Harvesting Coillte's Forests:
The Right Tree at the Right Time

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Summary

Coillte Teoranta harvested approximately 1.4 million m³ of timber in 1990. By 2010 this annual harvest volume will increase to 3.5 million m³. This increased harvest volume, which largely will have to be exported, either as finished products or as round timber, has focused attention on the necessity for efficiency and rationalisation in the overall timber industry. The Department of Forestry, University College Dublin, in co-operation with Coillte, has developed a number of prototype planning procedures, designed as decision-support tools for forest management. Their main function is to illustrate the possible benefits to the company of the integration of operations research techniques in both operational and strategic planning procedures. The area that this paper focuses on is timber allocation and transportation. Past procedures, changes that have been made up to the present and proposed future developments are illustrated with the aid of hypothetical examples, using data from Coillte's data bases.

1. Introduction

Two developments have emphasised the importance of efficient timber harvesting and allocation procedures.

Firstly, in 1989 the state Forest Service was transformed into a commercial semi-state company, Coillte Teoranta. The long-term viability of the company requires the existence of a cost-efficient and profitable timber processing industry, capable of competing on export markets. The processing industry needs a timber producing industry which delivers raw material in the right form at the right time in the right place at the right price. As part of an industry-wide rationalisation process which is taking place, Coillte has targeted the areas of harvesting and transportation for efficiency improvements and cost reductions. One specific area where efficiency improvement possibilities have been identified is in the transportation of raw material from forests to processing locations. Both the reduction of transport distances, and the allocation of specific products to the appropriate mills should be targeted in any cost reduction strategies.

Secondly, as a result of past planting and management schedules, the annual timber harvest volume in Coillte's forests will increase from 1.4 million m^3 in 1990 to 3.5 million m^3 in 2010. This rapid increase necessitates improved planning and scheduling procedures in order to benefit fully from the improved flexibility and expanded processing alternatives which this expansion offers. Existing industries will increase production capacities and new operations will be introduced. In order to ensure a structured and organised approach to this expansion and introduction of new processing capacity, integrated management procedures and planning tools are required to examine the impacts of various strategic decisions both on the industry as a whole and on individual mills.

This paper presents an overview of work done in the Department of Forestry, University College Dublin on the development of a prototype integrated harvest scheduling and timber allocation decision support system for operational and strategic planning in Coillte Teoranta. The paper sets out the past, present and proposed future decision-making structures and highlights areas where the developed decision support system could be of use. The first two sections deal with the harvest and sales planning procedures as operated by the company till recently. Further sections will discuss developments, both implemented and proposed, to these planning processes.

2. Harvest Planning

The basis of Coillte's timber supply planning is a detailed sub-compartment forest inventory. This contains details on species, planting year, yield class, stocking etc. This attribute data, together with the associated spatial data, is stored and manipulated in Coillte's Geographic Information System (GIS) (Dodd, 1991).

A thinning regime and rotation length is prescribed for each sub-compartment by the forest manager. A Forest Investment Appraisal Package (FIAP) is available at this stage to evaluate a number of feasible management alternatives (Harper, 1988). The alternative which appears to best meet management objectives can then be selected.

The inventory data, thinning and rotation classifications, and yield models are used to produce a twenty year inventory forecast. The output of the inventory forecast then undergoes a smoothing process and production targets for the first five years are produced.

With the aid of Coillte's GIS, sub-compartments which are due for thinning or clearfell in the planning period are indicated. The forest manager then draws up sales proposals by grouping stands due for production into saleable lots. At the regional level, the regional manager will be assisted in this process by the regional marketing manager. The sales proposals are then input to the harvest forecasting procedure to produce a five year

production forecast. The first year of the planning period is known as the harvest programme year. Further information regarding terrain conditions and timber quality, volume and size are collected for the programme year and a harvest schedule is produced.

3. Sales Planning

The harvest schedule is then handed over to sales and marketing personnel who are responsible for linking the supply and the demand. This process involves the balancing of the products that are wanted by the timber processing industry with what is available from the forests. Products are defined based on the timber quality and volume in each top diameter category. A price is then assigned to each product. Sales proposals are sub-divided into homogenous sales (usually one product per sale). Each sale is then assigned a method of sale and /or customer.

