Economic aspects of the selection system of management at the Masaryk Forest Training Forest Enterprise Křtiny

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ABSTRACT: The objective of the paper is to establish an economic result of the management of forest stand under a selection system as exemplified on a model subcompartment. A qualitative research of tree species occurring in Subcompartment 116 D at the Training Forest Enterprise (TFE) was made for this purpose. Cost and yield models of management were constructed and expected model costs and yields were calculated to establish a model economic result for the subcompartment. The models are entered actual data related to the general principles of management, to the volume of implemented silvicultural operations, and to the production capacity of the site. The volume of logging operations is based on a model decennial allowable cut and its assortment structure. A starting point for the establishment of costs are prices of concrete works set up by the TFE for the year 2004. Yields are calculated on the basis of average prices for raw timber assortments published by the Czech Statistical Office for the period from January to April 2004.

Keywords: selection system; grading; cost model; yield model; profitability

Sustainable forestry and near-natural forest management are two terms very frequently referred to at present. While the former term represents a standard method of management used in most Czech forests, near-natural forest management calls for a more refined and differentiated way of the execution of management measures in forest stands. The selection system of management reflects best the very substance and philosophy of near-natural management in the forest.

Silvicultural problems of the selection system were discussed for example by Souček (2002), whose study brought an assessment of the development of tree numbers, standing volume and standing volume diameter distribution in the locality Opuky. Höher (2002) understands the selection forest to be a target in the further development of the forest concept in Erdmannshausen. Szanyi (1999) studied the structure and regeneration processes of a fir-beech shelterwood forest in conversion into the selection forest on the basis of data from two mixed forest stands in the Laborecké hory Mts. Knoke (1999) studied how to best optimize the value of standing volume in the selection forest. Poleno (1999) discussed benefits of the regeneration felling procedure by selecting individual trees. Šach (1996) presented a possible procedure for the conversion of forest stands managed under a system involving coupes into selection forest, the procedure described by him representing a generalization of instructions for the conversion. Results of conversions into selection forests at the Masaryk Forest Training Forest Enterprise (TFE) in Křtiny, operated as a special-purpose facility of Mendel University of Agriculture and Forestry (MZLU) in Brno, were presented by Truhlář (1995) with included felling indicators and calculated local volume tariffs.

Economic issues of forest production, answers to which or at least to some of them could be used for the purpose of this paper were studied e.g. by Pulkrab (2003). Lessons learnt from the operation of the selection system in Klokočná were presented by Ferkl (2003). Possibilities of silvicultural system economic assessment were studied and published by Dudík and Kalousek (2000). Tutka (1998) was interested in the substance of effectiveness in different silvicultural systems, especially with respect to costs. Dudík et al. (2003) studied economic aspects of the evaluation of some harvesting technologies. Kubů (1996) carried out a modelling of costs spent for regeneration, protection and tending of forest stands arisen through natural or artificial forest regeneration.

Investigation of sources in which instigations could be found for the task solution or which could be linked up led us to a conclusion that the solution of this task is focused on two mutually related and integral parts. The one part concerns the possibilities and methods of acquisition of input data that would be suitable for economic modelling. As it follows from the evaluation of the issue resolved, current and previous papers have mostly dealt with the description and assessment of the historical or existing condition of forest stands managed under a selection system. Therefore the present paper is also focused on possibilities and acquisition of documentary data that would suit the purpose of model economic assessment at least, i.e. cost and yield aspects of management in selection forests. The other part of the study is a proper economic assessment based on the model documentary data, i.e. development of cost and yield models on the example of a model subcompartment in the selection forest.

In order to construct the cost and yield models, efforts were made to obtain actual, available and relevant data about selection forest stands at the Training Forest Enterprise that would become a groundwork for the construction of the models. Therefore, characteristics of stands included in the TFE primary management group of stands in the conversion to selection forest were investigated. Model curves of diameter frequencies served for a comparison with actual numbers of diameter frequencies in the individual stands as presented in the Forest Management Plan (FMP) (Truhlář 1993).

A variant that investigates model costs and yields on an example of Model Subcompartment 116 D was chosen for the purposes of the task solution. The model solution was preferred as the author of the paper intended to operate with a conception of cost and yield aspects of this silvicultural system at TFE and to establish possibilities of a theoretical approach to the problem solution. Another reason was the lack of availability of precise and complete data applicable in a detailed and exact evaluation of actual costs and yields of all subcompartments (and hence of the whole primary management group of stands). Yet another reason for the paper to include the model part is that its results are not restricted only to draw general conclusions and statements. The author attempts at an assessment of possibilities to quantify the economic potential of the selection system at TFE.

Natural conditions

Subcompartment 116 D is situated in the Klepačov locality which belongs to the TFE-operated territory. Climatic conditions are characterized by mean annual precipitation of 618 mm and mean annual temperature amounting to 6.8°C. The subcompartment lies at an altitude ranging from 350 to 410 m. Terrain relief is characterized by a moderate slope of W aspect in the E part, which gradually passes into a mildly undulating ridge falling in steep slopes into glens at the N and NW margins. Geological basement is the Brno igneous rock, mainly amphibolic granodiorites with the covers of loess loams. Predominant soil types are Typic Cambisols both mesotrophic and oligotrophic, and Typic Luvisol. The group of forest types according to the Brno typological school of Prof. Zlatník is classified as *Querci-fageta* and *Fageta quercina*. Stand area of the subcompartment is 7.67 ha. Detailed information about the natural conditions see Truhlář (1995).

