FORESTRY COMMISSION
OCCASIONAL PAPER 38

Forestry Expansion –
a study of technical, economic and ecological factors
Development of the British Wood Processing Industries

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Forestry Commission, Edinburgh

ISBN: 0 88666 5673 - © CROWN COPYRIGHT 1991 - Forestry Commission, 231 Corstorphine Road, Edinburgh, EH12 7AT.

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The principal concern of British forestry in the twentieth century has been the creation of the national woodland estate and its restoration after wartime destruction. For more than half the period since the establishment of the Forestry Commission in 1919, the national policy objective was to provide a strategic reserve of standing timber against the possibility of a lengthy war, without stating the timber assortments precisely or envisaging their processing. Even after the abandonment of the strategic reserve policy in 1959, there was apparently no requirement for the Forestry Commission to select areas for afforestation with an eye to the eventual utilisation of the timber that would be grown; politicians looked for rural employment in forestry to offset the shedding of jobs in farming, rather than economic efficiency in terms of return on capital. In the last two decades, certainly, the Forestry Commission has done much to ensure the establishment of new wood processing mills and the end-use of the construction industry has been identified as most desirable as providing the highest stumpage value or gross margin, but this did not extend to the locational values of afforestation.

Although the Forestry Commission, since its inception, has had powers of compulsory purchase of land, these have never been employed for the purpose of creating state forest by the acquisition either of existing woodlands or of land for planting. The land for public forestry has been purchased or long-leased as opportunities arose on the open market; the location of state forests has been determined by where land happened to be offered for sale rather than by plans for a future processing industry. It is true that the ceiling prices set by the Treasury virtually restricted to the uplands the post-1950 land purchases by the Forestry Commission, resulting in the concentration of state forests in Scotland and Wales, but it seems that little influence was exerted on the selection of areas by analysis of transport costs to centres of population or to the existing or expected centres of wood processing.

Private forestry based on the traditional landed estates is dispersed, having largely grown from a period when local markets for timber were strong and when the non-market benefits of woodland were particularly important to their owners, who valued policy woods, game coverts and treed landscapes, and who built their production forestry around these features.

After 1960 the private sector management companies periodically expressed interest in the concentration of land purchases for afforestation with a view to timber marketing (for instance, Rankin, 1972). None the less, such was the pressure from willing investors in peak years during the period when tax incentives were effective, that a shortage of suitable land was the factor limiting the rate of investment and, with some exceptions, company afforestation has been as dispersed as the Forestry Commission's. So far as is known, the Forestry Commission has never withheld a planting grant on the grounds that the plantation would not usefully serve a wood processing factory, nor has the Inland Revenue refused Schedule D tax remission for that reason. The location of afforestation in both public and private sectors has not been planned to serve the siting of new wood processing industries. In the period up to about 1960 some special market conditions permitted this dispersal of woodlands without severe financial penalty. Until the cuts imposed by Lord Beeching, there was an intricate railway network whose branch lines penetrated almost every parish in Britain, apart from the Scottish Highlands. Every yard of track was laid on wooden sleepers which required regular replacement, so that a huge market existed for this product. For the marketing of timber and for forest management, it was particularly important that sleepers were purchased at standard prices irrespective of the railway station or depot to which they were delivered, from Caithness to Cornwall, and this uniform pricing policy applied also to other major railway timber requirements, such as wagon bottoms. Forest dispersal thus imposed no penalty on the marketing of these large dimension timbers which made up, in 1954 for instance, 10% of sawn softwood production.

To a large extent the same was true of small roundwood for which the largest single market was coal mine props. The deep-mined coal industry was far more extensive pre-1960 than in 1990, from Kent to Fife, and most divisions of the National Coal Board bought timber locally; the Scottish Division, from 1954, used more than 85% locally grown timber, (subsequently the Board increased the proportion of British grown timber in deep mines so that Scotland used 100% British props, Wales 85% and England about 70%, but the volumes involved diminished sharply; see Table 1). Since the market for mining wood was dispersed, there would have been little, if any, financial reward to be gained from a geographical concentration of the forest resource, particularly as the processing required is minimal. The National Coal Board divisions purchased timber at fixed regional prices free-on-transport plus carriage costs (up to a limit of carriage cost to be paid by the Board). Once again the pricing schedule and the nature of the product for this large customer combined to reduce the penalty of forest dispersal, although even by 1954 growers gave evidence to the Watson Committee (UKFC, 1954) that they doubted 'whether, without the introduction of some scheme for the equalization, or partial equalization, of transport costs, growers in the remoter districts can receive an economic price for their produce'.

Table 1 Use of timber in deep mines in Britain, 1950-1977

	1950	*1960*	*1977*
Deep mined coal produced, million tonne	208	189	100
Timber purchased, million m^3			
Props and splits	1.815	0.960	0.234
Sawn	0.830	0.990	0.411
Total timber	2.645	1.950	0.645
m^3 timber per 1000 tonne coal mined:			
Total timber	12.7	10.3	6.4
Props and splits	8.7	5.0	2.3

Finally in this baseline summary, there was, until the 1950s, the market for timber in the estate and local sawmills that were an inheritance from the nineteenth century. In a rural economy based on tenanted farms, the landlord required a continual supply of sawn timber for building repairs, fencing, bridges etc., and many estates ran their own sawmill, or sustained a local mill by purchasing their requirements. In this respect forestry lingered later than the other services that characterised the previously self-sufficient rural parishes: the corn mill, the brewery, the smithy and so on. Never the less the estate sawmills and village sawmills diminished rapidly in the decade after the Second World War. As farms became owner-occupied, the estate proprietor's need for timber fell and he could win more profit by selling logs to a well-equipped commercial mill than by cutting them at home on a rack bench of low efficiency. Furthermore the removals of estate timber between 1939 and 1945, which fell more heavily on the private woods than on the Forestry Commission's, had often left too little mature timber to justify an estate mill. The continuity of supply was broken and the processing stopped.

