TOPOGRAPHY OF SPOIL HEAPS AND ITS ROLE IN PLANT SUCCESSION AND SOIL FAUNA PRESENCE

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The spoil heaps from brown coal mining without technical reclamation are interesting specific sites for ecological relationships observation. This research was aimed at investigating whether topographic features, which determine soil nutrient and moisture distribution, in combination with soil fauna (wireworm and earthworm) presence, affect plant community composition at a spontaneously revegetated post mining area with an undulating surface. Two sites of different age with three types of topographic features were selected, soil moisture and nutrient contents were measured, and plant community composition and soil macrofauna community were sampled at each position. Wireworms were present at all positions and were most abundant at the bottoms of waves at the younger site; their presence was correlated with the presence of several plant species with high palatability for wireworms, but the direction of the interaction is not clear. Earthworms were only present at the older site and had the highest abundance at flat sections. Earthworm presence affected the amount of nitrogen in soil – the highest nitrogen content was at the site with the highest earthworm density and was followed by a higher diversity of plant community. The plant community composition was generally correlated with plant available nutrient content – especially P and N. We infer that topographic features affect nutrient and soil fauna distribution, which consequently influences the plant community composition.

plant community composition, spontaneous succession, earthworms, wireworms

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INTRODUCTION

During formation of spoil heaps in the brown coal mining areas, the overburden is heaped in longitudinal rows. Most areas are subject to technical reclamations, where the surface is levelled out and later trees or herbs are planted there. However, some parts have been left in their original state, preserving the unique microtopography – waves 1–1.5 m high and 6–7 m wide. These areas are also left to spontaneous development without human intervention. Adjacent to some of these sites we can find areas that have been levelled out but not revegetated, so there is a possibility of comparison of soil and plant community development on flat and undulating landscape during primary succession (Frouz et al., 2001). Studies on succession at various post mining sites showed that leaving spoil material in heaps has a positive effect on diversity of plant and animal assemblages mostly due to high spatial diversity of the stands, age (the older stands have higher diversity than the same old sites with technical recultivation), and material type of heaps. The spontaneous succession can be used on the non-extreme stands surrounded by natural vegetation (Prach, Pysek, 2001; Topp et al., 2001, 2010; Hodacova, Prach, 2003). Spatial variability causes diversity in nutrient availability, soil moisture, soil texture, which then causes diversity in plant community composition (Frouz et al., 2011).

Spatial variability also affects soil fauna – moisture availability, accumulation of litter, accumulation of loose material, accumulation of plants. There is some evidence in literature that wireworms are highly affected by soil moisture and temperature in their activity and distribution, but also depending on the soil type and structure and plant community composition; they generally tend to migrate into areas with higher soil moisture, although avoid soils that are subject to flooding (Campbell, 1937; Evans, 1944; Finney, 1946; Parker, Howard, 2001). At some stands on the spoil heaps the grass *Calamagrostis epigejos* becomes abundant and eventually dominates the plant community, as is common in other disturbed ecosystems at early successional stages (Prach, 1987; Wiegleb, Felinks, 2001; Somodi et al., 2008). This fast growing plant often out-competes all other plant species and creates monospecific stands on soils rich in nitrogen. It is an important ecosystem engineer which alters condition of soil surface. Dominance of this species is caused by very rapid vegetative reproduction and also by very tough, slowly decomposable litter, which inhibits the growth of other plant seedlings (Rebele, Lehmann, 2001; Massey et al., 2007; Mudrak et al., 2010). Even though the autecology of *C. epigejos* has been intensively studied (Rebele, Lehmann, 2001; Gloser, 2002; Kavanova, Gloser, 2005), little is known about its interaction with belowground herbivores and other soil fauna.

It is well known that soil development is driven by changes in vegetation during spontaneous succession (Frouz et al., 2001, 2008), but at the same time, soil organisms can influence plant performance and the composition of the plant community during succession by changing the soil environment or by direct consumption of plant tissue (Brown, Gange, 1989, 1992; Thompson et al., 1993; Wurst et al., 2004; De Deyn, Van Der Putten, 2005; Roubickova et al., 2009).

