Production Potential of the Forests in the Czech Republic

Karel Pulkrab,^a Roman Sloup,^{a,*} and Vilém Podrázský^b

This article discusses the production potential (and limits) of the forests in the Czech Republic (CR). The calculation respects ecological limits set by typological system and the Czech forestry legislation. The key criterion of the production evaluation is the total mean increment. Usually, a forest owner can choose amongst several variants of management. The analysis in this work examines the two limit variants - the minimum and maximum production potential. The results show that, e.g., the Norway spruce share might be 19 to 48% of the total area of Czech forests (51.4% at present). The target management the owners opt for (Norway spruce, pine, oak, and beech) can, in the future, influence the timber processing industry, the main purchaser of timber raw material from Czech forests. The maximum variant shows 9,134 thousand m³ of available coniferous round timber, while the minimum one only 3,802 thousand m³ per year. Therefore, the timber processing industry should keep a close watch on the situation and either try to persuade forest owners to choose the alternative of the target management that would provide sufficient assortment for timber processing, or adjust the manufacture to the possible changes in the species composition of the forests.

Keywords: Production potential of the forests; Wood; Timber assortment; Management intensity

Contact information: a: Department of Forestry Economics and Management, Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague, Kamýcká 129, Praha 6 165 21 Czech Republic; b: Department of Silviculture, Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague, Kamýcká 129, Praha 6 165 21 Czech Republic; *Corresponding author: sloup@fld.czu.cz

INTRODUCTION

Forest management provides raw material for the timber processing industry, but it also plays an important role in the landscape functions and in the socio-economic space. Natural forests and plantation forests in Europe represent the most prominent part of all European landscapes. At the same time, they serve as the source of many materials as well as non-material benefits (Bouriaud *et al.* 2013; Podrázský *et al.* 2014). Forest ecosystems and their dynamics are very resilient with respect to variations in state and management demands (Vacek and Lepš 1987; Vacek *et al.* 2012; Krejčí *et al.* 2013).

The importance of forest management intensity to address sustained yield was recognized long ago (Von Carlowitz 1713), but quantitative and spatial patterns of forest management intensity have been missing or restricted to particular problem areas (Levers *et al.* 2014). The determination of the production potential of the forests on the national level requires consideration of the limits, defined by the forests area, their species and age composition, site and production conditions, and also environmental limits (Kouba 1991; Vilén *et al.* 2012). The methodology, created in the Czech Republic and based on variable levels of the management intensity, allows variable assessment of the impact on the forest

production function in the future. It is a compromise between intensive forest management and the limits given by environmental aspects.

The present study presents a model picture of the production potential of Czech forests, taking into consideration the demands of sustainability and environmental functions. In the Czech Republic, the forest owner or manager usually chooses (within ecological limits) from several variants of target tree species (target management). The analysis especially considers the recommended species composition, the soil-improving species' share, rotation periods, and target managements. The aim is to support sustainable forestry while taking ecological aspects into account.

MATERIAL AND METHODS

The production calculation is based on the results 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" coordinated by the Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague.

The methodical procedures used in the study can be summarized in the following way:

- creating model limit ecologically tolerable variants of the Czech forests' potential production,
- calculating the impact of the tree species composition (defined within so called target managements) on the production capacity of Czech forests,
- the analysis is not based on actual species composition, the analysis investigates potential capacities of Czech forests,
- two limit variants of tree species composition were analyzed the production potential minimum and maximum,
- within the limits, all variants of tree species composition are possible; the choice is up to the owner,
- thus, in an extreme case, the owner might opt for "the ecological form of management" with the minimum production potential, *i.e.* choose a high share of ecologically favorably species, referred to as "soil-improving species" in the Czech typology (includes esp. all broad-leaved species). In the other extreme, the owner would emphasize the market production function, *i.e.* opt for the Norway spruce in particular. Even in this case, though, they are obliged to grow at least a minimum share of soil-improving species set by law, in relation to the group of forest habitat types, usually *ca.* 30%.

The calculation is based on the following input data:

- 1. Ecological limits of forest management;
- 2. Calculation of the production potential of Czech forests.

