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SHORT COMMUNICATION

Development of tertiary roads in the Lednice-Valtice Cultural Landscape

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ABSTRACT: The Lednice-Valtice Cultural Landscape is an exemplary area that has been influenced by purposeful human activity for a long time. Under these conditions the nonesuch, highly cultural and ecologically valuable landscape complex has come into being. The tertiary road system is a part of this landscape and was built as one of its secondary structures. Forest and rural road systems were designed for higher efficiency of management and better utilization of land with 73% increase in hauling road density and 16% increase in rural cart-road density in the period under consideration. On the basis of evaluation of forest and rural road network development, evaluation of forest conditions and forest management the analysis of tertiary road development and forest management in this area can be made. Finally it is possible to draw up general methodology and principles of forest opening-up in respect of sustainable development. This methodology and principles in combination with design principles of rural roads and in accordance with functionally integrated management could be applied in the landscape management of this area and also in similar ones.

Keywords: tertiary road; forest road; forest opening-up; all-society functions of forest; rural road

The aim of the project *Development of Tertiary Roads in the Lednice-Valtice Cultural Landscape* was to define relations between the development and utilization of tertiary roads and the maintenance of the Lednice-Valtice Cultural Landscape (LVCL) in a historical context. Furthermore, in virtue of these relations, to draft the methodology and fundamentals of opening-up, in accordance with functionally integrated management in the landscape.

The above-mentioned aims practically mean to quantify indicators of the tertiary road network in the chosen area and in the monitored periods of the 20th century. The tertiary road network can be divided into forest and rural transport networks in accordance with Czech Act No. 13/1997. Forest transport network and rural road network were separately evaluated by the methodology of Beneš (1985, 1986) in the combination with the methodology of Forest Management Institute (FMI). Then it is necessary to quantify the real potential of forest stands to fulfil forest functions by help of the methodology of Vyskot et al. (2003). In virtue of these data from forest management plans the main factors of the forest management must be evaluated and the relations between the forest transport network and forest maintenance of this nonesuch area must be defined. As a result, the general methodology and principles of forest opening-up in combination with designing principles of rural roads should be drawn up. That could also be applied to the other areas in accordance with functionally integrated management in the landscape.

MATERIALS AND METHODS

The analysis of available and accessible backgrounds about the LVCL was the first step of methodology development. LVCL was chosen as an exemplary area that which has been influenced by purposeful human activity for a long time. Under these conditions the nonesuch, highly cultural and ecologically valuable landscape complex has come into being. Relatively large documentation exists about the forest management of this complex. The period of the last hundred years was chosen for the interpretation of forest opening-up in historical development, because some changes took place in social and property right settlement. These changes in property rights were connected with the establishment of the Czechoslovak Republic and with the development after the years 1945 and 1948. The beginning of the second part of the twentieth century was very important from the aspect of landscape management because new machine technologies were used in that period.

Transport areas determined in the Regional Plans of Forest Development (RPFD) were chosen as model areas for the evaluation of forest opening-up, of the real potential of forest functions and forest management. These transport areas are as follows: ZI115, ZI116, ZI117 in the Pohansko area, ZI307, ZI308 in the Horní les area, ZI302, ZI303, ZI304, ZI306 in the Kančí obora area and ZI402, ZI404, ZI406, ZI407, ZI408, ZI409 in the Boří les area. Conditions were evaluated for the years 2000, 1964, 1934, only Pohansko transport areas were evaluated for the years 2000, 1964, 1924 (common symbol 193x is used in the text for the years 1924 and 1934). Transport areas ZI300, ZI400 and ZI500 were used for the evaluation of the rural road system, specifically their parts without forest land.

