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Norway spruce in forest ecosystems of the Czech Republic in relation to different forest site conditions

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ABSTRACT: The paper analyses the representation of Norway spruce (*Picea abies* [L.] Karst.) (hereinafter spruce) in relation to different conditions of forest sites. The analysis is based on data from the National Forest Inventory conducted in the Czech Republic in 2001–2004 (hereinafter NFI), stratified according to units of the Forest Site Classification System (Plíva 1971, 2000). Results of the analysis provide a structured image of the current share of spruce. The formerly published information on the natural share of spruce was corroborated and the recommended share of spruce in the target species composition of the spruce management system was analyzed. The analysis documents the applicability of NFI data in the technical discussion concerning the future form of forest ecosystems in the Czech Republic. The results can be used as the groundwork for concrete forest management decision-making and will contribute to the study of the biological diversity of forest ecosystems.

Keywords: Norway spruce; biodiversity; Forest Site Classification System of the Czech Republic; National Forest Inventory

Results of the National Forest Inventory conducted in the Czech Republic in 2001–2004 (NFI CR: Introduction, Methods, Results) indicated that the spruce took up a total area of 1,138,424 ha and was the most widespread tree species in the Czech Republic (47.7%). The primacy of spruce is given both by natural conditions and by the history of forest management (Nožička 1957; Málek 1961). Forest owners favour the species for its easy management, relatively fast growth and manifold use of wood mass. That is why the spruce reaches even outside of its natural range.

However, some authors e.g. Spiecker (2000), Kahle et al. (2005), Kantor (2005) and others warned against risks connected with the growing of spruce pointing out that a great threat to spruce could be expected due to more frequent spells of extreme drought especially on sites outside its natural range. Souček and Tesař (2008) informed that the total volume production of spruce monocultures, considered to be one of the main factors for selecting the species composition in the past, was not so important any longer. An increased emphasis is put on timber quality and to a greater extent than ever also on the fulfilment of non-wood production functions of the forest. The authors also warned against the damage to pure spruce stands by incidental felling, which increases with the increasing divergence of site conditions from the spruce growth optimum. Therefore, the determination of sites of the spruce growth optimum with respect to the natural range of this species remains a topical issue. But discussions of experts show that their views on the spruce share in forest ecosystems of the Czech Republic are equivocal.

The forest management issue is tackled also by the National Forest Programme (NFP) by the year 2013, which is considered a concept of sustainable forestry. Sustainable management means the stewardship and use of forests and forest lands in such a way, and to such an extent, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social

functions at local, national, and global levels, and that does not cause any damage to other ecosystems (2nd Ministerial Conference on the Protection of Forests in Europe, Helsinki 1993*)*. Although such an all-encompassing definition might seem appealing, it does not lend itself easily to quantifiable science (Monserud 2003).

In dealing with key actions Nos. 6, 7, and 9 of the NFP, a general opinion has been presented for a long time that the share of spruce in forest ecosystems of the Czech Republic is too high. The aim of this paper is to characterize the structured representation of spruce according to the Forest Site Classification System (Plíva 1971, 2000) and to refine its recommended share in evaluating the target species composition of the forest stand.

Brief historical context

The forests have always covered a greater part of the territory of the Czech Republic and its colonization by humans during the prehistoric times never reached densities that would represent a threat to the original forest ecosystem. An essential change occurred in the 12th century when agricultural colonization began and areas of the original forest ecosystems started to be converted into farmland or pastures. The size of forest ecosystems began to shrink considerably due to the growing population and ever-increasing consumption of timber. This trend lasted with some interruptions such as Thirty Years' War (1618–1648) until the 18th century, when the deforestation of the Czech Republic's territory reached its culmination and when a mass planting of forests was resumed (Nožička 1957).

The effort focused on the greatest possible benefit from the forest led the forest owners to the growing of tree species with the highest increment, best processing characteristics and most favourable merchantability, namely spruce and pine – even on inappropriate sites. At the same time, seed material was used in forest regeneration with no regard of its origin. Forests were established as homogeneous and even-aged cultivated forest stands – usually spruce plantations in regular rows. Clear felling was a dominant management system and the artificially established young plantations were tended stereotypically. Broadleaves were often considered as undesirable species (ÚHÚL 2007).