In the present study we tested whether the method of levelling the ground (which was originally undulating, as a result of the heaping process) at the spoil heaps, without consequent introduction of new species, affects abiotic conditions (moisture, nutrient content). We investigated the change of plant community composition and soil macrofauna presence caused by landscaping consequently. We tested this at two sites of different age, to assess how this effect changes during succession.

MATERIAL AND METHODS

Study area

The study was carried out at a post-mining area in the Sokolov brown-coal mining district in the Czech Republic (50°14′ 30.711″N, 12°40′44.96″E). The average altitude of the spoil heaps is about 500– 600 m a. s. l., mean annual precipitation 650 mm and temperature 6.8°C. The spoil heaps originated from open-cast brown-coal mining and consist mainly of Tertiary clays of the so-called Cypris Formation, which are well supplied with mineral nutrients (Frouz et al., 2001). The pH of the substrate in initial successional stages is 8–9. The study was conducted in two unreclaimed areas – the younger plot (E) was about 18 years old (i.e. the spoil heaps were deposited 18 years ago), the older plot (I) was about 29 years old. Both are characterized by longitudinal rows of depressions and elevations formed during the heaping process, with an adjacent flat area, that has been levelled out but is of similar age. The tops of waves are about 1.5–2 m above the base of the depressions and individual rows are 6–7 m apart.

The younger site has a plant community formed mainly by herbaceous vegetation with dominant *C. epigejos* and with scattered shrubs and small trees (*Betula pendula, Salix caprea, Populus tremula*), the soil surface is bare or has a very thin layer of litter in depressions.

The older site has plant cover formed mainly by herbaceous vegetation with dominant *C. epigejos* and with scattered trees. The litter layer in depressions can be 3–5 cm thick, with greater thickness underneath trees.

At each site we selected three positions according to topography: tops of waves (top), depressions in between waves (bottom), and ground that has been levelled out (flat). At each position we randomly selected 5 plots – replicates.

Soil fauna and plant sampling

A total of 30 samples were collected (15 on younger site and 15 on older site). Five 20 × 20 × 20 cm soil core samples were taken from each plot and each topographic position (tops of waves, bottoms, and levelled ground) and hand-sorted for soil macrofauna, namely wireworms and earthworms. Wireworms were then classified into three groups by sizes – stage 1 (< 5 mm), stage 2 (5–10 mm), and stage 3 (> 10 mm), which roughly correspond with age of the larvae. The Elaterid larvae were then determined into genus according to Klausnitzer (1978). Earthworms were classified as adults and subadults and determined into species according to Pizl (2001). All of the soil sampling was done in late September 2015.

Plant community composition was assessed based on phytosociological plots 1 × 1 m, lying next to soil core samples.

Soil parameters measurements

Composite soil samples were taken from the depth of 0–20 cm at each sampling point for soil moisture, microbial respiration, C, N, and other major element measurements. The soil samples were then kept at 4°C prior to analyses.

Soil microbial respiration was measured in 100 g of dry soil weight according to Frouz, Novakova (2005). CO_2 produced in the vials was trapped by 3 ml of 1M NaOH. Vials were kept at 20°C, and after 10 days the amount of trapped CO_2 was established by

Table 1.Results of ANOVA and Tukey's*post hoc* test for contents of nutrients at individual plots

Plot	Nutrients content (mg/kg)						Moisture (%)	Microbial respiration ($mg\ CO_2/100\ g/day$)
	P	Ca	Mg	K	C	N		
EB	8.96[a]	4085.72[ab]	1247.74	335.30	4962	358[abc]	28.21	11.64
EF	13.025[ab]	4480.78[ab]	1372.38	291.58	4868	295[ac]	27.04	10.93
ET	9.06[a]	3887.90[a]	1343.80	306.26	4702	286[c]	26.47	10.34
IB	18.50[ab]	5011.00[ab]	1264.35	254.30	3718	460[ab]	30.02	12.28
IF	23.02[b]	5103.30[b]	1241.68	263.70	4150	494[b]	26.90	10.76
IT	21.12[b]	4989.02[ab]	1268.00	270.96	3974	454[ab]	24.30	10.96
$F(5;22)$	4.965	3.81	1.248	2.118	1.479	6.201	1.696	1.7
P	0.003	0.012	0.321	0.142	0.237	0.001	0.177	0.177

EB = bottoms of waves on younger plot, EF = flats on younger plot, ET = tops of waves on younger plot, IB = bottoms of waves on older plot, IF = flats on older plot, IT = tops of waves on older plot

[a–c]plots with the same letter did not differ significantly at $P<0.05$

HCl titration, after the addition of $BaCl_2$. The soil moisture was measured gravimetrically – 50 g of sample was dried for 24 h at 105°C.

