TOWARDS A SUSTAINABLE

Paper Cycle

Sub-Study Series

⑫ Transport in the Paper Cycle

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TRANSPORT IN THE PAPER CYCLE

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TRANSPORT IN THE PAPER CYCLE

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EXECUTIVE SUMMARY

No study of the sustainability of a sector would be complete without looking at the transport which is employed within it. This report assesses the use and impact of transport within the paper cycle and identifies possible means of reducing the negative effects and future trends which may affect transportation in the sector.

Pulp mills have traditionally been built in the vicinity of forests and/or ports which are usually distant from major centres of consumption, hence a significant amount of long distance transport is required to get paper to consumers. In general, transport increases as value is added along the product chain, although there is some evidence that the increasing use of recycled fibre may be influencing the location of some mills as well as affecting transport within the cycle. The costs of transport in the paper cycle appears to be significant with transport costs accounting for between one quarter and one third of fibre costs and delivery costs estimated to be between 7% and 19% of total costs.

The environmental and social impacts of transport generally are becoming an increasing cause of concern. Globalisation is likely to increase both the volume and distance of goods transported, however the increase for the paper sector is predicted to be below the industry average. To estimate the magnitude of environmental impacts from transport compared to other stages of the paper cycle IIED commissioned PIRA to run a life cycle model to provide indicative results for the paper cycle in Europe. This suggested that transport accounts for 11% of the oil consumption within the cycle and is responsible for 20% of NO_x emissions and 12% of VOC emissions. The time and place of these emissions however are as important as the actual levels, hence transport at stages of the cycle is likely to be much more significant than at some others.

Mode choice is also an important factor in the overall impact of transport. Rail and particularly marine transport is relatively benign compared to road transport hence sourcing pulp and paper related goods from distant places may not be as environmentally detrimental as might be expected if the bulk of the transportation is marine. Increased recovery of waste paper tends to increase urban road transport, a form of transport with high potential impacts. The PIRA study analysed the effects of increasing the European recycling rate from the current average of 36% to 54%, finding that although emissions of some air pollutants during transport in the paper cycle do increase significantly, over the whole cycle resource use and emissions are reduced.

The report concludes that due to the costs and impacts of transport, stakeholders in the paper cycle should consider it far more systematically. While it may be difficult to change some determining factors such as the location of raw materials and consumer markets, companies may have more control over other factors such as the location of mills or mode choice. Steps should be taken to minimise the use of transport, particualrly in cases where it is likely to have the most impact (ie urban road transport). However more comprehensive statisitics and detailed analysis is required to enable impacts to be judged more clearly and to enable policy makers to examine the policy implications of their decisions.

1 INTRODUCTION

Transport is key to all industrial cycles and often forms a significant proportion of overall costs of production. As such, no study of the sustainability of a sector would be complete without looking at the implications of the transport services employed within it.

The environmental impact of freight transport and distribution are becoming increasingly recognised as a major constraint to the transition to sustainable development. There is a growing consensus, particularly in Europe, that transport volumes need to be curbed and that the social and environmental costs of transport need to be internalized. These trends have potential impacts well beyond the transport and distribution stage of the cycle, with implications for the location of mills, international trade flows, the type of fibre that is used in production processes, and the type and volume of paper products consumed.

Surprisingly, there has been little work done on transport in specific industrial sectors and almost none on transport in the pulp and paper sector. Life cycle analyses tend to either ignore transport altogether or, if comparing various scenarios, assume that there will be little change between them. Few paper eco-labelling schemes appear to consider transport explicitly and some specifically excludes it.

This study aims to:

- assess the main transport flows and modes used in the paper cycle and identify future trends in transport use in the sector.
- estimate the magnitude of environmental impacts caused by transport compared to other stages of the paper cycle and compare the impacts of using recycled and virgin inputs.
- discuss possible ways of reducing the environmental impact of transport in the sector.

Section 2 of the report looks at current transport of pulp and paper related goods, its cost, and future trends. Section 3 assesses the environmental impact of this transport. Section 4 summarizes the findings and discusses policy implications.

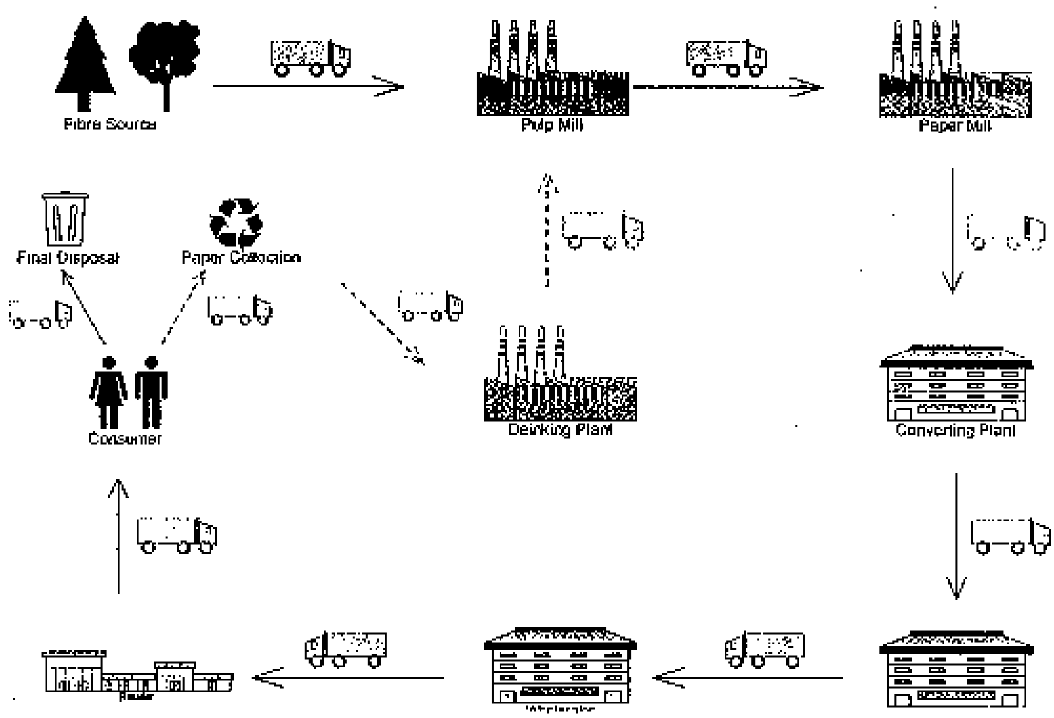
2 TRANSPORT USE DURING THE PAPER CYCLE

2.1 Introduction

Determining the transport-intensity of particular sub-sectors is difficult since official transport statistics are not usually disaggregated sufficiently and since countries tend to calculate their transport statistics in different ways making comparisons problematic. In addition there seems to have been surprisingly little discussion of transport in the trade press. Life cycle analyses either ignore transport altogether or conclude that it is insignificant, often because only transport at a few transport stages of the cycle have been considered, thereby underestimating its impact.

Transport occurs at every stage in the paper cycle and is represented schematically in Figure 2.1a. Firstly, fibrous raw materials are transported from their source to pulp mills. If the mill is integrated the paper is produced on-site, otherwise pulp is transported to a paper mill or sold on the open market. Paper is then transported to converting firms which transform them into paper products. Paper and paper products are transported to consumers through retail and wholesale outlets. Once used there are several different routes that the wastepaper can take. Either it is separated by businesses or households and collected before being transported to a deinking plant and then transported to recycled fibre mills, or it is collected as part of municipal waste and transported to a landfill, compost or incineration site.

Figure 2.1a Transport in the Paper Cycle



2.2 Transport Intensity of the Paper Cycle

2.2.1 The Relative Transport-Intensity of the Paper Cycle

Although much detailed data on transport use exists for specific paper sector commodities in various different countries, this is not particularly illuminating in the absence of comparable data for other sectors. For comparative purposes, perhaps the most useful data comes from input-output tables. These indicate the value of the transport services purchased to produce one unit of a particular product (e.g. one unit of newspaper). They do not include any in-house expenditures on transport (i.e. fuels and vehicles) or the indirect transport of intermediate inputs such as chemicals, fuel or machinery.

American data is particularly useful since the size of the country and the relative size of the economy means that the figures will include the effects of all forms of transport and problems associated with the classification of traded inputs are avoided. The figures for sub-sectors and a number of substitute sectors are given in Table 2.2a. For example, radio and television can be substitutes for newspapers and plastics for paperboard containers.

Table 2.2a Direct Transport Requirements (% input per unit of output) in Selected US Sectors in 1987

	Paper & Allied Products	Paperboard Containers	Newspapers & Periodicals
Rail	1.01	1.12	0.35
Road	1.98	2.24	0.66
Water	0.13	0.07	0.09
Air	0.47	0.19	1.89
Total	**3.59**	**3.62**	**2.99**
	Communication Sectors	**Plastics & Synthetics**	**Radio & Television**
Rail	0.09	1.17	0.12
Road	0.01	1.40	0.21
Water	0.15	0.32	0.01
Air	0.00	0.15	0.72
Total	**0.25**	**3.04**	**1.06**

Source: USDOC SCB, May 1994, Table 3.1

The paper related sub-sectors have overall transport intensities in the range 2.9%-3.6%. The other sectors have a lower - but much wider - range, with both the communications and radio and television sectors having much lower transport-intensities. Only plastics and synthetics has transport use comparable to paper-based production. These figures imply that the paper sector is somewhat more transport-intensive (in cost terms) than the main substitute sectors. As such, substituting away from paper-based end uses to other end uses which are not based upon paper consumption would tend to reduce transport.

