STRATEGIC PLANNING OF THE FOREST SECTOR: SUMMARY REPORT OF A NORDIC MEETING

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FOREWORD

The objective of the Forest Sector Project at IIASA is to study long-term development alternatives for the forest sector on a global basis. The emphasis in the Project is on issues of major relevance to industrial and governmental policy makers in different regions of the world who are responsible for forestry policy, forest industrial strategy, and related trade policies.

The key elements of structural change in the forest industry are related to a variety of issues concerning demand, supply, and international trade of wood products. Such issues include the development of the global economy and population, new wood products and substitution for wood products, future supply of roundwood and alternative fiber sources, technology development for forestry and industry, pollution regulations, cost competitiveness, tariffs and non-tariff trade barriers, etc. The aim of the Project is to analyze the consequences of future expectations and assumptions concerning such substantive issues.

The research program of the Project includes an aggregated analysis of long-term development of international trade in wood products, and thereby analysis of the development of wood resources, forest industrial production and demand in different world regions. The other main research activity is a detailed analysis of the forest sector in individual countries. Research on these mutually supporting topics is carried out simultaneously in collaboration between IIASA and the collaborating institutions of the Project.

This paper summarizes problems and issues confronting the forest sector of Nordic countries which were presented and discussed at the **Nordic Meeting for Strategic Planning of the Forest Sector** held in

Jyväskylä, Finland, 8-12 March 1982. The importance of forest sector modeling, in particular, the Forest Sector Project, for clarifying and proposing possible solutions to these problems is emphasized.

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ABSTRACT

Strategic planning of the forest sector in Nordic countries focuses on the major long-term problems and issues which are or will be confronting forestry and the forest industry. In this paper these problems and issues are described. Examples of strategic planning and the use of models and computers in the forest industry are given. It can be concluded that current forest sector modeling is of major importance for strategic planning of the forest industry in Nordic countries.

PREFACE

As part of the research program of the Forest Sector Project of the International Institute for Applied Systems Analysis (IIASA) there has been a series of regional meetings held for decision-makers, planners and scientists working in the forest sector. The third regional meeting, the *Nordic Meeting for Strategic Planning of the Forest Sector* was held in Jyväskylä, Finland, 8-12 March 1982.

The purpose of this meeting was to bring together Nordic specialists in the strategic planning of the forest sector, whether they work at a company, regional, national or global level. Altogether there were 34 participants from Finland, Sweden, Norway, the US, Canada, and from IIASA. The participants are listed in Appendix B of this report.

The 22 presentations which are listed in Appendix A were given by representatives of industry, governments, and associations, as well as by scientists. The topics covered the major strategic problems and issues of the forest sector in Nordic countries, the current efforts of planners to deal with these problems, the efforts of scientists to provide tools for studying and dealing with these issues, and the North American commitment to the Forest Sector Project of IIASA.

This report provides a brief summary of the meeting. Because the readers of this report should include not only planners and scientists but also decision makers interested in the strategic planning of the forest sector, all technical details were deleted. For more information the interested reader is referred to the individual speakers.

All the participants at the meeting contributed to this report by writing summaries of their talks and by making other documents available. Although our report is largely based on this material in general, we do not

refer to individual papers in the text. We hope to have covered accurately all the major points of discussion and wish to thank each participant for making this meeting such a fruitful one.

The Authors

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1. INTRODUCTION

1.1 The Forest Sector

The forest sector comprises two main components: forestry and the forest industry. The forest sector has some specific features which affect its planning and decision making. First, the growth period of trees from seeds to mature trees is very long, in Nordic countries from 60-120 years. This results in poor flexibility as changes in the structure of forests cannot take place very quickly. Second, the growing stock of trees is at the same time both a product and a production machinery which gives flexibility in choosing the exact time for the realization of production.

Also the industrial side of the forest sector has some specific features. First, the forest industry is a processing industry which means that it is usually very capital intensive. Furthermore, the economic lifetime of an investment is long for industry as well, e.g. for pulp and paper machinery at least 20 years, in some cases even more than 50 years. Second, the production technology of the forest industry is based on old and well-known principles. Therefore, productivity is tightly connected to the age structure of production capacity and the mill size.

Wood is one of the most versatile raw materials. This gives flexibility in its use. On the other hand, the life cycle of most forest products has been very long. New products are rarely put on the market. Therefore, it is not the product that attracts the consumer but rather its price. This means that price has become a main factor in market competition. It has led to a low profitability worldwide, and the traditional forest industry

is often characterized as a "mature industry."

1.2 Strategic Planning

Strategic planning is the planning of those activities which have long-range consequences. Though short-term management decisions are necessary, the long range strategic planning aspects are crucial for the forest industry.

In recent years, strategic planning has become increasingly important because of the diminishing growth of the markets. In a rapidly expanding market the timing of entering new capacity was not that important. Today, however, cyclical fluctuations connected to increased investment costs have serious consequences for companies. Investing in a new pulp mill for example, means an outlay of more than 300 million US dollars. With a return on investment delayed for two years for market reasons the financial burden may prove fatal for the company involved.

In the forest industry, strategic planning usually takes place at company level. Apart from this, in Nordic countries, there are also other possibilities. One of them is based on cooperation between companies. This has become important as decisions made in one company increasingly affect other companies in the same line of production. By combining the efforts of the forest industry as a whole, some major problems concerning, e.g., technological development and wood supply, would be eased.

Planning systems differ, for example, in terms of the implemental concepts, the actual planning process, and the time-span or planning period. However, some common basic elements exist. In the forest industry these include:

- markets
- products
- raw materials (wood and chemicals)
- energy
- technology
- productivity
- inventions and innovations
- human resources (management, workers)
- financial resources
- societal constraints and social responsibility (protection of the environment, employment, etc.)

