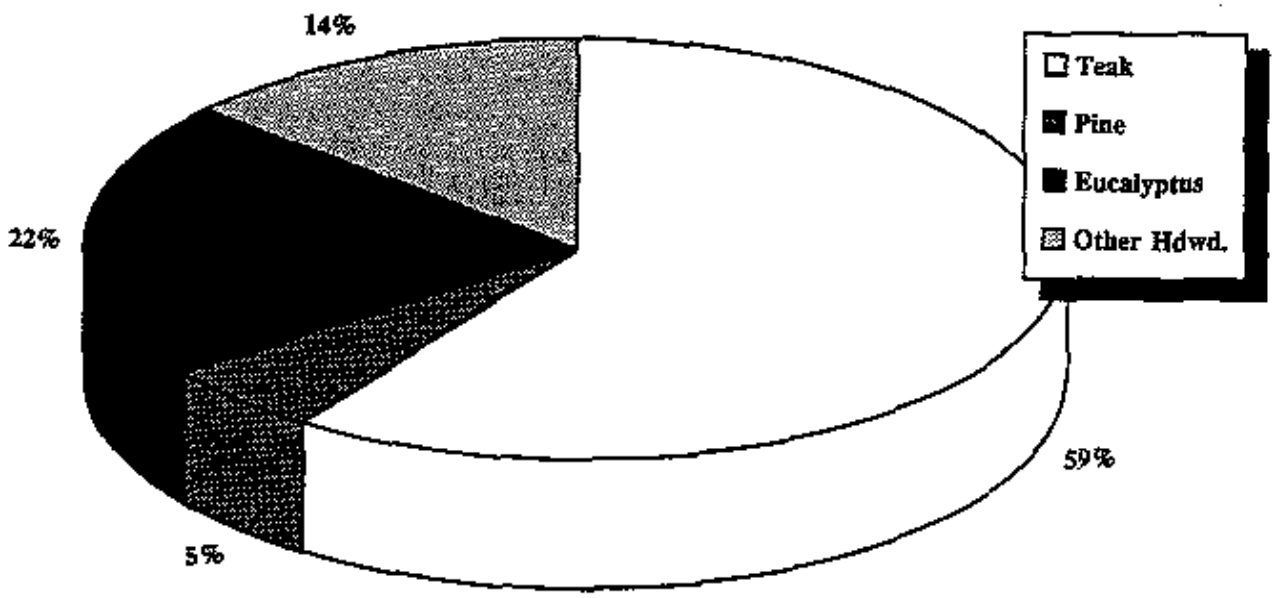
Between 1960 and 1989, an average of 515,000 hectares were converted annually from forests to other uses, mostly agriculture. Forest cover has gone from 53% of the land area in 1961 to 25% today. Since 1989, the rate of deforestation has lessened, but continues. While plantations are increasing, they add at the most 42,000 hectares per year, not enough to offset the amount of land logged or converted to other uses.

Of the roughly 13 million hectares of forest land remaining in Thailand, about 55% is moist, tropical hardwood forest located mostly in the northern region; 45% is coniferous. The tropical forests contain literally thousands of species. Teak is the most well-known, but other species known to the wood trade include yang (keruing), teng, and rosewood. Rubber tree plantations in the south cover approximately 1.5 million hectares, and although provide raw material to the domestic forest product industry, are not included in the plantation estimates given above. Thailand's total timber inventory is estimated to be 600 million cubic meters.

Reliable statistics on forest land ownership are not available. For the country as a whole, including all land-uses, private ownership accounts for 52% of the total land area. Various forms of governmental ownership – national and local – make up the balance. For forest land specifically, the government owns all remaining natural forests, and a large percentage of plantation forests either directly, or through joint-ownership of various agricultural enterprises.

Thailand's National Forest Policy has established a goal to reforest 7 million hectares. Approximately 755.7 thousand hectares of timber plantations have been established, but the goal remains very distant. The Royal Department of Forestry (RDF) controls 75% of existing plantations and, as previously mentioned, the remaining 25% is owned through various entities, most of which involve the government in some capacity. Approximately 60% of industrial plantations are Teak, and 35% are other broadleaved species such as Eucalyptus, Acacia auriculiformis, Gmelina arborea, Melia azederal and asuarina. Pines have been planted on about 5% of the industrial plantation area.

Est. Distribution of Industrial Plantations - Thailand



III. CURRENT LEVEL OF UTILIZATION

In 1989, to stem massive deforestation, the Thai government ended all logging concessions on national forests, and effectively banned logging within Thailand. Since then, timber/fiber harvests have come from small "demonstration areas" managed by the Royal Forestry Department (RFD), thinnings from

commercial Teak and Eucalyptus plantations, expended rubber trees cut on rubber plantations in the southern part of the country, and illegal land-clearing. Official log production has dropped from nearly 5 million cubic meters in 1988, to below 120,000 cubic meters in 1993. Actual production was closer to 800,000 cum, including supply from industrial plantations.

Since 1989, when logging was banned, the Thai wood industry has faced increasing difficulty securing raw material. Timber/fiber imports have escalated rapidly and, for a period, the Teak forests of neighboring Burma were supplying logs to the Thai sawmill industry. Over the past three years, the Burmese government has moved to suspend logging concessions in the border area, and trade has diminished. Still, "documented" imports of logs from Burma in 1993 were estimated at over 700,000 cum. Thailand is currently also importing hardwood logs from Malaysia, Cambodia, Laos, and Vietnam.

The sawmill industry is comprised of approximately 450 small, inefficient mills, only a small proportion of which may be operating at any given time. Many of the existing sawmills lack access to power and are hand-operated. The wood processing industry produces lumber for construction and furniture applications, and an assortment of other products ranging from flooring to picture frames. Domestic demand for construction materials is increasing at a robust pace comparable to the economy's growth. Thus, Thailand's imports of wood products have increased dramatically, and currently account for over 70% of consumption.

