

Chapter IX: A decision support system for forest management planning under climate change

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Introduction

Climate change may substantially impact the forest sector around Europe, therefore, forest managers need new tools that aid the efficiency and effectiveness of forest management under changing environmental conditions. Namely, they need decision support systems (DSS) incorporating growth and yield models that are sensitive to environmental changes. A decision support system is a computer-based information system which supports decision making activities. In forest management, a DSS can allow a forest practitioner to evaluate the future consequences of various management decisions. In this chapter, we look at an example of a DSS applied to a eucalypt forest in Portugal.

In the Mediterranean area, several studies point to the warming of winters and to the increase of both the length of the dry season and the frequency of extreme events like forest fires. This will impact growth and survival of plants as well as their geographical distribution and the composition of plant communities. Eucalypt is the most important forest species in Portugal, extending over 812 000 ha corresponding to 26% of the forest territory (according the last national forest inventory). It is the main source of raw material used by the pulp and paper industry, a leading Portuguese export driven industry

In Chamusca, (Central, Portugal), the eucalypt test forest extends over 6138 ha. Chamusca is a rural county 120 km away from Lisbon. The forest landscape was classified into 1722 stands with areas ranging from 4.8 to 18 ha. The current distribution of stand area by age class is very even, with ages ranging from 0 to 16.5 years, and an average age of 8 years. In this case study, a typical eucalyptus rotation may include up to 2 or 3 coppice cuts, each coppice cut being followed by a stool thinning that may leave an average number of shoots per stool ranging from 1 to 2. Harvest ages ranged from 9 to 14 with a 1-year interval. Initial density was 1400 trees per ha.

The Decision Support System

In order to analyse how the forest management should be adapted under changing climatic conditions we developed a DSS (SADfLOR v ecc 1.0). This DSS integrates four independent and compatible modules, encapsulated in one single graphical interface. The four modules are: i) a management information system to store all relevant information about the target forest

(e.g. inventory), ii) a prescription generator module including growth and yield functions (GLOB3PG process-based model) iii). a decision module to assemble these alternative prescriptions into a consistent mathematical model which is solved, iv) a reporting module which allows viewing and reporting the results generated by the decision module.

The DSS helps develop an easy formulation of the problem (Figure 1). It provides information to the user in order to develop and adapt forest management plans. The main steps to use in order to evaluate forest management plans under changing climatic conditions are:

1. Selection of study area and inventory data.
2. Selection of the climate change scenarios.
3. Generation of management alternatives.

