Lesn. Cas. For. J. 62 (2016) 89–97 DE GRUYTER OPEN DOI: 10.1515/forj-2016-0009

Lesnícky časopis - Forestry Journal
http://www.nlcsk.sk/fj/

ORIGINAL PAPER

Forest management economics based on forest typology

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Abstract

In forest management, natural conditions have long been systemized by groups of forest habitat types (GFHT). Based on them, appropriate economic measures can be taken and economic efficiency of silviculture calculated. Management intensity, the term related only to timber production in the past, has recently been defined more broadly within the sustainable, close-to-nature forest management concept. It includes economic-ecological and efficient management, and reflects potential production as well as ecological effects of forest stands. Nature and natural development are preferred where artificial interventions are unnecessary (Plíva 2000). This concept uses a specific GFHT as the elementary unit as it allows to exactly identify ecological and economic potential, management measures, quantification and monetary expression of elementary components of economic efficiency. Such optimization of management measures and their economic projections analysis can be considered a comprehensive biological-ecological-economic analysis.

Keywords: Groups of forest habitat types; management intensity; ecological potential; economic potential

Editor: Martin Moravčík

1. Introduction

Sustainable and site-befitting forest management means “the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions that do not cause damage to other ecosystems” (Second Ministerial Conference, Helsinki 1993, Anonymus 2003).

Analyses of forestry production conditions distinguish among different natural conditions, conditions of workplaces, technologies, management, human factors etc. Natural conditions express general production features of forests and site characteristic that – to a large extent – go along with forest typological classification. Differences in natural conditions are reflected in different tree species, quality and age structures of forest stands and, consequently, in different assortment structures and allowable total cuts (Kupčák 2006).

Natural conditions of forests in the Czech Republic (CR) vary considerably. In forest typology, the elementary unit of growth conditions differentiation is the forest habitat type (FHT). The contemporary approach to FHT is basically identical with Zlatník’s classical definition (1956): “Forest habitat type is an aggregate of natural geobiocoenosis and all geobiocoenoses originating from it, from the viewpoint of development, and partly geobiocoenoses changed to a certain extent, including development stages.”

Forest habitat types associate in groups of forest habitat types (GFHT) in accordance with their ecological relation expressed by important economic features of the site. At present, these typological units are subject to Regulation No. 83/1996 (Ministry of Agriculture) on regional plans of forest development and management units. Moreover, FHT serves as a criterion for forest land prices (see Regulation No. 3/2008 to Act No. 151/1997 on property evaluation[1]).

The GFHT approach is based on Plíva (1971, 1980, 1998, 2000) who elaborated a methodology for GFHT utilization for forest management differentiation in accordance with the concept of sustainability and efficiency. The author draws on his previous works and adjusts the data to the concept of sustainable management (SM), particularizes them for selected GFHT and adds more information to support a multipurpose utilization. He associates GFHT by intensity and targets of management.

According to Plíva (2000), “management intensity” in the concept of SM and close-to-nature management acquires broader sense than in the original approach supporting timber production and rationalisation and intensification (or, maybe, together with labour and means investment). Plíva supports economic-ecological and, last but not least, efficient management. He reflects not only the value of potential production but also ecological effects of forest stands which affect – and limit – the management intensity. His approach leaves more up to the nature and natural development where artificial intervention is unnecessary.

The stands are actively influencing their surroundings, and the effect is expressed by their ecological functions, i.e. positive effects of forest on its environs. Their overall influence in GFHT is, therefore, ecological potential (EP), and simultaneously, production potential (PP) of a GFHT is determined by the production function (value of production). Quantitative markers EP and PP influence manage-

[1] GFHT are units of the typological system associating forest habitat types by its ecological relation expressed by important economic features of the site (Appendix No. 24 to Regulation No. 3/2008).

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ment intensity (MI). Both potentials influence MI reversely as well (increasing ecological function makes MI decrease down to protection forest intensity; reversely in case of production function), therefore their comparison in GFHT determines appropriate MI. In fact, both potentials are of comparable extent as they comprise the full scale of potential alternatives of all GFHT (Pulkrab et al. 2009).

The article investigates management measures and methods of GFHT-based economic features calculations. These issues represent the introductory part of the National Agency for Agricultural Research project called "Differentiation of the Management Intensities and Methods to Ensure Forest Biodiversity and Economic Sustainability of Forestry" (hereinafter referred to as the project). One of the project's principle objectives is to define appropriate management measures of silviculture and harvest, and to calculate economic efficiency of forestry in an easy-to-use system based on typology.

2. Methods

The methodological approach of the project is based on the essential structure of GFHT – in relation to ecological and production (timber production) forest function.