Based on the decision of forest owners, the trend continued, which is the reason for more than a half of forest ecosystems in the Czech Republic occurring on non-native sites in the third and fourth generations. Particularly the homogeneous spruce stands are affected most often by disasters due to abiotic and biotic factors (Zahradník 2008).

MATERIAL AND METHODS

The groundwork for the analysis is data from the National Forest Inventory in the Czech Republic (hereinafter NFI) acquired from the field collection in 2001–2004 (Government Decree No. 193/2000). The analysis links up with results from the first NFI cycle that were processed by a set of mathematical and statistical methods (Zach 2004).

The NFI results indicate that the total forest area in the Czech Republic is 2,751,586 ha and the percentage of forestland is 34.9%. This means that forests in the country exceed the area of land intended for the fulfilment of forest functions (Report on the State of Forests and Forestry in the Czech Republic by 2009 mentioned 2,664,794 ha, i.e. 33.8% of the state territory). A reason for this difference consists in different definition of the forest according to the NFI methodology (Kučera 2010) and according to the Forest Law.

Table 1. The division of spruce inventory plots according to the proportion of spruce in the mixture on the inventory plot

Proportion of spruce in the mixture	Forest inventory plots (%)	[–]	[+]
P (91% and more)	20.3	–0.7	0.7
D (61–90%)	10.7	–0.5	0.5
F (41–60%)	4.9	–0.4	0.4
M (1–40%)	11.8	–0.5	0.5
Total	47.7	–0.8	0.8

Terminology of intervals (P – pure, D – dominant, F – fifty-fifty and M – minor) was adopted from the Ecosystem analyses of Regional Forest Management Plans 1996–2001 (Macků, 2001).

The % of forest inventory plots denotes mean value; [-] and [+] sings denote confidence interval of mean value.

The total number of inventory plots assessed within the presented analysis was 9,251, i.e. 66% of all plots included in the forest land according to the NFI methodology. All analyzed inventory plots were homogeneous with no further division into sub-plots. Of them, 6,352 inventory plots with the occurrence of spruce were stratified. According to the spruce proportion in the mixture, the inventory plots were classified into four basic groups: 1–40%, 41–60%, 61–90%, 91–100% (Table 1).

The occurrence of inventory plots with a significant proportion of spruce in the mixture (i.e. 41–100%) in the particular Forest Site Complexes (hereinafter FSC) was displayed in the ecological network of the Forest Site Classification System of the Czech Republic (Plíva 1971; 2000; Viewegh et al. 2003) (Fig. 1).

The number of spruce inventory plots on which the spruce is a dominant species (i.e. 61–90% and 91–100%) was compared with the number of inventory plots complying with the forest land definition according to the NFI methodology and FSCs with the highest representation of spruce were analyzed.

Based on data from historic and typological surveys (Nožička 1957; Málek 1961; Plíva 2000; Průša 2001), the natural range of spruce was delineated in relation to the Forest Site Classification System of the Czech Republic. Subsequently, the natural and recommended shares of spruce were compared with the NFI data.

The extent of spruce sites was delimited on the basis of forest typology and the obtained results were summarized for particular Forest (Altitudinal) Vegetation Zones (hereinafter FVZ). The analysis of the natural spruce share was converted based on available results from a typological survey (Plíva 2000 with regard to Vokoun 1997). The analysis of the recommended spruce share was done in two variants. The first variant was focused on analyzing the recommended spruce share in the target species composition according to FSCs (Plíva 2000) in the spruce (mixed) management system and the second one analysed the recommended share of spruce in a similar manner taking into consideration alternative pine, oak and beech management systems (Smejkal et al., 2004). In the latter case, the share of spruce was decreased by expected proportions of the alternative management systems (Appendix No. 4 to Decree No. 83/1996). The expected proportion of the alternative management systems corresponds to their current share, which was derived from the database of forest management plans and guidelines. The obtained results concerning the natural and recommended share of spruce were compared with the current share of inventory plots with a significant proportion of spruce in the mixture (i.e. 41–100%).

