Sandpit Lakes in the Třeboň Basin Biosphere Reserve (Czech Republic)

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Abstract
Eleven lakes belonging to three freshwater systems were investigated in the Třeboň Basin Area (Suchdol, Halámky and Veselí) in 2004. These lakes were formed after a completion of mining activities under the groundwater level. Their littoral habitats differ in the thickness (presence) of an organic soil horizon, availability of water, dynamic of growth macrophytic vegetation and in their trophic level – from oligotrophic to eutrophic. The trophic level is determinated by the land use in the surroundings. Such diversity of conditions allows the study of general processes of a formation of water and marsh ecosystems in the anthropogenically impacted area (sand extraction, recreation and angling). The mining companies are bound to make an appropriate recultivation of lakeshores.

Key words: Sandpit lakes; Vegetation; Human activities; Recultivation; Land use

Introduction
Třeboň Basin was included in the Biosphere Reserve net UNESCO in 1977. Two years later it was declared a Landscape Protected Area according to Czech Law. The region is renown for a rich variety of wetland ecosystems, many of which are made by humans. The core area of the region is protected as wetlands of international importance („Třeboň fishponds“) according to Ramsar Convention (Jeník *et al.* 1996). The extraction of gravel and sand is currently one of the greatest human impacts on the landscape of the Třeboň Basin Biosphere Reserve. Situated in the Lužnice river floodplain, the sand pits are filled with water infiltrated from the Lužnice Riverbed. The resulting lakes represent new types of aquatic ecosystems in the Třeboň Basin region. By their depth and fairly steep slopes they markedly differ from other wetland habitats in the region, including fishponds.
Man-made lakes: it is possible to call all the water bodies, which arise from human activity – sand mining. This includes the water systems with definite function or post mining lakes. These lakes often provide water of high quality, which can be effectively used in the future. Their ecological value is important too. Mostly the lakes affect their surrounding area and form the area of important natural values (Janský *et al.* 2003). The post mining lakes (sand and gravel sand) are the most widespread lakes in the Czech Republic. They are situated near bigger or smaller watercourses. The lakes have the character of large water bodies.
The sandy bottom poor in nutrient and the depth of the lakes are the main factors, which determine the character of the man-made lakes. It is possible to classify the lakes as oligotrophic (OPSR Halámky 2002). Their use is various, and depends on the size, depth and the condition of the lake. The ecological function is important too (Janský *et al.* 2003).
The current gravel sand mining is running in two ways: over and below the surface of groundwater. In the first case of mining (over the surface of groundwater), the exploited areas are after the recultivation retroceded for original function i. e. forestry and agricultural production. These human activities (land use) significantly affect the eutrophication of sand pit lakes ecosystems. By the gravel sand mining bellow the surface of groundwater entirely new biotopes are formed – relatively deep lakes (often over 20 meters deep) with narrow littoral belts and shore vegetation (Hanák *et al*. 1985).
These ecosystems are always under the human influence after the end of the mining. The human comes mostly for recreation, when the vegetation is completely exterminated in some places. The angling has the same influence. The anglers keep their places by cutting out and treading the vegetation. Some lakes are so large, that the forty-year succession is running on the one side of the lake and intensive mining is running on the other side. The shore vegetation is always influenced by the water quality (mechanic turbidity and the water transparency) or by the waves from the passing dredger hitting on the shore.

In comparison with other wetland habitats, surprisingly little is known about the vegetation of sand-pit lakes and its relation to the both environmental factors and various types of human activities.
The objectives of this work were: 1) to document the present state of the vegetation of 11 sandpit lakes belonging to three systems within the Třeboň Basin Biosphere Reserve, in order to provide a basis for long- term monitoring; 2) to relate the vegetation composition to main environmental factors and main ongoing human activities including recultivations; 3) to map the land use of the surrounding areas and explain the eutrophication of these ecosystems.

