Effect of disturbance on the vegetation of peat bogs with *Pinus rotundata* in the Třeboň Basin, Czech Republic

Vegetační změny blatkových rašelinišť Třeboňské pánve po různých typech narušení

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Various stages in the succession of vegetation of peat bogs following disturbance were studied in the Třeboň Basin, Czech Republic. The disturbance was of two types: (a) natural, represented by windthrow, with subsequent bark beetle attack, and fire, and (b) human-made peat digging and industrial peat milling. The species composition at different stages in succession following disturbance were compared with that in undisturbed plots. Regeneration of peat bog vegetation was faster after a natural than after human-made disturbance. The lowest impact was caused by windthrow, followed by fire. Regeneration after peat digging took much longer. Regeneration after industrial peat harvesting only occurred if the groundwater table level remained high.

K e y w o r d s: bark beetle, bog pine, bryophytes, fire, peat harvesting, regeneration, species composition, succession, vascular plants, windthrow

Introduction

Peat bogs dominated by the bog pine *Pinus rotundata* Link. in Central Europe are relic habitats (Steiner 1992, Spitzer 1994, Dierssen & Dierssen 2001, Bastl et al. 2008). The bog pine is a remarkable taxon endemic to Central Europe (Jalas & Suominen 1973) with a rather limited distribution. Moreover, it readily hybridizes with *Pinus mugo,* and with *P. sylvestris* mainly at disturbed sites (Businský 1998, Bastl et al. 2008). Peat bogs dominated by tree-shaped *P. rotundata* typically occur at altitudes up to ca 800 m a.s.l. At higher altitudes hybrids with *P. mugo* prevail.

The Třeboň Basin before peat harvesting was one of the two areas with the highest concentration of peat bogs with non-hybrid *P. rotundata* (the other was the Black Forest in Germany, Dierssen & Dierssen 2001). The vegetation of undisturbed sites in the Třeboň Basin is described in detail by Neuhäusl (1972) and the Holocene history by Jankovská (1980).

Peat harvesting on a large scale started in the 19th century. However, at that time it was done in the traditional way with only shallow drainage. In the second part of the 20th century, large scale industrial peat harvesting began, which involved deep drainage. In addition to peat harvesting, some peat bogs were occasionally disturbed by high winds, followed by bark beetle outbreaks (Kučerová et al. 2000, Kučerová et al. 2008) and recently also by fire (Kučerová et al. 2008). In contrast to undisturbed peat bogs the vegetation of these disturbed sites is not systematically described with the exception of Žofinka peat bog (Kučerová et al. 2008). Knowledge of the changes that occur in vegetation following disturbance could help in the restoration of peat bog vegetation (Salonen 1987, Phadenhauer & Grootjans 1999, Schrautzer et al. 2007). The expectation is that different types of disturbance result in different changes in the vegetation and subsequent succession (Pickett & White 1985).

In view of the condition of the peat bogs in the study area we decided to: (a) compare sites disturbed by different natural events, i.e., fire, wind and a bark beetle outbreak, with undisturbed vegetation at one locality; (b) compare sites disturbed by the natural factors with those disturbed by peat harvesting; (c) describe the succession over several years following fire; (d) describe the succession sere after industrial peat milling; and (e) evaluate the results from the point of view of the restoration of natural peat bog vegetation.

Methods

Site description

The Třeboň Basin is located in the southern part of the Czech Republic, latitude 48° 49' N, longitude 14° 53' E, altitude 430–480 m a.s.l. The seven peat bogs studied are spread over a large area of approximately 600 km^2 (Fig. 1). The mean annual temperature is about 7 °C and annual precipitation varies between 600 and 650 mm (Vesecký et al. 1958).

Natural disturbances were studied in the Žofinka National Nature Reserve (Fig. 1), where several different disturbed sites were identified. A large area of old growth *P. rotundata* forest was damaged by wind in the first half of the 1980s, followed by a bark beetle outbreak. It must be mentioned that even this natural disturbance could be aggravated by human activities, because most of the area around the reserve was drained up until 1970, which probably destabilized the sensitive climax vegetation inside the reserve. Consequently, nearly all pines died due to the combined effect of these perturbations. In 1994, a fire, initiated probably by lightning, damaged an area of several hectares; a similar fire in August 2000 nearly completely destroyed a further 1.5 ha of the remaining old growth. Thus, four different stages were available at this locality: two differently aged stages disturbed by fire, one disturbed by wind and a bark beetle infestation, and an untouched section with an old growth of *P. rotundata*. Human-made disturbances occurred at several other localities where peat was extracted both by traditional peat digging (Kozohlůdky and Červené blato) and industrial peat milling (Borkovice, Mažice, Příbraz and Branná).

Peat digging involves cutting peat by hand with specialized tools and results in large steep sided pits with flat bottoms, often with straight edges. The groundwater table after digging usually remains high and the pits are often flooded. Industrial peat harvesting involved milling in the area studied. Before milling, the bog is drained. All the vegetation is removed and the ground is levelled. The top layers are then gradually milled to produce a powdered peat that is left to dry. Then it is gathered into ridges for a large harvester to collect. The groundwater table after milling usually remains low.

