



Universitatea
Transilvania
din Braşov

HABILITATION THESIS

SUMMARY

Title: Forest roads and wood quality – important factors in sustainable forest management

Domain: Forestry

Author: Assoc. Prof. Dr. Eng. Elena Camelia MUŞAT

Transilvania University of Braşov

BRAŞOV, 2024

The habilitation thesis represents, on the one hand, a natural continuation of the research addressed in the doctoral thesis with the title "*Research on the quality of standing trees in localities, parks, and street alignments*" defended at Transilvania University of Brașov, in 2011, on the quality assessment of wood from the trees growing in public areas of Brașov. On the other hand, the habilitation thesis also includes the results from the research performed during the teaching activity and research period after the PhD studies. The topics addressed are related to the subjects taught, more precisely the impact of fires on trees, the factors that lead to damage to people's health in the professional process and work accidents in the case of wood harvesting, the capitalization of the harvesting residues for energy purposes, the characteristics of the wood chips from short-rotation crops, and, of course, forest roads following sustainable forest management.

A synthesis of these concerns and studies is further presented in the habilitation thesis entitled "*Forest roads and wood quality - important factors in sustainable forest management*", structured in two parts corresponding to the two research directions addressed. The first part includes five chapters that address various aspects related to forest roads according to the current level of forest accessibility and the consequences of increasing the load capacity of vehicles used for wood transport. The second part focuses on the quality of wood and the wood resources that can be used to meet the demands of today's society, which is in continuous development and requires an increasing volume of high-quality wood.

The first chapter presents a short introduction regarding wood transport and forest roads network, and also some general information related to wood quality. At the end of the first chapter are presented the scientific publications which support the habilitation thesis.

The second chapter of the habilitation thesis, entitled "*Evolution over time of the forest road network and its impact on the environment*" is structured on the two objectives pursued. In the first part, information regarding the evolution over time of the transport routes in Romania is provided, starting from the transport by railways and water and reaching a greater expansion of road forest transport. In this context, a situation of the forest roads network under the management of the largest administrator of forests and forest roads in Romania - National Forest Administration Romsilva, is presented. The second part of the chapter explains the impact of forest roads on the environment, from the design stage to the execution stage and then to the use stage, presenting the effects of these investment objectives on the soil, water, flora, and fauna.

The selection of suitable routes for the forest roads in the design stage can lead to the protection of the threatened areas, and the negative effects on the environment can be somehow limited. The construction phase has the greatest negative impact on the environment and thus the choice of materials, working technologies, and, above all, the machinery to carry out the work present importance, especially in the limitation of unwanted effects on the soil.

The third chapter of the habilitation thesis, entitled "*Timber transport in Romania*" addresses three objectives. The first objective refers to the monitoring of timber transport in the case of a main forest road, in terms of the volumes transported and vehicles used. The second objective concerns the specific transport distances of the wood intended for both local beneficiaries and companies dealing with wood processing. Both the transport distances and volumes transported by species and assortments as well as the vehicles used for transport are

analyzed. The third problem addressed in this chapter refers to the loading process in high-capacity vehicles and discusses aspects corresponding to the methods of loading round wood in forest trucks and forest platforms, the structure of the wood loading process on specific working phases, as well as issues related to productivity and the stationary times imposed if the wood reaches large processing mills.

It was noticed that the wood from the forests managed by the state through the forest districts or public institutions administrating the forests owned by local public administrations reaches mainly the local beneficiaries but also other wood processing companies. In addition, the transports with low volumes of multi-species involve short distances from the loading points to the first or the only unloading point. The type of vehicle used to transport wood can greatly influence the loaded volume for transport, but also in a load, so at the forestry platforms, the loading is done with cables, which allows the loading of several pieces at once. This leads to longer durations related to each loaded load, and also a reduced loading of means of transport. On the other hand, with forestry trucks, the loading capacity can be achieved relatively easily, because the logs are loaded one by one and can be properly placed to ensure stability during transport and efficiency.

The fourth chapter entitled "*The impact of tonnage on the bearing capacity of forest roads*" presents, in the first part, the results regarding the degradations identified on paved forest roads, as a result of traffic, large volumes transported to a race, unfavorable weather conditions that the transport was carried out, but also the failure to carry out maintenance and repair works on time. In the second part of the chapter, simulations using the finite element method for evaluating the behavior of road structures under the action of traffic, characterized either by different vehicles or different loads are presented.

These aspects are particularly important because the maximum permissible total mass for trucks with trailers and, implicitly, the mass of transport trucks have undergone significant increases in a short time, which delayed the investments in forest roads to ensure an adequate bearing capacity. In addition, the greatest degradation occurs in the months with the most transports and the highest volume, and the most common degradations were ruts and pits. As a result of the simulations carried out using the finite element method, it was found that the foundation soil is one of the main elements that influence the bearing capacity of forest roads, which increases or decreases according to whether the quality of the foundation soil is better or weaker. However, by increasing the quality of stone materials in the road structure, small increases in the bearing capacity of forest roads are obtained, which, once again, supports the recommendation to use local stone materials. However, by increasing the thickness of the road layers as well as by adding new road layers during road rehabilitation, a slight improvement in the bearing capacity of the roadway is obtained.

