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FLOODPLAIN AND ITS DELIMITATION

M. Křížek, F. Hartvich, T. Chuman, L. Šefrna, M. Šobr, T. Zádorová: *Floodplain and its delimitation.* – Geografie–Sborník ČGS, 111, 3, pp. 260–273 (2006). – The article is conceived as an introduction to the study of the floodplain. It deals with the delimitation of the floodplain from geomorphologic, pedologic, hydrologic and geoecologic point of view. It also describes the basic geomorphological forms and natural processes, constituting the floodplain system and participating in its formation.
KEY WORDS: floodplain – geomorphology – fluvial processes – fluvial sediments – fluvisoils, floods – invasive species.

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1. Introduction

In the context of landscape, the floodplain is a specific area typical of great dynamics of natural, especially fluvial, processes. Also, the anthropogenic influence and use are intensive in this area. Yet, the delimitation is not easy since there are a number of natural processes participating in the floodplain formation, which also modify individual forms within the floodplain. These forms have been created by preceding processes and also by the floodplain itself, and therefore the difference between the floodplain and the surrounding relief forms may be blurred and the borders of the floodplain thus become less clear. The understanding of past and present natural processes in the floodplain makes it possible to optimize the human impact in floodplains, established with economic and settlement activities, with the aim to minimalise the damage caused by the flooding water courses.

The main target of this article is describing of delimitation of floodplain from the geomorphological, hydrological, pedological and geoecological points of view, including determination of principles of its delimitation.

2. Methods

The characterization and delimitation of floodplains were based on scientific literature search and the results of the field research above all in the Otava River catchment (2002–2005) and selected parts of Rusava River catchment (1997–2006), Trkmanka River catchment (1993–2006) and Sázava River catchment (2006).

Geomorphological delimitation of floodplain was made on the basis of geomorphological mapping and morphometric analyses of DMT with grid size 5x5 m. Geomorphological mapping was based on searching real edges between neighbouring basic genetic geomorphological units of relief – plane floodplain and steeper slopes of fluvial terraces steps or valley slopes, which have different inclination.

Hydrological delimitation of the floodplain is possible carry out with use marks of flood situation (fluvial sediments, elevation of water level). We can use terrain mapping or aerial photographs evaluation.

Pedological methods of floodplain delimitation are based on distribution of fluvisols. In the soil survey, the soil types are mostly identified on the basis of the distribution of diagnostic horizons and properties in the soil profile.

Delimitation of the floodplain from the viewpoint of biology and landscape ecology is primarily based on a field research. It considers the change of plant communities on the moisture gradient outwards the stream.

3. Definitions of the floodplain

There are several different basic definitions to delimit the floodplain, corresponding to scientific disciplines concerned. Apparently, every discipline approaches the definition in a different way and therefore we shall outline at least the basic distinctions of the concepts of individual disciplines.

Foreign, similarly as Czech, general physical-geographical literature considers particularly the morphology, or rather geomorphology of the

Tab. 1 – Natural processes forming the floodplain according to Brierley, Fryirs (2005), modified

Geomorphological process	Description
Lateral accretion	Transported material deposits on the convex bank of the curve. It accumulates inside the channel and then it is transported.
Vertical accretion	Material from suspension sediments after a stream overspill. It is incorporated into floodplain sediments by bioturbation and it occurs destruction of primary lamination.
Braid channel accretion	Material sediments during extreme floods inside the channel and big stabile islands originate. This process is typical of multi-channel rivers.
Oblique accretion	It happens inside the channel. Muddy-sandy sediment sheeds are gradually joined to the bank and they increase in magnitude till they become a part of accumulation level.
Counterpoint accretion	Depositing of sediments near curves and meanders in places of secondary circulation and back current origination. The way of depositing is similar to vertical accretion.
Abandoned channel accretion	It happens when an abandoned channel fills with flood sediments, most frequently after a meander cut-off.

Tab. 2 – Natural processes taking part in re-modelling of the floodplain, according to Brierley, Fryirs (2005), modified

Geomorphological process	Description
Lateral migration	Meander movement in space of the floodplain as a result of gradual siltation and lateral erosion within a channel.
Downcutting /cutoffs/	Incising and cutting-off a part of a channel, mostly a meander.
Channel transition /avulsion/	Significant change of channel position, genesis of a new channel, typically after an extreme flood.
Stripping	Process of upper surfaces floodplain layersremoval by rapidly flowing water.
Flood channel formation /floodchannels/	Formation of otherwise abandoned channels run through during flooding.
Channel expansion	Process of channel enlargement typically by side bank erosion.

floodplain. This is, however, complemented by pedological, landscape and landuse characteristics, as for example "Columbia Electronic Encyclopedia" (www.answers.com/topic/flood-plain. Retrieved May 05 2005): "The floodplain is an area along the course of a river formed by the deposition of sediment during periodic floods. The floodplain is typical of such features as levees, oxbow lakes and delta plains. Floodplains are generally very fertile, thus forming rich agricultural lands. The disadvantage of farming on a floodplain is the natural hazard of ."

