

ACCESSORY PUBLICATION

Managing the world's most international river: the Danube River Basin

Nike Sommerwerk^{A,G,H}, Jürg Bloesch^B, Momir Paunović^C, Christian Baumgartner^D, Markus Venohr^A, Martin Schneider-Jacoby^E, Thomas Hein^F and Klement Tockner^{A,G}

^AIGB, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Müggelseedamm 310, 12587 Berlin, Germany.

^BIAD, International Association for Danube Research, Stauffacherstrasse 159, 8004 Zürich, Switzerland, and Eawag, Swiss Federal Institute of Aquatic Science and Technology, Überlandstrasse 133, 8600 Dübendorf, Switzerland.

^CInstitute for Biological Research, 142 Despota Stefana Boulevard, 11060 Belgrade, Serbia.

^DDonauauen National Park GmbH, 2304 Orth an der Donau, Schloss Orth, Austria.

^EEuroNatur – European Nature Heritage Fund, Konstanzer Str. 22, 78315 Radolfzell, Germany.

^FUniversity of Natural Resources and Applied Life Sciences, Vienna, Institute of Hydrobiology and Aquatic Ecosystem Management, Max - Emanuelstrasse 17, 1180 Vienna and WasserCluster Lunz, Dr Carl-Kupelwieser-Prom. 5, 3293 Lunz/See, Austria.

^GInstitute of Biology, Free University Berlin, Takustrasse 3, 14195 Berlin, Germany.

^HCorresponding author. Email: sommerwerk@igb-berlin.de

Accessory Publication

A) Protected areas along the Danube River and its major tributaries

Only areas that are managed by an administrative authority committed to nature protection are listed. *River ecosystems comprise only a small part of the total size (websites accessed 18 August 2009).

Name	River-km	Country	Major landscape elements	Total area [ha]*	Website
Danube Delta Biosphere Reserve	115 - Black Sea	Romania	delta	564,054	http://www.ddbra.ro/en/index.php
Danube Biosphere Reserve	53 - Black Sea (Chilia Arm)	Ukraine	delta	49,676	http://www.dbr.org.ua

Srebarna Nature Reserve	393 - 391	Bulgaria	natural river banks, islands, lakes	902	http://whc.unesco.org/en/list/219
Kalimok-Brushlen Protected Site	463 - 434	Bulgaria	natural river banks, islands, marshes	6,000	http://www.kalimok.org
Persina Nature Park	600 - 560	Bulgaria	natural river banks, islands, marshes	21,762	http://www.persina.bg
National Park Djerdap	1041 - 940	Serbia	Iron Gate Gorge, hillslopes	63,608*	http://www.npdjerdap.org/en/aktuel.html
Iron Gate Nature Park	1075 - 935	Romania	Iron Gate Gorge, hillslopes	115,655*	http://www.portiledefierp.ro/
Deliblatska Pescara	1091 - 1076	Serbia	natural river banks, various transition zones	29,352*	http://www.vojvodinasume.rs/indexnivo_en.php?&nivo_1=8&nivo_2=34
Special Nature Reserve Koviljsko-Petrovaradinski Rit	1251 - 1231	Serbia	natural river banks, highly connected river section	4,840	http://www.vojvodinasume.rs/indexnivo_en.php?&nivo_1=8&nivo_2=32
Kopacki Rit	1412 - 1382	Croatia	natural river banks, floodplains	17,700	http://www.kopacki-rit.hr/
Special Nature Reserve	1433 - 1366	Serbia	natural river banks, floodplains	19,648	http://www.vojvodinasume.rs/indexnivo_en.php?&nivo_1=8&nivo_2=33
Duna-Drava National Park	1499 - 1433	Hungary	natural river banks, highly connected river section	49,479	http://www.ddnp.hu
Duna-Ipoly National Park	1713 - 1657 (several distinct areas)	Hungary	natural river banks, islands	60,314*	http://www.dinpi.hu
Szigetköz	1852 - 1806 (several distinct areas)	Hungary	highly connected river section	9,158	http://www.szigetkoz.info/galeriak/2007_conference/index_2.htm
Protected landscape area Danube Floodplains	1864 - 1780 (several distinct areas)	Slovakia	highly connected river section, islands	12,284	http://www.sopsr.sk
Danube Floodplain National Park	1917 - 1880	Austria	highly connected river section	9,300	http://www.donauauen.at
Protected landscape and Word Heritage Site Wachau	2050 - 2020	Austria	riverine landscape, hillslopes	18,387	http://www.wachau.at/donau/WN/?id=31947
Naturpark Obere Donau	2750 - 2658	Germany	valley, karstic river bed	135,000	http://www.naturpark-obere-donau.de/
Lonjsko Polje	Sava River	Croatia	highly connected river section	50,600	http://www.pp-lonjsko-polje.hr/
Gajna (protected landscape, partly ornithological reserve)	Sava River	Croatia	floodplain, pastures	1,500	http://www.bed.hr/EN/Gajna.html
Obedska Bara	Sava River	Serbia	swamp forest and vegetation, ponds, meadows	20,000	http://www.vojvodinasume.rs/indexnivo_en.php?&nivo_1=8&nivo_2=35
Zahorie	Morava River	Slovakia	floodplain forest, side-arms, meadows	27,522	http://www.sazp.sk/slovak/struktura/copk/chodniky/chkoza.html

