ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume LIX 16 Number 3, 2011

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

I. Machar, V. Pechanec

Received: October 6, 2010

Abstract

MACHAR, I., PECHANEC, V.: *Application of geoecological concept of the alluvial landscape in the creation of nature reserve (case study from Czech Republic).* Acta univ. agric. et silvic. Mendel. Brun., 2011, LIX, No. 3, pp. 123–134

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 (MÍCHAL, PETŘÍČEK, 1998) on the basis of data from Forest Management Plan (www.uhul.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 (ŠINDLAR *et al*., 2010), (2) delimited groups of geobiocoene types (GBT, BUČEK, LACINA, 1999), (3) habitats of Natura 2000 system (HÄRTEL *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 VACEK (2003). The area of the future NNR was created by the overlay of the map layers using method gap-analysis (BURLEY, 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 geobiocoene types in study area is on Fig. 2. Six groups of geobiocene types (STG) – 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 seral series 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 edatope 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

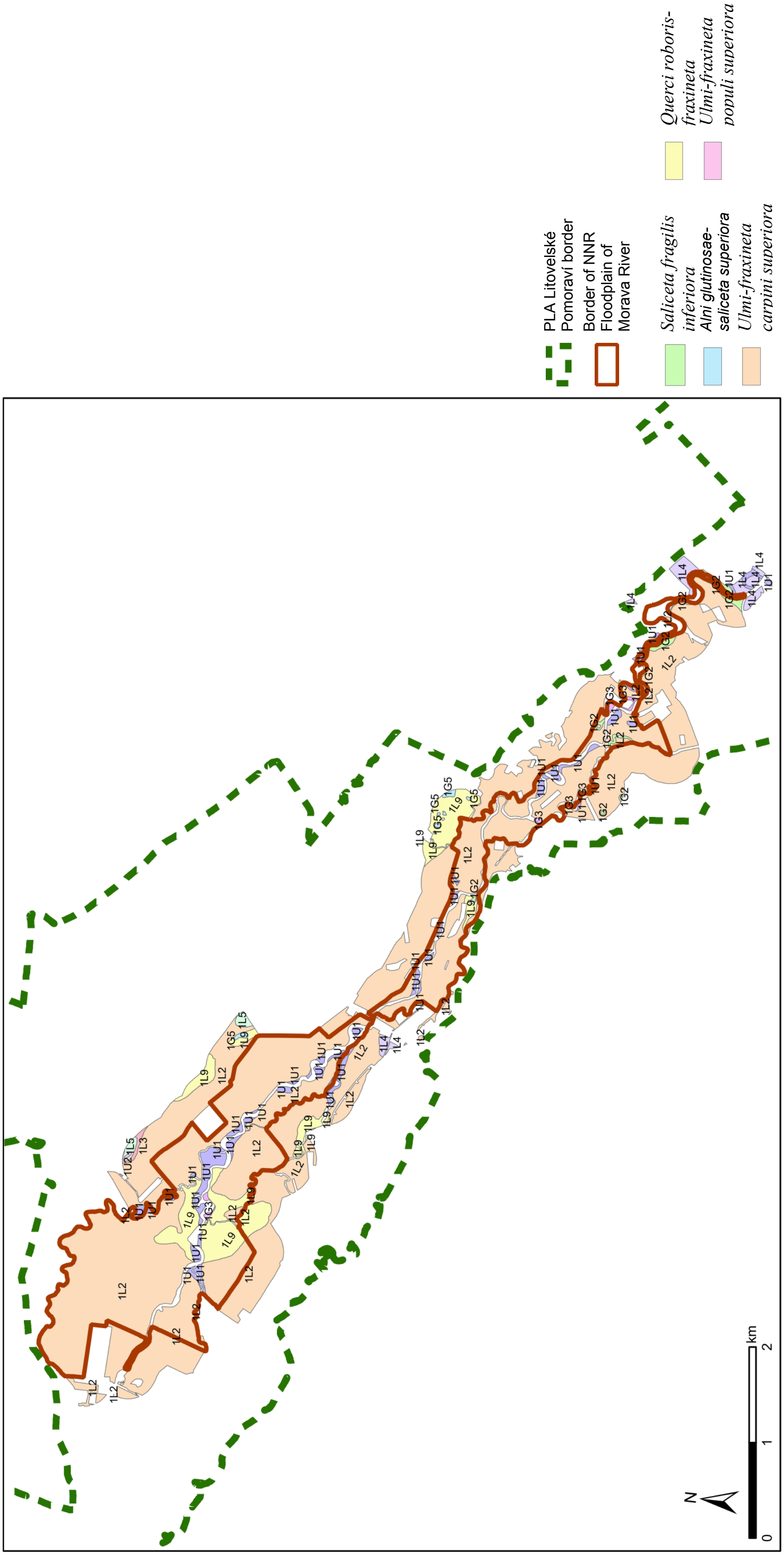
I: *Overview of forest types in the area of the proposed NNR Floodplain of the Morava River*