NFI data were evaluated by mathematical-statistical methods and therefore the results include the confidence interval defined by the positive [+] and negative [–] statistical error. This means that the determined mean value in the mentioned confidence interval has a probability of 95% (Likeš, Laga 1978; Zach 2004).

Ecological series	Extreme				Acidic						Trophic			Maple		Ash		Gleyed				Wet		Peat
Edaphic categories	X	Z	Y	J	M	K	N	I	S	F	C	B (W)	H	D	A	L	U	V	O	P	Q	T	G	R
Forest Vegetation Zones																								
9 - dwarf pine		8	1			3																		3
8 - spruce		19	1		2	41	4		1									3			8	2	9	15
7 - spruce with beech		2	4		11	175	24		25									9	12	22	1	4	36	11
6 - beech with spruce		2	12	3	7	368	89	21	149	5		13		5	16	5	2	55	63	109	6		17	8
5 - beech with fir		2	4		19	424	61	24	464	36		181	27	8	28			37	75	48	4		9	7
4 - beech		1	3		2	165	19	30	271	14	1	148	31	17	14	7		5	73	74	10		6	5
3 - beech with oak			3	3	4	190	24	64	239	6	4	68	75	21	17		1	2	32	24				
2 - oak with beech					1	38		18	25		7	12	13	3	2				8	11	3			
1 - oak					3	2						1				2		1	3	4	3	1		
0 - pine		1	2		1	26	21				4								2	6	3	1	12	4

Fig. 1. The occurrence of inventory plots within the ecological network of the Unified Typological System of Czech Forests (Forest Site Classification)

Particular FSCs are presented together with spruce-significant inventory plots (41–100%). Dark coloured are FSCs with the number of spruce inventory plots ≥ 30 (i.e. with a significant occurrence of spruce)

Table 2. The representation of spruce according to pure and dominant its proportion of spruce in the mixture on the inventory plot

Distribution of spruce	% of sites	[–]	[+]	Dominant forest site complexes (FSCs)[1]
Pure (91% and more)	20.3	–0.7	0.7	5S, 6K, 5K, 7K, 4S, 5B, 3S, 6S, 6P
Dominant (61–90%)	10.7	–0.5	0.5	5K, 5S, 3S, 4S, 3K, 6K
Total (61–100%)	31.0	–0.8	0.8	5S, 5K, 6K, 4S, 3S, 7K, 5B, 3K, 6S, 6P

[1]FSCs are presented in the descending order from the highest proportion of spruce

The % of sites denotes mean value; [–] and [+] sings denote confidence interval of mean value

RESULTS AND DISCUSSION

The stratification of NFI plots by FSCs provided information about the representation of spruce in forest ecosystems of the Czech Republic in relation to different forest site conditions (Fig. 1). The results show that the spruce is bound mainly to sites poor in nutrients and to water-affected sites.

Based on Fig. 1, we can state that the spruce is represented largely in edaphic categories K (acidic) and S (fresh). The comparison of spruce representation on the given sites revealed that in terms of the area coverage the largest representation of this species is in FVZ 5. The current share of spruce in FVZ 2 is also worth mentioning because for example in FSC 2B, the species was not represented at all in the past and in other FSCs (e.g. 2T, 2Q) it was interspersed only sporadically.

The representation of homogeneous spruce forests (Table 2) and spruce-dominated forests in the territory of the Czech Republic is 20.3% and 10.7%, respectively. 57.9% (–1.5%, +1.5%) of these forests occur on sites where the spruce has spread naturally or where its share may be still significant regarding the species ecological requirements.

