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Forest transport roads according to natural forest regions in the Czech Republic

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ABSTRACT: Important parts of the forest sector are forest engineering constructions and capital construction of forest road network which improve the optimal management of forests and forest stands and their reasonable opening by a forest road network. The basic frameworks of forest road network are forest transport roads of various grades and categories. The paper discusses the basic parameters of forest transport roads such as the length of forest transport roads and their density outspread to the area of a particular district above all. The conditions of forest opening in 41 Natural Forest Regions of the Czech Republic and in the Czech Republic as a whole are shown and confronted on the basis of these parameters. A dilemma of the double division of forest transport roads according to the standard ČSN 73 6108 – Lesní dopravní síť (Forest Transportation Network) and according to the methodology used by Forest Management Institute in Brandýs nad Labem is also described in the paper. Although it is not suitable to use two methods of evaluation, there is no tendency to unify it.

Keywords: forest transport roads; Natural Forest Regions; forest opening

Important parts of the forest sector are forest engineering constructions and capital construction of forest road network above all. The principle of optimal forest and forest stand management is their reasonable opening by a forest road network. The basic frameworks of forest road network are forest transport roads of various grades and categories.

The optimal opening of forests and forest complexes means the optimal spacing of routing of forest roads, traffic trails, purposeful land and air communications with their optimal structure (the multitude and the composition, or representation of various types of communications) realized within the forest transport network so that the length of constructed communications and their area (the appropriation of production area) would be as small as possible together with the achievement of as high as possible percentage of area opening and optimal skidding distance through various technologies of timber skidding.

In current practices the opening of forests and forest complexes is realized by the construction of forest transport network. In accordance with the effective standard ČSN 73 6108 – Lesní dopravní síť (Forest Transportation Network) the forest transport network includes forest transport roads, skidding roads and technological communications. Forest transport roads are forest roads of 1L grade and forest roads of 2L grade. The network of skidding roads consists of skidding communications of 3L grade and 4L grade. Forest transport roads of 1L grade are roads equipped with carriageway which provide year-long wood transport by design vehicles. Forest transport roads of 2L grade are metalled or unmetalled transport roads which provide seasonal operation by design vehicles.

In the 1980s and 1990s beside transport roads special forest roads were also constructed by the forest operation. They serve for wood transport and they were built according to standardized directive Svážnice 1/Tsm/86 (Slope Roads), which were not liable to duty to get a building permission and to reporting duty and they were provided from operation

Table 1. Classification of forest roads by the Forest Management Institute (www.uhul.cz, 2007)

Type	Grade	Operational ability	Min. width of highlight (m)	Max. slope (%)	Min. radius (m)	Surface	Object and usage	Note
Transport roads	1L	permanent	4.0	10–12	15	dust-free carriageway, bitumen, concrete, mud	yearlong wood transport by design vehicle	technical facilities according to ČSN 73 6108
	$2L_1$	seasonal or permanent	3.5	10–12	15	simple carriageway with dust surface or with operation strengthening	seasonal wood transport by design vehicle	technical facilities according to ČSN 73 6108
	$2L_2$	seasonal	3.5	8–10	15	on grounds with high bearing capacity earth, without operation strengthening	seasonal wood transport	requisite technological facilities
Skidding roads and lines	3L	seasonal	3.0	8–10	15	earth or partly operational strengthened	skidding by tractors or by clam skidders	limited technological facilities
	4L		1.5		–	earth, with humus	skidding by tractors or by horses	without technological facilities

resources. These slope roads of types 1S and 2S were inventoried to forest transport roads during traffic research. Subsequently it was necessary to classify these transport slope roads according to their parameters pursuant to new norms and legislation and to classify their quality.

That is why it was decided to divide the slope roads of both types (1S, 2S). One part of them is classified as Other Areas, according to § 3 of Forest Act No. 289/1995 of the 3rd of November 1995. These forest roads were designated $2L_1$ (in principle forest roads of 2L grade in according to ČSN). Also other roads that do not conform to forest roads of 2L grade because of their characteristics and facilities were used for forest transport. In future the higher frequency of transportation and stepwise refinement of their parameters is awaited. At the present time it is not possible to classify these roads to forest roads of 2L grade, in accordance with the norm in force and that is why they are classified as forest roads of $2L_2$ grade and these are counted to non-stocked forest land according to § 3 of Forest Act No. 289/1995.

This classification of forest roads of 2L grade is used by the Forest Management Institute during traffic research of forest roads which is realized within the forest inventory in the Czech Republic. Obviously this classification is not fully compatible with the norm in force ČSN 73 6108. A brief description of grades of forest roads according to the classification of the Forest Management Institute is in Table 1.

The most important parts of permanent forest opening are forest transport roads equipped with carriageway (1L) which makes their year-long use possible.

METHODS

Because the level of forest opening is one of the important indicators of forest management in state, it is needful to describe it as precisely as possible. The level of forest opening is best deduced from the condition and the multitude of forest transport roads. Extensive research is conducted by the Forest Management Institute to describe the conditions of forest transport roads.

Traffic research is realized in the framework of the forest inventory. It serves not only to find out the level of forest management in the Czech Republic but also to form new forest management plans. The forest inventory is done for Regional Plans of Forest Development which are worked out for individual Natural Forest Regions of the Czech Republic.