Forest Type	Name of the forest type	Area (ha)	Area (%)	Natural tree composition
1L2	elm floodplain forest with goutweed	466.32	92,01	DB 4-5 JS 1-2 LP 1-2 JL 1-2 JV HB TPC VR OL
1L9	oak-ash forest with nettles	35.51	7,01	DB 4-5 JS 3-4 OL 3-4 LP JV JL
1U1	POPLAR FLOODPLAIN FOREST with nettles	0.76	0,26	TPC 3-4 DB 1-3 OL 2-3 JL 1-2 VR 1-2
1G1	willow-alder forest Alluvial	1.32	0,57	OL 6-9 VR 1-3 TPC 1 LP OS BR JS

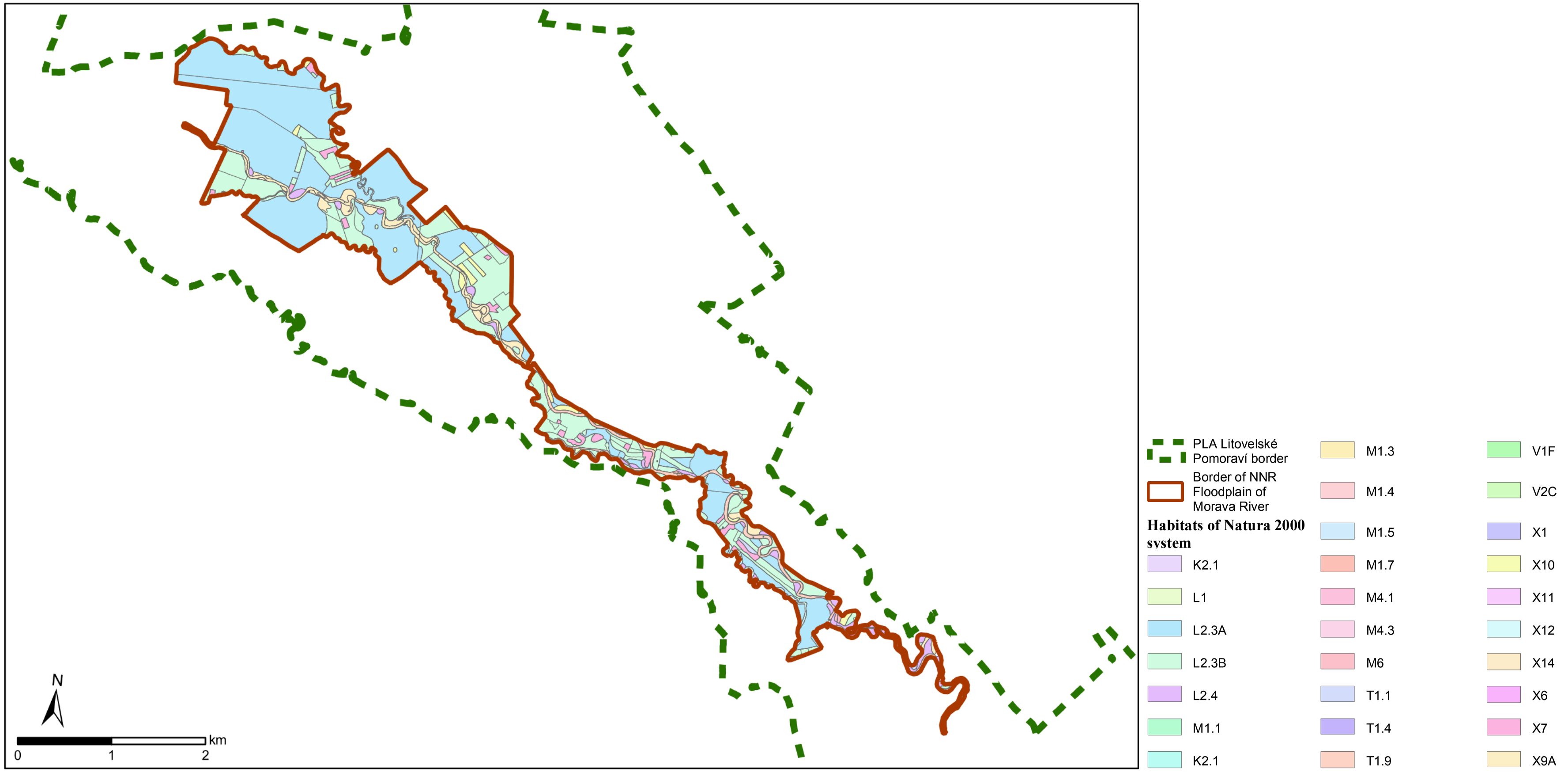
DB – pedunculate oak *(Quercus robur)*, JS – common ash *(Fraxinus excelsior)*, LP – small-leaved linden *(Tilia cordata)*, Jl – elm *(Ulmus laevis)*, JV – Norway maple *(Acer platanoides)*, HB – european hornbeam *(Carpinus betulus)*, TPC – black poplar *(Populus nigra)*, BR – silver birch *(Betula verrucosa)*, VR – white willow *(Salix alba)*, OL – common alder *(Alnus glutinosa)*

1: *Habitat types in dynamic fluvial succession series in the area of the proposed NNR Floodplain of the Morava River*

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 m^2 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 12^{th} 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.