Material and methods

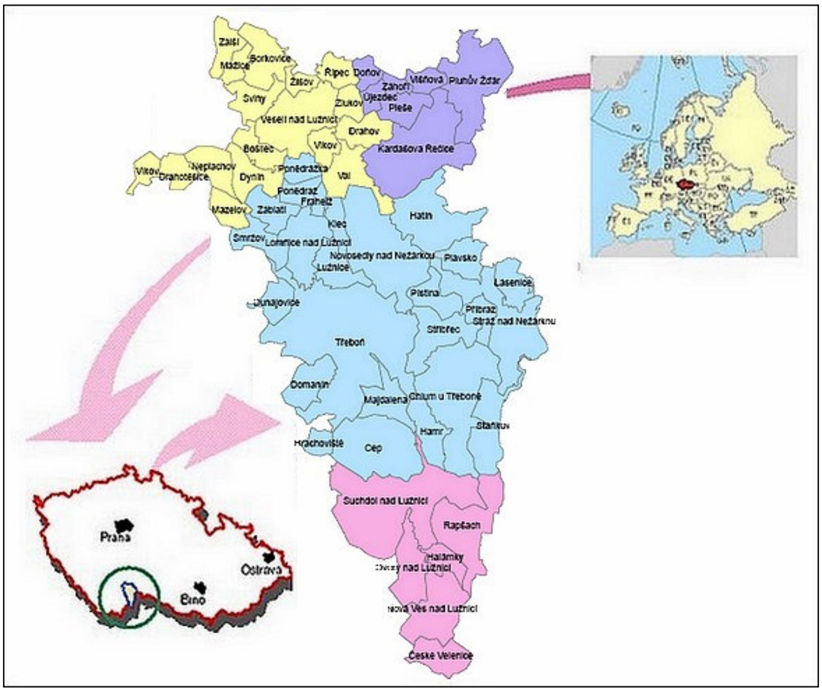
Site description

The study sites are situated within four systems along the Lužnice river (see figure 1).
Halámky system on the right shore of the Lužnice river includes four lakes near Halámky village: North, Middle, South and East lake. Intensive extraction of gravel sand was done within this system. The shores, which were not forested (in contrast to the other sites), are unique in terms of succession of littoral plant associations. Since the mining start to this day there has been made 25 ha of forestry recultivation, 22 ha of water recultivation and 6 ha were left to the natural succession (marsh formation) on this locality (Vrána 2000).
Suchdol system on the left shore of the Lužnice river (near Cep village) was in 2000 formed by the lakes Cep (the largest of all), southern lake Cep I, Tušť and Františkov. In 2001, the gravel sand bar between the lakes Cep and Cep I was removed and a great deal of the water subsequently flew from Cep I into Cep. The extraction proceeds by the dredger. These lakes are important potable water source (Kotrčka 2000). The lakes Tušť and Františkov on the right shore of the Lužnice river are in the cadastral area of the Františkov village. The extraction of this locality ended in 2000.
Veselí system includes five lakes situated in the alluvium of the Lužnice river. Two lakes (Horusice and Horusice I) are situated on the left shore. These lakes are highly eutrophic because of an inflow from the near fishponds and run-off from the agricultural land. The other three lakes (Veselí, Veselí I, Vlkov) are situated on the right shore of the Lužnice river (Kotrčka 2000).
Next parameters of the sandpit lakes can be seen in table 1.

***Table 1** The overview of some sandpit lakes parameters (Rajchard and Procházka 2001)*

Sandpit lake	Water lake level (ha)	Average depth (m)	Duration
Cep	123	7	1949-2007
Cep I	40	6,5	1983-2007
Tušť	39,5	5	1955-2000
Františkov	9	4,5	1970-1975
Halámky North lake	33,47	16	1970 – 1994
Halámky South lake	18,75	4	1976 – 1985
Halámky Middle lake	22,74	14	1976 – 1979
Halámky East lake	Mining	17	1976-2007
Horusice I	15	2,5	1977-1986
Horusice	23	6,5	1972-1983
Veselí I	24	3,5	1981-1986
Veselí	10	3,5	1963-1986
Vlkov	46	2,8	1963-1986

Figure 1 *The area of interest.*



Study of freshwater vegetation

Two types of records were taken on 11 of a total of 13 sandpit lakes, belonging to four systems (two lakes were excluded from the surveys because of ongoing intense sand extraction).