3.1 Geomorphological definitions of the floodplain

Demek (1988) defines the floodplain as an accumulation plain along a water course constituted by unconsolidated sediment, transported by and deposited in this stream, usually partially or fully flooded during high floods. This and similar definition describing the floodplain from a geomorphological point of view occurs with slight modifications analogically with other authors (Whittow 1984; Collin 1988; Anhert 1996; Hugett 2003). Allen (1997) and Levin (1978) in Brierley, Fryirs (2005) interpret the floodplain as an area delimited by forms originated by fluvial geomorphological processes. Brierley, Fryirs (2005) determine the area of the floodplain between the borders of the channel and the valley, i.e. valley floor.

The geomorphological view of the floodplain thus emphasises its genesis and relief morphology, making these features prior for its definition. The definition implies that the floodplain is formed by fluvial sediments accumulated as a result of fluvial geomorphological processes in this area. Thus, the floodplain can also be described and delimitated by specific geomorphologic processes, which take place in this area, and shapes that originate.

System of fluvial processes (Tab. 1 and Tab. 2), may be divided into two basic groups: erosional fluvial processes with predominant removal of material, and accumulation fluvial processes, with predominant sedimentation. The character of mentioned fluvial processes changes,

Tab. 3 – Main natural geomorphological forms of fluvial origin located outside the channel, according to Brierley, Fryirs (2005), modified

Landform	Description
Floodplain	Alluvial surface formed by fluvial sediment aggradation; distant gradation of sediment grain-size is typical.
Alluvial terrace	Terrace formed by fluvial material which had originated before the current floodplain, typically lying above the current channel and floodplain. Three types may be distinguished: accumulation, erosional and embedded terraces. Within the terrace, plateau and the terrace step may be distinguished according to inclination.
Levee	Asymmetrical wall above flat surface of the floodplain along the channel.
Crevasse splay	Accumulation body, typically cone-shaped, formed under a crevasse behind aggradational, flood protection or other anthropogenic levee.
Floodchannel, back channel	Side, otherwise abandoned, channel formed and flooded by high floods, above the current channel, mostly at a side of a floodplain.
Flood runner	Direct linear depression in the floodplain, which diverts water during floods, connects individual parts of the channel and shortens the length of the stream.
Backswamp, floodplain wetland	Wet depression, where inundation lakes originate during floods.
Sand wedge	Asymmetrical (inclined towards the channel with steeper side) wedge-shaped fluvial accumulation, which is typically formed near the channel, mostly in places with less developed levee. A typical feature is that particles are well-assorted according to grain-size.
Floodplain sand sheed	More or less equally mighty and disposed accumulation in a floodplain covering a larger area. These accumulations participate in floodplain vertical profile and cause increase in its magnitude.
Abandoned channel, paleochannel	A channel with no stream flowing through. Over time, it is usually filled with fluvial material in case of overspill from the main channel.
Ridge and swale topography	They are relicts of former positions of channels in intensive lateral accretion.
Valley fill	Relatively flat, not well-pronounced, not clearly delimited area filling in the bottom, where indistinct channel irregularly appears. This area is often wet.
Floodout	Cone- or lobe-shaped acumulation body formed as a result of channel elevation (e.g. because of siltation) to the level of the floodplain surface and subsequent sedimentation.
Meander cutoff, ox bow	Part of meander channel separated from the watercourse channel.
Chute cutoff	New channel formed after cutting off (incision) of a meander
Channel	Place of watercourse concentration; involves bed and banks.
Anabranch (secondary) channel	Side channel (with lesser depth and width than the main channel), run through by a flow water. Typical of anastomose streams.
Crevasse	Place through which water leaks into a floodplain after bank disruption. Fluvially incised area of a levee.
Alluvial fan	Cone-shaped accumulation body intersecting the floodplain of the main stream from an adjacent valley, ravine or gorge as a result of a sudden decrease in drift capacity of the side stream.

depending on the position of a given part of a floodplain in terms of gradient curve of river, which may change due to endogenous processes (tectonic movements), exogenous processes (e.g. damming river by landslide) or anthropogenic processes (e.g. construction of dams, stream diversion, etc.).