Forest types as elementary units of differentiation of forest growth conditions (growth of trees, their production and silviculture) are grouped by their ecological (soil and climatic) affinity expressed by phytocoenosis (association) or manifest features (characteristics) of the site into GFHT. Inductively created GFHT, systemized into an ecological (edaphoclimatic) network constituted a solid framework with a feedback and a deductive procedure expressed by the following definition (Amendment No. 4 to Regulation No. 83/1996): "GFHT are determined by forest altitudinal zone (FAZ) and edaphic category." The definition is tempting to schematically fill in the network on one hand, but on the other, it lets us adjust the system more clearly to facilitate practical application. As mentioned above, the ecological forest functions (active influence of stands on forest environs) are generally called ecological potential (EP) and the production function, expressed by the value of potential production, is called production potential (PP).

We distinguish EP by the importance of cardinal functions, i.e.:

1. Infiltration – infiltration of precipitation into the soil, its retention, retardation and accumulation; loss control by interception.
2. Erosion control (slopes of 40% and steeper; or milder in case of erosion risk) – prevention of surface outflow and soil erosion; facilitation of high retention and infiltration.
3. Suction – forest stands absorb water and drain superfluous water to let the soil accumulate precipitation and slow down the drainage.
4. Precipitation supporting (climatic) function (complementary function 1, 2, 3 in the 7th and 8th FAZ) – zones of frequent mists in mountain zones improving water balance by supporting precipitation.

Other ecological functions of stands occurring only in some localities (parts) of GFHT:

- water protecting – lanes of shore stands (mostly within L and U categories)
- mesoclimatic – protection from negative mesoclimatic effects, especially in frost hollows,
- other soil protection functions (deflation, landslides, avalanches, banks controlling functions) considered when evaluating the erosion control function,
- (forest) protection – self-preservation function of forest ecosystems in extreme conditions limiting the forest existence.

2.1. Economic parameters of production potential evaluation

The calculation is based on the following prerequisites:

1) potentional forest production yields calculation was based on yield tables (Černý et al. 1996);
2) sorting was based on assortment tables for Norway spruce, Scots pine, beech and oak stands in "N" quality – healthy, undamaged, straight stems (Pařez 1987a, b);
3) considering main collections in each girth class (6+ to 1), currently traded in CR and evaluated in market prices published by the Czech Statistical Office for year 2013;
4) the elementary space unit for evaluation was GFHT;
5) the principal synthetic indicator of evaluation effect was the gross yield of forest production (GYFP);
6) the calculation of direct silviculture and harvest operation costs is based on performance standards (Nouza, Nouzová 2003) considering the following: adding a 15% mean flat surcharge to the basic norm; accepting the flat wage rate of CZK 65.00/standard hour in silvicultural operations and CZK 80.00/standard hour in harvesting operations (the estimated republic's average the value of which might vary in different regions); adding the flat rate of social and health insurance (34% to labour costs); adding flat substitutes (39% to labour costs).
   Calculations cover also reasonable indirect costs of 35% to direct costs; roads and slope roads maintenance are not included in the costs.

Five grades of MI are defined by comparison of PP with the ecological functions importance grade of an ecosystem (EP), and, within the five grades, several types of target management are set (in accordance with the character of natural conditions and the main target tree species). These two broadly set units serve to make general principles clear, but do not substitute GFHT nor management units. MI by GFHT is presented in the ecological network of the typological system (where PP and EP grades are also mentioned) and is scaled A–E, see Table 1.

Table 1. Differentiation of management intensity.

	Management Intensity	Relation PP ↔ EP
A	Highly intensive management	PP highly exceeds EP
B	Intensive management	PP (considerably) exceeds EP
C	Standard management	PP mildly exceeds EP
D	Limited management	EP exceeds PP
E	Protection forests management	EP highly exceeds PP

Gross yield of forest production is presented in Table 2.

Table 2. The gross yield of forest production value by target management (thous. CZK).