2: *Groups of geobiocoene types according to* BUČEK, LACINA *(1999) in the study area of the proposed NNR Floodplain of the Morava River*



Total of	K2.1	L1	L2.3A	L2.3B	L2.4	M1.1	M1.3	M1.4	M1.5	M1.6	M1.7	M4.1	M4.3	M6	T1.1
HA	1.1491	0.2272	307.9647	180.9347	22.1140	0.0909	0.0537	4.7635	0.0093	0.0001	0.0128	4.5154	0.0277	0.1166	0.6565
Total of	T1.4	T1.9	V1F	V2C	V4B	X1	X10	X11	X12	X14	X6	X7	X9A	X9B	
HA	1.4123	0.3182	23.8896	0.7593	0.0038	0.0303	0.0237	11.7081	0.2296	12.2854	0.2484	1.0224	14.7354	0.5366	

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)*

II: *Forest stands naturalness in the area of the proposed NNR Floodplain of the Morava River according to forest types*

Forest type	1st level of naturalness (ha)	2nd level of naturalness (ha)	3rd level of naturalness (ha)	4th level of naturalness (ha)	5th level of naturalness (ha)	TOTAL (ha)
1L2	295.00	126.00	4.40	7.12	33.80	466.32
1L9	29.39	4.21	0.56	0.00	1.35	35.51
1U1	0.00	0.00	0.76	0.00	2.13	0.76
1G1	0.00	0.00	0.00	1.32	0.00	1.32

III: *Species composition of the stands in the area of the proposed NNR Floodplain of the Morava River*

Tree species (standard abbreviations)	Percentage(%)
JS	33.1867
DB	24.9752
LP	19.2252
OL	6.7155
KL	3.6465
TP	3.6045
JV	2.8213
SM	2.4860
BR	0.8933
HB	0.5704
TPS	0.5681
OS	0.3255
DBC	0.2797
ORC	0.1285
MD	0.1253
JL	0.0793
VR	0.0786
TPC	0.0724
BB	0.0475
TR	0.0203

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)*, KL – sycamore maple *(Acer pseudoplatanus)*, SM – Norway spruce *(Picea abies)*, TP – poplar *(Populus euroamricana)*, TPS – white poplar *(Populus alba)*, OS – European aspen *(Populus tremula)*, DBC – red oak *(Quercus rubra)*, ORC – black walnut *(Juglans nigra)*, MD – European larch *(Larix decidua)*, BB – hedge maple *(Acer campestre)*, TR – wild cherry *(Cerasus avium)*

