Design of forest road network in relation to all-society functions of forests

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ABSTRACT: The basic condition of forest management development is the accessibility of the forest. A design of the forest road network in relation to all-society functions of forests has been made in the catchment of the Vilčok stream. The catchment is situated in Protected Landscape Area Beskydy. The method *Quantification and Quantitative Evaluation of Functions of Forests as a Basis for their Evaluation* (VYSKOT et al. 2003) was used for the design. This method can be applied to road planning. It can serve as another component in the decision-making process of the planning of forest road construction.

Keywords: forest road network; all-society functions of forests; total real potential and effect; design of forest road

Nowadays the evaluation of the optimal forest accessibility is based on the geomorphological and technological classification of the forest area. The optimal density of forest road network is approximately determined by the factor of the terrain division (BENEŠ 1991). The efficiency of accessibility is evaluated according to the geometrical and theoretical skidding distance. When evaluating the optimal accessibility, the reduction of the skidding distance is taken into account; however, the existing proposals of the road network have not prioritized the effect and impact on the all-society functions of forests.

MATERIALS AND METHODS

The catchment of the Vilčok stream was chosen for the evaluation and design of the forest road network in relation to the all-society functions of forests. The catchment is situated in Protected Landscape Area (PLA) Beskydy east of the Šance water basin. The Vilčok stream flows into the Říčka stream, which is a left-hand affluent to the Řečice. The Řečice discharges into the Šance water basin. The area of this catchment is 240 ha. The road network optimization was solved in the framework of research projects of the Department of Forest Engineering and Reclamation, Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry in Brno (BENEŠ 1985).

The stands on 53% of the catchment area are composed of Norway spruce (*Picea abies* L.) at 90% and more. The remaining area is covered with European beech (*Fagus sylvatica* L.), silver fir (*Abies alba* Mill.) and Norway spruce (*Picea abies* L.). Stands with degree of damage I take up 50% of the catchment area. Stand with degree of damage I is a medium damaged stand.

The routing of the current forest road network was evaluated and a new design of the road network in the area was made, both in relation to the all-society functions of forests. Different variants were compared according to geometrical skidding distance and road network density by the BENEŠ (1991) method. The data was processed on the basis of the values of the real potential of the functions of forest stands according to the management complexes of stands and stand type and values of the real effects of functions of the forest stands by the VYSKOT et al. (2003) method.

According to VYSKOT et al. (2003) the real potentials and the real effects exactly determine the functional ability of stands in the objective situation, independently of the instantaneous social demand. The real potentials of forest functions are quantified functional potentials of forests under optimum ecosystem conditions. The real effects of forest functions are actual quantified functional effects under actual ecosystem conditions.

The individual parts of stands in the catchment were evaluated. Each part of stand was allocated to a factual stand type according to tree species composition and percentage representation of the individual tree species. The parts of stands were assigned to function objective management complexes of stands according to forest type groups. Then value degrees of real function potentials were found according to management complexes of stands for stand type (0–6).

The value of the total real potential of functions of forests (RPfl) is the sum of the values of particular functions (0–36): bioproduction, ecological-stabilization, hydric-water-management, edaphic-soil-conservation, social-recreation and sanitary-hygienic. The real effect

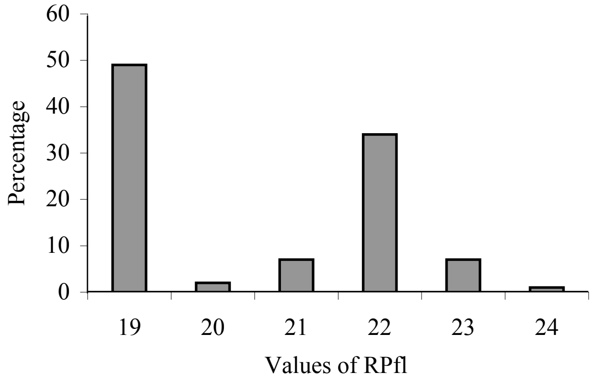

Fig. 1. The percentage of individual values of total real potential according to the area

of all-society functions of forests is defined as the degree complement of the real function potential. The real effect was defined according to the actual function-reduction criteria of forest stand conditions (the criteria of age, stocking and health condition). The values of age and stocking were taken from a management book. The management book is a part of the forest management plan. The book includes data on forest condition, proposals of management measures, table of areas. The health condition of the stands was defined according to terrain reconnaissance and Decree No. 78/1996.