The first type of records was focused at documenting the main features of the vegetation with respect to the vertical structure and dominant plant species, as related to the main environmental characteristics and a human impact. The records were taken in squares placed in regular distances along the shores of each sandpit lake during summer 2004. The distances between squares were set separately for each lake in order to obtain similar numbers of records (15 to 18) per lake. The area (5 x 5 m) and position of the squares on the elevation gradient were selected so that the squares included all types of the shore vegetation, from aquatic to terrestrial. The lakeward side of the square most frequently coincided with the shoreline, but in some cases it extended into deeper water. A total vegetation cover, a total height of the vegetation and dominant plant species and a cover of single vegetation layers (E1: 0 to 0.5 m, E2a: 0.5 to 1 m, E2b: 1 to 4 m, E3: over 4 m) were recorded for each square. The height limits of vegetation layers were set according to prevailing dominant plant species. Thus, the height limit of E2b layer (4 m) corresponded to the height of reed belt species (mainly *Phragmites australis* and *Phalaris arundinacea*) and the height of E2a layer corresponded to the height of tall sedges (mainly *Carex acuta*). If woody plants were present in the square, their probable origin was characterised by categories “natural succession”, “plantation”, or “original wood”. “Plantation” included woodland consisting of dense trees of the same species occurring in regular intervals (usually *Pinus sylvestris*). “Original wood” was assigned to woody vegetation of a similar species composition and total height as was found also further from the lakeshore. In addition, the following characteristics were assessed for each square: slope exposition, the shore profile stair-like, steep: over 45^{o}, moderate: 20 to 45^{o}, flat: below 20^{o}, and main types of human impact (sand extraction, paths, recreation, fishing). The extent of the human impact was expressed as a percentage area within the square.

The second type of records was aimed to document the species richness of the littoral vegetation. Standard phytosociological relevés were placed on species rich sites of varying slope exposition. Eight relevés were taken at each lake. The size of the relevés was determined by the width of the belt of the littoral vegetation and a distance of 5 m of the shoreline. All plant species were recorded using the seven-degree abundance-dominance scale according to Braun-Blanquet (Dierschke 1994). The following characteristics were recorded in the same manner as in the first type of records: total

vegetation height and cover of particular vegetation layers, slope exposition, the shore profile, main types and extent of human impact. In addition, thickness of organic horizon, degree of shading (using a semiquantitative scale of 0 to 3), water level and water transparency, as Secchi disk depth (at two places on each lake) was recorded.
Gradients in vegetation and the environment were reconstructed using the DCA and CCA algorithms of the CANOCO 4.5 package (ter Braak and Šmilauer 2002). The percent frequency of the species was used and rare species were downweighted. The vegetation data set was subjected first to Detrended Correspondence Analysis (DCA), in order to assess the overall variation patterns in species composition. Ordination site scores were correlated to environmental factors using Pearson's correlation coefficient. All environmental variables were plotted onto DCA ordination diagrams as supplementary environmental data for better ecological interpretation of the axes.
Subsequently, we used CCA to further examine the species-environmental relationships. Ten environmental variables were subjected to forward selection (ter Braak and Šmilauer 2002, Lepš and Šmilauer 2003) in order to determine the variables that best account for the species distribution. Then we tested marginal and conditional effects of each of these explanatory variables on species composition. The effect of the first canonical axis was tested by permutation test (499 permutations were always used). The tests of statistical significance were performed for all four canonical axes.

Mapping of the land use
The land use of the adjacent areas is one of the most important indicator for eutrophication of the sand pit lake ecosystems. For example, the forests serve as a natural filter for incoming water with a lot of nutrients. On the other hand, the fields, which are substantially fertilized by organic manure, are direct source of the nutrients.
The mapping of land use was made on sand pit lakes and its near surroundings according to the methodical key Sýkorová *et al.* (2006) (see table 2). The aim of the mapping is to record the current situation of the landscape with the assistance of units defined in the methodical key. Ortophoto maps of the area were used for individual mapping and the basic maps of the Czech Republic in the scale 1:10 000 were used for orientation during the fieldwork. Furthermore, the maps were digitally compiled.