The detailed methods are developed for taking exterior data. All the roads which lead through the forest or contact it and roads outside the forest which are at least sometimes used by forest management

Table 2. Importance of forest roads (www.uhul.cz, 2007)

No. Code	Description
100	Wood is skids from both sides of the road; forest is from both sides of the road (necessary buildings with roads – buttress walls, bridges etc.) ditches and slopes are counted to the area of forest road
200	Wood is skids only form one side of the road; forest connects the forest road (and its auxiliary buildings) only from one side
300	Roads (or motorways) out of forests; it is possible to skid wood or transport it on these roads, these roads are counted only if the horizontal distance of intersect between the road and the transect to the nearest forest is no longer than 75 m; if tidy obstructions are between the forest and the road (i.e. railway, river etc.), then the road is not counted, because it has no importance for the part of the forest. Intersections, which are situated in smaller "no-forest" places in forest, are counted only in accordance to the above remarks. If in close local area are more roads in the zone of 75 m, only the road closest to forest complex is counted, but only if it has importance for skidding or transporting wood

are included in research. They are divided into forest roads and public roads.

Traffic research is connected with categorization; it means to classify forest roads into single grades and categories. Categories of forest roads are the conjoint class mark for the forest roads of the same value in terms of forest operation. The value of forest road indicates the importance of forest road for wood skidding and wood transporting (Table 2).

Forest roads are categorized by a number and a letter, which characterize traffic importance of the road and by the fraction after dash which characterizes the space setting of the road and design speed. The number signs the grade of the road, the letter "L" means that the road is forest road. The fraction describes the category of the forest road. In accordance with the Forest Management Institute forest roads are divided by the classification described in Table 3.

Forest road classification in accordance with ČSN 73 6108 – Forest Transportation Network is similar (s. the Introduction). Technical parameters of roads classified as categories 1L, 2L, or $2L_1$ and $2L_2$, if it is possible to dispose them, are used as input data for calculation of basic parameters of forest road network.

The length of transport roads of single grades is the primary index of forest road network. This value calls a multitude of forest roads. Forest roads are counted with total length but from public only the parts which go through the forest or follow the forest border are counted. The length of forest roads is found out from traffic maps and is marked in km to the nearest 100 m.

On the basis of the multitude of forest roads next indexes of forest road network are calculated. The density of forest transport roads falls into the most important indexes of forest road network. The density of forest transport roads, like the index of forest road network, is calculated as the quotient of the multitude of forest transport roads and the area. The unit of the density of forest transport roads is m/ha.

The density of forest transport roads is calculated by the following formula:

$$H = \frac{D}{P} \quad \text{(m/ha)}$$

where: H – density of forest transport roads,
D – total length of forest transport roads in the district (m),
P – area of the district (ha).

Table 3. Forest road classification (www.uhul.cz, 2007)

No. Code	Description
100	Forest roads of the 1st class – 1L: transport roads which provide for yearlong transport by design vehicle because of their space setting and technical facilities. Roads are every equipped by carriageway constructed from various materials, free width of the carriageway is min. 4.0 m. Maximal longitudinal gradient of the vertical alignment of the road is 10%, in extreme mountain lies 12%
200	Forest roads of the 2nd class – $2L_1$: transport roads with seasonal or permanent operation, they are equipped by single carriageway with dust surface or with operation strengthening
300	Forest roads of the 2nd class – $2L_2$: transport roads with seasonal operation, unconsolidated. Only on grounds with high bearing capacity
400	Forest roads of the 3rd class – 3L: exporting and skidding roads useful for tractors and special clam skidders. Minimal free width of the road is 3.0 m. Surface may be equipped with operation strengthening, local operation strengthening or without strengthening. Technical facilities are limited on surface strengthening, ground improvement and needful drainage
500	Forest roads of the 4th class – 4L: minimal top width if the road is 1.5 m, without technical facilities

Table 4. Natural Forest Regions of the Czech Republic (OPRL, 2002)