2.2.2 Factors Currently Affecting the Transport Intensity of the Sector

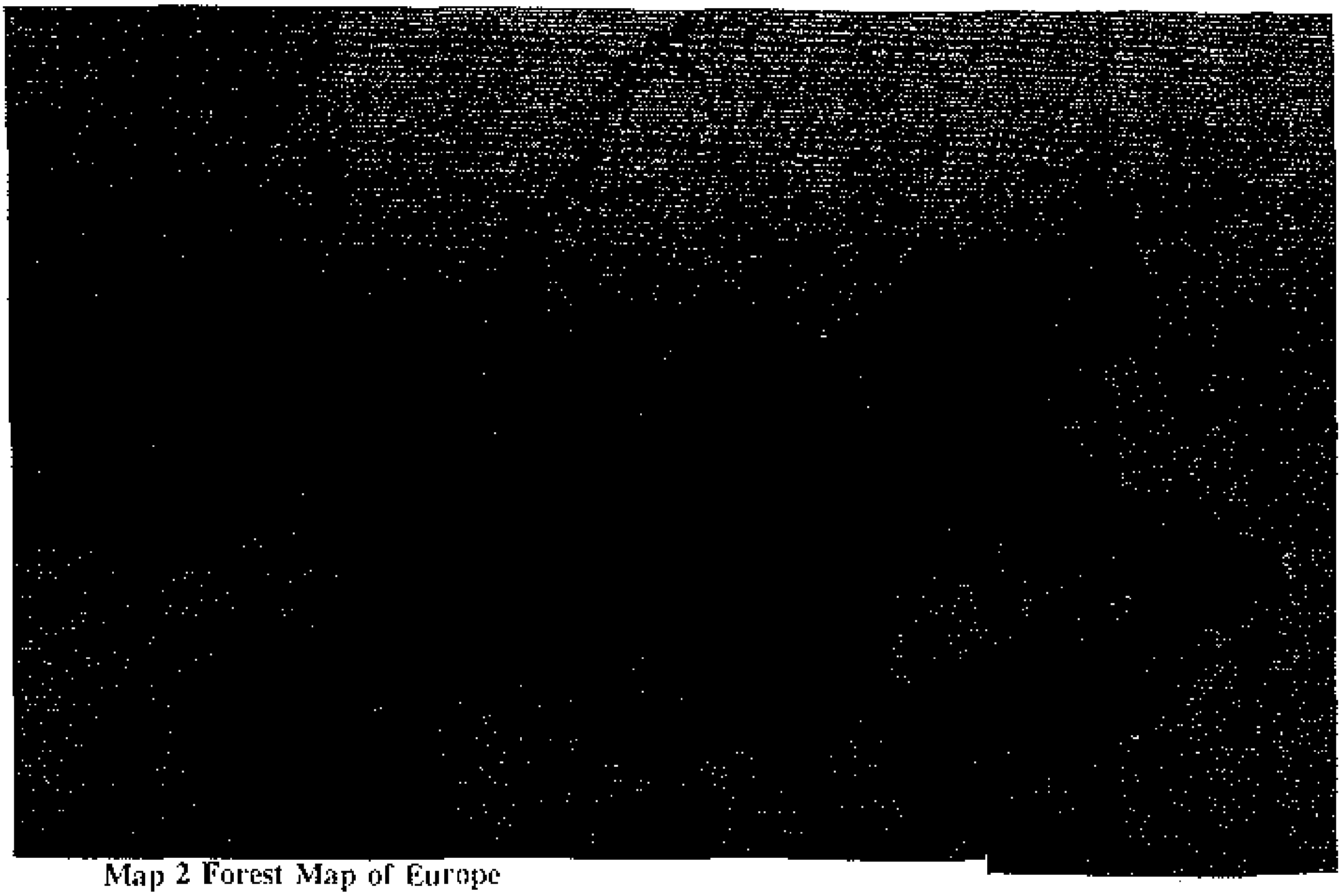
There are a number of factors which affect the transport intensity of the paper cycle, including location of raw materials and major markets, the stage of the cycle at which transport occurs, and the transport mode employed. Some of these may be easy to influence, while others are much more difficult to affect.

Location of Raw Material Inputs and Major Consumer Markets
The relationship between the location of raw material inputs and major consumer markets is probably the factor which has the biggest impact on transport use within a sector. In the case of the paper sector, the major production and consumption centres are often far distant from each other. Traditionally mills have been located near the forests which are the major source of the primary raw material inputs and at some distance from the major population centres which are the main consumer markets. Hence, a significant amount of long distance transport is required at some stage of the production process to get paper to consumers. Indeed, the existence of large areas of boreal forests in specific parts of certain countries (e.g. Sweden, Canada, the former Soviet Union) is usually due to the low population density in the vicinity (Taiga Rescue Network 1995). In this sense distances are great by definition, which is not true of most other sectors.

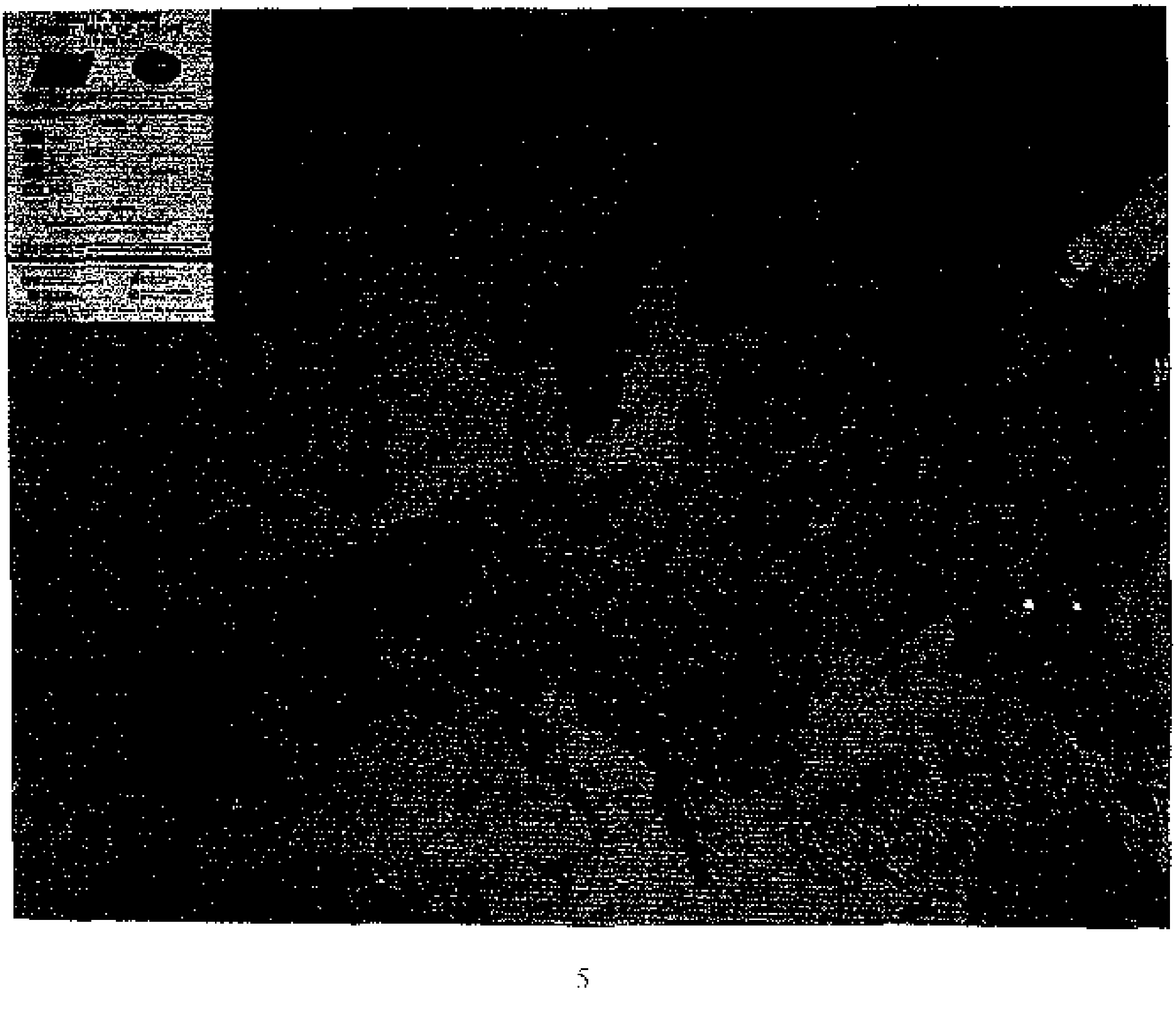
The separation of production sites and major markets may be reflected within a country, between countries and even between continents. For example, in countries such as Sweden, which is a major producer of forest products, but has a relatively small domestic market, this results in a high proportion of industrial freight transport being accounted for by forest industry products; 62% of rail exports, 45% of marine export and 38% of road exports. Within Sweden itself 34% of freight transport by rail and 19% by road is attributable to forest products (Skogsindustrierna 1994.) The international separation of the major markets for paper products from the main forest areas can be graphically illustrated by the two maps shown overleaf which show the location of forest resources and the population density in Europe.

