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Effect of limestone-paved track on the Rokytecká Mire, Bohemian Forest

Lenka Soukupová[1,*], Jana Husáková[2], † Filip Lederer[3] & Jiří Váňa[4]

[1]*Institute of Botany, Academy of Sciences of the Czech Republic, CZ-252 43 Průhonice, Czech Republic*
[2]*Na Třebešíně 10, CZ-100 00 Praha, Czech Republic*
[3]*Faculty of Education, University of Western Bohemia, Klatovská 51, CZ–320 13 Plzeň, Czech Republic*
[4]*Faculty of Nature Sciences, Dept. of Botany, Charles university,*
Benátská 2, CZ-128 01 Praha 2, Czech Republic
**papackova@ibot.cas.cz*

Abstract

Impact of a track, paved by limestone gravel, has been evaluated with regard to a mountain bog of significant conservational value. Repeated phytosociological survey in 1996 and 2000 extended by sequential aerial photographs from 1949, 1962, 1982, 1994 and 2000, and by analyses of soil and water chemistry were employed in the identification of successive changes. Long-term drainage via a deep downslope ditch, construction of a body paved by allochthonous material, and subsequent dispersal of limestone particles by vehicles and wind modified the standard mire hydrology, peat-forming process and bog-surface morphology. Since 1949, enhanced spreading of Norway spruce is evident, woodless bog centres have disappeared and new bog-lakes appeared near the track. Due to the effect of limestone, the soil $pH_{aq.}$ and content of Ca reached enormous values 8.1 and 1110 mg/100 g, respectively. Combined impact of both the drainage and base-rich substrate triggered a decline of sphagnum mosses and opened suitable microhabitats for almost 200 alien species, including cyanobacteria, algae, bryophytes and vascular plants. Track segments affected by limestone hosted twice as many vascular species as the limestone-free segments with respective means±s.d. 76.5±18.7 and 40.2±17.0. Among the bryophytes, five strict calciphilous species were observed: *Barbula unguiculata*, *Didymodon fallax*, *Ditrichum flexicaule* f. *densa*, *Encalypta streptocarpa* and *Pellia endiviifolia*. Water in the track ditch became inhabited by the Cyanobacterium *Leptolyngbya foveolarum*, and by abundant diatoms – a phenomenon never observed in the pools and lakes of the surrounding bog. Marginal strips along the track became invaded by numerous subtermophilous vascular plants seldom encountered at the elevation of 1100 m; 8 species – *Galium verum*, *Astragallus glycyphollos*, *Chelidonium maius*, *Clinopodium vulgare*, *Euphrasia nemorosa*, *Viscaria vulgaris* and *Calamagrostis epigeios* – reach here their altitudinal maximum in the Hercynian mountains of Czechia. Between 1996 and 2000, the track segments within the bog were enriched by a prominent number of newly arrived species (mean±s.d.: 39±7.5), but only 3.6±2.6 species have been lost. In the same period, conspicuous disappearance of about 30 species was observed in the track segments situated in cool valley bottoms. The Administration of the Šumava National Park is urgently recommended to initiate a restoration programme which should prevent further degradation of biodiversity in the Rokytecká Mire belonging to the international network of Ramsar sites.

Key words: bog degradation, limestone effect, drainage, invasion of alien plants

INTRODUCTION

Undisturbed bogs are inherently marked by sustainable oligotrophic acid environment influenced by permanent waterlogging. Disturbance of both the water and trophy balance results in a step-by-step degradation of the whole ecosystem, including a change of the entire plant communities. Drainage itself causes progressive sinking of underground water that evokes, at first, a loss of uppermost water-saturated layer (called acrotelm) with peat-forming *Sphagnum* species (INGRAM 1983, EDOM & GOLUBCOV 1996). With the proceeding drainage, the desiccating peat is oxidised and slowly vanishes due to mineralization; later on succession of forest species, including trees, takes place.

Effect of added alkaline substances, namely of Ca^{2+}, is accompanied by an increase of pH, which causes the *Sphagnum* decline (MACKENZIE 1992, KAROFELD 1996). In their experiments, CLYMO (1973) and CLYMO & HAYWARD (1982) found that combined effect of $pH > 5.5$ and calcium concentration > 20 $mg.l^{-1}$ was lethal for most of the *Sphagnum* species. Abandoned sites become colonized by the species alien to bogs (MÁLKOVÁ 1992, KAROFELD 1994, SOUKUPOVÁ & al. 1998). These species indicate the degree of disturbance and may threaten biodiversity of the surrounding mire.

Path, track and road network promote long-distance spreading of invasive species and enable their establishment in remote habitats of nature reserves. This process is enhanced by introduction of allochthonous substrates for the construction and paving of tracks (HUSÁKOVÁ 1986, MÁLKOVÁ & WAGNEROVÁ 1995, MÁLKOVÁ & KULOVÁ 1995). In Central Europe, important remote near-nature region are mountains which were entered by many lowland species invading along the communications (PIEKOŚ & MIREK 1974, ROSTAŃSKI 1977, KOPECKÝ 1978, HUSÁKOVÁ & GUZIKOWA 1979, BUREŠ & al. 1992, MÁLKOVÁ 1992–1994, DOSTÁLEK 1997, HUSÁKOVÁ & ŠPATENKOVÁ 1999). Although some of these invaders do not survive in severe cold

Fig. 1. – Segment W5 of limestone-paved track through Rokytecká Mire in August 9, 2000. In the foreground *Verbascum nigrum*, a subthermophilous inhabitant occurring here since 1972, is in flower. To the left, through the spots with sprinkled limestone gravel, soil sampling was carried out along the transect BT.

Obr. 1. – Pohled na vápencovou cestu Rokyteckou slatí v úseku W5 k 9. srpnu 2000. V popředí kvetoucí *Verbascum nigrum*, subtermofilní nepůvodní druh, jehož výskyt tu trvá již od r. 1972. Nalevo, v místech s rozstříknutým vápencem, byly provedeny odběry pro půdní analýzy na příčném transektu BT.

conditions longer than a few years, others may acclimate and after several years enter the surrounding communities, and/or may bring about genetic erosion (KRAHULCOVÁ & al. 1996). In national parks and other large-scale protected areas, regular control of vegetation along the tracks in remote natural sites is recommended (ŠTURSA 1964, HUSÁKOVÁ 1984, MÁLKOVÁ & KŮLOVÁ 1995, SOUKUPOVÁ 2001) in order to prevent endangerment of these areas by undesirable invasions.

The following study was carried out to reveal vegetation change along a limestone track cutting the largest mountain bog complex of Central Europe, which is conserved as Zone I of the Šumava National Park, and together with other mires of Bohemian Forest, is listed in the international network of the Ramsar sites. Both drainage and increase of alkalinity affect the surroundings of this track which is heavily attacked by invasion of alien plant specimen. Our observation should bring about comprehensive knowledge of plant indicators with regard to the degree of disturbance and vegetation dynamics.

SITE DESCRIPTION

Rokytecká Mire (Rokytecká Slať in Czech, Weitfäller Filz in German) is situated on the upland of the Bohemian Forest at 49°05'N, 13°25'E, 1120 m a.s.l., where mean annual temperature is 3.2°C and precipitation total 1337 mm, and where snowpack lasts for 6.5 months. The mire covers about 200 ha (DOHNAL 1965) and represents the largest block of the patterned mires in Central European middle–mountains. According to STEINER (1997), this complex belongs to poorly known extrazonal bogs of the Central European Upland Province. Its development started by paludification in the Late Glacial and has been continuing for the past 11000 years (SVOBODOVÁ & SOUKUPOVÁ 2000). Recently, this mire serves as a Central European refuge for a number of species marked by boreal distribution, such as *Betula nana, Menyanthes trifoliata, Sphagnum compactum.* Plant communities in Rokytecká mire were studied repeatedly (KLEČKA 1928, SOFRON & ŠANDOVÁ 1972), and only recently an analysis of the blue-greens and algae was carried out by LEDERER (1998) and LEDERER & al. (2001).

The mire consists of four large woodless bog expanses surrounded by closed-canopy stands of pine krummholz *Pinus* × *pseudopumilio* (JENÍK & SOUKUPOVÁ 1999). Open bog centres are marked by notable patterning of bog lakes, bog pools, mud-bottoms, hollows, quagbogs, lawns, ridges and hummocks. Woodless expanses are occupied mainly by communities of the *Eriophoro vaginati-Trichophoretum caespitosi* and *Scheuchzerio-Sphagnetum cuspidati* (SOFRON & ŠANDOVÁ 1972, pers. observ.), lagg is marked by occurrence of scarce *Betula carpatica* and includes fen soaks with the *Willemetio-Caricetum paniceae* and *Carici rostratae-Sphagnetum apiculati.* Adjacent communities on mineral grounds are sedge marshlands and mat grasslands, and waterlogged spruce forests. Montane forests of the surroundings are dominated by spruce-sycamore and/or mixed beech-spruce-fir stands.

Despite remote location of the mire from human settlements, extensive human impact must be assumed for marginal areas of the bog during the last two centuries, at least. Smuggler trails and cattle paths leading to summer pasture land crossed the mire in the past century (KLOSTERMAN 1891). For the purposes of local foresters hay was mown from mat grasslands once a year (in August) and was carried out by ox-driven rack-wagons (KLEČKA 1928). Before the World War II, a trail crossed the mire (PACOVSKÝ 1929), first as a corduroy causeway whose surface might have been later stabilised by crystalline rock from the surroundings. Soon after 1948, the area became a part of the infamous "Iron Curtain", and a new track was paved by limestone (VANĚČEK 1972). In the early eighties, the drainage ditch along the track was deepened and the track body was repaired again by means of limestone (Figs. 1, 2). Since the declaration of the Šumava National Park in 1991, the track has been used by foresters. In

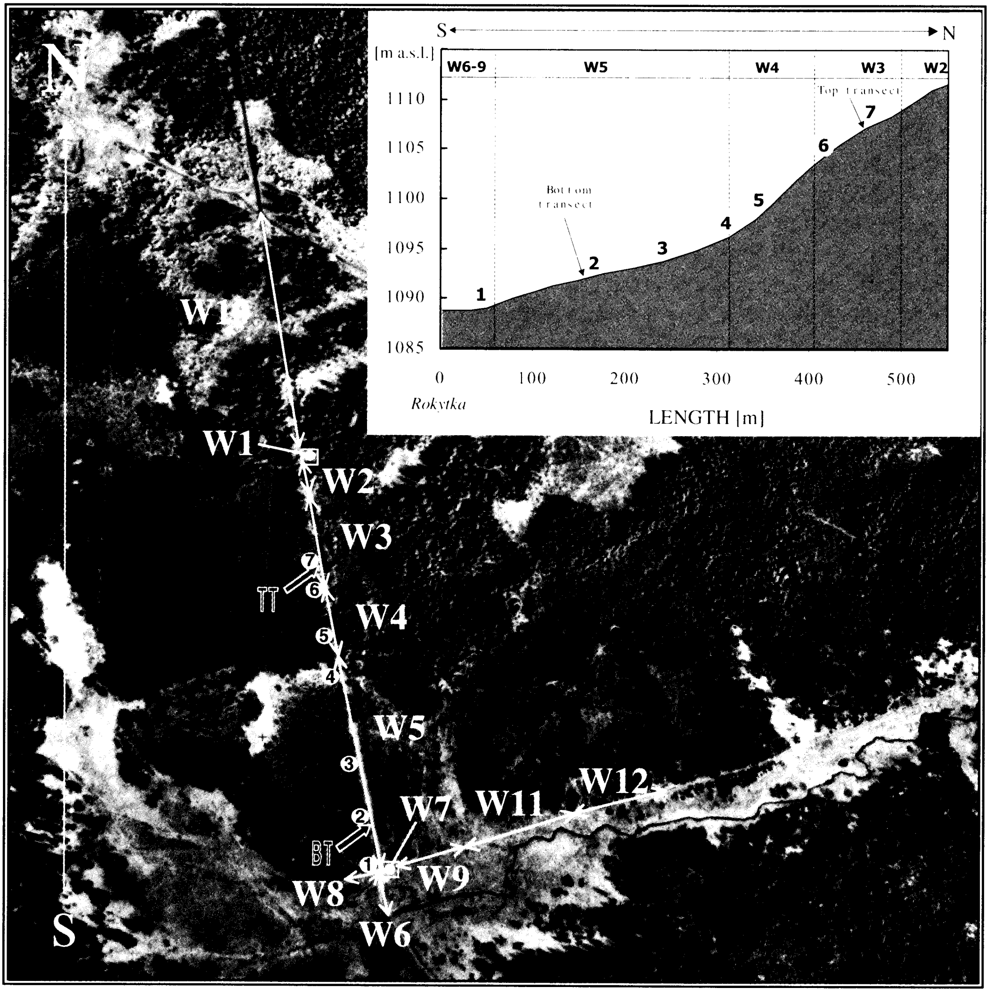

Fig. 2. – Situation of the limestone track through Rokytecká Mire taken from air, with indication of the studied segments W1 to W 12 and location of sampling sites for water (seven white circles) and sampling transects of soil (TT – top transect, BT – bottom transect). *Top right*: Longitudinal section of the path crossing the Rokytecká Mire with delimitation of the studied segments W2 to W9, location of transects for soil analyses in top and bottom part of the bog (BT, TT) and of sampling sites for water placed in the western ditch (1 – beneath the bog, 3 – stand of *Carex rostrata*, 4 – *Viola palustris* inside loose *Carex rostrata* beneath bog without krummholz, 5 – below the steeper slope with *Juncus effusus* and *Salix caprea*, 6 – above steeper slope, without vegetation, 2 and 7 – ditch within the transects for soil analyses).

