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River landscapes and extreme floods in Central Europe (1997, 2002): need for long-term research

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ABSTRACT

Extreme floods of the Vltava and Elbe river catchments at the end of the summer 2002 were similar in some aspects to those of 1997 in Moravian and Eastern-Bohemian rivers. The flood-plain of the Tichá Orlice river – enriched by new sediments and new plant species – became an experimental area useful for testing and monitoring major ecological processes following the "two-hundred-years" flood. Selected results of the research are presented: e.g., the role of seed bank, the viability and germination ability of seeds, community resistance in relation to expansive species and a comparison of vegetation development on different flood sediments.

From the geomorphological point of view, the river basin is formed by depressions, elevations, terraces, etc., of differing age and structure. The flood may either fill-in terrain depressions, or further increase the differences by depositing material onto elevated sites. All this replaces the old mosaic of biotopes by another (Kovář 2003, Kovář et al., 2003). A set of bare sediment habitats contributes to rejuvenation of the ecosystem; alien elements, both structural and chemical, change it to a certain degree. The changing green mantle of the river landscape probably reflects climate changes interacting with man-influenced land surfaces.

Key words: River landscape, extreme floods, climate change, succession, biodiversity, expansive species

INTRODUCTION

Two main factors acting in flooded ecosystems may be distinguished: (1) WATER, causing both *disturbance* – e.g., mechanical destruction of plants – and *stress* – mostly physiological, e.g., shortage of oxygen, and (2) SEDIMENT transported by the flood, affecting vegetation both mechanically incl. dispersal of seeds, and by nutrient loads promoting fast-growing species. Biodiversity is thus changed (Kovář et al., 2002).

Concerning revitalization of the pre-flood (original) vegetation, we need to establish out:

(1) how many species of the original community may survive the flood,
(2) what sediment thickness can be overcome by the original species,
(3) how surviving species are affected by the physical and chemical characteristics of the sediment,
(4) how the structure of the community is changed by removal of particular species, and by nutrients loaded by flood.

From the point of view of the new species brought about by the flood, we want to discover:

(1) how rich is the imported seed-bank,
(2) what stand attributes support seed germination and seedling growth of the alochtonous diaspores, or of the seed rain from nearby autochtonous vegetation,
(3) the longevity of the imported seed-bank.

From the two processes, *regeneration* and *introduction*, we would like to assess:

(1) the proportion of autochtonous and alochtonous species of the newly formed stands,
(2) the speed of casual recovery of a dense stand on sediments of different type,
(3) the type of new stands and successional series following the flood.

RESULTS

The Tichá Orlice river floodplain was investigated after floods in July 1997 (Figs 1, 2). One year after this major flooding, there were between 30 to 50 species on the fresh sediments deposited by several rivers. Some species reappeared which were once a counterpart of the meadow community before various hydro- and agrotechnical measures. Also, the spreading of invasive species was recorded, as well as of species from biotopes accompanying rivers. Some species, formerly of sporadic occurrence, largely increased their frequency and cover. Some species of autochtonous communities, able to penetrate the thick sediment layer, apparently increased in size, similar to those meadow plants growing at the fringe of the sediment zone. Where the sediment thickness changed gradually, a rather sharp boundary was noted between overgrown and bare sediment, suggesting the decisive role of sediment thickness in fast re-vegetation of sediment.

Seedbank of the flood sediments

During the flooding a lot of material accumulated, which differed in texture and also in thickness. Completely new stands were created of which two types were distinguished: (1) stands on sandy alluvial substrate and (2) stands of stony type with an admixture of gravel. Both were compared with a third type (3) the meadow, which was covered only by thin and disjunctive layer of sediment. In the new material, a low content of nearly all nutrients is typical, creating extreme habitats for plant growth.

The first part of this study is devoted to seed bank (Janoušková 2001): (a) to the seeds that were brought in accumulated material and (b) to the following dynamics of seed bank. In this case, the data was also used to compare the influence of varying strenghts strong floods (during three years of study there were two

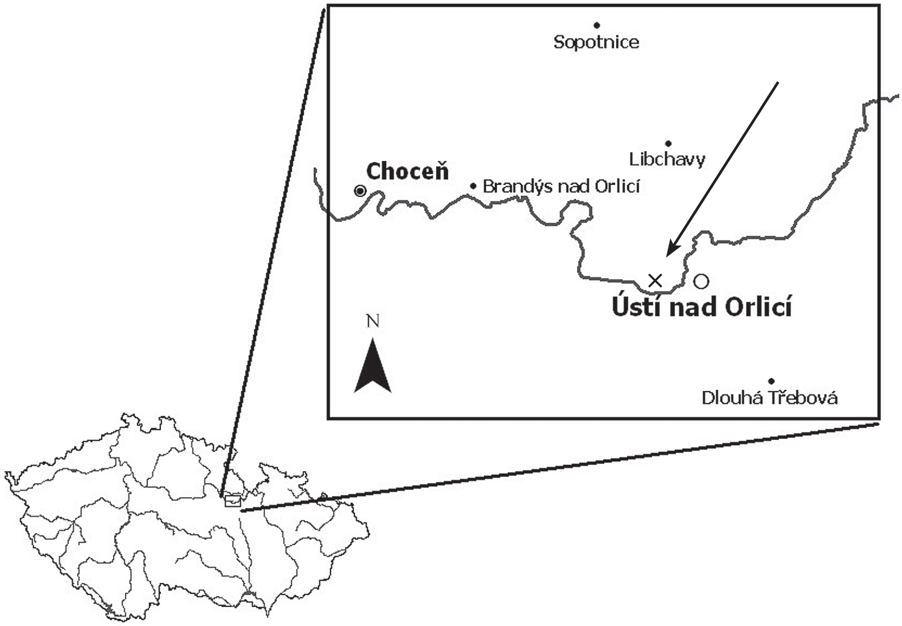

Fig. 1: Czech Republic – arrow shows the analysed locality with floodings in 1997

