AUTHOCHTHONOUS NORWAY SPRUCE OUTSIDE MOUNTAIN REGIONS IN THE CZECH REPUBLIC*

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In the Czech Republic, Norway spruce (*Picea abies* Karst.) is considered autochthonous in the mountains as well as at lower altitudes. However, certain papers admit its originality only in the mountains. Three historic maps (from the years 1746, 1853, and 1946) showing tree species composition, published in the guide for FAO excursion in Czech forests in 1956, were evaluated and compared with the current tree species composition. The studied forest estate is located in the uplands, in the 4th vegetation belt. The data show that spruce made a substantial part of the tree species composition on Stagnosols as well as Cambisols. Even on Podzols, dominated by pine, spruce played an important role. While the spruce and pine composition was increasing at the expense of fir, oak proportion remained roughly the same. Comparing the tree composition on the evaluated area in the years 1746 and 2001, the composition of spruce increased from 39.8% to 46.4%, of pine from 32.2 to 42.2%, while that of fir decreased from 20.7 to 1.8%.

autochthonous population; soil type; history; map; spruce

INTRODUCTION

Norway Spruce (*Picea abies* Karst.) is one of the most widely planted spruce species, both within and outside its native range, and one of the most economically important coniferous species in Europe as well as in the Czech Republic. Its extensive planting started at the beginning of 19th century and this activity of foresters is nowadays considered highly controversial. Spruce is appraised for its economic value but its planting at lower altitudes is often being rejected by environmentalists who claim that it grows naturally only in the mountains. The natural range of tree species including spruce plays a very important role in deciding which forests we will have and herewith it is a source of endless struggle between foresters and environmentalists about the future of our forests.

The statement that spruce is native only in the mountains is supported also by the system of vertical zonation of vegetation expressed in forest vegetation belts which are characterized by their dominant woody species. In the Czech Republic, nine vegetation belts were defined and designated after the major native tree species (Table 1). Although thenative occurrence of tree species does not directly correspond with the designation of the vegetation belts, according to certain studies reconstruction of the native tree species composition has been more or less derived from the vegetation belts. Spruce is not mentioned among native trees at lower latitudes excepting on Stagnosols where is íntroduced only as admixed species (Plíva, 1984). Poleno, Vacek (2007)| also claimed that spruce is native as admixed species only on acid Stagnosols in the 4th vegetation belt.

Such statements have led to the opinion that spruce is autochthonous only in the mountains, its spread to lower altitudes contradicts its native range, and its planting there has been considered profitable just from the economic viewpoint. On the other hand, certain reports came with a hypothesis that autochthonous spruce had populated also lower vegetation belts in uplands and hilly regions. Thus the question is whether spruce originally occurred only in the mountains in the Czech Republic or whether its native range on the Czech territory was wider and therefore it can be considered autochthonous also at lower altitudes.

When speaking about spruce distribution, two terms should be considered – natural share (representation or composition) and natural occurrence (spread or extension). M á l e k (1961) reported that the natural occurrence of spruce is broader but at lower altitudes spruce was only an admixed tree species growing on specific habitat types mainly on waterlogged soils where spruce survived as a relict species. However,

* Supported by the Ministry of Agriculture of the Czech Republic, Project No. QI102A079.

Table 1. System of vegetation belts in the Czech Republic (tree species in parenthesis are co-dominant)

Vegetation belt	Dominant tree species	Altitude (approximate)
1	oak	150–250
2	(beech) oak	200–350
3	(oak) beech	300–450
4	beech	400–550
5	(fir) beech	550–700
6	(spruce) beech	600–800
7	(beech) spruce	800–1000
8	spruce	1000–1350
9	dwarf pine	1350 and more

reports from the 16–17th centuries indicated its existence at lower altitudes without quantification of its composition (Ambrož, 1949).

As soon as natural conditions became a basis of forest management planning, a forest habitat typology was created for determination and description of natural conditions including natural tree species composition. In the Czech Republic, two distinct areas are recognized following the differences between two geological massifs. While a strip lying by the eastern border is formed by the Carpathians, the major part of the republic is constituted by the Bohemian Massif. Zlatník (1978) and other authors (Vorel, 1979; Málek, 1983) recognized that the species composition in the 4th vegetation belt dominated by beech was in some parts of the Bohemian Massif altered by the mixture of oak and conifers. Pine and fir were mentioned as major coniferous species and if spruce was introduced, then only as an admixed tree species. This evidences that in the Bohemian Massif spruce was autochthonous also at lower altitudes, although maybe not everywhere – the report from the year 1787 stated that the tree species composition in the north-eastern part of the Bohemian Massif had been formed by dominant fir (*Abies alba*) and beech (*Fagus sylvatica*) (Dušek, 2010).

