APPLICATION OF GEOECOLOGICAL CONCEPT OF THE ALLUVIAL LANDSCAPE IN THE CREATION OF NATURE RESERVE (CASE STUDY FROM CZECH REPUBLIC)

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Abstract


The geoecological concept of the alluvial landscape describes the variability and consecutive character of alluvial ecotopes and biocenoses, which are interrelated in terms of their homeorhetic development, in their dynamic ecological stability. This article deals with application of this landscape concept in the frame of creation of nature reserve as core zone of the Litovelské Pomoraví Protected Landscape Area (Czech Republic). Complex protection of the whole floodplain ecosystem, which comprised all components of the fluvial succession series of alluvial habitats, was proposed on the basis of determination of geomorphological type of the river system. Analyses of the floodplain forest stands status within the study area were performed using methods that are normally used in the elaboration of management plans of protected areas within forest land on the basis of data from Forest Management Plan. The area of the proposed NNR was created by the overlay of the special map layers using method gap-analysis in the frame of GIS.

dynamic fluvial succession series, floodplain forest, GIS analysis, Litovelské Pomoraví

The following theories can be included among the main landscape-ecological concepts of the Central European alluvial plain (DEMEK et al., 2008): the River Continuum Concept (SEDELL et al., 1989), the River Landscape Concept (MALANSON, 1993; ŠTĚRBA et al., 2008), geomorphological typology of watercourses for the needs of nature conservation and landscape protection (ANGRADI et al., 2004; ROSGEN, 1994) and the fluvial succession series of alluvial habitats (BUČEK, LACINA, 1994).

This article deals with application of this landscape concept in the frame of creation of nature reserve as core zone of the Litovelské Pomoraví Protected Landscape Area (Czech Republic). This geoecological concept describes the dynamic essence of ecological stability of the alluvial landscape. The concept describes the variability and consecutive character of alluvial ecotopes and biocenoses, which are interrelated in terms of their homeorhetic development, in their dynamic ecological stability. The concept is based on the structure of the alluvial landscape, which is formed by a mosaic of hydrobiocenoses of watercourses, riverine lakes, riparian wetlands, meadows and floodplain forests of different types from the most wet alder-willow forests to the most dry hornbeam-elm-ash forests. The dynamic fluvial series of alluvial habitats is a series of water, wetland and terrestrial biogeocenoses, both natural and human-conditioned, in different stages of their successional development, which continually evolve depending on fluvial landscape-forming processes in the floodplain. The whole dynamic fluvial succession series of alluvial habitats is formed by a lot of habitat types (for details see MACHAR, 2001a).

The completeness of the dynamic fluvial series of alluvial habitats and their successional development depend on permanent function of fluvial processes...
in the floodplain (shifting and branching of the channel, flooding and sedimentation, etc.). The consequences of the fluvial processes affect hydrological conditions (ground water level and its fluctuations, the extent and duration of floods) and the character of individual segments of biogeocenoses on a long-term basis. Therefore, the maintenance of alluvial landscape biodiversity depends not only on static protection of certain areas but also on functioning of natural fluvial landscape-forming processes. Complete dynamic fluvial series of alluvial habitats can only be maintained and protected if the natural fluvial processes are maintained or restored at least in some sections of the alluvial landscape (POOLE, 2002). An ecosystem approach is suitable for the understanding of the dynamics of alluvial processes (PITHART et al., 2008; TRÉMOLIERES, SCHNITZLER, 2007).

METHODS AND MATERIALS
Analyses of the floodplain forest stands status within the study area were performed using methods that are normally used in the elaboration of management plans of protected areas within forest land (MICHAL, PETRIČEK, 1998) on the basis of data from Forest Management Plan (www.uhel.cz). Data on parts of the stands were available and, therefore, the analysis of the forest status within the area of the proposed NNR was performed according to forest types (Tab. I). The area of the proposed reserve was delimited using GIS ArcInfo 2.0. The following map layers were overlaid: (1) presumed maximum dimensions of the meander belt of the Morava River anastomotic channel network (SINDLAR et al., 2010), (2) delimited groups of geobiocene types (GBT, BUČEK, LACINA, 1999), (3) habitats of Natura 2000 system (HÁRTEL et al., 2009) and (4) degrees of naturalness of forests stands (VRŠKA, HORT, 2003). The main aim was to include all GBTs, which were identified within the area, into the future National Nature Reserve Floodplain of the Morava River, each with a sufficient area for spontaneous development of forest ecosystem by VÁCEK (2003). The area of the future NNR was created by the overlay of the map layers using method gap-analysis (BURLÉY, 1988). For easier identification, boundaries of the NNR were adjusted to the boundaries of parts of the forest stands according to the Forest Management Plan even at the cost of consolidation of some parts of the stand of low ecological stability or altered tree composition.