MATERIAL AND METHODS

The set-up and construction of Model Subcompartment 116 D initial data for cost and yield modelling

The models are constructed with the use of data actually measured in Subcompartment 116 D, borrowed from available sources – especially from FMP (Truhlář 1993) or FMP appendixes (Lesprojekt 2003), or computed from the established or borrowed data. Yield modelling includes only benefits from the wood-producing function of Subcompartment 116 D, i.e. model receipts from timber sales. To obtain the model receipts, a qualitative research of tree inventory in Subcompartment 116 D was conducted in October 2001 in order to determine the actual qualitative condition of trees and to have a clear image about the future model qualitative structure of assortments from harvesting operations. Tree species of interest were Norway spruce (*Picea abies*), fir (*Abies alba*), pine (*Pinus sylvestris*) and beech (*Fagus sylvatica*). The total representation of the species in the subcompartment was 99.5% (Truhlář 1993).

Legislative support for the qualitative assessment of tree inventory was found in Czech standards ČSN 48 0055 (1985) and ČSN 48 0056 (1985) which – although not being obligatory any longer at the time of research – provided a good legal base in the absence of any other standard, and technical requirements following from these old standards were used to work out assortment tables. The volume of these valuable assortments (assortments of Quality Class I and II) was determined on the basis of a procedure described by Dejmal (1986). The volume determination of valuable assortments issues from the known underbark tree volume of all tree species in the investigated diameter classes (interval of 4 cm).

The model tree volume was determined by using two-argument volume tables constructed by Lesprojekt (1952) where model volumes in bark were found out for the investigated tree species on the basis of diameter and corresponding fitted height. Conversion of the results to underbark volume was made by using bark allowance coefficients according to Dejmal (1986), who based his values on coefficients developed by Pařez (1973). The model one-tree volume established in this way applies only to the respective tree species in the diameter classes of Subcompartment 116 D. The model volumes established in this way were further worked with. The second possible option is a possible use of calculated volume tariffs of the primary management group of stands for the diameter classes of the respective tree species (Truhlář 1995).

Recommended Regulations for Timber Measurement and Grading in the Czech Republic (Anonym 2002) were issued at the end of 2002 – hereinafter "Recommended regulations" – which are not binding but used. Input data for the office processing of qualitative research results from Subcompartment 116 D were modified to accommodate the classification. As the collection of field data in the forest stand was very detailed, the number of trees from which the hypothetical assortments of Quality Class I or II could be obtained and the assumed length of valuable assortments (once again separately for each diameter class and each tree species) could be newly modified so that the technical parameters of the expected valuable assortments would correspond to the recommended regulations. The new modification of the data also meant a determination of limits in the form of the least diameter class considered in the calculation of the volume of valuable assortments for the respective species.

Other calculations and procedures were made at a model level, i.e. at the level of model subcompartment 116 D. Model standing volume in the model subcompartment was established by using results from the calculation of model tree volume for each diameter class and species. The model tree volume was used along with the tree numbers in individual diameter classes derived from a model curve of diameter frequencies (Truhlář 1995) for the calculation of the model timber volume of the whole model subcompartment for each tree species with a 100% representation in the subcompartment and for the respective diameter classes. This model volume of each fully represented species was reduced to the species share in the target species composition specified in the general directives of management for the primary management group of stands as in the appendix to FMP of 2003 (Lesprojekt 2003). By summing up these volume shares of individual diameter classes of the tree species a model standing volume was obtained by diameter classes, consisting of the species and their representations specified in the general directives of management. It is assumed that the representation of a tree species within the framework of the target species composition is identical in the individual diameter classes.

As no detailed data on the assortment structure of realized felling were available, it was necessary to establish an assortment structure of model allowable cut in Model Subcompartment 116 D. The first step to investigate a model assortment structure of allowable cut is to determine the allowable cut volume. In order to assure sustainability of management and hence a good balance between felled volume and yield, it is expected that the volume of model allowable cut equals the model total current increment (TCI) of the subcompartment. Primary data for modelling the allowable cut volume was therefore TCI and the magnitude of increment percent. Decree of the Ministry of Agriculture No. 84/1996 (Anonym 1996) defines the method of TCI calculation for forest stands managed under a selection system. In its appendix in the calculation of increment percent the last FMP (Lesprojekt 2003) considers the calculated current increment and assumes "the increment percent to be the same in all diameter classes". Neither TCI nor increment percent are distinguished according to individual species. The data are to represent the whole subcompartment.

This is why an increment percent of 2.42% (2.20% for conifers and 3.62% for broadleaves) was used for the purpose of calculating the increment of Model Subcompartment 116 D. With regard to the defined model standing volume of individual tree species in diameter classes, the figure was subsequently used for the calculation of model annual increment according to diameter classes and tree species. Summing up annual increments according to diameter classes and tree species we arrive at a value of annual increment for the whole subcompartment, i.e. its annual or decennial allowable cut. The above-mentioned values of increment percent represent the whole primary group of stands managed in conversion to selection forest and were borrowed from the last version of the appendix to FMP (Lesprojekt 2003).

The assortment structure of the decennial allowable cut determined by the above described method was established by using tables for grading the volume of timber to be felled in a certain year (Dejmal 1986). Since the result of the evaluation of tree inventory qualitative characteristics in Subcompartment 116 D was its average quality, the model did not take into consideration any representation of valuable tree species assortments, this being a concrete reason not to change the recovery coefficients of timber assortments. It is assumed for the purposes of the establishment of allowable cut assortment structure that Quality Class IIIA according to the former ČSN 48 0055 (1985) and ČSN 48 0056 (1985) is most neared to by Quality Class IIIB according to the Recommended regulations (2002). And further on, Quality Class IIIB according to the former ČSN standards is most neared to by Quality Class IIIC according to the Recommended regulations. The classification of other commercial assortments and fuel wood according to Dejmal 1986) remains unchanged.