No.	Title	Area (ha)	Characteristics
1	Krušné hory	180,015	temperature 4–7°C, rainfall 600–1,200 mm, vegetation types 2.–8., forest coverage 67%, in lower localities Cambisols, in higher localities podzolic soil and muskeg, bedrock is created by granite and metamorphosed rocks
2a	Podkrušnohorské pánve – Chebská a Sokolovská pánev	55,368	temperature 7°C, rainfall 600–700 mm, forest coverage 12%, Cambisols, pseudogley or gley soils, muskeg, bedrock is created by sedimentary rocks
2b	Podkrušnohorské pánve – Mostecká a Žatecká	103,141	temperature 8°C, rainfall 450–500 mm, forest coverage 4.5%, vegetation types 1.–2., Cambisols, brown soils, bedrock is created by sedimentary rocks
3	Karlovarská vrchovina	109,164	west of the Slavkovský forest and east Tepelská highland, temperature 5–7°C, rainfall 600–800 mm, vegetation types 3.–7., forest coverage 49%, Cambisols, pseudogley or gley soils, podzolic soils, bedrock is created by granite and metamorphosed rocks
4	Doupovské hory	69,711	temperature 5–8°C, rainfall 450–700 mm, forest coverage 26%, Cambisols, bedrock is created by sedimentary rocks
5	České středohoří	130,549	Verneřické and Malešické středohoří, temperature 5–9°C, rainfall 450 to 800 mm, forest coverage 26.5%, in lower localities Cambisols, pararendzinas, bedrock is created by neutral or ultra alkaline rocks and ash rocks
6	Západočeská pahorkatina	398,616	temperature 7–8°C, rainfall 500–650 mm, forest coverage 30.4%, Cambisols, pseudogley, Luvisols, podzolic soil, bedrock is created by sedimentary rocks
7	Brdská vrchovina	98, 287	temperature 6.6–7.5°C, rainfall 600–800 mm, forest coverage 66%, Cambisols, pseudogley, bedrock is created by agglomerate, sandstone and slates
8	Křivoklátsko and Český kras	154,999	temperature 7–9°C, rainfall 480–620 mm, forest coverage 38.65%, Cambisols, rankers, pseudogley, rendzinas or Lithosols, bedrock is created by slates, in Český kras are limestone
9	Rakovnicko-kladenská pahorkatina	179,399	temperature 7–8°C, rainfall 460–570 mm, forest coverage 28%, Cambisols, antrosols, bedrock is created by sediments – especially sandstone
10	Středočeská pahorkatina	660,146	temperature 7–7.5°C, rainfall 540–660 mm, forest coverage 30%, Cambisols, pseudogley, bedrock is created by granite
11	Český les	108,237	temperature 6–7°C, rainfall 700–1,000 mm, forest coverage 60%, Cambisols, pseudogley, bedrock is created by gneiss and granite and alkaline massive
12	Předhoří Šumavy and Novohradských hor	280,917	temperature 6–7°C, rainfall 570–730 mm, forest coverage 35%, oligothrofic Cambisols, bedrock is created by gneiss and metamorphosed rocks
13	Šumava	211,302	temperature 4–6°C, rainfall 700–1,400 mm, forest coverage 66.5%, cryptopodzolic soils, muskeg, bedrock is created by gneiss and granite
14	Novohradské hory	14,450	temperature 4–6.5°C, rainfall 750–950 mm, forest coverage 81.5%, cryptopodzolic soils and Cambisols, bedrock is created by gneiss and granite
15a	Jihočeské pánve – Budějovická pánev	77,591	temperature 7.5°C, rainfall 550–600 mm, forest coverage 13.2%, acid Cambisols and cryptopodzolic soils, bedrock is created by gneiss and sands
15b	Jihočeské pánve – Třeboňská pánev	167,983	temperature 6.8–7.8°C, rainfall 600 mm, forest coverage 38.5%, acid cryptopodzolic soils and muskeg, bedrock is created by sands and clays
16	Českomoravská vrchovina	782,368	temperature 5–10°C, rainfall 600–750 mm, forest coverage 33.5%, Cambisols and pseudogley, bedrock is created by granite, gneiss, sandstones
17	Polabí	713,145	temperature 7.5–9°C, rainfall 480–700 mm, forest coverage 14%, Cambisols, black soils and brown soils, luvisols, bedrock is created by sediments – sandstones, sands and clays
18	Severočeská pískovcová plošina Český ráj	218,763	temperature 7–8°C, rainfall 550–800 mm, forest coverage 39%, Cambisols, podzolic soils, luvisols, bedrock is created by sediments, vulcanite
19	Lužická pískovcová vrchovina	50,707	temperature 5–8.5°C, rainfall 670–1,000 mm, forest coverage 74%, Cambisols, cryptopodzolic soils, podzolic soils, bedrock is created by sandstones, vulcanite
20	Lužická pahorkatina	63,952	temperature 7°C, rainfall 700–900 mm, forest coverage 28%, Cambisols, luvisols, pseudogley, bedrock is created by granite