Data on the spruce representation in relation to the species proportion in the mixture (Table 2) may become a part of the evaluation of biological diversity (Report on the Fulfilment of Objective 2010 in the Protection of Biodiversity in the Czech Republic). The current share of forest ecosystems dominated by spruce is 31.0%; however, the actual share of homogeneous spruce stands is lower. As to its size (0.05 ha), the inventory plot gives reliable information about an individual mixture of trees and does not allow to evaluate a group mixture of tree species at the stand level. The stand is a unit of spatial division of the forest in forest management plans, whose average size is 3.19 ha. It follows that the data presented in Table 2 represent maximum possible values of the current share of spruce in the forest ecosystems of the Czech Republic. The issue

Ecological series	Extreme				Acidic					Trophic				Maple		Ash		Gleyed				Wet		Peat
Edaphic categories	X	Z	Y	J	M	K	N	I	S	F	C	B (W)	H	D	A	L	U	V	O	P	Q	T	G	R
Forest Vegetation Zones																								
9 - dwarf pine		8	1			3																		3
8 - spruce		19	1		2	41	4		1									3			8	2	9	15
7 - spruce with beech		2	4		11	175	24		25									9	12	22	1	4	36	11
6 - beech with spruce		2	12	3	7	368	89	21	149	5		13		5	16	5		55	63	109	6		17	8
5 - beech with fir		2	4		19	424	61	24	464	36		181	27	8	28		2	37	75	48	4		9	7
4 - beech		1	3		2	165	19	30	271	14	1	148	31	17	14			5	73	74	10		6	5
3 - beech with oak			3	3	4	190	24	64	239	6	4	68	75	21	17	7	1	2	32	24				
2 - oak with beech					1	38		18	25		7	12	13	3	2				8	11	3			
1 - oak					3	2						1				2		1	3	4	3	1		
0 - pine		1	2		1	26	21				4								2	6	3	1	12	4

Fig. 2. The occurrence of inventory plots within the ecological network of the Unified Typological System of Czech Forests (Forest Site Classification)

Particular FSCs are presented together with spruce-significant inventory plots (41-100%). The natural share of spruce in the ecological network is represented in black and grey colour (Plíva 2000 with regard to Vokoun 1997). The black background with white figures denotes sites with the natural share of spruce ≥ 40%. The grey background with black figures denotes sites with the natural share of spruce < 40%

was studied in detail by Kraus and Zeman (2008) and is mentioned in the National Forest Programme by the year 2013 in Chapter 3 – The present condition of forests and forestry in the Czech Republic.

The analysis of the natural share (Fig. 2) of spruce showed that its share in forest ecosystems of the Czech Republic was 11.1%, the information corresponding with the outputs of typological surveys (Plíva 2000; Průša 2001).

The natural range of spruce is considered to be an area on which the spruce obviously occurred prior to substantial interventions of man in the landscape. Historic and typological works demonstrated the occurrence of spruce also at lower altitudes. Documents about the spruce distribution originate from the 16th and 17th centuries, i.e. from the period during which the natural species composition was not altered yet by intensive forest management (Málek 1961). In his work, the author demonstrated that the area on which the spruce naturally occurred was considerably larger than the area on which it did not occur. The natural share of spruce at lower and middle elevations should be imagined only as an admixture because at these altitudes, the spruce can play a role of dominant tree species only under particularly favourable soil and microclima-tic conditions.

Available studies (Nožička 1957; Málek 1961) indicate that the spruce occurred practically at all elevations and Málek pointed out two centres of its natural occurrence – the first one at elevations of about 600–800 m a.s.l., and the second one at altitudes above 1,000 m a.s.l. He also informed that the total natural share of spruce in the species composition of forests was low in spite of the fact that the natural range of spruce was considerably large. The share of spruce at lower elevations was of relict character. The spruce formed extensive forest ecosystems at mountain elevations with favourable macroclimatic conditions.

The occurrence of spruce at middle and lower elevations is limited by macroclimatic conditions (temperature, precipitation) and it is mainly the edaphic and microclimatic conditions that enable the species occurrence. Here, the spruce can be found on extrazonal sites with lower temperatures, moist to wet and waterlogged soils and shady aspects where it grows in cold river valleys, brooks and in canyons and gorges (Málek 1961).