Obr. 2. – Letecký snímek vápencové cesty Rokyteckou slatí s vyznačením analyzovaných úseků W1 až W12 a umístění odběrových míst vody (7 bílých kroužků) a odběrových transektů půdy (TT – horní transekt, BT – dolní transekt). *Vpravo nahoře*: Podélný řez cestou procházející Rokyteckou slatí s vymezením studovaných úseků W2 to W9, umístěním transektů na složení půdy v horní a dolní části rašeliniště (BT, TT) a odběrových míst pro vodu ze příkopu západně vedle cesty (1 – pod rašeliništěm, 3 – v porostu *Carex rostrata*, 4 – *Viola palustris* uvnitř řídké *Carex rostrata* pod rašeliništěm bez kosodřeviny, 5 – pod strmějším svahem s *Juncus effusus* a *Salix caprea*, 6 – nad strmějším svahem, bez vegetace, 2 a 7 – příkop v rámci transektů pro půdní analýzy).

2000, the limestone layer has been pitched by asphaltic bitumen to stop sprinkling and splashing of limestone, by heavy trucks, into the surrounding bog.

The analysed part of the track encompasses about 1.5 km of communications, and was divided to 12 segments (Fig. 2). Limestone-paved segments W1 to W7 and W10 of the total length 960 m are placed in the N-to-S orientation between the hill top and Rokytka bridge. Limestone-free segments W8, W9, W11 and W12 include 450 m of old paths situated just below the bog, upright to the main track. Segments W2 to W5 intersect the very bog, segments W1 and W10 traverse mineral bedrock in the length of 340 m, segment W6 consists entirely of allochthonous material, and segments W7, W8, W9, W11 and W12 are situated on transient sites between bog and mineral bedrock just above the floodplain of the brook.

METHODS

In order to reveal the effect of limestone-paved track in the bog we have analysed three items: sequential aerial photographs, chemical composition and occurrence of plant species. The aerial photographs from 1949, 1962, 1982, 1994 and 1999, provided by Vojenský topografický ústav Dobruška, were used for evaluation of long-term changes around the track. Both chemical and plant composition were analysed repeatedly in 1996 and 2000, in order to estimate short-term changes.

Chemical analyses

Soil samples were taken in September 20, 1996 and on May 23, 2001 from the two 10 m-long transects placed across the track and its nearest surroundings (Fig. 3); in 2001 the central part of the track crown could not be re-analysed as it was already pitched by asphaltic bitumen. Surface layer down to 0.05 m below the plant carpet was scraped in even volumes, every 0.1 m along the analysed part of the transect. Fine earth after air-drying was analysed for $pH_{aq.}$, pH_{KCl} and Ca^{2+}, Mg^{2+}, K^+, Na^+ by AAS in flame after extraction by NH_4 OAc at pH=7.0 (chemical laboratory of Institute of Botany, Czech Academy of Science). Exchange capacity was assessed as sum of cations Ca, Mg, K and Na.

Water in the ditch was sampled on 5 microsites in August and September 2000 and on 7 microsites in May 23, 2001 (Fig. 2). Bog water was sampled on 8 microsites from lagg to mire expanse on June 14, 2001. Conductivity and pH were assessed *in situ* by multimeter WTW multiline P4 with pH elektrode SenTix 41 and conductivity sensor TetraCon. Assessment of Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-}, $N\text{-}NO_3^-$ were carried by common hydrochemical methods in Laboratory of Water Management for Vltava Catchment in Plzeň, and by laboratory of Agency for Nature and Landscape Protection of CR in Brno, in 2000 and 2001, respectively.

Plant composition

Cyanobacteria and algae were sampled in August and September 2000, from five selected microsites, where waters meet from the bog and from beneath the limestone track. Water for the abovementioned chemical analyses was taken here as well. The biological material was analysed by means of standard algological procedures (HINDÁK & al. 1978). Samples were observed *in vivo* by light microscope Lambda with computer image analysis of JVE, and afterwards fixed by formaldehyde. If diatoms were present, permanent pleurax preparations were used for determination (FOTT 1954).

Inventories of higher plants in field were carried out in 1989 (brief inventory of vascular plants), 1996 (vascular plants including their abundance) and 2000 (bryophytes, abundance of vascular plants). Altitudinal maxima for the Czech Republic were identified after consulting of Květena ČR (HEJNÝ & SLAVÍK 1988, 1990, 1992, SLAVÍK 1995, 1997, 2000), HUSÁKOVÁ

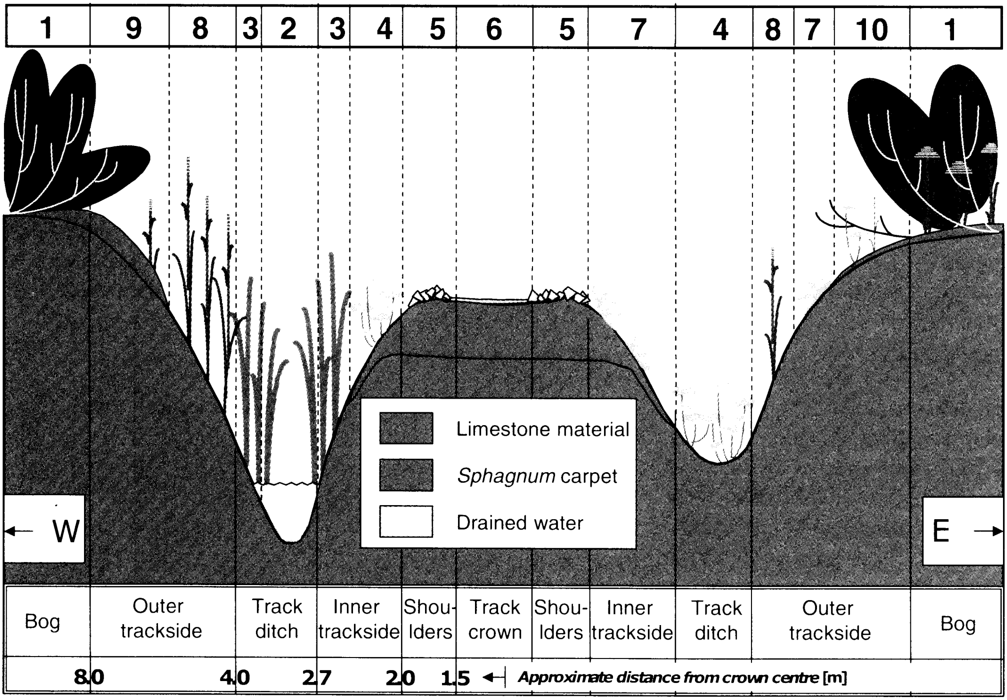

Fig. 3. – Schematic cross-section of 20 m through the limestone-paved track in the Rokytecká mire. *Explanations*: 1– bog krummholz with penetrating forest species, 2 – algae of drainage ditch, 3 – emergent macrophytes, 4 – perennial invaders, 5 – bare coarse limestone gravel, 6 – bryophytes on fine limestone gravel, 7 – annual invaders, 8 – died-off *Sphagnum* with forest species (*Calamagrostis villosa*), 9 – declining *Sphagnum russowii*, 10 – loose mixture of perennial forbs and graminoids.

Obr. 3. – Schematický cca 20metrový průřez napříč vápencovou cestou, která prochází Rokyteckou slatí. *Vysvětlivky*: 1– rašeliništní kosodřevina s pronikajícími lesními druhy, 2 – odvodňovací příkop s řasami a sinicemi, 3 – emergentní makrofyta, 4 – vytrvalé šířící se druhy, 5 – neosídlený hrubý vápencový štěrk, 6 – mechorosty na jemném vápencovém štěrku, 7 – jednoleté šířící se druhy, 8 – odumřelé rašeliníky s lesními druhy (*Calamagrostis villosa*), 9 – odumírající *Sphagnum russowii*, 10 – řídká směsice vytrvalých dvouděložných a graminoidů.

(1984), MÁLKOVÁ (1992) and PROCHÁZKA & KOVAŘÍKOVÁ (1999). Nomenclature follows NEUHÄUSLOVÁ & KOLBEK (1982).

To assess the abundance of plants along the track, standard phytosociological sampling could not be applied. Therefore frequency of species was noted in individual segments (Fig. 2) on both tracksides, in belts of 2 m in width. The abundance scale was applied according to HEJNÝ & al. (1973): 1 – very rare, 2 – rare, 3 – scattered, 4 – frequent, 5 – abundant. On the basis of phytosociological and floristic knowledge of the broader Bohemian Forest and its surroundings, plant species were classed as (i) species native for mires of Bohemian Forest (even from lower altitudes), (ii) forest species – coming from the surrounding montane forests and clearings, (iii) species from oligotrophic grasslands, (iv) species from mesotrophic grasslands, (v) ruderal species, and (vi) subthermophilous immigrants (including calciphilous species); see Appendix 2.

For evaluation of changes in composition and abundance of vascular plants between 1996 and 2000, multivariate statistical methods were applied in the programme CANOCO (JONGMAN & al. 1995). Occurrence of species in various segments of the track was evaluated by PCA, changes in time were analysed by CCA analysis.

RESULTS

Track morphology and its effect

The limestone track crosses the northern area of the bog complex in its narrowest position in the direction to Javoří pila (Fig. 2). To the west of the track, the most valuable part of the bog is characteristic by its patterning. Comparison of aerial photos taken in 1949 and 1999 suggests that the upper eastern part is loosing its original bog character and is becoming drier (Fig. 4). Individual segments distinguished for the track coincide with the changes in the adjacent bog parts as follows: Surroundings of W2 were penetrated by spruce wood, most prominently after 1982. An open centre westwards W3 became completely wooded by dense *Pinus* × *pseudopumilio* krummholz, and a deep bog-lake developed from a shallow pool. East of the segment W4, placed on the steepest slope, drainage triggered dramatic change: the bog became completely forested by Norway spruce. Segment W5 comprises the bottom part of the bog, which altered prominently after 1949 both due to the track's impact and progressive succession. Eastwards, the impact of low water level is more prominent, krummholz is denser and a new bog-lake appeared. W7 is a little crossroads and a parking site, with washed out

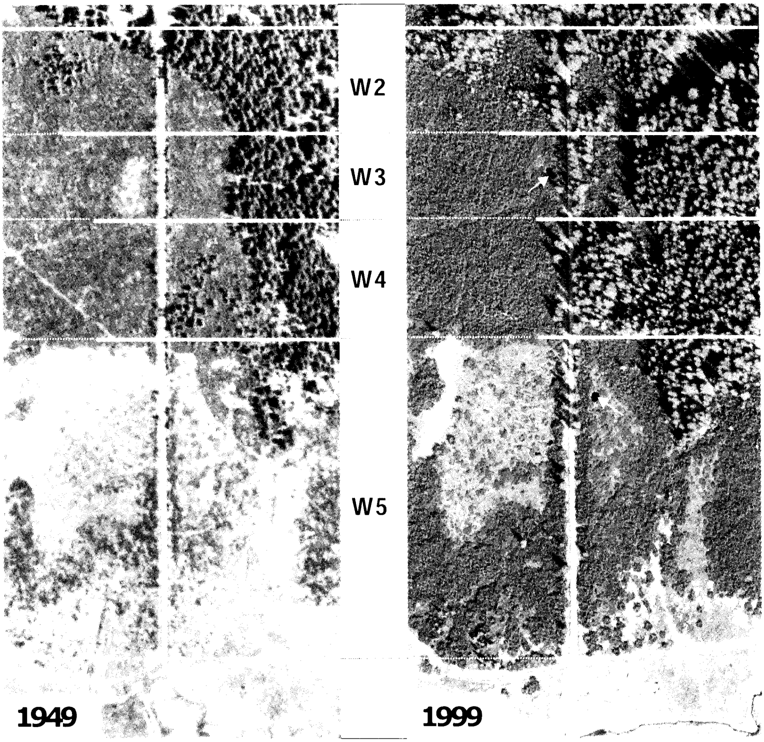

Fig. 4. – Changes of bog near the limestone track through Rokytecká slať after 50 years of its existence and their relation to segments W2 to W5. Bog eastwards the track is retreating due to serious change of hydrological regime. Arrows point to newly arisen bog lakes.
Obr. 4. – Změny rašeliniště v blízkosti vápencové cesty procházející Rokyteckou slatí po 50 letech její existence a návaznost na studované úseky W2 až W5. Rašeliniště situované východně od cesty degraduje v důsledku vážného pozměnění hydrologického režimu. Šipky ukazují na nově vzniklá rašeliništní jezírka.

limestone gravel, which represents a segment with the effect of limestone only since the early eighties.

