Study of uneven surfaces distribution on forestry roads

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Abstract. The article is focused on the importance of studying Russia’s forestry roads. Providing the vehicles movability along forestry roads is necessary for combating forest fires. Thus, for adequate selection of vehicles parameters it is necessary to know and model the forestry roads surface. Field experiments to measure diameters of fallen branches, trees and rootstocks on forestry roads and their interposition have been carried out, their snapshots are shown. Diagrams with experimental and theoretical values are given. The flow-chart of methods modeling discreet uneven surfaces distribution (fallen branches, trees and rootstocks) and their interposition on forestry roads is given. Using these data it is possible to forecast and calculate the area passability under the condition of profile passability; to calculate vibration loading modes when moving over this type of roads and loading of power trains.

About 90 % of the planet’s organic substance total reserves are accumulated in forests. Russian forests occupying approximately 1/5 of the world’s forest is one of the basic factors providing steady development of mankind. [1]

45% of Russia’s territory are covered with forests, hundreds of kilometers of them being impenetrable areas [2]

Forest is a stabilizer of the majority of negative effects of environmental impact. Thus, forest resources should be regarded not only as a source of timber but also as preservation of the environmental factor in such condition at which resource exploitation will have the maximum beneficial effect for the economy and future generations. For hundreds of years forests have served as an economy “storage house” and their resources seemed inexhaustible. Forest as a source of timber, wood fuel, wild game and other products has always been one of the major suppliers of raw materials for mankind.

Forest fires are major factors determining the state and dynamics of Russia’s forest resources, especially in Siberian and the Far East. In the European part of the country the structure and dynamics of forest resources are mostly influenced by intermediate and final felling and reforestation. [1]

At clean, partial and fire-prevention felling, motor-and-tractor and felling equipment is used. It moves over unprepared surface, which is earth foundation abounding with branches, fallen trees and rootstocks. On forestry roads and off-roads in the long term the number of such obstacles increases. Consequently, they turn into hardly passable obstacles. For final felling and in continuously used roads the fallen branches and trees are removed, whereas for one-time passage and sanitary felling the road cleanup is not practical, the exception being the trees presenting serious profile obstacles.
Therefore forestry roads have been analyzed and branches, trees and rootstocks and their interposition have been measured. The research was carried out in Nizhny Novgorod region with forests occupying about 50% of its area.

Within the framework of research with support of RFBR 12-08-10004-κ «Field management to determine micro-profile of roads for transport and technological vehicles», works to measure and classify earth foundation micro-profile have been carried out, forestry roads in Nizhny Novgorod region being examined in particular. Further on, the research results were amended [3-5].

![Figure 1. Examples of fallen branches, trees and rootstocks on forestry roads.](image1)

Diameters of fallen branches, trees and rootstocks and their interposition have been measured on different forestry roads.

![Figure 2. A snapshot of measuring diameters of fallen branches, trees and rootstocks and their interposition](image2)
At different periods, areas of forestry roads, characteristic of different forests have been measured: coniferous forest (basically pine), deciduous (basically aspen) and mixed (pine, aspen, birch). Each area length was not less than 1 km for each forest type.

The experimental data have been processed and characteristic dependences obtained.

The number of uneven surface dependences (branches, trees and rootstocks) on their diameter and dimensions between them is expressed by:

\[ N(x) = \begin{cases} A \frac{1}{\lambda} e^{-\lambda x}, & \text{at } x \geq 0 \\ 0, & \text{at } x < 0 \end{cases} \]

where \( A = a \Delta x, \lambda, A, a > 0 \) – layout parameters, \( \Delta x \) – diameters discretization interval or dimensions between them.

If diameters of uneven surfaces layout is considered in the given dependency, then \( x = D \) – uneven surface diameter, \( \Delta x = \Delta D \) – diameters discretization interval, \( N(x) = N(D) \) – the number of uneven surfaces greater than \( D \) at the preset \( D \) and \( \Delta D \), \( \lambda = \lambda_D, A = A_D, a = a_D \).

If dimensions of uneven surfaces interpositions layout is considered, then \( x = L \) – the distance between uneven surfaces, \( \Delta x = \Delta L \) – discretization interval, \( N(x) = N(L) \) – the total number of distances between uneven surfaces greater than \( L \) at the preset \( L \) and \( \Delta L \), \( \lambda = \lambda_L, A = A_L, a = a_L \).

It is obvious that \( \max[N(D_{\min})] = \max[N(L_{\min})] \). Consequently:

\[ a_L \Delta L \frac{1}{\lambda_L} e^{-\frac{L_{\min}}{\lambda_L}} = a_D \Delta D \frac{1}{\lambda_D} e^{-\frac{D_{\min}}{\lambda_D}} \]

where \( D_{\min}, L_{\min} \) – minimal accepted values.

Thus, interconnection of parameters has been obtained, taking into account layout of uneven surfaces diameters and dimensions between them.

Parameters being part of dependences (1) are shown in Figure 3: \( \Delta D = 2, \lambda_D = 3.2 \), for deciduous forest– \( a_D = 1530 \), for coniferous \( a_D = 2185 \), for mixed \( a_D = 955 \).

![Figure 3. Diagram of uneven surfaces number (fallen branches, trees and rootstocks) more than \( D \) for 1 km depending on their diameters. Experimental values are marked by dots, theoretical ones – by lines. The results are given for coniferous, deciduous and mixed forests](image-url)
Figure 4. Diagrams of a total number of distances between uneven surfaces (fallen branches, trees and rootstocks) more than $L$ for 1 km depending on distances between them. Experimental values are marked by dots, theoretical ones – by lines. The results are given for coniferous, deciduous and mixed forests.

Parameters being part of dependences (1) are shown in Figure 4: $\Delta L = 2$, $\lambda_L = 3.2$, for deciduous forest – $a_L = 600$, for coniferous $a_L = 690$, for mixed $a_L = 375$.

Figures 3 and 4 show data characteristic of forestry roads in different states of abandonment. The road in the mixed forest has not been used for about 1.5-2 years, in coniferous and deciduous – for about 4-5 years. Consequently it can be concluded that the number of fallen trees and branches on the forestry roads will be determined by the period of abandonment (the period of time the roads have not been continuously used).

Formulae (1) and (2) allow to forecast the distribution pattern of fallen branches, trees and rootstocks without conducting time-consuming measurements on the given forestry road area. It is necessary to know only the number of the fallen items on the measured area.

According to the above-mentioned the following flow-chart of methods of modelling forestry roads microprofile properties can be offered, taking into account the fallen branches, trees and rootstocks (see. Figure 5).
Figure 5. Flow-chart of modelling methods of discreet uneven surfaces (fallen branches, trees and rootstocks) of forestry roads

Thus, knowing only one parameter – the number of fallen branches, trees and rootstocks per kilometer, distribution number depending on diameter and distance between relative positions can be obtained.

According to the research, no clear dependence between diameters and interpositions has been obtained. Consequently, it would make sense to set these parameters at random.

A flow-chart of an array of dependences (1) is shown in Figure 6.

Thus, finally block $WR = [D_p, L_p]$ of dimensions $2xN$ is obtained. The first column shows the uneven surface dimension, the second one – the distance to the next uneven surface.

Using dependences (1) and (2) and the methods, shown in Figures 5 and 6 it becomes possible to model the profile of a forestry road abounding with discreet obstacles. These data are necessary: to forecast and calculate the area passability under the condition of profile passability; to calculate vibration loading modes when moving over this type of roads and loading of power trains.
Figure 6. Flow-chart of methods of an array, consisting of uneven surfaces diameters and their inter-positions.

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