An example of the problems and planning areas in the Nordic forest industry is the Södra Skogsägarna group in Sweden. The corporation consists of Södra Skogsägarna Economic Association for wood trading and the company, Södra Skogsägarna AB, for wood processing. The members of the Association include over 40,000 private forest owners in southern Sweden. The turnover of the group is approximately half a billion US dollars. The most important fields of production for the company are sawn timber, pulp and paper. The production capacity is approximately 500,000 cubic meters of sawn timber, 900,000 tons of pulp, and 150,000

tons of paper of different qualities.

The president of the group and his staff are responsible for strategic planning. The objectives expressed in the paragraphs of the charter of the Association form the basis for all strategic planning. Four areas need special strategic action, namely: (1) wood supply, (2) industrial policies, (3) financing, and (4) membership development. Main objectives connected to these areas are the following:

(1) Wood supply
- increasing timber supply from members,
- increasing cooperation with other forest owner associations,

(2) Industrial policies
- shutdown of unprofitable units,
- streamlining the industrial structure,
- building integrated paper mills, and
- cooperation with other forest owner associations having industrial activities.

(3) Financing
- shutdown of unprofitable units,
- establishing joint companies,
- selling low yield assets,
- increasing capital contribution from members and owners.

(4) Membership development
- improving solidarity from members,
- recruiting new forest owners as members.

This example briefly summarizes the complexity of issues confronting some companies in Nordic countries and points out that the problems and issues facing the industry are interlinking, and all major issues should be considered simultaneously when making decisions in the forest sector.

In the following section these problems and issues will be looked at one by one. Comparisons will be made between Nordic countries; although all share the same problems, the relative importance of an issue varies from one country to another.

2. PROBLEMS AND ISSUES FACING THE NORDIC FOREST SECTOR

2.1 The Wood Market and Forest Ownership

The growing stock in the Nordic forests (Denmark, Finland, Norway and Sweden) has increased from 4,000 million m^3 (over bark) to 4,700 million m^3 in 1950-1980 and it will increase in the future at least during this century. Only in Finland was the stock decreased during the 1960s, but at the moment it is increasing rather rapidly because of forest improvements and savings in cutting made in the 1970s. Proportionally, the

increase was greatest in Sweden up to 1970.

The estimate of gross increment per annum in Nordic countries has increased from 150 m^3 to 167 million m^3 in 1950-1980. The estimate of annual drain was only 115 million m^3 in 1950. It reached its highest value to date, 148 million m^3, in 1970, went down to 127 million m^3 in 1975 and was 143 million m^3 in 1980. The gap between the increment and drain is expected to enlarge which means that the forest will be in the stage of underproduction in the future.

At the end of the agrarian period the forests were over-utilized. Since then the amount and age of the growing stock have increased. Industrialized welfare societies seem to be doomed to conditions where the forest resources are only partly utilized.

From the point of view of developing the forest industries, there is a proportional shortage of pine, especially of pine sawlogs, and an abundance of spruce, especially of spruce sawlogs, and low quality birch. In Finland, in order to satisfy the need of pine pulpwood in the future, the greatest problem will be to thin the new young tree-stands which cover 5-6 million ha of the total area of 19 million ha of forest land.

The availability of sufficient wood supply has been an area of growing concern for the forest industry in Nordic countries. One baffling issue is the forest owner's behavior and whether by raising prices, the availability of wood raw material will increase.

If the forest owners would cut on a sustained yield basis, the domestic supply of pulpwood would match the total demand of industry. In spite of a high price for pulpwood and many mechanisms to stimulate an increase in the annual cut, it has not so far been possible to reach a wood supply corresponding to a sustained yield. The main reasons could be the small-scale of the forests, the agricultural policy which has reduced the need for farmers to use their forest land, forest taxation, the high cost of cutting and transportation in remote forest areas, and in Norway, the steep terrain.

The Norwegian pulp and paper industry has imported pulpwood for many years, since the domestic supply has not matched the needs of industry. Under normal market conditions for the industry and with the present level of domestic supply, 1- 1.3 million m^3 of pulpwood should be imported annually to help meet a total demand of 6 - 6.5 million m^3.

Though the wood supply does fluctuate with prices for wood raw material in Norway as it does elsewhere, the effect of a rise in price even in a short-term is small. Therefore, in Norway the pulp and paper industry cannot use the price of wood as the main tool to increase the supply of pulpwood.

From the end of the second world war until the beginning of the 1970s the Swedish forest industry has expanded rapidly. The consequence was that the available wood raw material source was insufficient for the industrial capacity since the 1970s. Therefore, the rate of expansion must be moderated. Companies with low profits will have to close down. This is in line with the market mechanisms. However, in the case of a pulpmill which is the main source of employment in a given area it will be difficult for former employees to find new job opportunities. Part

of the population will have to move and shops will close. The commercial and industrial life will be weakened and public services will be reduced. After taking all these issues into account, it may not be possible to close down an unprofitable mill.

Another problem related to the insufficient wood raw material base is that it is more difficult for the Swedish and other Nordic forest industry to utilize the increasing scale of economies compared with the situation for the overseas competitors. (In the beginning this disadvantage can at least be partially offset by creating bigger units by putting the old ones together.) The labor productivity will increase more slowly. As a consequence, the processing costs will be higher and the profit lower than for the competitors. The financial base for the expansion of the forest industry will disappear.

After the boom of 1973-1974 the forest industrial production and the consumption of wood decreased. When the forest industry again increased its production and wood consumption in 1979, the harvesting of non-industrial estates did not increase at the same rate. Many observers explain this by the non-industrial ownership structure. The high marginal taxes and inflation mean that those forest owners who are not dependent on the forest for income or employment have less incentive to cut. Even if the biological increment is decreasing due to this, existing alternative capital investment is less attractive.