In countries where a high proportion of non-wood fibres are used to make paper, pulp mills are usually located in agricultural areas or near sugar mills if the major raw material is bagasse (sugarcane residue). Indeed transport of raw materials is usually one of the limiting factors in the size of non-wood mills since transport costs generally limit the economic collection area to within a 100km radius of the mill (IIED Substudy No. 7).

Map 1 Population Density



Map 2 Forest Map of Europe



Stage of the Production Cycle at Which Transport Occurs
Different stages of the production cycle have different transport requirements. The stage in the cycle at which goods are transported depends on the relationship between the value of the product, its physical characteristics and the distance to principal markets.

In general the higher the value of a product per unit volume or mass the less consequential the transport costs. Given the relatively low value and large mass of pulpwood compared to downstream paper products this would imply that goods in the paper cycle are more likely to be transported in more processed form. Over 90% of pulpwood fibre is utilised in the country of origin (IIED Substudy No.1), whereas further along the paper chain as value is added, higher proportions of products are exported. See tables 2.2b, c and d below. For example, Scandinavia is a significant producer of paper products, despite having a small domestic market since it is more economic to convert wood into higher value added products and export these than to export the wood itself.

Statistics on the trade of pulp and paper related goods give a good indication of the amount and type of transport which is occurring and illustrate the separation of producers and markets.

Figure 2.2a Truck Carrying Pulpwood, Korsnas Mill, Sweden

Trade in Wood Fibre

Very little wood fibre enters international trade and what does can be divided into 'border trade' that results from the natural extension of procurement regions across political boundaries and 'ocean trade' reflecting imbalances of wood fibre supply and demand and/or differences in regional wood fibre prices which more than compensate for transport costs.

The majority of the global trade in conifer wood fibre occurs within Europe and the Baltic region. The major trade flows in the region are accounted for by the movement of roundwood pulpwood into Finland from Western Russia, the movement of pulpwood and chips into Sweden from countries bordering the Baltic and shipments of roundwood and chips from France and Germany to neighbouring countries. This is mainly due to surplus supply and price differences which exceed freight costs (IIED Substudy No.1).

It is generally more economic to transport chips rather than roundwood over long distances, due to the savings in loading, unloading and shipping costs. The trade in chips has increased substantially since the advent of 'dedicated chip carriers', and chips have been accounting for an increasing percentage of wood fibre trade over the last 15 years. In 1982, roundwood accounted for 51% of trade compared to 39% for chips and 10% for other residues, but by 1992 these figures had reversed and it was estimated that 53% of wood fibre trade consisted of the movement of woodchips (IIED Substudy No. 1).

Box 2.2a Japanese Import of Woodchips

In the early 1960s Japan launched a strategy to increase pulp self-sufficiency. This policy was reinforced by market conditions in the 1970s and 1980s, when it was cheaper for Japan to import chips than pulp. In recent years Japan has been responsible for the overwhelming majority of woodchip trade, accounting for 79% of the global trade in 1992.

In 1970, the US Northwest supplied 82% of Japanese imports of coniferous woodchips. However after American prices rose in the 1980s the Japanese made a concerted effort to diversify their sources, and supplies have shifted away from the US - which now accounts for only 30% of coniferous woodchip supply - and SE Asia, toward countries of the Southern hemisphere which have developed large plantation resources such as Chile, South Africa and Australasia.

A few years later market conditions changed again, further affecting trade flows and transport patterns. When woodchip exports were first permitted from Chile in 1987 it seemed that Chile would quickly become a major exporter to the European and Asia Pacific markets. However as domestic prices have increased to international freight-equalised levels, the export of conifer chips has been replaced by much higher native hardwood fibre exports, and Europe and Asia-Pacific have sourced coniferous chips from other countries.

There are several trends which are likely to reduce the transport of woodchips over the next few years. Firstly, it appears that it will soon be more competitive for the Japanese to import pulp rather than chips. Secondly, there is a global trend to transport higher value added products such as pulp and paper products rather than wood fibre. Thirdly the US Northwest and Canada are facing fibre shortages in their domestic markets which is likely to reduce the supply for woodchips available for export.

Sources: WRI 1994 and Irland 1994

Trade in Pulp and Paper Products

For wood pulp, the major flows are from Canada and the Nordic countries to Western and Central Europe. Canada also ships pulp to East Asia as does the Southern US. In the case of paper products by far the largest exporter is Canada which is the dominant supplier to the US market. Western and Central Europe import a great deal of paper from Canada and the Nordic countries and there is a significant movement of paper across the US from producers in the South to markets in the rest of the country (IIED Substudy No.2).

Waste Paper

Waste paper is a now an important globally traded commodity. In 1980, 5.1 million tonnes of wastepaper were exported worldwide, by 1993 that figure had more than doubled to 11.2 million tonnes. The biggest flow is from the US to Asia, followed by trade within Europe mainly from Germany (Jaakko Pöyry 1993).

Table 2.2b Bilateral Trade in Wood Pulp in 1993 (1000 tonnes)

Importers	Exporters				
	Canada	USA	Sweden	Finland	Brazil
Europe	2466	1758	2556	1246	659
North America	4208	178	33	11	465
Latin America	175	590	1	0	69
Asia	2320	2415	227	185	657
Australasia	87	44	2	7	10
Africa	45	70	32	1454	0

Table 2.2c Bilateral Trade in Newsprint in 1993 (1000 tonnes)

Importers	Exporters			
	Canada	USA	Sweden	Finland
Europe	2294	9	1502	983
North America	6930	13	58	21
Latin America	502	228	1	17
Asia	738	647	292	210
Australasia	37	8	0	6
Africa	18	21	20	13

Table 2.2d   Bilateral Trade in Kraftliner in 1993 (1000 tonnes)

Importers	Exporters			
	Canada	USA	Sweden	Finland
Europe	122	644	1056	154
North America	192	157	0	1
Latin America	6	717	3	2
Asia	158	1108	110	33
Australasia	0	15	0	0
Africa	0	75	44	3

Source: International Fact and Price Book 1995 Pulp and Paper International.

Mode Employed

The transport mode (road, rail, water, air) used to move paper-related goods has a significant impact on both the environmental impact and cost of transport in the cycle.

Table 2.2e indicates the modal split in cost terms for each unit of transport purchased in the listed sectors in the US. It does not indicate the exact proportion of each mode used in physical terms (i.e. ton of freight kilometres) since costs vary, with air transport being much more expensive than other modes.

- Road transport is the most highly used mode, followed in most cases by rail.
- Air transport tends to be used more intensively in more highly processed sectors.
- Water transport is used more intensively at early stages of product processing, a higher proportion of wood and paper is transported by water than paper products.

The mode split in the substitute sectors varies greatly. Interestingly, non-print media (radio and television) possess an almost identical modal split to print media (newspapers and periodicals).

Table 2.2e *Proportions of Direct Transport Requirements by Mode in the US in Value Terms in 1987*

	Paper & Allied Products	Paperboard Containers	Newspapers & Periodicals
Rail	0.28	0.31	0.12
Road	0.55	0.62	0.22
Water	0.04	0.02	0.03
Air	0.13	0.05	0.63
	Communication Sectors	**Plastics & Synthetics**	**Radio & Television**
Rail	0.36	0.38	0.11
Road	0.04	0.46	0.20
Water	0.60	0.11	0.00
Air	0.00	0.05	0.68

Source: USDOC SCB, May 1994, Table 3.1

Aggregate European data reveals that 3 million tonnes of paper, pulp and waste paper were transported by rail, 3.6 million tonnes by road and 2.5 million tonnes by inland waterway in 1991 (Eurostat 1994).

Factors which Affect Mode Choice
In many cases there will be little choice about which mode can be used but there are a number of factors which influence it.

- Product Characteristics

Lighter goods will tend to use relatively more road transport than heavier goods which will be more dependent on rail or marine transport. Similarly, more highly processed good will tend to rely more on road transport.

- Geographical Terrain

The geographical characteristics associated with the location of the fibre source has an important influence on the available means of transport. Forest resources are often situated in areas with difficult terrain and limited access, which restricts transport options. In many cases roads have to be built specifically for the purpose of extracting wood. If the producing country has an accessible coastline pulp mills will often be situated on the coast, giving them easy access to maritime transport and overseas export markets. See maps below.

- Technological Development

Technological change can also influence mode choice. For example the construction of transcontinental railroads and the Erie, Suez and Panama canals had dramatic effects on mode choice in the movement of wood products. Innovations such as ice breakers, roll-on-roll-off vessels and dedicated chip carriers have also changed trade routes and influenced the form in which wood products travel (Irland 1994).

