FLOODPLAIN ECOLOGY AND MANAGEMENT

The Lužnice River in the Třeboň Biosphere Reserve, Central Europe

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Front cover photo: Meandering section of the Lužnice River which was the object of this study. Photo J. Ševčík.

Back cover photo: The intensely studied floodplain segment of the Lužnice River in the southern part of the Třeboň Biosphere Reserve. Photo J. Ševčík.

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tion when all 1 m^2 plots were ordinated. The coefficient reached the value of 0.912 (Prach 1992). The role of all three main gradients is further discussed in Chapter 9.

The three vegetation types, the most common along the cross-section (*Alopecurus* meadows; *Phalaris* marshes; and former meadows dominated now by *Urtica dioica*) were studied in detail in their productivity and nutrient dynamics (Chapters 6.1; 6.2). Population ecology of the expansive dominants is dealt with in Chapter 5. The cross-section transect, described here from the vegetation point of view, is dealt with in some other chapters (especially Chapters 3.3; 6.3).

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4.1.4. Restoration of degraded meadows: an experimental approach

Karel Prach and Jana Straškrabová

Abandonment of regularly mown, species rich meadows, and their following alterations to monotonous swards of *Phalaris arundinacea* or *Urtica dioica* were mentioned many times in the previous chapters as one of the most concpicuous recent changes which happened in the studied floodplain mostly in seventies and eighties. We estimated that it usually takes two decades for *Phalaris* or *Urtica* to overgrow the meadows. Similar changes have also occurred in floodplains of many other rivers in the country (Rychnovská 1972; Straškrabová & Prach 1996). We addressed the question, how long does the opposite process take, if a previously abandoned meadow is started to be cut again. Although this process is not still seen to occur spontaneously in the Lužnice River floodplain, we expect it to be, at least locally, important in the future. Thus, we proposed an experiment to demonstrate the rate of restoration of the degraded meadows after the re-establishment of regular cutting regime.

Study site and methods used

The part of the floodplain, where the experiment was performed, is located ca. 300 m downstream from the cross-section described in Chapter 4.1.3., on the right bank looking downstream. It had been left without mowing for ca. 20 years. *Phalaris arundinacea* dominated ower the most area, together with *Urtica dioica* in the most elevated parts.

A transect was fixed in 1989 in the total length of 150 m, starting at the river bank and ending at the top of the nearest terrace. The whole transect was surveyed by a level-meter to measure the elevation along the transect. Phytosociological records were made in each 1 m^2 plot along the transect in the beginning of June (1989-1994), i.e. cover degrees for each species present in the plots were visually estimated in percentage. Vegetation was cut along the transect in the strip of 150 × 5 m in size, three times a year in the beginning of the experiment (1989, 1990), later on only two cuts were conducted because of the unsufficient increase in biomass later in the seasons of 1991-1993.

Phytosociological records were processed by the ordination technique CCA (CANOCO/CANODRAW programme – ter Braak & Šmilauer 1993). The cover data were transformed into the ordinal scale 1-8, corresponding to the degrees of the Braun-Blanquet scale (see van der Maarel 1979). The symbol *r* was not distinguished from +. The set of samples was subdivided into two equal subsets according to elevation, corresponding to the wet and dry parts of the transect. Because of the high number of samples, centroids were used in the graphic output (Fig. 4.18), each representing the position of wet and dry parts in six successive years. Principal species exchange was expressed using the same programme.

Seed bank was analysed after four years of the re-established regular moving. Five soil cores, 5 cm in diameter, were taken to the depth of 5 cm from cut and uncut variant in the begining of April, 1993, and cultivated in a greenhouse. Emerged seedlings were counted and determined, some of them after a prolonged cultivation till pre-mature plants.

Aboveground biomass samples were taken from the randomly selected plots of 0.5 × 0.5 m, five in each variant and each date. Sampling was performed just before cutting of the whole transect. Aboveground biomass was assorted to particular species and dead biomass, oven-dried at 90°C, and weighed.

Seed bank and biomass analysses were performed only in the elevated (dry) part of the transect.