The demise of the small sawmills in Britain is in some contrast to the situation in other parts of Europe. In countries such as France and Switzerland which suffered neither an interruption of roundwood supply nor the same sudden change in the structure of the rural economy, the opportunities have remained for the sustention of village sawmilling and the small mills persist in greater numbers than in Britain. Nevertheless these small mills are usually undercapitalised in respect of both saw machinery and kiln facilities, and they may find difficulty in competing with well equipped specialist mills with a much larger throughput. This apparently accounts, for instance, for the recent import of hardwood logs to Britain from France, by millers whose technical efficiency more than offsets the heavy transport costs.

The problems of marketing roundwood in Britain, which had been increasing through the 1950s, reached a crisis by 1960, with three powerful factors combining:

1. The coal mining industry, already beginning to close some less efficient pits, made a substantial switch from wooden props to steel hydraulic props, thus substantially reducing demand in the largest single market for roundwood.

2. British Rail, on top of a great reduction in the track mileage as branch lines were closed, switched entirely from wooden railway sleepers to steel and concrete sleepers, followed soon afterwards from wooden freight wagons to steel.

3. The new forests planted in the 1930s were beginning to 'come-on-stream', in both the state and private sectors, and the total volume of timber cut began to rise after the destructive war fellings, with a prospect of continuing increase in subsequent years.

These problems were first formally addressed by the Watson Committee (1956) which submitted its report on the Marketing of Woodland Produce in 1956. In retrospect it seems unfortunate that this competent committee was given terms of reference that were so superficial in relation to the real problems developing for the whole forestry industry:

> With the object of promoting confidence and stability, and bearing in mind both the output from Forestry Commission woodlands and the need to develop markets, to consider what measures might be taken within the home timber industry to improve the arrangements for marketing produce from privately owned woodlands; and to report.

The internal evidence of the Report shows, particularly in its paragraphs on pulp and board mills, that the Watson Committee could have produced sensible and effective proposals in respect of markets in new wood processing mills, had it not been restricted to the private sector (in the circumstances an entirely meaningless constraint); instead its attention was confined to revision of the structure of the private forestry sector and to growers' co-operatives.

Planning the establishment of new processing industries had to await the publication of two economic studies in 1958 and 1959: Small Pulp Mill Survey and Board Mill Survey (Forestry Commission, 1958 and 1959). Under the auspices of the Organisation for European Economic Cooperation, the Consulting Engineers Messrs Sandwell & Co Ltd. of Vancouver conducted a survey to determine whether or not small scale paper-pulp mills would be economic in seven member countries of OEEC, including the United Kingdom. Since there was a growing demand in the UK for fibre board and wood particle board, the Forestry Commission decided to ask the firm simultaneously to study the economics of small board mills. It was seen that the problems of limited water supply or of effluent disposal might make it impossible to develop a paper-pulp mill but would allow some types of board mill to succeed. It was also thought that 'limited or scattered raw material resources and high transport costs might make a pulp mill uneconomic', (Forestry Commission, 1959).

The forecast increase in the yield of small roundwood from British forests, coupled with the evident falling away of demand for pitwood, produced considerable pressure by timber growers for government action to encourage the establishment of paper-pulp or board mills or both. The first response came in the formation of a consortium of the four largest companies then engaged in pulp trading and paper manufacture in the UK. The consortium company carried out feasibility studies which led to Scottish Pulp and Paper Mills Ltd building the integrated pulp and paper mill at Fort William in 1965.

With regard to the Fort William mill two points are especially significant. Written in 1956, the Watson Report wisely said, 'One point for consideration ... will be whether to aim at the early establishment of a series of small mills or to await the time when supplies are sufficient to justify the installation of a really large unit., (Watson Committee, 1956). The pressure from growers for the early creation of a market for small roundwood was intense and it coincided with the desire of the Government to promote job creation in the Highlands. As a result, the mill at Fort William was built earlier than the knowledgeable industrialists would have wished and, throughout its life, it had to compete with mills in Scandinavia and Canada that were much larger and consequently enjoyed substantial advantages of scale economies. At its maximum, the rated capacity of this chemical process mill was 80 000 tonnes of air-dry pulp, although for most of its life its production was well short of that figure.

The second point, of particular interest for the present developments in the forestry industry, is that the chief architect of the Fort William development, Dr Frankel, made a clear request to the Forestry Commission for the ownership of three or four state forests to be transferred to the mill company, or at least that the company should command the forest management. Even for a mill that was arguably too small, the investment was such that the ownership of the wood supply and the ability to determine the silviculture were matters of deep concern. The request for the forests was refused but it foreshadowed a need that has increased as time has passed and as processing mill investment costs have escalated, for the mill manager to be relieved of his worst anxiety: that wood supplies may fail or fall short of his needs.