Segments W8, W9, W11 and W12 include old limestone-free tracks built on ancient fen, which have been occasionally used by walkers in the past 10 years. Segment W8 was not almost used in the last 10 years and is covered by the tussocks of *Nardus stricta*. Segments W1 and W10 cross mineral grounds above the bog; the former serves as an occasional parking site or for storage of trees and does not contain limestone. Segment W6 is an artificial embankment composed of mineral substrate built about 15 years ago.

On the cross-section, the track includes 10 microhabitats (Fig. 3). Before autumn 2001, the track crown was covered by fine-grained limestone, which provided "suitable" environment for bryophytes and a few annual species. Both shoulders were formed by coarse limestone, an environment less hospitable for the establishment of plants. In late autumn 2000, the track crown was pitched by asphaltic bitumen and both kinds of microhabitats were covered by this new material.

Tracksides are inclined both side to the ditch. Western ditch is 0.9 m deep, filled by streaming water and covered by emergent macrophytes. Its slopes are rather steep, coarse gravel in the upper part of the inner trackside is occupied by perennial invaders (Fig. 1). Eastern ditch is shallow, mostly wet but lacking open water. As whole, it provides suitable environment for perennial invaders. In the upper part of the trackside slope, annual invaders are established. Original surface of the bog is situated higher than the surface of track. Where *Sphagnum* died off due to the limestone influence on the outer trackside, bare peat is occupied by perennial grasses and forest forbs, namely by *Calamagrostis villosa* and *Senecio nemorensis*. In the upper part of the outer trackside, where acrotelm has not been completely excluded yet, luxuriant shrubs of *Vaccinium myrtillus* are developed. Under the krummholz stands, moss carpets of *Sphagnum russowii* are present already.

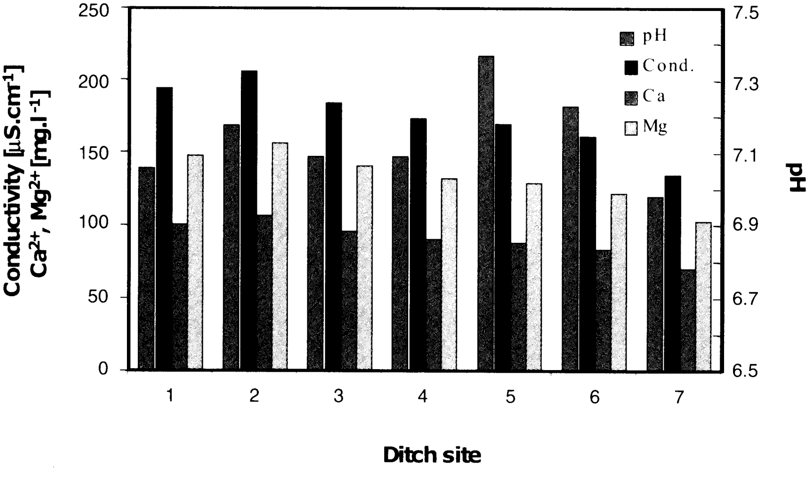

Fig. 5. – Chemical parameters of water sampled upwards the ditch along the track paved by limestone in the Rokytecká mire on May 22, 2001.

Obr. 5. – Chemické složení vody v příkopu vzhůru podél vápencové cesty procházející Rokyteckou slatí ke 22. květnu 2001.

Table 1. – Comparison of chemical content of water in bog an that sampled in the ditch along the limestone-paved track through the Rokytecká mire in August/September 2000 from sites where composition of cyanobacteria and algae was analyzed.

Tabulka 1. – Srovnání chemického složení vody odebrané v srpnu a září 2000 na rašeliništi (bog) a v příkopu (ditch) podél vápencové cesty Rokyteckou slatí v místech, kde byla analyzována skladba sinic a řas.

	Unit	**Bog**	**Ditch**
pH		4	6.7–7.2
Conductivity	$\mu S.cm^{-1}$	48	151–2.7
Ca	$mg.l^{-1}$	<5.0	45
Mg	$mg.l^{-1}$	<3.0	<3.0
$N\text{-}NO_3^-$	$mg.l^{-1}$	2	0.8
Cl^-	$mg.l^{-1}$	<5.0	<5.0
SO_4^{2-}	$mg.l^{-1}$	<5.0	<5.0

Chemical composition

Water in the ditch between the track and bog became highly minerotrophic. In comparison with the bog, pH in the ditch water increased from about 4–4.2 up to 7–7.3, conductivity from 24–48 $\mu S.cm^{-1}$ up to 150–230 $\mu S.cm^{-1}$, concentration of Ca^{2+} from 1–2.5 $mg.l^{-1}$ to about 200 $mg.l^{-1}$ (in spring) and that of Mg^{2+} from 0.3–0.7 $mg.l^{-1}$ to about 150 $mg.l^{-1}$ (in spring). Concentrations of both cations in the ditch were higher in spring. Concentration of nitrates, Cl^- and SO_4^{2-} in the ditch did not show any substantial change (Table 1).

Water trophy in the ditch raises gradually downwards the slope: conductivity from 135 to 206 $\mu S.cm^{-1}$, Ca^{2+} from 70 to 107 $mg.l^{-1}$, Mg^{2+} from 103 to 156 $mg.l^{-1}$ and pH from 7 to 7.2 (Fig. 5). The highest values of pH of almost 7.4 were found in the steepest sites of a ditch occupied by *Juncus effusus*; luxurious stands of *Carex rostrata* occurred on sites with less streaming water where pH was lower (about 7.1).

Mineral composition of soil is heavily affected by limestone. In 1996, pH value of the track crown reached to 8.1. This value decreased gradually with the increasing distance from the track centre (Table 2) so that in the outer trackside of the top transect, pH reached already values less than 5. Outer trackside of the bottom transect is more affected and pH decreases only beneath the krummholz in the zone with declining *Sphagnum*. Exchange capacity was higher in 2000 than in 1996. Its values in bottom transect BT were higher than in the top transect TP. They increased gradually from the track crown to the maximum in the outer trackside at the distance of 4 to 5 m far from the track.

Distribution of calcium and magnesium in soil is more complicated. Their contents gradually increased from the track crown across the inner to outer trackside. In the bottom transect, the highest contents of Ca and Mg (1110.5 and 34.4 mg/100 g dry soil, respectively) were found in the dense stands of *Calamagrostis villosa* (zone 8 in Fig. 3), and even at bog surface beneath krummholz with the acrotelm, the respective contents reached about 150 and 20 mg/ /100 g dry soil. Namely the content of Mg is maintained relatively high even beneath the krummholz. This resulted due to wind allocation of limestone in the form of tiny dust, which cause more rapid enrichment of the soil than the coarse gravel (Table 2). A really high Na content was found in the ditch bottom in 1996 and was accompanied by lower Ca content.

Table 2. – Cation content and acidity of substrates sampled in 1996 (September 20) and 2001 (May 23) in the neighbourhood of the limestone-paved track in Rokytecká mire. **DIST** [m]: transversal distance from the center of track; W3, W5, W7, W8, W9: track segments (see Fig. 1); *TT, BT*: – top and bottom transects across the track. **POSITION** – see Fig. 3.

Tabulka 2. – Obsah kationtů a acidita substrátu odebraná v transektech napříč vápencovou cestou na Rokytecké slati opakovaně 20. září 1996 a 23. května 2001. **DIST** [m]: příčná vzdálenost od středu cesty, W3, W5, W7, W8, W9: úseky cesty viz obr. 1; *TT, BT*: – horní (ve W3) a dolní transekt (ve W5) napříč cestou (umístění viz Obr. 1). **POSITION** – viz Obr. 3.

POSITION	**DIST.**	**Year**	**PLANT COVER** (prevailing)	**pH**$_{aq.}$	**pH**$_{KCl}$	**Ca**	**Mg**	**K**	**Na**	**exch.c.**
						mg/100g				mgeq/100g
Crown	*0.0 - 1.5*	1996	bryophytes	8.1	8.05	507.15	6.42	0.88	0.12	25.86
Shoulder		1996	annual and perrennial invaders	7.7	7.3	464.71	5.94	3.52	0.97	23.81
W3 *TT*	*1.5 - 1.8*	2001	annual invaders	8.0	7.6	818.96	8.36	22.65	1.27	42.19
Inner trackside *TT*	*1.8 - 2.3*	2001	perrennial invaders	7.9	7.5	846.89	10.60	24.57	0.45	43.78
W5 *BT*	*1.3 - 2.0*	2001	perrennial invaders	7.9	7.7	816.06	8.92	22.04	0.38	42.04
Ditch bottom		1996	*Molinia coerulea, Carex rostrata*	4.5	4.0	379.45	21.97	72.02	13.68	23.18
W3 *TT*	*2.3 - 2.7*	2001	*Carex rostrata*	7.8	7.3	556.31	10.33	21.21	0.85	29.19
W5 *BT*	*2.1 - 2.7*	2001	*Carex rostrata*	7.6	7.3	887.14	11.80	24.62	1.28	45.92
Outer trackside		1996	*Calamagrostis villosa*	7.9	7.4	490.33	7.07	3.88	0.73	25.18
W3 *TT*	*2.7 - 4.0*	2001	*Calamagrostis villosa*	4.9	4.0	139.38	17.04	44.53	1.65	9.57
W5 *BT*	*2.7 - 4.0*	2001	*Calamagrostis villosa, Senecio nemorensis*	7.3	7.1	920.08	14.78	35.30	0.61	48.06
W5 *BT*	*4.0 - 5.2*	2001	spreading *Calamagrostis villosa*	6.6	6.2	1110.50	34.44	51.52	4.19	59.75
Krummholz *BT*	*5.3 - 8.8*	2001	disturbed acrotelm, *Calamagrostis* solely	4.4	3.6	189.44	23.64	88.94	1.33	13.73
Bog *BT*	*8.8 - 10*	2001	*Sphagnum, Vaccinium myrtillus, V.vitis-idaea*	4.0	3.0	146.86	19.95	88.77	1.79	11.32
W7		2001	loose *Festuca rubra, Agrostis capillaris*	7.9	7.7	777.56	8.03	17.80	0.35	39.93
W9		2001	partly closed *Agrostis capillaris*	7.0	6.0	143.44	4.98	38.14	0.44	8.56
W8		2001	*Nardus stricta*	4.7	3.7	40.10	7.17	44.65	0.99	3.78

Plant bioindicators

Cyanobacteria and algae

Number of species and their distribution along the track ditch differs substantially from those in the surrounding bog. In the whole Rokytecká Mire, 86 species have been observed, however, only half of this number has been found in the track ditch inside the bog (Appendix 1) and 13 species were common for both the bog and the track.