In the floodplain area, there is a range of fluvial shapes (Tab. 3) or shapes, whose origination was at least partly participated by fluvial action (cf. Hrádek 2003). Still we can find such geomorphological forms, whose genesis is not inherently connected with fluvial processes. Landslide bodies can intervene in floodplain areas from adjacent slopes or they may block them completely (Křížek 2003).

3.2 Geological definition of the floodplain

Among other scientific disciplines, geological understanding of the floodplain is the most similar to geomorphological conception of this area. Geological definition describes the floodplain as "flat valley floor activated during flooding of a stream"; the floodplain is composed of horizontal young (Holocene), gravel, sandy, loamy or clay sediment, often displaying irregularities caused by braiding of a stream, origin of islands, meanders, alluvial fans and delta plains, debris, landslides etc. (Collin 1988). Geology thus concentrates especially on geological composition and stratigraphy of the floodplain, and the genesis is only secondary (cf. Collins, Walling, Leeks 1997). Apart from fluvial material grain size, which decreases with the length of particle transport and thus also with the length of the floodplain, geological composition of sediments can change as well, depending on the variability and position of source areas. A typical example is the Morava River, which carries particles from the Czech massive downstream and after joining the Bečva River, sediments of flysch origin appear within transported and deposited material. Inhomogeneity and spatial variability of fluvial sediment was examined by Walling, He (1998) and Nakamura, Kikuchi (1996).

3.3 Hydrological definition of the floodplain

Hydrologically speaking, the floodplain is influenced by hydrological aspects of the stream (Ehrlich 2006) and at the same time by an extreme flow of running water during floods. Hydrology focuses on groundwater level, porous permeability of sediments, permanent saturation (e.g. Gilvear 1999) and on the character and magnitude of discharge through the floodplain during floods. From the viewpoint of hydrology and water management, the floodplain is sometimes associated with the flooded area during floods.

Hydrologists view the floodplain as natural inundation area, suitable for water retention in the landscape during floods (Janský 2004). Inundation area is a space adjacent to a stream, where water floods during high flood fluxes. Thus, a wide stretch of water flows in the direction of the steepest slope of the valley, ignoring the direction of the channel. In time of these high flood discharges, water is overburdened with suspension load, depositing in the inundation area. During an overspill of the channel into the floodplain, the depth of water is relatively small and because of significant hydraulic resistance the flow has a relatively low speed (Kemel 2000). Sediments, especially larger particles, mostly deposit along the banks (and thus bank levees originate), finer particles sediment further from the banks. Thanks to its high diffusion capacity, the floodplain (inundation area) is important during floods because it can reduce the speed of the flood wave. The flood wave flattens in large inundation areas and culminates with lower flow and water magnitude than in areas of narrow valleys with not very developed floodplains.

3.4 Pedological definition of the floodplain

The floodplain is an area with the occurence of fluvisols and gleysols – hydromorfic and semihydromorfic soils are typically situated in the bottom positions of valleys, forming the flat strips of land adjacent to the riverbed outside older sandy gravel terraces. Recent, mostly fine textured fluvial sediments can be used as bedrocks. Originating from the soil cover of upper reaches of the catchment, they are eroded, transported and resedimented in the inundation zone. All the main soil classification systems (USDA, 1990; WRBS 1999; RPF 1995) define the fluvisol as a genetically young (recent) soil whose formation does not reflect some processes, which are typical for mature soils. The alluvial groundwater impact on the fluvisol can be permanent or temporary, but the reduction features in the profile are restrained thanks to the groundwater flowing and oxidation. Only in case of stream-channel regulations, which can be the cause of the groundwater level decreasing or elimination of the seasonal flooding, the soils become relict.

According to our recent soil classification (Němeček et al. 2001), the floodplain contains fluvisols (original floodplain soils), which may (on the subtype level) reach a significant variability in grain size (modal, psefitic, arenic, and pelic), hydromorphism (gleyic, pseudogleyic), chemical composition of sediments (carbonated, non-carbonated) and formation (stratified, cambic).