The methodology of Beneš (1986), who quantified the indicators of forest opening-up in the gravitational area, was used for the evaluation of forest opening-up. The author defined the basin as a gravitational area, whose watershed forms the transport ridge and so determines the integrated area for transport. The methodology was modified at this point and the forest opening-up was evaluated in the transport areas determined in the RPFD for Forest Natural Area 35 – Dolnomoravské úvaly (ÚHÚL 1999). Another modification of Beneš methodology by RPFD methodology was the inclusion of public roads located inside the transport areas in forest opening-up quantification. Forest maps and GIS levels of the opening-up in RPFD were used as primary resources of data. Other important sources of information about tertiary roads were old forest and military maps from the Moravian Provincial Archives, Forest Management Institute in Brno and Czech Geodesic Institute. Maps and GIS levels were compiled by help of ArcView 8.3 software and GIS levels of forest opening-up were modelled for chosen transport areas. The transport areas were composed of forest map grid, level of forest road, level of chosen transport areas from RPFD and level of points of concentrated fellings. The network of points of concentrated felling was put into the JTS-K system so that the first point coordinates x, y = 0.0. Only points pertaining to the evaluated transport areas were chosen for further evaluation. Auxiliary levels were used for the measurement of the length of forest roads (L), containing also a logging railway in the Pohansko area (in 1964, 1924), real skidding distance (D_s) and geometric skidding distance (D_g). D_s was measured from the points of concentrated cutting to the nearest skidding road and along the skidding road to the forest road, in order to respect water sheets, eventually the forest boundary. The attributes of single levels were exported and compiled in the MS Excel program again. After that, the values of theoretic skidding distance (D_t), the density of forest roads (H) and the efficiency of forest opening-up (U) were computed. The Beneš methodology modified only at the point of transport areas was used for the quantification of length (L) and density (H) of rural roads. The other parameters were not computed because the design of rural transport network is fitted to the ownership of fields.

The methodology of quantification of forest functions by Vyskot et al. (2003) was used for the quantification of forest condition. The methodology is based on the ecosystem observation of the forest. The real potentials of the forest functions (RP_{ff}) were evaluated as a quantified function ability of the real forests in the optimally possible conditions. The forest management books were the main data source. Data on the single parts of stands with the area, management groups of stands (MGS), species composition (tree species and composition), age and forest type, if it was indicated, were used from the management books. Function management groups of stands (FMGS) were assigned to the management groups of stands according to the data from Forest Management Plan (FMP) 2000–2009, and FMGS according to the forest type were assigned to the data from FMP 1964–1973. FMGS prevailing in the transport areas were assigned to the data for the period of 193x (1926 and 1934) when the forest types were not described. The results are modified databases that were run by a program developed at the Department of Landscape Formation and Conservation, Faculty of Forest and Wood Technology, Mendel University of Agriculture and Forestry in Brno. This program assigned FMGS and values of RP_{ff} to the single parts of stands. The program works in the form of an extend macro in the background of MS Excel. Approximately 50% of the parts of stands with their forest composition did not agree with FMGS, which was subsequently substituted. The standardized forest types and RP_{ff} values of the parts of stands in FMP 2000–2009 were taken from Kupec (2004).

The evaluation of the forest management was done by the analysis of available data on the forest condition. These data contained mainly the numbers from the tables and text parts of the FMP. The main easily comparable indicators of forest condition: area, tree species and age composition of forests, their age and rotation in the management set of stands were observed. Information about economic activities in the management set of stands, harvesting and transport technologies was acquired above all from the text parts of FMP.

The necessary information and data were drawn from the following materials: FMP of the Židlochovice Forest Enterprise valid for the period 2000–2009 (Lesprojekt 2000), RFDP for Forest Natural Area 35 – Jihomoravské úvaly (ÚHÚL 1999), data inventory of the Moravian Provincial Archives F481 – Břeclav Forest Enterprise (1952) 1956–1973 (it contains only management books, text parts and forest maps for the working-plan area of Břeclav-Luh and working-plan area of Břeclav-Písky, which were obtained from the archives of Forest Management Institute, the branch office in Brno). Another source was the Moravian Provincial Archives F 31 – Lichtenstein Forest Establishing Office in Břeclav 1734–1946. The inventories of Moravian Provincial Archives F 94 – section Valtice (1391)–1945, F 43 – section Břeclav 1520–1946, F 313 – Forest District in Břeclav 1945–1951, F105 – Židlochovice, state forests and farms (1876) 1919–1945 were also studied. These inventories contained some references about forest management in the area of interest but their content or time span was inapplicable. Contrariwise the other documents were not found or did not come down. Therefore RP_{ff} was not evaluated for transport areas ZI302, ZI303, ZI304, ZI306 and ZI402, ZI407, ZI409 in the year 193x.

