INFLUENCE OF SOME FACTORS ON THE DENSITY OF FOREST ROADS IN THE SKIDDING WITH ANIMALS

TRAJANOV Z., NESTOROVSKI Lj., TRAJKOV P.

Ss. Cyril and Methodius University in Skopje, Faculty of Forestry in Skopje, Skopje, Macedonia
Correspondig author e-mail address: ztrajanov@sf.ukim.edu.mk

ABSTRACT: In the paper are presented the results from the investigation of the optimal density of forest roads. We know from practice that there isn't universal solution to open forests and determine the optimal density of forest roads. In this research paper will analyze the density of forest roads in the skidding with animals (horse). Animals skidding as traditional still which occupies an important place in practice in Macedonian forestry. Several factors affect the solution for optimal density of forest roads because it is necessary to analyze the impact of these factors on the final solution. The obtained solutions represent a basis for solving the forest transportation practice.
Keywords: forest, roads, optimal density, animals, skidding

1 INTRODUCTION

In Republic of Macedonia skidding with horses is very widespread and has a long tradition. In practice, a part of the log skidding nowadays is done by horses (drags), and a great percentage of the firewood skidding is done by horses (pack-saddled). Recently, there has been an abandonment of this kind of skidding, but it will continue to exist in the future.

In practice, the transport of wood assortments is the most expensive phase of the direct process of production. Therefore, a need to find a solution for calculating the minimal expenses for transport is imposed, in a situation when all the planned activities of forest management would be successfully fulfilled.

There is a direct dependence between the minimal expenses of skidding and the optimal solution of the forest road network which can be expressed by: density of road network, spatial arrangement, and quality of roads. With that, the network of forest roads should evenly open the whole area, where the evenness doesn't refer to the distance between roads, but it refers to economic needs, economic significance and environmental importance of specific parts of the forest.
Field researches have been carried out on the mountain Plackovica, in the area Leva Reka. The relief of the terrain is medium developed, crissed-crossed by many smaller or bigger watercourses. The gradient of the terrain varies, on average it is 41%. The geological base is silicate and above it there is dark brown forest soil – Districhen kambisol. Rarely, the rocks come out on the surface and usually they are isolated smaller amounts. The climate is continental, i.e. mountainous. In conditions like these, the community of beech tree forest is developed, ass. Fagetum montanum, where the dominant wood type is the beech tree.

Beside the beech trees, in the earthbound part, grass plants and bushes can be isolated too. From a theoretical viewpoint, in the calculations a period of 100 years is being analyzed. This period coincides with the felling cycle of reproductive woodcutting. In that way, with the help of the felling cycle, one can define the volume of wood which will be used in a certain area for a specific time, time during which all the roads will be built in order to finish the woodcutting in every part of the area, as well as prompt and correct fulfillment of the protection and cultivation tasks in the forest. In these researches a situation has been analyzed, in which the truck roads are storey-placed in the area, one above the other. Therefore, the skidding is done by using four operations, such as:

skidding of technical wood in increase, skidding of technical wood in fall, skidding of firewood in increase, and skidding of firewood in fall. Skidding with horses is done by a common technology of working.

2 METHOD OF WORKING

The methodology described in Z. Trajanov's doctoral thesis [3] has been used in the production of this scientific paper. Therefore, one should begin with the following mathematical principles.

The optimal density of road network is calculated by differential calculations, i.e. the first deduction from the total costs for transport.

The equation (1) is used for calculating the optimal density of road network for wood transport.

$$\frac{DTsum}{DGkp} = 0 \qquad (1)$$

Total costs for horse skidding - *Tsuma,* are calculated with the equation (2).

$$Tsuma = Ta + Tkp + Tav \qquad (2)$$

Tkp – costs for truck roads
Tav – costs for animal drags
Ta – costs for horse skidding

This formula is the basis for calculating the optimal density of road network. Similar methodology has also been used in other researches from this area, in the Republic of Macedonia, researches of R. Akimovski (2). The reason why this methodology is being used, as well as the introduction of changes, is because of the new mathematical software which can solve complicated problems. Therefore, in contrast to the past situations when many parameters have been neglected in order to get simpler formulae for calculation, the new software solutions do not put limits to the number of unknown parameters and the combining of various mathematical operations. The new software also provides us with flexibility, i.e. easy calculations for each situation separately, all in order to get more accurate results. This paper will analyze the solutions obtained for a specific situation in the practice of skidding of wood assortments with horses, in the mountain Plackovica in Republic of Macedonia.

3 RESULTS FROM THE RESEARCH

This mathematical model for estimating the optimal density of road network as a basis for calculations takes the economic parameters, i.e. estimation of the minimal costs for a specific situation. The other functions of the road network are adjusted according to the result obtained. It means that the result obtained will go through as many transformations as needed, imposed by the other non-economic characteristics of the forest viewed by sociological, tourist, recreational, economic and environmental aspect.