In the composition of bog, Chlorophyceae and Zygnematophyceae prevail, being accompanied by Cyanobacteria and some diatoms. Along the track, predominance of diatoms is striking (Fig. 6). Most common feature is the cyanobacterium *Leptolyngbya foveolarum*, which was found also in the disturbed part of Hůrecká Mire affected by limestone (Soukupová & al. 1998). Algae *Achnanthes affinis, A. flexella, Achnanthes* sp., *Caloneis silicula, Cymbela gracilis, Gomphonema olivaceum, Navicula radiosa, Pinnularia subcapitata, Closterium acerosum, Cosmarium hornavanense* and *C. subcostatum* belong to species alien to bogs.

Bryophytes

The limestone track is occupied by a number of bryophytes which are alien not only to the bog and neighbouring Norway spruce forests, but to the Bohemian Forest as a whole. The

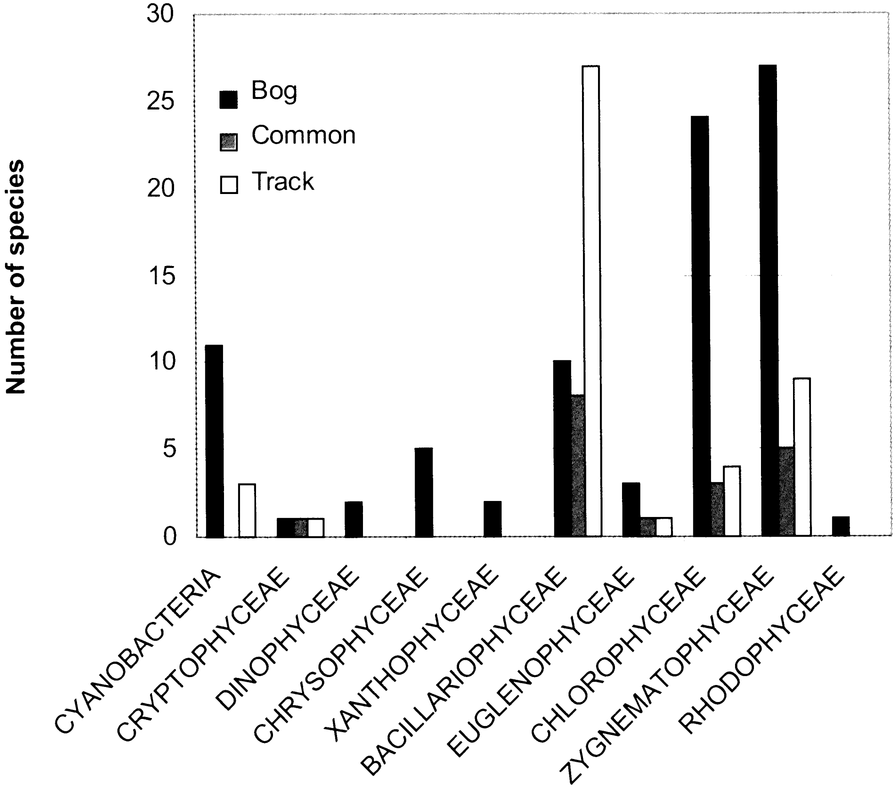

Fig. 6. – Basic comparison of composition of blue-greens and algae in the very bog and in the ditch along the limestone-paved track crossing the bog Rokytecká Mire. For details see Appendix 1.

Obr. 6. – Základní porovnání skladby flóry sinic a řas na nenarušeném rašeliništi a v příkopu podél vápencové cesty procházející rašeliništěm Rokytecká slať. Podrobně viz Příloha 1.

track in Rokytecká mire is not built of compact limestone gravel like that in Hůrecká Mire (SOUKUPOVÁ & al. 1998) and therefore its impact due sprinkling reaches rather far beyond the track itself. Heavy trucks sprinkle the limestone mud and air-whirls blow the tiny dust several meters far into the bog (Table 2), where the *Sphagnum* mosses die off due to their enormous sensitivity to alkaline substances.

Diversity of bryophyte species along the track is rather high, three distinct groups can be distinguished according to their environmental relationship. First group are native species that are able to withstand the change of acidity or they occur on microsites unaffected by limestone. It includes common species of bogs and/or surrounding forest (*Dicranum scoparium*, *Pleurozium schreberi*, *Barbilophozia floerkei*, *Barbilophozia lycopodioides*, *Sphagnum* sp. div.) as well as species of forest clearings and wet grasslands (such as *Brachythecium rutabulum*, *B. salebrosum*, *Rhytidiadelphus squarrosus*).

The next group are invasive species, which spread along the tracks or ditches. They are not strict calciphytes, however, many of them may appear on microsites with rather high pH or may co-occur together with strictly basiphilous species: *Brachythecium albicans*, *Bryum creberrimum*, *B. pallens*, *B. pseudotriquetrum*, *Hypnum lindbergii*, *Philonotis fontana* or liverwort *Marchantia polymorpha* subsp. *ruderalis*.

The last group of strict calciphytes is represented by 4 to 5 species: *Barbula unguiculata* (the species prefers alkaline substrates, but it might be met also outside them), *Didymodon fallax*, *Ditrichum flexicaule* f. *densa*, *Encalypta streptocarpa*, and liverwort *Pellia endiviifolia*. Three of these species were found also in Hůrecká Mire, while *Didymodon fallax*, and *Pellia endiviifolia* are missing there. In contrast, *Tortella inclinata*, frequent in Hůrecká Mire, has not been found in Rokytecká Mire. Both *Didymodon fallax* and *Tortella inclinata* are alien in the native bryoflora of the Bohemian Forest. The former species was observed in mortar joints of ancient touristic chalet beneath the Svaroh summit as a new finding for the Bohemian Forest in 1995, however, the site is secondary. According to the available information, *Pellia endiviifolia* has not been observed in the Bohemian Forest so far.

All the mentioned calciphyte species were brought to the locality with the imported limestone, like in the case of Hůrecká Mire. Only solely sporophytes, spores as well as other diaspores were observed in all the mentioned species (most often, though rarely were found by *Didymodon fallax*).

Vascular plants

From the total number of 177 species found along the track in 1996 and 2000, only less than 11% are native in communities of the adjacent bog, fen and waterlogged spruce forests. The remaining 157 species are alien to mountain mires. About 11% of species entered from the surrounding forests and their clearings. Almost half of species arrived from grassland communities, especially from oligotrophic grasslands of both the higher and lower altitudes (30%), less species came from nutrient richer grasslands of lower elevations (13%). Of great importance for the biodiversity deterioration in the Rokytecká Mire is massive spreading of ruderal species, which represent 30% of the species observed along the track. Serious change of environment is expressed by the occurrence of basiphilous (*Sanguisorba minor* and *Poa compressa*) or even of rather calcicolous species, such as *Linum catharticum*, *Ajuga genevensis*, *Vicia sylvatica*; and also of subthermophilous species, e.g. *Cardaminopsis arenosa*, *Verbascum nigrum* (Fig. 1). Eight species reached here new altitudinal maxima for the Czech Republic: *Galium verum*, *Astragallus glycyphyllos*, *Chelidonium majus*, *Clinopodium vulgare*, *Euphrasia nemorosa*, *Viscaria vulgaris* and *Calamagrostis epigejos*. Most of these subthermophilous species is met in the segments W2, W3, W4, W5 and W7, situated inside the bog. Only *Clinopodium vulgare* was found along the track in the spruce forest on mineral.

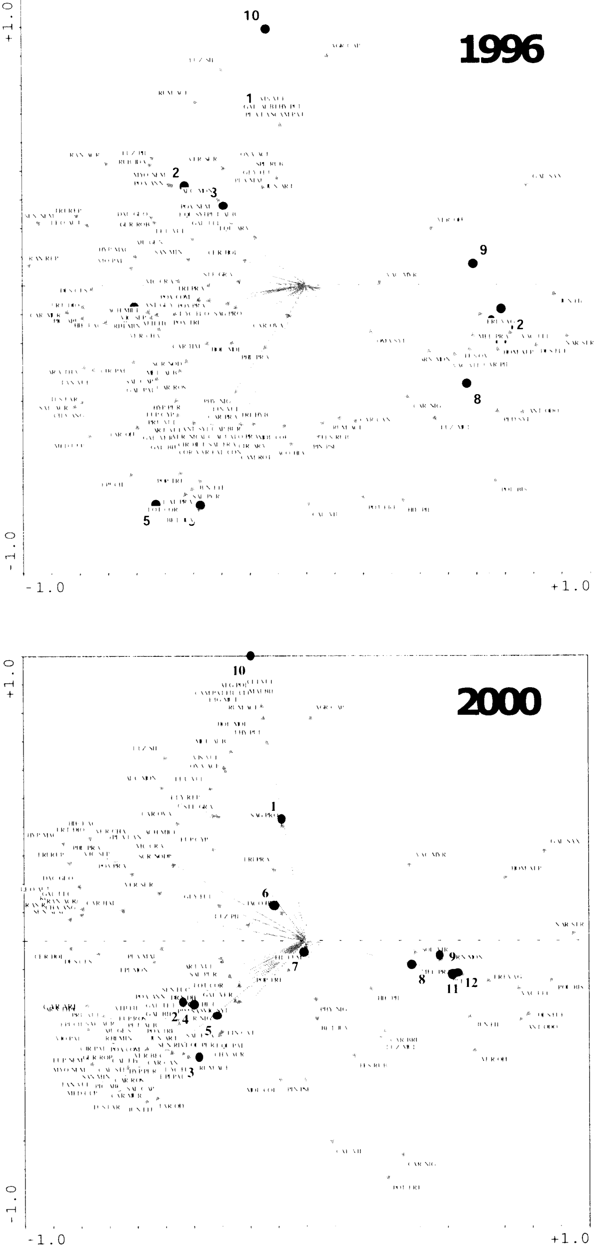

Fig. 7. – Track segments (circles 1 – W1, 2 – W2 etc.) ordinated by PCA for 1996 and 2000 according to the linear response of vascular plants (lines with arrows); plant abbreviations include first three letters of genus and species given in Appendix 2).

Obr. 7. – Ordinace PCA úseků cesty (plné body 1 – W1, 2 – W2 až 12 – W12) pro roky 1996 a 2000 na základě lineární odpovědi cévnatých rostlin (průměty se šipkami); zkratky rostlin jsou utvořeny vždy z prvních tří písmen rodového a druhového jména uvedeného v Příloze 2.

Spatial differentiation along the tracks

Individual segments of the track differed according to the presence of limestone on the track. PCA ordinations based on species abundance in 1996 (Fig. 7: top) and 2000 (Fig. 7: bottom) ordered the segments unpaved by limestone (W8, W9, W11 and W12: positive values of 1st axis) separately from those paved by limestone (W10, W1 to W6). The number of species along the segments paved by limestone, attained to 76.5±18.7 (mean±s.d.), which was twice as high as the number along segmentt unpaved by limestone (40.2±17.0: Table 3).

Track segments unpaved by limestone and lacking deep ditch (W8, W9, W11 and W12) are marked by the appearance of species from oligotrophic grasslands (*Nardus stricta, Polygonum bistorta, Arnica montana, Anthoxantum odorata, Veronica officinalis, Carex pilulifera*), bog species (*Vaccinium uliginosum, Eriophorum vaginatum, Melampyrum pratense*), species of fens (*Juncus filiformis, Pedicularis sylvatica*) and several species of surrounding forests (*Deschampsia flexuosa, Homogyne alpina, Galium saxatile, Solidago virgaurea, Omalotheca sylvatica*).

Species composition of limestone-paved track differed between those segments crossing the bog itself (W2 to W5) and those on mineral ground (W1, W10, W6, W7). Limestone segments across mineral soil area are accompanied mostly by common species of path margins in Bohemian Forest, such as *Rumex acetosella, Campanula patula, Thymus pulegioides, Vis-*

Fig. 8. – *Rubus idaeus* on the outer trackside of the limestone-paved track in Rokytecká mire (segment W2) as an example of penetration of species from the surrounding forests and clearings to the bog (August 2, 2000, photo by P. Husák).

Obr. 8. – *Rubus idaeus* na vnějším zářezu vápencové cesty Rokyteckou slatí v úseku W2 jako příklad pronikání lesních a pasekových druhů na rašeliniště.