Consumption of pulp and paper is also growing rapidly, at a rate of about 6.5% per year. Thailand's five pulp mills and 43 paper and paperboard mills have a combined capacity of 2.2 million tonnes. Thailand's pulp production totaled approximately 390,000 tonnes in 1993, including about 180,000 tonnes of wood pulp. Wood raw material consumption by the pulp industry was estimated at 390,000 cum - nearly all of which came from small "demonstration," and farmer owned Eucalyptus plantations.

About 60% of Thailand's consumption of pulp, and 30% of paper and paperboard, is imported. In 1993, Thailand imported 279,600 tons of pulp fiber from the US, Canada, Brazil, Chile, and Indonesia. Thailand also imported 164,500 tons of wastepaper from the U.S., Germany, Netherlands, Malaysia, and Hong Kong. Pulp exports for 1993 were minimal - only 21,700 tonnes were exported to S. Korea, India, Malaysia, and Indonesia.

Table 4 - Production of Wood and Paper Products, 1993

Lumber (000 cum)	715
Plywood & Panels (000 cum)	260
Wood Pulp (000 tonnes)	180
Paper & Paperboard (000 tonnes)	1,280

Allocation of Roundwood Harvest

The 1989 logging ban effectively reduced legal and, to a large extent, illegal logging. The ban is intended to remain in effect until Thailand's forest cover recovers to 40% of total land area. This will take many years, assuming afforestation programs are successful. In the meantime, Thailand remains a significant net importer of raw material and finished forest products. Logs are procured primarily from concessions in other Southeast Asian countries. It should also be noted that FAO estimates total fuelwood consumption in Thailand at 36 million cum per year. Obviously, this dwarfs both industrial roundwood consumption,

and domestic roundwood production. Due to the lack of confirming data concerning both demand for fuelwood, and current sources, we will not include fuelwood demand in our analysis. Still, the relative size of this demand must be considered a driving force behind the continued illegal exploitation of Thailand's remaining forest resources.

In 1989, log output of Teak and other tropical species totaled 4.0 million cubic meters. By 1990, legal log production had dropped to only 409,200 cubic meters. For 1993, the total log harvest was estimated at just 120,000 cubic meters. This figure is not thought to include harvests from fiber plantations of approximately 400,000 cum. Therefore, the total domestic wood supply is estimated at 520,000 cum. Documented imports for 1993 were 1.7 million cum, leaving a shortfall of approximately 250,000 cum from non-industrial, and undocumented sources.

Table 5 - Estimated Roundwood Use, 1993
(000 cum)

Industry Sector	
Sawmill Industry	1,430
Plywood & Panel Industry	650
Pulp Industry	340
Total	2,470

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

Thailand's climate and topography are highly favorable for producing fast-growing timber crops. It is also favorable for growing cash crops such as rice, corn, soybeans and sugar which produce much faster economic returns. As part of its afforestation efforts, the government has been attempting to persuade farmers to set aside crop land for tree-growing. It has met with little success, despite the fact that tree-growing is a much less labor-intensive economic activity. Farmers view tree plantations as competitors for water, and claim that Eucalyptus plantations lower the water table needed for other crops.

Despite these difficulties, plantations are perhaps the only hope for greatly expanding fiber supply in Thailand. A typical Eucalyptus plantation is managed for pulpwood, or poles (for fences and light construction), on a 5 year rotation. Planting is by hand, there are few if any silvicultural treatments undertaken, and the final harvest is generally harvested by the landowner using chainsaws, axes, and manual labor. Extremely favorable growing conditions can easily produce yields of 30 cubic meters/ hectare/year on 5 year rotations, and improvement of silvicultural practices could further increase net annual yields. If 10% of Thailand's agricultural land were converted to short rotation hardwood plantations, the additional fiber supply could support several large pulp manufacturing operations.

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES

Deforestation from expanding agriculture, new settlements, illegal wood cutting and encroachment by private developers have greatly reduced Thailand's forest area. According to some estimates, fewer than 1 million hectares of forest has been undisturbed by some kind of agricultural, logging, or

development activity. Despite the 1985 National Forest Policy, which aims to re-establish forest cover on 40% of the country, the Royal Thai Government's efforts in promoting afforestation have been hampered by an inability to enforce forest protection measures.

Intensive forest plantation growth rates in Thailand are potentially among the highest in the world. However, government and private efforts to expand plantations have been frustrated by cultural, political, and economic forces. The first efforts of the early 1980's involved the acquisition of farmland by the government, or purchase of farmland by private industry, for plantation purposes. This was fiercely opposed by farmers who were enjoying excellent export markets for cash crops such as rice and tapioca, and by an evolving environmental movement concerned about water consumption by Eucalyptus species, and the conversion of farmland to industrial plantations. Domestic forestry companies such as Advanced Agro and Phoenix were unable to secure significant landholdings, and interest in establishing fiber plantations in Thailand on the part of foreign investors waned. One such venture, Japan's Thailand Eucalyptus Resource Company (TERCO), suspended operations in the early 1990's due to an inability to purchase land.

In recent years, however, there has been renewed interest in plantations in Thailand, combined with a new strategy that includes smaller plantings on only marginal and non-agricultural lands, landowner assistance programs for agro-forestry schemes, and a wider array of plantation species. Companies such as Siam Cement hope to plant as much as 3000 Ha. per year of "promotional plantation forests" on private farmlands, to supplement their fiber requirement. Although a significant increase in the overall plantation area is possible in the decade ahead, the economics of procurement from small, scattered plantation areas will increase the relative cost of this wood fiber to the manufacturing sector.

VI. PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020

Thailand's economy will continue to grow rapidly for the next several years. Demand for building and furniture materials, plus packaging and other paper products will mirror other activity in the economy, as will growth in the pulp and paper industry. Thus, Thailand's requirements for timber/fiber will grow significantly over the next 10 to 20 years, and Thailand will continue to be dependent on imports for much of its supply.

