Research on principles of making access to mountain forests by forest road network

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ABSTRACT: We consider making access to forests and forest complexes as an optimal allocation of routes of forest roads, land and air communications and transport routes with their optimal structure (composition, proportion of separate types) being implemented within forest transportation network in such a way that the length of constructed communications and their area (area, coverage of production area) would be as small as possible and at the same time the highest possible percentage of access to the given area in the particular territory would be reached as well as optimal skidding distance for applying the latest technologies of timber transportation in forests. Forest roads are the basis of permanent access. The paper presents the results of research and knowledge of making access to mountain forests in a model territory of LHC Ďumbier in the Low Tatra Mts. We describe an ecologically suitable model of making access based on making access by permanent skidding roads constructed at an optimal spacing, which are proposed to be interconnected by cable systems for timber transportation or on slopes with gradient over 70% with the use of helicopters for timber transportation. Principles of making access to mountain forests are also presented that are worked out for the field of preparation and projection intentions of further access, proposals and projection, implementation and maintenance of constructed communications and special facilities which will secure optimal access, minimal damage and maximal benefits in the given area.

Keywords: forest roads; forest road network; mountain forest

With the aim of rational management of forests the construction of forest transportation network has been in progress in a systematic way in forest complexes of Slovakia. A new Slovak technical standard STN 73 6108 – *Forest Transportation Network* efficient since July 2000 has been applied to the construction of this network. The standard lays down categorization, system of classification and basic parameters of separate types of special communications and facilities being used for making access to forest environment as well as requirements for their design, construction and maintenance.

At present when road transportation of wood prevails in forestry (other forms such as transportation in water streams or small forest railway hardly exist), almost only the forest transportation network is used for transportation in forest. Its technical condition and total area become an urgent economic and ecological problem (especially after Act No. 543/2002 on Nature and Landscape Protection was passed).

Making access to forests and forest complexes is implemented in practice by the construction of primary and secondary forest road network which in accordance with the above-mentioned STN comprises main forest roads of 11 and 21 class, earth skidding roads of 31 class, which are known under the older name as slope roads, permanent skidding roads with maximal longitudinal gradient within 20% as well as public roads of different classes and categories that pass through the forest. Particularly main forest roads with roadway that enable the whole-year use of these roads provide permanent access.

Making access to forest stands as spatially smaller, organizationally and specifically delineated parts of forest land is implemented within the technological preparation of workplaces mostly by the tertiary network, it means by temporary special communications and facilities of lower class and lower level of equipment, for example in accordance with the above-mentioned technical standard permanent skidding roads with longitudinal gradient over 20%, temporary skidding earth roads, skidding lines, various technological lines (hoist, hauling and others), cable and transport routes for use of cable systems and other simple wood transportation, chutes of various construction, and also certain sections of permanent road network passing through these lands. Forest depots and roadside landings as well as different terrain adaptations for helicopter landing, though this type of ecological transport has been used only sporadically, form a special part of forest transportation network.

To express quantitative parameters of access to a territory or to an area so-called basic indicators of access are used most frequently, for example density in metres per ha, spacing of roads as well as other indicators (theoretical, geometric and real indicator of skidding distance), efficiency of making access (%) or efficiency of the network of forest roads, or indicator of average skidding distance. Indicators of the proportion of separate types of roads and special communications in the given territory are used most frequently to express qualitative parameters of access, it means the ratio of high quality forest roads and earth communications of different quality.

Analysis of problems

There exist many methods and ways to solve the problem of making access to forests and forest complexes that are always influenced by the type of used method, input indicators and background data, or the approach and solution of a particular author. Thus we can classify the methods into several groups, for example economic methods where mathematical and analytical procedures in proposing the network of forest roads are used on the basis of the indicator of investment return or term of repayment, its reciprocal value – coefficient of effectiveness or by means of synthesis diagram, by optimization of transport road, which are based on experiences and requirements of practice in combination with the level of technologies used in a logging process in combination with the use of graphical illustrations, maps and data on production tasks, which serve rather for the solution of separate road sections and routes than the whole network. As for modern methods that have been worked out and used recently, these are methods of making access based on the application of GIS in CAD (computer-aided design) systems in combination with DMT (digital model of terrain) and with the use of especially multi-spectral images from remote survey. Separate methods and procedures are given in detail in different references and technical documents.

It is necessary to apply the given knowledge and to search for optimal solution so that the axiom "to achieve maximal access to forests and forest stands with minimal number or length of constructed roads" could be valid.

In the past the access to forests in Slovakia was usually carried out according to General Plan of Forest Transportation Network, which was prepared by Lesoprojekt Institute in the framework of the preparation and renewal of forest management plans. This procedure was very efficient particularly in early stages when there existed only few roads in forests or when there were no roads at all. At present Lesoprojekt carries out so-called survey of forest road network within transportation survey by request, which describes the current forest road network and at the same time proposes the plan of construction of new roads in future. But this work is not the official land-use planning documentation, even in its approval the organs of state administration are present too. In the process of forest road construction it is also necessary to proceed at present in accordance with Act No. 50/1976 Land-use Planning and Construction Regulations with its latest amendments (Construction Act). The basis should be STN 73 6108 *Forest Transportation Network* and Act No. 543/2002 on Nature and Landscape Protection. Although the construction of forest roads has recently decreased due to the lack of available financial sources and necessary maintenance and repairs of existing communications and special facilities are neglected, basic principles and procedures for optimal access are changing only minimally and they can be applied in every construction under consideration.