- Investment in Infrastructure

This will vary from country to country and can have significant impact on transport modes employed. In russia, there are few ports and typically goods have to travel 1000-3000km to reach the coast (Kyberg 1995). These distances can usually only be travelled by rail and transport costs are a significant expense. However, the proportion of goods transported by rail has declined as prices have risen dramatically over the last few years (Hagler 1995, Kyberg 1995). The pulp and paper company Weyerhaeuser recently cancelled their joint venture in Russia over issues of stability and logistics control (Coates 1995).

Investment in transport infrastructure can also be undertaken by the firms themselves. In the UK the Aylesford newsprint mill in Kent which makes paper from 100% recycled fibre recently announced that it would be building a new rail terminal to enable paper to be transported directly from the mill to continental Europe via the recently opened Channel Tunnel (Paper Europe 1994).

- Institutional Arrangements

Institutional arrangements can also have dramatic effects on the modes used to transport forest products. For example, in Canada the 1987 National Transport Act incorporated a number of provisions which were designed to make the rail sector subject to competitive pressures. This resulted in the share of rail increasing significantly while truck and marine transport fell. However, these competitive provisions only apply to federal railways not provincial railways. As such, inland mills in British Columbia which are dependent on provincial lines are at a disadvantage (Heads *et al.* 1994).

Once again, as is the case with infrastructure investment, not all of these arrangements are determined exclusively by the government. For instance, the introduction of "minibridges" which facilitated joint-mode (rail-to-marine) transport in the United States generated an increase in forest product rail transport (Wisdom 1993).

2.3 Cost of Transport in the Paper Cycle

Transport costs are often amalgamated into other costs such as harvesting or delivery costs and as such it is difficult to determine the precise proportion of total costs which are attributable to transport. For example, transport makes up a high proportion of the direct costs of harvesting. It has been estimated recently that the direct costs of moving a felled tree from plantation site to mill is in the region of US$10-11/$m^3$ and up to 90% of this can be due to transport costs. US$3-4/$m^3$ is taken up in the skidding or forwarding of logs to the roadside alone. Overall, transport costs can account for as much as one-quarter to one-third of the fibre price. This is confirmed by more dated figures which list transport costs to domestic pulp mills for various countries, see Table 2.3a below.

Table 2.3a Relative Transport Costs of Pulpwood (US$/m^3 in 1985)

	Total	Transport	Percentage
Chile	12	3	25
Brazil	15	4	26
S. USA	27	6	22
Sweden	40	10	25

Source: Ewing and Chalk (1988).

It appears that although absolute costs differ by region, in relation to total production costs (which include stumpage fees and harvesting) the figures are more or less equivalent, irrespective of the distance, equipment and terrain in the different countries. The same study indicates that the absolute transport costs for pulpwood in individual countries are somewhat less than those for sawnlogs.

Transport seems to account for a significant proportion of overall costs in the pulp and paper sector. Estimates of delivery costs to major markets (which include both transport and sales costs) vary from 7% to 19% (IIED Substudy No. 11, Price Waterhouse 1992, Ewing and Chalk 1988). In a cost analysis of the industry (IIED Substudy No.11) delivery costs were found to be of a similar order to the cost of energy and other raw materials, while fibre costs were about three times higher. However, these costs do not take into account transport at other stages of the cycle, such as during harvesting. Since transport can account for as much as one third of fibre prices this would indicate that the overall transport is one of the major costs involved in the pulp and paper cycle.

The tables below illustrate the proportion of total costs which are attributable to delivery costs. What is striking about these figures is that transport costs do not increase proportionally with distance travelled. This is due to the much higher costs per ton kilometre associated with rail and road transport compared to ocean transport. This is evident if the figures for British Columbia interior and coastal mills are compared. The small difference in total distance between them increases the transport costs by 30% in the case of kraft pulp.

Table 2.3b Delivery Costs for Market Pulp Delivered to Rotterdam

	Softwood		Hardwood	
Producing Country	Delivery Costs	Total Delivered Costs	Delivery Costs	Total Delivered Costs
Canada	65	554	65	440
Scandinavia	55	575	55	538
Latin America	70	450	70	426

Table 2.3c Delivery Costs for Newsprint to the US Market

Producing Country	Delivery Costs to US market	Total Delivery Costs
Canada (Virgin fibre based)	57	427
USA (recycled fibre based)	40	531

Table 2.3d Delivery Costs for Newsprint to the Western European Market

Producing Country	Delivery Costs to WE	Total Delivered Costs
Scandinavia (virgin fibre based)	98	531
WE (recycled fibre based)	55	789

Table 2.3e Delivery Costs for Uncoated Woodfree Paper to Western Europe

Producing Country	Delivery Costs to WE	Total Delivered Costs
Scandinavia	135	893
Western Europe	90	1179

Source: IIED Substudy No. 11

2.4 Future Trends in Transport in the Paper Cycle

In this section the effect of three important trends which have potential repercussions for transport use in the pulp and paper sector are examined: globalisation of the sector, increased recycling of wastepaper, and the internalisation of social and environmental costs in the price of goods and services.

2.4.1 Globalisation of the Pulp and Paper Sector

The pulp and paper industry is becoming an increasingly globalised and concentrated sector (see IIED Substudy No. 17 for more details). Although the increased concentration of ownership may have little effect since ownership and location of mills are increasingly unrelated, there may be significant changes in transport use arising from trade liberalisation. This has been recognised by the Task Force of the European Commission which named transport as the one sector through which the liberalisation of the internal market would have the greatest effect since it is complementary to liberalisation in all other sectors which use transport intensively (Gabel and Röller 1993). In the case of the United States the 'total industry output multiplier' for the four transport sectors, which measures the percentage increase in transport use following a 1% increase in output in all other sectors, range from 1.8% to 2.1%. (USDOC SCB, May 1994).

Gabel and Röller (1993) studied the impact of trade liberalisation on transport use in various industrial sectors and concluded that it was likely to increase geographical specialisation and concentration of production as comparative advantage emerges and economies of scale are exploited. At the same time they concluded that consumption would disperse geographically as falling import barriers, lower product prices and higher per capita incomes would widen markets internationally. This is likely to increase the average distance from points of production to points of consumption.

The study concluded that due to the general increase in transport arising from increased volumes of goods travelling increased distances, trade liberalisation will cause a major increase in environmental damage. For the paper industry however, the changes are below the industry average (see Table 2.4a below) with the increase in trade after complete trade liberalisation predicted to be 22% for wood products and 20 % for paper and the increase in transport to be 34% and 28% respectively.

Table 2.4a Percentage Increase in Trade Flows (unit-kms) after Elimination of Non-Tariff Barriers

Industry	All countries	Intra-EU Trade	Exports into EU
Wood	34	33	35
Paper	28	28	11
Printing and Publishing	35	32	39
Foodstuffs	23	20	25
Electrical machinery	160	150	181
Tobacco	25	28	11
Surgical/ Optical Instruments	34	32	37

Source: Gabel and Röller 1993

However, a proportionate increase in environmental degradation is not a foregone conclusion since the environmental impact of transportation is heavily dependent on the mode used. For instance, in the event that the geographical pattern shifts away from trade between pairs of countries which have surface transport links, toward countries which are further apart but separated by a body of water, the environmental impacts of transport in the sector may decrease, even if transport use (expressed in tonne kilometres) increases (see discussion on relative impact of different modes in section three).

Moreover, even if the environmental impacts of transport are more adverse following liberalization, this does not necessarily imply that overall impacts of the production process will increase. For instance, if liberalization allows regions to specialize in the production of goods for which their ecosystem is better suited other effects in the production process may be less severe (i.e. the impact of emissions on the receiving environment or the use of resources as material inputs) than would be the case in the absence of trade.

And finally, it is not only liberalization within the industry itself which can affect transport use in the pulp and paper sector. Indeed more significant effects might arise from liberalization of the transport sector, one of the most distorted sectors in terms of trade flows.

2.4.2 The Repercussions of Recycling on Transport Use in the Sector

The last few years have seen a large increase in the use of recycled fibre in most grades of paper which has potentially significant impacts in terms of the location of paper production and the intensity of transport service use in the sector.

Increased recycling has three separate influences on transport in the paper cycle. One is the growing trade in wastepaper which was discussed in section 2.2. The second is the influence that a greater use of recycling has on the location of mills, and the third is the transport involved in the collection of wastepaper.

Location of Mills
In the past, pulp and paper mills were generally located near the fibre source and/or near good export points such as ports. The increasing use of recycled fibre may be changing the balance although evidence of this trend is somewhat limited.

In the USA most large old newsprint (ONP) consuming mills are currently located in or near major population centres. However as the market has developed more and more mills are installing recycled fibre capacity at existing plants which are generally remote from major population centres and will therefore have to source most of their waste paper from suppliers hundreds of miles from the mill (Iannazzi and Strauss 1994), thus increasing the transport required.

