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PHYTOCOENOLOGICAL AND PRODUCTION EVALUATION OF THE NATURAL OAK AND SECONDARY PINE FORESTS OF THE BORSKÁ NÍŽINA LOWLAND

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Abstract

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In this contribution we deal with phytocoenological and production evaluation of the original thermo- and acidophilous oak forests and secondary pine monocultures situated on the eolic sands of the Borská nížina lowland. Established differences in species composition are as follows: secondary pine forests are poorer in vascular plant species – there is a typical absence or retreat of many species, especially those typical in light-demanding broad-leaved forests. These include *Anthericum ramosum, Carex caryophyllea, Betonica officinalis, Polygonatum odoratum, Vincetoxicum hirundinaria, Silene nutans* and many others. There are also a few, such as *Acetosella vulgaris*, *Calluna vulgaris, Carex ericetorum* and *Thymus serpyllum*, which prefer pine secondary forests. On the other hand, bryophytes including *Pleurozium schreberi, Pseudoscleropodium purum,* and *Leucobryum glaucum* have distinctly higher cover in secondary pine forests. The following primary production has been established; the oak forest herb layer has 1814.5 kg.ha^{-1} (above ground 872.1 kg.ha^{-1}, below ground 942.4 kg.ha^{-1}) and that of pine forest has 472.8 kg.ha^{-1} (above ground 250.6 kg.ha-$^{-1}$, below ground 222.2 kg.ha^{-1}). The difference in moss production is even more profound, with oak forests having only approximately 283.5 kg.ha^{-1}, while secondary pine forests registered 1,910.8 kg.ha^{-1} .

Key words: oak forest, pine forest, floristic composition, biomass production, Borská nížina lowland

Introduction

As indicated by the name itself, this contribution is linked to a series of articles by Šomšák, Kubíček (1994, 1995, 2000) which focused on phytocoenological and production characteristics in the original forest ecosystems and also the changes induced by Scotch-pine monocultures.

These were massively applied throughout the entire region of the Borská nížina lowland during recent centuries. This article is closely related to the work of Šomšák, Kubíček (1994) which examined *Pino-Qurcetum* association oak-pine forests. These occupy xeric sand dunes traditionally considered to be a major, or even exclusive, original forest type here (e.g. Krippel, 1965; Ružička, 1960). These authors also reported on derived *Pleurozio schreberi-Pinetum* association of Scotch-pine monocultures. However, in our opinion, the question of potential vegetation in sand dunes, and also in this entire region, is more complex than elucidated so far, and it still has not been satisfactorily answered. Earlier authors, including Ružička (1960), noted that some acidophilous oak forests may exist here, but certainly not to a wide extent. On the other hand, adjacent region of sand dunes in the Czech Republic list the occurrence of only acidophilous oak forest (*Festuco ovinae-Quercetum roboris* Š m a r d a 1961 association of *Genisto germanicae-Quercion* N e u h ä u s l et N e u h ä u s l o v á-N o v o t n á 1967 alliance). Other authors in Western Europe including Philippi (1970) do not consider Scotch-pine to be a climax tree in their respective sandy regions. Following this idea, we recorded stands consisting entirely of oaks in this Borská nížina lowland region which, together with secondary pine forests, form the main subject of this study. We have not named this syntaxon here because its classification has so far remained unclear. However, syntaxonomical and phytocoenological issues are the subject of our next article already under preparation.

Study area

The study area is contained in the Borská nížina lowland in western Slovakia. Herein, we focused on its subunit portion – named Bor – which has served as a military training area since its declaration in 1928. The area is composed of eolic siliceous sands dominated by Podzols and Arenosols, and these are very poor in nutrients. Annual average temperature is 9–9.6 °C, but during the vegetation period it is 14–15 °C, while annual precipitation is in the range of 550–650 mm, with prevailing evapotranspiration.