RESULTS AND DISCUSSION

It is evident from the quantification of forest opening-up in the evaluated transport areas in the period 193x–1964 that the total length of forest roads increased from 184,865 m to 232,064 m and the density of hauling roads increased from 12.24 m/ha to 18.97 m/ha. This change can be explained by the coming of machine technology in harvesting and timber transport at the end of the 1950s with increasing demand on technical characteristics of forest roads. On this account, the reconstruction of forest transport network was acceded to at the beginning of the period 1964–2000. The reconstruction partly included the reclassification of forest roads and above all the construction of forest roads which enable almost year-long traffic. The total length of forest roads was reduced to 125,023 m in 2000, which means a 26% reduction in the period 193x–2000. But in 2000 the density of hauling roads increased to 21.19 m/ha. Total increase in hauling road density was 73% in the period 193x–2000. The total length of forest roads declined because of advanced costs of the constructions and repairs of roads. The efficiency of the forest opening-up was 53.56% in 193x, 45.96% in 1964 and 53.09% in 2000. The resultant change in the efficiency of forest opening-up was minimal in the period 193x–2000.

Comparing with data on the optimal opening-up in plans, presented by Beneš, we can see a relatively low number, although the values of forest road density are corresponding with optimal values. This kind of opening-up shows the location of forest roads which very often go along the border of transport areas and also the influence of nature conditions (favourable conditions from the aspect of the ground bearing capacity in the area of Háje and, on the contrary, of soil with the poor load-bearing capacity in the Pohansko area). As we can see in the RPFD, the present opening-up is sufficient (no construction of forest roads is planned) although the change in the forest road density led to an increase value of the real skidding distance in the majority of cases. In technical terms this change is compensated by the load and capacity of skidding technology in skidding also to a longer distance.

The progression of rural road network is a combination of new machine technologies and changes in ownership rights during the second half of the 20th century. Stronger machine technologies allowed farming in large fields and also allowed planning the rural road network of lower density. The total length of rural roads 147,987 m and their density of 38.00 m/ha were highest in 1964. But finally the values of total length 114,237 m and of density 29.30 m/ha in 2000 were lower than in 193x (length 129,193 m, density 33.12 m/ha). A decrease in total length and density of rural roads was 12%. The density of cart-roads increased from 5.46 m/ha to 6.36 m/ha in the period 193x–2000. An increase in density was 16%. However, this increase was not continual. In 1964 the density of cart-roads was only 2.29 m/ha. Lower density of rural roads was substi-

Table 1. The basic parameters of tertiary road network

Transport area	Period	H (m/ha)	U (%)	Period	H (m/ha)	U (%)	Period	H (m/ha)	U (%)
ZI115	193x	27.36	44.42	1964	28.02	44.07	2000	23.29	64.92
ZI116		18.55	61.85		27.44	55.23		20.60	39.60
ZI117		13.64	56.64		15.56	46.38		18.67	54.18
ZI302		10.42	56.69		12.31	41.95		28.30	44.65
ZI303		7.98	61.21		18.62	59.08		12.26	81.24
ZI304		0.00	0.00		15.16	88.67		24.24	56.74
ZI306		8.84	58.14		14.15	52.40		14.59	38.90
ZI307		15.94	47.02		6.32	84.05		21.97	64.04
ZI308		8.54	58.71		8.47	57.42		23.57	32.88
ZI402		17.02	40.05		45.63	29.99		33.84	46.76
ZI404		13.56	49.62		26.70	59.96		29.51	51.87
ZI406		22.79	29.95		30.15	58.17		28.92	51.01
ZI407		10.60	43.13		13.32	38.92		23.36	58.46
ZI408		19.40	37.68		20.17	40.64		33.75	48.60
ZI409		16.80	49.66		24.52	51.66		29.40	27.04
ZI300		27.17	–		38.65	–		20.90	–
ZI400		46.71	–		49.77	–		42.49	–
ZI500		14.92	–		19.79	–		15.44	–

tuted by their higher quality. The basic parameters of the tertiary transport network are in Table 1.