The combined harvest and sales planning procedures were basically sequential, with very little opportunity for back linkages and iterative processes, often resulting in inefficient use of timber resources. An
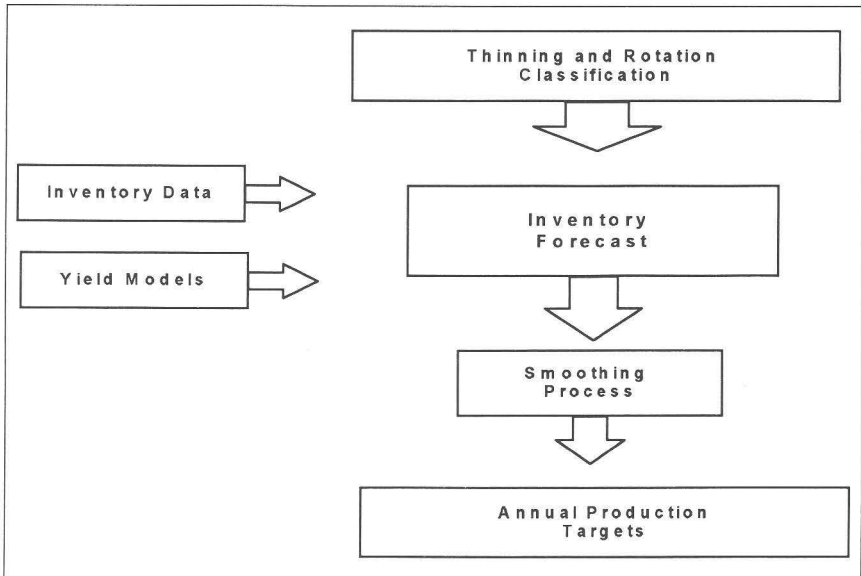

Figure 1. Data sources and procedures used in the setting of annual production targets.
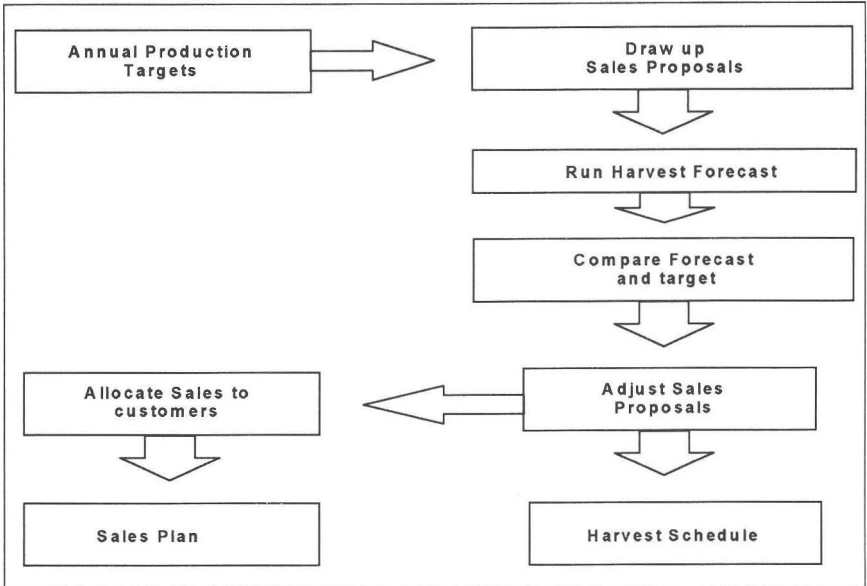
Figure 2. The steps in the decision process from production targets to harvest and sales plans.

overview of the planning process is given in figures 1 and 2. A detailed discussion of the procedure can be found in an article by O'Brien and Phillips (1991).

