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Summary of the PhD. thesis

Relationships between vegetation and environment within a montane floodplain

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České Budějovice
2007

This research was supported by grants of the Czech Grant Agency GAČR526/00/1442 and the Ministry of Education of the Czech Republic 6007665801 and by financial support from the Administration of the Šumava National Park and the Czech Ministry of the Environment.

General introduction

River floodplains have attracted considerable attention during recent decades. As important ecotones between terrestrial and freshwater ecosystems (e.g., PINAY et al. 1990, HOLLAND et al. 1991), they play a crucial role in the control of fluxes of energy, materials and organisms throughout the surrounding landscape (DÉCAMPS 1984, CHAUVET & DÉCAMPS 1989, MITSCH & GOSSELINK 1986, WARD 1989, NAIMAN & DÉCAMPS 1990, NAIMAN et al. 1989, PRACH & RAUCH 1992, DÉCAMPS 1993, MALANSON 1993, BILLEN et al. 1995). Distinctive features of alluvial systems include the open character of the fluxes, and the spatial and temporal heterogeneity of all environmental variables, which are principally related to the river's natural dynamics. A mosaic of hydro-geomorphological and vegetation units is the most evident feature of this heterogeneity (HUPP & OSTERKAMP 1985, PRACH et al. 1996, NAIMAN & DÉCAMPS 1997, BORNETTE et al. 1998).

Although the predominant flows occur in the longitudinal, downstream dimension, we must also incorporate lateral and vertical flows into our views on the functioning of any river floodplain. All such flows are only fully operating in natural floodplains, where there is good connectivity between the river and its corridor (PRACH et al. 1996). However, natural connectivity between the river and its floodplain has decreased along many large rivers in Europe due to long-term degradation (AMOROS et al. 1987, DÉCAMPS et al. 1988, PRACH et al. 1996, LARGE & PRACH 1998, GODREAU et al. 1999) and the diversity of interactions between vegetation and environment has been considerably reduced far and wide. Thus, it is eminently useful to study the ecological functioning of those river corridors which still preserve the natural character of their streams and floodplains – in order to understand natural processes as a necessary basis for the potential rehabilitation of disturbed rivers and their floodplains (JOYCE & WADE 1998).

The most diverse of environmental mosaics are usually expressed along larger streams with wide and physically complex floodplains: where the lateral dimension in land-water ecotones is best developed (MALANSON 1993). Topographic variation, primarily conditioned by fluvial dynamics and regular flood pulses, here results in many different microhabitats and predetermines unusually diverse environmental and vegetation patterns. The flat, broad floodplains of lowland rivers, with their horizontal dimension, naturally differ in their heterogeneity from the narrow floodplains of montane streams, with their largely manifested vertical dimension of the valley. A rather unusual situation develops if a montane river forms an open flat valley, which is just the case of the river in this study.

In any floodplain, three main river-induced gradients are the most evident and they are also considered to be responsible for vegetation pattern: (1) a moisture gradient; (2) a nutrient gradient, and (3) a gradient of disturbance intensity (DAY et al. 1988). The disturbances can be either natural (floods) or human-induced (e.g. mowing of alluvial meadows). Although all the above-mentioned gradients are important and related each other, water-table fluctuations are usually considered to be a key factor, i.e. the main driving variable (e.g. MALANSON 1993). PRACH (1992) demonstrated the topographic-moisture gradient to be the most responsible for vegetation variability in the floodplain of the Lužnice River in combination with the disturbance regime. Detailed hydrological studies have revealed that among a site's variation, the relative importance of different water sources is reflected in a hydrochemical pattern (GILVEAR et al. 1997, GILLER & WHEELER 1988). Spatial correlation of variations in

groundwater chemistry and water table with vegetation, biomass and biodiversity have been documented, for example, by WILLBY et al. (1997) and ROSS et al. (1998).