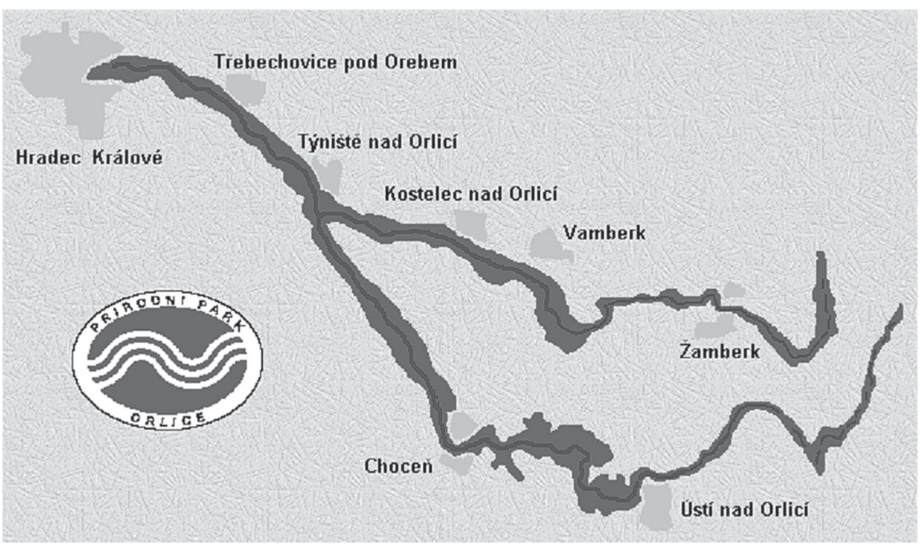

Fig. 2: Map of Natural park Tichá Orlice (based 1996 for its landscape character, values of nature and health restoration)

weaker floods recorded in early spring 1999 and 2000 which affected the locality). Soil samples for seed bank analysis (Baskin & Baskin 2001, Kropáč 1966) were taken from each of the three types of substrata, in spring 1998 from 0–5 and 5–10 cm depth and in autumn 1998, spring 1999, autumn 1999 and spring 2000 only from the depth 0–5 cm. The seedling emergence method was used. The samples from autumn were stratified in a cold refrigerator (about 3 °C) so that the seeds produced in the same season would germinate simultaneously.

Seed bank analysis in three years (1998–2000) and two sampling periods in each year (spring, autumn) recorded 2211 seedlings belonging to 54 species (9 monocotyledons and 45 dicotyledons). The number of species recorded increased with time (Fig. 3).

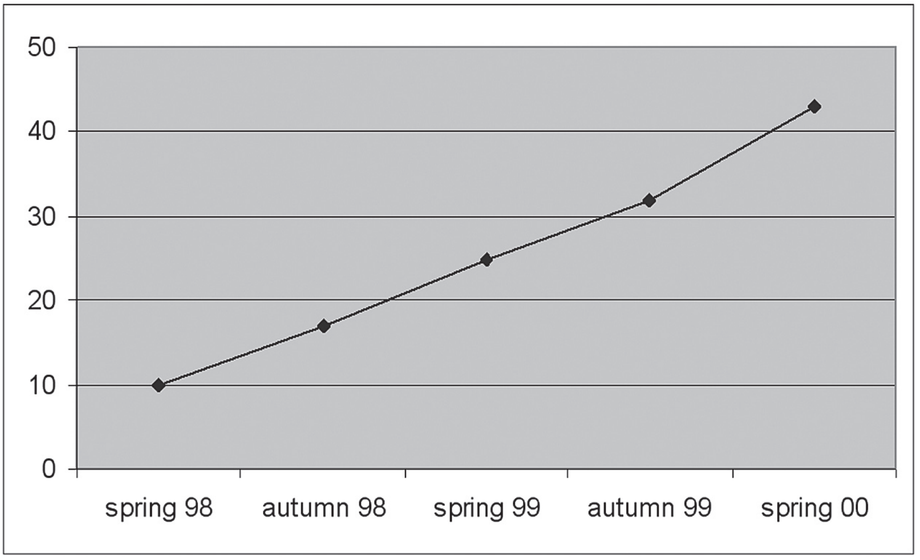

Fig. 3: Number of plant species recorded on the sediments in the field

While the number of species recorded gradually increased (Fig. 3), the number of seedlings showed a different trend: spring sampling in 1999 and 2000 yielded about twofold diaspore numbers compared with autumn samplings (Fig. 4) even though both spring and autumn samplings followed after one growth season, were sampled from the same place and the samples were treated similarly. The differences are thus due to further, local floods of minor extent (1999, 2000) that reached the locality before the spring sampling.

The individual types of sediments showed a similar trend (Figs. 5–7). There was no increase in seed number in spring 1999 in gravel sediment.

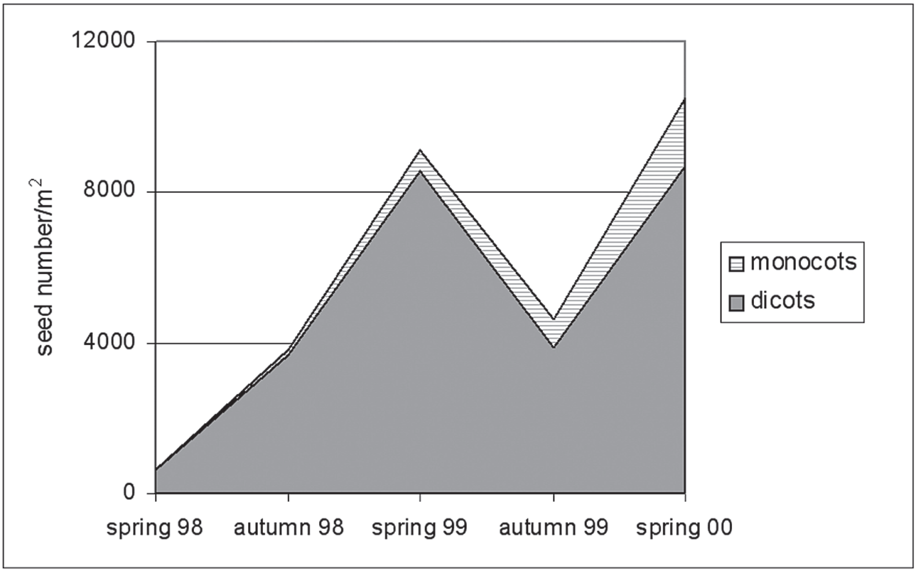

Fig. 4: Numbers of plant species in soil seed bank assessed by seedling emergence method

