The Sava White Book: Threats and opportunities for one of the most valuable rivers of Europe

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Introduction

The Sava White Book, published by EuroNatur and River-Watch, gives an extensive and comprehensive overview of the current situation of the Sava River and offers suggestions for area-specific restoration projects. It is intended as a planning resource for building a vision for the future of the Sava river floodplain corridor.

The Sava River is the largest tributary of the Danube in terms of discharge. It has a catchment area of more than 97,800 km² and a length of 926 km (if considering the longer of two source branches, the Sava Dolinka; see figure 1). Its average discharge at the confluence with the Danube is 1,570 m³/s. The middle and lower Sava are internationally recognized for its huge hardwood forests, the large near-natural flood retention system around the famous Lonjsko Polje Nature Park in Croatia, and the Obedska Bara Nature Reserve in Serbia. The river reached international attention due to the 100 year flood event in 2014.

The alpine upper Sava in Slovenia crosses several breakthrough stretches and small basins, and today is partially impounded by hydropower dams. Downstream of Zagreb, the Sava valley is broad and the river continues with a small gradient all the way to the confluence with the Danube in Belgrade. The character of this meandering lowland river reach is influenced by the southern tributaries, which include the Kupa, Una, Vrbas, Bosna and Drina. At its lowest course, starting about 100 km upstream from the confluence with the Danube, the Sava is influenced by the backwater of the Danube dam Iron Gate I.

1. Current situation

Riparian land structure: For the first time, a continuous land structure mapping for the entire river corridor was carried out mainly based on high-resolution satellite images on a scale of 1:25,000. It includes more than 40 land structure classes. The lower Sava valley hosts large alluvial ash, oak and poplar forests mainly managed by state forestry companies. In addition, willow softwood galleries prevail along all banks. Numerous oxbows, floodplain swamps and wet grasslands characterize the river system. Together with faster flowing southern tributaries featuring numerous gravel bars, these rivers build a unique riparian corridor with rich landscapes and diverse habitats for many species.

The outstanding number of hardwood forests, totalling 63,300 ha in the active floodplain and another approximately 78,000 ha outside the flood protection dikes (influenced by high groundwater and back flooding from tributaries), as well as the large intact wet pastures within the active floodplain (about 25,000 ha) are of particular importance. In addition, pioneer stands on gravel bars cover up to 1,300 ha (mainly along southern tributaries) and are important for the whole river landscape but particularly for the lower Sava.

Hydromorphology: The hydromorphological assessment describes how human activities have altered the natural shape and flow of the river and document the modifications of the riverine landscape. Since some hydromorphological processes, such as incision of the riverbed, have very gradual effects on the river ecosystems, it is important to know about modifications of the past. Many large European river stretches fall in the range “moderately modified” to “extensively modified” (classes 3 and 4 or “yellow” and “orange”, respectively) within a five class

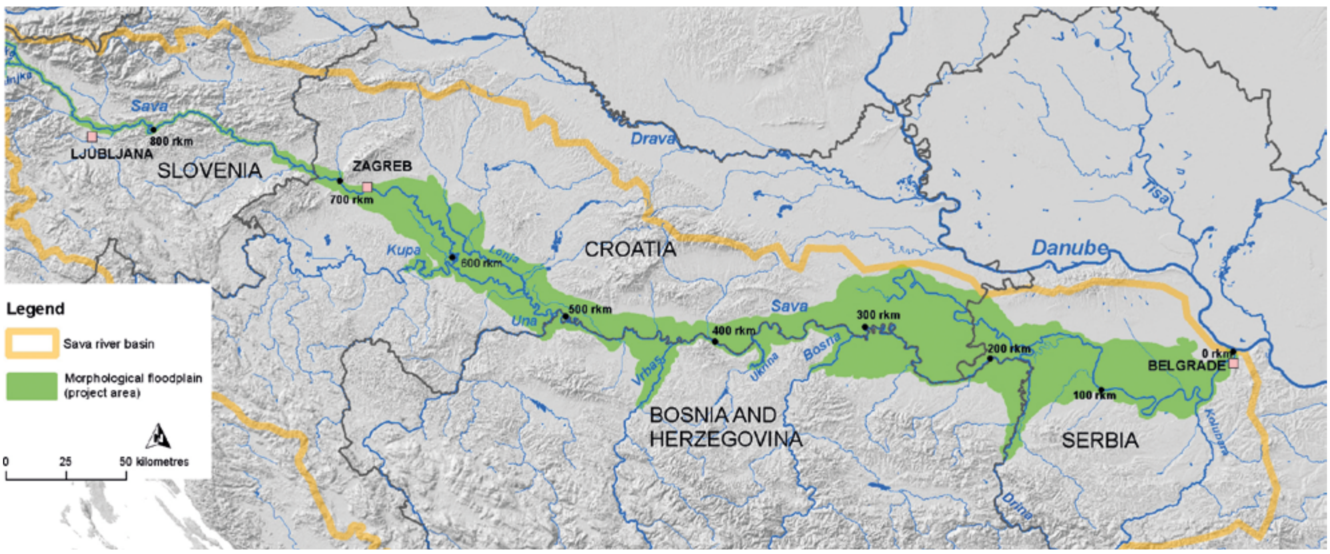

Figure 1. The morphological floodplain of Sava River with the Sava and its tributaries.