Table 2 *United map key (Sýkorová et al. 2006)*

Basic unit	***Subunit***	***Number code***	***Letter code***
Arable land	Bare land	**1.1**	**HP**
	Stubble-field	**1.2**	**STR**
	Wheat	**1.3**	**PS**
	Barley	**1.4**	**JE**
	Oats	**1.5**	**OV**
	Rye + triticale	**1.6**	**ZI**
	Corn	**1.7**	**KU**
	Rape	**1.8**	**RE**
	Peas	**1.9**	**HR**
	Broad bean	**1.10**	**BO**
	Potatoes	**1.11**	**BR**
	Poppy	**1.12**	**MA**
Meadows and pastures	Trefoils	**2.1**	**JT**
	Dry meadows	**2.2**	**SL**
	Mezophyll meadows	**2.3**	**MEL**
	Wet meadows	**2.4**	**VLL**
Wetlands	Reeds, sedges	**3.1**	**MORA**
	Willows, alder carrs	**3.2**	**MOVR**
Succession areas	Natural seedings of woody plants	**4.1**	**SUD**
	Barrens (soils let to stand-still)	**4.2**	**SUL**

	Ruderals (dung-yards, scrap-yards)	**4.3**	**SUR**
Fruit groves	Fruit groves, garden	**5.1**	**OSAD**
	Alleys	**5.2**	**AL**
Forest areas	Deciduous forests	**6.1**	**LL**
	Coniferous forests	**6.2**	**LJ**
	Mixed forests	**6.3**	**LS**
	Clearings and forest glades	**6.4**	**PA**
Water areas		**7**	**VOPL**
Bare river beds and shores		**8**	**OBPL**
Built-up areas	Compact built-up area	**9.1**	**ZAS**
	Scattered built-up area	**9.2**	**ZAR**
	Quarry, sandpit	**9.3**	**LOM**
	Communications	**9.4**	**KOM**

Results

The shore vegetation and its assessment

Totally, 196 relevés were elaborated on 11 sand pit lakes, where the dominants of vegetation, its general vertical structure and the degree and types of human activities were noticed. The human influenced 10 to 70 % of the area of the studied localities (see table 3). The least influenced places were lakes of the Veselí system. On sand pit lakes, where the extraction was still not finished or was finished only short time ago, there is the human impact 50 to 70 % (Cep I lake) of the area. Angling is the most often activity on the Veselí system and bathing and other recreation on the lakes Tušť and Františkov (there is the camp and the hotel nearby). The Vlkov lake is the most visited in the summer months (75 %). On the lakes Cep, Cep I and Halámky the effect of the extraction dominates. The other lakes were yielded to natural succession of plant and animal associations but always in the human presence. The most affected growths are reeds with species *Phragmites australis, Typha latifolia, Typha angusti folia, Glyceria maxima* etc.

Table 3 *Human activities and the vegetation structure of 11 sandpit lakes in BR Třeboňsko [%].*

Sandpit lake	**Square**							
	1	2	3	4	5	6	7	8
Františkov	*B, A 20*	B 10	B 5	-	B, P, A 20	T 5	-	B 5
Tušť	B 5	B, A 10	B 5	P 5	B, A 50	B 70	-	B, A 20
Cep	B, A 20	P, A 5	P 5	B, R 30	A 40	R 50	P 5	A 20
Cep I	M 90	B, R 30	B 10	B 5	-	P 5	P, M, R 5	P 5
Horusice	B, A 50	-	B 10	B 20	R 50	-	B, P 15	B 30
Horusice I	B 50	T 5	M 5	-	-	-	-	B 50
Vlkov	B 75	-	B, P 20	-	-	-	B 20	P, A 10
Veselí	B, P 5	-	-	A 20	B, A 60	-	B, A 90	T 25
Veselí I	-	T 5	-	-	B 50	T 5	-	B 25
Halámky North lake	B, A 50	B, P 20	P 5	B, P, R 20	M 100	M, P 5	B, P 25	B 40
Halámky South lake	R 20	R 60	R 5	-	P, R 5	-	-	B 20

B – bathing, A – angling, P – path, M – mining, R – relief, T – tread down

There were 158 species found on the studied sand pit lakes. Horusice I (78 species) and Cep (72 species) had the highest species richness. On the other side, Františkov and the South lake Halámky had the lowest number of species (41 species). The woody vegetation was represented mainly by willows (*Salix fragilis*, *S. caprea*, *S. cinerea*). Among herbaceous species, *Lythrum salicaria*, *Lysimachia vulgaris*, *Ranunculus repens* and *Gallium palustre* were frequently found.