	Group of forest habitat types																								
	transitional			extreme			exposed				acid			nutritious				gleyed				waterlogged		alluvia	
	W	C	X	Z	Y	J	A	F	N	M	K	I	S	B	H	D	V	O	P	Q	T	G	R	L	U
9 dwarf pine																									
8 spruce				NS 0.8	NS 1.2		NS 2.6	NS 3.1	NS 3.1	NS 2.3	NS 2.7		NS 2.7				NS 3.1			NS 2.8	NS 2.1	NS 4.6	NS 2.1		
7 beech- spruce				NS 1.0	NS 1.2			NS 3.9	NS 2.9	NS 2.2	NS 3.0		NS 3.2	NS 3.3			NS 5.1	NS 4.0	NS 3.8	NS 3.1	NS 3.3	NS 4.8	NS 3.3		
6 spruce- beech					NS 1.1		NS 4.3 EB 1.3	NS 4.4 EB 1.8	NS 3.0 EB 0.8	EB 0.6 NS 2.2	EB 2.3 NS 3.2	EB 1.1 NS 3.3	NS 5.1 EB 1.9	EB 2.5 NS 5.8	EB 2.1 NS 5.2	EB 2.5 NS 5.9	EB 2.2 NS 5.7	NS 4.4	NS 3.0	NS 2.7		NS 4.8	NS 4.8		
5 fir-beech	NS 4.5 EB 1.6	EB 1.6			NS 0.9	EB 0.6	NS 5.3 EB 1.4	NS 4.4 EB 1.9	NS 3.2 EB 0.9	EB 0.6	EB 1.2 NS 3.3	EB 1.2 NS 3.3	NS 5.3 BK 2.3	NS 5.8	EB 2.3 NS 3.0	EB 2.5 NS 5.8	EB 2.2 NS 5.8	NS 4.4	NS 3.7	NS 2.7 SP 2.0		NS 5.4	NS 2.8		NS 4.9
4 beech	EB 1.6	EB 1.1 SP 1.5			SP 0.7		NS 4.9 EB 1.3	NS 4.6 EB 1.7	SP 2.2 NS 3.4 EB 1.0	SP 0.5 OA 0.5	NS 3.3 EB 1.3	EB 1.3 NS 3.3	EB 1.9 NS 4.1	EB 2.3 NS 5.4	EB 2.3 NS 5.4	EB 2.5 NS 6.1	NS 6.1 EB 2.2 OA 4.1	NS 5.1 OA 4.1	NS 3.6 OA 1.3	SP 0.8		NS 5.4	NS 5.1		
3 oak-beech	EB 1.8	EB 1.3 SP 0.9			SP 0.6	EB 0.01	NS 4.3 EB 1.2	NS 3.8 EB 1.6	SP 1.1 NS 3.4 EB 0.9	SP 0.2 OA 0.3	SP 0.8 EB 2.5	SP 0.7 NS 3.4 EB 2.5	EB 2.1 NS 4.0	EB 2.3 NS 5.4	EB 2.3 NS 5.5	EB 2.1 NS 4.6	NS 6.0 EB 2.2 OA 4.0	NS 4.0 EB 1.7 OA 4.8				NS 5.0		AL 2.4	NS 6.7
2 beech-oak	OA 1.2	EB 0.6 OA 0.8		OA 0.4			OA 2.0		SP 0.7 OA 0.8	SP 0.2 OA 0.3	SP 0.7 OA 0.7	SP 0.9 OA 1.0	SP 1.9 OA 1.4	OA 2.6	OA 3.6	OA 1.7	OA 2.2	OA 3.0	SP 1.1	SP 0.8				OA 4.6	
1 oak		SP 0.6 OA 0.5	OA 0.4	OA 0.4		OA 0.5	OA 0.8		SP 0.6 OA 0.6	SP 1.3	SP 0.2 OA 0.4	SP 0.7 OA 0.7	SP 1.1 OA 2.5	OA 1.9	OA 1.2	OA 1.7	OA 2.2	OA 2.6	SP 1.3	SP 0.8				OA 3.8	OA 4.4
0 pine		SP 1.5		SP 0.3	SP 0.3				SP 0.9	SP 0.2	SP 0.8							SP 2.4	SP 2.4	SP 0.4	SP 2.0	SP 2.4	SP 0.6		

Explanatory notes: NS – Norway spruce, SP – Scots pine, OA – oak, EB – European beech, LA – larch, FI – fir, AL – alder.

3. Results and discussion

Table 3 presents groups of forest habitat types and their representation in CR. The following forest site complexes are among the most frequent GFHT: 5K (*Abieto-Fagetum acidophilum*), 6K (*Piceeto-Fagetum acidophilum*), 3K (*Querceto-Fagetum acidophilum*), 2K (*Fageto-Quercetum acidophilum*), 5S (*Abieto-Fagetum oligo-mesotrophicum*), 5B (*Abieto-Fagetum mesotrophicum*), 3H (*Querceto-Fagetum illimerosum mesotrophicum*) (Kupčák & Pulkrab 2012).

The output of the project and its methodology is identification and quantification of economic parameters of management in relation to management measures. The calculations respect ecological limits implied by the CR typological system and legislation. The analysis considered the recommended tree species representation, the share of soil improving species, rotation period and target management (Norway spruce, Scots pine, oak and beech).

Types of target managements by Plíva (2000) are defined by framework units with the same target management, and the same essential tree species of the target composition which mark the type of the management, set management intensity and the forest management system.

In given natural conditions, the target composition defines the optimal PP when the forest ecosystem keeps stable (ecological stability, or acceptable instability), therefore the related management system is optimal as well. Production of alternative managements systems cannot be higher, but can possibly improve ecological forest functions.

Target managements open the way for setting framework principles in specific MI but their presence also provides ample information on management prerequisites and targets in broader areas.

3.1. Alternatives of target management

The following tables enumerate the ecologically acceptable alternatives of target management (Norway spruce, Scots pine, oak and beech) by GFHT. Tree composition (in %) by GFHT for Norway spruce and Scots pine target management in the ecological network of typological system is shown in Table 4, tree composition for oak and beech target management is presented in Table 5.