Specific characteristics and importance of forest roads in making access

Communication system and communications in general are materially specified transportation connections for the transport and movement of transportation means, people and animals, solid and gaseous substances and various kinds of materials, liquids, gases and energy. They ensure quick transfer of news and information. According to their type of use we distinguish land, rail, water, height, air, pipeline and other communications. The most frequently used communications in forestry are forest roads of different type, class and category, which as special land communications form a basis of forest transportation network. Their characteristics are as follows:

- They form the basis of every type of access to forests and forest complexes and ensure high efficiency and fluency of the management of forests and forest land;
- They are the basis of area stand arrangement and forest management, they simplify and clarify the system of the management of forests;
- They condition management intensity, they facilitate mechanization of logging-transportation process and make the necessary technological preparation of workplaces more economic, they help to increase labour productivity, usability of machinery and introduction of new technologies for wood production;
- They fulfil an important preventive function in forest fires and fire extinction, enable quick access and close contact of firemen with burning parts of forests;
- Main forest roads shorten skidding distances and thus reduce forest soil erosion, accelerate the transportation process in forest and ensure early and fluent wood deliveries to customers, reduce losses of timber and damage to standing trees in shortening of skidding lines;
- They fulfil important ecological, recreational, sport, health, aesthetical and economic forest functions and are of military-strategic importance in fulfilling the defence doctrine of the state.

Initial conditions and characteristics of mountain forests from the aspect of making access to them

In mountain forests the task of making them accessible is extremely important because due to their geo-morphological and climatic conditions they are sensitive not only to potential and real erosion of forest soil arising in the logging-transportation process but also to difficulty of access and movement of people and mechanisms on steep slopes as well as to difficulties with implementation of suitable technologies and specific character of management and marketing of these sensitive ecological regions. Jurík et al. (1984) intimately describes the importance and development of forest roads in relation to forest access.

In the past in making access to forests in "high mountains" so-called "valley system of making access" was used, which was namely transporting of timber into valley by the shortest possible route. Timber was skidded from the stump to the place where it was possible regarding terrain conditions and then by means of animals or hauling on different earth roads with the help of various earth communications, equipment and mechanisms down to the valley to a log depot. Such transportation was based on the local gravitational-territorial principle, in which timber skidding prevailed in comparison with timber transport due to the absence of forest roads. Today when in timber transportation timber transport prevails as the fastest, cheapest and the most mechanized phase in comparison with the phase of timber skidding, the system of making access also changed from local to large area and multifunctional making access. With this system it is more advantageous and rational, particularly in mountain forests, to interconnect several parallel valleys by slope forest roads and to make access to a more complex and larger part of the territory. The need of total length of roads to make access to a given territory is lower as well. Thus the most injurious phase of timber skidding is shortened with regard to damage to soil and forest environment and is replaced by a more ecological transportation phase – hauling that causes lower soil erosion.

As a criterion of delineation of mountain forests authors give different characteristics, for example altitude, gradient and length of slopes and other geomorphological characteristics. Recently the works of Hladík et al. (1993) have been more and more frequently used. They use classification of forests into forest altitudinal zones as a criterion, when they classified mountain forests of forest ecosystems into the 5th, 6th, 7th and 8th dwarf pine forest altitudinal zone.

According to Lukáč (1993) about 50% of the volume of logging operations are carried out in mountain forests of Slovakia, while on lands with the gradient over 51% the proportion of logging volume is 25–30%. About 21% of mountain forests of Slovakia are situated in very difficult conditions of the flysch zone where ecological limits of operation mechanization and making access to forests by forest roads are priorities.

In another paper Lukáč (1997) reported that stands with the slope more than 40% covered about 39.43% of the total area of forests in Slovakia, which is about 756,766.6 ha of forest land.

Ecological aspects and ecologically friendlier methods of management of mountain forests are today recognized as a priority and they have been used more and more frequently even due to a long-term greater impact of air pollutants and decline of top parts on mountainous ridges in the 6th and 7th forest altitudinal zone. These altitudinal zones account for a major part of the area of mountain forests also in our model territory in the Low Tatra Mts., where research on making access to the 6th and 7th forest altitudinal zone was carried out. In the 6th altitudinal zone there are situated mostly commercial forests and in the 7th zone protective forests which will be subjected to an even stricter regime of management, with more restrictions from the aspect of making access and mechanization of operations, particularly when the Act on Nature and Landscape Protection comes into effect.