Results and Discussion

Changes in species composition

Restoration of the cutting regime immediately induced fast changes in vegetation cover as it is seen in Table 4.5. The dominant species typical of abandoned meadows, namely *Phalaris arundinacea* and *Urtica dioica* dramatically decreased in their dominance during the observed period. On the other hand, species typical of the regularly managed meadows in the area (see Chapter 4.1.3) started to increase (*Alopecurus pratensis, Deschampsia cespitosa, Poa* spec. div., *Ranunculus repens).* Instead the monotonous cover of *Phalaris arundinacea* over the major portion of the transect, the vegetation started to differentiate regarding moisture conditions reflected in the elevation. Sedges (*Carex gracilis, C.vesicaria, C.vulpina*) increased in their occurrence in the lowest part of the moisture gradient, being followed by *Deschampsia cespitosa* in the higher elevation, and then by *Alopecurus pratensis*. In the highest elevation species appeared being typical to the driest alluvial meadows in the Lužnice River floodplain, such as *Avenastrum pubescens, Holcus lanatus,* and *Festuca rubra* (see Chapter 4.1.3). After the five years period, the species composition was comparable with that of the cut meadows.

Similarly fast changes were observed in the case of species diversity (Table 4.6). The number of species per 1 m^2 (species density) nearly doubled after one year. The maximum in the second year of the experiment can be explained by the fact that be-

Table 4.5. Changes in average cover [%] of principal species in 1 m^2 plots along the transect across the Lužnice River floodplain after a regular mowing regime was re-established (in 1989, after a period of ca. 20 years without mowing).

Species/Year	1989	1990	1991	1992	1993	1994
Alopecurus pratensis	14.4	20.3	16.3	26.5	26.8	30.4
Deschampsia cespitosa	0.0	0.0	0.4	0.6	1.6	1.7
Phalaris arundinacea	28.0	35.1	12.3	4.4	1.0	0.9
Poa palustris	0.0	0.7	1.5	2.5	2.9	4.7
Ranunculus repens	0.0	5.8	10.8	29.2	42.4	43.5
Urtica dioica	18.4	7.8	2.0	0.0	0.0	0.0

Table 4.6. Average number of species per 1 m^2 and the total number of species along the whole transect.

Year	1989	1990	1991	1992	1993	1994
Number of species per 1 m^2	4.0	7.3	8.9	6.9	8.1	8.2
Total number of species	28	48	61	71	79	70

tween the decline of the dominants of abandoned meadows and expansion of grasses typical of managed meadows there was space available for establishment of various other species including some ruderals. The average species density in regularly managed meadows nearby reached 8.6 species per 1 m^2, thus, we can conclude that the meadows were restored in this characteristic in very short interval of two years. The increase in the number of species along the whole transect was similarly abrupt, reaching nearly three times higher number compared with before the experiment started.

It was remarkable that there were no substantial differences in species composition of seed bank between managed and unmanaged variants (Straškrabová 1994). In the soil of the cut transect seeds of 13 species were found, in the uncut 19. All the species, participating in the seed bank, were also maturing on the transect. Transport of material in alluvial meadows is very intensive (Pinay *et al.* 1992; Chapter 1, etc.), and it is possible to pressume that transport of seeds is also high. Thus, the comparably fast restoration of the alluvial meadows under study is probably conditioned by the fact that seeds easily penetrate by flooding from their sources nearby. Persistent seed bank probably plays unimportant role because typical meadow species do not usually posses the long seed viability (Baker 1989).

Results of the samples ordination demonstrate that the fastest changes in floristic composition happened during the first 3 years of the re-established mowing in both wet and dry parts of the transect (Fig. 4.18). Differences between the last two years seem to be small especially in the dry part. Thus, even the results of the ordination support the conclusion that 5 years were a sufficient interval to restore the meadows. If we compared the species composition of the experimental transect with that of the regularly mown meadows nearby (Chapter 4.1.3) it was fairly the same, especially in the dry parts. The principal species, occurring in the experimental transect, are seen in the ordination diagram (Fig. 4.19). The distribution of species in relations to site moisture and longevity of cutting is in general accordance with autecological demands of the species (see Chapter 4.1.3). Reconstructed species exchange during the experiment based on the CCA ordination is given in Fig. 4.20.

