

Floodplains – Links between Countries and Landscapes

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Abstract

The primary function of floodplains remains to be to ensure the safe passage of flood waves. As flood control problems are serious along some river sections, this also requires international cooperation. In landscape ecology, floodplains perform two related functions: they are riparian buffer zones (vital for maintaining river water quality) on the one hand and ecological corridors (ensuring connectivity and high biodiversity) on the other. Floodplain wetlands play an important part of the ecological integrity of riverine ecosystems as they fundamentally influence the ecological status of adjacent water bodies. It is all the more important since along most of its length the Danube crosses densely inhabited areas with intensive agriculture, large-scale industries and well-developed communication networks. Consequently, environmental pressure on the active and protected floodplains is of considerable extent and sharp conflicts arise between different land use types. Land use types promoting the fulfilment of the riparian buffer zone function must have priority. Unfortunately, only restricted sections of the Danubian floodplain are retained in seminatural conditions. In the Danube catchment 80% of the former wetlands are now disconnected and cannot fulfil their nature conservation role. The national NATURA 2000 networks are so much dependent on seminatural riparian ecosystems that they cannot be efficient without floodplain restoration measures. Predictable climate change tendencies (increasing drought liability) are also a threat to the survival of floodplains as ecological corridors. Remediation efforts are necessary along extensive floodplain sections and better connectivity is identified as an important target. According to the Danube River Basin District Management Plan (ICPDR 2009, p. 76): "The ICPDR's basin-wide vision is that floodplains/wetlands in the entire DRBD are re-connected and restored. The integrated function of these riverine systems ensures the development of self-sustaining aquatic populations, flood protection and reduction of pollution in the DRBD."

Keywords: *floodplain, flood hazard, riparian corridor, Danube.*

Rezumat. Luncile – legături între țări și peisaje

Funcția primară a luncilor rămâne aceea de a asigura trecerea în condiții de siguranță a undelor de viitură. Deoarece problemele legate de controlul inundațiilor sunt grave de-a lungul unor sectoare de râuri, acest fapt necesită de asemenea cooperare internațională. În ecologia peisajului, luncile îndeplinesc două funcții care sunt relaționate: acestea sunt zone tampon riverane (vitale pentru menținerea calității apei râurilor), pe de o parte, și coridoare ecologice (asigurând conectivitate și o mare biodiversitate), pe de altă parte. Zonele umede ale luncilor joacă un rol important în integritatea ecologică a ecosistemelor fluviale deoarece acestea influențează fundamental starea ecologică a corpurilor de apă adiacente. Este cu atât mai important deoarece pe întreaga lungime a Dunării, aceasta străbate zone dens locuite cu agricultură intensivă, industrii pe scară largă și rețele de comunicare bine dezvoltate. Prin urmare, presiunea mediului asupra luncilor active și protejate este de proporții considerabile și apar neconcordanțe mari între diferite tipuri de utilizare a terenurilor. Tipurile de utilizare a terenurilor care promovează îndeplinirea funcției de zonă tampon riverană, trebuie să aibă prioritate. Din păcate, doar sectoare restrânse ale luncii Dunării sunt păstrate în condiții seminaturale. În bazinul Dunării 80% din fostele zone umede sunt acum deconectate și nu își pot îndeplini rolul de conservare a naturii. Rețelele naționale NATURA 2000 sunt atât de dependente de ecosistemele riverane seminaturale, încât nu pot fi eficiente fără măsuri de restaurare a luncii. Tendințele de schimbare climatică previzibile (creșterea riscului la secetă) sunt de asemenea o amenințare pentru supraviețuirea luncilor ca și coridoare ecologice. Eforturile de remediere sunt necesare de-a lungul sectoarelor extinse de luncă și o conectivitate mai bună a fost identificată ca un scop important. Conform Planului de management al Bazinului Fluviului Dunărea (ICPDR 2009, p.76): „Viziunea la nivel de bazin a ICPDR este că luncile/zonile umede din întregul Bazin Fluvial al Dunării sunt re-conectate și restaurate. Funcția integrată a acestor sisteme fluviale asigură dezvoltarea populației acvatice care se auto-susține, protecția împotriva inundațiilor și reducerea poluării în Bazinul Fluvial al Dunării”.