Methods

Phytocoenological relevés in the field and classification of the forest communities were performed by the Zurich-Montpellier school, plant names follow Marhold, Hindák (1998). Soil names are according to the IUSS Working Group WRB (2006). Estimation of the herb layer above ground biomass was carried out on the selected sample plots applying the method of indirect sampling (Kubíček, Brechtl, 1970) modified for non-recurrent sampling (Kubíček, Jurko, 1975; Kubíček, Šimonovič, 1975; Kubíček, Šomšák, 1982; Kubíček, 1983).

Results and discussion

Characteristics of oak forests

Site conditions

Oak forests, which we consider to be original here, are best-preserved in military training area in the sites adjacent to the firing ranges. They occupy stabilized sand dunes where is no impact of underground water. Most of mature soils belong to Brunic Arenosols (Dystric),

which are typical for relatively deep cambic-like B horizon (20–60 cm thick), moderate organic carbon contents in A horizon (C_{org} ~ 2 %) and acidic soil reaction (pH-H_2O ~ 4.6 and 5.0 in A and B horizons respectively). Vertical stratification of Brunic Arenosols (Fig. 1a) indicates that these soils have hot been significantly touched by forest management measures for a long time.

Floristic composition

The tree layer is dominated by *Quercus petraea* agg. while other species form an admixture. The shrub layer formed by thermophilous species is usually poorly developed, while the herb layer is rich in species. The *Festuca ovina* agg. is a typical dominant species, and this is especially accompanied by light-demanding forest and ecotone species (*Betonica officinalis*, *Trifolium alpestre, Teucrium chamaedrys*, *Vincetoxicum hirundinaria*), species of shallow less productive soils (*Hylotelephium maximum, Poa compressa, Silene nutans, Steris viscaria*), grassland species (*Achillea millefolium, Agrostis capillaris, Hypericum perforatum, Poa angustifolia*), plus others. Despite the sandy substrate, obligate psamophilous species are quite rare here, with the presence of *Peucedanum oreoselinum* most constant. The cover of the moss layer is not very high, with *Pleurozium schreberi, Plagiomnium affine* and *Polytrichum formosum* representing the most common and abundant species. A more detailed floristic composition is given in Table 1.

Characteristics of secondary Scotch-pine forests

Site conditions

These stands enjoy the same the conditions as the oak forests; the only difference is that the application of the *Pinus sylvestris* Scotch pine adversely affects the ecological conditions. These Scotch-pine plantations are on different soils, with young pine stands being planted on mechanically adjusted sites of Protic to Haplic Arenosols (Dystric), whereas older Scotch-pine stands grow on Albic Podzols with acidic leaching. All Albic Podzols are acidic in both the A and B horizons of pH-H_2O ~ 4.1 and 4.6 respectively (Fig. 1b).

Floristic composition

The tree layer comprises mono-dominant *Pinus sylvestris,* with other species only accessory. The shrub layer is almost negligible and the herb layer is generally poor in species with low cover. Dependent on type, its physiognomy is determined by species including *Festuca ovina* agg., *Calluna vulgaris* or *Calamagrostis epigejos*. The moss layer is distinctly well-developed and it dominates the herb layer. The typically dominant species here is *Pleurozium schreberi* and this is accompanied by *Dicranum polysetum* and *Pseudoscleropodium purum*. Additional species, including *Hypnum cupressiforme, Leucobryum glaucum* and *Polytrichum formosum,* form an admixture.

1a 1b

Fig. 1. Profile of Brunic Arenosol (Dystric) occurring under oak forest (a) and Albic Podzol from Scotch pine forest (b).

Comparison of the floristic composition of the natural oak forest with pine monocultures

Our earlier data was used to compare floristic composition (Kollár, 2004; Mazúrová, 2006). Pine monocultures were sampled on sites located near oak forest areas with similar natural conditions, and the results are registered in Table 1. Changes in floristic composition were established as follows: pine monocultures triggered secondary regressive succession, with many herb layer species retreating or even disappearing in this process. Firstly, the following species tied to light-demanding forests, ecotone and grasslands became impacted; *Achillea millefolium* agg., *Anthericum ramosum, Betonica officinalis, Carex caryophyllea, Polygonatum odoratum, Silene nutans, Veronica chamaedrys, Vincetoxicum hirundinaria* and others. Secondly, there was an obvious increase in the cover of some bryophytes, which colonize accumulated pine needle litter. These bryophytes included *Pleurozium schreberi, Dicranum polysetum* and *Pseudoscleropodium purum*. These results are compatible with those of Šomšák, Kubíček (1994), with the course and intensity of these processes being dependent on time and forestry management.