The Report on the State of Forests and Forestry in the Czech Republic by 2009 informed that the natural share of spruce in forest ecosystems was 11.2% and the recommended share of spruce should be

Table 3. The comparison of natural, recommended and current shares of spruce

FVZ	Recommended share of spruce						Natural share of spruce						Current share of spruce according to NFI spruce proportion in the mixture[2]					
	Plíva (2000)			Smejkal et al. (2004)[1]			Plíva (2000)			Spruce occur on these sites (according to NFI)			1–100%			41–100%		
	(%)	[–]	[+]	(%)	[–]	[+]	(%)	[–]	[+]	(%)	[–]	[+]	(%)	[–]	[+]	(%)	[–]	[+]
9	+	0.0	0.0	+	0.0	0.0	+	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1
8	1.3	–0.2	0.2	1.3	–0.2	0.2	1.2	–0.2	0.2	0.8	–0.1	0.2	0.8	–0.1	0.2	0.8	–0.1	0.2
7	3.5	–0.3	0.3	3.5	–0.3	0.3	3.2	–0.3	0.3	2.6	–0.3	0.3	2.7	–0.3	0.3	2.5	–0.3	0.3
6	8.3	–0.5	0.5	8.1	–0.4	0.5	4.5	–0.3	0.4	7.6	–0.4	0.5	8.0	–0.4	0.5	7.1	–0.4	0.4
5	14.2	–0.6	0.6	12.6	–0.5	0.6	1.7	–0.2	0.2	12.5	–0.5	0.6	13.2	–0.6	0.6	11.1	–0.5	0.5
4	9.7	–0.5	0.5	8.4	–0.5	0.5	0.1	0.0	0.1	0.8	–0.1	0.2	9.1	–0.5	0.5	6.7	–0.4	0.4
3	10.9	–0.5	0.5	8.0	–0.4	0.5	+	0.0	0.0	0.1	–0.1	0.1	9.3	–0.5	0.5	5.9	–0.4	0.4
2	+	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	–0.3	0.3	1.0	–0.2	0.2
1	+	0.0	0.0	+	0.0	0.0	+	0.0	0.0	0.1	0.0	0.1	0.4	–0.1	0.1	0.1	–0.1	0.1
0	0.4	–0.1	0.1	0.4	–0.1	0.1	0.3	–0.1	0.1	1.4	–0.2	0.2	1.5	–0.2	0.2	0.6	–0.2	0.2
Sum	48.3	–0.8	0.8	42.3	–0.8	0.8	11.1	–0.5	0.5	26.0	–0.7	0.7	47.7	–0.8	0.8	35.9	–0.8	0.8

[1]Follows out from the expected share of alternative beech, pine or oak management systems

[2]Proportion of spruce in the mixture on the inventory plot

The % sing denotes mean value; [–] and [+] sings denote confidence interval of mean value; + sign denotes the disseminated representations of spruce

at the level 36.5%. Similar information was published by Průša (2001), who claimed the natural and recommended share of spruce to be 12.2% and 36.8%, respectively. Opinions concerning the natural and recommended share of spruce differ among particular authors; for example, Šindelář (1996) presumed the natural share of spruce at 15.0% but his information about the recommended share of spruce was 30.0%.

The target species composition of forest stand is a recommended share of tree species at felling age expressed in percent, which is optimal with respect to the wood-production and non-wood production functions of the forest on the given site and in the given Natural Forest Area.

Table 3 compares the natural, recommended and existing share of spruce according to particular authors with the results of the NFI.

At first sight, the share of spruce may appear to be low in each Forest Vegetation Zone (FVZ). The reason is that it is determined from the total forest area in the Czech Republic (2,751 586 ha). If only the area of FVZ 5 were taken as 100%, the actual share of spruce in the FVZ would be about 60%. The significance of Table 3 consists in a possibility to compare the structured share of spruce.

If we consider only the FSCs that have been classified by typological research as natural sites for spruce, the share of spruce on these FSCs is 26%, which is by 14.9% more than the natural share of the species (Plíva 2000). At the same time, we can state that more than a half of the area covered by spruce occurs on optimum (natural) sites and the highest share (12.5%) of the species is in FVZ 5 (Table 3).