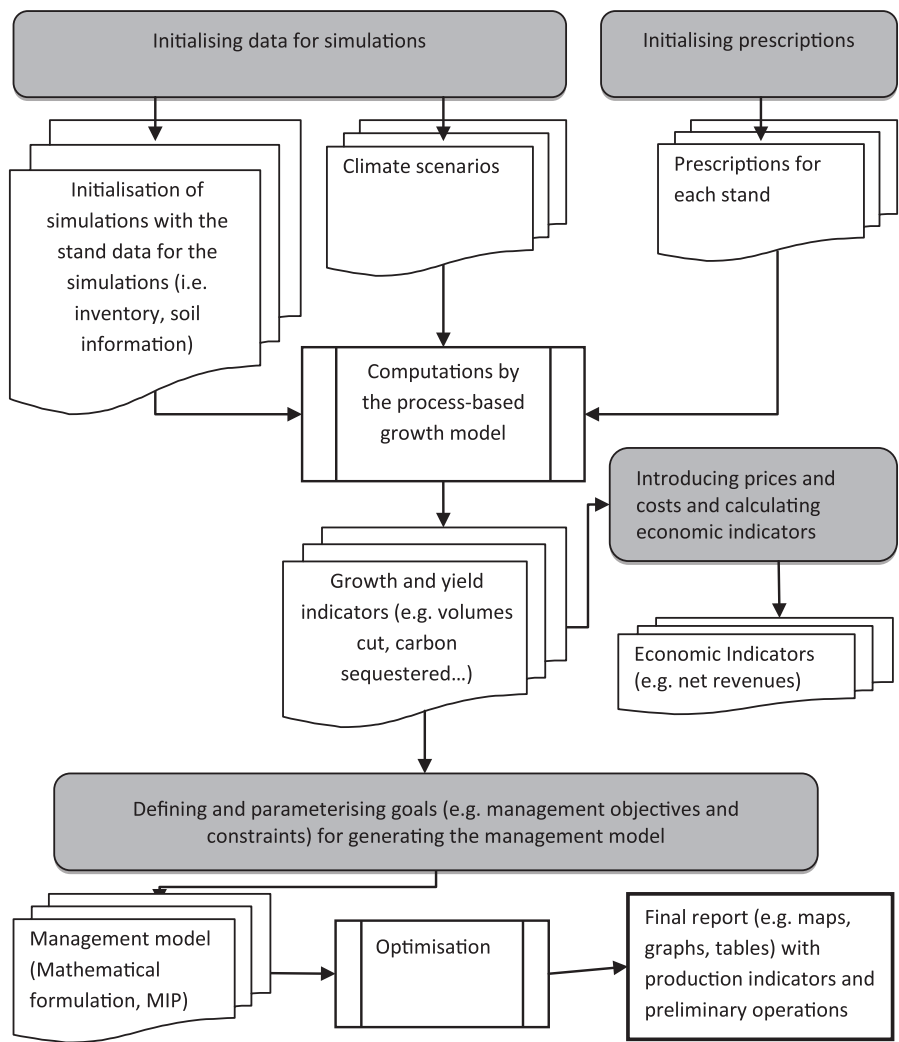


Figure 1. Scheme of the simulation-optimization process.

4. Simulating all management alternatives in all the stands of the forest over the planning horizon (i.e. 30 years).
5. Introducing prices and costs of operations and calculating revenues.
6. Optimizing forest management.
7. Finally, the report with the strategic management plans is produced. The report includes information in tables, maps, word documents.

Some results

The proposed approach was first used to assess the climate change effect on the potential eucalypt pulpwood yield and carbon stock in the whole study area over a 30 year time horizon. Results under “current climate” showed that the maximum eucalypt pulpwood yield would be around 2.35 million m³ with a corresponding value of 81.13 million € and total carbon stock was 228.3 Mg C. Under the “climate change” scenario the timber production was reduced to 2.19 million m³, the corresponding forest value was reduced to 74.7 M € and carbon stocks decreased to 212.7 Mg C.

The DSS was further used to check what would happen if the optimal management plans developed for current climate were implemented under climate change conditions. If the forest management plans designed for current climate conditions are not adapted to climate change, the pulpwood yield would be slightly reduced but the harvests in consecutive years would be very uneven.



Figure 2. Percentage of change in the total harvested area (%) per age class associated with the constrained solutions i.e. maximization of forest value (Max FV) under 15% even flow constraints for the optimal solution under the climate change scenario assumed here (CC) compared to the solution found for current climate conditions.

If the total area cut at different ages is accounted for, results show that under climate change conditions a delay in the optimal year of cuttings is observed. For example, when switching from current climate scenario to the climate change scenario, the area cut when the stands are 9 to 11 years old is reduced by up to 20%, while the area cut when the stands are 12 and 14 years old increases by 12 and 13% (Figure 2). This clearly shows a delay in the harvest ages at landscape level.

Conclusions

Climate changes may substantially impact the forest adding uncertainty to future forest productivity. For this reason forest managers need new tools that may increase the efficiency and the effectiveness of forest management under changing environmental conditions.

The DSS presented here allows the analysis of the impacts of climate change on managed forests. According to the results, the changing environmental conditions will impact forest growth and forest production decisions. In this context, the DSS developed may help forest owners to prepare management plans under uncertain future conditions.