Other southeast Asian countries which have been supplying logs and pulpwood to Thailand -- Cambodia, Burma, Malaysia, and Vietnam -- are reconsidering their export policies in light of their own forest depletion problems. Thus, fiber supply will remain very tight in Thailand in the foreseeable future.

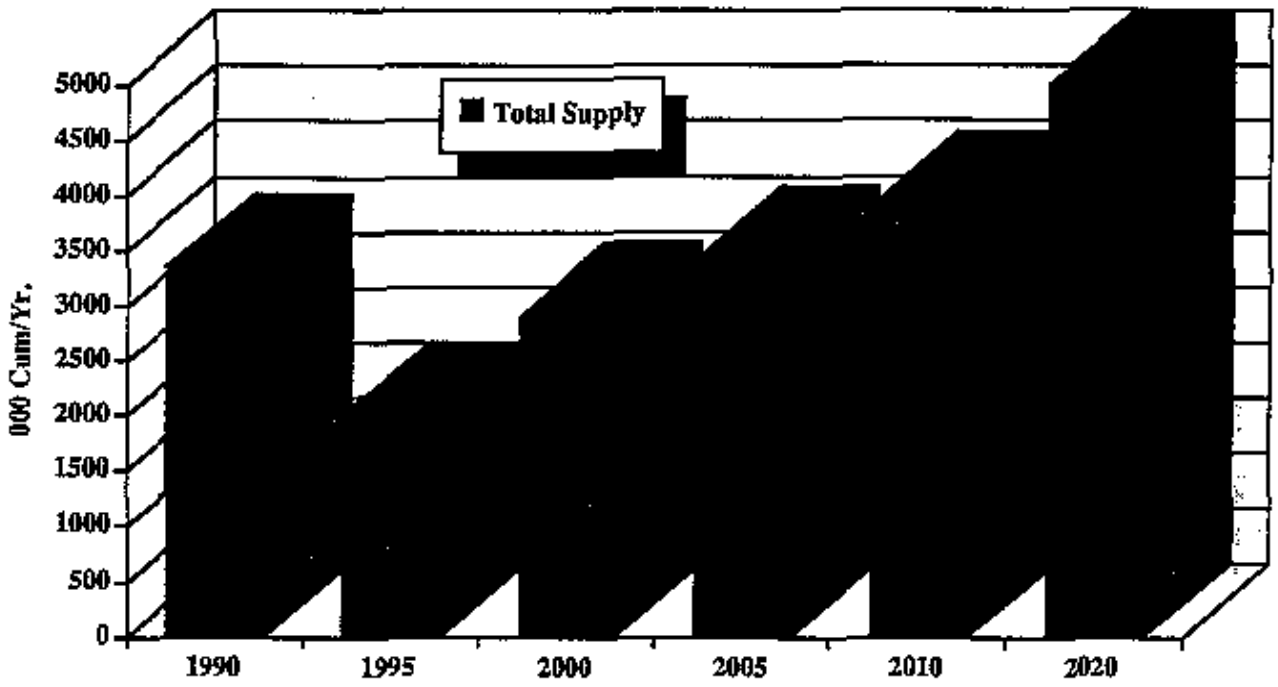
In spite of this, several new pulp and paper projects are underway. Thailand's industry appears to be expanding, spurred by prospective demand, but somewhat indifferent to the raw fiber needed to support expansions. In 1993, Thailand produced approximately 1.28 million tonnes of paper and paperboard, equivalent to about 0.5% of total world production. Output is projected to double by the year 2000 and quadruple by 2010. At that point, Thailand's contribution to world pulp and paper supply will be over 1.0%.

The following projections assume that efforts to stop deforestation will only be marginally successful, and that future domestic Thai timber supply will come exclusively from currently established and anticipated fast-growing plantations. Projections include an annual contribution of 1.5 million cum from rubberwood plantations.

Table 6 - Projected Timber/Fiber Availability
(000 cubic meters)

Year	Total
1990	3,353
1995	2,000
2000	2,900
2005	3,400
2010	3,900
2020	5,000

Projected Available Timber Supply - Thailand



VII. REFERENCES

Asia Pacific Papermaker, "Thailand: Industry Still Sparkles", pp. 25-26, July 1994.

Bayliss, Martin, "Thailand; Concentrating on Essentials", Asia Pacific Papermaker, pp.27-29, December, 1994.

FAO Forestry Paper 112. Forest Resources Assessment 1990: Tropical Countries. Rome

ITTO: Drake, P. et.al. "Analysis of MacroEconomic Trends in the Supply and Demand of Sustainably Produced Tropical Timber from the Asian Pacific Region" Sept. 1993

Pandey, Devandra. "An Assessment of Tropical Forest Plantation Resources." Uppsala: Swedish Univ. of Ag. Sciences, Dept. of Forest Survey. Oct. 1992.

Thai Pulp and Paper Industries Association, 1994 Directory.

USDA Foreign Agricultural Service, ATO Reports, "Annual Forest Product Reports", 1990-1995.

Wood Resources International Ltd., estimates and in-house files.

Profile of Forest Resources and Forestry Practices

U.S. South

I. GENERAL STATISTICS

Table 1 - Land & Forest Area

Total Land Area (ha)	216,321,000	
Forest Area (ha)	85,764,000	(40%)
Est. Production Forest (ha)	80,660,000	(37%)

Table 2 - Forest Land Ownership

	(000 ha)	(%)
Federal/State	6,479	8.0%
Other Public	1,818	2.3%
Forest Industry	15,793	19.6%
Other Private	56,570	70.1%
Total	80,660	100%

Table 3 - Productivity

	Conifer	Hardwood	Total
Net Annual Growth (million cum)	152.2	133.9	278.2
MAI per hectare (cum/ha/yr)	4.0	3.0	3.4
1993 Harvest (million cum)	149.8	88.7	253.3

Area of Industrial Plantations: 11,000,000 Ha., or 30% of conifer resource

II. FOREST RESOURCES

For purposes of this profile, the U.S. South is defined as the following 13 states: Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, and Texas. This is consistent with the classification system used by the U.S. Forest Service, enabling the use of readily available data.