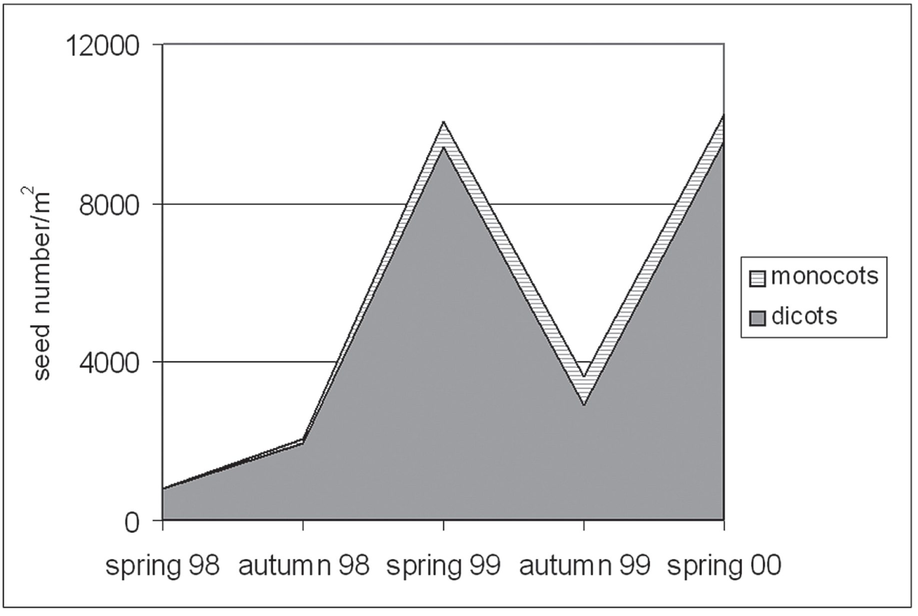

Fig. 5: Trend of the soil seed bank development on sandy sediment

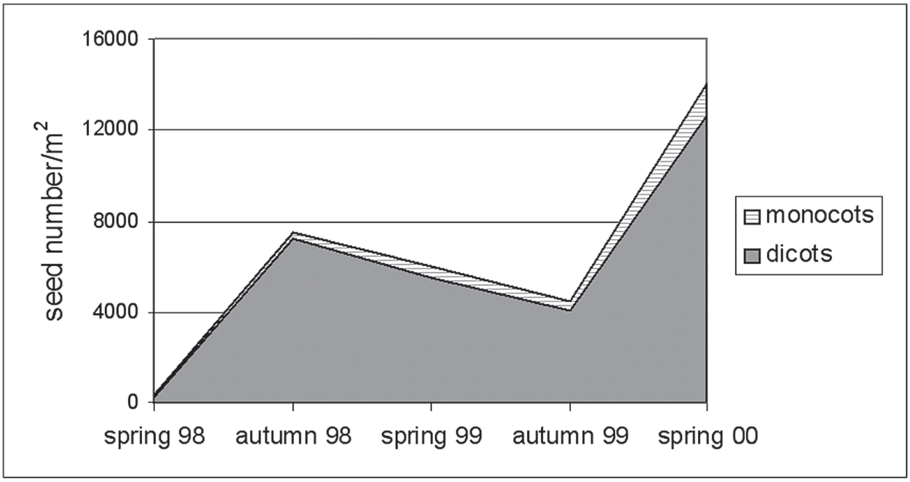

Fig. 6: Trend of the soil seed bank development on gravel sediment

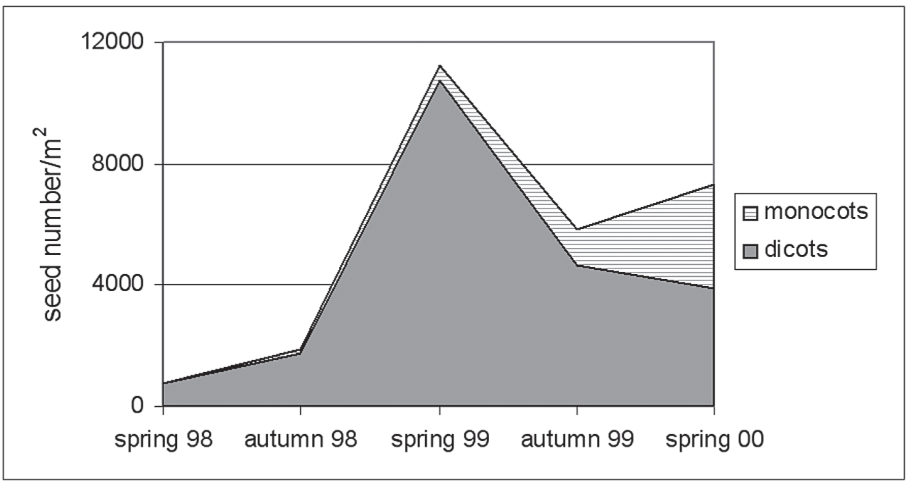

Fig. 7: Trend of the soil seed bank development on alluvial meadow without sediment

Proportion of most abundant species (*Stellaria media, Urtica dioica* – plants typical of river alluvia) even increased with time. Such species as *Poa pratensis*, *Geranium pratense, Ficaria verna, Arrhenatherum elatius* and other (predominantly plants of mown meadows) became more abundant in the late samplings. In the seed bank, *Melandrium rubrum* is a remarkable species which was absent before the 1997 flood. The proportion of graminoids is increasing.

Similarity of the vegetation and seed bank composition

Jaccard's coefficient of similarity was used to compare the seed bank with aboveground vegetation (Jaccard 1901):

$$IS_J = 100.\ c / (a + b + c)$$

c – number of species occurring in both lists
a – number of species present only in vegetation
b – number of species present only in the seed bank

This comparison is based on presence of species in the seed bank and in vegetation (Looney & Gibson 1995).

For the seed bank, data from spring 1998, 1999 and 2000 were used; for vegetation, abundance data were recorded on permanent plots in July 1998, 1999 and 2000.

Tab. 1: Average values of Jaccard's index (%) are given in the left column; standard deviation in the right column. Index letter indicates the differences between the years (Tukey test)

	1998^{a}		1999^{b}		2000^{b}	
	□	SD	□	SD	□	SD
sandy sediment	0.9	1.8	15.12	10.03	12.4	6.771
gravel sediment	3.15	3.163	8.025	5.131	13.83	4.963
meadow	5.3	2.197	20.32	6.628	18.32	8.297

Tab. 2. Results of analysis of variance (ANOVA) for repeated measurements, time factor

ANOVA Summary of all Effects						
1-SUBSTRATE. 2-YEARS						
	df	MS	df	MS		
	Effect	Effect	Error	Error	F	p-level
1	2	83.90242	9	72.9561	1.15004	0.359108
2	2	488.7671	18	37.49082	13.03698	0.000316
12	4	33.10367	18	37.49082	0.882981	0.493751

Similarity of the seed bank and vegetation is relatively low. As Tables 1 and 2 reveal, no difference was noted between the substrates. However, Jaccard's index differs between years. The Tukey test showed differences between 1998 and 1999–2000: similarity increased with time. Even though there was no significant difference between the sediment types, the coefficient was always highest for the meadow (Tab. 1). The differences are more pronounced in Fig. 8.