Also in Finland certain trends in the sales behavior of private non-industrial forest owners suggest that the forest industries will have to rely on the domestic raw material supply at a much lower rate than the allowable cut. For the industry the situation in Finland is very bad because about 80% of the cutting possibilities are in private non-industrial forests

A special feature which affects the wood market in Finland is the acceleration of the magnitude of cyclical fluctuations. A change in the demand for forest products creates increasing fluctuations in the industrial production. The fluctuation in wood supply is greater than in the industrial use of wood and the amplitude is biggest in wood prices. This phenomenon causes severe disturbances to the whole economy of Finland.

The cost of wood raw material is one of the most important cost factors of the forest forestry. Therefore, it is very important that the structure of the available cut of the forests is taken into account when the structure of the production capacity is being planned. For example, in the Finnish company Enso-Gutzeit there has been a strong development of the pulp and paper industry, whereas the development of the capacity of sawmilling has been slow compared to the structure of the forests. By adding to the capacity of sawmilling, wood in the form of chips will be available for the pulpmills, ensuring one part of the flow of raw material to the pulp mills. Therefore, when planning the production capacity of the company, it is very important to find an economical and profitable way of increasing the capacity of sawmills to reach a level which fits the structure of the forests.

2.2 Energy Costs

Energy accounts on average for more than 10% of the price of Nordic forest industry products exported to Western Europe. As the relative energy consumption in the forest industry will increase, the price of energy will be one of the most crucial issues facing the industry. Electricity is about twice as expensive in Nordic countries as in Canada, but clearly cheaper than in Western Europe. The price of oil in Scandinavia is on the European level, but considerably higher than in North America.

Although the energy problem is faced by all Nordic countries, it is particularly acute in Finland. As a nation, Finland simply has less hydroelectric power and is therefore more dependent on the world market for cheap energy sources. On the other hand, the Finnish forest industry is a world leader in using back-pressure power and process wastes, but the competitors are gradually catching up.

2.3 Profitability

Although the worldwide profitability of the forest industry is decreasing, the performance of different companies and countries is not the same. On average, the profitability of the Nordic forest industry has been lower and it has fluctuated more than in North America. In recent years, however, the difference has smoothened substantially. In the years 1975-1981 the average gross profit margin of the forest industry was in Sweden 11.7%, in Finland 12.9%, in Canada 13.6%, and in the USA 14.0% of sales. A minimum requirement in order to guarantee the continuity of business is considered to be 20%.

When evaluating the profitability of companies, there are three levels:

1) the net-profit level
2) the rate of return on capital
3) the gross rate of return on total capital

In Finland and Sweden, the ratios 2 and 3 were about the same from 1974-1980. In place thereof, the level of net profit was much higher in Sweden than in Finland due to the heavy leverage of Finnish companies.

When applying a profitability and financial model at firm level in Finland, Sweden, and the US, researchers at the School of Business Studies of the University of Vaasa in Finland concluded that:

1) every country has its own institutional settings which determine the national pattern of the growth-profitability behavior of corporations,
2) growth, profitability, and level of capital expenditures cannot be planned independently of each other,
3) Only the details of financial planning should be optimized for shorter periods.

2.4 Investments and the Capital Market

The forest industry is very capital-intensive. The capital cost of a new mill does not vary considerably from one country to another. In place thereof, there are significant differences in the self-financing ability, especially as compared to investments. Despite its poor self-financing ability, the Nordic forest industry has made new and replacement investments to improve its product range and to keep its production machinery technically competitive. As capital costs have risen rapidly, investment expenditure has risen faster than internally generated funding. This has increased the indebtedness. In other words, the financial position of the forest industry has deteriorated significantly. This makes it even more difficult to adapt to changes in the competitive environment and markets.

Low-interest loans which have been easily available partly explain the high indebtedness of the forest industry in Nordic countries, especially in Finland. Since the early 1970s the inflation rate has been higher than the interest rate. Thus it has been profitable to operate with external capital. This mechanism works as long as the growth rate is continuously high enough. Unfortunately, it looks as if the era of fast growth in the traditional forest industry is over.

2.5 Technological Development

Innovations in the forest industry have usually only meant improvements in existing technology and products. Completely new processes and new products have come on the market very rarely.

The slow technological development has at least partly caused the low profitability of the forest industry. Therefore, the development of new products and new methods of processing are of great importance to the future of the forest industry, especially in Nordic countries which cannot compete with countries having cheap and abundant raw materials and possibilities to utilize economies of scale.

Traditionally, the forest industry has not invested very much in research and development. In Finland, for example, the relative R&D expenditures in the forest industry have decreased in recent years. In 1971 the share of R&D of the value added was 2.4% in paper products and 1.6% in all industrial products. In 1981, the figure for paper products had decreased to 1.4%, but increased for all industrial products to 2.0%. The corresponding figure for wood products (sawn wood, panels, etc.) was only 0.4% in 1981.

In the forest industry, the lags between the development of new products and processes and their actual implementation on a broad scale are large. Therefore, strategic planning should take technological developments seriously into account. It can be concluded that more resources must be invested in R&D activities. This a question of life and death to the forest industry in Nordic countries.

2.6 The Role of the Government

Since the forest industry in Nordic countries depends heavily on the international market, governments have a major influence on the industry when delineating a foreign trade policy. For example, by specifying a liberal foreign trade policy and special tariff agreements with EFTA, the Soviet Union, the EEC and the smaller members of the CMEA of COMECON, the Finnish government has been able to support its forest sector. It is of vital importance that the worldwide trend toward liberalization of trade continues. This will require implementation of trade policies by the government.

The government can affect the forest sector in other ways as well, e.g., participating in the regulation of the markets of factors of production such as labor, capital, wood, and energy. For the labor force, the government can intervene by establishing general income policies and helping to settle major disputes between employers and employees.

In the capital market, state-regulated banks such as those in Finland have charged relatively low interest rates on credits in the forest industry. This partly compensates for the sales-tax which aggravates investment activities in Finland.

The availability of wood at moderate prices for the industry seems uncertain. In Finland it would be difficult for the government to impose some sort of compulsion on the forest owner to sell timber to the industry. However, the government can search for alternatives such as changes in forest taxation and subsidies.