RESULTS AND DISCUSSION

The real potentials of bioproduction and sanitary-hygienic functions have the highest values, but the real potentials of ecological-stabilization function have the lowest values in the catchment of interest. It is due to the high proportion of Norway spruce (*Picea abies* L.) in the stands of the Vilčok catchment. The hydric-water-management function has the highest real effects.

Parts of the stands with the average total real potential have the highest representation in the catchment, in particular with the value 19 (Fig. 1). The value 19 is the sum of potentials of particular functions. The values 17 to 20 mean average total real potential of functions. VYSKOT et al. (2003) stated that the average total real potential of functions had 62% representation in forests of the Czech Republic. The values 21–26 mean high total real potential of functions. Parts of stands with a high total real potential (ΣFv) are situated mainly in the southern and south-eastern parts of the catchment. These parts of stands have the highest values of the real effects of the individual functions and, within the framework of their potential, these stands fulfil all the functions at 80% and more.

The forest roads 1L (forest roads with all-year traffic) and 2L (forest roads with seasonal traffic) were investigated in the area of interest. Parts of stands with different real potential are often adjacent to these roads. This is due to the fact that the forest road network, mainly the hauling roads, has always been used as a permanent line of forest division. That is why stands with different

Table 1. State before Beneš's design (BENEŠ 1985)

Density of hauling roads (m/ha)	8.83
Accessibility of the forest (%)	45
Geometrical skidding distance (m)	626

Table 2. State after Beneš's design (BENEŠ 1985)

Density of hauling roads (m/ha)	32.5
Accessibility of the forest (%)	74
Geometrical skidding distance (m)	104

values of the total real potential are situated along one forest road. It is due to different species composition and representation of tree species in individual parts of the stand. It is possible to claim that the stands have a high functional effect because the total real potential is evaluated as medium-increased and high. That is why we can ignore the value differentiations of the individual parts of stands along the road.

The forest roads should not intervene in the parts of the stand with high total real potential. The observed parts of the stand reach higher functional ability in the optimal possible conditions; they are functionally more effective and so more valuable than parts of the stand with low potential. If we disrupt these parts of stand, the detriment will be higher than due to the intervention in the parts of stand with low total real potential. The forest road network is however essential for forest operations. This means that if there exists a possibility of leading the road through other than valuable stands, it should be made use of. But if the exclusion of the road from some parts of stand would mean the inaccessibility of these stands for forest operations, it would be necessary to build the road in spite of it, but with respect to some measures that would decrease its negative influence on the affected stands with high effects.

It is evident that the construction of forest road influences all-society functions of forests. But if we apply the method to concrete parts of stands before and after the road construction, the values of total real potential will not change. But the situation is different in real effects. The real effect is found according to the actual function criteria of the forest stand conditions (the functional reduction criteria of age, stocking and health condition). The age of stands cannot be influenced by the road construction. The road construction does not have to influence the stocking. The area of the part of stand (which the new forest road of type 1L or 2L goes through) will be reduced by the road area but the stocking will not be changed. However the forest road can influence the health condition of the stand. Especially in the case of damage to the root system of trees near the forest road, canopy opening and tree damage, which can essentially influence their health condition.

The road construction also strongly influences the hydric-water-management function. KREŠL (1978) stated that interception and transpiration decreased as a result of deforestation of the required zone for the forest road equally to its width. But evaporation increases at the same time. The road bed (the form of its surface) decreases the surface accumulation and infiltration practically to a negligible value. It means that rainfall infiltration into the soil is restricted and the road accelerates the origination of overland flow. Cutting slopes along roads drain the adjacent area and influences overland and subsurface flow that is caught by road ditches and concentrated into other places – into the culverts. Its speed increases and conditions for development of erosion damage are formed under outlets from the culverts.