Applying the recovery coefficients (Dejmal 1986) to the model standing volume in the respective diameter classes we obtain the assortment classification of standing volume for a particular tree species in diameter classes. Multiplying the standing volume divided as described above by the model increment percent we obtain the assortment classification of annual or decennial increment according to diameter classes and tree species. The increment divided in this way in fact represents the volume and the assortment classification of the model allowable cut. Examining the classification of assortments for each tree species we obtain – after a numerical sum-up – a model assortment structure of allowable cut of the whole subcompartment for the individual tree species. It is assumed for the further calculation that the felling will be implemented at a full volume of allowable cut once in the decennium and will concern all diameter classes and all tree species.

The time framework of modelling is a period of ten years – a decennium. The time is considered fully sufficient because the modelling is made in a situation that assumes the model (normal) stand condition. The selection of the ten-year modelling framework is bound to the time of circulation (i.e. period of time in which felling returns back to the same plot), which in our case equals the control period (i.e. lapse of time between two inventories).

Costs of Model Subcompartment 116 D

Model costs represent a sum of expected costs connected with the management of forest stand under a selection system, i.e. in Model Subcompartment 116 D. Differentiation of model costs follows from the TFE chart of operations (2004). Concrete sub-operations were surveyed in the framework of selected silvicultural and logging operations, for which total standard time consumption was calculated in standard hours. Types of concrete model sub-operations follow from actual activities (sub-operations) carried out in the TFE forest stands managed under a selection system. A field spatial framework for cost modelling is the stand area of the model subcompartment

Table 1. Model Subcompartment 116 D – Assortment structure of the model decennial allowable cut

Quality class	Spruce	Fir	Pine	Beech
	(m^3 underbark)			
III B	167.31	–*	37.05	89.96
III C	23.04	132.59	2.47	21.10
IV – pole	9.99	5.52	1.62	–
V – pulpwood	21.76	14.62	2.06	53.53
VI	6.23	4.87	2.63	11.56
Total	228.33	157.60	45.83	176.15
Total	607.91			
Total per 1 ha	29.77	20.53	5.96	22.97
Total per 1 ha	79.23			
Total per 1 ha/year	2.98	2.05	0.60	2.30
Total per 1 ha/year	7.93			

*Recommended regulations (2002) specify for fir the following extent of defects in Quality Class III – logs for sawmill processing only from III C
Applicable to the whole Model Subcompartment 116 D (7.67 ha) with the considered target tree species composition
Applicable to the entire model period of time, i.e. 10 years

up to the locality of roadside landing; in other words, the subject of interest is model costs connected with the operations carried out inside the specified area. In order to adhere to the space demarcated for the modelling and to obtain at the same time marketable assortments in desirable structural composition, the cost modelling included an additional sub-operation 126 001 – Timber handling at roadside landing – cross-cutting.

A list of model silvicultural operations and sub-operations used in the cost model:

Operation: *016 Reforestation by planting*

Sub-operation: 016 211 First planting into unprepared soil – manual – hole planting

Operation: *023 Game control in young forest stands*

Sub-operation: 023 111 Coating of plantations with repellents – summer

Sub-operation: 023 121 Coating of plantations with repellents – winter

Operation: *024 Weed control in young forest stands*

Sub-operation: 024 031 Mowing – manual – whole area

Operation: *031 Cleanings*

Sub-operation: 031 451 Cleanings – conifers – above 4 m – mechanized

A starting point in the specification of the type and range of modelled silvicultural sub-operations was the actual extent of work in these sub-operations carried out in Subcompartment 116 D recorded in FMP (Truhlář 1993).

A list of model logging operations and sub-operations used in the cost model:

Operation: *112 Timber harvesting TFE – Contractors*

Sub-operation: 112 018 in selection forest

Operation: *122 Skidding – Contractors*

Sub-operation: 122 002 Skidding – locality stump – roadside landing

Operation: *126 Timber handling at roadside landing*

Sub-operation: 126 001 Cross-cutting

A starting point in the specification of the type and range of modelled logging sub-operations was effort to process the volume of model decennial allowable cut for the whole Model Subcompartment 116 D at a required structure. The structure is presented in Table 1.

Model costs arise in the first year of the ten-year period of time, and the last cost is considered in Year 3 – this applying for the purposes of modelling. With respect to methodology, the model costs were established by using the itemization of costs. This classification of costs also corresponds to the general calculation formula mentioned for example by Synek et al. (2002). Direct costs of TFE per rated unit of the j^{th} sub-operation of the i^{th} operation in the a^{th} year ($PNMc_{i(j)a}$) follow from TFE calculations. Rated unit is represented by 1 standard hour (*Nh*). The values of $PNMc_{i(j)a}$ are considered to be same in the entire model period of time for the purposes of model functionality verification. The $PNMc_{i(j)a}$ values enter the first year of cost modelling period at a level of the year 2004.

The resulting model norm of time consumption per rated unit for a concrete sub-operation and in the case of logging sub-operations surveyed additionally for the diameter class of $d_{1.3}$ was established from available industrial standards and labour consumption directives (MLVH, 1978; JMSL, 1983; MLVH, 1986) by taking into account the model conditions based on actual natural and other conditions of Subcompartment 116 D managed under a selection system at TFE. The number of rated units per each concrete sub-operation follows from the model volume of labour that is to be carried out in the framework of each sub-operation concerned. A groundwork for the field of logging operations is a model structure of assortments and a volume of allowable cut for individual diameter classes. A groundwork for the field of silvicultural operations is a volume of labour carried out in Subcompartment 116 D in the last decennium.

The level of indirect costs was resolved by introducing an overhead surcharge used to establish overhead costs in operative or plan calculation (Synek et al. 2000). In this paper, the overhead surcharge represents the ratio of TFE overhead costs to direct costs as expressed in percent. In our case, the production and management overhead costs of TFE forest operations are expressed by means of KRP_a overhead surcharge coefficient which represents its decimal expression. For the purposes of model functionality verification the overhead surcharge coefficient is considered at the same level in the whole model period.