Type of disturbance, the age of the successional stages and the number of analysed relevés for particular localities are presented in Table 1.

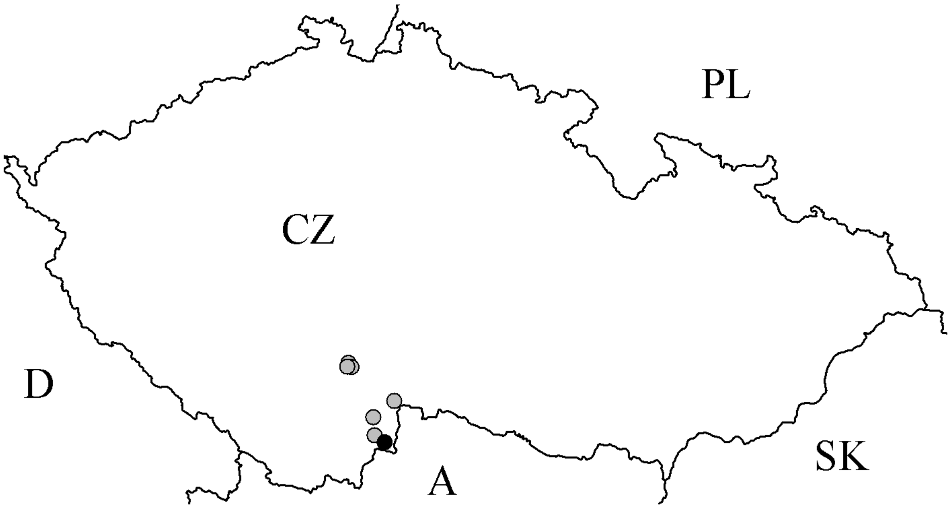

Fig. 1. – Location of the study sites in the Třeboň Basin, Czech Republic. Study site Žofinka is indicated by the black symbol.

Table 1. – Localities and successional stages at which the data was collected.

Site	Latitude	Longitude	Disturbance	Successional age [years]	Respective numbers of samples	Reference
Příbraz	49°02' N	14°57' E	milling	2, 4, 10	2, 2, 4	Bastl (2004)
Branná	48°57' N	14°48' E	milling	3, 6, 8	2, 2, 2	Bastl (2004)
Mažice	49°13' N	14°37' E	milling	15, 20	5, 2	Bastl (2004)
Borkovice	49°14' N	14°37' E	milling	25	9	Bastl (2004)
Kozohlůdky	49°13' N	14°39' E	digging	50	15	Bastl (2004)
Červené blato	48°52' N	14°52' E	digging	70, 90	9, 12	Bastl (2004)
			undisturbed	200[a]	2	Bastl (2004)
Žofinka	48°49' N	14°53' E	fire	1, 2, 7, 8	10, 10, 10, 8	Jakšičová (2003)
			wind	14	5	Jakšičová (2003)
			undisturbed	200	5	Jakšičová (2003)

[a] estimated from the age of the oldest trees

Field sampling

The vegetation in 5 × 5 m plots was recorded using traditional phytosociological relevés based on visual estimates of the percentage of the cover made up of each species. The adapted 7-degree Braun-Blanquet scale, with the degree 2 divided (van der Maarel 1979), was used. Both vascular plants and bryophytes were recorded. Ten plots were permanently marked in representative (homogenous) parts at each of two sites previously disturbed by fire and observed for two seasons. These sites provided information on the successional stage of the vegetation 1 and 2 years, and 7 and 8 years after a fire (Jakšičová 2003). Five relevés of the same size were made at sites disturbed by wind and bark beetle attack, and five in an undisturbed part of the Žofinka National Nature Reserve (Jakšičová 2003).

For peat bogs damaged by peat harvesting vegetation records (68 in total) previously presented by Bastl (1994) and considering only vascular plants and species of *Sphagnum* were used. The size of the samples in that study was also 5 × 5 m. Estimate of when these disturbances occurred were obtained from official records of the mining companies, by interviewing local people and analyses of the annual growth rings of trees.

Nomenclature follows Kučera & Váňa (2003) for bryophytes and Kubát et al. (2002) for vascular plants.