4. Present Situation

Two important improvements have been identified in the decision-making process (see figure 3 for a schematic overview). First of all, the process of reconciling actual production with production targets has been redesigned and the user has been given the opportunity to investigate large numbers of management alternatives with very little effort. In order to make this possible, two modifications were introduced. Firstly, the forecasting procedure was completely redesigned and expanded, incorporating up-to-date growth functions and assortment tables. Secondly, the forecasting module was integrated with the company's existing operational Forest Management Information System (FMIS) data bases. The result of these modifications makes it possible to advance or delay the harvesting of sales proposals by simply changing the production year in the data base, automatically adjusting harvest volumes and classes in the forecast accordingly.
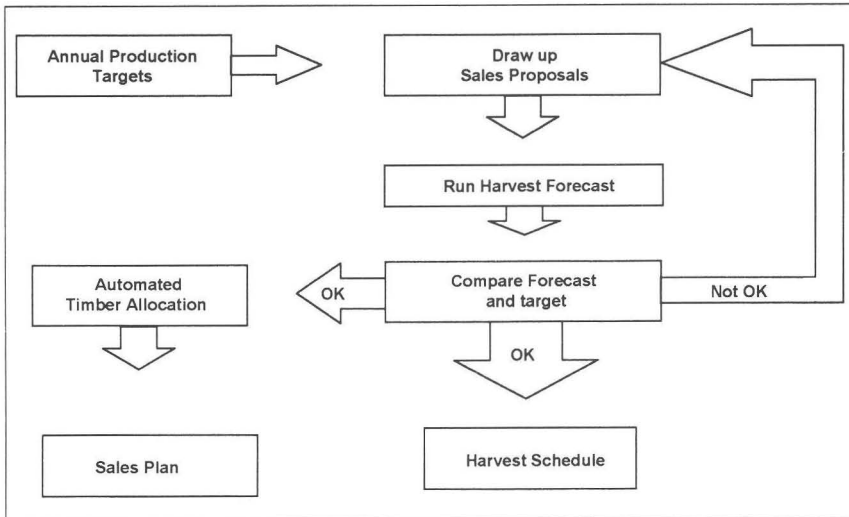
Figure 3. Modified decision process, including the iterative harvest forecast procedure and the proposed automated timber allocation procedure.

The second important area of improvement concerns the allocation and transportation of timber from forests to mills. The next sections of this article describe a prototype automated timber allocation procedure developed by the Forestry Department, UCD. Both the development work and the possible benefits of the procedure for the company are discussed. At the moment the procedure, together with a number of alternatives, is being evaluated for use during the annual sales allocation process. However, the procedure has been used in a number of cases as a tool for strategic decision-making within the company.

When examining Coillte's timber sales plan for 1991, the importance of the development of a systematic allocation procedure becomes apparent. The sales plan consists of 2674 sales in 245 forests, each sale consisting of up to 6 species and 5 assortments, giving a possible total of 30 supply categories per sale. Taking only the 20 largest sawmills and wood processing plants into account, each with up to 10 demand categories, the task of allocating the volumes in the supply categories of each sale according to the specific demands of the mills in each demand category in a cost effective manner, becomes impossible without the use of computerised Operations Research (OR) techniques (Nieuwenhuis, 1989).

The objective of the allocation procedure to be developed was the optimal allocation of the timber in the forests to the processing locations, constrained by supply and demand restrictions for each of the product categories considered. The term 'optimal allocation' can have a number

of different meanings, depending on the angle of approach to the problem. Possibilities include: transport cost minimisation, profit maximisation, and harvest cost minimisation. The developed procedure minimises the transportation cost, as this was considered the most variable cost when linking forests and mills. Additional constraints may have to be introduced in relation to restrictions imposed by the transportation network, such as truck weight and size restrictions. A wide range of factors has to be considered in trying to optimise the transportation aspects of forest operations. The most important cost factor involved is the product of volume transported times the transport distance (i.e. m^3*mile or m^3*kilometre). By minimising the sum of all m^3*kilometre values for all allocated products in all sales, the main factor determining overall transport cost has been minimised. The impact of backloading on the overall transport cost is not taken into account by the model. The developed model consists of three parts: the Input procedure, the Allocation procedure, and the Output procedure (Williamson, 1991; Williamson and Nieuwenhuis, 1991).