DISCUSSION

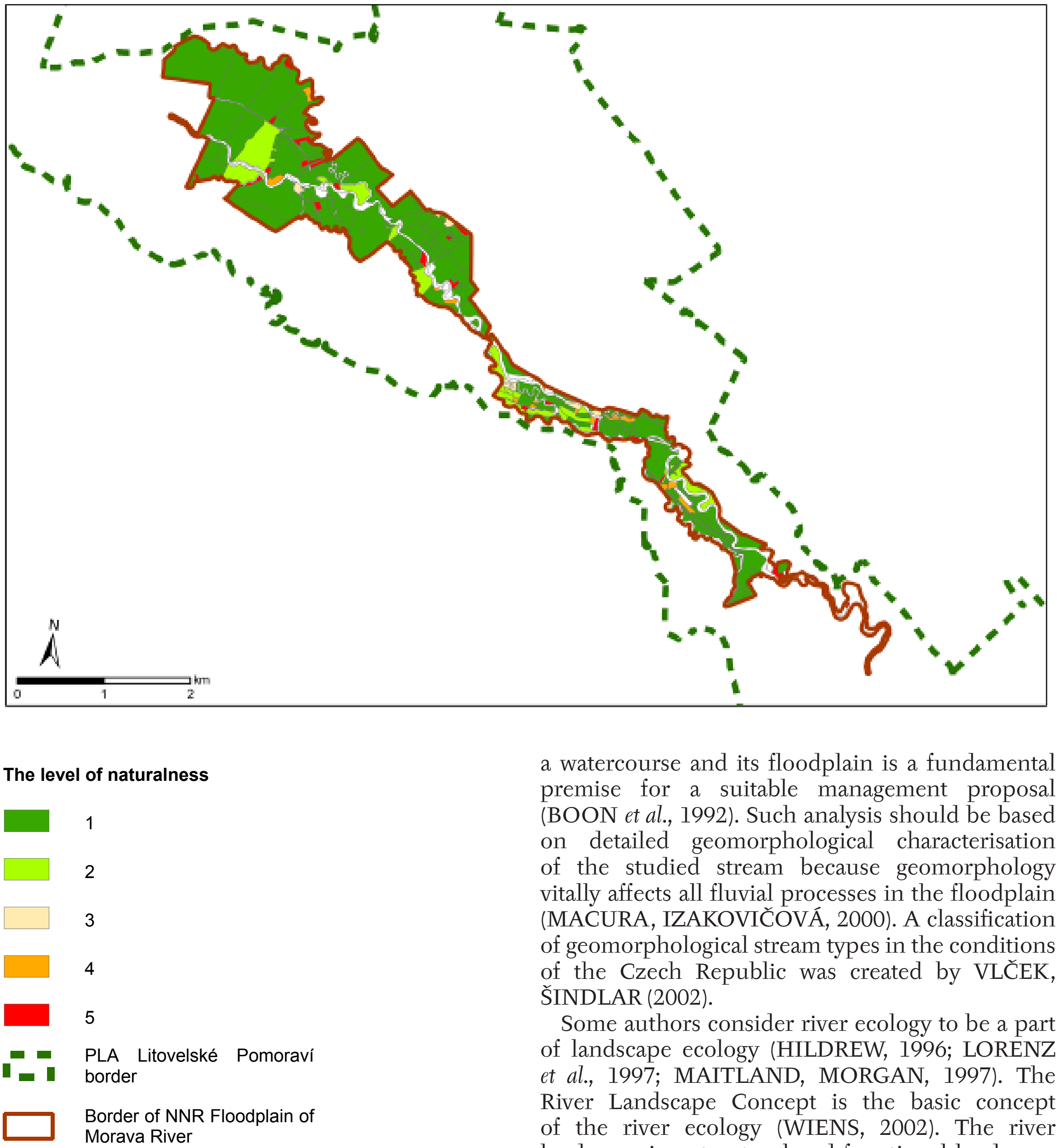
The theory of fish zones, which was described by A. Frič very early (FRIČ, 1882), can be regarded as a precursor of the River Continuum Concept that was introduced by VANNOTE *et al.* (1980). The River Continuum Concept was further developed by the *Flood Pulse Concept* (JUNK *et al.*, 1989). The idea 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

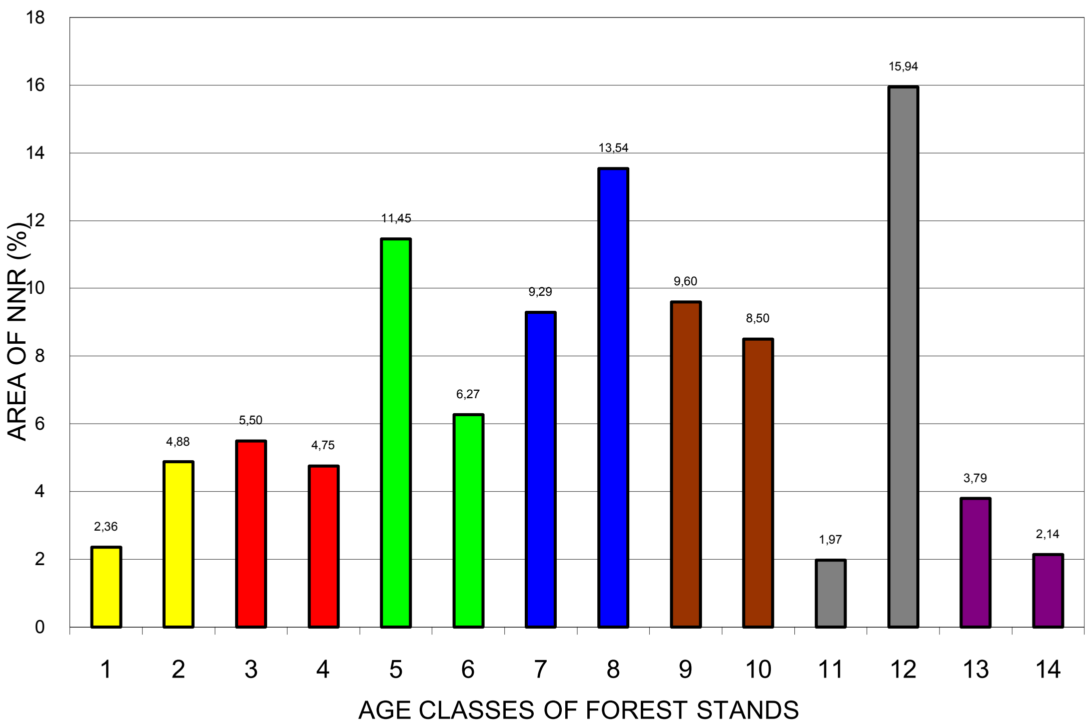


4: *Naturalness of floodplain forests in the study area of the proposed NNR Floodplain of the Morava River*