In the 6th and 7th forest altitudinal zone there are mostly slopes with longitudinal gradient over 20 degree (40%), which can be considered critical from the viewpoint of timber stability and slope accessibility for earth skidding machinery. It means classification of these terrains according to technological categorization as cable system terrains, where mostly cable systems and equipment should be used for timber skidding or helicopters for transportation of timber and other materials in effective combination with forest roads.

A transport survey conducted within the renewal of FMP provided data of Lesoprojekt Zvolen describing the structure of road network in the forests of SR as to 31 Dec. 2002 (Table 1).

Other roads of lower class and special communications have not been monitored and no records about them are available. With the given value 17.94 m/ha theoretical spacing of roads is 557 m. As public roads are used by the forest sector only in forest transport, namely in its last phase, they are not considered in the calculation of skidding distance. Because the calculation of double-sided skidding distance (from left or from right, from down or from up) is based on own forest roads, the theoretical skidding distance is about 279 m.

According to several technical sources an optimal value of forest road density in the forests of SR ranges from 20 to 25 m/ha in dependence on terrain conditions. It means that it is needed to construct still about 6,000 km of forest roads to reach the theoretical number of km necessary for optimal access to forests. If we take for example density 25 m/ha as an indicator of access, theoretical road spacing would be 400 m. It would mean with two-sided timber skidding to the road located in the centre of filed an average theoretical skidding distance 200 m. With the density 20 m/ha average spacing of roads would be 500 m and half skidding distance is 250 m, which is close to optimal values for timber skidding by short-laid out cable systems as a phase of ecological timber skidding with minimal erosion and better protection of soil surface. These data are of general character and they serve as basic statistical information. They should not be directly used for the intentions of further making access in particular conditions because as every statistical mean they have only an orientation value.

A shift of management in forests to ecologically friendlier forms and methods will require a denser forest road network of higher quality, which means that we will continue in making access to forests and forest complexes by the forest road network for a long period.

METHODS

Characteristics of model territory

The aim of the study was to carry out a survey of current access in a model territory, to assess the state and knowledge and to work out a proposal of principles of ecological access to mountain forests by the forest transportation network.

After obtaining necessary data field research on making access in several spheres was carried out, specified in more detail in the part dealing with the solution for separate years. We conducted a survey of access to separate parts of a model territory in the Low Tatra Mts. – LHC Ďumbier. By its natural conditions this territory represents a typical area for classifying into the category of mountain forests. The following data prove that as well: altitude 550 to 2,043 m, average annual temperature 6.3°C, average precipitation 727 mm, tree species composition with prevailing conifers (71.4%) and remaining broadleaved species (28.6%), the area on the slope greater than 40% takes up almost 92.8%, which is a

Table 1. Structure of road network in the forests of SR

Road network passing through forest		Length (km)	Density (m/ha)
Forest roads	Hauling forest roads of 1L class (with roadway)	6,337	3.17
	Hauling forest roads of 2L class (locally paved)	14,847	7.43
	Earth roads of 3L class + permanent skidding roads (PSR)	15,880	7.95
	Total	37,064	18.55
Public roads	Hauling roads of 1L type	3,212	1.61
Total (own and extraneous)		40,276	20.16

typical cableway terrain, according to the assessment of Lesoprojekt representing technological type 3 – cable system type. The growing stock of commercial forests is 253 m^3/ha and in protective and other forests the growing stock is 164.3 m^3/ha. Allowable cut in commercial forests is 34.0 m^3/ha and in others 3.2 m^3/ha.

As for the geological structure, the Low Tatra Mts. is composed of crystalline core and cover of Jurassic sediments. The crystalline core is mostly built of biotitic quartz diorites and granodiorites (so-called Ďumbier granite), migmatite orthogranites (bastard granites), mica schists and other crystalline slates. The territory on the margin of the mountains, and also some saddlebows on the northern and southern side of the main ridge, is composed of quartzites, Jurassic slates and especially different types of limestones and dolomites.

The geological structure of the model territory LHC Ďumbier is built of the following systems:

The crystalline complex is composed of crystalline slates, amphibolites, pegmatites and aplites. The Mesozoic cover is composed of quartzites and sandstones of lower Triassic, clayey and clay-sand slates and sandstones of lower Triassic, breccias limestones of the upper range of lower Triassic dark limestones and vermicular limestones of middle Triassic era, dolomites and light limestones of middle Triassic. The Mesozoic Kriznanske is built of dark limestones – Lias, Carpathian Keuper – upper Triassic, light limestones Karst – Lias, limestones and limy hornstones – Dogger. The Mesozoic of Choc is composed of Permian crumbly slates and sandstones, Permian vulcanite, melaphyres and porphyry melaphyres, violet slates and sandstones of lower Triassic, limestones and dolomites of middle Triassic. Then the territory is formed of tectonically and hydrothermal variable rocks and covering formations composed of glacier-fluvial drifts and moraines of Pleistocene, stone seas and marked deluviums of Pleistocene and Holocene, debris and dejection cones of Pleistocene and Holocene as well as fluvial drifts of Holocene.