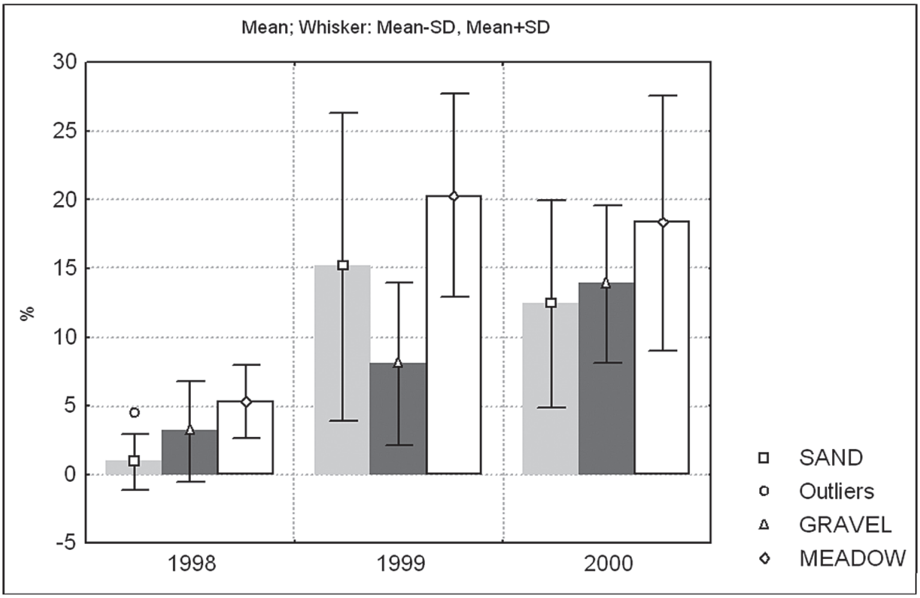

Fig. 8: Values of Jaccard's index of similarity between the seed bank and vegetation

Conclusion: The material brought in the strong floods (1997) contained only a few seeds. Its main part was of meadow origin. During the three following years, the number of species in the soil seed bank increased, whereas the total number of seeds varied during the year: after the spring (and less strong) floods in 1999 and 2000, total number of seeds raised almost twice.

The two types of alluvial deposits were both similar from the point of view of vegetation and the seed bank. There were great differences between soil seed bank and vegetation on meadow and especially on alluvial deposits. Its seed bank seems to stagnate. In the seed bank species like *Urtica dioica, Stellaria media, Artemisia vulgaris, Chenopodium album* and *C. polyspermum* still dominate and the seed bank is only slowly enriched with new species, mainly from neighboring meadow.

Response of plants to flood sediment

The second part aims at the response of vegetation to alluvial deposits: (a) by comparing biomass artificially covered with 10 cm layer of sand with uncovered vegetation; (b) by measuring parameters of selected species growing on or outside alluvial deposits.

To be able to test the immediate response of plants to freshly deposited sediments, we piled plots of a grassland at the studied locality with sand (Fig. 9). This experiment should reveal the immediate vegetation response to flooding, namely the ability of individual plant species to grow through deposits of different heights.

Fig. 9: Experimental quadrat overlayed with 10 cm of sand; June 1999

The experiment started at the end of March, 2000. Ten pairs of quadrats (each 0.5 × 0.5 m) were chosen randomly in a relatively homogeneous meadow stand (all. Arrhenatherion). Each pair of quadrats was placed close to each other so that the plant composition was comparable as well as the quantitative proportion of individual species.

One of the quadrats of each paired plot was enclosed by 50x50x10 cm wooden frame. These frames were filled with the fine sand of flood deposits. All 20 squares were left to spontaneous development for three months. At the beginning of July 2000, the aboveground biomass was removed with scissors approx. one cm above the ground surface, in parallel in both paired squares. With respect to the stand height, it was necessary to sample only those plant individuals rooting in the experimental plot. Immediately after sampling, the aboveground biomass was hand sorted into individual plant species. It was dried at 60 °C and weighed.

Altogether 35 species were recorded – 28 on control plots, 21 on sand-treated plots. 13 species grew only on control plots and 7 species grew only on overlayed plots. Most abundant was *Galium album* (in all the plots), *Poa pratensis + P. trivialis* (in 17 plots out of 20), *Arrhenatherum elatius* and *Alopecurus pratensis* (in 14 plots). Only one occurrence of the species *Agrostis stolonifera, Cerastium holosteoides, Galium aparine, Holcus lanatus, Myosoton aquaticum, Ranunculus* *acris, Sanguisorba officinalis,* and *Vicia sepium* was recorded (in control plots) and *Fallopia convonvulus, Lycopus europaeus, Medicago* sp. and *Polygonum aviculare* (in treated plots).

Arrhenatherum elatius, Galium album and *Poa pratensis + P. trivialis* contributed to species composition in control plots most of all, followed by *Geranium pratense, Alopecurus pratensis, Phalaris arundinacea* and *Hypericum perforatum* (Fig. 10). Dead biomass was also sampled on control plots with 21.8% (SD = 1.2) in average.

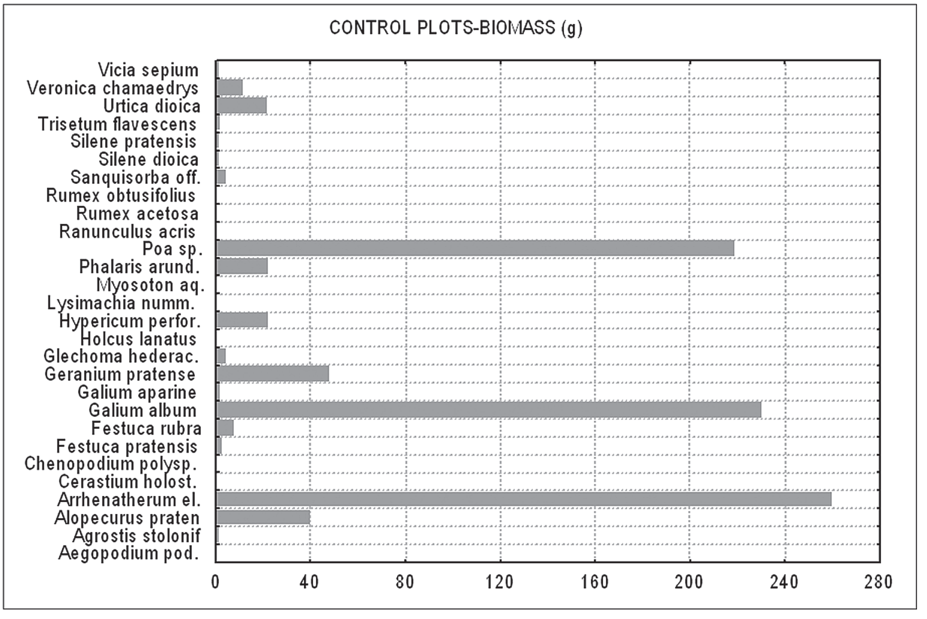

Fig. 10: Biomass of individual plant species in control plots

Sandy sediment showed more levelled biomass of individual species. *Chenopodium album* with the highest biomass was followed by *Phalaris arundinacea, Urtica dioica, Aegopodium podagraria, Galium album, Hypericum perforatum, Rumex obtusifolius, Polygonum lapathifolium* etc. (Fig. 11).