Regarding the historic context and the currently existing problems of homogeneous spruce forests, it is considered useful to strive for reaching the recommended share of spruce 36.8% (Průša 2001), which can be achieved through the recommended spruce share of 42.3% (Smejkal et al. 2004).

Fig. 3 illustrates the recommended share of spruce (Plíva 2000) in the target species composition according to FSCs in the spruce (mixed) management system.

The recommended share of spruce according to Plíva (2000) is 48.3% and it can be concluded that the value corresponds in general with the NFI results. The NFI results show that the existing representation of spruce in Czech forests is 47.7%. To achieve the recommended spruce share of 36.8% (Průša 2001), the current representation of spruce should be reduced just by 10.9%.

The output from the analysis is a list of the most appropriate FSCs for a modification of the spruce share to the level of 36.1%. The FSCs in question are as follows: 0M, 0K, 0C, 0O, 0P, 1M, 1K, 1B (W), 1L, 1V, 1O, 1Q, 2M, 2K, 2I, 2S, 2C, 2B (W), 2H, 2D, 2A, 2O, 2P, 2Q, 3Y, 3J, 3M, 3K, 3N, 3I, 3S, 3F, 3C, 3B (W), 3H, 3D, 3A, 4Y, 4M, 4K, 4N, 4I, 4S, 4F, 4C, 4B (W), 4H, 4D, 4A (Fig. 4). The summarization of spruce inventory plots in the mentioned FSCs revealed the proportion of spruce at 11.6% (–0.5%, +0.5%).

Data following from Fig. 4 may become the groundwork for a discussion about the spruce representation on concrete sites. Based on this survey, a number of changes can be calculated with respect to the site conditions of forest ecosystems. By interconnecting the NFI data with the typological (i.e. forest

Ecological series	Extreme				Acidic					Trophic				Maple		Ash		Gleyed				Wet		Peat
Edaphic categories	X	Z	Y	J	M	K	N	I	S	F	C	B (W)	H	D	A	L	U	V	O	P	Q	T	G	R
Forest Vegetation Zones																								
9 - dwarf pine		8	1			3																		3
8 - spruce		19	1		2	41	4		1									3			8	2	9	15
7 - spruce with beech		2	4		11	175	24		25									9	12	22	1	4	36	11
6 - beech with spruce		2	12	3	7	368	89	21	149	5		13		5	16			55	63	109	6		17	8
5 - beech with fir		2	4		19	424	61	24	464	36		181	27	8	28	5	2	37	75	48	4		9	7
4 - beech		1	3		2	165	19	30	271	14	1	148	31	17	14			5	73	74	10		6	5
3 - beech with oak			3	3	4	190	24	64	239	6	4	68	75	21	17	7	1	2	32	24				
2 - oak with beech					1	38		18	25		7	12	13	3	2				8	11	3			
1 - oak					3	2						1				2		1	3	4	3	1		
0 - pine		1	2		1	26	21				4								2	6	3	1	12	4

Fig. 3. The occurrence of inventory plots within the ecological network of the Unified Typological System of Czech Forests (Forest Site Classification)

Particular FSCs are presented together with spruce-significant inventory plots (41-100%). Sites on which the share of spruce is recommended (Plíva 2000) are represented in black colour

Ecological series	Extreme				Acidic					Trophic				Maple		Ash		Gleyed				Wet		Peat
Edaphic categories / Forest Vegetation Zones	X	Z	Y	J	M	K	N	I	S	F	C	B (W)	H	D	A	L	U	V	O	P	Q	T	G	R
9 - dwarf pine		8	1			3																		3
8 - spruce		19	1		2	41	4		1									3			8	2	9	15
7 - spruce with beech		2	4		11	175	24		25									9	12	22	1	4	36	11
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2 - oak with beech					1	38		18	25		7	12	13	3	2				8	11	3			
1 - oak					3	2						1				2		1	3	4	3	1		
0 - pine		1	2		1	26	21				4								2	6	3	1	12	4