Table 3. – Changes in occurrence of vascular plants and their frequency along the tracks in Rokytecká mire between 1996 and 2000.
Tabulka 3. – Charakter a četnost změn ve výskytu a abundanci cévnatých rostlin na různých úsecích cest Rokyteckou slatí zjištěných v rozmezí let 1996 a 2000.

	Limestone-paved								**Limestone-free**			
	mineral				bog							
Track segment W	10	1	6	7	4	2	3	5	9	11	12	8
newly arrived	26	4	11	25	37	34	46	25	6	0	3	4
spreading	3	2	1	-	7	4	8	4	0	3	4	4
retreating	2	6	8	-	7	1	3	7	1	2	1	8
died-off	4	6	26	4	10	5	6	13	0	7	0	33
no change	26	34	43		39	36	22	41	17	15	22	19
Total No. of species	61	52	89	44	100	80	85	90	24	27	30	68

caria vulgaris, Oxalis acetosa, Ligusticum mutellina, Filaginella uliginosa, and *Clinopodium vulgaris* (positive values of 2nd ordination axis).

Limestone segments inside the bog (W2 to W5) are occupied by a great variety of species. Apart from ruderal species, like *Tussilago farfara, Tanacetum vulgare, Epilobium ciliatum, Galeopsis bifida, G. tetrahit, Artemisia vulgaris, Taraxacum officinale, Calamagrostis epigeios, Geranium robertianum,* surprisingly a high number of subthermophilous species grows here (*Linum catharticum, Coronilla varia, Galium verum, Verbascum nigrum, Melilotus albus, Hypericum perforatum*). Moreover, several forest and clearing species (*Senecio nemorensis, S. fuchsii, Athyrium filis-femina, Dryopteris dilatata, Chamerion angustifolium, Rubus idaeus*) occur preferentially along these track segments (Fig. 8).

Changes between 1996 and 2000

Migration in segments

During the investigated four years, presence of species on the track displayed remarkable shifts: altogether 29 new species immigrated and 19 species disappeared between 1996 and 2000. The establishment of immigrants differed among the segments (Table 3). Limestone segments in the bog were species-richest by the newly arrived species (mean±s.d.: 39±7.5), and even limestone segments on mineral area were invaded by rather high number of species (16.5±9.3). On limestone-free segments, appearance of new species was scarce (3.3±2.2). Number of declined species was similar in all kinds of segments (7.0±3.2, 10.0±9.3, 10.0±13.6, respectively) suggesting that relatively most species disappeared in the limestone-free segments, and relatively most species survived on the limestone segments of the bog.

PCA based on species composition in 1996 ordered the limestone segments one after the other regardless the bedrock, according to the direction from where the species were coming, i.e. from W10, through W1, W2, W3, W4, W5 to W6 (Fig. 7: top). In 2000 (Fig. 7: bottom), the limestone segments from the bog (W2 to W5) were ordered separately from those on the mineral bedrock (W6, W7, W1 and W10). This suggests that before 1996 the immigration process prevailed along the limestone track, while in 2000 the distribution of species coincided more with the suitability of the colonised environment. A remarkable change in ordination is obvious for segment W6 that was built completely of allochthonous material and was noted by conspicuous turnover of species.

CCA ordination of data on change in the species abundance from both 1996 and 2000

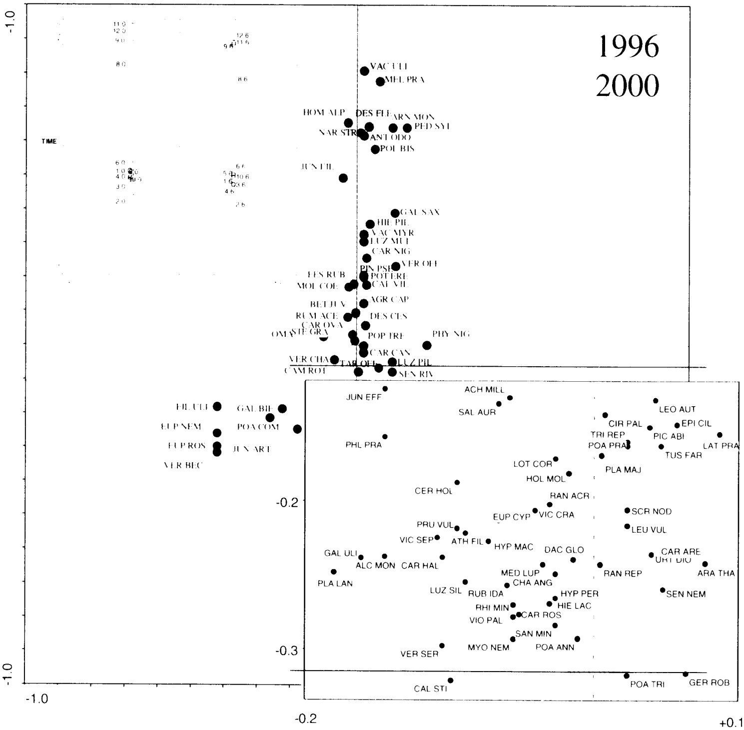

Fig. 9. – CCA ordination of changes in the studied segments of the limestone-paved track across Rokytecká Mire between 1996 and 2000 based on abundance of vascular plants. In the upper left corner, the ordination of the track segments W1 to W10 is given: 1.6 – position of segment W1 in 1996; 1.0 – its position in 2000 etc. The change in occurrence of species in the shaded area new was not important. For better resolution the section in the right bottom is magnified. Abbreviations of plants include first three letter from both the genus and species names given in Appendix 2. For futher explanation see text.

Obr. 9. – Ordinace CCA na základě abundance cévnatých rostlin zachycuje změny mezi roky 1996 a 2000 ve studovaných úsecích vápencové cesty procházející Rokyteckou slatí. V levém rohu nahoře je promítnuta ordinace úseků cesty W1 až W12 v letech 1996 a 2000, přičemž označení 1.6 udává pozici úseku W1 z r. 1996, označení 1.0 pak jeho pozici z r.2000 atd. Uvnitř šedě podložené plochy byly změny ve zastoupení druhů minimální. Kvůli lepšímu rozlišení je část vpravo dole zvětšena. Zkratky rostlin se skládají z prvních tří písmen rodového a druhového jména uvedeného v Příloze 2. Podrobněji viz text.

(Fig. 9) confirmed again that the limestone-paved segments differed from limestone-free segments (W8, W9, W11, W12). The latter are marked by the rather stable occurrence of originally bog species *Vaccinium uliginosum* and *Melampyrum pratense*, and of the group of species, which are stable and abundant here and occasionally enter other segments (*Nardus stricta, Pedicularis sylvatica, Deschampsia flexuosa, Anthoxanthum odoratum, Polygonum bistorta, Homogyne alpina,* and *Arnica montana*). Most of these species are character plants of acidic grassland communities of the alliance *Violion caninae* Schwickerath 1944. *Juncus filiformis, Carex nigra, Hieracium pilosella,* and *Vaccinium myrtillus* represent the species, which apart of their occurrence in limestone-free segment are penetrating to the limestone-paved segments in bog.

Limestone-paved segments were ordinated together and the intensity of spreading follows first axis of CCA ordination. Negative values of the first axis corresponds to the new immigrants prevailingly to bog segments, such as *Veronica beccabunga, Euphorbia nemorosa,* *E. roskoviana, Fillago uliginosa, Galeopsis bifida, Poa compressa, Juncus articulatus, J. effusus, Phleum pratense, Galium uliginosum,* and *Plantago lanceolata*. Moreover, the ordination suggests the shift in species composition from prevalence of tall ruderal species in 1996 (positive values of 1st axis) to species of oligo- and mesotrophic grasslands in 2000. This agrees with the general trend of succession along roads and tracks, which was mentioned also by HUSÁKOVÁ & ŠPATENKOVÁ (1999).

Species dynamics (see Appendix 2)

Among the newly appeared species native to mires, most of them were represented by species of minerotrophic fens and laggs (e.g., *Carex rostrata, C. canescens, C. echinata, Calycocorsus stipitatus*); on the segments outside the bog they were not present or even retreated. Species from this group were most often found as new findings in the limestone-free segments adjacent to the bog, however, their turnover (arrival of new species versus disappearance of old species) was high. Retreat and disappearance of species from this group prevailed along the mineral segments (e.g., *Carex nigra, C. canescens*).

For arrival and establishment of species from the surrounding forests and clearings (Fig. 8), the limestone segments within the bog were suitable (e.g., *Rubus idaeus, Chamerion angustifolium, Calamagrostis villosa, Senecio nemorensis, Omalotheca sylvatica*), some of them again later retreated (*Luzula pilosa, Hieracium lachenalii, Homogyne alpina, Poa nemoralis, Melandrium rubrum*). Most of these species occurs on the limestone segments situated on the limestone-free segments outside the bog (e.g., *Calamagrostis villosa, Deschampsia flexuosa* and *Homogyne alpina*). On wind- and cold-exposed sites many of these species again died off (*Rubus idaeus, Senecio nemorensis, Athyrium filix-femina, Salix caprea*).

The group of species derived from oligotrophic grasslands is differentiated among (i) those which are omnipresent, such as *Agrostis tenuis* or *Potentilla erecta,* (ii) those which are new or frequent on the limestone segments, such as *Hypericum maculatum, Galium uliginosum, Achillea millefolium, Stellaria graminea, Luzula multiflora* or *Festuca rubra,* (iii) those which newly arrived only to the limestone segments in the bog, such as *Euphrasia roskoviana, Pimpinella saxifraga, Dianthus deltoides, Hypochaeris radicata, Lychnis flos-cuculi, Epilobium palustre* or *Equisetum palustre,* (iv) those which newly arrived only to the limestone segment on mineral area, such as *Ligusticum mutellina, Thymus pulegioides* or *Holcus mollis*, (v) those which are retreating and/or disappearing from the limestone segments and are common on limestone-free segments, such as *Veronica officinalis, Galium saxatile, Polygonum bistorta, Hieracium pilosella* or *Anthoxanthum odoratum*, (vi) retreating or disappearing species from both limestone-paved (*Cardamine pratensis, Phyteuma nigrum, Arnica montana, Carex muricata* agg.) and limestone-free segments (*Carex pilulifera, Festuca ovina*).

Occurrence and changes in species from the mesotrophic grasslands show higher resemblance: namely *Ranunculus acris, R. repens, Rumex acetosa, R. alpestris, Taraxacum officinale* agg., *Leontodon autumnalis,* and *Veronica chamaedrys* occur on the majority of segments regardless location and substrate. Limestone segments were suitable for new appearence of *Festuca pratensis, Alchemilla monticola, A. acutiloba, Vicia sepium,* and *V. cracca*, those located only in the bog area were newly settled by *Plantago lanceolata, Dactylis glomerata,* and *Leontodon hispidus*, and those only in mineral area by *Filipendula ulmaria* and *Arrhenatherum elatius*. A few species declined (*Lathyrus pratensis* and *Trifolium pratense*).

The remaining two groups of ruderal and subthermophilous species did not arrive to the limestone-free segments at all, and those being present, shortly disappeared. Limestone-paved segments are noted by high turnover in immigration and extinction of species. In general, the limestone-paved segments in the bog area provided more frequently suitable microhabitats for colonization of both ruderal (*Calamagrostis epigejos, Chamomilla suaveolens, Lolium pe-*

renne, Plantago maior, Rumex obtusifolius, Galeopsis tetrahit, G. bifida, Melilotus albus, Salix purpurea, Cerastium holosteoides, Juncus bufonius) and subthermophilous species (*Linum catharticum, Hypericum perforatum, Veronica beccabunga, Vicia sylvatica, Poa compressa*). A few immigrants arrived to limestone-paved segments on mineral, e.g. ruderals *Filaginella uliginosa, Aegopodium podagraria, Elytrigia repens* or subthermophilous *Clinopodium vulgare, Euphorbia cyparissias*. Among the ruderals on the limestone segments, the highest disappearance of newly colonized species was observed, in particular in the mineral area (*Fallopia convolvulus, Capsella bursa-pastoris, Spergularia rubra, Trifolium hybridum*), less in bog (*Anthriscus sylvestris, Equisetum arvense, Heracleum sphondylium, Urtica dioica, Tanacetum vulgare*). Some extinction was also observed among the subthermophilous species, i.e., *Coronilla varia, Astragallus glycyphyllos* in the bog area, and *Cerastium arvense, Linaria vulgaris* in the mineral area.

