Ekológia (Bratislava) Vol. 28, No. 1, p. 52–65, 2009

FIRE IMPACT ON THE SECONDARY PINE FOREST AND SOIL IN THE BORSKÁ NÍŽINA LOWLAND (SW SLOVAKIA)

LADISLAV ŠOMŠÁK[1], PAVEL DLAPA[1], JOZEF KOLLÁR[2], FERDINAND KUBÍČEK[2], VOJTECH ŠIMONOVIČ[2], ANTON JANITOR[2], RÓBERT KANKA[2], IVAN ŠIMKOVIC[1]

[1] Department of Soil Science, Faculty of Natural Sciences, Comenius University, Mlynská dolina B2, 842 15 Bratislava, Slovak Republic; e-mail: dlapa@fns.uniba.sk
[2] Institute of Landscape Ecology of the Slovak Academy of Sciences, Štefánikova 3, P.O.Box 254, 814 99 Bratislava, Slovak Republic

Abstract

Šomšák L., Dlapa P., Kollár J., Kubíček F., Šimonovič V., Janitor A., Kanka, R., Šimkovic, I.: Fire impact on the secondary pine forest and soil in the Borská nížina lowland (SW Slovakia). Ekológia (Bratislava), Vol. 28, No. 1, p. 52–65, 2009.

Forest fire is an important phenomenon affecting forest ecosystem. It causes essential changes in ecological conditions (e.g. light availability, water and nutrient regime). The aim of this paper is to evaluate its impact on soil as well as herb and moss layer of the secondary pine forest. The study area is located in the southwestern part of Slovakia (Borská nížina lowland). Marked changes in physical and chemical soil properties were induced by forest fire. Soils moisture contents were higher in burnt soil probably as a result of increased soil wettability. Infiltration rate decreased on the burnt area due to sealing of pores by ash material. Burning of soil organic matter caused increase in soil pH and available nutrients. In the period of 2005–2007, floristic composition, biomass production and presence/absence of mushrooms were recorded both for burnt and neighboring control areas. Compare to the control stands, especially nitrophilous (synanthropic) species are appearing, first of all *Conyza canadensis, Solidago canadensis* and *Chamerion angustifolium*. Also composition of mycoflora is changed – its composition is shifted on the behalf of pioneer and indifferent species. Moreover, the pine natural seeding is obvious here. Information on succession is supported by biomass production estimation.

Key words: forest fire, impact, pine secondary forest, mushrooms, soil properties, Borská nížina lowland

Introduction

Forest fire is a sudden, partly or entirely uncontrolled event delimited by space and time affecting unfavourably all forest functions. In forest ecosystems, it causes direct as well as indirect damages. Its impact is very complex (Boerner, 1982, 1983; Clayton, 1976; Angelstam, 1998, Egelmark, 1993; Gromtsev, 2002; Johnson, 1992; Päätalo, 1998; Parviainen, 1996; Tinner et al., 1999; Zackrisson, 1977). Concerning its origin, it is classified into the anthropogenous or natural damaging factors (Osvald et al., 2005). Almost all forest fires recorded through Central Europe belong to those caused by man, i.e. induced by anthropogenous factors. The number of forest fires recorded in Slovak Republic is too high. According to the Slovakia operative fire review (Osvald et al., 2005), in the period of 1998–2004, it was ranged from 852 up to 1056 per year. It is estimated, that direct damages reach about 443 million Slovak crowns per year. It depends on the burnt area, fire type (underground, ground or tree-top) and last but not least on the forest ecosystem social value. For example in 1992, on the Borská nížina lowland fire destroyed 1700 ha of secondary pine forest with damage of about 56 million Slovak crowns, while fire damage on the much smaller area in the Slovenský raj National Park (67 ha) was estimated to be as far as 366 million Slovak crowns.

The contribution is focused on the forest fire impact on the Borská nížina lowland secondary pine forest ecosystem and its soil of the area of 0.6 ha. Concerning its area or direct damage it is not considered to be the critical one, but it represents the most typical fire of the area. Such fires usually occur during early spring or late summer (August, September), when there is a lack of precipitation and soil cover, especially the litter, is extremely dry. Most of the fires recorded in the study area belong to the ground fire type, where only ground vegetation is burnt. Only in some particular cases, such as the fire during extremely dry August 1992, all fire types take place.

The aim of the article is to point out at fire impact on soil properties and draw secondary succession progress on the burnt area of 40–60 years old pine forest, which belongs to the vegetation spread on siliceous blown sands of the Borská nížina lowland. Besides vascular plants, some attention was paid also to the macroscopic mushrooms. The results are supported by data on the herb and moss layer biomass of damaged and undamaged pine stands.

Methods

Classification of the forest ecosystems is based on some published studies dealing with pine forests of the region (Ružička, 1960; Krippel, 1965; Šomšáková, 1988; Šomšák et al., 2004). Names of vascular plants, mosses and mushrooms comply with Marhold, Hindák (1998). To study secondary succession progress of the burnt area, neighbouring undamaged stand was analyzed, which served as a control plot for phytocoenological comparison and vascular plant and bryophyte biomass differences. The area of phytocoenological relevès was 20 x 20 m. Abundance and cover of vascular plants was estimated by 7 member (r, +, 1, 2, 3, 4, 5) scale, while cover of bryophytes was estimated in percentage. The relevès were taken 3 times within the first year after the fire and once a year in the period of 2006–2007.