Míchal (1994) claimed that spruce was a non-native tree species in the 4th and lower vegetation belts and its occurrence there was only a result of the artificial spread. Its occurrence in the 5th belt was admitted only on waterlogged and peaty soils and spruce as autochthonous species could be taken into consideration only in the 6th and higher belts. Also Žárník, Křístek (2007) showed in their models of actual and natural distribution of spruce that spruce was native from the 5th vegetation belt. Similar approach was reflected not only in papers of non-governmental organizations of environmentalists dealing with forestry (Hnutí DUHA, 2009), but also in the official paper evaluating the status of forests and forestry in the Czech Republic (Ministry of Agriculture of the Czech Republic, 2009). On the other hand, map of spruce distribution in Europe (EUFORGEN, 2008) showed that in the Czech Republic (the Bohemian Massif) spruce was autochthonous almost everywhere except lowlands.

The reconstruction of the former native tree species composition is in many ways difficult. The pollen analysis can show the spruce distribution in the past but this statement can also lead to misinterpretation due to long-distance pollen transport and different sources of contamination (Latalowa, Van der Knaap, 2006). As from the end of the 18th to the middle of the 19th century the large areas of the Central European lowlands and mountains were reforested with coniferous trees, mainly Scotch pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), and tree species composition dramatically changed, the reports from the middle of the 18th century should show the original status of the forests from the tree species composition viewpoint (Zerbe, 2002). However, these forests could not be named pristine in any strict sense of this word because the human impact on their structure and species-mix began long time ago (Farell et al., 2000). Hosius et al. (2006) placed the onset of human impact on forest ecosystems in Central Europe back to about 1200 B.P. spreading rapidly in many centers of high population growth and expanding settlements. Nevertheless the rapid change of tree species composition associated with the onset of production-oriented forest management started at the beginning of the 19th century (Hüttl et al., 2000). Zerbe (2004) within the example from Spessart (northwestern Bavaria, Germany) indicated that degraded forest sites were afforested with coniferous trees, mainly in the first half of the 19th century. Therefore, the data from the first forest management plans created in the middle of the 18th century should show the native tree species composition.

The investigation of the native tree species composition is necessary mainly from the nature protection reasons. The native tree species composition is determined by permanent ecological condition of a site. It means that groups of forest habitat types are also suitable for defining objects and aims of nature protection (Holušová, Holuša, 2012).

MATERIAL AND METHODS

In the year 1956 large excursions into forests in various parts of the Czech Republic were organized for FAO staff (Lesprojekt, 1956). While preparing the excursion into the south Bohemian forests, three old forest maps (from the years 1746, 1853, and 1946 – Figs. 1–3, respectively) were utilized. The first map (1746), which includes the composition of the main tree species, was a part of one of the first