As the sole and most important products considered in the models are timber assortments marketed from the locality of roadside landing, the costs of sales will be considered zero with regard to their nature (as mentioned by Synek et al. 2000). Full output costs of the model subcompartment therefore represent a sum of expected direct and indirect costs on the surveyed sub-operations carried out in the model subcompartment of the TFE forest stand managed under a selection system. Viewed from this point, the full output costs of the sub-operation equal the output costs of the sub-operation.

Time factor is not considered in cost (and yield) modelling as the used value of interest rate would

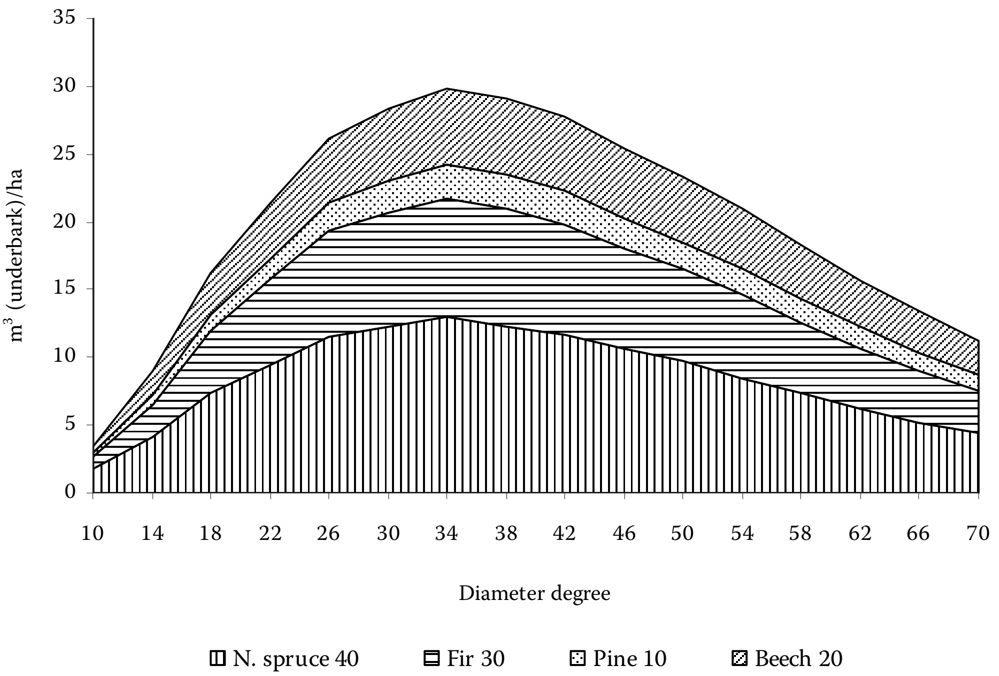

Fig. 1. Model standing volume of diameter classes in Model Subcompartment 116 D per 1 ha

distort modelling results. Apart from this, it is assumed in the models that an absolutely larger part of costs will be expended in the first year of the model period of time. For the costs relate to the operations of timber harvesting, skidding and timber handling at roadside landing because it is assumed that the receipts from timber sales are also realized in the first year of the model period. The numerical expression of individual direct costs used per rated unit of the concrete sub-operation in the given year ($PNMc_{i(j)a}$) as well as the percentage of direct cost-related indirect costs (expressed by overhead surcharge coefficient KRP_a) are based on the documentation supplied by TFE. Data in the documentation taken over from TFE follow from the TFE management directives No. 19/2003 (Hloušek, Šilhánek 2003) in effect since January 1, 2004.

Yields of Model Subcompartment 116 D

Model yields represent a sum of expected yields from the model subcompartment. Their surveying comes out of a model assortment structure of model decennial allowable cut of Model Subcompartment 116 D. Assumed model receipts from raw timber sales were calculated on the basis of the expected total produced volume of individual timber assortments according to species and average price per 1 m^3 of the particular assortment. These receipts represent the sole and the most important constituent of model yields. Other revenues, for example receipts for slash, Christmas trees or receipts from game management activities are not considered. Receipts from timber sales are realized from the locality of roadside landing.

In this paper average price per 1 m^3 of the particular assortment is average price of a concrete raw timber assortment for domestic market for the period from January–April 2004, borrowed from data published by the Czech Statistical Office (ČSÚ 2004). The only exception was the assortment of coniferous pole timber whose average price was borrowed from the survey of timber supplies implemented by TFE (in the studied period) because the Czech Statistical Office does not usually publish the average price for this assortment. For the purpose of modelling, the yields arise only in the first year of the 10-year model period of time. The yield model does not take into account any other corporate yields, i.e. financial and irregular ones (Synek et al. 2000), i.e. not even the costs relating to these yields.

Comparison of results from modelling costs and yields of Model Subcompartment 116 D

The sense of this comparison is to establish a model economic result from the management of the model subcompartment under a selection system in the framework of the model period of time (*HVm*). According to Kupčák (2003), economic result is a difference between yields and costs of the enterprise (in our case forest enterprise) for a definite period of time. In this paper, yields represent the model yields from Model Subcompartment 116 D (*Vm*), costs representing full output costs or output model costs of Model Subcompartment 116 D (*VNm*). The abovementioned concept of comparing the results of cost and yield modelling makes it possible to establish some other economic indicators such as economic effectiveness or indicators of cost (yield) profitability (Synek et al. 2002).