It is in accordance with the Czech typological system that in some GFHT, only one target management is acceptable; in most GFHT, though, the owner can choose from two or three alternatives of target management. The following list (based on Tables 4 and 5) shows us areas of acceptable target managements from the total 2,659,832 ha of Czech forests:

- 420,254 ha – Norway spruce target management only,
- 1,321,939 ha – Norway spruce target management or another, usually beech,
- 154,271 ha – Scots pine target management only,
- 37,238 ha – Scots pine target management or another, usually oak,
- 170,230 ha – oak target management only,
- 308,541 ha – oak target management or another, usually Scots pine,
- 79,795 + 10,639 ha – beech target management only,
- 127,672 ha – beech target management or another, usually Norway spruce.

3.2. Management intensities

Table 6 presents a survey of management intensities in the ecological network of the typological system. Presented data do not reflect the contemporary forest stand state and composition but anticipate the results on the basis of maximum PP of target composition and site characteristics (potential). PP was defined on the basis of gross yield of forest production (GYFP). In the table, alternatives of target managements with maximum production potential, i.e. gross yield of forest production, were opted for. The grade of production potential is provided with each GFHT (top left) based on the value scale (see Table 2); on the bottom left, there is the grade of ecological potential based on cited Plíva's works; in the middle, there is the target management with the highest GYFP in the particular GFHT and it also presents the grade of MI as the difference between ecological and economic potential.

The table shows GFHT with the highest PP: 2L (*Fraxineto-Quercetum alluvialis*), 3U (*Acereto-Fraxinetum vallidosum*), 3B (*Querceto-Fagetum mesotrophicum*), 3H (*Querceto-Fagetum illimerosum mesotrophicum*), 3V (*Querceto-Fagetum fraxinosum humidum*), 4B (*Fagetum mesotrophicum*), 4H (*Fagetum illimerosum mesotrophicum*), 4D (*Fagetum acerosum deluvium*), 4V (*Fagetum fraxinosum humidum*), 5B (*Abieto-Fagetum mesotrophicum*), 5D (*Abieto-Fagetum acerosum deluvium*), 5V (*Abieto-Fagetum fraxinosum humidum*), 5S (*Abieto-Fagetum oligo-mesotrophicum*), 6B (*Piceeto-Fagetum mesotrophicum*), 6D (*Piceeto-Fagetum acerosum deluvium*), 6H (*Piceeto-Fagetum illimerosum mesotrophicum*), 6V (*Piceeto-Fagetum fraxinosum humidum*) and 7V (*Fageto-Piceetum acerosum humidum*). GFHT with the highest EP are the following: 7R (*Piceetum turfosum acidophilum*), 7Z (*Fageto-Piceetum humilis*), 8A (*Aceri-Piceetum lapidosum*), 8F (*Piceetum lapidosum mesotrophicum*), 8N (*Piceetum lapidosum acidophilum*), 8R (*Piceetum turfosum [montanum]*), 8Y (*Piceetum saxatile*) and 8Z (*Sorbeto-Piceetum [humilis]*).

Management intensity, originally encompassing only timber production and rationalization and intensification, has adopted a broader sense in the concept of sustainable management. Management intensity is used to define concrete management measures, which can support some of the principles of sustainable management, e.g.:

- diversity of species and its aiming at natural character (lower MI), or, possibly, closer links to target species (higher MI),
- nature-friendly management approach – preferring natural processes where artificial intervention is unnecessary,
- e.g. rotation period – the higher the intensity, the closer to target assortments; the lower the intensity, the more inherent the ecological aspect; when the ecological functions prevail, the rotation period prolongs, even up to the physical age limits, in extreme cases,
- in Table 6 the comparison was based on the target management alternatives with the highest PP (as apparent from the title of the table).

Table 3. Representation of groups of forest habitat types in Czech Republic [%].