In contrast, Young (1995) cites the case of Weyerhaeuser which is shifting much of its production away from close proximity to wood fibre sources to Iowa, a state with few wood resources but one which is strategically located for waste paper sources in the Mid-West. At this point it is not clear whether other companies will follow suit

There is also the relatively new trend of the 'urban minimill' which has been widely reported in North American paper trade magazines. *Pulp and Paper Week* describes minimills 'springing up in urban centres to take advantage of fibre rich municipalities'. They tend to be located in urban industrial parks hence the fibre supply will come from the 'mills backyard' and the product is fed to markets in the same backyard so minimising transport distances and costs (Young *et al.* 1994).

Transport Requirements for Waste Paper Collection
The amount of waste paper which is recovered varies significantly from country to country, depending on a variety of factors including population density, public interest in recycling, type of paper being produced, export markets, government regulation and voluntary standards on recycled content requirements.

The transport involved in this collection has the potential to have a significant environmental impact since the vast majority of collection schemes depend upon road vehicles (which have a severe environmental impact compared to most other modes) collecting in high population urban areas (increasing the impact of pollution with localised effects).

The extent to which wastepaper collection increases urban transport is dependent upon how the scheme is operated and where the paper is collected from. If households take it to a depot at the same time as they do their shopping little extra transport will be generated. If household collection schemes collect paper along with other waste this is likely to decrease the overall transport required to collect waste, compared to the situation if an entirely separate scheme is in operation. Schemes which collect from offices will collect a higher percentage of paper per trip than those which collect directly from households.

Transport requirements and their environmental implications are rarely included in the literature on recycling schemes and nor is transport rigorously considered in most life cycle analyses. As part of this study IIED commissioned PIRA to run a model analysing the impact of transport compared to other stages of the paper cycle. This included a scenario which examined the consequences of significantly increasing the use of recycled fibre in order to make some estimate of the transport implications that this would have. The results of this are discussed in section 3.2.3.

Wastepaper is a globally traded commodity, as discussed in section 2.2. In most cases this is because the importing country lacks fibre resources and it is more competitive to import waste paper than wood fibre. In some cases the driving force for the transport of waste paper is the demand by major consumers for recycled content products and/or government regulation which legislate its use. In some cases this can have perverse consequences, see Box 2.4a below.

Box 2.4a The Impact of US Recycled Content Legislation US-Canada Wastepaper Trade

The pulp and paper sector forms an important part of Canada's economy. It is a country with large forest resources and a relatively low population thus there has been little incentive to recover waste paper. In 1989 only one mill used recycled fibre and almost all newsprint was produced from virgin fibre. The use of recycled fibre was confined to those grades (tissue and containerboard) which offered greater cost effectiveness than virgin fibre. However in the early 1990s there was a dramatic change and by 1993 approximately half of Canada's forty mills were using recycled fibre and the percentage of recycled fibre in the total newsprint furnish had increased to approximately 11-12% (Temanex 1993).

The reason for this sudden increase was the change in attitude to recycling and the introduction of recycled content legislation in the US. The US is Canada's major export market, importing 52% of Canada's total production of market pulp, newsprint and other paper and paperboard products (Heads et al 1994) and 73% of it's newsprint production. In the late 1980s and early 1990s there was massive publicity about 'the garbage crisis' in the US and fears that there was very little landfill space remaining. By 1989, this had led to the US newsprint market (the world's largest) beginning to demand newsprint with a minimum recycled content. By 1993, thirteen states had imposed mandatory recycled content requirements and a further twelve had voluntary minimum levels. Together these states accounted for 75-80% of US newsprint consumption.

This resulted in something of a crisis for the Canadian newsprint industry in the early 1990s. Since then there has been a significant increase in old newsprint recovery which by 1993 stood at 48% of consumption. However, in order to meet recycled content regulations they required 1.3 million tonnes of old newspapers and magazines and a 48% recovery rate in Canada only generated 575,000 tonnes. Although there is potential for increasing the recovery rate, particularly of old magazines in Canada, even with 100% recovery the Canadian population will not be able to generate sufficient wastepaper to supply industry requirements since total domestic generation of wastepaper is less than requirements at existing levels of exports to the US.

Canadian firms have been making up the shortfall by importing waste paper from the US. In 1993, approximately 800,000 tonnes were imported. Rail is the primary mode of transportation of wastepaper, although for certain mills it may be cheaper to ship wastepaper by boat from some American cities (Prins *et al.* 1992). Obviously the distance and costs involved will vary depending on the distance of individual Canadian mills from American cities. In general, western Canada faces higher transportation costs from the US than Ontario and Quebec (Prins *et al.* 1992), putting them at a disadvantage.

This example clearly demonstrates the need to think through the wider implications of policies to encourage the use of recycled fibre. It may make sense to encourage increased wastepaper recovery rates where there is the potential to do so, but recycled content legislation which results in wastepaper being transported to countries with large wood resources seems less sensible. From an environmental perspective it would almost certainly make more sense to provide incentives for sustainable forest management in these countries than to introduce recycled content laws which increase transport use.

This point is illustrated in a model developed by INSEAD (Weaver *et al.* 1995) which examines the environmental costs of pulp and paper production transport and disposal in Europe. It concludes that under current technological conditions the environmentally optimal paper production scenario would be one in which consumer countries recover wastepaper and manufacture paper and board from the recycled material, and Scandinavia supplies Europe's residual need for virgin fibre. The model is purely physical and as such cannot be used prescriptively without the application of additional economic data. Moreover, internal (domestic) transport is not considered, generating a significant bias, particularly with respect to the environmental impact of recycling.

2.4.3 Internalisation of Externalities

This section focuses on those price changes which are associated with attempts to internalize the environmental effects of production process, both in the sector itself and in transport. Measures which affect the pulp and paper sector directly - i.e. stumpage fees to internalize user costs and emission standards to internalize pollution costs - may have important consequences in terms of transport use since any measures which affect trade flows will affect the transport intensity of the sector. For example, the unilateral imposition by some countries of stringent regulations on the emission of chlorine compounds by paper mills into receiving waters could have the effect of altering trade flows, and thus transport use in paper production. Similarly, Sedjo and Lyon (IIED Substudy No. 2) believe that conservation measures will constrain production in western Canada and the US, and hence North American exports of both pulpwood and pulp will be reduced. They also anticipate an increased flow of market pulp from Chile, South Africa and Brazil, mainly to East Asian markets, following the reduction in US exports.

The effect of environmental cost internalization in the transport sector is also likely to have significant consequences on the spatial pattern of production since environmental effects in transport are notoriously non-internalized. The introduction of appropriate measures has the potential to affect the relative price of transport in general as well the relative price of alternative transport modes. The importance of these effects is dependent upon the responses of the pulp and paper sector to price changes for transport services overall (the sectoral price elasticity of demand for transport services) as well as the degree of mode substitutability within the industry (sectoral cross-mode price elasticities). The greater the own-price elasticity the more responsive will the sector be to aggregate price changes and the greater the cross-mode elasticities the more responsive will the sector be to relative price changes across modes.

In general, one would suppose that both aggregate and cross-mode price elasticities are likely to be quite low at the early stages of production for all of the reasons discussed previously. Since forest resources are geographically specific and immobile, relocation of production sites in order to reduce transport requirements is not always feasible. Moreover, since the areas tend to be relatively inaccessible, infrastructure is likely to be limited, indicating that mode substitution is rarely an option. In addition, the specific geographical terrain (i.e. proximity to rivers or coasts, topography of the terrain, etc) may restrict potential mode choices. And finally, since the products tend to be bulky and low value, only a sub-set of modes are likely to be cost-effective. However, further down the production process both aggregate and cross-mode elasticities should increase since all four of these factors cease to be as significant.

Estimates at the sectoral level are not readily available. However, a recent aggregate estimate found that the price elasticity of freight transport demand (expressed in tonne kms) was -0.23 for the United States (Vouyoukas 1995). This indicates that a 10% increase in the aggregate price of freight transport services will result in a 2.3% decrease in demand. The same study estimated that the price elasticity for road freight transport demand in Japan was -0.21.

3 The Environmental and Social Impact of Transport in the Paper Cycle

3.1 The Environmental and Social Impact of Freight Transport

The environmental and social impacts of transport in general are a cause of increasing concern, particularly in industrialised nations. Much work has been done on the costs and benefits of transport and there is now a general recognition that the external costs - those costs not paid for exclusively by transport users such as accidents, pollution, noise, loss of time in congestion - are too high. The OECD has estimated that these costs come to approximately 5% of GDP (Alexandre 1995) .

The impact of transport depends on a number of factors including, the mode of transport used, the location of the emission and the presence of other pollutants. The following sections will focus on the effects of road, rail and water transport as they are the principal modes used by the pulp and paper sector.

3.1.1 The Environmental Costs of Freight Transport

Environmental concerns arising from the use of transport are many and varied. For instance, road construction in virgin forest regions may lead to significant environmental impacts, directly through land-take and pollution emissions, and indirectly through increased access. However, since it is pollution that has generated the most controversy, particularly in terms of comparative emissions from different modes, this section concentrates on air and water pollution.

Air Pollution
According to the OECD, motor vehicle use is now generally recognised as the source of more air pollution than any other human activity. Although much of this is related to passenger transport, diesel-powered road vehicles and trains emit carbon dioxide (CO_2), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x), hydrocarbons and particulate matter (PM), which are of particular concern for health and environmental reasons (Alexandre 1995).