In central Europe, most rivers and their floodplains have been altered by various human activities (OPRAVIL 1983) and there are very few rivers which still possess natural flow dynamics (KHAITER et al. 2000). In the Czech Republic, the traditional river-engineering-oriented approach to rivers led, particularly in the 1970s and 1980s, to the canalization of nearly all remaining unregulated rivers, including even small montane streams which had no real effects on flood reduction or the agricultural use of river corridors. In relation to that, the well-preserved part of the montane floodplain of the Vltava River gave a notable opportunity for a detailed ecological study of a relatively natural alluvial environment. Being part of the extensive border region, neglected for political reasons, many human activities had been reduced here for almost the whole second half of the 20th century. As a result, important ecological processes were left to be preserved or were less influenced than those in heavilypopulated and intensively-used interier landscapes. From a biogeographical point of view, the importance of this fluvial landscape widely overcomes its regional dimension. Its high proportion of relic habitats, particularly peatlands, as well as the frequent boreal or boreomontane elements in its local flora contribute to a specific character of vegetation: the area can be viewed as 'an island of boreal landscape in central Europe'.

Aims of the thesis

The main aim of the thesis were: (1) to describe the vegetation pattern and vegetation-environment relationships within a relatively well preserved montane floodplain, (2) to analyse the area from biogeographical point of view, and (3) to propose the optimal management approach for maintaining both high biodiversity and natural processes within the floodplain.

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Contents

The thesis is composed of four original studies:

1.
Linking vegetation pattern to hydrology and hydrochemistry in a montane river floodplain, the Šumava National Park, Central Europe.

BUFKOVÁ I. & PRACH K., 2006: ***Wetlands Ecology and Management*** **14: 317-327**

Vegetation cover of higher plants (in 4 x 4 m plots), groundwater table and water chemistry in boreholes were sampled at 43 sites along three cross-section transects in a flat floodplain of the Upper Vltava River in the Šumava Mountains (Šumava National Park, Czech Republic) with the aim to describe the relationships between vegetation and aluvial environment. Correlations between hydrochemical and plant community characteristics were calculated, and an ordination method (CCA) was used to express relationships between the abiotic factors and vegetation. The following characteristics were significantly correlated with the vegetation pattern: mean position of the water table, distance from the river, and pH, concentration of NH_4, and content of humic acids in the groundwater. Two distinct zones were distinguished in the floodplain: Zone I was under direct influence of the river, and exhibited higher pH and ammonium content in largely fluctuating groundwater; and Zone II, covering more than half of the floodplain extent, was under the prevailing influence of water coming from the adjacent upland, and exhibited lower pH, higher content of humic acids, and a higher and relatively stable groundwater table. The diverse mosaic of the riparian communities, especially of tall-sedge and tall-grass marshes and alluvial meadows, were typical for the former zone, while peatland vegetation characterised the latter one. The floodplain still exhibited a rather oligo- to mesotrophic status with only very local eutrophication, and harboured diverse and valuable plant communities, the protection of which should be among the priorities of the National Park authorities.

2.
Relationships between vegetation and environment within the montane floodplain of the upper Vltava River (Šumava National Park, Czech Republic)

BUFKOVÁ I., PRACH K. & BASTL M., 2005: ***Silva Gabreta, Supplementum*****, 2: 1-78**

Vegetation units were described in detail and then vegetation mapping performed at a broader scale of the studied upper Vltava floodplain (Šumava National Park, Czech Republic), and detailed analyses of vegetation and hydrochemical parameters conducted along three cross-sectional transects. Data analysis using multivariate methods showed that the following characteristics appeared to be significantly correlated with the vegetation pattern: mean position of water table; distance from the river; pH, concentration of NH_4, and content of humic acids in groundwater. Two distinct zones, each covering approximately half of the floodplain, were distinguished : Zone I, under the direct influence of the river; and Zone II, under the prevailing influence of water coming from adjacent upland and/or from upwelling deep groundwater. A diverse mosaic of riparian communities was typical for Zone I, while

peatlands characterised Zone II. The high diversity of the floodplain vegetation, and the occurrence of many rare, endangered and phytogeographically important species, indicate the uniqueness of the floodplain wthin central Europe. The floodplain still exhibits an oligotrophic-mesotrophic status, with only very localised human-induced eutrophication, and its protection should be among the priorities of the Šumava National Park.