Biomass production was sampled in the same time as phytocoenological relevès in compliance with indirect sampling (Kubíček, Brechtl, 1970) modified for non-recurrent sampling (Kubíček, Jurko, 1975; Kubíček, Šomšák, 1982).

For mushrooms, only their presence on the all burnt area (0.6 ha) and control site (and its wider vicinity) was recorded.

Studied soils belong to Dystric Cambisols according to WRB (FAO, 2006). Approximately 2.5 kg of soil samples were taken at several depth levels of burnt and reference soil profiles. The samples were then prepared for analyses: air-dried at room temperature, ground and passed through a 2 mm sieve. Standard methods (Fiala, 1999) were used for chemical and physical analyses. Soil pH was determined at a soil/solution ratio of 1:5. Amount of accessible phosphorus was determined in Mehlich II extracts. Soil moisture content was determined by gravimetric method. Infiltration experiments were realized in the field using single-ring infiltrometer (20 cm diameter). Soil water repellency persistence was determined using the water drop penetration time (WDPT) test (Letey, 1969). Air-dried soil samples (10 g) were placed in Petri dishes, three drops of distilled water (volume: 58 ± 5 μL) applied from a medicinal dropper onto the sample surface, Petri dishes were closed (in order to avoid evaporation) and the actual time required for complete droplet infiltration recorded. Tests were terminated after 43,200 s (12 h). In subsequent processing, the average of three WDPT values was used. The following classes of the persistence of water repellency were distinguished according to Bisdom et al. (1993): < 5 s, hydrophilic; 5–60 s, slightly hydrophobic; 60–600 s, strongly hydrophobic; 600–3600 s, severely hydrophobic, and > 3600 s, extremely hydrophobic.

Results and discussion

Effect of wildfire on soil properties

The most frequently cited hydrological change to soil concerns its wettability. Although often characteristic of soils in long unburnt terrain under a wide variety of vegetation types (Doerr et al., 2000), fire can induce water repellency in non-repellent soil, and either enhance or reduce pre-existing surface repellency, depending on the amount and type of litter consumed and on the temperature reached (DeBano, Krammes, 1966; DeBano et al., 1970; Doerr et al., 2004). Physical impact of the fire is evidenced by reduced persistence of soil water repellency. WDPT times were decreased from above 6000 s to less than 10 s (Fig. 1). Originally strongly hydrophobic soil became hydrophilic after fire. This changes due to thermal decomposition of organic substances causing soil hydrophobicity (so called amphiphillic substances). In topsoil horizon also moisture contents were found to be significantly higher probably as a result of increased soil wettability in burnt soil (Fig. 2). Another physical effect of the soil burning is change in the course of infiltration curves measured at the study sites. As it can be seen in Fig. 3, the course of infiltration differs in burnt soil due to development of subsurface layer with decreased permeability for water. The observed results agree with the usually accepted opinion that the effect of wildfire on infiltration is its reduction relative to comparable unburnt area (Shakesby, Doerr, 2006). As potential causes mentioned in literature we can consider the increased soil water repellency (DeBano, 1971) or the sealing of pores by fine ash particles (Neary et al., 1999). Because significant increase in soil water repellency had not been observed anywhere in the burnt soil profile we endorse an opinion that the main cause of the decrease in infiltration rates on the burnt area is the sealing of pores by ash material. Reduced infiltration capacity of the soil and destruction of the vegetation and litter caused significant change in soil moisture regime which changes significantly ecological conditions at burnt study site.

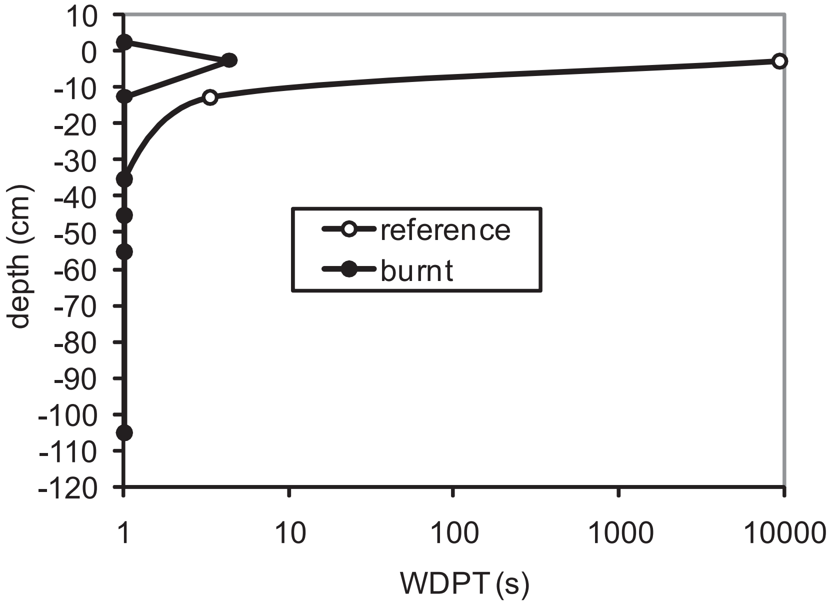

Fig. 1. Persistence of water repellency measured by WDPT test in burned and reference soil profiles.