Conclusion: The response of the vegetation to the fresh alluvial sediments differed. Five basic types of plant species were distinguished: type 1 – species dominant in the meadow (*Galium album, Arrhenatherum elatius, Poa pratensis, P. trivialis*), types 2 and 3 species from the meadow but with different ability to grow through the deposits. In type 4, there were only two species (*Rumex obtusifolius* and *Aegopodium podagraria*). They both were very successful on

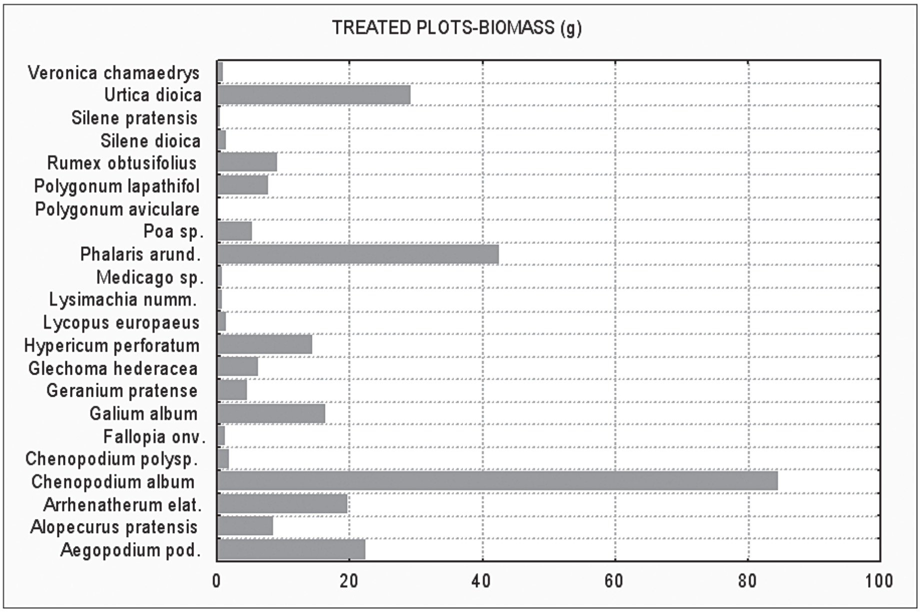

Fig. 11: Biomass of individual plant species on treated plots

the new deposits but rare in the meadow. The last one, type 5 species germinating from seeds (they raised from seed bank or from the surrounding vegetation). These species formed the major part of the vegetation on new alluvial deposits (*Chenopodium album, C. polyspermum, Polygonum lapathifolium*). The specimens of species growing both on the alluvial deposits and in the meadow flowered more abundantly, were taller (not significantly) and wider on the alluvial deposits. This was caused especially by low competition and higher availability of the light on the deposits.

Vegetation succession in permanent plots

In the Tichá Orlice-river lowland, a set of permanent plots was established, covering the two main types of flood-deposited sediment substrates, sand and gravel (Koppová 2001). The height of the sediment cover was ascertained by a test hole. In addition to this, five plots were recorded on the meadow which had been overflooded and disturbed by non-continuous gravel layer, 3–5 cm thick. This served as a control, assuming a rapid regeneration of the original stand under such a thin layer of sediment. Size of the quadrats was 1x1 m, divided into 9 subquadrats by metallic wires. In each of the subquadrats, all plant species were recorded incl. their percentual abundance (Fig. 12).

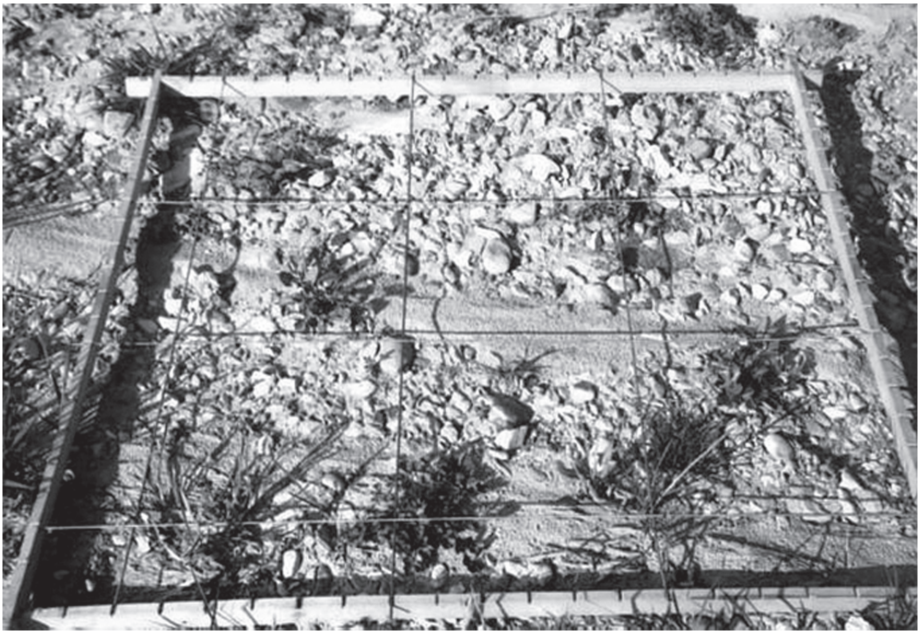

Fig. 12: Permanent plot on the gravel flood sediment

Due to the vertical structure of the stands composed of several sublayers, the total sum of abundances in particular subquadrats can be higher than 100%. Data were recorded: May 1, 1998; May 31, 1998; June 16, 1998; September 10, 1998; May 3, 1999; June 8, 1999; August 15, 1999; June 21, 2000; June 30, 2001. For comparability of records between the subsequent years, the correspondent records (from May, June, etc.) were analyzed.