Dynamics of the spreading

According to the abovementioned comparison, limestone-paved track provides suitable environment for the migration of species. Where the track crosses the bog, the environment is more suitable for the ecesis of newly arrived species, and especially the establishment takes place there of ruderal and subthermophilous species as well as those of oligotrophic grasslands. Retreat of these species is rather low and this implies that most of the immigrants are well established. A higher decline of species was observed only in the cold and windy valley, adjacent to the bog (in segments W8 and W6 disappeared 33 and 26 species, respectively). This implies that the environment inside the disturbed bog provides, apart from the favourable water and nutrient regime, suitable microclimatic conditions supporting plant survival.

Long-term occurrence of some ruderal and subthermophilous species in these elevations can be proved by a comparison with some older floristic data. Vaněček (1972) recorded 6 alien species on the same limestone track about 30 years ago. Half of them were found during our investigations (*Verbascum nigrum, Melilotus albus*, and *Coronilla varia*), but we have not noted *Anchusa officinalis, Echium vulgare*, and *Jasione montana*. In 1989, i.e. 10 years ago, 19 species were observed by Husáková; occurrence of all of them was recorded by our investigations. This shows a high degree of plant survival and suggests that at least some of the species may develop seeds and/or other reproductive organs.

DISCUSSION

Synchronized impact by both drainage and alkaline compounds is a severe threat to natural bogs. While the sole effect of drainage is stepwise and causes long-term degradation of the whole ecosystem, the effect of alkaline substances is immediate. While the former factor brings about shifts in plant communities after decades (Edom & Wendel 1998), the latter becomes evident almost immediately. While the effect of added alkaline compounds might be reversible after their removal (Karofeld 1996), prevention of proceeding drainage enables conservation of only so far undisturbed bog parts (Brooks & Stoneman 1997).

Limestone added to the oligotrophic bogs evokes the change in pH and in calcium (+ magnesium) content. Combination of both these high values is lethal for most acidophilous species and in the near surrounding of the limestone-paved track through Rokytecká Mire the upper limits of pH (5.5) and Ca (2 $mg.l^{-1}$) for *Sphagnum* growth (Clymo 1973, Clymo & Hayward 1982) were surpassed many times in both cases (Table 1, Fig. 4). As a consequence, the affected microsites were marked by a decline of *Sphagnum* carpet and of acidophilous vascular plants, such as *Vaccinium uliginosum, Eriophorum vaginatum, Calluna vulgaris* (Appendix 2). Open peat surface with the added nutrients remains free and "fertilized" for the ecesis of species alien to bogs.

Absence of 1/3 of the common bog plants and more than 80 % of species alien to bogs were observed in mires affected by alkaline air pollution in the Northeast Estonia (Karofeld 1994). Along the limestone-paved track in Rokytecká Mire, the proportion of alien vascular species was even higher (90%), and the absence of common bog blue-greens and algae in the track ditch reached almost 85%. The number of 147 vascular species found along the limestone-paved track across Rokytecká Mire was about the same as that of 140 species noted by Karofeld (1994) in two NE Estonian complexes of Niisaare and Liivjärve Bogs. Also, the immigration of the aliens shows certain similarities despite the difference in biogeographical regions. For example, in both disturbed mire areas the common appearance was observed of *Populus tremula, Chamerion angustifolium, Rubus idaeus, Solidago virgaurea, Angelica sylvestris, Luzula pilosa, L. multiflora, Taraxacum officinale, Calamagrostis epigeios, Tussilago farfara, Urtica dioica, Cirsium heterophyllum, C. palustre, Rumex acetosa, Cerastium holosteoides, Dactylis glomerata, Carex ovalis, Potentilla erecta, Prunella vulgaris, Festuca rubra, Hieracium pilosella*. The comparison proposes that the bog degrading due to alkaline enrichment is generally suitable for establishment of tall herb and ruderal species which are prevailingly well equipped for long-distance anemochoric dispersal.

Rather high proportion of species from oligotrophic grasslands, found along the limestone-paved track in Rokytecká Mire, suggests that their occurrence is related also to the change of hydrological regime. Most of them are clonal plants with tiny seeds which might be easily dispersed by means of transport vehicles. Open unshaded tracksides are suitable for their survival.

Establishment of the subthermophilous species was most probably initiated by their import of the allochthonous material from the limestone quarries at the foothills of Bohemian Forest near Horažďovice, as mentioned already by Vaněček (1972). Their long-term occurrence in these altitudes is obviously enabled by microclimate promoted by the very bog, which warms--up during the summer season (e.g., in early September 1997 the temperature of a bog-lake reached to almost 40°C) and afterwards released slowly the heat so that the first autumnal frosts do not harm the plants (e.g., during September 21, 1997 with monthly temperature minimum of −11.8°C on the Modrava plains, the ground temperature on the Rokytecká Mire fell down only to −0.3°C). Effect of the prolonged season in autumn, caused by heat storage of peat and sheltering against severe winds provided by krummholz, may thus support not only survival of subthermophilous species, but also contribute to improved survival of other alien species and increase probability of their generative reproduction. Meeting of non-native and native taxa may bring about unwanted cross-breeding (Krahulcová & al. 1996) and competitive suppression of original species. Long-term survival of aliens in suitable conditions inside the bog may provide an outlying site for their further disperse to remote biotopes.

We may conclude that the limestone-paved track across Rokytecká Mire due its three-dimensional effect threatens the biodiversity of a valuable bog, belonging to the international network of Ramsar sites. Preservation of the natural biodiversity of this bog is a key priority and the impact of alkaline enrichment and progressing drainage by a track should be prevented. The Administration of the Šumava National Park is urgently recommended to develop a restoration programme that might prevent damage of the supreme value of the national park.

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SOUHRN

Biodiversita horského rašeliniště Rokytecká slať, patřícího k plošně nejrozsáhlejším rašeliništním komplexům „Středoevropské náhorní provincie“ (*sensu* STEINER 1997) je výsledkem delikátního ekologického vývoje, který tu probíhá od pozdního glaciálu. Dlouhodobá existence nenarušeného rašeliniště je neodlučně spjata s udržením převážně ombro-oligotrofního prostředí a trvalého zamokření. Při výraznějším pozměnění obou těchto faktorů dochází k narušení celého ekosystému, včetně rostlinných společenstev. Odvodnění vede k postupujícímu zaklesávání hladiny podzemní vody, které způsobuje nejprve ztrátu akrotelmu, tj. svrchní vodou nasycené vrstvy s rašelinotvornými rašeliníky. S dalším odvodňováním prosýchající rašelina oxiduje a díky mineralizaci se postupně odbourává. V případě přísunu alkalických látek, jako kupříkladu Ca^{2+}, se zvyšuje pH a v důsledku pak opět odumírají rašeliníky (letální je zejména kombinovaný vliv $\mathrm{pH} > 5{,}5$ a koncentrace vápníku > 20 mg.l^{-1}). Oba tyto nežádoucí procesy působí kolem cesty opakovaně zpevňované drceným vápencem procházející rašeliništěm Rokytecká slať. Cílem studie bylo postihnout míru a dynamiku tohoto narušení s ohledem na význam vegetační biodiversity tohoto rašeliništního komplexu.

Průzkum se opíral o floristickou a opakovanou fytocenologickou analýzu řas, sinic, mechorostů a cévnatých rostlin doplněnou o chemické rozbory půdy a vod. K identifikaci výrazných sukcesních změn bylo využito sekvence leteckých snímků z let 1949, 1962, 1982, 1994 a 2000. Dlouhodobé odvodnění hlubokým příkopem svedeným po svahu, blokující působení alochtonního materiálu cestního tělesa a rozptyl drobných vápencových částic vozidly a větrem do okolí, významně pozměnily rašeliništní hydrologii, rašelinotvorný proces i povrchovou morfologii rašeliniště. Od roku 1949 postoupilo šíření smrku dovnitř rašeliniště, zanikla některá otevřená rašeliništní centra, v blízkosti cesty vznikla nová jezírka (Obr. 4). Díky vápenci dosáhlo pH$_{\mathrm{aq.}}$ v půdě až 8,1 a vápník 1110 mg/100 g (Tabulka 2); ve vodě příkopu pak dosáhlo pH až 7,2, vodivost 206 µS.cm^{-1}; koncentrace vápníku 107 mg.l^{-1} mnohonásobně přesahuje letální hodnotu pro rašeliníky (Tab. 1, Obr. 5). Vyvolaný ústup rašeliníků otevřel vhodné mikrohabitaty pro ecesi téměř 200 nepůvodních druhů sinic, řas, mechorostů a cévnatých rostlin. Úseky cesty s vápencem hostily dvakrát více cévnatých rostlin než úseky bez vápence. Mezi mechorosty bylo nalezeno 5 striktně kalcifilních druhů – *Pellia endiviifolia, Didymodon fallax, Ditrichum flexicaule* f. *densa, Encalypta streptocarpa* a *Barbula unguiculata,* přičemž první dva zcela chybí v přirozené skladbě bryoflóry Šumavy. Vodu v příkopu podél cesty obývají hojně rozsivky a sinice *Leptolyngbya foveolarum.* K ecesi mnoha nepůvodních druhů nežádoucích pro rašeliništní biodiversitu došlo ve zhruba 25 m pásu podél cesty, postiženém rozptylem vápencových částic a prachu. Významná je zejména víceletá přítomnost četných subtermofilních druhů, 8 druhů zde v 1100 m n.m. dosahuje svého altitudinálního maxima pro hercynská pohoří ČR: *Galium verum, Astragallus glycyphollos, Chelidonium maius, Clinopodium vulgare, Euphrasia nemorosa, Viscaria vulgaris* a *Calamagrostis epigeios.* K ústupu uchycených druhů dochází jen ve velmi omezené míře: mezi roky 1996 a 2000 bylo na vápencových úsecích cesty uvnitř rašeliniště přítomno v průměru (± s.d) 39±7.5 nově zaznamenaných druhů, zatímco jen 3.6±2.6 druhů ustoupilo. Na základě zjištěného stavu doporučujeme Správě Národního parku Šumava zahájit účinnou asanaci o narušených partií rašeliniště, zejména odstranění vápencového materiálu a úpravu vodního režimu tak, aby nedocházelo k další degradaci biodiversity tohoto unikátního přírodního území zařazeného mezi mezinárodně významné mokřady Ramsarské konvence.

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Appendix 1. – The list of Cyanobacteria and algae found inside the bog Rokytecká mire and on its contact with the limestone track (R1 to R5); x – presence of species.

Příloha 1. – Druhová skladba sinic a řas na rašeliništi Rokytecká slať a na jeho kontaktu s vápencovou cestou (R1 až R5); x – presence druhu.