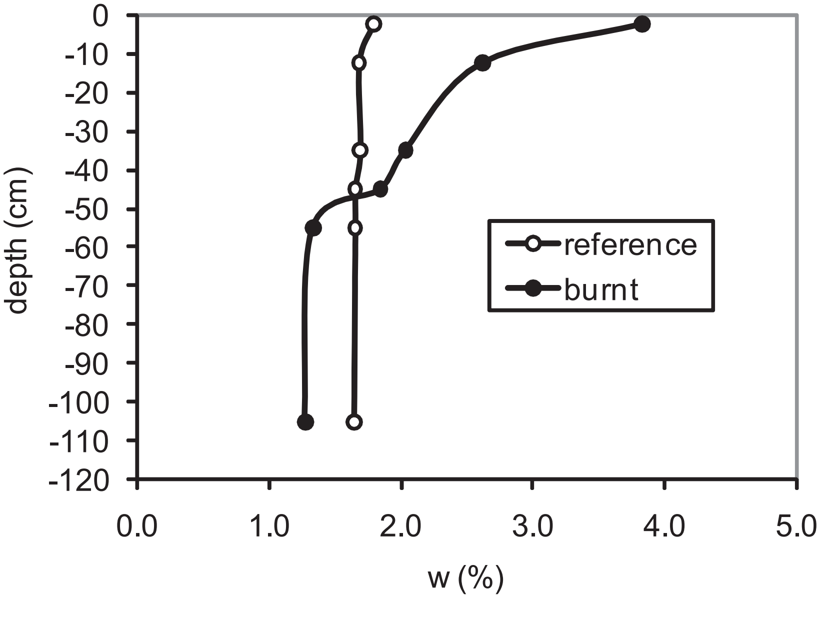

Fig. 2. Actual moisture content in two soil profiles measure 10 month after fire.

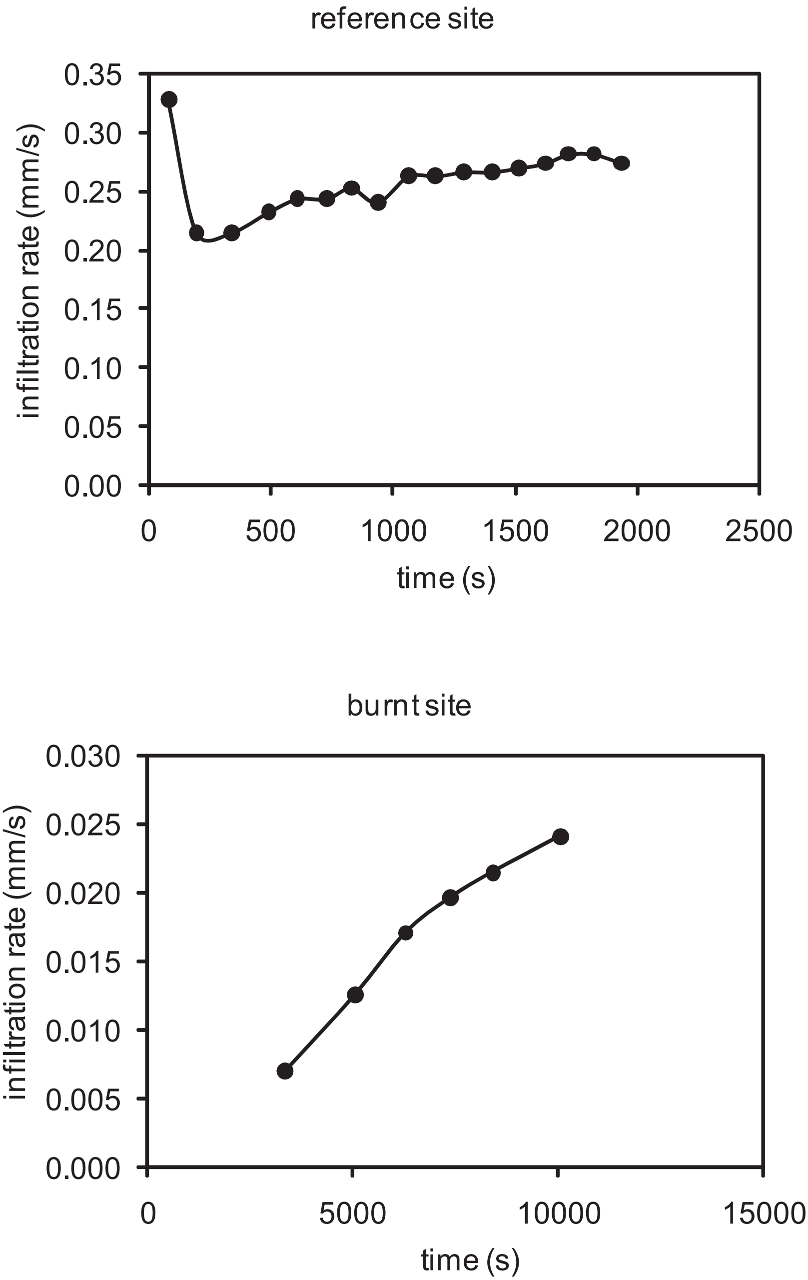

Fig. 3. The results of infiltration experiments on two study sites. Note that different scales are used for the y-axes.