Ecological Limits

The typological system of the Czech Republic considers the following ecological functions: infiltration, erosion control, desuction, and precipitation-inducing (climatic function).

The calculation respects the ecological limits that reflect the forest habitat typological system of the Czech Republic and applicable legislation. The analysis takes into account the recommended tree species composition, the share of soil-improving tree species, the rotation period, and target management, named after the main commercial tree species. In the study, four principal variants of target managements were considered: Norway spruce [*Picea abies*], Scots pine [*Pinus sylvestris*], oak [*Quercus robur* L.], and beech [*Fagus sylvatica*].

The production potential of management is fundamentally influenced by the choice of target management. "Target management" is not a new term (Plíva 2000). In the past, it was related to application of forest typology, although the term target management (*e.g.*, "Norway spruce target management on fertile soils") was erroneously confused with monocultures.

The types of target management, as Plíva presents, are defined by coherent units with the identical target management and the same species in the target tree species composition, labelling the target management type and setting the intensity and methods of management.

As the target tree species composition represents the optimum potential production value in given natural conditions while simultaneously ensuring sustainability of the forest ecosystem (ecological stability or acceptable destability), the appropriate target management type is optimal as well. Alternative management types cannot provide a higher value of production, though they might suit the ecological forest functions better.

Not only do the target management types help to define the general principles and management intensity, but, in larger areas, also provide detailed information on the prerequisites and targets of management.

Groups of forest habitat types

Groups of forest habitat types – GFHT – as the basic differentiation units of forest growing conditions (tree growth and production) are defined by their ecological affinity (both soil and climatic) expressed by phytocenose or obvious features of the sites.

Inductively created GFHT, set in the ecological (edaphic-climatic) net, established a solid system with a clear feedback and the deductive procedure expressed by the following definition (Appendix No. 4 to Regulation No. 83/1996): GFHT are defined by the forest altitudinal zone (faz) and the edaphic category. The definition helped the schematic completion of the net and clarified the system for practical application.

Rotation period

The presently applied rotation period in the CR is set in the "Basic recommendations by the management units (Regulation No. 83/1996)". The rotation period for respective target management and stand types is set by Appendix No. 3 of Regulation No. 83/1996. There are time spans set to the rotation periods, and it is up to the forest owners to choose one (on recommendation of the forest management plan author). In this analysis, the mean value was used as the neutral one, as it does not advance reduction nor prolong the rotation period.

Variants of target managements

Ecologically tolerable variants of target management (Norway spruce [*Picea abies*], Scots pine [*Pinus sylvestris*], oak [*Quercus robur* L.] and beech [*Fagus sylvatica*]) by groups of forest habitat types are shown in Tables 1 and 2.

The Czech typological system traditionally allows two or three variants of target management for the majority of GFHTs, though for some there is only one available.

The data in Tables 1 and 2 can be summarized in the following way:

The total area of the forests in the CR is 2,659,837 ha (Ministry of Agriculture 2011) and allows:

- Solely the Norway spruce target management on the area of 420,254 ha.
- The Norway spruce target management or an alternative (mainly beech) on the area of 1,321,939 ha.
- Solely the Scots pine target management on the area of 154,271 ha.
- The Scots pine target management or an alternative (mainly oak) on the area of 37,238 ha.
- Solely the oak target management on the area of 170,230 ha.
- The oak target management or an alternative (mainly Scots pine) on the area of 308,541 ha.
- Solely the beech target management on the area of 79,795 + 10,639 ha.
- The beech target management or an alternative (mainly Norway spruce) on the area of 127,672 ha.

Production Potential Calculation

The calculation is based on the following prerequisites:

- 1) The calculation of forest production potential yield was based on the yield tables (Černý *et al.* 1996).
- 2) The calculation of the potential yields of tending felling were based on the analysis performed in the framework of the cited project (an original proposal of the volume and intensity of thinning was elaborated for all four researched target managements).
- 3) The sorting was based on tables (Pařez 1987a,b) for "N" quality healthy, undamaged, straight stems.
- 4) In each girth class (6+ to 1) main collections, currently traded in the Czech Republic, were considered.
- 5) The basic space unit for evaluation was the group of forest habitat types (GFHT).
- 6) The principal synthetic indicator of evaluation effect was the total mean increment (TMI).