3.
Vegetace Vltavského luhu na Šumavě a problém reliktních praluk

SÁDLO M. & BUFKOVÁ I., 2002: ***Preslia*****, 74: 67–83**

The nutrient-richer and open habitats were recorded mostly in the strip zone along the river. Their current vegetation was studied and several communities were distinguished, i.e. alluvial woodland and scrub (communities of *Betula pubescens-Alnus incana, Salix cinerea, Salix triandra* and *Spiraea salicifolia-Phalaris arundinacea*), and tall grassland of sedges, grasses and forbs (communities of *Cirsium heterophyllum-Filipendula ulmaria, Phalaris arundinacea, Carex buekii-Phalaris arundinacea,* and *Carex gracilis*). The species composition of these communities is characterized by many elements of boreal/continental distribution (e.g. *Polemonium coeruleum, Pseudolysimachion longifolium, Spiraea salicifolia, Betula pubescens*), and that of Central-European mountains (e.g. an endemic species *Aconitum callibotryon*). A hypothesis of the relict origin of this vegetation is given and supported by recent dynamics of habitats and vegetation, as well as by findings of palynology, palaeoecology and history of land-use, and by the composition and history analogical to relict vegetation of the northernmost Europe. It is assumed that this vegetation originated in the mosaic-like and half-open landscape of the Early Holocene (preboreal, boreal) and it survives under a combination of stress and permanent habitat rejuvenation caused by the meandering river.

4.
Vodní makrofyta a mokřadní vegetace odstavených říčních ramen horní Vltavy (Hornovltavský luh, NP Šumava)

BUFKOVÁ I. & RYDLO J., 2007: ***Silva Gabreta,*** **submitted**

Vegetation survey of river cut meanders within the montane floodplain of the Upper Vltava River was performed in 2004. Both semi-terrestrial and water vegetation related to small water bodies (oxbow lakes, backwaters) well reflect montane and oligotrophic status of studied floodplain. There was found high proportion of plant communities typical for wetlands in northern or northwestern Europe (*Nupharetum pumilae, Myriophylletum alterniflori, Equiseto limosi-Caricetum rostratae, Comarum palustre* and *Menyanthes trifoliata* com., *Sparganietum minimi, Utricularia ochroleuca* com.). Oxbow lakes in the floodplain are terrestrialised by floating *Sphagnum* mats with vegetation of al. *Sphagno recurvi-Caricion canescentis* generally typical for oligotrophic lakes and peatlands. Different vegetation was found in southeast margin of the floodplain influenced by Lipno dam and characterised both by different hydrology and trophy status where plant communities typically occuring in lowland and more eutrophic floodplains were already presented.

Summary of results

Water table position and chemical composition of the shallow groundwater exhibited large spatial variations across the floodplain along all three transects and the variations were well reflected in the vegetation pattern. Water table fluctuations, the minimum water table height, and pH were negatively correlated with distance from the river. Plant species richness and the Shannon index were positively correlated with distance from the river and negatively correlated with the maximum water table height and water table fluctuations. Moreover, the Shannon index exhibited a positive correlation with total organic carbon (TOC) and a negative relationship with pH. Diverse hydrological and hydrochemical conditions across the floodplain were reflected in the vegetation patterns demonstrated in the ordination diagrams. The direct gradient analysis (CCA) showed that the following five environmental variables appeared in the forward selection to be significantly correlated with the vegetation pattern: water table, pH, distance from the river, NH_4 content, and content of humic acids. Samples from the mesotrophic river bank vegetation, including tall-sedge, and tall-grass marshes, and tall-herb stands were typicall for sites where trophic status was indicated by higher pH and ammonium nitrogen content. Treeless fens occurred in sites with higher water table and higher content of humic acids. Oligotrophic peatlands, including both wooded raised bogs and fens usually occurred far from the river, and low pH was their typical feature. The mesic alluvial meadow sites typically occurred on elevated sites of the floodplain and were only rarely flooded. They were mostly mesotrophic. The indirect gradient analysis (DCA) apparently arranged the samples along the first ordination axis, which can be interpreted as a trophic gradient. The second ordination axis appeared to reflect increasing moisture. The *a priori* distinguished vegetation units occurring along the transects, can be grouped into four broader groups:

I – (eu)mesotrophic tall stands, which include tall-sedge and tall-grass marshes, both on river-bank and permanently-wet sites, tall-herb stands, successional stands with *Spiraea salicifolia* and also low willow stands;

II – alluvial meadows whether managed or abandoned;

III – treeless peatlands, including short-sedge mires, *Molinia caerulea* fens, and dwarfshrub fens;

IV – wooded peatlands including bog pine forests and woody fens.

