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Habilitation thesis: Methods of promoting integrated, proactive and predictive forest management, under risks and uncertainty conditions

(A) Abstract

This report synthesizes all the papers I published in the last two decades on forest planning, system analysis and forest economics. The document is organized in two main sections: scientific and professional achievement, and 2) further development plans, split into two tracts: research ideas, supposedly rendered into further doctoral theses, and educational initiatives. The first section starts with a brief resume of the research projects carried out before and after joining the USV team as consultant freelancer, followed by a list of research projects run through USV, including an ERASMUS plus project. The most important ones are further described in detail after reporting the editorial work carried out for Bucovina Forestiera. The main outcomes of the PhD thesis are summarized in a separate section, where I presented the articles published in the Czech journal *Lesnictvi* and *Revista pădurilor*. Two important papers are worth being mentioned in this context since important features of a modern forest management still hinges on those approaches: 1) a discriminant function for selecting the most appropriate silvicultural system for whatever mature stand, considering regeneration process and ecological compatibility between the light requirement of the main species and regeneration process, and 2) a marginal allocation scheme of investments in new forest roads, based on the highest ratio between money invested and incremental forest rent. The first model is important because the decision to select whatever more resource-demanding system, like group system or irregular shelterwood system, requires shorter hauling distances, and the importance of this parameter can be quantified. Having a discriminant function at hand, a sensitivity analysis may show the longest hauling distance to achieve in order to produce, on long term, the vertical structure required by the ecosystem services assigned to each future stand.

The third section is dedicated to multicriteria decision-making methods where a great deal of interest went to analytic network and hierarchical processes (ANP/AHP). All in all, I have published in English four different articles dealing with different decisional situations, and one article in Romanian language, dealing with an iterative group decision making process. Carrying out a sensitivity analysis on the inconsistency index, as if each and every decision-maker would have been excluded from the decision-making process, the AHP can be reiterated until a stopping condition is satisfied: be it either a certain threshold of the inconsistency index, or a given number of iterations. We also used the AHP in more complex situations, such as benefits, costs and risks analysis of choosing one or more alternatives of forest roads, resuming more or less the beloved topic of optimizing the forest accessibility. We grounded our model on a complex network of criteria in order to take into consideration economic, ecological, and social issues of having or not having a certain combination of forest roads in place. I also published two articles on ANP, one for ranking the four departments of Romanian forest districts, and the later one on setting up a new forest management unit for non-industrial forests.

The main contributions to forest planning consist of a new approach of maturity age, and two articles on integrating the GIS facilities into forest management. The classical model used for setting up the technical maturity (corresponding to the highest growth of the aimed grade) was improved in the sense that decaying rate is being taken into account. A recursive model assuming that a certain share of trees decays gradually from one quality class to the next one was developed and applied to better assess the annual expected forest rent. Moreover, considering two distributional patterns of the four quality classes in which trees are classified according to Romanian technical standards, I

explained how the actual tree quality can be incorporated into the decision-making process, considering two extreme and ideal situations: 1) all high quality trees are thickest ones, while the thinnest ones fetch low quality classes, and 2) a quite even distribution of the four quality classes among the four diameter classes. We operated with four diameter meta-classes in order to match the four quality classes and produce the two hypothetical distribution of the trees. For each extreme situation we estimated the forest rents and then we simulated a Monte Carlo distribution of the effective rents, between these two extreme situations, whose occurrence probabilities are supposed to be zero. In so doing we demonstrated that fine-tune adjustments are still possible because the optimal rotation of the beach and Norway spruce shall be 10-20 years lower. The new model behaves better for cop-piced oak stands supposed to be converted to high forests, where the optimal rotation shall be diminished to 70-90 years, while stands regenerated from natural seedlings can be harvested at much higher ages of 130-140 years.

Windthrows are quite common in Norway spruce stands and these disturbances have always been challenging the sustained yield principle. In order to incorporate these likely events into the forest planning, we combined a classical Markov chains model with a Bayesian one in order to foresee to which extent the amount of wood supposed to be harvested as salvage fellings shall be deducted from the annual allowable cut. Having no clue about the heavy storms that may occur in the next decade we assumed that regular winds are producing endemic wind-throw, being facilitated by slenderness, terrain conditions and whatever canopy gap nearby. The learning set of data refers to the disturbances produced between 1999 and 2009 in Brosteni forest district and the likelihoods of being affected by a windthrow in the coming decade have been estimated for the same stands, between 2009-2017. Finally, the Receiver Operating Characteristic methodology was applied in order to find out which permutation of facilitating factors produced the most reliable endemic windthrow probabilities.

Other important results refer to a combination of tradable permits and revolving bonds meant to encourage logging companies to adopt environmentally-friendly harvesting technologies. Having a set of factual data about the damages produced by seven logging companies, and assuming the social costs of damaging remnant trees, seedlings and soil will be internalized by the companies unable to perform high-quality harvesting operations, we demonstrated how less competitive companies went out of business after ten years.

Regarding the economic evaluation of the ecosystem services we produced, besides one documentary article, three important contributions: 1) a black-box approach on assessing the opportunity cost of deforestation (based on the change of the average runoff coefficient, produced by deforestation), and 2) an ANP approach of developing a guide to collecting the money needed for paying the ecosystem services.

The main contributions to the educational process are thoroughly described in the last section, starting with a spreadsheet solution to graduation test submitted by students prior to defending their final project, and ending with a series of research projects that might be developed in the years to come. All subjects taught at the Faculty of Forestry were also presented along with the main connections between disciplines.