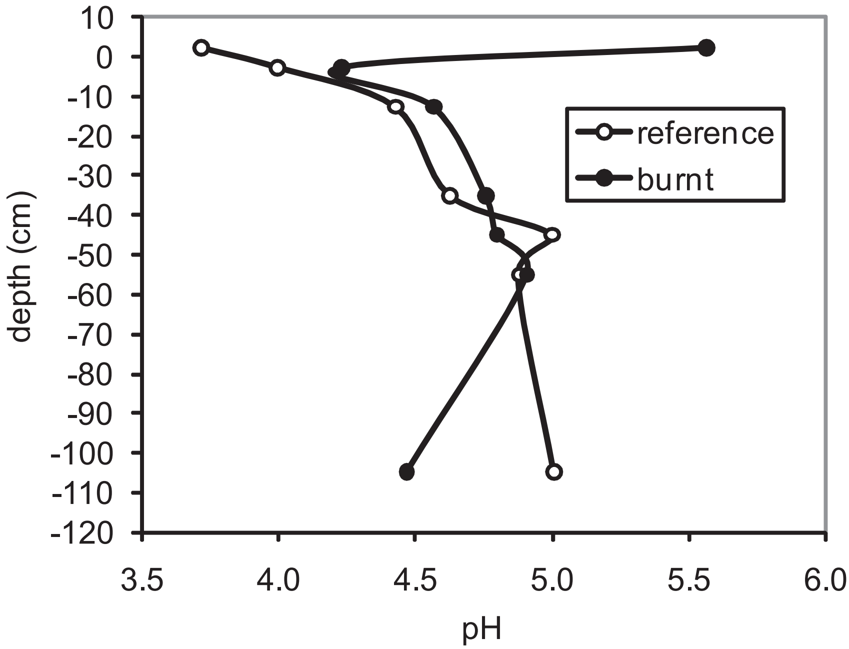

Fig. 4. Change in soil pH caused by soil burning in burned and reference soil profiles.

As mentioned above, fire altered soil physical properties but one of the most important impacts on soil ecosystem is combustion of soil organic matter (SOM). Therefore soils beneath burnt stands showed also changes in soil chemical properties. Depending on the fire intensity, the dryness of the surface SOM and underlying soil, thickness of the organic layer itself, consumption of organics can range from scorching (producing black ash) to complete ashing (producing white ash) (Neary et al., 1999). Burning of soil organic matter caused destruction of soil acidity as organic acids were decomposed resulting in slight increase in soil pH. This change is evidenced by increase in soil pH from less than 4.0 to values exceeding 5.5 (Fig. 4). In such way originally extremely acid soil were changed to very acid in the surface soil horizon. Decomposition of humus substances also caused release of nutrients. DeBano and Conrad (1978) measured N and P changes in the litter layer after a prescribed fire. While the N loss from litter totalled 5% of the pre-burn litter N, the P pool in litter increased 43% due to the accretion of ash from the burnt vegetation. The effect of burning on soil N presents an interesting paradox. As opposed to N losses to the atmosphere, soil N can be made more available following low-intensity burning by non-biological and biological means, converting organic forms to inorganic ammonium nitrogen and nitrate nitrogen (Neary et al., 1999). In the case of burnt soils under consideration we can suppose that the low intensity fire increased levels of plant available nutrients (N, Ca, Mg, K, and P) immediately after fire. We measured increase in content of available phosphorus (from <1 to 3.8 mgP/kg) in burnt topsoil compared to non-affected soil measured one year after wildfire. Increased nitrogen availability is evidenced by occurrence of nitrophilous species (*Conyza canadensis*, *Solidago canadensis* and *Chamerion angustifolium*). But nutrients released following the fire can be lost later through soil leaching. It can be noticed that such changes in soil acidity and nutrient status represent additional significant change to soil conditions for plant growth.

The characteristic of an original (undamaged) stand

The stand is a part of large secondary pine forest complex developed on siliceous blown sand of the Borská nížina lowland. The range of altitudes is 170–297 m a.s.l. Precipitation is about 636 mm per year, year average temperature 9.4 ˚C. Contemporary pine forests arose by pine (*Pinus sylvestris*) plantation on the sites of original pine-oak (*Pino-Quercion* Medw.-Kornaś in Medw.-Kornaś et al. 1959), oak (*Potentillo albae-Quercion* Zol. et Jak. 1967 and possibly also *Genisto germanicae-Quercion* Neuhäusl et Neuhäuslová-Novotná, 1967 alliances) and oak-hornbeam forests (*Carpinion betuli* Issler 1931). They can mostly be classified into the *Pyrolo umbellatae-Pinetum* (Libb. 1933) Schmid 1936 association (Šomšák et al., 2004) (synonyms: *Pino-Quercetum* Krippel 1965, *Pino-Quercetum zahoricum* Ružička 1960) and *Pleurozio schreberi-Pinetum* Šomšáková 1988 association. We assume that observed stands were established either on the sites of oak forest from the *Potentillo albae-Quercion* Zol. et Jak. 1967 alliance traditionally classified into the *Frangulo alni-Quercetum robori-petraeae* Michalko 1991 association (Michalko, 1991; Šomšák, Kubíček, 2000), what is indicated by species as *Convallaria majalis, Molinia caerulea* agg. and *Luzula pilosa* recorded in wider vicinity, or oak-hornbeam forest. Species composition is shown in Table 1.