Comparison of herb and moss layer production between natural oak forest and pine monocultures

The data on biomass production is shown in Table 2, and here herb and moss layer production reflect changes in floristic composition. It was established that total herb layer production of pine

T a b l e 1. Shortened synoptic table of the oak and secondary pine forests.

	PF	OF		PF	OF
Species differing oak forests			***Constant species***		
Tree layer			*Calamagrostis epigejos*	V	V
Quercus petraea agg.	III	V	*Festuca ovina* agg.	V	V
Herb layer			*Hypericum perforatum*	V	V
Achillea millefolium agg.	I	V	*Tithymalus cyparissias*	V	V
Anthericum ramosum	I	V	*Luzula campestris*	IV	V
Polygonatum odoratum	II	V	*Quercus petraea* agg.	IV	V
Silene nutans	III	V	***Other species***		
Vincetoxicum hirundinaria	II	V	**Tree layer**		
Poa nemoralis	I	II	*Quercus robur*	I	I
Betonica officinalis	–	IV	**Shrub layer**		
Campanula rotundifolia agg.	II	IV	*Quercus petraea* agg.	I	II
Carex caryophyllea	–	IV	**Herb layer**		
Clinopodium vulgare	–	IV	*Agrostis capillaris*	III	III
Fallopia convolvulus	II	IV	*Hieracium murorum*	III	III
Hylotelephium maximum	I	IV	*Frangula alnus*	III	II
Melampyrum pratense (*incl. subalpinum*)	I	IV	*Brachypodium sylvaticum*	II	II
Poa angustifolia	III	IV	*Fragaria vesca*	II	II
Steris viscaria	I	IV	*Viola rupestris*	II	II
Teucrium chamaedrys	III	IV	*Viola canina*	II	II
Trifolium alpestre	I	IV	*Asperula tinctoria*	I	II
Veronica officinalis	II	IV	*Crataegus monogyna*	II	I
Campanula persicifolia	–	III	*Dianthus carthusianorum* agg.	I	II
Lembotropis nigricans	II	III	*Galium verum*	I	II
Festuca rubra agg.	–	III	*Geranium sanguineum*	I	II
Hieracium lachenalii	–	III	*Melica nutans*	I	II
Hieracium racemosum	I	III	*Mycelis muralis*	I	II
Koeleria pyramidata	–	III	*Pinus sylvestris*	II	I
Moehringia trinervia	I	III	*Rubus fruticosus* agg.	II	I
Peucedanum oreoselinum	III	III	*Betula pendula*	I	I
Poa compressa	I	III	*Dactylis polygama*	I	I
Solidago virgaurea	II	III	*Ligustrum vulgare*	I	I
Veronica chamaedrys	–	III	*Rosa canina* agg.	I	I
Moss layer			*Viola tricolor* agg.	I	I
Plagiomnium affine	I	III	*Asparagus officinalis*	–	II
Species differing Scotch pine monocultures			*Danthonia decumbens*	II	–
Tree layer			*Fraxinus excelsior*	–	II
Pinus sylvestris	V	I	*Genista tinctoria*	–	II
Herb layer			*Hieracium echioides*	–	II
Acetosella vulgaris	V	II	*Peucedanum cervaria*	–	II
Calluna vulgaris	III/V	II	*Phleum phleoides*	–	II
Anthoxanthum odoratum	IV	II	*Pimpinella saxifraga*	–	II
Cerastium arvense	IV	III	*Platanthera bifolia*	–	II
Sorbus aucuparia	IV	II	*Pseudolysimachion spicatum*	–	II
Thymus serpyllum	IV	I	*Scabiosa columbaria*	–	II
Carex ericetorum	III	II	*Scorzonera purpurea*	–	II
Pilosella officinarum	III	II	*Trifolium montanum*	–	II
Moss layer			*Verbascum thapsus*	–	II
Dicranum polysetum	V	I	**Moss layer**		
Pleurozium schreberi	V	IV	*Leucobryum glaucum*	III	II
Hypnum cupressiforme	IV	I	*Polytrichum formosum*	II	III
Ceratodon purpureus	II	I	*Dicranum scoparium*	I	I
Plagiomnium rostratum	II	–	*Polytrichum juniperinum*	I	I
Pseudoscleropodium purum	II	–			