To address all possible varieties of fluvisol soil profile composition character, Kubiena's (1953) classification should be also referred to. This classification emphasises ecological aspects and resembles the differentiation of typical floodplain and forest vegetation. This categorization of floodplain soils distinguishes rambla (gravel, light, not rich in nutrients, with alderwoods), paternia (middle-heavy to heavy, nutritive, hydromorphic, typical of willow-poplar forests) and vega (heavy soils with stabile profile, only exceptionally flooded, hardwood forests). They are ordered according to grain-size, pedogenic processes and hydromorphism. Traditionally, the terms are used by ecologists and geobotanists (Chytrý, Kučera, Kočí, eds. 2001).

3.5 Floodplain definition and delimitation from the viewpoint of biology and landscape ecology

Biology and landscape ecology delimit the floodplain according to regionalization of floodplain biochores, ecosystems, and plant and animal communities (Collin, 1988; Gruell, Gregory 1995). Floodplains are considered significant landscape features, defined by the law – Act No. 114/1992 (218/2004) as well as forests, fish ponds, peat bogs, streams and lakes. Floodplains are indispensable ecological corridors for plant and animal migration and have other vital ecological functions in the landscape (climatic, water retention, stabilizing, etc.) Despite its exceptional biological and landscape ecological value, floodplains have been heavily modified in many places to the extent that is difficult to recognize its natural character.

In contrast with other significant clearly distinguishable and identifiable landscape features, the delimitation of floodplain happens to be quite complicated from the viewpoint of biology and landscape ecology. There are only few clear biological definitions of the floodplain. These definitions are mostly based on plant communities that play a significant role in determining the floodplain. According to Novotná (2001) floodplain is delimitated by characteristic herbaceous vegetation. Ložek (2003) delimitates the floodplain not only by typical plant communities but also by typical fauna. More complex definition was presented by Bayley (1995), who defines the floodplain as a part of the river-floodplain ecosystem that is regularly flooded and drained, and it represents a type of wetland.

The integration of the floodplain among the significant landscape features, defined by the law – Act No. 114/1992 (218/2004), was followed by the definition of the floodplain from the conservation point of view issued by the Ministry of the Environment. The floodplain is delimitated as a biotope whose creation and typical plant communities depend on hydrological characteristics of the stream. Plant communities play a significant role in determining the floodplain and finding the floodplain border is more a question of a complex biological evaluation of a particular area.

4. Principles of a floodplain delimitation

4.1. Geomorphological principles of the floodplain delimitation

The floodplain is separated from other parts of the relief (e.g. from valley slope or fluvial terrace level) by an edge with more or less significant inclination change, which is manifested in cross-section profile (Křížek, Engel 2004; Hartvich 2006). The morphological significance of the delimitation of the floodplain depends on geomorphological processes, which function not only in the floodplain area, but also outside, in subcatchments or in other parts of the whole catchment. These processes relate to variability and changes of energy of geomorphological processes based on relief energy and energetic input of exogenous processes based on cyclic and long-term climatic changes.

Geomorphological definitions of the floodplain are based on its specific geometrical properties, qualitatively distinct from its surroundings. Its morphology may be observed by morphometric methods or geomorphological mapping.

A principle of floodplain delimitation with the assistance of geomorphological mapping takes advantage of searching and determination of position and shape of edge between different basic genetic units of relief, i.e. floodplain and valley slopes, possibly fluvial terrace step (fig. 1). These units with regard to different origination have dissimilar shape, aspect and inclination etc.. Boundary of floodplain is run the length of noticable change of inclination between plane or moderately inclined floodplain and sloping neighbouring relief. This boundary is identical with the edge between both types of genetical geomorphological units.

Hartvich in Langhammer et al. (2006) defines the floodplain with the aid of relatively simple calculation applied to DEM grid, which relates to detailed surface contour maps. Apart from direct calculation in the grids, the floodplain may be defined morphometrically on the basis of cross-section shape (fig. 2). The shape may be quantified using various indices based on

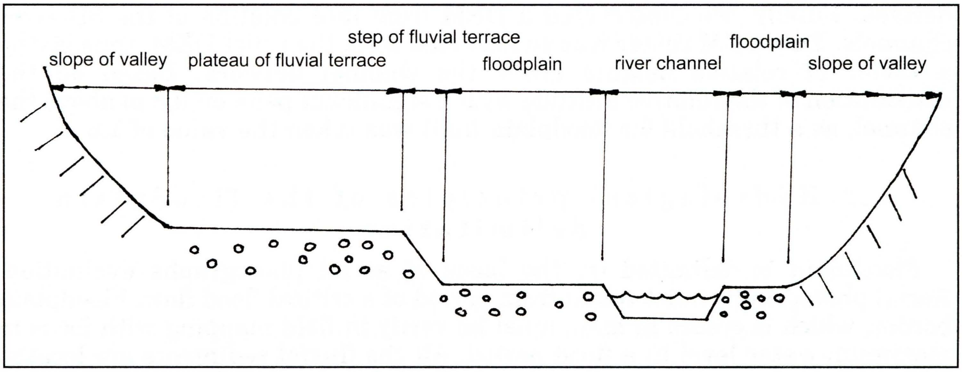

Fig. 1 – Cross-section scheme of valley bottom with genetic units of relief. Orthogonal lines show position of edges of these units.