CO can impair perception and reflexes and cause drowsiness. SO_2 irritates the eyes and lungs and both SO_2 and NO_x (NO and NO_2) contributes to acid rain affecting vegetation, aquatic life, buildings and human health. NO_x also reacts with hydrocarbons in the presence of sunlight to form ozone (O_3), damaging vegetation and - at concentrations above 0.05-0.08ppm - contributing to coughs, eye irritation, headaches and asthma. Certain hydrocarbons may be carcinogenic and lead emissions may lead to ailments related to the circulatory, nervous and reproductive systems. Lead is particularly dangerous for small children. CO_2 and NO_x also contribute to global warming, while O_3 may also be a net greenhouse gas, although it absorbs both incoming and outgoing radiation (see RCEP 1994).

Both the World Health Organisation and the OECD have recognised that the scale of air pollution from motor vehicles is unacceptably high (Whitelegg 1993). Table 3.1a below lists the air pollution emissions from transport in the UK. However, it should be emphasized that this includes passenger transport. This is particularly important for road transport since it is not only the level of emissions which will be affected by including passenger transport, but also the mix since most passenger cars use petrol, while very few freight vehicles do so.

Emissions from electricity-powered trains are largely dependent on developments within the electricity supply industry (ESI) and not the rail sector itself. For instance, the installation of flue-gas desulphurisation within the ESI in European countries has reduced emissions of SO_2, but at the expense of increased emissions of CO_2. Similarly, increased construction of nuclear power plants will reduce most air pollutants, but at the expense of increased generation of solid radioactive waste. This illustrates the importance of fully specifying sectoral linkages when attempting to determine the environmental effects of alternative forms of transport.

Table 3.1a Air Pollution Emissions (1000 tonnes) from Transport in the UK in 1992

	SO_2	PM	NO_x	CO	VOCs	CO_2
Road	62	215	1398	6029	949	30000
Rail	3	-	32	12	8	1000
Air[1]	3	1	14	11	4	1000
Water[2]	8	3	130	19	14	2000
Transport	76	219	1574	6071	975	34000
Total	3500	457	2750	6708	2556	155000

Source: UK Dept. of the Environment, *Digest of Environmental Protection and Water Statistics* (London: HMSO, 1994)

Water Pollution
Not surprisingly, most water pollution arises from marine transport, although the effect of emissions from power stations should also be addressed for electric-powered rail transport.

Marine transport can be either inland or oceanic, with the latter usually involving larger vessels. Unlike other transport modes pollutants from marine transport are not primarily associated with the combustion of fossil fuels, but with the direct discharge of substances. For instance, 80% of marine oil pollution is "operational," arising from loading/unloading cargo, accidents, combustion leakage, and intentional discharges (CEC 1992). The first three can certainly be considered a function of the use of water as a transport mode, but it is not clear that the latter should be since in many cases it is more accurately seen as a disposal option, albeit one which is frequently unsatisfactory and illegal.

3.1.2 Social Impacts of Freight Transport

This section examines three important "social" costs of freight transport: congestion,

[1]Emissions less than 1 km in altitude.

[2]Emissions from coastal shipping (< 12 miles).

accidents and noise. Since these primarily affect road transport, the discussion will not include other modes. Unfortunately, in all three cases the data is not available for costs specifically related to freight transport, so the figures will reflect passenger transport costs as well. In addition, since such costs are closely dependent upon the country concerned most of the data is for one country (the United Kingdom) for illustrative purposes. And finally, it should be emphasized that these costs are likely to be most closely related to urban stages of transport. With respect to freight transport in the pulp and paper sector this means that transport of the most highly processed goods and collection of wastepaper would be the relevant transport stages.

Accidents

According to the UK Department of Transport, there were 5,217 fatalities, 60,441 serious injuries, and 275,483 minor injuries on UK roads in 1990. (DTn 1991, Table 2.50) Clearly the true social cost of such fatalities and injuries is, in some sense, incalculable. However, The UK Department of Transport estimates their 'value' using a 'willingness-to-pay' approach. On the basis of their 1990 figures (DTn HENI 1990) the cost of road accidents in 1990 exceeded £6 billion.

Congestion

The costs of increased congestion on the roadway network has become an issue of increasing importance in the United Kingdom, particularly in London. This is hardly surprising given the costs involved. For instance, in 1989 the CBI estimated that the total annual cost of congestion on London roads was equal to £3 billion (CBI 1989). An OECD study placed the figure for the European Community at 2.6% to 3.1% of GNP (CBI 1989).

Noise

A study of dwellings in England estimated that 3.9 million houses were subject to "unacceptable" noise levels in 1979 (Noise Advisory Council 1980). According to a Transport and Road Research Laboratory (TRRL) report 8% of the English population was exposed to road traffic related noise levels in excess of L_{10} (18-hour) 70 dB(A) in 1977.[3] Since the 1975 Noise Insulation Regulations provide free noise insulation for all households exposed to traffic-related noise levels greater than 68 L_{10} dB(A)[4], this indicates that the effects of such noise levels are significant. Estimating the welfare costs of such levels of exposure is difficult. A French study has estimated that the external cost of exposure to traffic noise may be as much as 0.1% of GDP (Barde and Button 1990). Nelson (1982) provides a convenient summary of the main results of eight studies which attempt to estimate the effect of traffic noise on property values. Although the range of estimates for the decreases in property values per unit of noise level is quite large (0.08% - 1.05%) it is felt that the arithmetic mean of 0.42% gives a good indication of the average effects of noise levels on property values.

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[3]They also found that 25% were exposed to noise levels over 60 L_{10} (18-hour) dB(A) and 80% over 50 L_{10} (18-hour) dB(A). See Harland and Abbott (1977).

[4]Noise Advisory Council (1980), 5.

3.1.3 Relative Impact of Different Modes

Table 3.1b illustrates the impact of pollution emissions arising from the transport of one tonne of freight one kilometre. Air and road transport are much more damaging of transport in terms of air pollution and energy use than water and rail. The energy required to transport one tonne of freight one kilometre by road would transport it over 4km by rail and almost 7 km by water.

Road transport is by far the major contributor to environmental degradation producing 90% of CO, at least 30% of CO_2, 50% of NO_x, 80% of benzene, 50% of lead, 40% of hydrocarbons and its noise affects 16% of the population (Alexandre 1995). Rothengatter calculated the emissions of various pollutants from different modes in Germany in 1987 (see Table 3.1b below). Although the calculations are based on German data they are indicative of emissions across the EU.

Table 3.1b Specific Energy Consumption (kJ/tonne-km) and Specific Air Pollution Emissions (grams/tonne-km) in Germany

	Rail	Water	Road	Pipeline	Air
Energy Consumption	677	423	2,890	168	15,839
CO_2	41	30	207	10	1,206
CH_4	0.06	0.04	0.3	0.02	2.0
VOC	0.08	0.1	1.1	0.02	3.0
NO_x	0.2	0.4	3.6	0.02	5.5
CO	0.05	0.12	2.4	0	1.4
*SO_2	0.18	0.05	0.18	NA	NA

Source: Whitelegg 1993, * OECD 1991

The effect of many of the above pollutants are heavily dependent on the location of emissions and the presence of other pollutants (e.g. the co-existence of hydrocarbons and NO_x as precursors to O_3) hence the environmental effects of a given level of emissions will differ. For this reason the same level of emissions from road vehicles - at least urban road vehicles - will result in greater environmental and health damages since they are emitted in closer proximity to other precursors and to pedestrians and dwellings.

3.2 The Environmental Impact of Transport Compared to Other Stages of the Cycle

This section aims to determine the order of magnitude of environmental impacts from transport during the paper cycle and compares it to impacts from other stages of the cycle. After examining many existing life cycle analyses it was decided that none of them addressed transport in sufficient detail for our purposes and PIRA International was commissioned to run a life cycle model to provide indicative results of the impact of transport in the paper cycle in Europe. Europe was chosen since it was not feasible to look at the global cycle and

PIRA had access to accurate European data.

There were two overall aims to this study. Firstly, to determine how important transport emissions and resource use are relative to overall life cycle emissions and resource use. Secondly, to examine the environmental consequences of two scenarios, one in which a more environmentally benign transport mode is used for some stages of the cycle and one in which the use of recycled paper and hence the transport associated with it is substantially increased. The results are indicative only but should give an indication of the magnitude of transport related impacts in each case.

