Strategic forest simulation model – an application in Internet

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Abstract

Advanced forest planning includes an iterative communication between forest owner, consultant and forest planning software. This working paper presents a preliminary study, which objective is to develop an application of strategic forest simulation model to be used interactively and iteratively in Internet. The simulation model is used to predict the production frontier of a forest area. The auxiliary models are used to produce information about allowable cut in two management periods (in short and long time horizons) for the decision maker to help in adjusting her cutting objectives within a possible range. The simulation model calculates the production frontier of the forest holding for given sets of exogenous variables. The endogenous variables include the volume of standing timber after two management periods and the annual regeneration area during the management periods. The predicted values of the forest level variables produced by the model can be economically interpreted and they can be used as an input data in the strategic analysis. Iterative communication between a decision maker, consultant and a forest planning software is needed to accomplish the planning process. Information networks, for example Internet, provide an effective way to communicate with decision maker and planning software.

Keywords: forest management, internet, iterative planning, production possibilities, strategic planning

1 Indroduction

In strategic forest planning, the general strategy for the management of forest holding is defined. The goal is to maximize the forest owner's utility by allocating the resources according to the his/her goals. At the strategic planning stage, it is important to shed light on creating a broad conception of the decision base (Wheelen & Hunger 1995). The decision base includes the available alternatives, information about the consequences of the alternatives, and the preferences of the decision maker with respect to these alternatives (Bradshaw & Boose 1990).

In advanced forest planning, the planning process includes an iterative communication between the forest owner, the consultant and the forest planning software. A real iterative communication necessitates the direct feedback from the consultant, the forest owner and the forest planning software (e.g. Kangas 1996). Thus, the forest owner and the consultant has to be physically in the same room. This kind of planning session is one of the most expensive parts of the planning process. However, information networks, for example Internet, provide an alternative way to organize the planning process in that respect.

One characteristic of strategic forest planning is that it covers a long time period and all resources are assumed variable. The information needed in strategic planning, the production possibilities of a forest holding, can be achieved by defining the production functions of the forest. They can be used to evaluate the relationship between input and output variables and also the rates of product transformation in order to produce different alternatives. The interdependency and development of forest level variables (e.g. cutting incomes, working possibilities, growing stock, biodiversity) are of interest. The means for achieving the forest-level goals, as defined in strategic planning, are worked out during tactical planning, which produces stand-level management prescriptions.

The complexity of the model needed and the variables included in it depend on the solved issue and the data available. Strategic forest planning needs information about the production possibilities of a forest area, and stand level or tree level data are not always available. This kind of situation may arise, for example, when the forest owner is considering an investment decision to purchase an additional piece of forest land. Then, the planning process has to be carried out using more aggregated forest level information, which is more often available.

In this working paper is presented a study, which objective is to develop an application of strategic forest simulation model to be used interactively in the Internet. The model includes the interaction of growing stock, cutting volumes, and regeneration area of a forest area. Following the economic interpretation of the predictions, these predictions can be used as an input data in strategic planning.

2 Strategic forest simulation model

The model used in this study is adopted from the study of Kajanus et al. (1998). It can be used to evaluate the relationship between input and output variables and also the rates of product transformation in order to produce different alternatives.

In the model, the known exogenous variables describe the initial state of the forest area. The exogenous objective variables include the cutting volumes during two management periods, namely the first five years and the next fifteen years. The endogenous variables describe the management outcomes during and after the two management periods (Table 1).

In the model, initial volume (V_0) and initial volume by tree species ($Vpine_0$, $Vspruce_0$, $Vbirch_0$), initial log volume ($Vlog_0$), shares of age classes ($Age<20_0$, $Age2080_0$, $Age>80_0$), increment (i), and area of the forest holding (Area) are exogenous variables, which are assumed to be known. Removals during the two management periods (R_{1-5} and R_{6-20}), representing the cutting incomes of the forest holding, were chosen as the exogenous objective variables. Based on this information, the model predicts the values of the endogenous variables: the annual regeneration areas during the two management periods (RA_{1-5}) and (RA_{6-20}), the volumes of standing timber at the end of respective time periods (V_5, V_{20}), the volume of the birch ($Vbirch_{20}$), and share of old forests ($Age>80_{20}$) at the end of the planning period. The annual regeneration areas indicate employment possibilities (or necessities) offered by the forest holding, and the volumes of standing timber indicate, for example, the value of assets. The mean volume of birch and share of old forests are endogenous variables that can be used in assessing the development of biodiversity (Kajanus et al. 1998).

The simultaneous equation model computes the production frontier of the forest holding for a given set of

Table 1.The categories of exogenous and endogenous variables.