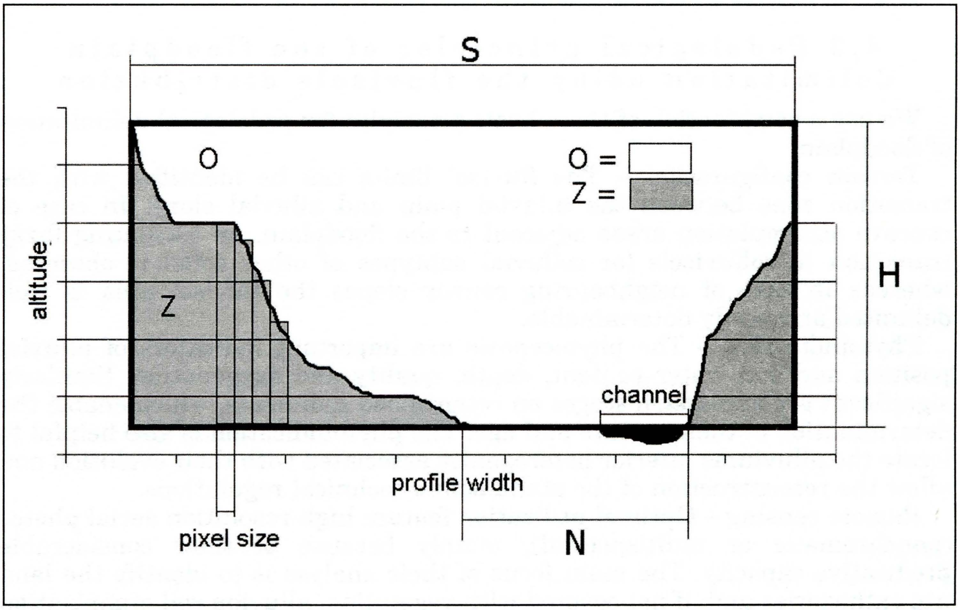

Fig. 2 – Elementary parameters used for the calculation of the morphometrical indices – width of the valley (S), depth of the valley (H), width of the valley floor (N) and the ratio of the area under the relief on the rectangle, given by the width and depth of the valley (Z) and the same above the relief (O).

several simple parameters, particularly the valley width (S), the depth of the valley (H), the width of the valley floor (N) and the proportion of the area under the terrain in a rectangular cross-section given by the depth and width of the valley (Z); Hartvich in Langammer et al. 2006.

As an input into the morphometrical floodplain span analysis we used a DEM based on DMU25, a contour line layer with an interval of 5 m, and a layer of streams from ZABAGED 1:10,000. The DEM was treated in ArcHydro Tools and turned into AgreeDEM, a smoothened raster with the continuous flow path solution. From the AgreeDEM a raster of slope inclination was derived. Finally, we constructed a DEM from interpolation of the 3D river channels. This DEM raster was substracted from the relief DEM, thus giving a raster of relative heights above the channel network. Based on the distribution of the relative altitude with a significant peak on 0,8 m above the channel, as a threshold for floodplain limit was taken the value of 1,6 m.

4.2 Hydrological principles of the floodplain delimitation

Floodplain is delimited on the basis of aerial photographs evaluation. Aerial photographs must result from period of a critical flood flow. Floodplain border, which is create in map, must be verify in field mapping with focus to maximum water level in a flood period. All the fluvial sediments are located in floodplain, in some cases they create floodplain border. Fluvial sediments, especially larger particles, mostly deposit along the banks, finer particles sediment further from the banks.

4.3 Pedological principles of the floodplain delimitation using the fluvisols distribution

We use a combination of three basic principles for pedological delimitation of floodplain:

Terrain configuration – The fluvisol limits can be identified with the transition zone between the alluvial plain and alluvial slope. In case of concave accumulation areas adjacent to the floodplain, an oscillating fuzzy transition to colluvisols (or colluvial subtypes of other soils) is observed, whereas in case of neighbouring convex slopes the fluvisol area is well delimited and easily determinable.