As for the great need of energy in the forest sector the government can look at ways of supplying energy at competitive prices.

Another important role the government can play in the development of the forest industry is providing training and supporting research. In Nordic countries the governments arrange the basic training at all levels and also maintain universities and research institutes.

Finally, the government can actually own parts of forest industry companies. This is of particular importance in Sweden and Finland. In Finland there are two large forest industry companies where the government is the major shareholder: Enso-Gutzeit and Veitsiluoto.

In Sweden, by buying the majority of shares of non-profitable or bankrupt forest companies, the government has not only provided direct support for the company, but also reduced unemployment. This has recently happened in Finland as well.

2.7 End Product Markets

The Nordic countries are favorably situated in relation to their markets. They are very close to the EEC, the world's biggest net importing region of forest products. And the Nordic countries really dominate the EEC's import markets. In coniferous sawnwood their share is 40%, in pulp 45% and in paper and paperboard 50% of the EEC's imports.

For the Nordic countries development and fluctuations of demand and the role of North American producers will be the key factors in the market competition during the remaining years of this century. The

demand for forest products has depended mainly on economic and population growth. The large variance in consumption patterns between different countries causes, however, considerable prediction problems. The consumption of paper has, for instance, been more than twice as large in the USA as compared to Switzerland at a time when the two countries have had approximately the same standard of living.

The demand for forest products depends also on supply and price trends for competing materials. Plastics reduce the demand for packaging papers, but increase the demand for composite materials and packages. New packaging and transport systems have reduced the demand for sack paper in the industrialized countries. However, because of their strength and good workability, wood products will retain their position as construction material.

Electronics and electronic information technologies reduce the demand for newsprint and magazine paper, but surprisingly the growing use of electronic business machines has increased the demand for business papers. It is worth remembering that technological changes affect the demand for forest products noticeably more intensely and earlier in some countries than in others.

2.8 Employment and Regional Development

The forest industry in the Nordic countries plays a very important role in maintaining the level of employment of specific regions.

Rural settlement pattern is one factor influencing the location of forest industries. Finland represents an excellent example of forest sector communities whose fates are tightly interconnected with the rise, expansion, and decline of forestry and forest industry. Since the 19th century, the overwhelming forest-industrialization promoted Finland's societal integration without destroying the traditional agrarian system, making small-farming possible in the backwoods and the founding of many independent farms according to the demands of the propertyless rural people. Finnish society is deeply embedded in the rise and expansion of its forest sector, which has greatly promoted the fulfillment of basic needs. Capital intensive processing and logging have, however, created problems of employment. Nevertheless, the forest sector has promoted the stability and pattern of Finnish society.

3. USE OF MODELS AND COMPUTERS IN THE FOREST INDUSTRY: TWO NORDIC CASES

3.1 MoDo Company

The MoDo Group is a traditional Swedish forest industry company that has developed into an integrated international complex with a Swedish base. The Group consists of five units: Fine Paper, Consumer Products, Market Pulps including Wood Products and Prefabricated Houses, Forestry, and Hydroelectric Power. The annual turnover is close to 1 billion US dollars and 7,500 persons are employed of which 2,000 work outside Sweden.

Understanding the "environment" of the company is the first and most important step in strategic planning. The environment consists of

- market
- competitors
- raw material supply
- society

There are many different ways of increasing the understanding of the environment. Because of the complex relationships between the different factors involved computer models can be developed. As a tool for strategic planning the computer model has to be easy to understand and to use. Only then can the management develop the confidence needed to use the results of the model in the planning process.

With this in mind a project group at MoDo has, together with a research team from the Faculty of Forestry of the Swedish Agriculture University, developed a computer model, that is used as a tool for strategic planning for MoDo.

The tool is an interactive simulation model which is based on a formulation of the relationship between the forest products market, the Swedish and competing forest industrial production and the wood supply (Figure 1). The use of the forest as a source of fuelwood energy supply is also taken into account. Results typically span a 20 year period and include investment cycles and business cycles.

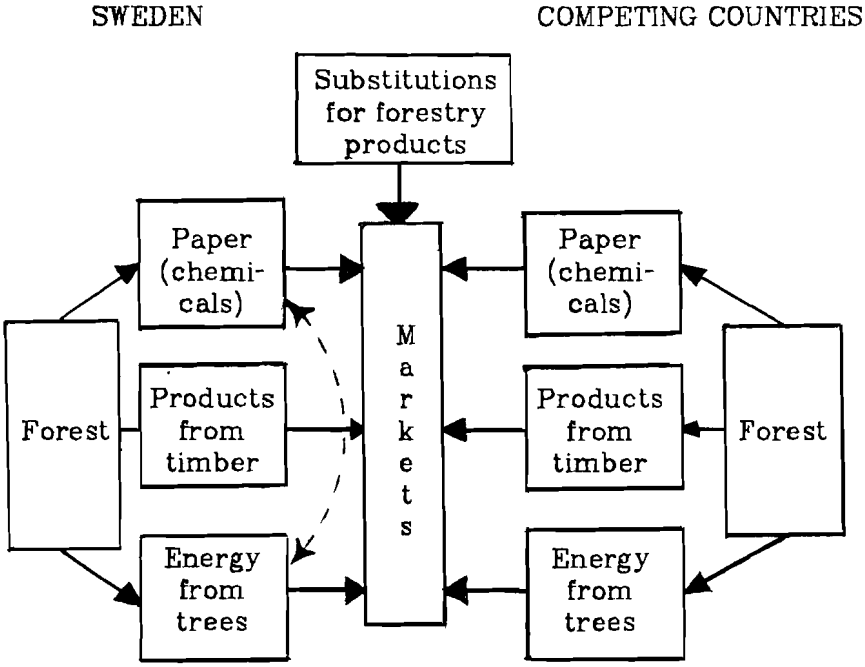

Figure 1. MoDo's strategic planning model.