Study area
The fluvial series of alluvial habitats of Litovelské Pomoraví was described in the study by MACHAR (2008) using the method of biogeocenological transects (BUČEK, LACINA, 2006). Protection of dynamic development of fluvial processes is necessary for conservation of this landscape phenomenon and, therefore, complex protection of the whole floodplain ecosystem, which comprised all components of the fluvial succession series of alluvial habitats, was proposed on the basis of determination of geomorphological type of the river system (KIRCHNER, IVAN, 1999). A new national nature reserve (NNR) was proposed that was tentatively named Floodplain of the Morava River (SERVUS, MACHAR, 2001).

RESULTS
Fig. 1 shows different habitat types of the fluvial succession series (meandering river, gravel-sand deposits, initial succession stages of willow-poplar forest, poplar-elm-oak forests, hornbeam-elm-oak forests) and represents a typical picture of the central area of the proposed NNR Floodplain of the Morava River. In this area, the forest site type groups dependent on water prevail (elm alluvium – 80%, poplar alluvium – 15%). An overview of forest types and their representation in the study area is presented in Tab. I. Map of groups of geobiocene types in study area is on Fig. 2. Six groups of geobiocene types (STC) – see Table 3 were identified, classified and described in detail (MACHAR, 2008). The individual STG form in the area of the alluvial forest of Litovelské Pomoraví is a so-called fluvial serial of alluvial biotopes. Within the fluvial seral dynamic section of alluvial biotopes, the initial alluvial community usually consists of willows, with significant proportion of high stands on the newly created edafote of alluvial deposit on the banks or river islands. The willows are followed by Querci-roboris fraxineta of the higher class which exhibit numerous specimens of subalpine plants species. At a greater distance from the water stream, Ulmi-fraxineta of a higher class are to be found, usually on lighter, sandy and well-ventilated soils (subtype

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Name of the forest type</th>
<th>Area (ha)</th>
<th>Area (%)</th>
<th>Natural tree composition</th>
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<tr>
<td>1L2</td>
<td>elm floodplain forest with goutweed</td>
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<td>92.01</td>
<td>DB 4-5 JS 1-2 LP 1-2 JL 1-2 JV HB TPC VR OL</td>
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<td>DB 4-5 JS 3-4 OL 3-4 LP JV JL</td>
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<td>1U1</td>
<td>POPULAR FLOODPLAIN FOREST with nettles</td>
<td>0.76</td>
<td>0.26</td>
<td>TPC 3-4 DB 1-3 OL 2-3 JL 1-2 VR 1-2</td>
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<tr>
<td>1G1</td>
<td>willow-alder forest Alluvial</td>
<td>1.32</td>
<td>0.57</td>
<td>OL 6-9 VR 1-3 TPC 1 LP OS BR JS</td>
</tr>
</tbody>
</table>