Table 4 to be continued

No.	Title	Area (ha)	Characteristics
21	Jizerské hory and Ještěd	53,680	temperature 3–6°C, rainfall 800–1,700 mm, forest coverage 74%, cryptopodzolic soils and Cambisols, bedrock is created by granite and gneiss
22	Krkonoše	40,755	temperature 0–6°C, rainfall 900–1,600 mm, forest coverage 79%, cryptopodzolic soils and podzolic soils, bedrock is created by granite and gneiss
23	Podkrkonoší	184,580	temperature 5–8°C, rainfall 650–900 mm, forest coverage 30%, Cambisols and podzolic soils, Luvisols and brown soils, pseudogley, Fluvisols and gley, bedrock is created by sediments – esp. slate
24	Sudetské mezihoří	58,033	temperature 6–7°C, rainfall 700–900 mm, forest coverage 36%, Cambisols pararendzina, cryptopodzolic soils, bedrock is created by sediments and extrusive rocks
25	Orlické hory	38,594	temperature 4–6°C, rainfall 800–1,300 mm, forest coverage 55%, Cambisols and podzolic soils, bedrock is created by gneiss and migmatites
26	Předhoří Orlických hor	90,250	temperature 6–7°C, rainfall 700–900 mm, forest coverage 26%, Cambisols, Luvisols and pararendzinas, bedrock is created by sandstones, fylits
27	Hrubý Jeseník	68,808	temperature 4°C, rainfall 1,200 mm, forest coverage 82.3%, Cambisols, cryptopodzolic soils, bedrock is created by gneiss and Phyllites
28	Předhoří Hrubého Jeseníku	168,187	temperature 4.5–7.5°C, rainfall 600–1,100 mm, forest coverage 52.5%, Cambisols, cryptopodzolic and podzolic soils, bedrock is created by gneiss, granite and slate
29	Nízký Jeseník	271,472	temperature 6.2–8.1°C, rainfall 700–850 mm, forest coverage 35.6%, Cambisols, Luvisols and Fluvisols, bedrock is created by metamorphosed sediments – esp. slate
30	Drahanská vrchovina	157,914	temperature 5–10°C, rainfall 500–750 mm, forest coverage 55.4%, Cambisols, Luvisols and rendzinas, bedrock is created by metamorphosed sediments – slate, limestone
31	Českomoravské mezihoří	283,358	temperature 6–8°C, rainfall 600–800 mm, forest coverage 28.6%, Cambisols, Luvisols and pseudogley, bedrock is created by sandstones
32	Slezská nížina	67,782	temperature 8–9°C, rainfall 580–780 mm, forest coverage 9.8%, Luvisols and pseudogley, bedrock is created by floury soils
33	Předhoří Českomoravské vrchoviny	361,577	temperature 6–9°C, rainfall 500–650 mm, forest coverage 31.3%, Cambisols and Luvisols, bedrock is created by migmatits, gneiss and limestone, granite
34	Hornomoravský úval	173,608	temperature 7.5–9°C, rainfall 550–650 mm, forest coverage 6.4%, Fluvisols, brown soils and gley, bedrock is created by sands and floury soils
35	Jihomoravské úvaly	294,552	temperature 8.5–9.5°C, rainfall 500–600 mm, forest coverage 13.9%, Fluvisols, Cambisols, brown soils and black soils, bedrock is created by sandstones, claystone and limestone
36	Středomoravské Karpaty	124,909	temperature 7–10°C, rainfall 450–750 mm, forest coverage 30.8%, Cambisols and brown soils, bedrock is created by sediments – floury soils
37	Kelečská pahorkatina	44,324	temperature 7–9°C, rainfall 550–750 mm, forest coverage 16.9%, Cambisols, bedrock is created by sediments
38	Bílé Karpaty and Vizovické vrchy	154,800	temperature 7–9°C, rainfall 550–900 mm, forest coverage 35.7%, Cambisols and Luvisols, rankers, bedrock is created by sediments and flysch belt
39	Podbeskydská pahorkatina	179,680	temperature 7–9°C, rainfall 650–960 mm, forest coverage 14.4%, Cambisols and Luvisols, bedrock is created by sediments – sands and floury soils
40	Moravskoslezské Beskydy	82,432	temperature 2–8°C, rainfall 900–1,400 mm, forest coverage 75.2%, Cambisols and cryptopodzolic soils, bedrock is created by sediments – sandstones and claystones
41	Hostýnsko-Vsetínské vrchy and Javorníky	133,958	temperature 5–9°C, rainfall 650–1,100 mm, forest coverage 52.3%, Cambisols and Luvisols, Fluvisols, bedrock is created by sediments – sandstones, claysoils and floury soils

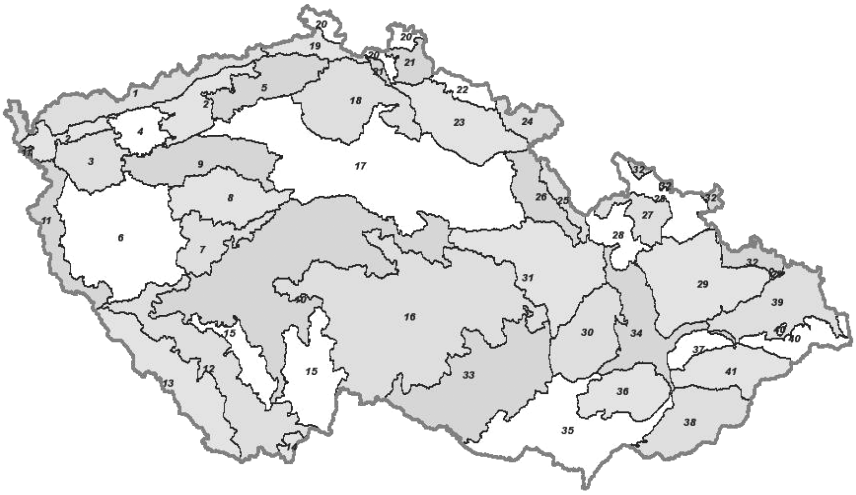

Fig. 1. The map of Natural Forest Regions (www.uhul.cz, 2007)

The Czech Republic is divided into Natural Forest Regions, which are continuous districts with similar growing conditions for forests; that is why the traffic research is conducted in accordance with the borders of these regions. The density of forest transport roads may serve as the index of the level of forest management in Natural Forest Regions.

The Czech Republic is divided into 41 Natural Forest Regions (Fig. 1). Two of them are subdivided into two sub-regions. It is Natural Forest Region No. 2 – Podkrušnohorské pánve and Natural Forest Region No. 15 – Jihočeské pánve. Because of this division the total number of Natural Forest Regions in the Czech Republic rose up to the final number 43.