Table 1. Tree Species Share (in %) by GFHT for Norway Spruce [*Picea abies*] and Scots Pine [*Pinus sylvestris*] Target Management in the Ecological Net of the Typological System

	GROUP OF FOREST HABITAT TYPES																								
Line		ext	reme			exp	osed			acid			n	utritio	us			pseud	ogleyed	1	wa	aterlog	ged	all	uvial
faz/cat.	Х	Ζ	Y	J	Α	С	F	Ν	М	К	I	S	В	Н	D	W	V	0	Р	Q	Т	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	NS85 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 EB 7 FI 4 AL 4	NS 85 EB 7 FI 4 AL 4		NS 85 EB 7 FI 4 AL 4	NS 70 EB 20 LA5 FI 5				NS 85 EB 7 LA 4 FI 4	NS 70 EB 20 LA5 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		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 LA5 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 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		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 LA5 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 / SP 80 OB 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 0A 30	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 LA5 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 0A 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 RB 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 85 EB 7 FI 4 AL 4			NS 50 EB 30 FI 20

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2				SP	SP 70	SP	SP 70	SP 70	SP 70				SP 70	SP 80				
- -				70	OA 30	70	OA 10	OA 20	OA 20				OA20	OA 20				
beech-				OA		OA	LA 5	LA 5	LA 5				LA 5					
oak				30		30	FI 5	FI 5	FI 5				FI 5					
1				SP	SP 70	SP	SP 70	SP 70	SP 70				SP 70	SP 80				
- ook				70	OA 30	85	OA 20	OA 20	OA 20				OA20	OA 20				
Uak				OA		OA	LA 5	LA 5	LA 5				LA 5					
				30		10	FI 5	FI 5	FI 5				FI 5					
						LA 5												
0	SP	SP 95		SP	SP 85	SP	SP 85					SP 85	SP 70	SP 85	SP95	SP 95	SP 95	
nino	95	OA 5		95	OA 10	85	OA 10					OA 10	OA 20	OA 10	OA 5	OA 5	OA 5	
pine	OA 5			OA 5	LA 5	OA	LA 5					LA 5	FI 10	LA 5				
						10												

faz = forest altitudinal zone, cat. = category, NS - Norway spruce [Picea abies], SP - Scots pine [Pinus sylvestris], OA - oak [Quercus], OB - other broadleaves, EB - European beech [Fagus sylvatica], LA - European larch [Larix decidua], FI - Silver fir [Abies alba], AL - alder [Alnus]

The evaluation of the production potential of all target management variants has to be complemented by the following aspects:

- In the analysis, two limit variants were studied a combination of target managements by the individual GFHT with the minimum production efficiency, and a combination of target managements by GFHT with the maximum production potential; therefore, theoretically, the real production potential might range within the analysed limits.
- The production potential might range within wide limits between the minimum (rather "ecological" variants of management) and the maximum (rather "economic" variants).
- All the variants within the above mentioned limits strictly adhere to ecological demands given by the Czech legislation.
- All calculations are based on present prices of forest production output (Czech Statistical Office 2013).

RESULTS

The survey of the total mean increment is shown in Table 3.

Table 2. Tree Species Share (in %) by GFHT for Oak [*Quercus robur* L.] and Beech [*Fagus sylvatica*] Target Management in the Ecological Net of the Typological System