The zones of optimal costs are best shown by a three-dimensional presentation. The costs of horse skidding in relation to the extent of using the volume of wood in the course of the period analyzed and the dependence from the density of road network is shown in diagram 1.
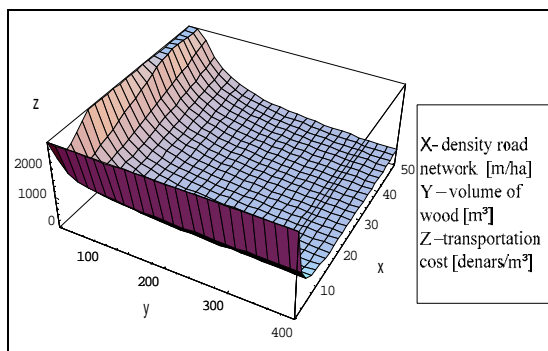

Diagram 1: Relation of the total costs of horse skidding to the volume of wood and the density of road network (1 euro = 61,5 denars)

From the diagram one can see that the costs are the biggest when using small volume of wood and in situations when there is little density of the road network. With increasing of the road density, as well as of the volume of wood, at the beginning the costs decrease intensively so that later they will start to decrease moderately.

3.1 Influence of the quantity and the quality of the forest which is being managed

The potential of the forest, such as the volume of woodcutting in quantity and quality, have influence on the optimal density of the road network.

On the basis of the methodology presented, one can establish a connection between the density of the road network and the volume of wood which is used in forest management in the course of the analyzed period of 100 years. At that, the optimal density is analyzed in four situations with different portions of the firewood (0.3, 0.6, 0.9, and 1.0) in relation to the total volume of wood which is used in the course of the analyzed period. Data about the optimal density of the road network in relation to the volume of wood is given in table I.

Table I: Optimal density of the road network in relation to the quantity of the volume of wood and the portions of firewood

$Q[m^3/ha]$	50	150	250	350	450	500
coefficient	Gkp [m/ha]					
firewood (0,3)	9,8	19,5	26,6	30,3	34,2	36,0
firewood (0,6)	8,4	17,1	22,7	27,0	30,6	32,3
firewood (0,9)	6,8	14,2	19,3	23,1	26,4	27,8
firewood (1,0)	6,3	13,1	17,9	21,7	24,7	26,1

The results obtained for the optimal density of the truck road network in relation to the volume of wood, as well as to the portions of firewood, are graphically shown in diagram No.2.
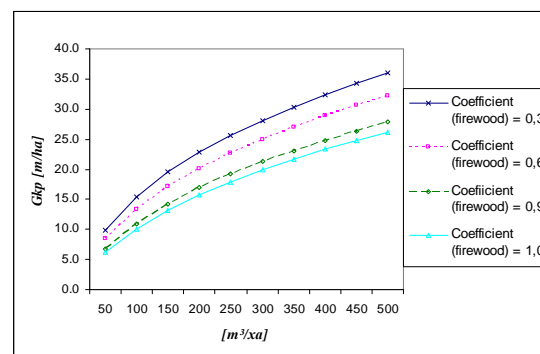

Diagram 2: Optimal density of the truck road network in relation to the quantity of the volume of wood and the portions of firewood

From the chart and the diagram, one can see that with the increase of the used volume of wood, there is also an increase of the optimal density of the road network. Moreover, if the portions of firewood are bigger, the density of the road network decreases even more.

If, under the same circumstances, only one parameter is being analyzed, one will see how it can influence the solution. In that way, when using on average 300 m^3/ha a year for the analyzed period of 100 years, and under the same circumstances of working, the following analyses can be received.

3.2 Influence of the technology of working, viewed by the length of working hours and efficient use of those working hours

The organization of the working process i.e. the choice of technology of work, as well as the efficient use of working hours, have an influence on the costs of transport. Therefore, there is an influence of the technology of working on the density of the road network.

The influence of the length of working hours for skidding of wood assortments in relation to the optimal density of the road network is graphically shown in diagram 3.
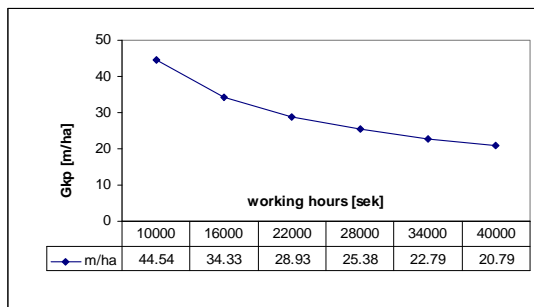
Diagram 3: Influence of the working hours during the day on the optimal density of the road network

The extension of working hours decreases the costs for skidding, i.e. it influences the decrease of the optimal density of road network. Therefore, in practice, all the factors which can shorten the normal working hours during the day should be avoided. In the practice, in Republic of Macedonia, a considerably negative model is the model of daily transport of the workers to their place of work. With such organizational arrangement, great losses have been made because of the lower productivity in working.

