Argumentation of Optimum Road Density in the Forests of Ukraine

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Abstract:
The state of forest roads network in Ukraine and some countries of Europe is analyzed. The optimum values of forest roads density are substantiated for different geomorphologic conditions on the basis of analysis of forest road planning results.

Keywords: forest roads network conditions, model of timber transport development, density of forest roads network.

1 Introduction

Forest roads is a kind of entrance to the forest areas, the possibility of providing its essential functions, rational and ecologically safe use of natural resources, effective functioning of the tourism and recreation industry. Transport routes play a critical role at the forestry production of mountainous area, where forest areas are scattered over a large territory and such territory has the following characteristic features: difficult relief and soil-hydrological conditions, low concentration of harvestable timber per unit area, one-sided cargo traffic and other factors are. The development of road networks in forested areas has a positive effect on the intensification and expansion of opportunities for many sectors of the economy and, promote the population with the employment, reduction of staff turnover, improvement of working and living conditions of the population. But so far in Ukraine there is not any concept concerning the extension of forest roads network with the recommendations regarding its main parameters and choice of technology of primary timber transportation. The aim of this study is to substantiate the optimal density of forest road network in different geomorphological regions of Ukraine under the conditions of the economically viable use of promising timber transport means.

2 The forest road network condition

It should be noted that the work concerning the investigations of the road network condition of the forest areas in Ukraine, its assessment and inventory are nearly absent. Therefore at first we analyze the data concerning other countries, in particular those that have natural and geomorphological conditions similar to Ukraine. The study [9] provides a detailed analysis of forest access network in neighboring Slovakia, which according to its location, structure and density, should ensure optimal transport accessibility of forestland. Forest access network of this country includes forest road network (Table. 1), intended for the timber hauling by trucks and the skid road network, intended for the timber skidding by tractor means, and in some cases, and under favorable conditions, for the timber hauling by trucks.

Table 1: Characteristics of forest transport network in Slovakia

Type	Forest roads		Skid roads
Category	1L	2L	Tractor road
Purpose	Main hauling	Local hauling	Skidding
Peculiarities	- year-round use; - high traffic density	- seasonal use	- unsurfaced road; - constructed acc. to the parameters of the forest roadbed
Maximum longitudinal slope, %	up to 10 (12)	up to10 (12)	up to 12
Permissible contact pressure, кPa	650 +	450-550	450
General length*, km	8 534,2/5 842, 0	11 608,3/11 092,9	13 934,1
Density, m/ha	4,43/3,03	6,01/5,74	7,23

Note: * - as of 1997; in the denominator - road of forestry enterprises.

As seen from the Table. 1, the majority of the forest roads (84%) and all the skid roads are owned by the forestry enterprises. Overall length of forest road network is 34 076.6 km, which determines its density - 17.67 m / ha. However, if one takes into account only forest roads, their density is 10.44 m / ha (that is similar to Ukrainian indicator). According to the recommendations of scientists (Dvorščák P., 1997; Klč P., 1997) the optimal density of the forest road network for the geomorphological conditions of Slovakia should be about 20 m / ha, providing the road interval within 400-600 m.

Similar recommendations exist for other European countries that basically have been already implemented (Table. 2) (Dvorščák P., 1997). According to statistics, the total length of roads in the forests of the State Forestry Committee of Ukraine in 2007 was 74.4 thousand km (among them around 17 thousand km (22,8 %) – public roads, which runs through the State Forest Fund) (Prystya O. D., 2008). The density of forest road network is 10,1 m/ha (excluding public roads - 7,8 m / ha). Moreover, this is average index, to which relatively extensive network of roads in low-lying parts of the region significantly affects. In the foothills and in particular the mountain areas this index is much lower and according to our assumptions it varies in the range of 3,5-6 m / ha. This index was obtained by summarizing the data of our own researches (Rozhanka forestry unit of State Enterprise «Slavske forestry») (Styranivsky O. A. and Styranivsky Yu. O., 2010), and – researches of Ukrainian Research Institute of Mountain Forestry (State Enterprise «Osmoloda forestry», State Enterprise «Velykyy Bychkiv forestry» and Nyzhniy Bystryy forestry unit of State Enterprise «Khust forestry») (Boychuk, I. and Korzhov, V., 2005; Korzhov, V. L. and Roman D. I., 2004). Around 40 % forest areas have the road density less than 4 м/га. Mountain forest areas, where the density of roads exceeds 10 m / ha is less than 2% (Parpan, V. I., Korzhov, V. L., Korniyenko, V. P. and Sydoryk, Yu. K., 2005). Very often, forest roads are in unserviceable condition. In particular, in Nyzhniy Bystryy forestry unit the percentage of the forest roads that need repair or reconstruction is 31.5%.

To forest transport network it is usually referred unsurfaced or so-called "tractor" roads, which, unlike Slovakia ones, are constructed without complying with the standards of road construction (they are not equipped with the drainage systems, slope of separate parts is more than 30%, the width of roadbed is mostly less than 4 meters).