Characteristic of burnt stand

The fire occurred in August 2004 belongs to the surface type (Osvald et al., 2005) representing the fire which burnt litter, mosses and ground vegetation. However, as the fire destroyed shrub layer as well, it has also some signs of combination of surface and tree top fire. Fire took place, according to the eyewitnesses, during windlessness and its speed was about 10 $cm.sec^{-1}$. Concerning various thicknesses of bryophytes and litter, the site was not burnt evenly. The deepest burning was recorded for bryophytes, mainly for *Leucobryum glaucum*. Such mosaic-like character of burnt area determines its plant colonization and secondary succession progress. Different species occupy differently burnt parts (Svoboda, 1952). The species composition is offered in Table 1.

T a b l e 1. Phytocoenological table of observed sites.

Sites	Control site	Burnt site				
Date	10.6. 05	10.6.05	5.8.05	1.9.05	29.6.06	10.7.07
E3	65	65	65	60	50	40
E2	10	0	0	0	0	0
E1	20	70	75	80	90	85
E0	90	1	1	1	2	2
Species						
E3						
Pinus sylvestris	4	4	4	3	3	3
E2						
Frangula alnus	3					
E1						
Quercus petraea agg.	1	r	+	+	+	+
Melampyrum bohemicum	1		+	+	+	+
Calluna vulgaris	+					
Carex ericetorum	+					
Dryopteris carthusiana	+		r	r	+	+
Sieglingia decumbens	+					
Sorbus aucuparia	+		+	+	r	r
Luzula campestris	+	r	r	1	+	+
Rubus fruticosus agg.	+			+	+	+
Festuca ovina agg.	+	+	+	1	1	1
Viola canina	+					
Luzula pilosa	+	r	r	r	r	r
Hieracium murorum	+	r	r	r	r	r
Pinus sylvestris	+	3	3	3	3	3
Betula pendula	+		1	1	1	1
Rubus idaeus	+				+	+
Peucedanum oreoselinum	+	r	+	+	+	+
Solidago virgaurea	r	r	r	r	+	+
Convallaria majalis	r					
Avenella flexuosa	r					
Frangula alnus	1	r	1	1	2	2
Agrostis tenuis	+				+	1
Calamagrostis epigejos	r	r	+	+	3	3
Conyza canadensis		2	3	3	2	1
Acetosella vulgaris		1	1	1	1	1
Chamerion angustifolium		1	1	1	+	+
Epilobium ciliatum		+	1	1	+	+
Arabis hirsuta		r	r	r		
Lactuca serriola		r	r	r		
Phytolacca americana		r	1	1	1	1
Populus alba			r	r	r	r
Sonchus oleraceus			r	r	r	
Chenopodium album agg.			r	r	r	r
Campanula rotundifolia agg.			+	+	+	+
Moehringia trinervia			r	r	+	+
Solidago canadensis			+	1	2	3
Achillea millefolium			r	r	r	r
Cirsium arvense			+	+	+	r
Senecio sylvaticus			r	r	r	r
Solanum nigrum			+	+	+	+

T a b l e 1. (Continued)

Eupatorium cannabinum			r	+	+	+
Veronica officinalis				r	+	+
Populus tremula				r		
Taraxacum sect. *Ruderalia*				r	r	r
Verbascum sp.				r	r	r
Fallopia convolvulus				r	r	r
Bidens tripartitus				r	r	r
Sambucus nigra				r	r	r
Carex fritschii					+	1
Carex hirta					+	+
Cirsium vulgare					r	
Erechtites hieracifolius					+	+
Filago arvensis					+	r
Fragaria vesca					r	+
Pilosella echioides					r	r
Hypochaeris radicata					r	+
Jasione montana					+	+
Koeleria pyramidata					+	+
Luzula campestris agg.					+	+
Origanum vulgare					+	+
Plantago major					r	r
Rubus idaeus					+	+
Salix caprea					+	+
Juncus effusus						r
Eo						
Pleurozium schreberi	55%					
Leucobryum glaucum	25%	1%	1%	1%	1%	1%
Dicranum polysetum	10%	1%	1%	2%	2%	2%
Hylocomium splendens	5%					
Pseudoscleropodium purum	2%	1%	1%	1%	1%	1%
Polytrichum juniperinum	1%					
Brachythecium starkei	1%					

Localities:

1. Burnt area: Dates 10.6.2005, 5.8.2005, 1.9.2005, 29.6.2006, 10.7.2007, southern exposition, slope 1˚, northward of Horné Valy settlement, 48°34´28.4´´ N, 17°07´45.3´´ E
2. Control area: 400m^2, southern exposition, slope 1°, adjacent site to the previous.