Data elaboration

The data were processed using Principal Component Analysis (PCA), based on a model of a linear species response to underlying environmental gradient, or Detrended Correspondence Analysis (DCA) based on a unimodal species response. PCA was used if the length

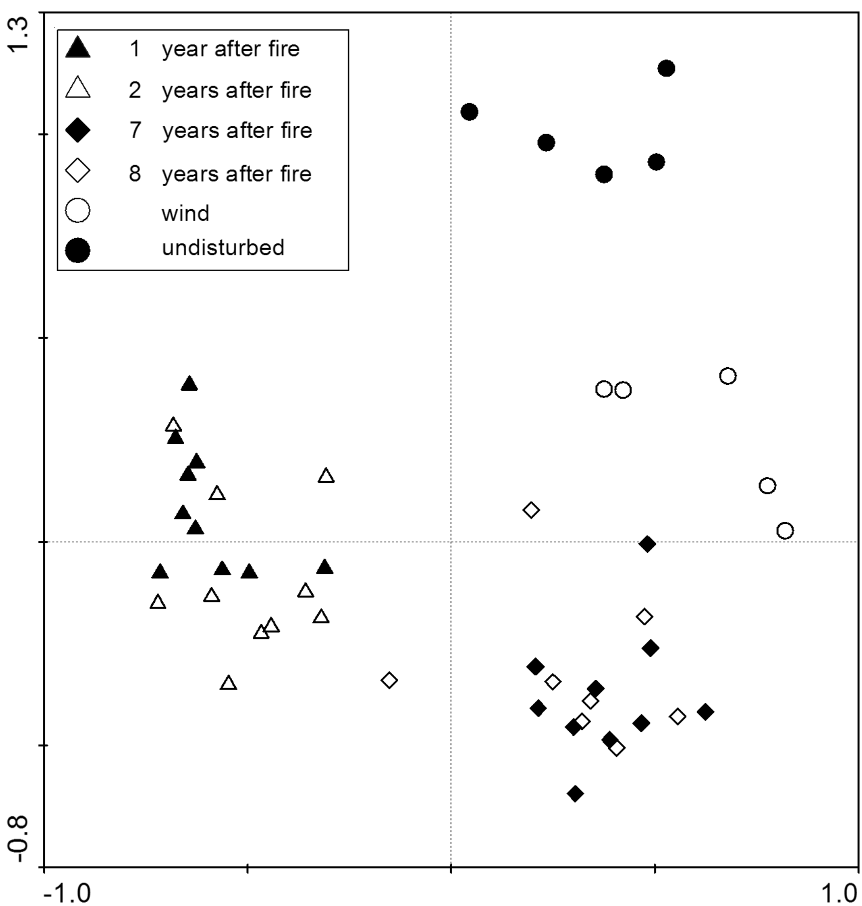

Fig. 2. – Unconstrained ordination (PCA) of samples from sites disturbed by different events and an undisturbed site in the Žofinka National Nature Reserve.

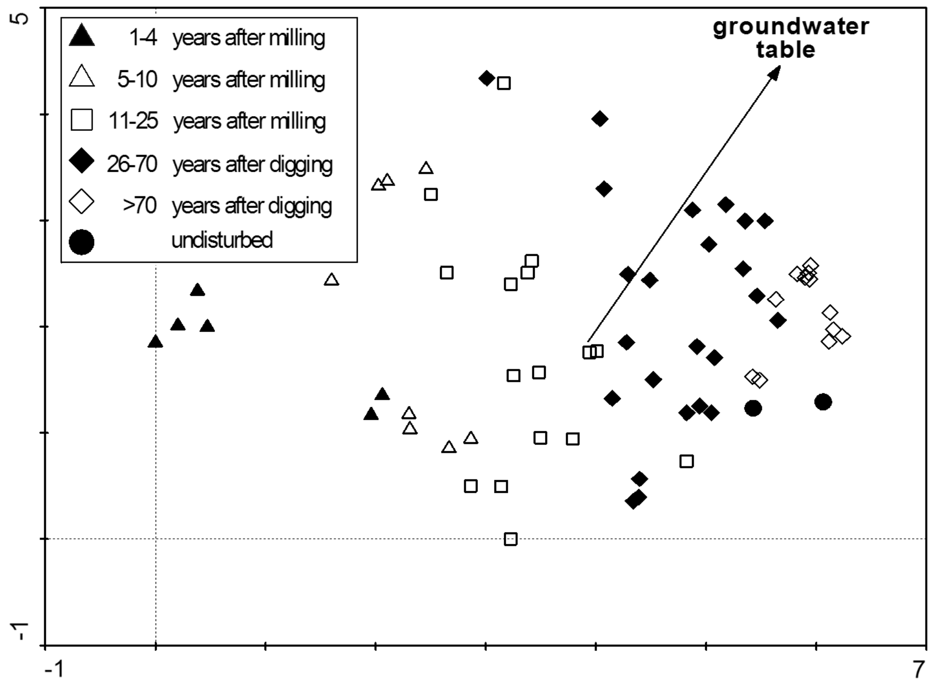

Fig. 3. – Unconstrained ordination (DCA) of samples from sites disturbed by peat extraction and undisturbed sites at the Branná, Borkovice, Červené blato, Kozohlůdky, Mažice and Příbraz peat bogs with the level of the groundwater table treated as a passive variable.

of the longest gradient in trial DCA was less than 3 SD units (Lepš & Šmilauer 2003) and DCA if it was more than 4 SD units (Lepš & Šmilauer 2003). There were no analyses with gradients between 3 and 4 SD units long. PCA was used for data from the site disturbed by fire and windthrow (48 samples, species in all vegetation layers, Fig. 2) and DCA for data from sites disturbed by peat extraction (68 samples, species in all vegetation layers, Fig. 3) and all the sites studied (116 samples, with species in all the vegetation layers included, Fig. 4, inset diagram; 116 samples, with species in the shrub and tree layers excluded, Fig. 4). Because of the differences in the way the data on moss species was collected only *Sphagnum* species were included in this data set.