DB – pedunculate oak (Quercus robur), JS – common ash (Fraxinus excelsior), LP – small-leaved linden (Tilia cordata), JL – elm (Ulmus laevis), JV – Norway maple (Acer platanoides), HB – european hornbeam (Carpinus betulus), TPC – black poplar (Populus nigra), BR – silver birch (Betula verrucosa), VR – white willow (Salix alba), OL – common alder (Alnus glutinosa)
Fluvisol arenic). The prevailing STG in the alluvial forests of study area are *Ulmi-fraxineta carpini* of a higher class in the driest part of the alluvium out of the reach of regular floods. They are to be found at Fluvisol soils rich in minerals with favorable humification. The mosaic of fluvial series biotopes is complemented by alder bushes of a higher class at those sites which are constantly soaked with stagnant water. This type of STG is to be found in small mosaic-shaped fragments (at places, areas of several m² only). Within the framework of the Natura 2000 system, Litovelské Pomoraví was listed as a national list of important sites at the European level. Map of habitats of Natura 2000 system is on Fig 3. An overview of the forest naturalness according to the comparison of real and natural tree composition in different forest types is given in Tab. II and also in Fig. 4 for the whole area of the proposed NNR. The diversity of the species composition of the forest is shown in Tab. III. This table shows tree composition of the floodplain forest stands within the area of the proposed NNR. The dominance of *Fraxinus excelsior* and *Quercus robur* is the result of historical forest management and corresponds with the dominance of GBT *Ulmi-fraxineta carpini superiora* within the study area (see Fig. 2). Fig. 5 shows the age structure of the forest stands within the area of NNR. The age structure of the Litovelské Pomoraví forest is slightly irregular from the point of view of “forest age classes” (Fig. 5). Ecologically negative is above all the deficiency of the older age classes from the 12th class on, i.e. only a small number of exceptionally old and over-mature trees, which are in a significant way important for the biodiversity of the forest geobiocenosis. Fig. 6 shows the resultant delimitation of the proposed NNR as a core area of Protected Landscape Area Litovelské Pomoraví.
Groups of geobiocenetic types according to BUČEK, LACINA (1999) in the study area of the proposed NNR Floodplain of the Morava River.
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PLA Litovelské Pomoraví border
Border of NNR Floodplain of Morava River
Habitats of Natura 2000 system

<table>
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<tr>
<th>Total of</th>
<th>K2.1</th>
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<th>L2.3A</th>
<th>L2.3B</th>
<th>L2.4</th>
<th>M1.1</th>
<th>M1.3</th>
<th>M1.4</th>
<th>M1.5</th>
<th>M1.6</th>
<th>M1.7</th>
<th>M4.1</th>
<th>M4.3</th>
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<td>180.9347</td>
<td>22.1140</td>
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<td>0.0001</td>
<td>0.0128</td>
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<th>T1.9</th>
<th>V1F</th>
<th>V2C</th>
<th>V4B</th>
<th>X1</th>
<th>X10</th>
<th>X11</th>
<th>X12</th>
<th>X14</th>
<th>X6</th>
<th>X7</th>
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<td>23.8896</td>
<td>0.7593</td>
<td>0.0038</td>
<td>0.0303</td>
<td>0.0237</td>
<td>11.7081</td>
<td>0.2296</td>
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<td>0.2484</td>
<td>1.0224</td>
<td>14.7354</td>
<td>0.5366</td>
</tr>
</tbody>
</table>

3: Habitats of Natura 2000 system in the study area of the proposed NNR Floodplain of the Morava River (abbreviations of habitats according to CHYTRÝ et al., 2001)
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I. DISCUSSION

The theory of fish zones, which was described by A. Fríc very early (FRIČ, 1882), can be regarded as a precursor of the River Continuum Concept that was introduced by VANNOTE et al. (1980). The River Continuum Concept was further developed by the Flood Pulse Concept (JUNK et al., 1989). The idea of transversal transport of materials and energy in respective river sections that affects the production of organic matter in the floodplain, a so-called flood pulse, was added.

A further significant expansion of the River Continuum Concept was the River Productivity Model according to THORP, DELONG (1994), which estimates the biomass production within the river and its replenishment by the biomass from adjacent floodplain ecosystems on the basis of measurements of organic carbon production within the ecosystems of the alluvial landscape.

The River Continuum Concept is complemented by the Stream Hydraulics Concept (STATZNER, HIGLER, 1985) that considers water velocity, which is determined by geomorphology and discharge, to be a crucial factor in the floodplain ecosystem, and also by the River Discontinuity Concept (WARD, STANFORD, 1995) that emphasizes crucial influence of discontinuities (e.g. larger dams) on the river's continuity. The discontinuity is determined by the length of the change in the river route, and by the significance of the difference from the normal course of the river (STRAŠKRABA, TUNDISI, 1999). Other authors emphasized the interaction of the water course with its floodplain and seasonal (temporal) changes of the conditions in floodplain ecosystems (TOCKNER, MALARD, WARD, 2002).