The rest of the soil sample was dried at room temperature and homogenized by dry sieving through a 2 mm mesh. Afterwards it was analyzed for main elements. P, Ca, Mg, and K were analyzed in the plant available forms in the extract solution according to Mehlich III (T r a n et al., 1990). Plant available phosphorus was assessed spectrophotometrically, as phosphomolybdate blue, at wavelength 750 nm on spectrophotometer Cary 60 UV-Vis, Agient Technologies, Santa Clara, USA, . Potassium was measured on atomic absorption spectrophotometer (55B AA Spectrometer, Agient Technologies, Santa Clara, USA), using acetylene-air mixture flame. Calcium and magnesium contents were assessed by the same method, but lanthanum solution was added to the sample for ionization elimination.

Total carbon and total nitrogen were analyzed using high temperature catalytic combustion on the Primacs SNC, Scalar, Breda, Netherlands. The samples were introduced into the high temperature combustion oven, there at 1050°C the carbon was completely oxidized to CO_2 in the presence of a catalyst. The CO_2 was measured by non-dispersive infrared detection for total carbon. Total nitrogen was converted to NxOy which was reduced at 600°C to N_2. The N_2 gas was measured by thermal conductivity detection.

Statistical analyses

One way ANOVA was used to evaluate the effect of plot age and topographic position on all collected data (plants and fauna). For evaluating differences between individual treatments, Tukey's HSD test was used. These analyses were performed in program STATISTICA Version 9.0 (Statsoft, Tulsa). Program CANOCO 5 (S m i l a u e r, L e p s, 2014) was used for Canonical Correspondence Analysis (CCA), for

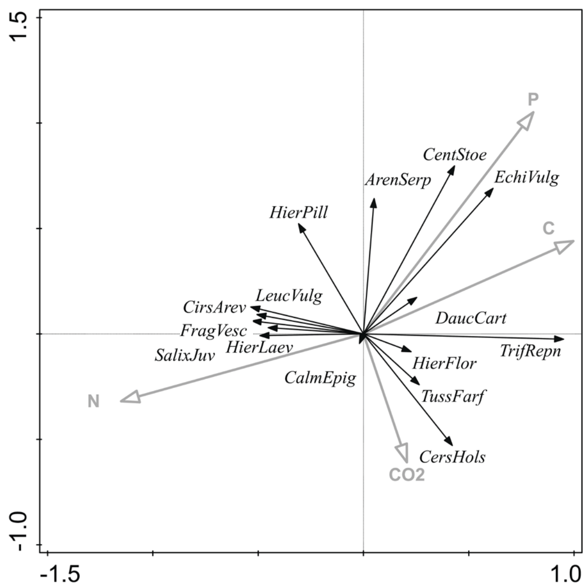

Fig. 1. Regression biplot of environmental variables and species found by Canonical Correspondence Analysis

black arrows indicate species (showing 15 best fitting species), grey arrows indicate the nutrient content of soil (N – nitrogen, P – phosphorus, C – carbon) and soil properties (CO_2 – microbial respiration); environmental variables were selected from a total of 11 using forward selection; the first axis explains 10.0% of cumulative variance; total explanatory variables account 26.3%

ArenSerp = Arenaria serpyllifolia, CalmEpig = Calamagrostis epigejos, CentStoe – Centaurea stoebe, CersHols = Cerastium holosteoides, CirsArve = Cirsium arevense, DaucCart = Daucus carota, EchiVulg = Echium vulgare, FragVesc = Fragaria vesca, HierLaev = Hieracium laevigatum, HierPill = Hieracium pilosella, HierFlor = Hieracium floribundum, LeucVulg = Leucanthenum vulgare, SalixJuv = Salix juvenile, TrifRepn = Trifolium repens, TussFarf = Tussilago farfara establishing the interactions between individual phytosociological plots, plant species, soil macrofauna presence, and environmental conditions. Variation partitioning from CANOCO 5 was used to investigate the contribution of vegetation and soil properties effect on earthworm and wireworm diversity. Vegetation in this analysis was represented by the first axis from RDA (Redundancy analysis) and the soil properties were represented by available phosphorus, soil moisture, and soil microbial respiration.