4.1 Use of the allocation model for operational planning
4.1.1 Comparison of actual and optimal timber allocation strategies for 1990
To quantify the potential reduction in total transport distance and associated transport cost obtainable by using the timber allocation model, the "actual" and "optimal" allocation strategies for 1990 were examined. Summary results of the 1990 sales allocation, for transport distance, are presented in figure 4. A reduction in average transport distance from 79.2 km to 48.8 km was shown to be feasible, a 38 % improvement. This corresponds to a possible reduction in transport cost of up to IR£1,000,000. It has to be emphasised that the "optimal" allocation only is optimal in relation to the **transport distance.** Additional costs, and operational and tactical constraints such as timber quality, machine scheduling and site access, will make it impossible to implement this allocation strategy without modifications. The influence of these modifications on the overall cost structure can however be quantified and, as a result, informed management decisions with respect to the company's sales allocation and transport policy can be made.

4.1.2 Selection of suitable ports for export sales
Because of an over-supply of small timber, Coillte currently exports approximately 120,000m³ of pulpwood per annum. Ports with their timber handling facilities and capacities were included in the network and a series of analyses was performed, using various export quality and quantity assumptions, to determine the best possible combinations of sale allocation and port selection to facilitate a range of export volumes and destinations.

4.1.3 Rail transportation of round timber

The use of rail transport for long distance movement of timber has been studied. The rail network, including loading and unloading facilities and linkages with the road network, has been integrated in the overall transport network. Because of uncertainties in relation to handling and associated costs, and the present infeasibility of introducing rail transport on a viable commercial scale, this aspect of the transport analysis was not studied in depth. It is envisaged, however, that rail transport will become a viable alternative in the near future.

4.2 Use of the allocation model for strategic planning

For strategic planning purposes, the level of detail does not need to be, and in most cases can not be, as great as for operational planning. Consequently the original model was modified slightly to allow it to be used to assist in strategic planning (Williamson and Nieuwenhuis, 1993). Medium to long-term timber forecasts were used as the timber supply data as opposed to actual timber sales. Timber supply data were available by 1 kilometre National Grid co-ordinates, but in order to reduce the problem to a manageable size, the timber supply data were aggregated to 10 kilometre National Grid squares. The timber supply was assumed to originate from the centre of each grid square. In addition, the timber supply was subdivided into only three products (i.e. pulp, pallet and sawlog).
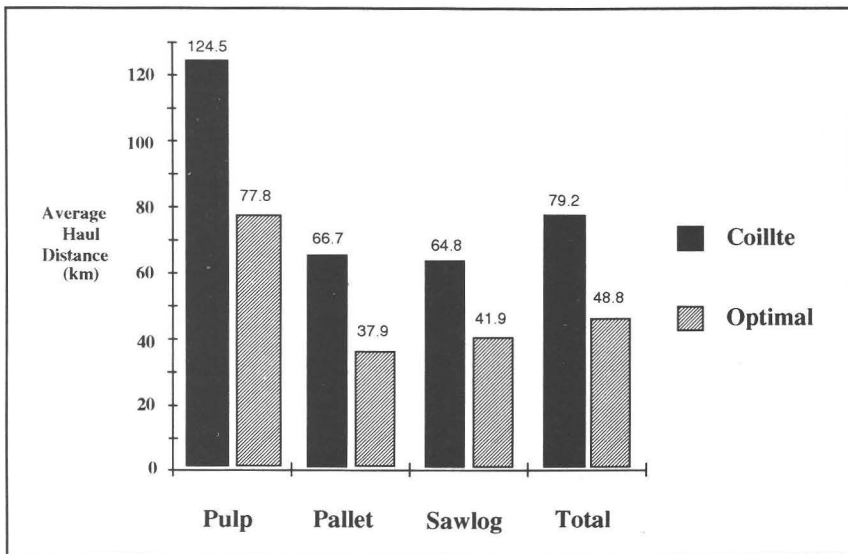

Figure 4. Actual and optimal average haul distances for 1990 allocations of pulp, pallet and sawlog. Total volume allocated is 957,534 m^3.