The forest condition, indirectly expressed by values of the real potential of forest functions, corresponds to changes in the tree species composition of forest stands. The total real potential of forest functions (ΣRP_{ff}) is classified by so-called Class of ΣRP_{ff}. In the period 193x–2000 more than 90% of forest stands were classified into class III, which means average ΣRP_{ff}. Class II and class IV are represented by a small percentage of forest stands. Small changes of ΣRP_{ff} turned up in virtue of forest management differentiation in accordance with nature conditions. Changes were set up also by demand for different timber assortments at the end of the forties of the twentieth century, when forest management was aimed at the production of thick assortments of the best quality. Therefore were made conversion of sprout forests into high forests in Háje area. The extension of rotation allowed to increase of forest stands composed from more than tree species. In 193x were determined 2 rotations (25 and 100 years), 4 different rotations (maximum 120 years) in 1946 and finally 10 rotations in 2000 (maximum 150 years). However main commercial species was not changed. The forest transport network is also used as recreational tracks and for leisure time activities (since 1990 much more intensively). Forest roads also provide better utilization of social-recreational effects and health-hygienic functions of the forest. The percent distribution of classes of ΣRP_{ff} is in Table 2.

The development and utilization of forest transport network in the monitored period corresponded with demands which were posed on the forest transport network in terms of forest management. The emphasis on forest use from game keeping to logging and harvesting of minor forest products was relocated at the beginning of the twentieth century. The forest road alignment, their constructional facilities and their classification have been changing depending on changes in the forest management and technologies. These changes have a long-term character connected with costs of constructions of forest transport network. But for technical and economic reasons, these changes did not correspond with the speed of changes connected with the implementation of skid-

Table 2. Classes of ΣRP_{ff} – percent distribution

Period	Class of ΣRP_{ff}	ZI115	ZI116	ZI117	ZI307	ZI308	ZI404	ZI406	ZI408	Sum
2000	I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	II	8.6	5.8	7.5	10.1	12.4	0.2	1.2	0.0	4.5
	III	91.4	94.2	92.5	89.9	87.6	94.4	91.3	98.4	93.4
	IV	0.0	0.0	0.0	0.0	0.0	5.4	7.4	1.6	2.1
	V	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	VI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	II	1.5	0.8	10.0	0.0	1.8	0.2	1.6	0.3	2.2
	III	98.5	99.2	90.0	100.0	98.2	99.5	88.4	95.1	95.3
	IV	0.0	0.0	0.0	0.0	0.0	0.2	10.0	4.5	2.6
	V	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	VI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
193x	I	0.0	0.0	0.0	–	–	–	0.0	0.0	0.0
	II	0.0	0.0	1.8	–	–	–	0.0	0.3	0.4
	III	100.0	100.0	98.2	–	–	–	100.0	91.8	97.3
	IV	0.0	0.0	0.0	–	–	–	0.0	7.8	2.3
	V	0.0	0.0	0.0	–	–	–	0.0	0.0	0.0
	VI	0.0	0.0	0.0	–	–	–	0.0	0.0	0.0

der technologies, let us say the speed of implementation of these technologies did not correspond with the condition of the forest transport network.

Like the changes in forest management, some changes connected with landscape management have an effect on the forest transport network. The forest transport network was originally designed in conformity with the conception of landscape park, let us say only its component unit was used. The forest transport network represents a historical secondary landscape unit, respecting specific nature conditions.

In this case there were changes mainly in the flood plain area. These changes were caused by the regulation of the Dyje River as prevention against the spillage of flood water to the forest stand, which was harmful to the forest transportation network. Contrariwise, the ameliorating channel constructions influenced the conditions of skidding.

The ameliorating channels increase costs of constructions and repairs of the forest transport network because it is necessary to build bridges across these channels. The forest transport network was an integral part of landscape during the whole monitored period, also in terms of its opening-up. The forest transport network is connected to the network of other tertiary roads and highways and is also used as forest department border in forest management.

The methodology used for the project solution has proved good by determination of evaluated areas as transport areas appointed within RPFD. The transport areas respect the borders of forest owners and spatial arrangement of the forest. That is why there are no problems with the forest condition evaluation (the borders of transport areas do not cut forest stands). Because the spatial arrangement of the forest is principally resistant in the historical context of the evaluated area, transport areas can be determined on the basis of forest maps from various periods. Determined transport areas were not affected by the realignment of the Dyje River. The realignment was the cause of watershed contour change and the rise of new watersheds in the area of floodplain forests. In this regard, the evaluation of opening-up in the watersheds by the methodology of Beneš was a little bit questionable, the same as the subsequent evaluation of forest condition and forest management.