Progress of secondary succession within 2005–2007

1. Tree layer, despite being unburnt, is drying out gradually. In 2005, there was no difference compare to the origin state (its cover was about 65%), however one year later it reached about 50% and in 2007 just 40%.
2. Shrub layer made of *Frangula alnus* was destroyed entirely.
3. Herb layer was affected vividly. On some less burnt parts, original species, e.g. *Peucedanum oreoselinum, Festuca ovina, Hieracium murorum, Solidago virgaurea, Koeleria pyramidata* survived. Already first vegetation period after the fire, many synanthropic species appeared increasing its number next years (Table 1). Of these, species as *Calamagrostis epigejos, Acetosella vulgaris, Lactuca serriola, Phytolacca americana, Populus alba, Sonchus oleraceus, Chenopodium album* agg.*, Moehringia trinervia, Achillea millefolium, Cirsium*

arvense, Senecio sylvaticus, Solanum nigrum, Eupatorium cannabinum, Taraxacum sect. *Ruderalia, Fallopia convolvulus, Bidens tripartitus, Sambucus nigra, Carex hirta, Cirsium vulgare, Erechtites hieracifolius, Filago arvensis, Fragaria vesca, Hypochaeris radicata, Origanum vulgare, Plantago major, Rubus idaeus, Salix caprea, Solidago canadensis, Conyza canadensis, Chamerion angustifolium, Epilobium ciliatum* should be mentioned first of all. For all burnt area, intensive ecesis of *Pinus sylvestris* seedlings is important to mention – we recorded over 50 seedlings per m^2. It is linked with uncovered soil surface hand in hand with increased moisture – a phenomenon typical for the forest fires as described above. This is indicated also by hygrophilous species *Juncus effusus*.

4. Bryophytes were burnt almost fully and within observed 3 years did not recover visibly.

Participation of mushrooms on secondary succession

Pine forests of the area are markedly rich in mushroom species. Many of them can be found also on burnt sites. Some of them present first organisms after the fire – e.g. *Pyronema omphaloides, Pholiota highlandensis, Rhizina undulata* etc. Therefore, also mycoflora of both damaged and undamaged stands was recorded. The record was taken on 1. 9. 2005 after heavy rains. For the burnt area, two groups of mushrooms were found: the first consists of species preferring burnt sites and the second includes indifferent species (occupying both burnt and undamaged site). First group consists of species as follows: *Faerberia carbonaria, Hebeloma antracophila, Geopyxis carbonaria, Myxomphalia maura, Pholiota carbonaria, Pyronema omphaloides, Tephrocybe antracophila, Tephrocybe atrata.* Though some others were recorded only on the burnt site, they can grow on undamaged areas as well. Their occurrence on the burnt site is linked to less damaged parts. They are as follows (sorted alphabetically): *Amanita citrine, Cantharellus cibarius, Mycena uracea, Naucoria amarescens, Paxillus antrotomentosus, Paxillus involutus, Psathyrella coprophila, Psathyrella gossipina, Rhizina undulate, Suillus bovines, Tephrocybe ambusta, Telephora terrestris*

Herb and moss layer biomass

The basic results of the production-ecological measurements obtained from the selected burnt area during three years (2005–2007) are summarized in Table 2. First of all we sampled the burnt sites (BS) and in 2005 after fire also control site (CS). The Table 2 contains following information: aboveground herb and moss biomass (A), belowground herb biomass (B), total herb and moss biomass (A+B = T) and ratio aboveground/belowground (A/B) biomass.

The results show considerable differences between burnt and control sites. Control site represents a forest community *Pleurozio schreberi-Pinetum* with dominant species in biomass as *Campanula rotundifolia* agg.*, Frangula alnus, Melampyrum bohemicum, Rubus fruticosus* agg. and seedlings of main trees – *Pinus sylvestris* and *Quercus petraea* agg. Other species have only fewer ratios on the total biomass values. The total herb layer biomass is about 510 $kg.ha^{-1}$, but with mosses it is more than 7.6 t. ha^{-1}, which corresponds with our

T a b l e 2. Herb and moss layer biomass in observed sites (control site – CS, burnt site – BS) in $kg.ha^{-1}$, dry weight during 2005–2007.

Year	2005	2005	2005	2005	2005	2006	2006	2006	2006	2007	2007	2007	2007
Species	A [$kg.ha^{-1}$]	B [$kg.ha^{-1}$]	A/B	T	A [$kg.ha^{-1}$]	A [$kg.ha^{-1}$]	B [$kg.ha^{-1}$]	A/B	T	A [$kg.ha^{-1}$]	B [$kg.ha^{-1}$]	A/B	T
Site	CS	CS	CS	CS	BS	BS	BS	BS	BS	BS	BS	BS	BS
Betula pendula					2	22.63	4.38	5.17	27.01	89.37	26.44	3.38	115.81
Calluna vulgaris	0.89	0.46	1.93	1.35									
Campanula rotundifolia agg.	23.40	0.57	41.05	23.97									
Dryopteris carthusiana	11			11	11								
Elytrigia repens				0	2								
Carex ericetorum	0.590			0.59									
Festuca ovina agg.	12.78	9.37	1.36	22.15	2	14.44	6.84	2.11	21.28	19.87	18.40	1.08	38.27
Frangula alnus	25.90	27.96	0.93	53.86	98	5.83	6.28	0.93	12.11	113.80	69.64	1.63	183.44
Melampyrum bohemicum	100.67	13.44	7.49	114.11						1.06	0.09	11.78	1.15
Peucedanum oreoselinum	5.16	7.16	0.72	12.32	1					1.38	3.49	0.40	4.87
Pinus sylvestris	40.51	14.60	2.77	55.11	78	99.36	19.29	5.15	118.65	381.67	167.40	2.28	549.07
Phytolacca americana				0	34	16.92	7.22	2.34	24.14	197.64	119.56	1.65	317.2
Quercus petraea agg.	42.70	75.58	0.56	118.28		6.02	19.10	0.32	25.12				
Rubus fruticosus agg.	24.58	17.15	1.43	41.73	22	32.34	11.30	2.86	43.64	34.49	11.94	2.89	46.43
Sorbus aucuparia	18.98	17.17	1.11	36.15									
Acetosella vulgaris	0.45	0.25	1.8	0.7	3	43.96	12.32	3.60	56.28				
Calamagrostis epigejos	1.12	0.71	1.58	1.83	13	558.50	64.14	8.70	622.64	555.40	301.25	1.84	856.65
Agrostis tenuis	7.07	6.39	1.11	13.46		4.74	1.32	3.59	6.06				
Conyza canadensis				0	664	50.11	13.92	3.60	64.03				
Epilobium cf. *ciliatum*				0	6	5.00	1.11	4.50	6.11				
Fallopia convolvulus					18								
Lactuca serriola					3								
Luzula campestris	1.96	1.28	1.53	3.24	9	7.93	1.98	4.01	9.91	6.86	25.06	0.27	31.92
Veronica officinalis						2.44	1.21	2.02	3.65	5.74	5.96	0.96	11.7