4.2.1 Location of New Timber Processing Industries

The possible introduction of any new timber processing industry into the country will make it necessary to investigate the influence of the location of these plants on the overall timber transport situation. Although the final decision on the location of such industries depends on many factors, such as land availability, infrastructure, grants, the type of production process, long-term timber production forecasts, processing capacity of the proposed plant and political pressures, the inclusion of transport analysis in the decision making process is important, both for existing industries and the planned mill. In conjunction with the spatial analysis capabilities of the GIS and with projected timber forecasts, a number of areas or zones where there will be concentrations of timber production in the future can be identified. In addition, by examining other factors such as proximity to ports and markets, a short list of possible processing plant locations can be produced. The allocation model can then be used to analyse the influence of the siting of such a plant, at each location, on the overall transport cost for the industry as a whole and on the cost changes for individual mills.

The results of an example transport analysis are presented in Figure 5. A pulpwood mill with a capacity of 150,000 m^3 was introduced at two possible locations: A and B. The influence of the location of the new mill on both the new mill's transport cost as well as the transport cost of existing mills, was analysed. The results show that location A is preferred, both with respect to the average transport distance of the existing industries and of the new mill. This advantage of location A with respect to transport costs has to be weighted against the other factors before the best location for a new timber processing industry can be determined.
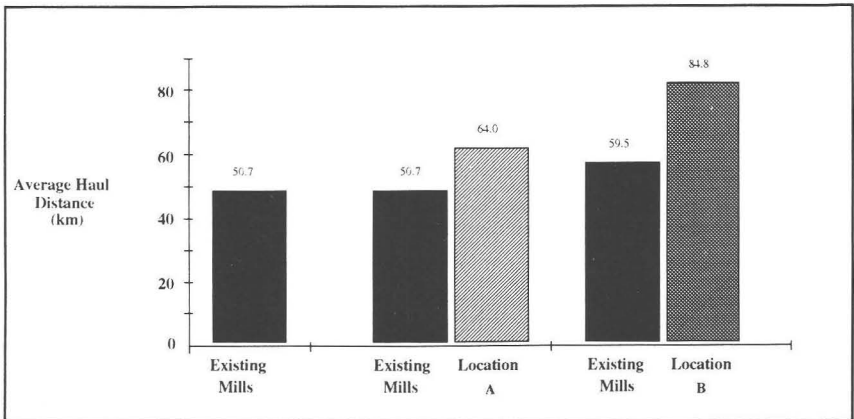

Figure 5. A comparison of average haul distances for two possible pulpmill locations.

4.2.2 Rationalisation of the Irish timber processing industry

The volume of Coillte's annual timber harvest is increasing each year. In 1990 Coillte harvested approximately 1.4 million m^3 of timber. By 2000 this annual harvest will increase to just over 2.6 million m^3, and further increase to 3.5 million m^3 by 2010. This increase in timber supply will require a corresponding increase in processing capacity and markets for the processed timber. A study was commissioned to evaluate the state of the Irish sawmilling industry and make recommendations for its future development. The resulting report concluded that there was a strong need to develop export markets and that Irish mills have under-utilised capacity which decreases their cost competitiveness. The report stressed the need to establish an Irish based export market consortium and consolidate and rationalise the sawmilling industry, if Irish mills are going to stay competitive in the export markets (Simons, 1991). Consequently, Coillte and the Irish Timber Council have been co-operating in the preparation of a programme for a structured approach to the expansion and rationalisation of the industry.

The developed timber allocation and transport analysis procedure could be of major use to the overall industry in the process of investigating changes in plant locations and capacities. The impact of the location of new timber processing industries on the transport cost of the overall industry has been discussed in the previous section. But other possibilities, such as changes in capacities of existing plants, can be analysed and quantified in relation to the effect on individual mills and, more importantly, on the overall displacement in the industry.