For data from the plots subjected to fire and for which there was a quantitative explanatory variable available, time since disturbance (38 samples, woody species excluded, Fig. 5), constrained ordination Redundancy Analysis (RDA) of a linear response of species to an environmental gradient (Lepš & Šmilauer 2003) was used. Species of trees and shrubs were not considered because we could not distinguish few individuals of tree and shrub layer remained after fires from newly established ones.

For the analysis of the data from the plots after industrial peat milling, for which the quantitative explanatory variables, time since disturbance and groundwater table level, were available (30 samples, species in the tree layer not present in samples, Fig. 6), constrained ordination Canonical Correspondence Analysis (CCA) of a unimodal response of species to an environmental gradient (Lepš & Šmilauer 2003) was used.

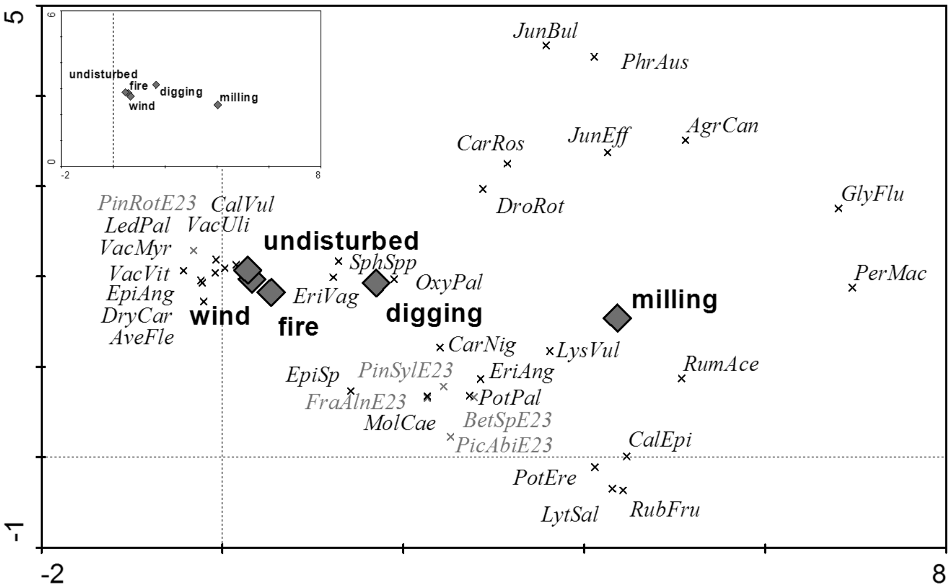

Fig. 4. – Unconstrained ordination (DCA) of samples from all the peat bogs studied in the Třeboň Basin, in which centroids for types of disturbance are projected and in which the species of shrub and tree layers are treated as passive and shown in grey. The results of the analysis that included shrub and tree layers are presented in the inset diagram. Scores of the samples on axis 1 approximately reflect the relative intensity of disturbance. *AgrCan* (*Agrostis canina*), *AveFle* (*Avenella flexuosa*), *Bet*SpE23 (*Betula* sp. E_2+E_3), *CalEpi* (*Calamagrostis epigejos*), *CalVul* (*Calluna vulgaris*), *CarNig* (*Carex nigra*), *CarRos* (*Carex rostrata*), *DroRot* (*Drosera rotundifolia*), *DryCar* (*Dryopteris carthusiana*), *EpiAng* (*Epilobium angustifolium*), *Epi*Sp (*Epilobium* sp.), *EriAng* (*Eriophorum angustifolium*), *EriVag* (*Eriophorum vaginatum*), *FraAln*E23 (*Frangula alnus* E_2+E_3), *GlyFlu* (*Glyceria fluitans*), *JunBul* (*Juncus bulbosus*), *JunEff* (*Juncus effusus*), *LedPal* (*Ledum palustre*), *LysVul* (*Lysimachia vulgaris*), *LytSal* (*Lythrum salicaria*), *MolCae* (*Molinia caerulea*), *OxyPal* (*Oxycoccus palustris*), *PerMac* (*Persicaria maculosa*), *PhrAus* (*Phragmites australis*), *PicAbi*E23 (*Picea abies* E_2+E_3), *PinSyl*E23 (*Pinus sylvestris* E_2+E_3), *PinRot*E23 (*Pinus rotundata* E_2+E_3), *PotEre* (*Potentilla erecta*), *PotPal* (*Potentilla palustris*), *RubFru* (*Rubus fruticosus* agg.), *RumAce* (*Rumex acetosella*), *Sph*Spp (*Sphagnum* sp. div.), *VacMyr* (*Vaccinium myrtillus*), *VacUli* (*Vaccinium uliginosum*), *VacVit* (*Vaccinium vitis-idaea*).