RESULTS AND DISCUSSION

Evaluation of the results from qualitative research of Subcompartment 116 D tree inventory according to the Recommended regulations (2002) gives a relatively unambiguous conclusion. With respect to the low volume of valuable assortments in Norway spruce (0.91 m^3/ha) and pine (1.73 m^3/ha), due to the absence of valuable assortments in beech and eventually also due to an impossible differentiation of valuable assortments in fir a statement can be made that the tree inventory does not reach a high technological standard (according to Dejmal 1986) under existing conditions. The stand of Subcompartment 116 D is classified as of mediocre quality and the volume of valuable assortments will not be considered in further calculations. In addition, it would only have to be a part of the volume that could be taken into account (with respect to further modelling) since lump felling of the whole subcompartment stand never occurs during timber harvesting. Fir could not be differentiated for Quality Class I and II assortments as the Recommended regulations do not specify technical requirements for the fir assortments. The relevance of considerations about a comparative relation between the technical requirements for assortments according to the former ČSN standards 48 0055 (1985) and 48 0056 (1985) and according to the Recommended regulations (2002) was once again corroborated by the new conversion key of the Czech Statistical Office (Pavluv 2004) approved for the purposes of maintaining the time series between the previous and current composition of representatives of coniferous and broadleaved assortments.

Per-hectare model underbark standing volume of the subcompartment is 319.30 m^3 (135.33 m^3 Norway spruce, 93.39 m^3 fir, 63.45 m^3 beech and 27.13 m^3 pine). The standing volume structure according to species in diameter classes follows from Fig. 1 in which the model underbark standing volume is presented in cubic meters in diameter classes per hectare area of the model subcompartment. Figures attached to the names of tree species in the diagram show the percentage representation of the species.

Based on increment percent, the established model annual total underbark current increment (TCI) amounts to 7.93 m^3 timber to the top of 7 cm per hectare (2.98 m^3 Norway spruce, 2.05 m^3 fir, 0.60 m^3 beech and 2.30 m^3 pine per hectare). The data are calculated taking into account the target tree species representation for Model Subcompartment 116 D. Volume and assortment structure of the model decennial allowable cut of the model subcompartment are presented in Table 1.

The level of increment percent (2.46%) of Model Subcompartment 116 D was not used since the increment percent of the entire primary management group of stands is only slightly lower (2.42%). Apart from this, the increment percent of the whole group of stands was computed from a larger data volume, which eliminates possible errors.

Model costs are constructed for a generally defined model subcompartment of 7.67 ha uneven-aged non-mixed forest stand. Numerical outputs of the models can be converted per 1 hectare. Forest stand species composition of the model subcompartment is given by the set-up target species composition of the primary management group of stands No. 8442 (Lesprojekt 2003). Age is of no significance in the stands managed under a selection system since the characteristic is not investigated in these stands due to obvious reasons.

Another result of cost modelling focused on the establishment of model output costs (*VNm*) of the subcompartment was a definition of cost relations of which the most significant ones are presented below:

$$PN_{i(j)a} = CSN_{i(j)a} \times PNMc_{i(j)a} + DPN_{i(j)a} \quad (1)$$

$$PNm = \sum_{a=1}^{n} (\sum_{i=1}^{x} (\sum_{j=1}^{y} PN_{i(j)a})) = \sum_{a=1}^{n} \sum_{i=1}^{x} \sum_{j=1}^{y} PN_{i(j)a} \quad (2)$$

where: $PN_{i(j)a}$ – direct costs in CZK of the j^{th} sub-operation of the i^{th} operation in the a^{th} year,

$CSN_{i(j)a}$ – total consumption of standard time in standard hours for execution of the j^{th} sub-operation of the i^{th} operation in the a^{th} year,

$PNMc_{i(j)a}$ – direct costs of TFE in CZK for time rated unit (1 standard hour) of the j^{th} sub-operation of the i^{th} operation in the a^{th} year,

$DPN_{i(j)a}$ – partial direct costs in CZK (if applicable) not included in $PNMc_{i(j)a}$ and relating to the execution of the j^{th} sub-operation of the i^{th} operation in the a^{th} year,

Table 2. Total consumption of standard time for implementation of silvicultural and logging sub-operations in Model Subcompartment 116 D

Sub-operation	Total consumption of standard time $CSN_{i(j)a}$		
	standard hours – total	standard hours per 1 ha	standard hours per 1 m^3
016 211 (first planting)	28.80	3.75	–
023 111 (repellent-summer)	58.50	7.63	–
023 121 (repellent-winter)	58.50	7.63	–
024 031 (mowing)	35.40	4.62	–
031 451 (cleaning)	15.20	1.98	–
112 018 (timber harvesting)	367.89	47.96	0.60
122 002 (skidding)	177.59	23.16	0.29
126 001 (handling – one-man power saw)	53.41	6.96	0.09
126 001 (handling – UKT tractor)	46.54	6.07	0.08
Total	841.83	109.76	1.06

Applicable to the entire model period and to an area of 7.67 ha

PNm – total model direct costs of the model subcompartment in CZK,
i – order of the operation (i = 1, 2 ... x),
j – order of the sub-operation (j = 1, 2 ... y),
a – order of the year (a = 1, 2 ... n; n = 10).

$$NN_{i(j)a} = PN_{i(j)k} \times KRP_a \qquad (3)$$

$$NNm = \sum_{a=1}^{n} \sum_{i=1}^{x} \sum_{j=1}^{y} NN_{i(j)a} \qquad (4)$$

where: NNm – total model indirect costs of the model subcompartment in CZK,
$NN_{i(j)a}$ – indirect costs of the j^{th} sub-operation of the i^{th} operation in the a^{th} year in CZK,
$PN_{i(j)a}$ – direct costs of the j^{th} sub-operation of the i^{th} operation in the a^{th} year in CZK,
KRP_a – overhead surcharge coefficient expressing in decimal number the level of overhead cost percentage as related to TFE direct output costs in the a^{th} year,
i – order of the operation (i = 1, 2 ... x),
j – order of the sub-operation (j = 1, 2 ... y),
a – order of the year (a = 1, 2 ... n; n = 10).

