MODELLING FOREST INDUSTRY DEVELOPMENT

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ABSTRACT

Important principles in modelling forest industry development in New Zealand are enunciated. Recent sector modelling efforts by the Forest Service and Forestry Council and those contained in the CNIPS report are briefly reviewed, before presenting an outline of the integrated and hierarchical modelling of the sector carried out by the authors. The need to reflect a wide range of interests, objectives, emphases and data aggregations is catered for in this approach, as is the ability to allow ready interaction with a wide range of contributors to, and potential users of the results.

1. INTRODUCTION

This paper aims to describe what is involved in modelling forest industrial development in New Zealand, to review the presently available means for so doing, to report on progress with research into methodology relevant to this field which is being developed by a group at the University of Canterbury, and to indicate one suitable planning approach for the forest sector to follow in the near future.

Until very recently, emphasis in modelling the New Zealand forest sector has been devoted largely to forecasting likely volumes of one or at most a few log categories over the next thirty years or so region by region (see, for example, Familton, 1969; Hosking, 1972; Levack, 1977; Elliott and Levack, 1981). The Forest Industry Study put out by the Development Finance Corporation in 1980 heralded a change in emphasis, by directing more attention to marketing, manufacturing, transporting and harvesting.

These, and other relevant considerations not confined just to the forest sector have been examined to varying extents by planners and researchers; their efforts are briefly summarised here in Section 3 of this paper. Before considering these contributions, however, it may be useful to set out what we believe

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are the crucial elements in modelling the forest sector in New Zealand, to gain a better appreciation of the advantages and disadvantages of the various methodologies that are outlined later.

2. MODELLING APPROACH

The following aspects could be regarded as important elements in modelling the New Zealand forest sector:

(1) Determining likely supplies of each of several categories of wood products over time.

(2) Forecasting market demands for various kinds of final products.

(3) Planting, tending and harvesting crops to match supply with demands.

(4) Transporting raw materials and final products.

(5) Selecting, locating, building and operating appropriate manufacturing plants.

(6) Financing the associated capital investment and foreign exchange that will be needed.

(7) Rationalising and regulating use of national sources of energy.

(8) Using labour effectively.

(9) Quantifying and documenting the consequential needs for vehicles, equipment, roads, port-handling and shipping capabilities.

(10) Imposing sufficiently sensitive constraints on environmental and social considerations.

(11) Providing inter-sector linkages.

Obviously no one single model nor one single person, or organisation, is capable of representing this wide range of functions efficiently. There have to be useful inputs by, and good co-operation among various people, such as forest growers, loggers, managers, wood users and consumers, regional and national planners, researchers and national and local government politicians. The need to provide access to and exchange of nationally important data on all, not just some, aspects listed in the previous paragraph is critical in order to allow researchers and planners to explore a full range of possibilities, and decision-makers to effect comparisons of results without having to make allowances for greatly different starting data.
Because so many people need to contribute to the modelling it is also important that the models used are interactive, coherently structured, iteratively operated and efficient to run: that is, users or contributors should be able, first, to sit down at a computer terminal and modify inputs and outputs without having either to change the structure of the model or regenerate it from scratch; secondly, to transfer inputs and outputs easily between different models; thirdly, to ensure compatibility of results between different models; and fourthly, because of the magnitude of the problem-solving, to ensure that the computers and manpower required to obtain solutions are used to as good effect as is humanly practicable.

Because there are so many possible markets, processing options and forest-growing practices to consider, it is also important that as few precluding assumptions as possible be made until late in the modelling process. By forcing through one or more scenarios that are ill-conceived at the outset, only misleading or, at best, very poor information may be gleaned from the modelling. A far sounder practice is to establish a framework which allows the model rather than the modeller to identify particularly useful mixes of options that are worth exploring further, and also the reasons for the choice, thus providing a keener insight into what is finally the "best" decision to take.

Another important point to recognise is the need to plan with more than one objective in mind. Decisions concerning use by the forest sector of national resources have ramifications beyond the boundaries of the immediate system and cannot be assessed adequately if only a single, all-encompassing objective is imposed. Furthermore, sectoral planners are often unable to quantify benefits or goals arising from different objectives when they embrace differing units of measure. Maximising net present worth, for example, may have to be tempered with minimising reliance on foreign exchange or favouring employment opportunities in one region as against another or restricting the levels of port throughput, road cartage, capital investment, etc. Multiple-criteria decision-making techniques are called for.