Scope of Life Cycle Assessment

PIRA applies the Life Cycle Assessment definition given by the Society of Environmental Toxicology and Chemistry (SETAC) which they define as:

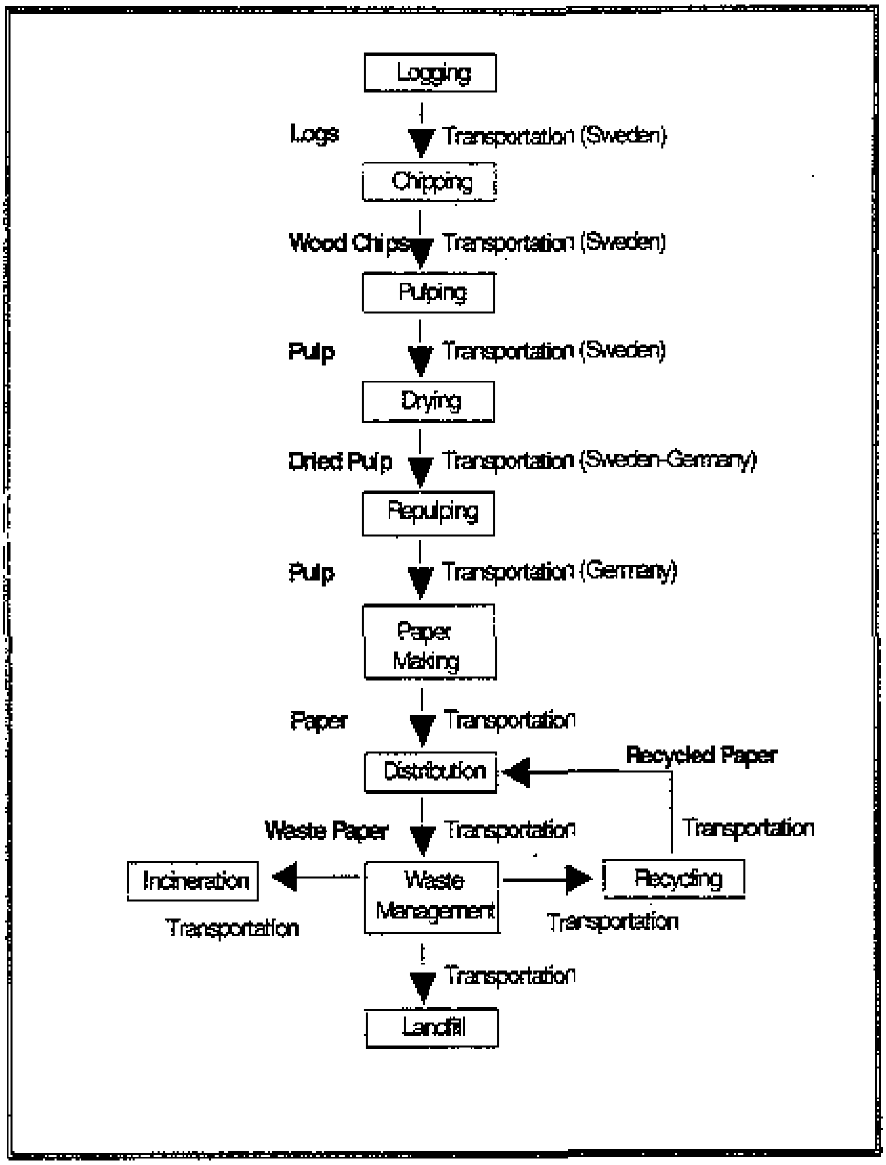
> 'a process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and material uses and releases to the environment; and to identify and evaluate opportunities to affect environmental improvements.'

The functional unit of analysis in the study is 1000 kg of unbleached uncoated paper. It is assumed that the pulp is produced in Scandinavia and transported to markets in Germany where it is transformed into paper, consumed and disposed. Wastepaper recovery and reprocessing is undertaken in Germany. This was chosen to be as representative as possible of the situation in Europe at the present time. In 1993 the European Union imported more pulp from Sweden than from any other country and 38% went to Germany. Germany consumed 5225000 tonnes of pulp, of which 3339000 tonnes were imported (PPI 1995).

The stages included in the assessment are:

- logging, chipping and pulping
- all transport operations
- production and use of fuels
- generation of electricity and heat including fuel production
- disposal of process wastes.

Figure 3.2a Stages Included in the Life Cycle Assessment



Manufacture and maintenance of capital equipment and of buildings, manufacture of ancillary inputs and printing, converting and coating operations are not included. Full details of the systems boundaries and the methodology are used can be found in PIRA's final report to IIED.

3.2.1 Base Case

The transport assumptions were designed to be broadly representative of a typical paper cycle in Europe and are detailed in table 3.2a below. The environment intensity of transport relative to the total environment intensity is shown in table 3.2b.

Table 3.2a Transport Assumptions for the Base Case

Stage of the Cycle	Mode	Distance	Vehicle	Route
Harvest site to pulp mill	Road	75km @ 50% utility	30t truck diesel	100% rural
Pulp mill to paper mill	Marine Road	90km @ 100% utility 1080km @ 50% utility	 30t truck diesel	 756km motorway 216km urban 108km rural
Paper mill to converter	Road	37km @ 100% utility	30t truck diesel	Average split
Converter to retailer	Road	150km @ 70% utility	30t truck diesel	Average split
Retailer to consumer	This is excluded from the assessment since very few trips are made solely to buy paper.			
*Consumer to recycled collection facility	Road	128km	3t car petrol @ 0.003% utility	115km urban 13km rural
Collection facility to recycling plant	Road	788km @ 50% utility	30t truck diesel	Average split
Consumer to landfill/ incinerator	Road	25km @ 50% utility	30t diesel truck	Average split

* this distance is the sum of the small trips that the requisite number of consumers need to make to produce the amount of recycled fibre used. The recycling rate used was the European average. See PIRA's final report to IIED for more details.

All transport distances refer to round trips (ie. a sea journey of 90km refers to transport distances of 45km outward and 45km inbound). Therefore, the utility, illustrates the quantity of material carried as a proportion of the vehicle's carrying capacity.

Table 3.2b The Environment-Intensity of Transport in the Paper Cycle Relative to Total Environment Intensity.

Environmental Class	Resource Use & Waste	Units	Transport	Total	% accounted for by transport
Resources	Coal	MJ	0.1041	300.5071	0.03%
	Oil	MJ	21.4030	193.3939	11.07%
	Gas	MJ	1.2813	28.6452	4.47%
	Other Non-Renewabless	kg	0.0156	3.7972	0.41%
	Renewable Resources	kg	0.0000	4299.1024	0.00%
Air Pollution	CO	kg	1.0177	13.3753	7.61%
	CO_2	kg	69.3406	2980.0642	2.33%
	NO_x	kg	1.2400	6.0973	20.34%
	SO_2	kg	0.2290	12.1097	1.89%
	VOC	kg	0.3196	2.7097	11.79%
	Metals	kg	0.0000	0.0020	0.00%
	Dust	kg	0.0843	7.1462	1.18%
Water Pollution	Halides	kg	0.0000	0.1190	0.00%
	Wastewater	kg	2.3578	46439.9113	0.01%
	Metals (water)	kg	0.0000	0.0371	0.00%
	TDS	kg	0.0001	12.3215	0.00%
	TSS	kg	0.0019	4.6843	0.04%
	Oils&Greases	kg	0.0000	0.0011	0.00%
	COD	kg	0.0000	0.0012	0.00%
Soil Pollution	BOD	kg	0.0000	0.0171	0.00%
	Landfill Weight	kg	0.0616	827.7926	0.01%
	Landfill Volume	m^3	0.0772	1034.7394	0.01%

Not surprisingly, the main environmental impact from transport in the paper cycle is the use of fossil fuels and the emissions of pollutants to the atmosphere. Transport accounts for 11% of the oil used in the paper cycle and 4.5% of the gas consumption. It should be emphasised however, that these proportions will vary significantly with the fuel mix used. Transport also accounts for a significant proportion of the airborne pollutants, notably 20% of NO_x and 12% of volatile organic compounds (VOCs).

The location of these emissions are significant since their effects are particularly dependent on the presence of other climatic and environmental conditions, which is not the case for the environmental effects of some other airborne pollutants (e.g. global warming arising from CO_2) and much less true of others (e.g. acid rain arising from SO_2). As such the actual affect of NO_x and VOC emissions from transport relative to other stages of the cycle is not directly proportional to the proportion of their emissions.

VOCs and NO_x are both precursors to atmospheric ozone through photochemical reactions in the presence of sunlight. Since the reaction can take as long as six hours and since the presence of other precursors are preconditions for the reaction, actual generation of ozone depends upon the place and time of emission. If transport emissions are principally urban and there are large concentrations of other precursors, then the actual environmental effects of the emissions will be proportionally much greater than the percentage of emissions would indicate. However, if manufacturing and extraction stages are relatively more closely located to urban centres and transport emissions are predominantly rural the converse would be true.

It is not possible to determine which of these two possibilities is more likely *a priori*, but a number of points are worth emphasizing. Firstly, emissions of these two pollutants will have more significant consequences for some transport stages (i.e. converter-to-printer) than others (harvesting-to-pulp mill) due to the likely location of economic activities. Secondly, since both pollutants are emitted in the same combustion process in transport stages, synergistic precursors will be present by definition, which might not be true of emissions of the two pollutants from other processes in the life cycle. And finally, the only other pollutant with a reasonably significant proportion of emissions arising from transport - CO (8%) - also has localized effects, in addition to its contribution to global warming. Thus, it is clear that in the case of transport cycle the place and time of emission is at least as significant as the actual level.