The information about Natural Forest Regions and Regional Plans of Forest Development is very comprehensive, that is why only basic descriptions of Natural Forest Regions are shown in the article (Table 4).

Regional Plans of Forest Development are legislatively laid down by Forest Act No. 289/1995 and by Decree No. 83/1996 of the Ministry of Agriculture of the Czech Republic about Regional Plans of Forest Development and about forest management groups as formal instruments of national forest policy. Fundamentals of forest management are recommended in Regional Plans of Forest Development. Requirements for Regional Plans of Forest Development arise from the principle of sustainable forest management. Regional Plans of Forest Development are worked out for Natural Forest Regions and their validity is 20 years. A part of Regional Plans of Forest Development is the traffic map at a scale 1:25,000, which shows the actual and projected condition of communications of forest transport network. Public communications are designated by yellow colour in the map, transport roads of the 1st grade by red, transport roads of the 2nd grade by blue and skidding roads placed to the 3rd grade are designated by green colour. Unbuilt, but projected roads are designated by a dashed line in the map. The demonstration of the traffic map is in Fig. 2.

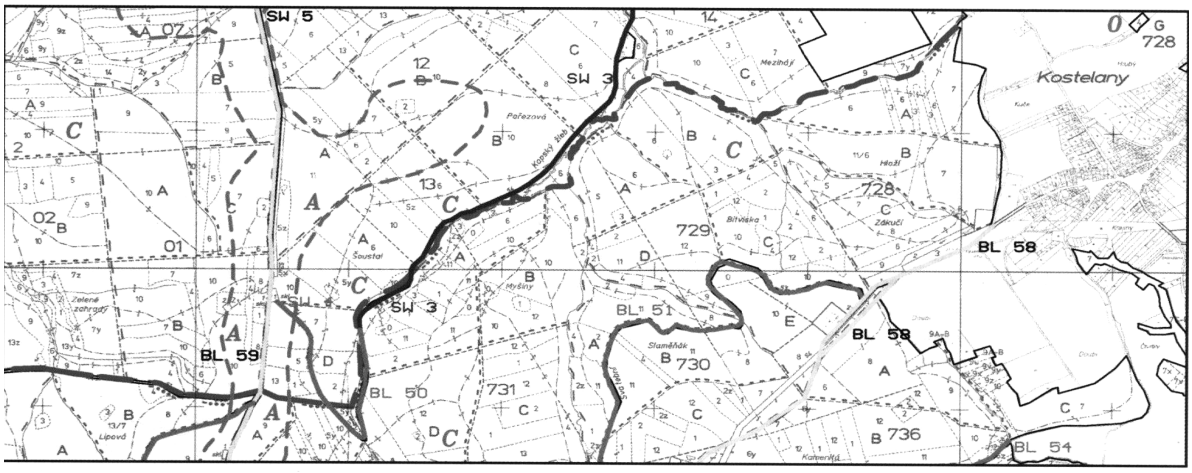

Fig. 2. Traffic map, scale 1:25,000 (OPRL, 2002)

Table 5. Forest transport roads in forests of the Czech Republic according to Natural Forest Regions