	GROUP OF FOREST HABITAT TYPES																								
Line		extr	eme			exp	osed			acid			I	nutritiou	IS		k	seudo	gleyed		wat	erlog	ged	alluv	/ial
faz/cat.	Х	Z	Y	J	Α	С	F	Ν	М	К	I	S	В	Н	D	W	V	0	Ρ	Q	Т	G	R		U
9								1																, ——+	
dwarf																								1	
pine																								1	
8																								,ł	
spruce																								1	
7																								,ł	
beech-																								, I	
spruce																								, I	
6					EB 70		EB 70	EB 80	EB 70	EB 70	EB 60	EB 60		EB 60	EB 60		EB 60							t	
spruce-					OB 10 LA 20		OB 10 LA 20	OB 10 LA 10	OB 10 LA 10	OB 10 LA 20	NS 20 OB 20	OB 20 NS 20		NS 20 OB 20	NS 20 OB 20		NS 20 OB 20							, I	
beech					-		-	_																, I	
5				EB 60	EB 70	EB 80	EB 70	EB 80	EB 80	EB 60	NB 60	OB 70	EB 60							,					
fir-				NS 20 FI 20	OB 10 LA 20	OB 10 LA 10	OB 10 LA 20	OB 10 LA 10	OB 10 LA 10	NS 20 OB 20	NS 20 OB 20	OB 20 NS 20	OB 20 NS 20	NS 20 OB 20	NS 20 OB 20	EB 10 LA 20	NS 20 OB 20							, ,	
beech					-		-	_																1	
					EB 80	EB 80	EB 70	EB 80	OA 80	EB 60	EB60	EB 60	EB 60	EB 60	EB 60	OA 70	EB 60	OA 90	OA 70					I	
4					OA 10 LA 10	OA 10 LA 10	OA 10 LA 20	OA 10 LA 10	EB 10 LA 10	NS 20 OA 20	NS 20 OA 20	OA 20 NS 20	0A 20	NS 20 OA 20	NS 20 OA 20	EB 10 LA 20	NS 20 OA 20	LA 10	EB 10 LA 20					1	
beech					2.10	5110	2120	2.10	5110	0/120	0/120		NS 20	0,120	0/120	2.20	/ OA90		2120					1	
	ļ!	 	<u> </u>	ED 80	FD 80	ED 80		FD 90	04.80	50700	5070	5860	EDCO.	FR 60	ED 60	0470	LA 10	50.60				ļ!	└───┦	AL 60	
3				LA 10	OA 10	OA 10		OA 10	EB 10	A10	OA 10	OA20	OA20	NS 20	NS 20	EB10	NS 20	NS 20						AL 80 NS 20	
oak-				FI 10	LA 10	LA10		LA 10	LA 10	LA20	LA 20	NS 20	NS 20	OA 20	OA 20	LA20	OA 20	OA 20						EB 20	
beech																	/ OA 90 LA	/ OA 90 LA						1	
																	10	10						ا ا	
2		OA 60			OA 60	OA 80		OA 80	OA 80	OA70E	OA70	OA70	OA 00	OA	OA 90	OA70	OA 90	OA 90						0A	
beech-		EB 10			EB 10	LA10		LA 10	LA 10	20	LA 20	LA 20	50 LA 10	90 LA 10	LA 10	LA20	LA 10	LA 10						100	
oak					LA 10																			اا	
1		OA 70		OA 80	OA 80	OA 80		OA 80		OA70E	OA70	OA70	OA 00	OA 00	OA 90		OA 90	OA 90						0A 100	0A
oak		SP 30		EB 20	LA 10	LA10		LA 10		20	LA 20	LA 20	90 LA 10	90 LA 10	LA 10		LA 10	LA 10						100	100
0	OA																							,	
pine	100																							, I	

See Table 1 for abbreviations

Table 3. Limit Height of the Total Mean Increment (m³/ha/y) by the Groups of Forest Habitat Types and Target Management in the Ecological Net of the Typological System