It is also worth stressing that considerable time is needed not only to collect reliable data, manipulate these raw data into a manageable form, run models and evaluate results, but also to refine all inputs through continual calibration against interim findings and through special studies of those elements that are most influencing the solutions obtained.
Lastly, there is a great need for standardisation of software used so that, with the ever-increasing proliferation of computer hardware, the problems of running models on different machines are minimised. This is particularly relevant if computer bureaux are to be employed as agents, though, at this developmental stage, that issue is perhaps not yet pressing. Nevertheless, it should be recognised that research into sector modelling cannot be envisaged on a commercial bureau system because of the huge costs involved, and so the matter to resolve first is transportability between research machines.

3. SECTOR MODELS IN OPERATION

The Forest Service, at present, has statutory responsibility for forest sector modelling in New Zealand. The integrated suite of models now used by the Forest Service for this purpose consists of:

1) IFS (Garcia, 1981) — an interactive forest simulator to ascertain future volume yields from areas of known age.

2) GROHA (Levack and Jennings, 1981) — uses output from IFS and estimates the flow of resources needed for growing and harvesting the forests in terms of “jobs, machines, buildings and costs” (Levack and Lee, 1982).

3) MOVPRO (Lee, 1982) — simulates the transport, processing and marketing resource requirements for a pre-specified regional development scenario using outputs from IFS and after satisfying commitments to existing industry.

4) RSUM (Lee, 1981) — aggregates all previously determined resource flows and calculates foreign exchange requirements, net revenue with and without foreign exchange weighting, present net worth and internal rate of return of the scenario, and employment creation and dependency indices.

These models are still under development, but have been used for regional modelling exercises in Northland, the Central North Island and, to a lesser extent, in Nelson to simulate the effects of regional scenarios for growing, harvesting, transporting, processing and selling forest produce. O. Garcia (pers. comm.) has recently developed a linear programming addition to IFS (called FOLPI) which derives an optimum cutting strategy for a forest, then uses IFS again to simulate modifications to that optimum. Levack has also mentioned enhancements in the
transfer of data among the various sub-systems, and improved information from ancillary runs of SILMOD (Williams and McGregor, 1982). New features in MOVPRO also take advantage of interaction with SILMOD runs and, in addition, it now has a means of aiding the user to select promising processing options to try.

The Forestry Council set up a Sector Wood Supply Modelling Committee which has recommended an annual stock-taking and reporting of important forest resource statistics county by county. The recommendations were accepted by the Forestry Council late in 1982 and a small working group is presently engaged in implementing the procedures. Several annual refinements will probably be needed before a satisfactory description of the forest is achieved, but, once underway, it is hoped that the exercise can be extended to the manufacturing side. Perhaps the proposed study by the Conversion Planning Project Team at the Forest Research Institute will help to create a good basis for developing such an extension.

The CNIPS findings published in April 1983 address many of the problematical elements itemised in Section 2 of this paper. The supply forecasts were provided through the IFS, GROHA, MOVPRO suite of models in which incrementation of industrial capacity followed rigid, unrealistic scenarios that seem to us more likely to mislead than assist planners. Whilst this exercise may have provided a very useful forum for exchanging ideas and making known broad implications of the expanding resource, the modelling methodology per se seems to us to be all that is undesirable: the various components are disjointed, not coherently structured, and anything but interactive, iterative and efficient. A more desirable modelling strategy is required, if sector modelling is to be of real value to all those contributing to, and wishing to take advantage of it.

4. MODELLING DEVELOPMENTS AT THE UNIVERSITY OF CANTERBURY

We have adopted an approach at the University of Canterbury which attempts to follow the precepts outlined in Section 2 as closely as possible. Aggregated, large-scale mathematical programming models are run to determine optimal strategies for managing the whole forest sector throughout New Zealand in terms of: re-establishment and new planting; silvicultural tending; harvesting; processing that matches manufacturing potential
with possible market demands; movement and transport of logs, intermediate and final products; location and size of processing capacity. This coverage provides a framework within which to examine more specific objectives of the modelling so that a coherent picture of the investments needed for growing and harvesting the resource, transporting and processing it, and marketing the outturn, can be broken down by kind and period, together with an indication of the infra-structural support that will be needed.

The original intention was to concentrate on solving national issues first before looking more closely at regional implications, because the expansion of the forest industry is likely to be export-orientated and must stake its claim, therefore, for national rather than regional assets. This national model consists, therefore, of eight regionally independent sub-models linked by national assets in the form of capital, foreign exchange, energy, labour, export opportunities and demands for final products that transcend regional boundaries. Each regional sub-model has constraints on areas available for planting, crop productivity, harvesting technology, location and size of processing plants and transportation of commodities, all of which factors require evaluation that is independent of that in other regions. Details of the silvicultural regimes, harvesting systems, final product categories and other such characteristics can be found elsewhere (e.g., Whyte et al., 1981; Baird and Whyte, 1982; Whyte and Baird, 1982).