The process of regeneration is reflected in changes of species present after the flood. All species recorded on permanent plots within the four-year study were thus grouped into three categories: (1) meadow species belonging to the alliances *Arrhenatherion* and *Alopecurion* (class *Molinio-Arrhenatheretea*), (2) species of moist river margins: classes *Galio-Urticetea* (but not *Arction lappae* belonging to "ruderal" species)*, Plantaginetea majoris* (alliance *Agrostietalia stoloniferae*) and *Querco-Fagetea* (alliance *Alnion incanae*), and (3) species quickly occupying open, disturbed places ("ruderal" species): classes *Chenopodietea, Artemisietea vulgaris, Secalietea, Plantaginetea majoris* and their lower units.

142 species of vascular plants were recorded altogether, on all types of substrate and in all years; 124 species out the total were recorded in June. Fig. 13 shows the total numbers of species recorded in June in individual years.

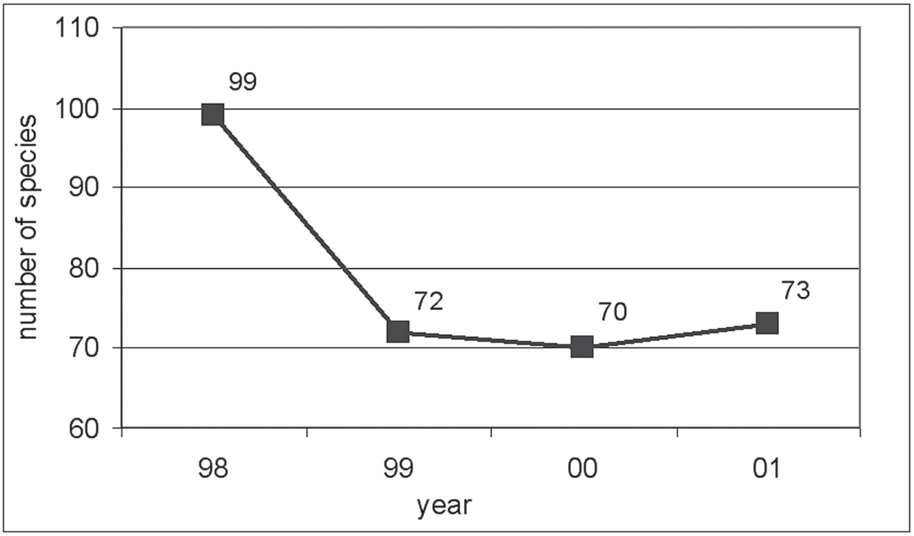

Fig. 13: Trend in total number of species between 1998 and 2001

Total numbers of species differ between the substrates (Fig. 14). The trend in species numbers on sand resembles the trend for total species. There was a decrease in meadow species numbers the first season after the flood but again an increase in 2001. In contrast, the gravel sediment hosted levelled number of species in all the years recorded.

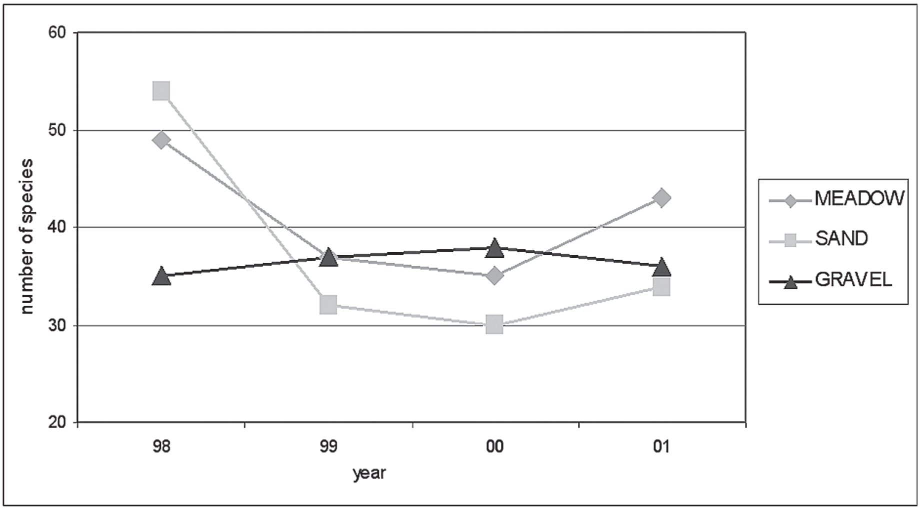

Fig. 14: Number of species on the substrates from 1998 to 2001

Changes in total vegetation abundance within the plots indicate the colonisation development of new sediments (Fig. 15). The lowest rate of colonisation exhibits gravel patches (4 years represent the average time for establisment of close vegetation cover). Sand patches are overgrown more quickly – one year after the flood the vegetation abundance is 75–80%. In general, all plots had 100% cover of new vegetation in 2000. Abundance in the meadow stands decreased in the first year after the floodings by about 15%, however, during subsequent years it was increasing. In those stands, the abundance 100% was reached in the spring 2000.