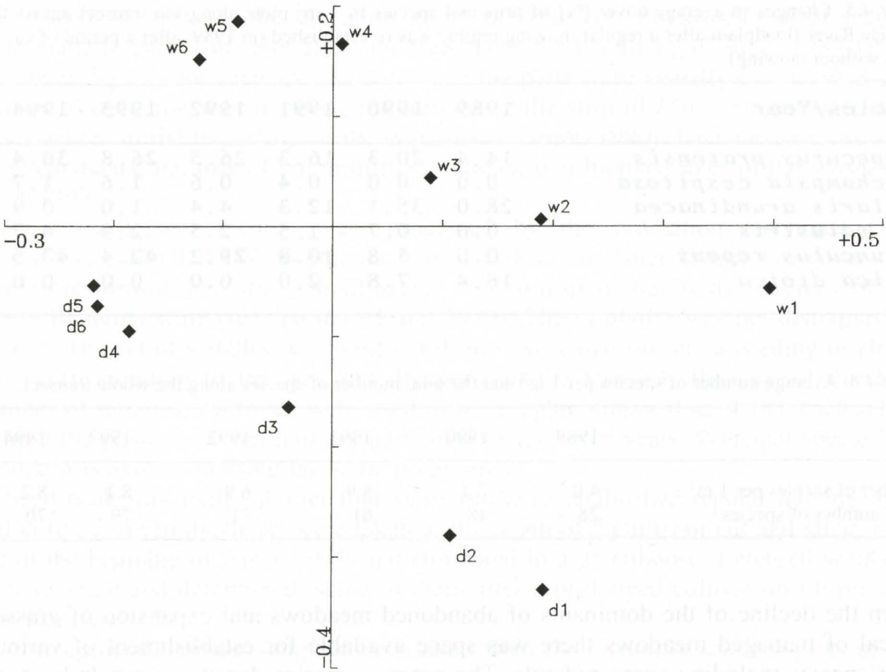

Fig. 4.18. Ordination (CCA) of samples, i.e., all 1 m² plots subdivided into two equaly large groups according to elevation: wet (w) and dry (d). Instead all particular plots (150) centroids representing the two groups in the particular years (1989-1994) are plotted.

Changes in productivity

These are well recognizable from the comparison of biomass of the mown and unmown variants – Table 4.7. After four years of cutting, the biomass of the mown variant was in the first cut 190% greater than the biomass of unmown one. In the second cut the biomass of the unmown variant was naturally greater than in the mown one, however the total productivity was evidently higher in the mown variant. The higher biomass of the mown variant in the first harvest was, besides other reasons, caused by earlier growth of *Alopecurus pratensis* in comparison with *Phalaris arundinacea* (Rychnovská 1985), dominant species of the respective stands.

As expected, cutting decreased amount of dead biomass, which represented only about 12% of that of unmown variant after four years of the experiment. Dead biomass in the mown variant decreased (Table 4.7) during the experiment. This development increased light penetration to the soil surface and opened space for establishment of new species, mainly heliophytes with shorter statue and lower ability of competition. Some of those species would not probably be able germinate in soil covered with several centimetres of litter and mature in closed cover of tall grasses such as *Phalaris arundinacea* (see Grime *et al.* 1988).

Conservative estimations of productivity can be obtained as a sum of biomass in the time of each harvest of the mown variant, and as the maximum biomass of unmown variant, respectively. Estimations of productivity are also summarized in