Phytoindication – The phytocenosis are important indicators of alluvial position and soil water content, depth, quality and oxygenation. Similarly significant are succession stages on recent flood sediments, which enable the determination of their texture and age. The phytoindication is also helpful to locate the alluviums interior heterogenity associated with their evolution and allow the reconstruction of the stand before technical regulations.

Remote sensing – Optimal utilization feature high-resolution aerial photos (panchromatic or multispectral), mainly because of their considerable predicative capacity. The main focus of their analyse is to identify the land use cathegories and, if not covered with vegetation, alluvion soil organization according to humus and water content.

4.4 Principle of the floodplain delimitation from the viewpoint of biology and landscape ecology

The floodplain may be defined as flat valley floor, periodically flooded, with high level of groundwater, typical of a mosaic of areas with vegetation of different succession stages – ranging from herb vegetation of young fluvial sediments, stages of willow shrub, to alluvial forests – and it can by also distinguished by its fauna (Ložek 2003).

Although vegetation patterns vary widely among different stream and river types, sizes and regions, the following are some of the more common vegetative patterns. Vegetation is highly variable in the longitudinal as well as lateral view.

In floodplains of mountain and submountain streams, vegetation is mechanically disrupted by large amounts of material move every year, and exists only in herb formations. Every year powerful disturbances prevent the occurrence of tree layer. Gravel bed load is colonized by rare herb vegetation not rich in species (*Calamagrostis pseudophragmites, Myricaria germanica, Phalaris arundinacea*) that belongs, according to Habitat Catalogue of the Czech Republic, to a group of habitats M4 – River gravel banks. In calmer sections, there occur willows (*Salix daphnoides, S. eleagnos, S. purpurea*). With decreasing stream gradient willows start to dominate (*Salix fragilis, S. purpurea, S. triandra, Salix daphnoides*) together with rich herb undergrowth of different ecological demands from the group of habitats K1–Willow carrs, K2–Riverine willow scrubs and M1–Reed and tall-sedge beds. In calm parts of lowland watercourses, willow shrub changes into alluvial forests (group of habitats L2) which, according to the Habitat Catalogue of the Czech Republic, can be divided into Montane grey alder galleries, Ash-alder alluvial forests, Hardwood forests of lowland rivers, Willow-poplar forests of lowland rivers. Alluvial forests are species-rich azonal stands with species tolerant of temporary flooding, with highly developed spring herb aspect. *Alnus glutinosa, A. incana, Fraxinus excelsior, Ulmus laevis, U. minor, Salix alba, S. fragilis, Populus alba, P. nigra, Quercus robur* typically occur in tree layer. In the shrub layer, *Sambucus nigra* or *Prunus padus* can be found. Herb layer is rather rich in species and typical of the occurrence of spring geophytes.

In most parts, alluvial forests have been converted into agricultural land throughout the history. In places with less intensive farming (mowing, pastures), ecologically valuable communities of alluvial meadows developed, distinguished according to the Habitat Catalogue of the Czech Republic as Alluvial Alopecurus meadows, Wet Cirsium meadows, Continental inundated meadows, Intermittently wet Molinia meadows, and Continental tall-forb vegetation. Alluvial meadows biotopes depend on the existence of the management which led to its origination. All biotopes naturally occurring in floodplains are then dependent on the maintenance of natural dynamics of a watercourse with regular flooding.

Floods also help spreading of invasive plant species, which have recently become numerous in some river floodplains. These are especially *Impatiens glandulifera, Solidago gigantea, Helianthus tuberosus, Reynoutria japonova, R. sachaliensis* or the hybrid R. × *bohemica.*

5. Discussion

From more geomorphological definitions (e.g. Demek 1988; Whittow 1984; Collin 1988; Anhert 1996; Hugett 2003; Allen 1997 and Levin 1978 in Brierley, Fryirs 2005; Brierley, Fryirs 2005) of floodplain follow that river channel is not element of floodplain, but we understand a floodplain area from the general geomorphology point of view, which includes also a river channel, because processes making a river channel participate in origin and development of a floodplain too. That´s why we can define a floodplain to the all intents and purpose as an area which is created by water course channel and an accumulation plain constituted by fluvial unconsolidated sediment situated along a water course, and which is divided from other parts of relief by an edge with more or less significant inclination change.