Table 2. Result of ANOVA and Tukey's *post hoc* test for morphological parameters of *C. epigejos* in plots

	Length of rhizome	Number of ramets	Sheet width
E	8.99^{b}	10.57^{a}	0.57^{b}
I	7.91^{a}	14.21^{b}	0.49^{a}
F(1;26)	4.308	4.393	8.411
P	0.048	0.046	0.008

E = younger plot, I = older plot

^{a,b}plots with the same letter did not differ significantly at $P < 0.05$

RESULTS

Nutrient availability, moisture, and microbial respiration

There were statistically significant differences in the content of total N at different positions ($F = 6.20$; $P = 0.001$). The highest content of total N was at flat areas at site I (494 mg kg^{-1}). The lowest content was at the tops of waves at site E (286 mg kg^{-1}). The other plots cannot be significantly different from each other (Table 1). Statistically significant differences were also recorded for the amounts of plant available P ($F = 4.97$; $P = 0.003$). The highest content of plant available P was at flat areas of site I (23.02 mg kg^{-1}). Similar values were measured for the tops of waves at site I (21.12 mg kg^{-1}). The lowest P content was at the bottom of waves at site E (8.96 mg kg^{-1}). Similar values were measured at the tops of waves at site E (9.06 mg kg^{-1}) (Table 1). There were also statistically significant differences in the amount of calcium ($F = 3.81$; $P = 0.012$) at different positions. The highest content of Ca was at flat areas at site I (5103.3 mg kg^{-1}). The lowest content was at the tops of waves at site E (3887.9 mg kg^{-1}) (Table 1).

There were no statistically significant differences in soil moisture ($F = 1.70$; $P = 0.177$). Soil moisture was the highest in the depressions – at site I 31.7% and at site E 28.2%. Moisture at the tops of waves and flat areas was similar – at site E 26.5% and 26.9% (top and flat respectively) and at site I 24.3% and 26.9%.

There were no statistically significant differences in microbial respiration between the positions or the sites. Respiration was the highest in depressions and similar at the tops of waves and flat parts (Table 1).

Plant community composition

There were thirty plant species in total. Species *Salix* sp., *Cirsium arvense*, *Fragaria vesca*, *Hieracium laevigatum*, and *Leucanthemum vulgare* are generally found together and at locations with high soil N content. *Trifolium repens*, *Daucus carota*, *Arenaria serpyllifolia*, *Centaurea stoebe*, and *Echium vulgare*, on contrary, grow on N poor stands (Fig. 1). *Hieracium pilosella*, *Cirsium arvense*, *Faragaria vesca*, *Salix juv.*, *Hieracium laevigatum*, and variosus hybrids by *Epilobium* sp. are plant species that grow at the older site (I), while *Cerastium holosteum*, *Trifolium repens*, and *Echium vulgare* were only found at the younger site (E) (Fig. 2). *Calamagrostis epigejos* was unaffected by environmental variables, by site or topographic position.

The phytosociological plots show similarities between the tops of waves and the flat sections, and they are most closely correlated with available P (Fig. 3). However, tops of waves had significantly lower number of species than flat sections at both sites ($F(2, 25) = 3.480$; $P = 0.046$). The plots at the bottoms of waves have a uniform plant community composition and are best correlated with microbial respiration.

We also followed the morphological differences in plants of *C. epigejos* represented by the number of ramets, numbers of inflorescences, weight and length of inflorescences, surface area of leaves, and length of underground shoots in one patch.