It would also be possible to compare the deforestation of a zone for a forest road to a clear cut and to calculate the detriment of the stands. This value can be compared with the costs of construction of a road going outside the parts of stands with high total real potential. This possibility can be taken into consideration only if both variants allow regular management in the forest.

Building a forest road in this catchment is very difficult because of the unfavourable terrain conditions (high slope – mainly the terrain for cable systems).

BENEŠ (1985) was interested in the solution of the forest road optimization in this catchment. Optimization with several treatments was implemented according to his design. His design was directed only towards the forest road density, the accessibility of stands for skidding machines, design characteristics of forest roads and their relationships to terrain configuration. But he did not take into account the all-society functions of forests.

Four states were compared according to the density of hauling roads, relative rate of access and geometrical skidding distance.

1. State before BENEŠ's design (Table 1) (BENEŠ 1985)
2. State after BENEŠ's design (Table 2) (BENEŠ 1985)

Table 3. Present state

Density of hauling roads (m/ha)	38.5
Accessibility of the forest (%)	66
Geometrical skidding distance (m)	102

Table 4. State after the design according to all-society functions of forests

Design 1 (R10, R11)[1]	
Density of hauling roads (m/ha)	34.4
Accessibility of the forest (%)	73
Geometrical skidding distance (m)	103
Design 2 (R6, R8, R10, R11)[1]	
Density of hauling roads (m/ha)	27.5
Accessibility of the forest (%)	72
Geometrical skidding distance (m)	127
Design 3 (R6, R7, R10)[1]	
Density of hauling roads (m/ha)	24.6
Accessibility of the forest (%)	62
Geometrical skidding distance (m)	164

[1]forest roads proposed to be discontinued
R1,…,R11 – road numbers (Fig. 2)

3. Present state (Table 3)
4. State after the design according to the all-society functions of forests (Table 4)

The routes of forest roads that are proposed to be discontinued go through the parts of stands with high real potential of functions of forests. Geometrical skidding distance will increase and the density of forest roads will

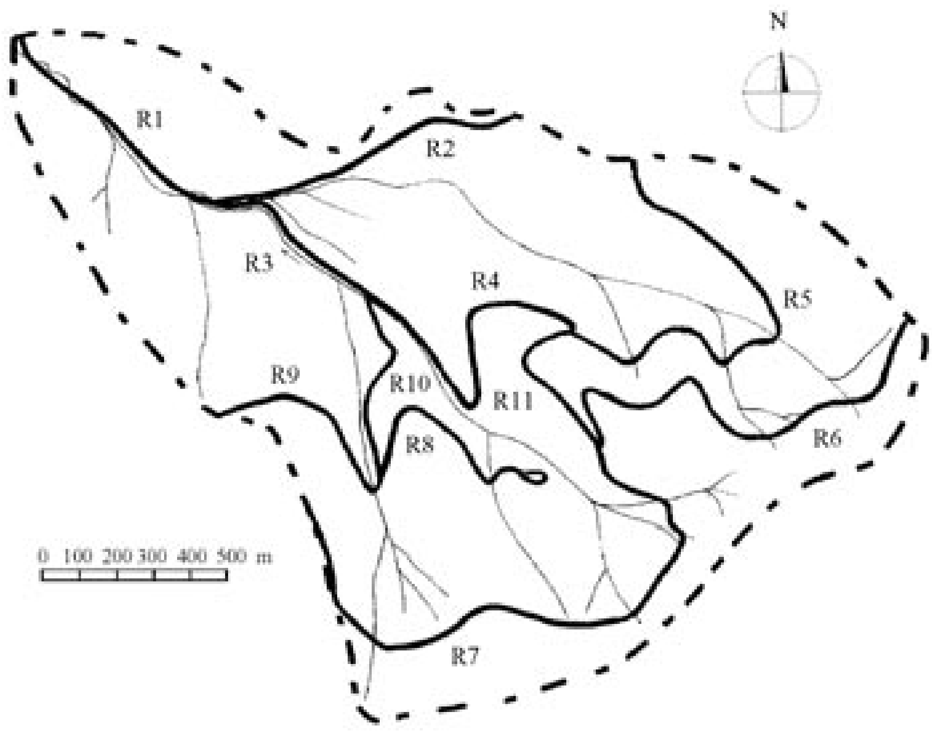

Fig. 2. Map of the Vilčok catchment with stream and roads

decrease by discontinuation of these roads in comparison with the present state.