B) Restoration case studies

UPPER DANUBE

1) Morava River (Slovakia and Austria): reconnection of meanders

- Situation before/ after human impact

Originally a meandering river, more than 90 % of the river course faced intensive river regulation during the 20th century, like dike construction, canalisation, and elimination of all major meanders.

- Restoration project

Within the project *GEF-Biodiversity* four cut-off meanders were partly reconnected to the river between 1993 and 1995 (Morava-Rkm 12, 19, 65). The aim was to increase the flow dynamics in the former anabranches. The bypass-canals stayed fully active, water inflow to the re-opened meanders was limited by rock dams.

- Situation after restoration

The expected washout of settled sediments did not occur, and the opened meanders suffered severe sedimentation after restoration. The morphology and the sediment layer did not develop towards an active meander. Biotic response showed an increase of fish taxa; mainly additional rheophylic species. Invertebrate and plant communities shifted towards the riverine set of species, but could not be considered equivalent to those observed in active meanders.

Another type of meander re-opening was tried on the Austrian side of Morava River at river-km 18, where the meander was reconnected at the downstream part to the river which lead to severe sedimentation in the outflow area of the meander.

- Lessons learnt

The results provide evidence that reconnected meanders might be unsustainable if a parallel shortcutting is not blocked. It is one of the only projects where full meander bends of lowland rivers have been reconnected and the resulting hydromorphologic changes were well-documented (Phare Project Report 1999).

MIDDLE DANUBE

2) Wachau (Austria): side arm restoration, <http://www.life-wachau.at>

- Situation before/ after human impact

The Danube has an alpine character in that region, with coarse gravel as bed sediment.

Mean water flow velocity is 1.5 to 2.0 m s⁻¹, mean water discharge is 1.950 m³ s⁻¹. Due to

regulation works in the 20th century the river banks are fixed by embankments, and side arms are cut-off by rocky dams.

- Restoration project

A silted side arm has been reconstructed by dredging near Rossatz-Rührsdorf (Rkm 2013.5 – 2010.0) at a total length of 3.5 km in winter 2005/2006 to create habitat for rheophilic fish species. Implementation by Austrian Waterway Agency via donau and local partners; subsidised by the EU LIFE-Programme.

- Situation after restoration

The side arm has been active since dredging, with flow velocities similar to those in the main river and no aggradation of the river bed in the side arm. The density of rheophilic fish and number of fish species has increased considerably, and the side arm obviously became important for fish reproduction. Shelter from ship waves may be one of the major reasons.

- Lessons learnt

Endangered rheophilic fish communities can be supported efficiently by restoration of side arms, if a flowing water regime is guaranteed throughout most of the year.

3) National Park Donau-Auen (Austria): side arm restoration and river bank restoration

<http://www.donauauen.at>

- Situation before/ after human impact

Danube characteristics see case study 2, Wachau.

- Restoration project

To enhance riverine morphodynamics, several side arms have been reconnected since 1995 (Rkm 1905.0 – 1895.5; 1905.2 – 1902.0; 1910.1 – 1906.5) and since 2005 river embankments and groynes have been removed from 2.85 kilometres (Danube Rkm 1885.75 – 1882.9) and from 1.2 km (Danube Rkm 1883.1 – 1881.9) (Accessory Publication, Part C). The long-term goal of the project is to come as close as possible to the pre-regulation status of this Danube section. Implementation is by the Austrian Waterway Agency (via donau) and Danube Floodplain National Park; subsidised by the EU LIFE-Programme.

- Situation after restoration

Reconnected sidearms show considerable erosion of lateral fine sediment layers and meandering is starting to take place. However, morphodynamics are not yet sufficient for

adequate bedload gravel transportation. Sidearms have not increased water depth by incision.

Along the Danube natural river banks were restored within half a year with lateral erosion rates of up to 10m, though the erosion rate is currently declining (Accessory Publication, Part C).

- Lessons learnt

Revitalisation of floodplains, flood control and inland navigation are compatible, when win-win situations are created. In these cases it is even possible to obtain or to proactively protect riverine landscapes with steep river banks several meters high, to have gravel relocation rates that allow for the formation of gravel banks and to have river banks structured with large woody debris.

4) Lobau (Austria): reconnection of floodplains

<http://www.magwien.gv.at/umwelt/wasserbau/hydrologie/dotationlobau.html>

- Situation before/ after human impact

The floodplain area “Lobau” is situated along the left bank of the Danube River at the eastern border of the city of Vienna (Rkm 1924 – 1907). During the 19th century, this former braided-anabranching floodplain complex was disconnected from the main channel by the construction of lateral embankments and a flood protection dyke. Land use change has led to a 74% decrease in surface water area and has dramatically altered habitat composition and related ecosystem functions.

- Restoration project

Lobau floodplains have been reconnected to an artificial flood relief channel of the Danube since 2001 (flow input: up to $1.5 \text{ m}^3 \text{ s}^{-1}$ during the vegetation period, mean discharge during 2001-2008: $0.25 \text{ m}^3 \text{ s}^{-1}$).

- Situation after restoration

The improved connectivity between water bodies at higher mean water levels in the floodplain has decreased the risk of massive eutrophication events, improved the water levels in small oxbows and some semi-aquatic areas, and conserved the existing species diversity in aquatic habitats (e.g. Bondar-Kunze et al. 2009, Funk et al. 2009).

Lessons learnt

Increased connectivity has led to more diversified aquatic and semi-aquatic habitats and more intense biogeochemical cycling. However, due its vicinity to Vienna, societal

demands, like flood protection, drinking water supply (20% of the drinking water for Vienna), and recreation (~650,000 visitors per year – census 2006) challenge floodplain management of the Lobau. A multi-criteria decision support system that integrates ecological and societal demands has been developed in order to identify future measures able to serve multiple uses and rehabilitate the hydrological connectivity in certain parts of the floodplain area (Hein et al. 2006b).

5) Krapje Djol (Croatia): reflooding of oxbow

- Situation before/ after human impact

The spoonbill colony Krapje Dol is the heart of the Nature Park Lonjsko Polje. In 1963 the oxbows became the first Ornithological Reserve of Croatia. In 1988, 180 pairs of spoonbills and 210 pairs of herons nested there. During the implementation of the UN – World Bank SAVA 2000 program the site suffered as its surroundings were drained in a polder, large flooded pastures were transferred to arable land and herbicides delivered by airplane directly over the colony. A ditch drained the water from the oxbow and the site dried out in 1989 (Dezelic and Schneider-Jacoby 1999).

- Restoration project

Two important steps led to the recovery of the site. In 1989, a rehabilitation project was planned by the Croatian Institute for Nature Protection and EuroNatur to restore the water level in the oxbow. Moreover, a pipe was built to re-flood the area. It is in use when the water level in the Sava is above 620 cm. Funding was provided by the Zoological Society Frankfurt.

- Situation after restoration

In 1991, the first spoonbills returned. In 2004, the colony has reached 80 pairs of spoonbills and 370 herons. In 1997 the plant *Stratiotes aloides* was spotted again in Krapje Dol.

- Lessons learnt

Flooding without a pump and depending on the natural water regime of the Sava was the best solution. Water quality improves after the first flood wave. Today, the site is once again one of the key attractions of the Nature Park Lonjsko Polje and the mixed heron and spoonbill colony Krapje Dol offers a great insight in the biodiversity of alluvial wetlands (see: http://www.zoo.ch/xml_1/internet/de/application/d1/d90/f1541.cfm)

DELTA

6) Danube Delta (Romania): opening of agricultural polders

- Situation before/ after human impact

Until the 20th century vast areas of the Danube Delta faced only minimal human impacts through extensive fishery and reed harvesting. Since then the Danube Delta has undergone multiple human impacts like embankment, channelization and drainage. Moreover, large areas were diked and the polders used for agriculture.

- Restoration project

The Babina polder (2.100 ha) was reconnected to the river in 1994, Cernovca polder (1.580 ha) followed in 1996, and recovery has been monitored by the Danube Delta National Institute (www.indd.tim.ro)

- Situation after restoration

Within a few years a redevelopment of the site-specific biodiversity occurred and ecosystem services like nutrient retention and fish recruitment became obvious. Additionally, the reconnected polders enable reed harvesting, grazing, fishing and eco-tourism (Schneider et al. 2008).

- Lessons learnt

Already small scale measures to open large polder areas can lead to the restoration of natural wetlands. These cost-effective and thus realisable measures could serve as an example for the revitalisation of comparable areas in the Danube Delta. In order to keep polders active, the location of the in- and outflow has to be chosen appropriately.

C) The Danube river bank (Rkm 1885.75 – 1882.9) before (a) and after (b) restoration. The largest restoration project along the Danube is actually carried out between Vienna and Bratislava. About 50% of the riprap will be removed to allow natural bank processes (Photos C.Baumgartner).

(a)



(b)



D) Observer organizations within the ICPDR

(Source: www.icpdr.org and respective websites of the organizations, accessed 18 August 2009)