The first DCA axis is the longest one (see figure 2, table 4) and explains 6.7 % of the total species variability. The second axis explains 5.4 % of the total species variability. The first DCA axis was significantly correlated with maximum water level in the littoral belt, total height of the vegetation, cover of E3 layer, shading, depth of organic horizon and extent of human impact. The maximum water level and the type of shore profile were correlated with the second DCA axis (see table 5).

***Table 4** Summary of detrended correspondence analysis (DCA) of 88 relevés of sandpit littoral vegetation (Třeboň Basin, Czech Republic).*

Axis	Eigenvalue	Length of gradient	Species environment correlation	Cumulative percent variance	
				Species data	Species-environment relation
1	0.613	4.050	0.700	6.7	10.1
2	0.491	3.332	0.602	12.1	16.7
3	0.417	3.210	0.698	16.7	0.0
4	0.320	3.333	0.660	20.2	0.0
Total inertia	9.127				

***Figure 2** DCA ordination diagram of vegetation samples with passive environmental variables.*

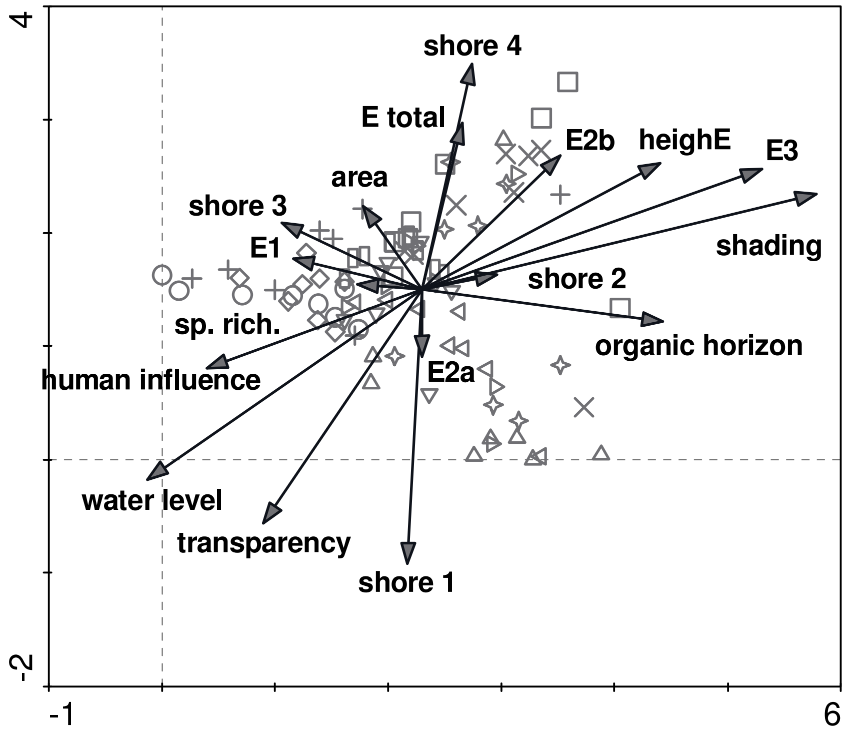


***Table 5** Correlation coefficients between environmental variables and DCA ordination axes (see figure 2). P<0.05, n.s – not significant.*

	AX1	AX2	AX3	AX4
Area (m2)	n.s.	n.s.	0.48	n.s.
Water level (cm)	-0.24	-0.21	n.s.	n.s.
HeighE	0.22	n.s.	-0.34	-0.38
Shore P	n.s.	-0.27	0.22	n.s.
E0 %	n.s.	n.s.	n.s.	0.27
E2 %	n.s.	n.s.	n.s.	-0.36

E3 %	0.34	n.s.	-0.31	n.s.
Shadow	0.43	n.s.	-0.30	n.s.
Depth of organic horizon (cm)	0.27	n.s.	n.s.	n.s.
Percent area with human impact	-0.26	n.s.	n.s.	n.s.
Diversity	n.s.	n.s.	n.s.	0.28