We monitored the actual state of making access to the model territory according to determined gravitational territories or separate parts of the given territory. Not only current classes and categories of constructed roads and composition of separate types of special communications were studied but also construction materials used for building roads as well as their real state of damage by water erosion. At the same time road spacing and average skidding distances were monitored. Methods of GIS were used.

Making access to forests in relation to the Act on Nature and Landscape Protection

The given law for territorial protection lays down five degrees of protection whereas the range of restrictions grows with higher degree of protection. The whole territory of Slovakia is classified into the 1st degree of protection; protected landscape areas are classified into the 2nd degree, national parks into the 4th degree and nature reserves and nature landmarks into the 5th degree. A larger part of mountain forests in Slovakia is situated in protected landscape areas and national parks. Of the total area of forests in Slovakia about 43% of forests are classified into these degrees of protection.

There exist various antagonistic attitudes and precedents, especially in the field of construction of forest transportation network, its maintenance and repair, especially in higher degrees of territory protection and their protective belts. Pursuant to this act already in the 1st degree of protection an opinion of the organ of nature protection is required concerning the approval and change of for example forest management plan, plan of reclamations, plan of construction of roads and local communications, project of land engineering works, etc.

In making access to forests, construction and main-tenance of roads, special communications and facilities on forests lands it is valid that the owner or user is obliged to prevent erosion or water-logging. Timber skidding, storing and transportation must be carried out not to cause any damage to own or neighbouring forest stands, forest lands, forest roads and to timber felled or to minimize damage to the lowest possible extent.

Methodical procedure in making access by application of GIS methods

General procedure of works was based on common solutions of similar tasks that were solved in collaboration with Technical University Zvolen (Klč et al. 2002a,b) and it was as follows:

- To develop a digital model of the terrain of LHC Ďumbier, LUC Municipal Forests Brezno;
- To digitize all necessary lines and to assess the current state of forest road network in the given area;
- To complement the existing road network so that it will be suitable for technological conditions for the management of stands at a timber line;
- To work out classification of terrain slopes;
- To propose optimal accessibility by the forest transportation network according to created digital model of terrain;

– To compare three variants of making access (old, old complemented, new access) according to the characteristics of forest road network;
– To evaluate advantages and disadvantages of GIS and CAD systems utilization in planning accessibility to forests.

DTM preparation was based on a scanned map of transportation survey of LHC Ďumbier, LUC Ml Brezno – Čertovica at a scale 1:20,000. In the programme CartaLinx contours, road network, network of water streams as lines and borders of the units or area stand arrangement were digitized as polygons. Altitude was an attribute for contours and for JPRL own digital classification. Digitized layers were processed in IDRISI programme. After the raster processing of all vectored layers a height model of the terrain will be created by interpolation between layers and subsequent filtering of all logical errors. Based on the height model the programme calculates gradients of slopes and classifies them into chosen classification degrees. Classification of gradients was applied to decision making on the route direction. The choice of classification degrees of the slopes of the terrain surface is as follows: within 20%, from 21 to 40%, from 41 to 50%, from 51 to 70%, over 70%.

Justification of the choice of particular classification degrees: 20% gradient was chosen to distinguish areas with small slope; 40% gradient is generally considered as the border between tractor and cableway terrain, whereas tractors can move up to 50% longitudinal gradient under certain conditions (at right angles to the contour).

The routing of the axis of forest roads was made by the method of directing line. Positive cardinal points were imaginary points in plots that must be made accessible and points that can be connected to the existing road network. Localities with extreme slopes of terrain and places with high density of water streams were determined as negative points. In routing the longitudinal slope from 2 to 10% and minimal radius of arches 15 m were observed.

With complementing the existing road network it was decisive to get to inaccessible stands and to shorten skidding distances. With the given relatively dense network of forest roads there are not many possibilities how to propose a new road.

Several variants were used to propose a new model access (as if there were not any roads in the studied territory). In general we tried to propose roads with the spacing of 500 m, it means to be possible to reach 250 m to each side. From the existing forest network in the model territory we considered two stable valley roads that formed the skeleton of further access.

The routing of the axis of forest roads was made in MICROSTATION programme in the image of generated contours at a 5m spacing.

All characteristics were measured for separate forest categories in the studied territory for three variants of making access (except for measuring the actual skidding distance due to high time requirement).

The actual skidding distance for every stand (for the old road network) – the distance defined by the geometrical centre of the stand and the closest point on some of the existing roads to which it is possible to skid extracted timber – was measured in MICROSTATION programme. It was taken into account that timber cannot be skidded through sharp ridges or valleys. Resultant skidding distances were calculated as weighted arithmetical means whereas the areas of separate stands were weight. The areas of separate plots were the output of CARTALINX programme.

The length of the existing roads was the output of CARTALINX programme and the length of new roads was measured in MICROSTATION programme. Based on the length of roads and area of forest categories the density of forest road network was calculated according to the equation:

$$H = \frac{\Sigma L}{P}$$

where: H – density of forest road network (m/ha),
ΣL – sum of lengths of roads in the studied territory (m),
P – area of the territory in which we study the density of road network (ha).