The statistical significance of the environmental variables was tested using the Monte-Carlo permutation test (MCPT), based on split-plot design model to exclude the effect of subsequent sampling of the same plots. All analyses were performed using the program package CANOCO for Windows version 4.5 (ter Braak & Šmilauer 2002).

Results

The results of the ordination (PCA) of all relevés from the disturbed sites in the Žofinka NNR, with shrub and tree layers included, are shown in Fig. 2. The first ordination axis explained 24.7% and first two 43.5% of the variability. The samples from the burned plots formed a clear sequence in the ordination diagram corresponding to their successional age. The older samples are close to those disturbed by wind and affected by bark beetles

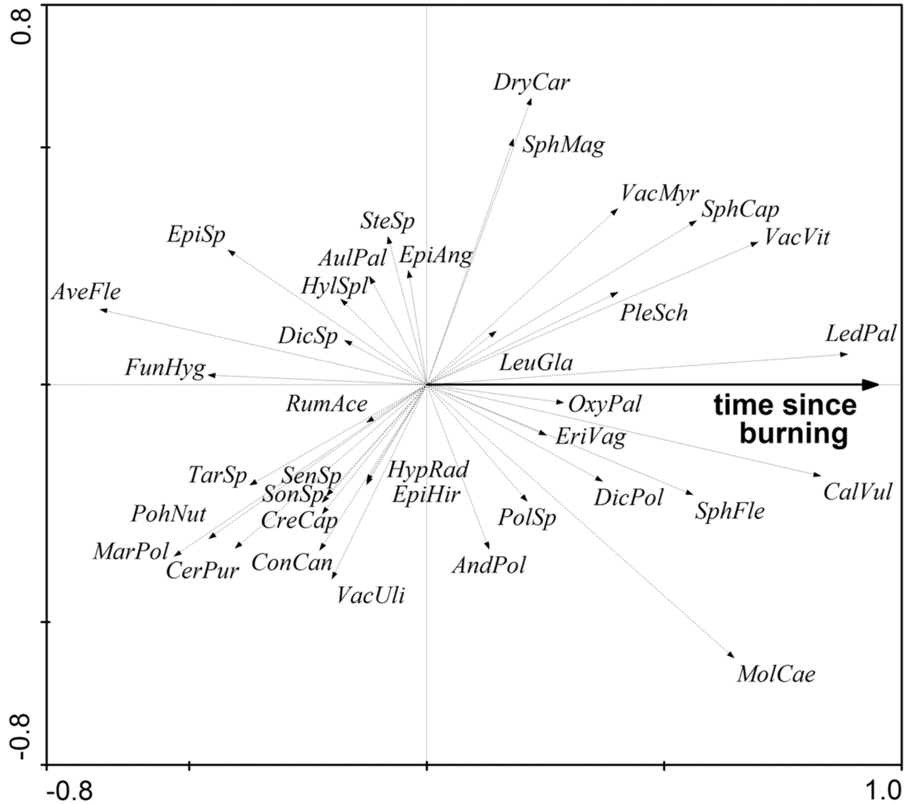

Fig. 5. – Constrained ordination (RDA) of species from burned plots in the Žofinka National Nature Reserve. Time since burning (1–8 years) was the only explanatory variable used. *AndPol* (*Andromeda polifolia*), *AulPal* (*Aulacomnium palustre*), *AveFle* (*Avenella flexuosa*), *CalVul* (*Calluna vulgaris*), *CerPur* (*Ceratodon purpureus*), *ConCan* (*Conyza canadensis*), *CreCap* (*Crepis capillaris*), *DicPol* (*Dicranum polysetum*), *DicSp* (*Dicranum* sp.), *DryCar* (*Dryopteris carthusiana*), *EpiAng* (*Epilobium angustifolium*), *EpiHir* (*Epilobium hirsutum*), *Epi*Sp (*Epilobium* sp.), *EriVag* (*Eriophorum vaginatum*), *FunHyg* (*Funaria hygrometrica*), *HylSpl* (*Hylocomium splendens*), *HypRad* (*Hypochaeris radicata*), *LedPal* (*Ledum palustre*), *LeuGla* (*Leucobryum glaucum*), *MarPol* (*Marchantia polymorpha*), *MolCae* (*Molinia caerulea*), *OxyPal* (*Oxycoccus palustris*), *PleSch* (*Pleurozium schreberi*), *PohNut* (*Pohlia nutans*), *Pol*Sp (*Polytrichum* sp.), *RumAce* (*Rumex acetosella*), *Sen*Sp (*Senecio* sp.), *SonSp* (*Sonchus* sp.), *SphCap* (*Sphagnum capillifolium*), *SphFle* (*Sphagnum flexuosum*), *SphMag* (*Sphagnum magellanicum*), *Ste*Sp (*Stellaria* sp.), *Tar*Sp (*Taraxacum* sp.), *VacMyr* (*Vaccinium myrtillus*), *VacUli* (*Vaccinium uliginosum*), *VacVit* (*Vaccinium vitis-idaea*).

and the latter do not differ from undisturbed plots. The main difference between undisturbed plots and those disturbed by wind lies in the species composition of the tree layer.