The considerable economic impact of building and operating the Fort William pulp and paper mill was described by Greig (1971) who calculated the regional income and employment multipliers. The mill had an important influence in keeping open the railway line from Crianlarich to Fort William and thence to Mallaig; the line carried roundwood from the depot at Crianlarich to the mill, as well as finished paper to southern markets. Subsequently a large modern sawmill investment was attracted to the site adjoining the pulp mill, the rationale being that butt logs went to the sawmill while the tops of the trees were pulpwood. It was an example of an integrated mill complex which, in other parts of the world with a well-developed wood economy, is the norm in modern forest industry.

The Forestry Commission played the leading part in the negotiations establishing the Fort William mill: the technical specifications for the wood supply, the price schedules, the price revision break points etc. Crucially, also, it was the Forestry Commission that gave the firm forward commitments of volumes of wood to be delivered. That pattern has been repeated many times over the last two decades: as national forest authority the Forestry Commission has rightly taken the lead, but private growers have given weak backing, showing reluctance in making forward commitment of wood supply and preferring to sell it 'spot'. This behaviour is recognised as hindering the development of new processing industry. A major attraction of the UK for international wood industrialists in the last two decades has been the increasing wood yield not committed to an existing mill, but that yield is of interest only if it becomes committed and can be relied upon to be available to the industrial investor. Reliability of raw material supply is at least as important as price to the manufacturer: that reliability has been provided by the Forestry Commission, sometimes at the cost of their future income, and the forestry sector as a whole is indebted to the Commission for that service.

In the years after 1960 there was a remarkably rapid development of pulp mills based on home grown wood: mechanical pulp at Ellesmere Port and Gravesend (Bowaters), at Workington (Thames Board Mills), and at Bristol (St. Annes Boardmill); and semi-chemical pulping at Sudbrook (Ashton Containers) and at Kemsley (Bowaters). The rated capacity of these mills amounted to about 370 000 tonnes of air-dry pulp (i.e. excluding Fort William) although, for a variety of reasons, this total was never reached as production and even the capacity was reduced somewhat before the changes following 1980.

Over the same period wood-based panel manufacture also developed, almost entirely involving particle board (i.e. 'chipboard'). Manufacturing capacity for fibre-board has fallen or remained almost unchanged for three decades and production has actually fallen as machinery has become older. Plywood production in the UK involves tropical hardwoods, not home grown timber, and is on a small scale.

Particle board manufacture developed in many mills: Scottish Timber Products at Stirling; Scotboard at Irvine; Weyroc at Annan, Hexham, Weybridge and Thetford; Mallinson at Newcastle; Hills at Stockton; Kronospan at Chirk; Flakeboard at Coleford; and Spanboard at South Molton. In some cases company names have altered subsequently as a result of mergers and take-overs; some plants have been, or are now, owned or linked to firms with other interests in wood processing, or with building firms, or with the manufacture of the machinery central to the manufacture of particle board itself. Most of the mills, and all the larger ones, began by relying on forest thinnings but during the 1970s there was a marked shift towards the use of secondary sources of raw material, mainly sawmill residues but also those from joinery works. Since 1977 forest roundwood has provided only about 40% of the fibre requirement, wood residues from mills about 60%. Particle board capacity now exceeds 600 000 m^3 per annum, fierce competition from foreign manufacturers having reduced production in the 1970s by some 25%.

The growth of particle board manufacture in the UK was closely linked to changes in the sawmilling industry. When saw log supplies were very limited, from 1946 to about 1970, millers had to buy whatever species and log sizes were on offer: consequently mill design had to be flexible (for this reason, large single band saws were commonly installed) and sawmilling strategy was aimed generally at converting a high percentage of each log into saw timber, even at high cost in milling, effectively maximising the output per unit of input in shortest supply. As the available volume of saw logs increased, this strategy could change; the miller could then rely on buying a continuing supply of logs of particular specifications and could therefore design a mill to match them. Furthermore there was no need to win the maximum possible volume of sawnwood from each log, since the supply was now easier, provided that the residue could be sold for an attractive base price. This requirement was met by the market provided by the particle board manufacturer. The two industries are interdependent: the particle board mills depend on the sawmills for half or more of their raw material and the sawmillers are relieved of the need for much expensive re-sawing to win saleable products and profit from the slabwood.

The designs of the new generation of sawmills for softwoods drew much on overseas experience, mainly from Scandinavia. Mills are generally designed to handle a much

smaller range of log diameters than previously. Most are at least partly automated, with mechanical or laser measurement of the size and shape of each log entering the breakdown saw, and most are able to make two or more cuts at a single pass of the log through the machine. The existence of a ready market for residues for pulping or board manufacture has allowed some mills to use chipper headrigs instead of saws for the primary breakdown of the log, – that is to reduce the cylindrical log to a rectilinear cant by chipping directly to the desired shape, instead of sawing away 'the waste'. The new mills also have facilities for kiln drying the sawn wood and they pay close attention to grading the products, many through the installation of machine stress-graders, in order to meet the quality requirements of the construction industry. With modern machinery they are better able to saw the precise sizes and to meet clearly defined specifications for the strength and stiffness of their principal product in a highly competitive market. As a result of these technical improvements, the best of British sawn softwood is able to compete satisfactorily on the open, unprotected market with foreign supplies.

The Forestry Commission played an active part at the start of the sawmilling revolution by joining with a private firm in the investment, planning and management of the Ari Sawmill in Argyll, which was unfortunately destroyed by fire after a relatively short life. Subsequently it was ruled that the Forestry Acts did not allow the Commission to engage in commercial wood processing and it has not done so again. Never the less the introduction of the Ari Sawmill marked a radical change in sawmilling technology in Britain.