									(GROUP	OF FO	REST H	ABITA	T TYPES											
Line		extr	reme			exp	osed	·		acid			1	nutritio	JS		Ł	oseudo	gleyed		wat	erlog	ged	alluv	vial
faz/cat.	Х	Z	Υ	J	Α	С	F	Ν	М	К	I	S	В	Н	D	w	v	0	Р	Q	Т	G	R	L '	U
9 dwarf pine																									
8 spruce		NS 0,85	NS 1,18		NS 2,56		NS 2,95	NS 2,92	NS 2,96	NS 3,62		NS 3,60					NS 3,61			NS 3,44	NS 2,14	NS 4,88	NS 2,14		
7 beech- spruce		NS 1,00	NS 1,18				NS 4,43	NS 3,32	NS 3,19	NS 3,79		NS 4,01	NS 4,78				NS 5,32	NS 5,31	NS 4,41	NS 3,58	NS 3,91	NS 5,32	NS 3,91		
6 spruce- beech			NS 1,33		NS 5,07 EB 3,63		NS 5,27 EB 4,29	NS 3,89 EB 2,94	EB 2,63 NS 3,51	EB 3,23 NS 4,43	EB 3,46 NS 4,95	NS 6,52 EB 4,47	EB 5,21 NS 7,21	EB 4,77 NS 6,65	EB 5,21 NS 7,21		EB 4,88 NS 7,09	NS 5,72	NS 4,49	NS 3,92		NS 5,34	NS 5,37		
5 fir-beech			NS 1,19	EB 1,56	NS 6,82 EB 3,77	EB 3,95	NS 5,27 EB 4,29	NS 4,11 EB 3,11	EB 2,70	EB 3,59 NS 4,99	EB 3,59 NS 4,99	NS 6,74 EB 5,10	NS 7,19	EB 5,10 NS 5,10	EB 5,21 NS 7,21	NS 6,18 EB 4,21	EB 4,88 NS 7,12	NS 5,80	NS 5,29	NS 4,40 SP 2,75		NS 5,93	NS 3,44		NS 5,33
4 beech			SP 1,00		NS 6,19 EB 3,91	EB 3,18 SP 3,54	NS 5,77 EB 4,41	SP 2,81 NS 4,55 EB 3,35	SP 2,60 OA 2,03	NS 5,32 EB 3,87	EB 3,87 NS 5,32	EB 4,60 NS 5,93	EB 5,10 NS 7,17	EB 5,10 NS 7,17	EB 5,21 NS 7,65	EB 4,21	NS 7,56 EB 4,88 OA 3,79	NS 6,63 OA 3,78	NS 4,93 OA 3,09	SP 2,74		NS 5,92	NS 5,70		
3 oak- beech			SP 0,87	EB 1,05	NS 5,72 EB 3,71	EB 3,43 SP 2,81	NS 5,51 EB 4,21	SP 3,04 NS 4,50 EB 3,17	SP 2,42 OA 1,89	SP 3,06 EB 3,53	SP 2,95 NS 4,71	EB 4,59 NS 5,84	EB 5,10 NS 7,17	EB 5,10 NS 7,19	EB 4,70 NS 6,38	EB 4,46	NS 7,51 EB 4,88 OA 3,76	NS 5,71 EB 4,16 OA 4,12				NS 5,61		AL 4,22	NS 6,85
2 beech- oak		OA 0,61			OA 2,46	SP 2,31 OA 2,43		SP 2,55 OA 2,31	SP 2,42 OA 1,87	SP 3,10 OA 2,49	SP 3,32 OA 2,70	SP 4,10 OA 2,99	OA 2,61	OA 3,18	OA 2,84	OA 2,52	OA 3,15	OA 2,81	SP 3,36	SP 2,74				OA 3,65	
1 oak	OA 0,62	OA 0,58		OA 0,73	OA 2,33	SP 2,32 OA 2,03		SP 2,39 OA 2,15	SP 2,94	SP 2,60 OA 2,19	SP 3,10 OA 2,52	SP 3,51 OA 2,85	OA 3,10	OA 2,57	OA 2,84		OA 3,15	OA 2,54	SP 3,51	SP 2,74				OA 4,15	OA 5,58
0 pine		SP 0,48	SP 0,60			SP 2,17		SP 2,51	SP 1,69	SP 2,44		ľ						SP 3,90	SP 2,85	SP 2,02	SP 2,89	SP 3,26	SP 1,20		

NS = Norway spruce target management, SP = Scot pine target management, OA = oak target management, EB = European beech target management, faz = forest altitudinal zone, cat. = category

The potential limit tree species share in the Czech Republic is presented in Table 4.