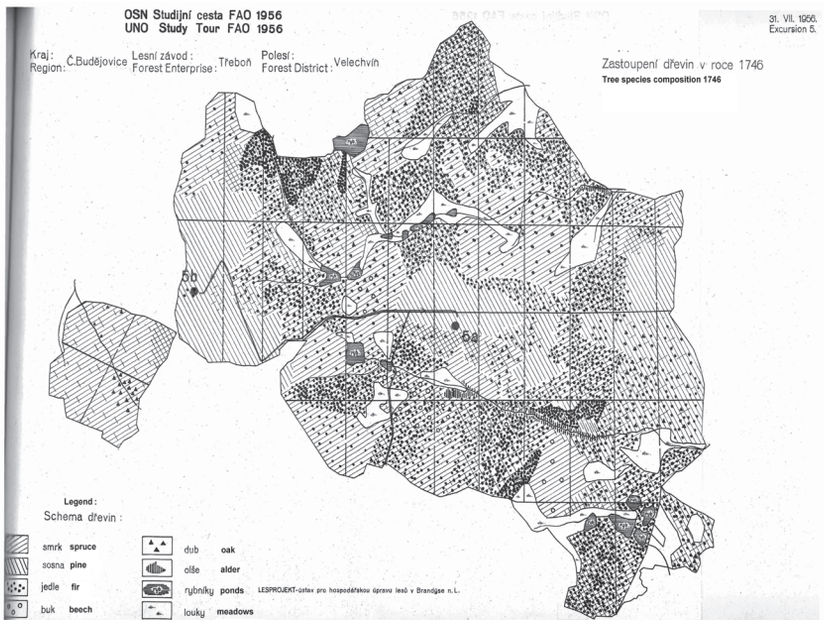

Fig. 1. Forest map 1746

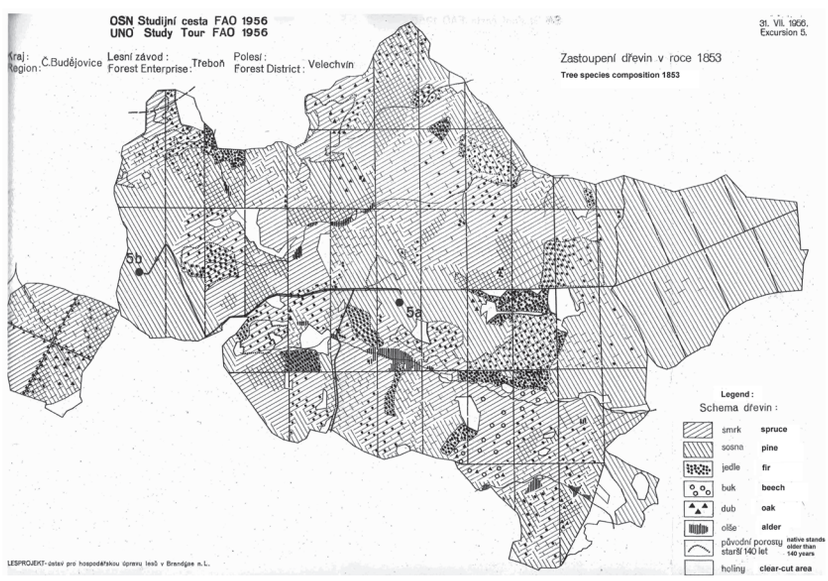

Fig. 2. Forest map 1853

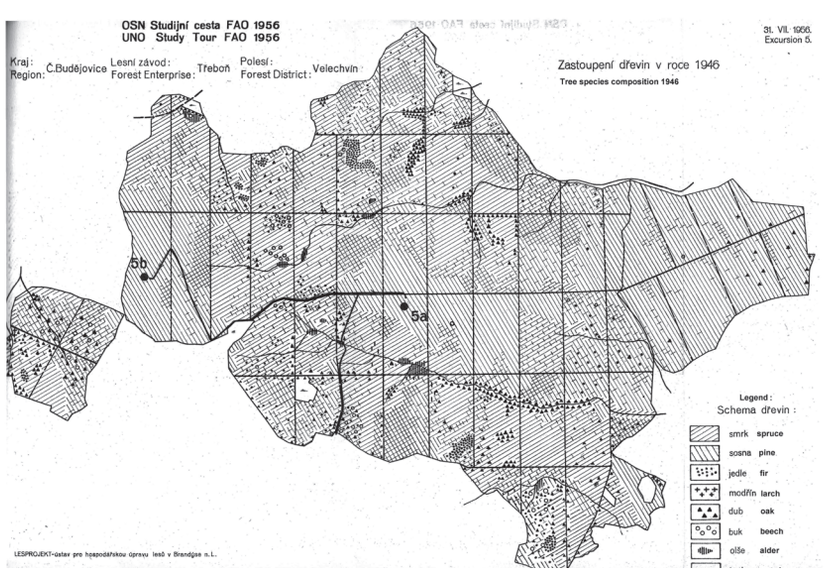

Fig. 3. Forest map 1946

Table 2. Dominant forest habitat types and soil types in the area

Group	Forest habitat types	Soil type (FAO soil taxonomy)	Area	Percentage
1	0M – Poor oak-pinewood	Podzol (Arenosol)	506.9	26.2
2	4K – Acid beechwood	Cambisol	396.14	20.5
	4O – Fresh oak-firwood	Stagnosol	1028.38	53.3
3	4P – Acid oak-firwood			
	4Q – Poor oak-firwood			
Total			1931.42	100