The steady development of the wood processing industries in concert with the increasing forest yield was drastically interrupted in 1980 when a combination of circumstances destroyed the pulp sector. In each pulping process – chemical, semi-chemical and mechanical – the UK mills were markedly smaller than their contemporaries in Scandinavia and Canada which were their commercial rivals, and suffered diseconomies of scale in processes where these are substantial. The Fort William mill, based on a chemical process, had never in its life enjoyed real freedom from technical problems; by 1980 it had reached an age when substantial capital replacement would be expected in any chemical plant on account of corrosion and obsolescence. That need came, however, when severe inflation in the British economy was being tackled by the government with very high interest rates and the bank borrowing rate for the mill's recapitalisation would have exceeded 20% per annum. The bank base rate drove the sterling exchange rate to more than US $2.40, at which it was cheaper for paper makers to buy market pulp in North America than in the UK. The final touch was that this coincided with the international oil crisis which forced up energy prices substantially in all industrial countries. The UK government, on the principle that the market forces should be left free to act on high energy users, refused to protect the British domestic pulp industry (or the steel industry etc.), whereas both the Swedish and Canadian governments subsidised energy for their pulp industries.

In the circumstances there was nothing the British pulp producers could do other than cease production; the two largest mills never reopened. Fort William ceased to make pulp, although it continued to make paper with imported pulps. The mechanical pulp mill at Ellesmere Port also closed. The wood growers, including the Forestry Commission, immediately negotiated contracts to sell pulpwood to Scandinavian mills and roundwood was exported from ports all round the country. Although the press was

quick to ridicule these sales since it appeared the UK was exporting at a low price the raw material of the paper it would then have to import at far higher cost, they had the great merit, as a short term measure, of keeping the forest labour employed and maintaining specialised harvesting machines in use; the sales also sustained the cash flow of wood harvesting companies and ensured that some essential silvicultural work was continued. Five years later, with inflation reduced, interest rates lower and the US dollar exchange rate against the pound well down from its previous high, the renaissance of business activity in Britain reversed all the factors that had caused the pulp mills to close. Further, two fresh factors attracted new investors: the ever-increasing yield of British forests, uncommitted to any mill, and the prospect of the completion of the internal market of the European Community in 1992.

Since the European Community is a heavy net importer of wood products, it is hardly conceivable that import duty would ever be imposed upon the raw material, although there is strong probability that duty will continue to be levied on the import of manufactured paper. International companies which trade in pulp and paper have an incentive, therefore, to establish a paper mill inside the EEC. Such an investment offers manufacturing and marketing flexibility, since in changed circumstances the mills might be supplied with market pulp or with wood chips for pulping, in addition to processing British grown wood. The two largest pulp-paper mills in the UK have been founded and are owned by Finnish companies.

There are now five major integrated paper mills in the UK using home grown timber as their raw material for pulping: Bowater Paper in Kent, St Regis Paper in Gwent, Thames Board Mills in Cumbria, Shotton Paper Mill at Deeside near Chester and Caledonian Paper Mill at Irvine in Strathclyde. Their products include newsprint, carton and linerboards for packaging and lightweight coated paper for magazines etc.; some of these papers are exported, as well as supplying a growing proportion of UK demand. It is noteworthy that Thames Board, Shotton and Caledonian Paper are all largely or entirely dependent on spruce for their raw material, virtually absorbing the whole current supply of small roundwood; Bowater Paper and St Regis technologies are based on hardwood species.

The restructuring and expansion of the 1980s has resulted in eight wood-based panel mills: the Oriented Strand Board mill at Inverness, the hardboard mill at Kemsley on the Thames, the cement-bonded particle board mill at Caerphilly, and particle board mills at Stirling, Irvine, Hexham, Chirk and South Molton. At the Stirling mill of Caberboard there is also a production line for Medium Density Fibreboard, an important new product.

There are more than 500 commercial sawmills in the UK, ranging in capacity from less than 1000 m^3 to more than 50 000 m^3. Two-thirds of the total capacity is provided by only 16 mills and this trend towards large automated mills with full kilning facilities and machine stress grading of the main products (especially construction timbers) is expected to continue. Approximately half the sawnwood output is of spruce and a quarter is Scots pine.

Over the period of active afforestation in Britain many studies have been made which have attempted to evaluate the forestry investment (Hiley 1956; Walker 1958; Johnston,

Grayson and Bradley 1967 etc.) but these have all been predominantly microeconomic in their approach, as also was the Ellison Report (1962) which was concerned with the methodology of comparing an afforestation investment with an alternative. In contrast to these, the cost-benefit study by HM Treasury (1972) was, for the most part, macroeconomic in approach. Until then, the scrutiny of the Forestry Commission's work and of the Exchequer support given to private forestry had been purely in current financial terms. The Treasury study considered the return on the investment, both in financial terms and in employment, import saving, recreation etc. It concluded that 'if, as seems to be the case, there is no alternative long-term supply of imported raw materials, then UK timber growing and processing become a single integrated industry...'. That is the crucial conclusion of the Treasury study; its authors in 1972 saw no alternative supply of logs with which the UK wood processing industries might be provided and without which they would have to close. It was paradoxical that the 1972 study, in its analysis subsequent to the quotation, ignored the interaction with the processing industries and valued the return on the afforestation investment simply by the price of timber at the forest gate, as if, in economic terms, the wood market was a perfect one.