The analysis of alternatives or specific strategic actions for the company to take is normally delegated to a task force group. The work of the group requires a specific company-oriented set of models. MoDo has developed a separate model of its mill structure in order to study different alternatives and is now developing a dynamic distribution model.

The company has earlier used a wood transportation model but will now develop a dynamic wood supply model of the same kind as the distribution model but inverted. The task force reports the results of these different models to the board which uses the information for strategic decisions.

3.2 Veitsiluoto Company

The utilization of computers in the forest industry has increased considerably in recent years. The 1960s were the period of big administrative computers and the 1970s the period of dedicated process computers. The 1980s will be the period of millwide computers used simultaneously in management, information and control. This has been made possible by the development of the computer technology, and, especially communications techniques.

In Veitsiluoto Company the utilization of computers has been rather extensive. The rising costs and as a result the reduced operating margins have forced the company to look for means of improving the efficiency of operations and using computers. The first computer was installed in 1965 and used for administration. During the 1970s altogether 26 computers were installed of which 17 were process computers for the control of paper machines, pulp processing and sawmilling. During recent years the number of millwide computers has increased rather quickly and today there are altogether nearly 40 computers which build a complicated network of process control, information and data handling.

The experience from Veitsiluoto Co. shows the importance of the implementation process for computers — this is especially important on the control level. Basically it is material for the users to look at the computer as a tool and not as a master.

4. NORDIC FOREST SECTOR MODELS

4.1 Background

Since the late 1950s, the modeling of separate parts of the forest sector has been increasingly popular. Timber growth models, harvesting simulation models, and land use models are examples of the numerous applications.

In place thereof, models covering the whole forest sector (forestry and the forest industry) either at national or regional level are not yet very common. Recent experience from some countries indicates, however, that these holistic models can be of major importance in policy analyses and other planning activities.

In the Scandinavian countries there are several forest sector models. Most of them are simulation models but also the linear programming method has been used. The oldest model and probably the first forest sector model in the world is the Society and Forestry model that was made for all the Scandinavian countries, i.e., Finland, Norway and Sweden. Partly building on this tradition a Finnish simulation model was developed and later on a Swedish model. Another Swedish model exists building on a linear programming model developed by the World Bank. The Finnish simulation model formed a basis for a new model using dynamic linear programming.

4.2 The Society and Forestry Project

Since the 1960s there has been an increasing awareness of the fact that the world's natural resources are finite. Consequently, alternative strategies to a continued materialistic expansion have attracted increasing attention. In some countries and in some industrial sectors, slow growth policies have already become a reality. The Scandinavian forestry sector represents an upcoming example: after a rapid increase in the consumption of wood by the forest products industry in the 1950s and 1960s, the annual harvest has now reached a fairly stable level. Thus, a transition from a period of rapid growth to one of modest growth has become necessary.

This situation formed the point of departure for a research project carried out between 1974 and 1978 by the Resource Policy Group in Oslo. The project, entitled "Society and Forestry," was financed by the Technical Research Councils in Norway and Sweden and was given the following terms of reference:

- To identify the problems arising from the constraints made by the limited wood resources on continued growth in the forest products industry.
- To elucidate the consequences of policies that were proposed in order to facilitate the transition from a period of rapid growth to one of modest growth in the industrial use of wood.
- To design a model for the simulation of conceivable development patterns in the Scandinavian forest sector during the next 30-50 years, for a number of different assumptions.

To meet these objectives, the Resource Policy Group undertook policy analyses with two interrelated components. First, they assembled reference panels composed of senior representatives of groups with stakes in the future of the forest sector (managers, land owners, employees, government policy-makers). These panels met to define the problems that the forest sector would be likely to face and to propose policies to mitigate those difficulties. In addition, the panel members played a vital role in determining the relationships to be analyzed and evaluated in the second component, the formal analysis. Because of this substantial contribution to the analysis, the panel participants were in a position to implement the conclusions they considered appropriate.

The conceptual framework and formal model system represent an instrument by means of which a variety of possible transition paths can quickly be generated. Each transition path (model simulation) provides a picture of one possible line of development in a transition from a period of rapid growth to one in which production volume will remain by and large constant.

Model simulations are no more than the logical consequences of a number of assumptions in respect of trends and causal relationships. The principal causal relationships are shown in Figure 2.

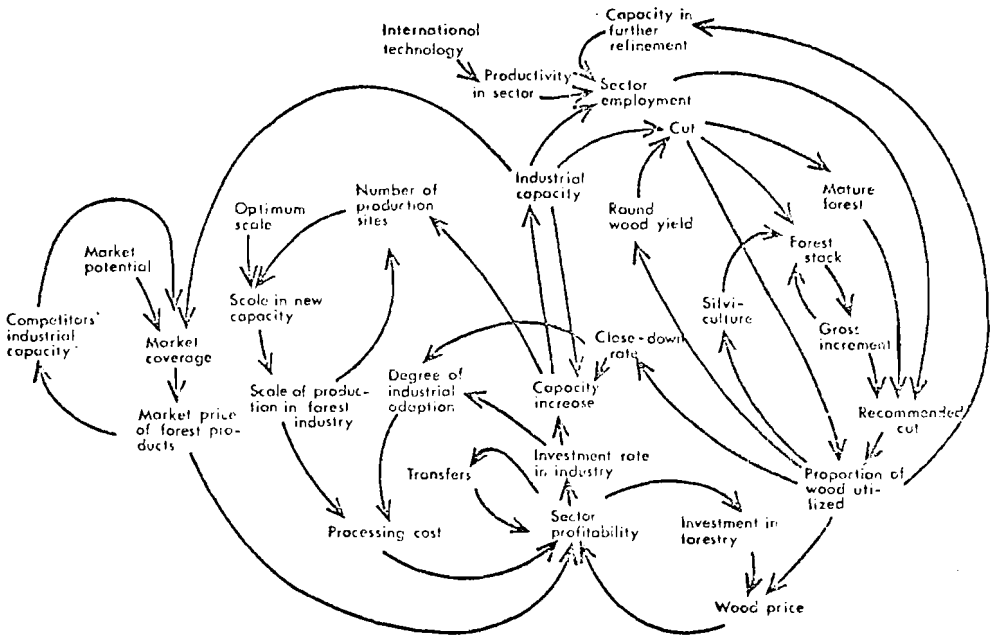

Figure 2. Major cause-and-effect relationships in the Society and Forest model.

