Visual interactive planning in the private forests of Finland

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Abstract

Finnish forest owners are more and more interested in the scenic value of forests, diversity of the landscape, and other non-numerical management goals. At the same time, people are less and less familiar with forestry concepts. This situation calls for visual planning, which is easily understandable to everyone. Visual planning means realistic presentation of the information; the present and future states of the forest are shown as computer illustrations, aiming at photorealism. However, visual planning is not only landscape simulation. It also means presenting numerical goals and their interactions with diagrams, guiding the optimization process trough graphical interface, etc. Visualization does not mean replacing numbers by illustrations, but converting the results of numerical calculations into graphical visualizations. Several projects on forest visualization are going on in Finland. This article describes the work which has been done for visual interactive forest planning in the research projects at the University of Joensuu. The work has resulted in a new user-interface of a planning software. The interface enables the participation of several decision makers in the planning session.

Keywords: forest visualisation, decision support, forest planning, optimisation

1 Introduction

Forest owners and others are more and more interested in the scenic value of forests, diversity of the landscape, and other non-numerical management goals. At the same time, people are less and less familiar with the forestry concepts such as volume per hectare or stocking. One more feature of the present and future Finnish forestry is that many forest holdings are owned by a group heirs who have different opinions and expectations. There are also instances in which it is preferable to plan simultaneously the management of several neighbouring forest holdings. Landscape level ecological planning is a typical example of these instances.

The present situation calls for visual interactive group planning in the private forestry of Finland. Visualisation is needed to make the impacts of management decisions understandable to everyone, and to evaluate non-numerical goals. Interactive planning is needed because all decision-makers can not express their objectives precisely and without ample feedback from the planning system. Interactive planning includes, besides interactive optimisation, also two-way communication between forest owners and the planning consultant and among the decision makers (Pykäläinen 1998). A simple and easy-to-use interface of the planning software is a key issue in this context.

Group planning is required because there are often more than one decision maker. Group planning is negotiation, compromising and adjustment rather than straightforward optimisation. The number of objectives is often high because of many stakeholders. Thus, the planning task may be very complex. Furthermore, all the stakeholders are not equally educated and experienced in forestry. In group planning, the need for visual and interactive decision support is even greater than in the case of a single decision maker.

Ideally, group planning with a visual interactive interface is like driving on the production frontier of the forest (Pukkala 1997). The location of the plan on the frontier can be changed by driving toward increasing income, scenic beauty, land expectation value or any other goal. The interface gives immediate feedback about the effects of a move on the values of objectives. The effects

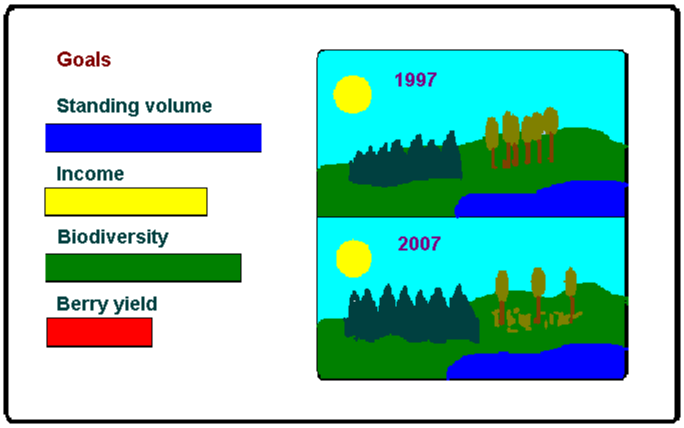

Figure 1. The ideal interface for interactive multi-objective forest planning is visual and simple to use (Pukkala 1997).The Importances of management objectives are altered by adjusting the bar lengths with the mouse.The landscape visualisation is automatically up-dated.

of forestry operations on the future landscape are seen visually on the computer screen (Fig.1).

The software for interactive planning should not require complicated data preparation steps, technical skills or understanding of special planning concepts such as simulation or mathematical programming (Pukkala 1997). The apparent simplicity of the system is not achieved by forgetting complicated analysis, but by automating the analysis and concealing complicated calculations behind an interface that is easy to use and understand. The software should run on portable computer so that the planning sessions can be organized in a location which is convenient to the forest owners.

This paper describes a new visual interactive interface for the MONSU planning software (Pukkala 1998). Visualization is utilized when defining the objectives of the stakeholders, and for illustrating the present status of the forest and impacts of forestry operations on the future landscape. The interface is currently being tested in forestry practice in eastern Finland.