	Bog	R1	R2	R3	R4	R5
pH	4.0	6.9	6.9	6.9	6.9	6.7
Conductivity (mS/cm)	48	156	221	152	227	151
CYANOBACTERIA						
Aphanocapsa sp.	x					
Aphanothece microscopica NÄG.	x					
Aphanothece sp.	x					
Chroococcus obliteratus RICHTER	x					
Chroococcus subnudus (HANSG.) CRONB. et KOM.	x					
Cyanodictyon turfosum LEDERER	x					
Eucapsis starmachii KOM. et HIND.	x					
Gloeothece rupestris (LYNGB.) BORN. in WITTR. et NORDS.	x					
Hapalosiphon hibernicus W.et G.S. WEST	x					
Leptolyngbya foveolarum		x	x	x		x
Merismoarcus sp.	x					
Merismopedia angularis THOMPSON	x					
Phormidium sp.					x	
Pseudanabaena sp.					x	
RHODOPHYTA						
Batrachospermum vagum (ROTH) AG.	x					
CRYPTOPHYTA						
Cryptomonas sp.	x	x				
Chilomonas oblonga PASCH.	x					
DINOPHYTA						
Gloeodinium montanum KLEBS	x					
Gymnodinium sp.	x					
CHROMOPHYTA						
CHRYSOPHYCEAE						
Bitrichia ollula (FOTT) FOTT	x					
Dinobryon pediforme (LEMM.) STEIN	x					
Gloeochrysis turfosa (PASCH.) BOUR.	x					
Lagynion simplex (FOTT) FOTT	x					
Synura sphagnicola KORŠ.	x					
XANTHOPHYCEAE						
Chlorobotrys cf. *gloeothece*	x					
Chlorobotrys polychloris PASCH.	x					
BACILLARIOPHYCEAE						
Achnanthes affinis		x				
Achnanthes flexella (KUETZING) GRUNOW						x
Achnanthes sp.		x				
Caloneis silicula CLEVE		x				

Appendix 1. – continued
Příloha 1. – pokračování

	Bog	R1	R2	R3	R4	R5
pH	4.0	6.9	6.9	6.9	6.9	6.7
Conductivity (mS/cm)	48	156	221	152	227	151
Cymbela gracilis						x
Cymbela naviculiformis AUERSW.		x				
Cymbella sp.		x				x
Eunotia bilunaris (EHRENB.) GRUN.	x					x
Eunotia tenella (GRUN.) HUST.	x					
Eunotia valida HUST.	x					x
Eunotia sp.	x					x
Fragilaria construens (EHRENB.) GRUN.		x				
Fragilaria leptostauron			x			
Frustulia rhomboides (EHRENB.) D.T.	x	x				x
Gomphonema olivaceum DESMAZIERES		x				x
Meridion circulare AG.						x
Navicula cryptocephala KUETZ		x				
Navicula subtilissima CL.	x		x			
Navicula radiosa KUETZ		x				
Navicula sp.		x				x
Nitzschia sp.		x				x
Pinnularia apendicullata (AG.) CL.	x					
Pinnularia gibba EHRENB.	x	x				
Pinnularia microstauron (EHRENB.) CL.	x	x				
Pinnularia viridis (NITZSCH) EHRENB.		x	x			
Pinnularia subcapitata		x				
Pinnularia sp.	x	x				
Tabellaria flocculosa (ROTH.) KÜTZ.						x
EUGLENOPHYTA						
Euglena acus EHRENB.	x					
Euglena mutabilis SCHMITZ	x	x				
Menoidium sp.	x					
CHLOROPHYTA						
CHLOROPHYCEAE						
Binuclearia tectorum (KÜTZ.) BEGER in WICHM.	x					
Botryococcus pila KOM. et MARVAN	x					
Carteria turfosa FOTT	x					
Chloromonas chlorogoniopsis (ETTL) GERL. et ETTL	x					
Chloromonas sp.	x					
Chlorosarcina sp.	x					
Coccomyxa confluens (KÜTZ.) FOTT	x					
Coccomyxa subglobosa PASCH.	x					
Coccomyxa sp.	x					
Desmococcus vulgaris (NÄG.) BRAND	x					
Eremosphaera viridis DE-BARY	x					
Gloeocystis polydermatica (KÜTZ.) HIND.	x					

Appendix 1. – continued
Příloha 1. – pokračování

	Bog	R1	R2	R3	R4	R5
pH	4.0	6.9	6.9	6.9	6.9	6.7
Conductivity (mS/cm)	48	156	221	152	227	151
Gloeocystis vesiculosa NÄG.	x					
Gloeocystis sp.	x					
Microspora stagnorum (KÜTZ.) LAGERH.	x	x				x
Microspora tenuiderma LOKH.	x					
Microthamnion kützingianum NÄG.	x					
Microthamnion strictissimum RABENH.	x					
Monoraphidium tatrae (HIND.) HIND.	x	x				
Oedogonium itzigsohnii DE BARY	x					
Oedogonium sp. steril.	x	x				
Oocystis solitaria WITTR.	x					
Stigeoclonium sp. juv.						x
Trebouxia cladoniae	x					
Trebouxia sp. div.	x					
ZYGNEMATOPHYCEAE						
Actinotaenium cucurbita (BRÉB. ex RALFS.) TEIL.	x					
Bambusina brebissonii KÜTZ.	x					
Closterium acerosum		x				
Cosmarium hornavanense RUZICKA		x				
Cosmarium obliquum NORDST.	x					
Cosmarium pygmaeum ARCH.	x					
Cosmarium regnellii WILLE	x					
Cosmarium subcostatum NORDST.					x	
Cosmarium sp. div.	x					
Cylindrocystis brebissonii MENEGH.	x	x				
Cylindrocystis crassa DE-BARY	x					
Euastrum binale TURP. ex RALFS	x					
Euastrum gayanum DE-TONI	x					
Euastrum sp.	x					
Mesotaenium chlamydosporum DE-BARY	x					
Mesotaenium macrococcum (KÜTZ.) ROY et BISSET	x					
Mougeotia sp. steril.	x			x	x	x
Netrium digitus (EHRENB.) ITZIGS. et ROTHE	x					
Netrium oblongum (DE-BARY) LÜTKEM	x					
Penium silvae-nigrae RABENH.	x					
Penium sp.	x					
Pleurotaenium minutum (RALFS) DELP.	x					
Spirogyra sp. steril.	x	x	x		x	
Staurastrum crenulatum (NÄG.) DELP.	x					
Staurastrum irregulare W. et G.S. WEST	x					
Staurastrum orbiculare		x				
Staurastrum simonyi HEIMERL	x					
Staurastrum sp.	x	x				

Appendix 1. – continued
Příloha 1. – pokračování

	Bog	R1	R2	R3	R4	R5
pH	4.0	6.9	6.9	6.9	6.9	6.7
Conductivity (mS/cm)	48	156	221	152	227	151
Xanthidium concinnum ARCH.	x					
Xanthidium sp.	x					
Zygogonium ericetorum KÜTZ.	x	x				

Appendix 2. – Species frequency of vascular plants along individual track segments W1 to W12 in 1996 (96) and 2000 (00). Shading in left caption refers to changes in species occurrence and frequency between the studied years. For scale of species abundance see text (Hejný et al. 1973)

Příloha 2. – Zastoupení druhů cévnatých rostlin v jednotlivých úsecích cesty W1 to W12 v letech 1996 (96) a 2000 (00). Charakter stínování vyznačuje změny ve výskytu a zastoupení druhů ve srovnávaném období (new – druhy nové v r. 2000, spreading – druhy šířící se, retreating – druhy ustupující, die off – druhy vymizelé). Stupnice abundance *sensu* Hejný et al. (1973): 1 – velmi vzácné, 2 – vzácné, 3 – roztroušeně, 4 – časté, 5 – hojné.

	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
spreading	10	10	1	1	6	6	7	7	4	4	2	2	3	3	5	5	9	9	11	11	12	12	8	8
retreating	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00
die-off																								
NATIVE TO MIRES																								
Juncus effusus	.	.	.	.	3	.									2	2	.	.	.	.	.	.		
Picea abies juv.	.	.	2	2	2	.	+	1	3	3	2	2	3	3	2	2	.	.	1	1	.	.		
Salix aurita			.	.	3	3	+	3	3	3	3	3	2	3	3	3	.	.	.	.				
Viola palustris			.	.	1	.	.	.	2	3	2	2	2	2			.	.	.	.	.	.	.	.
Carex rostrata	.	.	.	.	.	.	.	.			2	2			3	3	.	.	.	.	.	.	.	.
Juncus filiformis	.	.	2	2	.	.	+	.			.	.					2	2	2	2	3	3	3	3
Carex nigra	3	.	2	.	3	3			3	3					3	3	3	3	3	3	3	3	3	3
Carex canescens	.	.	.	.	2	.	.	.	.	.					.	.	.	.	.	.	.	.	3	.
Calycocorsus stipitatus	.	.	.	.	.	.	.	.	2	2	2	3			.	.	.	.	.	.	.	.	.	.
Carex echinata	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.
Molinia caerulea	.	.	.	.	.	.	.	.	2	2	.	.			3	3	2	2	.	.			2	.
Pinus pseudopumilio juv.	.	.	.	.	1	.	.	.	1	1	.	.	1	2	1	1	.	.	.	.	2	2	1	1
Vaccinium myrtillus	2	2	.	.	1	.	.	.	1	.	.	.					.	.	.	.	2	3	2	2
Betula sp. juv.	.	.	.	.	3	2	+	2	1	2	1	.	.	.	2	2	.	.	.	.	1	2	1	2
Aconitum hians	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Vaccinium vitis-idaea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	2	.
Melampyrum pratense	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	2	1
Vaccinium uliginosum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	2	2	1	2
Eriophorum vaginatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	2	2	.	.
Calluna vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.
FORESTAL																								
Equisetum sylvaticum	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.
Senecio fuchsii	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.
Deschampsia flexuosa	.	.	.	.	.	.	.	.	2	2			.	.	.	.	3	3	3	3	3	3	3	2
Calamagrostis villosa	.	.	2	2	3	2	.	.	3	3	3	3	3	3	4	4	3	3	3	3	3	3	3	3
Senecio nemorensis	3	3	2	2	2	.	.	.	3	3	3	3	3	3	3	3	.	.	.	.	.	.	+	.
Rubus idaeus	2	3	2	2	1	.	.	.	3	3			3	3			.	.	.	.	.	.	+	.
Luzula sylvatica	2	3	2	2			.	.	.	.	2	2	.	.			.	.	.	.	.	.	+	.
Chamerion angustifolium			.	.	2	2	.	.	3	3	2	2	2	2	3	3	.	.	.	.	.	.	+	.
Omalotheca sylvatica			2	2	2	2	+	.									2	.	.	.	.	.	2	2
Epilobium montanum			.	.	.	.	.	.	.	.					.	.	.	.	.	.	.	.	.	.
Oxalis acetosella			2	2	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.
Salix caprea	.	.	.	.	3	.	.	.	3	2			2	2			.	.	.	.	.	.	.	.

Appendix 2. – continued
Příloha 2. – pokračování

	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
spreading	10	10	1	1	6	6	7	7	4	4	2	2	3	3	5	5	9	9	11	11	12	12	8	8
retreating	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00
die-off																								
Athyrium filix-femina	.	.	1	1	1	.	.	.	1	2	.	.	.	1	.	2	.	.	.	.	.	.	.	.
Dryopteris dilatata	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Petasites albus	.	.	.	.	.	.	.	.	.	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.
Populus tremula juv.	.	.	.	.	2	2	+	2	2	2	.	.	.	.	1	.	.	.	.	.	.	.	1	2
Hieracium lachenalii	.	3	.	3	.	.	.	.	3	2	3	2	2	2	3	2	.	.	.	.	.	.	.	.
Luzula pilosa	2	2	2	.	.	.	.	.	2	1	2	2	3	2	2	.	.	1	.	.	2	2	.	.
Homogyne alpina	.	2	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	3	2	3	3	3	2	.
Melandrium rubrum	2	2	.	.	2	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.
Solidago virgaurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Poa nemoralis	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Maianthemum bifolium	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
OLIGOTROPHIC GRASSLANDS																								
Ligusticum mutellina	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thymus pulegioides	3	3	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Holcus mollis	.	2	2	2	3	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Achillea millefolium	3	3	.	.	2	2	.	.	2	2	.	3	.	.	2	2	.	2	.	.	.	.	.	.
Galium uliginosum	3	2	.	3	.	.	.	.	.	2	.	3	.	3	2	2	.	.	.	.	.	.	.	.
Cardaminopsis hallerii	.	3	2	2	.	.	.	.	.	2	.	2	.	.	3	2	.	.	.	.	.	.	+	.
Campanula rotundifolia	.	3	2	2	2	2	.	.	.	4	.	.	.	.	2	2	.	.	.	.	.	.	2	2
Stellaria graminea	3	3	2	2	2	2	.	.	2	2	.	.	.	2	2	2	2	2	.	.	.	.	2	2
Hypericum maculatum	3	3	2	3	2	2	.	2	2	2	.	3	.	3	2	2	.	.	.	.	.	.	+	.
Carex ovalis	3	3	3	3	3	3	.	2	2	2	.	2	.	2	2	2	.	.	.	.	3	2	3	3
Festuca rubra	.	.	3	3	3	3	+	4	2	2	2	2	.	3	2	2	2	2	2	3	2	2	2	2
Luzula multiflora	.	.	2	2	2	.	.	.	2	2	.	.	.	2	1	2	2	2	2	2	2	3	2	.
Cirsium palustre	.	.	2	2	2	2	.	2	3	2	3	3	.	2	2	2	.	.	.	.	.	.	2	2
Prunella vulgaris	.	.	2	2	2	2	.	3	.	2	.	2	.	2	3	2	.	.	.	.	.	.	.	.
Myosotis nemorosa	.	.	2	1	.	.	.	.	2	2	3	3	.	2	.	3	.	.	.	.	.	.	.	.
Juncus articulatus	.	.	1	.	.	.	.	.	.	1	.	2	.	.	.	2	.	.	.	.	.	.	.	.
Rhinanthus minor	.	.	.	.	2	3	.	3	2	2	3	3	.	2	.	.	.	.	.	.	.	.	.	.
Euphrasia nemorosa	.	.	.	.	.	2	.	.	[illegible]	[illegible]	[illegible]	[illegible]	.	3	.	.	.	.	.	.	.	.	.	.
Chaerophyllum hirsutum	.	.	.	.	.	1	.	.	[illegible]	[illegible]	.	.	.	3	.	.	.	.	.	.	.	.	.	.
Lychnis flos-cuculi	.	.	.	.	1	.	.	.	[illegible]	[illegible]	.	.	2	2	.	.	.	.	.	.	.	.	.	.
Epilobium palustre	.	.	.	.	.	.	.	.	[illegible]	[illegible]	.	.	[illegible]	[illegible]	[illegible]	[illegible]	.	.	.	.	.	.	.	.
Lotus corniculatus	.	.	.	.	2	2	.	.	[illegible]	[illegible]	.	.	.	.	2	3	.	.	.	.	.	.	.	.
Pimpinella saxifraga	.	.	.	.	.	.	.	.	[illegible]	[illegible]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Angelica sylvestris	.	.	.	.	.	.	.	.	[illegible]	[illegible]	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veronica serpyllifolia	[illegible]	[illegible]	2	1	.	.	+	3	[illegible]	[illegible]	3	3	.	.	.	.	.	.	.	.	.	.	.	.
Euphrasia rostkoviana	.	.	.	.	.	.	.	.	[illegible]	[illegible]	[illegible]	[illegible]	.	.	.	.	.	.	.	.	.	.	.	.
Hypochoeris radicata	.	.	.	.	.	.	.	.	.	.	[illegible]	[illegible]	.	.	.	.	.	.	.	.	.	.	.	.
Glyceria fluitans	.	.	2	2	.	.	.	.	.	.	[illegible]	[illegible]	[illegible]	[illegible]	.	.	.	.	.	.	.	.	.	.