Abbreviations: PF – secondary pine forest, OF – natural oak forest. I–V: classes of constancy. Data from Kollár (2004) and Mazúrová (2006).

T a b l e 2. Biomass of the herb and moss layer of natural oak forest and pine monoculture. Abbreviations: No. – number of individuals [10^3.ha^{-1}], A – aboveground biomass [kg.ha^{-1}], B – belowground biomass [kg.ha^{-1}], T – total biomass (A+B) [kg.ha^{-1}], A/B – ratio of aboveground and belowground biomass, columns PQh-PsPt – data of Šomšák, Kubíček (1994): PQh – *Pino-Quercetum hylocomietosum*, PQf – *Pino-Quercetum festucetosum* (treated as the original forests), PsPc – *Pleurozio schreberi-Pinetum* with *Calluna vulgaris*, PsPt – *Pleurozio schreberi-Pinetum typicum* (treated as the monocultures).

	oak forest					pine forest					PQh	PQf	PsPc	PsPt
Species	**No.**	**A**	**B**	**T**	**A/B**	**No.**	**A**	**B**	**T**	**A/B**				
Herb layer														
Agrostis capillaris	300	37.84	13.007	50.847	2.9092	90	6.699	5.907	12.606	1.1341	–	–	–	–
Anthericum ramosum	12	5.841	15.145	20.986	0.3857	2	1.032	3.267	4.299	0.3159	–	–	–	–
Calamagrostis epigejos	12	6.576	8.659	15.235	0.7594	100	41.636	47.92	89.556	0.8689	5.1	4.7	4.6	1.3
Campanula rotundifolia agg.	16	12.426	13.089	25.515	0.9493	2	0.248	0.065	0.313	3.8154	–	–	–	–
Festuca ovina agg.	25300	325.838	182.51	508.352	1.7853	8500	105.21	66.249	171.459	1.5881	64.9	72	213	–
Koeleria pyramidata	114	16.778	21.674	38.452	0.7741	28	9.655	14.309	23.964	0.6748	–	–	–	–
Lembotropis nigricans	10	3.672	3.85	7.522	0.9538	20	2.056	0.431	2.487	4.7703	–	–	–	–
Quercus petraea agg.	18	7.225	11.899	19.124	0.6072	12	11.153	10.497	21.65	1.0625	–	–	–	–
Tithymalus cyparissias	46	24.952	7.371	32.323	3.3852	10	6.493	2.983	9.476	2.1767	–	–	–	–
Viola rupestris	2	0.548	0.183	0.731	2.9945	2	0.543	0.399	0.942	1.3609	–	–	–	–
Acetosella vulgaris	–	–	–	–	–	4	1.044	0.365	1.409	2.8603	–	–	–	–
Calluna vulgaris	–	–	–	–	–	190	53.546	58.296	111.842	0.9185	–	91.9	349.3	–
Fragaria vesca	–	–	–	–	–	8	2.748	2.01	4.758	1.3672	–	–	–	–
Hieracium murorum	–	–	–	–	–	2	0.455	0.335	0.79	1.3582	–	–	–	–
Hypericum perforatum	–	–	–	–	–	4	1.657	0.535	2.192	3.0972	–	–	–	–
Luzula campestris	–	–	–	–	–	4	0.774	0.658	1.432	1.1763	–	–	–	–
Peucedanum oreoselinum	–	–	–	–	–	2	1.821	4.917	6.738	0.3703	–	–	–	–
Danthonia decumbens	–	–	–	–	–	20	3.013	2.836	5.849	1.0624	–	–	–	–
Thymus serpyllum	–	–	–	–	–	20	0.833	0.248	1.081	3.3589	–	–	–	–
Achillea millefolium	28	15.317	4.644	19.961	3.2982	–	–	–	–	–	–	–	–	–
Allium montanum	10	2.033	3.31	5.343	0.6142	–	–	–	–	–	–	–	–	–