Since the model timber sales costs are considered to be zero, it holds true that:

when ONm = 0, then

$$UVNm = PNm + NNm = VNm \qquad (5)$$

where: ONm – total model timber sales costs of the model subcompartment in CZK,
$UVNm$ – model full output costs of the model subcompartment in CZK,

Table 3. Costs of the implementation of sub-operations in the model subcompartment in the model period

Sub-operation	Model costs in CZK		
	direct costs $PNm_{i(j)}$	indirect costs $NNm_{i(j)}$	output costs $VNm_{i(j)}$
016 211 (first planting)	6,470	2,802	9,272
023 111 (repellent-summer)	6,170	2,672	8,842
023 121 (repellent-winter)	6,170	2,672	8,842
024 031 (mowing)	2,655	1,150	3,805
031 451 (cleaning)	1,520	658	2,178
112 018 (timber harvesting)	44,147	19,116	63,263
122 002 (skidding)	39,070	16,917	55,987
126 001 (handling – one-man power saw)	6,409	2,775	9,184
126 001 (handling – UKT tractor)	10,239	4,433	14,672
Total	122,850	53,195	176,045

Applicable to the entire model period and to an area of 7.67 ha

Table 4. Model receipts from the sales (in CZK) of raw timber assortments in the model period

Quality class	Spruce	Fir	Pine	Beech
III B	242,265	–	42,608	131,791
III C	28,017	161,229	2,356	23,590
IV – pole	5,365	2,964	870	–
V – pulpwood	14,166	9,518	1,329	27,568
VI	1,813	1,417	765	4,855
Total	291,626	175,128	47,928	187,804
Total (*TDm*)		702,486		
Total per 1 ha	38,022	22,833	6,249	24,486
Total per 1 ha		91,590		
Total per 1 ha/year	3,802	2,283	625	2,449
Total per 1 ha/year		9,159		

Applicable to the whole Model Subcompartment 116 D (7.67 ha) with the considered target tree species composition
Applicable to the entire model period of time, i.e. 10 years

PNm – total model direct costs of the model subcompartment in CZK,
NNm – total model indirect costs of the model subcompartment in CZK,
VNm – model output costs of the model subcompartment in CZK.

$$VNm = \sum_{a=1}^{n}\sum_{i=1}^{x}\sum_{j=1}^{y} VN_{i(j)a} = \sum_{a=1}^{n}\sum_{i=1}^{x}\sum_{j=1}^{y} (PN_{i(j)a} + NN_{i(j)a}) \quad (6)$$

where: *VNm* – model output costs of Model Subcompartment 116 D in CZK,
$VN_{i(j)a}$ – output costs of the j^{th} sub-operation of the i^{th} operation in the model subcompartment in the a^{th} year in CZK,
$PN_{i(j)a}$ – direct costs of the j^{th} sub-operation of the i^{th} operation in the a^{th} year in CZK,
$NN_{i(j)a}$ – indirect costs of the j^{th} sub-operation of the i^{th} operation in the a^{th} year in CZK,
i – order of the operation (i = 1, 2 ... x),
j – order of the sub-operation (j = 1, 2 ... y),
a – order of the year (a = 1, 2 ... n; n = 10).

Functionality of cost model relations was verified on the calculation of decennial model costs of the model subcompartment. According to the above-mentioned relations, the cost data are obtained for a range of rated units entered into the modelling. However, if the data are put in which relate to the entire area of the model subcompartment, they can be converted per 1 hectare, etc. Inputs into the model expressed in CZK are without V.A.T.

The result of the constructed cost model of Model Subcompartment 116 D, which represents a model stand managed under a selection system, is the definition of cost model relations, numerical outputs with data on direct, indirect and output costs, data on total consumption of standard time in standard hours for execution of a concrete sub-operation in the model period of time, and graphic outputs with data on the costs of individual operations in the model period of time. Tables 2 and 3 show the most significant numerical outputs.

Model output costs for the implemented extent of operations in Model Subcompartment 116 D in the 10-year model period (*VNm*) represent a total sum of 176,045 CZK; rounded model output costs per hectare amount to 22,952 CZK and model output costs per hectare and year are 2,295 CZK.

Model yields are constructed for a generally defined model subcompartment of 7.67 ha uneven-aged non-mixed forest stand. Numerical outputs of the models can be converted per 1 hectare. Forest stand species composition of the model subcompartment is given by the set-up target species composition of the primary management group of stands No. 8442 (Lesprojekt 2003). With respect to managerial economics, the yields in question are operational corporate yields gained from the economic activities of the enterprise (Synek et al. 2000).

Another result of yield modelling focused on the establishment of model yields (*Vm*) of the subcompartment was a definition of yield relations of which the most significant ones are presented below:

If we assume that the only yields in this modelling of yields in the subcompartment (*Vm*) are those originating from the sales of raw timber assortments in the model period (*TDm*), it holds true that:

$$Vm = TDm \quad (7)$$

where:

$$TDm = \sum_{a}^{n}\sum_{d}^{r} TD_{da} = \sum_{a}^{n}\sum_{d}^{r}\sum_{e}^{l} (PC_{d(e)a} \times PMJ_{d(e)a}) \quad (8)$$

Vm	– model yields of Model Subcompartment 116 D in CZK,
TDm	– model receipts from the sales of raw timber assortments from Model Subcompartment 116 D in the model period ("model receipts") in CZK,
TD_{da}	– receipts from the sales of timber assortments of the d^{th} tree species in the a^{th} year in CZK,
$PC_{d(e)a}$	– average price in CZK per rated unit (m^3) of the e^{th} timber assortment of the d^{th} tree species in the a^{th} year,
$PMJ_{d(e)a}$	– number of rated units in m^3, i.e. volume of the e^{th} timber assortment of the d^{th} tree species in the a^{th} year,
a	– order of the year (a = 1, 2 ... n; n = 10),
d	– order of the tree species (d = 1, 2 ... r),
e	– order of the assortment (e = 1, 2 ... l).