To the extent that domestic timber growing and processing can be legitimately treated as a single industry, then it is the total level of output (or employment, etc.) of the integrated activities which properly measures the immediate contribution of the 'forestry-related' sector to the UK economy. Furthermore, the operations of the forestry-related sector will typically, through conventional multiplier processes, stimulate activity in other national industries.

To the authors' knowledge, the 'impact' of forestry-related activity on the UK economy in this sense has not previously been measured though such quantification is an essential pre-requisite to a comprehensive evaluation of the domestic forestry and timber sector's 'true' economic contribution. To this end, the following discussion provides a 'snap-shot' of the impact of forestry-related activity on the UK economy for the year 1984, chosen, as described below, because of the availability of necessary inter-industry linkage data.

As indicated immediately above, the subsequent discussion is concerned with estimating, for a particular period (1984), the direct and secondary impact of forestry activities on the UK economy. As a subsidiary objective, the distribution of forestry impact on the individual member countries of the UK will be assessed.

Similar to other industries and sectors, forestry in the course of its operations purchases labour, material and services inputs and produces output which it sells in various markets. The scale and nature of forestry activity itself determines its direct effect on the UK economy. The scale and nature of forestry's interactions with the rest of the economy determines its secondary effects.

Thus in order to quantify forestry's impact on the UK economy, the following are required:

1. Data based on the size and pattern of sales and purchases (including labour) made by the forestry industry.

2. A model which can utilise the forestry industry data and any other relevant information to measure the 'multiplier' or secondary effects on the UK economy.

The principal source of base year forestry data was an intensive survey undertaken by Mutch (1989). Purpose-designed, the survey collected fairly-detailed sales and purchases information from a large sample of forestry enterprises which were grossed-up for the industry as a whole. Where finer detail and/or supplementary information was required, recourse was made to the forestry row and column of the Central Statistical Office's Input-Output tables for the UK in 1984, (CSO, 1988).

Using these two data sources, it was possible to estimate the size and pattern of UK forestry's sales and purchases in 1984. A summary of the results is given in Table 2.

Table 2 UK forestry sales and purchases, 1984

UK Sector (SIC)	*Sales to* (£ million)	*Purchases from* (£ million)
Agriculture, forestry, fishing	68.2	68.7
Energy/water supply	0.0	20.7
Mineral extraction	0.0	3.5
Metal goods/engineering/vehicles	0.0	18.5
Other manufacturing	212.0	22.2
Construction	6.0	11.4
Distribution/hotels/catering	0.0	1.2
Transport/communication	0.3	18.9
Banking/insurance/finance	0.0	26.0
Other services	0.0	7.0
Sub total	286.5	198.1
Market sales	97.5	–
Wages	–	201.8
Other primary purchases	–	- 15.9
Totals	384.0	384.0

The value of forestry output in 1984 was £384.0 million. £286.5 million of this, or 74.6%, was sold as intermediate material to other UK industries, primarily timber processing sectors and forestry itself. The remaining £97.5 million was sold to final markets, including export markets. The largest single payment made by the forestry sector was wages and salaries paid to its own workers, which accounted for 52.6% of output value. Table 2 also shows that forestry purchased £198.1 million, 51.6% of output value, of goods and services from other UK sectors. It will be noted that there is a

negative figure of £15.9 million for other Primary Purchases made by forestry. This consists of two principal elements: (1) net subsidies paid to forestry and (2) apparent gross losses made by forestry. However, while subsidy payments were calculated from the survey data, the gross profit/loss figure was calculated as a residual balancing item, and hence is less reliable.

As indicated previously, forestry's observed interactions with other UK sectors have economy-wide ramifications on UK activity through 'knock-on', or 'multiplier' effects. Three separable, though interactive, elements of the total multiplier impact are generally recognised:

1. Inter-industry backward linkage effects. The demand by forestry for goods and services of other sectors stimulates production in these sectors, for instance in engineering and vehicle manufacture, in fuel and fertiliser production. To produce the additional output, these industries make operating purchases from their suppliers . . . and so on. The cumulative increment in economic activity attributable to these inter-industry purchases is known as the 'inter-industry backward linkage effect'.

2. Inter-industry forward linkage effects. The availability of domestic forestry output (i.e. raw timber) may stimulate activity in timber processing sectors. Similarly, the availability of domestic processed timber may generate additional activity in industries further along the timber-using chain. The total of any activity created in user sectors attributable to the availability of domestic forestry output is known as the 'inter-industry forward linkage effect'.

3. Household income/consumption effects. Forestry pays its labour force income in the form of wages and salaries and self-employment income. Forestry workers spend part of this income on consumer goods and services, creating income for the workers in these latter sectors, who in turn purchase goods and services . . . and so on. The total impact on economic activity through these income/expenditure interactions is known as the 'household income/consumption effect'.

In practice, to a greater or lesser extent, all the multiplier processes described in 1-3 above operate simultaneously in an inter-related manner. The total UK economic activity generated by forestry in this way (excluding the activity of forestry itself) is forestry's secondary impact.