Table 3. Area covered with the tree species in investigated years and tree species composition

Year	Spruce	Pine	Fir	Oak	Beech	Alder	Others	Total
Area (ha)								
1746	769.42	622.81	398.87	86.24	31.03	22.92	0	1931.29
1853	823.99	794	205.93	61.86	15.6	29.94	0	1931.32
1946	869.76	789.5	93.91	131.38	22.07	20.78	3.99	1931.39
2001	897.61	814.17	35.39	91.48	32.31	8.77	51.69	1931.42
Tree species composition (%)								
1746	39.8	32.2	20.7	4.5	1.6	1.2	0	100
1853	42.6	41.1	10.7	3.2	0.8	1.6	0	100
1946	45	40.9	4.9	6.8	1.1	1.1	0.2	100
2001	46.4	42.2	1.8	4.7	1.7	0.5	2.7	100

forest management plans in the Bohemian Kingdom (Ú H Ú L , 2001).

Thanks to the fact that the forest repartition and the network of boundary lines have remained practically untouched from 1746 until the present, the changes in spruce occurrence during the past 260 years could be reconstructed.

The study area (forest estate) called Velechvin is located in the southern part of the Czech Republic roughly 20 km north of České Budějovice (coordinates for the centre of the forest estate: 49°04′26.9″N; 14°35′38.2″E, average altitude 485 m a.s.l.).

Natural conditions are described by the dominant forest habitat types based on the dominant soil types classified into 3 groups (Table 2).

As published in the report of the excursion, in the historical maps the individual compartments are covered with marks and hatches which depict tree species. The area of the compartments and subcompartments is defined in the last forest management plan (FMP). Therefore tree species composition on the maps can be estimated in percent in the subcompartments and the area of their distribution can be calculated according to the assessed percentage. The present composition is simply summed from the stand description in the last FMP created in 2001. The stands for comparison were selected according to the status in the year 1746 because the forest area has been growing gradually until now. Significance in changes of the tree species composition over the whole area was tested by the *t*-test.

MS EXCEL (2010, Version 14) and STATISTICA (2009, Version 9.0,) software packages were used for all the analyses performed.

RESULTS

While within 1746–2001 spruce and pine composition continuously grew, that of fir decreased from 20.7% to the present 1.8% (Table 3). Regarding the soil types, the results show that fir composition decreased mainly on Cambisols and Stagnosols. On Podzols, where pine is dominant, spruce reached 15% of composition in the year 1746 and spruce and oak compositions were approximately the same over the years.

Spruce existed not only on Stagnosols, but also on other soil types (Figs. 4–6).

The *t*-test comparing compositions of 4 main tree species (spruce, pine, fir, oak) within 139 subcompartments on all soils was used. There were significant differences in compositions for spruce between the years 1746–1946, 1746–2001, and 1853–2001 ($P < 0.001$). For pine the differences were between the year 1746 and the years 1853, 1946, and 2001 ($P < 0.001$), for fir the differences were in all combina-

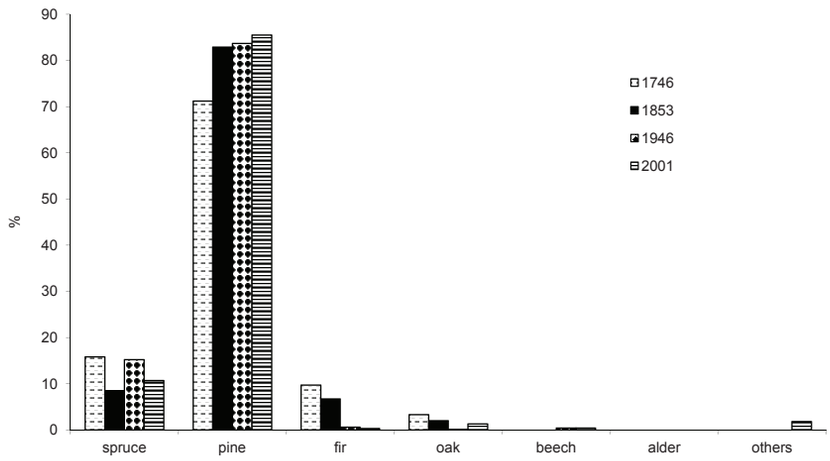

Fig. 4. Changes in tree species composition (podzols, arenosols)