Functionality of yield model relations was verified on the calculation of decennial yields of Model Subcompartment 116 D. According to the above-mentioned relations, the yield data are obtained for a range of rated units entered into the modelling. However, if some data are put in which for example relate to the entire area of the model subcompartment, they can be converted per 1 hectare, etc. Inputs into the model expressed in CZK are without V.A.T.

The result of the constructed yield model of Model Subcompartment 116 D, which represents a model stand managed under a selection system, is the definition of yield model relations, numerical and graphic outputs with data on the assortment structure of the model decennial allowable cut in Model Subcompartment 116 D, and the numerical and graphic outputs with data on the model receipts from the sales of raw timber assortments in the model period of time. Table 4 presents the most significant numerical outputs.

Yields of Model Subcompartment 116 D (Vm), which are in fact model receipts from the sales of raw timber assortments in the 10-year model period, represent a total of 702,486 CZK; rounded yields per hectare amount to 91,590 CZK and yields per hectare and year are 9,159 CZK. The model receipts are at full realized in the first year of the model period.

The cost and yield models are constructed so that the input data can be selected separately for each year of the model period. Relations of the cost model defined in this paper make it possible to work with costs and yields incurred in the course of the whole model period of time. Furthermore, they even make it possible to modify the model period duration.

The comparison of costs and yields is entered by model yields (Vm) and model output costs (VNm) in CZK. The framework of this comparison is given by the nature of input data in which the framework was described at a place where the method of their calculation is explained. What the results of the comparison are related to is clarified below.

Model economic result from the management of the model subcompartment under a selection system in the model period (HVm) can be calculated from the following relation:

$$HVm = Vm - VNm \tag{9}$$

Mean annual per-hectare model economic result from the management of the model subcompartment under a selection system ($HVmrh$) can be calculated from the following relation:

$$HVmrh = \frac{HVm}{n \times p} \tag{10}$$

where:	HVm	– model economic result of the model subcompartment in CZK,
	Vm	– model yields of the model subcompartment in CZK,
	VNm	– model output costs of the model subcompartment in CZK,
	$HVmrh$	– mean annual per-hectare model economic result of the model subcompartment in CZK,
	n	– number of years in the model period,
	p	– area of the model subcompartment in ha.

Model economic result (HVm) – representing a model profit in this case – is 526,441 CZK. It applies to the entire area of Model Subcompartment 116 D and to the whole model period. Mean annual per-hectare model economic result ($HVmrh$) – representing the mean annual per-hectare model profit in this case – is 6,864 CZK after rounding. It applies to an area of 1 hectare of Model Subcompartment 116 D and to a period of 1 year. In this connection it should be noted that the values of profit are the values of profit before tax.

Based on the above-mentioned data other economic indicators can be calculated such as economic effectiveness or indicators of cost/yield profitability. The method of calculation can be found e.g. in Synek et al. (2002). Indicator of model subcompartment economic effectiveness is 3.99. Profitability of costs and yields is 2.99 and 0.75, respectively, the model indicators relating to the year 2004. The calculation of indicators for actual data of 2004 and their comparison with the model indicators will be possible as soon as the actual data on the TFE forest activities and their management in 2004 are available.

The comparison of financial results of the modelling is very problematic, the reasons being e.g. different levels of direct costs per rated unit entered into the modelling, different levels of overhead load, etc. The calculated results relate only to the model conditions which were formulated on the basis of actual factors affecting the respective sub-operations implemented at the Training Forest Enterprise in the forest stand of Subcompartment 116 D managed under a selection system. An important role in the comparison of results is played e.g. by skidded stem volume, skidding distance, means of skidding, etc. Other factors of significance are also the types of industrial standards and labour time consumption directions used, or whether the time consumption used for the operation is of a character of average data, etc.

CONCLUSION

The objective of the paper was to develop and verify the cost and yield models of management in the selection silvicultural system of management according to the above specified conditions. We have succeeded to express in numbers the costs, yields and economic result of selection system management on an example of Model Subcompartment 116 D. Results of the solution and conclusions presented in the chapter Results and Discussion relate therefore only to the model subcompartment. The process of modelling was based on an assumption that the stand structure of the subcompartment was in normal condition, i.e. that the standing volume and structure as well as the total current increment oscillate around their normal values, the oscillation resulting from the carried out harvesting operations. The age of the subcompartment plays no role in this case; it is the period of circulation which is important and which is overlapping with the model period. In this respect, the results of the study represent model results. On the other hand, however, the level of calculated results cannot be considered unchangeable as in reality better or worse results may be achieved in the otherwise identical conditions. This depends mainly on the applied method and chosen silvicultural practices.

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Ekonomické aspekty výběrného způsobu hospodaření na Školním lesním podniku Masarykův les Křtiny

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ABSTRAKT: Cílem práce bylo zjistit hospodářský výsledek hospodaření v porostu výběrného hospodářského způsobu na příkladu modelového dílce. Za tímto účelem byl proveden kvalitativní průzkum dřevin dílce 116 D na Školním lesním podniku. Byl vytvořen nákladový a výnosový model hospodaření a vypočítány předpokládané modelové náklady a výnosy, z nichž byl zjištěn modelový hospodářský výsledek dílce. Do modelů vstupují skutečné údaje související s rámcovými směrnicemi hospodaření, s provedeným objemem prací pěstební činnosti a s produkčními schopnostmi stanoviště. Objem prací těžební činnosti vychází z modelové výše a sortimentní struktury decennálního etátu. Východiskem zjištění nákladů jsou ceny konkrétních prací stanovených Školním lesním podnikem pro rok 2004. Podkladem pro výpočet výnosů jsou průměrné ceny sortimentů surového dříví zveřejněné Českým statistickým úřadem za období leden až duben roku 2004.