NFR	Forest roads (km)				Other roads (km)			Total (km)	Area of forest ground (ha)	Actual density (m/ha)
	L1	$L2_1$	$L2_2$	Suma	L1	$L2_1$	Suma			
1	482.3	605.7	164.5	1,252.5	478.8	31.2	510.0	1,762.5	121,942	14.5
2a	15.0	28.6	4.4	48.0	51.0	5.3	56.3	104.3	7,426	14.0
2b	12.2	6.7	9.2	28.1	15.5	4.1	19.6	47.7	4,630	10.3
3	247.6	287.6	38.8	574.0	244.9	10.3	255.2	829.2	53,359	15.5
4	20.5	118.2	3.6	142.3	53.1	10.4	63.5	205.8	20,202	10.2
5	79.7	135.2	25.1	240.0	98.3	3.0	101.3	341.3	34,593	9.9
6	266.6	737.8	310.1	1,314.5	582.8	127.8	710.6	2,025.1	126,089	16.1
7	282.0	565.2	117.7	964.9	309.0	48.7	357.7	1,322.6	64,673	20.5
8	164.0	251.8	183.1	598.9	315.6	81.7	397.3	996.2	59,905	16.6
9	105.1	273.1	160.5	538.7	235.0	66.8	301.8	840.5	50,491	16.6
10	865.7	1,157.1	780.7	2,803.5	1,031.6	275.7	1,307.3	4,110.8	196,286	20.9
11	405.5	277.7	136.6	819.8	13.2	0.0	13.2	833.0	62,212	13.4
12	388.0	444.3	801.8	1,634.1	381.9	238.4	620.3	2,254.4	98,774	22.8
13	932.7	688.5	428.0	2,049.2	352.0	82.3	434.3	2,483.5	140,263	17.7
14	94.4	143.4	42.7	280.5	30.4	2.2	32.6	313.1	11,125	28.1
15a	44.3	43.2	46.7	134.2	81.5	31.9	113.4	247.6	10,581	23.4
15b	444.5	545.4	185.5	1,175.4	286.1	132.7	418.8	1,594.2	64,401	24.8
16	964.0	1,431.9	939.8	3,335.7	1,367.0	186.4	1,553.4	4,889.1	263,589	18.5
17	236.0	561.0	600.0	1,397.0	618.8	222.9	841.7	2,238.7	106,759	21.0
18	341.0	246.6	228.5	816.1	424.6	34.8	459.4	1,275.5	84,706	15.1
19	149.6	214.9	45.7	410.2	156.5	4.8	161.3	571.5	37,655	15.2
20	46.5	145.8	10.2	202.5	64.0	8.1	72.1	274.6	17,750	15.5
21	215.9	304.1	10.6	530.6	137.2	10.8	148.0	678.6	40,035	17.0
22	173.6	156.8	111.6	442.0	103.9	8.9	112.8	554.8	33,977	16.3
23	66.8	381.6	87.3	535.7	281.7	67.0	348.7	884.4	55,596	15.9
24	38.2	63.0	112.7	213.9	67.3	23.0	90.3	304.2	21,290	14.3
25	80.3	121.0	143.2	344.5	89.1	7.0	96.1	440.6	21,149	20.8
26	41.6	100.8	82.7	225.1	159.9	21.0	180.9	406.0	23,187	17.5
27	423.9	562.4	76.6	1,062.9	124.5	1.3	125.8	1,188.7	5,666	21.0
28	544.8	1,024.2	19.7	1,588.7	162.7	31.9	194.6	1,783.3	88,330	20.2
29	579.4	823.1	0.0	1,402.5	0.0	0.0	0.0	1,402.5	80,904	17.3
30	476.4	589.3	268.5	1,334.2	557.1	33.4	590.5	1,924.7	87,525	22.0
31	251.8	452.1	280.4	984.3	483.9	36.3	520.2	1,504.5	81,061	18.6
32	33.6	33.5	0.0	67.1	0.0	0.0	0.0	67.1	6,646	10.1
33	459.7	461.9	622.7	1,544.3	610.7	37.1	647.8	2,192.1	113,266	19.4
34	95.0	107.2	8.8	211.0	19.9	0.0	19.9	230.9	11,954	19.3
35	168.0	167.6	187.7	523.3	101.2	2.9	104.1	627.4	40,809	15.4
36	259.7	93.8	65.3	418.8	88.8	2.0	90.8	509.6	38,448	13.3
37	36.1	51.6	2.5	90.2	15.7	0.0	15.7	105.9	7,505	14.1
38	276.4	149.4	116.6	542.4	139.9	10.9	150.8	693.2	56,333	12.3
39	130.4	154.6	0.0	285.0	0.0	0.0	0.0	285.0	25,917	11.0
40	825.1	714.4	0.0	1,539.5	0.0	0.0	0.0	1,539.5	64,015	24.0
41	398.4	404.9	0.0	803.3	0.0	0.0	0.0	803.3	70,622	11.4
Total CR	**12,158.2**	**15,826.5**	**7,482.1**	**35,466.8**	**10,329.9**	**1,899.8**	**12,229.7**	**47,696.5**	**2,662,641**	**18.0**

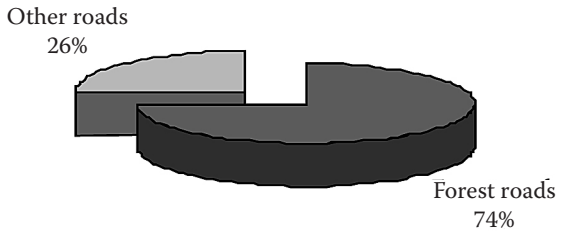

Fig. 3. Transport roads in accordance with ownership

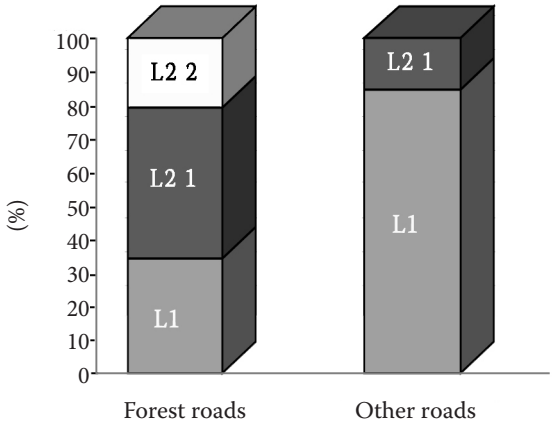

Fig. 4. Classes of transport roads according to ownership

RESULTS

One of the most important parameters of the forest transport network or other communications as well, is the total length of communications of single grades. In accordance with the aforementioned classification forest transport roads are divided, in addition to grades, into forest roads and other roads leading through the forest. The main parts of other roads take especially public roads; in addition to them other roads also contain rural roads.

The total length of single grades of forest transport roads in forests in the Czech Republic was rated during the forest inventory in the Czech Republic carried out by Forest Management Institute (www.uhul.cz, 2007). This total value (the last line of Table 5) related to the Czech Republic is important information, but the precision is not predicative enough. This fact forced us to divide the Czech Republic (Table 5) into smaller areas and to evaluate the length of forest roads and other parameters at a smaller scale. The small area gives the better evaluation but it is not useful to separate each forest, so we use the division into Natural Forest Regions described in Table 4 used by the Forest Management Institute.