T a b l e 2. (Continued)

Species	oak forest					pine forest					PQh	PQf	PsPc	PsPt
	No.	A	B	T	A/B	No.	A	B	T	A/B				
Anthoxanthum odoratum	4	0.398	0.116	0.514	3.431	–	–	–	–	–	–	–	–	–
Asperula tinctoria	98	11.298	11.869	23.167	0.9519	–	–	–	–	–	–	–	–	–
Betonica officinalis	20	15.732	39.945	55.677	0.3938	–	–	–	–	–	–	–	–	–
Brachypodium sylvaticum	88	13.047	7.167	20.214	1.8204	–	–	–	–	–	–	–	–	–
Campanula persicifolia	6	1.604	0.241	1.845	6.6556	–	–	–	–	–	–	–	–	–
Carex caryophyllea	276	47.452	39.321	86.773	1.2068	–	–	–	–	–	–	–	–	–
Clinopodium vulgare	2	0.704	0.263	0.967	2.6768	–	–	–	–	–	–	–	–	–
Geranium sanguineum	2	2.759	5.571	8.33	0.4952	–	–	–	–	–	–	–	–	–
Hylotelephium maximum	24	4.399	32.179	36.578	0.1367	–	–	–	–	–	–	–	–	–
Hypericum perforatum	4	2.207	0.806	3.013	2.7382	–	–	–	–	–	–	–	–	–
Luzula campestris agg.	48	4.849	19.909	24.758	0.2436	–	–	–	–	–	–	–	–	–
Peucedanum cervaria	62	78.703	47.682	126.385	1.6506	–	–	–	–	–	–	–	–	–
Peucedanum oreoselinum	76	145.163	382.86	528.023	0.3792	–	–	–	–	–	–	–	–	–
Poa angustifolia	26	2.394	1.627	4.021	1.4714	–	–	–	–	–	–	28.5	27.6	–
Polygonatum odoratum	6	2.78	13.04	15.82	0.2132	–	–	–	–	–	–	–	–	–
Pseudolysimachion spicatum	34	46.734	23.64	70.374	1.9769	–	–	–	–	–	–	–	–	–
Silene nutans	26	4.346	6.437	10.783	0.6752	–	–	–	–	–	–	–	–	–
Solidago virgaurea	2	1.221	2.008	3.229	0.6081	–	–	–	–	–	–	–	–	–
Steris viscaria	16	3.265	6.592	9.857	0.4953	–	–	–	–	–	–	–	–	–
Teucrium chamaedrys	56	5.272	3.669	8.941	1.4369	–	–	–	–	–	–	–	–	–

Table 2. (Continued)