2 The interface

2.1 Planning process

The forests of an individual landowner are divided into sub-areas for planning and management purposes. These sub-areas are called stand compartments. They are homogenous with respect of site, growing stock and future management. A compartment may have several management options, which in planning jargon are called treatment schedules. The task of forest planning is to find such a combination of treatment schedules for compartments which best meets the objectives of the forest owners when evaluated at the level of the whole forest property. Searching for the best combination may be done by using numerical optimization.

With our method, the outcomes of different treatment schedules of compartments are predicted by the planning software prior to optimization (Fig. 2). This information is collected into planning model together with the management objectives specified by the decision makers. The planning model is then solved using numerical optimization. The result is the first proposal for a forest management plan. This plan may be improved by adjusting the management

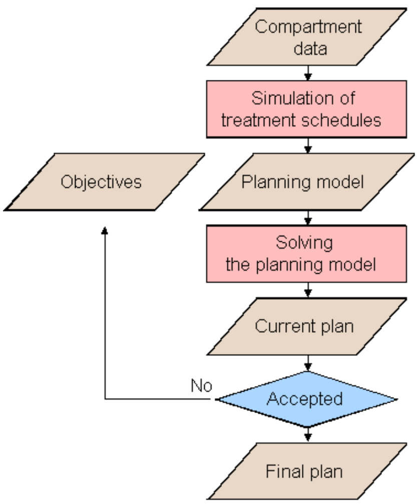

Figure 2. Flow chart of goal-based interactive forest planning.

objectives and their importance and resolving the problem. This process is called interactive optimisation.

2.2 Interactive optimization

In our system, the comparison of decision alternatives is based on an application of multi-attribute utility theory and a heuristic optimization algorithm (Pukkala and Kangas 1993).

The total utility of a plan (U) depends on the utilities that decision makers would experience if the plan is implemented:

$$U = \sum_{k=1}^{n} w_k u_k \qquad (1)$$

in which n is the number of decision makers, and w_k and u_k are the weight and utility of the kth decision maker, respectively. The utility that a single decision maker expects from the plan is computed from

$$u_k = \sum_{i=1}^{m_k} a_{ik} u_{ik} \qquad (2)$$

in which m_k is the number of objectives of decision maker k, a_{ik} is the importance of objective i, and u_{ik} is the sub-utility obtained through objective i.

Optimisation begins with the specification of decision makers. Every decision maker has the same initial weight, i.e. all the w_k are equal. Then, every decision maker estimates his or her utility function by selecting the goal variables from a list presented by the planning software, giving approximate relative importances for the goals (a_{ik} in Equation 2), and forming a sub-utility function for every goal variable. The sub-utility function is determined through the smallest and largest possible values of the objective variable, its target level, and the relative priorities of the smallest value, target level, and the largest value (Fig. 3).

The software then produces an initial solution by maximising the total utility (Equation 1) using the heuristic algorithm of Pukkala and Kangas (1993). The solution is displayed as a dialogue (Fig. 4) which enables the users to change the importances of goals (a_{ik} in Equation 2), or the weights of decision makers (w_k). The users change the lengths of horizontal bars that indicate the

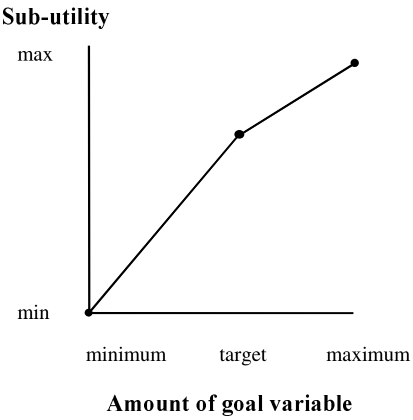

Figure 3. A sub-utility function is used to compute the partial utility from a management objective. The planning software automatically finds the minimum and maximum value of the objective variable using single-objective optimization.The decision maker enters the target level. He or she also gives (or accepts) the relative priorities of the minimum, target and maximum value.