These values of the length of transport communications were compared with the areas of forests in single Natural Forest Region. The actual density of forest transport roads in single Natural Forest Regions was calculated this way. Collective data on the network of forest transport roads in single Natural Forest Regions are in Table 5.

For better plasticity of some important parts of the table some figures were designed.

In Fig. 3 the division of forest roads in accordance with ownership is shown. Forest roads are roads of forest owners, other roads are especially public roads which lead through forests. Figs. 4 and 5 show the lay-out of classes of transport roads.

The density of forest opening by the forest transport roads in Natural Forest Regions of the Czech Republic is shown in Fig. 6.

The table shows that the actual average density of forest transport roads in forests of the Czech Republic is 18.00 m/ha. From the figure it is evident that the majority of the Natural Forest Regions do not attain this value (28 out of 43, i.e. 65%). As for the density of forest transport roads, the worst situation is in Natural Forest Region No. 5 – České středohoří, where the density of forest transport road network, forest and public roads does not reach the value of 10 m/ha. On the other hand, the highest density of forest transport roads is in Natural Forest Region No. 14 – Novohradské hory. The value of the density of forest transport roads in this region is 28.1 m/ha.

DISCUSSION

The basic problem of forest opening evaluation is not fully compatible classification of forest roads in ČSN 73 6108 – Forest Transportation Network compared with the classification used by the Forest Management Institute during traffic research. The division of forest roads of the 2L grade into grades $2L_1$ and $2L_2$ brings about some problems. First of all in some cases it is relatively hard to discern the grade of road. In accordance with ČSN 73 6108 – Forest Transportation Network forest roads of 2L grade are transport roads which provide seasonal operations by design vehicles thanks to their space setting and

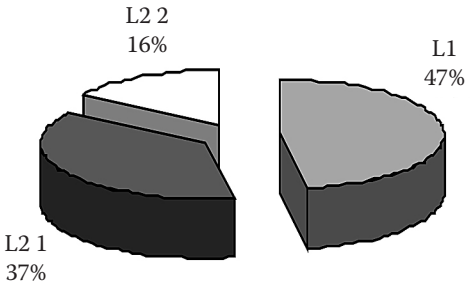

Fig. 5. Classes of transport roads

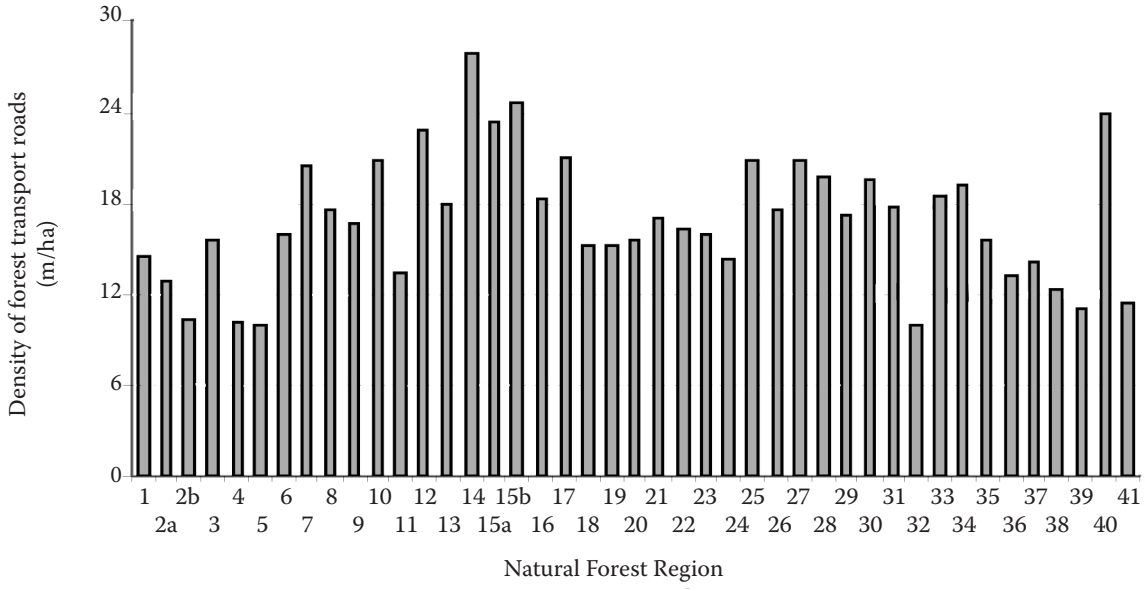

Fig. 6. Actual density of forest transport roads

needful technical facilities. In accordance with the bearing capacity of subsoil it is recommended to metal the surface or carry the road with simple dust carriageway. On bearable subsoils these roads may be constructed unmetalled. Minimal width of the traffic lane is 2.5 m, minimal free width of the road is 3.5 m. Maximal longitudinal gradient of the vertical alignment depends on the morphology of terrain, on the type of subsoils, their bearing capacity and on the type of the surface. After all it should not rise up to 12%. This definition includes the description of both forest roads $2L_1$ and forest roads $2L_2$, used by the Forest Management Institute. For this reason, this division of forest transport roads of 2L grade seems to be unreasonable. Simple definitions of other communications of forest transport network are in similar both divisions.