It was concluded in the project that the transition for the Scandinavian forest sector from a period of rapid growth to one of modest growth will be accomplished by solving one or more of the following problems:

- A tendency towards increased wood prices.
- A tendency towards excessive cuts.
- A tendency towards over-expansion of the industrial capacity.
- A tendency towards reduced competitiveness owing to static production volume.
- A tendency towards lower employment in the sector.

- A tendency towards accelerated centralization.
- A tendency towards intensified conflict between the wood producers and the environmental and recreational interests.

4.3 Finnish Forest Sector Models

Because of the rapid expansion of the production capacity of the primary forest industries in Finland, the annual allowable cut was temporarily exceeded at the beginning of the 1960s. This led to increased investments in forestry to guarantee sustainable yields in the future. Concern over the optimal allocation of forestry inputs was the first step towards building a forest sector model.

It became evident, however, that it was not reasonable to concentrate on wood production in isolation from the forest industry. Therefore, a project to construct a policy analysis model for the whole forest sector was initiated in 1974. The aim of the project was to develop a tool for decision makers to study and evaluate the long-term consequences of different policy options. The study was completed in 1979.

The model, called MESSU, is built up of seven submodels (modules) shown in Figure 3.

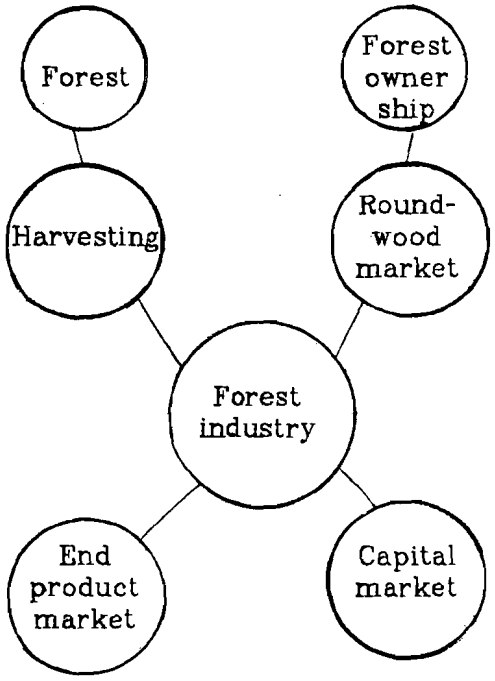

Figure 3. The general structure of a simulation model for the Finnish forest sector (MESSU).

A policy analysis model does not have very much value if it is not used. This might occur if the users have no trust in the model. An important precondition for this trust is that the users are familiar with the model structure. In practice this means that the users must be connected to the model building process. This was one of the main ideas when the project was started. For this purpose, a *reference group* consisting of high level decision makers in different interest groups of the forest sector was established at the very beginning.

Using a simulation technique one can evaluate the consequences of specific policies. However, using only simulation it is difficult to find a "proper" (or optimal) policy. For this an optimization technique is needed. Because of the complexity of the forest sector system, linear programming may be considered as the most appropriate technique for this case. It is worthwhile to note that the optimization technique itself should be used on some simulation basis, i.e., different numerical runs of the model based on different assumptions and objective functions should be carried out to aid the selection of an appropriate policy.

Based on the experience gained from the simulation model MESSU, a dynamic linear programming (DLP) model was constructed for the Finnish forest sector in 1978-80. The model is comprised of two subsystems, forestry and the industrial subsystem, which are linked to each other through the wood supply. The forestry submodel describes the development of the volume and age distribution of different tree species within the nation or its subregions. In the industrial submodel various production activities such as saw mill industry, panel industry, pulp and paper industry as well as further processing of primary products are considered. For a single product, alternative technologies may be employed. Besides supply of wood and demand of wood products, production is restricted through labor availability, production capacity, and financial resources. The production activities are grouped into financial units and the investments are made within the financial resources of such units. Objective functions related to GNP, balance of payments, employment, wage income, stumpage earnings, and industrial profit have been formulated. Terminal conditions have been proposed to be determined through an optimal solution of a stationary model for the whole forest sector.

4.4 Dynamics of Wood Utilization

The market, if allowed to operate freely, determines the utilization of wood. The market is strongly affected by technological change, which alters the ratio of price to wages for existing products and also changes the product mix. Thus the future use of wood is partially related to technological change which will alter the importance of different wood uses.

The change of wood use is a slow process in which interesting dynamics occur. A shortage of capacity may give high profitability in a single field for many years, and enable the acquisition of the wood it needs even at rising prices. Competing uses of wood may thus be halted for some time. However, during periods of overcapacity, new areas of wood use may expand more easily.

Taking this as a background and building on the experience from the Society and Forestry project a project was started at the Swedish University of Agricultural Science in 1979 with the purpose of analyzing the dynamics of wood utilization for construction wood, paper and energy. As a tool for the analysis a simulation model was developed in close cooperation with MoDo company. The model contains three essential control mechanisms: 1) the market control, 2) the capacity control, and 3) the capacity utilization control.

The model typically produces scenarios for each sector over a twenty year period, being characterized by the demand development, the business cycles, the investment cycles, and trends in the allocation of wood.

One main conclusion from the project is that one should never forget the dominating role of the market. It is most important to observe market changes and to have a good picture of what is to be expected. Of great importance is also the the availability of wood when new market trends occur. Initiative and financial strength are important here.