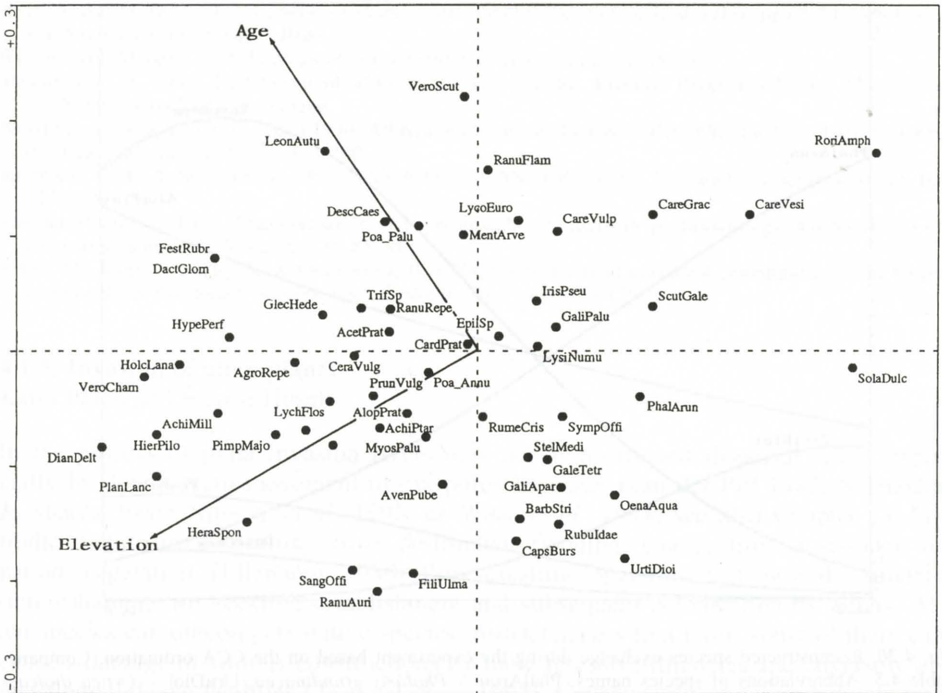

Fig. 4.19. Ordination (CCA) of species. The vectors represent elevation and time since the experiment started. In the left upper quadrant, there are mostly species typical of wet, often cut meadows; in the left bottom, species typical of cut and drier meadows; in the right part of the diagram, species growing mostly in uncut marshes are arranged approximately according to their moisture demands. For the explanation of the species names see Appendix (higher plants).

Table 4.7 for each year and variant. It is evident that, except for the wet year 1991, the productivity of the mown variant was higher than unmown one. Measuring biomass was repeated only 2-3 times a season, so the estimates of production are very approximate. Nevetheless, productivity of the restored meadows in the elevated part of the transect was quite comparable with that of regularly mown meadows nearby (Chapters 6.1, and 6.2).

The fast change from the *Phalaris* or *Urtica* stands to the *Alopecurus* meadow is desirable from the point of view of a potential agricultural exploitation. *Alopecurus pratensis* is much palatable than *Phalaris arundinacea* (Tetter *et al.* 1988). This is the most productive species in the area.

It was demonstrated in this experiment that restoration of the alluvial meadows in the Lužnice River floodplain is comparably easy and fast. There are two main reasons for fast restoration: (a) species typical of regularly cut meadows survived at least in some individuals inside the degraded stage; and (b) transport of diaspores is usually easy by floods even from their sources upstream. The productive meadows are acceptable for both ecologists and agriculturalists, thus their restoration over the floodplain would be highly desirable.