Percent of areas with access was calculated according to three different methods.

Percent of accessibility is ratio of area with access and total area whereas area with access is belts of which axes are existing roads and width of belts is calculated spacing of forest roads (Jurík et al. 1984).

Percent of accessibility is the ratio of the area with access to total area whereas the area with access is belts the axes of which are existing roads and the width of belts is an ideal skidding distance in the given area, it means 200 m (Klč 2002a,b).

Percent of area accessibility (theoretical) is based on that area with 100% access (with regard to terrain conditions) that is the area with the density of forest road network 25 m/ha (Klč 2002a,b).

Accessible area and total area of the studied regions (separate forest categories) for the first two methods were generated and calculated by means of modules BUFFER and AREA of IDRISI programme.

RESULTS

Some results of making access to forests by forest roads in model territory

The forest user's unit which was chosen as a representative model territory for research on making access to mountain forests has the total area of 3,986 ha whereas commercial forests cover 1,554 ha and protective forests 2,432 ha.

The actual state of making access in the studied model territory is in accordance with the objectives and given methodical procedures characterized briefly as follows:

In commercial forests totally 76,285 m of forest roads of different classes and categories (Table 1) and in protective forests 19,634 m of special communications of primary and secondary forest road network are constructed, which is more than 89 km in total. (A difference 6.285 km results from the fact the route of the road is a border between commercial and protective forests, it means it is counted twice.) Of that there are 30,553 m of roads of 1L category, 39,869 m of 2L category and 19,212 m of 3L category, which is a relatively very good ratio of separate types (structure, proportion) of forest roads.

Average density of forest roads in the model territory is on average 22.49 m/ha while the density of forest roads in commercial forests is almost 49.08 m/ha and in protective forests 7.88 m/ha.

Average spacing of forest roads (theoretical) is 440 m the whereas spacing of roads in commercial forests is 200 m and in protective forests almost 1,270 m.

Actual average skidding distance on the whole area is 346.5 m while in commercial forests it is 148.5 m and in protective forests 570.8 m.

An important result of transportation survey is also that the category of commercial forests is accessible more than optimally. With the considered optimal value 25 m/ha accessibility is more than 196%, which is not only "economic luxury" or "hazard" but also useless ecological defect with all negative consequences for nature.

A positive result following from the forest road network is its total low damage and relatively small damage to most of forest roads, which is an example of good care as well as relatively suitable natural and geological conditions for road construction in the given territory in the Low Tatra Mts.

On the basis of these data and knowledge we can state that the geological parent rock in the model territory as well as in a larger part of the Low Tatra Mts. is relatively stable and favourable for the construction of forest roads even of lower classes and on these communications, providing that there exists proper laying out and optimal longitudinal slope of communication (3–7%) is observed, we can expect minimal damage to communications by water erosion. Consequently we can draw an important conclusion that with the low intensity of transport it is not necessary, not even desirable, to construct slope forest roads of 1L class with dustproof treatment of roadway in such conditions. It is frequently enough to build forest roads of 2L or 3L class with local reinforcement of road gain, which are economically more reasonable and at the same time suitable for making access to mountain forests, especially in combination with cable systems. With regard to the use of local materials for construction, such a solution is thus economically and ecologically acceptable and justified.

Coming out from the comparison of average data on access to forests in Slovakia with making access to mountain forests in the model territory we can state that average statistical data must be used only for orientation and for making access to a particular territory it is necessary to base the solution on concrete local data and conditions and in a complex way. Only in that way we can prevent strategic faults in planning making access to the given territory. As an example we can give the above-mentioned data on an excessive number of forest roads in commercial forests in the model territory (49 m/ha).

In the shortest possible time it is desirable to carry out a new physical inventory of road network in the forests of Slovakia or to classify data on making access from official statistics in a suitable way according to different interest fields and areas.

Specialists in the forest environment study and seek for reasons of low utilization of cables and cableways in the forests of Slovakia though the technology of cable systems in combination with forest roads is an almost ideal technological model of solution, particularly in mountain forests. Also from average data on access to Slovak forests this technology seems to be easily implemented (density of roads, spacing, skidding distance). One of the reasons of low utilization of cableway systems (at present within 2%) in addition to so-called "broken skidding", narrow economic view and low demands on management of tractor technologies in practice it is also sufficient and on some places even very dense road network in commercial forests. Therefore it is necessary to consider making access to these forests what type of technologies of timber skidding and transportation should be applied in the current difficult ecological and economic situation, what principles of management and organization of work to use, etc.

Principles of ecologically making access to mountain forests by forest transportation network

On the basis of the results of this solution and generalization of obtained knowledge from field surveys and other research works on making access to mountain forests we can say that these problems will also be relatively difficult to solve in future and for their solution high professional skills and specialization of workers as well as sophisticated specific hardware and software as well as instruments will be necessary.

Data on the state of access to mountain forests in Slovakia are minimal or none according to present database sources. The only official data source, obtained in renewal of forest management plans though today only sporadically, is at the institute Lesoprojekt.