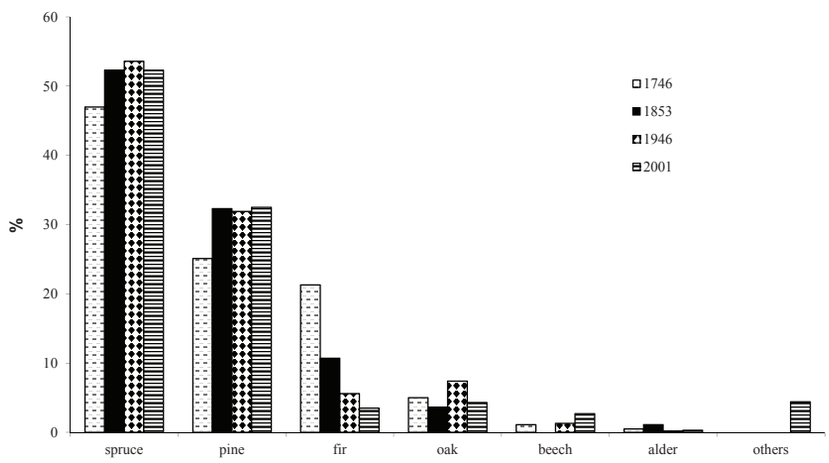

Fig. 5. Changes in tree species composition (cambisols)

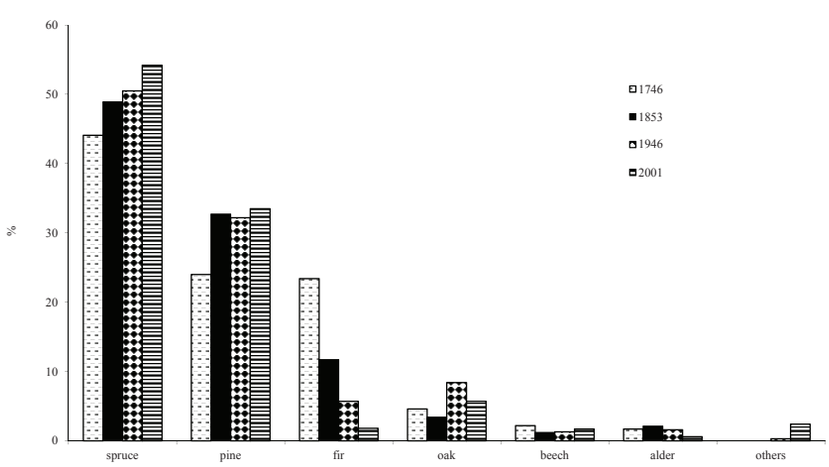

Fig. 6. Changes in tree species composition (stagnosols)

tions ($P < 0.001$). Finally, for oak the differences were between the years 1746–1946, 1853–1946, 1853–2001, and 1946–2001 ($P < 0.02$).

Beech as one of supposed dominant tree species, especially on Cambisols, was reported only as an admixed species with low composition and consequently did not

play crucial role in the development of tree species composition on the area. The beech composition on the whole area varied from 0.8% (1853) to 1.7% (2001).

DISCUSSION

The results showed that historically spruce was dominant on two soil types (Cambisols and Stagnosols) while pine dominated on Podzols. Spruce composition was the most intensively growing between the years 1746–1853 and later on this growth, as well as that of pine, weakened. It corresponded with the gradual disappearance of fir. In contrast, composition of oak showed different trends. After the statistically insignificant decrease between the years 1746–1853, the composition was growing till the year 1946 and since then it has been decreasing.

Spruce naturally occurred on the area at lower altitudes in larger composition than previously believed. In contrast, P l í v a (1984) mentioned that natural tree species composition was pine 80%, oak 10%, and birch 10% on the forest habitat type Poor oak-pine wood, beech 70%, oak 10%, and fir 20% on the Acid beech wood, and finally oak 40%, fir 40%, beech 10%, and alder 10% on the Acid oak-fir wood. It means no spruce was assumed to be a part of the natural tree species composition. M í c h a l (1994) also showed that spruce came down to lower altitudes only exceptionally as an admixed tree species on waterlogged soils. Even on waterlogged soils the author did not mention the spruce composition. However, M á l e k (1983) introduced spruce as a part of a natural mixed forest with oak and fir. P o l e n o , V a c e k (2007) assumed spruce with the composition of 1–10% only on acid and poor Stagnosols (acid oak-fir wood, poor oak-fir wood), on fresh Stagnosols (fresh oak-fir wood) spruce was assumed only to 1% of composition.