Species	Minimur	n variant	Maximu	m variant
	% share	area (ha)	% share	area (ha)
NS	19	509,093	48	1,268,476
SP	17	455,231	6	158,659
EB	36	935,278	20	533,643
OA	16	413,738	15	387,138
OB	6	148,421	0,2	5,852
LA	4	117,033	7	174,618
FI	1	37,530	3	87,934
AL	0.5	12,129	0.5	12,129

	Table 4. Limit	Tree Species	Share in the	Czech Republic
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NS = Norway spruce, SP = Scots pine, EB = European beech, OA = oak, OB = other broadleaves, LA = larch, FI = fir, and AL = alder

The summarisation of the respective GFHT data allows calculation of the minimum and maximum variant when classified by the tree species or by coniferous and broadleaved, and the total volume of the natural production, as can be seen in Fig. 1.



Fig. 1. Total production potential (TPP) by tree species in the economically minimum and maximum variant (thous. m³/year)

A comparison of the potential and real production of the forests in the Czech Republic was drawn. The presented calculation helped analyze the natural potential production of timber in the Czech Republic.

The real volume of felling in the monitored period depends on the felling of rotation stands, having been established continually since 1830, when the approach to forest management was substantially different. The analysed variants of potential perspective capacities of Czech forests are based on current knowledge of forest disciplines. Principal concepts of the currently applied typological system and forest management originated in the 1970s and were further elaborated in the cited work of K. Plíva (2000) and in

Regulation 83/1996. The full impact of current opinions on forest management will be known within decades (considering the long-term nature of forest production).

The following graphs present:

- Comparison of the total natural potential and the real volume of felling (Fig. 2).
- Comparison of the natural potential and the real volume of the coniferous production (Fig. 3).
- Comparison of the natural potential and the real volume of the broad-leaved production (Fig. 4).



Fig. 2. Comparison of potential limit production (TPP total min. and TPP total max.) with the total felling in the CR between 1950 and 2011 (mil. m³)



Fig. 3. Comparison of the potential limit production (TPP coniferous min. and TPP coniferous max.) of coniferous timber with the coniferous felling in the CR between 1950 and 2011 (mil. m³)

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Fig. 4. Comparison of the potential limit production (TPP broad-leaved min. and TPP broad-leaved max.) of broad-leaved timber with the broad-leaved felling in the CR between 1950 and 2011 (mil. m³)

The comparison of the potential minimum and maximum total production potential (TPP) leads to the observations that:

- The indicators of the potential and real felling volume are not entirely compatible.
- The TPP limits relate rather to the long-term perspective of the Czech forests.
- The real volume of felling is especially influenced by the tree species share of the forest stands, as seen in Table 5; the current tree species share differs significantly from the potential one.

Table 5. Comparison of the Optimum and Current Tree Species Share in ForestStands in the CR

Tree species	Tree species share									
	MIN pote	ential variant	MAX pot	tential variant	Real cu	rrent share				
	%	area (ha)	%	area (ha)	% share	area (ha)				
	share		share							
Norway spruce	19	509,093	48	1,268,476	51.4	1,334,417				
Scots pine	17	455,231	6	158,659	16.7	432,915				
European beech	36	935,278	20	533,643	7.7	198,652				
oak	16	413,738	15	387,138	7.0	182,327				
larch	4	117,033	7	174,618	3.9	100,956				
fir	1	37,530	3	87,934	1.0	26,859				
other broadleaves	7	160,550	1	17,985	11.0	284,171				
(including alder)										

The comparison shows that in the future, the Norway spruce share (for instance) might range between 19 and 48% of the total area of the Czech forests. The decision on tree species composition lies within the owner's authority; therefore, it is very difficult to predict the share of Norway spruce stands. Nevertheless, it will almost certainly be (maybe significantly) lower than now. Similarly, the share of other tree species can be analysed, especially beech and oak, whose share will grow considerably from the present 14% to 36%, or even 58%.

- The deviation of the potential TPP from the real felling volume is also caused by the non-optimum share of the age class, as seen in Table 6.