Subject to the limitations of its simplifying assumptions, a suitable vehicle for quantifying forestry's multiplier effects is an appropriate input-output model. To a greater extent than alternative impact methodologies, an input-output model explicitly identifies and quantifies inter-industry linkage effects*. For the present study, it was possible to derive a suitable model from the aforementioned 1984 UK Input-Output Tables (CSO, 1989). These tables provide, for 1984, a detailed and comprehensive

*For a non-technical introduction to input-output analysis, see: Miernyk, 1965.

record of the sales and purchases made by 102 separately identified sectors. In developing the model for the forestry impact study, two modifications were made to the basic input-output tables as prepared by the CSO:

1. Using the survey data collected by Mutch (1989), the forestry sector's individual sales and purchases were separated from the combined forestry/fishing accounts presented in the original tables. In addition to forestry data, the Edinburgh University study also collected original information on timber processing sectors. As the outcome of intensive sector-specific surveys, the Edinburgh data were evaluated as being more accurate than the CSO original (whose resources were distributed over the table as a whole) and, hence, was substituted as appropriate. Given the accounting identities underlying input-output accounts, some re-balancing of the tables was required, which, given the relatively small adjustments needed, was undertaken manually.

2. In impact analysis, where the emphasis is on incremental activity changes, it is necessary to recognise that there is, in general, a 'trade off' between labour income and other sources of household income. Thus, an increase in labour income implies the hiring of more workers and/or paying existing workers higher wages. Both effects will, on average, lead to reductions in transfer income, such as unemployment payments and social security benefits. Thus, the household sales and purchases entries in the input-output tables were adjusted to reflect incremental rather than average income changes. In practice, this is a relatively conservative adjustment, in that it will tend to reduce the measured impact of forestry.

The 'hybrid' 1984 UK input-output table provided the model framework for assessing the impact of forestry on the economy in that year. However, in order to implement the model, it was also necessary to address the issue of which of forestry's purchases and sales transactions would, in fact, initiate the multiplier processes described previously.

The question of forestry's backward linkages (i.e. purchase-induced) and household income effects is relatively uncontroversial: in the absence of strong capacity constraints, which there is little reason to believe occurred in the UK in 1984, the 'backward linkage' and 'household income/consumption' multiplier effects can be taken to be fully applicable, as described above.

The crucial issue concerns the identification of forestry's forward linkage effects (i.e. multiplier process (2 above). As shown in Table 2, the fact that UK forestry sells part of its output to UK timber-using sectors is not in question. The important point is the extent to which these timber-using industries could sustain their existing levels of activity in the absence of domestic forestry raw materials supply; in particular, if imported raw wood could, economically and technically, be readily substituted for domestic sources, then the 'forward linkage' impact of UK forestry would be, effectively, zero.

Thus, forestry's forward-linkage impact revolves around the concept of critical supply dependency i.e. which elements of UK timber-using (or, more broadly, timber-servicing) activities would not exist, for economic or technical reasons, in the absence of a domestic forestry raw material supply?

The importance of this point has been recognised before, most notably in the Treasury report mentioned above (HM Treasury, 1972).

Unfortunately, having raised the issue, the Treasury report did not pursue it, and proceeded to treat forestry on a 'stand alone' basis (i.e. in the phraseology of this chapter, it considered only the direct effects). Given that the whole issue of forward linkage effects is controversial, the present study adopted a conservative approach. In particular, it was assumed that only the following sectors could be critically-supply dependent:

1. timber processing;

2. paper, pulp and board.

Thus, for example, while it was true that haulage companies transported domestically-produced timber and products, it is assumed that they would have transported imported equivalents without detriment to their own activities.

Having thus narrowed the number of sectors which could have been critically supply dependent on domestic forestry to two, the central issue is to determine to what extent, if any, timber processing and paper/pulp/board were critically supply dependent on UK forestry output in 1984. Three sources were drawn on to try to assess this: usage of domestic versus imported wood by these two sectors as shown by the UK 1984 Input-Output tables, the Edinburgh University survey of forestry and timber industries, and discussions with timber industry experts.

Given the conceptual and practical difficulties in measuring critical-supply dependency, it is perhaps unsurprising that the initial range of estimates obtained was wide: 10-58% of the output of the timber processing sector and 2-54% of the output of the paper, pulp and board industry. After further research and discussion, it was felt that for the present study it was appropriate to assume that 21.6% of the value of total output of the timber processing sector and 2.0% of the value of output of the paper, pulp and board industry were critically supply dependent on UK forestry output in 1984. It is worth noting that all the industry experts consulted felt that the chosen percentages were conservative, which will in turn lead to a conservative estimate of forestry impact. Also, of course, it cannot be assumed that these percentages remain unchanged over time; indeed, the reverse is likely to be true. However, whatever the period under consideration, the principle of identifying 'critical', as opposed to 'actual', supply dependency remains of prime importance in correctly specifying the forestry impact scenario.

Thus the input-output model was used to assess the impact of the following levels of activity on the UK economy; 100% of forestry output (£383.4 million) plus 21.6% of timber processing output (£599.0 million) plus 2% of paper/pulp/board output (£39.1 million). The results of the impact analysis are shown in Table 3.

Table 3 Forestry impact on the UK economy in 1984 with critical-supply dependency sector

	Forestry impact on:	
	Output (£m) (1984 prices)	*Employment* (FTEs)
Agriculture, forestry, fishing	408.2	11.84
Energy/water supply	137.5	1.38
Mineral extraction	63.1	1.26
Metal goods/engineering/vehicles	104.5	3.66
Other manufacturing	798.1	20.75
Construction	28.2	0.68
Distribution/hotels/catering	113.9	5.47
Transport/communication	114.8	4.36
Banking/insurance/finance	161.0	4.67
Other services	25.1	1.46
Totals	1954.4	55.53

Given the assumptions made, it is estimated that, in 1984, domestic forestry activity generated over £1.95 billion of industrial output in the UK and 55530 full-time equivalent (FTE) jobs. The importance of the contribution made by the critically-supply dependent linkage effects is highlighted by the fact that, taken in isolation, forestry's own backward linkages generated only £839 million of output and 24600 FTE jobs.