The results of the ordination (DCA) of all relevés from sites disturbed by peat extraction are presented in Fig. 3, with groundwater table as a passive variable**.** The first ordination axis explained 11.1% and first two 18.4% of the variability. The samples from the plots affected by peat harvesting formed a clear sequence in the ordination diagram corresponding to their successional age, from milled plots (left side) to those disturbed by peat digging (right side). Plots with high groundwater tables occur in the upper part of the diagram and those with low groundwater tables at the bottom. The successional trend, even at

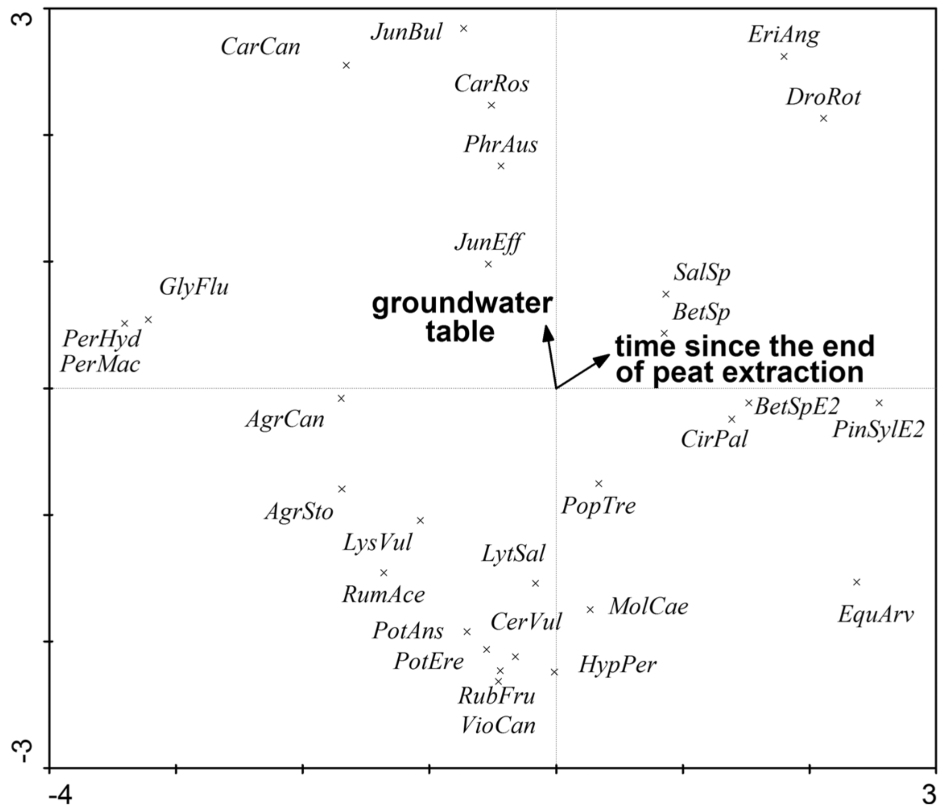

Fig. 6 – Constrained ordination (CCA) of species from plots disturbed by industrial peat milling at Branná, Borkovice, Mažice and Příbraz peat bogs. Time since the end of peat extraction (2–25 years) and level of the groundwater table (–10 to –110 cm) were used as explanatory variables. *AgrCan* (*Agrostis canina*), *AgrSto* (*Agrostis stolonifera*), *Bet*Sp (*Betula* sp.), *Bet*SpE2 (*Betula* sp. E_2), *CarCan* (*Carex canescens*), *CarRos* (*Carex rostrata*), *CerVul* (*Cerastium vulgatum*), *CirPal* (*Cisrsium palustre*), *DroRot* (*Drosera rotundifolia*), *EquArv* (*Equisetum arvense*), *EriAng* (*Eriophorum angustifolium*), *GlyFlu* (*Glyceria fluitans*), *HypPer* (*Hypericum perforatum*), *JunBul* (*Juncus bulbosus*), *JunEff* (*Juncus effusus*), *LysVul* (*Lysimachia vulgaris*), *LytSal* (*Lythrum salicaria*), *MolCae* (*Molinia caerulea*), *PerHyd* (*Persicaria hydropiper*), *PerMac* (*Persicaria maculosa*), *PhrAus* (*Phragmites australis*), *PinSyl*E2 (*Pinus sylvestris* E_2), *PopTre* (*Populus tremula*), *PotAns* (*Potentilla anserina*), *PotEre* (*Potentilla erecta*), *RubFru* (*Rubus fruticosus* agg.), *RumAce* (*Rumex acetosella*), *Sal*Sp (*Salix* sp.), *VioCan* (*Viola canina*).

sites heavily disturbed by milling, seems to be towards a restoration of more natural vegetation, especially in plots with medium and high groundwater tables.