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



5: *Age structure of the forest stands in the area of the proposed NNR Niva řeky Moravy*

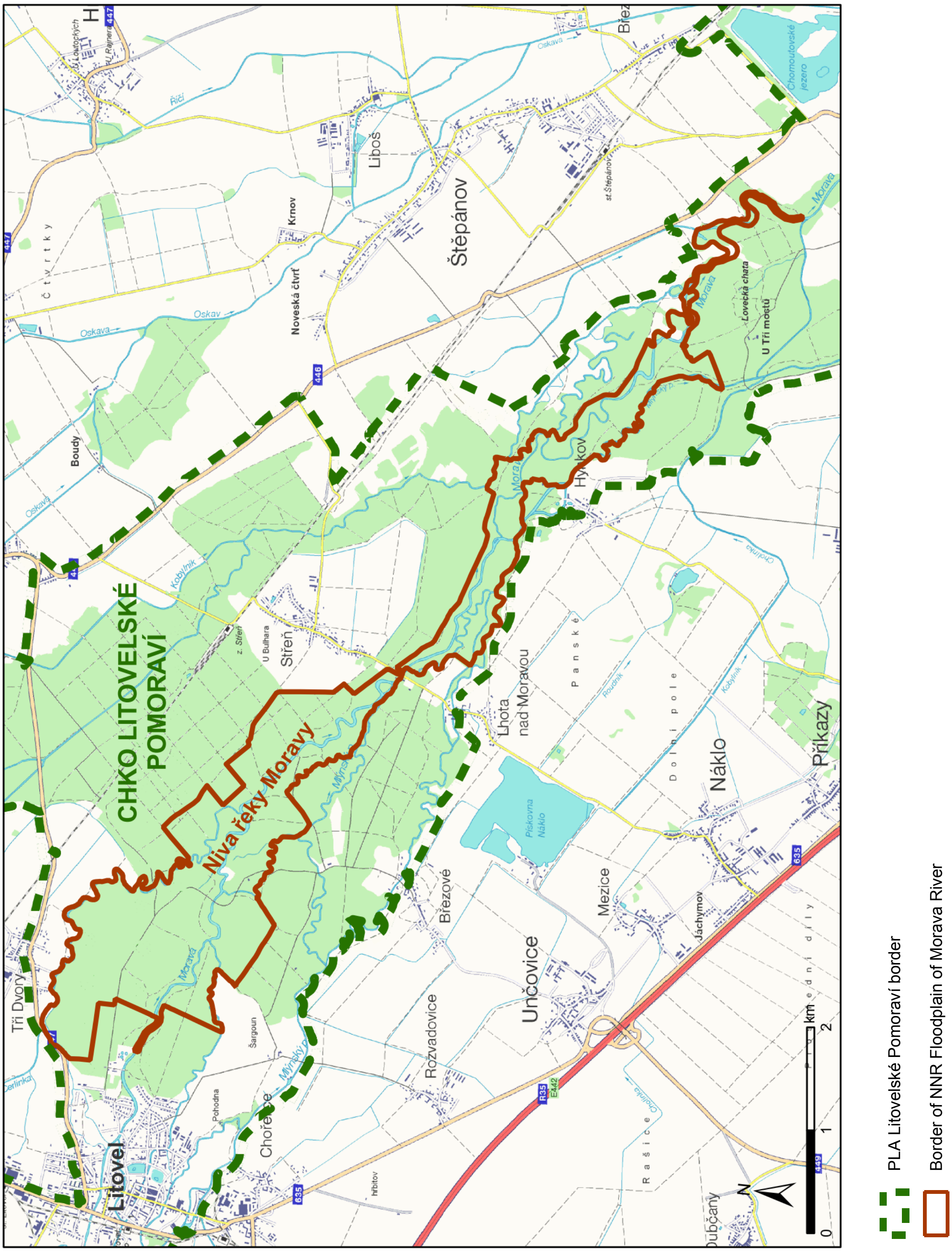
et al., 2007; PRACH *et al.*, 1996). The River Landscape Concept is directly linked to the definitions of the floodplain (LOŽEK, 2003; PETŘÍČEK, 1998). The river landscape is formed by a set of floodplain ecosystems and spatially delimited by the first stream terrace or by the base of slopes at the margins 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 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.

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



6: *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 geobiocoenoses, 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.

Acknowledgment

The works associated with this paper have been supported by a grant from the Ministry of the Environment of the Czech Republic: TARMAG – Biodiversity and Target Management of Habitats of Coppiced Forests in the Frame of NATURA 2000 System, which is developed at Faculty of Forestry and Wood Technology MUAF in Brno.