5. CURRENT RESEARCH ON THE FOREST SECTOR

5.1 IIASA's Forest Sector Project

The IIASA Forest Sector Project is an international effort dealing with the problems of the forest sector on a national and global level. The primary goal of the Project is to study the long-term development of the world market for wood products (i.e., fuelwood, pulpwood, sawlogs, pulp, paper, sawn timber, and different types of panels, as well as different types of converted wood products). The scope of the Project is the entire forest sector (including forestry and forest industries). It covers a period of 20-50 years.

The global trade analysis can only be carried out at a coarsely aggregated level with respect to product classification and regional subdivision. To supplement the trade analysis for regions which are (or may become) major producers in wood products, it is desirable that a detailed analysis of national forest sectors be carried out. For such work, IIASA can act as a technical consultant advising regional and national research groups who wish to carry out the actual detailed analysis.

As a consequence, the Forest Sector Project is divided into two tasks:

- National Forest Sector Analysis, and
- Analysis of World Trade in Forest Products.

These tasks are parallel and interdependent efforts, requiring two different, but generally compatible, types of models.

The IIASA Forest Sector Project is very dependent on the work done by the collaborators in many nations. Two examples are given in this section. One is about the Swedish Forest Sector Study and the other one about a model for analyzing the Finnish roundwood market.

National Forest Sector Analysis

National Forest Sector Analysis will be carried out by implementing national forest sector models, which will be constructed by the international collaborative network. (The project's collaborative network includes approximately 40 institutions in 16 countries and four international organizations.) A central part in the promotion activities is to construct a ***prototype model*** which will serve as a framework for the collaborators to build a detailed national forest sector model. The prototype model includes for the moment seven central modules — Demand, Product Market, Forest Industry, Roundwood Market, Regulation, Forest Management, and Forest Inventory.

Analysis of World Trade in Forest Products

In order to study the competitive development of the global forest sector, bilateral and multilateral trade flows between a selected number of producing and consuming regions over the 50-year horizon will be analyzed for a specific range of wood products. Such a study of trade implies analysis of production and consumption in each of the regions together with the interactive forces which influence exchange patterns between these regions. To study production one has to analyze, for instance, technological development and investments in forest industries as well as forestry and forestry ecological issues. For demand analysis, wood intensive non-forest sectors (e.g., construction and printing industries) have to be studied. One approach for analyzing the global trade of forest products is the general equilibrium theory and some of its modifications.

National or regional economies are modeled as convex welfare maximization problems subject to the explicit requirement that export and import payments have to be in balance. World market prices are drawn from world market equilibrium conditions. The problem of finding the equilibrium prices, regional exports and import and production is formulated as a weighted world welfare maximization problem subject to regional production possibilities and world market clearing. The solution is optional for each region. The weighting values for the regions can be found by using a fixed point algorithm.

5.2 Sweden's Forest Sector Project

In Sweden the study of policy analysis for the national forest sector has been subdivided into a number of subsystem studies which are connected with each other primarily through "soft" linking procedures. When developing and working with these subsystems a close connection was established to IIASA. This is especially true when it comes to the trade of forest products. The resulting project is carried out as a joint effort by the Swedish University of Agricultural Science and Umeå University.

The different components of the Swedish project are interrelated to each other as shown in Figure 5.

These different components are interrelated to each other in our study in the following general way:

Framework of analysis

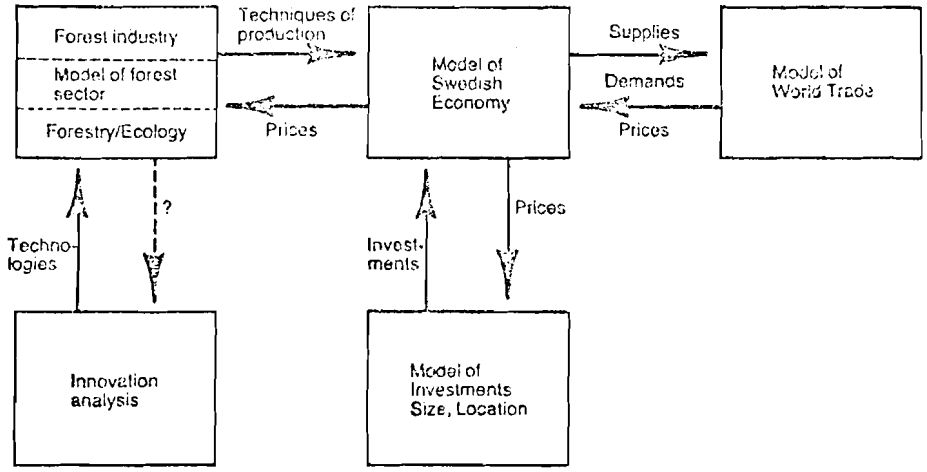

Figure 4. Framework of analysis in the Sweden's Forest Sector Project.

The Swedish forest sector study is systems analytic —the inherently complex dynamic interdependencies between different industries inside and outside the forest sector will be recognized. However important and challenging mathematical methods may be, the Swedish study derives the major inspiration from an explicit policy orientation recognizing that Swedish forest sector decisions are of a large scale, strategic and subject to many conflicting objectives, often associated with different pressure groups.

5.3 Stackelberg Equilibria for the Finnish Roundwood Market

During recent years the total cost of roundwood for the Finnish forest industry has been of the order of US$ 1.5 billion annually. The share of stumpage price represents roughly one half whereas harvesting, transportation, etc. account for the rest. The purpose of this study is to investigate the long range equilibrium price for wood (and thereby total roundwood cost) under various conditions for the world market of wood products.

The analysis is based on a steady-state formulation of a Stackelberg game where forestry sets the price for wood (by timber assortment) and industry then decides upon the amount of wood to buy at this price. Both parties are assumed to be profit maximizers. Thus, the amount of wood results from industrial profit maximization. The equilibrium price is a price which results in a sustained yield demand and which maximizes forestry profit over alternative prices.