T a b l e 2. (Continued)

Salix caprea						8.22	2.61	3.15	10.83	4.73	2.54	1.86	7.27
Rubus idaeus										35.45	10.33	3.43	45.78
Carex fritschii										19.36	16.50	1.17	35.86
Carex hirta										52.54	4.49	11.70	57.03
Solidago canadensis					51	637.03	249.35	2.55	886.38	372.48	210.84	1.77	583.32
Solidago virgaurea					8	8.35	2.58	3.24	10.93	10.40	16.61	0.63	27.01
Eo													
Hylocomium splendens	2550			2550									
Pleurozium schreberi	3287			3287									
Leucobryum glaucum	805			805	99								
Dicranum polysetum	463			463									
Sum of E1	317.76	192.09		509.85	1025	1523.82	424.95		1948.77	1902.24	1010.54		2912.78
Sum of E0	7105	0		7105	99	0	0		0	0	0		0
Total	**7422.76**	**192.09**		**7614.85**	**1124**	**1523.82**	**424.95**		**1948.77**	**1902.24**	**1010.54**		**2912.78**

Abbreviations: A – aboveground biomass, B – belowground biomass, A/B – ratio of aboveground and belowground biomass, T – sum of aboveground and belowground biomass

previous results from similar secondary pine forests on the Borská nížina lowland (see e.g. Šomšák, Kubíček, 1994).

On the other hand, situation for burnt site is different. Already first biomass measurements after the fire (2005) show major differences. As the consequence of nutrient release and higher light income, herb layer was getting character of well-covered clear-cutting vegetation. Therefore, the total herb layer biomass reached as far as 1 $t.ha^{-1}$ and the decisive species in biomass was presented by *Conyza canadensis,* with only four other species – *Frangula alnus, Phytolacca americana, Pinus sylvestris,* which represent about 80% of total value. In further observed years (2006 and 2007) we recorded higher biomass values yet, mainly that of aboveground, with increasing trend. In 2006 there were following values: aboveground biomass about 1.5 $t.ha^{-1}$, belowground biomass 0.4 $t.ha^{-1}$ and the total biomass almost 2 $t.ha^{-1}$ and in 2007 – aboveground biomass about 2 $t.ha^{-1}$, belowground biomass about 1 $t.ha^{-1}$ and the total value was about 3 $t.ha^{-1}$. The decisive species in biomass were first of all seedlings of the main tree (*Pinus sylvestris* and in 2007 also *Frangula alnus, Betula pendula)* and some other species typical for higher receipt of light as *Calamagrostis epigejos, Phytolacca americana, Solidago canadensis* and some other grass-like species as *Luzula campestris, Carex fritschii, Carex hirta.* Moss layer production is negligible here.

Translated by J. Kollár, P. Dlapa and F. Kubíček

Acknowledgements

The authors are grateful to the Slovak Grant Agency for Science (VEGA) – Grant No. 2/0027/08, 1/3058/06 and 1/0476/09 for partial supporting this work.

References

Angelstam, P.K., 1998: Maintaining and restoring biodiversity by developing natural disturbance regimes in European boreal forest. J. Veg. Sci., *9*, 4: 593–602.

Bisdom, E.B.A., Dekker, L.W., Schoute, J.F.T., 1993: Water repellency of sieve fractions from sandy soils and relationships with organic material and soil structure. Geoderma, *56*: 105–118.

Boerner, R.E.J., 1982: Fire and nutrient cycling in temperate ecosystems. Bioscience, *32*: 187–192.

Boerner, R.E.J., 1983: Nutrient dynamics ofvegetation and detritus following two intensities of fire in the New Jersey Pine Barrens. Oecologia, *59*: 129–134.

Clayton, J.L., 1976. Nutrient gains to adjacent ecosystems during a forest fire: An evaluation. Forest Science, *22*: 162–166.

DeBano, L.F., 1971: The effect of hydrophobic substances on water movement in soil during infiltration. Soil Science Society of America Proceedings, *35*: 340–343.

DeBano, L.F., Conrad, C.E., 1978: The effect of fire on nutrients in a chaparral ecosystem. Ecology, *59*: 489–497.