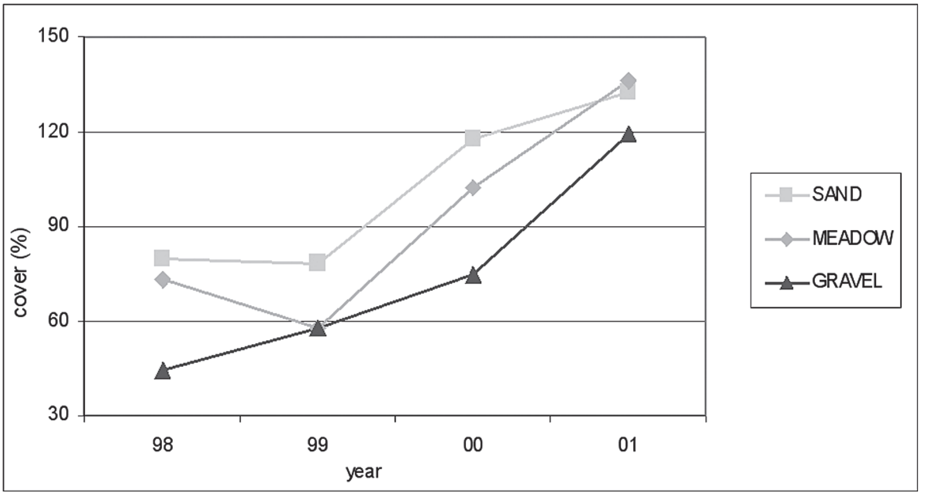

Fig. 15: Trend in average cover on the substrates from 1998 to 2001

Influence of river floods on expansion of invasive species

Nutrient-poor sandy and stony sediments created an open space for local expansion of both native and alochtonous species (Köppl 2002) such as *Impatiens glandulifera, Solidago canadensis, Veronica filiformis, Sedum hispanicum* etc. One of them was *Bunias orientalis* L., a perennial invasive species already introduced to warmer areas of the Czech Republic in 18th century, which has spread along roads and railways. It is assumed that *B. orientalis* has become also part of multispecies herb communities where occasional disturbance by mowing and/or floods has enabled survival and reproduction of this species. The spreading of individuals brought about by floods into meadows represents the phenomenon of establishment of a population of *B. orientalis* within a more structured community in comparison with the original simple plant assemblage in open habitats. We hypothesize that long-term persistence of *B. orientalis* as a component meadow species is enabled by intraspecific selection of certain genetic type. This statement is supported by existence of species rich meadows in Romanian mountains (Kovář 2002), where *B. orientalis* forms an important part of vegetation (e.g. Caliman Mts.).

The study site is located along the river meandering about 1 km E from the town Brandýs nad Orlicí (Kovář 2002, Křivánek & Kovář 2002, Křivánek 2003). The meadow is mown once or twice a year. The dominant plant community belongs to the alliance *Arrhenatherion* neighbouring with shrubs and trees representing the alliance *Alnion incanae* along the river; synanthropic vegetation covers the railway body.

First records of *B. orientalis* in the territory were published in the 20th century (Procházka & Kovář 1976, Kovář 1983). In that time, the species was found S-E from the study site in a railway junction in Česká Třebová on the main E-W transport line. During 1980's and 90's, fast linear expansion of the species continued alongside the railway in the Tichá Orlice river valley – the territory of our work. After the great flood in 1997 and then a series of smaller floods in the Tichá Orlice river valley the species was monitored also in mown meadows communities on river banks.

We surmise that rapid expansion of the river landscape started following the great flood in 1997, which overlayed vegetation with sediments and suppressed the pre-flood meadow community. The following questions thus arise:

1. Do the two populations of *B. orientalis* found on the railway body and neighbouring alluvial meadow differ in age?
2. Did the 1997 flood cause the expansion of *B. orientalis* – i.e., did the flood help *B. orientalis* to migrate across the river?
3. What is typical for morphology of *B. orientalis* roots? Is there any effect of flood on root morphology?

To verify the hypothesis about expansion after the flood disturbance the following action was taken:

1. Randomly chosen squares (3 × 3 meters) were sampled for all the individuals present – 141 plants together.
2. Seven transects were fixed from the railway body into meadow across the river through the second part of meadow on the opposite bank, in 5 m distance each from the other. The nearest individual of *B. orientalis* was sampled at every 5 meters of each transect. Altogether, 60 individuals were collected.

The age of individuals was determined by the herbochronological method (Dietz & Ullmann 1997, 1998): main root was cut about 2–5 cm under its fork to root-heads (about 10–20 cm under the soil surface) and cross sectioned by microtome. The slides 100 µm wide were stained with histochemical dye phloroglucinol in HCl which coloured red the lignified cell walls of deuteroxylema vessels. The structures were analysed under the binocular and microscope.

CONCLUSIONS

1. ***Root morphology***: *B. orientalis* is non-clonal perennial hemicryptophyte with strong post-like roots. At optimum, roots are as long as 1 m and about 6 cm wide. Anatomically, roots have wide parenchymatic area with local lignifying. Especially older roots may have centres near the soil surface destroyed by rot. Close to the rosette, the main root is divided into a few root-heads. It was not possible to distinguish if forming of root-heads was only caused by disturbances or if it was typical for this species. However, we assume that root-head phenomenon was caused by disturbance (the same structures were found in flooded and also in mown communities).

2. ***Time of expansion:*** Age analysis of 141 individuals collected in squares in June 2001 and their size parameters were subjected to statistical methods (Fig. 16). The highest correlation was found between age and root diameter. The oldest individuals were 4 years old. These results support the hypothesis that the 1997 flood supported expansion of *B. orientalis*.

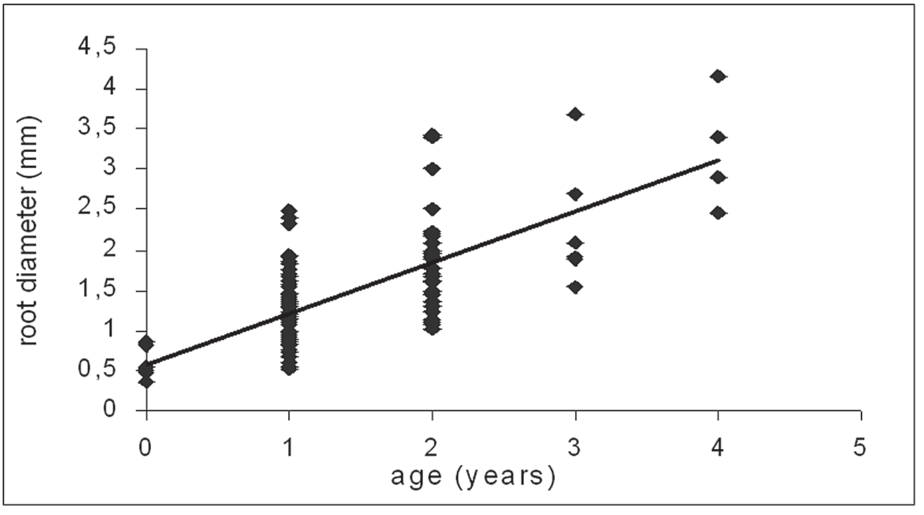

Fig. 16: Relationship of morphological parameters of *Bunias orientalis* to age of plant individuals

3. ***Direction of expansion:*** Expansion from railway body was verified by collection of individuals from transects in September 2001. 5 plants from each transect were cut from the right bank meadow and another 2–4 plants on the left bank. 3 individuals older than 4 years were found (about 15 meters from the railway body on the right bank), two 5, and one 6, years old. Analyses showed that some individuals already grew in a meadow community before the flood but the main expansion started after the flood disturbance. The age of plants decreased with the rise in distance from the railway body. It showed that the main focus of expansion was in the area alongside the railway body. The species expanded to the right bank meadow, migrated across the river and also colonized the opposite left-bank meadow (Fig. 17). There are very few possibilities to colonise the left-bank river alluvium for individuals crossing the river, because trees and shrubs create wide, unmown and shaded belts with high canopy. Outside the transect we also sampled a set of individuals on the railway body. The oldest plants were 6 years old and we assume that this is the maximum possible age under these conditions (however, Dietz & Ullmann 1998 found plants about 12 years old, under different conditions).