Geomorphological delimitation of floodplain based on inclination changes of basic genetic geomorphologigal units of relief, which are distinguished by field geomorphological mapping, has a lot of strong points:

A value of a limit inclination is not set "ad hoc" (predetermine) and that´s why it respects specific features of neighbouring relief and development of valley from its upper to lower parts. In the concrete floodplain need not be flat or slightly concave but it can be slightly convex in cross-section (Huggett 2003). With convex floodplains, the surroundings of the river are lie higher than the areas under the foothill of valley slopes, which is related to higher accumulation especially of bottom sediments (bedload) than material in suspension (suspension load), which is distributed to parts of the floodplain further from the river in case of overspill. This type of floodplain is typical of major rivers. This morphological type of floodplains is frequent in cultural landscape. It is connected with flood protection dike construction along channels and piling-up of material on original natural levees. In contrast, flat floor is a consequence of lateral accretion, i.e. sedimentation inside the meander, or more frequent channel change (Huggett 2003). Changing behaivour of cross-section curves of floodplain implies changing of strength of edges, which delimit floodplain.

In the valley bottom field geomorphological mapping can differentiate floodplain from lower fluvial (alluvial) terraces and alluvial fans. It makes essential merit in comparison with GIS morphometrical methods. Also this method of delimitation of floodplain is more detailed than GIS morphometrical methods and it does not include fault in cartography documents.

On the other hand this method has constriction with floodplain delimitation in flat relief without well-developed edges between neighbouring basic genetic geomorphological units of relief. These non-developed edges are result of specific evolution of wide relief, which are remodelled by intensive exogenic geomorphological processes, for example mass movement or eolic processes. Some floodplain like that are developed in sedimentary rocks of a fore-deep in the West Outer Carpathians. Next drawback of field geomorphologic mapping and its delimitation of floodplain is huge time demands.

Simple rule of GIS morphometrical delimitation of floodplain is not absolutely perfect and there are certain complications, which may confuse the results. That is why field geomorphological research is necessary.

The most obvious source of confusion is some inaccuracy or incompatibility of the input data, such as incorrect position of the rivers on the valley side. This is due to data inaccuracies, but there are also intrinsic problems – for example, lower quaternary terraces, which may appear as floodplains, as their vertical difference may not reach the contour interval, thus the terraces appear to be a direct continuation of the floodplain. Also in areas where the floodplain is not significantly limited by morphological borders (wide, shallow valley bottom), the GIS delimitation may overestimate real flood span.

On the other hand, the GIS floodplain delimitation has also advantages. Granted that the input data are accurate enough, it is very simple and fast technique for rough floodplain delimitation for practically unlimited area at once. It is also completely unbiased by the subjective attitude of the operator. Also within the urbanised areas the field mapping brings problems with the floodplain delimitation, which may be solved using the DEM delineation for these difficult places.

From the viewpoint of hydrology and water management, the floodplain is sometimes associated with the flooded area during floods, which is, however, ambiguous and inaccurate delimitation because of the variability of flood events. Culmination discharges of different magnitude during different flood situations cause different spillage of water into inundation area. Bridge (2003) defines the floodplain as a regularly flooded area with seasonal floods. Because in our country flood discharges are not seasonal this definition cannot be fully accepted.

Pedological methods of delimitation of the floodplain based on the fluvisol profile stratigraphy or reduction feature has some limits. The direct method is not applicable in sufficiently dense sampling network and thus the indirect methods based on landforms, phytoindication and remote sensing are broadly used. Distribution of fluvisols is very influenced by human activity in the landscape. For example regular alluvial sedimentation and alluvial groundwater level is frequently disrupted by anthropogenic channel transformation. Moreover the fluvisol distribution does not very often correspond to the maximum extent of floods. In addition, the transition zone between floodplain and fluvio-deluvial or deluvial substrate is highly subjective. In case of substrate homogenity and high contrast of soil types (e.g. molic humus horizons and unconsolidated carbon substrates) the remote sensing is the most valuable for delimitation of the floodplain. The phytoindication can be used as supportive method in extensively used floodplains.

As mentioned above plant communities provide great opportunity to determine the floodplain. To do so the habitat mapping within the NATURA 2000 preparation provides definitely the most valuable and up to date information about the natural vegetation. The Territorial Systems of Ecological Stability (TSES) mapping could be the second valuable source of information. Particular attention was given to the natural vegetation in the TSES concept as well. The above mentioned data are however only available for the floodplains with natural or semi natural character. In cases of heavy floodplain transformation e.g. channel metamorphism, converting the natural floodplain into building sites or arable land, the method based on vegetation mapping is impracticable and other approaches to delimit the floodplain should be used.