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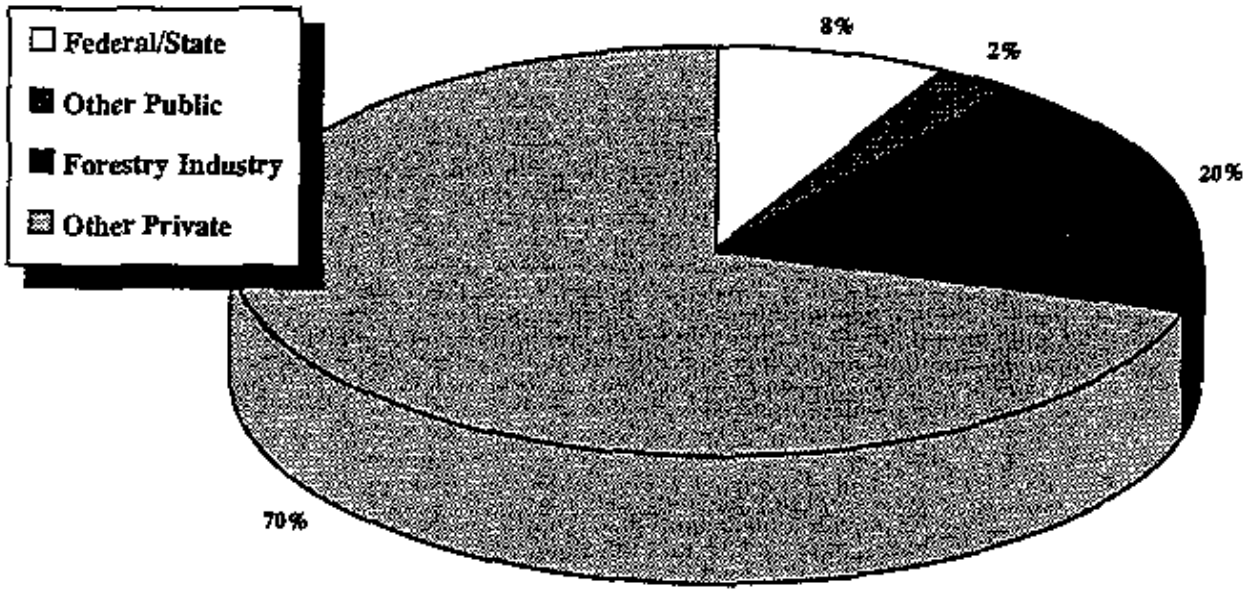
Forest Land Ownership - US South



The Southern region of the United States is generally regarded as one of the more productive timber-producing regions in the world. It contains 23% of the U.S. softwood growing stock, and 44% of the hardwood growing stock. The region accounts for 45% of total U.S. annual timber growth and 55% of removals -- softwood removals account for 53% of the U.S. total; hardwood removals account for 59%.

Over the past two decades, the South's share of U.S. timber production has been steadily rising. It is projected to increase still further since most of the new growth opportunities for timber production in the U.S. are located there. A combination of warm climate, flat and rolling topography, and a political/cultural environment that favors private ownership has fostered investment in Southern pine plantations.

Southwide, production forests cover 80.7 million hectares, or 37% of the land area. Conifer pine types comprise nearly one-third of the forest types, hardwoods about 50% and the balance is generally mixed oak-pine stands. The vast majority (90%) of timberland is owned privately. Industry owns 20%; farmers and other private landowners control 70%. Except in local areas, where forest industry companies or other large landowners may own large tracts, ownership of forest land is not concentrated. The average private holding, for both individuals and corporations, is approximately 15 hectares.

The forests of the U.S. South contain 7.1 billion cubic meters of growing stock, of which conifers comprise 41%, and hardwoods 59%. Conifer resources are dominated by Southern yellow pine species including Loblolly (P. Taeda), Slash (P. elliottii), Longleaf (P. palustris), and Shortleaf (P. echinata). Most (52%) of the conifer forests in the south are of the Loblolly/Shortleaf forest type.

Conifer stands in the South comprise approximately 36.6 million hectares which can be divided into Pine Plantations (30%), Natural Pine Forests (39%), and Oak/Pine Forest types (31%). About 730,000 hectares are planted in the South each year, but only one-third are newly established plantations, primarily on formerly natural pine stands, or agricultural land. Loblolly pine is the preferred species for planting in most areas, but Shortleaf and Slash pine are also used.