The statistically significant differences were recorded for the average length of rhizome ($P = 0.048$), number of ramets ($P = 0.046$), and leaf width ($P = 0.008$) among the younger plot (E) and older plot (I) (Table 2).

Soil macrofauna presence

The wireworms were determined as *Agriotes lineatus* (L.) according to Klausnitzer (1978). The highest numbers of wireworms were found at site E in depressions, 3 individuals per sample on average, which equals to 75 individuals per m^2. At the tops of waves the numbers were the lowest, at both sites there was only one individual in one out of 5 samples (on average 5 individuals per m^2 for both sites). In general, there were higher numbers of wireworms at site E – 22 in total. At site I there were only 4 individuals in total (from all soil samples) (Fig. 4). The differences were statistically significant, with the site effect being stronger ($F = 10.75$; $P = 0.003$) than the topographic position ($F = 6.72$; $P = 0.004$). Most of the larvae were in medium size group (68%).

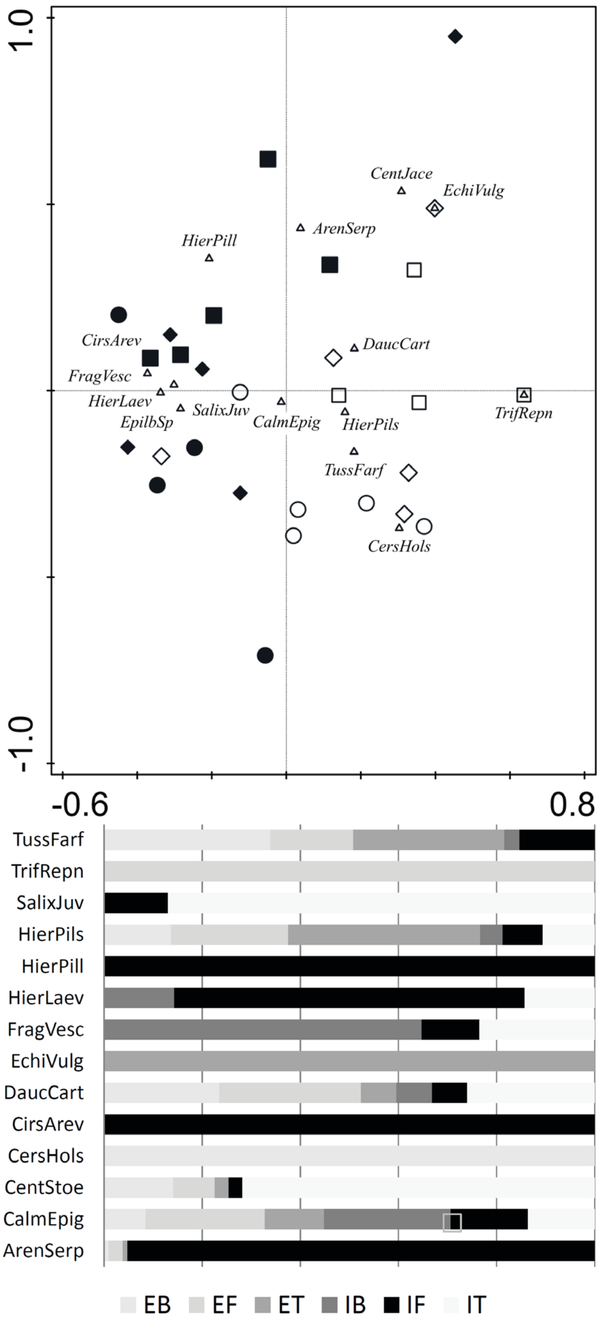

Fig. 2. Canonical Correspondence Analysis species scatter plot

species are displayed by pie charts with individual sections showing their presence at individual stands; the 15 best fitting species are shown as triangle; the first axis explains 10.0% of cumulative variance; total explanatory variables account 26.3%; bar graph shows the ratio of topographic position at 15 best fitting species; species registered in different positions

transparent circle = bottoms of waves on younger plot, transparent square = flats on younger plot, transparent diamond = tops of waves on younger plot, full circle = bottoms of waves on older plot, full square = flats on older plot, full diamond = tops of waves on older plot, *ArenSerp = Arenaria serpyllifolia, CalmEpig = Calamagrostis epigejos, CentStoe = Centaurea stoebe, CersHols = Cerastium holosteoides, CirsArve = Cirsium arvense, DaucCart = Daucus carota, EchiVulg = Echium vulgare, EpilbSp = Epilobium sp., FragVesc = Fragaria vesca, HierLaev = Hieracium laevigatum, HierPill = Hieracium pilosella, HierFLor = Hieracium floribundum, SalixJuv = Salix juvenile, TrifRepn = Trifolium repens, TussFarf = Tussilago farfara*