If necessary, it would be more suitable to divide forest roads of 3L grade. This grade of forest roads should be divided in accordance with the longitudinal gradient below 12% and above 12%. This division should be substantiated by the reason that forest roads of 3L grade with longitudinal gradient below 12% should be relatively simply reconstructed to forest roads of higher grades in accordance with the norm. Forest roads with higher longitudinal gradient cannot be classified as forest roads of 2L or 1L grade although they are metalled.

The optimal opening of forests and forest complexes can be characterized by optimal density of forest roads (m/ha). According to various authors it ranges from 20 to 25 m/ha in different geological and morphological conditions of the Czech Republic. According to the Management Forest Institute the optimal density of forest transport roads is 15 m/ha in lowlands, 22.5 m/ha in highlands and 27.5 m/ha in mountain regions (Kolektiv 2006). These optimal values can be used during the evaluation of forest opening in single Natural Forest Regions.

Beneš (1986) recommended these target values of the density of forest transport roads in single morphological types of terrain: in lowlands and tablelands with the slope of terrain to 15% 15 m/ha by obtainable efficiency 90% and average geometrical skidding distance 170 m; in highlands 22 m/ha by obtainable efficiency 70% and average geometrical skidding distance 150 m; in mountains with suitable values of morphological parameters 19 m/ha by obtainable efficiency 80% and average geometrical skidding distance 170 m; in mountains with unsuitable values of morphological parameters 24 m/ha by obtainable efficiency 70% and average geometrical skidding distance 160 m.

In the conditions of the Slovak Republic the problem of forest opening in mountain regions was solved by Klč (2005). He described an ecologically suitable model of forest opening 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 above 70% with the use of helicopters for timber transportation. Principles of opening in mountain forests are also presented that are worked out of preparation, proposals and projection, implementation and maintenance of constructed communications and special facilities which will secure

optimal opening, minimal damage and maximal benefits in the given area.

If we consider from these recommended values and have a respect to the fact that forests in the Czech Republic lie in highlands and in mountain regions above all the value of the average density of forest transport roads 18 m/ha does not seem so high. On the other hand the forest roads of 3L grade with longitudinal gradient below 12% are not calculated into this value although these roads can be used for wood-transport in suitable conditions or they can be rebuilt to forest roads of higher grades. If these roads of 3L grade would be calculated to the density of forest roads useable for timber transport, total density will rise up twice or more.

Although the density is one of the most important parameters of forest transport network it is not predicative absolutely. This value gives information about the length of roads and the area, but it does not predicate the spacing of roads. After all, the efficiency of the network would be very different although the value of the road density is similar but as the basic parameter which shows the level of forest opening in various conditions is well usable.

To discuss our results with the other above-mentioned authors is problematical because the evaluation done in this way (division of the Czech Republic) is original and untypical. Such evaluation is usable in conditions of the Czech Republic and may be used for the evaluation of other localities according to local terrain conditions. Because of the originality of this work it was impossible to compare the results with results of other scientists from the world.

CONCLUSION

The length of forest transport roads and the density of forest opening by forest transport roads are two important indexes of forest transport network. Contrary to their length the density of forest transport roads is related to the area of forests. That is why this index seems to be one of the most important and most objective parameters of forest transport network at all. The value of the density of forest transport roads is different in single Natural Forest Regions. In most regions the values of the density of forest transport roads do not reach up to the optimal density professed by the Forest Management Institute for single types of terrain. In thirteen Natural Forest Regions the density of forest transport roads does not reach up the value 15 m/ha, which is the optimal value of density in lowlands. The value of the optimal density of forest transport roads rises up with broken terrain. It can be stated that the level of forest transport network in the Czech Republic is not adequate, but if the forest roads of 3L grade with longitudinal gradient to 12% were modified for wood transport, the density of forest transport roads would expressively increase. The level of forest opening in forests in the Czech Republic would also increase.

The results of the paper are presented in accordance with the standard ČSN 73 6108 and the Forest Management Institute but the evaluation by the natural forest regions is original. These results are the basic source of information which will further be analyzed and used to prepare detailed works.

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Lesní odvozní cesty podle přírodních lesních oblastí České republiky

ABSTRAKT: Důležitým úsekem lesního hospodářství je lesnické stavebnictví a především investiční výstavba lesní cestní sítě. Základem optimálního obhospodařování lesů a lesních porostů je jejich racionální zpřístupnění lesní dopravní sítí. Kostrou lesní dopravní sítě jsou lesní odvozní cesty různých tříd a kategorií. Článek hovoří o základních ukazatelích lesní dopravní sítě, jako jsou délka lesních cest a především jejich hustota. Na základě těchto parametrů

je ukázán a porovnán stav zpřístupnění lesů ve všech 41 přírodních lesních oblastech České republiky. Článek se stručně zabývá problémem dvojího, ne zcela kompatibilního členění lesních odvozních cest – jednak podle ČSN 73 6108 – Lesní dopravní síť, jednak podle metodiky Ústavu pro hospodářskou úpravu lesa v Brandýse nad Labem, používané při dopravním průzkumu realizovaném v rámci inventarizace lesů České republiky.

Klíčová slova: lesní odvozní cesty; přírodní lesní oblasti; zpřístupnění lesů

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