Table 2: The density of forest road network in some European countries

Country	Description (name) of the region	Density of the forest road network, m/ha
Switzerland	Plain	54
	Jura Mountains	42
	Foothills	16
	Alps	7
Austria	Small areas (up 200 ha)	37,1
	Forest areas (over 200 ha)	29,7
	State forests	22,3
Sweden	Mountain forests	33,3 (8,6)
	Southern part	20,8
	Central part	12,0
	Northern part	7,1
Germany		up to 55 (from 10)

Note: in brackets - protected forests.

Even according to these, scattered data, we can conclude that the technical state and main parameters available forest transport network in the Forest Fund of Ukraine does not meet the requirements of sustainable development of forestry, its density is several times lower compared with the European countries with similar geomorphological conditions.

3 Modeling of the forest transport development

In order to provide argumentation of optimum density of road network and means of primary wood transportation we have elaborated a conceptual model of transport development of forest areas, and its algorithm contains the evaluation of all possible expenses for timber skidding, that is a function of roads network density (Styranivsky O. A. and Styranivsky Yu. O., 2004) (Fig.1).

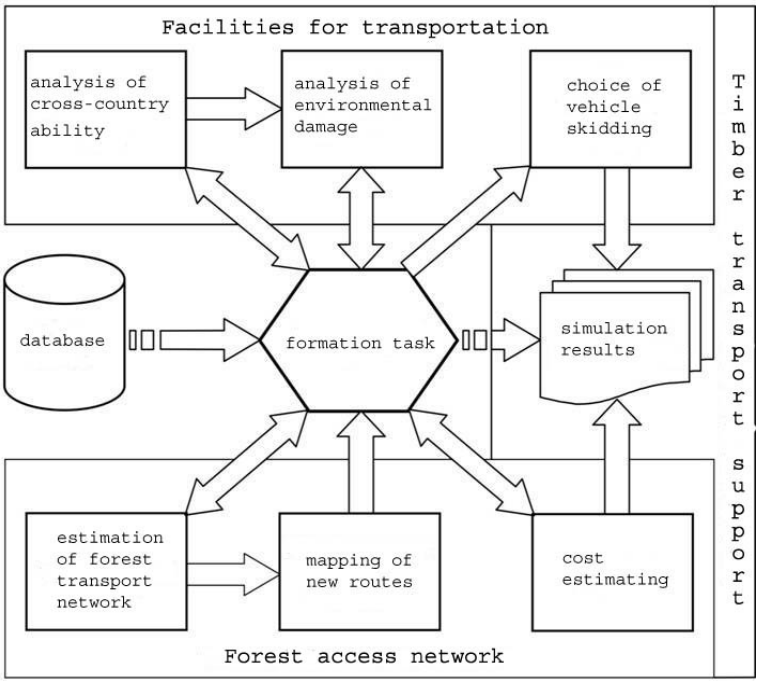

Figure 1: Conceptual model of the planning of forest transport development

One of the blocks of the developed model contains mathematical relations that describe the relationship between the density of the forest road network (DRN) and road interval **s**.

$$s = c_n \cdot c_s / DRN, \quad (1)$$

where c_s – corrective coefficient of slope $c_S = \cos\nu / \cos\eta$; c_n - corrective coefficient of the forest road network; ν - maximum longitudinal gradient of forest road; η – slope terrain.

Equation (1) can be written for the length of skid roads l_{sr}.

$$l_{sr} = c_{sr} \cdot c_n \cdot c_s / DRN, \quad (2)$$

where c_{sr} – corrective coefficient skidding network, which takes into account the angle of contact of skidding lines to the forest automobile road.

The value of **s** is a parameter of transport availability and equals to maximum skidding distance or doubled value under the condition of transportation, respectively, only down the hill (skidder), or up and down the slope (cable system, skidder on the plains).

In the a result of the performed modeling of the transport development of forest areas the relations of density of forest transport network from skidding distance were obtained (Fig. 2). These relations relate to wood skidding up and down the slope.

4 Research results

Basing on the performed investigations economically reasonable distance of wood skidding by the means of cableway (350-400 m) and skidder (600-800 m) was determined, as well as the optimal density of the forest roads network for different geomorphological regions of Ukraine that corresponds to this values:

- Carpathian mountainous area (steep hills, slope over 20°), wood skidding by the means of cableway up and down the hill to a distance of 400 m - 17,5-19,0 m/ha;
- Carpathian mountainous area (sloping hills, slope 11°-20°), wood skidding by the means of wheeled skidder down the hill to a distance of 800 m – 16,7-18,0 m/ha;
- flat and hilly terrain (slope up to 10°), wood skidding by the means of skidder up and down the hill to a distance of 600 m – about 11 m/ha.