There were no earthworms found at site E. At site I there were 11 earthworms found in total, 55% were adults and all were determined as species *Aporrectodea caliginosa* according to Pizl (2001). Numbers of earthworms were higher in the flat areas (average 1.4 individuals per sample, 35 individuals per m^2), however the differences, due to overall low numbers of earthworms, were not statistically significant.

We also tested the effect of the environmental variables (nutrients, moisture, respiration) and vegetation on earthworms and wireworms by CCA analysis. Environment and vegetation together explained 32.4% of the variability of the net effect; vegetation explained 16.4% ($P = 0.004$), environment only 1.9% ($P = 0.286$), 14.1% was explained jointly (Fig. 5).

DISCUSSION

The content of total N, K, Mg, and Ca was rather higher than the average values from grassland areas of the Czech Republic (Kalina, 2005; Mladek et al., 2006). Nitrogen is a very important element that affects growth of plants, their spreading, and is also building material of plant biomass. The contents of total N generally increase with increasing age of soils (Ciarkowska et al., 2016). In our study, the highest total N was measured at the bottoms of waves at the younger site. Tops of waves were poor in N probably due to erosion, greater temperature swings, and smaller retention of water at these positions, which causes faster mineralization and depletion from tops and transport to the depressions, together with water, litter, and finer soil particles (Zhu et al., 2014). The alkaline Tertiary clays that form these spoil heaps are generally rich in total P (Sourkova et al., 2005; Frouz et al., 2008), but situation is different for the content of the plant available P – compared to the amount of available P from permanent grasslands in the Czech Republic (Kalina, 2005), we found a very low content. This is most probably related to the high content of Ca, which forms insoluble calcium phosphate, which generally reduces P availability to plants in soil (Tunesi et al., 1999; Addiscott, Thomas, 2000; Braschi et al., 2003). Higher amounts of available P at the older site are results of the combination of biotic and abiotic processes during succession, which involve P uptake by plants, mineralization of organic matter, extraction of the insoluble forms of P by mycorrhizal fungi and decrease in pH, which causes dissolution of calcium phosphate (Ciarkowska et al., 2016). Higher contents of P, Mg, and Ca in the flat areas could be attributed to higher levels of weathering on the flats – during the process of levelling of ground the layers of cypris clays are disrupted and broken into smaller particles, which are then more susceptible to mineral and chemical weathering (Smeck, 1985; Sourkova et al., 2005).

The plant community composition differed between the two sites, which can be attributed to different successional stages but also to different positions at the spoil heap, causing differences in species pool sources. The species found only at the younger site are *Cerastium holosteum*, *Tussilago farfara*, *Daucus carota*, *Trifolium repens*, and *Echium vulgare*. These species belong to the intermediate strategy type (CSR), except *E. vulgare*, which poorly copes with stress and is rather an R-strategy plant. *Fragaria vesca*, *Cirsium vulgare, Arenaria serpyllifolia* or *Centaurea jacea* were found only at the older site, but even these species are not clear-cut in life strategy. Ellenberg's indicator value did not show different ecological claims. The plant community composition differed between sites E and I, which can be attributed to the different age (difference between sites is 11 years) and associated successional stage of these sites, but the plant communities do not show distinct life-strategies shifts at this stage.