Four canonical axes of CCA with all environmental variables were significant ($P < 0.01$), explaining about 9.7 % of the total variability in the species data. Species-environmental correlation is similar to that in unconstrained ordination (see table 5). According to the forward selection, water level in the littoral belt, water transparency, shading, and relevé area were the four most important variables.
Water transparency was affected by ongoing sand extraction (causing a mechanical turbidity) or, alternatively, by the density of planktonic algae in older lakes with a higher trophic status (36-209 cm). The relation between the trophic status, water transparency and composition of aquatic vegetation has been well documented (Pokorný *et al.* 1990). Exchange of plant species is to be expected in the newer, and therefore still less eutrophicated sandpit lakes with proceeding eutrophication (and the associated reduction of water transparency owing to the increasing production of planktonic algae).
The vegetation development is associated with accumulation of organic material, as indicated by the significance of the organic horizon on the first DCA axis. The development of the organic soil horizon coincides with the development of the tree and the upper shrub layer, occurring on flat or stair-like shores. The woody vegetation of such sites was dominated mainly by willows (*Salix fragilis*, *S. caprea*, *S. cinerea*). Among herbaceous species, *Lythrum salicaria*, *Lysimachia vulgaris*, *Ranunculus repens* and *Gallium palustre* were frequently found.
As follows from the correlation matrix of relation of individual characteristics studied (see table 6), neither the monitored types of human activity nor the characteristics of the vertical stand structure follows from is in the significant relation with the age of the sand pit lake (years from the beginning of the mining). The number of years past from the end of the mining is in significant relation with the extraction and with the E2b layer development. Hard littoral flora was dominant there. Total human impacted area was not in correlation with small areas activities i.e. angling or paths but was in correlation with large areas activities i.e. bathing and mining. The frequention of bathing was negatively correlated with the total cover and E2b layer development.

Table 6 *Correlation matrix of human activity and vegetation cover on 11 sandpit lakes in Třeboň Basin area*