6. Conclusion

Geomorphological definition of the floodplain is most outright if we consider spatial delimitation of this area. That´s why we can define a floodplain to the all intents and purpose as an area which is created by water course channel and an accumulation plain constituted by fluvial unconsolidated sediment situated along a water course, and which is divided from other parts of relief by an edge with more or less significant inclination change. In fact, other definitions, based on different disciplines, implicitly draw on it. The area of the floodplain is highly dynamic in terms of natural and anthropogenically accelerated changes of geomorphological, hydrological, pedological and vegetational conditions.

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Shrnutí

ÚDOLNÍ NIVA A JEJÍ VYMEZENÍ

Článek je koncipován jako úvod do studia údolní nivy, který se zabývá problematikou jejího vymezení a charakteristikou z fyzickogeografického hlediska, především pak z pohledu geomorfologie, pedologie, hydrologie a krajinné ekologie. Také popisuje její základní geomorfologické formy a přirozené procesy, které jsou součástí systému údolní nivy a které se na jejím formování podílejí. Cílem této studie je charakterizovat vymezení údolní nivy z pohledu základních fyzickogeografických disciplín, které se tímto prostorem zabývají, včetně nastínění principů jejího vymezení, a určit její základní definici.

Údolní niva představuje v rámci krajiny specifický prostor, který se vyznačuje velkou dynamikou přírodních procesů, především fluviálních. Zároveň je tento prostor výrazně antropogenně ovlivněn a využíván. Přesto vymezení údolní nivy není triviální, protože na její modelaci se podílí celá řada přírodních procesů, které modifikují jednotlivé tvary v rámci údolní nivy vytvořené předešlými procesy, ale i samotnou nivu a mohou stírat rozdíl mezi ní a okolními formami reliéfu. Hranice údolní nivy se pak stávají méně zřetelné.

Při vymezování údolní nivy byla použita široká škála geomorfologických, pedologických, hydrologických a geoekologických metod, které se opíraly o terénní průzkum, tvorbu a analýzu digitálního modelu území a vyhodnocení dat z dálkového průzkumu Země.

Z rešeršní části článku vyplývá, že prostor a ohraničení údolní nivy je v jednotlivých fyzickogeografických disciplínách vymezován různě. Z toho plynou disproporce v určení průběhu jejích hranic vzhledem k okolí. Průběh a zřetelnost těchto hranic je navíc výrazně ovlivněna antropogenní činností. To se projevuje zejména ve změnách rozmístění fluvizemí a ve změnách vegetačního pokryvu, tedy v rozhodujících ukazatelích pro vymezení údolní nivy z pedologického, resp. krajinně ekologického hlediska. Taktéž se u nich, stejně jako u hydrologického vymezení, projevuje větší časová závislost vázaná na periodicitu a rozsah záplav. Ukazuje se, že geomorfologické vymezení údolní nivy je z prostorového hlediska nejjednoznačnější. Údolní nivu lze pak definovat v širším slova smyslu jako území tvořené korytem vodního toku a akumulační rovinou budovanou fluviálními nezpevněnými sedimenty podél vodního toku, která je od okolního reliéfu z každé strany oddělena hranou, na níž dochází k víceméně nápadné změně sklonu. Princip vymezení údolní nivy pomocí terénního geomorfologického mapování je založen na hledání a určení polohy a průběhu hran mezi rozdílnými geneticky stejnorodými plochami, tj. údolní nivou a údolním svahem, případně stupněm fluviální terasy (obr. 1). Hranice údolní nivy je vedena v linii výrazné změny sklonu mezi rovinnou či mírně skloněnou údolní nivou a sklonitějším okolním reliéfem, která je totožná s hranou oddělující obě genetické plochy. Druhý (morfometrický) princip vychází z vymezení ploch podle předem stanoveného mezního sklonu, na základě vytvořeného DMR. Tento způsob je rychlejší, ovšem je limitován kvalitou DMR, tedy musí být korigován terénním mapováním.

Obr. 1 – Příčný profil částí údolního dna se zakreslením jednotlivých genetických stejnorodých ploch a vymezením hran, které je oddělují.
Obr. 2 – Základní parametry pro výpočet morfometrických indexů – šířka údolí (S), hloubka údolí (H), šířka údolního dna (N) a podíl plochy pod terénem na obdélníkovém průřezu, vymezeném výškou a šířkou údolí (Z) a nad terénem (O).

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