Cuvinte-cheie: *luncă, risc la inundații, coridor riveran, Dunărea.*

INTRODUCTION

Floodplains are major binding elements between landscapes of mountainous, hilly or lowland character ensuring the flow of water, sediment and nutrients between them. Floodplains can be investigated from diverse aspects. It is common that the starting point is a geomorphologic one and the objective is to reveal landform assemblages, the origin and age of individual landforms, or the rate of floodplain sedimentation. Particular importance is attributed to hydrological studies which are directed to the energy of flood flows, flood hazard or opportunities for water storage in floodplains. Research from landscape ecological viewpoint is inseparable from riparian vegetation mapping, plant/animal community and habitat surveys as well as from the estimation of communities for nature conservation. For the human utilization of protected floodplains, the potentials for agriculture, forestry, construction, tourism and game management have to be evaluated. Finally, landscape ecological assessments are also concerned with the nature and degree of floodplain restoration and its conditions and tasks.

Why do floodplains deserve particular attention in landscape ecology? In the eastern half of Europe large-scale farming, the spreading of monoculture have deteriorated the ecological structure of the landscape. Landscapes have been impoverished in landscape elements, which are indispensable in ensuring connectivity. In addition to their nature conservation values, the significance of riparian zones, wetlands and forests, parts of the ecological

network (Jedicke, 1994), is growing. (In this respect, not only the floodplains of major rivers but those along smaller water-courses can be valuable.)

For the human society, floodplains are important arteries of communication between countries. Focusing on the main hydrological axis of the Carpathian Basin, it can be claimed that the Danube River still has a great potential as an international navigation route (WWF 2002) and, similarly, its floodplain is not yet exploited properly for transportation purposes (VITUKI 2007). Although even in Roman times the limes, the eastern boundary of the Empire ran along the right bank of the Danube over at least 700 km from Vindobona (today's Vienna) to Singidunum (Belgrade) (Visy, 1989), the wide swampy floodplain was essentially a no man's land, a hardly passable natural defense zone between the civilized and the "barbarian" world. The limes road was built parallel with the Danube along the margin of the floodplain, only exceptionally at a distance more than 3 km from the contemporary active channel. On the huge alluvial fan the active channels of the dynamic anastomosing system alternated and shifted position rapidly. In medieval times a characteristic floodplain economy developed. Besides fishery, it involved forestry, orchards, grazing and gathering – human activities which were based on the close interaction between the river and its floodplain. The end of the 18th century and the beginning of the 19th saw the first planned regulation measures (Table 1).

Table 1
Medium-water regulation efforts along the Danube (by Lóczy, based on UNESCO 1999)

Section	Period of main activities	Reduction of river length (%)	Measures
<i>Upper Danube</i> in Baden- Württemberg	1820–1890	-73	channel straightening, cut-offs, flood-control dykes, bank stabilization
in Bavaria	1826–1867	-15	channel straightening, cut-offs, flood-control dykes, bank stabilization, channel deepening by dredging and explosions
in Austria	1850–1914	ca. -15	by-channel closures, bank stabilization, flood-control dykes, training walls
<i>Middle Danube</i> in Hungary	1871–1914	-18	flood-control dykes, by-channel closures, cut-offs, bank stabilization, groynes, confluence relocations, protecting walls along urban sections
in Serbia	1894–1977	ca. -10	flood-control dykes, bank stabilization, groynes
<i>Lower Danube</i> in Romania/Bulgaria	no regulation	-	only dredging and some bank stabilization, flood-control dykes
<i>Danube Delta</i> (Sulina branch)	1860–1901	-30	straightening, dredging, longitudinal structures, canal building

Flow regulation measures disrupted this connection but, at the same time, opened the

opportunities for navigation along the Danube and the intensive agricultural utilization of floodplains

protected from floods. Explained by a range of political and economic reasons, at the dawn of the industrial age railways and major roads were not built on the Danubian floodplains. This proved to be partly an advantage in the 20th century, when the new concept of nature conservation could primarily rely on the narrow belts of forests on the active floodplain constrained between flood-control dykes.