Species	oak forest					pine forest					PQh	PQf	PsPc	PsPt
	No.	A	B	T	A/B	No.	A	B	T	A/B				
Thymus serpyllum	82	1.251	0.512	1.763	2.4434	–	–	–	–	–	–	–	–	–
Trifolium alpestre	10	2.011	4.718	6.729	0.4262	–	–	–	–	–	–	9.7	8.1	–
Veronica chamaedrys	58	11.867	3.636	15.503	3.2638	–	–	–	–	–	–	–	–	–
Vicia hirsuta	34	1.394	0.163	1.557	8.5521	–	–	–	–	–	–	–	–	–
Vincetoxicum hirundinaria	2	0.387	1.681	2.068	0.2302	–	–	–	–	–	–	–	–	–
Galium verum	8	1.812	1.392	3.204	1.3017	–	–	–	–	–	–	–	–	–
Moehringia trinervia	–	–	–	–	–	–	–	–	–	–	6.9	–	–	–
Orthilia secunda	–	–	–	–	–	–	–	–	–	–	1.3	–	–	–
Mycelis muralis	–	–	–	–	–	–	–	–	–	–	9	–	–	–
Festuca dominii	–	–	–	–	–	–	–	–	–	–	8.1	–	–	8.3
Melampyrum pratense	–	–	–	–	–	–	–	–	–	–	–	6.2	–	–
Melica nutans	–	–	–	–	–	–	–	–	–	–	–	41.9	–	–
Daphne cneorum	–	–	–	–	–	–	–	–	–	–	–	9.8	–	–
Pyrola rotundifolia	–	–	–	–	–	–	–	–	–	–	–	–	–	1.5
Other species	–	–	–	–	–	–	–	–	–	–	9.8	36.8	36.8	6.4
Herb layer total		**872.095**	**942.39**	**1814.484**			**250.62**	**222.23**	**472.843**		**108.2**	**405.3**	**687.4**	**17.5**
Moss layer														
Pleurozium schreberi	13%	–	–	198.419	–	68%	1792.3	–	–	–	4576	281.8	1674.3	6645.9
Leucobryum glaucum	–	–	–	–	–	3.20%	18.178	–	–	–	166.4	–	–	249.2
Dicranum polysetum	–	–	–	–	–	8%	98.884	–	–	–	832	281.8	–	830.7
Pohlia natans	–	–	–	–	–	0.80%	1.352	–	–	–	–	–	–	–
Hypnum cupressiforme	5%	–	–	74.853	–	–	–	–	–	–	–	–	–	–
Polytrichum formosum	1%	–	–	4.453	–	–	–	–	–	–	–	–	–	–
Plagiomnium affine	1%	–	–	5.803	–	–	–	–	–	–	–	–	–	–

T a b l e 2. (Continued)

Species	oak forest					pine forest					PQh	PQf	PsPc	PsPt
	No.	**A**	**B**	**T**	**A/B**	**No.**	**A**	**B**	**T**	**A/B**				
Brachythecium vellutinum	–	–	–	–	–	–	–	–	–	–	249.6	–	–	–
Brachythecium starkei	–	–	–	–	–	–	–	–	–	–	–	281.8	–	–
Pseudoscleropodium purum	–	–	–	–	–	–	–	–	–	–	–	169.1	–	–
Dicranum scoparium	–	–	–	–	–	–	–	–	–	–	–	–	279.1	–
Other species	–	–	–	–	–	–	–	–	–	–	416	112.7	279.1	166.2
Moss layer total	–	–	–	**283.528**	–	–	–	–	**1910.758**	–	**6240**	**1127.2**	**2232.4**	**7892**
Mosses + herbs	–	**1155.623**	–	**2098.012**	–	–	**2161.4**	–	**2383.601**	–	**6348.2**	**1532.5**	**2919.8**	**7909.5**
Ratio herb/moss layer production	–	**3**	–	**6**	–	–	**0.1**	–	**0.2**	–	**0.02**	**0.3**	**0.3**	**0.002**

monocultures at 472.8 kg.ha^{-1} is 3.8 times lower than that of the oak forest with 1,814.5 kg.ha^{-1}. (The latter above ground mass has a multiplication factor of 3.5 and the below ground mass has 4.25). However, the moss layer production increased dramatically by 6.75 times, moving from 283.5 kg.ha^{-1} to 1,910.8 kg.ha^{-1}. This is so productive that the sum of herb and moss layer production is slightly higher than pine monocultures at 2,383.6 kg.ha^{-1} when compared to oak forest production of 2,098 kg.ha^{-1}. Therefore, mosses provide most biomass production in pine monocultures, while herb layers achieve this in oak forests. Both these types have the same production dominance by *Festuca ovina* agg. In pine monocultures, *Calluna vulgaris* and *Calamagrostis epigejos* also contribute significantly while *Peucedanum oreoselinum* plays a co-dominant role in oak forests. Other herb layer species are much less productive Overall, the pine forest *Pleurozium schreberi* moss species is the most dominant productive species with 1,792.3 kg.ha^{-1}.