Exogenous variables	**Exogenous objective variables**	**Endogenous objective variables**
Initial Volume$_{t=0}$	Removals$_{T=1-5}$	Volume $_{t=5}$
Log Volume$_{t=0}$	Removals$_{T=6-20}$	Volume $_{t=20}$
Pine Volume $_{t=0}$		Regeneration Area $_{T=1-5}$
Spruce Volume $_{t=0}$		Regeneration Area$_{T=6-20}$
Birch Volume $_{t=0}$		Birch Volume $_{t=20}$
Age under 20-years $_{t=0}$		Age over 80 years $_{t=20}$
Age between 20-80-years $_{t=0}$		
Age over 80 years $_{t=0}$		
Increment		
Area		

exogenous variables. To predict the range of the exogenous objective variables (R_{1-5} and R_{6-20}), two auxiliary models can be used. These models predict the maximal removals during the first five-year period ($MaxR_{1-5}$) and the maximal even flow of removals over the entire twenty year planning period ($MaxEvenFlowR_{1-20}$; Table 2).

The structure of the simultaneous equations is close to that of a recursive model, although they cannot be solved recursively. The models are solved by applying Cramer's rule (see e.g. Koutsoyiannis 1979). The auxiliary models are used to produce information about the allowable cut during two management periods to help the decision maker adjust her cutting objectives within a possible range. The simultaneous equations calculate the production frontier of the forest holding for given sets of exogenous variables. Moreover, the range of exogenous variables is restricted so that the values of endogenous variables are non-negative.

3 An application in Internet

The model is used by proceeding the following steps:

Step 1. Open the Internet web site.

Step 2. Press The Strategic Forest Simulation Model - button in the web page to run the model application.

Step 3. Input the values of variables describing the initial state of the forest area.

Step 4. The auxiliary models predict the maximal removals during the first five- year period ($MaxR_{1-5}$) and the maximal even flow of removals over the entire twenty year planning period ($MaxEvenFlowR_{1-20}$). Using these predictions, the objectives can be adjusted within the suggested range of objective variables.

Step 5. Input the values of the objective variables, i.e. the cutting volumes during two management periods (the first five years and the next fifteen years).

Table 2.The equations and variables used in the models are as follows (endogenous variables underlined):

$$V_5 = f_1\,(Vpine_0, Vspruce_0, Vbirch_0, Vlog_0, i, R_{1-5},)$$
$$V_{20} = f_2\,(\underline{V_5}, Vbirch_{20}, Age{<}20_0, i, R_{1-5}, R_{6-20}, R_{6-20}/V_0,)$$
$$RA_{1-5} = f_3\,(\underline{V_5}, Vpine_0, Vspruce_0, Vbirch_0, Age{<}20_0, Age{>}80_0, R_{1-5}/V_0,)$$
$$RA_{6-20} = f_4\,(\underline{V_5}, \underline{RA_{1-5}}, \underline{V_{20}}, Age2080_0, Age{>}80_0, R_{6-20},)$$
$$Vbirch_{20} = f_5\,(\underline{V_{20}}, \underline{RA_{1-5}}, Vbirch_0, Age{<}20_0, Age{>}80_0, i, R_{1-5}, R_{6-20}/V_0,)$$
$$Age{>}80_{20} = f_6\,(\underline{V_{20}}, \underline{RA_{6-20}}, Vlog_0, Age{>}80_0, i, R_{1-5}, R_{1-5}/V_0,)$$

Auxiliary models:

$$MaxR_{1-5} = f_7\,(V_0, Vlog_0, Age2080_0, Age{>}80_0)$$
$$MaxEvenFlowR_{1-20} = f_8\,(Vpine_0, Vspruce_0, Vbirch_0, Vlog_0, Age2080_0, i, Area)$$

Step 6. The model calculates the management outcomes during and after the two management periods.

As an example the model was applied to a forest holding of 112,2 ha in size and situated in eastern Finland. The case forest was characterised by its high standing volume (150 m^3/ha) and relatively high share of old forests with plenty of cutting possibilities. About 50 % of sites represented medium fertility (*Myrtillus* site). Scots pine accounted for 38 % of standing volume, Norway spruce 55 % and broadleaves 7 %.

Known variables were as follows:

V_0	= 150,4 m^3/ha
$Vpine_0$	= 56,6 m^3/ha
$Vspruce_0$	= 82,6 m^3/ha
$Vbirch_0$	= 11,2 m^3/ha
$Vlog_0$	= 71,8 m^3/ha
$Age<20_0$	= 28,7 %
$Age2080_0$	= 26,0 %
$Age>80_0$	= 45,3 %
increment-%	= 3,9 %
Area	= 112,2 ha

It is possible to present the results in numeric or graphical form to support the strategic planning and decision making process. To illustrate the results of the model, production frontiers were produced for the case holding (Fig. 1).