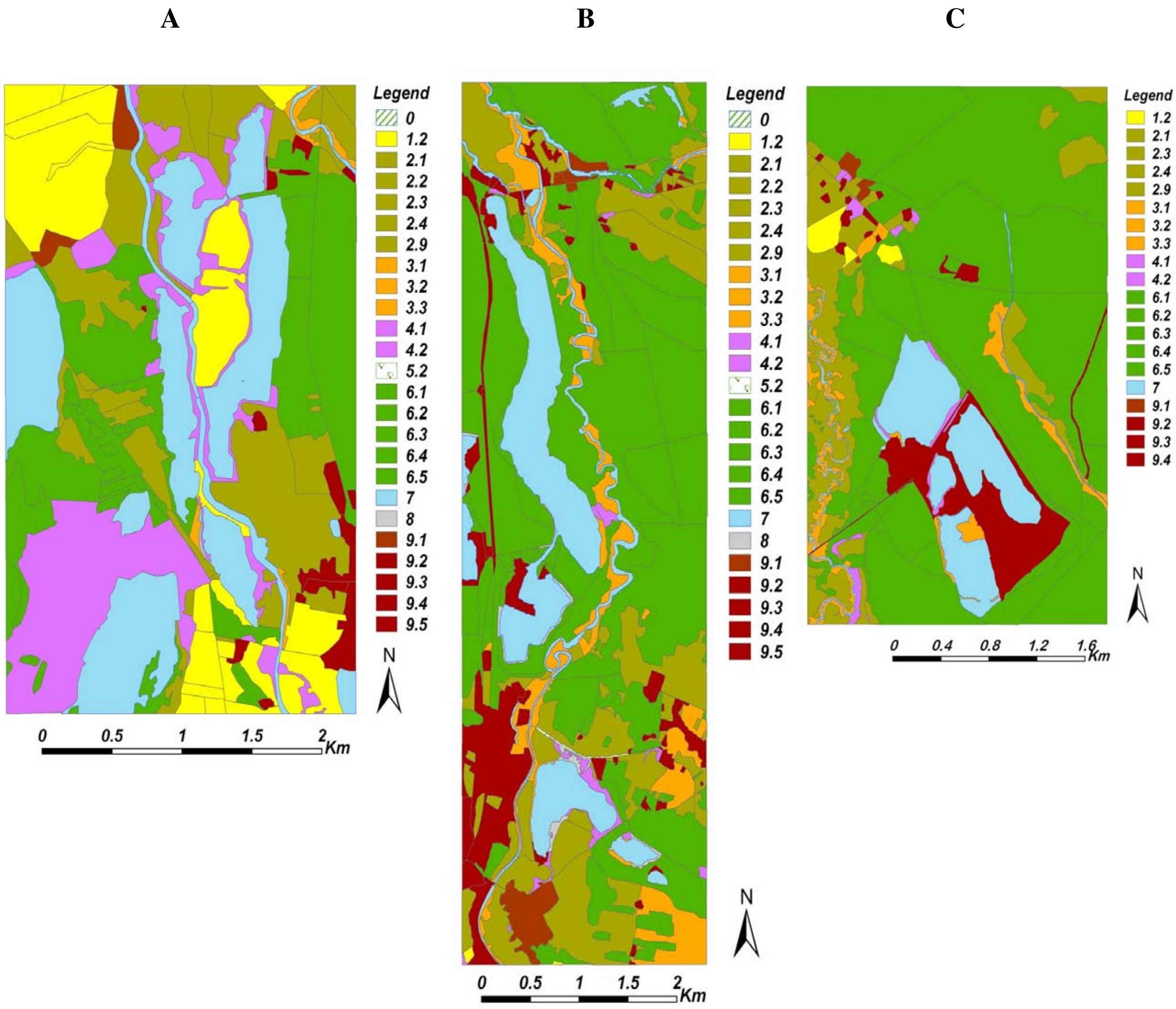
	Sand-pit	Start of mining	End of mining	Human impact	Path	Angling	Bathing	Mining	Stand height	Total cover	E1a cover	E1b cover	E2 cover
Start of mining	-0,14												
End of mining	**0,27**	**-0,37**											
Human impact	**0,34**	0,00	0,20										
Path	-0,19	-0,11	0,14	-0,12									
Angling	-0,12	-0,03	-0,04	0,19	**0,31**								
Bathing	0,20	-0,09	0,08	**0,64**	-0,12	0,20							
Mining	**0,39**	0,20	**0,36**	**0,47**	-0,18	-0,17	0,11						
Stand height	**-0,35**	-0,15	-0,02	**-0,49**	0,19	0,05	-0,29	**-0,33**					
Total cover	**-0,37**	0,16	-0,23	**-0,74**	0,14	-0,02	**-0,48**	**-0,38**	0,21				
E1a cover	**-0,26**	0,00	0,00	-0,20	**0,36**	0,13	-0,05	-0,22	0,22	**0,24**			
E1b cover	**-0,31**	-0,02	-0,03	**-0,33**	0,23	-0,02	-0,21	-0,16	**0,28**	**0,44**	0,09		
E2 cover	-0,05	0,21	**-0,25**	**-0,46**	-0,19	-0,06	**-0,34**	-0,18	-0,07	**0,61**	**-0,31**	-0,19	
E3 cover	-0,18	-0,19	0,08	**-0,33**	0,11	-0,06	-0,23	-0,20	**0,67**	-0,01	0,11	0,13	**-0,26**

The most often carried out recultivation is the forest. The shores around nearly all lakes are planted by pine trees (*Pinus sylvaticus*) some time with seedaged woods (*Betula pendula, Alnus glutinosa* and *Salix sp.*). There were small islands left for the increase in biodiversity and as a protection against the predators. It was not possible to consult the recultivation plans, because they haven't existed till now (only for Halámky system) and the new ones are not done for the giving in public.

Land use of the adjacent areas

The result of the land use mapping is a GIS layer on the ortophoto map (see figure 3) (as Mundia and Aniya 2006). Here it is possible to see the most intensively exploited areas and the type of the exploitation (forest, field, water areas and other surfaces). On the basis of the land use map is possible to make the hypothesis, how the land use influences the water nutrient conditions (Thanapakpawin *et al.* 2007). The land use mapping was carried out in 2007 at the first time and it is necessary to possess the time line data. That is the reason why to continue (Sýkorová *et al.* 2006).

Figure 3 *Land use maps of studied sandpit lake systems (A – Veselí sytem, B – Suchdol system, C - Halámky system).*



Discussion and conclusion

The sand pit lakes represent new types of aquatic ecosystems and emphatic landscape element in the Třeboň Basin region. And that is the reason why insufficeintly information exists about it (Krupauer *et al.* 1990).