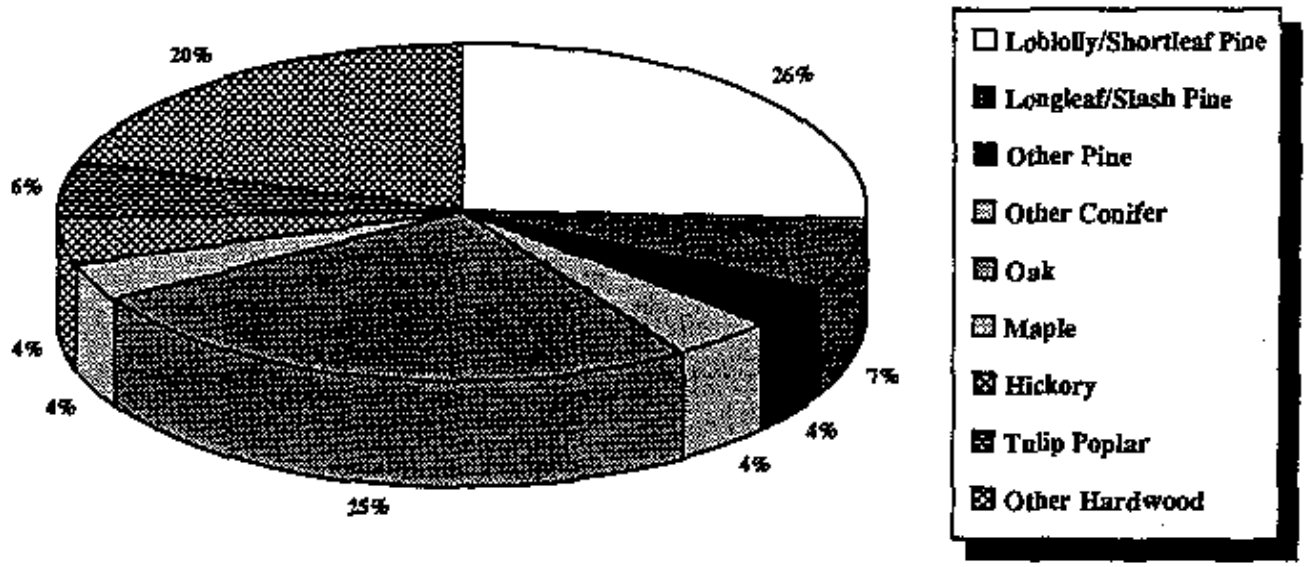
Table 4 - U.S. South Forest Types

	South Central		Southeast		Total South	
	(000 ha)	(%)	(000 ha)	(%)	(000 ha)	(%)
Loblolly & Shortleaf	10,391	22.4%	8,635	25.2%	19,026	23.6%
Longleaf & Slash	1,281	2.8%	4,437	12.9%	5,718	7.1%
Oak Pine	7,551	16.3%	4,017	11.7%	11,568	14.3%
Total Conifer	19,223	41.5%	17,089	49.8%	36,312	45.0%
Oak-Hickory	19,768	42.7%	10,394	30.3%	30,162	37.4%
Oak-Gum-Cypress	6,291	13.6%	4,829	14.1%	11,120	13.8%
Other Forest Types	986	2.1%	767	2.2%	1,753	2.2%
Non-Stocked	78	0.2%	1,237	3.6%	1,315	1.6%
Total Hardwood & Non-Stocked	27,123	58.5%	17,227	50.2%	44,350	55.0%
Total	46,346	100.0%	34,316	100.0%	80,662	100.0%

Table 5 - Species Distribution by Volume

	South Central		Southeast		Total South	
	(mill. cum)	(%)	(mill. cum)	(%)	(mill. cum)	(%)
Loblolly/Shortleaf	1,130	30.7%	739	20.0%	1,869	25.3%
Longleaf/Slash	135	3.7%	327	8.8%	462	6.3%
Other Yellow Pines	80	2.2%	205	5.5%	285	3.9%
Other Conifers	99	2.7%	199	5.4%	298	4.0%
Total Conifers	1,444	39.3%	1,470	39.7%	2,914	39.5%
White & Red Oak	1,022	27.8%	773	20.9%	1,795	24.3%
Maple	103	2.8%	166	4.5%	269	3.6%
Hickory	212	5.8%	103	2.8%	315	4.3%
Yellow Poplar	149	4.1%	249	6.7%	398	5.4%
Other Hardwoods	745	20.3%	659	17.8%	1,404	19.0%
Total Hardwoods	2,231	60.7%	1,950	52.7%	4,181	56.7%

Species Distribution by Volume - US South



III. CURRENT LEVEL OF UTILIZATION

Growth rates vary throughout the South. About 17% of the forest land base is capable of producing greater than 8.4 cubic meters per hectare per year; 45% is capable of producing better than 5.9 cubic meters per hectare per year; and over 86% is capable of producing 3.5 cubic meters per hectare per year or more. Average growth across all stands of natural and planted pine is approximately 4.5 cubic meters/ hectare/year. For intensively managed pine plantations on high sites, growth can reach 15 cubic meters/ hectare/year.

The resource situation in the U.S. South must be viewed in the context of events in other U.S. regions. Since 1989, the annual harvest on federally-owned forests in the western United States has been reduced by about 28 million cubic meters because of litigation over environmental issues, and changes in land management objectives. The Western reduction has placed unforeseen pressure on the southern resource, and has significantly tightened conifer growth/drain ratios. While hardwood growth exceeded removals by 51% (growth/drain = 1.51:1) in 1991, harvests of conifer generally equalled growth. Production of major forest products for 1993 was as follows.

Table 6 - Production of Wood & Paper Products, 1993

Lumber (000 cum)	33,965
Plywood & Panels (000 cum)	24,700
Wood Pulp (000 tons)	48,300
Paper & Paperboard (000 tons)	46,780

The U.S. South accounts for over 70% of the U.S. wood pulp production, 60% of its paperboard output and half of its paper production. It is home to approximately 155 paper and board operations and an equal number of pulp mills. The Southern paper industry is generally regarded as efficient and globally competitive. In the regional sawmill and plywood industries, approximately 40% of the raw material consumed is reflected in solid wood output; the balance is in chips and other by-products. When the use of these manufacturing and other forest residues are taken into account, the pulp and paper industry consumes the bulk (60%) of the fiber produced in the South.

Timber/Fiber Consumption - Southern U.S.

Pulp/Paper Industry	60%*
Solid Wood Industry	28%
Fuelwood	9%
Export& Other	3%

*Includes residues

Allocation of Roundwood Harvest

While sawlogs and veneer logs account for the largest category of roundwood harvested, pulpwood's share is significant and growing. In 1991, about 40% of the total harvest was pulpwood material. Southern yellow pines -- primarily Loblolly and Slash --are the dominant pulpwood species in the region. More than 70% of the pulpwood harvest is pine despite the fact that pine and pine-hardwood forest types comprise less than half of the forest land. This is reflected in the grades of paper and paperboard manufactured in the South -- unbleached kraft paperboard, newsprint and uncoated free sheet. However, the ready availability of lower-cost hardwood has led to its greater utilization in the pulp and paper industry.

In the South, roundwood pulpwood accounts for 72% of all pulpwood consumed by the industry. The balance is from manufacturing residues including chips from sawmills and from "chip'n'saws" (sawmills based on chipper canter initial breakdown technology). Chip'n'saws are widely used in the South and allow efficient output of small dimension lumber (mostly 2x4's) and chips from small diameter logs.