The DCA ordination of all relevés from all analysed plots and peat bogs is presented in Fig. 4, with plotted passive variables representing the type of disturbance and projected passive species in the shrub and tree layer (E_2+E_3)**.** The first ordination axis explained 11.0% and first two 17.7% of the variability. The centroid of samples from industrially milled bogs is rather far from that of undisturbed plots. All centroids of the sites disturbed by natural forces are very close to the centroid of undisturbed vegetation. Species typical for particular types of disturbance were e.g. *Rumex acetosella*, *Calamagrostis epigejos*, *Agrostis canina* and *Juncus effusus* for milled sites, *Oxycoccus palustris* and *Carex nigra* for sites affected by digging, *Epilobium* sp. div. for burned sites and *Ledum palustre* and *Vaccinium uliginosum* for sites affected by windthrow and undisturbed sites. A typical woody species for undisturbed sites is *Pinus rotundata*. With increasing intensity of disturbance there is an increase in the proportion of *Pinus sylvestris* and *Frangula alnus* followed by *Betula* sp. div. and sometimes *Picea abies*. When we included species of shrub and tree layers (E_2+E_3) in the analysis the results remained very similar (Fig. 4, see inset diagram) and the first ordination axis explained 10.8% and first two 18.2% of the variability.

Detailed views of particular successional seres for which there is sufficient data, i.e. the seres after burning and after industrial peat milling, are presented in Figs 5 and 6. In the case of post-fire succession, species in the diagram of the direct ordination (RDA) clearly demonstrate their relationships to the time since burning (Fig. 5). The first ordination axis explains 29.8% and first two 40.7% of the variability. The first canonical axis is highly significant (MCPT, 9999 permutations, F = 15.26, P = 0.0001). In the initial stages of succession, i.e. in the opposite direction to the vector successional age, there are species such as *Conyza canadensis*, *Senecio* sp. div., *Sonchus* sp. div., *Taraxacum* sp. div., *Epilobium* sp. div., which all typically colonize only the initial stages of succession. They are accompanied by bryophytes of similar strategy: *Funaria hygrometrica* (typical of burned sites), *Ceratodon purpureus*, *Pohlia nutans* and *Marchantia polymorpha*.

However, over the eight years of the observation these species substantially decreased in occurrence or completely disappeared. Instead, species typical of peatland either regenerated from underground organs and then spread or were newly established from seeds (*Ledum palustre, Calluna vulgaris, Vaccinium myrtillus*). A group of typical peatland species, which regenerated immediately after the disturbance and exhibit no strong correlations with successional age, are *Vaccinium uliginosum* and *Andromeda polifolia*. The following bryophytes, typical of natural peat bog forests, quickly colonized the area: *Sphagnum capillifolium* and *S. flexuosum* or *Pleurozium schreberi* at drier sites. *Polytrichum* sp. div. became established almost immediately after burning. Since they are typical species of natural forests they did not exhibit any trend during this period. The only species typical of all the burned plots, irrespective of their age, was *Molinia caerulea,* which was also present but less dominant in undisturbed vegetation. Its abundance continuously increased over time.

In the case of succession after industrial peat milling, the species in the diagram of direct ordination (CCA) clearly demonstrate a relationship to the time since disturbance and the groundwater table (Fig. 6). The first ordination axis explained 10.7% and the first two 19.5% of the variability. The first canonical axis and both canonical axes together were highly significant (MCPT, 999 permutations, F = 3.23, P = 0.001 and F = 3.26, P = 0.001 respectively). Species typical of a wet sere are in the upper part of the diagram, while those typical of a dry sere in the lower part. In the initial stages of succession, there were species (listed from high to low groundwater levels) such as *Carex canescens*, *Glyceria fluitans*, *Persicaria* sp. div., *Agrostis* sp. div., *Rumex acetosella*, *Potentilla* sp. div., *Rubus fruticosus* agg. and *Viola canina*. In the successional stages of about 10 to 15 years old *Carex rostrata*, *Phragmites australis*, *Juncus effusus* and *Molinia caerulea* occur and first fast growing trees started to dominate (*Salix* sp. div., *Betula* sp. div., *Populus tremula*). In the oldest recorded stages (25 years) *Eriophorum angustifolium* and *Drosera rotundifolia* were typically recorded in wet sere and *Pinus sylvestris* and *Equisetum arvense* in dry sere.

Discussion

The present results clearly demonstrate that the effect of natural disturbances, i.e. fire, wind and herbivorous insect outbreaks, on peat bog vegetation is only temporary and not very severe, unlike the effects of anthropogenic disturbances. Regeneration of a typical bog pine community is rather fast, even after an apparently severe disturbance such as a nearly complete burn.

In the burned plots, the ruderal species, which typically colonize newly disturbed substrata (see Grime et al. 1988) did not become dominant and disappeared within a few years. These results are in agreement with a similar analysis based on data from the same locality (Kučerová et al. 2008). The low importance of ruderal species was probably caused by the fact that the disturbed sites were relatively small and surrounded by natural and semi-natural vegetation. Thus the diaspores of easily dispersed ruderal species had little chance of reaching these sites (Strykstra et al. 2002).