In an evaluation of the usefulness of the timber allocation procedure in this rationalisation process, it was used in an iterative manner to analyse the consequences of a number of demand/supply scenarios from a timber transportation point of view. The principle objective of the analysis was to investigate the sensitivity of timber transportation costs to processing capacity concentration. Results indicated that, depending on the mill location in relation to other mills and to timber supply, a relatively small change in mill capacity can have major impacts on optimal transport patterns (i.e. on the optimal catchment areas). However, the impact on the overall transport cost is in most cases relatively small. Because of the impact of supply and demand patterns on the industry as a whole, this information is of major significance when rationalisation decisions are made on the best location for processing capacity concentration. Although the rationalisation of the timber processing industry depends on many other factors, the benefits of performing such a transport analysis are that the effects of proposed decisions can be quantified. This allows an objective informed decision, as regards transportation costs, to be made. In addition, many of the other factors, assuming they are quantifiable, can be included in this type of analysis procedure.

5. Future Situation

At present the decision-making process is almost completely a sequential one, allowing for very little optimisation through iterative procedures. Any modifications that are made in the harvest forecast, using the new forecasting module, are done on a trial and error basis without the aid of a system to indicate the best course of action consistent with management objectives. In addition, the harvest schedule is drawn up rather independently from the sales plan.

Integration of these planning processes will allow for optimisation over time. An important consideration in the harvest scheduling process is the spatial distribution of the timber supply and demand. A study is being embarked upon to assess the feasibility of developing a system to assist in the temporal and spatial scheduling of timber harvests in an optimal fashion. See figure 6 for a schematic outline of the proposed decision steps.

Such a system has far reaching implications and would impact significantly on the work practices and procedures currently in place in the company.
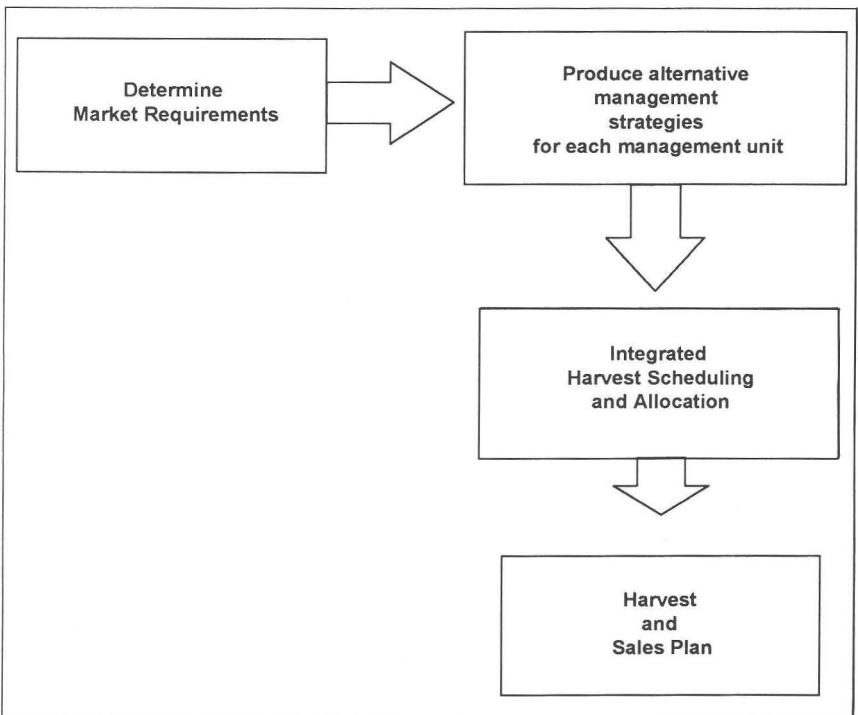

Figure 6. Proposed decision process, incorporating a fully integrated harvest scheduling and timber allocation procedure.

However, it is envisaged that the introduction of an integrated system will improve the company's capacity to supply the processing industry with the required timber at the right time at a competitive price.

The developed allocation procedure has demonstrated and quantified a number of benefits of computerised OR techniques in operational and strategic planning. It has contributed to an investigation and analysis of the company's current timber harvest planning and timber allocation procedures. It is envisaged that the allocation model will change considerably and will be replaced by a more comprehensive timber harvest planning and timber allocation decision support system. However, the present system has indicated the potential benefits of using OR techniques and that fact alone has made the development of the model a worthwhile and successful project.

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