Table 7 - Estimated Roundwood Use - 1991
(000 Cum & %)

	Softwood		Hardwood		Total	
Sawlogs	65,920	42.3%	29,091	33.1%	95,012	39.0%
Pulpwood	63,366	40.7%	32,748	37.2%	96,113	39.4%
Veneer Logs	20,342	13.1%	2,167	2.5%	22,509	9.2%
Fuelwood	1,969	1.3%	22,150	25.2%	24,120	9.9%
Other Products	4,203	2.7%	1,805	2.1%	6,008	2.5%
Total	155,800	100.0%	87,962	100.0%	243,762	100.0%

By Percentage

	Softwood	Hardwood	Total
Sawlogs	69%	31%	100%
Pulpwood	66%	34%	100%
Veneer Logs	90%	10%	100%
Fuelwood	8%	92%	100%
Other Products	70%	30%	100%
Total	64%	36%	100%

Comparison of this data with estimates of available growth, yields the following Growth/Drain estimates.

	Pine Plant.	Natural Pine	Natural Hdwd.
Est. Annual Allowable Cut (mill. cum)	40	112	134
1993 Harvest (mill. cum)	30	120	89
1993 Growth/Drain Ratio	1.33	.93	1.51

IV. GENERAL SILVICULTURAL AND PLANTATION MANAGEMENT PRACTICES

Despite a very large industrial conifer plantation resource, most of the forests of the U.S. South are naturally regenerated, mixed species stands. Many forests have naturally regenerated on abandoned farmland, or after the harvest of sawtimber stands. Although all public and industry lands are managed on a multiple-use basis, there are many privately held wood-lots for which formal forest management plans do not exist. Timber is simply harvested when the owner is need of cash.

One aspect that differentiates the U.S. South from most other forest regions of the world is the fact that harvests are unregulated on the private forests that make up nearly 90% of the resource. Although we calculate a sustainable yield, or allowable cut for the region, based on growth, there is no regulatory control of harvesting activities. Harvests can exceed growth for an extended period of time, if attractive market prices induce increased supply.

Over the coming years, however, it is anticipated that plantation pine will play a much greater role in supplying the fiber needs of this region. In terms of area, the Southern U.S. region possesses two-thirds of the world's fast-growing industrial conifer plantations. Pine plantations comprise about 13.6% of the timberland in the South, up from 2.5% in 1952. Better than two-thirds of the Southern pine plantations are on industry-owned land. While owning just 20% of the forest land, forest industry planted over half of the new plantations in 1994.

By 2010, pine plantations should cover 16 million hectares -- 20% of Southern timberland, and 65% of Southern pine acreage. An estimated 20% of current removals are from pine plantations -- a number expected to grow rapidly. By 2010, over half of the Southern conifer removals will come from plantations.

Most southern pine plantations are managed on sawtimber rotations of 30 - 40 years. On high site index land, rotations for sawtimber can be as short as 22 years. In some areas, pulpwood rotations of 15 to 20 years are also used. Growth rates on good sites average 7 cubic cum/ha/yr., but can exceed 10 cum/ha/yr., on the best sites under intensive management.

Plantation management techniques vary across the South, depending on site conditions and landowner objectives. The most intensively managed plantations use a regime of mechanical site preparation (sometimes augmented with herbicides), followed by planting, herbicide release, fertilization and pre-commercial thinning. Prescribed burning is often used to reduce fuel loads and kill competing vegetation. Approximately 1.8 million hectares are prescriptively burned in the South each year. Genetically-improved Loblolly pine is the most common seedling variety planted. In some coastal and pocosin areas, ditches are dug to lower the water table for more successful stand establishment. It is this plantation establishment activity on "wetland" areas, that has caused environmental concerns. Typical stocking is 1500 seedlings per hectare. Pulpwood stands typically use denser stocking, but are thinned more

frequently. For a typical sawtimber rotation, a commercial thinning of pulpwood size trees is usually possible by year 13, and again in year 20.

Table 8 - Industrial Plantation Parameters

	Conifer
Land Costs (US$/Ha)	800
Site Prep & Planting (US$/Ha)	430
Annual Maintenance (US$/Ha/Yr)	25
Rotation (Yr)	22
Annual Yield (Cum/Ha/Yr)	10
Site Prep	
Scarification	Yes
Bedding	No
Initial Stocking Levels (stems/Ha)	1500
Chemical Weed Control	At Planting/Yr. 3-5
Chemical Insect Control	No
Chemical Fertilization	Increasing - Yr. 3-5
Pruning (yr)	No
Thinning (yr)	7-Pre-Com, 13, 20

Management of Southern hardwoods on a plantation basis is not generally practiced in the U.S. South. This is due in part to the abundance of native hardwood in the region, and the relatively slow growth of temperate hardwood species. Approximately 20,000 hectares of short-rotation hardwood plantations have been established over the past 20 years, mostly for experimental purposes. Short-rotation hardwood plantations typically require greater investment, and more intensive management than conifer to be successful. Cottonwood has been the most popular species, although some plantations have been established with oak, ash, and sweetgum. Rotation length is 7 to 15 years, with yields of 15-20 cum/ha/yr. possible. The regeneration method is usually coppice.

Harvesting systems in the U.S. South are rapidly moving away from motor-manual operations, toward mechanized feller-buncher/forwarder, or feller-buncher/grapple skidder systems. Most timber continues to be harvested in tree-length, or 10-12 meter lengths, and merchandized on a landing, or in a sorting yard. Due to the generally even-aged management that is practiced in the region, clear-cutting is the most common, and preferred method of final harvesting. On flat coastal plain areas, clear-cut sizes can be as large as 400 hectares. However, most are less than 200 hectares, and trending smaller. Nearly all harvesting in the region is done by private contractors, most of which are small compared to the company operations that once predominated. As will be discussed, the combination of private landownership, and independent harvesting operations, will make adherence to any mandated "sustainable forestry" initiatives very difficult to enforce in the U.S. South.