The significant changes in the political systems of the countries of the Danubian region and their accession to the European Union opened up new opportunities for the joint exploitation of the active and protected floodplains. The elaboration of a long-term strategy for the development of the Danubian region, which is also expected to underline the significance of floodplains, is under way.

DIRECTIONS IN FLOODPLAIN STUDIES

Scientific studies of floodplains are conducted from a range of starting-points (Lóczy et al., 2011) and the term floodplain is used in different senses. Hydrologically, a floodplain means the active floodplain only or the floodway: the strip of land along the river where inundation can be expected with some probability. The geomorphological or genetic floodplain has a much wider extension: it covers the whole area where a typical landform assemblage (including point bars, natural levees, abandoned channels, backswamps etc.) is found. The mapping of floodplain morphology (Kis and Lóczy, 1985) supports the identification of locations in the floodplain with the greatest inundation hazard. The geological floodplain is delimited by the occurrence of fluvial deposits on both sides of the river, while in a pedological approach the presence of fluvisols indicates the floodplain. Since in physical geographical analyses Geographical Information Systems are an increasingly commonly applied tool, it is worthwhile to propose a topographic floodplain definition: a floodplain is a flat surface identifiable by an automated procedure taking advantage of the parameters of curvature and altitude (Lóczy et al., 2011).

In publications on landscape ecology, the term riparian zone often replaces the floodplain. This strip of land is usually much narrower than the genetic floodplain but fulfils buffer and corridor functions (Bohl, 1986). In the identification of wetlands hydrophilous vegetation, hydromorphic soils and characteristic soil conditions are equally regarded major criteria (Environmental Laboratory 1987). In many countries, increasing attention is devoted to the legal definition of floodplains. In Hungary Government Decree 21/2006 mentions the

floodplain of design flood (i.e. the 100-year flood) as "high-water channel" and regulates building and other human activities within its limits. However, even hydrologists are in problem when they have to deal with a design flood (Hankó et al., 2003).

Since physical and social influences have been combined to shape floodplains, a holistic view (embracing both the active and the protected floodplain) seems most appropriate in their study.

FLOOD HAZARD

The primary problem of floodplains worldwide is flood hazard, i.e. their primary function is to allow the safe passage of flood waves. This had been often emphasized for large rivers but in recent decades a re-assessment of flood hazard became necessary (Lóczy, 2010). The traditional explanation of floods in the Danube system has to be modified. Probably as a corollary of climate change, the flow regime of the Danube and its tributaries are changing: the threat from ice-jam floods is decreasing, while the probability of floods from winter rainfall is increasing, the beginning of snowmelt is shifting to later dates and often coincides with spring rainfall periods.

Another sign of the changing assessment of flood hazard is the increasing attention devoted to floods of smaller watercourses induced by local cloudbursts. In recent decades inundations along small rivers (like the Zagyva, Bódva, and Kapos in Hungary) or even along minor streams caused considerable damage. In small hilly catchments with steep slopes the collection of unsaturated runoff may raise water levels in streams extremely rapidly and such flash floods sweep through the narrow floodplains along channelized beds of low flood conductivity (Czigány et al., 2010). As a recent example the flood of the Tolcsva Stream (Tokaj-Eperjes Mountains, NE-Hungary) can be mentioned. On May 7, 2010, a hailstorm of 120 mm per day intensity flooded the stream, which inundated the village of Komlóska. (For further examples see Czigány et al., 2010; Lóczy, 2010.)

With remarkable efforts flood waves are usually retained within the confines of dykes but the prolonged high water of rivers causes excess water inundations over extensive areas of agricultural land. For instance, on June 7, 2010, the Hungarian Ministry of Environment and Water Management announced that – as a consequence of monthly precipitation above 300 mm in May – 167 000 hectares of land were covered with water. The entire area could not be drained since then. The conclusion to be drawn from such weather extremes is that land use priorities have to be reconsidered by

authorities. In the previously waterlogged floodplains crop cultivation and pasturing lands should be restricted, while in the vicinity of settlements building permits have to be issued with utmost care to prevent later damage to houses.