Quite the opposite situation was observed in the case of large-scale burning of pine (*P. sylvestris*) plantations in the Záhoří lowland in W Slovakia, which is in more or less the same climatic region. There, ruderal species totally dominated during the first six years of succession (K. Prach, unpublished). A similarly high importance of ruderal species in the initial and early stages of post-fire succession is reported for other geographical areas. It must be emphasized that in temperate deciduous forests fires are rare events and confined to relatively small areas. Thus the species have not adapted to these conditions as much as those in the boreal zone (Archibold 1989). The fast spread of species of the *Ericaceae* and *Vacciniaceae*, either based on vegetative regeneration (resprouting) from underground organs or from seeds, is reported for burned heathland (Sedláková & Chytrý 1999). The trend observed in the case of vascular plants was followed also by bryophytes. The set of species typical of initial post-fire succession were followed quite fast by species typical of natural peat bog forests.

Succession after peat harvesting depended mainly on the level of the water table. In the case of traditional peat digging, the level of the water table did not drop much and peat was often extracted only down to the water table (Dohnal et al. 1965). Thus, the regeneration of the peat-forming process was possible (see also Salonen 1990, Lindsay 1995, Sliva 1997, Dierssen & Dierssen 2001). As evident from the oldest plots (ca 90 years), the species composition was very similar to that of undisturbed plots with only differences in the quantitative cover of the species. A weak point, which limited further generalization, is the fact that there are no young successional stages of this sere as traditional peat digging ceased in this area more than 50 years ago. On the other hand, there are no really old stages of succession following industrial milling, which is more recent.

The succession following industrial peat milling does not result in the re-establishment of peatland vegetation unless the level of the water table is artificially increased (Lindsay 1995, Brooks & Stoneman 1997, Rochefort & Campeau 1997, Sliva et al. 1997). Recently assisted restoration of the water regime after large-scale harvesting was started in the study area. Based on initial data from a similar project in the nearby Šumava Mts, some regeneration is possible (P. Horn & M. Bastl, unpublished data). If the water table remains low, the succession results in pine-birch woodland, but with common Scots pine (*P. sylvestris*) rather than bog pine (*Pinus rotundata*) (Bastl 1994, Prach & Pyšek 2001, Konvalinková 2006).

The general successional trend among the industrially harvested plots, however, seems to be the re-establishment of peatland vegetation if the water table level remains relatively high. The re-establishment of typical peat land vegetation on deeply drained sites never occurs. Besides the water table, the thickness and character of the remaining peat layer can also influence the course of succession (Salonen 1990, Rochefort & Campeau 1997). However, there is insufficient detailed data on this phenomenon.

The effects of natural disturbances on vegetation, i.e. fire and wind followed by a bark beetle outbreak, seem to be negligible compared to that of peat harvesting, as the samples from naturally disturbed sites are close to those from undisturbed plots on Fig. 4. The sample score on axis 1 of the figure can be considered as a relative measure of the severity of disturbance. The slightly different position of plots affected by fire and those affected by wind in main and inset diagram (Fig . 4) is mainly because only a few old growth trees survived fire in a few plots. Thus, the vegetation of burned plots appears to be more similar to that of undisturbed plots if shrub and tree layers are included.

Finally, the results of this research have implications for nature conservation and restoration of peat bogs. If a disturbed site is small, the level of the water table remains the same and it is surrounded by original vegetation, regeneration is rather fast. Ruderal species do not become well established and are quickly followed by species typical of natural peatland vegetation. In the case of sites where peat was milled, it is strongly recommended that the level of the water table should be brought back up to the surface. This will induce a new peat-forming process and the re-establishment of typical peatland plant life, especially if at least remnants of untouched peatland are present in the surroundings (Neuhäusl 1992, Konvalinková 2006). To speed up the processes, some transplantation of both higher plants and bryophytes may be helpful (Sliva 1997). We believe that such attitude towards restoration will be adopted soon by local authorities, especially in the Protected Landscape Area and the Biosphere Reserve of the Třeboň Basin.

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Souhrn

Na rašeliništích v Třeboňské pánvi byla studována různá stádia sukcese vegetace vzniklá po různých typech narušení. Jednalo se o dva hlavní typy narušení: (a) přírodní, reprezentované polomem s následným napadením podkorním hmyzem a narušením požárem a (b) lidskou činností, reprezentované borkováním a průmyslovou těžbou rašeliny frézováním. Bylo porovnáváno druhové složení sukcesních stádií po výše zmíněných narušeních s druhovým složením nenarušených ploch. Regenerace rašeliništní vegetace byla rychlejší po přírodních narušeních než po narušeních způsobených lidskou činností. Nejmenší vliv mělo narušení větrem, následované narušením požárem. Regenerace po narušení borkováním již trvala značně déle. Regenerace po průmyslové těžbě frézováním byla možná pouze v případě zachování relativně vysoké hladiny podzemní vody.

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