Despite the length of working hours, an important parameter is also the efficient use of those working hours, i.e. – a coefficient of efficient use of the working hours (index – k).
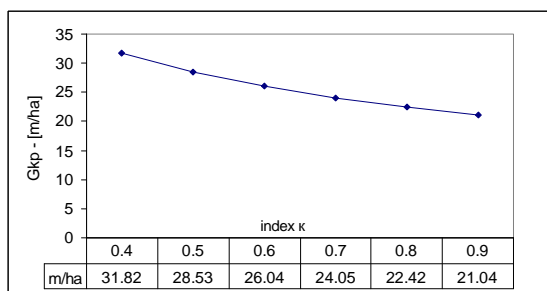

Diagram 4: Influence of index k – coefficient of efficient use of working hours – on the optimal density of road network

The influence of index k – coefficient of efficient use of working hours – on the optimal density of the road network, for the analyzed models, is shown in diagram 4. From the graphic presentation one can see that the optimal density decreases with the increase of the efficient use of working hours, i.e. by avoiding the stagnations in the working process.

3.3 Influence of the spatial arrangement of roads and the choice of the direction for skidding (factor x)

The choice of the type of skidding, in increase and in fall, is also a factor which can make a certain technology of working better or worse. By making the right choice whether certain assortments will be skidded in increase or in fall, the time for skidding can be shortened and with that the costs for skidding will be reduced as well.

The coefficient xa is a part (fraction) from the distance between truck roads Rkp, which should optimally be skidded in increase at the horse skidding.

According to the model covered by Z. Trajanov [3], with the help of analyzing the optimal time for skidding

of all the assortments in a certain coppice, a theoretical model for determining the value of factor xa has been obtained.

With the help of differential estimating, i.e. by calculating the first deduction of xa by using the above mentioned technology, the value of xa can be established as 0.24. It means that the skidding would be made most optimally if 24% of the volume of wood which gravitates to the higher road, i.e. increase should be skidded in increase, and the rest should be skidded in fall. From this relation one can come to a quite logical conclusion that the horse while skidding in increase will not achieve good performance.

The data of the dependence of coefficient x or the area which would be skidded in increase in relation to the optimal road network is shown in diagram 5.
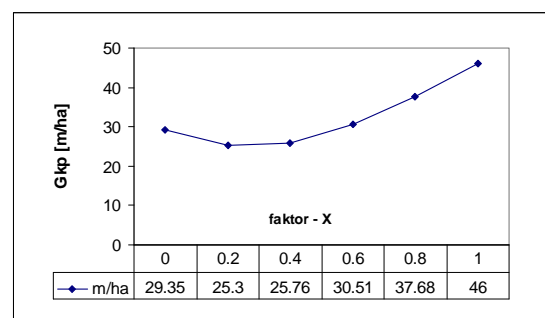

Diagram 5: Influence of coefficient x – the area which is skidded- on the optimal density of road network

The trend of optimal density decreases with the increase of coefficient x to a certain value, i.e. it reaches a minimum of the index at 0.24, after which there is a trend of increasing of the density of road network.

3.4 Influence of the non-economic aspects for opening the forest

Unlike the factors which are related to forest management and which can be calculated, in practice, the solution of the optimal density of the road network depends on many other factors which are not related to the forest management and which can not be expressed by a value. Thus, in practice, it is often necessary to build roads which will connect certain settlements, tourist facilities, recreational facilities, economic facilities, hunting facilities and so on. Also, it is of no less importance the significance of forest roads in relation to protection in general, primarily to protection from forest fire. Therefore, in practice, one should find a solution where the road would be multi-functional, and by doing so, one would get a good solution viewed from many different aspects, such as: functional, financial, economic and environmental aspect. In the end the projection of the road network should meet all the requirements of the forest.

4   CONCLUSIONS

- There is no universal solution to the problem of optimal density of the road network. A reason for that are the numerous parameters with a changeable character, which also have an influence on the optimization of the costs for transport.

- As a basis for estimating the optimal density of road network, one takes the economic effect from working. Despite this basis, the solution would go through further corrections so that all the planned non-economic activities in the forest could be fulfilled.
- With the increase of the volume of wood which would be used in the analyzed period, the density of the road network increases as well.
- With the increase of the portions of firewood in the volume of wood which would be used in the course of the analyzed period, there is a decrease of the optimal density of the road network.
- With the extension of working hours during the work day, the optimal density of the road network is decreased.
- With the increase of the efficient use of working hours during the day, the optimal density of the road network is decreased.
- An ideal fraction of the distance between truck roads which should be skidded in increase is 0.24, whereas in fall a fraction of 0.76 should be skidded. The closer we are to the ideal fraction, the more the optimal density of road network decreases and then one can make the smallest costs in the process of transport.
- In practice, one must find a projection of the road network which would express a compromise of all the requirements of the forest.

5 REFERENCES

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