DSS OPTIMAL - a case study from the Czech Republic

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ABSTRACT

Forest manager have traditionally planned harvests using their expert knowledge. This applies mainly to the spatial distribution of harvest units. The amount of timber to be harvested has then been regulated by market demand. Except the expert knowledge there is a set of rules, which can be automatized. Computerized harvest planning will lead not only to saving time of forest managers, but it will also enable them to explore various scenarios in a matter of minutes. We introduce Optimal - GIS tool for spatial and temporal decision of harvest scheduling. Using Optimal, forest manager can create harvest units by cutting polygons of forest stands in digital map. After the harvest units are created by the user, the adjacency matrix is automatically produced and passed to the solver module. Solver performs calculation using integer programming and then it returns spatial distribution of harvest units for each harvest period. User can set number of parameters and criteria according to ecosystem services and so to create different scenarios. Optimal® is Decision Support System designed and applied for clear cutting and shelterwood silvicultural systems with respect to the environmental and economic constraints.

INTRODUCTION

Already in the 18th century, many European foresters emphasized the notion of forest organization to produce an even flow of timber. Since then, a number of different methods have been developed for this purpose. The best known is the concept of the ideal normal even-aged forest. However, its application in practical forestry is problematic because of nature disturbances. Even so, the timber indicators used in the many countries of central Europe are derived from the concept of the normal even-aged forest.

At present time there is one timber harvesting indicator for small forest management areas (less than 500 hectares) implemented in the Czech legislation. This expresses the maximum possible final cut and is known as the cutting percentage. The indicator comes from the normal forest. However, a regulated forest with a balanced and regulated age-class distribution is not only difficult to achieve, but also undesirable for forest stability. In addition, the indicator is static, incorporating planning for one decade only, without the option to account for harvesting possibilities over a longer time period and does not consider the spatial possibilities of harvesting. This leads to strongly uneven decadal harvests within the FMA from the view of strategic future harvest planning. Next aspect is the size and spatial relationship of clear cuts limited by law. Namely it is: 1) The maximum area of the clear cut, 2) The minimum distance of two clear cuts harvested in the same period, 3) The maximum width of clear cut, 4) Harvesting of stands neighbouring the clear cut is strictly limited by adjacency relationship.

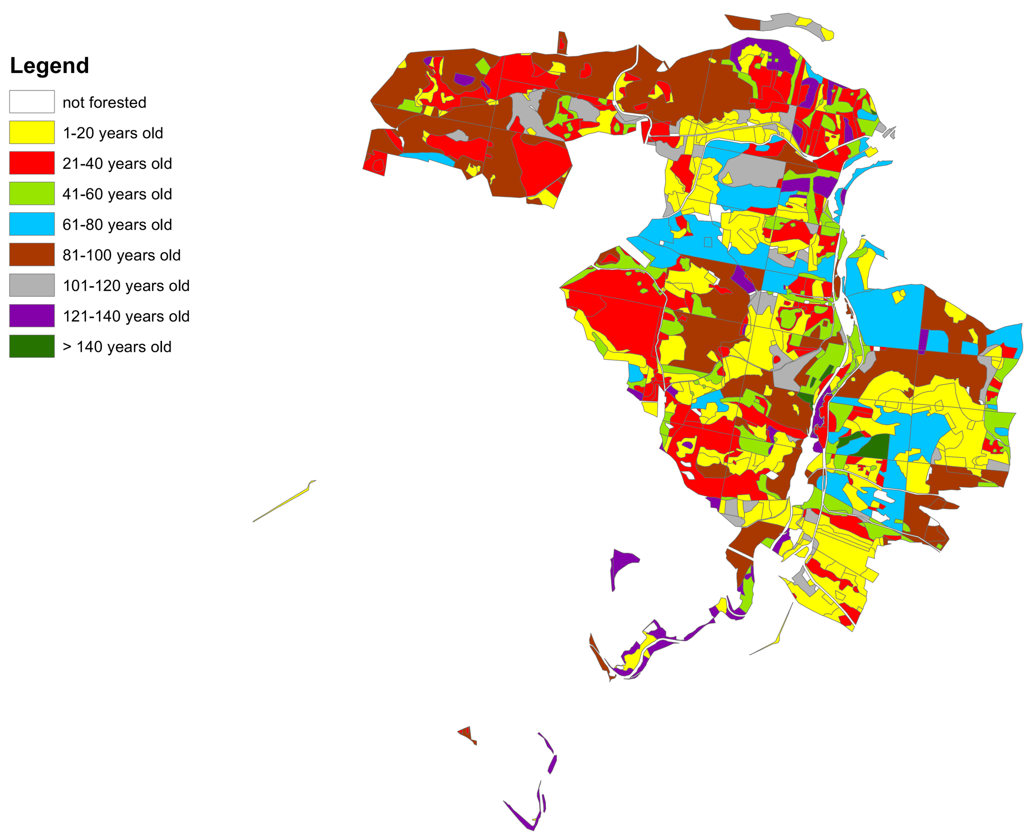
For the mentioned reasons, there is an increasing need to analyse the development of spatial structure because, it is not possible to achieve balanced final cut without the spatial aspect.