According to valid methodical procedures for the survey of forest road network data are not specified separately for mountain forests or according to forest altitudinal zones. These data give only overall technical data on the classification and length of constructed or proposed communications and current density of forest roads in the studied area. They are not classified according to forest categories or other important characteristics, which would be necessary for making access to mountain forests.

Until now making access to mountain forests has been made in the same way as making access to other forests and terrains. The basis of making access to forests in mountain areas is valley hauling roads in combination with slope roads, mostly earth roads, which were frequently constructed according to immediate need and financial possibilities of the manager. They are interconnected with other temporary or permanent earth communications of different level, frequently with unacceptable technical parameters. The tertiary network of technological lines and other special earth communications is connected to them. Such a model of making access is unsuitable for mountain forests, with regard to their high number (exceeding the optimum several times). It has negative impacts not only on greater soil erosion but also on ecology and economics of management.

In making access to mountain forests it is ne-cessary to come out from general principles of making access to forests as well as from specific conditions that distinguish mountain forests from other forests. Mountain forests in Slovakia are located mostly in the 6^{th} and 7^{th} forest altitudinal zone with gradient of slopes mostly over 40%, in so-called cableway terrains. Commercial forests cover the largest area of mountain forests, followed by protective forests and at higher altitudes on ridges and surroundings there are mostly large clearings and grasslands. Particularly forest categories play an important role in making access, as the density of forest roads in separate forest categories should be differentiated. In the category of commercial forests density should be higher than in protective forests. The layout and situation of roads in the terrain are important aspects for optimal access and total density of roads in the given locality or interest area.

Ecological model of making access to mountain forests

The basis of optimal ecological model of making access to mountain forests will also be in future namely the basis of forest roads of different classes and categories constructed in accordance with STN with optimal spacing. With regard to prevalence of cableway terrain in these forests, these roads will be interconnected with various cableway systems for timber skidding. The need of building earth skidding roads and special communications that have negative effects on ecology and natural environment in these sensitive regions will be eliminated in this way. We propose to use this system in making access to most of mountain forests in Slovakia in the terrain with maximal gradient of slope 70%. In the terrain with gradient of slope over 70% we recommend, if necessary, to use helicopters for timber transportation.

Making access to forests as a process is a difficult intervention to natural environment and therefore there is no possibility to establish a universal procedure valid under all conditions. Therefore we proposed certain principles for making access to mountain forests that should ensure an optimal procedure. Their observance should bring minimal damage and maximal benefits. These principles were worked out for separate regions according to the prevailing field of main activities. They are as follows:

Field of preparation and projection/design intentions

In planning access to forests it is necessary to come out from the present state of access to the given area and possibility of optimal interconnection of larger territorial units with the proposed road network.

It is necessary to use as a basis for planning access the results of the survey of forest road network carried out by Lesoprojekt.

It is necessary to use in an appropriate way other results of surveys carried out in the interest territory (geological, hydrological, ecological, pedologic and others).

It is necessary to come out from optimal density and optimal spacing of the routes of separate roads.

It is necessary to be aware of the fact that currently preferred friendlier systems of management require relatively denser access to forests.

To plan making access to mountain forests in a differentiated way and according to forest categories.

To observe optimal density of road network in the category of commercial forests within the range 7 to 14 m/ha.

To optimize the spacing of main forest roads within 400–500 m and optimal skidding distance (200 to 250 m).

In commercial forests to lay out forest roads preferentially on their upper border in order to make optimal access by cableway systems or to make access even to protective forests or their parts situated at higher altitudes.

It is desirable to make access by cableway systems or helicopters to the territories where the construction of permanent roads is not suitable from technical or ecological aspects (gradient over 70%).

To lay down by legislation the support to timber skidding by cableways and helicopters.

To renew obligatory surveys of forest road network in renewal of forest management plans.

Field of proposals and projection

To elaborate proposals and projects in accordance with valid legislation and technical standards.

In elaboration of projects to care about requirements of nature conservation and opinions of other competent organs.

To use GIS methods with CAD support in planning next access.

If possible, to propose the road layout in alternatives to minimize earth works in building the road embankment.

To observe an optimal longitudinal slope of road (3–7%).

To support preferential construction of roads in the category of protective forests (as their marginal parts) compared to making access to commercial forests.

Field of implementation

To implement every construction consistently according to the elaborated project.

To prefer in making access the construction of main forest roads with reinforced road surface.

To prohibit implementation of earth communications from the tertiary network.

To construct the network of earth communications in a complex way, preferentially only in cases of planned felling or in the area affected by natural disturbances.

If possible, to build earth roads only with parameters of main forest roads as road embankment of future road of higher class.

For the construction of forest roads to use materials not harmful to the nature and environment (certified materials).

To proceed in construction in an ecologically friendly way to surrounding environment and to use ecological technologies to the largest extent possible.

To use excavator technologies for the construction of road embankment on steep slopes.