Numerical tests have been carried out using a model dealing with two timber assortments (log and pulpwood) and with seven industrial products (sawn goods, panels, other mechanical wood products, chemical

pulp, mechanical pulp, paper and converted paper products). The results indicate that the current stumpage price is above the equilibrium price by a factor of two or three depending on the assumptions concerning world market conditions.

6. THE NORTH-AMERICAN COMMITMENT TO THE FOREST SECTOR PROJECT

It is the purpose of this section to lay out what appears to be the consensus goals among the North American participants for the North American component of the IIASA global model. The starting point is a list of objectives regarding the product that will result from the IIASA effort. The consensus is that the IIASA global model will be primarily useful as a tool for examining forest product international trade flows under a range of assumptions on supply-demand conditions and trade restrictions/barriers in participating countries. As a consequence, the following model characteristics would appear to be most important from the standpoint of utility to potential users in North America.

1. The global model should be compatible with the North American Timber Assessment Market Model — TAMM. That is, the basic North American component will be an adaptation (albeit an extensive one) of the basic TAMM structure including price responsive supply and demand.
2. Emphasis in the IIASA study should be on relative delivered product costs and prices in determining international trade flows in international markets. Costs should also be given explicit recognition in the determination of production volumes in those country models representing economies which are not centrally planned.
3. Operationally, emphasis in use of the IIASA model should be on "what if" simulations, i.e., alternative scenarios of trade flows and prices under various assumptions on economic forces and trade barriers.
4. Only a modest degree of a product detail will be possible in the initial model. However, data should be collected in sufficient detail to allow disaggregation to a level of anticipated refinement as well as compatibility with wood quality differences. In addition, it is recognized that for many countries internal and external trade flows (even within fairly narrow product categories) are often not homogeneous, substitutable products. Some allowance for this lack of product homogeneity should be introduced in the model.

For western market economies that are not centrally controlled, the country models should incorporate four basic modeling components:

1. Product demand processes. These processes would explain volumes consumed of various products and would recognize income and price substitution effects among major classes of forest products and other materials.

2. Product supply processes. These processes would explain volumes produced of various products and would have the following general attributes:
   a. They would be structured so as to be sensitive to production costs and incorporate an accounting for total variable costs of production.
   b. Investment decisions, i.e., adjustment of capacity over time to changing economic conditions, should be explicitly modeled.
   c. Product supply processes should allow for explicit treatment of product recovery (product output per unit of wood/fiber input) and for changes in recovery over time.
3. Demand for wood. The demand for timber can be derived from elements (1) and (2) above. This is an essential consideration since it is a point where technological shifts — notably those relating to timber utilization — would be introduced.
4. Wood supply processes. These processes would explain the cost and volume of wood delivered to processing facilities.
   a. As in the case of product supply, these processes should be sensitive to costs (in countries where this is appropriate) and incorporate an accounting structure for the variable costs of operation.
   b. Wood supply processes should incorporate such inventory and management inputs as necessary to describe short-term harvest.
   c. Some thought should be given to differences in wood input quality characteristics, such as softwoods and hardwoods, and sawnlogs and pulpwood.

In the exchange module of the global model, a spatial equilibrium framework should be adopted as the process for solving for trade flows and prices. In this framework each country would operate in local deflated currency units. Exchange rates and transport costs would then be an integral part of the global spatial equilibrium framework. For some countries, the exchange rate would be exogenous, while in others it would have to be treated as endogenous. In most countries, links to the rest of the economy would be through the exchange rate, demand shifters and non-wood costs. In some countries, such as the U.S., these links would be unidirectional, since events in forest products markets have little impact on the rest of the economy. In other countries, where the forest products sector comprises a major segment of the economy, these links must be two-directional.

Finally, for countries such as the U.S. with large domestic markets, several domestic producing regions, and complex patterns of internal trade, it seems desirable to limit the role of the exchange module to the determination of international trade flows. However, intra-national flows for large countries as the U.S. and Canada could be determined by a submodel which produces a domestic solution that may be conditional on international market conditions. Full equilibrium in this context may require several iterations of both the national and exchange models.

APPENDIX A: List of presentations

- *Finland - - An Ideal Type of Forest Sector Society?*
  Tarmo Koskinen
- *The Role of the State in the Development of the Finnish Sector*
  Ritva Hainari
- *Forest sector and Regional Development in the NORDCAN area*
  Jussi Raumolin
- *Impact of Business Cycles on Wood Supply*
  John Høsteland
- *Utilization of Computers to Improve the Competitiveness of Veitsiluoto Co*
  Eino Ravaska
- *Stackelberg Equilibria for the Finnish Forest Sector*
  Markku Kallio
- *Fixed Point Algorithms and the World Trade Model*
  Seppo Salo
- *Allocation of Forest Biomass in a Region*
  Sten Nilsson
- *Wood Resources and the Development of the Forest Industry in Nordic Countries*
  Kullervo Kuusela
- *Problems of the Wood Availability in the Planning of the Forest Industry*
  Yrjö Schidt

- *Wood Supply Situation for Norwegian Pulp and Paper Industry*
  Jens-Mikael Lund
- *The Planning Procedure of Forest Industries*
  Pentti Sierilä
- *Cash-based Profitability Comparison of Finnish and Swedish Forest Industry*
  Eero Artto
- *Strategic Problems and Planning of Soedra Skogsaegarna*
  Jan-Åke Lunden
- *IIASA's Forest Sector Project*
  Lars Lönnstedt and Risto Seppälä
- *Status of the Swedish Forest Sector Study*
  Åke Andersson
- *US Goals for IIASA National Model*
  Richard Pierson
- *Planning of a Forest Integrate*
  Olavi Lehtikoski
- *Instruments for Strategic Planing in Forest Industry*
  Carl Kempe
- *Profitability and Financial Growth Model Applied to Some Forest Industrial Corporations*
  Reijo Ruuhela

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