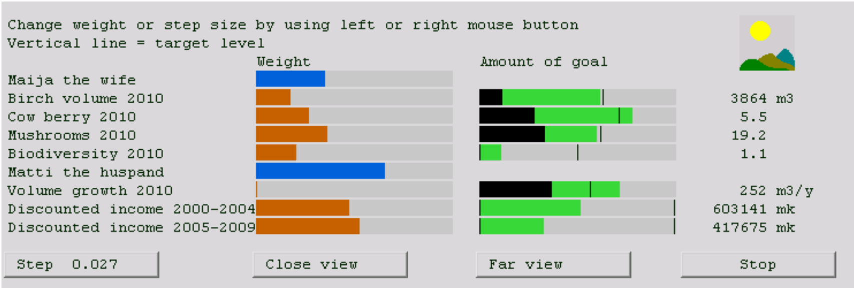

Figure 4. Interactive optimization is guided through a dialogue which allows the user to change the weights of decision makers and the importances of goal variables. The mouse pointer is moved on the bar and its length is changed with the left (decrease) or right (increase) mouse button. The step size of a change may be adjusted. Changing a given bar keeps the relative lengths of the other bars unchanged.

current values of w_k (blue bars) and a_{ik} (brown bars). The problem is resolved after every change and the new solution is immediately displayed. This gives an impression of travelling along the production possibility boundary of the forest. The decision makers have an easy and full control of the process, and they can immediately see the effects of adjusting w_k or a_{ik}.

2.3 Visualization

The dialogue used to control interactive optimization has buttons for distant scene and close scene (Fig. 4). These buttons enable the user to see visually the predicted development of the forest if the current plan is implemented. Visualizations help laymen to understand the consequences of accepting the current plan, and they ease the evaluation of non-numerical objectives. *Far view* button shows the forest from a viewpoint which not in the forest. An oblique aerial view is typically wanted. When displaying *close view*, the viewpoint is on the ground in the forest.

With both views, the user may change the season of the year and the location of the viewpoint. The far view window shows two separate visualisations which the user may specify independently (Fig. 5). One visualisation may show the present landscape and the other the same landscape at the end of the planning period. It is also possible to display two alternative plans (e.g. previous and current), the same area seen from different directions, etc.

The close view window allows the user to move in the forest. It is possible to adjust the distance of the viewpoint from the front edge of the area drawn, this allowing one to find a suitable viewing position. The view is shown in the beginning of the planning period, and at the end of user-specified sub-periods (Fig. 6).

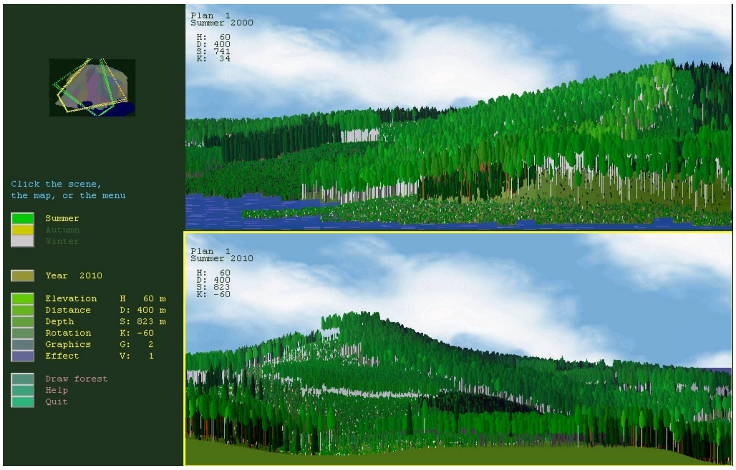

Figure 5. The *Far view* window of the user-interface. The user may proceed to optimization or to close view, and change the parameters of either of the two landscape visualizations.