Two individual succession series proceed in sandpit lakes. Within xeroserse, psamoserse take place in elevated parts of the sandy shores. Olson (1958) mentioned the length of psamoserse over 1000 years. The second successional serse detected on sandpit lakes is the freshwater hydrosere of eutrophic waters. It starts by submerged plants stage and continues from reed stage or high sedge and willow shrub stage eventually to flood-plain forest associations (Moravec *et al.* 1994).
The primary succession runs in newly originating biotopes without their own diasporas reserve. Within the primary succession, the biocoenosis is formed. It takes place in association with soil formation. The areas without vegetation and organic soil horizon are frequent on sandpit shores. Within the primary succession the species richness, the height of vegetation, the plants age, total biomass, number of vegetation layers, nutrient abundance, organic matter abundance and total cover increase rate. The rate of mineral nutrient cycling, total production and total biomass decrease. The secondary succession runs as a vegetation resumption after its destruction by natural factors or human activity (Moravec *et al.* 1994).
Different stages of primary succession take place in most of the sandpit lakes. Secondary succession proceeds on several lakes or their parts. They include periodically disturbed stands (human activities – mining, recreation). One objective of this study was to document the significance of the relation between the age of lakes and successional stage. The following characteristics were considered as indicative of the successional stage: the cover of vegetation and its height, species richness, organic horizon and vegetative turbidity, which can indicate the trophic level. The relation between trophic level, water transparency and water vegetation structure is well known (Pokorný *et al.* 1990, Hejný *et al.* 1996). With increasing trophic level, the light intensity in the water column attenuated by the growth of phytoplankton. The development of macrophyte associations could be expected on newer and only moderately eutrophied sandpit lakes.
Different plant species have different demands on their environment. Several rare species of sandpit lakes (*Drosera rotundifolia, Lycopodiella inundata* and *Illecebrum verticillatum*) were detected in relatively early successional stages (Křiváčková-Suchá and Rajchard 2005). The habitat character change with progressive succession and establishment of more competitive species, which are lost during the time. The tree vegetation looks like an old forest on older lakes. Tetter (1990) studied the spontaneous succession of herbaceous vegetation on the sandpit lakes shores. He analysed 29 species in an early succession stage, all of which were altogether confirmed in our study.
Shading by adjacent woody vegetation is another feature of the littoral vegetation of sandpits. As the littoral belt is usually very narrow, the stands are frequently shaded by forest plantations occurring on the more elevated parts of the shore. In comparison, much wider unshaded littoral belts are developed around fishponds, the shores of which are usually flat (Hroudová 1988, Hroudová and Zákravský 2002).
The extent of human disturbance (caused by sand extraction, movement of lorries transporting the sand, and recreation activities such as fishing and bathing) significantly affects species composition. The results of Křiváčková-Suchá *et al.* (2007) lead to the same conclusion. Therefore the danger of habitat disturbance should be taken into consideration when evaluating the sandpit biotopes as potential refuge habitats for plant species that disappear from other wetland habitats in the region.
The results of the work Křiváčková-Suchá *et al.* (2007) confirm these conclusions. The sandpit lake biotopes behave as potentional refuges for plant species passed from other marsh habitats in the region. The aim of the management is to set the priority (recreation or the landscape protection) on particular parts of lakes. The recultivations and land use are closely related to this management. Both influence the water quality and the shore character (Chattopadhyay *et al.* 2005, Johnson *et al.* 2005, Sonoda *et al.* 2001, Sekhar and Raj 1995), landscape structure, stability and biodiversity (Nevrelová 2004). That was the reason for land use mapping. There are a few possible methods for mapping i. e. DHSVM (Distributed Hydrology Soil Vegetation Model) after Thanapakpawin *et al.* (2007) or modificated model SWAT (The Soil Water Assessment Tool) after Inamdar *et al.* (2006) or ERS SAR interferometry after Strozzi *et al.* (2000). But for out conditions the methodical key after Sýkorová *et al.* (2006) was the best one. Some authors were interested in other factors as. For example Hagen *et al.* (2006) studied the biological indicators - influence of leaf breakdown related to land use category on the water quality. Ponge *et al.* (2006) demonstrated at the local level the species richness of edafon communities was negatively influenced by the land use diversity. We concentrated just on the land use mapping for the first season.

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