BENEŠ (1991) reported that the geometrical skidding distance should be between 140 and 180 m in the mountainous and hilly country. As can be seen in Tables 1–4, in none of the variants does the average geometrical skidding distance exceed the top limit of values reported by BENEŠ (1991).

Designs were aimed only at the road discontinuation in parts of stand with high real potential. These stands were considered to be functionally more efficient and thus more valuable.

Time constrained validity of the real effects and real potentials could be seen as a problem. Real effect indicates the state in the actual conditions. Its value will be different after a certain period of time. It is difficult to determine the exact stocking and health condition in a few years. The values of stocking depend on concepts of forest management, and also on variable natural conditions (windthrow disaster, etc.). Stocking can be decreased by silvicultural treatments, but it can revert to the original value, according to the age and intensity of treatment. It means that it is necessary to take into account the time when the evaluation of a certain part of stand is made. It is possible to claim that the forest road network designed according to real effects will be convenient for the all-society functions of forests in the actual conditions, but a few years later it does not have to be so.

The design of the forest road network can be realized only according to real potentials of forest stands. The real potential of forest functions is provided on the basis of management complex of stands and stand type.

The management complex of stands does not change, but the stand type changes with changes in the species composition. However, the forest road network is a long-term matter. During the regeneration of the stand, the species composition can be changed. Should the road go through parts of stands at felling age, the design according to real potentials of forest functions may not be optimal in the next rotation if the species composition is changed. It is theoretically possible to say that the design would be different after 10 or 20 years if it were realized at the end of rotation of the stand.

Example: The value of parts of stands for the real potential of forest functions is 19 (average total real potential of functions), if they are in management complex of stands 55 in the Vilčok catchment (for the species composition 90% and more of *Picea abies*). If the species composition is 70% of *Fagus sylvatica* and 30% of *Picea abies* in the next rotation, the real potential of forest functions will be 24 in these parts (high total real potential of functions). It is a large difference in this catchment because the real potential of forest functions reaches the values 19–24. So the part of stand would have the highest value in this catchment instead of the lowest value.

It means that the design will be valid only in the current rotation.

Therefore, there is only one solution. It is necessary to plan the species composition for individual species of newly established stand for stands that are at the end of their rotation. The resultant stand type should be as close to the natural species composition as possible and thereby reach the highest values of total real potentials.

CONCLUSION

The method *Quantification and Quantitative Evaluation of Functions of Forests as a Basis for their Evaluation* (VYSKOT et al. 2003) can be used for road planning and construction. It can serve as an extra component that will be a member of the decision process.

So far, the main criteria for the forest road construction remains to respect the terrain configuration and observe the parameters of the type of concrete forest road to facilitate the forest operations. The implementation of this method will be convenient if there is a possibility to build a road in several different directions. If it is not possible to have the forest road outside the parts of stands with high total real potential, some measures will have to be taken in order to minimize the negative effects even at the cost of increasing the costs of forest road construction.

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Návrh lesní dopravní sítě s ohledem na celospolečenské funkce lesa

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ABSTRAKT: Zpřístupnění lesa je základním předpokladem pro rozvoj všech činností lesního hospodářství. Návrh lesní dopravní sítě s ohledem na celospolečenské funkce lesa byl proveden v povodí potoka Vilčok, které se nachází v Chráněné krajinné oblasti

Beskydy. Pro návrh byla použita metoda *Kvantifikace a kvantitativní hodnocení celospolečenských funkcí lesů jako podklad pro jejich oceňování* (VYSKOT et al. 2003). Tato metoda bude moci být využita pro plánování lesních cest a může sloužit jako další prvek, který bude součástí rozhodovacího procesu při plánování výstavby lesních cest.