Field of care about constructed communications and special facilities

To prepare a long-term plan of making access to the interest territory with ranking of construction urgency.

To create continuously from economic results (over depreciation framework) sources for making access to forests, reorganization/reallocation of forest transportation network and care about constructed roads and special facilities (engineering works).

To eliminate in time small defects and disturbances on forest roads and to carry out effective prevention with regard to excessive damage to roads.

To use preferentially biological and biotechnological methods for sanitation of not perspective and devastated special communications located on forest land.

We can state that the process of making access to forests and forest stands in mountain areas has not been finished yet and the need of construction of new forest roads as well as reorganization of forest transportation network (change of unfavourable structure of roads, increase of the number of high quality of roads with roadway, optimal allocation of road routes, sanitation of unsuitable earth communications, etc.) is still an urgent problem at present. This state is marked by the development and state of economy in the country and opening scissors between the need and economic possibilities not only in making access but also in necessary permanent care about constructed communications and transportation equipment.

CONCLUSION

Making access to forests and forest complexes is taken to mean an optimal allocation of routes with optimal structure of separate types of communications and special facilities which are a part of forest transportation network in the given territory, whereas it is based on minimal need of implemented kilometres of roads and transportation routes as well as minimal occupation of production area to provide a maximal proportion of territory with access on permanent and temporary transportation network, to provide optimal skidding distance and apply the latest ecological technologies of timber transportation from forest.

Based on the obtained results and knowledge from field surveys and other research works carried out in the field of making access to mountain forests being verified in the model territory LHC Ďumbier in the Low Tatra Mts. we can state that these problems are relatively difficult and for their solution high professional skills and specialization of workers as well as sophisticated hardware and software necessary.

Use of modern methods for making access (GIS methods with CAD support) is welcomed and effective but it is conditioned by availability of open databank of digitized maps and other available data and equipment.

The process of making access to forests and forest stands in mountain areas has not been finished yet and the need of construction of new forest roads as well as reorganization of forest transportation network (change of unfavourable structure of roads, increase of the number of high quality of roads with roadway, optimal allocation of road routes, sanitation of unsuitable earth communications, etc.) is still an urgent problem at present. This state is marked by the development and state of economy in the country and opening scissors between the need and economic possibilities not only in making access but also in necessary permanent care about constructed communications and transportation equipment.

From the obtained knowledge we can deduce a trend that in commercial forests of mountain areas in Slovakia the need of further construction of forest roads decreases rapidly and the need of reorganizing the forest transportation network increases. On the contrary, in protective forests it seems that access to them is insufficient, which limits not only their optimal management but also the need of increased protection and implementation of remediation and preventive measures in the ecologically negatively affected part of forests (decline of ridge parts due to air pollutant effects), causes their insufficient preparedness for prevention of forest fires and limited possibility of direct extinguishing of forest fires and doing other management and other interests and needs.

The paper presents an economically suitable model of making access to mountain forests based on making access by/through permanent forest roads constructed with optimal spacing and interconnected by various cableway systems, or on slopes over 70% with helicopters.

It also presents principles of making access to mountain forests which are worked out for the field of preparation and projection intentions of further access, for the field of proposals and design, construction and maintenance of constructed communications and special engineering works (facilities). Their application should ensure an optimal procedure and minimization of damage (disturbance) as well as maximal benefits.

References

HLADÍK M., KORPEĽ Š., LUKÁČ T., TESÁR V., 1993. Hospodárenie v lesoch horských oblastí. Praha, VŠZ, LF: 123.

JURÍK Ľ. et al., 1984. Lesné cesty. Bratislava, Príroda: 407.

KLČ P., 2002a. Výskum ekologického sprístupňovania horských lesov lesnou dopravnou sieťou. [Záverečná správa.] Zvolen, LVÚ: 124.

KLČ P., 2002b. Vybrané výsledky a poznatky zo sprístupňovania horských lesov. In: Zborník z medzinárodnej konferencie Logistika technickej výroby dreva v Karpatoch. Zvolen, TU: 109–118.

LUKÁČ T., 1997. Lesné dopravníctvo. Zvolen, TU: 228.

LUKÁČ T. et al., 1993. Hospodárenie v lesoch horských oblastí. Praha, VŠZ, LF a Písek, Matice lesnická: 123.

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Výskum zásad sprístupňovania horských lesov lesnou dopravnou sieťou