Sectorally, the largest single output and employment impacts were in Other manufacturing, which includes timber processing and paper, pulp and board. The impact on Agriculture/forestry/fishing, which of course, includes forestry itself, was also substantial. However, it is also worth noting that 21.2% of output impact and 28.7% of employment impact were in the combined service sectors. Forestry's generation of activity in these sectors is, to a significant degree, attributable to the household income/consumption multiplier process.

Appropriate forestry impact 'multipliers' in the present study are defined to be the total effect on UK output/employment divided by the level of output/employment in the forestry industry itself. On this basis, the values of 1984 UK forestry 'multipliers' are shown in Table 4.

Table 4 UK forestry 'multipliers': 1984

Scenario	*Output multiplier*	*Employment multiplier*
1. Forestry alone (no critical supply dependency)	2.19	2.09
2. Forestry with critical supply dependency	5.10	4.71

These multiplier values confirm that, through 'knock-on' effects, the total contribution of forestry to the UK economy was significantly greater than the direct levels of activity in forestry itself. Furthermore, the significant differences between 'scenario 1' and 'scenario 2' multiplier values reinforce the point that the more critically dependent domestic timber users are on domestic timber supplies, the greater the impact of UK forestry on the UK economy as a whole.

In assessing and using the multiplier values of Table 4, two points of interpretation must be borne in mind: firstly, the multipliers in the present study cannot be directly compared to conventional input-output industry multipliers, which relate economy-wide impact to sectoral final output (as opposed to total sectoral output). Such conventional multipliers, which ignore forward linkage effects and associated issues relating to import substitution and critical supply-dependency, are more appropriate for sectors whose outputs are not used as potentially essential raw material inputs by purchasing industries.

Secondly, the multiplier values of Table 4 relate to the impact of the UK forestry industry as a whole at the state of maturity pertaining in 1984. Hence, they cannot be used to assess the marginal impact of a change in some specific aspect of forestry, such as planting or harvesting.

Again, as noted on page 14, both the absolute magnitudes of forestry impacts, and the resultant multiplier values, can be expected to change as the industry itself and its relationships with other domestic sectors evolve. The important point is that the secondary effects arising from forestry's linkages with the rest of the economy should be estimated in any 'snapshot' evaluation of its contribution to aggregate economic activity.

The study also attempted to 'distribute' the measured impact of forestry on the UK as a whole on its individual member countries. To do this, 'quasi' regional input-output models were derived for England, Scotland, Wales and Northern Ireland using a technique originally devised in the United States*.

The results of this exercise, in terms of distributing the output impacts of Table 3, is shown in Table 5.

Table 5 Distribution of 1984 UK forestry impact among member countries (£m output at 1984 prices)

Sector	*England*	*Scotland*	*Wales*	*N. Ireland*
Agriculture, forestry, fishing	207.2	137.0	43.3	20.8
Energy/water supply	90.2	31.3	13.8	2.2
Mineral extraction	54.1	4.0	4.5	0.5
Metal goods/engineering/vehicles	95.6	5.2	2.9	0.8
Other manufacturing	656.1	84.3	34.8	23.0
Construction	17.1	7.6	2.4	1.1
Distribution/hotels/catering	87.4	16.9	6.6	3.1
Transport/communication	94.6	13.4	4.8	2.0
Banking/insurance/finance	127.9	21.3	7.9	3.9
Other services	16.9	5.4	1.9	0.9
Totals (UK = £1954.4m)	1447.0	326.3	122.8	58.3

*For details of the specific implementation of this model in the recent study, see: McGregor, P. and McNicoll, I. (1989) The Impact of Forestry on Output and Employment in the UK and its Member Countries, Final Report to Scottish Forestry Trust, pgs 24-27 and 31-40.

The impact on each country's Agriculture/forestry/fishing sector, not surprisingly, broadly follows the location of forestry output itself i.e. England (50.6%); Scotland (33.7%); Wales (10.6%); and Northern Ireland (5.1%). However, the total output generated by forestry is more markedly biased in favour of England: England (74.0%); Scotland (16.7%); Wales (6.3%); and Northern Ireland (3.0%).

This latter result is attributable both to England's absolute size (in economic terms) being much greater than any other member country and to the fact that it is more self-reliant in many sectors. For example, English manufacturing and service industries benefit from increased forestry activity in Scotland etc. as well as that in England itself, and do so more than Scottish industries. However, in order to test whether forestry's impact was more or less geographically distributed than average, the model was run with a 'balanced' change in UK output (i.e. equal output change in all sectors). For this balanced change in total UK output, the model indicates that each individual member country's share would be as follows: England (81.9%); Scotland (11.5%); Wales (4.5%); Northern Ireland (2.1%).