Appendix 2. – continued
Příloha 2. – pokračování

	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
spreading	10	10	1	1	6	6	7	7	4	4	2	2	3	3	5	5	9	9	11	11	12	12	8	8
retreating	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00
die-off																								
Viscaria vulgaris	2	2	.	.	.	.	.	.	.	.	.	.	■	■	.	.	.	.	.	.	.	.	.	.
Carex brizoides	.	.	.	.	.	.	.	.	.	.	.	.	■	■	.	.	.	.	.	.	■	■	■	■
Equisetum palustre	.	.	.	.	.	.	.	.	.	.	.	.	■	■	.	.	.	.	.	.	.	.	.	.
Galium palustre	.	.	.	.	.	.	.	.	3	.	.	.	■	■	2	2	.	.	.	.	.	.	.	.
Cirsium heterophyllum	.	.	.	.	.	.	.	.	■	■	.	.	.	.	2	.	.	.	.	.	.	.	.	.
Dianthus deltoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	■	■	.	.	.	.	.	.	.	.
Hieracium lactucella	.	.	.	.	.	.	■	■	.	.	.	.	.	.	■	■	.	.	.	.	.	.	.	.
Eriophorum angustifolium	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis sylvatica	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	3	3	3	3
Nardus stricta	2	2	.	.	2	2	+	2	.	.	.	.	.	.	.	.	5	5	4	5	5	5	5	5
Deschampsia cespitosa	5	4	3	3	5	5	3	4	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3
Veronica officinalis	3	.	3	2	3	1	+	.	3	2	2	.	3	2	2	2	3	3	3	3	3	3	3	2
Galium saxatile	3	2	2	2	2	.	.	.	.	.	2	.	2	.	.	.	3	3	3	3	3	3	3	2
Agrostis capillaris	4	4	4	4	3	3	3	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3	3
Potentilla erecta	.	.	2	2	3	3	+	2	3	3	2	2	3	3	3	3	3	3	3	3	3	3	3	3
Polygonum bistorta	.	.	.	.	2	2	.	.	.	.	.	.	.	.	2	.	2	2	3	3	2	3	3	2
Hieracium pilosella	.	.	.	.	3	3	+	.	.	.	.	.	.	.	2	3	.	.	3	3	2	2	2	.
Anthoxanthum odoratum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	2	3	3	2	2	3	3
Arnica montana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	3	3	.	.	.	.	2	1
Festuca ovina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	2	.
Carex pilulifera	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	2	.
Senecio rivularis	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	1	.	.	.	.	.	.	1	.
Phyteuma nigrum	.	.	.	.	1	.	.	.	.	.	.	.	2	.	1	1	.	.	.	.	.	.	1	1
Cardamine pratensis	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex muricata agg.	2	.	.	.	2	.	.	.	2	.	2	2	1	2	2	2	.	.	.	.	.	.	.	.
MESOTROPHIC GRASSLANDS																								
Filipendula ulmaria	.	.	.	.	.	.	■	■	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alopecurus pratensis	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arrhenatherum elatius	.	.	.	.	■	■	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla acutiloba	.	.	.	.	1	1	.	.	■	■	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca pratensis	■	■	.	.	■	■	.	.	■	■	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla monticola	■	■	3	3	■	■	.	.	2	2	■	■	.	.	.	.	.	.	.	.	.	.	.	.
Vicia sepium	■	■	2	2	■	■	.	.	2	2	.	.	■	■	2	2	.	.	.	.	.	.	.	.
Vicia cracca	2	2	.	.	2	2	.	.	2	2	.	.	.	.	■	■	.	.	.	.	.	.	.	.
Galium album	2	3	.	.	.	.	.	.	■	■	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago lanceolata	3	3	.	.	.	.	.	.	■	■	■	■	■	■	■	■	.	.	.	.	.	.	.	.
Dactylis glomerata	3	3	2	.	2	2	■	■	■	■	2	2	■	■	2	2	.	.	.	.	.	.	.	.
Ranunculus acris	2	2	2	1	2	2	■	■	2	3	2	2	1	1	■	■	■	■	.	.	.	.	+	.
Ranunculus repens	3	3	3	4	3	3	.	.	4	4	3	3	3	4	4	4	.	.	.	.	.	.	+	.
Rumex acetosa et *alpestris*	.	.	.	.	■	■	.	.	1	3	■	■	1	3	2	.	■	■	.	.	2	.	2	.

Appendix 2. – continued
Příloha 2. – pokračování

Species new in 2000	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
spreading	10	10	1	1	6	6	7	7	4	4	2	2	3	3	5	5	9	9	11	11	12	12	8	8
retreating	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00
die-off																								
Taraxacum officinale agg.	.	.	.	.	2	2	+	3	2	2	2	2	2	3	3	3	.	.	2	2	.	.	.	.
Phleum pratense et *alpinum*	.	2	1	1	2	2	.	.	.	2	.	2	1	.	.	2	.	.	1	.	.	.	.	.
Poa pratensis	3	3	.	.	3	3	.	.	.	.	3	3	.	2	2	2	.	.	2	.	.	.	.	.
Leontodon autumnalis	3	3	3	3	2	2	+	3	3	3	3	3	3	3	3	3	.	.	2	.	.	.	+	2
Trifolium repens	4	4	4	4	3	3	+	3	4	4	4	4	3	3	3	3	.	.	.	.	.	.	3	3
Leucanthemum vulgare	3	3	.	.	2	2	.	.	2	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.
Leontodon hispidus	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chaerophyllum aureum	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.
Poa trivialis	.	.	.	.	.	.	.	.	.	.	3	3	.	.	2	2	.	.	.	.	.	.	.	.
Campanula patula	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veronica chamaedrys	3	3	2	2	3	3	.	.	2	2	2	2	2	2	3	2	.	.	.	.	2	2	3	+
Lathyrus pratensis	.	.	.	.	2	3	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	+	.
Trifollium pratense	.	.	2	1	2	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
RUDERAL																								
Filaginella uliginosa	.	2	.	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aegopodium podagraria	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Elytrigia repens	.	2	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scrophularia nodosa	2	2	.	.	2	.	.	.	.	2	.	.	.	.	2	2	.	.	.	.	.	.	.	.
Cerastium holosteoides	.	2	1	1	.	.	+	2	2	3	2	2	.	2	.	2	.	.	.	.	.	.	2	.
Galeopsis bifida	.	.	.	.	.	2	.	.	.	3	.	.	.	.	2	3	.	.	.	.	.	.	+	.
Artemisia vulgaris	.	.	.	.	2	2	.	.	1	2	.	.	.	.	.	1	.	.	.	.	.	.	+	.
Plantago major	2	.	4	4	2	2	+	3	.	3	.	3	2	2	.	3	.	.	.	.	.	.	2	.
Salix purpurea	.	.	.	.	2	2	.	1	.	3	.	1	.	.	1	.	.	.	.	.	.	.	.	.
Poa annua	.	.	2	2	.	.	.	.	2	.	2	2	.	3	.	.	.	.	.	.	.	.	.	.
Calamagrostis epigejos	.	.	.	.	.	.	.	.	.	.	.	2	.	2	.	.	.	.	.	.	.	.	.	.
Rumex obtusifolius	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Galeopsis tetrahit	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Chamomillla suaveolens	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Lolium perenne	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.
Melilotus albus	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus bufonius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Anthriscus sylvestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Equisetum arvense	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Heracleum sphondylium	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Geranium robertianum	.	.	.	.	.	.	.	.	2	2	2	2	2	1	.	.	.	.	.	.	.	.	.	.
Rumex acetosella	2	2	3	3	.	.	.	.	2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Urtica dioica	3	3	.	3	2	2	.	.	3	2	1	1	2	2	3	2	.	.	.	.	.	.	+	.
Sagina procumbens	.	1	2	2	2	.	+	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Epilobium ciliatum	.	1	.	.	3	2	+	2	3	1	1	2	2	2	3	3	.	.	.	.	.	.	2	1
Tussilago farfara	.	.	2	.	3	3	+	3	3	3	3	3	3	3	4	4	.	.	.	.	.	.	2	2
Tanacetum vulgare	.	.	.	.	1	.	.	.	3	2	1	2	2	2	2	.	.	.	.	.	.	.	.	.

Appendix 2. – continued
Příloha 2. – pokračování

species new in 2000	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
spreading	10	10	1	1	6	6	7	7	4	4	2	2	3	3	5	5	9	9	11	11	12	12	8	8
retreating	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00	96	00
die-off																								
Cirsium arvense	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium hybridum	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Capsella bursa-pastoris	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fallopia convolvulus	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spergularia rubra	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cirsium vulgatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Rumex crispus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
SUBTHERMOPHILOUS																								
Clinopodium vulgare	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphorbia cyparissias	.	2	.	.	2	2	.	2	2	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.
Linum catharticum	.	.	.	.	.	.	.	3	.	.	.	.	.	2	.	2	.	.	.	.	.	.	.	.
Poa compressa	.	.	.	.	.	2	.	.	2	2	.	2	.	2	.	3	.	.	.	.	.	.	.	.
Hypericum perforatum	.	.	.	.	2	.	.	2	2	.	.	2	.	2	.	1	.	.	.	.	.	.	.	.
Salix fragilis juv.	.	.	.	.	2	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Sanguisorba minor	.	.	.	.	.	.	.	.	2	2	.	1	2	2	.	.	.	.	.	.	.	.	.	.
Ajuga genevensis	.	.	.	.	.	.	.	.	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.
Veronica beccabunga	.	.	.	.	.	.	.	.	.	.	.	3	.	3	.	.	.	.	.	.	.	.	.	.
Vicia sylvatica	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Galium verum	.	.	.	.	.	.	.	2	.	2	.	.	.	.	2	.	.	.	.	.	.	.	.	.
Medicago lupulina	.	.	.	.	2	2	.	3	2	3	1	2	2	3	3	3	.	.	.	.	.	.	+	.
Cardaminopsis arenosa	.	.	3	2	3	2	.	1	2	2	2	2	1	2	3	1	.	.	.	.	.	.	+	.
Linaria vulgaris	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Chelidonium majus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Potentilla argentea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Cerastium arvense	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Astragallus glycyphyllos	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Verbascum nigrum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.
Coronilla varia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.