The plant communities on leveled-out areas were similar to the ones at the tops of waves, which is related to similar moisture, N content, and microbial respiration values (Fig. 3). This can be caused by the properties of the soils – they are very rich in swelling clay (montmorillonite), which has a high water-holding capacity (Frouz et al., 2001, 2008) so as our measurements were conducted in periods with relatively high precipitation (end of May, September), there was not time for them to dry out. Nevertheless, when the montmorillonite clay does dry out, in tends to shrink and become very hard, so it presents hostile conditions for plant roots as well as for soil fauna and may reduce their migration (Lavelle, Spain, 2001; Dunger, Voigtlander, 2009) or cause absence of some species that cannot cope with these conditions. The fact that *C. epigejos* can grow well under various conditions corresponds with the findings of Rebele, Lehmann (2001) and Lehmann, Rebele (2005). However Lehmann, Rebele (2005) found high phenotypic plasticity in populations growing in diverse conditions, which is not the case at the stands followed by us. This could be caused by smaller initial pool of genotypes, as the spoil heaps

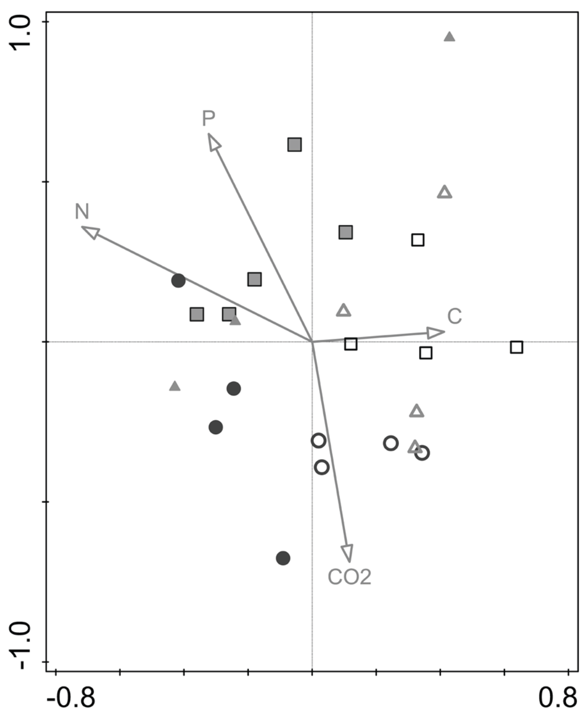

Fig. 3. Canonical Correspondence Analysis shows the samples and four environmental variables by forward selection (P – phosphorus, N – total nitrogen, CO_2 – soil microbial respiration, C – total carbon)

the first axis explains 10.0% of cumulative variance; total explanatory variables account for 26.3%
transparent circle = bottoms of waves on younger plot, transparent square = flats on younger plot, transparent triangle = tops of waves on younger plot, full circle = bottoms of waves on older plot, full square = flats on older plot, full triangle = tops of waves on older plot

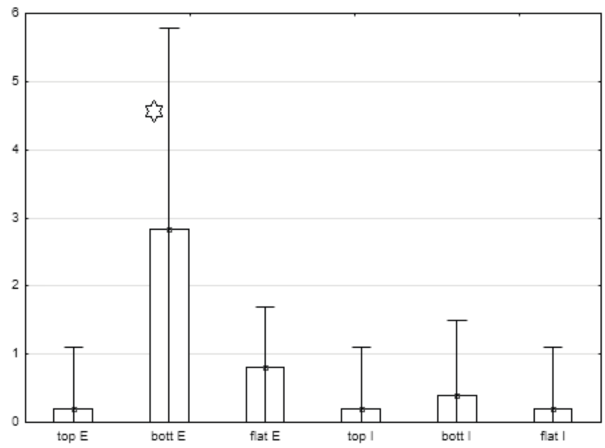

Fig. 4. Average numbers of wireworms at individual topographic positions at both investigated sites top E = tops of waves, site E; bott E = bottoms of waves, site E; flat E = flat section, site E; top I = tops of waves, site I; bott I = bottoms of waves, site I; flat I = flat section, site I. Error bars show standard deviation, asterisk indicates a significantly different result

function as an island in the surrounding landscape, therefore some of the rules of island biogeography imply here (A s h et al., 1994; P r a c h , 2003).