V. CURRENT AND EVOLVING ENVIRONMENTAL ISSUES

Environmental pressures in the United States have heightened considerably over the past ten years. Public lands in the Western United States were first to feel the impact of efforts to reduce logging, but private lands have increasingly been subject to regulations aimed at protecting endangered species,

wetlands, and other environmental values. The Forest Service, in its five-year planning update, estimated that state and local regulation would reduce future timber output by 3%. This will more than likely prove to be a conservative estimate.

As has been mentioned, there is a fundamental difference in the structure of the forest resources between the U.S. South and Pacific Northwest. In the South, nearly 90% of the conifer resources are owned by the forest product industry, or nonindustrial private landowners as opposed to public entities. While this would provide little protection from regulation in many countries, the U.S. has a long history of well defined, and protected personal property rights. In the U.S., if government regulation restricts the use of private property to the point where it's intended use is impossible, the government may be found to have "taken" the property, and be required to make financial compensation. The removal from timber production of private property in the U.S. South would not be possible without significant and prolonged litigation, and possible court ordered compensation. The issue of debate is to what degree can government regulate forest land use, and practices, without "taking".

Although a repeat of the U.S Pacific Northwest controversy is most unlikely, there are growing pressures on forest management practices in the U.S. South, primarily from non-governmental wildlife and ecosystem preservation groups such as the Environmental Defense Fund, Sierra Club, and Audoban Society. Some opponents have proposed:

- the reduction or elimination of harvesting operations on National and State Forests,
- the restriction or elimination of harvesting activities on wetlands,
- the elimination of stand conversion practices (especially on wetlands),
- the extension of pine rotations to protect late-successional species (i.e. Red-Cockaded Woodpecker), and
- the elimination of clear-cutting, and the increased use of uneven aged management schemes.

The current Republican-controlled U.S. Congress is scaling back some regulatory programs, but in the final analysis, will probably succeed in only slowing the growth of increased regulation. Proposed revisions to the Endangered Species Act and Clean Water Acts would lessen the federal government's role in regulating private lands, but in many states, state laws can be equally or more restrictive.

The Clean Water Act imposes regulations on the states to control non-point source pollution, including erosion and run-off emanating from forestry activities. Most Southern states have adopted Best Management Practices (BMP's), i.e. recommended guidelines, for control of non-point source water pollution as guidelines to landowners and forest operators. Three states -- Virginia, North Carolina and Florida -- have quasi-regulatory or mandatory BMP programs; six states -- Alabama, Arkansas, Georgia, Kentucky, Louisiana, and Mississippi -- have non-regulatory BMP's.

About 11.9 million hectares or 15% of the forested area in the South is classified as wetlands -- about 3 million acres of pine types and 8.9 million acres of hardwood types. These areas comprise 65% of the total forested wetlands in the United States and are considered to be ecologically critical to preserving bio-diversity and protecting water quality. Federal law currently exempts normal forestry activities from permit requirements for dredge and fill activities on these wetlands. However, this exemption is increasingly being challenged by environmental groups, and its removal would substantially reduce the conversion of natural pine and hardwood stands in the region, to pine plantations.

Partly in response to increased environmental concerns about forestry activities, the American Forest & Paper Association drafted and adopted "Sustainable Forestry Principles and Implementation Guidelines" in October 1994. In paraphrased form, the Basic Principles commit AF&PA members:

1) To practice a land stewardship ethic which integrates the reforestation, managing, growing, nurturing, and harvesting of trees for useful products with the conservation of soil, air and water quality, wildlife and fish habitat, and aesthetics.

2) To use, and promote among other forest landowners, sustainable forestry practices that are economically and environmentally responsible.

3) To protect forests from wildfire, pests, diseases, and other damaging agents in order to maintain and improve long-term forest health and productivity.

4) To manage forests and lands of special significance (biologically, geologically, or historically significant), in a manner that takes into account their unique qualities, and

5) To continuously improve the practice of forest management and also to monitor, measure and report, the performance of AF&PA members in achieving this commitment to sustainable forestry.

The implementation guidelines set some specific benchmarks that member companies will be required to meet. Among them are the limitation of clear-cut areas to no more than approximately 50 Ha., a required "green-up" period on contiguous harvest areas of 3 years, or until regeneration reaches a height of 1.5 meters, and adherence to all Environmental Protection Agency approved BMP's for protecting water quality. Guidelines do not address the use of chemicals and fertilizers, species bio-diversity, or control of annual harvests within sustainable yield limits. Although members will be required to educate logging contractors and private landowners on principles of sustainable forestry, and will be required to report on their efforts to do so, the means of enforcing this initiative is it's Achilles Heel.

As has previously been mentioned, the majority of wood supply in the U.S. South originates from nonindustrial forestland owners, who are under no regulation concerning the level of forest management practiced, or the timing or extent of harvests. In such a competitive, and unregulated market, it is very problematic to try and insure that wood is being harvested from lands that are "sustainably managed", without improperly restricting the free-flow of goods to the market. Until this issue is solved, "Sustainable Forestry" in the U.S. South will require careful definition.

The Southern Pine Beetle is a major pest problem in some parts of the South. The Forest Service estimates that 4 million hectares are infested. Other pest problems include fusiform rust, littleleaf disease, and gypsy moth. The outbreaks of most of these pests are usually controlled by accelerated harvesting. Unless outbreaks become unexpectedly more severe, they are not likely to significantly affect long-term timber/fiber supply.

Prescribed burning is widely used as a method of weed control and decreasing the risk of wildfire. The weather permits safe burning during no more than 10 to 20 days per year, but smoke from the wide use of prescribed burning has triggered regulatory action, limiting the number of fires in "non-attainment" areas - areas not currently meeting air quality guidelines.

An important factor influencing pulpwood consumption is the extent of paper recycling. Paper recovery and reuse has increased dramatically in recent years. Nationally, the industry believes it will recover 50% of all paper produced by the year 2000 and utilize at least 40%. Accelerated recycling shifts the demand curve for pulpwood a few years into the future, and thus extends fiber supply. However, the technologically feasible maximum recycling rate will likely be reached soon after the year 2000.