REFERENCES

ANGRADI, T. R., SCHWEIGER, E. W., BOLGRIEN, D. W., ISMERT, P., SELLE, T., 2004: Bank stabilization, riparian land use and the distribution of large woody debris in a regulated reach of the Upper Missouri River, North Dakota, USA. River Research and Applications, 20: 829–846.

BOON, P. J., CALOW P., PETTS, G. E., eds., 1992: River Conservation and Management. John Willey and Sons Ltd., New York.

BUČEK, A., 1997: Povodně 1997 a vodohospodářské paradigma. Ochrana přírody, 52(9): 257–258.

BUČEK, A. & LACINA, J., 1994: Biogeografické poměry. In: Vybrané fyzickogeografické aspekty pro revitalizaci nivy Dyje v úseku VD Nové Mlýny – soutok s Moravou, pp. 46–98, Ústav geoniky AV ČR, Brno.

BUČEK, A. & LACINA, J., 1999: Geobiocenologie II. MZLU, Brno.

BUČEK, A. & LACINA, J., 2006: Biogeografická diferenciace v geobiocenologickém pojetí a její využití v krajinném plánování. In: DRESLEROVÁ, J. & PACKOVÁ, P., eds., Ekologie krajiny a krajinné plánování. Sborník ekologie krajiny 2. Lesnická práce, Kostelec nad Černými lesy: 18–29.

BURLEY, F. W., 1988: Monitoring biological diversity for setting priorities in conservation. In: WLISON E. O., ed., Biodiversity. National academy Press, Washington: 227 – 230.

DEMEK, J., DRESCHER, A., HOHENSINNER, S., SCHWAIGHOFER, B., 2008: The geology and geomorphology of floodplain. In: KLIMO, E., HAGER, H., MATIĆ, S., ANIĆ, I., KULHAVÝ, J., eds., Floodplain Forests of the Temperate Zone