Numbers of soil fauna were affected both by site age and by topographic position. Wireworms were most numerous in depressions at both sites. This could be attributed to higher moisture content (C a m p b e l l , 1937; E v a n s , 1944; F i n n e y , 1946; P a r k e r , H o w a r d , 2001) or more shade, therefore less extreme temperatures, but according to results of multivariate analysis it seems to be related more to biotic interactions between the soil fauna and vegetation. This is also supported by the fact that numbers of wireworms are lower at site I, which has different plant community composition from site E. Because wireworms are generalist root herbivores, they prefer roots with high palatability and high nutrient content (B r o w n , G a n g e , 1989, 1992; R a s m a n n , A g r a w a l , 2008), such as are the roots of *Tussilago farfara, Cerastium holosteoides or Daucus carota*, plant species that are most abundant at depressions at site E.

The finding that earthworms occur only at sites 20 years old or older corresponds with results of F r o u z et al. (2008) and is related mainly to soil conditions (R o u b i c k o v a , F r o u z , 2014). These soil animals seem to prefer the flat areas, although soil moisture is lower here than in the depressions, which may be due to patchiness of the habitat in the undulating part, as hills present migration constraints for earthworms. Because site I has been colonized only recently (A. Walmsley, personal observation; F r o u z et al., 2008), earthworms have not yet reached their potential population densities. Earthworm presence is generally followed by quick increase of N content

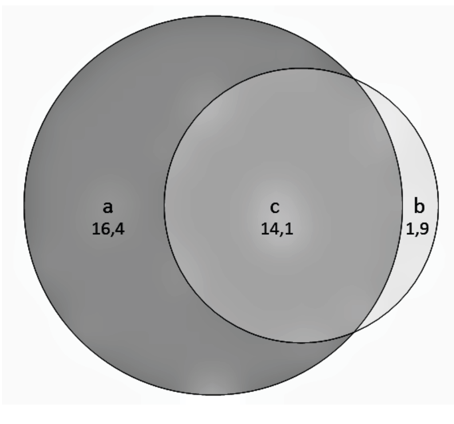

Fig. 5. Venn diagram, graphical representation of results from the variation partitioning.

The effects of environment and vegetation explain 32.4% of variability (a + b + c), net effect of vegetation is 16.4% (*P* = 0.004) (**a**); the ambience effect is 1.9% (*P* = 0.286) (**b**); 14.1% jointly explained (**c**). Explanatory data: vegetation, environmental; response data: worms. The first group (the bigger circle) is represented by CaseR1 from vegetation data, the second group (the smaller circle) is represented by phosphorus amount in soil from environmental dat

in soil (B o h l e n et al., 2004; F r o u z et al., 2006), which could explain why there is the highest N content in the soil at flat areas of site I, while at site E it is by far highest in depressions.

It seems that vegetation is a better predictor of wireworm and earthworm presence than the measured environmental factors. Variability, which is explained by the vegetation, reflects the biotic interactions between the soil macrofauna and vegetation. These relationships were noted in other studies as well (F r o u z et al., 2008; R o u b i c k o v a et al., 2009, 2012) and can be explained by direct or indirect trophic interactions. Plants present a food source for both wireworms and earthworms and therefore their life strategy that is related to chemical composition of their body and consequent palatability for herbivores and saprophags, can affect the abundance of soil fauna (F r o u z et al., 2001, 2008; W a r d l e et al., 2005). On the other hand, earthworms affect soil properties and processes, such as aggregate formation (M a r a s h i , S c u l l i o n , 2003), water holding capacity (F r o u z et al., 2006), activity of microflora by mixing plant litter and mineral soil (F r o u z et al., 2006), and nutrient availability (L a v e l l e , S p a i n , 2001). Generalist root herbivores can also substantially affect the abundance of some plant species and that way change the plant community composition (B r o w n , G a n g e , 1989, 1992; B l o s s e y , H u n t - J o s h i , 2003).

Spontaneous succession is a reclamation technique successfully used in areas with anthropogenic disturbances, especially in post-minig landscapes. Our study shows that mechanical terrain reshaping following overburden deposition affects the nutrient distribution in soils, which then influences plant community composition and soil fauna presence. It can also speed up the migration of some soil fauna to the sites. Presence of levelled-out areas together with areas with wave-like structure therefore presents a positive contribution to the habitat diversity at spontaneously revegetated sites.

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