Klíčová slova: lesní dopravní síť; celospolečenské funkce lesa; celkový reálný potenciál a efekt; návrh lesní cesty

V současné době vychází hodnocení optimálního zpřístupnění lesních porostů především z geomorfologického a technologického členění lesních území. Podle koeficientu terénu je orientačně stanovena optimální hustota lesní dopravní sítě. Při posuzování optimálnosti zpřístupnění je tedy brán ohled především na zkrácení přibližovací vzdálenosti, ale dosud nebyly v návrzích cestní sítě zohledňovány vlivy a dopady na celospolečenské funkce lesů.

Pro posouzení a návrh lesní dopravní sítě (LDS) s ohledem na celospolečenské funkce lesa bylo vybráno povodí potoka Vilčok, které se nachází na území CHKO Beskydy, východně od vodní nádrže Šance. Optimalizace cestní sítě tohoto povodí byla řešena již v rámci výzkumných úkolů pracovníků Ústavu lesnických staveb a meliorací Lesnické a dřevařské fakulty Mendelovy zemědělské a lesnické univerzity v Brně (BENEŠ 1985). Na území bylo hodnoceno vedení současné lesní dopravní sítě a byl proveden nový návrh, vše s ohledem na celospolečenské funkce lesa. Různé varianty pak byly porovnávány podle geometrické přibližovací vzdálenosti a hustoty cestní sítě podle BENEŠE (1991). Zpracování bylo provedeno na základě hodnot reálných potenciálů funkcí lesních porostů podle hospodářských souborů a porostních typů a hodnot jejich reálných efektů podle metodiky VYSKOTA et al. (2003). Jak uvádí VYSKOT et al. (2003), reálný potenciál a reálný efekt stanovují funkční schopnosti porostů v objektivní poloze, nezávisle na okamžité společenské potřebě, která je časově i věcně účelově subjektivní. Reálný potenciál vyjadřuje schopnosti v optimálně možných ekosystémových podmínkách, zatímco reálný efekt účinky v podmínkách aktuálních.

V zájmovém území byly sledovány lesní cesty 1L a 2L. K těmto cestám často přiléhají z každé strany porostní skupiny s rozdílným reálným potenciálem nebo efektem funkcí lesa. Je to způsobeno faktem, že lesní dopravní síť, zejména odvozní cesty, byla a je využívána jako trvalá linie rozdělení lesa. Proto dochází k situaci, že se podél lesní cesty nacházejí porosty s různou hodnotou celkového reálného celospolečenského potenciálu. Je to dáno různým druhovým složením a zastoupením dřevin v jednotlivých porostních skupinách. V povodí Vilčok dosahují nejvyšších hodnot reálné potenciály funkce bioprodukční a zdravotně-hygienické, naopak nejnižších hodnot potenciály funkce ekologicko-stabilizační, což vyplývá z vysokého procentuálního zastoupení smrku. Nejvyšších reálných efektů dosahuje funkce hydricko-vodohospodářská.

Metoda *Kvantifikace a kvantitativní hodnocení celospolečenských funkcí lesů jako podklad pro jejich oceňování* (VYSKOT et al. 2003) bude moci být využita při plánování a výstavbě nových cest. Může sloužit jako další prvek, který bude součástí rozhodovacího procesu.

I nadále musí zůstat hlavním kritériem výstavby LDS respektování konfigurace terénu a dodržení parametrů podle konkrétního typu lesní cesty pro umožnění činností lesního hospodářství. Při možnosti rozhodování, kdy bude možné vést trasu několika různými směry, je potřebné využití této metody. Pokud lesní cesta nebude moci být vedena mimo porostní skupiny s vysokým celkovým reálným celospolečenským potenciálem, budou muset být splněna opatření vedoucí k minimalizaci způsobených negativních účinků i za cenu zvýšení nákladů na výstavbu lesní cesty.