Following the evaluation of forest maps with the tree species composition, three questions may arise: Is it possible to reconstruct precisely tree composition based only on the maps with sketched composition legend? Is the natural occurrence of spruce larger than was previously supposed? Did human activity influence the spruce composition before the investigated term, i.e. before the year 1746?

To answer the first question, we must admit that the data from the maps are only rough and the precise composition cannot be reconstructed. Moreover, we do not know how exactly the data on the composition were taken. On the other hand, due to the fact that the forest repartition and the network of boundary lines have remained unchanged during the historical development, more or less true tree species compositions can be detected on smaller areas, i.e. in individual subcompartments, and therefore through summarizing the data from the subcompartments the real tree species composition can be approached.

The answer to the second question is closely linked up with this statement. We can state that spruce was a natural part of forest at lower altitudes. In addition, E l l e n b e r g (1986) claimed that in Czechoslovakia *Picea* went much further down into the warm basins than had previously been supposed. Also N o ž i č k a (1957) mentioned that in the year 1661 forests in the area were formed of pines, oaks, spruces, beeches, firs, and birches. In the hilly and upland region in Central Bohemia (the Brdy hills) spruce was a native part of the tree species composition and at lower altitudes (around the town of Spálené Poříčí) spruce was abundant at the beginning of the 19th century even in the stands aging over 100 years (S a m e k , 1957). This area was previously included in the 4th vegetation belt (A u d o l e n s k á , 2009).

The third question about human activities is crucial. Naturally, forests in Central Europe were influenced by human activities during the last millennium (F e r n o w , 1907; N o ž i č k a , 1957; Zerbe, Brande, 2003). But the intensive forestry joined with artificial regeneration was born at the end of the 18th century in Central Europe (F e r n o w , 1907; N o ž i č k a , 1957; P e ř i n a , 1958). Although the regular strip system for artificial regeneration was applied in Austria in 1766 to fir and spruce and in Prussia in 1764 to pine, in Bohemia the clearing system with artificial planting by seed was introduced as late as the beginning of the 19th century for the conifer forests (F e r n o w , 1907). Therefore natural tree species composition including spruce, which is described according to the map from 1746, can be regarded as corresponding with the real historical tree species composition. Looking back at the changes during the development of the tree composition since 1746, the spruce composition has been increasing very slowly and the increase of spruce and pine was at the expense of fir composition.

A higher composition of spruce in the study area was supported by A m b r o ž (1949) who mentioned spruce as the third most important native tree species here after fir and oak. He showed that according to the reports from the 17th century, the forest area Ševětín (part of our study area) was covered mainly with spruce. He presented evidence that in the study area the mixed old stand (150–200 years) formed by silver fir, spruce, and pine had existed already in the year 1864. His evidence came probably from the map and forest management plan from the year 1853 because he mentioned more than 140-year old stands (Fig. 2).

Furthermore we can pose another question if certain disasters or deforestation in the past did not bring about the spread of spruce. Even though spruce is not a typical pioneer species, it can, along with pines, spread on open areas. E.g. after calamities spruce can naturally expand from sites on Stagnosols to sites on Cambisols. K o u b a (2006) set together a historical overview of major disasters which heavily damaged the forests on the territory of the Czech Republic.

The disasters were caused by wind, insect, fire, frost, snow, and hailstorms. The overview showed that in the past the forests were damaged many times with no artificial afforestation or other human assistance during their regeneration.

CONCLUSION

If we compare the both sides of argumentation on whether or not spruce formed one of major parts of native forests at lower altitudes in southern parts of the Czech Republic, we must admit that spruce had naturally higher composition than was supposed. This fact shows that our ancestors, who spread spruce as a fast-growing tree species almost everywhere in Bohemia, drew not only from German experiences but also from the natural composition of domestic forests. In addition, it seems that the natural tree species composition was unexpectedly more varied and new findings in this way could influence the future decisions and plans concerning which tree species are appropriate for close-to-nature forestry in given natural conditions.

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Received for publication on January 23, 2013
Accepted for publication on June 7, 2013

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