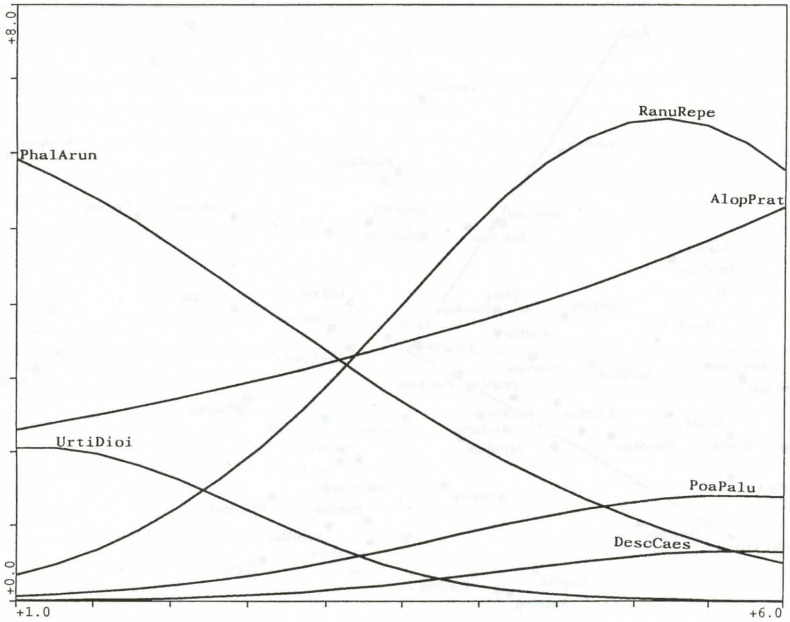

Fig. 4.20. Reconstructed species exchange during the experiment based on the CCA ordination. Compare Table 4.5. Abbreviations of species names: PhalArun – *Phalaris arundinacea*; UrtiDioi – *Urtica dioica*; RanuRepe – *Ranunculus repens*; AlopPrat – *Alopecurus pratensis*; Poa Palu – *Poa palustris*; DescCaes – *Deschampsia cespitosa*.

Table 4.7. Living aboveground biomass (W), standing dead and litter (D) and annual production (P) [$g_{dry\ mass} \cdot m^{-2}$] estimated for the cut and uncut variants in the elevated part of the experimental cross-section. Standard deviations are given in parentheses.

Date of cutting (sampling)		1990 11-Jun	15-Jul	1991 02-Jun	19-Aug	27-Oct	1993 08-Jun	17-Jul
Cut:	W	495(99)	199(48)	254(23)	209(33)	41(6)	336(69)	106(21)
	D	356(93)	261(78)	74(10)	109(32)	155(38)	76(24)	85(13)
	W/D	1.4	0.8	3.4	1.9	0.3	4.4	1.2
	P	593			495		444	
Uncut:	W	297(53)	436(122)	195(79)	707(336)	118(87)	180(59)	334(96)
	D	571(182)	651(150)	478(90)	919(245)	984(174)	609(204)	535(162)
	W/D	0.5	0.7	0.4	0.8	0.1	0.3	0.6
	P	436			701		344	

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4.1.5. Invasion of alien plants

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In the process of plant invasion rivers may act as a efficient dispersal agent, especially by downstream movement of diaspores by water (van der Pijl 1982; Schneider & Sharitz 1988; Nilsson *et al.* 1991; de Waal *et al.* 1994; see also Chapter 1). Periodic disturbances resulting from destructive flooding, can destroy or damage riparian vegetation (Ellenberg 1988) thus creating openings that provide suitable (micro)habitats for seedling establishment and subsequent colonization by aliens. Alien species can outcompete native species, restrict access to a river, some of them can cause a damage of various constructions by their agressive rhizomes and adversely affect flood defence facilities (de Waal *et al.* 1994). Consequently, riparian habitats into which an alien species was successfully introduced and naturalized may serve as foci for subsequent spread into the adjacent landscape (Pyšek & Prach 1993). For all these reasons, occurrence of invasive species in river corridors must be given an attention.

Among invasive plants, the following are considered to be the most agressive in riparian habitats over Europe (de Waal *et al.* 1994): *Impatiens glandulifera, Heracleum mantegazzianum, and Reynoutria japonica.* Locally, other species can be included to the list. We evaluated (Pyšek & Prach 1993) distribution and history of expansion of these species in the Czech Republic, regarding also their occurrence along rivers. Only *Impatiens glandulifera* was recorded largely invading along the Lužnice River (Fig. 4.21). The first record of this species from the Czech Republic is known from 1896 and already in 1909 was found as naturalized at Třeboň, along the Zlatá stoka channel (Čelakovský, herbarium of the National Museum, Prague). Since that time, the species has spread along streams in the Třeboň Biosphere Reserve including the Lužnice and Nežárka Rivers, however still avoiding the Upper Lužnice River section. A potential focus of spread was recorded in recent years at a tributary to the Lužnice River, ca 500 m from the river itself, just near the study plots (Fig. 4.21).

Generally, the Lužnice River floodplain in the Třeboň Basin, especially the segment under the most intesive study, is less infested by riparian invasive plants compared with most other Czech rivers. The other aliens causing problems in some central European rivers (*Reynoutria japonica, Heracleum mantegazzianum, Solidago canadensis, S. gigantea, Amorpha fruticosa, Rudbeckia laciniata, Aster* spec.div., *Helianthus* spec. div.) were not recorded or were only sporadic. We can subdivide aliens actually or potentially occurring in the Lužnice River floodplain into the following categories: