TISCIA monograph series

Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş

Edited by

László Körmöczi

Szeged-Arad
2011

Two countries, one goal, joint success!

Hungary-Romania
Cross-Border Co-operation
Programme 2007-2013

European Union
European Regional Development Fund

Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş

TISCIA monograph series

1. J. Hamar and A. Sárkány-Kiss (eds.): The Maros/Mureş River Valley. A Study of the Geography, Hydrobiology and Ecology of the River and its Environment, 1995.
2. A. Sárkány-Kiss and J. Hamar (eds.): The Criş/Körös Rivers' Valleys. A Study of the Geography, Hydrobiology and Ecology of the River and its Environment, 1997.
3. A. Sárkány-Kiss and J. Hamar (eds.): The Someş/Szamos River Valleys. A Study of the Geography, Hydrobiology and Ecology of the River and its Environment, 1999.
4. J. Hamar and A. Sárkány-Kiss (eds.): The Upper Tisa Valley. Preparatory Proposal for Ramsar Site Designation and an Ecological Background, 1999.
5. L. Gallé and L. Körmöczi (eds.): Ecology of River Valleys, 2000.
6. Sárkány-Kiss and J. Hamar (eds.): Ecological Aspects of the Tisa River Basin, 2002.
7. L. Gallé (ed.): Vegetation and Fauna of Tisza River Basin, I. 2005.
8. L. Gallé (ed.): Vegetation and Fauna of Tisza River Basin, II. 2008.
9. L. Körmöczi (ed.): Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş, 2011.

TISCIA monograph series
Volume 9

Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş

Edited by

László Körmöczi

This volume was prepared in the framework of „Habitats and ecosystem goods and services evaluation in the Mureş/Maros and Crisul Alb/Koros river valleys" (HURO0801/194) project that is implemented under the Hungary-Romania Cross-Border Co-operation Programme, and is part-financed by the European Union through the European Regional Development Fund, and the Republic of Hungary and Romania.

Szeged-Arad
2011

***The content of this volume does not necessarily represent the official position of theEuropean Union*.**

László Körmöczi (ed.): Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş. Tiscia Monograph Series 9, Szeged-Arad, 2011.

Published by the Depatment of Ecology, University of Szeged, H-6226 Szeged, Közép fasor 52., Hungary

Printed by Innovariant Nyomdaipari Kft.
Szeged, Textilgyári út 3., Hungary

ISSN 1418 - 0448

Contributors of the volume

Aurel Ardelean, Department of Ecology and Environmental protection,"Vasile Goldiş" Western University Arad
Gabriel-Gicu Arsene, Banat University of Agricultural Sciences and Veterinary Medicine Timisoara
Zoltán Bátori, Department of Ecology, University of Szeged
Miklós Bozsó, Department of Ecology, University of Szeged
Viktória Cseh, Department of Ecology, University of Szeged
Ioan Duma, Western University Timisoara
Andrea Fodor, Department of Ecology, University of Szeged
László Erdős, Department of Ecology, University of Szeged
Róbert Gallé, Department of Ecology, University of Szeged
Judit Gébert, Institute of Economics and Economic Development, University of Szeged
Tímea Kiss, Department of Physical Geography and Geoinformatics, University of Szeged
László Körmöczi, Department of Ecology, University of Szeged
Gábor Lőrinczi, Department of Ecology, University of Szeged
György Málovics, Institute of Economics and Economic Development, University of Szeged
Katalin Margóczi, Department of Ecology, University of Szeged
Viktor Oroszi, Department of Physical Geography and Geoinformatics, University of Szeged
Marian Petrescu, Department of Ecology and Environmental protection,"Vasile Goldiş" Western University Arad
György Sipos, Department of Physical Geography and Geoinformatics, University of Szeged
Dolly Tolnay, Department of Ecology, University of Szeged
Attila Torma, Department of Ecology, University of Szeged
Violeta Turcuş, Department of Ecology and Environmental protection,"Vasile Goldiş" Western University Arad
Márta Zalatnai, Department of Ecology, University of Szeged

Contents

DEVELOPMENT OF A HUNGARIAN-ROMANIAN ECOLOGICAL AND SOCIO-ECONOMICAL RESEARCH COOPERATION IN THE SOUTHERN GREAT PLAIN

László Körmöczi

Introduction

Trans-boundary regions of the Great Plain of the Carpathian Basin have many similarities and many differences. History of the formation of the basic rock and soils is the same, climatic conditions and water regime are very similar, landscape history is also similar, land use practices, however, are significantly different since long time that have resulted in different landscape and habitat structure. As the potential pool of flora and fauna is the same for the whole territory of the southern Great Plain, the deviation of the natural vegetation and fauna of the two sides of Hungarian-Romanian border may be due to the differences of land use.

Valleys of the rivers Körös and Maros are considerable landscapes of the Great Plain. The two rivers connect the human population of trans-boundary regions, and determine land use possibilities. In order to strengthen the sustainable land use we have to know the functioning of natural habitats and landscapes, the connecting and mediating role of the rivers.

In 2010, a new joint research project was organized by the Department of Ecology, University of Szeged and the Department of Ecology and Environmental protection,"Vasile Goldiş" Western University Arad. The aim of this project is to improve the ecological research activity and quality in the southern region of the Great Plain. Several studies have been implemented in the territory of the Tisza valley that evaluated the geography and hydromorphology of Körös and Maros region (Andó 1995, 1997, Jakab 1995, 1997, Kiss and Sipos 2005, Oroszi and Kiss 2005, Sipos *et al.* 2007, Fialka *et al.* 2007), flora and vegetation of the two rivers (Drăgulescu 1995, Drăgulescu and Macalik 1997, Molnár *et al.* 1997, Margóczi *et al.* 2000, Makra 2005), revealed the structure of particular animal communities (Sárkány-Kiss and Hamar 1995, Domokos *et al.* 1997, Markó 1997) and analysed the relationships among landscape elements, habitat structure and structure of biota (Gallé *et al.* 2000, Gallé 2002, Rakonczai 2006). Two monographs are devoted to summarize the results of the latest expeditions along the rivers Körös (Hamar and Sárkány-Kiss 1995) and Maros (Sárkány-Kiss and Hamar 1997). Above publications, however, do not take care for the transboundary differences in land use practices; evaluation of the effect of land use on the habitat and biota structure in the Great Plain is rather sporadic (e.g. Bellon 2004, Minca *et al.* 2007).

In the recent project, we planned to reveal the effect of the land use practices on the development of landscape structure, on the structure of natural vegetation and fauna. We intended to improve the Hungarian national habitat evaluation system, and apply for the transboundary region; and to assess ecosystem goods and services in the same target area.

Expected results and impacts:

• We cotribute to the elaboration of efficient and sustainable land use models that support and enhance the life of the trans-boundary region's inhabitants on long term, and at the same time preserve's the natural landscape and biodiversity. The economic growth and the quality of life depend on the rational use of natural values.

• The project provided with a good opportunity to improve a joint, Hungarian and Romanian, system for habitat and ecosystem goods and services evaluation. This new tool will help the public relevant bodies to develop effective sustainable development policies for the region.

• The human resources of the two partner universities were enhanced through experience exchange and participating in training sessions. Furthermore, the implementation of the project produced conditions and possibilities for further co-operation.

Members of the project team

This project was carried out in the framework of *Hungary-Romania Cross-border Cooperation program 2007-2013* as a joint research activity of "Vasile Goldiş" Western University of Arad as the lead partner and of University of Szeged as the project partner.

The project "*Habitat and ecosystem goods and services evaluation in the Mureş/Maros and Crisul Alb/Körös river valleys*" was implemented under the Hungary-Romania Cross-Border Co-operation Programme 2007-2013, and is part-financed by the European Union through the European Regional Development Fund, and the Republic of Hungary and Romania. Project code: HURO/0801/194.

Head of the project management team was Aurel Ardelean, Rector of "Vasile Goldiş" Western University of Arad. Supervisors were László Körmöczi for the University of Szeged and Violeta Turcuş for "Vasile Goldiş" Western University of Arad. The project was managed by Mihai Pascu and Márta Zalatnai.

Expert team members were

Aurel Ardelean, VGWU
Gabriel-Gicu Arsene, BUAV
Zoltán Bátori, USZ
Miklós Bozsó, USZ
Ioan Duma, WUT
László Erdős, USZ
Róbert Gallé, USZ
Tímea Kiss, USZ
László Körmöczi, USZ
György Málovics, USZ
Katalin Margóczi, USZ
Mihai Pascu, VGWU
Marian Petrescu, VGWU
György Sipos, USZ
Attila Torma, USZ
Violeta Turcus, VGWU
Márta Zalatnai, USZ

VGWU: Vasile Goldiş Western University Arad; USZ: University of Szeged; BUAV: Banat University of Agricultural Sciences and Veterinary Medicine Timisoara; WUT: Western University Timisoara

Study area

Investigations were carried out in two characteristic river valleys of the Great Plain. The two rivers – Körös/Criş and Maros/Mureş – connect transboundary areas. Their floodplains are similar in Hungary and Romania. Two representative areas were selected in the region of Körös/Criş; one was near Gyula (N46° 35' E21° 16') at the Hungarian side, and the other near Varsand (N46° 36' E21° 20') at the Romanian side. These two sites were very close to each other (Fig. 1). Two representative areas were also selected along river Maros/Mureş at Magyarcsanád (N46° 8' E20° 38'; Hungary) and at Bezdin (N46° 7' E21° 1'; Romania). Size of the selected areas was ca. 9 km^2 each, and represented the landscape structure and land use practices most characteristic for the target area.

The project consists of four main fields of investigation. The most characteristic landscape elements of the studied region are the two rivers: Mureş/Maros and Criş/Körös that run on a loose alluvium in the Great Plain, therefore the riverbeds are rather variable. One research activity aims to reveal the hydromorphology and to improve the knowledge on the processes of the formation of riverbed. Water regime of the rivers, frequency, intensity and duration of floods strongly determine the vegetation of the floodplain. Natural vegetation types are characteristic elements of landscapes, and provide habitat for the elements of the fauna. Thus the second research activity focused on the recent state of the vegetation (vegetation mapping), and on the history and development of the recent vegetation pattern. As the cenoses consist of plants and animals, it is evident that the investigation of actual fauna of the target areas is important and is the third group of studies. At last, the main biotic impact on the landscapes is that of the man. In the fourth project part we attempt to reveal the relationships of the local inhabitants and the habitat types, and to evaluate the ecosystem goods and services characteristic for the target areas.

Figure 1. Location of the experimental sites in the trans-boundary region.

According to the four areas of interest, field data collections were implemented by four groups of experts on the basis of the objects and purposes. One group studied the hydromorphology of the rivers. Two groups dealt with the vegetation and fauna of the sites selected. The fourth group met with representatives of the local inhabitants in order to make interviews for ecosystem goods and services evaluation. Details of the methodologies are described in each chapter

References

Andó, M. 1997: Hydrographic description of the Körös/Criş riversystem. – In: Sárkány-Kiss, A. and Hamar, J. (eds): The Criş/Körös River Valley. A study of the geography, hydrobiology and ecology of the river system and its environment. Szolnok - Szeged - Târgu Mureş

Andó, M. 1995: The geography of the River Maros (Mureş) and its river system. – In: Hamar, J. and Sárkány-Kiss, A. (eds): The Maros/Mureş River Valley. A study of the geography, hydrobiology and ecology of the river and its environment. Szolnok - Szeged - Tîrgu Mureş

Bellon, T., 2004: Living together with nature - Farming on the river flats in the valley of the Tisza. - Acta Etnographica Hungarica, 49, 243-256.

Blanka V. and Kiss T. 2006: Ártérfejlődés és növényzet kapcsolatának vizsgálata a Maros hullámterén (Biogeomorfológia). Tájökológiai Lapok 4/2. 301-308.

Blanka V. and Kiss T. 2006: Kanyarulatfejlődés vizsgálata a Maros alsó szakaszán. Hidrológiai Közlöny 86/4. 19-23.

Domokos, T., Bába, K. and Kovács, Gy. 1997: The terrestrial snails of the Hungarian section of the three Körös/Criş and the Berettyó/Barcău rivers and their

zoogeographical evaluation. – In: Sárkány-Kiss, A. and Hamar, J. (eds): The Criş/Körös River Valley. A study of the geography, hydrobiology and ecology of the river system and its environment. Szolnok - Szeged - Târgu Mureş
Dragulescu, C. 1995: The flora and vegetation of the Mureş (Maros) valley. . – In: Hamar, J. and Sárkány-Kiss, A. (eds): The Maros/Mureş River Valley. A study of the geography, hydrobiology and ecology of the river and its environment. Szolnok - Szeged - Tîrgu Mureş
Drăgulescu, C. and Macalik, K. 1997: The aquatic and paludal flora and vegetation from the Criş/Körös Valleys. – In: Sárkány-Kiss, A. and Hamar, J. (eds): The Criş/Körös River Valley. A study of the geography, hydrobiology and ecology of the river system and its environment. Szolnok - Szeged - Târgu Mureş
Fiala, K., Sipos, Gy., Kiss, T. and Lázár, M. 2007. Morfológiai változások és a vízvezető képesség a Tisza algyői és a Maros makói szelvényében a 2000. évi árvíz kapcsán. Hidrológiai Közlöny, 87/5. 37-46.
Gallé, L. and Körmöczi, L. (eds.) 2000: Ecology of River Valleys. Department of Ecology, University of Szeged, Szeged, Hungary.
Gallé, L., Gallé, R., Markó, B., Mikó, I. and Sárkány-Kiss, A. 2000: Habitat correlates of ground invertebrate assemblages in a flood plain landscape complex. In: Gallé, L. and Körmöczi, L. (eds): Ecology of River Valleys. Department of Ecology, University of Szeged, Szeged, Hungary.
Gallé, L. 2002: Flood-plain research at different spatial scales. – In: Sárkány-Kiss, A. and Hamar, J. (eds): Ecological aspects of the Tisa River Basin. 10 years anniversary regional conference 21nd – 24th March 2002. Târgu-Mureş, Romania, Târgu-Mureş - Szeged - Szolnok, pp. 7-16
Hamar, J. and Sárkány-Kiss, A. (eds.) 1995: The Maros/Mureş River Valley. A study of the geography, hydrobiology and ecology of the river and its environment. Szolnok - Szeged - Tîrgu Mureş
Jakab, S. 1995: Soils of the flood plain of the Mureş (Maros) River. . – In: Hamar, J. and Sárkány-Kiss, A. (eds): The Maros/Mureş River Valley. A study of the geography, hydrobiology and ecology of the river and its environment. Szolnok - Szeged - Tîrgu Mureş
Jakab, S. 1997: The geography of the Körös/Criş river system. –In: Sárkány-Kiss, A. and Hamar, J. (eds): The Criş/Körös River Valley. A study of the geography, hydrobiology and ecology of the river system and its environment. Szolnok - Szeged - Târgu Mureş
Kiss, T. and Sipos, Gy. 2005: Investigations of channel dynamics on the lowland section of River Maros. Acta Geographica 38. 1-15
Makra, O. 2005: Checklist of the associations of the Hungarian section of Tisza basin. — Tiscia 35, 9-16
Margóczi, K, Dragulescu, C. and Macalik, K. 2000: Vegetation description of representative habitat complexes along the Maros (Mureş) River I. The upper section (Vasláb/Voslobeni). In: Gallé, L. and Körmöczi, L. (eds): Ecology of River Valleys. Department of Ecology, University of Szeged, Szeged, Hungary.

Markó, B. 1997: Contribution to the knowledge of the ant-fauna (Hymenoptera, Formicidae) of the Crişul Repede river valley. – In: Sárkány-Kiss, A. and Hamar, J. (eds): The Criş/Körös River Valley. A study of the geography, hydrobiology and ecology of the river system and its environment. Szolnok - Szeged - Târgu Mureş

Minca, E. L., Petz, K. and Werners, S. 2007: An ecosystem services approach in the Tisza River Basin. — Tiscia 36, 35-40

Molnár, Zs., Bagi, I. and Kertész, É. 1997: Vegetation and flora of the Hármas-Körös river (Hungary) with some historical remarks. – In: Sárkány-Kiss, A. and Hamar, J. (eds): The Criş/Körös River Valley. A study of the geography, hydrobiology and ecology of the river system and its environment. Szolnok - Szeged - Târgu Mureş,.

Oroszi, V. and Kiss, T. 2005: The analysis of sediment accumulation and silting-up of a cut-off channel on River Maros near the city of Makó. Acta Geographica38. 27-39.

Oroszi, V. and Kiss, T. 2006: Területhasználat-változás a Maros egy hullámtéri öblözetében a XIX. századtól napjainkig. Tájökológiai Lapok 4/2. 309-316.

Rakonczai, J. (ed.) 2006: A vízből született táj. Az Arad-Békési-térség természeti értékei. Békés Megyei Önkormányzat

Sárkány-Kiss, A. and Hamar, J. (eds) 1997: The Criş/Körös River Valley. A study of the geography, hydrobiology and ecology of the river system and its environment. Szolnok - Szeged - Târgu Mureş

Sipos, Gy., Kiss, T. and Fiala, K. 2007: Morphological alterations due to channelization along the Lower Tisza and Maros Rivers (Hungary). Geographica Fisica e Dinamica Quaternaria, 30, 239-247.

LANDSCAPE HISTORY OF THE GYULA — VĂRŞAND REGION

Viktória Cseh, László Erdős, László Körmöczi

Introduction

Vegetation history assessment is gaining an increasingly important role in conservation efforts and researches, since it is essential to have knowledge about the environment, the landscape and its patterns and the processes and events that shaped the vegetation. Thus, landscape history assessment has become an important step in landscape wide researches. In the past two decades a growing number of papers were published on the subject (e.g. Molnár and Biró 1997, Biró and Tóth 1998, Rédei *et al.* 1998, Szirmai 2008, Molnár *et al.* 2008). The application of historical maps in the examination of landscape pattern changes has also become widely used and accepted (Biró 2006). Because of the accessibility of written sources and maps, these surveys can usually cover back till the 18th century. These researches can reveal the past usages of the landscape, the course of its development, and the extent and direction of its alteration and also the reason behind these. The resulting data can be further used in a wide range of applications, such as research, landscape planning and landscape assessment (Pickett 1991).

It is well known that the landscape of Hungary underwent a major transformation in the course of the past centuries. This transformation was influenced by both human presence and natural factors. Human land utilization has significantly altered the landscape of the Great Hungarian Plain. Throughout the centuries its inhabitants have utilized the fertile lands in various ways and with varying intensity. Canalizations and drainages have also brought further changes. To understand how and why a certain region have evolved to its present state it is therefore very important to familiarize oneself with its past. Our goal was to reveal the past of the alkaline steppes around the Gyula and Gyulavarsánd region. As a result we were able to learn the traditional ways of land utilization in the region, further assisting in the conservation of their natural values.

Material and methods

The following ten maps from different eras were used for the landscape history assessment: I Military Survey (1783); Plan des Markflecks Gyula (1784); Mappa Exhibens Situationem Dominii Gyulensis in Comitatibus Bekesiensi, Csongradiensi et Aradiensi existens et ad… (1788) (created by András Paulovits);

The Harruckern lordship's (Békés county, Csongrád county, Csanád county, Arad county) map (late 18th century); II Military Survey (1863); III Military Survey (1872-1884); Békés county (1881) (created by József Mihálfi); Public administration map of Arad county (late 19th century) (created by Ignácz Hatsek); Békés-Csaba (1910); Békés-Csaba (1911).

In addition, we have used a number of historical documents that held relevant data about land usage and vegetation (Kitaibel 1798 in Gombocz 1945, Ecsedy 1832, Komáromy 1834, Mogyoróssy 1858, Haán 1870, Gallacz 1896, Karácsonyi 1896, Hubai 1934, Scherer 1938, Dányi, Dávid 1960, Oláh 1975, Becsei 1979, Erdmann 1989, Dóka 1997, Dóka 2006, Szabó 2008), and also interviews with the locals.

In the era of the Hungarian Kingdom, the area in focus belonged to the counties of Békés and Arad. It is important to note, that after the peace treaty of Trianon in 1920, the region that belonged to Arad county was annexed to Romania. We therefore have much less data about changes regarding the 20th century.

Results

Before and during the Turkish Occupation (till the end of 17th century)

In its natural state the landscape of the Great Hungarian Plain consisted mainly of winding rivers and marshlands spanning large areas. The shape and location of the river beds were changing frequently. In lower areas close to the river, marshlands and pastures were the main food sources for the inhabitants. During larger floods the higher plains were fertilized by the silt left by the river. These provided excellent lands for agriculture. Due to the natural richness of resources, there has been a steady population in the vicinity of the three Körös Rivers since the Upper Palaeolithic era. However, the effects of human impact have only become noticeable since the last 500 years. There are countless ways humans utilized the land around them. The rivers provided sites for fishing while temporal wetlands were used for extensive grazing. Aside from providing game and lumber, forests also offered shelter in times of war. The rich wildlife of marshes was also exploited as a food resource by the local inhabitants (Dóka 1997). Higher plains that were not prone to flooding were essential, since they provided safe zones for the inhabitants to build permanent settlements (Scherer 1938) and for arable lands (Dóka 1997). In this area, active cultivation of crops only begun in the late 14th century (Karácsonyi 1896). It is important to note that the alkaline grasslands surrounding Gyula are considered "primary alkaline grasslands", meaning that they have formed naturally, before the beginning of the river canalizations. The water regime of these grasslands remained unchanged in the last 150 years, and their vegetation remained rich and characteristic. It is also presumed that the grasslands were inhabited by native ungulates (Vera 2000, Molnár and Borhidi 2003), this could mean that the grasslands in the Gyula region were natural pastures long before the effects of human animal husbandry.

In the 15th and 16th century, the majority of Békés county’s population lived from animal husbandry. Animals that were bred included horses, cattle, lamb and pork. Beekeeping was also practiced in areas near forests (Karácsonyi 1896). Grazing can be dated back to these centuries on wetlands south of the present location of Gyula (Scherer 1938). Wheat, barley, oat and millet were cultivated on the plough lands, while peas and cabbage were grown in the gardens. Also, Gyula was the only region to grow grapes in the whole county (Karácsonyi 1896). According to historical sources mentioning a large number of forests near Gyulavári and Varsány, the area must have been more forested than it is at present (Scherer 1938). These forests were somewhat farther, in territories which were not included in our study area.

The beginning of the Turkish Occupation brought a drastic change in the life of the locals. Gyula fell under Turkish control in 1566, and was not liberated until 1695. In the Turkish Empire the conquered land and its populace was the property of the sultan. The sultan then granted portions of these lands to civil servants and soldiers. However these lands were granted by the sultan for an unspecified time period and could be revoked at will. This system resulted in careless land use, and frequent pillaging (Anon. 1999). The following dubious time period made the population even more reliant on animal husbandry, than before (Karácsonyi 1896). The most important economical sector of the occupied territories was the agricultural sector. However, in contrast with today’s practise, the land was used for animal husbandry, and not for ploughing (Anon. 1999). The locals most commonly bred cattle. The horse keeping and the number of horses kept, was falling. Wheat, barley, oat and millet remained the most common crops cultivated on plough lands. Besides cabbage, gardens adopted carrots, parsley, onions and garlic (Karácsonyi 1896).

Only a small portion of the population was able to flee from territories occupied by the Turkish Empire. These included the population of cities, and nobles. The majority of the locals consisted of the serfdom who had no way of relocating. In the period before the Turkish Occupation, the Plain was characterized by an extensive network of villages. However, as a result of the war most of the smaller villages were destroyed and the remaining population moved to larger settlements. Throughout the one and a half centuries of the Turkish Occupation, the local population decreased or remained stagnant, thus the Plain was very scarcely populated. The population density was far below those of Western Europe. The increase of the population was hindered by wars, and the following pillaging and epidemics (Anon. 1999). Furthermore, the liberating troops and wars caused more damage to the region than the Turkish occupation beforehand. This further induced the expansion of marshlands into the ruined landscape (Dóka 2006). Agriculture on these long abandoned lands had to be re-established (Karácsonyi 1896). In the first period after the restoration of Gyula, animal husbandry remained the main form of job, plant cultivation was virtually nonexistent (Scherer 1938). This can partly be explained by the fact that notable population growth only begun after the ending of Rákóczi's War for Independence in 1711. Afterwards more and more land was drawn into agricultural use. Also, due to spontaneous and organized immigrations, a number of Slovakians, Romanians and Germans also settled in the area (Dóka 2006).

The 18th century

Animal husbandry was the most important sector, until the 18th century. It was practised mostly extensively (Erdmann 1989), meaning that the animals were out in the fields all year, and went after their food themselves. This is also pointed out by the fact, that at the end of the 18th century, most of the agriculturally usable territories were meadows and pastures (Dányi and Dávid 1960). Grazing and mowing was most common in the lower plains that were the most prone to flooding (Erdmann 1989, Dóka 2006). Belts were formed in the border around the settlements: the inner pastures and the plough land closer to the border and the outer pastures, most commonly farther away on the "leased fields". The cattle, horses, sheep and pigs lived mostly in the outer meadow. Wells were drilled on fields that were poor in water (Erdmann 1989), therefore wells on maps indicate pastures. "Leased fields" had an important role in the economy, not only as pastures, but also as meadows and plough lands. In some places, vineyards were established on "leased fields". In Békés county, it was common that these fields were not leased to the villagers, but to cattle traders, who bought cheap animals in Transylvania, feed them up on the rich fields, and then sold them in sales (Dóka 2006).

However, as a result of the population growth during the century and the increase in grain demand, and also because of the frequent floods on the riverside, more and more pastures were ploughed in. The shrinkage of land available for grazing resulted in the advancement of forage production and the extensive animal keeping was replaced by the semi-extensive animal keeping, which required a smaller territory for the animals. This meant that the animals roamed the pastures from spring to autumn, but spent the winter in their barn. Meadow management spread to produce food for the animals during winters, however, the meadows were not properly attended to, and the technology of the haymaking was undeveloped (Erdmann 1989).

In the 1700s the lands near the outskirts of Gyula were pastures, meadows and reed beds, while the plough lands were located farther away (Scherer 1938). Between the 1700s and 1760s depleted fields were used as fallows or meadows, and crops were moved to the next suitable location. However as of 1760 plough lands moved on to occupy the entire flood safe region, and with no more available land their expansion came to a halt. Lacking available land, the reed beds were cleared and were replaced by meadows and pastures (Scherer 1938). The arable lands were mainly used to grow wheat, barley, oats, millet and corn, while hemp, cabbage, tobacco, carrots, peas and lentils were grown in the gardens (Dóka 2006). At the end of the 18th century, a growing number of farmhouses were built, but back then the farmhouse was solely used for the purpose of wintering and watering the animals (Hubai 1934).

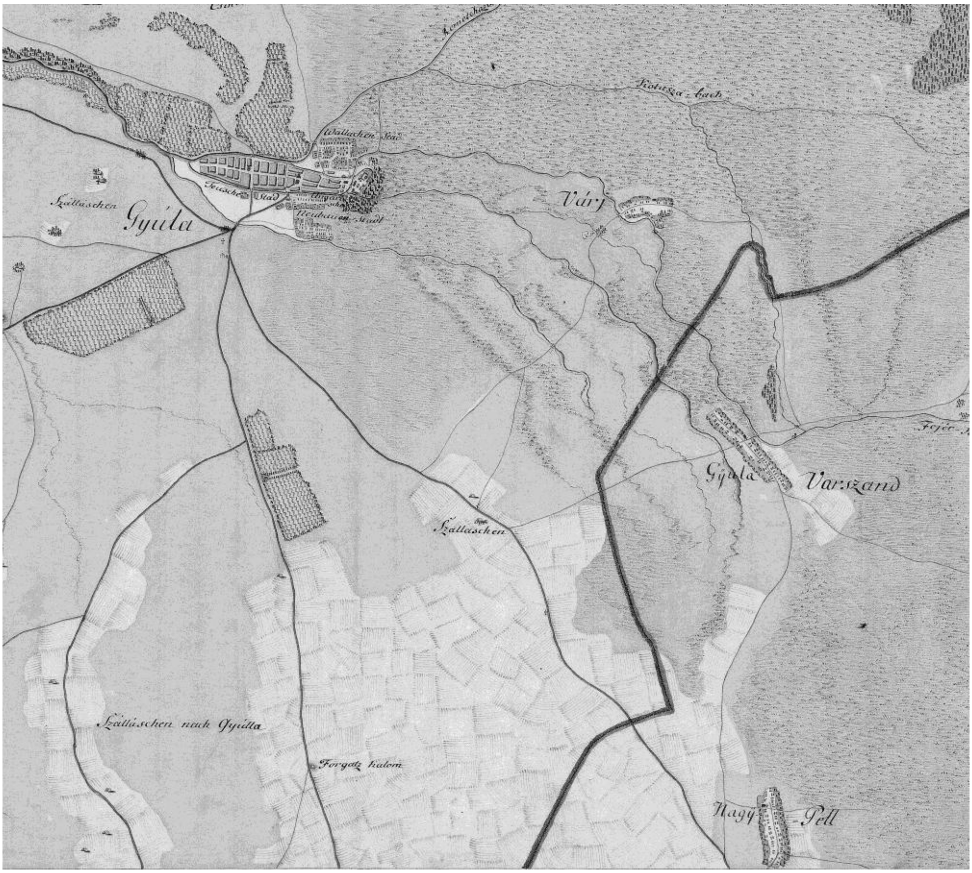


Figure 1. The structure of the landscape of Gyula region at the map of the First Military Survey (1783)

The earliest map made at the time to depict the land use is the I Military Survey (1783; Fig. 1). The traces of grazing are clearly visible as "accomodations" ("Szálláschen") are noted next to the fields examined. These buildings were used for the watering and wintering of the animals (Ecsedy 1832).

The map shows marshes near Gyulavarsánd, and there is an extensive marshland east of the region of interest. The I Military Survey’s (1783) description of the country also confirms, that the grasslands near Gyula are moist (saturated with water). The extensive marshlands provided a rich environment for a large number of bird species (storks, wild geese, herons, wild ducks), and also to mosquitoes (Scherer 1938). The map shows arable fields on the studied area, south-west of Gyulavarsánd.

Figure 2. The region of Gyula (Békés county) at the map of András Paulovics (1788)

This however is contradicted by a number of other historical sources we have found. The outline of today’s grassland can be clearly delineated on the map of

András Paulovits (1788; Fig. 2) that was made five years later. This shows evidence that the area was not ploughed in. This is further evidenced by Kitaibel (in Gombocz 1945). Alkaline grasslands and pastures are mentioned in his description from 1798. Furthermore, according to Scherer's (1938) description, the first arable lands near the city only appeared after the period of the flood control. It is also clearly visible on a late 18th century map of the Harruckern estate, that the region was not cultivated. Therefore it can be stated, that the information stored in the I Military Survey, is not accurate in this regard.

Turn of the century and the 19th century

In the late 18th and early 19th century, the continued population growth resulted in further drainage of marshes and the control of the Körös Rivers (Dóka 1997). Evidence of river control in the Körös region can be found in the 1740s, but these remained strongly limited until the 1770s (Gallacz 1896). Flood control works were also conducted on the south-east regions near Gyula, at the end of the 18th century, making more room for arable land (Scherer 1938). Imre Vida – the official responsible for the agriculture in the region – played a major role in the development of the region. In an effort to upgrade the Gyula lordship, he ordered the construction of channels to support watermills around the city, and widened a number of channels to open new trade routes and possibilities for transportation. He was also committed to the drainage of lands belonging to the lordship. In the 1800s a number of banks were erected that primarily served to protect the nearby roads from the floods (Dóka 1997).

A series of major economic changes took place on the turn of the 19th century. As a result of the emerging wars of the era, there was an increase in grain demand and export. The price of grain and other cereals started to rise. Methods for lamb breeding and keeping were also advancing, since the demand for wool also has risen. Cattle and horse breeders have also found a stable market. As a result, a large scale advancement of agriculture was observable. The breaking up of pastures, to be used for arable fields, and the use of fertilizer also became common. Gaining new land by clearing forests also became a practice in the era. Newer, more advanced tools and methods were developed and used in agriculture. New kinds of ploughs were used in ploughing, and harvesting of crops was done with scythes instead of sickles. Treading grain with horses was made obsolete by the discovery of the flail (Dóka 2006).

With the end of the Napoleonic wars, the times of prosperity had ended, and a period of economical recession began. At the end of the 1810s the price of grain began to fall bringing hard times for the Hungarian economy. This was somewhat mitigated by a brief uplift in the English textile industry, that resulted in growing demands for wool. To some extent the rising wool prices offered compensation for the profit lost on grain, but this brief uplift only lasted until 1825. However as the recession unfolded, the economy began to adapt to the new circumstances. From around the end of the 1820s goods produced by the peasantry had a growing demand. This was induced by the local traders, and the presence of large settlements. As distilleries and sugar production were constructed on the estates, the demand for beet and potato also rose. Finally corn and tobacco fields also began to gain larger ground (Dóka 2006).

The 19th century was the era of massive river and flood control efforts. While work on the Fehér Körös was finished in Arad County by 1855, the bed of the Fehér Körös was still intact in Békés county. Thus water rushing down from the higher regions is known to have caused damage there (Dóka 1997). After the 1855 flood in Gyula, it became necessary to regularize the bed of the river (Mogyoróssy 1858, Dóka 1997). Work was finished in the next couple of years. In the following 1860s the weather was dry and droughty, which switched the locals interests from flood control, to external water supplementation, however this did not last too long. With the end of the droughty period, in the 1870s work on flood control efforts renewed. A new need of draining inland waters arose, and as a solution, new canals were established. The control of Körös Rivers efforts were finished by 1879, and the succeeding efforts were concentrated on inland water drainage and fortification of the bank system (Dóka 1997). As a result, the marsh and lake coverage was shrinking – some entirely gone – but the region around Gyula generally remained saturated with moisture (Komáromy 1834, Haán 1870), this is also evidenced by a number of maps from the 19th and the 20th century.

Major changes in land usage were in progress in the wake of the river control efforts. Production on arable lands was increasing and their establishment on new lands weighted more heavily. Furthermore, in contrast to the 1860s tendencies in other parts of the country, the portion of land used as pastures and meadows was not growing in Békés county. New territories that were gained from draining were plowed whenever it was feasible. These new lands were primarily used for grain production (Dóka 1997). Cultivated plants included wheat, barley, oat, maize and millet (Ecsedy 1832). These changing land usage tendencies were also reflected in the livestock industry. Pigs were the first to be excluded from pastures, but as overall pasture coverage shrunk, soon sheep farming was also facing a recession (Dóka 1997). Slowly, the herds of cattle disappeared and most cattle were kept in barns (Scherer 1938). As stabling was gaining more ground, there was an increasing demand on feed, which somewhat balanced the grain centred land use of the time (Dóka 1997). The lower alkaline regions were used for harvesting hay, these has a small but quality yield (Mogyoróssy 1858). Although the share of livestock was dwindling in the century (Mogyoróssy 1858, Scherer 1938), livestock production had a dominating role up until 1850 (Hubai 1934). From the second half of the century, grazing was mostly practiced in lordships. This can be explained by the changes in society, induced by the emancipation of the serfdom.

With the cessation of the so called “robot” – the usual serf had to spend a portion of the week labouring on his lord's fields –, there was no manpower to cultivate the lands, and modern infrastructure to help a smaller labour base was nonexistent. However, these problems had only a minimal effect on the undemanding extensive livestock farming (Oláh 1975). The 19th century’s changes in livestock farming (extensive was abandoned for stabling livestock farming) have also brought forward a change in the used breeds of animals. It was not possible to exploit the expensive, high quality feed with undemanding, hardened animals that were used to grazing. Cross breeding was usually carried out in the lordships, with the peasantry getting hold of the animals breed there (Dóka 2006).

Figure 3. By the time of the Second Military Survey (1863) the region of Gyula has been transformed considerably.

Every village in Békés county was doing some kind of gardening. It could not escape the phylloxera disaster, which destroyed the grape cultures, but the region was repopulated by 1895 (Dóka 2006). Aside from the wineries, there were also a number of orchards. Most of the fruits produced were apples, pears, sour cherries, and plums, with also smaller plantations of apricots, peaches and almonds (Mogyoróssy 1858). A growing number of farmhouses were appearing in the countryside (Mogyoróssy 1858), but they were not used as residential. This was further evidenced by a prohibition that did not permit families to move in around the time of 1822 (Scherer 1938). The clusters of farmhouses were scattered through the landscape (Mogyoróssy 1858).

While the landscape stayed mostly moist and marshy, according to the map of the II Military Survey (1863; Fig. 3) drainage canals appeared. It is important to note that the location of lakes and watery grasslands mostly matches today’s semi natural, ploughing free areas. (For example, in place of the lake on the western side of the road, going towards Elek and Ottlaka, today alkaline grasslands, *Artemisia* salt steppes, degraded loess steppes and alkaline marshes can be found.) A number of lakes can be seen south-east of Gyulavarsánd, the larger ones are referred to by their names, in the map. The area of the Nagy Muzga Lake is mostly covered by alkaline grasslands nowadays. The Imputzita Felső Lake is now replaced by alkaline grasslands and *Artemisia* salt steppes mosaics. The Imputzita Alsó Lake is now covered by alkaline marshes, alkaline grasslands and *Artemisia* salt steppes. On the Hungarian side, south of Gyula, the outline of our region of study is a clearly visible marshy area called Farkashalom or Kis Pili dűlő. Shadoofs (wells) around the grassland indicate grazing land use, similarly to the areas around Gyulavarsánd. Farmhouses began to appear along the road going to Ottlaka and Elek. These were used as residential buildings after the 1850s (Hubai 1934). The fields near the road going from Gyulavarsánd to the south-west were already used as plough lands, and there were wooden and tone buildings on the fields.

While the III Military Survey only began 10 years later, it shows evidence of major changes in the landscape (Fig. 4). The number of canals increased, and the whole region became much dryer than before. The extent of the arable fields also increased with the land gained from the drainage. The number of farmhouses was also increasing, and there were dirt roads leading to the buildings. The houses were surrounded with plough lands. The Kispéli grassland remained a largely moist region, and beside the wells, there is specific notation, showing that the land was used for grazing. The previously mentioned lake on the western side of the road leading to Ottlaka and Elek became a pasture. The drainage is most visible on the Gyulavarsánd region. The Alsó and Felső Lakes are still shown, but are much smaller, and the Felső Lake is separated into two. The Nagy Muzga Lake was drained completely and is used as a meadow, crossed by the Élővíz channel. Many of the smaller lakes also disappeared; the remaining ones are surrounded by wells and reed beds. Wetlands around the lakes coincide with the present day semi natural grasslands. East of these regions there were dryer meadows that have been turned to plough lands. A portion of these plough lands were vineyards (Pili vineyards).

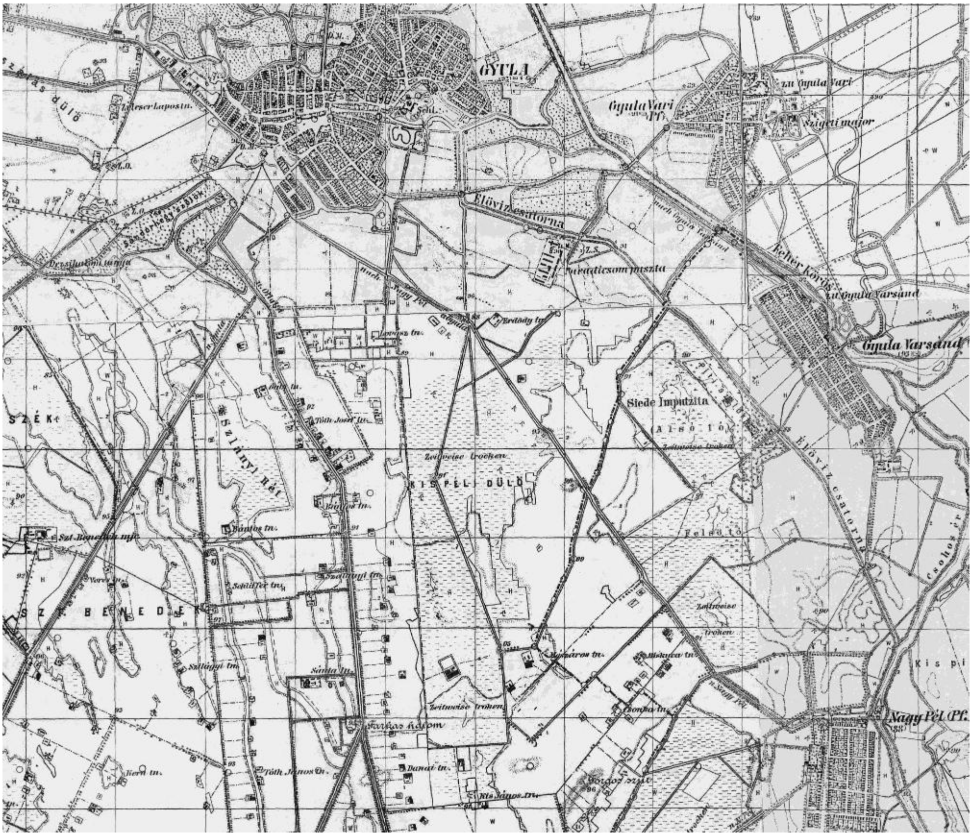


Figure 4. The map of the Third Military Survey (1872-1884) shows further changes.

Turn of the century and the 20th century

On the turn of the 19th and 20th century, the most important sector of livestock farming was cattle breeding. However, with the growing corn production, the number of pigs kept was also rising. Keeping horses was also popular, since it helped in labour-intensive agricultural tasks. While sheep farming was losing ground everywhere, there was still a large sheep population around Gyulavarsánd (Dóka 2006). However, in the course of the 20th century, the livestock farming undergone a series of major changes. According to Scherer (1938) “cattle farming had begun its endgame” in the early 20th century. Other sources (Kollega 1996-2000) indicate that until the 1960s, the major sector was cattle farming, and only then was it replaced by pig farming. The conclusion is that it was in the 20th century, that pig farming became the leading sector of the livestock industry. Poultry farming was undergoing rapid development, while sheep farming was dwindling away, and horse keeping was made mostly obsolete by modern agricultural equipment. The regression of lands used for fallow also had a great significance (Kollega 1996-2000).

Cereals took the leading role in cultivation. The most important product was grain. Coverage of barley and oats was decreasing in favour of corn. As a result of the developing vegetable oil industry, the total yield of sunflower fields was also increasing. Lastly, tobacco also had some significant share. To increase the yield of the fields, a number of different agro-technological procedures were also spreading, such as automation with modern machinery, soil fertilization, irrigation and pest management (Kollega 1996-2000). All these contributed to the growing environmental stress on the landscape.

Beginning from the early 20th century, a growing number of farmhouses was observable in the landscape. Aside from their residential functions, these farm clusters also served as economical centres (Hubai 1934). The Plain's system of farms remained a characteristic part of its network of settlements between the two world wars. It was not until the 1945s that its population started to decrease (Becsei 1979) and by the 1990s its population, extent and density decreased considerably. This is partly due to the events taking place between the 1940s and 1950s, when there was an effort to organize the locals in to the newly established farm villages. However, the main reason behind the sudden population decrease was the establishment of the farmers' co-operatives that led to the widespread abandonment of the farms, and the shrinkage of these settlements (Kollega 1996-2000). Moreover, the forced industrial concentration, and the collectivisations in the agricultural sector further reduced the population in agriculture-based regions – like Békés County – and contributed to abandonment of farms and smaller villages (Kollega 1996-2000).

The development of the present state

After 1920, the Hungarian – Romanian border separated the regions around Gyula and Gyulavarsánd. Thus the two regions developed differently and were subject to different influences. Gyula remained on the Hungarian side, and after the change of regime (1990), grazing ceased suddenly in its vicinity (J. Schön, personal communication). Until then, grazing was performed with cattle and sheep. Since the change-over, only small portions of land are grazed with some cattle, or sheep. Mowing is abandoned on a portion of the meadows, because there is no need for feed anymore (J. Steigervald, personal communication). In contrast, on the Romanian side, near Gyulavarsánd the entire grassland is grazed with cattle and sheep. Both sizes show extensive ploughing, however more grasslands have escaped this fate on the Romanian side. The semi-natural grasslands are grazed in Romania and mowed in Hungary. Only a handful of patches remain grazed near the farms (Erdős *et al.* 2011b). The conclusion is that land use on the two sides differs notably. The grassland on the Hungarian side is undergrazed, while the Romanian side is overgrazed, and this is reflected by the vegetation of the grasslands on both sides (Erdős *et al.* 2011a).

Discussion

Since data on land-use history can hold important information for conservation efforts. In this study, our aim was to reveal the land-use history of alkaline grasslands between the settlements of Gyula and Gyulavarsánd.

The alkaline grasslands around Gyula are primary that means they did not form as a result of the flood control efforts in the region, but they have been alkaline for centuries before (Molnár and Borhidi 2003). This was confirmed by Kitaibel (in Gombocz 1945) who reported saline vegetation in the area in 1798, although flood control in the region did not begin until 1770s, moreover the operations in the late 18th century could only have effected a small portion of the area in focus (Dóka 1997). It is presumed that these grasslands were inhabited by native herbivores before human land use (Vera 2000, Molnár and Borhidi 2003) later, in the Middle Ages they were used as pastures according to Scherer (1938), and from the 1770s grazing is clearly indicated by most of the available maps.

Grazing has continued up until the present day, however it had shown a steady decline (Hubai 1934, Scherer 1938, Szabó 2008). As a result of the drainages and the river controls the agriculturally usable area has greatly increased. This has induced a major shift in the proportion of the branches of cultivation. The area of the arable fields has increased while the extent of the pastures has decreased, therefore the extensive methods of the animal husbandry declined gradually (Kollega 1996-2000, Dóka 1997). By the end of the 20th century, grazing has almost completely disappeared in Hungary. There are no significant livestock in the area at present (Erdős *et al.* 2011a). One of the reasons is that the present day economic status does not make animal farming profitable. Following the treaty of Trianon in 1920, the Gyulavarsánd region belongs to Romaina, and was exposed to different economical and societal trends. The most important difference, is that grazing has continued in these territories ever since (Erdős *et al.* 2011a).

The alkaline grasslands in the region were not broken up. Although the map of the I Military Survey marks these meadows as arable fields, this is proven to be inaccurate, as a number of other maps from the 18th century and the notes of Kitaibel (in Gombocz 1945) contradict these claims. Thus, we conclude that the maps of the I Military Survey must be treated with caution.

The emergence of the world of small farms began in the late 18th century, and ended in the early 20th century. At the beginning, the farmhouses were only used for the watering and wintering of the animals (Ecsedy 1832, Hubai 1934, Scherer 1938), and for the storage of the harvested forage (Ecsedy 1832). From the second half of the 19th century, the building also became residential, and by the early 20th century, they have come to fill the role of economical centres (Hubai 1934). The expansion of the farm system in the second half of the 19th century was strongly related to the large-scale land shaping operations (flood control, marsh drainage) and the advent of intensive farming (Kollega 1996-2000). Population on the farm world started to dwindle in the 1945s (Becsei 1979), and by the 1990s, both its extent and population have diminished significantly. The main reason behind this was the collectivization of agriculture, and the transition to large scale production (Kollega 1996-2000).

While the region of interest remains soggy and marshy until the present day, it was more so in the 19th century, and back in the 18th century, large marshes and a system of smaller and larger lakes dominated the landscape. The conclusion is that the flood control works, beginning in the late 18th century, have caused the significant desiccation in the examined grasslands. Smaller lakes have completely disappeared, and the larger ones have shrunken extensively. By the early 20th century these remaining lakes are seen to be tiny, and most of them are gone by today. Semi-natural vegetation can still be found on regions, where these once soggy fields escaped being broken up.

References

Anonym (1999): Encyclopaedia Humana Hungarica 05. CD-ROM. - Enciklopédia Humana Egyesület, Budapest. (http://mek.niif.hu/01800/01885/html/)

Becsei, J. (1979): Néhány alföldi város (Békéscsaba, Békés, Gyula) és tanyavilágának településföldrajzi problémái. - Kandidátusi értekezés, Békéscsaba.

Biró, M. (2006): A történeti térképekre alapuló vegetációrekonstrukció és alkalmazásai a Duna-Tisza közén. - Ph.D. értekezés, Pécsi Tudományegyetem, Biológia Doktori Iskola, Pécs.

Biró, M. and Tóth, T. (1998): A 18-19. század vegetációjának rekonstrukciója az elmúlt ezer év tájhasználatának tükrében a Hármas-Körös mentén. - Crisicum I. Kőrös-Maros Nemzeti Park Igazgatóság Időszaki Kiadványa, Szarvas, 18-34 pp.

Dányi, D. and Dávid, Z. (1960): Az első magyarországi népszámlálás (1784-1787). - Budapest.

Dóka, K. (1997): A Körös és Berettyó vízrendszer szabályozása a 18-19. században. - Békés Megyei Levéltár, Gyula.

Dóka, K. (2006): A Körös- és Berettyó-völgy gazdálkodása az ármentesítés előtt és után. - Békés Megyei Levéltár, Gyula.

Ecsedy, G. (1832) [reprint 1982]: Gyulának polgári és egyházi állapotja a régibb s újabb időkben. - Rózsa Ferenc Gimnázium és Gyula Város Tanácsa, Békéscsaba.

Erdmann, Gy. (1989): Békésmegye és környéke XVIII. századi történetéből (közlemények). - Békés Megyei Levéltár, Gyula.

Erdős, L., Bátori, Z., Zalatnai, M., Margóczi, K., Tolnay, D., Cseh, V., Arsene, G.-G. and Körmöczi, L. (2011a): Comparison of two neighbouring alkaline grasslands with different land uses: a conservation management perspective. - Acta Botanica Hungarica 53, 89-100.

Erdős, L., Körmöczi, L., Bátori, Z., Zalatnai, M., Margóczi, K., Tolnay, D. and Cseh, V. (2011b): Gyula környéki szikes gyepek természetvédelmi szempontú értékelése. - In: Mócsy I., Szacsvai K., Urák I., Zsigmond A. R., Szikszai A. (szerk.): VII. Kárpát-medencei Környezettudományi Konfernecia. 216-220 pp.

Gallacz, J. (1896): Monográfia a Körös-Berettyó-völgy ármentesítéséről I-II. – Nagyvárad.

Gombocz, E. 1945. Diaria itinerum Pauli Kitaibelii I-II. - Verlag des Ungarischen Naturhistorischen Museums, Budapest.

Haán, L. (1870): Békés vármegye hajdana. - Lauffer Vilmos kiadása, Pest.

Hubai, I. (1934): Gyula földrajza. - Magyar Kir. Ferenc József Tudományegyetem Bölcsészet-, Nyelv- és Történettudomány Kara, Szeged.

Karácsonyi, J. (1896): Békésvármegye története I. kötet. - Dobay János könyvnyomdája.

Kollega Tarsoly, I. (1996-2000): Magyarország a XX. században. - Babits Kiadó, Szekszárd. (http://mek.niif.hu/02100/02185/html/index.html)

Komáromy, M. (1834) [reprint 1982]: Gyula várossáról és a hajdani Gyula várról. - Rózsa Ferenc Gimnázium és Gyula Város Tanácsa, Békéscsaba.

Mogyoróssy, J. (1858): Gyula hajdan és most történeti és statisztikai vázlatokban. - Réthy Lipót könyvnyomdája.

Molnár, Zs. and Biró, M. (1997): Vegetation history of the Kardoskút area (SE-Hungary) I.: History of the steppes from the Middle Ages to the present. - Tiscia 30, 15-25.

Molnár, Zs. and Borhidi, A. (2003): Continental alkali vegetation in Hungary: syntaxonomy, landscape history, vegetation dynamics, and conservation. - Phytocoenologia 21, 235-245.

Molnár, Zs., Fekete, G., Biró, M. and Kun, A. (2008): A Duna-Tisza közi homoki sztyepprétek történeti tájökológiai jellemzése. - In: Kröel-Dulay Gy., Kalapos T., Mojzes A. (szerk): Talaj-vegetáció-klíma kölcsönhatások. MTA Ökológiai és Botanikai Kutatóintézete, Vácrátót, 39-56 pp.

Oláh, J. (1975): Az akasztó-vésztői uradalmak gazdálkodása a XIX-XX. század fordulóján. - Budapest.

Pickett, S.T.A. (1991): Long-term Studies: Past Experience and Recommendations for the Future. In: Gisser, P.G. (ed.) Long-term Ecological Research. SCOPE, Johh Wiley and Sons, 71-88 pp.

Rédei, T., Barabás, S., Csecserits, A. and Kun, A. (1998): A hegylábi löszvegetáció maradványai a Budai-hegységben: Tájtörténeti rekonstrukciós kísérlet. - Kitaibelia, 3, 319-320.

Scherer, F. (1938): Gyula város története I-II. - Gyula m.város kiadása, Gyula.

Szabó, F. (2008): Két és fél évszázad az Alföld történetéből. - Békés Megyei Levéltár, Csongrád Megyei Levéltár, Szeged.

Szirmai, O. (2008): Botanikai és tájtörténeti vizsgálatok a Tardonai-dombság területén. - Ph.D. értekezés, Gödöllő, Szent István Egyetem, Környezettudományi Doktori Iskola.

Vera, F. W. M. (2000): Grazing ecology and forest history. - CABI Publishing, Wallingford.

Maps

I Military Survey (1783)
Plan des Markflecks Gyula (1784)
Mappa Exhibens Situationem Dominii Gyulensis in Comitatibus Bekesiensi, Csongradiensi et Aradiensi existens et ad… (1788) (created by András Paulovits) BéML XV.1.a.48.
The Harruckern lordship's (Békés county, Csongrád county, Csanád county, Arad county) map (late 18th century) BéML XV.1.a.47.
II Military Survey (1863)
III Military Survey (1872-1884)
Békés county (1881) (created by József Mihálfi) BéML XV.1.a.300.
Public administration map of Arad county (late 19th century) (created by Ignácz Hatsek) BéML XV.1.a.1.
Békés-Csaba (1910) BéML XV.1.d.9.
Békés-Csaba (1911) BéML XV.1.d.13.

INUNDATION AREA OF THE RIVER MAROS NEAR BÖKÉNY: LAND-USE HISTORY AND HABITAT MAPPING

Andrea Fodor, Zoltán Bátori, Viktória Cseh, Katalin Margóczi, László Körmöczi, László Erdős

Introduction

During human history, activities such as forest plantations and agriculture have considerably influenced the landscape. In conservation management, it is important to know the history of the area to be protected (e. g. Milchunas *et al.* 1988). The subunit of the Körös-Maros National Park near Maros is quite well-known (Paulovics 2002). However, its land-use history has never been analysed yet. In addition, its state has undergone rapid changes recently. Therefore, it may be useful to reveal its present state from a botanical perspective.

In this study, we revealed the land-use history of the subunit of the Körös-Maros National Park and we scrutinized its present state.

Material and methods

The river Maros has a marked bend near Bökény, a small settlement belonging to Magyarcsanád. Makó is about 12 km away. Mean annual temperature is 10.5-10.6 °C, mean annual precipitation is 580 mm (Ambrózy and Kozma 1990). Water quality of the Maros near Makó belongs to the category III (Somogyi 1990). Floods are most frequent in spring, whereas water level is mostly low in autumn (Somogyi 1990). The area belongs to the phytogeographic province Pannonicum, region Eupannonicum, district Crisicum (Borhidi and Sánta 1999).

In land-use historical analyses, historical maps and other historical documents, interviews with local inhabitants, and recent botanical data can be used and compared with actual field data (Molnár and Biró 2010).

In revealing the land-use history of the area, we used the following historical maps: Map of the first military survey (1784); Map of Csanád county (1802); Map of the second military survey (1864); Map of the state-owned forests of the river Maros and Bégamellék (1869); Map of the third military survey (1872-1884); Map of all forests of the Hungarian state, with the main tree species (1885); Map of the river Tisza valley: River Maros valley and the southern part of the Danube-Tisza interfluve (1892); Map of all forests of the Hungarian state, with the main tree species (1896); Administrative and agricultural map of Csanád county (1902); Makó and Nagyszentmiklós (1914); Topographical map of Sannicolau Mare (1972).

Besides, other historical data (Kitaibel 1810 in Lőkös 2001), documents on local history and natural conditions (Andó 1993, Marjanucz 2000, Tóth 2000) and recent reports (Paulovics 2002, Oroszi 2009), as well as interviews were used.

We also prepared a habitat map using ArcView GIS 3.2 (ESRI). Habitats were identified using the habitat guide (Bölöni *et al.* 2007a, 2007b).

Results

Land-use history

In the Middle Ages, several villages were located along river Maros. In the inundation area of the Maros, there were plenty of lakes, backwaters, brooks and islands, providing excellent opportunities for fishing, bird-catching and hunting. Higher loess plateaus were used for agriculture (Marjanucz 2000, Tóth 2000).

During the Turkish occupation of Hungary, plough-lands were uncultivated, roads were covered with plants, floods were greater and more frequent (Tóth 2000).

The area revived from the 1730s. The population lived on animal keeping, fishing and hunting, as well as from salt and wood transportation from Transylvania (Andó 1993). Neighbouring farmsteads were put into use (Tóth 2000).

By 1770, water-mills used the energy of the Maros. The ferry also played a significant role from the Middle Ages. Intimate connections between humans and the Maros are emphasized by the sigil of Apátfalva, dating from 1764, depicting a lapwing, some sedges and the river Maros (Tóth 2000).

Soldiers settled in at the end of the 18th century. They were allowed to use land and forests unrestrictedly. Viniculture started in Apátfalva in 1770. In 1779, local inhabitants had good plough-lands. On the island, they had remarkable plum orchards (their importance is echoed by the geographical names Kerekszilvás and Hosszúszilvás). In Apátfalva, stabling and semi-extensive animal keeping were typical. Hay-meadows along the river were flooded frequently at this time (Tóth 2000).

River canalizations began in 1754, but in a short time, the Maros returned into its original bed (Paulovics 2002). Therefore, the river flows in its original bed on the map of the first military survey (Fig. 1).

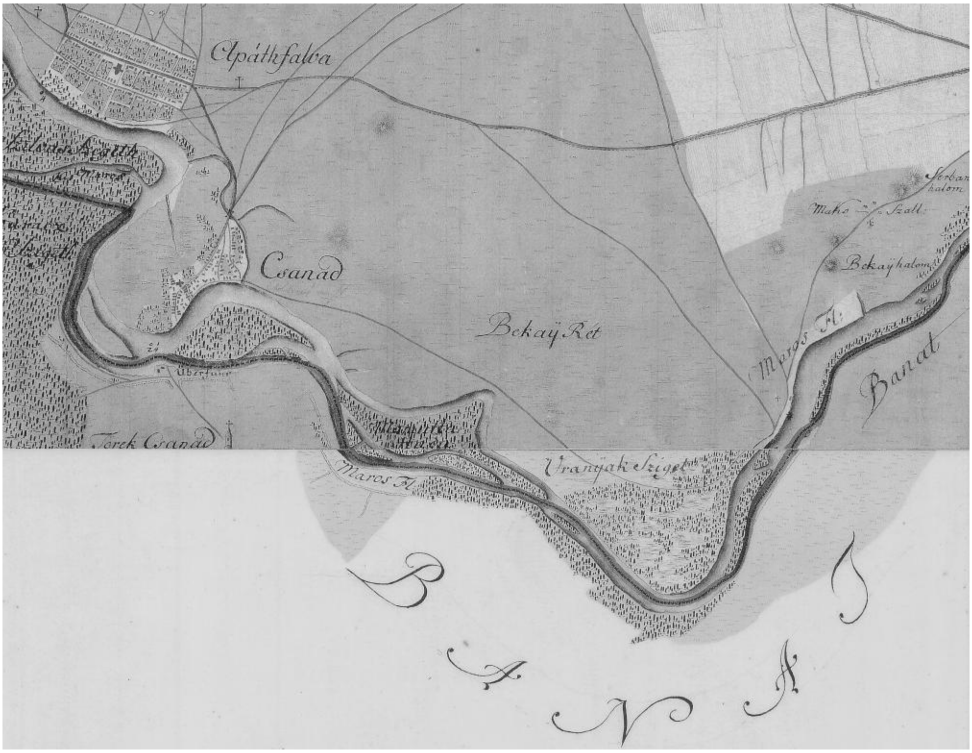


Figure 1. Map of the first military survey, coll. XX., sect. XXX. et XXXI. (1784)

According to the description of the first military survey, after long-lasting rains in spring, the whole area was flooded, including the village of Magyarcsanád, the roads leading to Nagylak, the nearby Bekay grassland and Bekay halom.

The area surrounded by the Maros bend was covered by forests which were flooded (Fig. 1). North of this region, a wet grassland can be seen. Further away, sweep-pole wells were situated on a grassland. Islands are also clearly visible on the map. According to the description of the first military survey, islands (e. g. Vranyak sziget, Vatta Mada sziget, as well as Szilvás, Szecső, Tárnok further downstream) were covered by forests of full-grown trees, white willow-forests of medium height or thickets. Near the Bekai halom, there were small swamps, which dried up often.

In 1793, because of the repeated floods, the village Magyarcsanád moved to the north, where it can be found at present.

In 1801, tobacco-growing started in Beka, at the place of the deserted medieval village Bökényfalva (Marjanucz 2000). The study area was called Béka on the map of József Vertics made in 1802 (Fig. 2.).

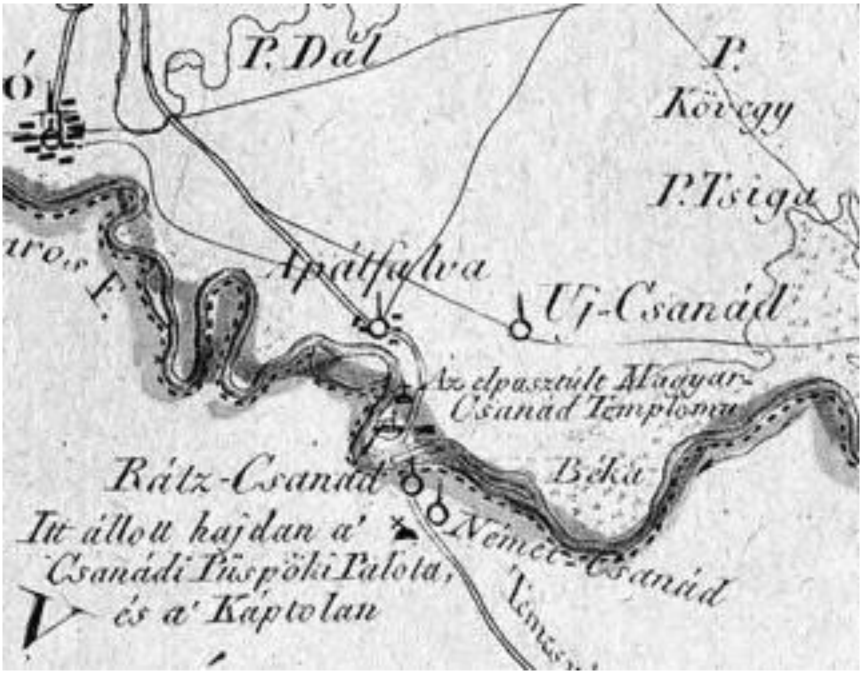


Figure 2. Map of Csanád county (1802)

Kitaibel (in Lőkös 2001) recorded in 1810 that the whole area around the former, abandoned Csanád was flooded. He found on the pasture near the new Magyarcsanád some species typical of steppes (e. g. *Astragalus austriacus, Isatis tinctoria, Salvia austriaca, S. verticillata*).

After severe floods had occured (e. g. in 1821 and in 1852), bends of the Maros were cut through. First cuttings were made in 1852 near Apátfalva. However, in 1879 the river was flowing in its original bed (Tóth 2000).

Considerable changes occured between the first and second military surveys. Both forests and reed beds decreased. The area surrounded by the bend of the Maros is called Buzsáki-erdő on the map of the second military survey (Fig. 3). This forest was interrupted by pastures. Also, pastures can be found north of this region. A forester's lodge was located in the northeast corner of the Buzsáki forest, near the river.

The river was flowing in several branches, which made sudden bends. The islands were covered by forests. After 1863, a 19 m wide road had to be separated from the collective pasture for the barge hauler horses along the river (Oroszi 2009).

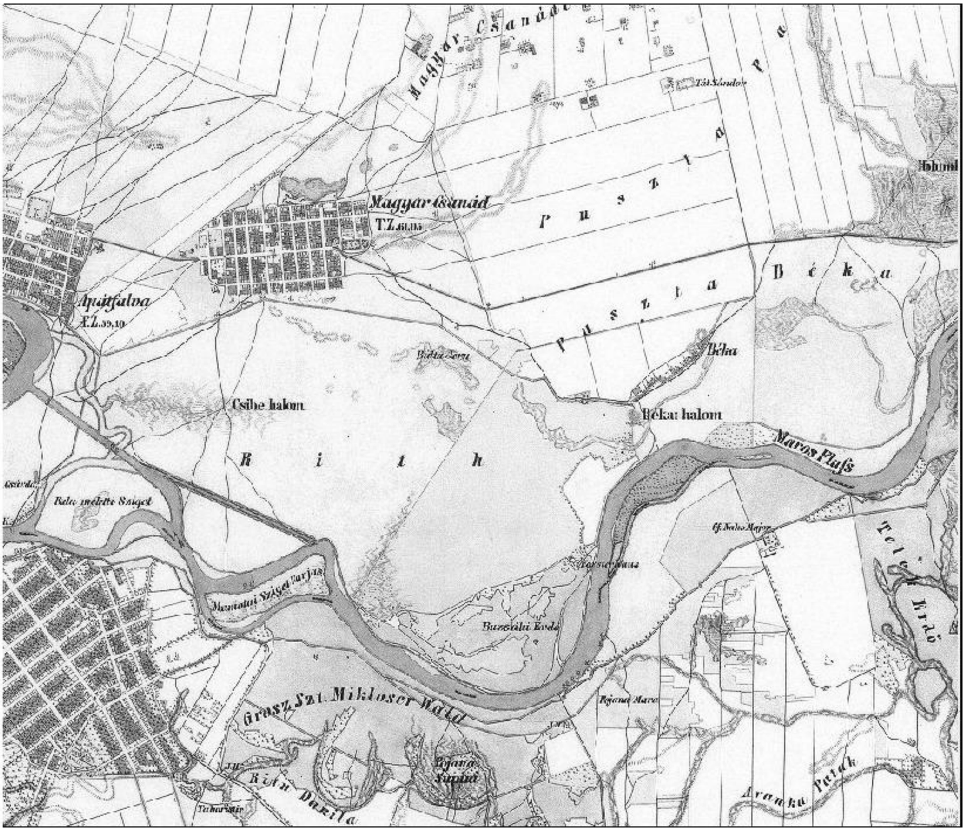


Figure 3. Map of the second military survey, col. XXXIX, sect. 62 (1864)

The map of the state-owned forests of the river Maros and Bégamellék (1869) shows that considerable parts of the study area were occupied by forests (Fig. 4).

The area called Beka must have been wooded a few years later, as shown by the map of the third military survey (1872-1884).

Also, the Map of all forests of the Hungarian state, with the main tree species, made in 1885 shows a forest on the study area.

On a map from 1892 (Map of the river Tisza valley: River Maros valley and the southern part of the Danube-Tisza interfluve), a forest can be seen, which is somewhat fragmented. North of the forest, there was a grassland, called "Lápos". Further away, there were some sweep-pole wells, indicating that grasslands were used as pastures. In this section, some small islands were situated in the river (Fig. 5).

Figure 4. Map of the state-owned forests of the river Maros and Bégamellék (1869)

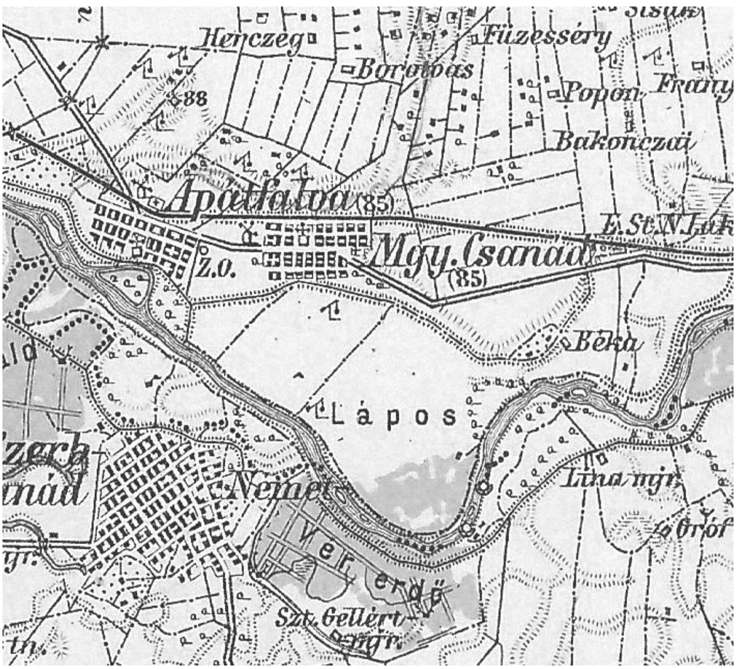


Figure 5. Map of the river Tisza valley: River Maros valley and the southern part of the Danube-Tisza interfluve (1892)

Similarly, it seems that the area was wooded in 1896, according to a forestry map (Map of all forests of the Hungarian state, with the main tree species; Fig. 6).

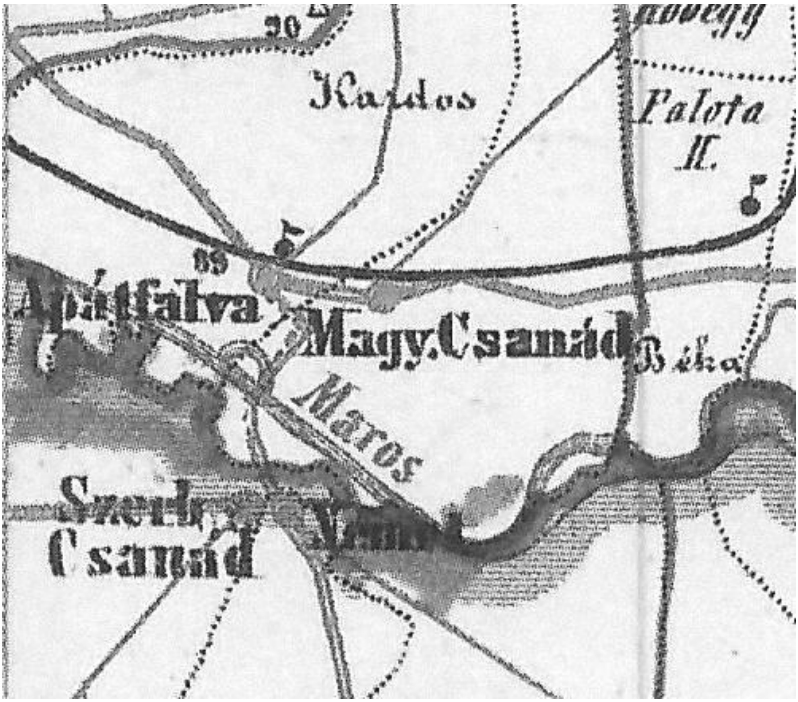


Figure 6. Map of all forests of the Hungarian state, with the main tree species (1896)

In 1902, a considerable part of the area under study was covered by forests according to the Administrative and agricultural map of Csanád county (Fig. 7). However, in a short time, forests along the Maros were cleared, and the area was used as arable land (Marjanucz 2000). By 1914, the area had been parcelled out into allotments, as it can be seen on the map of Makó and Nagyszentmiklós (Fig. 8).

The dominance of alien plants rose in the 20th century: for example, in 1949, one hectare of black locusts was planted on the pasture of Bökény.

Formerly, extensive orchards were pretty wide-spread in the area, and the farmers often lived in small huts from sping to autumn (J. Veréb, personal communication).

Till the regime change, grasslands were used intensively: they were fertilized and irrigated. After being mown in spring, grasslands were grazed first by horses, then by cattles, later by sheep and finally, at the end of the season by pigs (I. Csáki, personal communication). Although there were great forests in the area (Fig. 9), before 1990, nonindigenous poplar forests were planted exclusively (I. Csáki, personal communication).

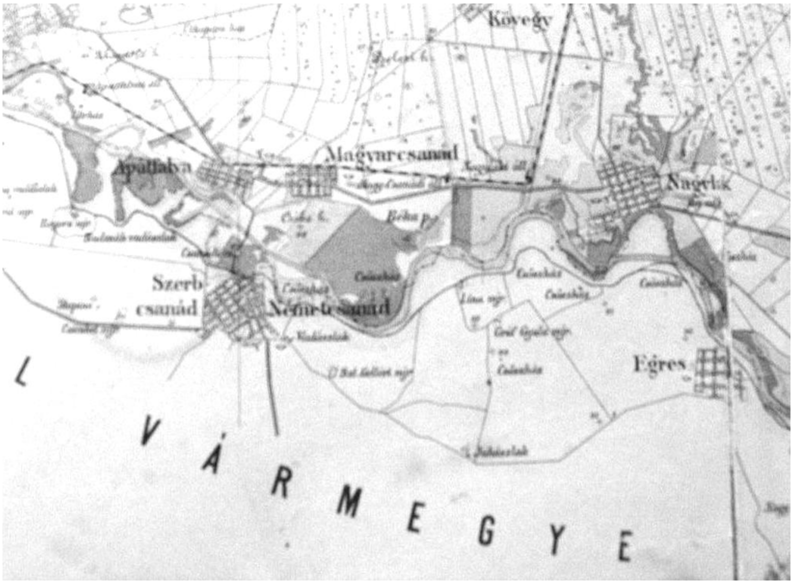


Figure 7. Administrative and agricultural map of Csanád county (1902)

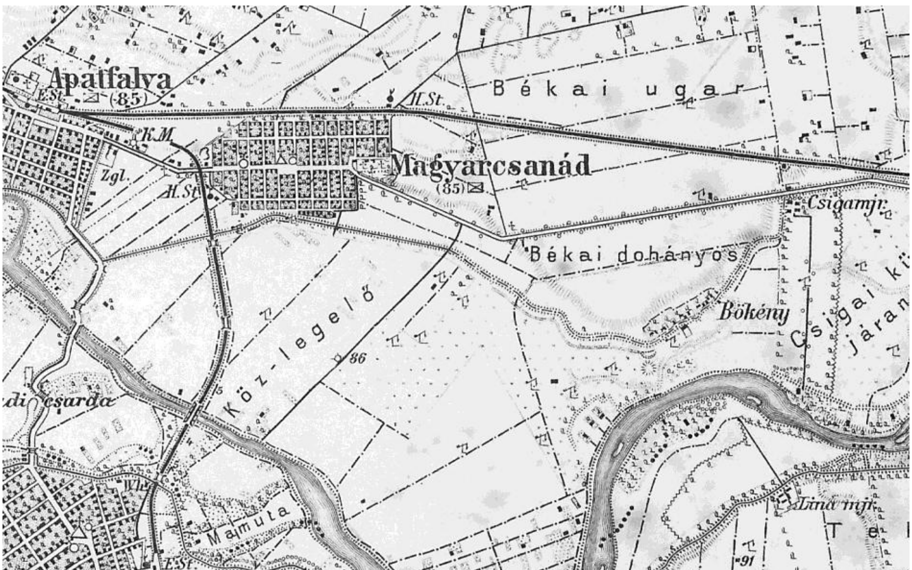


Figure 8. Makó and Nagyszentmiklós (1914). Study area is parcelled out.

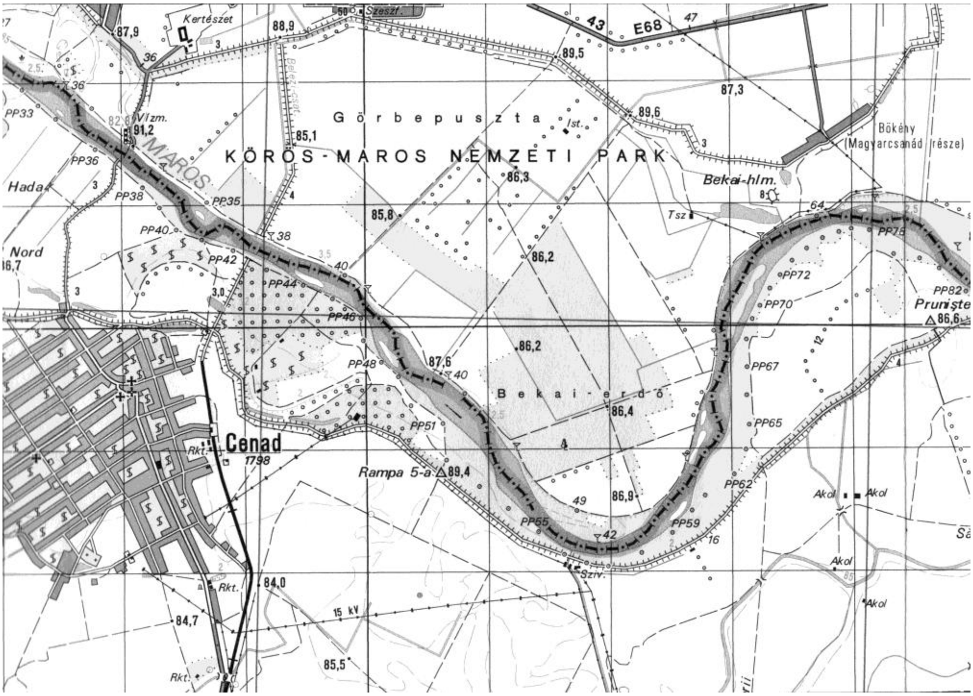


Figure 9. Topographical map of Sannicolau Mare (1972)

Present state

Habitat map of the area is presented in Figure 10. At present, grasslands are partly mown, partly grazed by sheep and cattles (I. Csáki, personal communication). Most of the forest patches are in a very bad condition, with poor field and shrub layers. They are planned for restoration with indigenous tree species (I. Csáki, personal communication). The poplar-willow riverine forest on the riverside, although invaded by alien species, supports relatively diverse herb and shrub layers. Proportion of orchards is low. The directorate of the Körös-Maros National Park intends to restore the extensive orchards with traditional fruit-trees (I. Csáki, personal communication).

We found the following valuable plant species in the target area:

Clematis integrifolia: a protected plant species; it is quite common on mesotrophic meadows on the study area.

Lamium album: although not protected, it is valuable (Paulovics 2002); we found this species in the edges of the riverine poplar-willow woodland.

Ornithogalum boucheanum: common on the Great Hungarian Plain, sometimes occuring in large numbers; we found this species in an edge of the riverine poplar-willow woodland.

Scilla vindobonensis: a protected plant species; this plant was found in the riverine poplar-willow woodland.

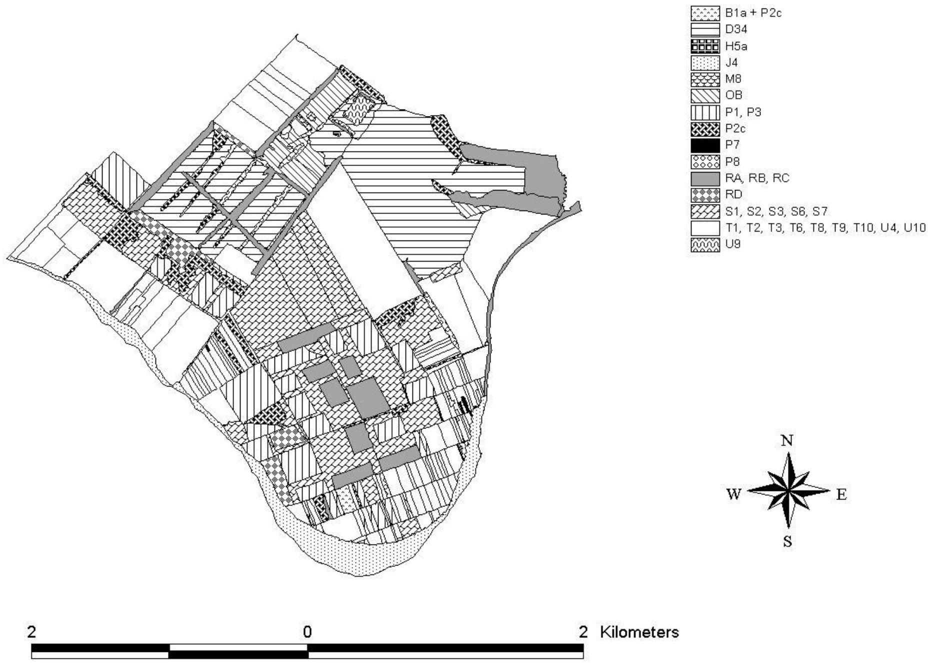


Figure 10. Present land-use map of the study area

Discussion

Our land-use historical study revealed that the area surrounded by the Maros bend was mostly covered by forests. These forests were somewhat fragmented: several maps indicate a mosaic of grasslands and forests in the area. North of this region, pastures were typical. Often the whole area was flooded by the river. Major changes occured from the beginning of the 20th century, when forests were cleared and land was parcelled out into allotments, alien species spread, grasslands were fertilized and extensive orchards decreased.

Although the potential vegetation is riverine willow-poplar woodland (Deák 2008), this habitat can be found in a narrow stripe along the Maros exclusively. The study area is dominated by plantations of invasive species and arable fields, which is usual in the region (Deák 2008). Mesotrophic meadows, used either as pastures or as hay-meadows, also cover a considerable area. Extensive orchards may also be valuable, with traditional Hungarian fruit-trees (Deák 2008). In the study area, we found some potentially valuable small orchards.

At present, there are intensive efforts to eradicate the invasive species *Amorpha fruticosa* and to replace alien trees with indigenous tree species.

We found two protected plant species. Although localities of *Scilla vindobonensis* are known along the Maros, it has not been reported from this locality (cf. Penksza and Kapocsi 1998, Farkas 1999).

References

Ambrózi, P. and Kozma, F. (1990): Marosszög – éghajlat (Marosszög – climate). In: Marosi, S. and Somogyi, S. (eds.): Magyarország kistájainak katasztere I (Cataster of the Hungarian small landscape units I.). – MTA Földrajztudományi Kutató Intézet, Budapest, p. 211.

Andó, M. (1993): Makó és környéke természeti földrajza (Physical geography of Makó and its surroundings). In: Blazovich, L. (ed.): Makó története a kezdetektől 1849-ig (The history of Makó till 1849). – Makó, 87-116 pp.

Borhidi, A. and Sánta, A. (eds.) (1999): Vörös könyv Magyarország növénytársulásairól (Red data book of the Hungarain plant associations). – TermészetBúvár Alapítvány Kiadó, Budapest.

Bölöni, J., Molnár, Zs., Illyés, E. and Kun, A. (2007a): A new habitat classification and manual for standardized habitat mapping. – Annali di Botanica nouva serie 7, 105-126.

Bölöni, J., Molnár, Zs. Kun, A. and Biró, M. (eds.) (2007b): Általános Nemzeti Élőhely-osztályozási Rendszer (General Nationla Habitat Classification System). – MTA ÖBKI, Vácrátót.

Deák, J. Á. (2008): Marosszög. In: Király, G., Molnár, Zs., Bölöni, J., Csiky, J. and Vojtkó, A. (eds.) Magyarország földrajzi kistájainak növényzete (Vegetation of the small landscape units of Hungary). – MTA ÖBKI, Vácrátót, p. 51.

Farkas, S. (ed.) (1999): Magyarország védett növényei (Protected plants of Hungary). – Mezőgazda Kiadó, Budapest.

Lőkös, L. (ed.) (2001): Diaria itinerum Pauli Kitaibelii III. – Hungarian Natural History Museum, Budapest.

Marjanucz, L. (2000): Magyarcsanád. – Száz Magyar Falu Könyvesháza, Budapest.

Milchunas, D. G., Sala, O. E. and Lauenroth, W. K. (1988): A generalized model of the effects of grazing by large herbivores on grassland community structure. – Am. Nat., 132, 87-106.

Molnár, Zs. and Biró, M. (2010): A néhány száz évre visszatekintő, botanikai célú történeti tájökológiai kutatások módszertana (Methods of the botanical land-use historical researches). In: Szilassi, P. and Henits, L. (eds): Tájváltozás értékelési módszerei a XXI. században (Evaluation methods of the landscape changes in the 21st century). – JatePress, Szeged, 151-180 pp.

Oroszi, V. (2009): Hullámtér-fejlődés vizsgálata a Maros magyarországi szakaszán, PhD-értekezés (Studies on floodplain-changes on the Hungarian section of river Maros). – SZTE TTIK, Szeged.

Paulovics, P. (2002): A Körös-Maros Nemzeti Park Maros ártér területi egysége természetvédelmi kezelési tervének megalapozó dokumentációja (Documentation of

the conservation management of the Maros subunit of the Körös-Maros National Park). – CSEMETE, Szeged
Penksza, K. and Kapocsi, J. (1998): A Maros-völgy edényes növényei I. (Vascular plants of the river Maros valley). – Crisicum 1, 35-74.
Somogyi, S. (1990): Marosszög – vízrajz (Marosszög – Hydrography). In: Marosi, S. and Somogyi, S. (eds.): Magyarország kistájainak katasztere I. (Cataster of the Hungarian small landscape units I.). – MTA Földrajztudományi Kutató Intézet, Budapest, p. 211.
Tóth, F. (2000): Apátfalva. – Száz Magyar Falu Könyvesháza, Budapest.

GEOMORPHOLOGICAL PROCESSES ALONG THE LOWLAND SECTIONS OF THE MAROS/MUREŞ AND KÖRÖS/CRIŞ RIVERS

György Sipos, Tímea Kiss, Viktor Oroszi

Introduction

The historical and economic importance of the Maros/Mureş and Körös/Criş Rivers is unquestionable. For a long time they had provided a direct link between Transylvania and the Great Hungarian Plain. This connection was however broken during the most of the 20^{th} century, but can be and should be revitalized by mutual Romanian-Hungarian efforts.

Due to frequent and highly destructive floodings and intensive channel formation both rivers were regulated in order to protect settlements and agriculture. Regulation works started gradually in the mid 19th century according to the most up-to-date river management schemes of the time, but the great scale measures and aims remained unfinished due to historical and political reasons. Nevertheless, as a consequence of channel regulation, the alienation of settlements and people from the river unstoppably began, and thus the common knowledge about their behaviour and the processes forming their channel become relevant for the public only during great floods or disastrous events.

Meanwhile, as a consequence of continuous measurements since the end of the 19^{th} c. the hydrology of Hungarian rivers is fairly well known. Numerous authors have studied the hydrological characteristics of the floods occurring on the Tisza and Maros/Mureş Rivers (Bogdánfy 1906, Károlyi 1960a, Bezdán 1998, 1999, Vágás 2000, 2001, Illés *et al.* 2003). As the water level of peak stages shows an increasing tendency on the Tisza, recently the development and reasons of extreme floods, affected greatly by the tributaries, have drawn the attention of researchers. Several studies have been written on the climatic and hydrological causes, and the changes experienced on the catchments (Nováky 2000, Rakonczai 2000, Somogyi 2000, Bodolainé Jakus 2003, Gönczy *et al.* 2004), while other studies have emphasized the significance of floodplain aggradation (Nagy *et al.* 2001, Gábris *et al.* 2002, Kiss *et al.* 2002, Sándor and Kiss 2006). The morphological processes acting in the river bed during floods have rarely been analysed even though these can also influence stages experienced at a given hydrological situation (Starosolszky 1956, Károlyi 1960ab, Sipos *et al.* 2007).

In the present study we aim to provide an overview of the main morphological and hydrological features of both rivers. However, in terms of morphological change River Maros/Mureş will be considered, as it is more actively responding to anthropogenic effects and interventions. The key processes that will be analysed are contemporary riverbed formation, channel pattern change and floodplain sedimentation.

The Maros/Mureş catchment

In terms of its shape the catchment of the Maros/Mureş River can be divided into two parts. The upstream part is square shape (approximately 250×100 km), while the downstream 200 km section with an E-W axis, starting from Deva, has only a width of 20-40 km (Laczay 1975). In all the shape of the catchment is elongated (Fig 1.). This feature slightly tempers the ferocity of floods developing on the mountainous sections as the flood wave flattens on the elongated lowland section (Boga and Nováky 1986). The Transylvanian catchment has a significantly higher density of valleys than that of the lowland parts, the Maros/Mureş river system is built up by 430 permanent waterflows (Laczay 1975), the registered total length of which is 11 189 km (Andó 1993, 2002).

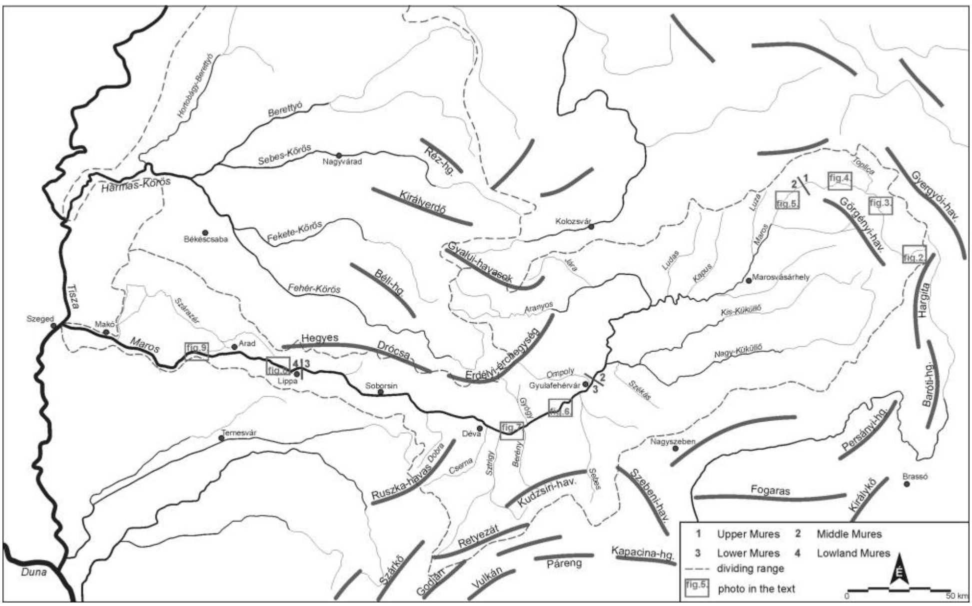


Figure 1. The catchment of the Maros/Mureş and Körös/Criş river systems by unifying several maps. Numbered rectangles mark the place of photographs shown taken on different sections of the Maros/Mureş River.

Figure 2. The so called ”touristic” source at Izvoru Mureşului (Marosfő) (850 m), and the “real” source 4-5 km to the N (1350 m).

Figure 3. The Upper Maros/Mureş close to Toplita (Maroshévíz). It passes the Depresiunea Giurgeului (Gyergyói-medence) with mild bends (flow from left to right)

Figure 4. Channel with gravel bars in the Topita-Deda (Maroshévíz–Déda) gorge (flow from left to right).

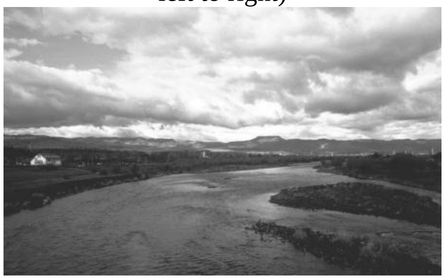


Figure 5. Braided pattern Middle Maros/Mureş leaving the gorge (flow towards the front).

The highes point of the catchment is 2511 m asl. high Retezat (Retyezát), while the lowest point is at 81 m asl. at the outlet of the river (Boga and Nováky 1986). The source of the river is located on the northern slopes of the Hargitha Mountains at Izvorul Mureşului (Marosfő) (Fig. 2). From the source to the outlet the river can be divided into four different reaches on the basis of slope conditions. The almost 110 km Upper Maros/Mureş passes through the Gyergyó Basin and in between the Giurgeului and Harghita Mountains (Gyergyói-havasok, Hargita) it reaches to the Toplita-Deda (Maroshévíz-Déda) gorge (Fig. 3-4.). The slope of this reach is very high, in average 369 cm/km (Török 1977). The next reach is the Middle Maros/Mureş, which has a length of 266 km. It passes the Câmpia Transilvaniei (Erdélyi Mezőség), the forelands of the Gurghiu Mountains (Görgényi-havasok) Târnava Hills (Küküllő hátság). Here the river flows in a valley as wide as 15 km at certain sections and built up by sedimentary rocks. Its slope is 50 cm/km on this reach. The 225 km long Lower Maros/Mureş is stretching between Alba Julia (Gyulafehérvár) and Lipova (Lippa) along a tectonic fult line separating the Apuseni Mountains (Erdélyi-érchegység) and the Southern Carpathians (Fig. 1). Its slope decreases to 30 cm/km. The Lowland

Maros/Mureş reaches from Lipova (Lippa) to the outlet, has a length of 162 km and a slope of 20-10 cm/km (Fig. 1).

Figure 6. Meandering section of the Lower Maros/Mureş at Alba Julia (Gyulafehérvár) (flow from left to right).

Figure 7. The river at Folt. At certain sections braided pattern with bars and islands appears again (flow from left to right).

Figure 8. The Lowland Maros/Mureş at Paulis (Ópálos). The river actively forms its channel which is proved by gravel bars and bank erosion (flow towards the front).

Figure 9. Widened channel of the river at Pecica (Pécska) with a gravely sand bar, and small in-channel islands.

The Körös/Criş catchment

The catchment of the Körös/Criş river system has a fan shape,. The area of the catchment is 27 537 km2, and thus it is the second largest tributary of River Tisza. As a consequence of the shape of the catchment flood waves arriving from the different sub-catchments reach the lowland almost simultaneously, and thus very severe floods can develop (Fig. 1). The Körös/Criş river system is composed of five main tributaries: Fehér-Körös/Crişul Alb (L=236 km, A=4275 km^2), Fekete-Körös/ Crişul Negru (L=168 km, A=4645 km^2), Sebes-Körös/ Crişul Repede (L=209 km, A=9309 km^2), Berettyó/ Beretău (L=204 km, A=6095 km^2) and Hortobágy-Berettyó (L=163 km, A=5776 km^2) (Andó 2002). The Körös/Criş system has its sources in the Bihor Mountains (Bihar) and the Apuseni Mountains

(Erdélyi-érchegység). The source of the Fekete-Körös/Crişul Negru is at 1460 m asl, the source of the Fehér-Körös/Crişul Alb is at 980 m asl. The slope of valleys in the upland catcment can reach 100-500 cm/km, while it is well below 20 cm/km, at the Hármas-Körös it is only a few cm/km.

Hydrology of the Maros/Mureş River

The Maros/Mureş and its tributaries are mostly fed by overland flow. Floods rise quickly, and last for only a short time, because of the geology (overwhelmingly crystalline rocks) of the catchment area and the high proportion of very steep slopes. Two floods are common during the year; the first is due to snowmelt in early spring, the second is caused by early summer rainfall. The rest of the year is characterized by low stages. By analysing the annual change of monthly mean discharges Boga and Nováky (1986) has shown that the maximum water delivery is usually at April (15 % of the total amount of water). Others also emphasize the importance of spring floods and point out that June rainfall may cause only a secondary flood wave (Csoma 1975). The minimum water delivery is at October, equalling 4.5 % of the total mean annual discharge (Boga and Nováky 1986).

Table 1. Characteristic stage, discharge and sediment load values at the Makó (Maros/ Mureş) gauge stations*, Maximum and minimum discharges at Gyoma (Körös/Criş)

		Maros/Mureş (Makó)	Körös/Criş (Gyoma)
Stage (cm)	maximum (1976-2000)	624	928
	mean (1976-2000)	36	
	minimum (1976-2000)	-104	-116
	bankfull	310	
Discharge (m^3/s)	maximum (1976-2000)	2 420	1 684
	mean (1976-2000)	161	
	minimum (1976-2000)	34	4.5
	bankfull	850	
Sediment load (t/y)	suspended load	8 300 000	
	bed load	28 000	
Specific sediment load** (t/m^3)	suspended load	1,6x1012	
	bed load	5,5x109	

* source: http://www.vizadat.hu and Bogárdi 1955, 1971)

** values of sediment load (t/y), divided by the mean discharge (m3/s)

At present, the slope of the studied lowland reach is 0.0028 while the mean velocity during mean-discharges is 0.6 m/s. The greatest flood on record was in 1970 with a peak discharge (Q_{max}) of 2420 m^3/s and a water level (H_{max}) of 624 cm. Nevertheless, the mean discharge (Q_m) is just 161 m^3/s, while the minimum recorded discharge (Q_{min}) is 34 m^3/s (H_{min}= -104 cm, 2003). Thus, the ratio between maximum and minimum values is 70 (Table 1).

Compared to other rivers of the region the Maros/Mureş transports a huge amount of sediment. The mean discharge of suspended load (0.05-0.02 mm) is 263 kg/s (8.300.000 t/y), but it may increase up to 10 kg/s during floods. The volume of the bed load (0.3-0.4 mm) is 0,9 kg/m^3 (28.000 t/y) (Bogárdi, 1974). The amount of the annually transported suspended load and bed load matches to similar values of the Tisza at Tápé and the Danube at Nagymaros, respectively. This fact also underlines the high sediment transport rate of the Maros/Mureş River.

Hydrology of the Körös/Criş River

Prior to the regulation works the hydrology of the river was determined natural factors, such as climate, geology and shape of the catchment. Human interventions however resulted an almost completely regulated river, with artificial channels and reservoirs, thus the river has lost its natural character. Floods however rise quickly due to the relief and shape of the catchment, and last for a long time on the lower reaches due to the impounding effect of the Tisza (Szlávik 1981). The development of severe floods is also facilitated by the fact that temporal differences might be significant in rainfall quantity and intensity, and the 25-30 % of the annual rainfall may occur within only 2-3 weeks (Szlávik 1981, Andó 2002). Flood waves may arrive as fast as 24-36 hours to the lowland sections, which makes flood prevention a difficult task.

As a consequence of the above the hydrograph of the Criş system is highly fluctuating. Similarly to the Maros/Mureş system floods related to snow melt are the most significant, and there can also be secondary early summer floods related to rainfall. Besides, the role of Mediterranean airmasses durin autumn rainfall and floods is also emphasised by some authors (Andó 2002). The highest water level was measured at Gyomandrő in 1970 (928 cm), while the lowest in 1935 (-116 cm), during the later the river almost entirely dried up. Therefore, the variability of discharges is much greater than in case of the Maros/Mureş (Table 1).

As a matter of its hydrology and catchment geology it manly transports suspended sediments on the lowland reaches. The greatest sediment concentration measured was 833 g/m^3.

Regulation works

The direction of the Maros/Mureş and the Körös/Criş changed frequently during the Quaternary, which is reflected by the large symmetrical alluvial fan of the Maros/Mureş and the great number of abandoned Holocene-Pleistocene paleochannels of both rivers (Mike 1991). Meandering reaches were surrounded by extensive swamps and wetlands (Fig. 10-11), and the rivers flooded vast areas every year. Inundation lasted for months, since point-bars and natural levees hindered the drainage of excess water.

Figure 10. Map of the I. Military Survey (1784) showing Apátfalva (Col.: 20, Sect.: 30)

During the 18-19th centuries unified regulation works attempted to make huge flood endangered lands suitable for agriculture all over the lowlands of the Carpathian Basin (Fig. 10-11). The large-scale works, including channelisation and the construction of 4220 kms of artificial levees (Dunka *et al.* 1996), resulted in the protection of 21,200 km^2 of land, a significant achievement in Europe. In the case of the Maros/Mureş levee construction started in 1752 and followed the banks of the river, in case of the Körös/Criş these works started a little later, in the beginning of the 19th century. Channel adjustments were carried out mostly between 1847 and 1872 on the Maros/Mureş and between 1855 and 1879 on the Körös/Criş. These measures reduced channel length significantly.

Due to the drastic decrease in length, the slope of the Maros/Mureş doubled (from 0.0014 up to 0.0028) and the river incised approximately 1.0 m (calculation based on decreasing lowest water stages; Rakonczai 2000). As a result of the closeness to the rim of the lower segment of the alluvial fan and the additional slope increase, the sediment transport has become more intensive and a down fan shift of the locus of deposition can be observed. Therefore, aggradation increased, and led to the appearance of new bars and islands in the river bed and the disappearance of ox-bow lakes on the active floodplain (Gazdag 1964, Ihrig 1973). Traditionally the Maros/Mureş was an important shipping route for salt and timber from Transylvania to the lowlands but, by the end of the 19th century, navigation was virtually impossible due to extensive mid-channel bar formation. River regulation therefore restarted in 1899. The existing bends were preserved, however, the low-stage channel width of the river was adjusted to 70 m at bend apexes and 40 m at crossovers. For training the river revetments were used on the concave and groins on the convex banks.

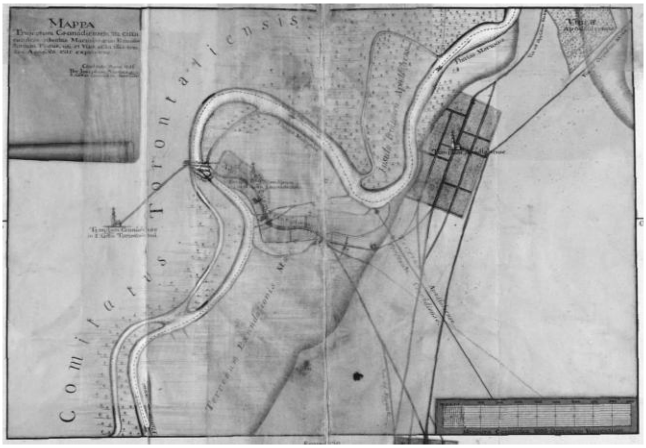


Figure 11. Hydrological map of the Maros/Mureş at Apátfalva, made by Vertics József (1796).

In case of the Körös/Criş the aim was not only increasing slope by cut-offs, but by deepening the channel itself. The maximum delivery rate was determined for each tributary, and channel dimensions were developed in harmony with these calculations. As a result the longest sections of artificial channels were made along this river in Hungary during the regulation works, actually a new river network developed on the lowlands.

After World War I. the history of regulations split up on the studied Maros/Mureş reach. On the lower, 28 km long Hungarian section (between the outlet and Makó) river training continued. All together 21.4 km long revetments and 53 groins were built, and the radius of the bends was adjusted to 500-800 m. However, at the same time the upper section between Makó and Nagylak became a border between Hungary and Romania. As no regulations were subsequently carried out on this reach it has been unmanaged for almost 90 years. Through the lack of bank protection, and due to the formerly straightened channel, the river bed of the Maros/Mureş widened (up to 300 m at some places), and new braids were born with islands and several different bar types, resulting in frequent thalweg shifts (Kiss and Sipos 2003). Aerial photographs and modern maps also show island braided reaches. The length of these on the managed 28 km long section is only 1 km; however on the unmanaged 22 km upstream, it increases to 6.6 km. Channel pattern changes were evaluated as a sensitive response to channelisation works (Sipos and Kiss 2003).

Hydraulical and sedimentological data of the Maros/Mureş plot the river to the meandering region on either the Leopold and Wolman (1957), Parker (1976) or van der Berg graphs (1995) (Sipos and Kiss 2004). However, the width/depth ratio of some sections exceeds the value of 50, determined by Fergusson (1987) as a threshold for braiding. These cross-sections correspond well to that of sand-bedded rivers with high bed-load discharge (Schumm 1985, Bridge 2003)

Geomorphological issues related to channel formation

Riverbed development on the Maros/Mureş at different water stages

Preliminaries

The role of different water stages in the river-bed dynamics of braided and slightly sinuous rivers is rarely discussed in geomorphological research. Most investigators concentrate on the effect of a single flood event when studying changes in channel pattern, bar-formation or bed-load processes (e.g. Borsy 1972, Wolman and Gerson 1978, Osterkamp and Costa 1987, Kochel 1988, Magilligan 1992; etc.).

A common difficulty in such investigations is the collection of precise and both spatially and temporally high density data. In most cases the solution to this problem is the restriction of data collection to short river sections, rivers of relatively low discharge, or to a short period of time. Another problem, which is emphasized in Whiting's (1997) study on flow fields, water and bed surface topography at two different water stages, is in relation to the relative depth of flow, which significantly influences the various terms in governing equations, and leads different researchers to a variety of conclusions. The measurements of Ryan *et al.* (2002) also support this idea. In addition, they emphasize that a shift from low to moderate transport of bed load occurs typically at about 80 per cent of bankfull discharge. Inevitably, this data should be important in terms of the character of bed topography changes at different discharges. In all, the role of different stages must be considered when channel geometry and bed topography are investigated (Jackson 1975, Dietrich *et al.* 1984).

Channel parameters and bed forms are studied most frequently in connection with floods, since dune and bar formation is the most dramatic and spectacular at the high stage (Bridge *et al.* 1986, Ham and Church 2000). Meanwhile, the investigation of a longer river reach has proved that the growth, decay and migration rates of dunes during floods are dissimilar at various sections during varied flood episodes (Lane and Richards 1997, Wilbers and Brinke 2003). In another case Eaton and Lapointe (2001) found that two floods of very different parameters did not cause qualitative changes in channel morphology. The importance of relatively low-magnitude floods in the development of disequilibrium state was also proved (Fullera *et al.* 2003). In the absence of large floods, bed-material transport rates decline over time, and material is mainly transported by higher stages which occur several times a year (Mosley and Jowett 1999, Ham and Church 2000). Based on Madej's research (1999), during a flood-free period subsequent to a great flood, the distribution of residual water depths may alter significantly. Mean residual water depth and depth variability increase over time, while the length of channel occupied by riffles decreases, resulting in an increase in the degree of bed heterogeneity relative to the time since the disturbance.

On a few occasions, rising and falling stages have also been investigated. Bridge and Jarvis (1982) found no evidence for the alteration of hydraulic geometry at the falling or rising stages, and no tendency was discovered in terms of the various cross-sections at any of the measuring stations. According to Carling *et al.* (2000), during the rising river stage, dunes tend to grow in height. However, during steady or falling stages the diminishing dunes actually increase in unit bed-load volume by a process of increased leeside accumulation.

In considering the role of low stages in channel development, it is nevertheless accepted that even low discharges should be considered in terms of bed formation (Bridge,, 2003). Different authors have different views on the active processes in braided rivers during low stages. According to Friedman *et al.* (1996), as a result of sediment input during high flow, the bed level rises; at lower stages the narrowing channel incises and thus high portions of the former river bed are left behind. On the other hand, some other studies report aggradation in the river bed during low stages (Owens *et al.* 1999, Ashworth *et al.* 2000). The model of Nicholas (2000) suggests that braided rivers may transport a significant proportion of their annual bed load during lower discharge periods.

In order to study bed evolution we have chosen the Maros/Mureş River, which is the second largest sand-bedded river on the Hungarian Great Plain. During the 19th century river regulation works, the meanders were cut off, the river bed was straightened and bars and islands started to develop. The lower 30 km section of the studied reach is still managed, but the upper 20 km has developed without human intervention since World War I.

One aim of the investigation was to determine the role of different stages on the cross-sectional channel geometry of a large river, with special attention to low-stage processes. A further aim was to locate braids, which are suspected to be the most significant zones of sedimentation along the river channel, and to determine their function in river-bed development (deposition – erosion).

Study area

The Maros/Mureş River is the second largest river of the Eastern Carpathian Basin. It is 749 km long with a catchment area of some 30 000 km^2, mostly situated in Romania. The lowest, 50 km section of the river was chosen as a study area. Of this a 28 km long reach is located entirely in Hungarian territory, while the remaining 22 km is part of the border between Hungary and Romania.

Hydrological events

Since the middle of the 19th century, hydrological measurements have been taken continuously on Hungarian rivers. On the reach studied, the daily stage and discharge data measurements at the Makó gauging station date back as far as 1876. Stage data are measured from the "0" point of the fluvio-meter, which was set to the level of the lowest water observed prior to 1876.Since then due to the decrease of low water levels, negative values have also appeared in records.

At the beginning of the period studied (from 1940 to 1981), floods (stages higher, than 350 cm) were common almost every year (Fig. 12). After 1981 several flood-free years followed. The durability of floods on Maros/Mureş is much shorter than on other rivers in the Carpathian Basin. The floodplain is inundated by the river on average 6 days a year; however, during the record flood of 1970 stages remained above bankfull for 81 days.

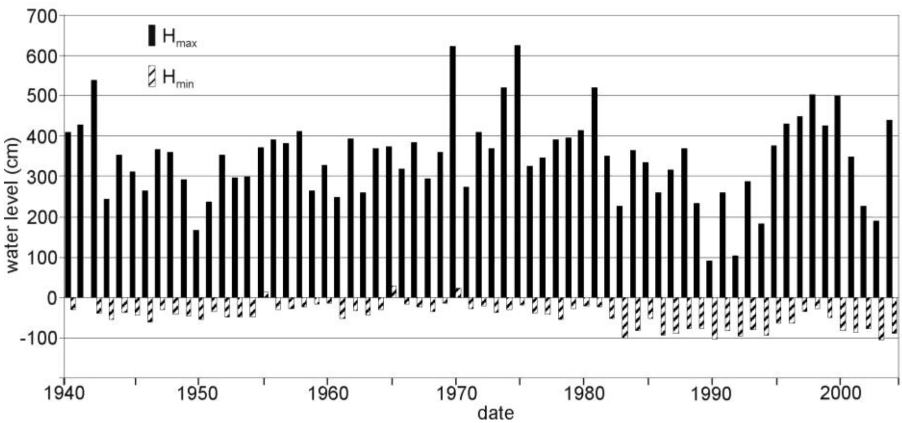


Figure 12. Annual maximum (H_{max}) and minimum (H_{min}) stages on the Maros/Mureş River at the Makó gauging station (1940-2004).

Based on the analysis of the 65 year gauging data set, the mean stage is approximately 54 cm, while the mode of the data set is at -10 cm, suggesting the importance of low stages. Between 1940 and 1981 the lowest stage never dropped below -50 cm, but since 1981 it has been between -50 and -104 cm. The lowest stage on record was observed at the start of our investigation in 2003. The period of low stages lasts approximately 10 months starting in June and terminating in March. The decreasing values of H_{max} and H_{min} during the last 20 years suggest a climatic change in the catchment area, which may be the reason for such extremely low stages.

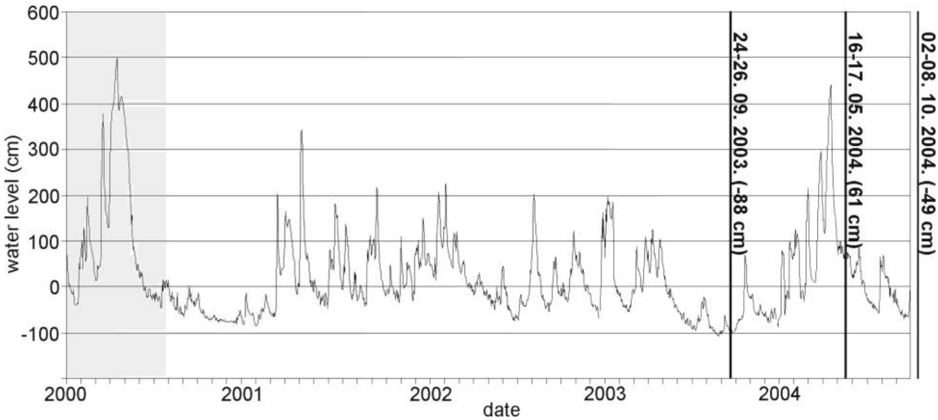


Figure 13. Hydrograph showing daily gauging data received at the Makó station from 2000 to 2004.

The extreme low-stage period followed a medium sized flood in 2000 (H_{max} = 500 cm Q_{max} = 1170 m^3/s) lasting for 2 weeks. For the rest of the year an unusually long low-stage period followed, when the water level never exceeded 0 cm (Fig. 13). The period between 2001 and 2003 was also characterised by low discharges, the water level hardly reaching the level of half bank height. However, daily stage fluctuations have been significant, occasionally exceeding 20 cm/day. At the beginning of 2004 a small flood was observed (H_{max} = 440 cm), but since then the stage and the rate of water-level changes have corresponded well to usual seasonal tendencies. The mean water stage for the past 5 years was 10 cm, while the most frequently occurring stage was –16 cm.

Methods

Data collection was undertaken at different spatial and temporal scale. Width measurements were done along the whole 50 km long section, cross-sections were surveyed in five braids, and at-a-station data were gained from the Makó gauging station. The longest period was covered by width measurements (from 1953), at-a-station data are available since 1988, and the cross-sectional measurements within braids started in 2003. Here data collected between 2003 and 2004 are analysed.

Before studying the role of different stages, their definition is necessary. Based on the long-term data set, those stages were considered low, which did not exceed “0” cm on the fluvio-meter (Q = 150 m^3/s). According to the calculations made by Török (1977), the channel forming discharge is at 248 cm (Q= 553 m^3/s). The bankfull level is at 310 cm (Q = 850 m^3/s). Water levels above this are considered as floods.

At-a-station cross-sectional measurements

Data were collected by the Hungarian Hydrological Service (ATIKÖVIZIG) between the same fixed points every month at the Makó gauging station. During certain hydrological periods (floods, extreme low waters) the measurements were more frequent, sometimes repeated daily or even as often as every eight hours. The depth was measured every 2 m to an accuracy of 1.0 cm. At the same time, discharge and velocity were also measured, but not bed-load transport rate.

From 1988 on, 365 at-a-station cross-sectional data sets are available. These sets represent different water stages and so, the relationship between water stages and different cross-sectional parameters can be studied. Maximum and mean depths and depth variability were determined. Depth variability is the difference between the maximum and mean depth, and refers to the shape of the river bed, as increasing difference implies a deeper thalweg, thus greater heterogeneity of bed topography.

Width measurements on the whole reach

In order to identify long-term width changes on the 50 km river section and the place of potentially braided structures, measurements were done on aerial photographs and map series from five dates (1953, 1973, 1981, 1991 and 2000) using Erdas Imagine 8.4 and Arc View 3.1 software. On the geo-corrected layers the bank-lines were digitized and a centreline was drawn for each date. On the basis of individual centrelines a line was interpolated, along which the width of the channel was measured every 100 m for each date.

The location of potential braids was determined by the average difference of maximum and minimum values per km (ad value). Those sections were considered braids where the difference between a section of peak width and the oncoming narrowest section exceeded the ad value for a given date.

Downstream cross-sectional measurements in braids

The underwater parts of downstream cross-sections at the chosen braids were surveyed with sonar equipment and a measuring rod. The width of the sections and height data of the emerged bars were determined with Total Station. The geographical position of cross-section end points was measured with GPS. Perpendicular cross-sections were made approximately every 100 m or, if the diversity of bed forms required, the distance between sections was decreased. Between the end points of neighbouring sections, diagonal sections were also sampled to increase the reliability of mean depth data. In all, 122 sections were made per survey. Data were gained from every 2.0 meters of the sections. Depth and height values were normalized to the water level of the channel forming discharge (248 cm).

Measurements were performed on three different dates over the course of a year. Low water measurements were made in September 2003 (H = -88 cm) and October 2004 (H = -49 cm), while after the falling stage, cross-sections were made in May 2004 at around the 65 year mean water level (H= 61 cm) (Fig. 13). Flood-stage measurements have not been made yet due to flashy and fierce waters making movement on the river almost impossible.

Results

Long term bar scale changes

The graph of average at-a-station cross-sectional parameters plotted against water stage shows that, as the water level rises, cross-sections become more asymmetric, because the thalweg is better defined though, average maximum depths do not change significantly. The average maximum depth is 5.15 m and 5.43 m at low and at flood stages, respectively, and this increases slightly by stage (Fig. 14). However, during low stages the mean depth values are greater, and the river becomes shallower on average by 0.6 m when water level reaches the highest category. This suggests that, during floods, large amounts of sediment are accumulated in the river bed, but that this will erode during low stages.

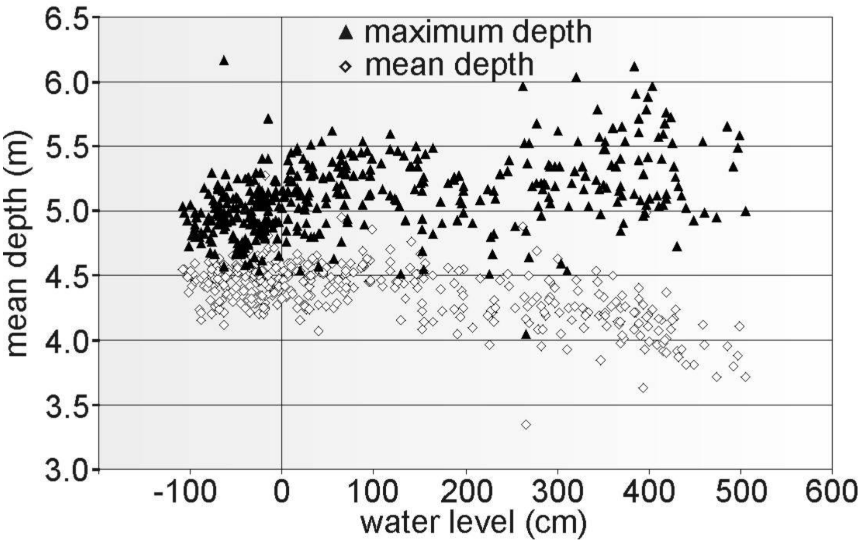


Figure 14. At-a-station mean depth and maximum depth values (m) plotted against water stage (cm) (from 1988 to 2004)

In order to reinforce this, 171 low-stage cross-sections were evaluated. Here the longest low-stage data set (18 measurements) from the period of July 1990 and April 1991 is analysed, when water stage never exceeded the "0" level (Fig. 15a). In the summer of 1990 water stages varied between –75 and -100 cm (Q = 35-51 m^3/s). The mean and maximum depth increased by 20 cm and 28 cm, respectively, equalling a 26 m^2 cross-sectional area increase. In the autumn the water stage rose by 50 cm (Q=65-100 m^3/s), resulting in an aggradation of 22 cm thick sediment in the cross-section. During the winter the water level fluctuated between -25 and -75 cm and thus the erosion of the river bed restarted with simultaneous thalweg shifts. A slight increase in maximum and mean depth was measured, though depth variability was no greater, than 0.4. Across all low-stage periods the maximum increase in cross-sectional area was 28%. The data proved that the dominant process during low stages is erosion, which is intensified by frequent thalweg changes.

Bed processes related to channel-forming discharge were studied at periods when stages varied between 250 and 350 cm (Q = 550-850 m^3/s), nearing flood discharges, but with a water level below bankfull. The longest channel-forming period was in March-April 1988, when three smaller flood-like waves succeeded (Fig. 15b). During the first wave, which was the highest (H_{max}=369 cm) and brought the greatest discharge (Q_{max}= 765 m^3/s), the value of maximum and mean depth changed cyclically by 1.0 m within 1-2 days. Consequently, during this period a great amount of sediment was transported through the cross-section. The change of bed topography suggests that the transport was maintained in the form of mid-channel bars and dunes. During the falling stage the maximum depth was reduced to 450-500 cm, and the mean depth decreased simultaneously. Therefore the surface of the bed became more even and elevated due to aggradation and frequent thalweg shifts.

Since 1988 only two floods have occurred on the Maros/Mureş (1998 and 2000). To show the role of floods in bed formation, the spring flood of 2003 (March-May) was chosen (Fig. 15c), as it provided the longest cross-sectional data set (27). Until the peak stage was reached, the maximum depth increased twice (up to 5.9 and 5.5 m). However, in-between the two dates it varied around 5.0 m. Meanwhile, the mean depth continuously decreased, which meant that a great amount of sediment reached the section, though it was transported away. During the falling stage, the maximum depth changed slightly, but mean depth increased further on. This should mean that the transport rate became smaller than it was during the rising stage. A comparison of the cross-sections before and after the flood shows that the depth variability decreased to 0.85, and their area was reduced by 14 m^2 (15%), suggesting river-bed aggradation during the falling stage, though the transport rate remained significant. The phenomenon is also shown by the discharge vs. water-level curves (Fig. 16) of greatest floods (1938, 1970, 1998, 2000). The water-level values belonging to the same discharge at the falling stage (upper section of the curve) are always higher by 0.7-1.0 m, than at the rising stage, implying a similar aggradation rate.

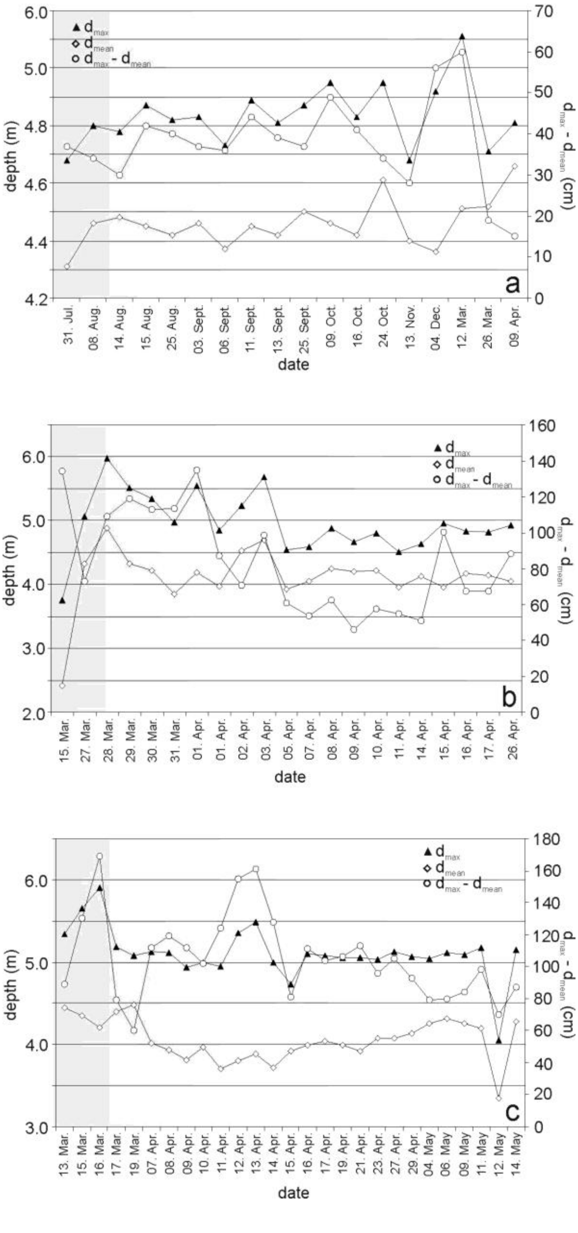


Figure 15. Changes of cross-sectional parameters during different stages: (a) low- stage period in 1990-91; (b) bankfull and channel-forming period in 1988; and (c) the flood of 2003.

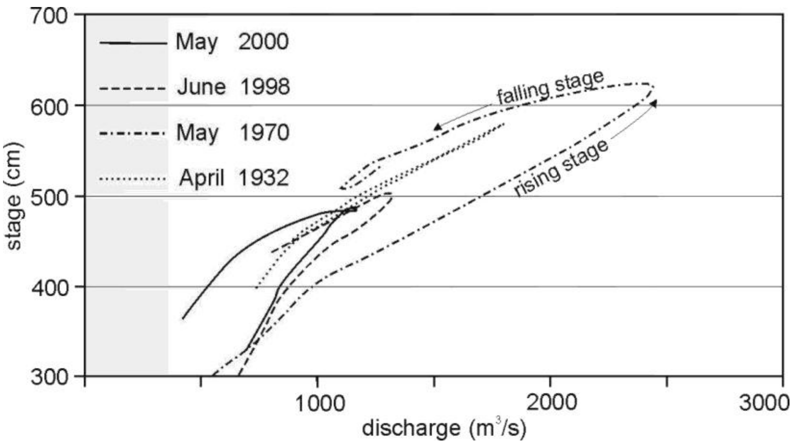


Figure 16. Water-level vs. discharge curves of the greatest floods at Makó.

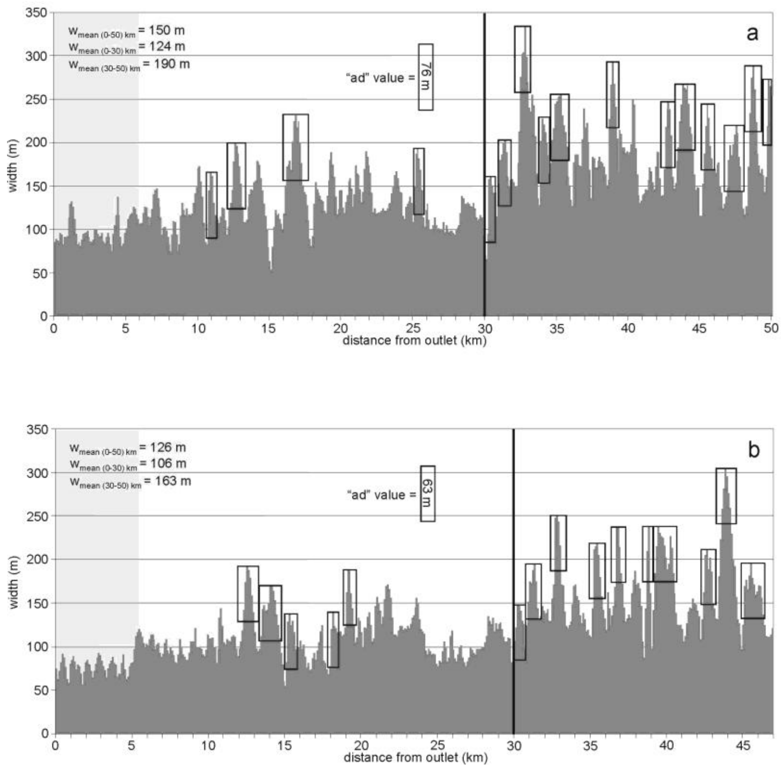


Figure 17ab. Width conditions of the studied 50 km long reach and the position of braids in (a) 1953 and (b) 1991.

Downstream width change, and identifying braids

The available geo-informatical database on channel width enabled detailed planimetric analysis from 1953 till 1991. In case of the first date, the mean width of the whole reach was 150 m. However there is a sharp fall in width data at around 30 km from discharge (Fig. 17ab, Fig. 18). Upstream from this point 190 m and 114 m were the mean and the minimum width, while downstream they were 124 m and 53 m, respectively (Table 2). The difference between the two identified sections was characteristic in all periods, as the upper part was consequently wider than the lower section. The shift in mean width data coincides with the limit of the length along which the river is managed with revetments and groins (Fig. 18).

Table 2. Changes in maximum and mean width values on narrow sections and in braids between 1953 and 1991.

	managed reach (0-30 km)				unmanaged reach (30-50 km)			
	1953	1973	1981	1991	1953	1973	1981	1991
w_{max} (m)	231	219	197	191	333	304	288	304
w_{min} (m)	53	70	65	55	114	111	95	87
braid wmean (m)	161	150	141	135	229	209	200	190
narrow section wmean (m)	118	115	109	101	171	166	153	147
wmean (m)	124	121	114	106	190	180	167	163

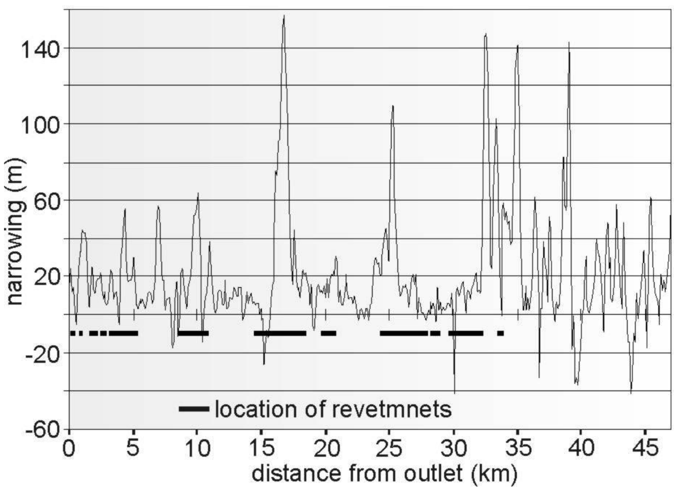


Figure 18. Width changes between 1953 and 1991, and the position of revetments and groins.

As mean data was calculated from a great diversity of widths at the different dates, the calculation of frequencies concerning widths was necessary in order to shed light on the changeability of channel width. Frequency calculations were made separately for the upstream and downstream reaches (Fig. 19). Downstream curves are narrower, implying that width values are more homogenous, while upstream curves are more asymmetric and show a great heterogenity of widths, with several peaks. When considering the peak of the curves on different dates, there is a move toward lower width values on both sections.

This tendency is also reflected in maximum, minimum and mean values (Table 2). Mean width decreased by 15 % from 1953 to 1991 (Fig 18.), while maximum values decreased by 9 % and 18 % on the upstream and downstream sections respectively. In relation to minimum values, there is a drop from 114 m to 87 m on the upstream section, while in terms of the downstream section there is almost no difference (Table2). There are two possible causes for the changes, both occurring in the 1940s. At the beginning of the decade bankfull and flood stages were frequent and so a great number of large bars developed. The cutting of riparian vegetation for war purposes coincided with this process, and resulted in bank erosion and thus channel widening. From then on, as flood frequency dropped, and low-stage periods lengthened, vegetation could colonise the banks and extensive side-bar surfaces (Kiss and Sipos 2003).

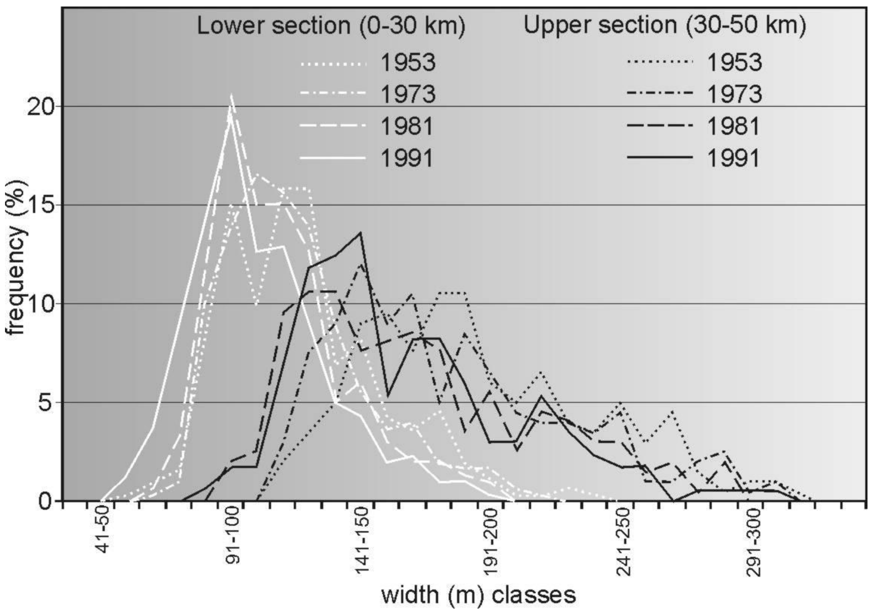


Figure 19. Frequency of width classes on the unmanaged (30-50 km) and the managed (0-30 km) reaches at the different dates.

Table. 3. Position, number and average spacing of braids on the study reach.

	1953	1973	1981	1991
ad value	76	75	69	63
Position of braids on the managed reach*	10.9	-	-	-
	12.6	12.7	12.6	12.6
	-	14.2	14.2	14.1
	-	-	15.4	15.4
	16.8	-	-	-
	-	-	-	18.2
	-	-	19.2	19.2
	25.3	-	-	-
Position of braids on the unmanaged reach *	30.4	30.4	30.3	30.3
	31.4	31.4	31.4	31.4
	32.5	-	-	-
	-	33	32.9	32.9
	34	-	-	-
	35.3	35.6	35.5	35.5
	-	37	36.8	36.8
	-	-	38	-
	38.9	39.1	38.9	38.9
	-	-	-	39.5
	-	-	40.3	-
	-	42.1	-	-
	42.8	42.9	42.8	42.7
	43.8	44	44	43.9
	45.5	-	-	45.6
	47.5	47.5	47.5	47.5**
	48.7	48.7	48.7	48.7**
	49.8	49.9	49.9	49.9**
No. of braids lower section	5	2	5	5
No. of braids upper section	12	12	14	13
average spacing upper section	1.76	1.77	1.68	1.7

*position: distance of the braid's peak width from the outlet (km)
** aerial photographs did not cover the uppermost 3 km. Supposed location, based on the constant position of braids.

Short term braid scale changes

In the last fifty years the width of the river has varied significantly and the presence of widened, braid-like structures is obvious. Their identification was based on the ad value, which varies between 63-76 m/km over the four dates and thus represents 50-52 % of the average width at each period (Fig 17ab). In terms of the upstream region, differences are even more emphasized and the ad value can rise to 185 m/km (in 1981). This is due to the presence of areas where the channel significantly widens then narrows. These units are island and bar braided or potentially island braided structures. The number of identified braids is varying between 14 and 19 on the whole reach at the four dates. The place of braids on the managed section was changing continuously, which was due to river management affecting channel width. However, the position of 3 braids seems to be constant from 1953. The number of upstream, unmanaged braids is between 12 and 14. From them 8 braids were stable during the investigated period. The most changes on this section can be related to widened straight reach between 35-42 km from the outlet, in which the place of braids can change easily (Table 3). The position of stable braids may slightly change over time mainly through narrowing at their downstream end, and the widening of upstream sections. Braids upstream are much wider, with an average maximum width of 230-250 m as opposed to the 160-180 m value of downstream braids, which only develop where no revetments or groins hinder the evolution of the river bed.

Due to slight changes in their position, necessarily, the spacing of braids is quite constant at the four dates, and resembles a riffle-pool sequence on the upstream reach. The wavelength of the riffle-pool sequence is approximately 1.7 km. However the distance between braids can be different (Table 3).

Cross-sections made at braids were used for investigating changes in channel geometry at different stages, and defining the function of braids in sediment transport in time and space. Braids were chosen in order to represent the upstream, unmanaged reach (site No. 1-3) and the downstream, managed reach (site No. 4-5), too (Fig. 20). An important characteristic of the selected braids is that those upstream contain islands, while those downstream do not.

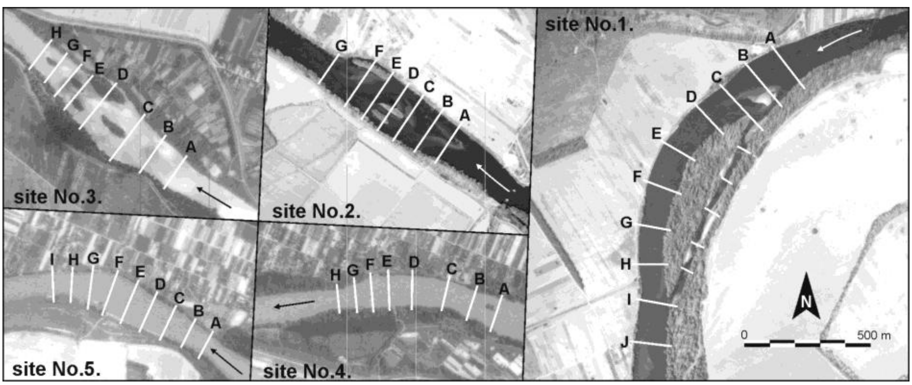


Figure 20. The studied braids (sites No.1-5) and the location of perpendicular cross-sections, along which depth measurements were done in 2003 and 2004.

The mean depth value for a whole braid was calculated as a sum of all depth data, and it was evaluated as a value resembling sediment storage, since the density of sampling was relatively high. Change in the mean depth was well observable in terms of the braids on the upstream reach. At study site No.1 the difference between the low-stage and the falling-stage values was 9.6 % and 8.0 %, however, going downstream these differences faded first to 6.6 % (site No. 2.), then to values around 4-5 % (site No. 3) (Table 4). The smallest changes (0 and 2.1 %) were observed in terms of study site No. 4, which is managed by both groins and revetments. In case of study site No. 5 the differences were similar to those of at site No. 3, even though the previous is located on the managed reach (but without groins or revetments), and the later one at the lower end of the unmanaged reach. This implies that both sections experienced similar changes in terms of the summed cross-sectional mean depth data, however, upstream braids (site No.1-2) were seemingly more variable in this respect.

The tendency of change is also obvious. The two autumn data in 2003 and 2004 represented almost the same values, the difference between these was lower, than 2 %; and seemingly 2003 low-stage data were higher than those measured in 2004. Falling-stage mean depths were always lower, than low-stage mean depths. Thus, at low stage each braid, except the managed one, experienced net sediment loss that was resulted by the out-washing of previously deposited sediment and bar forms. The sediment or bed-load input therefore, is due to floods and high water stage periods at springtime. The difference of the two autumn surveys suggests that the longer the low-stage period is the more sediment is removed from the channel.

Table 4. Summed mean depth data of the studied braids at dates of investigation.

	site No.1	site No.2	site No.3	site No.4	site No.5
d_{mean} 2003 low stage (m)	4.05	n.d.	4.06	4.20	4.20
d_{mean} 2004 falling stage (m)	3.66	3.54	3.88	4.11	4.04
d_{mean} 2004 low stage (m)	3.98	3.79	4.07	4.11	4.14
Difference of 2003 low stage and 2004 falling stage (%)	9.6	n.d.	4.4	2.1	3.8
Difference of 2004 low stage and 2004 falling stage (%)	8.0	6.6	4.7	0.0	2.4

By comparing individual perpendicular cross-sections at different dates, we can receive information on the location of accumulation and erosion at the braid scale during different water stages. Change of cross-sectional mean depths at the three dates (representing two typical water stages) are shown in Fig. 21a-d. In case of study site No.1 upstream sections experienced accumulation during the falling stage of the 2004 flood; e.g. the mean depth of section A at spring in 2004 was shallower, than at the previous and subsequent low water surveys by 0.90 and 0.53 m, respectively (Figs. 20 and 21a). Downstream sections represented continuously decreasing accumulation, and there was a change from section H, where falling-stage data were higher, thus net erosion could be suspected at the lower end of the braid compared to autumn data. The depth values of the cross-section series at the two low water stages represented an almost even distribution of mean depths in the braid during these periods, while the shape of the 2004 spring line resembles a sediment plug in the upstream half of the site, which might represented a local and temporal riffle-pool setting within the braid (Fig. 21a). The maximum depth variability of the braid was different after falling (2,9) and during low stages (1,5) referring to the decrease in river-bed heterogeneity and the dominance of sheet erosion.

At site No.3 the maximum difference in mean depth at the same section was 0.97 m (section C). This site showed a similar process concerning the location of accumulation and erosion (Fig. 21b), i.e. during falling stage accumulation occurred predominantly at the upstream end. The difference compared to the previous site was that the local riffle-pool system in the braid was apparent at low water stages, too.

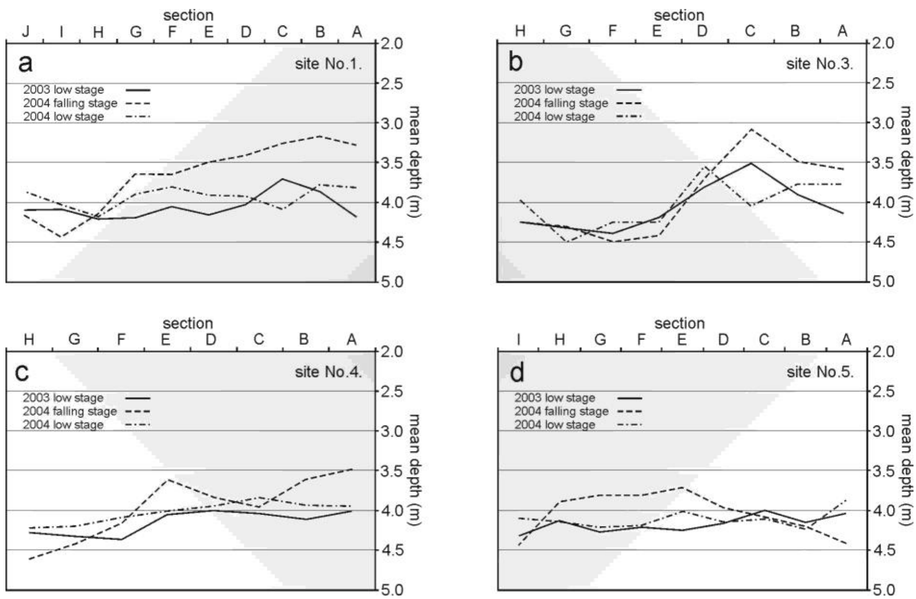


Figure 21. Mean depth changes at cross-sections of the studied braids at different stages.

On the managed reach, braid at site No.4 also represented increased sedimentation upstream, however the difference in mean depth data was much less, than at other places (0.39 m at section E), and cross-sections resembled an almost even bed surface at each dates (Fig. 21c). Site No.5, which is neighboured by trained reaches but itself is not managed neither by groins nor revetments, represented different accumulation processes, than any other braids analysed before. Increased sedimentation subsequent to the falling stage could be observed in case of downstream sections within the braid (0.45-0.55 m), while upstream sections experienced erosion from autumn 2003 to spring 2004, which means that the evolving sediment plug was positioned downstream (Fig. 21d). Maximum depth variability after falling stage was lower (1.9), than in upstream braids, suggesting that floods formed smaller bars in height, and the main thalweg was blocked, decreasing the heterogeneity of the bed. During low stage, as opposed to other cases, the value increased (2.8) probably due to the more stable position and less diversion of the thalweg, which resulted a more pronounced linear erosion.

Discussion and conclusions

The role of stages in bed formation

Results on mean depth and cross-sectional measurements have shown that each stages have their own function in transportation processes on a sand-bedded river like Maros/Mureş, where discharge and water level change rapidly and frequently during the year.

During floods, bankfull and channel forming discharges a great volume of sediment may be transported through cross-sections of the channel in the form of sediment pulses day by day. Thalweg shifts are frequent, and most of the sediment is carried in dunes the height of which can reach at least 1 m, thus depth variability may reach quite high values, e.g. in 1998 during the peak discharge it was 1.7 at narrow sections.

After floods or any cases when the water level falls at least 50 cm at a rate of 10 cm/day, accumulation will be the dominant process. However, the amount of deposited sediment differs greatly if straight and braided sections are considered. The at-a-station data and the discharge vs. water-level curves suggest that in straight reaches the decrease of depth, i.e. aggradation can be 0.7-1.0 m, which means a 10-15 % (10-14 m^2) decrease in the cross-sectional area. In the braids the values of aggradation can reach up to 22 % (140 m^2) at certain cross-sections, however, in average a 15 % cross-sectional change was measured here, too. The way of sedimentation differs in the narrow, straight and in the braided sections, as it is shown by depth variability values. In the narrow sections the surface during falling stages becomes even (depth variability = 0.85), but in the braids the accumulation forms large bars and depth differences are greater (depth variability = 1.9-3.0).

Aggradation at falling stage will provide deposits for low water sediment transport. During long-lasting low-stage periods most of the accumulated sediment is relocated. Therefore, in narrow reaches cross-sectional area increases, which means net erosion and an increase in mean depth. Braids experience similar transportation processes, when the mean of all cross-sections is considered however, there are well separable functional and morphological zones within one braid structure. In case of some individual cross-sections aggradation can also be observed, as a result of relocation. In cases of upper braids and narrow sections by the end of the low-stage period depth variability values decrease to 1.6 and 0.4, respectively, and cross-sections reflect more homogeneous river-bed topography, suggesting rather sheet than linear erosion during low-stage transport. In the lower braids depth variability increased by low stage, implying the importance of a single thalweg in linear erosion. The effectiveness of low-stage periods in transporting bed load is even more significant, if there are frequent 50-100 cm fluctuations in the water level, which act like small floods, and deposit further sediment ready to be relocated.

Function and characteristics of braids

Concerning total amount of sediment deposited during falling stage, braids store overwhelmingly more, than straight, narrow reaches. Therefore, their role must be significant in influencing transportation processes, through the storage of large volumes of sediment subsequent to floods and the continuous release of them during low stage.

The difference in location of sedimentation in braids is mainly reasoned by the structure of these units. At those braids, which are characterised by islands the sediment plug of the falling stage is deposited at their upstream end, because islands, usually located at the braids' lower end, increase stream power by decreasing channel width. Thus, they create a transportation zone in the downstream end. Braids with no islands are more likely to experience deposition at their downstream end during falling stage. However, increased bar formation due to extreme floods might create surfaces for vegetation to colonise, which after all, may lead to the development of islands and finally the shift of transportation zone (Fig.22). Thus, concerning braids two types of general setup can be separated: a pre-island-formation and a post-island-formation state. These states basically determine the locus of deposition.

In upstream braids with islands usually more sediment is accumulated. The change in the average cross-sectional area is the greatest in the uppermost braid (10 %), going downstream on the unmanaged reach the value decreases (6%), while concerning the managed reach in braids without islands it falls to 3 % and 4 %, meaning a one half reduction in the storage function of the braids.

Difference in braids also appears when taking a look at their width conditions, namely braids on the unmanaged reach are wider, than those downstream. However, a constant tightening of braids was observed during the last fifty years, and the rate of narrowing was identical, 28 % at both reaches. At the same time, the mean width of the whole river has decreased only by 15 %, showing that braids are more prominent places of narrowing. Changes in the regime of the river, and altered land-use can be placed in the background of this process. As it can be seen on the hydrograph of the last sixty years the frequency of floods has decreased, while that of extreme low waters increased. Therefore, the need for the sediment storing function of braids is less necessary, which leads to their tightening. The process is carried out by vegetation colonising side-bars.

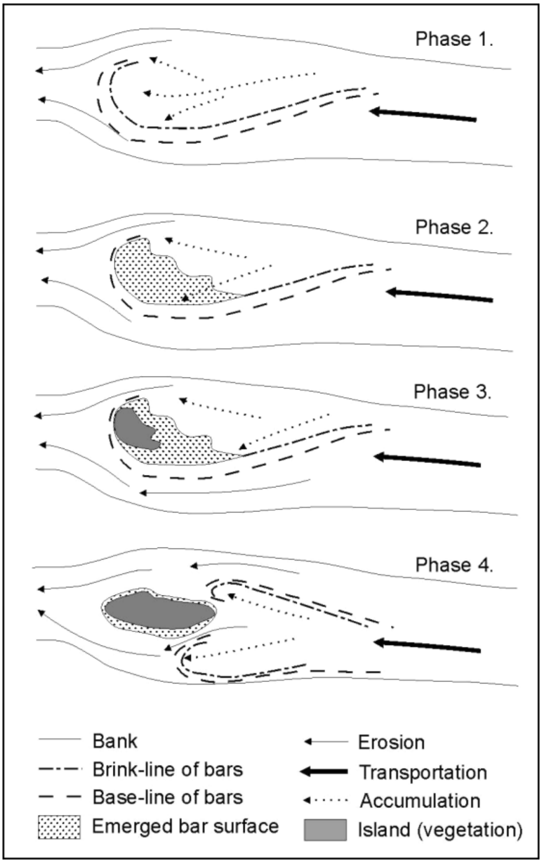


Figure 22. Hypothetical model of the relocation of accumulation and erosion during the evolution of a braid.

Finally, the significant role of low stage in channel forming seems to be well supported from two aspects. First, low waters are proved to be important in sediment transport by eroding and relocating sediments deposited during the falling stage of yearly reoccurring high stages. On the other hand, the long-term increase in the length of low-stage periods results channel narrowing and the decline of braids.

Long term geomorphological changes

Preliminaries

The horizontal and vertical parameters of channels (channel pattern), affected by several factors, are broadly discussed in different geomorphological and hydrological texts (Schumm 1977, Knighton 1998, Bridge 2003, Richard *et al.* 2005). The effects of different anthropogenic activities on channel morphology are less widely investigated. However, the results of these studies must be incorporated into the process of river management, as is emphasized by several authors (Newson 1997, Hey 1997, Gilvear 1999, Downs and Gregory 2004, Chin and Gregory 2005). Furthermore, some researchers have drawn attention to the fact that engineering works designed to stabilise the channel and to control floods often increased flood hazard (Tiegs and Pohl 2005, Pinter and Heine 2005).

Human activities affecting channel morphology and fluvial processes can be quite varied. Indirect influences, including changes of land-use and management on the catchment, urbanisation and land drainage, can alter run-off and sediment yield. A wide range of direct impacts influence the channel itself: e.g. dams, reservoirs and grade-control structures, channelization, artificial cut-offs and rectification, instream mining, installation of groynes, artificial bank stabilisation etc. (Newson *et al.* 1997, Knighton 1998, Uribelarrea *et al.* 2003, Antonelli *et al.* 2004).

Land management and urbanisation usually change basin hydrology, thus these can substantially alter flood frequency and lead to increased flood hazard (Stover and Montgomery 2001, Kondolf *et al.* 2002). Nevertheless, indirect human impacts are very often combined with local channel transformations, as in the case of Italian and Alpine rivers, where catchment scale and local impacts were superimposed and led to incision. The first phase of incision (at the end of the 19th c.) was derived from land-use and land-management changes, while the second phase (1945–60) was the result of instream gravel mining and construction of upstream dams (Rinaldi and Simon 1998). The same phases were divided by Antonelli *et al.* (2004) on the Rhone River, though they describe the second half of the 20th century as a relaxation period after human and climate induced channel adjustments. By contrast, sedimentation of the river-bed during the last 20 years has been reported on the Yellow River after a significant run-off decrease from the catchment due to climate change and altered human activities (Xu 2002).

Direct anthropogenic interventions on lowland alluvial rivers primarily aim at ensuring navigation and enhancing flood control. However, measures may lead to long profile degradation, channel narrowing (Liébault and Piégay 2001), or to incision (Rinaldi and Simon 1998, Arnaud-Fassetta 2003, Surian and Rinaldi 2003). Channelisation is one of the typical approaches during river training. Its effects were studied by Brookes (1985) and Yates *et al.* (2003). Both of them found that channelisation resulted an increase in slope and a decrease in roughness. The use of artificial cut-offs is another frequent method of training, especially in case of large alluvial rivers. Investigations show that it leads to increased stream power (Laczay 1977) and bed-load transport (Biedenharn *et al.* 2000), which can change channel geometry and water surface profiles (Smith and Winkley 1996). Processes are very similar to those acting in the case of a natural cut-off (rapid widening, accelerated bank erosion, formation of bars and riffles etc.), and in most cases, following the rapid changes of the first 2–3 years, the channel needs an additional few years to relax and to become stable (Hooke 1995).

Study Area

The Maros/Mureş River is the second largest river of the Eastern Carpathian Basin. It is 749 km long with a catchment area of some 30 000 km2, mostly situated in Romania. The lowest, 50 km section of the river was chosen as a study area. Of this a 28 km long reach is located entirely in Hungarian territory, while the remaining 22 km is part of the border between Hungary and Romania.

Methods

On the Maros/Mureş hydrological survey maps were not made, thus a regulation map series (1829), military survey maps (1865) and aerial photographs (1950, 1973, 2000) were used for the analysis. The earliest map series had a very good resolution, still, because of accuracy problems it was only used for the determination of relative indices.

Maps of different projection systems and aerial photographs were geocorrected by AutoDesk Land Desktop 2004 and Erdas 8.4 softwares, and transformed into the Unified Hungarian Projection System (EOV). Subsequent to this the centre-line and inflection points of the studied reach were determined by measuring and halving the distance between bank-lines at every 100 m. Based on this planform parameters, such as sinuosity (S), meander arc length / meander chord length (a/c) and total sinuosity (ΣP) evaluated. Based on the a/c values meanders were categorised according to the classification of Csoma (1973) and Laczay (1982)

Results

Channel pattern change prior to the regulation works

The planform of the pre-regulation river was investigated with the help of two map series. The base map series was originating from 1829 and made by Szathmáry. This was compared to the maps of the II. Austrian military survey, made around 1865 right during the regulation works. The original course of the river could be unambiguously identified on this map series as well. On the investigated reach the average sinuosity of the river was 2.09 and 2.16, however, based on the direction of flow, morphology of meanders the investigated reach can be divided into four sections. If these are compared, than morphological factors show significant differences (Table 5).

Table 5. Morphological parameterson the lower 50 km of the river prior to the regulations.

	1829			1865			
	S	ΣP	i/hátl	S	ΣP	i/hátl	p (m)
Section 1.	1,32	1,74	1,24	1,46	1,66	1,17	8537
Section 2.	2,23	2,76	1,68	2,17	2,91	1,70	32027
Section 3.	2,01	2,01	1,63	2,05	2,20	1,40	29048
Section 4.	2,58	2,58	1,68	2,71	2,71	1,65	26532
Entire section	2,09	2,31	1,64	2,16	2,48	1,57	96144

The most upstream section was characterised by meanders dissected by islands, the sinuosity of the main channel was the lowest here. The a/c ratio was right at the limit of well developed meanders according to the classification of Csoma (1973) and Laczay (1982) (Table 5, Fig 23). The width of islands on this section did hardly exceed the double of the net channel width, suggesting that these forms are reflecting a braided pattern. As a consequence Section 1. represented a transitional state between meandering and braided patterns.

Section 2 was characterized firstly by a main channel with well developed and mature meanders, and subchannels which themselves were meandering too. Sinuosity and the a/c values were considerably higher here (Table 5, Fig. 23). In 1829 and 1865 52 % and 43 % of meanders were falling to the mature category and first one, later two over-mature meanders could be identified on this section. Section 2. also contained islands, but the maximum width of these was approximately 4.5 times greater than the net width of the channel, thus these islands were probably dissected from the floodplain. the more detailed 1829 maps show in channel bars primarily at inflection points. Based on these morphological features this section had also a transitional pattern, however, in all it can be considered an anastomosing river reach. Meanwhile sub channels are also in between meandering and braided patterns.

Concerning the next section meandering was dominant, however sinuosity and meander curvature decreased here. In terms of planform Section 3. was similar to Section 1., though here, mature meanders were present in a higher proportion (47 and 53 %).

On Section 4., close to the outlet, meanders were jammed, providing a compound and in certain cases distorted pattern for the river. Although Section 4. represented only 10 % of the entire studied reach, 40 % of the meanders were identified here. As a consequence sinuosity was the highest here, its value was almost double of the values of Section 1. (Table 5, Fig. 23). No islands were identified on the reach. The proportion of mature meanders was still around 50 % but a/c values were higher even than on Section 2. Based on these Section 3-4. can be regarded unambiguously meandering before the regulations.

It is obvious that both map series clearly show the spatial change of channel patterns and meander curvature. There can be several causes in the background, such as different slope, the fining of the material of the river bed and the banks, or the impounding effect of the Tisza. It must also be emphasized, that according to the digital terrain models made by Botlik (2005) the edge of the Maros/Mureş alluvial fan is situated at Makó, which also coincides with the border between Section 2. and 3., meaning that braided like transitional patterns are rather characteristic on the alluvial fan, while truly meandering patterns appear only downstream of the fan edge.

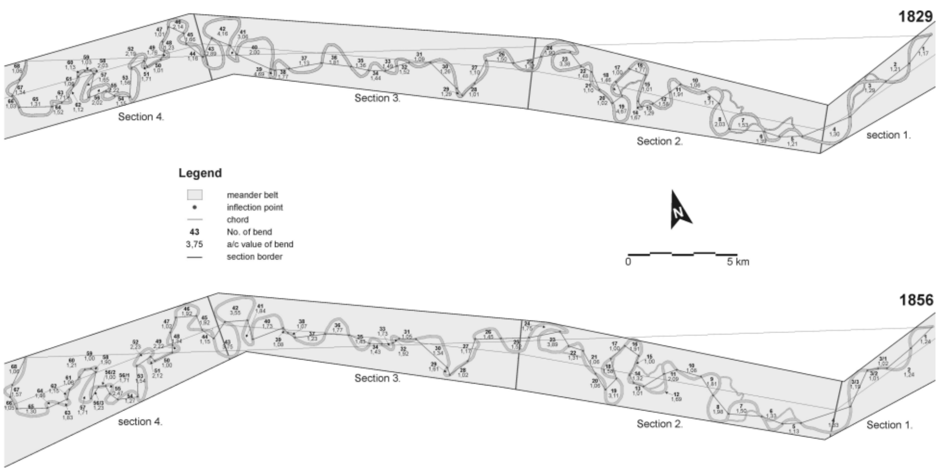


Figure 23. Morphology of the Maros/Mureş River prior to the regulations, based ont he map series of Szathmáry Sámuel (1829) and the II. Military survey (1865).

Beside spatial changes temporal differences can also be investigated with the help of the two map series, reflecting the natural pace of river development. The sinuosity and thus the length of the main channel increased, while average meander curvature values decreased. Sinuosity increase was resulted by the development of new bends (e.g. meander 3 on Section 1., and meander 58 on Section 4.). Decreasing a/c values were due to several reasons. Firstly the curvature of the newly developing bends is naturally lower, secondly two meanders were cut-off naturally between the two mapping (meander 14. and 39.), thirdly in case of certain bends the changing position of the inflection points resulted an increased chord length which in turn lead to a decrease in the a/c ratio (e.g. meander 21.). The temporal change of the a/c ratio can be seen on Fig 24., where positive values stand for the increase of curvature or to the development of new bends, while negative values represent cut-offs and replacement of inflection points.

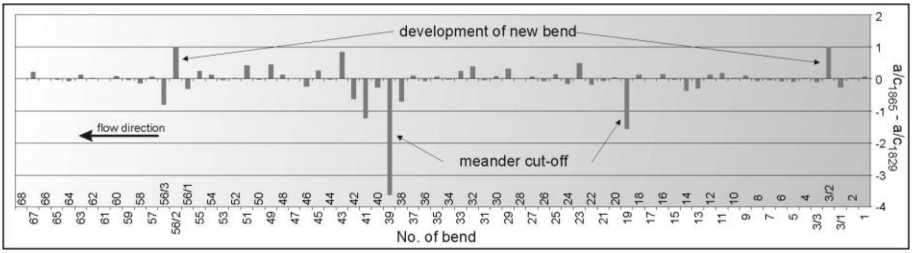


Figure 24. Difference of 1865 and 1829 a/c values of bends ont he studied section.

The analysis above clearly show that the river prior to the regulations was developing actively, its average morphological parameters significantly changed due to the development of new bends and the natural cut-off of others. It is also clear that in between the two mapping dates considerable changes occurred on each section, and the difference between average morphological parameters could be as much as 8-10 %, suggesting intensive processes, especially in the light of the changes in the past 50 years.

Channel pattern change in the past 50 years

The planform change of the Maros/Mureş was analysed with the help of aerial photo series from 3 dates (1953, 1973, 2000). On the basis of earlier results very slight changes were expected, and thus very precise measurements were necessary to detect changes. Measurements were made following uniform principles, width was measured at the same locations on each photo series, and the centreline was drawn by using the halving points of these cross-sections. When making average calculations for different sections, in each date the earlier demonstrated natural border lines were considered.

In all Section 1. was affected the least by regulation activities. Here the sinuosity values of the past 50 years fall close to that of the natural state (Table 6). The total sinuosity of the reach has increased according to the changes in the size and number of in-channel islands, however its maximum value was always the highest on this section. Meander curvature values have also increased (Table 6). Besides, the apex of meander 2. and 4. shifted 190-200 m from 1865 to 1953 and further 50-60 m from 1953 to 2000 (Fig. 25). Shifting can be explained by the maturing of the meanders and their slight downstream migration. As a conclusion however, this section has preserved its transitional state between meandering and braided patterns.

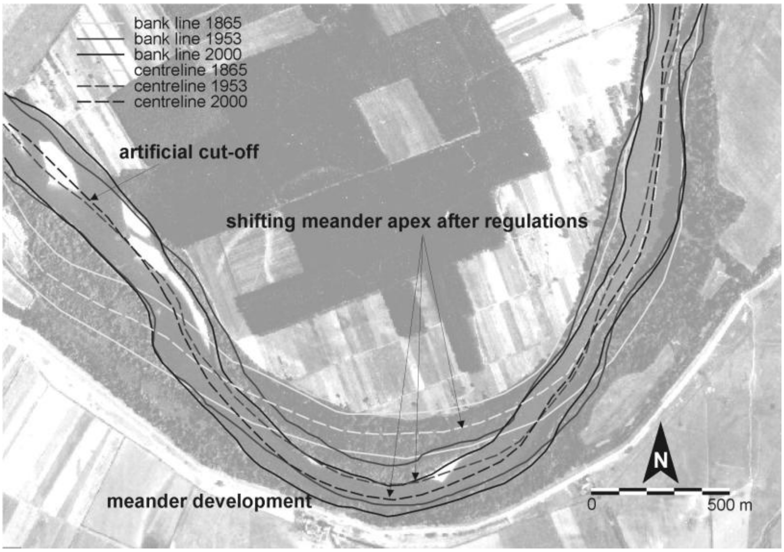


Figure 25. Shifting meander apex, and meander development at bend 4. (2000 aerial photo in the background).

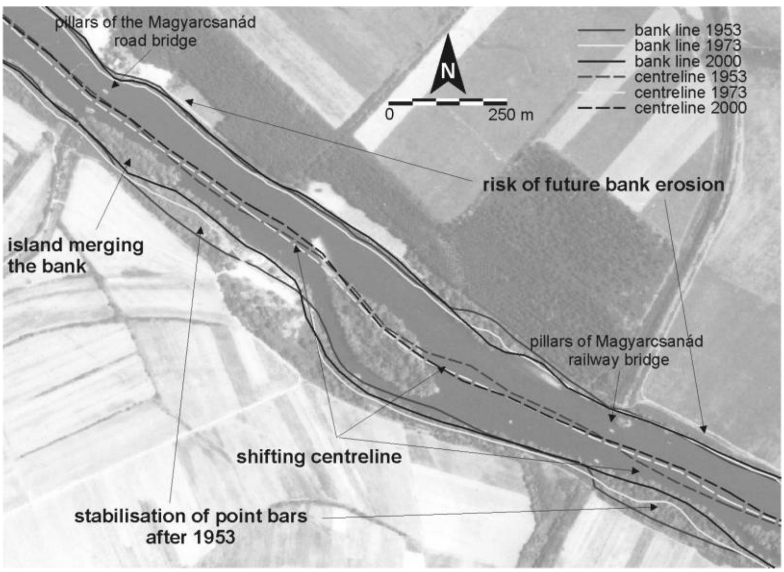


Figure 26. Shifting centreline at a straightened section (2000 aerial photo in the background).

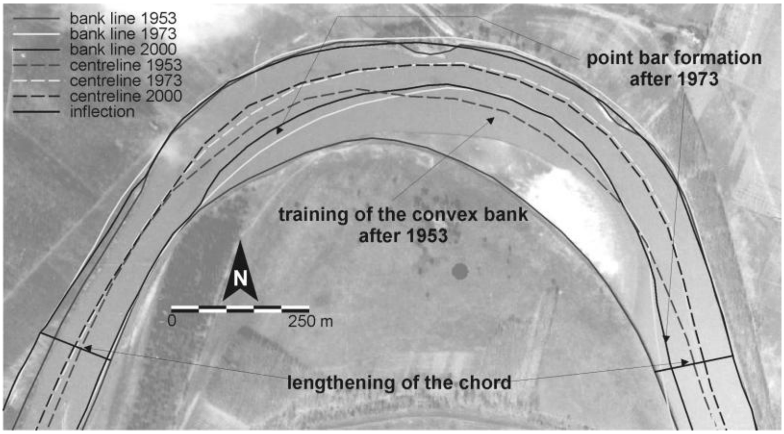


Figure 27. Development of a mature meander (bend 29) on Section 3. (2000 aerial photo in the background).

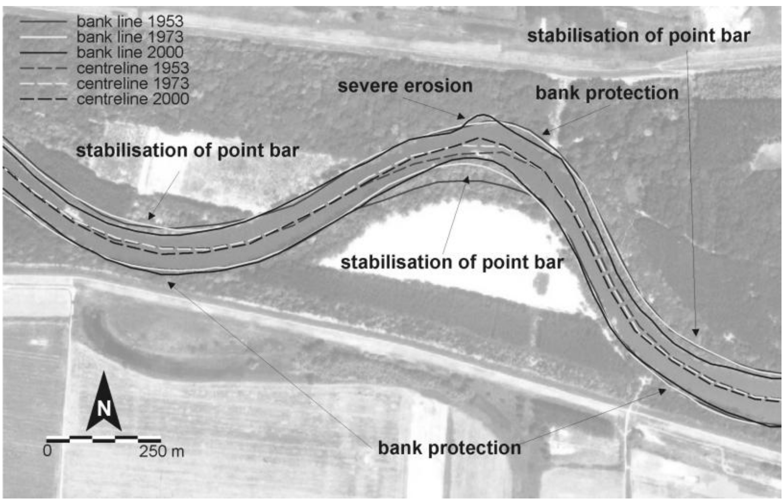


Figure 28. Shifting of centreline due to point bar formation on Section 4. (bends 40., 41. and 42.) (2000 aerial photo in the background).

In case of Section 2. the length of the centreline decreased by 56 % from 32-14 km (Table 6). Due to increasing slope the channel slightly incised, later at certain sections it widened and braided units of islands and bars developed. The significant shifting of the centreline (occasionally 60-70 m between 1953-2000) underlines the changing character of straightened Section 2 (Fig. 26). As a consequence centreline length has also varied significantly, however a/c values are far less than the threshold value (a/c = 1.1) for undeveloped bends. Based on the above, Section 2. has turned to be a truly braided reach due to the regulations.

Table 6. Change of morphological parameters determining channel pattern (length of centerline: p, sinuosity: S, total sinuosity: ΣP, meander curvature: a/c)

p (m)	1953	1973	2000
Section 1.	9205	9292	9312
Section 2.	14364	14326	14340
Section 3.	16613	16716	16775
Section 4.	9132	9168	9212
Entire section	49314	49502	49639
S	1953	1973	2000
Section 1.	1,3770	1,3900	1,3921
Section 2.	1,0213	1,0186	1,0196
Section 3.	1,1794	1,1867	1,1909
Section 4.	1,0862	1,0905	1,0957
Entire section	1,1404	1,1448	1,1478
ΣP	1953	1973	2000
Section 1.	2,0539	2,0103	1,9317
Section 2.	1,5877	1,5289	1,4737
Section 3.	1,2544	1,3052	1,2966
Section 4.	1,0862	1,0905	1,0957
Entire section	1,4537	1,4452	1,4134
a/cmean	1953	1973	2000
Section 1.	1,3187	1,3304	1,3245
Section 2.	1,0121	1,0091	1,0104
Section 3.	1,1345	1,1413	1,1449
Section 4.	1,0601	1,0633	1,0668
Entire section	1,0869	1,0897	1,0917

The length and sinuosity of the earlier meandering Section 3. has also decreased (by 43 %) due to the regulations. Nevertheless, here a slight increase can be detected between 1953 and 2000, but these changes were also caused by human intervention, namely the training of certain meanders in the 1950s. The best example in this respect is meander 29. (Fig 27), where the a/c value increased from 1.42 to 1.50 due to regulation activities (revetments). Later, from the 1980s due to the formation and stabilisation of 40-50 m wide point bar surfaces (Blanka *et al.* 2006) inflection points were replaced, chord length increased and thus the a/c value decreased (a/c = 1.48). As opposed to the slight overall increase of curvature values on Section 3. 45 % of the reach still dose not meet the threshold morphological parameters of river bends.

Section 4. is outstanding in terms that its length decreased the most drastically due to the regulations, by 65 %. This is still the "most managed" reach of the river, as the concave bank of almost each meander is fixed by revetment structures. On the contrary, the sinuosity of the section slightly though, but continuously increased between 1953 and 2000 (Table 6). Centreline increase is mainly resulted by changes on the meanders closest to the estuary. Here point bar formation gradually pushes the centreline towards the protected bank (15 m in average). Still, only 4 bends can be classified as well developed on this section (Table 6). Based on the above it is obvious, that changes on Section 4. are the most significant in terms of a pattern rearrangement, though this is inhibited by bank protection structures (Fig. 28).

Conclusions

In all it turned clear that due to the regulation works the rate of morphological development has slowed down on both managed and unmanaged sections (Fig 29). Although on certain reaches there are obvious signs of channel pattern rearrangement, during the assessed 50 years the length of the centreline increased only by 325 m, while sinuosity increased by only 6 ‰, and the values of average meander curvature increased even more slightly, by 4.4 ‰. The decrease of total sinuosity is clear however (2.9 %), which is in close relation with the decreasing number of in-channel islands.

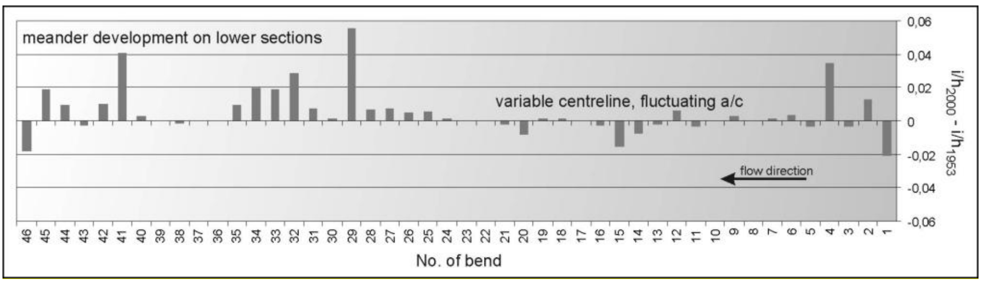


Figure 29. Difference of 1953 and 2000 a/c values of bends ont he studied section. If compared to Fig. 24, significantly smaller changes

Floodplain aggradation and floodplain geomorphology

Preliminaries

Extended floodplain areas were formed by the rivers of the Carpathian Basin, however as the consequence of mid-19th century river regulation works the area of floodplains were drastically decreased. The levee constructions split the uniform floodplain to an active artificial and an inactive protected floodplain which developed in different ways.

The development and geomorphological processes of floodplains are widely studied. According to early researches the dominant process on floodplains is lateral accretion in connection with channel migration (Friedkin and Lászlóffy 1949, Wolman and Leopold 1957, Károlyi 1960). According to Wolman and Leopold (1957) 80-90 % of the floodplain-material is derived from lateral accretion and only insignificant amount (10-20 %) is from vertical accretion deposited during floods. However, the latest one might be even missing in case of some floodplains (Allen 1965). Later, the researches emphasised the role of vertical accretion in floodplain processes, highlighting overbank aggradation, island and ox-bow lake sedimentation (Chorley *et al.* 1985). Factors influencing the development of floodplains were divided into two groups by Nanson és Croke (1992), where the main factors are (1) lateral point-bar accumulation; (2) vertical accretion of floodplains in the form of natural levees, sand sheets and fine floodplain sediments; and (3) channel aggradation of braided rivers. In their classification secondary processes are (1) silting-up of concave banks; (2) aggradation of convex banks of wide rivers and (3) accretion of oxbow lakes.

The overbank sedimentation on natural floodplains is a very complex process influenced by numerous factors, therefore its spatial and temporal pattern is quite uneven. The overbank accumulation is greatly dependent on the gemorphological features and micro-topography of the floodplain (natural levee, back-swamp, drainage ditches and abandoned channels etc.), which control overbank hydraulics (Nicholas and Walling 1997). Other factors, as riparian vegetation (Steiger *et al.* 2001, Kiss and Sándor 2009), distance from the active channel (Walling and He 1998, Oroszi 2008) and width of the floodplain (Gábris *et al.* 2002) also influence the sedimentation.

The natural floodplain development might be altered by human impact. Here the key factor is the sediment discharge modification, which was detected on each continent during the last 200 years (Owens *et al.* 2005), thus the rate of floodplain aggradation was increased by one order approximately (i.e. Knox 1987, Florsheim and Mount 2003, Benedetti 2003). Most studies explain it by catchment-scale human induced changes, like mining (Knox 2006), land conversion (Florsheim and Mount 2003), intensifying agriculture (Mücher *et al.* 1990, Lecce and Pavlowsky 2004, Knox 2006, Owens and Walling 2002), timber harvest (Constantine *et al.* 2005) and anthropogenically induced changes in fluvial dynamics (Hohensinner *et al.* 2004, Owens *et al.* 2005). Local human impact also can cause accelerated floodplain aggradation, like revetment construction (Károlyi 1960, Brown 1983), river regulation (Ten Brinke *et al.* 1998) and creation of narrow artificial floodplain (Gábris *et al.* 2002).

However in some cases the overbank sedimentation was reduced in response to better land management and soil conservation practices (Knox 1987, Benedetti 2003), forestation due to depopulation and socio-economic changes (Keesstra 2007). Besides, the impact of river incision in response to channelisation can decelerate overbank sedimentation, since incision can raise the relative elevation of the floodplain above the river bed, thereby the frequency of overbank flows and the overbank aggradation can be reduced considerably (Wyzga 2001).

Table 7. Overbank sedimentation on the artifical floodplain of the Tisza River since the 19^{th} century regulation works

Author	Location	Method	Period	Total amount (and rate) of overbank sedimentation
Károlyi (1960)	Along the Tisza River	comparison of elevations	1838-1957	Narrow floodplains: 0.8-1.6 m (0.6-1.3 cm/y) Wide floodplains: 0.2-0.5 m (0.1-0.4 cm/y)
Gábris *et al.* (2002)	Tiszadob	DTM	1846-1983	Floodplain: 0.15-0.59 m (0.1-0.4 cm/y)
Szabó *et al.* (2008)	Gulács	heavy metal markers	1946-2008	Floodplain: 0.58-0.60 m (0.9-1 cm/y)
Balogh *et al.* (2005)	Vezseny	pre-regulation buried paleosoils	1857-2005	Floodplain: 0.4-0.75 m (0.2-0.5 cm/y) Point bar: 1.70-1.83 m (1.1-1.2 cm/y) Ox-bow lake: over 1.5 m (over 1.0 cm/y)
Sándor and Kiss (2006) Sándor and Kiss (2008)	Nagykörű, Szolnok, Mártély	magnetic susceptibility, heavy metal markers	1856-2005	River bank: 0.60 m (0.4 cm/y) Point-bar: 0.92 m (0.6 cm/y) Floodplain: 0.35 m (0.2 cm/y) Before 1975: 0.5-0.6 cm/y After 1975: 1-1.5 cm/y
Szlávik (2001)	Middle and Lower Tisza	cross-section surveys	1976-1983	Riverbank: 0.35 m (5 cm/y) Point bar, natural levee: 0.70 m (10 cm/y)

Overbank sedimentation plays important role in the floodplain development of the Tisza and Maros/Mureş Rivers (Table 7), since they transport considerable amount of suspended sediment and their floodplain became significantly narrower after 19th century levee constructions. Nevertheless researches were carried out just on the Tisza River. However, the geomorphological setting of the Maros/Mureş River promotes overbank sedimentation, because its short lowland section is situated in the front of an extended alluvial fan and the regulation work was quite drastic, as the meandering river became almost totally straightened. These factors altered the rate of overbank deposition by means of increased slope and channel erosion, which increased sediment discharge. Besides, the land-use of the floodplain was also changed, as wetlands and meadows were replaced by dense forests increasing the roughness of the floodplain (Kiss and Sándor 2009).

The present study aimed to (1) determine the rate and longitudinal variations of overbank sedimentation on the lowland section of the Maros/Mureş River since the mid-19th century regulation works, and to (2) evaluate the rate of accumulation in relation to geomorphological setting and forms of the floodplain. The rate of overbank aggradation has key aspect in flood hydrology and flood forecast, as the elevated floodplain is able to transport less amount of water (Keesstra 2007), thus even levee heightening might be necessary in accordance with the amount of aggradation. According to the calculations of Gábris *et al.* (2002) and Kiss *et al.* (2002) the cross-sectional area of the floodplain was already reduced by 5-16 % due to overbank deposition along the River Tisza playing important role in the development of record floods betewen 1998 and 2006.

Methods

To determine the spatial and temporal pattern of overbank sedimentation along the Maros/Mureş River two approaches were applied. The amount of sedimentation and its longitudinal characteristics were calculated based on elevation difference of the active and protected floodplain areas using DTM. The temporal changes in sedimentation rate were determined by sediment and pollen analysis. As the aim of the study was to specify the overbank sedimentation of the active artificial floodplain since the regulations, the number of applicable dating methods was limited, therefore the pollen grains of invasive plants appearing at known date were applied.

Digital Terrain Modelling

The DTM represents the area (250 km^2) of 4 km buffer zone along the 34 km long lowland section of the Maros/Mureş River (Fig 30B). Between the 28-34 fluvial km only the northern zone was modelled because no maps were accessible for the southern, Romanian section.

The DTM was created in ArcGIS 8.2 applying 10 m pixel size, using topographical maps (scale: 1:10,000) made in 1983. The whole area was divided by cross-sections spaced in 1 km distance parallel with each other and near-perpendicular to the Maros/Mureş River. The measurements were made for the areas bordered by the cross-sections and the levees. In order to determine the amount of floodplain aggradation since 1880 differences in mean elevation data between the artificial (active) floodplain and the flood-protected (inactive) floodplain areas were calculated.

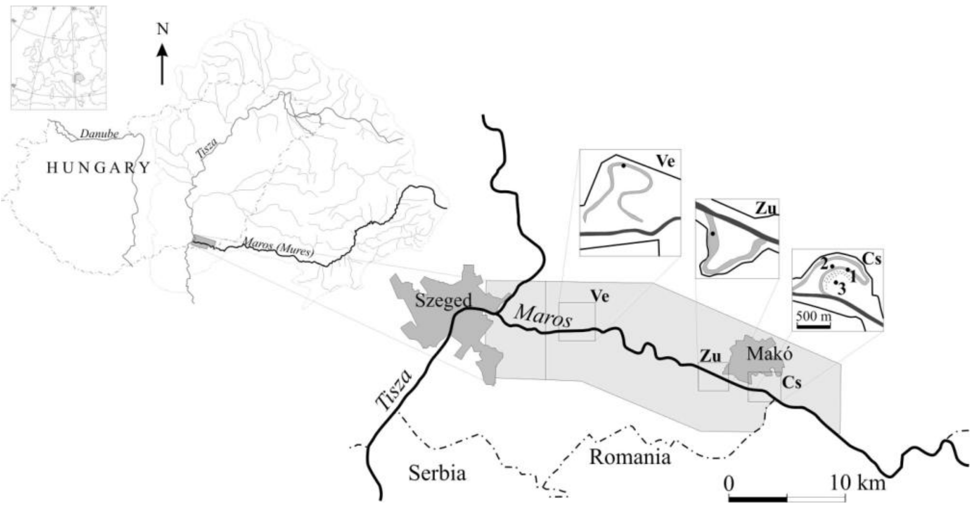


Figure 30. The study area is located on the Maros/Mureş River. The digital terrain model represents the 4 km buffer zone of the lowland section of the river. Sediment samples were taken at three sites (Ve, Zu. Cs) from cut-offs, and at Cs site from different geomorphological units (1-3).

Sedimentological and palynological analysis

The temporal variation of overbank accumulation was determined applying sedimentological and pollen analyses. Samples were collected at sites (Fig 30C) where (1) the grain size distribution changed sharply after the cut offs due to the increased distance from the active channel (e.g. the sandy deposits on the pre-regulation natural levee were covered by finer floodplain sediments, or in the cut-offs silt and clay were deposited over the coarse sand of the channel bed) and (2) always fine floodplain sediments were deposited, e.g. in a back-swamp (Table 8). Cut-offs (Cs1, Zu, Ve) were sampled from boreholes (5 cm interval), while at other sites (Cs2 and Cs3) sampling pits were established (2 cm sampling interval).

Table 8. Main characteristics of the sampling sites

Sampling site	Unit	Date of cut off	Distance from the active channel (m)	Floodplain width (m)	Vegetation	Sampled form	Elevation (m asl)
Csordajárás (Cs)	alluvial fan	1846	840	1700	meadow, plough field	cut-off (Cs1)	83.0
						natural levee (Cs2)	83.9
						back-swamp (Cs3)	83.2
Zugoly (Zu)	secondary alluvial fan	1864-72	450	2100	forests, orchards	cut-off	81.5
Vetyehát (Ve)	floodplain	1858	1740	2200	plough fields replaced by forests	cut-off	78.0

Grain size distribution of the samples was determined by Köhn-pipetten method and wet sieving, the organic content (%) was measured following Tyurin's method.

Pollen extraction followed the method of Zólyomi-Erdtman, the sporomorpha were studied under a 400-600× magnification, and identification was carried out on species, genus and family levels. Pollen diagrams were drawn under Tilia and TiliaGraph softwares. The arbour (AP) species were divided into allochthonous species representing upstream catchment areas and autochthonous species reflecting the local environment. The allochthonous pollen were used to identify greater floods (see Weninger and McAndrews 1989, Xu *et al.* 1996, Constantine *et al.* 2005).The herbaceous (NAP) species were also divided as above, but the autochthonous species were grouped into associations as pondweeds (*Lemnetea*), reed (*Phragmitetea*), wet meadows (*Molinio-Juncetea*), dry meadow and ruderal weeds (*Festuco-Brometea+Chenopodietea*), herbs of willow stands (*Salicetea* NAP) and other herbs. As introduced invasive species were used to date the sediment, they got into a separate group. The appearance date of an invasive species on the floodplain of the Maros/Mureş River was determined based on herbariums and descriptions. Those species were used for dating, which have well documented history and no close native relatives.

Results

Spatial pattern of aggradation based on DTM

The reach can not be considered as one entity, as it can be divided into five geomorphological units (Fig. 31).

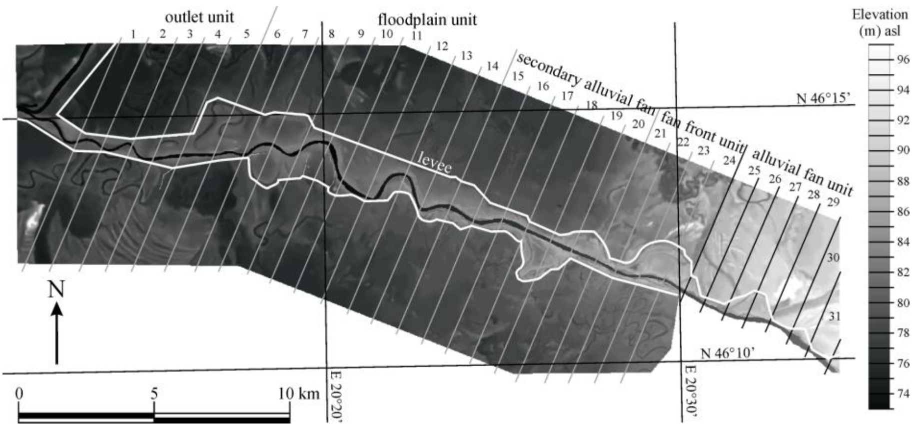


Figure 31. The digital terrain model of the study area represents the active floodplain bordered by levees, the lines frame the areas which were the basis of the height calculation. Based on the amount and pattern of aggradation the area was divided into five geomorpological units.

The alluvial fan unit is the highest characterised by Pleistocene sand ridges and shallow valleys dissecting the alluvial fan. In this unit the pre-regulation Maros/Mureş River had meandering-anastomosing pattern and slightly (0.3-1.5 m) incised floodplain. The levee was built on the edge of this lower floodplain section (Fig. 32). During the regulations this section of the Maros/Mureş River was totally straightened, thus the channel became deeper and much wider, the pattern changed into braided (Kiss and Sipos 2007). These changes affected the floodplain development, as along the regulated channel another lower floodplain was developed, therefore the artificial floodplain can be divided into a higher and a lower part (their difference is 0.8-1.1 m). Therefore, the duration of floods is not even on the artificial floodplain, the lower floodplain is inundated more often. Because of these terrace surfaces, it is not possible to calculate the aggradation using the DTM.

The southern segment of the fan front unit is characterised by abandoned meanders and point-bar remnants, whilst the higher northern part (by 1.2-1.9 m) is dissected by deep valleys and covered by sand dunes. In this unit the whole active floodplain is quite aggraded especially the areas near the active channel, though some pre-regulation forms are still visible. Comparing the mean elevations the amount of overbank accumulation is 1.62±0.27 m. Since the elevation of the protected floodplain segments differs considerably, it is also possible to calculate the amount of aggradation compared just to one flood protected segments. The amount of overbank aggradation is 0.89±0.45 m compared to the northern side, but 2.34±0.11 m compared to the southern one.

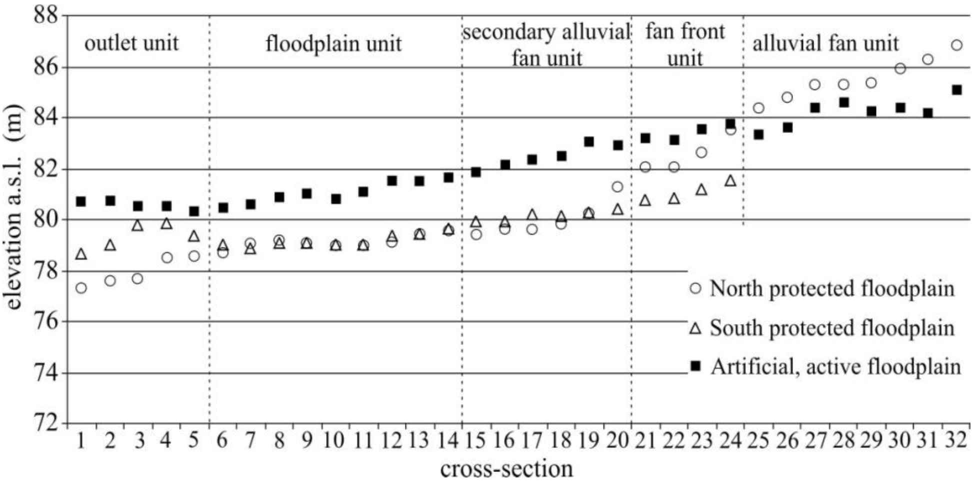


Figure 32. Elevation differences between the northern and southern flood protected areas and the elevation of the artificial (active) floodplain

The next unit can be considered as a secondary alluvial fan, which was developed after the levee constructions, as the form is limited to the artificial floodplain and it is much higher than the protected pre-regulation floodplain areas. The flood-protected area is characterised by breaches, crevasse-splays of the former meanders and back-swamps. In this unit the accumulation is the greatest (2.44±0.24 m), being the most intensive along the river in the form of natural levees. The aggradation shows an increasing tendency towards downstream, which suggest the active development of the secondary alluvial fan. Its northern and southern segments are nearly at the same elevation (height difference 0-0.8 m), therefore there is no significant difference in the amount of accumulation comparing the active floodplain height to these protected areas (North: 2.54±0.42 m; South: 2.35±0.27 m).

On the classical floodplain unit the fluvial form assemblage is the same as it was in the previous unit, but here the intensive aggradation is limited along the active channel in the form of point bars and natural levees, the further areas are characterised by moderate aggradation. Since the post-regulation aggradation did not bury the former geomorphological features, it can be seen that the former floodplain was also convex. The protected former floodplain areas are almost at the same elevation (their difference: 0.3-0.1 m). In this unit the overbank sedimentation of the artificial floodplain is 1.96±0.23 m. The sedimentation shows a decreasing tendency downstream (Fig. 33). As the elevation of the two protected sides is almost the same, here the calculated aggradation data is probably the most precise (North: 2.01±0.26 m; South: 1.91±0.23 m).

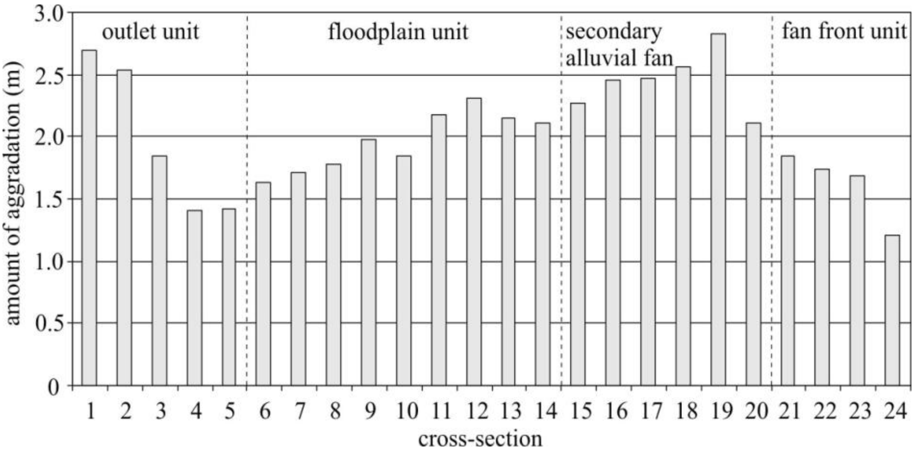


Figure 33. Amount of aggradation on the active floodplain since levee construction (1880-1983)

The outlet unit of the reach differs from the upstream units in its regulation history, because here the long cut-off section of the Maros/Mureş River got outside of the artificial floodplain, thus the post-regulation sediments were deposited on a flat surface instead of a convex one. The elevation difference between the northern and southern flood-protected area is the greatest (0.8-2.1 m) of all units. Before the regulations the northern area was a flat back-swamp with shallow breaches, but the southern area is characterised by a great paleo-channel with high point-bar system. The amount of aggradation is greater (1.98±0.60 m) than it was before showing an increasing tendency towards the outlet of the Maros/Mureş River. The pattern of the accumulation is also different, as it is the greatest in the back-swamp area instead of near the channel. In this unit the calculated accumulation data could be distorted by the high elevations of the southern paleo-point-bars, therefore compared to the southern inactive floodplain segment it is only 1.25±0.61 m, but compared to the deeper northern part it is 2.70±0.70 m m.

Temporal pattern of aggradation: analysis of sediment profiles

Sediment and pollen profile of a cut-off (Cs1) located on the fan front unit

The sediment record of the almost totally filled up cut-off was divided into three zones and the middle zone into two sub-zones based on the physical and palynological character of the samples (Fig. 34).

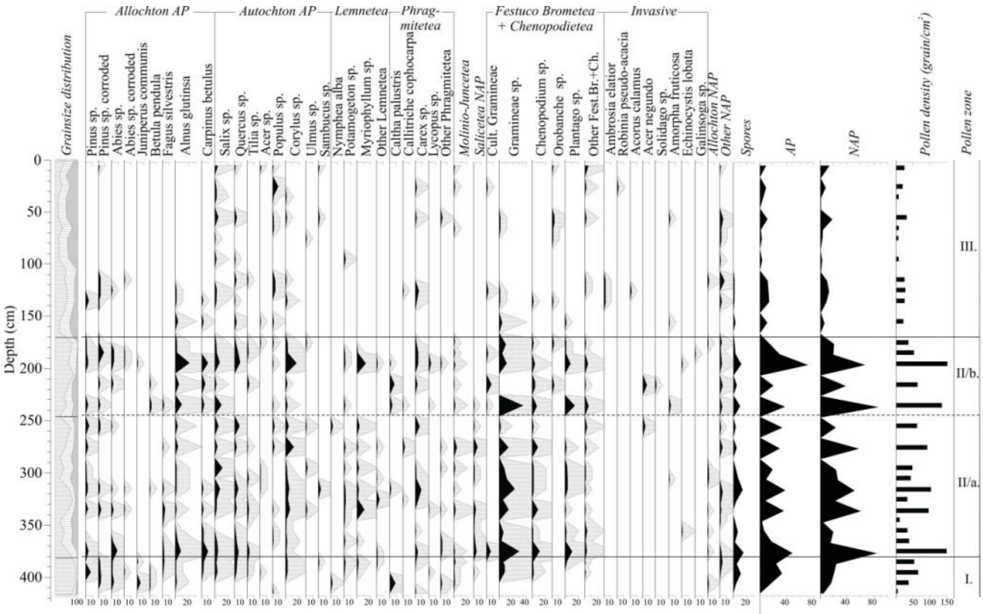


Figure 34. Sediment and pollen profile of a cut-off (Cs1) located on the fan front unit. The proportion (%) of pollen grains is exaggregated (10x) for better visualization, AP: arbour species, NAP: herbaceous species.

In the lowest zone (I. 380-420 cm) the samples contain high proportion (77-92 %) of sand. The coarse sand fraction (0.1-0.32 mm) represents the bed-load material of the river. The proportion of allochthonous pollen grains (*Pinus, Abies, Juniperus*) is high and because they were transported from the upper part of the catchment, very often the grains are corroded and broken. The pollen spectrum also reflects the environment of the site, where *Salix* and *Quercus* were the dominant species of the riparian forest. The samples of the zone were deposited before the cut-off (1846) when the channel was still active.

The samples of the middle zone (II. 170-380 cm) contain more clay and silt (25-50 %) and organic material, but sandy layers are intercalated in between them. In the II/a sub-zone (245-380 cm) pondweed species (*Myriophyllum*, *Potamogeton* and *Nymphea*) appear and *Carex* indicates the expansion of the marshland. The higher surfaces were covered by riparian forest (*Salix*, *Quercus*, *Populus* and *Ulmus*), pastures and plough-fields. This sub-zone represents an ox-bow lake in its juvenile stage with deep open water. Sand and allochthonous pollen from the catchment were washed into the lake during floods. The sandy layers are covered by finer, organic rich sediments deposited during falling stage or smaller floods. The pollen of *Amorpha fruticosa* were found in the 300-310 cm sample, the plant appeared in the area in 1884 (Tímár 1948), whilst the *Acer negundo* was found in the 250-260 cm sample and was discovered in 1889 (Priszter 1960).

The pollen spectrum of the II/b sub-zone (170-245 cm) reflects mature state of the ox-bow which most of the time was wetland and open water appeared just temporally in the deepest part during floods when allochthonous pollen were also transported to the site. The decreased amount of sand suggests that flood velocity decreased as the cut-off was gradually filled up. After floods pondweeds appeared, though the plants of wetland associations (i.e. *Caltha*, *Carex* and *Lycopus*) are continuously represented. These changes reflect the rapid sedimentation of the cut-off. Pastures and cultivated areas extended in the close vicinity of the site (reflected by cult. Gramineae, *Chenopodium*, *Orobanche*, *Plantago* and *Artemisia*). The pollen of the invasive *Solidago* sp. (at 210-220 cm) and *Galinsoga* sp. (at 180-190 cm) were found, however we could not identify them on species level, but their different species appeared in the area between 1870 and 1902 (Tímár 1948).

In the upper zone (III. 0-170 cm) the higher clay content of the samples indicates the exclusive deposition of suspended sediment. By this time the cut-off became aggraded in such extent, that it did not play role in water conductivity during floods, so the sediment could reach this point just in suspension. The wetland almost disappeared, hygrophilous species appeared temporally during floods. The riparian forest was driven back and near the site pasturing and ploughing became dominant. For dating the sediment the pollen of *Ambrosia artemisiifolia* (115-135 cm) can be applied, which appeared on the floodplain in 1955 (Priszter 1960).

Sediment profile of a natural levee (Cs2) on the fan front unit

The natural levee became inactive after the meander became cut off in 1846 (Fig. 30C). The sediment profile was divided into two zones (Fig. 35). Because the form is elevated its material is drier, therefore no pollen gains were found.

In the lower zone (I. 35-138 cm) the proportion of sand fraction is very high (80-85 %), but it is slightly finer (0.1-0.2 mm) than the present-day bed-load (0.2-0.3 mm) of the Maros/Mureş River. Between the sandy sediments silty (40 %) and clayey (20 %) layers rich in organic material are intercalated, which were probably deposited during falling stage of floods. These characteristics suggest that this zone represent the period of active natural levee formation.

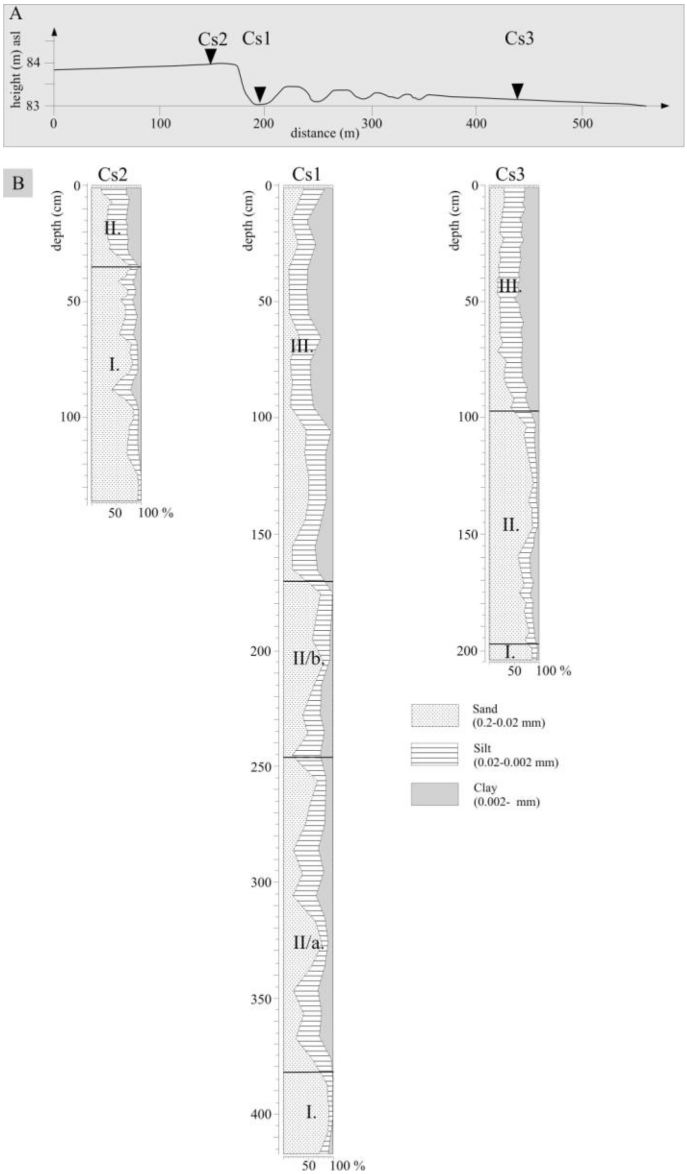


Figure 35. Sediment profiles of the Csordajárás (Cs) site, on the fan front unit. A: The Cs1 coring was made in a cut-off, the Cs2 on its natural levee and Cs3 in the backswamp area, behind the point-bars. B: Grain-size distribution (%) of the profiles.

The proportion of sand decreased to 30-40 % in the upper zone (II. 0-35 cm), and it is mostly consists of very fine sand. The proportion of silt and clay increases to 40 % and 20-30 % respectively. These samples correspond to the post-regulation period, when only suspended sediment could be transported and deposited at the site.

Sediment profile of the back-swamp (Cs3) on the fan front unit

The site is situated near the cut-off and natural levee described above. It was enclosed by the meander just behind its point-bar system and it was always a back-swamp (Fig. 30C). Unfortunately its samples are pollen sterile.

In the lower zone of the profile (I. 198-206 cm) the sand fraction is dominant (90 %), the proportion of medium sand is 60 % (Fig. 35). Finer fractions are underrepresented and the organic content of the samples is very low. These samples probably represent a point-bar and they were deposited when the meander was developing and the site was at the channel. In the middle zone (II. 98-198 cm) the amount of sand fraction decreases (60-80 %) and the medium sand fraction is replaced by finer sand. The sediments are getting finer (154-198 cm), but then they become coarser again (98-154 cm) as the proportion of sand reaches 90 %. The finer sediments of the upper zone (III. 0-98 cm) sign that the active channel got far from the site, thus just suspended sediment (silt and clay 40-40 %) was deposited.

Comparing the profile to the Cs2 sediment record it becomes possible do determine the age of the zones. Probably the lower and middle zones were deposited when the meander was still active, and gradually finer material was deposited as the channel migrated away from the site. The sediments of the upper zone were deposited after the regulation, when only final material could be transported here.

Sediment and pollen profile of the cut-off (Zu) located on the secondary fan unit

The lowest zone (I. 170-400 cm) consists of high proportion of sand (90-100 %), and the amount of medium sand representing the bed-load material is 10-35 % (Fig. 36). As these samples are almost pollen sterile it is difficult to reconstruct the environment. The bottom sample (390-400 cm) contains some pollen (9-23 grain/cm^2), whilst in the upper samples pollen density increases simultaneously with silt and clay content (310-350 cm: 5-8 grain/cm^2; 230-240 cm: 9-12 grain/cm^2). The pollen spectrum dominated by allochthonous, mostly broken pine pollen grains, but some autochthonous pollen also appeared (*Populus, Carex, Phragmites*, Gramineae and cultivated plants).

The middle zone (II/a. 170-90 cm) contains very fine material, since the proportion of silt increases to 45 % and the clay to 25 %. Though some sandy layers also appear, e.g. between 160 and 130 cm depth the sand fraction (0.2-0.1 mm) has double peak. These sediment property changes reflect that the channel was not active any more and sandy material was transported into the cut-off just during floods. The zone is rich in pollen, though the pollen density decreases upwards (130-160 cm: 54-154 grain/cm^2; 90-130 cm 3-54 grain/cm^2).

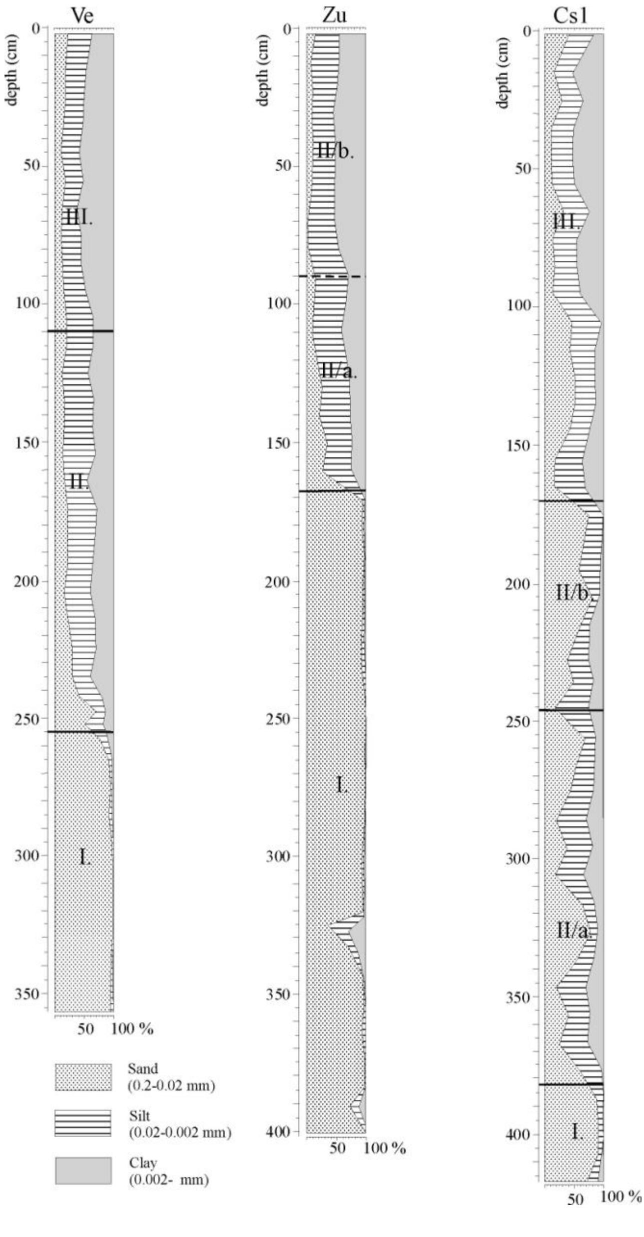


Figure 36. Sediment profiles of the studied cut-offs: Ve is located on the floodplain unit, Zu is on the secondary fan unit and Cs1 is situated on the fan front unit.

This zone contains considerable amount of alochtonous grains, like *Pinus* (very often broken), *Fagus* and *Alnus*. The pondweeds (*Nymphaea*, *Myriophyllum* and *Potamogeton*) indicate deep water in a juvenile stage ox-bow, which was surrounded by reeds. The riparian forest was dominated by willow and poplar species mixed with *Quercus*, *Fraxinus* and *Ulmus*. Some lands were cultivated nearby as it is indicated by cereals and weeds. The *Amorpha fruticosa* was introduced in 1885 to stabilise the riverbanks (Tímár 1948, Priszter 1960) and its pollen appeared in the 130-140 cm sample.

In the upper zone (II/b. 0-90 cm) the sediment is getting even finer, as the proportion of clay increased to 50 %. As the cut-off was aggrading and getting shallower the velocity of the flood water decreased considerably, therefore just suspended material was deposited. The intensive sedimentation is also reflected by a 1914 map, which show a filled-up cut-off covered by wet meadow. The pollen density of the samples is low (1-20 grain/cm^2). The environment of the cut-off did not change significantly, as still mixed willow stands are nearby. The species of the *Phragmitetea* are continuously represented, while the *Molinio-Juncetea* association reflect the existence of wet meadows. In the area the first appearance of the *Ambrosia artemisiifolia* was detected in 1955 (Priszter 1960), and its pollen grains were found in samples between 70 and 80 cm. In the upper samples (0-30 cm) the proportion of arboreal pollen decreases, though the *Populus* sp. becomes dominant in connection with the intensive poplar forest plantations in the 1960's. The cut-off became drier as only *Carex* sp. could grow, but the grasses, cereals and other cultivated plants and their weeds became more abundant. The pollen grains of the *Ambrosia* are represented in great number indicating its intensive spreading, which is also proven by the air pollution data of the last few decades (Makra *et al.* 2005).

Sediment and pollen profile of a cut-off (Ve) located on the floodplain unit

The lowest zone (I. 255-360 cm) contains mostly sand (90 %), where the high proportion (20-40 %) of medium sand represents the bed-load of the pre-regulation channel (Fig. 36). The pollen density of the samples is quite low (0-15 grain/cm^2), except a silty sample (330-340 cm: 77 pollen grain/cm^2). Besides of the great number of allochthonous pollen grains (*Pinus, Fagus* and *Alnus*) the local vegetation is also represented. Near the channel riparian forest dominated (*Quercus, Salix* and *Populus*) whilst the deeper areas were covered by marshes and wetlands.

In the middle zone (II. 110-255 cm) the grain-size and the proportion of sand decreases (20 %). Similarly to the site at Zugoly (Zu II/a zone) a double peak of 0.1-0.2 mm sandy deposits can be identified at 255-230 cm depth. Based on its pollen content the zone can be divided. In the lower sub-zone (II/a 180-255 cm) the pollen density is high (maximum 282 grain/cm^2 at 250-255 cm). There are numerous allochthonous pollen and their broken fragments (*Pinus*, *Fagus*). The local forest was dominated by oak, poplar and hazel. In the ox-bow lake *Myriophyllum* was typical, while many marshland species also occurred (eg. *Callitriche*, *Lycopus* and *Carex* sp.). The elevated surfaces were cultivated as it is reflected by the corn pollen and some weeds (*Chenopodium*, *Plantago*).

In the upper sub-zone (II/b 110-180 cm) the pollen density decreases (0-14 grain/cm^2). The pollen spectrum is similar to the previous sub-zone, though the proportion of hygrophilous plants decreased. Probably it is in relation with the rapid aggradation of the cut-off which was probably dry most of the time, only great floods could supply some water and allochthonous sediment to the depression.

In the upper zone of the sediment profile (III. 0-110 cm) is getting finer, as the silt content decreases (30-35 %) and the clay content increases (50-60 %), indicating the increasing importance of suspended sediment in overbank sedimentation. Riparian forest is still dominant, but in the upper part of the zone (0-50 cm) *Populus* sp. becomes dominant in connection with the intensive forest plantation between 1953 and 1964. The increasing proportion of open-water pondweeds and wetland species indicate permanent water supply, which can be explained by the artificial modern water-retention of the cut-off.

Discussion

The average sedimentation rate of the studied area was 1.2 cm/y based on DTM, while the sedimentological and palynological data suggest 0.2-2.4 cm/y aggradation rate. These data are higher than the sedimentation rate measured on the Tisza River (Table 7), which can be explained by the different hydrological characteristics of the two rivers. The Maros/Mureş River has higher sediment discharge and slope, less intensive lateral migration, more irregular and narrower floodplain and the outlet of the river is very close to the margin of the alluvial fan. The rate of accumulation was not uniform in space nor in time, as it changed downstream and on the different fluvial forms.

Spatial changes

Aggradation rate along the river

First of all, a relation between the active artificial floodplain-width and the accumulation rate was analysed (Fig. 37). No unambiguous link was established between the parameters, though on the Tisza River Károlyi (1960) found negative, while Gábris *et al.* (2002) found positive relationship between them.

However, the geomorphological units of the studied reach presented characteristic tendency in the aggradation rate (Fig. 33). The overbank sedimentation was the most intensive in the secondary alluvial fan (2.44±0.24 cm/y), whereas in the outlet unit (1.98-0.6 cm/y) and in the floodplain unit

(1.96±0.23 cm/y) it was moderate, and low in the fan front (1.60±0.27 cm/y). The greatest difference between these units is slope, therefore the relation between the aggradation rate and slope was analysed (Fig. 38). These are directly proportional on the secondary alluvial fan and on the floodplain units, though as the slope decreases the standard deviation increases suggesting the influence of other factors (i.e. micro-relief or vegetation). In the case of the fan front and outlet units this relationship could not be found.

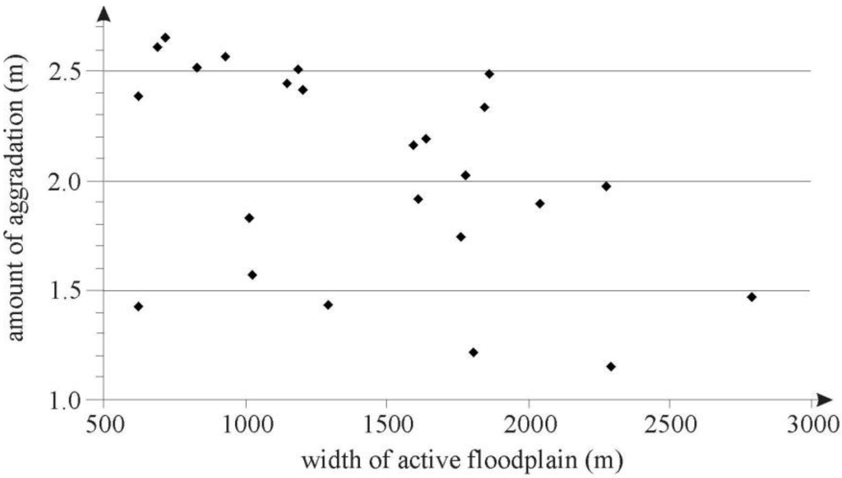


Figure 37. Relationship between the width of the artificial floodplain (m) and the amount of aggradation (m).

On the outlet unit the slope of the river plays secondary role in aggradation, as here the drain back effect of the Tisza is probably the major control on sedimentation. It can be proven by the increasing tendency (Fig. 33) of the aggradation towards the outlet (it is almost doubled) and by the pattern of the accumulation (Fig. 32). Here the greatest amount of aggradation is not along the active channel, but in the back-swamp area indicating the importance of particle settling from suspension in still water. The situation is totally different in the fan front unit, where the greatest slope and the smallest aggradation rate were measured. This phenomenon can also be explained by the velocity conditions (Fig. 39): here the velocity of the flood on the floodplain is quite great (0.3-0.5 m/s) due to the great slope of the floodplain and the low vegetational roughness (dominance of pastures and plough-fields). At this velocity the suspended sediment is in transportation according to the calculations of Bogárdi (1974), resulting smaller rate of aggradation.

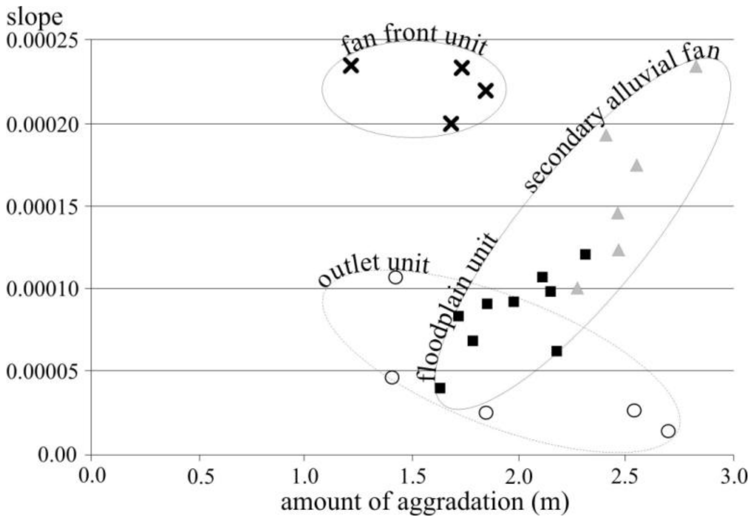


Figure 38. Relationship between the amount of aggradation (m) and the slope of the artificial floodplain on the different units of the study area.

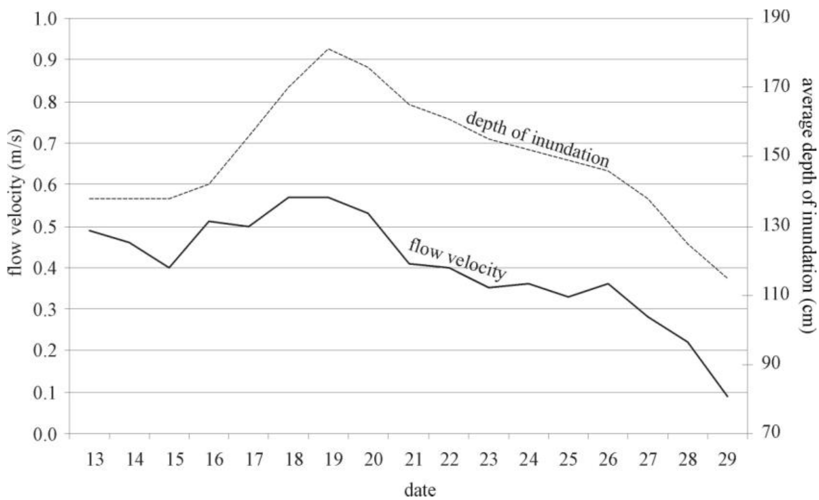


Figure 39. Average flood flow velocity and the depth of the inundation on the floodplain of the fan front unit in April, 2006.

Aggradation rate on different forms

The role of micro-topography was evaluated in the area of the fan front unit, where the sites (Cs1-3) were close to each other, but far from the present-day active channel (ca. 840 m) and the only one difference between them was elevation (Table 3). The average rate of overbank sedimentation was 0.2 cm/y on the former natural levee (Cs2) at the highest elevation, while it was tripled (Cs3 site: 0.6 cm/y) on the lower back-swamp area. The deepest part of the floodplain is the cut-off where the average rate of aggradation was the greatest (Cs1: 2.4 cm/y). Thus the elevation of the different geomorphological forms influences the aggradation rate via the duration, depth and energy of the inundation. Similar results were found by Benedetti (2003) and Walling and He (1998). Besides, these data derived from the sediment profiles correlate well with the average aggradation rate (0.9 cm/y) calculated for the whole floodplain applying the DTM.

The sedimentation was the most intensive (1.3-2.4 cm/y) in the low lying cut-offs, but its rate was different as a result of variation in the (1) date of the cut off, (2) duration of floods, (3) distance of the site from the active channel. According to earlier measurements on active overbank sedimentation, beyond the 250 m buffer zone of the channel only suspended sediment is transported and deposited on the floodplain of the Maros/Mureş River (Oroszi 2008). Since all investigated cut-offs are 450 m further than the active channel, therefore nowdays only suspended sediment reaches these sites by diffusion. However in their earlier development phase the flood velocity in the cut-off was probably greater, thus coarser material was also transported into them. The accumulation rate in Cs and Ve sites was higher than it was calculated for the whole floodplain based on the DTM (Table 9), which is acceptable, as deeper surfaces has higher accumulation rate. However, at Zu site the rate of sedimentation was lower than it was calculated applying the DTM. It can be explained by the date of the regulation, as this was the last meander cut off. According to some descriptions (Iványi 1948) during the regulations the bed-load transport of the straightened Maros/Mureş River had increased in such an extent that the originally 4-5 m deep channel became quickly extremely shallow (0.1-0.5 m) due to intensive bar development. Therefore, the older cut-offs were the scene of greater aggradation just because they acted longer as sediment trap during the regulation.

Table 9. Main characteristics of the sampled cut-offs

Site	Year of cut off	Distance from the active channel (m)	Mean aggradation rate (cm/y) based on sediment analysis	based on DTM
Cs1	1846	840	2.4	0.9
Ve	1858	1700	1.8	1.2
Zu	1872	450	1.3	2.1

Temporal changes

The results above suggest that the rate of aggradation could not be even during the last approximately 150 years (Fig. 40). Subsequently of the regulations, in the 19th century (between the date of the cut-off and 1884/89) the oxbow lakes in the cut-offs were in their juvenile development phase: they were deep and the sedimentation rate was high (1.9-2.4 cm/y) due to increased sediment load after the disturbance caused by the regulations. In the first half of the 20th century (1884/89-1960's) the sedimentation rate decreased (1.4-.2.1 cm/y). It can be explained by the decreased sediment input since the bank erosion and incision terminated in the straightened sections and the sediment trap function of the cut-offs gradually became less effective. The sedimentation rate became even smaller (0.5-0.9 cm/y) since the 1960's. This decreasing tendency is similar to the deposition history of other owbow-lakes (Tamás and Kalocsa 2003; Félegyházi 2009). However sedimentation rate became greater (2.6 cm/y) since the 1960's in the cut-off (Cs) situated in the fan front unit, which can be explained by local factors. The cut-off became so shallow that it was ploughed and due to soil erosion and the planation effect of ploughing more material was transported into it even during flood-free periods.

Conclusion

Accelerated overbank aggradation was measured along the Maros/Mureş River as a result of mid 19th century regulation works. It was so rapid, that within 50 years the cut-offs were filled up by sediment and lost their water cover. The accelerated sedimentation was in relation not just with the establishment of the narrow artificial floodplain, but also with channel adjustments. The artificial floodplain gave the spatial framework, but the real explanation of the accelerated aggradation is channel regulation. Due to these works the meanders of the lowland Maros/Mureş River were cut off, the channel became straightened. Since natural widening became dominant, it produced extra amount of sediment input for the Maros/Mureş River which is characterised by great sediment discharge in its natural state. The accelerated sedimentation was especially intensive in front of the alluvial fan, where a secondary alluvial fan was built.

The amount of sedimentation is unique in Hungary. Especially, if we consider, that the floods on the Maros/Mureş River are quite short compared to the Tisza River, thus the duration of at least 1.0 m deep floods is only one day in a year (Csoma 1975), and the return period of floods deeper than 2.0 m is 30 years (Boga és Nováky 1986). According to our calculations the floodplain was covered by at least 1.0 m deep flood for only 88 days during 105 years. This means, that the rate of accumulation is 1.5-2.7 cm/day during floods! Due to the aggradation the cross-sectional area of the active floodplain decreased by 19-35 %, therefore, the levees should be heightened to keep the flood hazard on its previous low level.

The original floodplain of the Maros/Mureş River was asymmetrical, therefore the calculation of overbank accumulation using DTM could be imprecise depending on the degree of asymmetry. Besides, the calculation probably overestimates the aggradation of the last 150 years, as the Maros/Mureş River always had convex, elevated floodplain near the active channel. Despite of these difficulties, the rate of overbank aggradation was similar by calculations based on the DTM and by analysing sediment profiles.

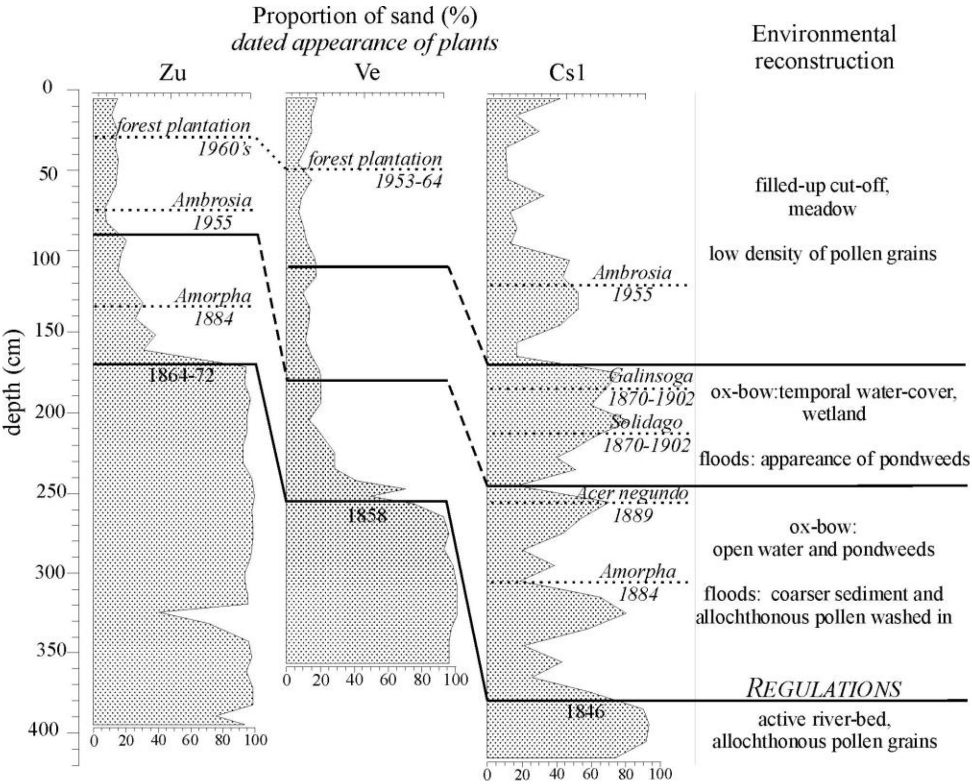


Figure 40. Comparison of the profiles of the cut-offs, paying special attention to the proportion of sand fraction in the sediment and the dated appearance of introduced plant species. Based on the pollen profiles environmental reconstruction was made for the sites indicating rapid aggradation of the cut-offs.

References

Allen, JRL. 1965. A review of the origin and character of recent alluvial sediments. Sedimentology 5: 89-191.

Andó, M. 1993. The geography of the Mureş River. Acta Geographica Szegediensis 31: 1–9.

Andó, M. 2002. A Tisza vízrendszer hidrogeográfiája. SZTE Természeti Földrajzi Tanszék, Szeged.
Antonelli, C., Provansal M., Vella C. (2004) - Recent morphological channel changes in a deltaic environment. The case of the Rhone River, France. Geomorphology 57, 385–402.
Arnaud-Fassetta, G. (2003) - River channel changes in the Rhone Delta (France) since the end of the Little Ice Age: geomorphological adjustment to hydroclimatic change and natural resource management. Catena 51, 141– 172.
Ashmore, P. E., 1991. How do gravel-bed rivers braid? Canadian Journal of Earth Sciences 28, 326-341.
Ashworth, P. J., Best, J. L., Roden, J. E., Bristowá, C. S. Klaasen, G. J. 2000. Morphological evolution and dynamics of a large, sand braid-bar, Jamuna River, Bangladesh. Sedimentology 47, 533-555.
Balogh, J, Nagy, I, Schweitzer, F. 2005. A Közép-Tisza mente geomorfológiai adottságainak és a hullámterek feliszapolódásának vizsgálata mintaterületeken. Földrajzi Értesítő 54/1-2: 29-59.
Benedetti, MM. 2003. Controls on overbank deposition in the Upper Mississippi River. Geomorphology 56: 271-290.
van der Berg, J.H., 1995. Prediction of alluvial channel pattern of perennial rivers. Geomorphology 12, 259−279.
Bezdán, M. 1998. Kölcsönhatások a Tisza-vízgyűjtő folyóin. Hidrológiai Közlöny 78/4: 247-249
Bezdán, M. 1999. A Tisza balparti mellékfolyóinak hatása az árhullámokra. Hidrológiai Közlöny 79/2: 89-99
Biedenharn, D.S., Thorne, C.R., Watson, C.C. (2000) - Recent morphological evolution of the Lower Mississippi River. Geomorphology 34, 227–249.
Bodolainé Jakus, E. 2003. Az 1998. évi őszi tiszai és más nagy árhullámok időjárási okairól. Vízügyi Közlemények 85, Különszám I: 21-33
Boga, L, Nováky, B. (edts) 1986. Magyarország vizeinek műszaki-hidrológiai jellemzése. A felszíni vízkészlet mutatói: Maros. Vízgazdálkodási Intézet, Budapest: 32.
Bogárdi, J. 1954. Hordalékméréseink eddigi eredményei. Vízügyi Közlemények 36/2: 135-146.
Bogárdi J. 1974: Sediment transport in alluvial streams. Budapest, Akadémiai Kiadó, 826.
Bogdánfy, Ö. 1906. A természetes vízfolyások hidraulikája. Budapest: Franklin Társulat.
Borsy, Z., 1972. Sedimentological and geomorphological investigation on the Szatmár Plain after the record flood of 1970. Földrajzi Közlemények 21, 38−42.
Bridge, J.S., 2003. Rivers and floodplains: forms, processes, and sedimentary record. Balckwell, Oxford, pp. 141−214.
Bridge, J. S., Gabel, S. H., 1992. Flow and sediment dynamics in a low sinuosity, braided river: Calamus River, Nebraska Sandhills. Sedimentology 39, 125–142.
Bridge, J.S., Jarvis, J., 1982. The dynamics of a river bend: a study in flow and sedimentary processes. Sedimentology 29, 499−541.
Bridge, J.S., Smith, N.D., Trent, F., Gabel, L., Bernstein, P., 1986. Sedimentology and morphology of a low-sinuosity river: Calamus River, Nebraska Sand Hills. Sedimentology 33, 851−870.
Brookes, A. (1985) - River channelization: traditional engineering methods, physical consequences and alternative practices. Progress in Physical Geography 9, 44–73.

Brown, AG. 1983. An analysis of overbank deposits of a flood at Blandford-Forum, Dorset, England. Revue de Geomorphologie Dynamique 32: 95-99.

Carling, P.A., Golélz, E, Orr, H. G., Radecki-Pawlik, A., 2000. The morphodynamics of fuvial sand dunes in the River Rhine, near Mainz, Germany. I. Sedimentology and morphology. Sedimentology 47, 227–252.

Chin, A., Gregory, K.J. (2005) - Managing urban river channel adjustments. Geomorphology 69, 28– 45.

Chorley, RJ, Schumm, SA, Sugden, DE. 1985. Geomorphology. Methuen, London

Church, M., Jones, D., 1982. Channel bars in gravel bed rivers. In: Hey, R. D., Bathurst, J. C., Thorne, C. R., (Eds.), Gravel-bed rivers. John Wiley and Sons Ltd., Chichester, pp. 291-338.

Constantine, JA, Pasternack, GB, Johnson, ML. 2005. Logging effects on sediment flux observed in a pollen-based record of overbank deposition in a northern California catchment. Earth Surf. Process. Landforms 30: 813-821

Csoma, J. 1975. A Maros hidrográfiája. In Vízrajzi Atlasz sorozat 19. Maros. VITUKI Budapest: 7-12.

Dietrich, W.E., Smith, J.D., Dunne, T., 1984. Boundary shear stress, sediment transport and bed morphology in a sand-bedded river meander during high and low flow. In Elliot, C.M. (Ed.), River Meandering: Proceedings of the Conference, Rivers '83, American Society of Civil Engineers, New York, pp. 632–639.

Downs, P.W., Gregory, K.J. (2004) - River channel management. Towards sustainable Catchment Hydrosystems. Arnold, London.

Dunka, S., Fejér, L., Vágás, I., 1996. History of the regulation works on River Tisza. Vízügyi Múzeum, Budapest.

Eaton, B.C., Lapointe, M.F., 2001. Effects of large floods on sediment transport and reach morphology in the cobble-bed Sainte Marguerite River. Geomorphology 40, 291–309.

Félegyházi, E. 2009:Ártéri lapályok elhagyott meder- és morotvatavainak feltöltődési sebessége. In: Kiss T. – Mezősi G. (edts): Recens geomorfológiai folyamatok sebessége Magyarországon. Földrajzi Tanulmányok 2, Szeged, 55-65.

Fiala, K., Sipos, Gy., Kiss T. 2006. Szabályozások hatására bekövetkező morfológiai változások a Tisza és a Maros alsó szakaszán. In Kiss A. – Mezősi G. – Sümegi Z. (szerk): Táj, környezet és társadalom. Ünnepi tanulmányok Keveiné Bárány Ilona professzor asszony tiszteletére.203-213.

Fergusson, R.I., 1987. Hydraulic and sedimentary control of channel pattern. In: Richards, K.S., (Ed.), River channels: environment and process. Blackwell, Oxford, pp. 129-158.

Florsheim, JL, Mount, JF. 2003. Changes in lowland floodplain sedimentation processes: pre-disturbance to post-rehabilitation, Cosumnes River, CA. Geomorphology 56: 305-323.

Friedkin, JK, Lászlóffy, W. 1949. A folyómedrek vándorlása. Vízügyi Közlemények 31/1-2: 98-116.

Friedman, J.M., Osterkamp, W.R., Lewis, W.M., 1996. The role of vegetation and bed-level fluctuations in the process of channel narrowing. Geomorphology 14, 341–351.

Fujuta, Y., 1989. Bar and channel formation in braided streams. In: Ikeda, S., Parker, G., (Eds.), River Meandering. American Geophysical Union, Washington DC, pp. 417–462.

Fullera, I. C., Largeb, A.R.G., Milan, D. J., 2003. Quantifying channel development and

sediment transfer following chute cutoff in a wandering gravel-bed river. Geomorphology 54, 307–323.
Gazdag, L., 1964. River system of the Száraz-ér. Földrajzi Értesítő 13. 367−374.
Gábris Gy, Telbisz T, Nagy B, Belardinelli E. 2002: A tiszai hullámtér feltöltődésének kérdése és az üledékképződés geomorfológiai alapjai. Vízügyi Közlemények 84/3: 305-318.
Gillyén, J., 1912. A Maros-szabályozás mai állása. Vízügyi Közlemények 1912/1, 63–64.
Gilvear D.J. (1999) - Fluvial geomorphology and river engineering: future roles utilizing a fluvial hydrosystems framework. Geomorphology 31, 229–245.
Gönczy, S., Molnár, J., Szabó, G. and Sándor, A. 2004. Az erdőirtások hatása az árvízi vízhozamokra a Felső-Tisza kárpátaljai mellékfolyóin. Földtani Kutatás 41/3-4: 52-56
Gurnell, A. M., Petts, G. E., Hannah, D. M., Smith, B. P. G., Edwards, P. G., Kollmann, J., Ward, L. W., Tockner, K., 2001. Riparian vegetation and island formation along the gravel-bed Fiume Tagliamento, Italy. Earth Surface Processes and Landforms 26, pp. 31–62.
Ham, D.G., Church, M., 2000. Bed-material transport estimated from channel morphodynamics: Chilliwack River, British Columbia. Earth Surface Processes and Landforms 25, 1123−1142.
Hey, R.D. (1997) - River engineering and management in the 21st century. In: Thorne C.R., Hey R.D., Newson, M.D. (eds) Applied fluvial geomorphology for river engineering and management. Wiley, Chichester, 3–13.
Hohensinner, S, Habersack, H, Jungwirth, M, Zauner, G. 2004. Reconstruction of the characteristics of a natural alluvial river-floodplain system and hydromorphological changes following human modifications: the Danube River (1812–1991). River Res. Applic. 20: 25-41.
Hooke, J.M. (1995) - River channel adjustment to meander cutoffs on the River Bollin and River Dane, northwest England. Geomorphology 14, 235– 253.
Howard, A.D., 1996. Modelling channel evolution and floodplain morphology. In Anderson, M.G., Walling, D.E., Bates, P.D. (Eds.), Floodplain Processes. John Wiley and Sons, Chichester, pp. 15–61.
Ihrig, D. (edt) 1973. A magyar vízszabályozás története. VÍZDOK Budapest: 356-361.
Illés, L., Konecsny, K., Kovács, S., Szlávik L. 2003. Az 1998. novemberi árhullám hidrológiája. Vízügyi Közlemények 85, Különszám I: 47-76
Iványi, B. 1948. A Tisza kisvizi szabályozása. Vízügyi Közlemények 30/2, 131-304.
Jackson, R.G., 1975. Velocity–bedform–texture patterns of meander bends in the lower Wabash River of Illinois and Indiana. Geological Society of America Bulletin 86, 1511–1522.
Jiongxin, X., 1997. Evolution of mid-channel bars in a braided river and complex response to reservoir construction: an example from the Middle Hanjiang River, China. Earth Surface Processes and Landforms 22, pp. 953–965.
Károlyi, Z. 1960a. A Tisza mederváltozásai – különös tekintettel az árvédelemre. Tanulmányok és kutatási eredmények 8. Budapest: VITUKI.
Károlyi, Z. 1960b. Zátonyvándorlás és gázlóalakulás - különös tekintettel a magyar Felső-Dunára. Hidrológiai Közlöny 40/5: 349-358
Keesstra, SD. 2007. Impact of natural reforestation on floodplain sedimentation in the Dragonja basin, SW Slovenia. Earth Surface Processes and Landforms 32/1: 49-65.

Kiss, T., Sipos, Gy., 2003. Investigation of channel dynamics on the lowland section of River Maros. Acta Geographica Szeged. 39, 41-49.
Kiss, T. – Sipos Gy. 2007: Braid-scale geometry changes in a sand-bedded river: Significance of low stages. Geomorphology 84, 209-221.
Kiss, T, Sipos, Gy, Fiala, K. 2002. Recens üledék-felhalmozódás sebességének vizsgálata az Alsó-Tiszán. Vízügyi Közlemények 84/3: 456-472.
Kiss T. – Sándor A. 2009: Land-use changes and their effect on floodplain aggradation along the Middle-Tisza River, Hungary. Landscape and Environment 3/1, 1-10.
Kochel, R.C., 1988. Geomorphic impact of large floods: review and new perspectives on magnitude and frequency. In: Baker, V.R., Kochel, R.C., Patton, P.C., (Eds.), Flood Geomorphology. Wiley-Interscience, New York, pp. 169−187.
Knighton, D. 1998. - Fluvial forms and processes. A new perspective. Arnold, London.
Knox, JC. 1987. Historical Valley Floor Sedimentation in the Upper Mississippi Valley. Annals Ass. of American Geographers 77/2: 224-244.
Knox, JC. 2006. Floodplain sedimentation in the Upper Mississippi Valley: Natural versus human accelerated. Geomorphology 79: 286-310
Kondolf, G.M., Piégay, H., Landon, N. (2002) - Channel response to increased and decreased bedload supply from land use change: contrasts between two catchments. Geomorphology 45, 35–51.
Kvassay, J. 1902: A szabályozások hatása a folyók vízjárására Magyarországon. Vízügyi Közlemények 15: 7-27.
Laczay, I. 1975: A Maros vízgyűjtője és vízrendszere. A Maros szabályozása és kanyarulati viszonyai. Vízrajzi Atlasz sorozat 19. Maros. VITUKI, Budapest: 4-6, 20-23.
Laczay I. (1977): Channel pattern changes of Hungarian rivers: the example of the Hernád River. In: Gregory K.J. (ed) River channel changes. Wiley, Chichester. 185–192.
Lane, S.N., Richards, K.S., 1997. Linking river channel form and process: time, space and causality revisited. Earth Surface Processes and Landforms 22, 249−260.
Lecce, SA, Pavlowsky RT. 2004: Spatial and temporal variations in the grain-size characteristics of historical flood plain deposits, Blue River, Wisconsin, USA. Geomorphology 61/3-4: 361-371.
Leopold, L.B., Wolman, M.G., 1957. River channel patterns: braided, meandering, and straight. US Geol. Survey Prof. Paper 282.
Liébault, F., Piégay, H. 2001. - Assessment of channel changes due to long-term bedload supply decrease, Roubion River, France. Geomorphology 36, 167–186.
Madej, M.A., 1999. Temporal and spatial variability in thalweg profiles of a gravel-bed river. Earth Surface Processes and Landforms 24, 1153−1169.
Makra, L, Juhász, M, Béczi, R and Borsos. E. 2005: The history and impacts of airborne Ambrosia (Asteraceae) pollen in Hungary. Grana 44: 57-64.
Magilligan, F.J., 1992. Thresholds and the spatial variability of flood power during extreme floods. Geomorphology 5, 373−390.
Márton, Gy., 1914. A Maros alföldi szakasza és fattyúmedrei. Földrajzi Közlemények 52, pp. 282-301.
Mezősi, J, Donáth, É. 1954: A Tisza és Maros oldott és lebegtett anyagának vizsgálata. Hidrológiai Közlöny 34/3-4: 140-148.

Mike, K. 1991. Magyarország ősvízrajza és felszíni vizeinek története. Aqua Kiadó, Budapest.
Morisawa, M., 1985. Rivers: form and process. Longman, London.
Mosley, P., Jowett, I., 1999. River morphology and management in New Zealand. Progress in Physical Geography 23, 541–565.
Mücher, HJ, Slotboom, RT, ten Veen,. WJ. 1990: Palynology and micromorphology of a man-made soil. A reconstruction of the agricultural history since late-medieval times of the Posteles in the Netherlands. Catena 17: 55-67.
Nagy, I., Schweitzer, F., Alföldi, L. 2001. A hullámtéri hordaléklerakódás (övzátony). Vízügyi Közlemények 83/4: 539-564
Nanson, GC, Croke, JC. 1992: A genetic classification of floodplains. Geomorphology 4: 459-486.
Nelson, J. M., 1990. The initial stability and finite-amplitude stability of alternate flows in straight channels. Earth Science Reviews 29, 97–115.
Newson M.D. (1997) - Land, water and management. Sustainable management of river basin systems. Routledge, London.
Newson, M.D., Hey, R.D., Bathurst, J.C., Brookes, A., Carling, P.A., Petts, G.E., Sear, D.A. (1997) - Case studies in the application of geomorphology to river management. In: Thorne, C.R., Hey, R.D., Newson, M.D. (eds) Applied fluvial geomorphology for river engineering and management. Wiley, Chichester, 311–365.
Nicholas, A.P., 2000. Modelling bed load yield in braided gravel bed rivers. Geomorphology 36, 89–106.
Nicholas, AP, Walling, DE. 1997. Investigating spatial patterns of medium-term overbank sedimentation on floodplains: a combined numerical modelling and radiocaesium-based approach. Geomorphology 19: 133-150.
Nováky, B. 2000. Az éghajlatváltozás vízgazdálkodási hatásai. Vízügyi Közlemények 82/3-4: 418-448
Oroszi, VGy. 2008. Egy árvíz okozta ártérfeltöltődés - esettanulmány a Maros 2006 évi áradása kapcsán. In: Kiss T., Mezősi G. (edts) Recens geomorfológiai folyamatok sebessége Magyarországon; Szeged: 73-83.
Osterkamp, W.R., Costa, J.E., 1987. Changes accompaying an extraordinary flood on a sand-bed stream. In: Mayer, L., Nash, D., (Eds.), Cathastrophic flooding. Allen and Unwin, London, pp. 201−224.
Owens, PN, Batalla, RJ, Collins, AJ, Gomez, B, Hicks, DM, Horowitz, AJ, Kondolf, GM, Marden, M, Page, MJ, Peacock, DH, Petticrew, EL, Salomons, W, Trustrum, NA. 2005. Fine-grained sediment in river systems: environmental significance and management issues. River Res. Applic. 21: 693-717.
Owens, PN, Walling, DE. 2002. Changes in sediment sources and floodplain deposition rates in the catchment of the River Tweed, Scotland, over the last 100 years: the impact of climate and land use change. Earth Surf. Process. Landforms 27: 403-423.
Owens, P.N., Walling, D.E., Leeks, G.J.L., 1999. Deposition and storage of fine-grained sediment within the main channel system of the River Tweed, Scotland. Earth Surface Processes and Landforms 24, 1061−1076.
Parker, G. 1976. On the cause and characteristic scales of meandering and braiding in rivers. Journal of Fluid Mechanics 76, 457-480.
Pinter A., Heine R.A. 2005. - Hydrodynamic and morphodynamic response to river

engineering documented by fixed-discharge analysis, Lower Missouri River, USA. Journal of Hydrology 302, 70–91.
Priszter Sz. 1960. Adventív gyomnövényeink terjedése. A Keszthelyi Mezőgazdasági Akadémia Kiadványai 7, Budapest; 3-34.
Rakonczai, J., 2000. Hydro-geographical consequences of environmental change on the Hungarian Great Plain. In: Pálfai, I., (Ed.), Role and importance of surface waters on the Hungarian Great Plain. Nagyalföld Alapítvány, Békéscsaba, pp. 16‒27.
Rakonczai J. 2000. A környezet hidrogeográfiai összefüggései az Alföldön. In A víz szerepe és jelentősége az Alföldön, Pálfai I (ed). Békéscsaba: Nagyalföld Alapítvány. 16-27
Repetto, R., Tubino, M., Paola, C., 2002. Planimetric instability of channels with variable width. Journal of Fluid Mechanics 457, 79–109.
Richards, K.S., 1982. Rivers: Form and Processes in Alluvial Channels. Methuen, London.
Richard G.A., Julien P.Y., Baird D.C. 2005. - Statistical analysis of lateral migration of the Rio Grande, New Mexico. Geomorphology 71, 139–155.
Rinaldi M., Simon A. (1998) - Bed-level adjustments in the Arno River, Central Italy. Geomorphology 22, 57– 71.
Ryan, S.E., Porth, L.S., Trondele, C.A., 2002. Defining phases of bed load transport using piecewise regression. Earth Surface Processes and Landforms 27, 971–990.
Sándor A, Kiss T. 2006. A hullámtéri üledék-felhalmozódás mértékének vizsgálata a Közép- és az Alsó-Tiszán. Hidrológiai Közlöny 86/2: 58-62.
Schumm S.A. 1977. - The fluvial system. Wiley, New York
Schumm, S.A., 1985. Patterns of Alluvial Rivers. Annual Review of Earth and Planetary Sciences 13, 5-27.
Schweitzer F. 2001. A magyarországi folyószabályozások geomorfológiai vonatkozásai. Folyóink hullámtereinek fejlődése, kapcsolatuk az árvizekkel és az árvízvédelmi töltésekkel. Földrajzi Értesítő 50/1-4: 63-72.
Sipos, Gy., Kiss, T., 2003. Formation and evolution of fluvial islands on the border section of River Maros. Vízügyi Közlemények 85/4, 225-238.
Sipos, Gy., Kiss, T., 2004. Island development and morphological stability on the lowland reach of River Maros, Hungary. Geomorphologia Slovaca 4, 52-62.
Smith L.M., Winkley B.R. (1996) - The response of the Lower Mississippi River to river engineering. Engineering Geology 45, 433– 455.
Somogyi S. (edt) 2000. A XIX. századi folyószabályozások és ármentesítések földrajzi és ökológiai hatásai Magyarországon. Budapest
Steiger J, Gurnell AM, Ergenzinger P, Snelder DD. 2001. Sedimentation in the riparian zone of an incising river. Earth Surf. Process. Landforms 26: 91-108.
Starosolszky Ö. 1956. Az emberi beavatkozások hatása a vízfolyások morfológiai viszonyaira. Vízügyi Közlemények 38/2: 248-252
Stover, S.C., Montgomery, D.R. 2001. - Channel change and flooding, Skokomish River, Washington. Journal of Hydrology 243, 272– 286.
Surian, N., Rinaldi, M. 2003. - Morphological response to river engineering and management in alluvial channels in Italy. Geomorphology 50, 307–326.
Szabó, Sz, Molnár, LSz, Gosztonyi, Gy, Posta, J, Prokisch, J. 2008. A nehézfém-szennyezettség vizsgálata egy felső-tiszai holtmeder környezetében. In: Szabó J,

Demeter G. (edts): Geographia Generalis et specialis. Debrecen: 255-260.
Szlávik, L. 2001. A Tisza-völgy árvízvédelme és fejlesztése. In: I. Magyar Földrajzi Konferencia CD-kiadványa, Szeged: 52.
Tamás EA, Kalocsa B. 2003. A Rezéti-Duna feltöltődésének vizsgálata. In: Somogyvári O. (edt) Élet a Duna-ártéren. Pécs: 43-49.
Ten Brinke, WBM, Schoor, MM, Sorber, AM, Berendsen, HJA. 1998. Overbank sand deposition in relation to transport volumes during large-magnitude floods in the dutch sand-bed Rhine River system. Earth Surface Processes and Landforms 23: 809-824.
Tiegs, S.D., Pohl M. 2005. - Planform channel dynamics of the lower Colorado River: 1976–2000. Geomorphology 69, 14– 27.
Tímár, L. 1948. A Tisza- és Marosmente új növényei. Acta Soc. Bot. Hungaricae, Sep. Borbasia: 8-61.
Török, I. 1977: A Maros folyó 0-51,33 fkm közötti szakasza általános szabályozási terve. Alsó-Tisza Vidéki Vízügyi Igazgatóság, Szeged.
Uribelarrea D., Perez-Gonzaleza A., Benito G. (2003) - Channel changes in the Jarama and Tagus rivers (central Spain) over the past 500 years. Quaternary Sci. Reviews 22, 2209–2221.
Vágás, I. 2000. A Tisza és árvizei. Hidrológiai Tájékoztató 40/1: 45-50
Vágás, I. 2001. Az ezredforduló árhullámai a Tiszán. Magyar tudomány 48/8: 958-866
Walling, DE, He, Q. 1998. The spatial variability of overbank sedimentation on river floodplains. Geomorphology 24: 209-223.
Wathen, S. J., Hoey, T. B., 1998. morphological controls on the downstream passage of a sediment wave in a gravel-bed stream. Earth Surface Processes and Landforms 23, 715–730.
Weninger, JM, McAndrews, JH. 1989. Late Holocene aggradation in the lower Humber River valley, Toronto, Ontario. Canadian Journal of Earth Sciences 26: 1842-1849.
Whiting, P.J., 1997. The effect of stage on flow and components of the local force balance. Earth Surface Processes and Landforms 22, 517–530.
Wilbers, A.W.E., Brinke, W.B.M.T., 2003. The response of subaqueous dunes to floods in sand and gravel bed reaches of the Dutch Rhine. Sedimentology 50, 1013–1034.
Wolman, M.G., Gerson, R., 1978. Relative scales of time and effectiveness of climate in watershed geomorphology. Earth Surface Proccesses and Landforms 3, 189−208.
Wolman, MG, Leopold, LB. 1957. River Flood Plains: Some observation on their formation. U.S. Geological Survey Professional Papers 282-C: 85-107.
Wyzga, B. 2001. Impact of the channelization-induced incision of the Skawa and Wisloka Rivers, Southern Poland, on the conditions of overbank deposition. Regul. Rivers: Res. Mgmt. 17: 85-100.
Xu, J. 2002. - River sedimentation and channel adjustment of the lower Yellow River as influenced by low discharges and seasonal channel dry-ups. Geomorphology 43, 151– 164.
Xu, Q, Yang, X, Wu, C, Meng, L, Wang, Z. 1996. Alluvial pollen on the North China Plain. Quaternary Research 46: 270-280.
Yates, R., Waldron, B., van Arsdale, R. (2003) - Urban effects on flood plain natural hazards: Wolf River, Tennessee, USA. Engineering Geology 70, 1 –15.

EFFECTS OF DIFFERENT LAND-USES ON ALKALINE GRASSLANDS – IMPLICATIONS FOR CONSERVATION

László Erdős, Zoltán Bátori, Márta Zalatnai, Katalin Margóczi, Viktória Cseh, Dolly Tolnay, László Körmöczi

Introduction

The basic purpose of conservation biology is to provide practical information useful in conservation management (Margóczi *et al.* 1997, Aradi *et al.* 2004). Due to the changes in farming methods in agriculture, semi-natural grazed grasslands are threatened throughout Europe (van Wieren 1995). Alkaline grasslands belong to the most typical communities in the Carpathian basin (Illyés *et al.* 2007), covering considerable areas, a great proportion of which is natural or near-natural (cf. Kun 1998, Kelemen 1997, Molnár and Borhidi 2003). If we are to maintain the natural values of these alkaline communities, we have to gather data on which measures to made.

In this study, we chose two neighbouring alkaline grasslands, which belong to different countries, thus their land-use is assumed to be different. Our aim was to determine the present land-use types and their effects on conservation values. Moreover, we wanted to give specific proposals on the management of the areas under study.

Material and methods

Two neighbouring near-natural alkaline grasslands were chosen for our investigations. They are separated by the Hungarian-Romanian state border. The grasslands are located between Gyula and Elek on the Hungarian side and southwest of Vărşand (Gyulavarsánd) on the Romanian side. Distance between the two grasslands is approximately 1.5 km, and abiotic parameters are nearly identical. Mean annual temperature in Gyula is 10.2 °C, mean annual precipitation is 581.3 mm (Hubai 1934, also see Ambrózy and Kozma 1990). History of land-use on both sides of the border are basically identical. A detailed analysis of the land-use history of the area is given by Cseh *et al.* (2011).

A habitat map was prepared based on field studies carried out during the summer 2010. Habitats were identified using the habitat guide (Bölöni *et al.* 2007a, 2007b). Naturalness of every patch was recorded according to the modified Németh-Seregélyes scale (Bölöni *et al.* 2007b). In addition, a land-use map was prepared. Habitat and land-use maps were made with the program ArcView GIS 3.2 (ESRI).

Coenological relevés were made in June 2010 in 4 m² plots. Percentage cover of all vascular plant species was estimated. We made relevés in every community types; the number of relevés made in every particular community type is proportional to the area covered by that community.

Species numbers of the plots were calculated and the two grasslands were compared with the Wilcoxon-Mann-Whitney test, using Past 1.99 (Hammer *et al.* 2001).

Diversity ordering was applied in order to analyse the diversity of the two most typical habitats, *Artemisia* salt steppes and salt meadows. In the case of both habitats, comparisons were made between the Hungarian and the Romanian sides. We used Rényi's diversity function, since it is one of the most useful diversity ordering methods (Tóthmérész 1995). Rényi's function is given by equation (1). MS Excel was used for these computations and for the graphical representation of the diversity profiles.

$$H\,(R) = \left(\log \sum_{i=1}^{S} p_i^{\alpha} \right) \Big/ 1-\alpha \qquad (1)$$

We characterized the naturalness of the *Artemisia* salt steppes and salt meadows by calculating the spectra of the social behaviour types (SBT) and the ecological indicator value N of Borhidi (1993, 1995), based on frequency data. Differences between the Hungarian and Romanian sides were searched for with the Wilcoxon-Mann-Whitney test, using Past 1.99 (Hammer *et al.* 2001).

We also calculated the proportion of the plants belonging to different phytosociological groups within each plot. Again, differences between the Hungarian and Romanian sides were identified with the Wilcoxon-Mann-Whitney test, using Past 1.99 (Hammer *et al.* 2001).

During field studies, we recorded all information possibly important from a nature conservation perspective (dumping grounds, waste thrown away, damage to soil, artificial landscape elements).

Plant species names are used according to Simon (2000).

Results

Habitat maps of the grasslands are shown on Figs. 1-2 (Erdős *et al.* 2011). For the sake of simplicity, some categories were merged on the maps. We found a total of 25 habitat types. Below we give a brief description of the near-natural types.

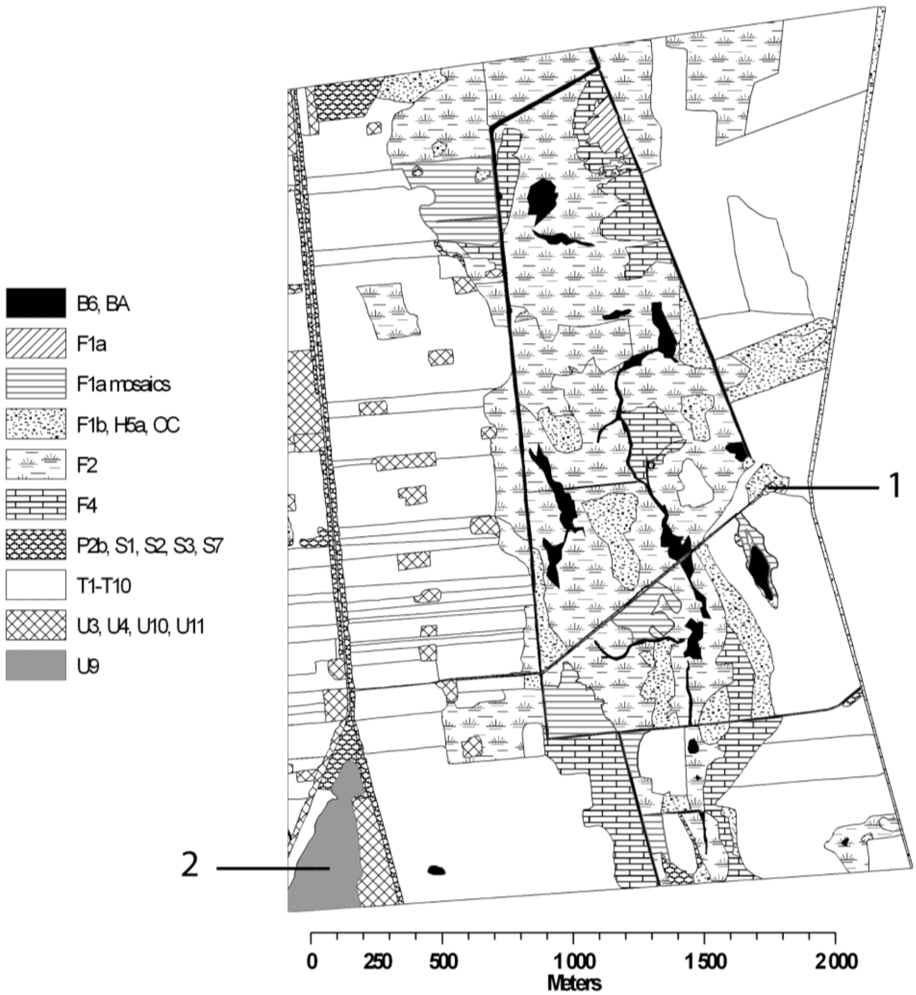


Figure 1. Habitat map of the Hungarian grassland. 1=waste dump, 2=artificial pond.

Salt marshes (B6) have generally been preserved in a good condition. All of the stands on the Hungarian (mown) side belong to the naturalness category 5, while there are stands on the Romanian (grazed) side belonging to the naturalness category 4, 4r3 or 3. It is worth mentioning that we found a small isolated salt marsh stand on the Hungarian side. Although it is surrounded by arable fields, it is in a relatively good condition (category 5r3). Proportion of *Artemisia* salt steppes (F1a) is much greater on the Romanian side, but their naturalness values are usually lower than on the Hungarian side. Salt meadows (F2) dominate both grasslands. Their condition is generally good, but stands near agricultural fields are degraded. Dense and tall *Puccinellia* swards (F4) cover extensive areas on the Hungarian side, while their extension is much lower on the Romanian side, where their naturalness values are usually lower. Annual salt pioneer swards of steppes and lakes (F5) belong to high naturalness categories. Closed loess steppes (H5a) are degraded on both sides, the naturalness values never exceeding 3. Proportion of degraded dry habitats (*Achillea* salt steppes – F1b and uncharacteristic dry and semi-dry grasslands – OC) is also important on both sides. On both sides, we found one waste dump, the location of which is indicated on Figs.1-2. The waste dump on the Romanian side is much bigger. In addition, artificial ponds were created on both sides (Figs.1-2).

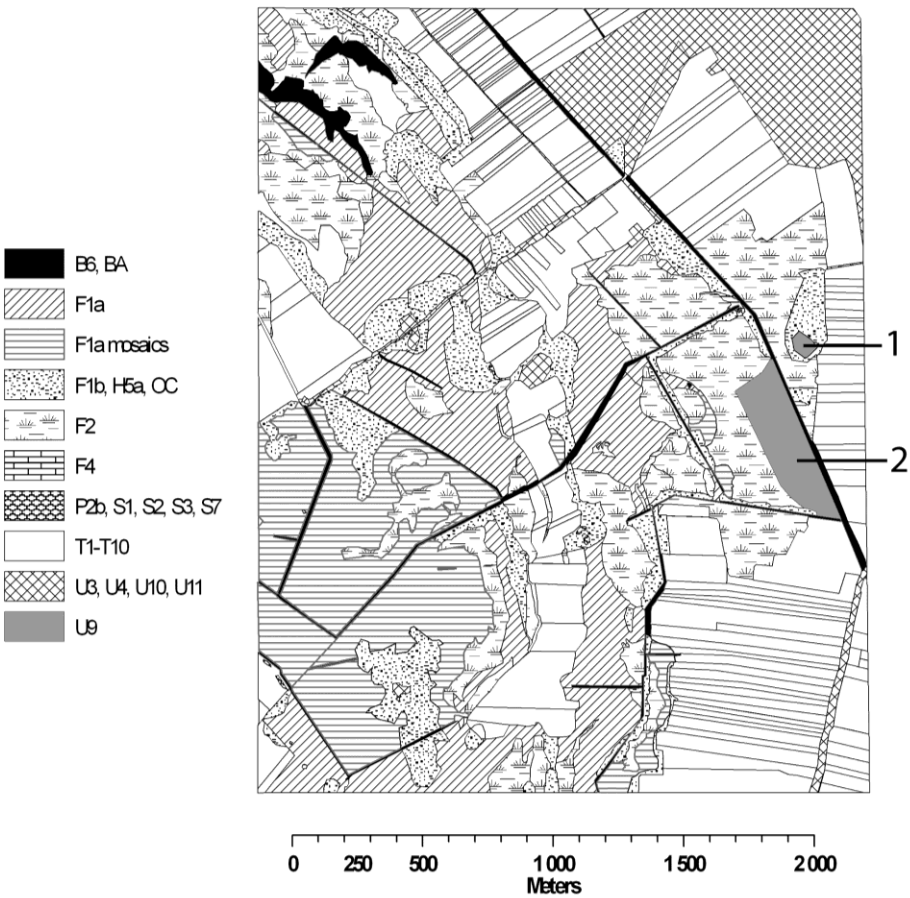


Figure 2. Habitat map of the Romanian grassland. 1=waste dump, 2=artificial pond.

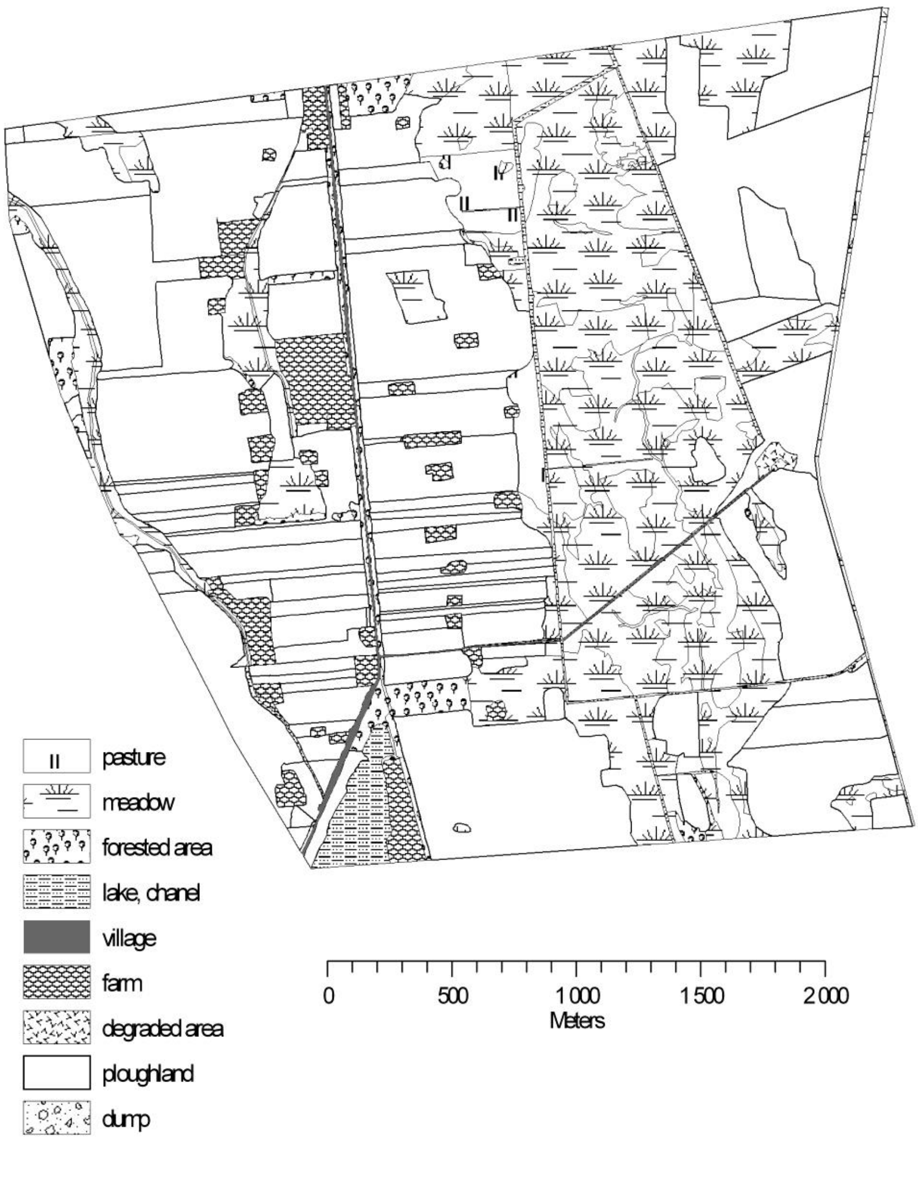


Figure 3. Land-use map of the Hungarian grassland.

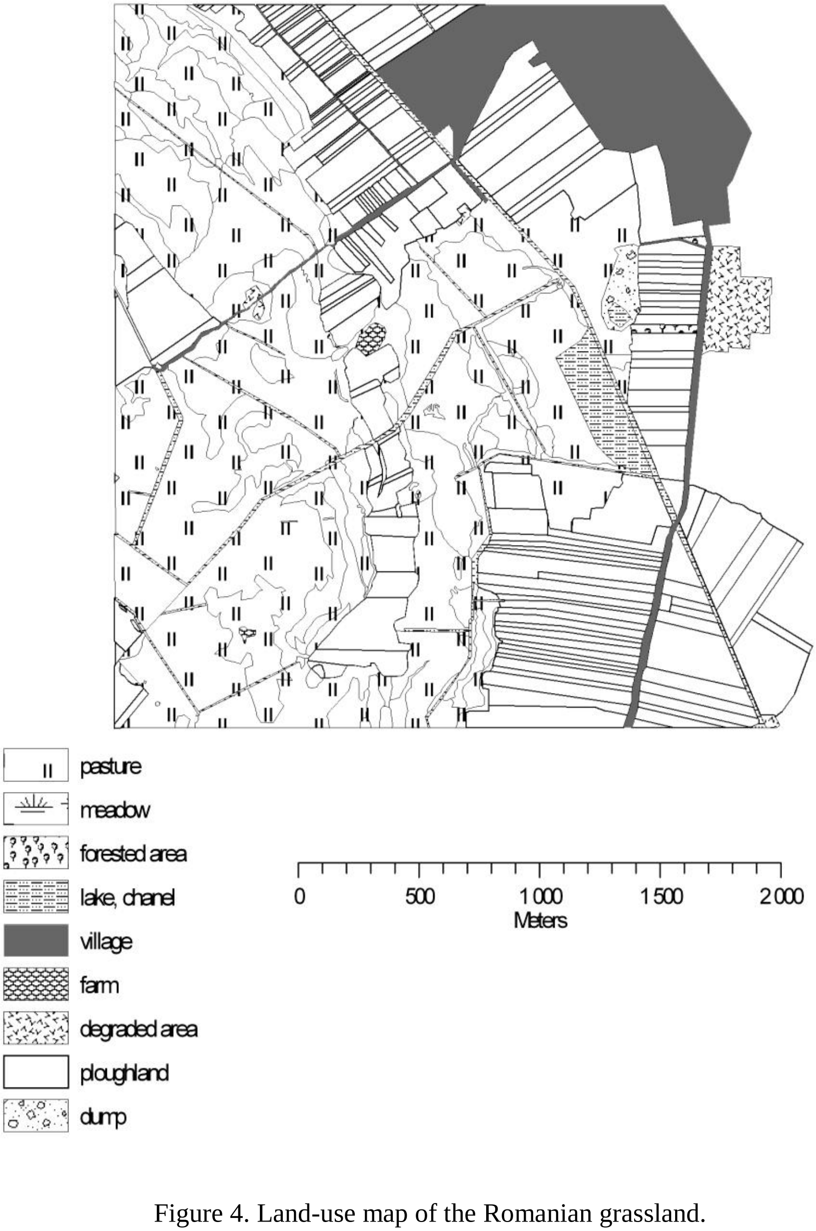


Figure 4. Land-use map of the Romanian grassland.

Land-use maps are presented on Figs. 3-4. Unfortunately, both sides are dominated by arable fields, although in Romania, greater parts of the near-natural grasslands remained unploughed. The overwhelming majority of the near-natural grasslands on the Hungarian side is hay-meadow, and only a small fraction is grazed. In contrast, nearly the whole grassland is a pasture on the Romanian side. There are several small farms scattered on the Hungarian side, but only a few farms on the Romanian side.

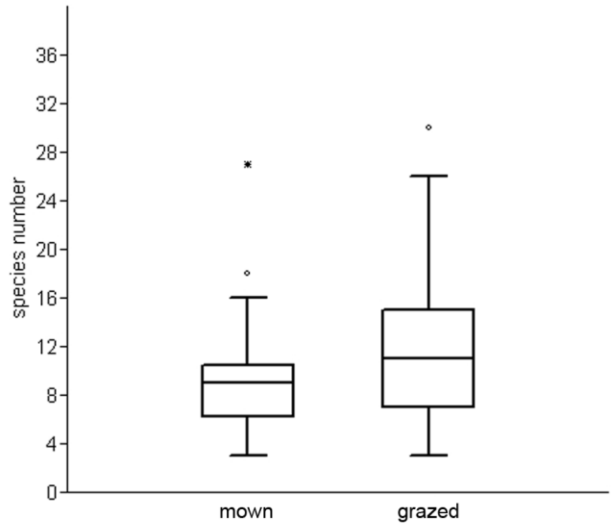


Figure 5. Species number of the two grasslands.

Species number of the plots is higher on the Romanian (grazed) side if every habitat type is considered (Fig. 5), although differences are not significant according to the Wilcoxon-Mann-Whitney tets (U=537, p=0.0805).

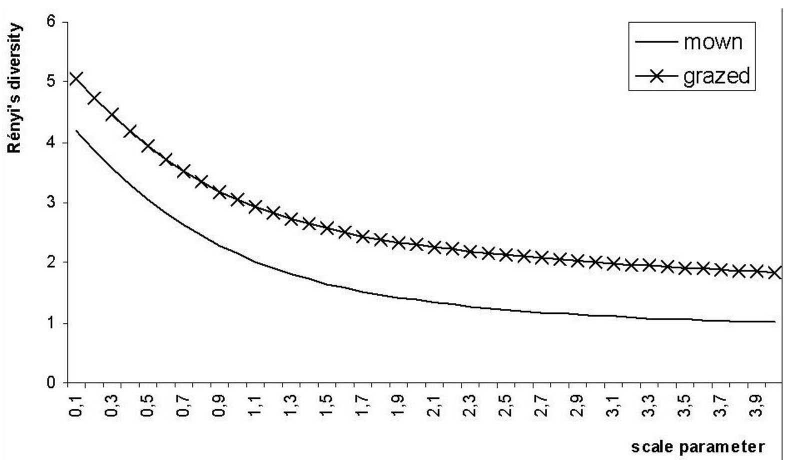


Figure 6. Diversity profiles of the *Artemisia* salt steppes.

In the followings, we analyse the Artemisia salt steppes and the salt meadows exclusively, since these are the most typical habitats on the area under scrutiny. However, our main conclusions are very similar if every habitat type is considered (cf. Erdős *et al.* 2011).

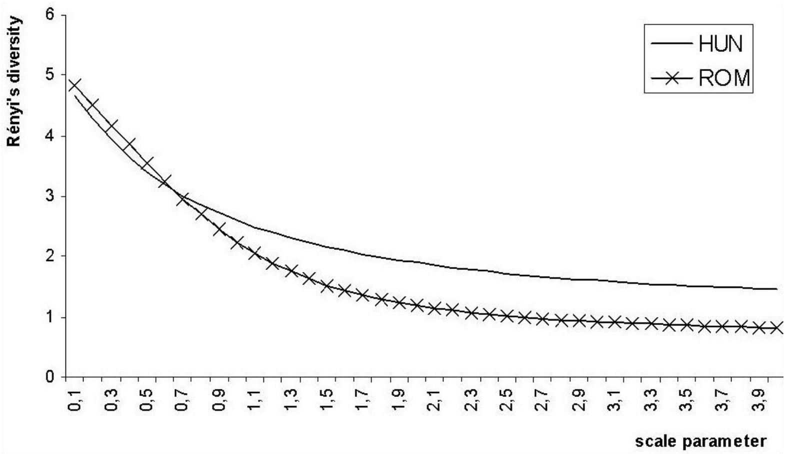


Figure 7. Diversity profiles of the salt meadows.

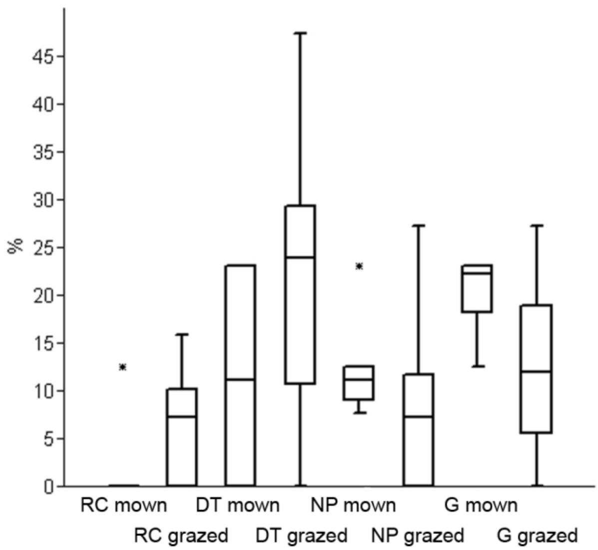


Figure 8. Group participation of the social behaviour types in the case of *Artemisia* salt steppes.

In the case of *Artemisia* salt steppes, results of the diversity ordering are clear, indicating higher diversity on the Romanian (grazed) side (Fig. 6). In contrast, in the case of the salt meadows, the two grasslands (mown vs. grazed) can not be ordered (Fig. 7).

If we look at the spectra of the social behaviour types, differences between the grazed and mown grasslands are not significant if *Artemisia* salt steppes are considered. However, differences are quite close to the significance level in the case of ruderal competitors (U=22, p=0.0689), disturbance tolerants (U=19.5, p=0.0567), natural pioneers (U=21, p=0.0764) and generalists (U=19, p=0.0506), indicating that the Romanian side is more disturbed (Fig. 8.).

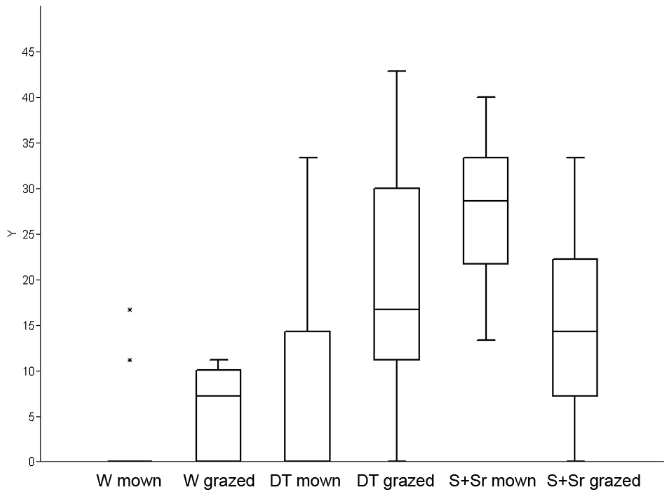


Figure 9. Group participation of the social behaviour types in the case of salt meadows.

If salt meadows are considered, weeds and disturbance tolerants are more typical of the grazed grassland (U=61, p=0.0282 and U=48, p=0.0141, respectively), whereas specialists are more typical of the mown grassland (U=46.5, p=0.0143) (Fig. 9).

No considerable differences were found in the group participation of the N indicator values between the grazed and mown grasslands.

In the case of *Artemisia* salt steppes, proportion of plants belonging to the phytosociological group *Festuco-Puccinellietea* is higher on the Hungarian side (U=18.5, p=0.0457), while proportion of indifferent species is higher on the Romanian side (U=15, p=0.0211) (Fig. 10). Similarly, salt meadows of the Hungarian side possess more *Festuco-Puccinellietea* (U=47, p=0.0171) and less indifferent plants (U=50.5, p=0.0285) than salt meadows of the Romanian side (Fig 11).

On the Romanian side, litter was found everywhere scattered on the pastures, the landscape has been destroyed due to power lines and abandoned buildings, and soil surface is damaged because of tractors. In contrast, on the Hungarian side there is only limited litter, landscape is nearly intact and soil surface is only rarely damaged (Erdős *et al.* 2011).

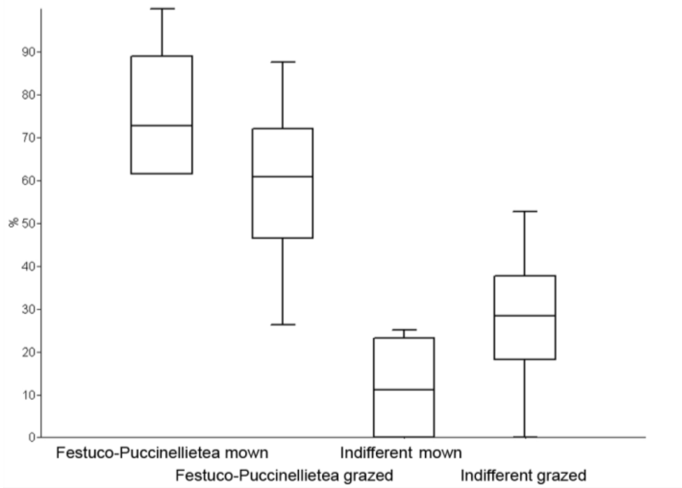


Figure 10. Group participation of the *Festuco-Puccinellietea* and indifferent species in the case of *Artemisia* salt steppes.

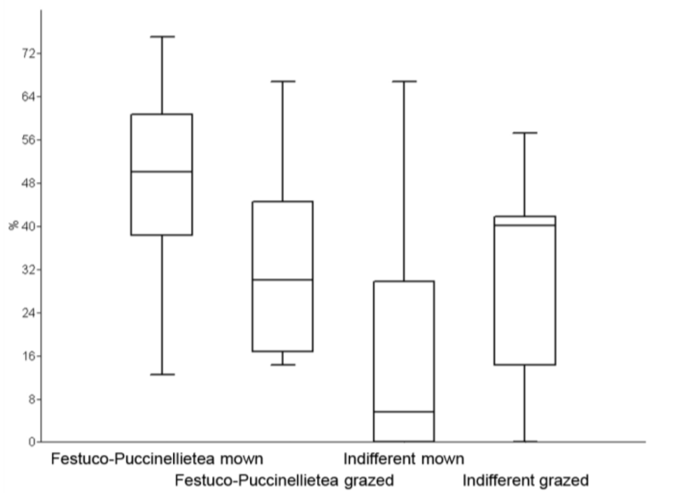


Figure 11. Group participation of the *Festuco-Puccinellietea* and indifferent species in the case of salt meadows.

We found that *Plantago schwarzenbergiana*, an endemic species occurs in great numbers on both sides of the border. Also, the endemic plant *Limonium gmelinii* ssp. *hungaricum* is common everywhere on the near-natural grasslands under study.

Discussion

We found a mosaic pattern of various habitats. The near-natural areas are dominated by salt meadows, *Artemisia* salt steppes and dense and tall *Puccinellia* swards. At higher elevations, small loess steppe fragments are scattered in the alkaline matrix. These are usually degraded, in spite of the fact that the surrounding alkaline vegetation is natural. Loes steppe fragments are common within alkaline areas throughout the Carpathian basin (Kelemen 1997), and they were known near Gyula as well (Tóth 2003). Their naturalness values are lower probably because both resistance and resilience of alkaline communities is pretty high (cf. Kelemen 1997, Kun 1998, Molnár and Borhidi 2003). Thus, a certain disturbance event may result in a considerable degradation within loess steppes, while the very same disturbance has much less effect on the alkaline communities.

Our investigations showed that differences in the land-use (hay-meadows on the Hungarian side, pastures on the Romanaian side) result in marked differences in the vegetation. Species richness of the grazed grasslands seemed to be higher, although differences were not significant. Diversity of the *Artemisia* salt steppes proved to be higher on the grazed side, whilst diversities of the salt meadows could not be ordered. Thus grazing may have a greater effect on *Artemisia* salt steppes.

We found that naturalness values of habitats on the Romanian side were often lower. In addition, proportion of plants typical of disturbed, degraded habitats is also somewhat higher on the Romanian side. We conclude that grasslands of the Romanian side may be overgrazed.

We found high numbers of the species *Plantago schwarzenbergiana*. This species was known from the area (Kertész 2000, Tóth 2003). Also, other valuable species which are legally protected in Hungary occur on the grassland studied and the immediate surrounding, such as *Aster sedifolius* ssp. *sedifolius*, *Bassia sedoides*, *Orchis laxiflora* (Kertész 2000, Tóth 2003). Moreover, these grasslands provide habitats for some protected animal species (Lőrinczi *et al*. 2011), thus we conclude that the area should be protected.

Proposals for conservation management

In the followings we give specific proposals to the management of the studied grasslands, based on the statements of Erdős *et al.* (2011).

The Romanian side seems to be overgrazed, which is one severe threatening factor to alkaline communities, resulting in degradation (Kelemen 1997, Kun 1998, Molnár and Csízi unpublished data, Molnár and Borhidi 2003). With careful grazing techniques and traditional methods such as “acatolás” or “töviskelés”, adverse effects of overgrazing could be minimized even if the grazing pressure remained the same as it is currently (cf. Kelemen 1997, Molnár and Csízi unpublished data).

The illegal waste dump should be eliminated as soon as possible. Invasive species (mostly *Xanthium italicum* and *X. spinosum*) should be eradicated from their potential centres of infection (near roads and small farms). Pastures possess considerable aesthetic values (Sanderson *et al.* 2004). Littering on the Romanian side greatly reduces this value. Therefore, attitude of local inhabitants to natural values should be changed. If people of the nearby settlements valued their grasslands more, protection from waste and undesirable landscape elements would be easier.

According to the land-use historical analyses (Cseh *et al.* 2011), the grasslands on the Romanian side have undergone a radical drying tendency. This is undoubtedly an undesirable process, diminishing the alkaline character (Kelemen 1997). Therefore, efforts should be made to halt further drying.

As indicated earlier, the pasture is valuable from a nature conservation perspective, therefore, the whole grassland should be legally protected, which is currently lacking on the Romanian side.

The grassland on the Hungarian side is mown, and only a small fraction is grazed. Since the second half of the 19th century, livestock grazing has decreased around Gyula (Cseh *et al.* 2011). Although undergrazing does not belong to the most threatening factors in the case of primary alkaline communities (Molnár and Borhidi 2003), it could be harmful in some cases (Molnár and Csízi unpublished data, Kelemen 1997, Kun 1998). Molnár and Borhidi (2003) suggest that alkaline steppes were grazed by native ungulates long before human history, which is in good accordance with the megaherbivore hypothesis (Vera 2000). Moreover, traditional grazing is culturally more valuable (cf. Molnár and Borhidi 2003, Molnár and Csízi unpublished data) than mowing. It is likely that grasslands in the proximity of Gyula were grazed for centuries (Cseh *et al.* 2011). Therefore, grazing of the studied grassland, as the traditional land-use method, should be re-established, preferably with traditional Hungarian varieties (Hungarian grey cattle, Racka sheep). However, adverse effects of the grazing should be minimized.

Mosaic grazing would also be possible, where undergrazed and overgrazed patches alternate (Molnár and Csízi unpublished data). Also, mown and grazed patches could alternate (cf. Ölvedi 2010).

The illegal waste dump should be eliminated on the Hungarian side, too. The interviews with the inhabitants of Gyula pointed out that local people are not really aware of the natual values of their immediate surrounding (Málovics *et al*. 2011).

Although drying tendency on the Hungarian side is not as marked as on the Romanian side, we think that further drying should be avoided. We found several very deep drainage ditches, which are especially harmful (Kelemen 1997), and we suggest that they should be filled in.

Although the grassland of the Hungarian side is a Natura 2000 area, protection of the site would be necessary at a higher level.

Acknowledgements

We would like to thank Zsolt Molnár, Miklós Bozsó, Violeta Turcus, Mihai Pascu, Gábor Lőrinczi, Ágnes Méri, Éva Kertész, Gabriel-Gicu Arsene and Gusztáv Jakab for their help.

References

Ambrózy, P. and Kozma, F. (1990): Éghajlat. Békési-sík (Climate. Békés-plain). In: Marosi, S. and Somogyi, S. (eds): Magyarország kistájainak katasztere I. – MTA Földrajztudományi Kutató Intézet, Budapest, p. 311.

Aradi, Cs., Gőri, Sz. and Lengyel, Sz. (2004): Természetvédelmi gyakorlat és konzervációbiológia: a kutatás szerepe a gyakorlati természetvédelemben (Conservation practice and conservation biology: the role of research in practical conservation). – Term.véd. közlem. 11, 21-30.

Borhidi, A. (1993): A magyar flóra szociális magatartás típusai, természetességi és relatív ökológiai értékszámai (Social behaviour types of the Hungarian flora, its naturalness and relativ ecological indicator values). – Környezetvédelmi és Területfejlesztési Minisztérium Természetvédelmi Hivatala és Janus Pannonius Tudományegyetem, Pécs.

Borhidi, A. (1995): Social behaviour types, the naturalness and relative ecological indicator values of the higher plants in the Hungarian Flora. – Acta Bot. Hung. 39, 97-181.

Bölöni, J., Molnár, Zs., Illyés, E. and Kun, A. (2007a): A new habitat classification and manual for standardized habitat mapping. – Ann. Bot., n. s. 7, 105-126.

Bölöni, J., Molnár, Zs. Kun, A. and Biró, M. (eds.) (2007b): Általános Nemzeti Élőhely-osztályozási Rendszer (General National Habitat Classification System). – MTA ÖBKI, Vácrátót.

Cseh, V., Erdős, L. and Körmöczi, L. (2011): Landscape history of the Gyula — Vărşand region. In: Körmöczi, L. (ed.): Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş. Szeged-Arad, pp. 7-20.

Erdős, L., Bátori, Z., Zalatnai, M., Margóczi, K., Tolnay, D., Cseh, V., Arsene, G.-G. and Körmöczi, L. (2011): Comparison of two neighbouring alkaline grasslands with different land uses: a conservation management perspective. Acta Bot. Hung. 53, 89-100.

Hammer, Ř., Harper, D. A. T. and Ryan P. D. (2001): PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontol. Electron., 9pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Hubai, I. (1934): Gyula földrajza (Geography of Gyula). Thesis. – Magyar Kir. Ferenc József Tudományegyetem, Szeged.

Illyés, E., Bölöni, J., Kovács, G. and Kállayné Szerényi, J. (2007): A száraz gyepek jelentősége, elterjedése, helyük a vegetációmozaikban és termőhelyi viszonyaik Magyarországon (Importance and distribution of xerophilous grasslands in Hungary, their state in the vegetation mosaic and their ecological conditions). In: Illyés, E. and Bölöni, J. (eds): Lejtősztyepek, löszgyepek és erdőssztyeprétek Magyarországon (Slope steppes, loess steppes and forest steppes in Hungary). Magánkiadás, Budapest, 12-19 pp.

Kelemen, J. (1997): Szikes gyepek (Alkaline grasslands). In: Kelemen, J. (ed): Irányelvek a füves területek természetvédelmi szempontú kezeléséhez (Guidelines for tconservational treatment of grasslands). TermészetBúvár Alapítvány Kiadó, Budapest, 129-165 pp.

Kertész, É. (2000): Adatok a Dél-Tiszántúl flórájához (Data to the flora of South-Tiszántúl). – A Békés Megyei Múz. Közl. 21, 5-48.

Kun, A. (1998): Száraz gyepek Magyarországon (Xerophilous grasslands in Hungary) In: Kiszel, V. (ed): Természetvédelem területhasználók számára (Nature conservation for land-users). – Göncöl Alapítvány, Vác.

Lőrinczi, G., Bozsó, M., Gallé, R., Torma, A. (2011): Preliminary results on the invertebrate fauna (Araneae, Orthoptera, Heteroptera and Hymenoptera: Formicidae) of alkaline grasslands of the Hungarian-Romanian border. In: Körmöczi, L. (ed.): Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş. Szeged-Arad, pp. 163-175.

Málovics, Gy., Margóczi, K. and Gébert, J. (2011): Ecosystem services at Magyarcsanád site as percieved by local people. In: Körmöczi, L. (ed.): Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş. Szeged-Arad, pp. 177-210.

Margóczi, K., Báldi, A., Dévai, Gy. and Horváth, F. (1997): A természetvédelmi ökológia kutatási prioritásai (Research priorities for conservation ecology). Term.véd. közlem. 5-6, 5-16.

Molnár, Zs. and Borhidi, A. (2003): Hungarian alkali vegetation: Origins, landscape history, syntaxonomy, conservation. – Phytocoenologia 33, 377-408.

Ölvedi, T. B. (2010): A kaszálás vegetációra és magkészletre gyakorolt hatásai (Effects of mowing on the vegetation and seed bank). – Bot. Közlem. 97, 159-169.

Sanderson, M. A., Skinner, R. H., Barker, D. J., Edwards, G. R., Tracy, B. F. and Wedin, D. A. (2004): Plant species diversity and management of temperate forage and grazing land ecosystems. – Crop Sci. 44, 1132-1144.

Simon, T. (2000): A magyarországi edényes flóra határozója (Key for the vascular flora of Hungary). – Nemzeti Tankönyvkiadó, Budapest.

Tóth, T. (2003): Újabb adatok a Dél-Tiszántúl flórájának ismeretéhez (New data to the flora of South-Tiszántúl). – A puszta 2003, 135-169.

Tóthmérész, B. (1995): Comparison of different methods for diversity ordering. – J. Veg. Sci. 6, 283-290.

Van Wieren, S. E. (1995): The potential role of large herbivores in nature conservation and extensive land use in Europe. – Biol. J. Linn. Soc. 56 (Suppl.), 11-23.

Vera, F. W. M. (2000): Grazing ecology and forest history. – CABI Publishing, Wallingford.

FLORA AND VEGETATION OF BEZDIN AREA

Violeta Turcus, Gicu Gabriel Arsene, Aurel Ardelean

Introduction

The Bezdin area has a surface of 977 ha, rivered by dead river branches and cogged canals, deeper originally. In this area, along with higher and dryer surfaces we found surfaces with year round stagnant water.

Cogged canal in Bezdin area

In the study area the Prundul Mare Nature Reserve is located, part of the Bezdin area and of the Mureş Floodplain Natural Park, on the left bank of the Mureş River, about 7 km downstream Pecica locality.

The forests between the dam and the river shore offers optimal conditions for nesting and feeding to some rare bird species, among which the Little Egret (*Egretta garzetta*), the Saker Falcon (*Falco cherrug*), the Lesser Spotted Eagle (*Aquila pomarina*), the Black Stork (*Ciconia nigra*), the Eurasian Eagle-owl (*Bubo bubo*), the Long-eared Owl (*Asio otus*). Within the nature reserve the Bezdin pond is to be found (actually an oxbow lake), on which lives the European White Waterlily (*Nymphaea alba* L.).

From the botany point of view the area is less known. The 1828 botanical studies of A. Rochel and those from 1858 of J. Heufel, in the east of Banat, make no reference to this area.

Later, L. Simonkai in his phytotaxonomic synthesis made in the 1880-1890 period on the flora and vegetation from the Arad surroundings, describes plant from Pecica and Semlac localities, getting though very close to the Bezdin area.

Other botanical studies were subsequently made by Al. Borza (1942-47), G. Bujoreanu (1942), and I.V. Oprea (1972) and by the team led by I. Moldovan (1972-1982).

Natural frame

The study area is located in the Arad Plain, geographic unit which presents altitudinal variations of low amplitude, between small hillocks which draw the old alluvial holms, reaching the negative shapes of the divagation and puddle cones or the plains formed by the former ponds, presently most of their surfaces being dried off.

The study area is limited at north and west by the Mureş River, to south-west and south by agricultural fields and pasture-lands belonging to Munar and Sanpetru German villages, and to east by the Pecica – Sanpetru German county road and the Sanpetru German village.

Image within the study area

The plain within the study area is of Holocene origin, having a progressive inclination from east to west, with altitudes beneath 100 m, with a pronounced divagation character, built on mires, clays, sands and loess like formations.

The following relief shape may be distinguished:

Depressions, low areas, old river beds and canals, cogged and deeply depressioned, which preserve year round stagnant water;

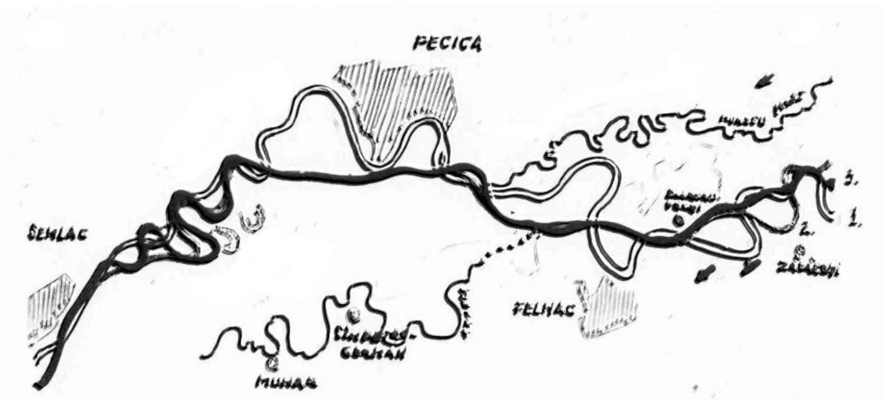
Low floodplain;

High floodplain;

The high floodplains have a dominant character and they are flooded in the dam – river shore area at medium high floods. The other relief shapes cover relatively small surfaces, island like, and they are flooded frequently or they are permanently covered with water.

The Arad Plain, and consequently the study area, is limited from east to west by the Mureş River, in the northern part of the study area. Due to the low energy of it`s declivity of just 0,1 m/km, the Mureş river bed is well developed and meandered with many secondary branches. The Mureş River, in the Bezdin area, has no tributary, but it`s discharge is variable, decreasing in summer to about 120 m^2/s, and provoking in the other seasons 2-3 floods with a high flood regime of over 2000 m^2/s.

The frequent raise of the water level above the flooding quote (410 cm) provoked often changes of the of the shores configurations and even of the meandering river bed, with many secondary branches. The Mureş River changed many times its river bed and shifted its course direction.



- The Mureş river course on the Lipszky map (1806) – 1.
- The Mureş river course at the end of the XIXth century – 2.
- The present Mureş river course – 3.
- Oxbow

Due to this reason, the floodplain situated at an altitude of 98-102 m, with a slight drop from east to west, it`s rivered by a network of canals, cogged oxbows and depressionary area, where water is accumulating during floods or from rainfalls and remains as ponds during long periods of time. These ponds are filled in also by low level phreatic water, situated at only 1,40-2,50 m deep, the substrate being formed of blue clay which gets down to 6,5-14 m.

This thick stratum retains water with free level, making small ponds and oxbows, or mires where the water level is changing upon the Mureş River water level. These terrains alternate with depressionary and muddy areas with high humidity, along with dry and sunny surfaces, the entire system occupying an area of 78 ha, meaning 8% of the Bezdin area.

Flora and vegetation

The study area has a floodplain woody steppe character, with many interesting characters.

Of the total surface (977 ha), about 8% (meaning 78 ha) are:

- depressions, low lands, old river beds and canals, clogged and profoundly depressioned, in which the water coming from rainfalls, flooding and the phreatic strata is kept year round in small ponds and oxbows;
- high humidity areas (with periodically stagnant water);
- sunny and dry areas (dams, forest openings, road sides, ruderal areas etc.).

The other 92% of the area (899 ha) are floodplain forest (gallery forests).

In each subunit of this region a specific flora and vegetation has formed, upon the life condition of the respective subunit.

General characterization of the flora

The flora of small ponds and oxbows in the central zone is represented by hydrophilic plants. Some of the species are floating and they are not fixed, as: Floating Watermoss (*Salvinia natans*), Greater Bladderwort (*Utricularia vulgaris*), Frog bit (*Hydrocharis morsus ranae*), Common Duckweed (*Lemna minor*), Ivy-leaved Duckweed (*Lemna trisulca*), etc. Other species are emerged, fixed through rhizomes, as: European White Waterlily (*Nymphaea alba*), Yellow Pond Lily (*Nuphar luteum*), or by roots, as Broad-leaved Pondweed (*Potamogeton natans*). The fixed, submerged species are not missing either, as: Water Soldier (*Stratiotes aloides*), Rigid Hornwort (*Ceratophyllum demersum*) etc.

European White Waterlily, emerged species the Bezdin Pond Flora fixed through rhizomes in the Bezdin Pond

In the central area the hydrophilic plants, towards the edge of the pond emerged amphibious species

Towards the edge of the ponds amphibious species are to be found, represented by the Bur-reed (*Sparganium ramosum*), Flowering Rush (*Butomus umbellatus*), Arrowhead (*Sagittaria sagittifolia*), European Water Plantain (*Alisma plantago aquatica*), Water Hemlock (*Cicuta virosa*), Purple Loosestrife (*Lythrum salicaria*) etc.

Broad-leaved Pondweed, emerged species fixed through roots in the Bezdin Pond

In the edge line of Bezdin Pond and in mires plants as Common Reed (*Phragmites communis*), Bulrush (*Typha latifolia*), Greater Pond-sedge (*Carex riparia*), Yellow Flag Iris (*Iris pseudacorus*), Crack Willow (*Salix fragilis*), White Willow (*Salix alba*), Almond Willow (*Salix triandra*) etc, are developing.

The flora of muddy areas is represented by mesophilic species, as: Yellow Loosestrife (*Lysimachia vulgaris*), Trifid Bur-marigold (*Bidens tripartitus*), Water Knotweed (*Polygonum amphibium*), Marsh Dock (*Rumex limosus*), Common Nettle (*Urtica dioica*), Water Mint (*Menta aquatica*), Grey Willow (*Salix cinerea*), etc.

Yellow Flag Iris emerged species in the edge of Bezdin Pond and mires in the Bezdin area

In dry and sunny areas, on dams, the most frequent species are: Meadow Fescue (*Festuca pratensis*), Furrowed Fescue (*F. rupicola*), Smooth Brome (*Bromus inermis*), etc., and in sunny, forest openings, Wood Sedge (*Carex sylvatica*), Remote Sedge (*Carex remota*) etc.

The forest flora comprises woody species of treed and scrubs, creepers and herbaceous plants.

The most important tree species are: White Willow (*Salix alba*), Crack Willow (*Salix fragilis*), White and Black Poplar (*Populus alba* and *Populus nigra*), Elm (*Ulmus campestris*), Common Ash (*Fraxinus excelsior*), Pedunculate Oak (*Quercus robur*), Pubescent Oak (*Quercus pubescens*) etc.

The underwood level is represented shrub species as: European Cornel (*Cornus mas*), Common Dogwood (*Cornus sanguinea*), Common Hawthorn (*Crataegus monogyna*), Privet (*Ligustrum vulgare*), Common Hazel (*Corylus avellana*), Spindle (*Euonymus europaeus*), Alder Buckthorn (*Rhamnus frangula*), European Cranberrybush (*Viburnum opulus*), Black Elder (*Sambucus nigra*), Purple Willow (*Salix purpurea*), Grey Willow (*Salix cinerea*) etc., and creeper species as Wilde Grapevine (*Vitis silvestris*), Old Man's Beard (*Clematis vitalba*), Common Ivy (*Hedera helix*), Hops (*Humulus lupulus*), Wild Cucumber (*Echynocistis lobata*) etc.

The surface of natural forest is reduced, about 6% of the total surface, being located mostly in the Prundul Mare area, the other forest surfaces being total or partially artificial.

The herbaceous strata is composed of the following more important plant species: Cocksfoot Grass (*Dactylis glomerata*), Wild arum (*Arum maculatum*), Yellow Loosestrife (*Lysimachia vulgaris*), Wind Flower (*Anemone nemorosa*), Bird-in-a-bush (*Corydalis solida*), Spotted Dog (*Pulmonaria officinalis*), White

Dead Nettle (*Lamium album*), Solomon's Seal (*Polygonatum officinale*), Lily of the Valley (*Convallaria majalis*).

The flora study was based on taxonomical, phyto-geographical, biological and ecological criteria.

Phyto-taxonomic analysis

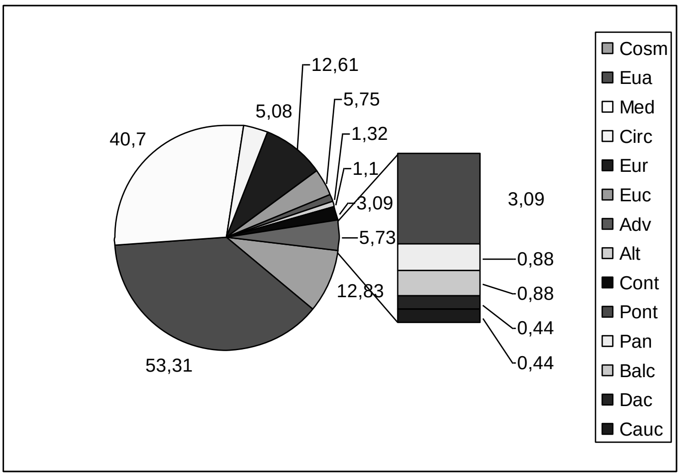
The phyto taxa conspectus of the studied area shows that the most spread species are the herbaceous plants characteristic to pastures and the ruderal plant species, reflecting hence the physiognomy of the regions predominant ecosystems.

It is worst mentioning that, from the total of 452 species identified in the study area about 7% are newly mentioned in the area. These taxa originate in the mountainous and sub-mountaineous regions of the Mureş river valley, spread by the water and acclimatized to the conditions from the study area.

The analysis of floral elements (geoelements)

The Bezdin area, from the point of view of the geoelements, it is situated in the Holarctic region, Euro-Siberian sub-region, Central-European and East-Carpathic province, “Western Plain” district.

The range of floristic elements presents as following:



Analyzing this range we can see that the Eurasian element dominate (Eua=53,31 %), followed by the Mediterranean (Med= 40,70%), European (Eur=12,61%), cosmopolite (Cosm=12,83%), central European (Euc=5,75%), circumpolar (Circ=5,08%), adventive (Adv=1,32%), Atlantic (Atl=1,10%), continental (Cont=3,09%), pontic (Pont=3,09%), panonic (Pan=0,88%), balkanic (Balc =0,88%), Caucasian (Cauc=044%) and Dacian (D=0,44 %).

The dominance of Eurasian element (Eua =53,31 %) indicate the appurtenance of the study area to the Euro-Siberian sub-region. The European elements in a wide sense are well represented (Eur = 12,61%), but we can see only a small number of Atlantic elements (Atl = 1,10%), which indicate the appurtenance of the inferior valley of the Mureş river to the central European floristic domain, within the Central-European and East-Carpathic province, “Western Plain” district.

The presence of circumpolar elements (Circ=5,08%), indicate the appurtenance to the Holarctic region.

The relatively high presence of southern origin species (Mediterranean elements), indicate a warm climate, favorising the growth and spread of termophilic species.

The region is rich in cosmopolite (Cosm = 12,83%) and adventive elements (Adv =1,32%), due to human influence on land use, confirming the former culturalization of the fields, and also the general ruderalisation of the regions vegetation.

The number of Dacian and balkanic elements is very low (D-B = 0,44% 0,88%).

Among the Eurasian elements, which can be found in remarkable quantities in many plant associations, we mention: *Populus alba, Populus tremula, Rhamnus chatarticus, Dactylis glomerata, Festuca pratensis, Asarum europeum, Viola silvatica, Astragalus glycyphylos, Salvinia natans* etc.

European species are present mostly in forests and mesophilic areas. We hence remember the following species: *Anemone ranunculoides, Pulmonaria officinalis, Ajuga reptans, Corydalis cava, Polygonatum latifolium, Lamium galeobdolon, Prunus spinosa, Cornus sanguinea, Ligustrum vulgare, Coryllus avelana* etc.

The best represented circumpolar species are: *Anemone nemorosa, Oxalis acetosella, Convalaria majalis, Poa pratensis*, etc.

The cosmopolite species examples are *Dryopteris filix-mas, Stellaria media, Poligonum aviculare, Agrostema githago, Capsella bursa-pastoris, Convolvulus arvensis, Xanthium spinosum, Datura stramonium* etc. They spread in parallel with areas deforestation, and others as *Phragmites communis, Typha latifolia, Lemna minor* etc., by accommodation to aquatic environment.

The Mediterranean and sub-mediterranean elements induce a characteristic note to the flora of the study area, through the following species: *Quercus cerris, Quercus robur, Cornus mas, Viola odorata, Geum urbanum, Lythospermum purpureo-coeruleum*, etc.

Adventive species as Robin*ia pseudoacacia, Amorpha fructicosa, Oenothera biennis* etc., are endemic species on other continents and they spread in the study area due to human voluntary or involuntary activity.

The atlantico-mediterranean elements are represented by *Ligustrum vulgare* and *Primula acaulis*, and the Dacian-balkanic elements by *Oenanthe banatica*.

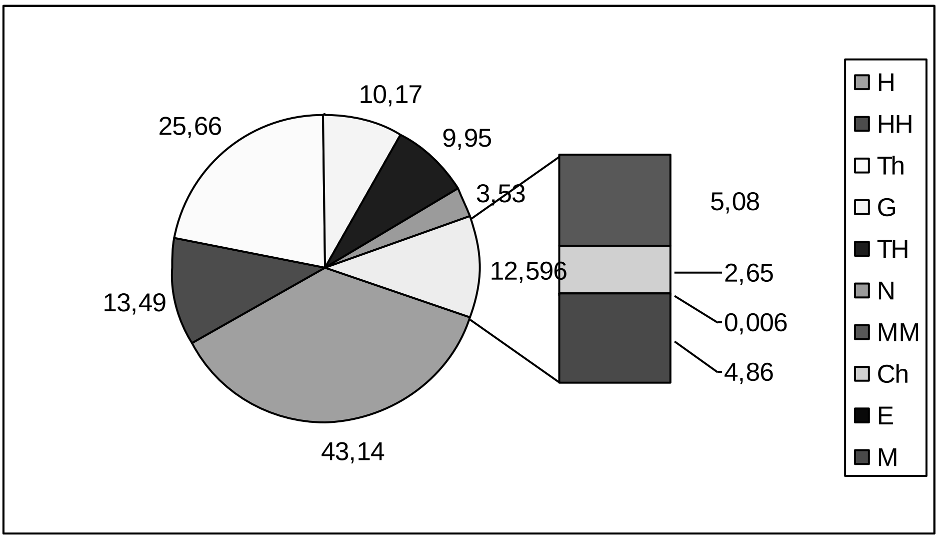
There are very few endemic species in the study area, and we were identifying the following Transylvanian-western endemic species: *Plantago major* and *Roripa kerneri*.

Bioforms analysis

Function to their percent participation in the study area, we observe the following percentages:

Hemicryptophytes (H = 43,14%),
Annual Therophytes (Th =25,66 %),
Biannual Therophytes(TH = 9,95%),
Helohidatophytes (HH =13,49 %),
Geophytes (G = 10,17%),
Nanophanerophytes (N =3,53 %),
Microphanerophytes (M = 4,86%)
Megaphanerophytes (MM =5,08 %),
Chamaephytes (Ch =2,65 %),
Epiphytes (E = 0,006%).

The bioforms range presents as following:



The high percentage of Hemicryptophytes indicate the presence of pastures and ruderal species. The large number of Therophytes is due to anthropogenic influences, made in a dry climate of woody-steppe, close to the dry steppe climate. The presence of Annual Therophytes confirms a former culturalization of the area, as also does the vegetations ruderalisation due to large agro-phytocenosys nearby. In descending order follow the Helohidatophytes, Geophytes and the Chamaephytes, which indicate the herbaceous physiognomy of the plant cover in the study area. The presence of Nanophanerophytes and Megaphanerophytes is the proof that in the area exist natural woodlands, luxuriant with creepers, where primitive elements of the typical floodplain woody-steppe are still preserved.

The ecological analysis

In order to perform an ecological characterization of the flora, three factors of major importance were taken in regard: air humidity (U), temperature (T) and soil reactivity (R). For these factors the H. Ellenberg scale was used, adapted to our countries conditions by ŞT. Csűrös and collaborators, expressing quantitatively both the species need towards a factor and the presence of the respective factor in the area.

Analyzing the flora of the Bezdin area we observe the following:

Humidity factor (U)

The highest percentage is owned by the mesophilic species with 23,8%, which indicate the existence of favourable humidity conditions year round.

The considerably high percentage of mesohigrophytes and hygrophytes confirm the presence of ponds and of the floodplain climate, which favors the development of these plants.

The participation of xeophytes and xero-mesophytes is realized by the southern and pontic xerotherme species, reflecting the warm climate and sometimes even dry climate during summer months.

Temperature factor (T)

More than half species – 61,5% - are mesothemes, reflecting favourable temperature conditions.

The mildly thermophile species cu 21,5% indicate the participation in a considerable number of the southern, submediterranean and Mediterranean thermophilic species in the study area.

Soil reactivity factor (R)

The existence of low-acid neutrophile species in a percentage of 36,8% indicate the adaptation of the studied flora to low-acid to alkaline soils, made by alluvial formations and sedimentary substrata.

As a conclusion, we can mention that all the ecological indices of the area confirm the existence of very favourable living conditions (humidity, temperature, trophicity), for plant species.

General characterization of the vegetation

In general, the study area vegetation has a mosaic character, determined by the Mureş floodplain micro-relief (Bezdin area), missing high disevelments, rivered chaotically by secondary river beds, low areas with ponds and mires. This micro-relief favorized the formation of a variety of floodplain biotopes, with specific biocenosys: aquatic, mires, mud's, pastures, dams, forest openings etc. Of the total surface of Bezdin area, 60% is occupied by woodlands, represented by derivate forests, consisting mostly of willows, ash and oak forests.

Bezdin Pond – view toward the bird watching tower

FLORA LIST

EQUISETACEAE

1. *Equisetum arvense* L.; U3 T3 R0; G, Cosm – humid areas, dam edge
2. *Equisetum ramosissimum* Desf.; U2 T0 R0; G, Cosm **-** dam edge
3. *Equisetum palustre* L.; U5 T 2 R0; G, Cosm – small ponds and swamps edge

DRYOPTERIDACEAE

4. *Dryopteris filix-mas* (L.) Schott; U4 T3 R0; H, Cosm – dark areas from the arcade forest

MARSILIACEAE

5. *Marsiliea quadrifolia* L.; U6 T3 R0; HH, Eua (Med) **-** small ponds and swamps edge

SALVINIACEAE

6. *Salvinia natans* (L.) All.; U6 T3 R3; HH, Eua - in stagnant water from small ponds, oxbows and swamps

CORYLACEAE

7. *Corylus avellana* L.; U3 T3 R3; M, Balc – in the arcade forest

BETULACEAE

8. *Alnus glutinosa (*L.) Gaertn.; U5 T3 R3; MM (M), Eua- oxbows edge and the Mureş River edge

FAGACEAE

9. *Quercus robur* L.; U3.5 T3 R0; MM, Eur- higher areas from floodplain forest
10. *Quercus cerris* L.; U2 T3.5 R3; MM (M), Med- higher areas from floodplain forest
11. *Quercus pubescens* Willd.; U1.5 T5 R5; MM (M), Med - higher areas from floodplain forest

MORACEAE

12. *Morus nigra* L.; U2 T3.5 R4; MM (M), Med (China) - in floodplain forest
13. *Morus alba* L.; U2 T3.5 R4; MM (M), Adv (Asia) - in floodplain forest

CANNABACEAE

14. *Humulus lupulus* L.; U3.5 T3 R4; H, Eua – near small ponds and oxbows and in the Prundul Mare forest

ULMACEAE

15. *Ulmus minor* Mill.; U3 T3 R4; MM, Eur – in floodplain forest
16. *Ulmus laevis* Pall.; U4 T3 R3; MM, Eur – in floodplain forest

JUGLANDACEAE

17. *Juglans nigra* L.; MM, Am, de N – in floodplain forest

SALICACEAE

18. *Populus alba* L.; U3.5 T3 R3; MM – M, Eua – humid areas in floodplain forest
19. *Populus nigra* L.; U4 T3 R4; MM – M, Eua - humid areas in floodplain forest
20. *Populus* X *canadensis* Moench; MM – M, Adv. (Am) - humid areas in floodplain forest
21. *Salix fragilis* L.; U5 T3 R4; MM – N, Eua (Md) - humid areas in floodplain forest
22. *Salix x rubens* Schrank; U4.5 T3.5 R3.5; MM – N, Eur, (Med) – Mureş River edge
23. *Salix alba* L.; U5 T3 R4; MM – N, Eua, (Med) - Mureş River edge and in the parks from Prundul Mare
24. *Salix triandra* L.; U5 T3 R0; N, Eua – swampy areas from floodplain forest
25. *Salix purpurea* L.; U5 T3 R4.5; N, Eua (Med) – humid areas from parks
26. *Salix cinerea* L.; U5 T3 R3; N, Eua, (Med) – in rush-beds and swampy areas

27. *Salix viminalis* L.; U5 T2 R4.5; N, Eua - swampy areas from floodplain forest
28. *Salix caprea* L.; U3 T3 R4; N, Eua - swampy areas from floodplain forest

URTICACEAE

29. *Urtica urens* L.; U3 T3 R4; Th, Cosm – roadsides, affluent in nitrogen and ruderal areas
30. *Urtica dioica* L.; U3 T3 R4; H, Cosm - roadsides, affluent in nitrogen and ruderal areas and in reed

LORANTHACEAE

31. *Loranthus europaeus* Jacq.; U3 T3.5 R0; Ch-N, Eur – semi parasitic on oak
32. *Viscum album* L.; U3.5 T3 R0; Ch (N), Eur – semi parasitic on oak

POLYGONACEAE

33. *Rumex maritimus* L.; U5 T3.5 R4.5; Th, Cosm – small pond edges, oxbows and swamps
34. *Rumex dentatus* L.; U4.5 T4.5 R4; Th – TH, Eua (Cont) - small pond edges, oxbows and swamps
35. *Rumex conglomeratus* Murray; U4 T4 R4; H, Circ - - small pond edges, oxbows and swamps
36. *Rumex stenophyllus* Ledeb.; H, Eua (Cont) - small pond edges, oxbows and swamps
37. *Reumex acetosa* L.; U3 T0 R0; H, Cosm – on dam and in openings from floodplain forest
38. *Rumex acetosella* L.; U2 T3 R2; H. Cosm – on dam and ruderal areas
39. *Polygonum amphibium* L.; U6 T3 R0; G – HH, Eur (Med) – oxbow edges, swamps and humid, muddy areas
40. *Polygonum lapathifolium* L.; U4 T0 R3; Th, Cosm – sandy areas in floodplain
41. *Polygonum persicaria* L.; U4.5 T3 R0; Th, Cosm – roadsides, diggings and floodplain
42. *Polygonum minus* Huds.; U4.5 T3 R4; Th, Cosm – humid areas in floodplain
43. *Polygonum aviculare* L.; U2.5 T0 R3; Th, Cosm – roadsides and ruderal areas
44. *Fallopia convolvulus* (L.) A&A.Löve; (*Polygonum convolvulus* L.) U2.5 T0 R3; Th, Eua (Med) – floodplain ponds
45. *Fallopia dumetorum* (L.) Holub; (*Polygonum dumetorum* L.) U T R; Th, Eua (Med) – humid areas from forest and bush

CHENOPODIACEAE

46. *Chenopodium hybridum* L.; U3 T3 R0; Th, Eua (Med) – floodplain ponds
47. *Chenopodium urbicum* L.; U3 T0 R3; Th, Eua (Med) - humid areas from forest and bush

48. *Chenopodium album* L.; U3 T3 R0; Th, Eua (Med) - ruderal areas
49. *Chenopodium polyspermum* L.; U3 T4 R0; Th, Eua (Med) - ruderal areas and floodplain
50. *Chenopodium vulvaria* L.; U3 T4 R4; Th, Eua (Med) - ruderal areas and roadsides
51. *Chenopodium rubrum* L.; U3.5 T0 R0; Th, Circ – humid areas in floodplain
52. *Chenopodium glaucum* L.; U3.5 T4 R0; Th, Eua – humid areas in floodplain
53. *Atriplex nitens* Schkuhr; Th, Eua - humid areas in floodplain
54. *Atriplex tatarica* L.; U2 T4 R0; Th, Eua (Med) - ruderal areas and roadsides

AMARANTHACEAE

55. *Amaranthus retroflexus* L.; U3 T3 R0; Th, Adv - ruderal areas and roadsides

CARYOPHYLLACEAE

56. *Silene vulgaris* (Moench) Garcke; U3 T3 R4; H (Ch), Eua (Med) – on dam
57. *Lychnis flos-cuculi* L.; U3.5 T2.5 R0; H, Eua (Med) – on dam and in forest openings
58. *Silene latifolia* Poir. subsp. *alba* (Mill.) Greuter & Burdet; (*Melandrium album* (Mill.) Garcke.) U3.5 T2 R3; H (Ch), Eua (Med) - ruderal areas, roadsides and on dam
59. *Silene viscosa* (L.) Pers.; (*Melandrium viscosum* (L.) Kelak.) U2.5 T3 R4; Th, Eua – dam basis
60. *Cucubalus baccifer* L.; U3.5 T3 R4; H, Eua – floodplain bush
61. *Gypsophyla muralis* L.; U2 T3 R2; Th, Eua – humid areas in floodplain
62. *Vaccaria hispanica* (Mill.) Rauschert; (*Vaccaria pyramidata* Medik.) U3 T3 R0; Th, Eua (Med) – on dam
63. *Dianthus armeria* L.; U2 T3 R3; Th, Eur - forestsides, forest openings and on dam
64. *Saponaria officinalis* L.; U3 T3 R0; H, Eua (Med) – Mureş River flood plain and on dam
65. *Myosoton aquaticum* (L.) Moench; (*Stellaria aquatica* (L.) Scop.) U4 T3 R0; Th – TH, Eua (Med) – humid areas in floodplain and willow parks
66. *Stellaria media* (L.) Vill.; U3 T0 R0; Th – TH, Cosm – in floodplain
67. *Stellaria holostea* L.; U3 T3 R3; H, Cosm – floodplain bush
68. *Stellaria graminea* L.; U2.5 T2 R3; H, Eua – humid areas in floodplain
69. *Cerastium pumilum* Curtis; U2 T3 R0; Th, Eur (Med) - on dam
70. *Arenaria serpyllifolia* L.; U2 T2.5 R0; Th, Eua (Med) – road sides and on dam

71. *Herniaria glabra* L.; U2.5 T3.5 R3; Th - TH – H, Euc (Med) - roadsides and on dam, ruderal areas

EUPHORBIACEAE

72. *Euphorbia helioscopia* L.; U3 T3 R0; Th, Cosm – roadsides and diggings
73. *Euphorbia serrulata* Thuill.; (*Euphorbia stricta* L.) U4 T3 R3; Th, Eur, Cont – humid areas near oxbows and channels
74. *Euphorbia palustris* L.; U4.5 T3.5 R4.5; H – HH, Eua (Cont) – humid areas near oxbows and channels
75. *Euphorbia cyparissias* L.; U2 T3 R4; H (G), Eua (Med) – arid areas and roadsides
76. *Euphorbia salicifolia* Host; U2 T3.5 R3; H, Pont – on dam

RANUNCULACEAE

77. *Clematis recta* L.; U2.5 T3 R4; H, Euc (Pont - Med) – in parks and floodplain bush
78. *Clematis vitalba* L.; U3 T3 R3; N-E, Euc (Med) - Prundul Mare forest
79. *Clematis integrifolia* L.; U3 T3.5 R5; H, Eua (Cont) – humid meadows
80. *Thalictrum flavor* L.; U4.5 T0 R4.5; H, Eua – humid areas in Prundul Mare
81. *Anemone nemorosa* L.; U3.5 T3 R0; G, Circ - Bezdin forest
82. *Anemone ranunculoides* L.; U3.5 T3 R4; G, Eur - Bezdin forest
83. *Ranunculus ficaria* L.; U3.5 T3 R3; H –G, Eua - Bezdin forest
84. *Ranunculus repens* L.; U4 T0 R0; H, Eua (Med) – roadsides and diggings
85. *Ranunculus acris* L.; U3.5 T0 R0; H – G, Eua – deep, humid areas in floodplain
86. Ranunculus polyanthemus L.; U2.5 T3 R3; H, Eur (Med) – forest openings and on dam
87. *Ranunculus sceleratus* L.; U4.5 T3 R4; Th, Circ – diggings and humid, muddy areas
88. *Ranunculus aquatilis* L.; U6 T4 R0; HH, Cosm – oxbow water, swamps and floodplain channels

ARISTOLOCHIACEAE

89. *Aristolochia clematitis* L.; U2.5 T3.5 R5; H (G), Med (Ec) – in floodplain forest parks
90. *Asarum europaeum* L.; U3.5 T3 R4; H (G), Eua – flood areas in Bezdin forest

NYMPHAEACEAE

91. *Nymphaea alba* L.; U6 T0 R4; HH, Eur (Med) – stagnant water of reservation pond
92. *Nuphar luteum* Sm.; U6 T0 R3.5; HH, Eue (Med) - stagnant water of reservation pond

CERATOPHYLLACEAE

93. *Ceratophyllum demersum* L.; U6 T3 R0; HH, Cosm - oxbow water, swamps and floodplain channels

PAPAVERACEAE

94. *Papaver rhoeas* L.; U3 T3.5 R4; Th, Eua – roadsides and on dam
95. *Papaver dubium* L.; U2 T3.5 R3; Th, Med (Euc) – on dam and in Prundul Mare floodplain
96. *Chelidonium majus* L.; U3 T3 R4; H, Eua (Med) - forestsides
97. *Corydalis cava* (L.) Schweigg. & Körte; U3 T3 R0; G, Eur (Med) – humid areas in forest
98. *Corydalis solida* (L.) Clairv.; U3 T3 R4; G, Eue (Med) - humid areas in forest
99. *Fumaria schleicheri* Soy.-Will.; U2.5 T4 R4; Th, Eua (Med) – ruderal areas

CRUCIFERAE (BRASSICACEAE)

100. *Rorippa islandica* (Oeder) Borbás; U5 T3 R4; Th – TH, Cosm – humid, muddy areas in floodplain
101. *Rorippa sylvestris* (L.) Besser; U4 T3 R4; H (G), Eua (Med) – humid areas and in diggings
102. *Rorippa austriaca* (Crantz) Besser; U4 T3.5 R4; H (G), Pont – humid areas and in diggings
103. *Rorippa amphibia* (L.) Besser; U6 T3 R4; HH, Eua, (Med) – stagnant water in floodplain
104. *Barbarea vulgaris* R.Br.; U3.5 T3 R3; Th – H, Eua (Med) – humid areas, diggings and floodplain
105. *Cardamine pratensis* L. U5 T3 R0; H, Circ – humid areas in floodplain forest
106. *Sisymbrium orientale* L.; U2.5 T4 R3; Th – TH, Eua (Med) - roadsides
107. *Sisymbrium officinale* (L.) Scop.; Th, Eua (Med) - roadsides
108. *Descurainia sophia* (L.) Webb ex Prantl; (*Sisymbrium sophia* L.) U2.5 T4 R4;Th-TH, Eua (Med) - roadsides
109. *Alliaria petiolata* (M.Bieb.) Cavara & Grande; (*Alliaria officinalis* Andrz.) U3 T3 R4; TH – H, Eua (Med) – roadsides and forest openings
110. *Sinapis arvensis* L.; Th, Cosm – roadsides and ruderal areas
111. *Alyssum alyssoides* (L.) L.; U1 T3 R0; Th – TH, Eua (Med) – sunny areas on dam
112. *Erophila verna* (L.) Chevall.; (*Draba verna* L.) U2.5 T3.5 R0; Th, Eua (Med) – on dam, roadsides and digging
113. *Capsella bursa-pastoris* (L.) Medik.; U3 T0 R0; Th – TH, Cosm (Med) - on dam, roadsides and digging
114. *Thlapsi arvense* L.; U2 T3 R4; Th-TH, Eua - on dam, roadsides and digging

115. *Thlapsi perfoliata* L.; U2.5 T3.5 R4.5; Th, Eua - on dam, roadsides and digging
116. *Cardaria draba* (L.) Desv.; (*Lepidium draba* L.) U2 T4 R5; H, Eua (Med) -
117. *Raphanus raphanistrum* L.; U2.5 T3 R0;Th, Eua - on dam, roadsides and digging

RESEDACEAE

118. *Reseda lutea* L.; U2 T3 R0;TH – H, Eua (Med) – roadsides and ruderal areas

VIOLACEAE

119. *Viola odorata* L.; U2.5 T3.5 R4; H, Alt-Med – in tunnel forest
120. 120.*Viola reichenbachiana* Jord. ex Boreau; (*Viola silvestris* Lam.) U3 T2.5 R3; H, Eua (Med) - in tunnel forest
121. *Viola elatior* Fr.; U4 T4 R4.5; H, Eua (Cont) – humid areas from forestsides and on dam basis
122. *Viola pumila* Chaix; U3 T3 R4; H, Eua – humid areas from floodplain
123. *Viola arvensis* Murray; U3 T3 R0; Th, Cosm - ruderal areas

HYPERICACEAE

124. *Hypericum perforatum* L.; U3 T3 R0; H, Eua (Med) - forestsides, roadsides and paths
125. *Hypericum tetrapterum* Fr.; (*Hypericum acutum* Mnch.) U4 T3 R4; H, Eua - around swamps, oxbows and channels

SAXIFRAGACEAE

126. *Chrysosplenium alternifolium* L.; U4 T2 R4; H, Eua – humid areas from floodplain

ROSACEAE

127. *Prunus spinosa* L; U2 T3 R3; M, Eua (Med) – forestsides and lawns
128. *Fragaria vesca* L.; U3 T2.5 R0; H, Eua – on dam and forest openings
129. *Geum urbanum* L.; U3 T3 R4; H, Eua (Med) – in tunnel forest
130. Potentilla supina L.; U4 T3 R0; Th – H, Eua (Med) - in Mureş floodplain
131. *Potentilla anserina* L.; U4 T3 R4; H, Cosm - in Mureş floodplain
132. *Potentilla reptans* L.; U3.5 T4 R4; H, Cosm – stagnant waters edge in floodplain
133. *Crataegus monogyna* Jacq.; U2.5 T3.5 R3; N, Eua (Med) – floodplain forests
134. *Pyrus pyraster* Burgsd.; U2 T3 R4; MM, Eur (Med) - floodplain forests
135. *Malus sylvestris* Mill.; U3.5 T3 R4; MM, Eur (Med) - floodplain forests
136. *Rosa canina* L.; U2 T3 R3; N, Eua (Med) – forestsides and lawns
137. *Rubus caesius* L.; U4.5 T3 R4; H-Ch, Eua (Med) – floodplain forests

LEGUMINOSAE

138. *Melilotus officinalis* (L.) Pall.; U2.5 T3.5 R0; TH, Eua (Med) - roadsides
139. *Trifolium fragiferum* L.; U3 T3 R5; H, Eua – humid areas in floodplain
140. *Trifolium hybridum* L.; U3.5 T3 R4; H, Eur - humid areas in floodplain and stagnant waters edge
141. *Trifolium repens* L.; U3.5 T0 R0; H, Cosm - humid areas in floodplain and stagnant waters edge
142. *Lotus corniculatus* L.; U2.5 T0 R0; H, Eua (Med) – on dam and forest openings
143. *Galega officinalis* L.; U4.5 T3 R4; H, Pont – Med – stagnant waters edge in floodplain
144. *Amorpha fructicosa* L.; U3 T4 R0; N, Adv –in floodplain, on Mureş side
145. *Glycyrrhiza echinata* L.; U4 T4 R0; H, Pont – Med -in Mureş floodplain
146. *Vicia dumetorum* L.; U3 T3 R4.5; H, Euc (Med) – on dam and in forests
147. *Vicia pisiformis* L.; U2 T3 R4.5; H, Euc - on dam and in forests
148. *Vicia grandiflora* Scop.; U3 T3 R0; Th, Pont – Cauc- Balc – on dam
149. *Vicia sativa* L.; U0 T3 R0; Th, Med – on dam
150. *Lathyrus vernus* (L.) Bernh.; U3 T3 R3; H, Eua – on dam and along Mureş
151. *Lathyrus tuberosus* L.; U2 T4 R4; H, Eua (Med) – on dam
152. *Lathyrus palustris* L.; U5 T2 R5; H, Circ – humid areas in Bezdin forest
153. *Robinia pseudacacia* L.; U2.5 T4 R0; MM, Adv – in floodplain forest

LYTHRACEAE

154. *Lythrum salicaria* L.; U4 T2.5 R0; H – HH, Eur – Mureş side and stagnant waters edge

ONAGRACEAE

155. *Epilobium hirsutum* L.; U4 T3 R3.5; H – HH, Eua (Med) – in rush-beds
156. *Epilobium parviflorum* Schreb.; U5 T3 R4.5; H, Eua – in rush-beds
157. *Epilobium montanum* L.; U3 T0 R3.5; H. Eua (Med) - near Bezdin pond
158. *Epilobium adnatum* Griseb.; H, Eua (Med) – near pond waters, swamps, channels,etc.
159. *Oenothera biennis* L.; U2 T4 R0; TH, Adv – Mureş side
160. *Circaea lutetiana* L.; U3.5 T3 R4; G, Eua (Med) – humid areas from tunnel forest

TRAPACAE

161. *Trapa natans* L.; U6 T4 R3.5; HH, Eua (Med) - in stagnant waters from small ponds and oxbows from floodplain

HALORAGACEAE

162. *Myriophyllum verticillatum* L.; U6 T3.5 R3.5; HH, Euc - in stagnant waters from small ponds and oxbows from floodplain

MALVACEAE

163. *Malva sylvestris* L.; U3 T3 R0; Th, TH, H, Cosm – roadsides and ruderal areas
164. *Malva neglecta* Wallr.; U3 T3 R0; Th, TH, H, Eua (Med) - roadsides and ruderal areas
165. *Althaea officinalis* L.; U3 T4 R4; H, Eua (Cont) – flood areas from floodplain
166. *Lavatera thuringiaca* L.; U2.5 T3 R0; H, Eua (Cont) – forestsides and bush

OXALIDACEAE

167. *Oxalis acetosella* L.; U4 T3 R3; H -G, Circ – flood areas in floodplain
168. *Oxalis stricta* L.; U3.5 T0 R0; H, Adv - – flood areas in floodplain

GERANIACEAE

169. *Geranium robertianum* L.; U3.5 T3 R3; Th-Th, Cosm – humid areas in floodplain forest
170. *Geranium palustre* L.; U4 T3 R4.5; H, Eua – stagnant waters in floodplain

TILIACEAE

171. *Tilia cordata* Mill.; U3 T3 R3; MM, Eur – floodplain forests

ACERACEAE

172. *Acer campestre* L.; U2.5 T3 R3; M- MM, Eur - floodplain forests
173. *Acer tataricum* L.; U2.5 T3.5 R4; M- MM, Eur (Cont) - floodplain forests

CELASTRACEAE

174. *Euonymus europaeus* L.; U3 T3 R3; M, Eur (Med) - floodplain forests
175. *Euonymus verrucosus* Scop.; U2.5 T3 R4; M, Eur - floodplain forests

RHAMNACEAE

176. *Rhamnus catharticus* L.; U2 T3 R4; M, Eua (Med) - floodplain forests
177. *Frangula alnus* Mill.; U4 T3 R3; *(Rhamnus frangula* L.) M, Eua (Med) - floodplain forests

VITACEAE

178. *Vitis vinifera* L. subsp. *sylvestris* (C.C.Gmel.) Hegi; (*Vitis sylvestris* Gmel.) M – E, Med (Pont) - floodplain forests
179. *Parthenocissus quinquefolia* (L.) Planch.; N, Adv - floodplain forests

ARALIACEAE

180. *Hedera helix* L.; N –E, Alt - Med - floodplain forests

CORNACEAE

181. *Cornus mas* L.; U2 T3.5 R4; M, Pont -Med - floodplain forests
182. *Cornus sanguinea* L.; U 3T3 R4; M, Ec - floodplain forests

UMBELLIFERAE

183. *Eryngium planum* L.; U2 T3 R4; H, Eua – along dam basis

184. *Aegopodium podagraria* L.; U3.5 T3 R3; H (G), Eua – humid areas in floodplain forest
185. *Pimpinella saxifraga* L.; U2.5 T0 R3; H, Eua (Med) - humid areas in floodplain forest
186. *Sium latifolium* L.; U6 T0 R4; HH, Eua – humid areas in tunnel forest
187. *Oenanthe aquatica* (L.) Poir.; U6 T3 R0; HH, Eua (Med) – in small ponds, oxbows and swamps
188. *Oenanthe banatica* Heuff.; U4 T3.5 R0; H, Dac-Balc - in small ponds, oxbows and swamps
189. *Aethusa cynapium* L.; U3.5 T3 R0; Th –TH - humid areas in tunnel forest
190. *Angelica sylvestris* L.; U4 T3 R3; H, Eua - in small ponds, oxbows and swamps
191. *Pastinaca sativa* L.; U3 T4 R4; TH – H – roadsides and on dam
192. *Chaerophyllum bulbosum* L.; U4 T3.5 R4.5; TH – H – forestsides and bush
193. *Conium maculatum* L.; U3 T3 R3; Th – TH, Eua (Med) – forestsides and diggings
194. *Cicuta virosa* L.; U5 T0 R3; HH, Eua – in rush-beds and diggings

PRIMULACEAE

195. *Primula veris* L.; (*Primula officinalis* (L.) Hill) U3 T2 R5; H, Atl-Med – along dam
196. *Primula vulgaris* Huds.; (*Primula acaulis* (L.) Hill) U3 T3 R3; H, Eua – humid areas in floodplain
197. *Hottonia palustris* L.; U6 T3.5 R3; HH, Eur - between reed in Bezdin pond
198. *Lysimachia nummularia* L.; U4 T3 R3; Ch, Eur (Med) – humid, muddy areas in floodplain
199. *Lysimachia punctata* L.; U3.5 T3.5 R3; H, Eur – humid areas in floodplain
200. *Lysimachia vulgaris* L.; U5 T2 R0; HH-HH, Eua (Med) - humid areas in floodplain and along dam basis

CONVOLVULACEAE

201. *Convolvulus arvensis* L.; U2.5 T3.5 R3.5; H – G, Cosm – on dam
202. *Cuscuta europaea* L.; U4 T0 R0; Th, Eua (Med) – parasite on nettle and hop in floodplain

ASCLEPIADACEAE

203. *Vincetoxicum hirundinaria* Medik.; (*Vincetoxicum officinale* Moench (Cynanchum vincetoxicum Pers.) U2 T4 R4; H, Eua (Med) – small ponds, oxbows and channels edge

BORAGINACEAE

204. *Heliotropium europaeum* L.; U2 T4 R0; Th, Med (Eur) – roadsides and on dam
205. *Lappula squarrosa* (Retz.) Dumort. subsp. *squarrosa;* (*Lappula myosotis* Moench) U1.5 T3.5 R4; Th-TH, Eua - roadsides and on dam
206. *Cynoglossum officinale* L.; U3 T3 R3; Th, Eua - roadsides and on dam
207. *Symphytum officinale* L.; U4 T3 R0; H, Eur – humid areas, oxbows and channels edge
208. *Cerinthe minor* L.; U3 T3 R0; TH (Th, H), Pont – Med - roadsides
209. *Echium vulgare* L., U2 T3 R4; Th, Eua – roadsides and on dam
210. *Pulmonaria officinalis* L.; U3.5 T3 R3; H, Euc – humid forest openings in floodplain
211. *Pulmonaria mollissima* A.Kern.; U2.5 T3 R4; H, Euc - – humid forest openings in floodplain
212. *Lithodora rosmarinifolia* (Ten.) I.M.Johnst.; (*Lithospermum purpurocaeruleum* L.) U2.5 T4 R4.5; H-G, Euc-Med – tunnel forest sides and bush
213. *Myosotis scorpioides* L.; (*Myosotis palustris* (L.) Hill) U5 T3 R4; TH-H, Eua – near stagnant waters in floodplain
214. *Myosotis sparsiflora* J.G.Mikan ex Pohl; U3.5 T3 R4; Th- Eua (Cont) – humid areas in floodplain

SOLANACEAE

215. *Solanum nigrum* L.; U3 T4 R0; Th, Cosm - ruderal areas
216. *Solanum dulcamara* L.; U4.5 T3 R4; Ch, Eua (Med) – openings in tunnel forest and small ponds edge
217. *Physalis alkekengi* L.; U3 T3 R4; H, Med (Euc) – forestsides, roadsides and diggings
218. *Hyoscyamus niger* L.; U3 T3 R4; H (Th - TH), Eua (Med) - roadsides
219. *Datura stramonium* L.; U3.5 T4 R4; Th, Cosm – roadsides and ruderal areas

SCROPHULARIACEAE

220. *Verbascum phlomoides* L.; U2.5 T3.5 R4; TH, Eua (Med) - roadsides
221. *Verbascum chaixii* Vill. subsp. *austriacum* (Schott ex Roem. & Schult.) Hayek; *(Verbascum austriacum* Schott ex Roem. & Schult.) U2 T3 R4; TH – H, Eua – roadsides and forest
222. *Verbascum blattaria* L.; U2.5 T3.5 R3; H, Eua (Med) - roadsides and forest
223. *Verbascum phoeniceum* L.; U2 T4 R4; H, Eua (Cont) – forest openings
224. *Scrophularia nodosa* L.; H, Eua – floodplain openings
225. *Scrophularia scopolii* Hoppe; U4 T3 R0; H, Eua – humid areas in forest and floodplain bush

226. *Gratiola officinalis* L.; U4.5 T3 R4; H, Eua – humid areas around small ponds, oxbows and channels
227. *Linaria vulgaris* Mill.; U2 T3 R3; H, Eua (Med) – on dam
228. *Veronica anagallis-aquatica* L.; U4.5 T0 R4; H – HH, Eur – near channels, deep, humid areas in floodplain
229. Veronica chamaedris L.; U3 T0 R0; H (Ch), Eua – forestsides and on dam
230. *Veronica beccabunga* L.; U5 T3 R4; H – HH, Eua (Med) – humid, low areas from floodplain and diggings
231. *Veronica prostrata* L.; U2 T4 R3; Ch, Eua (Med) – on dam
232. *Veronica spuria* auct., non L.; (*Veronica spuria* L.) U0 T3 R4; H, Eua - humid areas around small ponds, oxbows and channels in floodplain
233. *Veronica spicata* L. subsp. *orchidea* (Crantz) Hayek; (*Veronica orchidea* Crantz) U1 T4 R4; H, Euc – forestsides and openings
234. *Veronica arvensis* L.; U2.5 T3 R3; Th, Eua (Med) – on dam
235. *Limosella aquatica* L.; U4.5 T3 R0; Th, Cosm – humid, muddy areas in floodplain
236. *Melampyrum cristatum* L.; U2 T3 R5; Th, Eua – forest openings and bush

SCROPHULARIACEAE

237. *Lathraea squamaria* L.; U3 T3 R3; G, Eua – parasite on black poplar roots plop in flood areas of tunnel forest

LENTIBULARIACEAE

238. *Utricularia vulgaris* L.; U6 T0 R3.5; HH, Circ -in Bezdin pond

LABIATAE

239. *Salvia austriaca* Jacq.; U2 T3.5 R4; H, Pont – on dam
240. *Salvia pratensis* L.; U2.5 T3 R5; H, Eur (Med) – on dam
241. *Salvia nemorosa* L.; U2.5 T4 R3; H, Eue – on dam
242. *Salvia verticillata* L.; U2 T4 R0; H, Eur (Med) - roadsides
243. *Salvia glutinosa* L.; U3.5 T3 R4; H, Eur (Med) – humid areas in floodplain forest
244. *Mentha pulegium* L.; U4.5 T3 R5; H, Eua – humid, swampy areas, in floodplain
245. *Mentha arvensis* L.; U3 T3 R0; H-G, Circ - humid, swampy areas, in floodplain
246. *Mentha aquatica* L.; U5 T3 R0; HH – H, Eur (Med) – small ponds, oxbows and swamps edge
247. *Lycopus europaeus* L.; U5 T3 R0; HH, Eua (Med) – swamps and diggings
248. *Lycopus exaltatus* L.; U5 T3 R0; HH, Eua - swamps and diggings
249. *Lamium maculatum* L.; U3.5 T3 R4; H, Ch, (Eua) – humid area in floodplain forest

250. *Lamium album* L.; U3 T3 R0; H, Eua – forestsides and on dam
251. *Lamiastrum galeobdolon* (L.) Ehrend. & Polatschek; H (Ch), Eur (Med) - humid area in floodplain forest
252. *Galeopsis speciosa* Mill.; U3 T2 R0; Th, Eua - humid area in floodplain forest
253. *Stachys sylvatica* L.; U3 T2 R0; H, Eua – dark areas in floodplain forest
254. *Satchys palustris* L.; U4 T3 R4; H, Circ – humid areas, small ponds, oxbows and swamps edge
255. *Stachys recta* L.; U2 T5 R5; H, Pont - Med – openings in floodplain forest and on dam basis
256. *Stachys officinalis* (L.) Trevis.; U3 T3 R0; H, Eua (Med) – forest openings
257. *Marrubium vulgare* L.; U1 T4 R4; H, Eua - roadsides
258. *Leonurus cardiaca* L.; U3 T3 R0; H, Med – Eur – roadsides and ruderal areas
259. *Scutellaria galericulata* L.; U4 T3 R4; H, Eua – humid areas and rush-beds
260. *Scutellaria hastifolia* L.; U5 T3 R3; H, Eur – humid areas in floodplain
261. *Prunella vulgaris* L.; U3 T3 R0; H, Eua – forestsides and openings
262. *Ajuga reptans* L.; U3.5 T2.5 R0; H (Ch), Eur (Med) - forestsides and openings and on dam
263. *Ajuga genevensis* L.; U2 T3 R4; H, Eur - forestsides and openings and on dam
264. *Teucrium scordium* L.; U4.5 T4 R4.5; H, Eua (Med) -channels, oxbows and swamps edge

PLANTAGINACEAE

265. *Plantago tenuiflora* Waldst. & Kit.; (*Plantago minor* Fr.); H, Eua (Med) - roadsides
266. *Plantago media* L.; U2.5 T0 R4.5; H, Eua – roadsides and along dam
267. *Plantago lanceolata* L.; U3 T0 R0; H, Eua - roadsides and along dam

GENTIANACEAE

268. *Centaurium erythraea* Rafn; (*Centaurium minus* auct.) U3 T3 R2; Th, Euc (Med) – on dam
269. *Centaurium pulchellum* (Sw.) Druce; U3 T3.5 R4; Th, Eua (Med) – humid areas in floodplain

MENYANTHACEAE

270. *Nymphoides peltata* (S.G.Gmel.) Kuntze; U6 T3 R4; HH, Eua (Med) – in Bezdin pond

OLEACEAE

271. *Ligustrum vulgare* L.; U2.5 T3 R3; N, Atl – Med – dry forest areas and bush
272. *Frasinus excelsior* L.; U3 T3 R4; MM, Eur – higher areas in floodplain

RUBIACEAE

273. *Galium rubioides* L.; U2 T3 R4; H, Euc – forest opening and on dam
274. *Galium palustre* L.; U5 T3 R0; H, Circ – humid areas in floodplain and swamps
275. *Galium mollugo* L.; U3 T2.5 R3; H, Eua – in forest openings and bush
276. *Galium verum* L.; U2.5 T2.5 R0; H, Eua - in forest openings and bush
277. *Galium aparine* L.; U3 T3 R3; H, Eua – in bush and forest openings
278. *Cruciata laevipes* Opiz; (*Galium cruciata* (L.) Scop.) U2.5 T3 R3; Eua – forest openings in floodplain

CAPRIFOLIACEAE

279. *Sambucus nigra* L.; U3 T3 R3; MM – M, Eur (Med) – forestsides and on dam basis
280. *Sambucus ebulus* L.; U3 T3 R3; H, Eua (Med) - forestsides and on dam basis
281. *Viburnum opulus* L.; U4 T4 R4; M, Circ - forestsides and on dam basis
282. *Viburnum lantana* L.; U2.5 T2.5 R4; M, Euc - Med - forestsides and on dam basis

VALERIANACEAE

283. *Valeriana officinalis* L.; U2 T2 R2; H, Eua (Med) – humid areas, on dam, near Bezdin pond

DIPSACACEAE

284. *Dipsacus laciniatus* L.; U4 T3.5 R4; Th, Eua (Med) - roadsides, paths and diggings
285. *Dipsacus fullonum* L.; (*Dipsacus sylvestris* Huds.) U3.5 T3.5 R4; Th, Med (Euc) - roadsides, paths and diggings
286. *Dipsacus pilosus* L.; U4 T3.5 R4; Th, Eur – humid areas in Prundul Mare
287. *Knautia arvensis* (L.) Coult.; U2.5 T3 R0; Eur – on dam and roadsides
288. *Scabiosa ochroleuca* L.; U2 T4 R4; H, Eua (Cont) – on dam

CUCURBITACEAE

289. *Echinocystis lobata* (Michx.) Torr. & A.Gray; U4 T0 R4; Th, Adv – in parks from Mureş sides

CAMPANULACEAE

290. *Campanula trachelium* L.; U3 T3 R3; H, Eua (Med) – bush and lawns in floodplain
291. *Campanula patula* L.; U3 T2.5 R3; TH, Eur (Med) – along dam and in bush

COMPOSITAE

292. *Eupatorium cannabinum* L.; U4 T3 R3; H, Eua (Med) - near stagnant water in floodplain and in rush-bed
293. *Tussilago farfara* L.; U0 T3 R4; G (H), Eua (Med) – on dam

294. *Aster sedifolius* L.; subsp. *sedifolius;* (*Aster punctatus* Waldst. & Kit.) U4 T3 R2; H, Eua (Cont) – humid forest openings in floodplain
295. *Bellis perennis* L.; U3 T2 R0; H, Eur – in forest openings, roadsides and on dam
296. *Conyza canadensis* (L.) Cronquist; (*Erigeron canadensis* L.) U2.5 T0 R0; Th – TH, Cosm – roadsides, paths and diggings
297. *Inula salicina* L.; U2.5 T3 R3; H, Eua (Med) – forestsides and openings in floodplain
298. *Inula britannica* L.; U3 T3 R0; TH – H, Eua – humid areas on dam basis
299. *Pulicaria vulgaris* Gaertn.; U4 T3 R3; Th, Eua – muddy areas in floodplain
300. *Pulicaria dysenterica* (L.) Bernh.; U3.5 T3 R4; H, Euc – around swamps, oxbows and channels in floodplain
301. *Bidens tripartita* L.; U4.5 T3 R0; Th, Eua (Med) – humid, swampy, muddy areas in floodplain
302. *Bidens cernuus* L.; U5 T0 R0; Th, Eua – humid areas around oxbows, channels and swamps in floodplain
303. *Carpesium cernuum* L.; U3.5 T3.5 R5; Th, Eua (Med) – dark areas in floodplain forest
304. *Filago pyramidata* L.; (*Filago germanica* Huds.) U3 T3 R0; Th, Eua (Med) - dark areas in floodplain forest
305. *Logfia arvensis* (L.) Holub; (*Filago arvensis* L.) U1 T3 R0; Th, Eua (Med) – ruderal areas
306. *Filaginella uliginosa* (L.) Opiz ; (*Gnaphalium uliginosum* L.) U5 T3 R4; Th, Eua – muddy areas in floodplain
307. *Gnaphalium luteo-album* L.; U4 T3.5 R3; Th, Cosm – muddy, humid areas in floodplain
308. *Artemisia absinthium* L.; U2 T3 R4; H, Eua (Med) -in Prundul Mare area and deforested areas
309. *Artemisia vulgaris* L.; U2.5 T3 R4; H, Cir – in floodplain
310. *Artemisia pontica* L.; U2.5 T4 R4.5; H (Ch), Eua (Med) –diggings edge and deforested areas
311. *Tanacetum vulgare* L.; (*Chrysanthemum vulgare* (L.) Bernh., non (Lam.) Gaterau) U3 T3 R4; Ch, Eua (Med) – around stagnant waters in floodplain
312. *Leucanthemum vulgare* Lam.; (Chrysanthemum leucanthemum L.) U3 T0 R0; H, Eua – on dam
313. *Leucanthemella serotina* (L.) Tzvelev; (*Chrysanthemum serotinum* L.) U3 T0 R0; H, Pont – Pann – in willow parks and rush-beds
314. *Matricaria perforata* Mérat; (Matricaria inodora L.) U0 T0 R3.5; Th – TH, Eua – in deforested areas

315. *Chamomilla recutita* (L.) Rauschert; U2.5 T3.5 R5; Th, Eua – roadsides and ruderal areas
316. *Anthemis cotula* L.; U2.5 T4 R0; Th, Cosm - ruderal areas
317. *Anthemis arvensis* L.; U3 T3 R0; Th, Eur- ruderal areas
318. *Achillea millefolium* L.; U3 T0 R0; H, Cosm – on dam
319. *Senecio vulgaris* L.; U3 T3 R0; Th – TH, Eua - ruderal areas
320. *Senecio jacobaea* L.; U2.5 T3 R3; H, Eua (Med) – humid areas in floodplain forest
321. *Senecio doria* L.; U3 T0 R3.5; H, Eua – humid openings in floodplain forest
322. *Senecio paludosus* L.; U4.5 T3.5 R0; HH, Eua – oxbows, swamps and channels edge
323. *Echinops sphaerocephalus* L.; U2 T3 R3; H, Eua (Med) – forestsides and stagnant waters edge in floodplain
324. *Cirsium vulgare* (Savi) Ten.; U3 T3 R0; TH, Eua – ruderal areas and roadsides
325. *Cirsium brachycephalum* Jur; U4 T3 R0; TH – H, Pann – channels edge and rush-bed
326. *Cirsium canum* (L.) All.; U4.5 T3 R4.5; G, Eua (Cont) – humid lawns
327. *Carduus acanthoides* L;. U2 T3 R0; TH, Eua (Med) – roadsides, diggings and ruderal areas
328. *Carduus crispus* L.; U4 T4 R0; TH, Eua (Med) – oxbows, small ponds and channels edge
329. *Carduus nutans* L.; U1.5 T3 R3; TH, Eua (Med) – ruderal areas and roadsides
330. *Onopordum acanthium* L.; U2.5 T4 R4; TH, Eua (Med) - – ruderal areas and roadsides
331. *Arctium lappa* L.; U3.5 T3 R4; TH, Eua (Med) - ruderal areas and roadsides
332. *Arctium minus* Bernh.; U3 T3 R4.5; TH, Eua (Med) – ruderal areas and roadsides
333. *Actium tomentosum* Mill.; U3 T0 R5; TH, Eua – forestsides in floodplain
334. *Serratula tinctoria* L.; U3.5 T3 R0; H, Eur (Med) - forest openings in floodplain
335. *Centaurea jacea* L.; U1.5 T4 R4; H, Eua – humid areas in floodplain forest
336. *Centaurea nigrescens* Willd.; U3.5 T3 R3; H, Euc - humid areas in floodplain forest
337. *Centaurea calcitrapa* L.; U1.5 T4 R0; TH (Th), Eua (Med) - roadsides
338. *Xanthium spinosum* L.; U2.5 T4 R3; Th, Cosm - ruderal areas and roadsides

339. *Xanthium strumarium* L.; U3.5 T3.5 R4; Th, Eua - ruderal areas and roadsides
340. *Lapsana communis* L.; U2.5 T3 R3; Th, Eua (Med) - forestsides in floodplain
341. *Cichorium intybus* L.; U3 T0 R3; H (TH), Eua (Med) - ruderal areas and roadsides
342. *Leontodon autumnalis* L.; U3 T0 R0; H, Eua – on dam
343. *Leontodon hispidus* L.; U2.5 T0 R0; H, Eua – in forest openings and on dam
344. *Tragopogon dubius* Scop. subsp. *major* (Jacq.) Vollm.; (*Tragopogon major* Jacq.) U2.5 T3.5 R0; Th-TH, Euc- Med –roadsides and on dam
345. *Tragopogon pratensis* L. subsp. *orientalis* (L.) Kelak.; (*Tragopogon orientalis* L.) U3 T2 R3; TH - H(G), Eua (Med) – roadsides and on dam
346. *Scorzonera cana* (C.A.Mey.) O.Hoffm.; U2 T4 R4.5; H, TH, Pont-Med - roadsides
347. *Chondrilla juncea* L.; U1.5 T3.5 R4; H, Eua - ruderal areas and roadsides
348. *Taraxacum officinale* Weber; U3 T0 R0; H, Eua – on dam, forest openings, roadsides
349. *Lactuca saligna* L.; U1.5 T4 R4; Th – TH, Euc - ruderal areas and roadsides
350. *Lactuca serriola* L.; U1.5 T3.5 R0; TH, Eua - ruderal areas and roadsides
351. *Sonchus oleraceus* L.; U3 T0 R0; Th, Eua (Med) - ruderal areas
352. *Sonchus asper* (L.) Hill; U3 T0 R0; Th, Eua (Med) - ruderal areas
353. *Sonchus arvensis* L.; U3 T0 R0; H, Eua (Med) – humid, swampy areas in floodplain and roadsides
354. *Crepis foetida* L. subsp. *rhoeadifolia* (M.Bieb.) Kelak.; (*Crepis rhoeadifolia* M.Bieb.) U2 T3.5 R3; Th, Eua – Mureş sides, roadsides
355. *Crepis setosa* Haller f. U2 T3 R3; Th, Euc - ruderal areas and roadsides
356. *Hieracium pilosella* L.; U2 T0 R2; H, Eur (Med) – forest openings in floodplain
357. *Hieracium bauhini* Schult.; U1.5 T3 R3.5; H, Eur – forest openings in floodplain

ALISMATACEAE

358. *Alisma plantago-aquatica* L.; U6 T0 R0; HH, Cosm – small ponds, oxbows and swamps
359. *Alisma lanceolatum* With.; U6 T0 R4; HH, Eua - small ponds, oxbows and swamps
360. *Sagittaria sagittifolia* L.; U6 T3 R4; HH, Eua (Med) - small ponds, oxbows and swamps

BUTOMACEAE

361. *Butomus umbellatus* L.; U6 T3 R0; HH, Eua (Med) - small ponds, oxbows and swamps

HYDROCHARITACEAE

362. *Hydrocharis morsus-ranae* L., U6 T3.5 R3.5; HH, Eua (Med) - small ponds, oxbows and swamp
363. *Stratiotes aloides* L.; U6 T4 R4; HH, Eua - - small ponds, oxbows and swamps

POTAMOGETONACEAE

364. *Potamogeton natans* L.; U6 T2.5 R4; HH, Circ -small ponds, oxbows and swamps
365. *Potamogeton crispus* L.; U6 T3.5 R4; HH, Cosm - small ponds, oxbows and swamps
366. *Potamogeton pectinatus* L.; U6 T3 R4.5; HH, Cosm - small ponds, oxbows and swamps

NAJADACEAE

367. *Najas minor* All.; U6 T4.5 R4.5; HH, Eua - small ponds, oxbows and swamps

LILIACEAE

368. *Colchicum autumnale* L.; U3.5 T3 R4; G, Euc – in openings from Masa Tăcerii
369. *Gagea pratensis* (Pers.) Dumort.; U2 T3 R3; G, Eur – in forest openings from floodplain
370. *Allium oleraceum* L.; U3 T3 R0; G, Eur – humid areas in floodplain
371. *Allium vineale* L.; U2 T3 R4; G, Euc – on dam
372. *Allium scorodoprasum* L.; U2 T3 R4; G, Eur – on dam and in forest openings
373. *Scilla bifolia* L.; U3.5 T3 R4; G, Eur – forests in floodplain
374. *Ornithogalum umbellatum* L.; U0 T3.5 R4; G, Med - Euc – forestside and on dam
375. *Polygonatum latifolium* (Jacq.) Desf.; U3 T3.5 R4; G, Eur (Med) – forests in floodplain
376. *Polygonatum officinale* All.; U2 T3 R4; G, Eua - forests in floodplain
377. *Convallaria majalis* L.; U2.5 T3 R3; G, Eur - forests in floodplain

AMARYLLIDACEAE

378. *Galanthus nivalis* L.; U3.5 T3 R4; G, Circ - forests in floodplain

IRIDACEAE

379. *Iris pseudacorus* L.; U5.5 T0 R0; G (HH), Eur (Med) - small ponds, oxbows, water channels and deep water areas on dam basis

ORCHIDACEAE

380. *Epipactis palustris* (L.) Crantz; U4.5 T3 R4.5; G, Eua – in rush-bed

381. *Platanthera bifolia* (L.) Rich.; U3.5 T0 R3; G, Eua (Med) – humid areas in floodplain
382. *Listera ovata* (L.) R. Br.; U4 T3 R3; G, Eua (Med) – swampy, humid areas in floodplain forest
383. *Orchis laxiflora* Lam. subsp. *palustris* (Jacq.) Bonnier & Layens; (*Orchis palustris* Jacq.) U4 T3 R0; G, Pont- Pann – swampy, humid areas in floodplain forest

JUNCACEAE

384. *Juncus gerardi* Loisel.; U4.5 T3 R5; G, Circ – in rush-bed from swamps, small ponds and oxbows.
385. *Juncus bufonius* L.; U4.5 T0 R3; Th, Cosm - swampy, humid areas in floodplain

CYPERACEAE

386. *Cyperus fuscus* L.; U6 T3 R4; Th, Eua (Med) - swampy, humid areas in floodplain
387. *Cyperus flavescens* L.; U4.5 T0 R4; Th, Cosm – in oxbows, swamps and humid areas
388. *Cyperus glomeratus* L.; U5 T3 R4; HH, Eua (Med) – swamps edge, oxbows and channels in floodplain
389. *Eleocharis palustris* (L.) Roem. & Schult.; U5 T0 R4; G (HH), Cosm – small ponds, oxbows and channels edge
390. *Eleocharis acicularis* (L.) Roem. & Schult.; U5.5 T0 R0; Th, Circ – muddy areas and sandy beaches in floodplain
391. *Scirpus lacustris* L. subsp. *tabernaemontani* (C.C.Gmel.) Syme; U6 T3 R4; G (HH), Cosm – in oxbows, small ponds and swamps in floodplain and near Bezdin Monastery
392. *Scirpus lacustris* L. subsp. *lacustris;* U6 T3 R4; HH, Eua (Med) - in oxbows, small ponds and swamps in floodplain and near Bezdin Monastery
393. *Scirpus maritimus* L. subsp. *maritimus*; (*Bolboschoenus maritimus* (L.) Palla) U4.5 T3 R5; HH, Cosm – water and rush-bed edges
394. *Carex vulpina* L.; U4 T3 R4; HH – H, Eua (Med) – in deep, humid areas and around swamps in floodplain
395. *Carex muricata* L.; H, Eua (Med) – in deforested areas and forest openings in floodplain
396. *Carex praecox* Schreb.; U2 T3 R3; G, Eua – on dam
397. *Carex leporina* auct., non L.; H, Circ - forestsides and herbal forest openings in floodplain
398. *Carex remota* L. U4.5 T3 R3; H, Circ - herbal forest openings in floodplain
399. *Carex riparia* Curtis; U5 T4 R4; HH, Eua (Med)- swamps, small ponds, oxbows edges

400. *Carex vesicaria* L.; U5 T3 R4; HH(HH), Circ - swamps, diggings and deep water areas in floodplain
401. *Carex hirta* L.; U0 T3 R0; H, Eua (Med) – deep areas and diggings in floodplain
402. *Carex sylvatica* Huds.; U3.5 T3 R4; H, Eur (Med) – lawns in floodplain
403. *Carex distans* L.; U4 T3 R4; H, Eua (Med) – humid areas on dam basis

GRAMINEAE

404. *Bromus hordeaceus* L. subsp. *hordeaceus;* (*Bromus mollis* L.) U0 T3 R0; Th, Eua (Med) – lawns and ruderal areas
405. *Bromus arvensis* L.; U2.5 T3 R0; Th Eua (Med) –roadsides and on dam
406. *Bromus inermis* Leyss.; U2.5 T4 R4; H, Eua (Med) –floodplain
407. *Bromus tectorum* L.; U1.5 T3.5 R0; Th, Eua (Med) - ruderal areas
408. *Vulpia myuros* (L.) C.C.Gmel.; U1 T3.5 R2; Th, Eua (Cosm) - ruderal areas
409. *Festuca valesiaca* Schleich. ex Gaudin; U1 T5 R4; H, Eua (Cont) – on dam
410. *Festuca pseudovina* Hack. ex Wiesb.; U2 T4 R5; H, Cosm – on dam
411. *Festuca pratensis* Huds.; U3.5 T2 R0; H, Eua – on dam, forestsides an openings in floodplain
412. *Festuca arundinacea* Schreb.; U4 T3 R4; H, Eua (Med) – around oxbows, channels and small ponds in floodplain
413. *Festuca rupicola* Heuff.; U1.5 T4 R4; H, Eua –on dam and forest openings in floodplain
414. *Glyceria maxima* (Hart.) Holm.; (*Glyceria aquatica* (L.) Whalen., none (L.) Japers & Cypress) U5 T3 R4; HH (HH), Circ – oxbows, water draining channels and swamps
415. *Glyceria fluitans* (L.) R. Br.; U5 T3 R0; HH, Cosm - oxbows, water diggings channels and swamps
416. *Poa annua* L.; U3.5 T0 R0; H, Eua (Med) – roadsides and on dam
417. *Poa trivialis* L.; U4 T0 R0; H, Eua - in Mureş floodplain
418. *Poa pratensis* L.; U3 T0 R0; H, Cosm – on dam and lawns
419. *Dactylis glomerata* L.; U3 T0 R4; H, Eua – on dam, forest openings and roadsides
420. *Melica altissima* L.; U2 T4 R4; H, Eua –in oak forests
421. *Lolium perenne* L.; U3 T3 R0; H, Eua (Med) – roadside and on dam
422. *Lolium multiflorum* Lam.; U4 T3 R4; Th - TH – H, Atl – Med – on dam
423. *Elymus hispidus* (Opiz) Melderis; (*Agropyron intermedium* (Host) P.Beauv.) U2 T4.5 R4; G, Eua (Cont) – lawns and bush in floodplain
424. *Elymus caninus* (L.) L.; (*Agropyron caninum* (L.) P.Beauv.) U3.5 T0 R4; H, Eua (Med) – in tunnel forests
425. *Hordeum murinum* L.; U2.5 T4 R0; Th, Eua – on dam, roadsides and ruderal areas

426. *Phragmites australis* (Cav.) Trin. ex Steud.; U6 T0 R4; HH, Cosm – swamps, channels and oxbows edges
427. *Eragrostis pilosa* (L.) P.Beauv.; U3 T3.5 R0; Th, Euc (Med) - in Mureş floodplain
428. *Eragrostis minor* Host; U3 T4 R0; Th, Euc (Med) – in sandy areas
429. *Beckmannia eruciformis;* U4.5 T3 R4; Host. Th, Euc (Med) – swamps edge in floodplain
430. *Pholiurus pannonicus* (Host) Trin.; U0 T4 R4.5; Th, Pont-Pann-Balc - swamps edge in floodplain
431. *Holcus lanatus* L.; U3.5 T3 R0; H, Cosm - roadsides, paths and diggings edge
432. *Arrhenatherum elatius* (L.) P.Beauv. ex J.Presl & C.Presl; U3 T3 R4.5; H, Eua – roadsides and on dam
433. *Calamagrostis pseudophragmites* (Haller f.) Koeler; U5 T3 R5; H, Eua - Mureş sides
434. *Calamagrostis epigejos* (L.) Roth; U2 T3 R0; H, Eua – in bush and deep, humid areas in floodplain
435. *Agrostis canina* L.; U3.5 T3 R3; H, Cosm – low, humid areas in floodplain
436. *Agrostis stolonifera* L.; (*Agrostis alba* auct., non L.) U4 T0 R0; H, Circ - low, humid areas in floodplain
437. *Phleum pratense* L.; U3.5 T0 R0; H, Eua – on dam
438. *Alopecurus geniculatus* L.; U5 T0 R4; H, Eua – law, humid areas edge and swamps edge
439. *Crypsis schoenoides* (L.) Lam.; (*Heleochloa schoenoides* (L.) Host) U0 T4 R4.5; Th, Eua – humid areas in floodplain
440. *Crypsis alopecuroides* (Piller & Mitterp.) Schrad.; (*Heleochloa alopecuroides* (Piller & Mitterp.) Host ex Roem.) U0 T4 R4.5; Th, Eua - humid areas in floodplain
441. *Leersia oryzoides* (L.) Sw.; HH, Circ – humid areas and rush-bed
442. *Digitaria sanguinalis* (L.) Scop.; U1.5 T0 R4; Th, Cosm – roadsides and ruderal areas
443. *Typhoides arundinaceae* Mnch.; U5 T3 R0; HH, Circ – stagnant water edge

ARACEAE

444. *Arum maculatum* L.; U3.5 T3 R4; G, Euc (Med) – humid, dark areas in tunnel forest

LEMNACEAE

445. *Lemna trisulca* L.; U6 T3 R4; HH, Cosm – in oxbows, swamps, channels water
446. *Lemna minor* L.; U6 T3 R0; HH, Cosm - in oxbows, swamps, channels water

447. *Lemna gibba* L.; U3 T3 R3; HH, Cosm - in oxbows, swamps, channels water
448. *Spirodela polyrhiza* (L.) Schleid.; U6 T3.5 R0; HH, Cosm - in oxbows, swamps, channels water
449. *Wolffia arrhiza* (L.) Horkel ex Wimm.; U6 T0 R4; HH, Cosm - in oxbows, swamps, channels water

SPARGANIACEAE

450. *Sparganium erectum* L.; U6 T3 R0; HH, Eua (Med) – in rush-bed from stagnant water

TYPHACEAE

451. *Typha latifolia* L.; U6 T3.5 R0; HH, Cosm - – oxbows, small ponds, channels and stagnant waters in floodplain
452. *Typha angustifolia* L.; U6 T4 R0; G (HH), Circ – oxbows, small ponds, channels and stagnant waters in floodplain

Enumeration of the microrelief units and biocenoses (sites)
FROM THE MUREŞ FLOODPLAIN (BEZDIN AREA)

Crt. no.	Micro-relief type	Micro-relief characteristics	Biocenosys types in the micro-relief
1	Depressions in the floodplain region	Depressions, low areas, oxbows with water and cogged, ponds, mires, mud's	Aquatic and swampy biocenosys
2	Low floodplain with depressions	Muddy genetic soil with clay texture, eubasic (highly saturated), low alkaline with a normal nitric content, lacking P and K, profound edaphic volume	Floodplain forest biocenosys
3	Phreatic low floodplain, humid and frequently flooded	Alluvial genetic soil with muddy texture, eubasic (heavily saturated), low alkaline with a normal nitric content, lacking P and K, very profound edaphic volume	Floodplain forest biocenosys
4	Low floodplain – yearly flooded in long periods	Muddy genetic soil with muddy-clay texture, eubasic (heavily saturated), poor acid-poor alkaline with high nitric content, very low P content, low K content, profound and very profound edaphic volume	Floodplain forest biocenosys

5	Low floodplain with depressions and rarely flooded	Brown clay genetic soil (typical brown clay) of clay-muddy texture, eubasic (heavily saturated), low alkaline with rich nitric content, low P and K content, profound and very profound edaphic volume	Floodplain forest biocenosys
6	High floodplain, scarcely humid phreatic, not flooded or rarely and shortly flooded	Typical brown clay soil with muddy-fluffy texture, eubasic (heavily saturated), low alkaline with rich nitric content, low P and K content, profound edaphic volume	Floodplain forest biocenosys

CLASSIFICATION OF THE PLANTS ASSOCIATIONS

1. HERBACEOUS PLANTS	1.1 Ponds	1.1.1. Floating ponds vegetation	1.1.1.1. *LEMNA MINOR UTRICULARIA VULGARIS* (LEMNO - UTRICULARIETUM) association
			1.1.1.2. *HYDROCHARIS MORSUS-RANAE - STRATIOTES ALOIDES* (HYDROCHARI - STRATIOTETUM)
		1.1.2. Fixed submerged vegetation of the ponds	1.1.2.1. *MYRIOPHYLLUM SPICATUM - POTAMOGETON NATANS* (MYRIOPHYLLO - POTAMOGETUM)
		1.1.3. Fixed emerged vegetation of the ponds	1.1.3.1. *NYMPHAEA ALBA - NUPHAR LUTEUM* (NYMPHAEETUM ALBO - LUTEAE)
		1.1.4. Common Reed and Bulrush	1.1.4.1. *SCIRPUS LACUSTRIS - PHRAGMITES COMMUNIS* (SCIRPO – PHRAGMITETUM)
	1.2. Mires	1.2.1. Mires with Greater Pond Sedge	1.2.1.1. *CAREX RIPARIA* (CARICETUM RIPARIAE)
	1.3. Floodplain meadows	1.3.1. Humid meadows	1.3.1.1 *CAREX VULPINA* (CARICETUM VULPINEAE)
			1.3.1.2. *AGROSTIS ALBA* (AGROSTETUM ALBAE)

		1.3.2. Mesophilic meadows	1.3.2.1. *ARRHENATHERUM ELATIUS* (ARRHENATHERETUM ELATIORIS)
			1.3.2.2. *FESTUCA PSEUDOVINA* (FESTUCETUM PSEUDOVINAE)
		1.3.3. Xerophilic meadows	1.3.3.1. *FESTUCA RUPICOLA - BRACHYPODIUM PINNATUM* (FESTUCETO - BRCHYPODIETUM)
			1.3.3.2. *ACHILLEA MILLEFOLIUM - FESTUCA PSEUDOVINA* (ACHILLEO - FESTUCETUM PSEUDOVINAE)
2. WOODY PLANTS	2.1. Forests	2.1.1. Floodplain forests	2.1.1.1. *SALIX CINEREA* (SALICETUM CINEREAE)
			2.1.1.2. *SALIX PURPUREA* (SALICETUM PURPUREAE)
			2.1.1.3. *SALIX TRIANDRA* (SALICETUM TRIANDRAE)
			2.1.1.4. *SALIX ALBA - SALIX FRAGILIS* (SALICETUM ALBAE - FRAGILIS)
			2.1.1.5. *POPULUS ALBA, POPULUS NIGRA - SALIX ALBA, SALIX FRAGILIS* (POPULETO - SALICETUM)
			2.1.1.6. *QUERCUS ROBUR - FRAXINUS ANGUSTOFOLIA ssp. PANNONICA - ULMUS LAEVIS* (QUERCO - ULMETUM)
			2.1.1.7. *ROBINIA PSEUDACACIA* (ROBINIETUM PSEUDACACIAE)
			2.1.1.8. *PRUNUS SPINOSA - CRATAEGUS MONOGYNA* (PRUNOSPINOSAE – CRATAEGETUM)

Bezdin Forest, hard wood forest and muddy floodplain with Greater Pond Sedge

The forest made of hard wood species, surrounding the dead river branch which constitutes the Bezdin Pond, is about 100 years old. The structural species is the Pedunculate Oak (*Quercus robur* +-2).

Other species: *Pyrus achras, Ulmus laevis, Acer campestre, Carex prairie, Convallaria majalis, Cornus sanguinea, Inula salicina, Rhamnus catharticus, Populus alba, Vincetoxicum hirundinaria, Vitis riparia.*

On the edge of the dead river branch one may observe mixed the Sedge species and the muddy floodplain species.

Collected samples (5 × 5 m). *Salix alba* +, *Iris pseudacorus* + -2, *Alopecurus pratensis* +, *Ajuga genevensis* +, *Bidens tripartita* +, *Butomus umbellatus* +, *Carex gracilis* + -4, *Carex hirta* + -1, *Clematis integrifolia* +, *Chrysanthemum vulgare* +, *Daucus carota* +, *Eleocharis palustris* + -1, *Euphorbia palustris* +, *Lathyrus sylvestris* +, *Lythrum salicaria* +, *Lythrum virgatum* +, *Lycopus exaltatus* +, *Festuca pratensis* +, *Galium palustre* +, *Galega officinalis* +, *Glycyrrhiza echinata, Inula britannica +, Mentha aquatica +, Stachys palustris +, Senecio paludosus +, Alisma plantago-aquatica +, Scutellaria galericulata + -1, Sium latifolium, Stachys palustris +, Ranunculus cassubicus +, Ranunculus repens +, Symphytum officinale +, Lysimachia nummularia+, Teucrium scordium +, Thalictrum lucidum +, Xanthium spinosum +.*

Bezdin area, along the dead Mureş river branch, loess steppe with heavy grazing

Sample (25 × 25 m). *Pyrus achras* +, *Prunus spinosa* + -3, *Crataegus monogyna + Rosa corymbifera* +, *Agropyron repens* + -1, *Agrimonia eupatoria* +, *Achillea millefolium* +, *Achillea ochroleuca* +, *Allium vineale* +, *Artemisia* *campestris* +, *Astragalus cicer* +, *Bromus inermis* + -1, *Bothriochloa ischaemum* + -2, *Dypsacus laciniatus* +, *Centaurea indurata* +, *Centaurea jacea* +, *Chrysanthemum leucanthemum* +, *Cirsium arvense* +, *Consolida regalis* +, *Convolvulus arvense* +, *Coronilla varia* +, *Eryngium campestre* + -3, *Euphorbia cyparissias* +, *Fesctuca rupicola* + -3, *Fragaria collina* +, *Galium verum* +, *Knautia arvensis, Lathyrus tuberosus* +, *Lathyrus sylvestris* +, *Lotus angustissimus* +, *Lotus corniculatus* +, *Chamomilla recutita* +, *Medicago lupulina* +, *Medicago sativa* +, *Peucedanum alsaticum* +, *Pimpinella saxifraga* +, *Plantago media* +, *Poa angustifolia* +, *Potentilla argentea* +, *Potentilla heptaphylla* +, *Ranunculus steveni* +, *Rhinanthus angustifolius* + -1, *Salvia nemorosa* + -1, *Salvia pratensis* +, *Salvia verticillata* +, *Stachys germanica* +, *Stellaria graminea* +, *Thalictrum minus* + *Thymus pannonicus* +, *Trifolium diffusum* +, *Odontites rubra* +, *Ononis arvensis, Ornithogalum pyramidale* + *Verbascum blattaria* + *Verbena ofiicinalis* +, *Veronica chamaedrys* +.

Sample taken from the reed and Bulrush area along the Bezdin Monastery.

Bolboschoenus maritimus + -2, *Carex gracilis* 1-3, *Cirsium arvense* +, *Dypsacus laciniatus* + 1, *Euphorbia palustris* +-1, *Euphorbia platyphyllos* +, *Glycerrhia maxima* + -3, *Lycopus europeus* +, *Lythrum virgatum* + -1, *Lythrum salicaria* + -2, *Oenanthe aquatica* + -1, *Ranunculus repens* +, *Rumex pulcher* +, *Rumex crispus* +, *Salvinia natans* +, *Stachys palustris* +, *Mentha longifolia* +, *Mentha breviformis* +, *Prunella vulgaris* +, *Poa angustifolia* + -1, *Potentilla reptans* +, *Ranunculus repens* +, *Rorippa amphibia* +, *Sium latifolium* +, *Schoenoplectus tabernaemontani* +-1, *Symphytum officinale* +-1, *Xanthium spinosum* +.

On small spots we observed: *Puccinellia limosa, Puccinelia distans*

LEMNO – UTRICULARIETUM
Lemna minor
Lemna trisulca
Lemna gibba
Utricularia vulgaris
Salvinia natans

HYDROCHARI – STRATIOTETUM
Hydrocharis morsus-ranae
Stratiotes aloides

MYRIOPHYLLO – POTAMOGETUM
Myriophyllum spicatum
Myriophyllum verticillatum
Potamogeton natans
Potamogeton crispus
Potamogeton pectinatus
Najas minor
Hottonia palustris

NYMPHAEETUM ALBO – LUTEAE
Nymphaea alba
Nuphar lutea
Nymphoides peltata
Trapa natans

SCIRPO – PHRAGMITETUM
Scirpus lacustris
Scirpus lacustris subsp. *tabernaemontani*
Phragmites australis
Typha latifolia
Typha angustifolia
Glyceria maxima
Scirpus maritimus subsp. *maritimus*
Alisma plantago aquatica
Oenanthe aquatica
Oenanthe banatica
Iris pseudacorus
Sagittaria sagittifolia
Sparganium erectum
Lycopus europaeus

CARICETUM RIPARIAE
Carex riparia
Carex vulpina
Carex vesicaria
Equisetum palustre
Lathyrus palustris
Symphytum officinale
Agrostis stolonifera
Cirsium canum

CARICETUM VULPINEAE
Carex vulpina
Carex sylvatica
Carex remota

AGROSTETUM ALBAE
Agrostis stolonifera
Carex vulpina
Carex riparia
Festuca pratensis

ARRHENATHERETUM ELATIORIS
Arrhenatherium elatius
Poa pratensis
Festuca pratensis
Knautia arvensis
Leucanthemum vulgare
Campanula patula

FESTUCETUM – PSEUDOVINAE
Festuca pseudovina
Festuca pratensis
Poa pratensis
Knautia arvensis
Leucanthemum vulgare

FESTUCETO – BRACHYPODIETUM
Festuca rupicola
Brachypodium pinnatum
Lotus corniculatus
Vicia sativa
Pimpinella saxifraga
Heliotropium europaeum
Salvia pratensis
Salvia nemorosa
Stachys recta
Ajuga reptans
Veronica chamaedrys
Rhinanthus angustifolius
Capsella bursa-pastoris
Cardaria draba
Viola elatior
Bellis perennis
Leucanthemum vulgare
Lapsana communis
Cichorium intybus
Tragopogon dubius subsp. *major*
Taraxacum officinale
Primula veris

Ornithogalum umbellatum
Rumex acetosa
Bromus arvensis
Dactylis glomerata
Lolium perenne
Hordeum murinum
Phleum pratense

ACHILLEO FESTUCETUM PSEUDOVINAE
Achillea millefolium
Festuca pseudovina
Vicia sativa
Heliotropium europaeum
Salvia pratensis
Salvia nemorosa
Sambucus ebulus
Ajuga reptans
Veronica chamaedrys
Veronica prostrata
Rhinanthus angustifolius
Plantago media
Plantago lanceolata
Capsella bursa-pastoris
Cardaria draba
Lapsana communis
Cichorium intybus
Taraxacum officinale
Lychnis flos-cuculi
Saponaria officinalis
Ornithogalum umbellatum
Rumex acetosa
Bromus arvensis
Dactylis glomerata
Hordeum murinum
Phleum pratense

SALICETUM CINEREAE
Salix cinerea
Phragmites australis
Typha latifolia
Typha angustifolia
Carex riparia
Butomus umbellatus
Alisma plantago aquatica
Iris pseudacorus
Lythrum salicaria
Epilobium hirsutum
Eupatorium cannabinum
Equisetum palustre
Galium palustre
Geranium palustre
Mentha aquatica
Stachys palustris

SALICETUM PURPUREAE
Salix purpurea
Eupatorium cannabinum
Epilobium hirsutum
Galium palustre
Stachys palustris
Geranium palustre
Lythrum salicaria
Lysimachia vulgaris
Cardamine pratensis
Angelica sylvestris
Cirsium brachycephalum
Lamium maculatum
Ranunculus repens
Potentilla anserina
Trifolium hybridum

SALICETUM TRIANDRAE
Salix triandra
Salix purpurea
Salix fragilis
Salix alba
Rubus caesius
Agrostis stolonifera
Artemisia vulgaris
Tanacetum vulgare
Potentilla anserina
Lysimachia vulgaris
Saponaria officinalis
Cardamine pratensis
Angelica sylvestris
Lamium maculatum
Cirsium brachycephalum
Bidens tripartita
Urtica dioica
Symphytum officinale
Mentha aquatica
Phragmites australis

SALICETUM ALBAE – FRAGILIS
TREES LEVEL :
Salix alba
Salix fragilis
Populus nigra
B. SCRUBS LEVEL :
Salix triandra
Salix purpurea

Amorpha fructicosa
Rhamnus catharticus
Frangula alnus
Viburnum opulus
Euonymus europaeus
Euonymus verrucosus
C. CREEPERS:
Cuscuta europaea
Rubus caesius
Echynocistis lobata
Solanum dulcamara
Clematis vitalba
Humulus lupulus
Vitis vinifera subsp. sylvestris
Parthenocissus quinquefolia
D. HERBACEOUS PLANTS:
Agrostis stolonifera
Artemisia vulgaris
Urtica dioica
Tanacetum vulgare
Potentilla anserina
Bidens tripartita
Lysimachia vulgaris
Asarum europaeum
Chrysosplenium alternifolium

POPULETO – SALICETUM
TREES LEVEL :
Populus alba
Populus nigra
Salix alba
Salix fragilis
Alnus glutinosa

B. SCRUBS LEVEL :
Salix triandra
Salix purpurea
Rhamnus catharticus
Frangula alnus
Viburnum opulus
Viburnum lantana
Euonymus europaeus
Euonymus verrucosus
Crataegus oxyacantha
Crataegus monogyna
Corylus avellana
Cornus sanguinea
Sambucus nigra
C.CREEPERS :
Rubus caesius
Echynocistis lobata
Solanum dulcamara
Clematis vitalba
Humulus lupulus
Vitis vinifera subsp. sylvestris
Parthenocissus quinquefolia
D. HERBACEOUS PLANTS :
Saponaria officinalis
Cardamine pratensis
Epilobium hirsutum
Angelica sylvestris
Valeriana officinalis
Lysimachia vulgaris
Galanthus nivalis
Scilla bifolia
Asarum europaeum
Anemone nemorosa
Anemone ranunculoides
Ranunculus ficaria
Corydalis cava
Corydalis solida
Lathyrus vernus
Euphorbia cyparissias
Pulmonaria officinalis
Pulmonaria mollis
Lamiastrum galeobdolon
Polygonatum odoratum
Polygonatum latifolium
Viola reichenbachiana
Viola elatior
Galium aparine
Stellaria holostea
Arum maculatum
Geum urbanum
Geranium robertianum
Galeopsis speciosa
Scrophularia nodosa
Dypsacus silvestris
Dypsacus pilosus
Myosotis sparsiflora
Convallaria majalis
Hypericum perforatum
Euphorbia plathyphylla
Vincetoxicum hirundinaria
Physalis alkekengi
Aristolochia clematitis

QUERCO – ULMETUM
TREES LEVEL:
Quercus robur
Quercus cerris
Quercus pubescens

Fraxinus excelsior
Fraxinus angustifolia ssp. pannonica
Ulmus laevis
Acer campestre
B. SCRUBS LEVEL:
Salix cinera
Salix triandra
Viburnum opulus
Acer tataricum
Corylus avellana
Cornus sanguinea
Crataegus oxyacantha
Crataegus monogyna
Sambucus nigra
Prunus spinosa
C. CREEPERS:
Echynocistis lobata
Clematis vitalba
Humulus lupulus
Vitis vinifera subsp. *sylvestris*
D. HERBACEOUS PLANTS:
Lythrum salicaria
Eupatorium cannabinum
Cardamine pratensis
Valeriana officinalis
Lysimachia vulgaris
Geranium palustre
Galium palustre
Mentha aquatica
Stachys palustris
Equisetum palustre
Galanthus nivalis
Scilla bifolia
Asarum europaeum
Anemone nemorosa
Anemona ranunculoides
Ranunculus ficaria
Corydalis cava
Corydalis solida
Lathyrus vernus
Euphorbia cyparissias
Pulmonaria officinalis
Pulmonaria mollis
Lamiastrum galeobdolon
Convallaria majalis
Polygonatum odoratum
Polygonatum latifolium
Arum maculatum
Stellaria holostea
Galium aparine
Viola reichenbachiana
Geum urbanum
Geranium robertianum
Myosotis sparsiflora
Galeopsis speciosa
Scrophularia nodosa
Dypsacus silvestris
Dypsacus pilosus
Hypericum perforatum
Euphorbia plathyphyllia
Vincetoxicum hirundinaria
Physalis alkekengi
Aristolochia clematitis

ROBINETUM PSEUDACACIAE
(ROBINIETUM PSEUDACACIAE)
TREES LEVEL:
Robinia pseudacacia
Fraxinus excelsior
Quercus robur
Populus nigra
SCRUBS LEVEL:
Salix cinerea
Sambucus ebulus
Crataegus monogyna
Prunus spinosa
Rubus caesius
HERBACEAOUS PLANTS LEVEL:
Achillea millefolium
Geum urbanum
Lysimachia nummularia
Ononis arvensis
Plantago lanceolata
Plantago media
Eryngium campestre
Euphorbia cyparissias
Geranium dissectum
Arctium lappa
Urtica dioica
Hordeum murinum
Elymus repens
Cichorium intybus
Glechoma hederacea
Lolium perenne
Ranunculus polyanthemos
Xanthium spinosum
Taraxacum officinale

PRUNO SPINOSAE – CRATAEGETUM
TREES LEVEL:
Prunus spinosa
Crataegus monogyna

Populus alba
Populus nigra
Quercus robur
Ulmus laevis
Ulmus glabra
Fraxinus excelsior
SCRUBS LEVEL:
Cornus sanguinea
Rosa canina
Rubus caesius
C. HERBACEOUS PLANTS:
Dactylis glomerata
Poa pratensis
Achillea millefolium
Daucus carota
Echinochloa crus – galli
Elymus repens
Cichorium intybus
Sonchus oleraceus
Xantium strumarium
Taraxacum officinale
Chenopodium album
Linaria vulgaris
Plantago major
Plantago media
Plantago lenceolata
Ranunculus polyanthemos
Setaria verticillata
Setaria viridis
Inula britannica

POND ASSOCIATION

LEMNETUM MINORIS (OBERD 1957) MÜLLER ET GÖRS 1966

B	G	SPECIES	1	2	3	4
Hh	Cosm	*Lemna minor*	2	4	3	2
Hh	Cosm	*Lemna trisulca*	1	+	+	1
Hh	Cosm	*Lemna gibba*	1	1	+	+
HH	Eua	*Salvinia natans*	+	+	+	+
HH	Cp	*Utricularia vulgaris*	+	+	1	1

Not fixed, floating, hydrophilic plants

Reunites the Duckweed cenosis which populate the surface of stagnant waters, 30-80 cm deep waters, frequent in the edge area of Bezdin Pond and in mires surfaces. Constitute generally mono-association cenosis, in which often enter floating individuals of other aquatic not-fixed, paludous species.

Among bioforms, the hydro-helophytes dominate, and the phytogeographic (geophytes) character of the association is divided as follows: most of the elements are cosmopolites, and the rest of the elements are Eurasian and circumpolar.

MEADOW ASSOCIATION

ARRHENATHERION ELATIORIS (Br.-Bl. 1925) W. KOCH 1926

B	G	SPECIES	1	2	3	4
H	Ec (Md)	*Arrhenatherium elatius*	3-5	1	+	1
H	Cp	*Poa pratensis*	+	+	+	+
H	Eua	*Festuca pratensis*	-	+	+	-
H	E	*Knautia arvensis*	+	-	+	-
H	Eua	*Chrysanthemum leucanthemum*	+	+	+	+

Th	E	*Campanula patula*	+-1	+	+	+-1

Reunites the meadows from the humid soils of the sunny forest openings and the hay meadows from the protective dam. The separation in a particular class by J. Braun-Blanquet (1951) gets gradually justifying arguments as more and more phytocenotic studies are pursued.

The soil is rich in minerals, with a pH of 6,5-7. Is making well developed meadows, usually with three levels. From the floristic point of view, is characterized by the presence of mesophilic species, forming hay meadows with high hay production.

FOREST ASSOCIATION

RUBO-SALICION TRIANDRAE (MÜLLER ET GÖRS 1958 em. PASSARGE 1968)

B	G	SPECIES	1	2	3	4
Ph	Eua	*Salix triandra*	1	2	1-3	2
Ph	Ec	*Salix purpurea*	+	1-2	2	1-2
Ph	Eua	*Salix fragilis*	+	+	+	+
Ph	Eua	*Salix alba*	+	+	+	+
H	Eua	*Rubus caesius*	1-3	2	2	1
H	Cp	*Agrostis alba*	+	+	+	+
H	Cp	*Artemisia vulgaris*	+	+	+	+
H	Eua (Md)	*Chrysanthemum vulgare*	+	+	+	+
H	Eua	*Potentilla anserina*	+	+	+	+
Ch	Eua	*Lysimachia vulgaris*	+	+	+	+
H	Eua	*Saponaria officinalis*	+	+	+	+
Th	Eua	*Cardamine pratensis*	+	+	+	+
H	Eu (Md)	*Lamium maculatum*	-	+	+	-
Th	Eua	*Bidens tripartita*	+	+	+	+
H	Cosm	*Urtica dioica*	+-1	1	1	+
H	C	*Symphytum officinale*	+-1	+-1	+-1	+-1

This riverside coppice association is installed on developed alluvial soil, facultatively flooded. The characteristic of this association are evidentiated by the quantitative ratio among the structural species, by the fact that all the cenosis of these associations present a distinct three levels differentiation.

The willow stands are installed on the water bodies edges as straps with a heterogeneous floristic composition. Hence, the association’s foundation is imprinted by the Eurasian elements.

The woody species of this association are economically capitalized.

The vegetations sindynamic

The evolution and the succession of plant associations was made in close relationship with the soil and climatic factors, and with the action of natural and anthropo-zoogenic factors.

In the Bezdin Pond a specific aquatic and paludous vegetation may be found, with rare species for Arad County, as the European White Waterlily (*Nymphaea alba*), Greater Bladderwort (*Utricularia vulgaris*), Floating Watermoss (*Salvinia natans*). In the Prundul Mare area natural gallery forests with luxuriant vegetation may be found, as a last refuge of the plants characterizing the woody-steppe of the floodplain in the Mureş Plain.

Fringed Water-lily association on Bezdin Pond

The acceleration of the cogging process by accumulation and deposition on the bottom of the water body of organic matters resulted from hydrophytes decomposition (yearly deposition of 4-5mm of organic matter), as the processes of aerobe and anaerobe decomposition modify the water chemistry and insure favourable conditions for the further evolution of aquatic vegetation, which will form the emerged paludous hidato-halophilic vegetation (reeds and bulrush).

In the case of reeds, an intensification of the transpiration and photosynthesis processes is happening, which will lead to the growth of organic matters deposited on the bottom of the water body and the reduction of the water level. Hence, hydro-technic amelioration works are needed to preserve the water in ponds and oxbows. This phenomenon accelerated in the last decade, and due to this the eutrophication danger is present, in some places even the danger of hypertrophication and consequently the danger of disturbing the biological equilibrium of the stagnant waters. These phenomena, connected with other as the water deficit due to lack of flooding and rainfalls, water pollution, water draining, deforestation etc., endanger the perpetuation of some rare, vulnerable species, for which the study area represents the unique territory from this part of the country where the primitive flora elements are preserved, typical for floodplain woody-steppes.

Studying the flora and vegetation of the Bezdin area we observed a hopeful phenomena, that a series of species appeared, which are nor endemic, but they are mountainous and sub-mountaineous elements which accommodated to the living conditions existent in the area, enriching the flora of the region.

As conclusion, we can show that the various abiotic conditions (soil, humidity, light, temperature, soil reactivity, the degree of provision of nutritive elements), correlated with the variety of the micro-relief, justify the formation in the region of over 20 principal plant associations.

LIST OF RARE SPECIES

<table>
<tr><td>Nr. crt.</td><td>Species name</td><td>Endangering factors</td><td>Observations</td></tr>
<tr><td>1</td><td>Nymphaea alba - European White Waterlily Bezdin Pond</td><td rowspan="3">Water deficiency due to the lack of flooding, water pollution, pond eutrophication, draining</td><td rowspan="3">Between 1880-1890 they were found in many areas of Arad County (Ceala, Mureşul Mort). Today Bezdin Pond is the last refuge</td></tr>
<tr><td>2</td><td>Nymphoides peltata – Yellow Floatingheart Bezdin Pond</td></tr>
<tr><td>3</td><td>Nuphar luteum - Yellow Pond-lily Bezdin Pond</td></tr>
<tr><td>4</td><td>Salvinia natans – Floating Watermoss Bezdin Pond</td><td>Water deficiency due to the lack of flooding, water pollution, pond eutrophication, draining</td><td>Very rare species noted in the red book I.U.C.N.</td></tr>
<tr><td>5</td><td>Senecio paludosus – Ragwort Rush-beds in Bezdin Pond</td><td>Pollution, eutrophication</td><td></td></tr>
</table>

The cogging and eutrophication phenomena in some parts of the Bezdin Pond

LIST OF VULNERABLE AND ENDANGERED SPECIES

Crt. no.	Species name	Biotope	Endangering factors
1	*Butomus umbellatus* - Flowering-rush	Ponds, channels, swamps	cogging, eutrophication, draining
2	*Epipactis palustris* - Marsh Helleborine	Ponds, channels, swamps	cogging, eutrophication, draining
3	*Euphorbia palustris* - Marsh Spurge	Ponds, channels, swamps	cogging, eutrophication, draining
4	*Lythrum salicaria* - Purple Loosestrife	Ponds, channels, swamps	cogging, eutrophication, draining
5	*Nymphaea alba* - White Lotus	Bezdin Pond	cogging, eutrophication, draining
6	*Nymphoides peltata* - Yellow Floatingheart	Bezdin Pond	cogging, eutrophication, draining
7	*Nuphar luteum* - Yellow Pond-lily	Bezdin Pond and channels near Bezdin Monastery	cogging, eutrophication, draining
8	*Platanthera bifolia* - Lesser Butterfly-orchid	Humid areas in floodplain	deforesting
9	*Potamogeton natans* - Floating Pondweed	Bezdin Pond and channels	cogging, eutrophication, draining
10	*Sagittaria sagittifolia* - Hawaii arrowhead	Bezdin Pond and channels	cogging, eutrophication, draining
11	*Salvinia natans* - Salvinia	Bezdin Pond	cogging, eutrophication, draining

12	*Stachys palustris* - Marsh Woundwort	Ponds, channels, swamps	cogging, eutrophication, draining
13	*Senecio palodosus* - Ragwort	Bezdin Pond	cogging, eutrophication, draining
14	*Utricularia vulgaris* - Common Bladderwort	Bezdin Pond	cogging, eutrophication, draining

LIST OF MONTANOUS AND SUBMOUTANOUS SPECIES ACCOMMODATED IN THE STUDY AREA

Crt. no.	Species name	Biotope	Origin
1	*Anemone nemorosa* – Wind Flower	Flood areas in floodplain forests	Montannous element
2	*Anemone ranunculoides* – Yellow Anemone	Flood areas in floodplain forests	Montannous element
3	*Asarum europeum* – European Wild Ginger	Flood areas in floodplain forests	Mountainous element
4	*Chrysosplenium alternifolium* - Golden Saxifrage	Flood areas in floodplain forests	Mountainous element
5	*Cicuta virosa* – Water Hemlock	Rush-beds in floodplain	Mountainous element
6	*Colchicum autumnale* - Autumn Crocus	"Masa Tăcerii" forest opening edge	Mountainous element
7	*Corydalis cava* - Hollow-root	Flood areas in floodplain forests	Mountainous element
8	*Corydalis solida* – Yellow Corydalis	Flood areas in floodplain forests	Mountainous element
9	*Dryopteris filix-mas* – Male Fern	Flood areas in floodplain forests	Mountainous element
10	*Epilobium montanum* – Broad-leaved Willowherb	Flood areas in floodplain forests	Mountainous element
11	*Galanthus nivalis* – Snowdrop	Flood areas in floodplain forests	Mountainous element
12	*Geranium robertianum* - Herb Robert	Flood areas in floodplain forests	Mountainous element
13	*Lamium galeobdolon* – Yellow Archangel	Flood areas in floodplain forests	Mountainous element
14	*Lathrea squamaria* – Common Toothwort	Flood areas in floodplain forests	Mountainous element
15	*Oxalis acetosella* – Wood-sorrel	Flood areas in floodplain forests	Mountainous element
16	*Platanthera bifolia* - Lesser Butterfly-orchid flower	Flood areas in floodplain forests	Mountainous element
17	*Polygonatum latifolium* – Salomon's Seal	Flood areas in floodplain forests	Mountainous element

18	*Primula acaulis* - Common Primrose	Flood areas in floodplain forests	Mountainous element
19	*Primula officinalis* - Cowslip Flowers	Flood areas in floodplain forests	Mountainous element
20	*Pulmonaria officinalis* - Spotted Dog	Flood areas in floodplain forests	Mountainous element
21	*Pulmonaria mollis* - Common Lungwort	Flood areas in floodplain forests	Mountainous element
22	*Ranunculus ficaria* - Figwort	Flood areas in floodplain forests	Mountainous element
23	*Scilla bifolia* - Alpine Squill	Flood areas in floodplain forests	Mountainous element
24	*Stachys sylvatica* - Hedge Woundwort	Flood areas in floodplain forests	Mountainous element
25	*Stellaria holostea* - Greater Stitchwort	Flood areas in floodplain forests	Mountainous element
26	*Veronica orchidea* - Veronica-orchid	Flood areas in floodplain forests	Mountainous element
27	*Viola reichenbachiana* - Wood Violet	Flood areas in floodplain forests	Mountainous element
28	*Amorpha fructicosa* - Desert False Indigo	Floodplain, especially on Mureş River sides	element from America
29	*Echinocystis lobata* - Wild Cucumber	Parks on Mureş River sides	element from America
30	*Erigeron canadensis* - Canadian Horseweed	Roadsides, paths, diggings	element from America
31	*Oenothera biennis* - Evening-primrose	Floodplain, especially on Mureş River sides	element from America
32	*Populus canadensis* - Hybrid Black Poplar	Floodplain forests	element from America
33	*Robinia pseudoacacia* - Black Locust	Floodplain forests	element from America
34	*Xanthium spinosus* - Thorny Amaranth	Roadsides and ruderal areas	element from America

References

Ardelean A., 2007, "Flora si vegetatia judetului Arad" – The flora and vegetation of Arad County Ed. Academiei Romane, Bucuresti.

Ardelean A, 1999 – "Flora şi vegetația din Valea Crişului Alb" – The flora and vegetation from the White Cris Valley, Vasile Goldiş University Press, ARAD.

Ardelean A., 1977 - "Ocrotirea naturii în județul Arad" – Nature protection in Arad county, Arad

Ardelean A., Mohan Gh., 2008 – "Flora medicinală a României" – The pharmaceutical flora of Romania, Ed. ALL, Bucureşti

Ardelean A., Mohan GH. Nedelcu G., 1997 – "Plantele medicinale din Banat" – The pharmaceutical plants of Banat, Ed. Mirton Timişoara

Csűrös I., 1973, "Az erdélyi mezőség élővilágáról" – About the living world of Ardeal rural areas, Tud. Könyvkiadó, Bucureşti.

Heuffel J., 1858, Enumeratio plantarum in Banatu Temesiensis, Vindobonnae, Typis Caroli Ueberueter.

Hortobágyi T., Simon T., 1981, "Növényföldrajz, társulástan és ökológia" – Mapping, associations and ecology of plants, Tankönyvkiadó, Budapest.

Moldovan I., 1973, "Trecutul şi prezentul nufărului alb (Nymphaea alba) în județul Arad" – Past and present of the European White Waterlily (Nymphaea alba) in Arad county, Cunoaştere şi acțiune, Arad.

Pârvu C., 1980, "Ecosistemele din România" – Ecosystems of Romania, Ed. Ceres, Bucureşti.

Sanda V. şi colect., 1983, "Caracterizarea ecologică şi fitocenologică a speciilor spontane din flora României" – Ecological and phytocenological characterization of the spontaneous species of Romania`s flora, Studii şi comunicări 25, supliment, Muzeul Brukenthal, Sibiu.

Simonkai, L., 1983, "Arad vármegye és Arad város flórája" – The flora of Arad city and Arad county, Monogr. Bizottság, Arad.

Amenajamentul U.P. 1 BEZDIN – The forestry management plan for the 1. Bezdin production unit, Ocolul Silvic Ceala, colectiv I.C.A.S. Timişoara, 1982.

PRELIMINARY RESULTS ON THE INVERTEBRATE FAUNA (ARANEAE, ORTHOPTERA, HETEROPTERA AND HYMENOPTERA: FORMICIDAE) OF ALKALINE GRASSLANDS OF THE HUNGARIAN-ROMANIAN BORDER

Gábor Lőrinczi, Miklós Bozsó, Ioan Duma, Marian Petrescu, Róbert Gallé, Attila Torma

Introduction

Alkaline grasslands, which have been present in the Pannonian Basin since the Pleistocene (Kun 1998, Molnár and Borhidi 2003), belong to the most typical communities in this region (Illyés et al. 2007). In Hungary, alkaline grasslands form the third part of grassland habitats. Only a small proportion of these are of ancient origin, most of them are secondary, and originated mainly as the result of river regulations and drainages in the 19th and 20th century (Kun 1998). According to Molnár and Borhidi (2003) about 40 percent of alkaline grasslands can be considered as natural or semi-natural habitats from the point of view of nature conservation.

In Hungary, a total of 54 plant communities are known in saline habitats, which are though relatively species-poor but have characteristic and manifold species composition (Tóth and Szendrei 2006). The vegetation pattern of alkaline grasslands strongly depends on soil salinity, salt quality, depth of maximum salt content and water availability. The typical zonations of saline vegetation are *Artemisia* salt steppe, alkaline berm ("szikpadka"), Pannonic *Camphorosma* hollow, dense and tall *Puccinellia* sward, alkaline vein ("szikér"), salt meadow and salt marsh (Molnár and Borhidi 2003).

Due to the exceptionally rich fauna and mosaic flora with several endemics and subendemics (Kelemen, 1997), alkaline grasslands are valuable from a nature conservation perspective.

In 2010 a faunistic survey was carried out in order to compare the invertebrate fauna of two neighbouring alkaline grasslands separated by the Hungarian-Romanian border. Preliminary results of the study are presented in the following.

Materials and methods

The study was carried out in the border region of Gyula, Hungary and Vărşand, Romania. Data were collected with a variety of collecting methods in the following habitat types:

Gyula I: (1) loess steppe and salt meadow; (2) salt meadow; (3) salt meadow and *Artemisia* salt steppe; (4) loess steppe; (5) Pannonic *Camphorosma* hollow and dense and tall *Puccinellia* sward with salt meadow; (6) salt meadow; (7) *Artemisia* salt steppe with dense and tall *Puccinellia* sward patches and Pannonic *Camphorosma* hollow; (8) loess steppe patches; (9) transition from *Artemisia* salt steppe to dense and tall *Puccinellia* sward; (10) salt meadow.

Sampling was performed with pitfall trapping and sweep netting during summer 2010. At each habitat 5-5 pitfall traps (500 ml plastic jars filled with ethylene-glycol) were set at intervals of approximately 4 m. Trapping was continuous from 1 June to 22 September 2010. 5 sweep net samples (each of them consisted of 50 sweeps) were taken at each habitat in 1 June, 5 July, 4 August and 22 September. Net contents were emptied into sealable plastic bags filled with some ethyl alcohol.

Sweep netting (5 × 50 sweeps) was also employed in the following sites and habitat types:

Gyula II: (1) salt meadow with loess steppe and *Artemisia* salt steppe; (2) salt meadow; (3) new abandonment on arable lands and salt meadow.

Gyula III: (1) salt meadow and *Artemisia* salt steppe; (2) *Artemisia* salt steppe with salt meadow patches.

Szabadkígyós: (1) *Artemisia* salt steppe; (2) salt marsh.

Elek: (1) loess steppe; (2) salt meadow with Pannonic *Camphorosma* hollow, dense and tall *Puccinellia* sward and *Artemisia* salt steppe patches; (3) loess steppe; (4) *Artemisia* salt steppe.

Kétegyháza: (1) salt meadow and salt marsh; (2) salt meadow.

Vărşand I: (1) uncharacteristic grassland; (2) *Achillea* salt steppe with loess steppe patches; (3) loess steppe; (4) *Artemisia* salt steppe with salt meadow patches and salt meadow with *Artemisia* salt steppe patches.

Pilu: (1) uncharacteristic grassland (or degraded loess steppe); (2) *Achillea* salt steppe with *Artemisia* salt steppe patches; (3) degraded loess steppe; (4) *Artemisia* salt steppe with salt meadow patches and Pannonic *Camphorosma* hollow; (5) *Artemisia* salt steppe and salt meadow with loess steppe patches; (6) salt meadow with uncharacteristic grassland.

Pitfall trapping and D-vac sampling (using a Stihl® BG56 Leaf Blower/VAC vacuum sampling device) were conducted in the following sites and habitat types:

Gyula IV: (1) salt meadow; (2) salt steppe with uncharacteristic vegetation.

Vărşand II: (1) degraded loess steppe; (2) *Artemisia* salt steppe; (3) higrophile meadow close to an irrigation canal; (4) salt meadow with ruderal plants.

D-vac sampling consisted of 25 sample units of 1 m^2 with a ca. 5-minutes vacuum time per habitat. Sampling was performed in 4 July, 7 August, 22 August and 27 September.

Spiders were determined according to Heimer and Nentwig (1991), Loksa (1969, 1972), Roberts (1985, 1987), Nentwig et al. (2003), Fuhn and Niculescu-Burlacu (1971) and Sterghiu (1985). Orthopteran specimens were identified using the keys of Kis (1976, 1978), Harz (1957), Móczár (1969) and Knechtel and Popovici-Biznosanu (1959). True bugs were identified according to Benedek (1969), Halászfy (1959), Kis (1984, 2001), Kis and Kondorosy (1999), Vásárhelyi (1978, 1983) and Wagner (1952, 1966, 1967). Ant specimens were determined using the keys of Seifert (1988, 1997, 2007), Czechowski et al. (2002), Csősz (1999) and Kutter (1977).

Results and discussion

Araneae

A total number of 1541 spider individuals (1344 adult and 197 juvenile) of 97 species were identified from pitfall trap and D-vac samples (Table 1). Among the rare species we can mention *Urocoras longispinus* (Kulczynski, 1897).

We collected several agrobiont and agrophile species. *Pardosa agrestis* (Westring, 1862), *Meioneta rurestris* (C.L. Koch, 1836), *Alopecosa pulverulenta* (Clerck, 1757), *Trochosa ruricola* (De Geer, 1778) and *Erigone dentipalpis* (Wider, 1834) are known to occur at agroecosystems and disturbed habitat types (Hänggi et al. 1995, Bogya and Markó 1999, Kiss and Samu 2000, Samu and Szinetár 2002). The occurrence and the high numbers of collected individuals of these species are presumably brought about not the influence of the fauna of the surrounding arable fields. According to Wissinger (1997) the agrobiont fauna consists of species adapted to predictably ephemeral habitats, they evolved the "cyclic colonization" strategy form natural or semi-natural refuges. According to this theory the agrobiont fauna possibly originated from regularly disturbed habitat types such as the annually inundated alkaline grasslands (Szita et al 1998, 2002, Samu and Szinetár 2000).

There are several data on the spider fauna of the alkaline grasslands of this region (Szita et al. 1998, 1999, 2000). The previously little known gnaphosid spider was recently found also at saline steppes and salt marsh meadows (Dudás 2001, Szita et al. 2000).

Table 1. List of spider species collected from the study sites.

Family: Uloboridae	
Uloborus walckenaerius (Latreille, 1806)	6
Family: Theridiidae	
Episinus truncatus (Latreille, 1809)	12
Euryopis quinqueguttata Thorell, 1875	6
Neottiura suaveolens (Simon, 1879)	2
Phylloneta impressa (L.Koch, 1881)	1
Simitidion simile (C.L.Koch, 1836)	1
Steatoda phalerata (Panzer, 1801)	3
Family: Linypiidae	
Agyneta sp.	1
Ceratinella brevis (Wider, 1834)	4
Cresmatoneta mutinensis (Canestrini, 1868)	5
Diplostyla concolor (Wider, 1834)	16
Erigone dentipalpis (Wider, 1834)	2
Gonatium rubens (Blackwall, 1833	1
Linyphia hortensis (Sundevall, 1830)	12
Linyphia triangularis (Clerck, 1757)	4
Meioneta rurestris (C.L.Koch, 1836)	74
Micrargus apertus (O.P. –Cambridge, 1881)	1
Neriene peltata (Wider, 1834)	3
Trichoncus hackmani Millidge, 1956	2
Walckenaeria capito (Westring, 1861)	6
Walckenaeria sp.	1
Family: Tetragnathidae	
Pachygnatha clercki (Sundevall, 1823)	1
Pachygnatha degeeri Sundevall, 1830	3
Tetragnatha extensa (Linnaeus, 1758)	5
Family: Araneidae	
Araneus quadratus (Clerck, 1757)	3
Araneus diadematus Clerck, 1757	24
Argiope bruennichi (Scopoli, 1772)	38
Mangora acalypha (Walckenaer, 1802)	2
Family: Lycosidae	
Alopecosa accentuata (Latreille, 1817)	1
Alopecosa cuneata (Clerck, 1757)	3
Alopecosa pulverulenta (Clerck, 1757)	15
Arctosa leopardus (Sundevall, 1833)	1
Aulonia albimana (Walckenaer, 1805)	285
Hogna radiata (Latreille, 1817)	6

Pardosa agrestis (Westring, 1862)	31
Pardosa amentata (Clerck, 1757)	3
Pardosa hortensis (Thorell, 1872)	1
Pardosa prativaga (L. Koch, 1870)	27
Pirata latitans (Blackwall, 1841)	1
Pirata uliginosus (Thorell, 1856)	5
Trochosa robusta (Simon, 1876)	99
Trochosa ruricola (De Geer, 1778)	9
Trochosa terricola Thorell, 1856	22
Xerolycosa miniata (C.L. Koch, 1834)	2
Family: Pisauridae	
Pisaura mirabilis (Clerck, 1757)	36
Family: Oxyopidae	
Oxyopes heterophthalmus (Latreille, 1804)	1
Family: Titanoecidae	
Titanoeca veteranica Herman, 1879	1
Family: Liocranidae	
Agroeca lusatica (L. Koch, 1875)	1
Liocranoeca striata (Kulczynski, 1882)	2
Family: Corinnidae	
Phrurolithus festivus (C.L. Koch, 1835)	107
Phrurolithus minimus C.L. Koch, 1839	35
Family: Agelenidae	
Agelena labyrinthica (Clerck, 1757)	3
Family: Dictynidae	
Dictyna arundinacea (Linnaeus, 1758)	11
Dictyna latens (Fabricius, 1775)	3
Family: Miturgidae	
Cheiracanthium punctorium (Villers, 1789)	25
Family: Gnaphosidae	
Drassodes pubescens (Thorell, 1856)	9
Drassyllus praeficus (L. Koch, 1866)	38
Drassyllus pusillus (C.L. Koch, 1833)	4
Gnaphosa lucifuga (Walckenaer, 1802)	2
Gnaphosa rufula (L. Koch, 1866)	5
Haplodrassus minor (O.P.-Cambridge, 1879)	38
Haplodrassus signifer (C.L. Koch, 1839)	11
Micaria formicaria (Sundevall, 1832)	15
Micaria pulicaria(Sundevall, 1832)	1
Micaria sp.	1
Trachyzelotes pedestris (C.L. Koch, 1837)	56
Zelotes electus (C.L. Koch, 1839)	20

Zelotes gracilis Canestrini, 1868	3
Zelotes hermani (Chyzer, 1878)	5
Zelotes latreillei (Simon, 1878)	47
Zelotes sp.	1
Family: Sparassidae	
Micrommata virescens (Clerck, 1757)	1
Family: Zoridae	
Zora spinimana (Sundevall, 1833)	16
Family: Thomisidae	
Misumena vatia (Clerck, 1757)	2
Ozyptila pullata (Thorell, 1875)	3
Ozyptila simplex (O.P.-Cambridge, 1862)	3
Synema globosum (Fabricius, 1775)	1
Thomisus onustus (Walckenaer, 1806)	3
Xysticus cristatus (Clerck, 1757)	1
Xysticus erraticus (Blackwall, 1834)	1
Xysticus kochi (Thorell, 1872)	2
Family: Amaurobiidae	
Urocoras longispinus (Kulczynski, 1897)	1
Family: Philodromidae	
Philodromus aureolus (Clerck, 1757)	3
Philodromus fuscomarginatus (De Geer, 1778)	1
Philodromus margaritatus (Clerck, 1757)	1
Thanatus arenarius Thorell, 1872	23
Thanatus formicinus (Clerck, 1757)	1
Tibellus oblongus (Walckenaer, 1802)	13
Family: Salticidae	
Euophrys frontalis (Walckenaer, 1802)	3
Heliophanus cupreus (Walckenaer, 1802)	1
Heliophanus flavipes (Hahn, 1832)	1
Leptorchestes berolinensis (C.L.Koch, 1846)	1
Macaroeris nidicolens (Walckenaer, 1802)	1
Mithion canestrini (Ninni, 1868)	10
Pellenes nigrociliatus (Simon, 1875)	2
Phlegra fasciata (Hahn, 1826)	17
Talavera aequipes (O.P.-Cambridge, 1871)	1
Total:	**1344**

Orthoptera

A total of 7750 orthopteran specimens (5142 adult and 2608 juvenile) were identified from the pitfall trap, sweep netting and D-vac samples, which represent 42 species (Table 2).

The most abundant species was clearly *Melanogryllus desertus*, followed by *Euchorthippus declivus* and *Tartarogryllus burdigalensis.*

The number of species was the highest in the mosaics of loess steppes (21 species), saline meadows (22 species) and saline meadows with *Artemisia* salt steppe patches (18 species). We found two species, *Acrida hungarica* and *Epacromius coerulipes*, which are protected in Hungary. In addition, we collected two sporadic and six rare species.

Table 2. List of orthopteran species occurring in the study sites. P: protected species in Hungary, *: sporadic species in Hungary, **: rare species in Hungary.

Order: Ensifera	
Superfamily: Tettigonioidea	
Conocephalus discolor Thunberg, 1815	36
Decticus verrucivorus (Linnaeus, 1758)	2
Leptophyes albovittata (Kollar, 1833)	13
Leptophyes discoidalis (Frivaldsky, 1867)	1
Metrioptera bicolor (Philippi, 1830)	25
Metrioptera roeselii (Hagenbach, 1822)	10
Phaneroptera falcata (Poda, 1761)	2
Platycleis affinis Fieber, 1853	20
Platycleis grisea (Fabricius, 1781)	11
Platycleis intermedia (Serville, 1838)	1
Platycleis vittata (Charpentier, 1825)	89
Ruspolia nitidula (Scopoli, 1786) *	9
Tettigonia caudata (Charpentier, 1845)	3
Tettigonia viridissima (Linnaeus, 1758)	1
Superfamily: Grylloidea	
Gryllus campestris Linnaeus, 1758	64
Melanogryllus desertus (Pallas, 1771) **	2238
Modicogryllus frontalis (Fieber, 1844) **	9
Oecanthus pellucens (Scopoli, 1763)	25
Tartarogryllus burdigalensis (Latreille, 1804) **	463
Order: Caelifera	
Superfamily: Acridoidea	
Acrida hungarica (Herbst,1786) P	66
Aiolopus thalassinus (Fabricius, 1781)	185
Calliptamus italicus (Linnaeus, 1758)	1

Chorthippus brunneus (Thunberg, 1815)	18
Chorthippus dichrous (Eversmann, 1895) **	17
Chorthippus dorsatus (Zetterstedt,1821)	27
Chorthippus mollis (Charpentier, 1825)	5
Chorthippus oschei (Helversen, 1986)	275
Chorthippus paralellus (Zetterstedt, 1821)	293
Chorthippus vagans (Eversmann, 1848) **	18
Chrysochraon dispar (Germar, 1831)	3
Epacromius coerulipes (Ivanov, 1887) [P,]**	6
Euchorthippus declivus (Brisout de Barneville, 1848)	865
Euchorthippus pulvinatus (Fischer de Waldheim, 1846) *	11
Euthystira brachyptera (Ocskay, 1826)	12
Omocestus haemorrhoidalis (Charpentier, 1825)	133
Omocestus petraeus (Brisout de Barneville, 1855)	8
Omocestus rufipes (Zetterstedt, 1821)	5
Pezotettix giornae (Rossi, 1794)	53
Stenobothrus crassipes (Charpentier, 1825)	113
Stenobothrus lineatus (Panzer, 1796)	1
Superfamily: Tetrigoidea	
Tetrix subulata (Linnaeu, 1758)	2
Tetratetrix tenuicornis (Shalberg, 1893)	3
Total:	**5142**

Heteroptera

A total number of 505 adult individuals of 54 species were collected by pitfall traps and D-vac sampling (Table 3).

Sweep netting or suction sampling are generally used to sample Heteroptera assemblages in grasslands (Standen 2000, Coscaron et al. 2009), pitfall trapping is not necessary (Standen 2000). Collecting true bugs from the ground-level generally needs great effort and has trifling result compared with collecting from the vegetation (Rédei et al. 2003). However, the sampling of epigeic true bugs may result important and valuable faunistical data. Several rare and new species for the Hungarian fauna were collected exclusively from the ground surface (e.g. Torma 2005). In the alkaline grasslands of Gyula, several rare true bug species were collected by pitfall traps, too. These species were mainly predaceous true bugs, e.g. *Prostemma sanguinea* (Rossi, 1790), *Alloeorhynchus flavipes* Fieber, 1836, *Himacerus* (*Stalia*) *boops* (Schiödte, 1870) and *Pirates hybridus* (Scopoli, 1763). The phytophagous species were mainly polyphagous bugs, but some specialist herbivorous true bugs were also collected, e.g. *Piesma kochiae* (Beckegur, 1867), *Sciocoris sulcatus* Fieber, 1851 and *Vilpianus galii* (Wolff, 1802). Several species preferred alkaline grassland habitats, e.g. *Lygaeosoma anatolicum* Seidenstücker, 1960 and *Henestaris halophilus* (Burmeister, 1835).

The number of collected species was low comparing with both Hungarian (e.g. Vásárhelyi 1985, Kondorosy 2000, 2003, Kondorosy and Harmat 1998) and Romanian (e.g. Kis 1972, 1976, Torma 2009a, 2009b) Heteroptera faunistical studies, however it presumably change when processing of sweep netting material will be finished.

The nomenclature of true bugs followed the work of Kondorosy (1999).

Table 3. List of true bug species collected from the study sites.

Family: Tingidae	
Acalypta marginata (Wolff, 1804)	26
Kalama tricornis (Schrank, 1801)	4
Lasiacantha gracilis (Herrich-Schäffer, 1830)	1
Family: Miridae	
Acetropis carinata (Herrich-Schaeffer, 1842)	5
Adelphocoris lineolatus (Goeze, 1778)	2
Adelphocoris ticinensis (Mayer-Dur, 1843)	1
Amblytylus concolor Jakovlev, 1877	1
Charagochilus weberi E. Wagner, 1953	1
Hallodapus rufescens (Burmeister, 1835)	1
Lygus pratensis (Linnaeus, 1758)	2
Notostira erratica (Linnaeus, 1758)	7
Omphallonotus quadriguttatus (Kirschbaum, 1856)	3
Polymerus vulneratus (Panzer, 1806)	1
Family: Nabidae	
Alloeorhynchus flavipes Fieber, 1836	1
Himacerus (*Stalia*) *boops* (Schiödte, 1870)	1
Nabis (s. str.) pseudoferus Remane, 1949	1
Nabis (s. str.) punctatus Costa, 1847	1
Nabis pseudoferus / punctatus ♀♀	3
Prostemma aeneicolle Stein, 1857	4
Prostemma g. guttula (Fabricius, 1787)	1
Prostemma sanguinea (Rossi, 1790)	28
Family: Reduviidae	
Pirates hybridus (Scopoli, 1763)	3
Family: Piesmatidae	
Piesma kochiae (Beckegur, 1867)	6
Family: Lygaeidae sensu latu	
Beosus quadripunctatus (Müller, 1766)	3
Dimorphopterus doriae (Ferrari, 1874)	177

Emblethis griseus (Wolff, 1802)	2
Graptopeltus lynceus (Fabricius, 1775)	2
Henestaris halophilus (Burmeister, 1835)	2
Lygaeosoma anatolicum Seidenstücker, 1960	41
Megalonotus chiragra (Fabricius,1787)	1
Megalonotus sabulicola (Thomson, 1870)	1
Metopoplax origani (Kolenati, 1845)	4
Microplax interrupta (Fieber, l837)	2
Ortholomus punctipennis (Herrich-Schäffer, 1839)	2
Peritrechus gracilicornis (Puton, 1877)	3
Peritrechus nubilus (Fallén, 1807)	2
Plinthisus (*Plinthisomus*) *pusillus* (Scholtz,1846)	2
Tropistethus holosericeus (Scholtz, 1846)	4
Xanthochilus quadratus (Fabricius, 1798)	4
Family: Pyrrhocoridae	
Pyrrhocoris apterus (Linnaeus, 1758)	12
Pyrrhocoris marginatus (Kolenati, 1845)	6
Family: Rhopalidae	
Chorosoma schillingi (Schummel, 1829)	3
Myrmus miriformis (Fallén, 1807)	2
Stictopleurus crassicornis (Linnaeus, 1758)	17
Family: Cydnidae	
Geotomus punctulatus (Costa, 1847)	17
Legnotus picipes (Fallén, 1807)	30
Family: Scutellaridae	
Eurygaster maura (Linnaeus, 1758)	35
Family: Pentatomidae	
Aelia acuminata (Linnaeus, 1758)	1
Dolycoris baccarum (Linnaeus, 1758)	5
Podops inuncta (Fabricius, 1775)	4
Sciocoris cursitans (Fabricius, 1794)	7
Sciocoris distinctus Fieber, 1851	2
Sciocoris sulcatus Fieber, 1851	5
Vilpianus galii (Wolff, 1802)	3
Total:	**505**

Hymenoptera: Formicidae

A total of 9110 ant individuals (8925 workers, 128 queens and 57 males) were identified from the pitfall trap samples of July-September, which represent 25 species (Table 4), among which *Lasius nitidigaster* Seifert, 1996 is a new species for the Hungarian myrmecofauna (Lőrinczi, submitted manuscript).

The most abundant species was *Lasius paralienus*, followed by *Tetramorium cf. caespitum, Tapinoma erraticum* and *Myrmica slovaca*, the latter of which is a characteristic species of saline grasslands. These species, together with *Formica rufibarbis* and *F. cunicularia*, were also those that occurred almost in all habitat types. The number of species was the highest in the mosaics of loess steppes and saline meadows (up to 18 species), while the lowest in habitats consisting of Pannonic *Camphorosma* hollows and dense and tall *Puccinellia* swards (less than 8 species).

The presence of *Ponera testacea* in the collected material is worth noticing, since it has not been found in the Great Hungarian Plain so far, and only one syntopic occurrence of the two *Ponera* species has been recorded in Hungary (Csősz and Seifert 2003). *P. testacea* is widely distributed in Southern and Central Europe, where it associates with open and xerothermous grasslands, particularly those on sand, rocky limestone, dolomite and siliceous rock (Csősz and Seifert 2003, Czechowski and Radchenko 2010). The two specimens of *P. testacea* collected in Gyula were found in a habitat of loess steppe patches.

Table 4. List of ant species identified from the alkaline grasslands of Gyula.

	workers	queens	males
Subfamily: Ponerinae			
Ponera coarctata (Latreille, 1802)	-	2	-
Ponera testacea Emery, 1895	2	-	-
Subfamily: Myrmicinae			
Anergates atratulus (Schenck, 1952)	-	1	-
Myrmica gallienii Bondroit, 1920	97	23	1
Myrmica sabuleti Meinert, 1861	281	-	1
Myrmica scabrinodis Nylander, 1846	-	2	-
Myrmica slovaca Sadil, 1952	1013	37	-
Myrmica specioides Bondroit, 1918	138	2	-
Myrmica sp.	-	-	24
Solenopsis fugax (Latreille, 1798)	47	23	23
Tetramorium cf. caespitum	1470	4	-
Subfamily: Dolichoderinae			
Tapinoma erraticum (Latreille, 1798)	1158	-	-
Tapinoma madeirense Forel, 1895	146	-	-
Subfamily: Formicinae			
Camponotus atricolor (Nylander, 1849)	27	-	-
Formica cunicularia Latreille, 1798	68	-	-
Formica rufibarbis Fabricius, 1793	391	-	-
Formica sanguinea (Latreille, 1798)	15	-	-

Lasius carniolicus Mayr, 1861	1	-	-
Lasius distinguendus (Emery, 1916)	1	2	-
Lasius flavus (Fabricius, 1782)	-	2	-
Lasius fuliginosus (Latreille, 1798)	2	-	-
Lasius niger (Linnaeus, 1758)	709	1	-
Lasius nitidigaster Seifert, 1996	-	3	-
Lasius paralienus Seifert, 1992	2382	25	-
Lasius sp.	-	-	8
Plagiolepis pygmaea (Latreille, 1798)	56	1	-
Polyergus rufescens (Latreille, 1798)	921	-	-
Total:	**8925**	**128**	**57**

References

Benedek, P. (1969): Poloskák VII. Heteroptera VII. In: *Fauna Hungariae* 17(7). Akadémiai Kiadó, Budapest, pp 86.

Bogya, S., Markó, V. (1999): Effect of pest management systems on ground-dwelling spider assemblages in an apple orchard in Hungary. *Agriculture, Ecosystems and Environment* 73: 7-18.

Coscaron, M. C., Melo, M. C. Coddington, J., Corronca, J. (2009): Estimating biodiversity: a case study on true bugs in Argentinian wetlands. *Biodiversity and Conservation* 18: 1491–1507.

Csősz, S. (1999): A *Myrmica* genus (Hymenoptera: Formicidae) hazai és várható fajainak határozója (Identification of species of genus *Myrmica* occurring in Hungary). (in Hungarian). TDK (Scientific Conference for Students) dissertation, Szeged.

Csősz S., Seifert B. (2003): *Ponera testacea* Emery, 1895 stat. n. - a sister species of *P. coarctata* (Latreille, 1802) (Hymenoptera, Formicidae). *Acta Zoologica Academiae Scientiarum Hungaricae* 49: 201-214.

Czechowski, W., Radchenko, A. (2010): *Ponera testacea* Emery, 1895 (Hymenoptera: Formicidae) in Poland. *Polish Journal of Entomology* 79: 327-337.

Czechowski, W., Radchenko, A., Czechowska, W. (2002): The ants (Hymenoptera, Formicidae) of Poland. MIZ PAS, Warszawa, 200 pp.

Dudás, Gy. (2001): Adatok Dél-Heves pókfaunájához. *Folia Historico Naturalia Musei Matraensis* 25: 69-78.

Fuhn, I. E., Niculescu-Burlacu, F. (1971): Fam. Lycosidae. *Fauna Republicii Socialiste Romania (Arachnida)* 5 (3): 1-253.

Halászfy, É. (1959): Poloskák II. Heteroptera II. In: *Fauna Hungariae* 17(2). Akadémiai Kiadó, Budapest, pp 87.

Hänggi, A., Stöckli, E., Nentwig, W. (1995): Habitats of Central European spiders. *Miscellaneae Faunistica Helveticae* 4:1-460.

Harz, K. (1957): Die Geradflüger Mitteleuropas. VEB Gustav Fischer Verlag, Jena

Heimer, S., Nentwig, W. (1991): Spinnen Mitteleuropas. Paul Parey Verlag, Berlin und Hamburg 1-536.

Illyés, E., Bölöni, J., Kovács, G., Kállayné Szerényi, J. (2007): A száraz gyepek jelentősége, elterjedése, helyük a vegetációmozaikban és termőhelyi viszonyaik Magyarországon. - In: Illyés, E., Bölöni, J. (eds.): Lejtősztyepek, löszgyepek és erdőssztyeprétek Magyarországon. Magánkiadás, Budapest, pp. 12-19.
Kelemen, J. (1997): Szikes gyepek. - In Kelemen, J. (ed.): Irányelvek a füves területek természetvédelmi szempontú kezeléséhez. TermészetBúvár Alapítvány Kiadó, Budapest, pp. 129-165.
Kis, B. (1972): Ord. Heteroptera. L'entomofaune du "grind" de Caraorman, Delta du Danube. *Travaux du Muséum d'Histoire Naturelle "Grigore Antipa"* 12: 131-139.
Kis, B. (1976): Ord. Heteroptera. L'entomofaune du nord de la Dobrogea, la zone Măcin-Tulcea-Niculițel. *Travaux du Muséum d'Histoire Naturelle "Grigore Antipa"* 17: 135-143.
Kis, B. (1976): Cheie pentru determinarea Ortopterelor din Romania. Partea I. Subordinul Ensifera. *Muzeul Brukenthal Ştiințe Naturale Studii şi Comunicări*, 20: 123-166.
Kis, B. (1978): Cheie pentru determinarea Ortopterelor din Romania. Partea II. Subordinul Caelifera. *Muzeul Brukenthal Ştiințe Naturale Studii şi Comunicări*, 22: 233–276.
Kis, B. (1984): Heteroptera: Pentatomoidea. *Fauna Republicii Socialiste România, vol. 8, fasc. 8,* Editura Academiei Republicii Socialiste România, Bucureşti.
Kis, B. (2001): Heteroptera: Coreoidea şi Pyrrhocorioidea. *Fauna României, vol. 8, fasc. 9,* Editura Academiei Române, Bucureşti.
Kis, B., Kondorosy, E. (1999): Poloskák - Heteroptera IV. *Fauna Hungariae, vol. 17,* Manuscript.
Kiss, B., Samu, F. (2000): Evaluation of population densities of the common wolf spider *Pardosa agrestis* (Araneae: Lycosidae) in Hungarian alfalfa fields using mark-recapture. *European Journal of Entomology* 97: 191-195.
Knechtel, W. K., Popovici-Biznosanu, A. (1959): Orthoptera. Ordinele: Saltatoria, Dermaptera, Blattodea, Mantodea. Fauna Republicii Populare Române, 7(4): 1-336.
Kondorosy, E. (1999): Checklist of the Hungarian bug fauna (Heteroptera). *Folia Entomologica Hungarica* 60: 125-152.
Kondorosy, E. (2000): Adatok a Villányi-hegység poloskanépességének (Heteroptera) ismeretéhez. *Dunántúli Dolgozatok Természettudományi Sorozat* 10: 165-174.
Kondorosy, E. (2003): A Látrányi Puszta Természetvédelmi Terület poloska-népességéről (Heteroptera). *Natura Somogyiensis* 5: 113-122.
Kondorosy, E., Harmat, B. (1998): Contributions to the Heteroptera fauna of Őrség Landscape Conservation Area. In: Natural History of Őrség Landscape Conservation Area 3. (szerk.: Vig, K.). *Savaria, a Vas megyei Múzeumok Értesítője, Pars historico-naturalis* 24(2): 25-49.
Kun, A. (1998): Száraz gyepek Magyarországon. - In: Kiszel, V. (ed.): Természetvédelem területhasználók számára. Göncöl Alapítvány, Vác.
Kutter, H. (1977): Hymenoptera, Formicidae. In: *Insecta Helvetica Fauna* 6. - Schweizerische Entomologische Gesellschaft: Zürich, 298 pp.
Loksa, I. (1969): Pókok-Araneae I. Fauna Hungariae. Akadémiai Kiadó, Budapest 1-133.
Loksa, I. (1972): Pókok-Araneae II. Fauna Hungariae. Akadémiai Kiadó, Budapest 1-112.
Lőrinczi, G. (submitted manuscript): *Lasius nitidigaster* Seifert, 1996 - a new ant species (Hymenoptera: Formicidae) for the Hungarian fauna.
Molnár, Zs., Borhidi, A. (2003): Hungarian alkali vegetation: Origins, landscape history, syntaxonomy, conservation. *Phytocoenologia* 33(2-3): 377-408.

Móczár, L. (1969): Állathatározó I. kötet. Tankönyvkiadó, Budapest, 219-242.
Nentwig, W., Hänggi, A., Kropf, C., Blick, T. (2003): Spinnen Mitteleuropas/Central European Spiders. An internet identification key. http://www.araneae.unibe.ch
Rédei, D., Gaál, M., Hufnagel L. (2003): Spatial and temporal patterns of true bug assemblages extracted with Berlese funnels. *Applied Ecology and Environmental Research* 1 (1-2): 115-142
Roberts, M. I. (1985): The Spiders of Great Britain and Ireland 1. Harper Collins, London 1-154
Roberts, M. I. (1987): The Spiders of Great Britain and Ireland 2. Harper Collins, London 1-225
Samu, F., Szinetár, Cs. (2000): On the nature of agrobiont spiders. *The Journal of Arachnology* 30: 389-402
Seifert, B. (1988): A revision of the European species of the ant subgenus *Chthonolasius* (Insecta, Hymenoptera, Formicidae). *Entomologische Abhandlungen Staatliches Museum für Tierkunde Dresden* 51: 143-180.
Seifert, B. (1997): *Lasius nitidigaster* n. sp. - a new ant of the subgenus *Chthonolasius* Ruzsky (Hymenoptera: Formicidae). *Annales Zoologici* 46: 201-205.
Seifert, B. (2007): Die Ameisen Mittel- und Nordeuropas. Lutra-Verlags-und Vertriebsgesellschaft, Görlitz, 368 pp.
Standen, V. (2000): The adequacy of collecting techniques for estimating species richness of grassland invertebrates. *Journal of Applied Ecology* 37: 884-893.
Sterghiu, C. (1985): Fam. Clubionidae. *Fauna Republicii Socialiste România (Arachnida)* 5(4): 1-165.
Szita, É, Samu, F., Bleicher, K., Botos, E. (1998): Data to the spider fauna (Araneae) of Körös-Maros National Park (Hungary). *Acta Phytopathologica et Entomologica Hungarica* 33: 341-388.
Szita, É., Samu, F., Botos, E. (1999): Újabb adatok a Körös-Maros Nemzeti Park pókfaunájához. *Crisicum* 2: 93-97.
Szita, É., Samu, F., Botos, E. (2000): A Blaskovics puszta (KMNP) pók (Araneae) együtteseinek összehasonlító elemzése. *Crisicum* 3:157-164.
Szita, É., Samu, F., Fetykó, K., Szirányi, A. (2002): Testing the origin of agrobiont spiders: spiders in agricultural and natural grassland habitats of the Körös-Maros National Park, Hungary. In Samu, F., Szinetár, Cs. (eds.) *European Arachnology 2002*. 319-326.
Torma, A. (2005): Three new and a rare true bug species in the Hungarian fauna (Heteroptera: Dipsocoridae, Reduviidae, Lygaeidae). *Folia Entomologica Hungarica* 66: 35-38.
Torma, A. (2009a): Data to the terrestrial Heteroptera fauna of Moldva. *Acta Scientiarum Transylvanica* 17(1): 107-118.
Torma, A. (2009b): Data to the terrestrial Heteroptera fauna of Dobrogea. *Acta Scientiarum Transylvanica* 17(1): 89-103.
Tóth, T., Szendrei G. (2006): A hazai szikes talajok és a szikesedés valamint a sófelhalmozódási folyamatok rövid jellemzése. / Types and distribution of salt affected soils in Hungary, and the characterisation of the processes of salt accumulation. (in Hungarian). *Topographia Mineralogica Hungariae* 9: 7-20.

Vásárhelyi, T. (1978): Poloskák V. Heteroptera V. In: *Fauna Hungariae* 17(5). Akadémiai Kiadó, Budapest, 76 pp.
Vásárhelyi, T. (1983): Poloskák III. Heteroptera III. In: *Fauna Hungariae* 17(3). Akadémiai Kiadó, Budapest, 88 pp.
Vásárhelyi, T. (1985): A Barcsi borókás poloskafaunájának alapvetése (Heteroptera). *Dunántúli Dolgozatok Természettudományi Sorozat* 5: 101-104.
Wagner, E. (1952): Blindwanzen oder Miriden. In: *Die Tierwelt Deutschlands* 41. Veb Gustav Fischer Verlag, Jena.
Wagner, E. (1966): Wanzen oder Hetropteren I. Pentatomorpha. In: *Die Tierwelt Deutschlands* 55. Veb Gustav Fisher Verlag, Jena.
Wagner, E. (1967): Wanzen oder Heteropteren II. Cimicomorpha. In: *Die Tierwelt Deutschlands* 55. Veb Gustav Fisher Verlag, Jena.
Wissinger, S. A. (1997): Cyclic colonization in predictably ephemeral habitats: a template for biological control in annual crop systems. *Biological Control* 10: 4-15.

ECOSYSTEM SERVICES AT MAGYARCSANÁD SITE AS PERCIEVED BY LOCAL PEOPLE

György Málovics, Katalin Margóczi, Judit Gébert

Project objectives

The objective of the study discussed in this paper was to investigate and assess how local stakeholders perceive the natural environment they live in, what they find valuable and important for their "well-being" and life. The theoretical background of this valuation was the concept of ecosystem services. According to one of the most popular definitions, ecosystem services are the benefits human populations derive, directly or indirectly, from natural and human-modified ecosystems (MEA 2003). Thus the concept of ecosystem services describes exactly what we wanted to understand through our research: the importance of nature to a local community and the ways local people and their communities can benefit from their environment.

The area of the research

Geographical site description

Two study sites were chosen for developing a habitat evaluation system and assessment of ecosystem goods and services in the HURO/0801 program. One of these sites is along the River Maros, near to the Hungarian villages Apátfalva and Magyarcsanád. The study was focused on the floodplain, the area between the dike of flood-protection and the river bed. The width of the floodplain is quite wide here, about 2500 m.

The climate of the area is continental: mean annual temperature is 10,8oC, annual precipitation average is 567 mm and solar radiation is 2100 hours per year. This mesoclimate is modulated by the hydrological factors and by the vegetation. (Marosi and Somogyi, 1990). The hydrological character of the studied area is determined by the River Maros (Fig. 1). The river runs in its original, natural bed until it reaches Apátfalva. The river forms a large curve between Bökény and Apátfalva. The water dynamic of the river depends mainly on the hydrological events in Romania, and affected by the water level of River Tisza as well. The high water and flood usually comes in spring or in June, and the water level of the river is the lowest in September and October. The flooding period is not so long and the flooding level is not so high in the Maros floodplain as it is in the case of

Tisza. The studied area is on the higher level of the Hungarian Maros section, so the agriculture is only slightly endangered by floods (Oroszi, 2009).

Figure 1. Present situation of the studied area near the villages Apátfalva and Magyarcsanád. The border of Hungary and Romania is along the River Maros. Source: google earth

Accelerated overbank aggradation was measured along the Maros River as a result of mid 19th century regulation works. Due to these works the meanders of the lowland Maros River were cut off, the channel became straightened. Within 50 years the cut-offs made during the regulation works silted up. Since natural widening became dominant, it produced extra amount of sediment input for the Maros River which is characterised by great sediment discharge. The accelerated overbank sedimentation was especially intensive in front of the alluvial fan, where a secondary alluvial fan was built (Kis *et al.* 2010)

There are young alluvial soils on the floodplain area, but on the saved-side of the dikes there are mould soils, it is very good for agriculture.

Ecological description

A complex landscape-use (mosaics of arable lands, orchards, grasslands, and forests) preserving the marks of the smallholder landscape-use is characteristic on the Maros floodplain, at Apátfalva and Magyarcsanád. On the lower part of the river floodplain, near Szeged, planted forests and large-plot dominated landscape can be found, containing less habitat-patch and type (Deák 2010).

It is difficult to separate the natural and artificial habitats because the cultivated meadows and planted forest have some natural character, and even the arable fields are abandoned for some years, and ploughed again later.

The following natural vegetation types (habitats) can be found on the River Maros floodplain (Deák 2010):

Relatively common types:
floodplain meadows,
willow-poplar woodlands
oak-elm-ash alluvial forests,
annual wet pioneer vegetation
willow-shrubs,
extensive floodplain orchards
reeds and the floodplain *Bolboschoenus* dominated swamps

Less common types:
saved-side secondary saline landscapes,
lag-surfaces of high floodplains
habitat-complexes of the mosaics of non-saline grasslands, paleopotamals and forests
saved-side and active floodplain's oxbow lakes
navvy-holes

Rarely occcure:
sedgefields,
Glyceria, Butomus, Eleocharis, Alisma, Oenanthe dominated swamps,
eutrophic reed-grasses

The botanical studies described the presence of 645 plant species, 20 protected species among them. The most important species are: Iris spuria, Vitis silvestris, Lythrum tribracteatum, and Potamogeton filiformis (Paulovics 2002).

The floodplains are endangered by invasive plants everywhere in Hungary. The lower Maros floodplain is invaded strongly by Acer negundo and Amorpha fruticosa and in lesser degree Fraxinus pennsylvanica. The closed native forest, the long lasting surface water or continuous grazing or moving could stop its spreading and dominance.

The fauna of River Maros floodplain is much more less revealed than the flora. Only the Gastropoda Coleoptera, Lepidoptera and Aves are quite well studied. The saved and flooded part of the floodplain and the river bed as a habitat complex only together guarantees the survival of animal species. Several protected fish species were found in the river. The most valuable bird species are Charadrius dubius, Pernis apivorus, Ciconia nigra and 22 other strictly protected species, and 7 bat species are also described (Paulovics 2002).

The history of land use

There is a detailed study about the history of land use in this book (see Fodor *et al.*, 21-32 pages), we present a short summary here, it is necessary to understand the present situation of ecosystems.

In the middle ages the Maros valley was densely populated, but this culture was destroyed during the Turkish occupation. Most of the ruined villages have never been rebuilt.

Apátfalva used to be surrounded by a large pasture in 1784 (First Military Survey), and there were orchards and gardens as well at that time there (Oroszi 2009). Csanád is a very small settlement, but not in the present position. The river is braided, forms islands in their bed. There are some forest patches near the river (Fig. 2).

Figure 2. The studied area in 1784 Source: First Military Survey, Col.: 20 Sec.: 30

The neighborhood of Apátfalva is a large pasture. Forest patches are near the river, arable land is only several km to the east from the village.

A great flood destroyed a street in Apátfalva in 1820, consequently the river regulation started after this event. Dikes were built and certain meanders were cut off (Oroszi, 2009). Several cutoff can be seen on the map from 1864, but the river flows mainly in the old bed yet (Fig.3). The village Magyarcsanád was built this time, the extent of the settlements is similar to the present state. The grasslands were ploughed only in small patches, near to the villages, the border of the pasture and arable land is in the previous position. The eastern half of the grassland is indicated to wet meadow (blue color on the map). Forests are only in the large curve of the river, forming a mosaic with wet meadow patches. Larger forests are on the left side of the river (Grosz Szt. Mikloser Wald).

Later most of the grassland were ploughed around the villages, but between the dikes of flood-prevention and the river (on the present floodplain) several hundreds of grasslands remained until now.

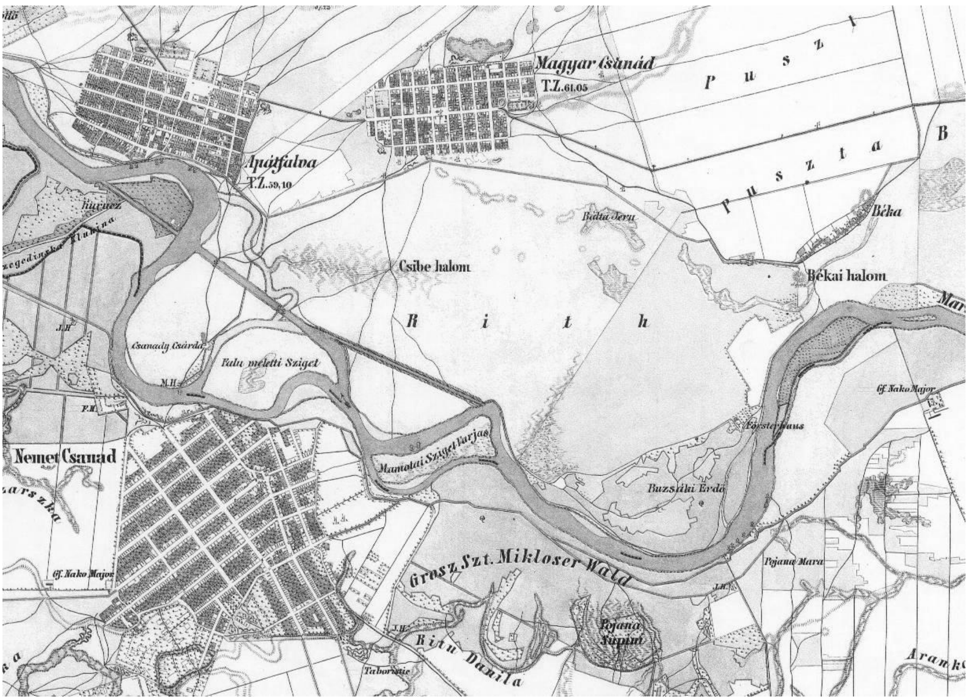


Figure 3. The studied area in 1864. Source: Second Military Survey Coll.39. Sec.: 62.

Land use during the socialist period (between 1945 and 1990)

During the socialist period the floodplain was managed mainly by a cooperative. A hybrid poplar plantation was developed on the half of the floodplain area, and the other half was arable land and grassland in 1:1 area rate. The pattern of the land use types was similar to the present situation. The arable land was cultivated intensively, using chemicals, fertilizers and large machines. An extensive channel system was built and the fields were irrigated from the River Maros. Mainly vegetables (turnip and garlic) and fruits were produced. The grasslands were managed intensively as well, using fertilizers and irrigation. After a very early mowing a large number of grazing anmals (horses, cattle, sheep and pigs) were grazed here successively, altogether about 2000 animals on about 300 ha grassland area. The natural forests in the large river curve were cut down, and small scale arable land parcels and private gardens were developed here. Hybrid poplar were planted on the place of wet meadow.

Figure 4. The most of the floodplain is nature protected, belongs to the Körös-Maros National Park (crosshatched). Source: Nature Conservation Information System (www.termeszetvedelem.hu)

The cooperative survived until 1997, and this is the year of the foundation of the Körös-Maros National Park (Fig. 4). So, the privatization of lands did not occur here, the national park took over the management of the area directly from the collective farm. Most of the floodplain between the dikes and the river remained in state ownership. After 2004 the area belongs to the Natura 2000 ecological network.

Evaluation method

There are several methods currently in use in social sciences to evaluate the role of ecosystem services (and the role of nature in general) in human societies. Monetary valuation providing cost-benefit analysis can be regarded as the most popular one in environmental economics (Hanley and Spash 1993). The theoretical basis of these methods lies in neoclassical economic theory. These methods deduce the value of ecosystem services from individual benefits. 1 The popularity of the method is indicated by the fact that ecosystem services have also been valuated on a global scale in sucg a way in 1996 (Costanza *et al.* 1996).

Certain methods of cost-benefit analysis and the monetary valuation of natural resources are criticized both by neoclassical environmental economists (Marjainé Szerényi 2000, 2005) and by the followers of competing economic paradigms, mainly ecological economics (Gowdy 1997, Málovics-Bajmócy 2009).[1]

Regardless to our position in the debate about nature's monetary valuation, the aim of our research (to explore and understand) demanded the use of alternative methods, because of the following reasons. According to the neoclassical paradigm valuation methods (especially conditional valuation) applicable in the monetary valuation of natural resources are quantitative methods. Such methods provide a generalization related to the most important explanatory variables related to certain phenomena, instead of providing an in-depth explanation of those (e.g. Why is natural environment important for certain communities?) (Babbie 2008). To understand social phenomena qualitative techniques are needed, such as in-depth personal interviews and focus group interviews.

To achieve our research objectives we have chosen qualitative methods because of the issues described above.[2] During the research that took place between the summer of 2010 and january 2011 altogether 28 in-depth semi-

[1] Further reading about the critique of nature's the monetary valuation can be found in CONCERTED ACTION: Environmental Valuation in Europe (EVE) project: http://www.clivespash.org/eve/publ.html#SJI

[2] This doesn't mean that qualitative methods are the best option to achieve our research objectives. It is possible that certain participatory approaches (e.g. Cornwall and Jewkes 1995, Aldres and Jacobs 2000, Gomez *et al.* 2011, Munté *et al.* 2011) would be more suitable for the same purpose. However, applying these methods would reach far beyond the financial, human and time constraints of the project.

structured interviews were conducted with local residents and land users about the ecosystem services they perceive. Economist and ecologist students of the Univerity of Szeged participated in the research after a short university course where they received a training about the principals of social science research methods, particularly qualitative interviewing. The survey was carried out in three phases from the summer of 2010 to January 2011. Working in pairs and in groups of three 28 semi-structured intervies were made with local farmers, members of NGO-s, teachers, hydrology and conservation specialists, and officeholders.[3] We have chosen semi-structured interviews because (1) this method has already been proven to be suitable in exploring and understanding the opinion of local people about nature in previous researches (Kelemen *et al.* 2009, Málovics and Kelemen 2009), and (2) because it allows unexpected observations wich was important for us because of the explorative nature of the research.

The first round of the subjects was selected with the guidance of the national park service ranger and using the snowball sampling method further subjects were chosen with the help of the previous ones. Most of the interviews were carried out in Apátfalva and Magyarcsanád, but interviews were made in Bökény and Csanádpalota as well.

One of the serious problems that may occur in a social study is that stated preferences (what people tell in a survey) may differ significantly from revealed preferences (what people really think about certain subjects or how they would really act in certain situations) (Babbie 2008). Thus we paid special attention to formulate questions that do not remind our subjects directly of the field of environmental protection and nature conservation. We did so knowing that today environmental protection and nature conservation have become social expectations, so in a survey where subjects are aware of the green aspect of the research, the stated and revealed preferences are very likely to differ. Stated prefrences will appear greener than revealed ones (Kelemen and Gómez-Baggethun 2008).

The following topics were discussed during the interviews depending on the subjects' occupation, current situation, options and prospects in life (see appendix for the detailed interview scheme):

Life and work of the subject. Local life options, farming possibilities.
Natural values of the area.
Changes of the natural environment.

[3] This amount of interviews is considered sufficient in a ”traditional” social study but similar studies (e.g. Kelemen *et al.* 2009) may produce a significantly higher number of interviews.

Notes have been taken during the interviews continuously instead of sound recording because according to our previous experiences a significant part of our subjects might find the latter one ”intimidating”: they were able to talk in a more open and free way when they knew that their voice was not recorded. Therefore when quoting an interview we refer to our notes and not recordings. The interviews are indicated with codes V1-V28, each code indicating a different interview.

Results

Inventory of the ecosystem services perceived by locals

Table 1. Ecosystem services in functional alignment

Provisioning services	Food Fodder Energy source, fuel Timber or other raw materials Biochemicals, natural medicines and pharmaceuticals Genetic resources Ornamental resources
Regulating services	Air quality regulation Climate regulation Water regulation Flood protection Erosion regulation Regulating species reproduction Break down of pollutants Pollination Pest control and disease protection Storm protection Protection against noise and dust Biological nitrogen fixation Conservation of nature and biodiversity
Cultural services	Cultural, historical and spiritual heritage values Scientific and educational services Recreation and ecotourism Aesthetic values Other cultural or artistic information, inspiration „Sense of place”
Supporting services	Soil formation Nutrient cycling Primary production

Source: MEA 2005, Hein *et al.* 2006

The typology of ecosystem services used in the research was developed based on the Millennium Ecosystem Assessment (2005) distinguishing four types of services: provisioning services (e.g. food, raw materials, fodder), regulating services (e.g. climate regulation, protection against floods, pollination), cultural services (e.g. education, recreation, artistic inspiration) and supporting services (MEA 2005) (Table 1). Due to recent criticism of the evaluation of supporting services (pl. Hein *et al.* 2006) we avoided dealing with them in this survey.

Provisioning services

According to our interviews it has become clear about the ecosystem services perceived by locals that key importance was given to provisioning services by nearly all subjects (and not only by farmers). When talking about food production the importance of production of field crops, vegetable cultivation and fruit production is highlighted and the exellent local agricultural potentials are emphasized.

„Crops, fruits, vegetables and greenery horticulture are typical here. We have a countrywide good quality soil." V9

„Soil is excellent in the area. On the Hungarian side of the river Maros soils yield very well and… natural features are very suitable for agriculture. Corn, wheat, oat are produced. Onion and garlic have become widespread too. Parsley is also typical." V17

„People mostly produce vegetables: onion and parsley. To a smaller extent livestock farming is also present: farmers produce fodder on their own lands and they mostly keep pigs. But they rather cultivate plants. In the past sugarbeet too, but now it's gone. There is sunflower, corn, wheat, oat, but no rape is produced. Parsley is just called "gyökér" (root) here. Other than that, more carrot and onion is produced here than garlic, that's rather done in Makó. Vegetables are delivered to Dorozsma, Budapest for seasonal grocery sales, but throughout the whole year as well. Washing and packing all seasons: from the frozen soil, outside in the cold, it's a tough job. Prices are unstable, it's only worth on the long run and only on a big land." V18

"There is little uncultivated land in the area. Mostly onion, parsley, paprika and tomato are produced. Tomato production is based on thermal water… There are small gardens in the flood plain where people grow vegetables… but due to the generation swift there are less and less vegetable gardens in the floodplain…" V7

"Floriculture is not present in the area. Fruits are typical, plum particularly, but it is disappearing, because cedars take over as people from the cities move in the area. It is a pity since the local plum pálinka is delicious and can have up to 40-50-60 percent of alcohol content." V20

In the past livestock production used to be an important ecosystem service besides plant cultivation in the area. By today it has lost its significance due to loss of market according to the locals. Very few locals do it for a living, animals are kept mostly just for the household.

„Three kind of land use can be found in the area: ploughland, grassland and forest. Grasslands have been grazed but since the sixties and seventies the number of livestock has fallen. János Gyenge has a herd grazing in the area and the national park has a herd of 100 Hungarian grey cattle." V1

"We used to have pigs too, we had about 100, also cows, horses, but not anymore." V3

„Livestock farming got ruined mostly because prices were pushed down and everything comes from abroad." V12

„My animals are: sheep and goats: 50 and also 3 cows, 15 pigs, 2 horses." V19

„We used to do farming. I used to be the cook in the kindergarten and my ex-husband used to work for the agricultural cooperative with fodder processing. We used to have a homestead where we prduced parsley. We had two cows and one bull. We took the milk to the milk collecting station every day, a litre costed 3 forints. Things went on like this between the sixties and nineties when we finally gave up farming… We used to grow corn and used to feed it to the pigs, we had 40 each year. We had one brood sow and we sold the piglets. Today, there are just two houses left where they keep pigs. We still do it, but these are slaughtered at an other house for us. We just keep them for our own consumption." V2

Besides agricultural production fish and game is a provisioning service mentioned frequently. According to the subjects fishing has lost much of its significance lately while hunting remains an important source of income.

„There is a hunting association that belongs to the city of Makó. They organize battues every autumn. You can shoot hare, pheasant and wild boar or deer too." V2

„The hunting society provides a source of living … The area of the hunting ground is 1800 hectares. 30% of the society's income comes from hunting. In the past they used to bread pheasants as well." V5

„The vicinity of the village is primarily an agricultural area. Two hunting societies hunt here: one from Makó and one from Magyarcsanád. Their areas border on each other here. They hunt for pheasant, fox, hare, roe deer, duck and goose in the grasslands of Beka. There are hunters from abroad, too, mainly Italians." V18

„Hunting tourism is also present. Fishing on river Maros is a rarity." V7

„There are two fishermen working in both Apátfalva and Nagylak. When the water is high they may catch fish as long as a meter, but they say that there used to be more fish in the river Maros and that the number of fishes has fallen significantly lately. There is a hunting association in Magyarcsanád, hunting is more typical in Bökény." V9

„There is an increasing amount of precipitation causing a lot of problems. River Maros is a natural border between Romania and Hungary. The biodiversity of the river and its surroundings is on a constant decline. Fishing has fallen back because there is barely any fish in the river. It's almost not worth to get the fishing license." V12

„Fishing is present on the river. There is a self-employed fisherman earning his living with it, he doesn't complain. He works on a 2 kilometers long section with good results. There is perhaps one more person but he doesn't make a living with it, he just earns a little extra.". V18

Sources of renewable energy are mentioned by several subjects, mostly biomass (wood) and the geothermic energy used in agricultural production.

„Subsistence crime is high, a lot of people steal wood." V1

„Gas is generally used for heating but it is expensive. So a lot of people switched to different sources of energy: wood in iron stoves is increasingly popular. Most of the firewood comes from Romania on trucks but there is a privately owned timber yard too. Unfortunately a lot of wood stealing occur on the flood plain. It's mostly done by poor people who don't have enough money to buy wood. To keep the stealing low certain areas are designated for cutting, the fallen wood found here can be collected by anyone…" V18

„ Greenhouses are heated by thermal water." V1

„There is not much uncultivated land in the area… tomato is cultivated in greenhouses that are heated by thermal water." V7

„Besides heating greenhouses there are plans about using thermal water for other purposes as well, for example developing tourism around it." V18

Many locals have mentioned the high natural potential of the flood plain. This is a provisioning service related to genetic resources.

„The Bökényi-öblözet has a high natural potential. It has been improving especially in the past 5 years thanks to planting wood." V1

„Red deer, golden jackal, white-tailed eagle and wild boar can be found on the flood plain. Red deers swim from Romania in the river Maros… It's important to protect bee-eaters and the rare snail called Drobaica banatica. We have to take care of deers, pheasants and hares because the highway is close and some use very strong poison." V5

„I love nature, I'm connected to it since my early childhood. I'm a big nature fan. Biodiversity is something that I find important, I love birds and butterflies, snails… We have to protect nature! Nature needs space… Punishment should be a lot stricter." V14

„There is some kind of a rare protected plant species living on the grasslands of Beka, but I don't remember its name. British botanists were looking for it here. And there are some rare fish species in the river, for example sterlet." V18

Fodder production used to be a more significant provisioning service, by today it has fallen back with the decline of animal husbandry.

„The area is characterised by three kinds of land use: ploughland, grassland and forest. Grasslands have been grazed but since the sixties and seventies the number of livestock has fallen. János Gyenge has a herd grazing in the area and the national park has a herd of 100 Hungarian grey cattle." V1

„In Újfalu houses have been built around '58-'60. The place called "Tehénjárás" is in that area, we used to have some land there. There used to be about 500 herds in the village, today there is about 5." V2

Besides the provisioning services listed above, honey and drinking water are mentioned and also biochemical, medical resources.

„I have more than a hundred colonies. I check them almost every day." V22

„In the past people used to take their drinking water from the river Maros. Today it is polluted.. An old lady in our village only used to drink the water of the river Maros in her entire life." V2

„The mud of the river Maros is well known for its healing effects. It is used against aching legs. A woman from the village used to walk to the river and cover herself with mud. In Makó it can be purchased in the shop. It is also used in the Makó Bath." V2

Regulating services

The interviewed people talked relatively little about regulating services and there were few regulating services mentioned at all during the interviews. Such regulating services are flood proteection, protection against erosion, safeguarding species reproduction, nature conservation and protection of biodiversity – as shown by the quotations below.

„It was good, that there were willow trees at the River Maros, they mitigated the flood effect,…The cooperative has planted willow, black nut and poplar trees ont he floodplain, they can protect against the high water, wawes, soil erosion, but they were used for wood production as well." V10

„The floodplain at Bökény has a high natural potential. It has been improving especially in the past 5 years thanks to planting wood." V1

„Red deer, golden jackal, white-tailed eagle and wild boar can be found on the flood plain. Red deers swim from Romania in the river Maros… It's important to protect bee-eaters and the rare snail called Drobaica banatica. We have to take care of deers, pheasants and hares because the highway is close and some use very strong poison." V5

„There are smaller islands on the river Maros. They are called "vesszős porond" and originate from fallen parts of the shore or are built by the river.

Willows grow on them and many interesting birds can be found there: little egret and night heron.” V18

Cultural services

All categories of cultural services described in the literature were mentioned by our subjects. The ones that got most attention (highest number of times mentioned) were cultural, historical and religious heritage as ecosystem service. They talked about the disappearing farmsteads ("tanya", a typically Hungarian kind of farmstead). The subjects also mentioned other cultural and spiritual heritage values of the natural environment.

„Everything related to people has changed a lot: the world of isolated farmsteads is disappearing. One of the reasons were the forced deportations of the seventies.” V7

„There used to be more than 400 fams (tanya) here. They have disappeared with the cooperative.” V20

„The number of farmsteads has dropped drastically in this area. There used to be hundreds of ”tanya” in the vicinity of Magyarcsanád and Apátfalva, most of which was still populated in 1960 but today there is only 3 of them left. In the past the area around the farms was kept in order. People planted black locust around them and they used it in several ways. Today they are not taken care of.” V17

„Whether the hill in Beka is a kurgan, a burial mound or a motte remains a mystery. There have been archeological excavations and findings too. There were excavations on the river bank too with findings of the peasant uprising of Dózsa. Around Káposztás there is a vertical segment of the river wall, the findings were there… There is a stone cross on the hill in Beka. There are several legends about it. The cross itself stands two meters high above the ground but its full lenght is about 4 meters high. It was brought from the Southern Carpathians. People refer to it as the „Belezi nagyköröszt” (big cross of Belez). Belez was an ancient settlement, there have been excavations when the road was built. There are several legends about the cross. According to one of them a medieval tournament was held there and the winner raised the cross to the memory of the looser of the game. An other legend says that this was the place where Dózsa was burnt and buried. Some think that László Kun was buried there. None of these stories is very likely, they are just legends.” V18

„There are several values in the village that should be protected. For example the gables of the houses. Or the 200 year-old oak tree whic was planted for the millenium and gave it’s name to the „Oak Tree School”. Other small schools have also been named after trees, besides this one. The church of the village should also be protected, although it isn’t a museum piece, it’s old.” V20

Recreation and tourism are mentioned frequently, too. River Maros and the surroundings serve as a beach and it is used for hiking as well. A forest school has opened recently, hunting and the rural environment also make this place suitable for tourism.

„There is a sandy area along the bank of the river called ”Lúdvár”, we go there to have a bath and swim. Water is warm and clean there, you can even see the bottom of the river.” V2

„The main characteristic of the village, the main attracion is popular tradition: the river is not so important. The river Maros is not as related to everyday life as it used to be.” V7

„The river Maros is the most important natural value. We used to spend days by the river with the kids each summer. I can’t imagine my life without the trees surrounding river Maros that also provide clean air.” V12

„There are many hiking routes in the area, for example from the village to Bökény there is a 15km long walking route. I walk it too on a regular basis.” V18

„The bank of the river Maros and its surroundings is becoming popular: people go there to hike, to have a picnic… The river isn’t really polluted, it would be nice to have a good beach. There is an illegal beach at Lúdvár. The river builds sandbanks there popular among swimmers and anglers as well. People make bonfires to cook and fry meat and have a picnic there.” V18

„We keep looking for other sources of income: we have opened the forest school that has become self-sustaining and rural hospitality is on the rise, people feel motivated in this.” V7

„Some try to pioneer rural hospitality. An old cottage has been transformed into a guest-house, hunters usually stay there. There are some regular guests too, for instance those working in the neighbourhood” V18

The third one is a cultural service mentioned by several subject: the so called sense of place ecological service.

„My ex-mother-in-law used to respect nature so much! Whenever she went out to the island she gave a hug and a kiss to the walnut tree…We love it here. I couldn’t imagine my life anywhere else anymore.” V2

„We are very keen on the river Maros but it is not being taken care of and it’s polluted.” V3

„Farming is a forced solution, because I wanted to stay here. We are so used to living here. Maros and the closeness of the fields and nature gives the magic of this landscape.” V8

„The river Maros is the most important natural value. We used to spend days by the river with the kids each summer. I can’t imagine my life without the trees surrounding river Maros that also provide clean air.” V12

Besides the above some subjects mentioned scientific and educational services, aesthetic values and other spiritual and artistic inspiration.

„The Szigetház forest school has been operating since 2000. The old building of the socialist party headquarters has been transformed for this. The program of the forest school consists of 2 parts. One is about nature and the other one is about tradition.” V20 pensioner, Apátfalva

„The river Maros defines the landscape, the river bank, the flood plain. It is a significant value, I have taken a set of photos of it too: the most beautiful corners of the floodplain in each season.” V18 teacher, Apátfalva

Thus according to our research locals primarily perceive the provisioning and cultural services that affect their lives the most directly, these are the ecological services they find the most important. The most important provisioning services are the ones that affect the livelihood of the community directly: services related to food production. The most valued cultural services are tourism, recreation and sense of place.

A conflict related to the conservation program of the Körös-Maros National Park (KMNPI)

Although the original aim of our research was „only” to explore and understand the way our subjects value and think about nature we have „bumped into” a local conflict that is worth mentioning. Especially because it appears to be a quasi-typical conflict in Hungary, as previous researches have explored similar conflicts regarding conservation projects in the near past in Hungary (Bodorkós and Mertens 209, Kelemen *et al.* 2009, Málovics and Kelemen 2009).

Description of the conservation program[4]

As it was mentioned above, he Körös-Maros National Park Directorate (KMNPI) took over the management of the area directly from the collective farm in 1997. Most of the floodplain between the dikes and the river remained in state ownership, and in nature conservation management. After 2004 the area belongs to the Natura 2000 ecological network. The KMNP has different management plans for different land use types, as grasslands, forest, arable lands, orchards, and they are involved in hydrological management as well.

The extent of the grasslands is about 300 hectares in the studied area. This is a special situation, because most of the Maros floodplain is used for forest plantation, so this large floodplain grassland is an important natural value. The main goal of the conservation management is to maintain the natural values by moderate grazing, but the number of grazing animals decreased drastically after 1990 here, as it happened in the whole country. A local farmer has 150 cows here now, and other two farmers has 60 and 40 sheep respectively. The private farmers rent the pasture from the national park. They have to use the pasture according to

[4] The information about the management goals and activity of the national park mainly comes from from a staff member of Körös-Maros National Park who is the leader of conservation management in the area.

the conservation rules, described in a contract. The base of the regulation is the national rules about the Natura 2000 grassland management. The national park has a herd of gray cattle (about 300 animals) in the Csanádi puszta (about 25 km from here). If the alkali pasture dries out there in late summer the herd is transported to the floodplain grasslands by truck.

The main goal is to develop a seminatural forest in the place of hybrid poplar plantation. The plantation was cut down, and the area were divided into 3 ha units. Native gray poplar and Hungarian ash saplings were planted, and oak seeds were sown. If the forest authority accepts the new forest the conservation manager plan to introduce other native tree species increasing the species diversity of the forest. Such forest establishment is rather unusual, the conservationist planned it exclusively for this area. Some dangerous invasive plants as Acer negundo, Amorpha fruticosa and Fraxinus pennsylvanica are abundant here. The only way to confine them to establish a dense natural forest or permanently managed grassland.

Maintaining of arable land is not a long term goal in the floodplain, it is not sustainable because of the continuous risk of flood. The state is the owner on the 80% of the 300 ha arable land and the national park manage this area. They try to convert it gradually to natural forest and grassland, but a certain part is rent by private farmers by now.

On the southern part of the floodplain, near to the river about 250 ha is a so called closed garden. The small parcels are in private ownership. Formerly the people cultivated orchards and vegetable gardens here. Some of them lived here during the whole year. Nowadays most of the area has been abandoned, but some owner try to manage it intensively, using chemicals and irrigation. The national park endeavors to by the abandoned gardens, and to establish traditional extensive orchards or natural forests here. It is a common problem, that the land owners often try to drive to their garden by tractor on the wet soil, and wade the protected area. The national park plans to build a good quality road in order to prevent this disturbation.

Regarding hydrological management, there is an extensive channel system on the area. The national park tries to use this system for developing a special ancient way of floodplain farming the so called “fokgazdálkodás”. The base of this method is the controlled spreading of the flood, and driving back the water to the river after the flood. The national park has won a tender, and built an artificial flood gate in order to drive the water such a way. This work is mentioned as “habitat reconstruction programme”. Unfortunately, in 2005 the hydrological work was destroyed by the flood, and the private farmers blamed the national park because of the destruction caused by the flood.

Features of the conflict

To understand the conflict it is necessary to know that most local feel that since the political transformation (of 1989) local economic opportunities have narrowed down seriously in the region. We find no more traditional factories, plants nowadays. Also, there is no market for local products and people buy the lower quality import products in the multinational supermarkets. A few hectares of land which used to be enough to support a family earlier is not enough anymore. The destruction and the privatisation of the system of agricultural cooperatives have ruined agricultural opportunities, because it would be absolutely necessary for the farmers to stand together instead of being divided. Unemployment rates are high in the area, farming can only provide less people with a living. Thus locals, mostly youth, feel to be forced to move to nearby cities, mainly to Makó to find a job. The population, partly because of the aforementioned reasons, is aging, young people seek opportunities elsewhere. This bad economic situation leads to spread of petty crime, people steal for a living. This means that the conservation program of the KMNPI is being carried out in an already pessimistic community hit by bread-and-butter worries and a strong percieved decline in well-being and economic opportunities.[5]

„The rate of unemployment is 60% in the area. The main source of income is agriculture, and seasonal agricultural work." V1

„A lot of people steal for a living: stealing wood, poaching and snail picking… It would be necessary to provide employment opportunities for the people because it would reduce these forms of crime, especially the stealing of wood." V1

„It's hard to sell agricultural products. People prefer to buy cheap, low quality products in the hypermarkets. This makes it more difficult for farmers to sell their products. Raising livestock is not worth anymore, people just keep as many pigs as they need for themselves. In the past 10 hectares of land was enough to live like a king, now it's harly even enough to get by." V3

„Bökény used to be cottar village where most of the population worked in agriculture. Each household had a cow. People kept working in agriculture during the time of the communist era, in the cooperative everyone had something to do and everyone new what to do. By today most people have either moved to an

[5] Economics ofthen uses objective and subjective indicators to assess the general well-being of individuals and societies. While objective indicators are factors that affect well-being (such as income, state of health, job opportunities), subjective indicators show the perceived well-being (people's opinion on their own happiness and satisfaction) (Stiglitz *et al.* 2009). The study described in this paper does not analyze the factors affecting general well-being in the area (e. g. rate of unemployment), only the subjective well-being outlined in the interviews.

other place or died. Lands have been sold. The smaller pieces of land were bought by one person or an other or the national park. Those who stayed are mainly pensioners. Today there is only one old men who still keeps cows: Imre Molnár, he is 70." V4

„In principle the village has a good agricultural potential but after the democratic transformation its system has changed and people can't really find any good source of income in the neighbourhood. With the transformation work opportunities in local factories disappeared, there are no more jobs in the local food-processing plants. There is no more livestock production and less land is owned by the government which can be maintained by less equipment." V7

„People mostly work in agriculture, but it's a poor village, unemployment is typical." V9

„Bökény is an aging village. Many people move away, there is a lot of old people. The empty houses are bought just to be used as weekend cottages, the village is dying out. In the past agriculture used to provide a living but today it is less and less worth it." V16

„There are many abandoned houses in the village. The village is aging, there are a lot of highly qualified people among the young ones, teacher, vet, doctor, engineer. But everybody moves away. The population is quickly decreasing. It used to be 3000 people, today it's 1540… In the past it used to be a very rich village that's why there are so many nice and big houses here, partly abandoned." V17

„There are 72 abandoned houses in the village. The village is aging. People in this „affluent society" have become poor, they are not able to maintainan their houses, they wear old clothes. V21

The conservation management and habitat reconstruction programme is realised in this environment that, according to our subjects, generates serious local conflicts. The origin of the conflict is the conservation management program of the Körös-Maros National Park (KMNPI) meaning a serious problem for several reasons to locals or a group of locals. One of the fundamental reasons is that the programme of the KMNPI results in land aquisitions from the part of the KMNPI and also land use limitations because of environmental reasons. These lead to even less and harder farming opportunities. Because the program deals with the lands in the flood plain, the conflict occurs to a different extent in the different villages and affects the different groups within the village (e.g, different profession) to a different extent. The conflict peaks in the Bökény area so Apátfalva and Nagylak are less involved, while Magyarcsanád is a lot more.

„The owners of the lands in the floodplain are on bad terms with the national park. The other owners cooperate with them." V5

„There are small gardens in the flood plain where people grow vegetables. …The protected areas are far from Apátfalva, so we are not really involved in this problem" V7

„I do farming for a living. I produce parsley. I have been living here since I was born, next to the dike. I have a firm opinion about the rangers. they hinder me in work." V13

„Most of our land is next to the forests of the hunting association or the lands of the national park. The latter ones suffer a lot of damage by game. But we only use mechanical protection, as we are forbidden to use chemicals. We are in conflict with the hunting society and with the national park because of these damages. For example time of mowing and the nestling period of certain birds has to be in a different time, we have already adapted to this." V15

„There is a serious conflict in the flood plain peaking mainly in Bökény. The source of the conflict is the regulation by the National Park. Some doesn't want to comply with these regulations. The resulting conflict peaks in Bökény because people live next to the controversial area instead of just visiting it from time to time." V12 farmer

The problem related to the activities of the national park is a multifold one. The organisation obstructs the economic opportunities of the area by restricting farming opportunities. The rate of the negative judgement about the national park is augmented by the fact that the given area has a particularly low population retention capacity, high unemployment rate, it's aging and has to fight serious social issues as well.

"Mowing is only permitted after the 15th of June but animals don't eat that grass anymore by then. We suffer a great loss due to the restriction." V13

„There is a lot of beautiful forests in the area. I don't agree with their treatment. Grasslands and meadows could be exploited, they are suitable for grazing but the national park doesn't do it in the proper way. They let the area get spoiled. We see things from a different point of view… During the socialist times after cutting a forest new ones were planted, hybrid forest of soft-wood. Those are exotic species and today the national park tries top lant oak instead of these forests. Invasively spreading desert false indigo is a lot of trouble, it needs constant eradication…It's a serious problem that the national park plants oak in the place of the soft-wood plantations. The national park should also bring economic profit and an oak forest doesn't produce any, only on the long run and the seedlings need much more care." V4

„Conservationists interfere with our lives unnecessarily. They obstruct my daily work. Agricultural opportunities are narrowing down wich is a serious problem to smallholders. There is less and less work. There are several evident problems with the activities of the national park. Logging and planting the seedlings in january, the restriction on deer and pheasant hunting. the destruction of the roads, chemicals can only be used with a permission…and I have never seen a Drobaica banatica snail" V13

„… I would push for the use of floating timber. The poor could also get some firewood, the river would become cleaner and sand extraction would become easier too. Of course it is forbidden to remove floating timber because of the reproduction of insects." (ironically) V9

„In the past there was a deal between nature and people, nature also got its share but people could also use the land. Today they want to protect everything only for nature." V21

A further problem besides the narrowing economic opportunities is that some don't see the environmental benefits of the area's treatment by the national park. One of the reasons is that to many locals the „original", „good" and „valuable" environment is an „ordered" one. These people have found the situation a lot better before the national park's appearance. According to them the landscape is „rather untidy" and „full of weeds". They are not convinced about the environmental benefits of the national park's activities.

„10-20 years ago there was serious agricultural production in the flood plain but conservationists took over and today there is only weeds there. In the past the floodplain wasn't a protected area, in my opinion it was more organised and kept clean." V9

„Nature is neglected in my opinion, as you can see there is indigobush everywhere. Formerly the flood plain didn't belong to the conservationists, so people used to take care of it but today it's neglected. I think they just can't take care o fit themselves. This landscape isn't really such an experience for the visitors, Maros is the only color in the area." V9

„I'm angry at the national park too. Before they took over the riverbank it was possible go hiking or ride a horse there, now it is overgrown by weeds, it's impenetrable. Until then the two villages took care of it together, while today noone. There are several islands on the river Maros, some are smaller and some are bigger. It would be nice to have some tourism based on this, organise hikes, birdwatching tours but this would destroy nature so it has to be left alone to nature, untouched." V20

„In the beginning many people leased a land from the national park but there were many floods, they got bored of it and the national park got the lands back. People can't lease anymore, while the national park clearly doesn't do anything with the lands. Nowadays everyone is stealing wherever whey can, conservation authorities included. They (the conservation authorities) have become just like a state within the state. They impose fines but hardly do anything else… I used to prefer the floodplain when the forested were planted in a more organised way. One could walk as far as the Beka hill, ride a bicycle, car. Today it's so neglected that it's not possible to get out there anymore…Usable lands shouldn't be left uncultivated with the excuse of conservation, because that's what is happening right now. Of course, it's obvious that the use of chemicals should be eliminated and the character and soundness of the landscape should be preserved, this is important to me and to everyone I know, to all of us…Unfortunately the area seems to be neglected now, perhaps because there is no more felling of trees and no more grazing. Conservation is important, it's obvious, it's just that I don't agree with the operation of national parks and other public nature, environment and landscape conservation agencies alike. These institutes have recently established themselves in the region and it seems that they are not doing their job, just take the government subsidies. The system of conservation institutes is a maffia. In the past, people used to solve these things on their own, they didn't have to be fined, but the water and forestry authorities used to look after their area better, too. I see that the area is deteriorating, the environment is more polluted, there are several examples of illegal dumping around the village because the landfill where they used to take construction waste is now privately owned and it is not being used for anything else or anything at all. Despite this, environmental management, is only about green taxes and fines until now, it isn't efficient at all. What the EU does is nothing but empty talk, it just makes suggestions and regulations. People, on their own level, if left alone could solve the problems related to nature much better." V10

Some think that the problem of weeds is a common responsibility of the national park and the farmers, the NP and farmers are also responsible for the resulting conflict.

„There is also trouble with those who let the weeds grow on the land they lease from the national park and suddenly decide to cut everything down. After the political transformation things have changed for the worse. The area looks like nothing has an owner which makes me sad." V4

„There are some weird guys among the farmers who don't accept the conservation regulations at all… V5

Some opinions are very critical towards intensive farming and the work of the national park as well. Traditional farming does no harm to nature but organically respects it – as opposed to both intensive farming and the conservation practices of the national park.

„Instead of destroying it, traditional land use sustains the land, the meadow. I'm proud of never having used a drop of chemicals on my land since the political transformation… I don't see a difference between nature and cultivated, grased land, a land in sustainable use. The conservation authorities… just plant and kill the forest, they don't treat it well. I would only allow mature and sick trees to be cut down… Farmers looks after nature on their own will." V19

A lot of locals expressed their respect for nature conservation as an ambition but according to them, KMNPI doesn't do it in the right way. In other words, these critics are not speaking against conservation in general, but rather critical towards the particular activities of the national park in the area. For instance, expelling locals is a real problem and it is a serious source of conflict. Some think that the area is not utilized and a „reserve-only" conservation strategy is applied in a region that has been preserved in a state worth protection precisely by former local land use.

„I understand and support the matters layed down in the contract with the national park. For example if river Maros floods the crop we don't have to pay the leasing money… In the past we used to take care of the forest ourselves within the cooperative instead of the conservation authorities. The forests and paths used to be more organised back then. Today it's forbidden to cut down the trees, certain areas we used to look after are overgrown by weeds, I don't know, I don't see what conservation does at those places. The forest doesn't look normal, there are no proper cuts anymore… It's true that the national park doesn't allow us to fell the trees, but perhaps they are right, I don't know. I'm not angry at them, I leave such matters to them." V11

„They have bought the road as well and because of the afforestation it is impossible to enter the area. Planting native trees is a good thing but now it is impossible to enter the forest. And the river bank would be so beautiful if there was an access to it and an educational path. It is forbidden to fish too. This is doesn't support hiking and discovering nature which is bad, although I don't want to defend anglers because they usually leave a lot of rubbish behind. This „Do not step on the grass!" strategy is bad tactics." V8

„Conservation is important but I would do a lot of things in a different way… Protecting nature is a good thing and it's important too, but it has to be something rational: a bird shouldn't have more rights than a human, for example!" V9

„It's nice, it's a positive thing (the goals of the conservation authorities), but they are very authoritarian… It isn't rational what they are doing… I'm not angry at them, I always try to come to an agreement, to find a compromise. How can you live with your neighbour like this?! We walk the same sidewalk. But it still hurts me a bit that I can't go to my land on the road that my family took from generation to generationm because it has become part of the national park." V3

„I have a land along the river in the flood plain, but I would give it up if I could get a proper compensation for it and if the national park would use it well. This is a flood plain, it is not a place for production." V8

Besides all this, a number of subjects have mentioned positive results of the KMNPI's activities that reaches beyond conservation – it affects employment for example. Some said that they were happy to sell their land to the national park.

„Protected areas are good, the ancient environment should be reconstructed. We have to take care of plants and animals. Birds need protection, we must respect every living creature. Parsley likes the soil here. Magyarcsanád, Makó is the heart of parsley. Conservationists do it well!.. Aforestation provides jobs, the regulations make our everyday life harder." V6

„The national park and the hunting society provide people with a living. The area of the national park is 3000 hectares and the hunting society has 1800 hectares." V5

„I have sold my lands in the flood plain to the national park. May it have trees that won't be cut… I'd better sell my products with bugs inside than using pesticides. We don’t need much, just to slowly collect some income for our basic needs.” V6

„Aforestation is a good thing but the lands where they have just planted those forests would make a very good ploughland.” V17

Thus the basic conflict can be caught in the fact that certain ecosystem services providing direct profit and basic (personal and communal) subsistence are lost to the local community as a result of the activities of the KMNPI. These are principally provisioning services but due to further constraints of land use some recreational and touristic services also belong here. Moreover, some locals do not perceive that there would be any new ecosystem services (related to conservation) appearing in turn nor can they see a rise in the quality of other ecosystem services. Others perceive the benefits of conservation but they see it as a result of a trade-off which means that the community has to give up on certain provisioning services.

The conflict is deepened by, as revealed in the above quotations, that a number of locals see the national park as an outsider without any familiarity with the place without any interest in local opinions or knowledge.

„Their work (the work of the conservationists) isn’t just needless but it’s also harmful to the environment. They act without thinking instead of asking the farmers about the circumstances…” V13

„Local people love, respect and value their environment but they often don’t understand the work of the national park and this leads to minor conflicts. Unfortunately low income doesn’t always allow for a sustainable life style.” V16 f

„The maintainance of the national park isn’t transparent. In the past animals and plants weren’t protected, but they are still here… Conservationists don’t try to help the farmers, they just keep repeating their own point.” V13

Furthermore, many people think that the national park waste a lot of money (does not use its resources effectively) even though their activities do not bring a short term profit. Consequently they see the national park as an organization which is indeed most of all interested in maximizing its own profit and not in nature protection.

„The national park gets a lot more money than the water authorities. Conservation today is the deepest well in the country, it just keeps swallowing our money without any profit.” V4

„The conservation authorities are just wasting money. The hunting association could also provide conservation. The economy of the national park is bad, more money should go for conservation itself and not into their hands. Our national values such as game should be protected. Because the price of a partridge is 8000 HUF Italians would only be shooting partridge, but there is no partridge, it can’t be bred because the pheasant breeding station was closed because pheasants eat protected animals… We try to maintain a good relationship with the national park but I don't like them. But we cooperate with the ranger… There is no need for a national park to take care of a forest, an old farmer could do the same for a lot less." V14

„Landscape protection is just empty talk and it leads nowhere. For example there is a lake near Bökény on a higher elevation than the bottom of the Maros so it dries out from time to time. Those smart guys decided to pump up water from the Maros there so that the birds can have water all year round. They built a channel and a lock, spent a lot of money and took a big part of the subsidy from the EU to their own pocket. But even the most stupid peasant saw that the lock gate wasn't built properly and that river Maros was going to destroy it. So it happened. The water came up in the channel and flooded lands that the floods didn't reach in the past and in the end there was no water left in the lake either… Landscape protection generates conflict between farmers, buys land but does the same as farmers: they cut trees, the purpose of planting trees is production and they even use pesticides… There is a lot of weed because landscape protection doesn't allow much mowing or grazing and there are so many mice and hamsters because the hunters have shot the foxes. It's nature's balance that should be kept, there is too much intervention. In Romania this is much more natural, there is grazing, that's why the bank of the river Maros is so nice, people go camping and enjoy nature. And thanks to grazing meat has a higher quality, too." V8

„They undertake unnecessary and costly investments, For example building the lock gate that cost a lot of money but isn't being used properly. Or the limitation of mowing. In the past no chemicals were used, farmers did harvest by hand, but today this isn't worth anymore. Everyone works with machines and a lot of chemicals… Mowing is only permitted after the 15th of June but animals don't eat that grass anymore by then. We suffer a great loss due to the restriction." V13

Regarding the attitudes related to the national park and its activities we can state that they range from absolute support (fewer subjects) throught highly critical but more or less tolerant attitudes to total rejection.

Summary: layers of the conflict

The so-called circle of conflict is a proper tool for the structured assessment of conflict situations (Fig. 5). This conflict typology is suitable for the identification of the conflicts resulting in deteriorated relations. Furthermore, it can bring to light possibilities of conflict prevention and resolution.

According to the diagram above, a value conflict occurs when good or bad, nice or ugly, right or wrong is perceived in a differnet way by different stakeholders. This difference leads to a conflict if one party tries to force its own scale of values on the other or stands for a value system that is inacceptable by the other party. Relationship conflicts develop when the stakeholders have strong negative feelings towards each other. Information conflicts stem from the lack of information, incorrect information processing, incorrect communication or different interpretations of available data. Structural conflicts are often the result of limiting factors independent of the stakeholders, such as distance or time limitation, organisational structure, difficulties in organizing etc. In an interest conflict there is a competition between the parties for different goods, for tools to accomplish their needs. The participants of this kind of conflict typically feel that their interests can only be achieved at the expense of the other party (Kalóczkai 2009).

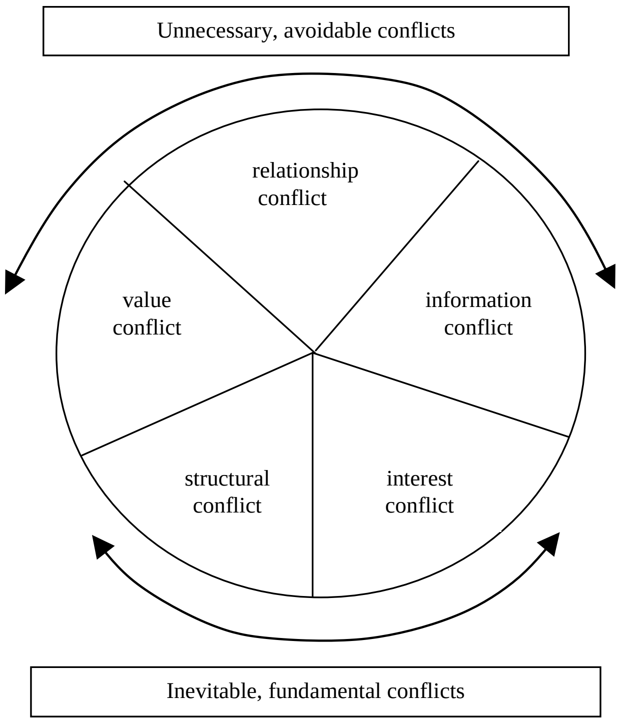


Figure 5. Circle of conflicts. Source: Kalóczkai 2009

According to the theory of the circle of conflicts value, relationship and data conflicts are relatively easy to avoid or to resolve, while structural difficulties and conflicts of interest lead to real, inevitable conflict situations and their occurance is just a matter of time.

By applying the typology of the circle of conflict in the situation we examined in our research, we can state that all the five conflict types occured. Exchange between different ecosystem types (and the loss of certain ecosystem types) can be regarded as an interest conflict. While the national park's interest is habitat reconstruction, it's the capitalisation of provisioning services, recreation and tourism which are most important for most locals. Thus the stakeholders feel: the different services can not be achieved at the same time, there is an exchange between the two.

This conflict of interest is further augmented by several other conflict types. One of them is that a significant part of the local population perceives the national park as an organisation with a main interest in material profit instead of conservation. This problem might have several reasons. It is possible – although we haven't met concrete references in our survey – that it stems from a structural conflict. Previous studies (Málovics and Kelemen 2009, Bodorkós and Mertens 2009, Kelemen *et al.* 2009) have shown that national parks are under a serious pressure from their sponsors (government) to generate steady profit.

The conflict is a potential information conflict as well because the „observations" in the local community related to KMNPI might also occur due to the insufficient information flow. It is also evident from the interviews that several subjects find the information and informing processes of the national park insufficient. These subjects feel that the national park doesn't communicate with them. Not only is the park uninterested in their opinion but it fails to inform them about the sense of the conservation program. The latter one might be the reason, among other things, why locals question the meaning of the conservation program, why they don't see its environmental benefits. A value conflict also contributes to this opinion. Our interviews show that to locals a „nice", „enjoyable", „natural" landscape doesn't necessarily refer to a situation after a habitat reconstruction but to a „proper" landscape, used and cultivated by humans. All the above conflicts lead to serious relationship conflicts: to a situation where a part of locals is already hostile towards the national park and the habitat reconstruction program.

Strenghts and limitations of the approach

As previously mentioned, we have been using a qualitative methodology, conducting semi-structured in-depth interviews choosing our subjects with the help of snowball sampling. During the research the strenghts and limitations of our approach have become increasingly clear.

One of the most important strenghts of our methodology lies in its indirect character: our subjects were unaware of the aim of our research and that we are particularly interested in their value judgements regarding nature. This allowed for the emergence of unexpected topics and unexpected observations and resulted in a relative openness about the KMNPI and their conservation activities allowing for occasionally even heavy criticism from the part of the locals. Thus we think that our method is suitable for revealing and understanding local conditions, conflicts and people's relation to ecosystem services. The information collected could serve as a basis for conflict resolution techniques. Also, by understanding the different layers of the environmental conflict, our results could lead to the revision of conflictual local/Hungarian conservation practices.

It has also become clear that our methodology has some serious limitations. Our sampling technique – the snowball method – only, but at least mainly, brought us to the local „elite”. Thus, besides the inavitable occurance of the reliability/generalization problem, we also had to take into account that the „sound” of certain groups/levels may remain completely unnoticed in our study.

A further serious limitation of our method is that it can not contribute on the proper understanding of the effects of land use on biodiversity, nature or landscape. The reason is multifold. It is partly because interviewed people have a different view of landscape (think of nature on a different scale) than the one an ecologist has to deal with in a given scientific research. In this research we had the „luck” of partly overlapping research sites with a team of ecologists and because most of our subjects found the topic of the conflict interesting they talked a lot about those are. This, however (1), is not necessarily sufficient to understand the effects of previous land use on the current state of landscape, because farmers generally spoke about the present and the conflict and (2) it is just a result of a coincidence, thus in different cases lacking a conflict this method does not necessarily provide substantive information on land use in the given area. Thus to gather substantive information about the effects of previous land use on the current state of a landscape the use of more direct methods may be necessary. Historical data are crucial in understanding landscape dynamics and in planning nature conservation management. It is generally accepted, that traditional ecological knowledge completes scientific ecological knowledge efficiently in the solution of nature conservation issues. Traditional knowledge seems to be relevant especially at local scales. Only an ecologist who knows well the ecological characters of the studied landscape can accomplish an effective collection of traditional ecological knowledge. If they do not undertake this job they will have to rely upon the collection and publications of social scientists and probably would not notice accidental false data, misconceptions and, particularly, thematic and lexical gaps in the collection. (Molnár *et al.*, 2009)

Employing university students – as the third main limitation of our method – might already result in collecting data with a lower quality than it would be possible with skilled sociologists. According to the results of this study however, to understand the effects of land use on the current state of a landscape it is not enough to employ sociologists but also research fellows who have suitable and sufficient knowledge in the field of ecology in order to be able to document the information heard about the landscape out in the field.

Conclusion

This paper attempts to reveal how local stakeholders perceive the natural environment they live in, what they find valuable and important for their "well-being" and life. It aims to assess the ecosystem services perceived by locals and to understand the relation of locals to these services.

Based on our research we can conclude that locals give a key importance to those provisioning and cultural services that affect their welfare directly. We found that the most important provisioning services were the services related to food production as they affect the existential situation of locals directly, while tourism, recreation and sense of place turned out to be the most appreciated cultural services.

Although it wasn't the original aim of this study, our research revealed a serious environmental conflict between certain groups of the local community (firstly but not exclusively farmers) and the national park triggered by the conservation program of the park. The issue is formed basic around conflicting interests but knowing previous Hungarian research and case studies, it is highly probable that there are also deep structural causes in the background. Further value and information conflicts appear that easy to avoid according to literature but also provide a basis for a serious relationship conflict. The environmental conflict revealed in this paper is not an isolated case in Hungary. Previous research (Málovics and Kelemen 2009, Kelemen *et al.* 2009, Bodorkós-Mertens 2009) has revealed other, similar cases of conflict (habitat reconstruction by national park on Natura 2000 area) at various sites in Hungary.

Finally we can conclude that the indirect aspect and the feature that allows for unexpected observations make our method suitable for assessing local conditions, conflicts and people's relation to ecosystem services. It can provide a basis for the application of conflict resolution techniques and the revision of local/Hungarian conservation practices. However, due to the sampling technique of the snowball method, the opinion of certain stakeholders remains „invisible" to our analysis. Furthermore, our method can not reveal the actual (past and present) effects of land use on biodiversity, nature or landscape, partly because the view of landscape perceived by locals differes from the one an ecologist has to deal with in a given scientific research. According to the results of this study however, to understand the effects of land use on the current state of a landscape it is not enough to employ sociologists but also research fellows who have suitable and sufficient knowledge in the field of ecology in order to be able to document the information heard about the landscape out in the field.

References

Aldred, J. and Jacobs, M. (2000): Citizens and wetlands: Evaluating the Ely citizens' jury. Ecological Economics, 34, 217-232.

Babbie, E. (2008): A társadalomtudományi kutatás gyakorlata. Balassi Kiadó, Budapest.

Bodorkós, B. and Mertens, C. (2009): Kié a föld? – Intézményi elemzés a természetvédelem helyi irányításáról. Természetvédelmi Közlemények, 15, 103-118.

Cornwall, A and Jewkes, R. (1995): What is participatory research? Soc. Sci. Med. 41, 12, 1667-1676

Costanza, R., D'Agre, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Kaeem, S., O'Neill, R., Paruelo, J., Raskin, R., Sutton, P. and van den Belt, M. (1997): The value of the world's ecosystem services and natural capital. Nature, 387, 253-260.

Deák, J. A. (2010): Csongrád megye kistájainak élőhelymintázata és tájökológiai szempontú értékelése. PhD értekezés, SZTE Földtudományi Doktori Iskola, Szeged.

Fodor, A., Bátori, B., Cseh, V., Margóczi, K., Körmöczi, L. and Erdős, L. 2011: Inundation area of the river Maros near Bökény: land-use history and habitat mapping. — In: Körmöczi, L. (ed.): Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş. Szeged-Arad, pp. 23-34.

Gómez, A., Puigvert, L. and Flecha, R. (2011): Critical Communicative Methodology: Informing Real Social Transformation Through Research. Qualitative Inquiry, 17, 235-245.

Gowdy, J. M. (1997): The Value of Biodiversity - Markets, Society, and Ecosystems. Land Economics, 73, 25-41.

Hanley, N. and Spash, C. (1993): Cost-Benefit Analysis and the Environment. Edward Elgar, Aldershot.

Hein, L., van Koppen, K.a, de Groot, R.S. and van Ierland, E.C. (2006): Spatial scales, stakeholders and the valuation of ecosystem services. Ecological Economics, 57, 209– 228.

http://www.clivespash.org/eve/publ.html#SJI

Kalóczkai, Á. (2009): Nemzeti parkok és gazdák: együttműködés és konfliktus. Szakdolgozat, Szent István Egyetem, Gödöllő.

Kelemen, E. and Gómez-Bagetthun, E. (2008): Participatory methods for valuing ecosystem services. – Essay for the 3rd Themes Summer School, Lisbon, Portugal, 25th May- 6th June 2008.

Kelemen, E., Málovics, Gy. and Margóczi, K. (2009): Ökoszisztéma szolgáltatások és tájhasználat váltás az Alpári-öblözetben. Természetvédelmi Közlemények, 15, 119-133. http://www.mbtktv.mtesz.hu/tvk/2009/11_kelemeneszter_119-133.pdf

Kiss, T., Oroszi, V., Sipos Gy. and Fiala K. (2010): Accelerated overbank accumulation after 19th century river regulation works: case study on River Maros, Hungary – Geomorphology (under review)

Málovics, Gy. and Bajmócy, Z. (2009): A fenntarthatóság közgazdaságtani értelmezései. Közgazdasági Szemle, 5, 464-483.

Málovics, Gy. and Kelemen, E. (2009): Non-monetary valuation of ecosystem services: a tool for decision making and conflict management. 8th International Conference of the European Society for Ecological Economics – Transformation, Innovation and

Adaptation for Sustainability. 29th June – 2nd July, Ljubjana, Slovenia – konferencia CD
Marjainé Szerényi, Zs. (2000): A természeti erőforrások monetáris értékelésének lehetőségei Magyarországon, különös tekintettel a feltételes értékelés módszerére. PhD értekezés, Budapest.
Marjainé Szerényi, Zs. (ed.) (2005): A természetvédelemben alkalmazható közgazdasági értékelési módszerek. Környezevédelmi és Vízügyi Minisztérium Természetvédelmi Hivatala – Budapesti Corvinus Egyetem Környezetgazdaságtani és Technológiai Tanszék, Budapest.
Marosi, S.and Somogyi S. (ed.) 1990: Magyarország kistájainak katasztere I-II. MTA Földrajztudományi Kutató Intézet, Budapest. 1023 p.
MEA (2003): Ecosystems and human well-being. A framework for assessment, Island Press, Washington, D.C.
MEA (2005): Ecosystems and Human Well-being - Biodiversity Synthesis, World Resources Institute, Washington, D.C.
Molnár, Zs., Bartha, S., and Babai, D. (2009): A népi növényzetismeret és az etnogeobotanikai, ökológiai antropológiai megközelítés szerepe napjaink vegetáció- és tájkutatásában. Botanikai Közlemények 96(1-2) (2009): 95-116.
Munté, A., Serradell, O. and Sordé, T. (2011): From Research to Policy: Roma Participation Through Communicative Organization. Qualitative Inquiry, 17, 256-266
Oroszi, V. (2009): A hullámtér-fejlődés vizsgálata a Maros magyarországi szakaszán, Doktori (PhD) értekezés, Szeged, SZTE TTIK, TFGT
Paulovics, P. (2002): A Körös-Maros Nemzeti Park Maros ártér területi egysége természetvédelmi kezelési tervének megalapozó dokumentációja. Kézirat. KMNP Ig.,Szarvas
Penksza, K., Kapocsi, J., Salamon, G. and Gyalus, B. (1997): A KMNP egyes védett és védelemre tervezett területeinek botanikai felmérése és értékelése. Kutatási jelentés No. 328. KMNP, Szarvas.
Stiglitz, J. E., Sen, A. and Fitoussi, J-P. (2009): Report by the Commission on the Measurement of Economic Performance and Social Progress. Internet: http://www.stiglitz-sen-fitoussi.fr/en/index.htm

Appendix

A draft interview for the fieldwork around Magyarcsanád

1. Personal livelihood, farming, activities:
    - Please, tell us about yourself. How long have you been living here and what do you do for a living?
    - Could you tell us about your job? (The point of this question is to let the subject talk freely about their life and work. We meet various different kinds of people, everyone has to be encouraged by slightly different questions. See the following examples of some possible questions to a farmer, a member of an NGO and a river-watcher.)
        - Farmer:
            - What do you produce?
            - How do you produce it (pest control, tilling etc.)?
            - How did you start farming and when?
            - How did people use to live in the past? (How about farming in the past?)
            - What kind of natural forces you need protection from?
        - Member of an NGO:
            - When was the society founded?
            - What is the purpose of the NGO?
            - Since when have you been participating in their work?
            - How did it all start?
            - How does the organisation work?
        - River-watcher:
            - How long have you been working as a river-watcher?
            - Is fishing typical source of income in the area and how typical is it?
            - What about angling?
            - What have changed about people’s habits related to fishing and angling?
    - What is life in Tiszaalpár/Lakitelek etc. like? (What do people do generally? What do they work?)
2. Local natural values:
    - Please, tell us about nature in the area, and about the environment.
    - What features make this area so special, valuable and useful?
    - What kind of farming is this land suitable for?

- What are the features, elements of the landscape (plants, animals, relief, hydrology, climate etc.) that would seriously affect your everyday life if it disappeared?

3. Changes of the natural environment:
   - How has nature changed since the time you can remember it?
   - Do you remember significant events when natural disasters (storms, floods etc.) caused serious damage to locals in the area?
   - What reasons do you think there are behind these changes?
   - How do these changes affect your daily activities and life?
   - How can you adapt to them?
   - How do you think this landscape is going to change in the future?
   - How would you like it to change?

ECOSYSTEM SERVICES AT GYULA SITE AS PERCIEVED BY LOCAL PEOPLE

Judit Gébert, György Málovics, Katalin Margóczi

Project objectives

The objectives of the study discussed in this paper was the same as in previous paper about „Ecosystem services at Magyarcsanád site as perceived by local people": assesing how local stakeholders value the natural environment they live in, what is their relationship to it and what they find important for their well-being and life. As already mentioned in the previous paper, the theoretical background of this research was the concept of ecosystem services. We defined ecosystem services as follows: *ecosystem services are the benefits human populations derive, directly or indirectly, from natural and human-modified ecosystems* (MEA 2003). So this definition from the Millenium Ecosystem Assesement describes our goal in this research as already mentioned earlier.

The area of the research

Geographical site description

Two study sites were chosen for developing a habitat evaluation system and assessment of ecosystem goods and services in HURO/0801 program. One of these sites is located near Magyarcsanád, at the River Maros (described in the previous paper in this book). The second study site is located between Gyula and Elek settlements The area is the central and northern part of the alluvial fan of the River Maros. The plain slightly slopes to the floodplain of the River Fehér-Körös. The potential vegetation is a loess steppe matrix on chernozemic soil, containing several islands of alkaline steppe and wetlands as well. The good quality, black, chernozemic soil areas are used for agriculture (arable lands), but the natural grasslands and meadows remained where the salt content of the soil is high, and temporally too wet. Mean annual temperature in Gyula is 10.2 °C, mean annual precipitation is 581.3 mm (Ambrózy and Kozma 1990).

Ecological description

Two neighboring near-natural alkaline grasslands were chosen for detailed botanical investigations. They are separated by the Hungarian-Rumanian state border. The grasslands are between Gyula and Elek on the Hungarian side and southwest of Vărşand (Gyulavarsánd) on the Rumanian side. Distance between the two grasslands is approximately 1.5 km, and abiotic parameters are nearly identical (Erdős et al. 2011a,b).

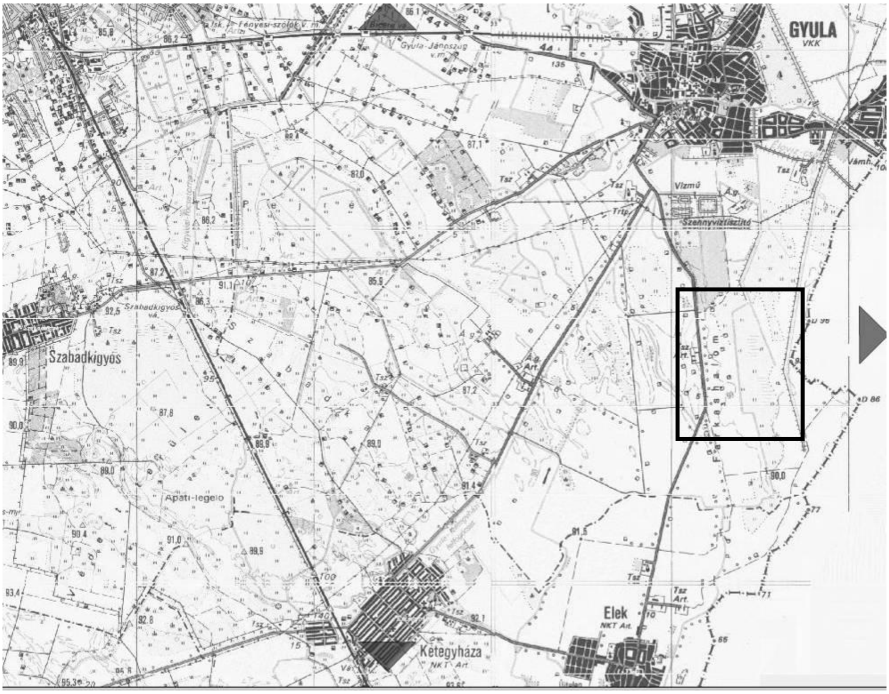


Fig. 1. Present map of the studied area between Gyula and Elek settlements (only the Hungarian part). The border of Hungary and Romania runs on the eastern side of the map. The rectangle shows the location of detailed vegetation survey (Erdős et al., 2011). (www.mepar.hu)

The habitat map of a sample site, representing the whole landscape, can be seen at the page 99 of this book (Fig. 1.; Erdős et al. 2011b). Table 1 summarizes the habitats investigated.

The dominant habitat type is salt meadow (F2) It is a tall grass meadow that have seasonal water cover at the beginning of the vegetation period and developed on solonetz or solontsak meadow soils. Characteristic grass species: *Agrostis stolonifera, Alopecurus pratensis, Beckmannia eruciformis*. Dry grassland patches and salt marshes forms island in the salt meadow matrix. Dense and tall *Puccinellia* sward patches developes on the especially wet and salty areas. Farmhouses forms line between the road and the grassland.

The botanical study indicates that this grassland is important and valuable from a nature conservation perspective. Because of the extent of the natural and near-natural patches, the occurence of valuable plant communities and some rare animal species (e.g. *Acrida hungarica*, *Asio flammeus*), it would be reasonable to protect the studied grasslands on a higher level.

Table 1. The codes and names of the habitat categories found in the sample area in the Hungarian side.

Code	Name
B6, BA	Salt marshes and fine scale mosaic or zonation of marsh communities of channels, ditches and artificial lakes
F1a	*Artemisia* salt steppes
F1b, H5a, OC	Mixed dry grassland with the plant species of loess and *Artemisia* steppes, and other indifferent species.
F2	Salt meadows
F4	Dense and tall *Puccinellia* swards
P2b, S1, S2, S3, S7	Tree plantations and spontaneous shrublands.
T1, T10	Arable lands
U3, U4, U10, U11	Antropogen areas (settlements, dumps, farms)
U9	Lakes

The history of land use

In the pre historical time this area probable was a large steppe with some forest and wetland patches. Large body ungulates grazed here, and the domestic animals of *Homo sapiens* replaced them later. Animal husbandry and pasturing was present in the middle ages near the town Gyula, and this remained the main land use type until the middle of the 19th century (Scherer 1938).

The map of the First Military Survey in 1784 shows grasslands (pusztas) near Gyula, but there are large arable lands on the south of it. Wetlands are very typical in the pusztas. (cf. Fig. 1. p 11. Cseh et al.)

Eighty years later the map of the Second Military Survey in 1864 shows a mosaic of wet meadows and arable lands. The landscape pattern in the area of detailed vegetation survey almost has not changed from this time: the contour of the meadow is nearly the same. The name of the area is Farkas halom vagy Kis Pili Dűlő. The row of farm houses can be found along the road between Gyula and Elek even in this time. The suitable areas were ploughed, and the wet and/or salty areas were used for grazing or mowing. The control of the River Fehér-Körös started, it runs in a straight channel near Gyula. There are some salt lakes between Gyulavarsánd and Nagypél, on the present Rumanian side. (cf. Fig. 3. p 15. Cseh et al. 2011)

The so called “szilaj” husbandry was very typical in the Hungarian puszta for centuries. The animals (mainly gray cattle) and the shepherds lived out, on the pasture whole year. In the late 19^{th} century the stalling husbandry developed instead of szilaj husbandry. The farmers bought new breeds instead of the old, stout and unpretending breeds, but they have to produce fodder for winter feeding the animals. At the beginning of the 20^{th} century mainly cattles and horses grazed in the pastures around Gyula, the importance of sheeps decreased (Dóka 2006).

During the socialist period (between 1945 and 1990) the agricultural land use were organized by a collective farm and a state farm on the fields between Gyula and Elek. The alkali grasslands were grazed intensively. The collective farm has about 200 beef cattle, the state farm has 400 ones, and 50-60 sheeps as well. The state farm was ended in 1985, and the collective farm in 1990.

Present land use and nature protection status

After 1990 most of the fields were privatized. For example, 266,5 ha of the botanically investigated grassland are in private ownership, 24 ha in common (several private owner), and 5,5 ha in state ownership.

The soil quality is good, and the main crops on the ploughlands are wheat, maize, sunflower and rape. Intensive agriculture (using large machines and chemicals) is common. Most of the alkali grasslands are not used, because the animal husbandry became rather uneconomic after 1990. The land owners can get agricultural subsidy, more on the arable land, and less on the grassland.

Fig 5. Nature protected areas. Dense grid: national park, cross-hatch: Natura 2000 area.

The Kígyósi-puszta belongs to the Körös-Maros National Park, it is more than 10 km to south-west direction from Gyula, so it is outside our study area. Between Gyula and Elek there is no nationally nature protected area, but almost all of the remained alkali grasslands are designated as Natura 2000 area, as “Pannonic salt steppes and salt marshes” habitats.

There is no conservation management on the studied area, but the Natura 2000 rules and subsidies try to drive farmers and land owners to maintain the natural values by moderate grazing and mowing. Several land owner does not like very much these rules.

Evaluation method

There are several methods in use currently to measure nature in general and the role of ecosystem services also. We decided to use qualitative method instead of quantitative one. We rejected quanitative methodes for example cost-benefit analysis although it is regarded one of the most popular technique in environmental economics (Hanley and Spash 1993). Our reasons in this decision were already mentioned in detail in the previous paper about Magyarcsanád site. But the main reason was that qualitative methodes better fits to our aims in this research, because they provide an in-depth explanation of valuing the nature by local people (Babbie 2008).

The research took place during the summer of 2010 and january 2011 altogether 28 in-depth semi-structured interviews were conducted with local residents and land users about the ecosystem services they perceive. As already mentioned in the Magyarcsanád site students of University of Szeged were taking part of this project. Our main topics was: (1) life and work of the subject (2) local life options, farming possibilities, (3) natural values of the area, and (4) changes of the natural environment.[6] As already referred and reasoned in the previous paper we paid special attention to formulate questions that do not remind our subjects directly of the field of environmental protection and nature conservation. We were avoiding to mention the green aspect of the research because today environmental protection and nature conservation have become social expectations so what people tell in a survey may differ significantly from what people really think about certain subjects or how they would really act in certain situations (Babbie 2008).

We carried out our survey in Gyula site in two phases resulting in 16 interview summaries. The first round of the subjects was selected with the guidance of the national park service ranger and further subjects were chosen with the snowball sampling method. Compared to Magyarcsanád site, locals were more suspicious: a lot of people refused to give an interview or even if

[6] For detailed interwiev sheme see appendix 1. in the Magyarcsanád site

participating they expressed themselves less openly, often sharing just a restrained opinion.

Out of the 16 interviews 10 were conducted with farmers (V1, V2, V6, V7, V8, V9,V13, V14, V15, V16) and 6 with locals with a different professional background: local politicians and water authority colleague, a national park service ranger and a member of a local hunting society (V3, V4, V5, V10, V11, V12) in short called non-farmers.

Results: inventory of the ecosystem services perceived by locals

The typology of ecosystem services used in the research was developed based on the Millennium Ecosystem Assessment (2005) as already discussed in the previous paper. MEA distinguis four types of services: provisioning services (e.g. food, raw materials, fodder), regulating services (e.g. climate regulation, protection against floods, pollination), cultural services (e.g. education, recreation, artistic inspiration) and supporting services (MEA 2005) as you can see in Table 2. Our study follows this structure about the four types of services.

Provisioning services

Food production: crop production and animal husbandry

We found that the most significant provisioning service is food production around Gyula: crop production and animal husbandry as described by a local farmer and a member of the city council:

„Mainly wheat, maize and alfalfa are produced here, sometimes sunflower too. In the past they used to produce barley and oat as well." V8 farmer

„Livestock production can be characterized by swine and cattle." V11 local politician

However we observed a shift in traditional crop production and animal husbandry: a lot of our subjects agreed on that animal husbandry is not profitable anymore, even those who used to earn a living with it have rather switched to crop production:

„You can't make a living of animal husbandry anymore, so people have switched to crop production." V1 farmer

„There used to be much more animals in the area. One easily made a living of animal husbandry, today it's not possible anymore because the value of milk and meat has fallen." V1 farmer

„One can't make a living of livestock production anymore nowadays: everyone who keeps animals is stupid, me too. There is no money in it at all and I'm still doing it." V6 sheep farmer

Table 2. Ecosystem services in functional alignment

Provisioning services	Food Fodder Energy source, fuel Timber or other raw materials Biochemicals, natural medicines and pharmaceuticals Genetic resources Ornamental resources
Regulating services	Air quality regulation Climate regulation Water regulation Flood protection Erosion regulation Regulating species reproduction Break down of pollutants Pollination Pest control and disease protection Storm protection Protection against noise and dust Biological nitrogen fixation Conservation of nature and biodiversity
Cultural services	Cultural, historical and spiritual heritage values Scientific and educational services Recreation and ecotourism Aesthetic values Other cultural or artistic information, inspiration „Sense of place”
Supporting services	Soil formation Nutrient cycling Primary production

Source: MEA 2005, Hein et al. 2006

„Cattle-breeding is more popular in this area. Pig keeping used to be typical but it isn’t worth anymore. Those who keep animals today also produce the fodder themselves.” V6 sheep farmer

„Local livestock has dropped very much, most dairy shops have closed.” V8 farmer

„There is not much animal husbandry here” V3 national park service ranger

„Less and less people make a living of agriculture. Crop production dominates over animal husbandry” V5 non-farmer

„Last year the number of our bee colonies have fallen from 90 to 50. We have sold them because it is less and less worth it. ” V13 bee keeper

As we can see from the above, our subjects still value the environment from the perspective of food production despite animal husbandry being less and less profitable. However the bitterness and disappointment of their comments on agricultural possibilities was striking. Despite the current situation there is still a lot of people who earn a living or produce an additional income by agriculture:

„It’s impossible to make a living of agriculture alone because the most necessary and basic market conditions aren’t given. So agriculture just provides a side money for most people.” V14 farmer

„It would be possible to practice agriculture, but farmers go bankrupt, smallholders are still trying but it’s hard.” V4 non-farmer

„Despite the falling prices there are still many people working in agriculture in the area.” V 14 farmer

„Most people have white collar jobs (for example clerk, civil servant), but on the outskirts many earn their living with agriculture,” V3 national park service ranger

„In the present circumstances future seems so hopeless that I wouldn’t recommed farming as a lifestyle to my children even if it was something they wanted to do. Within a few years, as soon as my smaller child grows up as well, I would like to move to Austria or Switzerland.” V15 farmer

„There were times when we weren’t able to sell the honey so we collected it in a barrel. It was almost a hundredweight.” V13 bee keeper

„I used to produce sugarbeet but I found myself in a trouble because the sugar-works in Sarkad closed (just like all the other sugar factories) so there was no market for it anymore.” V16 farmer

„Less and less people can make a living in agriculture or in the industrial sector lately.” V11 local politician

„They hardly get by.” V5 non-farmer

„We try to make a living as farmers but we hardly get by. It only works if we do certain things illegally, for example we employ black workers from time to time. I’m also a bricklayer but it’s hard to get a steady job in the area in this field, just a temporary black job. In winter I work for an Austrian land owner for a month or two.” V15 farmer

„There are no jobs in the region apart from agriculture and there are many people on a government aid.” V15 farmer

This attitude is only indirectly related to the perceived ecosystem services but being a determinant a determinant opinion it’s worth mentioning:

„Agricultural regulations are very hard on farmers. They make a fuss about the smalles details. I can’t keep fertilizers on the edge of my land, I have to move it after two months even if it’s just 10meters because they keep checkin by satellite.” V1 farmer

„It’s very hard to get a subsidy and it’s just the bigger properties that are supported.” V1 farmer

„The EU and the US have destroyed our agriculture (economy) on purpose. The aid is not distributed well, it doesn't reach the laymen. The system of the EU subsidies is not working either, it is worth bringing goods here from distant regions of the European Union and this destroys production in Hungary. Western corn rootworm got to Hungary with a reason, we have to buy American hybrid corn." V1 farmer

„The area has also been hit by the flood of cheap products from abroad that push down the already low buying-in prices making local farmers non-competitive. The production cost of milk is moving around 70 HUF/l while the one and only purchaser offers 30HUF/l for the product, less than half of the production cost. The 300 HUF/kg buying-in price of pork is also 300 HUF less than the production cost. It's the same with eggs: foreign eggs are cheaper (18 HUF), local ones are more expensive (25 HUF). We manage to sell our sheep to Italians." V14 farmer

„You can't ask the cow to wait while you are forming a queue for the papers" V1 farmer

„Sure, Budapest needs the new metro but we also need to get to Kecskemét and Szeged somehow." V1 farmer

„You need more and more advertising to be able to sell." V7 farmer

"It used to be possible to keep chicken in the city, today you can't because the crowing disturbs the neighbours." V7 farmer

„The government doesn't support us. There is a lot of fraud.". V13 bee keeper

„Once several colonies were stolen. The damage was 300 thousand forints. We called the police but they said there was nothing they could do." V13 bee keeper

„Good drugs have been withrawn now we are forced to bring in from abroad… These regulations were invented by someone who has never seen a bee." V13 bee keeper

„In my opinion it's just the ones with the good connections that get the subsidies. It's just requirements that come from 'up above', instead of purchasers or assistance ." V15 farmer

„The EU subsidies don't provide a solution to the problem because it's just a temporary help keeping the farms barely alive without the possibility of development." V16 farmer

Due to unfavourable regulations farmers do not sympathize with ecological agriculture although it's only mentioned in two interviews.

„It's easier for the owner of the ecological farm to get the subsidy because it's called 'ecological' (for example for biogas) although they buy their fodder treated with chemicals from us. " V1 farmer

„I have tried ecological bee-keeping too but it was not worth, there was too much paper work and injustice. The honey barrels weren't bought back. We had to get a map about the area where the bees collect and this made the job very difficult, we had to queue a lot at the municipality." V13 bee keeper

Besides excessive bureaucracy and regulations considered unnecessary by farmers our subjects find that the other reason for the unfavourable conditions for agriculture is the present, very concentrated land ownership structure. Most subjects agreed on production on small family farms and patchy landscape being better regarding agricultural production and the environment as well.

„What is going on is constant centralization in agriculture but it is driving us in a good direction because while a few get rich, the others are getting poor, many fall out of farming, it isn't good on the long run." V8 farmer

„After the privatisation of the cooperatives the lands were bought by those in higher positions and now all that land belongs to 2-3 people who get the work done for low wages and with just a few workers. The smallholders „of three cows" that were left l has all gone bankrupt because there is no purchasers anymore and there was noone to accept smaller quantities of produce anymore." V14 farmer

„The current situation should be kept and state land should be distributed to beginners to provide them with a source of income." V8 farmer

„Agriculture disintegrated after Trianon. A concentrated system of ownership has taken shape. There are 4 large estates in the area (of several hundred to thousand hectares) and a few family owned lands (50-100 hectares). The latter ones are being eliminated gradually. A lot of land is uncultivated because it is not profitable." V10 local politician

„Agriculture is weak due to the fact that people don't join forces, don't cooperate. It is a 'good' old Hungarian tradition that everybody struggles alone, everyone just works on their small, fragmented lands.." V11 local politician

„More and more land is concentrated in the hands of single owners, the area is more and more homogeneous." V1 farmer

„I believe in patchy landscape. There should be an adequate rate of ploughland and grassland. It isn't a livable landscape where there is ploughland alone. Microrelief is an important value in the area as well." V3 national park service ranger

Sense of isolation is typical among farmers, partly stemming from the inappropriate structure of subsidies and their small amount. However, the wish for independence, will to strive, abiding by agriculture also appears in the interviews:

„I don't need the subsidy, they should just restore the prices of meat and milk proportionally so that it's worth working" V1 farmer

„There are always new problems popping up, new diseases, new pathogens but we have to fight it and if the crop rotation is respected there will be no problem." V1 farmer

„I'm a mechanic originally. I have learnt everything by myself without anyone's help." V6 sheep farmer

„You have to work instead of living off government aid." V7 farmer

„We shouldn't forget that we are capable of independence." V7 farmer

„I think it is possible to make a living in agriculture, because if you love doing something, especially your job, you can make a living with it." V9 farmer

Let's close the part about the agriculture of Gyula and the food production services of the region with the opinion of one of the city's leaders making it clear that the city would like to give more importance to agriculture as well:

„We assess what kind of local cultivars are worth re-introducing. We have a tender in progress to build a road to the region. We must have a multi-faceted approach that's why we are trying to open to agriculture and produce and popularize local varieties." V10 local politician

„The city has spent the one billion HUF (3,779,877.19 Euros) of government aid for the wrong things: instead of supporting production office blocks were built." V10 local politician

Fodder

The most significant fodder related provisioning service around Gyula is mainly grazing for the people interviewed:

„The lands where my animals graze are on the south to Gyula. Good alkaline meadows where mowing is possible too." V6 sheep farmer

Grazing turned out to be an ecosystem service that farmers find important and they are missing it:

„In the past the roadside lands were grazed for money. Today a lot of meadows could be grazed but animals are rather kept in stables." V8 farmer

„Meadows used to be grazed in the past, but not anymore." V7 farmer

The national park service ranger has mentioned the same problem: grazing would be beneficial environmentally and economically as well:

„Grasslands should be grazed. There are 700 cattle in the grassland of Szabadkígyós. Extensive grazing is cost-effective and animals are healthier too, so it is economically good, while it sustains the succession stage of the grasslands. It brings back grassland species such as Eastern imperial eagle, red-footed falcon, European roller." V3 national park service ranger

Other provisioning services

Besides production of food and fodder occasionally other provisioning services occured as well. One of these services was biogas as an energy source:

„Here is the country's largest organic cattle which can produce biogas also" V11 local politician

An other ecosystem service was the timber of the local forests mentioned by a local politician and the ranger but not by farmers:

„There are significant areas of forests with a great empoyment potential.” V11 local politician

„A lot of people earn a living with agriculture, a few dozens with forestry.” V3

However there are less and les forests and growing rate of related abuse:

„The area of forests has decreased significantly in the past few years, decades. I think this is the reason why there are more and more birds of prey on my lands causing serious damage in the poultry stock” V15 farmer

„It is not worth to plant a forest because the wood will be stolen.” V1 farmer

Natural medicines accure in the are too in the form of medicinal water. It has only been mentioned by one of the subjects despite Gyula being famous for its spa:

„Water cure is important” V4 non-farmer

Biodiversity has also been mentioned during the interviews though only by two subjects and not with little emphasis:

„There aren’t many protected plants here, but a few characteristic species like hog’s fennel or Plantago schwarzenbergiana. In the forests by the river Fekete-Körös alpine plants can be found, too.” V3 national park service ranger

„The areas that aren’t being mowed have a rich fauna. Although they don’t bring a profit (deers are rather bad for agriculture), I love them still. Such a land is for example the Péli pasture that is nearly 150 hectares. ” V1 farmer

Regulation services

The only topic mentioned which is close to regulating servicies was that forests keep the air clean. So from the survey it appears that the subjects don’t perceive these services:

„The city is relatively clean, there is no problem with the air either, the forests keep it clean.” V4 non-farmer

Cultural services

A number of subjects talked about tumils around Gyula and a farmer mentioned the castle. Crafts was also perceived as a local cultural value:

„Farkashalom used to be a tumil that has been bisected during the road construction.” V2 farmer

„It’s outrageous that the city has raised a tree of life and constructed a recreation space by a kurgan but the owner ploughed up part of the land so bones and other archeological values came to the surface that I had to collect myels with the help of a friend in order to save them from getting lost in the ploughland.” V10 local politician

„I make wood carvings in my free time.” V2 farmer

„There are many kurgans in the area, rather around the rivers Körös. Conservationists have placed wooden headboards next to them and there was a regulation made prohibiting it to plough them or mow them. Kurgans are said to be burial places but some say that our ancestors set signal fires on the top of them to send messages to each other. Such hills are for example Kápolna hill or Gyürkehelyi hill." V16 farmer

„There are some very beautiful places in the neighbourhood (for example the castle) that should be cleaned up in order to attract more tourists which would bring money." V2 farmer

Tourism is an important cultural service in Gyula, however, its current state is perceived in a positive way only by non-farmers:

„The city is improving tourism." V4 non-farmer

„The situation of tourism has somewhat improved by Romania joining the European Union. More and more tourists come from there, not so many from the west." V4 non-farmer

„Tourism is one of the most important sources of income here. The main attractions are the castle bath which is open all year round and the various programs: castle theatre, castle games, festivals: pálinka festival, slaughterman festival." V5 non-farmer

„Tourism was blooming in the nineties but lately there is a decline in it too" V4 non-farmer

Our subjects didn't agree upon the question of tourism. As opposed to the non-farmers farmers were rather disapproving of it because in their opinion it surpasses agriculture too much:

„Tourism bothers us because it impedes livestock production in the city." V7 farmer

„It's only tourism that counts in the city not agriculture." V8 farmer

„The current leadership of the city sees a possible source of income and an opportunity for jobs in tourism and that's why they are improving it. The problem with it is that it's only making a very few people rich, it provides a source of income for just a very few which doesn't help us fight unemployment, it doesn't provide jobs to those who used to work in the agricultural and industrial sector." V16 farmer

The two local politicians that we have interviewed have a different opinion on tourism. One of them sees the future of the city in the development of tourism while the other one would also support agriculture:

„We run a lot of tender processes to promote medical tourism. […] The city's strategy is the development of medical tourism, we have renovated the castle bath, new hotels are being built." V11 local politician

„Besides tourism the city would like to support agriculture, […] Cultural programs don't bring enough money. […]Békéscsaba has always been riding the western winds; they have strong western connections. (For example the marketing of Csabai sausages is a lot better than the Gyulai's.) Gyula, on the other hand, has rather had connections to the east with cities along the Körös rivers where fruits were produced and animals bred and countrywide famous markets were held. But the Treaty of Trianon has cut those connections and the city had to seek a new role and it was believed to be tourism. Was it a good or a bad decision? That's an other question. We should turn more towards agriculture." V10 local politician

Supporting services

The only supporting service mentioned was good quality soil:

„Soil has a good quality here, it didn't fall pray to large scale agriculture." V10 local politician

No more supporting services have been mentioned by our subjects but in two fields nature appeared as an obstruction, a hostile force instead of being supportive: one of which was extreme weather conditions and the other is the problem of excess surface water:

„More and more pastures dry our weather gets hotter and hotter. " V1 farmer

„One year there are pastures, in the other there aren't. Once there is draught, while in other times egyszer szárazság jellemző, máskor nedvesebb időszak van" V6 sheep farmer

„The weather is changing constantly, it's extreme. 2010 was a very rainy year." V13 bee keeper

„This year it's very hard with the bees, they bite, they attack a lot. It's probably because of the changing weather conditions. It has been worsening for about 3-4 years.." V13 bee keeper

„We can't improve with such an unpredictable weather." V13 bee keeper

„This is the „storm corner" of Hungary, weather conditions are often extreme here. Lately it was the large amount of precipitation causing the trouble. There are channels to drive away excess water but they aren't in a good state. The alkaline lands can not be used, they aren't cultivated, there are grasslands only, so the most one can do there is mowing. The waste water treatment plant is near the alkaline lands (this also belongs to our company). In the past poplars were planted there to absorb the water but this way soil became polluted as well, and it is a very laboursome method, today waste water is cleaned with modern, automatized technology." V4 non-farmers

„Weather has become more extreme. Lately there have been several hot periods, summer stroms are more intense, there has been more precipitation in the previous months." V5 non-farmer

„Changing weather is making agricultural production harder and it is not good for grasslands either to get covered by water." V14 farmer

„Climate is changing, seasons are shifting, weather conditions are harsher and harsher. To sum it up, the state of the land is going to deteriorate in the future." V15 farmer

Problems related to excess surface water were mentioned by a number of subjects, although it appears to be a settled issue, because reservoirs and dikes are functioning well:

„Excess surface water has been a problem since the 1950-s, like for example in the case of the castle in Póstelek. A lot of things get destroyed, time destroys a lot of things and also people who don't manage things well." V2 farmer

„There is excess surface water. Big and strong dikes were built along the Körös rivers Between the dikes there is a reservoir." V7 farmer

„Excess surface water has appeared but my land is not really affected." V9 farmer

„Lands around Gyula mostly have excess surface water" V14 farmer

„A lot of fodder and protected plants perished because of excess surface water." V14 farmer

„There were a lot of problems with excess surface water between 1999 and 2002, this year it rained a lot but it didn't mean trouble until now. We are in serious trouble if the creeks of Maros fill up with water. Elders say that there used to be more water in the plains and it meant no trouble. The farm houses were built on the hills so they weren't flooded." V3 national park service ranger

„The floods of the Körös rivers were dangerous, Gyula always good flooded but lately we have no problem with it, we have good dykes and a reservoir." V11 local politician

Other results

Besides the ecosystem services perceived by locals, our survey has revealed conflicts, attitudes, problems that can only be related indirectly to the services provided by nature. These problems also part of the results so we feel that we need to mention them:

Processing industries in Gyula

Local processing industries are only indirectly related to ecosystem services processing raw materials but they were often mentioned together with agriculture. Similarly to crop production and animal husbandry our subjects felt disappointed and mostly agreed on that local processing industry is declining:

„Meat can be sold to the meat factories. The meat factory of Gyula is near bankrupcy There is a meat market in Nádudvar." V7 farmer

„The purchasers were napmen, they pushed down the prices. Meat comes from Debrecen and abroad to Gyula. We are risking our own property so we must work 365 days a year." V8 farmer

„The processing industry has been destroyed." V8 farmer

„I feel sorry that the well structured and modern waste water treatment plant can only work on 60-70 % of its total capacity because with the decline of the processing industry the full capacity can not be utilized." V5 non-farmer

„Today everything is transported away, processed and then transported back, nothing is done in the same place (for example the place of slaughter, processing and sales of livestock), this is not profitable." V8 farmer

„The dairy has closed in 2004, the production has dropped in the meat factory." V4 non-farmer

„I find the reduction of animal husbandry a big mistake, a sin even. The meat factory employs a very few people already, its buildings have either been demolished or they are empty. This has contributed to the growth of unemployment and with the weakening of purchasing pork has also become hard to sell." V5 non-farmer

„The local meat factory provides about 300 jobs. Since the prohibition of pig slaughter there is less and less people who can make a living of the meat industry." V10 local politician

„I can sell the milk with a lot of difficulties only, because the largest dried milk factory, the dairy in Gyula has also been closed." V16 farmer

„Among other things there used to be a stocking factory, iron industry, hydraulic industry, a milk powder factory, an agricultural machine factory, a furniture factory and the famous Gyulai meat factory. These factories, without exception, have become bankrupt or were destroyed. The famous Gyulai meat factory today works with poor materials, with the use of 60% fat and 40% cutting they produce low quality products that bring shame on tradition working on a significantly smaller area." V16 farmer

An opposing opinion also appears about local processing industry. Not all subjects had a negative opinion there are processes heading the opposite direction as well, not only deterioration. This positive opinion was only shared by one farmer and the two leaders of the city:

„The meat factory in Gyula only employs 390 people but it is still important." V11 local politician

„On the other hand, butchers working in family enterprices cooperate and produce high quality products not competitive in quantities but in quality with the meat factory. […]There is also a textile painting plant in Gyula that is unique in Hungary because all the others were displaced by Chinese products." V10 local politician

„Our butcher's market and economy go hand in hand." V7 farmer

Besides the crisis of agriculture and the processing industry several people complained about the resulting unemployment and migration of youth**:**

„There are few jobs and a lot of unemployed people" V4 non-farmer

„There is a lot of migration among local youth, perhaps it is a bit better on the Romanian side." V10 local politician

„People's ability to sustain themselves has decreased (perhaps due to urbanization), they don't know their rights, there is a lot of idle people" V11 local politician

„There is a huge unemployment around the city of Gyula." V14 farmer

Different attitude of farmers and people living in the city

We observed that if the subjects were farmers they reflected on different problems and they reacted with different emotions on a given subject than people not working in agriculture. One of the differences appeared already in the matter of tourism: farmers think that the city puts too much emphasis on it which hinders agriculture, while people living in the city praise the excellent touristic possibilities of the town.

Subjects not working in agriculture talked about the spririt of the town while farmers haven't mentioned it:

„There is a lot of green areas which makes the city a nice place." V4 non-farmer

„People of Gyula like their city and they are very hospitable" V5 non-farmer

„Related to city environment: pedestrian streets has been constructed which is good for tourism but bad for transport." V10 local politician

„Gyula is a nice place, a consolidated small town and it's silent. It's a city of gardens and bath." V3 national park service ranger

Farmers working in nature daily rather mentioned love of nature instead of the spirit of the town, talking about the importance of their connection with nature. They regret it doesn't have a value anymore. These feelings were not mentioned by the subjects working in other areas, outside agriculture:

„I'm sorry that my son will not continue farming.." V1 farmer

„Such a land is the Péli pasture, it's a place I love." V1 farmer

„I love nature, I have been connected to it since my early childhood, this is my job, I know a lot of things about nature." V2 farmer

„In the past people used to navigate with the help of natural objects such as hills, today they don't pay attention anymore, they've got the GPS." V2 farmer

„I hike a lot while I'm checking the lands and I love doing it" V9 farmer

Subjects living in a closer relationship with nature – the farmers and the national park service leader – were able to give a description of the surrounding landscape while the rest of the subjects with different occupations couldn't:

„Several branches of the late Fehér-Körös used to flow through Gyula. Today there is one regulated river bed that is called living water channel. North to it there are large flood plain forests, while on the south there is a patchy agricultural area where the lower, alkaline lands are not cultivated, those are grasslands. There aren't many protected plants here, but a few characteristic species like hog's fennel or Plantago schwarzenbergiana. In the forests by the river Fekete-Körös alpine plants can be found, too.” V3 national park service ranger

„Six years ago there was a larger fire on the grassland. They were fighting the fire for a week.” V6 sheep farmer

„There are alkaline lands in the area. The Körös rivers cause no trouble.” V7 farmer

„Today there are no more farm houses only next to the road directly, old farm houses have disappeared 20 years ago, they have been ’cleaned up’. Today it’s only those who have nowhere else to go who still live there or those who still have the possibility to do farming.” V8 farmer

„The landscape hasn’t changed a lot, there is a sand mine in the area.” V9 farmer

„During the past few years several sand mines were constructed in the area that have been abandoned later and transformed into fish-ponds thus placing artificial objects into the natural landscape.” V14 farmer

„Sand mines were constructed in the area and later they were abandoned. After that the pits have been transformed into fishing ponds.” V16 farmer

Locals’ view of nature conservation

Our research has revealed a conflict that was a characteristic in the Magyarcsanád site also: the discrepancy between the farmers and the nature conservationists. The most problems mentioned by farmers have reference to Natura 2000 area which is not controlled by the national park but by the Agriculture and Rural Development Office. Farmers typically had a negative opinion about the work of the nature conservationists or at least about the regulations, that farmers often found useless or even harmful for agriculture. However the majority of farmers realize that nature conservation is important yet they are hostile towards the work of the nature conservationists:

„It would be good if people had time, besides working day and night, to care about the environment.” V14 farmer

„I find nature conservation important, to do farming in a way that respects nature.” V1 farmer

„It’s important to protect nature.” V2 farmer

„Nature protection is important. Especially because I make a living with it.” V9 farmer

„Grazing is prohibited on the side of the dike. In the past sheep used to step on it which compacted the soil preventing leakage.” V1 farmer

„I wanted to change the landscape. I wanted to transform 40 hectares of ploughland into a forest, but the land has become a Natura 2000 area and planting forests is not allowed anymore. I can go on with farming but I’m not allowed to plant a forest.” V6 sheep farmer

„Years ago farmers were told that the grasslands, about 100hectares were going to become a Natura 2000 area. Everybody was against it but from 2 years ago it has become official. We try to respect it ever since even though we suffer an obvious loss: because of the regulation of the times of mowing we can only mow a worse quality hay so we need to rent different, not protected lands for hay." V16 farmer

„Compared to how it was in the past it is good that the grasslands are protected. Before the Natura 2000 it wasn't valued this much, they used to trample on it a lot due to agricultural work," V16 farmer

„I don't agree with the rules layed down by the National Park. There used to be an order in this neighbourhood, now we can't even cut the grass next to the road. I find the work of the National Park unnecessary. The animals and plants that are here used to live here in the past too. Nobody was here to protect them, but they still survived." V7 farmer

„We don't know the purpose of the National Park's activities. We find the whole work unnecessary." V7 farmer

„We should find the golden mean between environmental protection and profitable farming." V9 farmer

„I object to the land becoming a Natura 2000 area. Conservationists come up with very strict regulations and limitations.." V12 non-farmer

On the other hand, the local ranger complained that people don't understand nature conservation and the work of the national park:

„People don't understand nature conservation, they don't understand what we do. When we planted trees at the borders of the protected area they went through them with a disc. They don't understand the treatments we do either, for example when the weeds were growing around the trees so that the game don't destroy the seedlings which is also a forestry practice, people saw this as 'they struggled with the trees for a while but in the end they just left the whole thing'. Although, about grazing it was possible to gradually make them realize that extensive grazing is a better method."

„If the process that we have started in the protected area would continue, a forest steppe could form, but this requires that the land stays in state ownership controled by the national park, it should be the national park that decides what happens on these lands, but the political situation is not very promising today."

„The ESA (Environmentally Sensitive Areas) program and the target programs work very well (for instance in Kardoskút and Dévaványa), that's what would be needed here too."

„Since the times of the cooperative people have forgotten what was before intensive agriculture, the attitude has changed, farmers could only be convinced if they were paid enough money." V3 national park service ranger

There was a difference between people living in the city and farmers in their attitude towards conservation. While farmers expressed a hostile opinion related to the nature conservationists, those wo didn't work in farming had a positive opinion about the attitude of the city in the protection of the natural environment, but the two local politicians haven't mentioned the protection of nature or the environment in the city:

„Selective waste management has been a practice for quiete a long time in Gyula. A contractor does the selecting and baling of paper waste. Green waste is collected separately: each home with a garden has a separate bin for organic waste for the compost. The compost plant also works in the waste water treatment facility." V5 non-farmer

„The city of Gyula cares a lot about nature conservation." V5 non-farmer

„Natural environment has changed in a good direction, people have realized that it's for their own good to protect the environment. It can be noticed around the city, the town is cleaner and cleaner." V5 non-farmer

„The situation is going to improve, people and experts care more and more about the environment, less malpractice occur. For example there was a lot of damage done to nature in case of Nagymaros – they pay much more attention to avoid such errors. When trees are cut, they are replanted in time." V4 non-farmer

Conclusion

Although we tried to concentrate on the area described int he 2nd chapter, but the people, we have asked, especially in the town Gyula, sometimes speaked about the wider surrounding, including the forests to the North of the town, or about the national park area named Szabadkígyósi puszta to the West of the described area.

We can conclude from the interviews carried out in Gyula that the most important ecological services perceived by locals are mainly provisioning services: crop production and anmial husbandry, though the latter one is supplanted. Besides crop production fodder production was not mentioned on its own, but it rather appeared when the subjects talked about the grazing possibilities of grasslands. Many farmers have complained about inapproriate regulations making it unprofitable to make use of this ecosystem service. A few subjects mentioned other provisioning services too: biogas, local forests, medicinal water and biodiversity.

Among regulating services only the air filtering capacity of forests has been mentioned and just in one interview. This lets us conclude that people living in Gyula don't perceive the surrounding nature as a regulating, cleaning and protecting system.

Among the cultural services our subjects talked about the tumulis around the city that they found important and valuable. Tourism has a high significance as well, the thermal spa was also mentioned. Although the opinions differed about tourism: farmers found that this service is over-valued and it inhibits agriculture, while people working in other sectors have praised the city's attitude towards tourism considering it an important source of income.

Instead of supporting services they referred to nature as a source of risk and danger, a lot of farmers complained about the problems related to unsettled weather and excess surface water.

A phenomenon was obtrusive during the interviews: farmers and non-farmers otherwise reflected on the same questions, seen some of the problems from different perspective, as outlined in the context of the tourism. This is somewhat understandable as a natural phenomenon that a man's world view is influenced by his profession. Besides our sampling was not large enough that we could conclude far-reaching conclusions from these results about attitudes of farmers and non-farmers.

Besides the inventory of ecosystem services our research has revealed further local problems, conflicts. For example the declining of processing industries in Gyula, the unemployment and youth migration. An other conflict was the farmers hostility against the regulation of Natura 2000 areas, and the national park ranger's complaints about farmers.

References

Babbie, E. (2008): A társadalomtudományi kutatás gyakorlata. Balassi Kiadó, Budapest.

Cseh, V., Erdős, L. and Körmöczi, L. 2011: Landscape history of the Gyula — Vărşand region. — In: Körmöczi, L. (ed.): Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş. Szeged-Arad, pp. 7-22.

Dóka, K. (2006): A Körös- és Berettyó-völgy gazdálkodása az ármentesítés előtt és után. - Békés Megyei Levéltár, Gyula.

Erdős, L., Bátori, Z., Zalatnai, M,. Margóczi, K., Tolnay, D., Cseh, V,. Arsene, G-G. and Körmöczi, L. (2011a): Comparison of two neighbouring alkaline grasslands with different land uses: a conservation management perspective Acta Botanica Hungarica 53(1–2), pp. 89–100.

Erdős, L., Bátori, Z., Zalatnai, M., Margóczi, K., Cseh, V., Tolnay, D. and Körmöczi, L. (2011b): Effects of different land-uses on alkaline grasslands – implications for conservation — In: Körmöczi, L. (ed.): Ecological and socio-economic relations in the valleys of river Körös/Criş and river Maros/Mureş. Szeged-Arad, pp. 97-110

Hanley, N. and Spash, C. (1993): Cost-Benefit Analysis and the Environment. Edward Elgar, Aldershot.

Hein, L., van Koppen, K.a, de Groot, R.S. and van Ierland, E.C. (2006): Spatial scales, stakeholders and the valuation of ecosystem services. Ecological Economics, 57, 209– 228.

Kelemen, E., Málovics, Gy. and Margóczi, K. (2009): Ökoszisztéma szolgáltatások és tájhasználat váltás az Alpári-öblözetben. Természetvédelmi Közlemények, 15, 119-133.

Málovics, Gy. and Kelemen, E. (2009): Non-monetary valuation of ecosystem services: a tool for decision making and conflict management. 8th International Conference of the European Society for Ecological Economics – Transformation, Innovation and Adaptation for Sustainability. 29th June – 2nd July, Ljubjana, Slovenia

Marosi, S. and Somogyi, S. (eds.) 1990: Magyarország kistájainak katasztere I. MTA Földrajztudományi Kutató Intézet, Budapest. 1023 p.

MEA (2003): Ecosystems and human well-being. A framework for assessment, Island Press, Washington, D.C.

MEA (2005): Ecosystems and Human Well-being - Biodiversity Synthesis, World Resources Institute, Washington, D.C

Scherer F. 1938. Gyula város története I-II. Gyula m. város kiadása, Gyula.