Sampled sites are characterized by the following phytocoenological relevés:

1. Oak forest

22. 7. 2004, Záhorie military training area, geographical coordinates (WGS 84): 48°31'8.57" N, 17°13'36.55" E, relevé area: 400 m^2, sand dune top and its upper slopes, covers: E_3 70%, E_2 2%, E_1 95, E_0 10%, height of trees: 10 m, number of specie: 53, soil: Brunic Arenosol (Dystric)

E_3: *Quercus petraea* agg. 4, *Quercus robur* r

E_1: *Festuca ovina* agg. 2, *Peucedanum oreoselinum* 1, *Betonica officinalis* +, *Brachypodium sylvaticum* +, *Calamagrostis epigejos* +, *Campanula persicifolia* +, *Campanula rotundifolia* agg. +, *Carex caryophyllea* +, *Clinopodium vulgare* +, *Lembotropis nigricans* +, *Dianthus carthusianorum* agg. +, *Tithymalus cyparissias* +, *Fallopia convolvulus* +, *Agrostis capillaris* +, *Fragaria vesca* +, *Galium mollugo* agg. +, *Galium verum* +, *Pilosella officinarum* +, *Hypericum perforatum* +, *Koeleria pyramidata* +, *Luzula campestris* +, *Steris viscaria* +, *Peucedanum cervaria* +, *Anthericum ramosum* +, *Poa angustifolia* +, *Polygonatum odoratum* +, *Anthoxanthum odoratum* +, *Asperula tinctoria* +, *Hylotelephium maximum* +, *Silene nutans* +, *Teucrium chamaedrys* +, *Thymus serpyllum* +, *Trifolium alpestre* +, *Trifolium montanum* +, *Veronica chamaedrys* +, *Veronica officinalis* +, *Vicia hirsuta* +, *Vincetoxicum hirundinaria* +, *Galeopsis tetrahit* r, *Solidago virgaurea* r, *Achillea millefolium* agg. r, *Allium senescens* subsp. *montanum* r, *Pseudolysimachion spicatum* r, *Geranium sanguineum* r, *Moehringia trinervia* r, *Scabiosa columbaria* r, *Scorzonera purpurea* r, *Frangula alnus* r, *Viola rupestris* r

E_0: *Pleurozium schreberi* 1, *Plagiomnium undulatum* +

2. Secondary pine forest

14. 06. 2001 and July 2005, Záhorie military training area, geographical coordinates (WGS 84): 48°33'6.09" N, 17°16'0.66" E, slope: 3°, aspect: SE, covers: E_3 65%, E_1 40%, E_0 85%, height of trees 18 m, number of species: 35, soil: Albic Podzol

E_3: *Pinus sylvestris* 4, *Quercus petraea* agg. +

E_1: *Calluna vulgaris* 3, *Festuca ovina* agg. 1, *Agrostis capillaris* +, *Campanula rotundifolia* agg. +, *Carex ericetorum* +, *Lembotropis nigricans* +, *Danthonia decumbens* +, *Tithymalus cyparissias* +, *Anthericum ramosum* +, *Fragaria vesca* +, *Hieracium murorum* +, *Pilosella officinarum* +, *Hypericum perforatum* +, *Luzula campestris* +, *Peucedanum oreoselinum* +, *Anthoxanthum odoratum* +, *Pinus sylvestris* +, *Calamagrostis epigejos* +, *Quercus petraea* agg. +, *Acetosella vulgaris* +, *Silene nutans* +, *Thymus serpyllum* +, *Viola rupestris* +, *Steris viscaria* r, *Pulsatilla pratensis* r, *Solidago virgaurea* r, *Cerastium arvense* r, *Asperula tinctoria* r

E_0: *Pleurozium schreberi* 3, *Dicranum polysetum* 2, *Pohlia nutans* +, *Polytrichum piliferum* +, *Cladonia macilenta* subsp. *macilenta* +, *Cladonia furcata* subsp. *furcata* +, *Hypnum cupressiforme* +

In Table 2, we have attached part of Šomšák and Kubíček's (1994) results for comparison with our production data. In principle, it has been established that these two data sets correspond quite well. This is especially true and relevant for high moss layer production, and also for the low ratio between herb and moss layer production in secondary pine forests.

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