Organization	Main objectives	Entrance date	Website
World Wildlife Fund for Nature WWF International & Danube Carpathian Programme DCPO	NGO that promotes the development of solutions to the challenges the DRB region is facing	19.7.1999	http://www.panda.org/what_we_do/where_we_work/danube_carpathian/
International Association for Danube Research IAD (SIL)	Scientific NGO that links basic with applied sciences	27.9.1999	http://www.iad.gs/
Danube Commission CD	Implementation of Belgrade Convention (1948)	10.11.1999	http://www.danubecom-intern.org/
Danube Environmental Forum DEF	DRB-wide platform of environmental NGOs	23.11.1999	http://www.def.org.hu/
Regional Environmental Center for Central and Eastern Europe REC	Facilitating environmental dialogue, networking and regional cooperation	10.2.2000	http://www.rec.org/
Ramsar Convention on Wetlands RAMSAR	Intergovernmental treaty; conservation of wetlands and their resources	31.5.2000	http://www.ramsar.org/
Commission on the Protection of the Black Sea against Pollution BSC / ICPDR Black Sea Program Coordination Unit	Intergovernmental body to implement the environmental protection and rehabilitation of the Black Sea	13.11.2000	http://www.blacksea-commission.org/main.htm
Global Water Partnership GWP-CEETAC	Network that supports sustainable development and integrated water resource management	11.7.2001	http://www.gwpforum.org/serylet/PSP?iNodeID=125
UNESCO/IHP International Hydrological Programme	International scientific cooperative programme in water issues, capacity building, education in hydrology	11.7.2001	http://typo38.unesco.org/index.php?id=240
International Working Association of Water Works in the Danube Basin IAWD	Independent technical organization for the improvement and assurance of water quality in the Danube and its tributaries	30.11.2001	http://www.iawd.at/IAWD/Start.html
Die Donau - Danube Tourist Commission	Tourism marketing association among seven Danubian countries	13.12.2004	http://www.danube-river.org/en_home.html
VGB PowerTech e.V. (European technical association for power and heat generation, Essen, Germany)	Voluntary association of power plant companies dealing with power and heat generation	12.12.2005	http://www.vgb.org/en/startpage.html
Via donau - Österreichische Wasserstrassen-Gesellschaft	Association promoting waterways and inland navigation infrastructures	11.12.2006	http://www.via-donau.org/
European Barge Union EBU	Representation of inland navigation interests at a pan-European level	11.12.2006	http://www.ebu-uenf.org/
International Commission for the Sava River Basin ISRBC	Implementation of the Framework Agreement on the Sava River Basin (FASRB)	11.12.2006	http://www.savacommission.org/
European Water Association EWA	Independent NGO/NPO for management and improvement of water environment	5.12.2007	http://www.ewaonline.de/portale/ewa/ewa.nsf/home?readform
Friends of Nature International	NGO for nature protection, cultural heritage, promotion of "sustainable" mobility and "soft" tourism	5.12.2007	http://www.nfi.at/
Central Dredging Association CEDA	Independent NPO/NGO and professional society for dredging related issues	5.12.2007	http://www.dredging.org/
European Angler Alliance EAA	NGO promoting conservation of fish species and their habitats	5.12.2007	http://www.eaa-europe.org/

References

- Bondar-Kunze, E., Preiner, S., Schiemer, F., Weigelhofer, G., and Hein, T. (2009). Effect of enhanced water exchange on ecosystem functions in backwaters of an urban floodplain. *Aquatic Sciences* **71**, 437–447. doi:10.1007/s00027-009-0101-7
- Dezelic, R., and Schneider-Jacoby, M. (1999). Restoration of the spoonbill colony Krapje Dol. *Lonjsko Polje Nature Park Bulletin* **1**, 29–31.
- Funk, A., Reckendorfer, W., Kucera-Hirzinger, V., Raab, R., and Schiemer, F. (2009). Aquatic diversity in a former floodplain: remediation in an urban context. *Ecological Engineering* **35**, 1476–1484. doi:10.1016/j.ecoleng.2009.06.013
- Hein, T., Blaschke, A. P., Haidvogel, G., Hohensinner, S., Kucera-Hirzinger, V., *et al.* (2006). Optimised management strategies for the biosphere reserve Lobau, Austria - based on a multi criteria decision support system: using ecohydrological model approaches. *Ecohydrology and Hydrobiology* **6**, 25–36.
- Phare project report, OSS No. 98/5154.00 (1999). Restoration of the Morava-Dyje Hydrology and Fish Habitat. Final Report: Sub-project Restoration of the Slovak Morava River Meanders. Water Research Institute and Institute of Zoology, Bratislava.
- Schneider, E., Tudor, M., and Staras, M. (2008). Evolution of Babina polder after restoration works. Ecological restoration in the Danube Delta Biosphere Reserve Romania. WWF Germany and Danube Delta National Institute, Tulcea.