Methods of operational research in conjunction with modern information technology and geographic information systems (GIS) can be used to create a new type of forest management plans. The proposal of size, shape and position of forest harvest units in the FMA makes spatial forest management plan different from conventional plan used so far in the Czech Republic.

MATERIAL AND METHODS

The harvest scheduling tool Optimal® is presented for 494.8 hectares of real forest management area (FMA) managed using a clear cutting system (Figure 1.).

Figure 1. Forest stands map with 20 year age class intervals



It is apparent from Figure 2. that the real FMA with 10 year age classes are different from the regulated areas with age classes controlled by rotation (110 years) and regeneration (30 years)..

Figure 2. The real and regulated FMA for 10 year age class interval

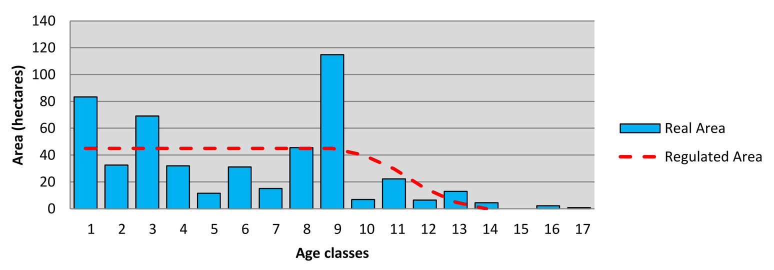


Figure 3. The creation of harvest units

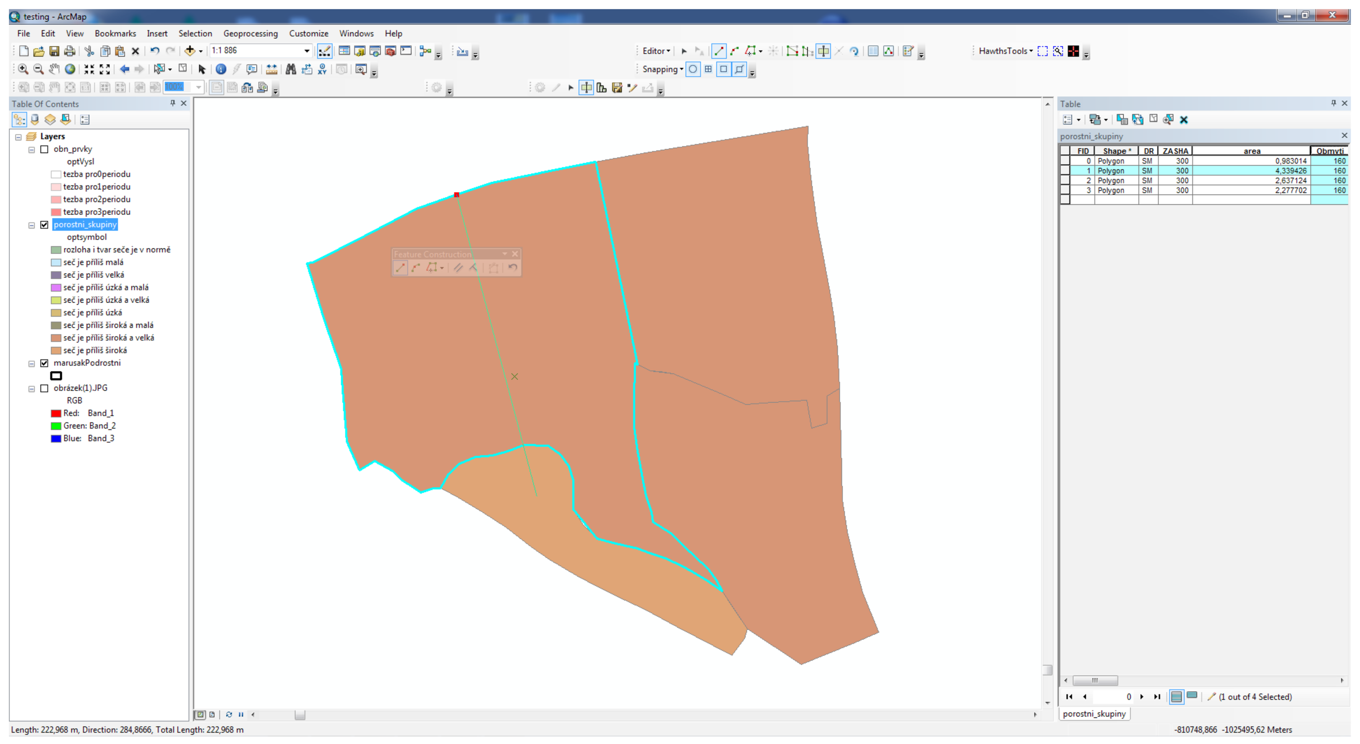
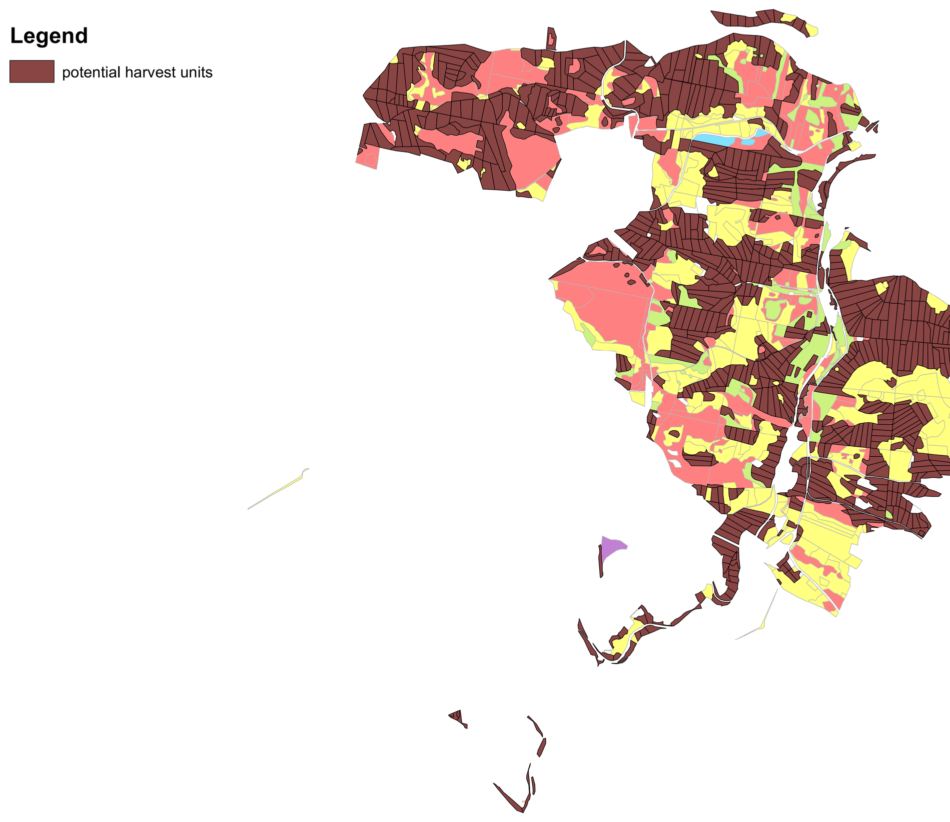