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BOOK REVIEW

AN ILLUSTRATED GUIDE TO MAPLES

ANTOINE LE HARDŸ DE BEAULIEU

Timber Press, Portland • Cambridge, 2003, 464 pp., hardcover, ISBN 0-88192-601-9

Many books and papers dealing with the maple morphology, taxonomy, systematics, propagation, cultivation or wood properties have been written, some of them published by Timber Press. From these I would select the monograph *Maples of the World* as the most comprehensive and authoritative source of information. Many illustrated guides or colour encyclopedias of cultivated maples have been published, too. From this category I would definitely choose *An Illustrated Guide to Maples*, again published by Timber Press, as the fabulous and almost ideal photographic companion to *Maples of the World*.

An Illustrated Guide to Maples tells a fully documented and exhaustive photostory of the aristocratic genus *Acer* in four-season gardens. Up-to-date, it is the largest illustrated reference on maples that assembled over 1,200 gorgeous photographs, taken mainly from West European and American gardens, but sometimes from natural habitats, too. The text is concise relying heavily on the illustrations to highlight the main features of each maple. They do this brilliantly.

The book begins with an introduction to the maple world giving telegraphic information on the history, leaf colours, bark, flowers, inflorescences, fruits, propagation techniques, hardiness, and hybridisation. The maple classification used in this volume follows de Jong's systematics, currently accepted in Europe but not in Japan. As this is not a taxonomic treatise, it was the author's choice to adopt the classification he considers as the most complete and the most recent to his knowledge. From this point of view, my comment is pertaining to the invalid name of *A. mono* used by the author. According to the nomenclatorial change ratified several years ago, a current valid name for this species is *A. pictum*.

Brief descriptions of the species include the epithet, common name, wild origin along with the year of introduction, general appearance, morphological characteristics of the trunk, buds, leaves, flowers, fruits, and information on the propagation. The book is laid out in alphabetical order – an ideal form which makes it very simple to find any given plant taxon. All maple species cultivated in Europe are included, whatever their origins. This huge inventory of species, subspecies, varieties and formae is depicted in very instructive photos of the bark, foliage, flowers, fruits and other relevant details, always accompanied by a photograph of a larger part of the plant. The author's goal was to present a wide diversity of maples from which landscape designers and gardeners may safely and reliably select the particular cultivar, form or species. Numerous photographs in this book are an ideal source of information. For me, dare I say, the most exciting illustrations belong to *A. sikkimense* ssp. *metcalfii*, the very rare maple with which I undertook several tissue culture experiments but never had a chance to see a habit and appearance of mature specimens. Finally, may I assure you what a remarkable maple it is. However, it is needed to say that it was not the author's intention to present a complete list of maple cultivars. Indeed, it is a technically impossible task for a single volume aimed mainly at true type species. Though the most popular cultivars frequently seen in public gardens and arboreta are mentioned in the book, at least one additional volume would be required for cultivars of the Japanese maple species only. Therefore, readers wishing to feast their eyes on *A. palmatum* cultivars will be disappointed (8 photos displayed on a single page only) despite many excellent illustrations of widely represented cultivars of *A. japonicum*, *A. shirasawanum* or *A. sieboldianum*. For this group of maple fanciers oriented to Japanese maples, I would recommend other titles, either *Maples for Gardens* published by Timber Press in 1999, or Yano's bilingual Japanese-English edition of *Book for Maples* from 2003.

The final chapter is an essay about diverse utilisations of maples in the landscape, from golf courses to bonsai. A glossary, list of discoverers and principal maple botanists, short bibliography with 20 references, index of common names and plant index offer further welcome information. Perhaps instead of an ordinary listing *Acer* names in an index, I would prefer if the author had developed a table which, in addition to page numbers, had columns for the hardiness zone appropriate for each maple taxon, sun/shade/shelter conditions, etc. Such a table would have made it much easier to use this illustrated guide also as a cultural guide for the complete designing and plantings.

Outstanding features of the book are the magnificent colour reproductions of excellent quality, moreover artfully arranged. The author along with the publisher have made the polished book with which I have the great respect and admiration. In this case a picture is indeed worth a thousand words. What an inspiring book that makes maple addicts many out of us.

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