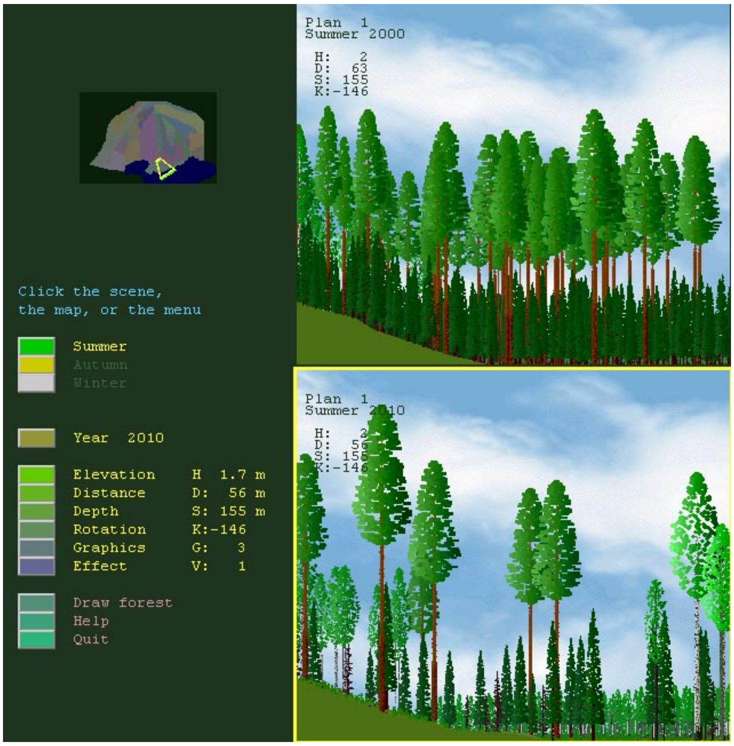

Figure 6. The *Close view* window of the user-interface. The user may proceed to optimization or to far view. The area shown is selected from the map with the left mouse button. The right mouse button displays information and visual output on the current treatment schedule of the compartment.

Landscape visualisation uses three sources of data (Fig. 7). The first is a digital terrain model which contains the elevation of the terrain, forest holding number, and compartment number at regular intervals in *x* and *y* directions (e.g. at 10-m or 20-m intervals). The second source is the predicted stand development in the alternative treatment schedules of compartments. The third source of information is interactive optimization; the current solution tells which schedule of each compartment is included in the plan.

Visualisations are created by drawing tree symbols on the terrain model. Information on the species composition and size distribution of trees is contained in the description of treatment schedules of compartments. Because stand development is described using individual trees, creating of visualizations is straightforward. Current solution tells which treatment schedule is to be utilized in drawing. Holding and compartment numbers in the terrain model form the necessary link between the terrain data and tree stand data. When producing the close view, the number of drawn tree symbols corresponds to the true number of trees in the front area, but fewer and fewer symbols are drawn with increasing distance. The same is true for the distant landscape, but the correspondence between displayed and true number of trees is weaker.

3 Discussion

The visual interface described in this paper is tightly integrated with a forest planning system. This is an advantage when using landscape visualization in practical applications. The effects of different plans on the landscape can be immediately seen on the screen.

The interface offers negotiation support for group planning. The importance of objective variables as well as their values are seen as graphical bars and numbers when

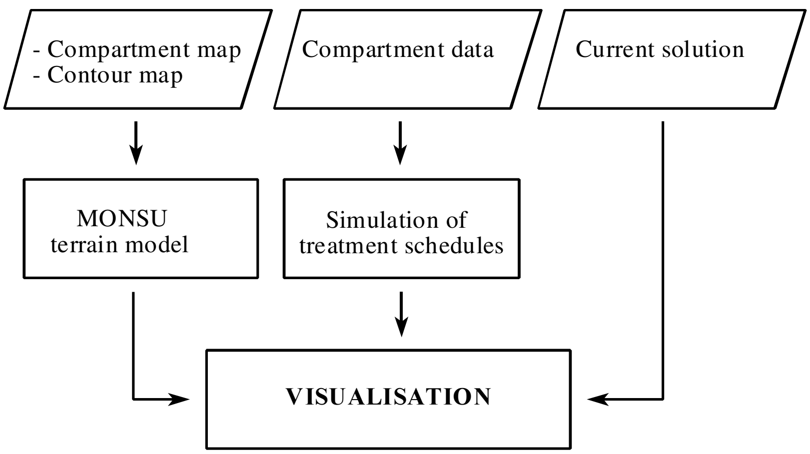

Fig. 7. The data sources of landscape visualisation.

negotiating about the plan. This is an illustrative way to show the relationships between objective variables. The decision makers can see whether the variables are competitive, indifferent or complementary. The users may also inspect what would be the effects of changing the weights of decision makers. This lessens unnecessary arguing in the case of indifferent and complementary objectives. It also guides a decision maker to stay passive until achieving his or her own objectives becomes endangered. With purely qualitative planning, this kind of conflict avoiding is not possible.

The stakeholders may have varying knowledge about forestry. Because of this, some of them might be in weaker position than the others when negotiating about the plan to be implemented. By using the interface presented here, this kind of inequality can be mitigated. Avoiding forestry jargon in planning interfaces and interpersonal communication is also an important means to increase the knowledge and understanding of the participants.

The interface described is under continuous development. Most probably it will develop towards multimedia utilizing sound and animations as additional ways to convey information. The user may be guided through the planning process via spoken sound files, and animation may be used to show the temporal development of the forest or to simulate trips in the present and future forest. No doubt visualization can also be used in a more sophisticated way in the preference analysis.

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