Figure 4. The potential harvest units



RESULTS

Using the GIS tool Optimal, forest management can be simulated by cutting polygons to create harvest units (Figure 3 and 4). Once the harvest units are created, the adjacency matrix is implemented and the data is transferred to the solver module. Solver performs calculation and returns a spatial distribution of harvest units for each harvest period for defined constraints. Figure 5 illustrates an example of allocation of harvest units for a 10% harvest flow.

Different variants of scheduling problem were calculated for FMA: (1) Adjacency constraints (Adj); (2) Harvest flow constraints (HF); (3) Combined adjacency and harvest-flow constraints (Adj + HF).

Sub variants of different harvest flow (0 – 60%) were calculated. Figure 6 presents the relationship between harvest flow percentage and harvested volume within a planning period. Figure 7 illustrates the relationship between harvest flow percentage and total harvest during the three planning periods. Results suggest what harvest flow percentage does not significantly increase total harvest. This can help to determine which minimal percentage of harvest flow should be used in forest management. In the presented FMA, the minimal percentage harvest flow should be 25%. Higher harvest flow percentage does not resulted in higher total harvest. Figure 8 presents a comparison of harvests with three alternative planning periods.

Figure 5. The optimal solution of spatial harvest distribution when 10% harvest flow is used

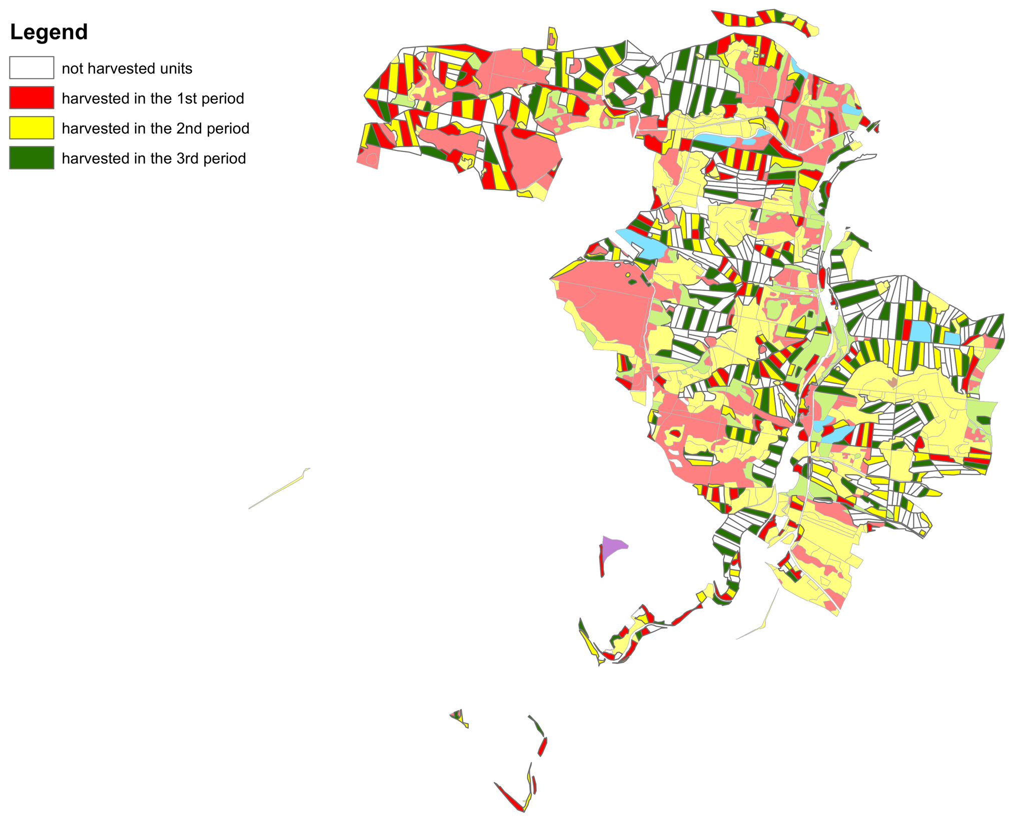


Figure 6. The harvested volume in the 1st, 2nd and 3rd planning period for different harvest flow percentages