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ABSTRAKT: Pod sprístupňovaním lesov a lesných komplexov rozumieme optimálne rozmiestnenie trás lesných ciest, pozemných a vzdušných komunikácií a dopravných dráh s ich optimálnou štruktúrou (zložením, zastúpením jednotlivých druhov) realizovanou v rámci lesnej dopravnej siete tak, aby dĺžka budovaných komunikácií a ich plocha (výmera, záber produkčnej plochy) boli čo najmenšie a zároveň sa tým dosiahlo najvyššie percento sprístupnenia uvažovanej plochy územia a optimálna približovacia vzdialenosť pre uplatnenie najnovších technológií dopravy dreva v lese. Základom alebo kostrou trvalého sprístupnenia sú lesné odvozné cesty. V príspevku sa uvádzajú výsledky z výskumu a zistené poznatky zo sprístupňovania horských lesov v modelovom území LHC Ďumbier v Nízkych Tatrách. Popisuje sa ekologicky vhodný model sprístupnenia založený na základe ich sprístupnenia trvalými odvoznými cestami budovanými v optimálnom rozostupe, ktoré sa navrhujú prepojiť lanovými systémami na dopravu dreva, resp. vo svahoch so sklonom nad 70 % s využitím vrtuľníkovej dopravy dreva. Uvádzajú sa zásady sprístupňovania horských lesov, ktoré sú rozpracované pre oblasť prípravy a projekčných zámerov ďalšieho sprístupňovania, oblasť návrhov a projektovania, oblasť realizácie a oblasť starostlivosti o vybudované komunikácie a účelové zariadenia, realizáciou ktorých sa v praxi zabezpečí optimálny prístup sprístupňovania s minimálnym rozsahom škôd na prírode a dosiahnu sa maximálne úžitky v tejto oblasti.

Kľúčové slová: lesné cesty; lesná cestná sieť; horské lesy

Príspevok uvádza výsledky výskumu zo sprístupňovania horských lesov získané v charakteristickom modelovom území Nízkych Tatier vo forme aplikovateľných zásad. V horských lesoch je úloha sprístupnenia významná a špecifická, pretože sa jedná o oblasti s vyššou nadmorskou výškou, vyššími zrážkami, strmými a dlhými svahmi, na ktorých potenciálne vzniká pri technologickom procese dopravy dreva nebezpečie zvýšenej tvorby erózie pôdy s jej ďalšími negatívnymi dôsledkami a budovanie siete lesných ciest je nielen technicky a ekonomicky náročné, ale v mnohých prípadoch aj z ekologických aspektov nevhodné.

Ako kritérium vylíšenia horských lesov sa v príspevku uvádza príslušnosť k piatemu až ôsmemu lesnému vegetačnému stupňu.

V súčasnosti sa na dopravu v lese využíva lesná dopravná sieť, ktorej základ tvorí lesná cestná sieť. Trvalé sprístupnenie lesov a lesných komplexov sa v praxi realizuje lesnou cestnou sieťou, ktorej technické parametre sú dané normou, a sprístupňovanie lesných porastov (ako priestorovo menších organizačne a špecificky vylíšených častí lesných pozemkov) sa realizuje v rámci technologickej prípravy pracovísk dočasne, terciálnou sieťou nižších druhov komunikácií, ktoré je potrebné po ukončení ťažbovodopravného procesu asanovať.

Doposial sa pri sprístupňovaní horských lesov postupovalo obdobne takým istým spôsobom ako pri sprístupňovaní ostatných lesov. Základ sprístupnenia tvoria údolné odvozné cesty v kombinácii so svahovými väčšinou zemnými cestami, ktoré sú ešte poprepájané ďalšími dočasnými alebo trvalými zemnými komunikáciami rôznej úrovne, často s nevhodnými technickými parametrami. Na tieto nadväzuje dočasná terciálna sieť technologických liniek a ďalších účelových komunikácií. Takýto systém sprístupnenia je pre horské lesy nevhodný.

Základom vhodného, ekologicky prijateľného modelu sprístupnenia horských lesov je kostra odvozných lesných ciest vybudovaných v optimálnom rozostupe (asi 500 m), ktorá bude dopravne prepojená lanovými systémami na približovanie dreva. Takto je vhodné sprístupniť väčšinu horských lesov na území Slovenska v terénoch až do maximálneho sklonu svahu 70 %. V terénoch so sklonom svahov nad 70 % sa odporúča v prípade potreby využívať vrtuľníkovú dopravu dreva.

Sprístupňovanie horských lesov je potrebné plánovať a realizovať diferencovane, podľa kategórií lesov s tým, že optimálna hustota lesných ciest v hospodárskych lesoch by mala byť do 25 m/ha s optimálnym rozostupom asi 500 m a v ochranných lesoch by mala byť hustota lesných ciest v rozsahu od 7 do

14 m/ha. Optimálny pozdĺžny sklon lesných ciest by mal byť v rozsahu 3–7 % a realizáciu terciálnej siete zemných komunikácií v týchto oblastiach je potrebné zakázať. V strmých svahoch pri výstavbe ciest by sa mala uprednostňovať bagrová technológia výstavby pred dózerovou; o vybudované cesty je potrebné komplexne a permanentne sa i starať.

Proces sprístupňovania lesov a lesných porastov v horských lesoch nie je ukončený a potreba budovania nových lesných ciest i prebudovanie doteraz realizovanej lesnej dopravnej siete je aktuálnym problémom súčasného i budúceho obdobia, ktoré je poznačené momentálnym stavom a vývojom hospodárstva s roztváraním „nožníc“ medzi potrebou a ekonomickými možnosťami vlastníkov a obhospodarovateľov lesa.

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