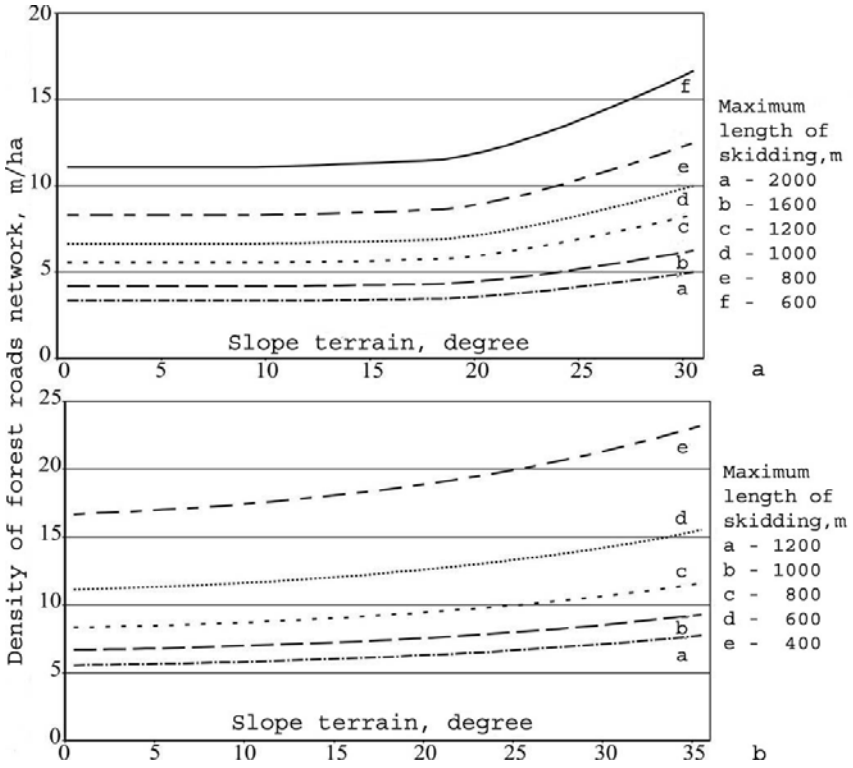

Figure 2: Dependence forest road network density from slope terrain, where skidding perform by: a – wheeled skidder; b –cable crane

According to the recommendation of State Forestry Committee of Ukraine (now - State Forest Resource Agency) forestry companies must construct at their own expense 1 km of forest road for every 25 thousand m^3 of final harvest. So, considering that the planned annual volume of final harvest is about 6,4 mil m^3, we can determine the annual construction of forest road at expense of forestry companies – more than 250 km. But the total annual demand in the construction of forest road is about 500 km estimated State Forest Resource Agency (Prystya O. D., 2010). This means that the construction of no less 250 km of forest roads should be financed from State Budget to maintain competitiveness of Ukrainian forestry companies.

5 Conclusions

Conditions forest road network is largely affects the efficiency of forest management in any natural and geomorphological conditions. Forest road network of Ukraine currently doesn't meet the sustainable development of forestry sector, because of it in short term before Ukrainian foresters must be delivered the following urgent tasks:

- to conduct a detailed accounting, inventory and condition inspection, and subsequently to monitor the forest road network with the representation of results in tabular and cartographic form, the most using modern GPS and GIS technology;
- to develop a plan of forest access network initially for some model forestry and then for all geomorphological regions;
- provide increased density of forest road network in mountainous regions, on average to 17 m/ha, and in the plains - at least 11 m/ha, while respecting the annual volume of construction about 500 km of new forest roads, including no less than 250 km at expense of forestry companies.

6 References

Boychuk, I. and Korzhov, V. (2005): Forest Road Network. *Lisovyy i Myslyvskyy Zhurnal* 4, 26-27, (in Ukrainian).

Korzhov, V. L. and Roman, D. I. (2004): Definitions and Technical Condition of the Road Network in Forests of SE "Velykyy Bychkiv Forestry". *Lisova inzheneria: tehnika, tehnologia i dovkillya. Naykovyy visnyk UkrDLTU* 14.3, 446-452, (in Ukrainian).

Parpan, V. I., Korzhov, V. L., Korniyenko, V. P. and Sydoryk, Yu. K. (2005): On the problem ecologization of mountain logging. *Proceedings of the International Conference „Naykovi osnovy vedennya staloho lisovoho gospodarstva", Ivano-Frankivsk*, 203-206, (in Ukrainian).

Prystya, O. D. (2008): The problem of sustainable development wood transport infrastructure and its solving. *Avtoshlyahovyk* 5(205), 46-48, (in Ukrainian).

Prystya, O. D. (2010): Saving forest. *Alternativnoe toplivo* 4(32), 32-37, (in Russian).

Styranivsky, O. A. and Styranivsky, Yu. O. (2004): Argumentation of transport development of mountain forest areas. *Lisova inzheneria: tehnika, tehnologia i dovkillya. Naykovyy visnyk UkrDLTU* 14.3, 371-380, (in Ukrainian).

Styranivsky, O. A. and Styranivsky, Yu. O. (2010): Ecological principles of transport development of mountainous forest areas. *Lviv: NLTU*, 208, (in Ukrainian).

Dvorščák, P. (1997): Ako dalej vo výstavbe lesných ciest na Slovensku? *Les* 7, 25-27, (in Slovak).

Klč, P. (1997): Sučasný stav a perspektivy realizácie lesných ciest. *Lesné cesty – stav a perspektivy ich rozvoja na Slovensku. Zbornik referátov zo seminára. Zvolen*, 5-20, (in Slovak).