FLOODPLAIN PATTERN AND BIODIVERSITY

Floodplains are important structural elements of catchments. The connections are equally manifested in a longitudinal (between river reaches or between tributaries and the trunk river), horizontal (slopes-floodplain-channel) as well as vertical sense (channel-groundwater) (Ward, 1997). As buffer zones floodplains reduce the flow of natural or anthropogenic pollutants from the catchment towards the channel. The landscape pattern of floodplains is generally controlled by the geomorphologic conditions (landform assemblages) and the variations in habitat due to water availability and soil formation, while it is often transformed by human intervention (first of all, flow regulation interrupting the communication between the active and protected floodplain zones) (Poole, 2002). (River and floodplain restoration aims at re-establishing such connectivity.)

For the longitudinal distribution of aquatic biota, adjusted to changing resources, the River Continuum Concept (Vannote et al., 1980) is applied. Along the upper reaches of a river biodiversity is limited by the minimum range of temperature, lack of light and nutrients. Along the lower reaches bed material is homogeneous, the water is turbid and deficient in oxygen. Consequently, biodiversity is usually highest along the middle reaches, where the conditions for life are optimal from all the mentioned aspects. More emphasis is put on floodplains in the Flood Pulse Concept (Junk et al., 1989), which emphasizes horizontal connectivity. The seasonal floods of more or less regular occurrence provide the riparian zone with water and nutrients, the co-existence of aquatic and terrestrial vegetation and – naturally in function of the geomorphologic pattern – high biodiversity (Hughes, 1997).

At the early stages of succession, allogenic abiotic disturbances (floods, sedimentation) are major factors in the distribution of pioneer vegetation, while subsequently, when the mosaical pattern of the landscape is already stabilized, autogenic biotic factors (such as competition for resources) become predominant (Hughes, 1997). The exceptionally high biodiversity survives even if human intervention makes abiotic conditions (e.g. water availability) unfavourable for the natural

vegetation. Research in the Danubian floodplain area of the Szigetköz in NW-Hungary (Szabó, 2004) confirms that only minimum maintenance is necessary to ensure the ecological corridor function of floodplains and, thus, species and landscape diversity. At the same time, this function also has an unfavourable effect: the dispersion of weeds and invasive plants takes place along these corridors.

SIGNIFICANCE AND LAND EVALUATION FOR THE FLOODPLAIN OF THE DANUBE

There are 71 international river basins in Europe, which cover 54% of the total area of the continent. On the average more than 10% of the water used in European countries arrives as river discharge from neighbouring countries and five countries draw 75% of their resources from upstream countries. The drainage basin of the 2860-km-long Danube is of special significance as the river crosses ten countries and it is the most international stream in Europe. To promote its role as a communication line, sustainable navigation plans are being elaborated for the various sections of the Danube. Coordinating efforts in the Danube basin towards the implementation of the European Water Framework Directive (WFD), the International Commission for the Protection of the Danube River (ICPDR) has prepared a survey of the impact of human activities and an economic analysis of water use. The WFD calls for a new appreciation of floodplain functions and new priorities in floodplain management.

Natural resources are difficult to evaluate in monetary terms. In spite of the methodological difficulties, the first attempt has already been made to evaluate water and land resources in the Danubian floodplain (Andreasson-Gren and Groth, 1995). Based primarily on ecosystem productivity and substitutability, the average economic value of the Danube floodplains was estimated at EUR 383 per hectare per year. Since the total floodplain area is about 1.7 million hectares, its value added up to EUR 650 million every year – at the 1990 course. Although some ecologically valuable wetlands may have disappeared in two decades, the value of the remaining areas must have considerably increased since then.

As a matter of fact, this estimation does not include all the potential values of floodplains as links between landscapes and countries.

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