The distribution of Shannon diversity index values indicates a considerable decrease in species diversity along the trophic gradient from nutrient-poor to nutrient-rich site conditions. The highest diversity is clearly related to the vegetation of short-sedge mires and grass fens, and to alluvial meadows. The high biodiversity values obtained for raised bogs and woody fens can be associated with the richness of the non-vascular species, especially bryophytes, that is typical for these kinds of plant communities. In contrast, tall-sedge and tall-grass stands inhabiting the mesotrophic, or slightly eutrophic, riverine zone are generally characterised by a low diversity of species.

Across the floodplain, the spatial variations of the analysed hydrological and hydrochemical parameters and vegetation revealed two distinct zones: Zone I was under direct influence of the river, and exhibited higher pH and ammonium content in largely fluctuating groundwater; and Zone II, covering more than half of the floodplain extent, was under the prevailing influence of water coming from the adjacent upland, and exhibited lower pH, higher content of humic acids, and a higher and relatively stable groundwater table. The regularly-flooded Zone I, adjacent to the river, is characterised by a broken microtopography, with frequent

alternations of surface elevations and depressions. Mineral sedimentation is the prevailing process here with a highly fluctuating water table whose mean position corresponds mainly to the local microtopography. Hydrologically-contrasting microhabitats, i.e. dry and wet, are able to develop here within the relatively small total range of elevation. The diverse mosaic of the riparian communities, especially of tall-sedge and tall-grass marshes (e.g. *Caricion gracilis, Caricion rostratae, Phalaridion arundinaceae, Magnocaricion elatae*), willow and alder stands (e.g. *Alnion incanae, Salicion albae, Salicion cinereae*) and alluvial meadows (*Alopecurion, Molinion,* and *Polygono-Trisetion*), were typical for this zone. In contrast, the usually wide peatland Zone II, adjacent to the hillslopes, is typical of a relatively flat surface topography and habitats are characterised by a rather stable water regime and an acidic, oligotrophic substratum. The water table is maintained near the surface for almost the whole year and its fluctuations are much lower then in Zone I. The pH of the groundwater considerably decreases from the river towards the hillslope edges of the floodplain. Waterlogging, with a generally low pH, has enhanced extensive peat formation within this zone. Various peatlands, both ombrotrophic and minerotrophic, were characterised this zone (*Sphagnion medii, Oxycocco-Empetrion hermaphroditi, Betulion pubescentis, Piceion excelsae, Sphagno recurvi-Caricion cannescentis, Caricion fuscae*).

The whole floodplain is characterized by high proportion of relic habitats including especially peatlands and vegetation of water macrophytes in oligotrophic pools. Relic origin was also suggested for some riverbank tall-sedge and tall-herb vegetation and woodlands exhibiting high number of species of boreal/continental distribution. This hypothesis is supported by recent dynamics of habitats and vegetation, as well as by findings of palynology, palaeoecology and history of land-use, and by the composition and history analogical to relict vegetation of the northernmost Europe.

The floodplain still exhibited a rather oligo- to mesotrophic status with only very local eutrophication, and harboured diverse and valuable plant communities, the protection of which should be among the priorities of the National Park authorities. The management scheme including both non-intervention approach and actively managed sites was proposed to maintain natural habitats and dynamic processes as well as high biodiversity of the floodplain.

General conclusions

Studied part of the Upper Vltava floodplain exhibits exceptionally high natural values. It represents the rare case of a broad, flat floodplain in the upper reaches of a river in the mountains. The variable mosaic of diverse plant communities, with the occurrence of many rare and endangered species of various phytogeographical origin, can be well interpreted by differences in hydro-geomorphological and hydrochemical site characteristics. The following characteristics appeared to be significantly correlated with the vegetation pattern: mean position of water table; distance from the river; and the pH, concentration of NH4, and content of humic acids, in the groundwater. Two distinct zones were distinguished: Zone I under the direct influence of the river; and Zone II, under the prevailing influence of water coming from the adjacent upland and/or the upwelling of deep groundwater. The diverse mosaic of riparian communities is typical for Zone I, while peatland characterises Zone II. The floodplain still exhibits an oligo-mesotrophic status with only very localised human-induced eutrophication, and its protection should be among the priorities of the National Park Authority.

Curriculum vitae

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Membership: - Czech Botanical Society
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Study courses abroad:
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