The rural transport network is designed in different conditions from those of the forest transport network. Natural (mainly terrain) conditions, organization, technologies and production time are different. The design of a rural road has to agree with the ownership structure of land. But rural roads often make a connection between forest and public transport systems. Therefore it is important to recognize also connecting function of rural roads, their condition and bearing capacity in the design process of the forest transport system. The interconnection of forest and rural roads is also important for better utilization of all forest functions.

The proposed methodology and principles of forest opening-up result from the methodology used for the project solution and conventions of opening-up formulated by Beneš. The conventions are completed by specifics resulting from nature and management conditions in the evaluated area and they are in conformity with functionally integrated management.

The procedure contains the following events:

– preparative works round-up and contingent data base update of the evaluated area, shown in RPFD and FMP. There are maps (stand map or contour and typological map), descriptions of current opening-up, descriptions of forest stands and management instructions for single management sets of stands;
– evaluation of the present forest opening-up conditions – to control the connection and its condition with public or other tertiary roads, within determined transport areas according to RPFD, calculation of opening-up indicators according to Beneš;
– comparing numbers of present opening-up indicators with indicators of optimal opening-up according by Beneš;
– optimization of forest transport network – on account of nature management conditions in view of specific limitation from further exploitation of the area so as the numbers of opening-up indicators were closest to optimal numbers.

CONCLUSIONS

On the basis of analysis results few expert conclusions can be drawn. The total length of forest roads was reduced by 26% but the total increase in hauling road density was 73% in the period 193x–2000. Attained values of opening-up effectivity in 2000 are a little bit lower – on average about 50%. The location of forest roads along the borders of transport areas has an influence on the low number of opening-up efficiency as well as nature conditions, especially in the floodplain forests. Development of the rural road system was similar to forest roads with a reduction in total length and 16% increase in cart-roads density. The forest condition, indirectly expressed by values of real potentials of forest functions, corresponds with changes in the tree species composition of forest stands. In the period 193x–2000 more than 90% of forest stands were classified into class III. The change in the tree species composition of forest stands was a result of forest management differentiation according to nature conditions and also of changed demand for produced assortments at the end of the forties in the twentieth century. The extension of rotation allowed to increase of forest stands composed from more than tree species. But main commercial species was not changed. (only the species composition was changed). In the whole monitored period development and utilization of forest transport network corresponded with necessaries that were imposed on the forest transport network in terms of forest management. Changes in landscape management were also reflected in the forest transport network. These changes were above all in the area of floodplain forests after the regulation of the Dyje River. The interconnection of forest and rural roads in the tertiary road system is also important for better utilization of all forest functions.

The proposed methodology and principles of landscape opening-up are based on the methodology used for the project solution. The expert conclusions enable the general application of acquired findings in the Lednice-Valtice Cultural Landscape and in the other areas, mainly with a similar potential of utilization and sustainable development.

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Vývoj účelových komunikací v lednicko-valtickém areálu

ABSTRAKT: Lednicko-valtický areál je ojedinělé území, dlouhodobě ovlivňované cílevědomou lidskou činností. Postupně tak vznikla kulturní, intenzivně využívaná krajina. Síť účelových komunikací je součástí této krajiny jako jedna z jejích sekundárních struktur. Lesní a polní cesty byly budovány s cílem zajištění vyšší efektivity hospodaření a lepšího využití půdy s nárůstem hustoty lesních odvozních cest o 73 % a 16 % u hlavních polních cest ve sledovaném období. Na základě zhodnocení vývoje lesní i polní cestní sítě, zhodnocení vývoje stavu a hospodaření lesa může být provedena analýza vývoje účelových komunikací a hospodaření v lese tohoto unikátního území. Ve výsledku lze navrhnout metodiku a zásady zpřístupnění lesa respektující předešlý vývoj. Tato metodika a zásady – v kombinaci se zásadami návrhu polních cest a s ohledem na funkčně integrované hospodaření – mohou být použity v managementu lednicko-valtického areálu nebo i jiných obdobných území.

Klíčová slova: účelová komunikace; lesní cesta; zpřístupnění lesa; celospolečenské funkce lesa; polní cesta

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