No.	GFHT	%	MI	No.	GFHT	%	MI	No.	GFHT	%	MI	No.	GFHT	%	MI
1	0X	+	E	44	3I	1.7	C	87	5B	2.8	A	130	4O	0.9	B
2	1X	0.1	E	45	4I	0.1	B	88	6B	0.1	A	131	5O	1.3	B
3	2X	+	E	46	5I	0.6	B	89	7B	+	B	132	6O	0.7	B
4	3X	+	E	47	6I	0.1	B	90	2W	0.1	C	133	7O	0.2	B
5	4X	+	E	48	0N	0.4	D	91	3W	0.3	C	134	0P	0.2	D
6	0Z	+	E	49	1N	+	D	92	4W	0.1	C	135	1P	0.3	C
7	1Z	0.3	E	50	2N	0.1	D	93	5W	+	C	136	2P	0.4	C
8	2Z	0.1	E	51	3N	0.3	D	94	1D	0.2	B	137	4P	1.5	C
9	3Z	+	E	52	4N	0.1	D	95	2D	0.2	B	138	5P	1.0	B
10	4Z	+	E	53	5N	0.7	D	96	3D	0.7	B	139	6P	1.2	B(C)
11	5Z	+	E	54	6N	0.7	D	97	4D	0.7	A	140	7P	0.2	C
12	6Z	+	E	55	7N	0.2	D	98	5D	1.1	A	141	0Q	0.3	D
13	7Z	0.1	E	56	8N	0.1	D-E	99	6D	0.1	A	142	1Q	0.2	D
14	8Z	0.3	E	57	1S	0.4	C	100	1A	+	D	143	2Q	0.1	D
15	9Z	0.1	E	58	2S	0.8	C	101	2A	0.2	D	144	4Q	0.5	D
16	0Y	+	D-E	59	3S	3.2	B	102	3A	0.5	D	145	5Q	0.2	C
17	3Y	0.1	E	60	4S	1.5	B	103	4A	0.2	D	146	6Q	0.1	C
18	4Y	+	D-E	61	5S	5.7	A	104	5A	0.7	C	147	7Q	+	D
19	5Y	0.1	D-E	62	6S	2.1	A	105	6A	0.3	C	148	8Q	0.1	D
20	6Y	0.2	D-E	63	7S	0.5	C	106	7A	+	D	149	0T	0.1	D-E
21	7Y	+	E	64	8S	0.2	C	107	8A	+	D-E	150	1T	+	D
22	8Y	+	E	65	0C	0.1	D-E	108	1J	0.1	E	151	3T	+	D
23	0M	0.8	D	66	1C	0.5	D	109	3J	0.2	E	152	5T	+	D
24	1M	0.6	C	67	2C	0.7	D	110	5J	0.2	D-E	153	7T	0.1	D
25	2M	0.9	D	68	3C	0.2	D	111	1L	1.0	A	154	8T	+	E
26	3M	1.1	D	69	4C	0.1	D	112	2L	0.2	A	155	0G	0.3	C
27	4M	0.1	D	70	5C	+	D	113	3L	0.4	C	156	1G	0.2	D
28	5M	2.2	D	71	3F	0.1	C	114	6L	+	D-E	157	3G	+	C
29	6M	0.4	C	72	4F	0.1	C	115	1U	0.1	A	158	4G	0.2	C
30	7M	0.1	C	73	5F	0.5	C	116	3U	0.2	B	159	5G	0.2	C
31	8M	0.2	D	74	6F	0.1	C	117	5U	0.2	C	160	6G	0.4	C
32	0K	1.3	C	75	7F	+	D	118	1V	0.2	B	161	7G	0.5	C
33	1K	0.8	C	76	8F	+	D-E	119	2V	0.1	B	162	8G	0.3	D
34	2K	4.0	C	77	1H	0.1	B	120	3V	0.2	A	163	0R	0.1	E
35	3K	4.6	C	78	2H	1.1	B	121	4V	0.1	A	164	3R	+	D
36	4K	1.5	B	79	3H	2.4	A	122	5V	0.7	A	165	4R	0.1	C
37	5K	9.7	B	80	4H	0.3	A	123	6V	0.8	A	166	5R	0.1	D
38	6K	6.0	C	81	5H	0.9	A	124	7V	0.1	C	167	6R	0.1	C
39	7K	2.2	C	82	6H	0.1	A	125	8V	+	D	168	7R	0.2	D
40	8K	0.6	C	83	1B	0.7	B	126	0O	+	C	169	8R	0.2	E
41	9K	+	E	84	2B	0.7	B	127	1O	0.7	B	170	9R	0.1	E
42	1I	0.7	C	85	3B	1.7	A	128	2O	0.3	B				
43	2I	1.8	C	86	4B	0.7	A	129	3O	1.0	B				

(Source: Plíva 2000)
Explanatory notes: No. = number, GFHT = groups of forest habitat types, MI = management intensity.

Table 4. Tree species share (in %) by GFHT for Norway spruce and Scots pine target management in the ecologic network of the typology system.