DeBano, L.F., Krammes, J.S., 1966: Water repellent soils and their relation to wildfire temperatures. International Association of Hydrological Sciences, *2*: 14–19.

DeBano, L.F., Mann, L.D., Hamilton, D.A., 1970: Translocation of hydrophobic substances into soil by burning organic litter. Proceedings Soil Science Society of America, *40*: 779–782.

Doerr, S.H., Shakesby, R.A., Walsh, R.P.D., 2000: Soil water repellency, its characteristics, causes and hydro-geomorphological consequences. Earth-Science Reviews, *51*: 33–65.

Doerr, S.H., Blake, W.H., Humphreys, G.S., Shakesby, R.A., Stagnitti, F., Vuurens, S.H., Wallbrink, P., 2004: Heating effects on water repellency in Australian eucalypt forest soils and their value in estimating wildfire soil temperatures. Int. J. Wildland Fire, *13*: 157–163.

Egelmark, O., 1993: Early pos—fire tree regeneration in a *Picea-Vaccinium* forest in northern Sweden. J. Veg. Sci., *4*, 6: 791–794.

FAO, 2006: Guidelines for soil description. Fourth edition. Food and Agriculture Organization of the United Nations, Rome.

Fiala, K., 1999: Standard methods of soil analyses (in Slovak). Výskumný ústav pôdoznalectva a ochrany pôdy, Bratislava, 142 pp.

Gromtsev, A.N., 2002: Natural disturbance dynamics in the boreal forest of European Russia. A review. Silva Fenn., *36*, 1: 41–55.

Johnson, E.A., 1992: Fire and vegetation dynamics: studies from the North American boreal forest. Cambridge University Press, New York.

Krippel, E., 1965: Postglacial development of forests in Záhorská nížina lowland (in Slovak). Biol. Pr., *11*: 1–99.

Kubíček, F., Brechtl, J., 1970: Production and phenology of the herb layer in an oak-hornbeam forest. Biológia (Bratislava), *25*: 651–666.

Kubíček, F., Jurko, A., 1975: Estimation of above-ground biomass of the herb layer in forest communities. Folia Geobot. Phytotax., *10*: 113–129.

Kubíček, F., Šomšák, L., 1982: The herb layer production of fir forests in the eastern part of the Slovenské rudohorie Mts. Biologické Práce, p. 59–180.
Letey, J., 1969: Measurement of contact angle, water drop penetration time, and critical surface tension. In DeBano, L.F., Letey, L.F. (eds), Proceedings of a Symposium on Water Repellent Soils. Riverside, p. 43–47.
Marhold, K., Hindák, F., 1998: Checklist of non-vascular and vascular plants of Slovakia (in Slovak). Veda, Bratislava, 687 pp.
Michalko, J., 1991: Košická kotlina basin forest communities (with reference to other basins and adjacent lowlands of Slovakian Carpathians (in Slovak). Acta Botanica Slovaca, A, *11*: 1–135.
Neary, D.G., Klopatek, C.C., DeBano, L.F., Folliott, P.F., 1999: Fire effects on belowground sustainability: a review and synthesis. Forest Ecology and Management, *122*: 51–71.
Osvald, A., Hlaváč, P., Chromek, I., 2005: Fire risk as a result of wind disasters (in Slovak). In Aktuálne problémy v ochrane lesa 2005. Lesnícky ústav, Zvolen, p. 82–89.
Päätalo, M-L., 1998: Factor influencing occurrence and impacts of fires in northern European forest. Silva Fenn., *32*, 2:185–202.
Parviainen, J., 1996: Impact of fire on Finnish forest in the past and today. Silva Fenn., *30*, 2–3: 353–359.
Ružička, M., 1960: Soil and ecological conditions of forest communities in the region of sands in Záhorská nížina lowland (in Slovak). Biol. Práce., *6*, 11: 7–88.
Shakesby, R.A., Doerr, S.H., 2006: Wildfire as a hydrological and geomorphological agent. Earth-Science Reviews, *74*: 269–307.
Svoboda, P., 1952: Forest life (in Czech). Brázda, Praha, 943 pp.
Šomšák, L., Kubíček, F., 1994: Phytocoenological and production evaluation of the original and secondary pine forests of the Záhorská nížina lowland. I. Alliance *Pino-Quercetum*. Ekológia (Bratislava), *13*: 335–348.
Šomšák, L., Kubíček, F., 2000: Phytocoenological and production evaluation of the original and secondary pine forests of the Borská nížina lowland. III.Alliance *Potentillo albae-Quercion petraeae* Z o l. et J a k. 1967. Ekológia (Bratislava), *19*: 54–63.
Šomšák, L., Šimonovič, V., Kollár, J., 2004: Phytocoenoses of pine forests in the central part of the Záhorská nížina lowland. Biológia, Bratislava, *59*, 1: 101–113.
Šomšáková, V., 1988: Association of mosses with pine forest of blown sands in Záhorská nížina lowland (in Slovak). Acta Fac. Rer. Natur. Univ. Comen., Bot., 36: 27–58.
Tinner, W., Hubschmid, P., Wehrli, M., Ammann, B., Conedera, M., 1999: Long-term forest fire ecology and dynamics in Switzerland. Journal of Ecology, *87*, 2: 273–289.
Zackrisson, O., 1977: Influence of forest fires on the north Swedish boreal forest. Oikos, *29*, 1: 13–32.