Despite there being 20,000 variables in this national model, the level of aggregation is still too broad for modelling the regional development of forest industry. The approach we have adopted is to construct a set of coherently integrated lower level models and solve them time and again in such a way that stable, compatible solutions are found from the most detailed to the most aggregated level within the whole set.

Each regional lower level model can be expanded to about 20,000 variables and 10,000 constraints. Instead of one notional forest emanating from a single, though changing, epicentre, and serving a similar notional utilisation centre, regional models cater for up to ten forest areas, ten processing centres, and ten species/regime combinations. After initial specifications of what exists at present, the model allocates in the best overall way so that cells which previously held zero entries may be filled during the planning horizon and, conversely, some initial activities gradually phased out.
Lower level models are not necessarily just for single regions. Any one component may be modelled in greater detail. For example, an efficient network code has been developed to explore a range of possible ways of transporting logs or intermediate products from point to point. Optimisation is carried out for several commodities over more than one time period and along capacitated arcs.

Linking the different levels of model can be done automatically or by manual transfer. At this stage of development, however, we are still favouring the latter because of the amount of learning that can be accomplished by such a process.

The models can be run by specifying production demands for different kinds of final or intermediate products, but the most powerful capability comes from allowing the model freedom within upper and lower bounds to produce what is “best” under a range of objectives. This is achieved in the following way: for each species/regime combination, the merchantable volume is broken down into a downward hierarchy of intermediate product proportions, namely clearwood, knotty constructional timber, poles, posts, pulp, chips and low-grade residues; up to 18 final products can then be manufactured, namely sawn timber of three general grades, veneer sheets, plywood, particle board, hardboard, softboard, medium density fibreboard, mechanical pulp, chemical pulp, newsprint, writing and printing papers, other papers and paperboard, export sawlogs, export pullogs, roundwood and chips. Information on rates of production and productivity have been gleaned from several sources: from mill studies, the Technical Supplement to the Processing Options Working Party (1981), van Wyk (1982), Jowsey (1981) and many others. As it has proved difficult to establish production costs which are functions of plant size as well as throughput, empirically derived cost functions are allocated on the basis of the size and kind of plant most likely to materialise in a first attempt to represent capital economies of scale: after the first run, more realistic coefficients can then be entered as needed.

Demands are tabulated in the form of optimistic, pessimistic and “best guess” for each final product category on the domestic and export markets. Substantial use has been made of School of Forestry marketing studies funded by the Forestry Council (see Ellis, 1981). Alterations in demands have a very significant impact on forest management as well as forest industry strategies,
and so we would support the CNIPS recommendation for better national intelligence on market prospects.

What is of prime importance, however, is that we do not force industrial scenarios and extrapolate from or interpolate between them, but rather allow the model to weigh the options and make choices. The next step is to examine why the model chose in that way, to examine the implications that are harder to quantify, and to assess whether or not there are other strategies that may be environmentally, or socially, or financially, or biologically, or managerially, or in any other relevant way nearly as good.

At this stage, then, the benefits of interactive and properly structured models which various parties can manipulate at a stage before the final decision is made are seen to best advantage. The system we have developed allows the users to include or exclude whatever is deemed necessary, to create new regimes or areas or processes which require changes only to the data and not the model, and to render post-optimality analysis much simpler than running through the whole modelling process again. Similarly, report-writing can be tailored to specific requests which reflect different interests as well as levels of detail.

5. RESULTS

This is not the right forum for releasing results, even if we were reasonably satisfied with them. Nevertheless, we believe that there appear to be strategies financially viable in some regions which would avoid to some degree the “investment bunching” referred to in the CNIPS report and would allow new industry to be put in place before the mid-1990s. Such a build-up would not be jeopardising the potential for longer-term profitability of the industry, provided that, and it is a major proviso, the assumptions on likely market demands are approximately right. Without firmer market predictions and without further validation and refinement of other data, it would be premature to give an indication of the opportunities we appear to have identified.

6. CONCLUDING REMARKS

Finally, we wish to reiterate the important need for co-ordination of modelling as well as for planning within and beyond the forest sector. There is evident need, to set standard formats of input and output for all sector models, for clear directions on how to and who should administer these standards, for clear responsibilities to be allocated for co-ordinating the modelling
research, and for agreed minimum channels of communication. The lead-time before massive commitments have to be made in expanding the forest industry is too short for a country like New Zealand to afford the luxury of unco-ordinated research in this complex field.

ACKNOWLEDGEMENTS

Support of the Planning Division of the Forest Service and Nelson forestry staff in particular is gratefully acknowledged.

REFERENCES