	Group of forest habitat types																								
Line	extreme				exposed				acid			nutritious					gleyed				waterglogged			alluvial	
faz[1]/cat[2]	X	Z	Y	J	A	C	F	N	M	K	I	S	B	H	D	W	V	O	P	Q	T	G	R	L	U
9 dwarf pine																									
8 spruce		NS 90 EB 10	NS 90 EB 10		NS 90 EB 10		NS 90 EB 10	NS 90 EB 10	NS 90 EB 10	NS 85 EB 7 LA 4 FI 4		NS 85 EB 7 FI 4 AL 4					NS 90 EB 10			NS 90 EB 10	NS 90 EB 10	NS 90 EB 10	NS 90 EB 10		
7 beech-spruce		NS 90 EB 10	NS 90 EB 10				NS 90 EB 10	NS 90 EB 10	NS 85 EB7 FI 4 AL 4	NS 85 EB 7 FI 4 AL 4		NS 85 EB 7 FI 4 AL 4	NS 70 EB 20 LA 5 FI 5				NS 85 EB 7 LA 4 FI 4	NS 70 EB 20 LA 5 FI 5		NS 90 EB 10	NS 90 EB 10	NS 85 EB 7 FI 4 AL 4	NS 90 EB 10		
6 spruce-beech			NS 70 EB 25 FI 5		NS 70 EB 20 LA 5 FI 5		NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5		NS70 EB20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5		NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA5 FI 5		NS 85 EB 7 FI 4 AL 4	NS 85 EB 7 FI 4 AL 4		
5 fir-beech			NS 70 EB 25 FI 5		NS 70 EB 20 LA 5 FI 5		NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5		NS 70 EB 20 LA 5 FI 5		NS70 EB20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI5/ SP 80 OA 20		NS 85 EB 7 FI 4 AL 4	NS 90 EB 10		NS 50 EB 30 FI 20
4 beech			SP 95 OA 5		NS 70 EB 20 LA 5 FI 5	SP 70 OA 30	NS 70 EB 20 LA 5 FI 5	SP 70 OA 30 / NS 70 EB 20 LA 5 FI 5	SP 70 OA 30	NS 70 EB 20 LA 5 FI 5		NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA5 FI 5	NS 70 EB 20 LA 5 FI 5		NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	SP 80 OA 20		NS 85 EB 7 FI 4 AL 4	NS 85 EB 7 FI 4 AL 4		
3 oak-beech			SP 95 OA 5		NS 70 EB 20 LA 5 FI 5	SP 70 OA 30	NS 70 EB 20 LA 5 FI 5	SP 70 OA 30 / NS 70 EB 20 LA 5 FI 5	SP 70 OA 30	SP 70 OA 20 LA 5 FI 5	SP 70 OA 20 LA 5 FI 5 / NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA5 FI 5	NS 70 EB 20 LA 5 FI 5		NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5	NS 70 EB 20 LA 5 FI 5			NS 85 EB 7 FI 4 AL 4			NS 50 EB 30 FI 20
2 beech-oak						SP 70 OA 30		SP 70 OA 30	SP 70 OA 30	SP 70 OA10 LA 5 FI 5	SP 70 OA 20 LA 5 FI 5	SP 70 OA 20 LA 5 FI 5							SP 70 OA 20 LA 5 FI 5	SP 80 OA 20					
1 oak						SP 70 OA 30		SP 70 OA 30	SP 85 OA 10 LA 5	SP 70 OA20 LA 5 FI 5	SP 70 OA20 LA 5 FI 5	SP 70 OA 20 LA 5 FI 5							SP 70 OA 20 LA 5 FI 5	SP 80 OA 20					
0 pine		SP 95 OA 5	SP 95 OA 5			SP 95 OA 5		SP 85 OA 10 LA 5	SP 85 OA 10 LA 5	SP 85 OA10 LA 5								SP 85 OA 10 LA 5	SP 70 OA 20 FI 10	SP 85 OA 10 LA 5	SP 95 OA 5	SP 95 OA 5	SP 95 OA 5		

Explanatory notes: [1] faz = forest altitudinal zone, [2] cat. = category, NS – Norway spruce, SP – Scots pine, OA – oak, EB – European beech, LA – larch, FI – fir, AL – alder.

Table 5. Tree species share (in %) by GFHT for oak and beech target management in the ecological network of the typological system.