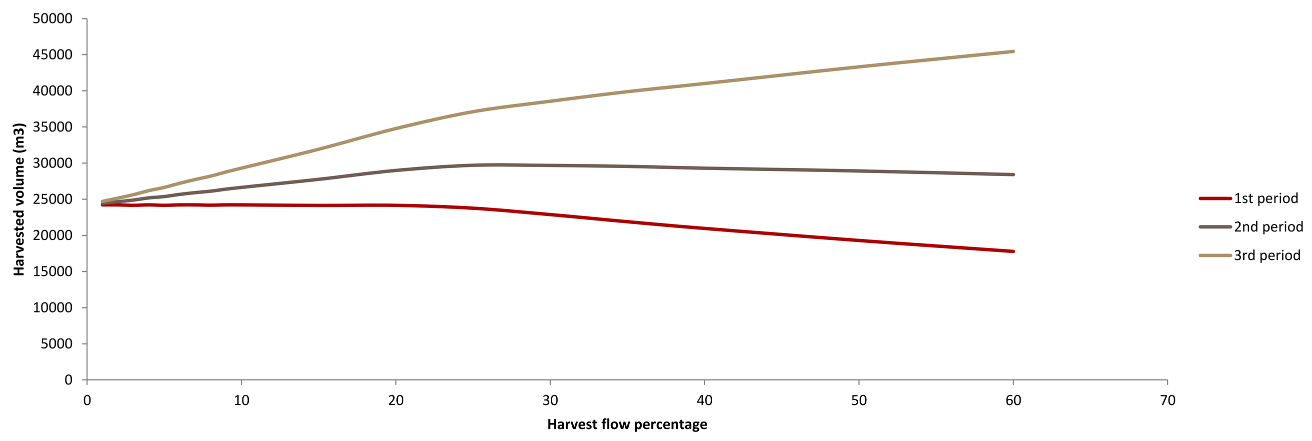


Figure 7. The total harvested volume for different harvest flow percentages

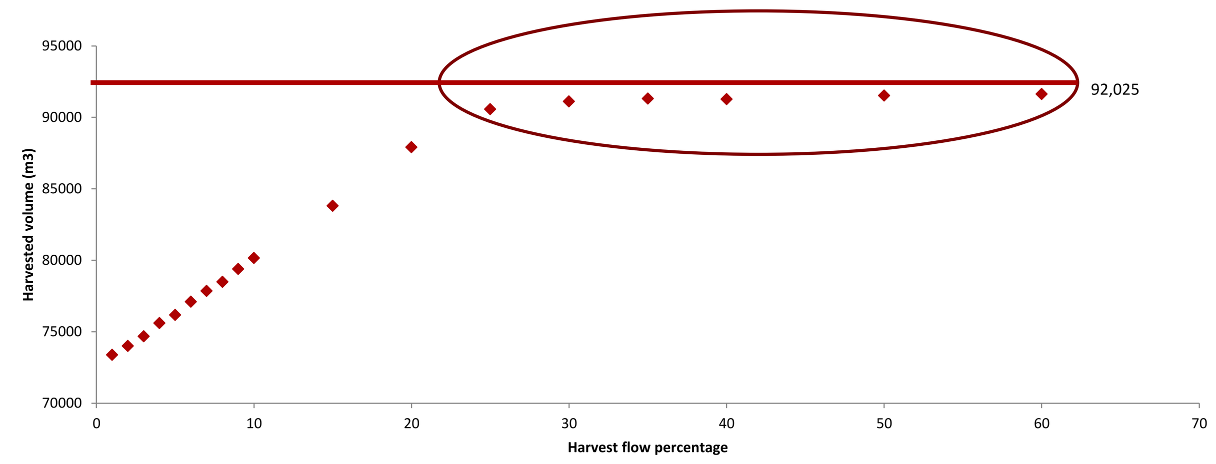
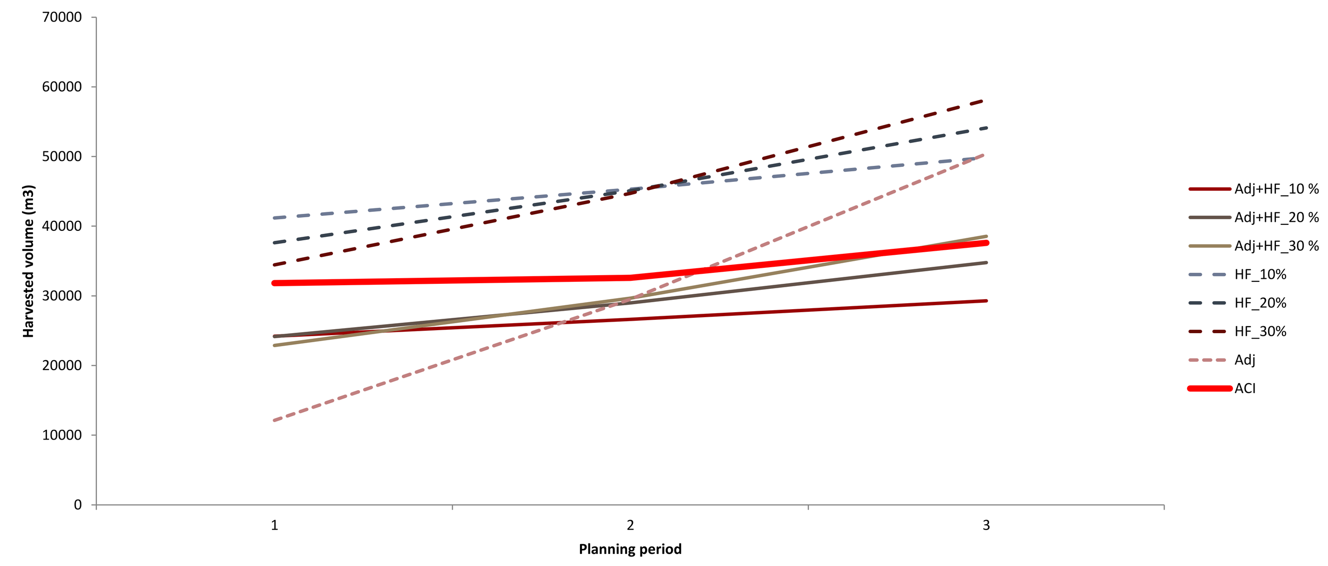


Figure 8. The harvested volume (estimated) over a planning horizon using alternative harvest scheduling



CONCLUSIONS

The results support that the system Optimal is a powerful tool for harvest scheduling for central Europe, especially in the Czech and Slovak Republic. Even though it can be used in other countries as decision support system Optimal includes tools for editing any kind of harvest units. It is concluded that there are advantages in using contrasting cut indicators, currently used in the Czech and Slovak Republic. The decision to support the system Optimal will be developed for other management systems and for non-productive forest functions such as biodiversity, water and soil protection, recreation etc.

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Optimal tools for optimal forest harvest planning