At a more detailed level it is interesting to note that the emissions associated with the ocean stage are insignificant, representing 0.5% of CO, 1.3% of VOCs, 1.8% of CO_2, 1.6% of NO_x, and 1.7% of SO_2 emissions attributable to transport, despite representing 5.8% of the total distance travelled. Thus, in terms of air pollution a large proportion of these emissions will be associated with the docking stages, any increase in the ocean distances (i.e. due to inter-continental trade) would have much less adverse consequences than an equivalent increase in other mode distances. The relative effects of rail and road are discussed below in the mode choice scenario.

3.2.2 The Effect of Mode Choice on the Environment-Intensity of Transport

As was discussed in Section 2 different modes have very different environmental consequences. From the base case it is clear that ocean transport has a disproportionately low environmental impact for the distance travelled. In addition, the overall impact of rail transport is generally substantially less than road. As such, a scenario was investigated in which some of the road transport was substituted by rail. Given the characteristics of the base case scenario the only places where this seemed feasible was in part of the journey between the pulp and paper mill and part of the journey from the converter/printer to the retailer. These accounted for 36% of the distance travelled.

Table 3.2c Change in Environmental Impact in the Mode Switch Scenario Relative to the Base Case.

Environmental Class	Resource Use & Pollutant	Base Case Transport	Change in Mode Switch Relative to Base Case	% in Mode Switch Relative to Base Case
Resources	Coal	0.1041	+10.7	103.55%
	Oil	21.4030	-6.3	96.72%
	Gas	1.2813	+0.6	102.09%
	Other NRs	0.0156	0.0	99.93%
	RRs	0.0000	+0.8	100.02%
Air Pollution	CO	1.0177	-0.1	99.50%
	CO_2	69.3406	+5.8	100.20%
	NO_x	1.2400	-0.4	93.02%
	SO_2	0.2290	+0.3	102.26%
	VOC	0.3196	0.0	99.87%
	Metals	0.0000	0.0	100.00%
	Dust	0.0843	0.0	99.52%
	Halides	0.0000	0.0	100.00%
Water Pollution	Wastewater	2.3578	+28.7	100.06%
	Metals (water)	0.0000	0.0	103.23%
	TDS	0.0001	+0.2	101.36%
	TSS	0.0019	0.0	100.10%
	Oils&Greases	0.0000	0.0	100.00%
	COD	0.0000	0.0	100.00%
	BOD	0.0000	0.0	100.00%
Soil Pollution	Landfill Weight	0.0616	+1.2	100.14%

The major difference between the mode switch scenario and the base case was that emissions of NO_x dropped by 7% overall, with transport in the mode switch scenario only contributing two thirds of the base case NO_x emissions. Since NO_x emissions are one of the most polluting aspects of transport this is significant. The exact extent to which environmental damage is reduced is difficult to judge however, since this depends on the location of emission and interactions with other pollutants, particularly VOCs.

It is difficult to treat the resource use results with confidence since the assumption was made that all rail journeys will be electric. Not only is this unlikely since at the early stage of the cycle but any change in resource use depends critically on what assumptions are made about the electricity supply industry.

3.2.3 The Effect of Recycling on the Environment-Intensity of Transport

The second scenario looked at the impacts of significantly increasing the use of recycled paper, in particular the impact this would have on transport related emissions. There were several reason for this. Firstly, the current trend is for the amount of recycled fibre used in paper to continue to increase. Secondly, many environmental groups are advocating much greater use of recycled fibre than would occur under current trends. In order to try and assess the impact of a much greater use of recycled fibre the European average recovery rate of 36% which was used in the base case was substituted by a recovery rate of 54%. This figure was used as it is one that has been reached by some countries but it is a significant increase from the current figure. The change in environment intensity relative to the base case is shown in Table 3.2d below.

In general, the results indicate that increasing the amount of recycled fibre used in the production of paper tends to increase the environment impact of the transport stages of production. Some airborne pollutants increase significantly in the transport stages, notably CO which increase by 40% and VOCs which increase by 17%. However, overall resource requirements and emissions are reduced in relation to the base case due to reductions at other stages in the cycle, in some cases very significantly indeed. In particular the reduction in the use of renewable resources and in the generation of landfill waste - two of the primary objectives of recycling are significant. Non-renewable resources use is reduced by over 10% in all cases apart from coal which increases by 5%.

Overall air pollution is generally reduced in the increased recycling scenario compared to the base case, with SO_2 and VOCs being the exceptions although the increases are small. However, it should be emphasised that as more transport emissions are urban, the effects in terms of damages may well be greater than the absolute changes indicated.

Conclusions

The results from the PIRA model should be treated as indicative only, but they do reveal some interesting information. The main finding is that transport accounts for a significant proportion of airborne pollutants, in particular NO_x and VOCs. The disproportionately small emission of pollutants from marine transport and results from the mode switch scenario suggest that emissions, particularly of NO_x can be significantly reduced by switching from road to rail and marine where possible, although the results from this scenario should be treated with some caution. The model also demonstrates that when the use of recycled fibre is increased the environmental impact of transport increases substantially for some pollutants. However overall this effect seems to be more than compensated by benefits accrued at other stages of the cycle.

Table 3.2d Change in Environmental Impact in the Increased Recycling Scenario Relative to the Base Case

Environmental Class	Resource & Pollutant	Base Case Transport	Change in Scenario Relative to Base Case	% for Scenario Relative to Base Case
Resources	Coal	0.1041	0.01	105.90%
	Oil	21.4030	2.21	87.79%
	Gas	1.2813	0.13	80.63%
	Other NRs	0.0156	0.00	77.65%
	RRs	0.0000	NA	77.39%
Air Pollution	CO	1.0177	0.41	82.87%
	CO_2	69.3406	6.66	87.55%
	NO_x	1.2400	0.09	96.66%
	SO_2	0.2290	0.01	102.32%
	VOC	0.3196	0.05	105.04%
	Metals	0.0000	0.00	80.00%
	Dust	0.0843	0.01	77.71%
	Halides	0.0000	0.00	80.00%
Water Pollution	Wastewater	2.3578	0.24	80.95%
	Metals (water)	0.0000	NA	103.23%
	TDS	0.0001	0.00	88.17%
	TSS	0.0019	0.00	82.24%
	Oils&Greases	0.0000	NA	72.73%
	COD	0.0000	NA	91.67%
	BOD	0.0000	NA	77.19%
Soil Pollution	Landfill Weight	0.0616	0.01	75.09%
	Landfill Volume	0.0772	0.01	75.09%

4 CONCLUSIONS

Fibre, pulp and in particular paper and wastepaper are transported all over the world, and, like most other sectors both volumes and distances are likely to increase in the future. The environmental impact of this is difficult to quantify since it is dependent on so many factors, including mode of transport used, location of emission and presence of other pollutants. In terms of the emissions of pollutants during the paper cycle, the major contribution from transport is emissions of air pollutants and road transport is the most significant mode interms of environmental degradation.

Marine transport is relatively environmentally benign and as such sourcing paper related goods from far-flung places may not be as detrimental as might be expected, provided that the bulk of the transport is by sea. Environmental impacts of transport are not linearly, or even necessarily positively, related to transport distances when mode choice is considered so minimising transport distances is not necessarily the best way to minimise environmental impact Perhaps more significantly attempts to minimize transport-related environmental costs may be achieved at the expense of environmental costs elsewhere in the production cycle. However, there is little question that both the scale of transport use and mode choice which exists in the sector at present have significant environmental consequences.

The scale of transport use in the sector is a function of costs in alternative production locations (as well as other factors such as resource availability), while the choice of transport mode within the sector is a function of relative costs of different modes (along with other factors such as speed and convenience). As such, the internalization of transport-related environmental externalities, by increasing transport costs, will tend to reduce demand for transport in aggregate, but generate increased demand for rail and water transport relative to air and road. Moreover, unlike many other goods and services the supply and cost of transport services, both in aggregate and in terms of different modes, is profoundly affected by infrastructure and institutions, for which the government is largely responsible. For both of these reasons the government has an important role to play in the determination of transport use and mode splits.

Increasing the use of recycled fibre does increase the environmental impact of transport since the majority of extra transport generated is urban road transport. The extent of increased transport impact depends to a large extent on the efficiency of collection. The PIRA model for paper production in Europe demonstrates that although the impacts of transport do increase under an increased recycling scenario the benefits from recycling which arise elsewhere in the production cycle are likely to outweigh this. However, situations such transport of recycled fibre to meet recycled content regulations (as has happened in North America) should be avoided. It would seems to make much more sense to use wastepaper in the vicinity of its collection area and produce paper mainly from sustainably managed forests in areas with abundant forest resources.

In general, the environmental impacts of freight transport is a major cause of concern and it is becoming increasingly likely that attempts will be made by policymakers to reflect some of the environmental costs of transport, thus affecting prices. Stakeholders in the paper cycle should therefore be looking much more systematically at transport in the paper cycle. While it may be difficult to change some determining factors, such as the location of raw material inputs and major consumer markets, companies may have more control over other factors such as the location of mills or mode choice. Steps should be taken to minimise the use of transport, particularly in cases where it is likely to have the most impact (ie urban road transport).

What has also been evident from this study is the lack of information on, and consideration of, transport in the paper cycle. More comprehensive statistics and more detailed analysis is required in order to enable impacts to be judged more clearly and to enable policy makers to estimate the transport implications of their decisions.

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