	Group of forest habitat types																								
Line	extreme				exposed				acid			nutritious					gleyed				water logged			alluvial	
faz[1]/cat.[2]	X	Z	Y	J	A	C	F	N	M	K	I	S	B	H	D	W	V	O	P	Q	T	G	R	L	U
9 dwarf pine																									
8 spruce																									
7 beech-spruce																									
6 spruce-beech					EB 70 OA 10 LA 20		EB 70 OA 10 LA 20	EB 80 OA 10 LA 10	EB 70 OA 10 LA 10	EB 70 OA 10 LA 20	EB60 NS 20 OA 20	EB 60 OA 20 NS 20		EB 60 OA 20 NS 20	EB 60 OA 20 NS 20		EB 60 NS 20 OA 20								
5 fir-beech				EB 60 NS 20 FI 20	EB 70 OA 10 LA 20	EB 80 OA 10 LA 10	EB 70 OA 10 LA 20	EB 80 OA 10 LA 10	EB 80 OA 10 LA 10	EB 60 NS 20 OA 20	EB 60 NS 20 OA 20	EB 60 OA 20 NS 20	EB 60 OA 20 NS 20	EB 60 OA 20 NS 20	EB 60 OA 20 NS 20	OA70 EB10 LA 20	EB 60 NS 20 OA 20								
4 beech					EB 80 OA 10 LA 10	EB 80 OA 10 LA 10	EB 70 OA 10 LA 20	EB 80 OA 10 LA 10	OA 80 EB 10 LA 10	EB 60 NS 20 OA 20	EB 60 NS 20 OA 20	EB 60 OA 20 NS 20	EB 60 OA 20 NS 20	EB 60 OA 20 NS 20	EB 60 OA 20 NS 20	OA70 EB10 LA 20	EB 60 NS 20 OA 20 / OA 90 LA 10	OA 90 LA 10	OA70 EB 10 LA 20						
3 oak-beech				EB 80 LA 10 FI 10	EB 80 OA 10 LA 10	EB 80 OA 10 LA 10		EB 80 OA 10 LA 10	OA 80 EB 10 LA 10	EB 70 OA 10 LA 20	EB 70 OA10 LA 20	EB 60 OA 20 NS 20	EB 60 OA 20 NS 20	EB 60 OA 20 NS 20	EB 60 OA 20 NS 20	OA70 EB10 LA 20	EB 60 NS 20 OA 20 / OA 90 LA 10	EB 60 NS 20 OA 20 / OA 90 LA 10						AL 60 NS 20 EB 20	
2 beech-oak		OA 60 SP 30 EB 10			OA 60 SP 20 EB 10 LA 10	OA 80 EB 10 LA 10		OA 80 EB 10 LA 10	OA 80 EB 10 LA 10	OA 70 EB- 10LA 20	EB 70 OA10 LA 20	EB 70 OA10 LA 20	OA 90 LA 10	OA 90 LA 10	OA 90 LA 10	OA70 EB10 LA 20	OA 90 LA 10	OA 90 LA 10						OA 100	
1 oak		OA 70 SP 30		OA 80 EB 20	OA 80 EB 10 LA 10	OA 80 EB 10 LA 10		OA 80 EB 10 LA 10		OA 70 EB 10 LA 20	EB 70 OA10 LA 20	EB 70 OA10 LA 20	OA 90 LA 10	OA 90 LA 10	OA 90 LA 10		OA 90 LA 10	OA 90 LA 10						OA 100	OA 100
0 pine	OA 100																								

Explanatory notes: [1] faz = forest altitudinal zone, [2] cat. = category, NS – Norway spruce, SP – Scots pine, OA – oak, EB – European beech, LA – larch, FI – fir, AL – alder.

Table 6. Management intensities in the ecologic network of the typological system by maximal gross yield of forest production.

	Group of forest habitat types																								
	transitional			extreme			exposed			acid			nutritious							waterlogged				alluvial	
	W	C	X	Z	Y	J	A	F	N	M	K	I	S	B	H	D	V	O	P	Q	T	G	R	L	U
9 dwarf pine	MI A MI B	4.0 2.5	–5.0 –3.5																						
8 spruce	MI C MI D	0.5 –2.0	–2.0 –0.0	3 NS–2.5 5.5	4 NS–2 6		4 NS–1.5 5.5	4 NS–1.5 5.5	4 NS–1.5 5.5	3 NS 0.5 2.5	3 NS 0.5 2.5		3 NS 0.5 2.5				4 NS–0.5 4.5			3 NS–0.5 3.5	3 SP–1.5 4.5	5 NS 0.5 4.5	3 NS–2.5 5.5		
7 beech-spruce	MI E	–2.5	–5.0	3 NS–2.5 5.5	4 NS–1.5 5.5			5 NS 0.55 4.5	4 NS–0.5 4.5	3 NS 1.5 1.5	4 NS 2.5 1.5		4 NS 2.5 1.5	4 NS 2.5 1.5			6 NS 2.5 3.5	5 NS 3 2	4 NS 1.5 2.5	4 NS 1.5 2.5	3 SP–1.5 4.5	5 NS 1.5 3.5	4 NS–0.5 4.5		
6 spruce-beech					3 NS–2 5		5 NS 1 4	5 NS 1 4	4 NS 0 4	3 NS 2 1	4 NS 3 1	4 NS 3 1	5 NS 4 1	6 NS 5 1	6 NS 5 1	6 NS 4.5 1.5	6 NS 4 2	5 NS 3 2	3 NS 1 2	3 NS 1 2		5 NS 2 3	5 NS 2 3		
5 fir-beech	4 NS 1 3	2 EB–1 2			3 NS–2 5	2 EB–3 5	5 NS 1 4	5 NS 1 4	4 NS 0 4	1 EB 0 1	4 NS 3 1	4 NS 3 1	6 NS 5 1	6 NS 5 1	3 NS 2 1	6 NS 4.5 1.5	6 NS 4 2	5 NS 3 2	4 NS 2 2	3 NS 1 2		5 NS 2 3	3 NS 0 3		5
4 beech	2 EB–1 3	2 SP–1 3			2 SP–3 5		5 NS 1 4	5 NS 1 4	4 NS 0 4	1 OA 0 1	4 NS 3 1	4 NS 3 1	4 NS 3 1	6 NS 5 1	6 NS 5 1	6 NS 4.5 1.5	6 NS 4 2	5 NS 3 2	4 NS 2 2	1 SP–1 2		5 NS 2 3	5 NS 2 3		
3 oak-beech	2 EB–1 3	2 EB–2 4			2 SP–3 5	1 EB–4 5	4 NS 0 4	4 NS 0 4	4 NS 0 4	1 OA 0 1	4 EB 3 1	4 EB 3 1	4 NS 3 1	6 NS 5 1	6 NS 5 1	5 NS 3.5 1.5	6 NS 4 2	5 OA 3 2				5 NS 2 3		3 AL 0 3	6 NS 3
2 beech-oak	2 OA–1 3	1 OA–3 4		2 OA–3 5			3 OA–1 4		1 OA–3 4	1 SP 0 1	1 OA 0 1	1 OA 0 1	2 SP 1 1	4 OA 3 1	5 OA 4 1	3 OA 1.5 1.5	3 OA 1.5 1.5	4 OA 2.5 1.5	2 SP 0 2	1 SP–1 2				6 OA 4 2	
1 oak		1 SP–3 4	2 OA–3 5	1 OA–4 5		2 OA–3 5	1 OA–3 4		1 OA–3 4	2 SP 1 1	1 OA 0 1	1 OA 0 1	3 OA 2 1	3 OA 2 1	2 OA 1 1	3 OA 1.5 1.5	3 OA 1.5 1.5	4 OA 2.5 1.5	2 SP 0 2	1 SP–1 2				5 OA 3 2	5 OA 3 2
0 pine		2 SP–2 4	1 SP–4 5	1 SP–4 5				2 SP–2 4	1 SP 0 1	1 SP 0 1							3 SP 1 2	3 SP 1 2	1 SP–1 2	3 SP–0.5 3.5	3 SP 0 3	1 SP–4 5			