Mechanisms of retention and transformation of material in rivers (cyclic transport and transformation processes within the longitudinal profile of the river continuum) are described in Model of nutrient spiralling effect (NEWBOLD et al., 1981). The main notion is the spiralling length which is the theoretical length of stream required for a transported particle to cycle among all components of the river – floodplain system. The spiralling length is usually short in shallow upper reaches with a rugged stream bed (e.g. the spiralling length of phosphorus is about 200 m in small forest streams) and long within the main channel in lower reaches. In Central Europe, the River Continuum Concept is applied mainly in the restoration of fish migrations (HOLČÍK, 2001).

The majority of watercourses in Central Europe were systematically or locally regulated in the past (JUST et al., 2003; ŠTĚRBA, MĚKOTOVÁ, 2003). Technical regulations were often induced by intensive agriculture within the floodplains or by an effort to protect built-up areas and communications against floods; and they often produce false expectations that the floods will be prevented (BUČEK, 1997). Anthropogenic alterations of
rivers and their catchments changed their natural character to such extent that it is not possible to find watercourses or their floodplains in natural status within the Czech Republic (PRACH et al., 2003).

Dynamic equilibrium of stream channel evolution processes is determined by its geomorphological type and the adjacent floodplain vegetation (SIEBEL, 1998). Channel evolution processes can be vitally affected by technical regulations (KENDER, 2004). Today, the general consensus is that it is necessary to protect well-preserved sections of watercourses with natural channel evolution dynamics and to specify their optimum management (EISELTOVÁ, 1995). An objective analysis of the status of a watercourse and its floodplain is a fundamental premise for a suitable management proposal (BOON et al., 1992). Such analysis should be based on detailed geomorphological characterisation of the studied stream because geomorphology vitally affects all fluvial processes in the floodplain (MACURA, IZAKOVIČOVÁ, 2000). A classification of geomorphological stream types in the conditions of the Czech Republic was created by VLČEK, ŠINDLAR (2002).

Some authors consider river ecology to be a part of landscape ecology (HILDREW, 1996; LORENZ et al., 1997; MAITLAND, MORGAN, 1997). The River Landscape Concept is the basic concept of the river ecology (WIENS, 2002). The river landscape is a structural and functional landscape unit that consists of a river and all other landscape components that were created or that are at least conditioned by the river, and also of all biotic and abiotic elements of the ecosystem. The main components of the river landscape are: the river, all active and cut-off branches, all lakes (permanent as well as periodic) within the floodplain, subsurface space beneath the river bed (hyporheic zone), the subsurface part of the floodplain (alluvial sediments), river banks and aggradation dykes, the surface of the alluvial plain that is usually affected by floods, other natural objects in the floodplain that were created by the recent (post-glacial) river activity, depend on the river and are directly connected with it, and also man-made artificial objects placed within river ecosystems – all these components including their biota (EISELTOVÁ

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**The level of naturalness**

1
2
3
4
5

PLA Litovelské Pomoraví border

Border of NNR Floodplain of Morava River

4: Naturalness of floodplain forests in the study area of the proposed NNR Floodplain of the Morava River
The River Landscape Concept is directly linked to the definitions of the floodplain (LOŽEK, 2003; PETŘÍČEK, 1998). The river landscape is formed by a set of floodplain ecosystems and spatially delimited by the first stream terrace or by the base of slopes at the margins of the river alluvium (WARD et al., 1998). Temporal limits of the river landscape are formed by the Holocene (HASLAM, 1997).

The river landscape has a typical elongated shape and its size ranges from tens and hundreds to many thousands square kilometres. The river landscape's functions are regarded as its characteristics too (JENÍK, PRACH, 1988; JONES, MULHOLAND, 2000).

The presented study in this article is an example of the natural reserve delimitation exclusively according to scientific demands by application of geocological concept of dynamic fluvial succession series of alluvial habitats. The main aim is to ensure complex protection of the whole fluvial succession series of alluvial habitats within the study area.