Fig. 4. The groundwork for a discussion on the modification of spruce share in Czech forest ecosystems
Particular FSCs are presented together with spruce-significant inventory plots (41-100%). FSCs on the black background with white figures denote the most appropriate sites for the modification of spruce share to reach the level of 36.1%

site classification) map, management measures can be applied to concrete sites. The state administration may use the results of this analysis to adjust endowment for the conversion of homogeneous spruce stands on inappropriate sites. In such a case, the results of the presented analysis will make it possible to assess the scope and costs of forest operations as well as their urgency in particular regions. These considerations should take into account findings and conclusions of works that document the significance of spruce as the main commercial species.

The optimized recommended share of spruce will be specified more precisely again during the second stage of the elaboration of Regional Plans of Forest Development (Decree of the Ministry of Agriculture No. 83/1996 on the elaboration of Regional Plans of Forest Development and on the determination of Management Complexes of forest site types).

Conclusions and recommendations for a further practical use of results of the present analysis

The article brings a new look at the share of spruce in forest ecosystems of the Czech Republic and the acquired knowledge will contribute to the fulfilment of the sustainable forestry concept. The results of the analysis provide a detailed breakdown of the spruce share by particular FSCs and this information allows to specify in detail the measures in respect of the area size as well as in respect of the localization of discussed changes. To achieve the recommended spruce share of 36.8%, the current representation of spruce should be reduced just by 10.9% in forest ecosystems of the Czech Republic. The results of the analysis will also be applied in the revision of forest typology and are of key importance for the analysis of the production potential of forest stands in relation to different forest site conditions.

The conclusions drawn from the obtained results are as follows:

(1) The analysis of NFI data stratified according to the Forest Site Classification System showed that the natural share of spruce in the species composition of forests in the Czech Republic is 11.1%. Thus, the formerly published results (Plíva 2000; Průša 2001) were corroborated.

(2) The analysis revealed that the current share of spruce on sites characterized by typological research as natural in terms of the original species distribution is 26%.

(3) The analysis of NFI data stratified according to the Forest Site Classification System scrutinized the recommended share of spruce, the value of which differs according to particular authors: 48.3% (Plíva 2000) and 42.3% (Smejkal et al. 2004).

(4) NFI results indicate that the area covered by spruce in the territory of the Czech Republic is 47.7% and the percentage corresponds with the recommended proportion of 48.3% (Plíva 2000). Taking into account the historic context and the contemporary problems of spruce monocultures it appears advisable to strive for the share of 36.8% recommended by Průša (2001). It can be achieved through the share of 42.3% recommended by Smejkal et al. (2004).

(5) Results of the analysis focused on the spruce share in relation to different conditions of forest sites can be used as the groundwork for the species composition modification. The analysis provides the summary of FSCs (Fig. 4) that

should be first considered for this procedure. Adequate measures should be focused mainly on the edaphic categories B (nutrient-rich), H (loamy) and FSCs of the maple ecological series in FVZ 2–4. The trophic ecological series of FVZ 2–4 and FSCs of the acidic ecological series in FVZ 1–4 would follow. The list can be added sites with pine management on FSCs – 0M, 0K, 0C, 0O, and 0P. This recommendation is based on a precautionary principle in relation to the stability of forest ecosystems and responds to the concept of sustainable forest management. It is based on an analytical evaluation of the natural, recommended and current share of spruce forest ecosystems in the Czech Republic. The optimized recommended share of spruce will be reviewed during the second stage of the elaboration of Regional Plans of Forest Development (Decree of the Ministry of Agriculture No. 83/1996).

(6) The interconnection of these results with the forest typological map will make it possible to quantify relevant management measures for particular regions.

(7) According to the analysis, the current proportion of homogeneous spruce forests in the total forest area is 20.3% (pure) and the current share of spruce-dominated forest ecosystems is 10.7% (dominant). The data can be used as indicators of the biological diversity of forest ecosystems in the territory of the Czech Republic.

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