VI. PROJECTED AVAILABLE TIMBER SUPPLY: 1995-2020

The potential to sustainably increase timber/fiber production in the U.S. South is uncertain, given the current inventory, region-wide growth rates, and harvest pressures. Reductions in timber/fiber supply from public lands in the Western United States have forced a greater dependence on Southern resources, and harvests have increased accordingly. The physical potential certainly exists to increase production in the region, especially with more intensified management of pine forests. However, various demographic, physiographic, and environmental factors could constrain available supply.

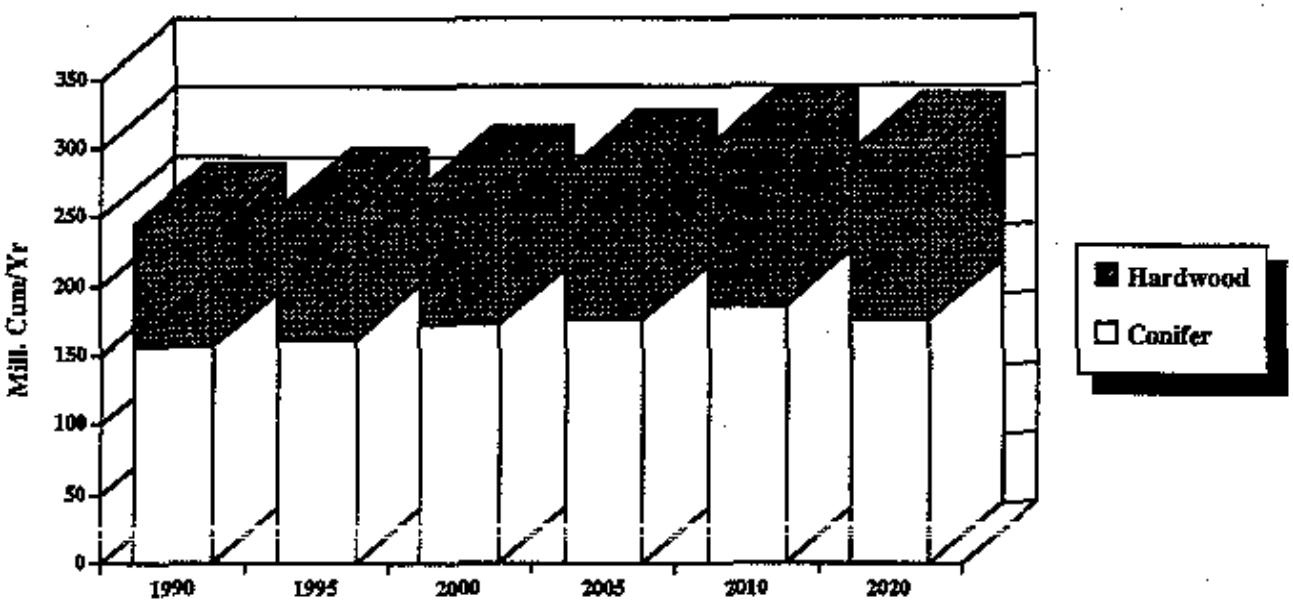
The current harvest trend is not sustainable unless growth rates increase significantly. The age-class structure of the inventory -- a high proportion of pine stands younger than 20 years -- suggests that growth rates will increase throughout the 1990's, but so will the harvest. Although the area of intensively managed plantations is projected to increase by 60% to nearly 20 million hectares, the trees that will serve the timber/fiber needs over the next 25 years are, for the most part, already in the ground.

Because of these and other considerations, U.S. Forest Service forecasts of timber/fiber supply from the U.S. South have been adjusted downward to produce the following more realistic projections:

Table 9 - Projected Timber/Fiber Availability
(million cubic meters)

Year	Conifer	Hardwood	Total
1990	156	88	244
1995	161	94	255
2000	172	99	271
2005	175	108	283
2010	185	116	301
2020	175	121	296

Projected Available Timber Supply - US South



VII. REFERENCES

Alig, Ralph, Darius Adams and John Chmelik, "The Interaction of Private Forest Investment and Long-Run Sustainable Harvest Volumes," Symposium Paper, July 3, 1995.

American Forest & Paper Association, "State Forest Practices Throughout the United States," 1993.

American Forest & Paper Association, "Sustainable Forestry Principles and Implementation Guidelines", October 14, 1994

Birch, Thomas W., "The Private Landowners of the United States, 1994," USDA Forest Service Review Draft.

Cubbage, Frederick W., Thomas G. Harris Jr., Robert C. Abt and Gerardo Pacheco, "Timber Supply in the South: Where is All the Wood?, Journal of Forestry, 93:7, July, 1995.

Cubbage, Frederick W., David N. Wear, "Can Non-Industrial Private Forest Landowners Make up the Shortfall in Timber Production from National Forests?", Society of American Foresters National Convention, 1993

Clawson, Marion. "Forests in the Long Sweep of American History", Science, Vol. 204 pp. 1168-1174, June 1979.

Georgia Forestry Association, "Best Management Practices for Forested Wetlands in Georgia".

Moulton, Robert J., Felicia Lockhart and Jeralyn D. Snellgrove, "Tree Planting in the United States, 1994," USDA Forest Service, May, 1995.

Smith, W. Brad, Joanne L. Faulkner and Douglas S. Powell, "Forest Statistics of the United States, 1992" METRIC UNITS, USDA Forest Service GTR NC-168.

U.S. Environmental Protection Agency, "Coastal Non-Point Pollution Management Measures Guidance", Published June, 1993

USDA Forest Service., The Forested Wetlands of the Southern United States. Editors; Hook, Donal and Lea, Russ. Gen. Tech. Rpt. SE-50, July 1988

Wood Resources International Ltd., "Wood Resource Quarterly" April 1989, and April 1994 , estimates and in-house files.