Extensive discussions about the optimum size of natural reserves passed in landscape-ecological and nature conservation literature (SOULÉ, SIMBERLOFF, 1986). The main topic was whether the maximum protection of species diversity of certain ecosystems can be ensured by either “a single large or several small” reserves of the same total area. Although the importance of small-size reserves cannot be doubted (SHAFER, 1995), conservationists usually aim at large-size reserves that would comprise, if possible, whole landscape ecosystems (e.g. PERES, TERBORGH, 1995). In reality, it is usually not possible and compromise solutions are used that consist in inner zonation of large protected areas (SUTHERLAND, HILL, 1995). The emphasis is given to the management of protected populations of rare species in reserves so that large metapopulations are taken into account (SOULÉ, TERBORGH, 1999), the influence of edge effect on interior species is restricted if they belong to the subject of protection (GIBBS, FAABORG, 1990) and individual reserves are interconnected (SIMBERLOFF, 1992) although it can be hazardous to some rare species. The discussed issue of the forest ecosystem minimum area (MACKŮ, MÍCHAL, 1990), which can be left in the non-intervention regime in the conditions of the Czech Republic, was summarized by KREČMER (2003).

The presented study does not deal directly with the management issue of the proposed reserve. Many authors dealt with the issue of representativeness of networks of protected natural areas in the Czech Republic (ZLATNÍK, 1968; MOUCHA, 1999; MOUCHA, 2004). In some regions, enlightened foresters tried to create an ingenious network of protected areas in the past, which would include representative examples of all forest ecosystems typical of the given region (ZLATNÍK, 1975). Special classifications of ecosystems usually based on vegetation physiotypes (PETŘÍČEK, 1982) were developed also in the Czech Republic for the purpose of creation of the representative network of protected areas. Practical problems connected with both political and commercial pressures...
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Border of NNR Floodplain of the Morava River as a core area of Protected Landscape Area Litovelské Pomoraví
against declaration of protected areas appeared in all discussions on this topic (MÍCHAL et al., 1992). In 2003–2005, a research project of the Ministry of Environment was realized dealing with the optimisation of the network of small-size specially protected areas in the Czech Republic (VYDROVÁ et al., 2006). In the present time, the issue of representativeness of the network of protected areas has been dealt with within the scope of delimitation of the Natura 2000 network, which relates to the whole area of the Czech Republic, was performed based on scientific data from the field mapping of habitats (CHYTRÝ et al., 2001) and should not take local and regional political and commercial interests into account (EUROPEAN COMMUNITIES, 2000).

CONCLUSION
The presented study in this article is an example of the natural reserve delimitation exclusively according to scientific demands by application of geoecological concept of dynamic fluvial succession series of alluvial habitats. The main aim was to ensure complex protection of the whole fluvial succession series of alluvial habitats within the study area.

SUMMARY
This article deals with application of the concept of dynamic fluvial series of alluvial habitats in the frame of creation of nature national reserve (NNR) as core zone of the Litovelské Pomoraví Protected Landscape Area (Czech Republic). The concept is based on the structure of the alluvial landscape, which is formed by a mosaic of hydrobiocenoses of watercourses, riverine lakes, riparian wetlands, meadows and floodplain forests of different types from the most wet alder-willow forests to the most dry hornbeam-elm-ash forests. The dynamic fluvial series of alluvial habitats is a series of water, wetland and terrestrial geobiocenoses, both natural and human-conditioned, in different stages of their successional development, which continually evolve depending on fluvial landscape-forming processes in the floodplain. Analyses of the floodplain forest stands status within the study area were performed using methods that are normally used in the elaboration of management plans of protected areas within forest land on the basis of data from Forest Management Plan. The area of the proposed NNR was created by the overlay of the special map layers using method gap-analysis (BURLEY, 1988) in the frame of GIS. The presented study in this article is an example of the natural reserve delimitation exclusively according to scientific demands by application of geoecological concept of dynamic fluvial succession series of alluvial habitats. The main aim is to ensure complex protection of the whole fluvial succession series of alluvial habitats within the study area.

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KIRCHNER, K. & IVAN, A., 1999: Anastomosing


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