The ratio of forestry output percentage impact to a balanced UK output impact in each country is as follows for this simulation:

England	0.91
Scotland	1.45
Wales	1.40
Northern Ireland	1.56

In short, forestry's impact in 1984 was more geographically dispersed than 'average' since, it benefited England relatively (though not absolutely) less and the other member countries relatively more. Relative to the value of its own forestry output, the total output generated by forestry activity in each country was as follows:

UK	5.10
England	7.81
Scotland	2.39
Wales	2.91
Northern Ireland	2.99

The fact that England's 'multiplier'* is higher than the UK as a whole and vice versa for any other member country is simply a reflection of the fact that England 'gains' from forestry activity in these other countries by exporting to them more goods and services than she imports from them. This is not an attribute of forestry itself, but rather an aspect of the general interrelationships among UK member countries. Thus, forestry itself was widely distributed throughout the UK, but the industries supplying its inputs

*These are not conventional multipliers (even allowing for forward linkage effects) which measure the total impact in a country of activity within that country e.g. the impact on Scotland of Scottish forestry. The ratio given in the text relate to the impact of UK forestry in Scotland relative to Scottish forestry.

and purchasing its outputs were relatively concentrated in England. The spatial pattern of impact could change over time depending on the location of firms which buy from, or sell to, the forestry sector.

CONCLUSIONS

This study does not attempt to justify afforestation in the UK by discounting possible future benefits which may accrue when new plantations mature next century for comparison with afforestation costs. Instead it explores the economic impact of forestry activity in 1984 by using a UK input-output model. It accepts the Treasury's (1972) contention that, given the inability of the UK wood-processing industries to replace their replace their roundwood supply through international trade and for the firms thereby to survive, forestry and timber processing should be regarded as a single industry.

In view of the significant 'critical dependencies' in the joint industry, the absence of UK forestry as the wood supply would impose binding constraints on many wood processors and would reduce UK total output; these critical dependencies in 1984 are conservatively estimated to have been just over 20% of the solid timber processing and 2% of paper, pulp and board industries' outputs.

On these terms, the suppression of forestry, which in 1984 had a basic output value of £384 million, would have reduced total gross output by £1.95 billion, implying a total output multiplier of 5.03. Thus for each £1 of UK forestry output, total UK output benefited by £5.08. This large multiplier is not surprising, being a consequence of the processing sectors' critical supply-dependence on domestically grown wood to the modest percentages given above, if the fractions of the outputs of timber processing etc. are added to the denominator, the total effective multiplier would be just under 2.0, which is reasonable and supports the high figure given).

The absence of forestry would also impose a heavy cost in the contraction of employment, there being an employment multiplier as defined of approximately 4.7.

These results refer to forestry and its dependent industrial activity as they were in 1984. As the allowable cut of wood from the UK forests increases with improved maturity and age-class distribution, so will the size of the sector's total output value increase and its relative importance in the UK total output. Indeed, as noted at various places in the text, it would generally be inappropriate to apply any of the specific numerical results from the 1984 case study to other periods and/or circumstances. The most important point is that the secondary impact of forestry on the UK economy is quantitatively both measurable and potentially substantial.

A striking feature of the results was the concentration of economic impact in England, despite the greater forestry activity in Scotland and Wales, relative to their area. Many of the indirect and induced effects of forestry occurred in industries which exist exclusively or principally in England; not only do English firms supply machines and services for forestry in the other counties, but there was a substantial 'export' of wood from Scotland in 1984 for processing in the South. Nevertheless the shares of total forestry-related

economic impact among the UK countries (England 74%, Scotland 17%, Wales 6%, Northern Ireland 3%) were more equable than the distribution of aggregate economic activity, the direct impact of forestry alone falls mostly where the forests exist but in addition there is some distribution of the indirect effect.

Forestry has a significant impact on the UK economy as a whole. That impact would be significant even if the processing industries and consumers of wood could turn completely to imported substitutes, a strategy which we believe to be quite impossible. The impact is much greater if users are critically supply-dependent on the wood grown in the UK, as we believe they are. Moreover forestry has the effect of increasing the geographical dispersal of economic benefit across the countries of the UK through industrial linkages, in spite of the inter-country transfer of unprocessed roundwood.

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'FORESTRY EXPANSION: A STUDY OF TECHNICAL, ECONOMIC AND ECOLOGICAL FACTORS'

This is one of a series of papers which form part of a study to consider the scale, location and nature of forestry expansion in Britain.

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Published by the Forestry Commission on 19th July, 1991.

The full list of papers is as follows:

Occasional Paper No	Title	Author
33	Introduction	Professor Ian Cunningham, Macaulay Land Use Research Institute
34	British Forestry in 1990	Hugh Miller, University of Aberdeen
35	International Environmental Impacts: Acid Rain and the Greenhouse Effect	Melvyn Cannell and John Cape, Institute of Terrestrial Ecology
36	The Long Term Global Demand for and Supply of Wood	Mike Arnold, Oxford Forestry Institute
37	UK Demand for and Supply of Wood and Wood Products	Adrian Whiteman, Forestry Commission
38	Development of the British Wood Processing Industries	Iain McNicoll and Peter McGregor, University of Strathclyde and Bill Mutch, Consultant
39	The Demand for Forests for Recreation	John Benson and Ken Willis, University of Newcastle
40	Forests as Wildlife Habitat	John Good, Ian Newton, John Miles, Rob Marrs and John Nicholas Greatorex-Davies, Institute of Terrestrial Ecology
41	Forestry and the Conservation and Enhancement of Landscape	Duncan Campbell and Roddie Fairley, Countryside Commission for Scotland
42	The Impacts on Water Quality and Quantity	Mike Hornung and John Adamson, Institute of Terrestrial Ecology
43	Sporting Recreational Use of Land	James McGilvray and Roger Perman, University of Strathclyde
44	The Agricultural Demand for Land: Its Availability and Cost for Forestry	David Harvey, University of Newcastle
45	Forestry in the Rural Economy	John Strak and Chris Mackel, Consultants
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