Klíčová slova: výběrný hospodářský způsob; sortimentace; nákladový model; výnosový model; rentabilita

Ze známých hospodářských způsobů výběrný způsob nejlépe vystihuje podstatu a filozofii přírodě blízkého hospodaření v lesích. Objekty reprezentující tento způsob hospodaření se nacházejí na Školním lesním podniku Masarykův les ve Křtinách Mendelovy zemědělské a lesnické univerzity v Brně. Nejdůležitějším cílem práce je vyčíslení předpokládaných nezbytných nákladů na dosažení výnosů souvisejících s hospodařením v porostu výběrného hospodářského způsobu.

Ke konci roku 2001 byl proveden kvalitativní průzkum dílce 116 D se zaměřením na dřeviny smrk (*Picea abies*), jedli (*Abies alba*), borovici (*Pinus sylvestris*) a buk (*Fagus sylvatica*). Ten měl poskytnout přehled o kvalitativní struktuře stromového inventáře, jež by byl zohledněn při modelování výnosů. Výsledkem bylo konstatování, že porost dílce 116 D je průměrné kvality (podle kritérií Dejmala 1986). Objem vylišených předpokládaných sortimentů I. a II. třídy jakosti byl u smrku 0,91 m^3/ha, u borovice 1,73 m^3/ha, u buku žádné cenné sortimenty nebyly vylišeny z důvodu nesplnění technických požadavků a pro jedli doporučená pravidla nespecifikují technické požadavky na sortimenty I. a II. třídy jakosti.

Vzhledem k charakteru dat, která byla k dispozici, bylo vyčíslení nákladů a výnosů provedeno na příkladu modelového dílce 116 D. Plocha dílce je 7,67 ha. Vypočtený objem vzorové zásoby činí 319,30 m^3 b. k./ha. Bylo zohledněno zastoupení každé dřeviny v cílové druhové skladbě pro hospodářský soubor 8442. Velikosti přírůstového procenta 2,20 % pro jehličnany a 3,62 % pro listnáče (Lesprojekt 2003) odpovídá celkový běžný přírůst, vzniklý na objemu vzorové zásoby, 7,93 m^3 b. k./ha. Sortimentní struktura decennálního etátu je stanovena pomocí tabulek pro sortimentaci těžebního fondu (Dejmal 1986). Výše etátu je rovna celkovému běžnému přírůstu.

Časovým rámcem modelování je období jednoho decennia, tzn. 10 let, které váže na dobu oběžní, která je v našem případě rovna období kontrolnímu. Náklady modelového dílce se vztahují k vybraným výkonům pěstební a těžební činnosti, které se na ŠLP v dílci 116 D převážně provádějí. Pro zjištění modelových nákladů bylo použito pojetí kalkulačního členění nákladů.

Výsledkem vytvořeného nákladového modelu jsou definované vztahy modelu, údaje o celkové spotřebě normočasu v Nh na vykonání konkrétního podvýkonu v rámci modelového období a číselné výstupy s údaji o přímých, nepřímých a vlastních nákladech v rámci modelového období.

Vyšetření výnosů modelového dílce 116 D vychází z modelové sortimentní struktury vzorového decennálního etátu. Na základě předpokládaného celkového vyrobeného objemu jednotlivých sortimentů dříví podle dřevin a průměrné ceny za 1 m^3 příslušného sortimentu dříví byly vypočítány předpokládané modelové tržby za prodej sortimentů surového dříví. Tyto tržby představují jedinou a nejdůležitější součást modelových výnosů. Tržby za prodej dříví jsou realizovány z lokality odvozní místo. Výnosy jsou v rámci modelu realizovány v prvním roce modelového období.

Výsledkem vytvořeného výnosového modelu jsou definované vztahy výnosového modelu, číselné výstupy s údaji o sortimentní struktuře vzorového decennálního etátu a dále číselné výstupy s údaji o modelových tržbách za prodej sortimentů surového dříví v rámci modelového období.

Modelové vlastní náklady na realizovaný rozsah prací představují celkem 176 045 Kč, na jeden hektar potom 22 952 Kč a na jeden hektar a rok 2 295 Kč po zaokrouhlení.

Objem vzorového decennálního etátu představuje 607,91 m^3 (na 7,67 ha). Modelové výnosy představují celkem 702 486 Kč, na jeden hektar potom 91 590 Kč a na jeden hektar a rok 9 159 Kč po zaokrouhlení.

Nákladový i výnosový model je konstruován tak, že vstupní údaje lze zvolit pro každý rok modelového období samostatně. Vztahy nákladového modelu, definované v této práci, umožňují pracovat s náklady a výnosy vzniklými během celého modelového období. Navíc umožňují délku modelového období i upravit.

Modelový hospodářský výsledek je 526 441 Kč. Průměrný roční hektarový modelový hospodářský výsledek, představující v tomto případě průměrný roční hektarový modelový zisk, je 6 864 Kč po zaokrouhlení. Předmětem dalšího zkoumání bude zohlednění faktoru času, např. i ve vztahu k variantám formy vlastnictví nebo velikosti dílce (majetku).

Pokud se týká číselných výstupů modelování nákladů a výnosů, je třeba zdůraznit, že se výsledky vztahují pouze k dílci 116 D na ŠLP, tzn., že výsledky jsou ovlivněny nejen konkrétními přírodními podmínkami, ale i ekonomickými poměry ŠLP. Bylo by chybou uvedené výsledky generalizovat a zevšeobecňovat ve vztahu k výběrnému hospodářskému způsobu.

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