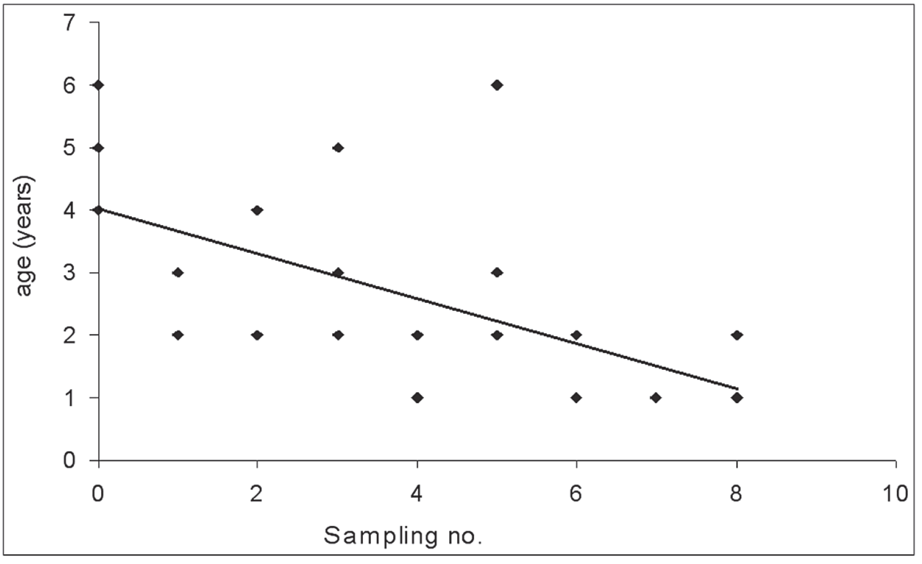

Fig. 17: Age of individuals and their distance from the railway body (samples for number 5 were collected on the opposite left-bank meadow)

4. ***Influence of landscape pattern:*** Linear elements in the Middle-European landscapes are rarely singular, their occurrence is often associated with the more or less interacting and/or parallel lines in dependence on land-surface structure.

A complex geomorphological pattern of river alluvia and valleys creates high energy potential leading to increased density of ecotones – boundary lines. Their combination with the other types of linear elements, e.g., cultural ones (railroads, pathways) could build a heterogeneous, but effective network for invasive plant species (Panetta & Hopkins (1991)). This is also the case of the territory where we studied the expansion of *B. orientalis* occupying lowland of the Tichá Orlice river since seventhies of the 20th century. Our observation shows the enormous supporting effect of the extreme summer flood in 1997 and the fact that particular phases of local expansion are related to the structure and connectivity of biocorridors (number of crossings: river/railway, river/road, railway/road) and to episodic disturbances which stimulate areal spreading of plant propagules. By this way, a "negative" function of biocorridors under specific circumstances implies from the point of view of land-use planning and conservation aim to maintain high biodiversity in landscape.

CONCLUDING REMARKS

The flooding caused an important disturbance to vegetation but, on the other hand, completely new stands with minimum competition were created. Significant differences in revegetation rate between sandy and gravel sites were found. Vegetation on sandy deposits recovered completely within two years, while the gravel deposits remained open to colonisation till the fourth year after the flood. Species composition differed, too. Just after the flood the number of ruderals and annuals (incl. some invasive and expansive species) increased, occupying newly open stands. On sandy sites, rapid colonisation by such clonal plants as *Phalaris arundinacea*, *Urtica dioica* or *Aegopodium podagraria* was recorded, while on gravel sites considerable numbers of ruderal plants remained for three years. The invasion of heliophilous species into meadow stands was observed during the first year after the flood but they were substituted by the original grassland vegetation until spring of the third year. The thickness of accumulated sediments (10–20 cm) was the crucial ecological factor for the majority of meadow plants. They were unable to grow through the sediments. They could regenerate only on meadow stands with 3–5 cm of deposits. Some species of the original meadow communities (Arrhenatherion and Alopecurion alliances) have the ability to grow through the sandy deposits. These are mainly grasses, especially *Phalaris arundinacea* and *Alopecurus pratensis* which are well adapted to flooding and burial by sediments. Only a few dicotyledonous species (*Geranium pratense*, *Sanguisorba officinalis*, *Galium album*) were registered growing successfully through 10 cm layer of sediments. Population density of *Impatiens glandulifera* decreases with the increase of distance from the river (habitats close to the river are probably exposed to seed redistribution). The highest population density of *Impatiens glandulifera* is in the communities affected by flood disturbance. Herbochronological analysis of local invasion of *Bunias orientalis* to the river lowland proves that this propagation was caused by the flood. The species invaded from the previous centre of occurrence in railroad body.

The sediment material brought in the strong type of flood contained a low number of plant seeds. The major part was of meadow origin. During the three following years the number of species in the soil seed bank increased, although the total number of seeds varied during the year: after the spring floods, the less strong ones – such as in 1999 and 2000 in the valley of the Tichá Orlice river – the total number of seeds almost doubled. There were important differences between soil seed bank on meadow and on alluvial deposits- Species like *Urtica dioica*, *Stellaria media*, *Artemisia vulgaris*, *Chenopodium album* and *C. polyspermum* dominate in the sediment seed bank, which is slowly enriched with new species from neighbouring meadow in the next years. The response of the vegetation to the fresh alluvial sediments differed. Five basic types of plant stands were distinguished. Those: (1) dominated by meadow species (*Galium album*, *Arrhenatherum elatius*, *Poa pratensis, Poa trivialis*), (2) and (3) dominated by species from the meadow but with different ability to growth through the deposits, (4) highly dominated ny *Rumex obtusifolius* and *Aegopodium podagraria* – a species very successful on new deposits but rare in the meadow, (5) dominated by the species germinating from seeds contained in new deposits (*Chenopodium polyspermum*, *C. album*, *Polygonum lapathifolium*). The species growing on both the alluvial deposits and the meadow were taller and more extended within the alluvial deposits, and they exhibited more abundant flowering. This phenomenon was caused especially by low competition and higher availability of light n the deposits.

The floods posed a wide range of questions regarding the importance of alluvia in river basins from the ecological point of view. By transferring great alluvial masses, a flood resorted the species spectrum and thus influenced biodiversity in a given locality. In this sense, it is an issue for long-term investigation of individual vegetation species and comparative studies on the situation before and after the floods.

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