of Europe. Kostelec nad Černými lesy, Lesnická práce: 11–38.
EISELTOVÁ, M., ed., 1995: Restoration of Stream Ecosystem – an integrated catchment approach. IWRB Publishing, Gloucester.
EISELTOVÁ, M., POKORNÝ, J., RIPL, W., BODLÁK, L., PECHAR, L., PECHAROVÁ, E., KUČERA, Z., 2007: Restoration of water and matter retention functions of a floodplain: ecology and economics. In: TRÉMOLIERES, M. & SCHNITZLER, A., eds., Floodplain Protection, Restoration, Management. Why and how. Lavoisier SAS, Paris: 190–199.
EUROPEAN COMMUNITIES, 2002: Management of Natura 2000 sites. Office for Official Publications of EC, Luxembourg.
FRIČ, A., 1882: Obratlovci Země české. Archiv pro přírodovědný výzkum Čech, Praha.
GIBBS, J. P. & FAABORG, J., 1990: Estimating the viability of ovenbird and kentucky warbler populations in forest fragments. Conservation Biology 4: 193–196.
HASLAM, S. M., 1997: The river scene. Ecology and cultural heritage. Cambridge University Press, Cambridge.
HÄRTEL, H., LONČÁKOVÁ, J., HOŠEK, M., 2009: Mapování biotopů v České republice. Agentura ochrany přírody a krajiny ČR, Praha.
HILDREW, A. G., 1996: Whole river ecology: special scale and heterogenity in the ecology of running waters. Archiv für Hydrobiologie, 113, suppl. 10: 25–43.
HOLČÍK, J., 2001: The impact of stream regulations upon the fish fauna and measures to prevent it. Ekológia (Bratislava), 20: 250–162.
HOŠEK, E., 1987: Lesy Litovelského Pomoraví pohledem historie. In: ŠIMEK, P., ed., Údolní niva, lužní lesy a návrh chráněné krajinné oblasti Litovelské Pomoraví, sborník referátů. Okresní středisko památkové péče a ochrany přírody, Olomouc: 61–85.
CHYTRÝ, M., KUČERA, T., KOČÍ, M., eds., 2001: Katalog biotopů České republiky. Agentura ochrany přírody a krajiny ČR, Praha.
JENÍK, J. & PRACH, K., 1988: Funkce řeky a říční nivy v krajině. Sborník VŠZ České Budějovice, 5(2): 5–15.
JONES, J. B. & MULHOLAND, P. J., 2000: Streams and groundwaters. Academic Press, San Diego.
JUNK, J. W., BAYLEY, P. B., SPARKS, R. E., 1989: The flood pulse concept in river-floodplain system. Can. J. Fish. Aquat. Sci. Spec. Publ. 106: 110–127.
JUST, T., ŠÁMAL, V., DUŠEK, M., FISCHER, D., KARLÍK, P., PYKAL, J., 2003: Revitalizace vodního prostředí. Agentura ochrany přírody a krajiny ČR, Praha.
KENDER, J., ed., 2004: Water in Landscape. Consult, Praha.
KIRCHNER, K. & IVAN, A., 1999: Anastomosing river system in PLA Litovelské Pomoraví. Geologické výzkumy na Moravě a ve Slezsku, VI: 19–20.
KREČMER, V., 2003: Rizika ponechávání lesních ekosystémů samovolnému vývoji. Lesnická práce, 82 (9): 479–498.
LORENZ, C. M., VAN DUK, G. M., VAN HATTUM, A. G. M., COFINO, W. P., 1997: Concepts in river ecology: Implication for indicator development. Regulated Rivers: Resource and Management, 13: 501–516.
LOŽEK, V., 2003: Naše nivy v proměnách času: Vznik a vývoj dnešních niv. Ochrana přírody 58 (4): 101–106.
MACKŮ, J. & MÍCHAL, I., 1990: Minimální velikost lesních biocenter. Lesnictví, 36: 707–717.
MACURA, V. & IZAKOVIČOVÁ, Z., 2000: Krajinnoekologické aspekty revitalizácie tokov. Slovenská technická univerzita, Bratislava.
MACHAR, I., 2001a: Ekologický nivní fenomén. In: PETŘÍČEK, V., ed., Sborník z konference Tvář naší země – krajina domova, Vol. I. Česká komora architektů, Praha: 135137.
MACHAR, I., 2001b: Krajinně-ekologická studie lužních lesů Litovelského Pomoraví. Dizertační práce. Ústav ekologie lesa, LDF MZLU Brno.
MACHAR, I., 2008: Floodplain forest of Litovelské Pomoraví and their management. Journal of Forest Science, 54 (8): 355–369.
MAITLAND, P. S. & MORGAN, N. C., 1997: Conservation Management of Freshwater Habitats – Lakes, Rivers and Wetlands. Chapman & Hall. London.
MALANSON, G. P., 1993: Riparian landscapes. Cambridge University Presss, Cambridge.
MÍCHAL, I. & PETŘÍČEK, V., 1998: Péče o chráněná území II. Agentura ochrany přírody a krajiny ČR, Praha.
MÍCHAL, I., BUČEK, A., HUDEC, K., LACINA, J., MACKŮ, J., ŠINDELÁŘ, J., 1992: Obnova ekologické stability lesů. Academia, Praha.
MOUCHA, P., ed.,1999: Přírodě blízké hospodaření v lesích chráněných krajinných oblastí. Sborník přednášek ze semináře 30. 3. 1999 v Průhonicích, Česká lesnická společnost: 41–46.
MOUCHA, P., ed., 2004: Péče o lesní porosty v ptačích oblastech Natury 2000. Sborník referátů. Česká lesnická společnost, Praha.
NEWBOLD, J. D., ELWOOD, J. W., O'NEILL, R. V., VANWINKLE, W., 1981: Measuring nutrient spiralling in streams. Can.J.Fish.Aquat.Sci. 38: 860–863.
PERES, C. A. & TERBORGH, J. W., 1995: Amazonian nature reserves: An analysis of the defensibility status of existing conservation units and design criteria for the future. Conservation Biology, 9: 34–46.
PETŘÍČEK, V., 1982: Síť maloplošných chráněných území ČSR: její vývoj, současný stav a perspektivy. Památky a příroda, 7: 37 –382.
PETŘÍČEK, V., 1998: Údolní nivy a jejich územní ochrana. In: Sborník ze semináře Krajina a voda v Příbrami, MŽP ČR, Praha: 45–50.
PRACH, K., HUSÁK, Š., ČERNÝ, R., KUČERA, S., GUTH, J, RYDLO, J., KLIMEŠOVÁ, J., 1996:

Species and vegetation diversity along the river. In: PRACH, K., JENÍK, J., LARGE, A., eds., Floodplain ecology and management. SPB Academic Publishing, Amsterdam: 62–80.
PRACH, K., ed., 2003: Ekologické funkce a hospodaření v říčních nivách. Ústav systémové a ekologické biologie ČAV, Třeboň.
ROSGEN, D. L. A., 1994: Classification of natural rivers. Catena, 22: 69–199.
SEDELL, J. R., RICHEY, J. E., SWANSON, J. E., 1989: The River Continuum Concept: A Basis for Expected Ecosystem Behaviour of Large Rivers. In: DODGE D. P. (ed.), Proceedings of the International Large River Symposium. Canadian Journal of Fisheries and Aquatic Sciences, Spec. Publ. 106: 49–55.
SERVUS, M. & MACHAR, I., 2001: Návrh Národní přírodní rezervace Niva řeky Moravy. Nepublikovaná studie pro MŽP ČR, Praha.
SHAFER, C. L, 1995: Values and shortcomings of small reserves. BioScience, 45: 80–88.
SIEBEL, H. N., 1998: Floodplain Forest Restoration. Alterra, Wageningen.
SIMBERLOFF, D. S., 1992: Do species-area curves predict extinction in fragmented forests? In: WHITMORE, T. C. & SAYER, J. A., eds., Tropical Deforestation and Species Extinction. Chapman and Hall, London: 75–89.
SOULÉ, M. & SIMBERLOFF, D., 1986: What do genetics and ecology tell us about the design of nature reserves? Biological Conservation, 35: 19–40.
SOULÉ, M. & TERBORGH, J., 1999: Continental Conservation: Scientific Foundations of Regional Reserve Networks. Island Press, Washington.
STATZNER, B. & HIGLER, B., 1985: Questions and comments on the River Continuum Concept. Can.J.Fish.Aquat.Sci. 42, s. 1038–1044.
STRAŠKRABA, M. & TUNDISI J. G., 1999: Guidelines of Lake Management, Vol. 9: Reservoir Water Quality Management. Shiga, Japan: Int. Lake Environment Committee Foundation. Tokyo.
SUTHERLAND, W. J. & HILL, D. A., 1995: Managing Habitats for Conservation. Cambridge University Press, Cambridge.
ŠINDLAR, M., LOHNISKÝ, J., ZAPLETAL, J., MACHAR, I., 2010: Wood debris in rivers – one of the key factors for management of the floodplain forest habitats of European importace. Journal of Landscape Ecology. In press.
ŠTĚRBA, O., 2008: The floodplain forest ecosystem from the viewpoint of landscape ecology. In: KLIMO, E., HAGER, H., MATIĆ, S., ANIĆ, I., KULHAVÝ, J., eds., 2008: Floodplain Forests of the Temperate Zone of Europe. Kostelec nad Černými lesy, Lesnická práce: 284–300.
ŠTĚRBA, O. & MĚKOTOVÁ, J., 2003: Říční krajina a povodně: Kauzalita a řešení. In: KVĚT, R., ed., Niva z multidisciplinárního pohledu V., sborník ze semináře v Geotestu, Brno: 7–8.
ŠŤERBA, O., MĚKOTOVÁ, J., BEDNÁŘ, V., ŠARAPATKA, B., RYCHNOVSKÁ, M., KUBÍČEK, F., ŘEHOŘEK, V., 2008: Říční krajina a její ekosystémy. Univerzita Palackého, Olomouc.
THORP, J. H. & DELONG, M. D., 1994: The riverine productivity model: an heuristic view of carbon sources and organic processing in large river ecosystems. Oikos, 70(2): 305–308.
TOCKNER, K., MALARD, F., WARD, J. V., 2002: An extension of the flood pulse concept. Hydrological Processes, 14 (16-17): 2861–2883.
VACEK, S., 2003: Minimum area of forest left to spontaneous development in protected areas. Journal of Forest Science, 49 (8) : 349–358.
VANNOTE, R. L., MINSHALL, G. W., CUMMINS, K. W., SEDELL, J. R., CUSHING, C. E., 1980: The River Continuum Concept, Can. J. Fish. Aquat. Sci. 37: 130–137.
VLČEK, L. & ŠINDLAR, M., 2002: Geomorfologické typy vodních toků a jejich využití pro revitalizace, Vodní hospodářství, 52 (6): 172–176.
VRŠKA, T. & HORT, L., 2003: Základní kritéria a parametry pro hodnocení přirozenosti lesních porostů. Pracovní materiál, Agentura ochrany přírody a krajiny ČR, Brno.
VYDROVÁ, A., KUCHAŘOVÁ, P., GRULICH, V., 2006: Optimalizace sítě MZCHÚ v ČR. Východočeský sborník přírodovědný, Práce a studie, Pardubice, suppl. 1/2006.
WARD, J. V. & STANFORD, J. A., 1995: The serial discontinuity concept: extending the model to floodplain rivers. Regulated Rivers: Resource and Management, 10: 159–168.
WARD, J. W., BRETSCHKO, G., BRUNKE, M., DANIELOPOL, D., GILBERT, J., GONSER, T., HILDREW, A. G., 1998: The boundaries of river systems: the metazoan perspective. Freshwater Biology, 40: 531–569.
WIENS, J. A., 2002: Riverine landscapes: taking landscape ecology into the water. Freshwater Biology, 47: 501–515.
ZLATNÍK, A., 1968: Teoretická kritéria pro výběr a rozlohu chráněných území. Československá ochrana prírody (Bratislava), 6: 31–46.
ZLATNÍK, A., 1975: Ekologie krajiny a geobiocenologie. Vysoká škola zemědělská, Brno.

Address

doc. Ing. Ivo Machar, Ph.D., Katedra biologie, Pedagogická fakulta Univerzity Palackého, Žižkovo nám. 5, 771 47 Olomouc, Česká republika, ivo.machar@upol.cz, RNDr. Vilém Pechanec, Ph.D., Katedra geoinformatiky, Přírodovědecká fakulta Univerzity Palackého, Tř. Svobody 26, 772 00 Olomouc, Česká republika, vilem.pechanec@upol.cz