Chapter five, entitled "*Possibilities of ensuring the costs imposed by the extension of the forest transport network*", focused on two research directions. The first one presents possible variants through which a fee can be charged for the utilization of the forest road network, to set a fund for the construction, maintenance, repair, and rehabilitation of forest roads. The second part of the chapter presents cost comparisons imposed by the execution of forest roads in various areas of the country, assuming that these investments are made by the administrator's forces (under his direction) or with the help of specialized companies (with third parties).

Taking into account all four stated principles, each with its advantages and disadvantages, it can be said that only principle 2 can be applied uniformly, at the level of the entire country, ensuring the collection of taxes before the start of the transport. But due to the

legislative regulations in force, it cannot be applied, which means that principle 3, which refers to the payment of a "forest transport vignette", becomes applicable. In addition, in the case of self-executed works, both the cost of stone materials and their transport are higher, which is identified with the higher values of works involving large quantities of stone materials. Another factor that can justify the higher values in the case of works carried out in-house consists in the insufficient provision of forestry departments with machinery specific to forest roads, which requires their rental from companies or Administrative-Territorial Units, of course with repercussions on the price of the work carried out.

The second part of the habilitation thesis focuses on the characteristics of the trees, wood quality, and the factors that can lead to a reduction in the wood quality or a significant loss of wood. These aspects are very important in the actual context when the demand for wood and wood products is in continuous growth.

Chapter six, entitled "*Dimensional characteristics, defects and stability of trees in urban green areas and in alignments*", addresses aspects of maintaining, as long as possible, the trees in public areas. Thus, issues regarding the tree species in the green spaces and their sizes are discussed. In addition, information and results are presented regarding the factors that influence the stability of trees, and finally, the investigations carried out with the tomograph and the resistograph to evaluate the internal quality of the wood and the defects that can endanger the development and longevity of the trees in the green areas.

It was found that trees in the cities, located either in the parks or along the streets, present a large number of defects that can affect their stability. The species most affected by the defects were the horse chestnut affected by multiple curves and knots, respectively the maple, in which ovality, forking, hollows, and frost-cracks predominated. The negative impact of defects, especially rot, in reducing the overall resistance of the trees to the wind and, therefore, the stability of the action of disturbing factors, was also emphasized. The black poplar trees in the alignment have crowns developed at a high height, which reduces the slenderness coefficient; they have trunks with a pronounced taper and a well-developed root system. All these lead to the good behavior of the trees under the direct action of the wind, keeping them stable. On the other hand, non-destructive or almost non-destructive techniques, such as acoustic tomograms, can be used successfully in investigations aimed at determining the changes inside the trunk, the reconstructed images providing information about the sound propagation speeds through the wood, at the analyzed level, but not for the entire trunk. In addition, the analysis of sound speeds does not reveal the type of defect, it still indicates areas of lower density that have a negative influence on sound propagation through the wood.

Chapter seven entitled "*Impact of forest fires on wood quality and subsequent tree development*", presents findings on forest fires that cause so much damage to the forest sector, reducing biodiversity and affecting trees in burned areas. To highlight the impact of different types of fires on wood quality and subsequent tree development, research was carried out in various locations in the country, with different characteristics. Thus, spruce, hornbeam, and beech that remained in the plots affected by underground or litter fires and tried to continue their existence have been evaluated.

Spruce trees left after a fire, some with a good state of vegetation but with wounds on the trunk, some with the tips already dry, and others completely dry, have inside areas with different stages of wood decay, arranged centrally or marginal on the surface of the section,

with proportions that differ from specimen to specimen. According to the results obtained by using the tomograph on hornbeam trees, some trees can be considered healthy because the sound propagation speeds through the wood have been increased, others show some small internal anomalies, but there are also trees that have shown clear signs of a decrease in wood quality. The presence of the red heartwood inside the trunk influenced the overall transfer speeds of the sounds between the sensors, which were higher when the sound wave crossed the red heart.

Chapter eight, entitled "*Wood resources in the current context - Losses and possibilities*", refers to the solutions that can be adopted to ensure quantities of wood that can be sustainably exploited to balance, to some extent, the growing demand for wood worldwide, due to the increase in the world's population and of the standard of living, given that, currently, catastrophic events, such as forest fires and windfalls, are more and more frequent and violent. The chapter presents results related to the valorization of harvesting residues and the dimensional characteristics of wood chips from crops with a short rotation cycle, being presented also aspects related to the humidity of the energy willow chips. Since the forest vegetation is very diverse in our country, some solutions are presented to capitalize on the potential of some species to improve the properties of the soil and to protect the roads from snowfall through blizzards, in the context of obtaining wood and forest fruits, as additional benefits.

It is particularly important to know the alternatives to obtain wood material suitable for certain uses, which do not require either high-quality raw material or large dimensions. To supplement the amounts of wood that can be used for energy purposes or even for the production of wood chip boards, it is important to utilize the harvesting residues and the fast-growing species. In addition, forest vegetation in various associations can help protect agricultural crops and communication routes by creating protective forest curtains. These, in addition to their protective role, can also provide, at certain time intervals, a certain amount of wood that can be used. Although the role of protective forest curtains is well-known, research has been developed in recent decades, focusing on the benefits offered for agriculture, stopping or slowing down the erosion processes of degraded lands, knowledge of the habitats created within the forest protective curtains and the protection of various objectives through changes in wind speed and direction, with direct implications on the effects they have in the case of sandstorms and snowfalls produced during the winter.