				Age clas	s (age spa	an in years)		
Year	Clearing	-			IV	V	VI	VII
		1-20	21-40	41-60	61-80	81-100	101-120	121+
1920	1	23	24	22	17	10	3	0
1930	2	31	31	31	19	11	5	0
1950	2	18	21	21	19	12	7	0
1960	1	17	21	20	19	13	6	3
1670	1	17	20	19	20	13	7	3
1980	1	17	15	20	20	15	8	4
1990	1.5	16.1	14.7	19.4	18.9	16.8	8.2	4.4
2000	1.2	16.7	15.5	14.7	18.8	17.3	10.2	5.5
2010	1.1	17	14.8	14.2	18	15.8	12	7.1
2012	1.2	16.9	14.8	14.7	17.1	15.7	12.2	7.5

Table 6. Development of Age Classes in Czech Forests

Source: Report on Forest Management of the Czech Republic 2012

In addition to the two principal reasons of discrepancy, the real volume of felling is also influenced by a differing rotation period (in comparison to the optimum one), incidental felling, non-felling of over-mature stands, and perhaps other unspecified influences.

This analysis is in fact the first attempt to tackle an important problem, *i.e.*, defining the disposable natural production of Czech forests. The volume and structure of timber resources can be calculated in many variants. One of them is apparent in Table 7 and Fig. 5.

Table 7 presents the minimum and maximum disposable volume of assortments of the potential main felling (PMF), *i.e.*, not the total volume of potential felling (TPP). The assortment of the potential TPP is presented in Fig. 5.

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Table 7. Minimum and Maximum Volumes of the Assortments of the Potential Main Felling (thous. m³/y)

	I.+II. qua Ic	ality grade ogs	III.A/B qualit	y grade logs	III.C qu	ality grade ogs	III.D+IV. qu log	uality grade gs
Tree species	min.	max.	min.	max.	min.	max.	min.	max.
Norway spruce	19	46	1,294	3,428	434	1,155	440	1,173
Scots pine	5	13	148	390	79	208	118	313
European beech	75	33	585	260	607	272	1,533	710
oak and other broadleaves	30	11	276	96	553	192	488	170
larch	7	7	163	137	87	73	128	106
fir	1	3	60	271	20	92	21	94

	coniferou	s pulpwood	broad	-leaved	te	otal
	and fu	lelwood	pulpwood a	and fuelwood		
Tree species	min.	max.	min.	max.	min.	max.
Norway spruce	139	389	0	0	2,326	6,190
Scots pine	63	166	0	0	413	1,090
European beech	0	0	426	208	3,225	1,483
oak	0	0	299	12	1,647	481
larch	56	38	0	0	442	362
fir	8	35	0	0	109	495
					8,162	10,101



Fig. 5. Minimum and maximum volumes of the assortments of the total mean increment in the CR (thous. m^{3}/y)

CONCLUSIONS

This analysis documents a relatively wide range of production potential for Czech forests, based on the limits given by administration and ecological demands, compared to the current trends. The main production indicator was the total mean increment.

- 1. The minimum and maximum use of particular tree species ranges in a broad limits.
- 2. This results also in the wide range of volume as well as value increment.
- 3. The Norway spruce ranges between 19 and 48 % of the forest area (51.4% at present), Scots pine between 6 and 17%, European beech 20 and 36% (cca 7 and 8% at present), oak species between 15 and 16% (7% at present), larch between 4 and 7%, silver fir between 1 and 3% and other broadleaves 1 and 7 % (11% at present).
- 4. The main assortment supply (coniferous roundwood) potential ranges also very widely, 3,802 to 9,134 ths. m³, which demands considerable adaptability and flexibility of the wood industry in the future.
- 5. The changes will be relatively slow, but adaptation strategies should be adopted by the industry in time.

ACKNOWLEDGMENTS

This work was supported by the Czech National Agency for Agricultural Research under contract No. QJ1220313: Differentiation of intensities and management practices in relation to forest biodiversity and economic sustainability of forestry and No. QJ1520299: Applying Douglas fir in forest management of the Czech Republic.

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Article submitted: October 29, 2014; Peer review completed: January 19, 2015; Revisions received and accepted: June 4, 2015; Published: June 12, 2015. DOI: 10.15376/biores.10.3.4711-4725