4 Discussion

In current advanced forest planning, the planning process includes an iterative communication between forest owner, consultant and a forest planning software. This kind of planning session is one of the most expensive parts of the planning process. In this working paper was presented a study, which objective was to develop a new application for strategic forest simulation to be used interactively in the Internet.

A simultaneous equation model (Kajanus et al. 1998), which included the interaction of the growing stock, cutting volumes, regeneration area, and variables indicating change in

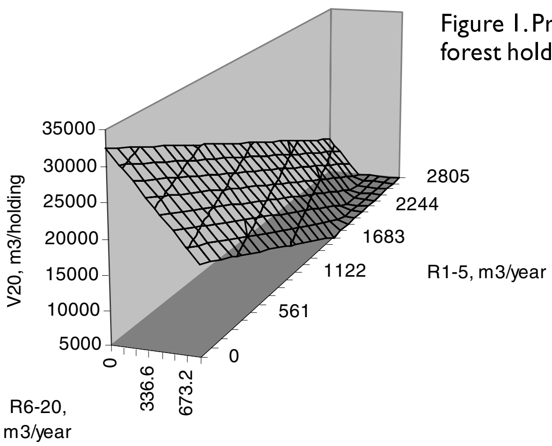

Figure 1. Production frontier of the case forest holding.

the level of biodiversity of the forest area, was used in this study. The model is used for predicting the production frontier of a forest holding. The main purpose of the model is to illustrate the production possibilities of a forest area. The model is suitable for planning situations where aggregate information on cutting levels or incomes, employment possibilities and growing stock are of interest. When the planning situation involves more detailed tactical issues, e.g. stand-level management prescriptions, more detailed models and accurate information should be used (Pesonen 1996, Kilkki & Siitonen 1976).

The main advantages of the model are its small requirements for input data and also its simplicity. The model, using remote sensing data, for instance, could be useful just prior to the preparation of a 10-year tactical forest plan to help in defining the forest-level goals. This could possibly even reduce planning costs by preventing unnecessary measurements in connection with forest inventory and by clarifying the objectives of the forest owner. As a result, the production possibilities of the forest holding and the objectives of the forest owner become clearer, and the first version of the tactical plan is close to the forest owner's objectives.

The model could be applied to a non-industrial private forest holding. The approach is also applicable to other forest planning situations. The model could be used in a situation, where the forest owner is considering the decision to buy an additional forest area and is interested in knowing the production possibilities of linking the new piece of forest to her existing forest holding**.** This kind of a model could also be used in forests owned by forest-industry companies and in regional forest planning. The model enables the linking of the forest production functions to joint production-frontier models, when considering the resource allocation of the whole enterprise. In all cases, the model can be used when strategic issues are of interest, e.g. when defining the overall strategy of managing a forest area (e.g. forest-level goals).

Internet provides an alternative way to organize the planning process

Internet could provide several benefits to forest planning. The planning process could be carried out more effectively by using information networks. For example, traveling costs could be minimized. The planning process could be carried out more quickly. The forest plans could be updated more easily by using information networks. The availability of advanced forest plans could be better, if the service could be get via Internet. Internet could be a good way to advertise forest plans. Internet could also bring more competition to forest planning. Moreover, in the future the electronic markets ares expected to be a growing business. However, in using Internet in forest planning, drawback can be the facilities and the willingness among decision makers to use the Internet at the moment. This situation is changing better all the time.

Internet could provide other benefits for forest planning as well. For example, the interaction to electronic timber market systems could be useful. Electronic markets have several advantages compared to more traditional ways of doing business. People become more equal with respect to their place of residence, through the electronic systems it is easy for any user to contact the market place. For the buyer it is easier to search for the most suitable item from a database instead of contacting each seller individually. This will also increase the likelihood of finding a suitable quality of raw material for further processing. The importance of a two-way information flow has also been stressed in the context of electronic markets. This is achieved e.g. through discussion groups and electronic mail. In the timber markets, it is assumed that procurement costs could be reduced by an electronic market place. This reduction could be achieved by describing the stand accurately enough, so that the buyer is able to make an offer without seeing the stand. E.g. Puutori could (Määttä & Pesonen 1998) reduce the need for prospective buyers to visit stands and thus lower the costs. Part of the gain could be transferred to sellers in increased timber prices. An important feature in the timber markets is also that such an electronic system would better meet the requirements of EU competition policies. Electronic information system can induce more competition by increasing the number of offers per stand. The new offers could come from small companies, who could get easier update information on stands for sale.

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