Explanatory notes: NS – Norway spruce, SP – Scots pine, OA – oak, EB – European beech, LA – larch, FI – fir, AL – alder, MI - Managment Intensity

A detailed definition of production potential based on all available data and legislation is the key output of our analysis. In relation to the production potential analysis we will also be able to particularize parameters of management intensity.

4. Conclusion

Economy of forest natural resources exploitation has a long tradition in Europe. The concept of sustainable management of forestry was articulated as early as at the beginning of XVIII century (Carlowitz 1713). The origin and development of this economic approach was documented by numerous authors. Nobel-winning economist P. A. Samuelson (1972) formulated the model of optimal sustainable forest natural resources exploitation (Holécy & Halaj 2015). EU administration supports sustainable forest management in resolutions signed at conferences on European forests protection, e.g.:

– Ministerial conference on the protection of forests in Europe (Lisbon 1998) – Resolution L2 Pan-European Criteria, Indicators and PEOLG for Sustainable Forest Management,
– Ministerial conference on the protection of forests in Europe (Vienna 2003) – Resolution V2 Enhancing Economic Viability of Sustainable Forest Management in Europe.

Our article presents a possible approach to the discussed issue – in the framework of the cited project "Differentiation of the Management Intensities and Methods to Ensure Forest Biodiversity and Economic Sustainability of Forestry". The authors ground their approach on essential natural characteristics of forests and conclude that GFHT is the only suitable unit for spatial valuation, Typological units allow us to quantify ecological limits and economic parameters of managements and compare alternative management systems.

The methodology of the concept respects Czech legislation on forest management, esp. Forest Act No. 289/1995 and Regulations No. 83/1996 and 84/1996.

The project reflects overall efficiency of investments in relation to the operational target and the whole set of management measures – from establishing the stand to its regeneration. Careful differentiation of site conditions and appropriate management is usually sufficient for cutting the budget while not limiting the management target nor changing the ecosystem condition to an extent preventing us to increase management intensity in relation to target production, if need be. Therefore, cost-saving measures include limiting unnecessary input costs, i.e. supporting lower management intensity and leaving enough space for self-regulation within natural processes. Considering the fact that all calculations are closely related to expert findings in forest typology, appropriate management measures and their economic impact analyses, our methodology can be presented as a complex biological-ecological-economic analysis of sustainable, site-befitting forest management.

– Apart from the above-mentioned outputs of the project – esp. for forest owners – the results can also be used for:
– expressing framework economic characteristics in regional forest development plans (RFDP) and other materials of forest management,
– evaluating efficiency of money input from public budgets (subsidies and benefits for forest management),
– applying environmental accountancy in forest management.

Acknowledgement

The article is based on the research project supported by the National Agency for Agricultural Research No. QJ1220313 Differentiation of the Management Intensities and Methods to Ensure Forest Biodiversity and Economic Sustainability of Forestry.

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