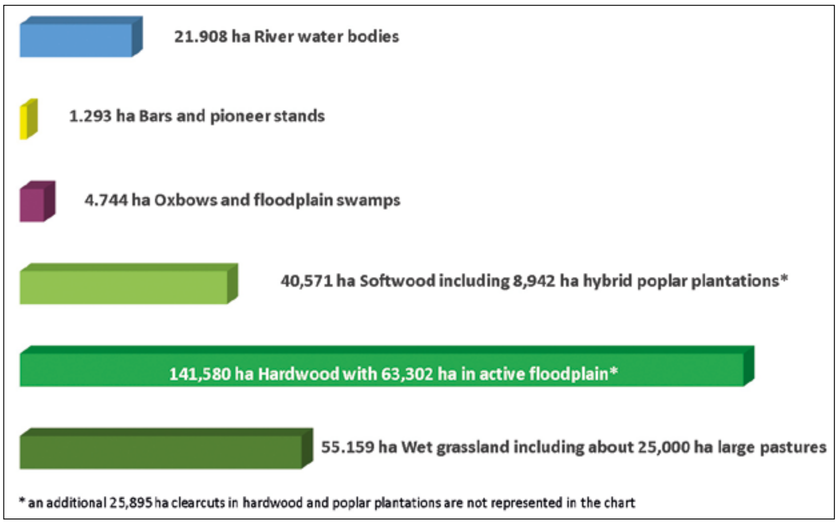

Figure 2. Areas of riparian land structure types with high ecological value (in total about 265,000 ha).

assessment system (European CEN Standards on hydromorphology). Impoundments have the lowest scores and fall into class 5. The Sava performs much better in the classification: 53 % of it falls into class 2 (slightly modified, "green"), predominantly in the long free-flowing middle stretch but also in the free-flowing upper stretches. A total of 4 % is rated as class 1, near-natural *(figure 3):* this comprises a

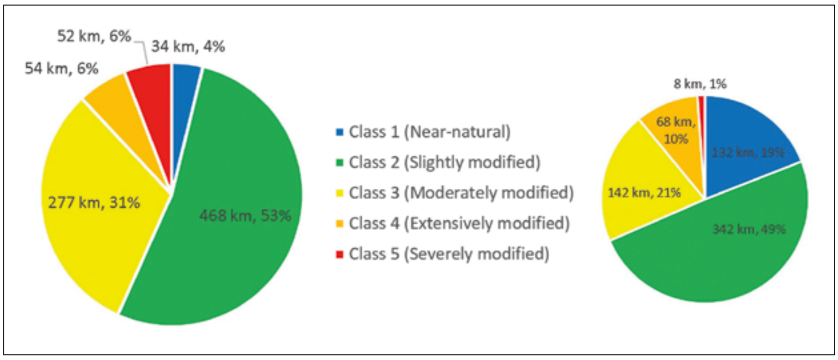

Figure 3. Overall hydromorphological assessment of the Sava (left) and its tributaries (right).

long gorge stretch on the upper Sava and some very short stretches in the meandering middle river reach.

This study's findings for the middle and lower Sava and its large southern tributaries contradict the official intention of the countries (International Sava River Basin Commission) to designate all of these stretches as heavily modified water bodies (HMWB), a classification that could potentially justify further significant alteration (e.g. hydropower, navigation).

Protected areas and biodiversity: The ecological importance of the Sava and its floodplains is reflected by the significant number and size of protected areas; about 36 % of the morphological floodplain [1] (322,875 ha) and 64 % of the Sava river course (excluding the two headwaters) are designated as protected areas. The most prominent are the Lonjsko Polje Nature Park in Croatia and the Obedska Bara Nature Reserve in Serbia, both of which are Ramsar sites. In addition, large stretches of the Sava and tributaries in Croatia as well as some stretches in Slovenia are Natura 2000 sites. Furthermore, the Sava basin is a pan-European biodiversity hotspot, hosting about 250 breeding bird species (e.g. little tern, spoonbill) or endangered fish species such as the huchen, the Cactus roach and the sterlet.

Floodplain loss: Along the Sava and its tributaries an area of merely 2,067 km² can still be flooded (active floodplain), while originally, the morphological floodplain area was as large as 8,943 km². This reveals a total loss of 77 %. This ratio is comparable with that for the Danube or any other large river in the region. However, there are significant local differences along the Sava. In the middle Sava in Croatia, more than 60 % of former floodplains are still active, allowing for a significant capacity for water retention during floods. This part of the Sava represents a unique example of large-scale natural flood mitigation and could function as a blueprint for other river stretches. However, downstream the Bosna confluence, almost 85 % of the original floodplains are cut off from the active floodplain. This was the area where the historic flood wreaked so much damage in 2014.

Natural flood mitigation: Flood defences received high priority after the 2014 historic flood along the middle and lower Sava. Seven major dike breaches between the Bosna and Drina confluences flooded large areas in Bosnia and Herzegovina and areas south of the Bosut forest on the Croatian side of the river. This highlights the absence of retention capacity and the negative effects of the disconnected floodplains in this reach of the Sava. The flooding of Obrenovac in Serbia was caused mainly by dike failure on the Kolubara tributary and low retention capacities in the adjacent Sava. In strong contrast stands the Upper Posavina flood system (Croatia) with a retention capacity of 1.6 billion m³ which is sufficient to protect the towns of Zagreb (bypass into Odransko polje), Sisak and Jasenovac. This retention system is capable of topping off the peak discharges in the Sava at up to 1,500 m³/s, significantly lowering peak water levels downstream. Unfortunately, all countries affected by the 2014 flood event are now focussing on the reconstruction and reinforcement of existing flood defence dikes and have not formulated ambitions to reconnect retention areas to the flood regime, with the exception of an area close to the Bosut mouth that is intended to become a flood storage polder.

[1] The morphological floodplain is defined as maximum area originally influenced by floods.

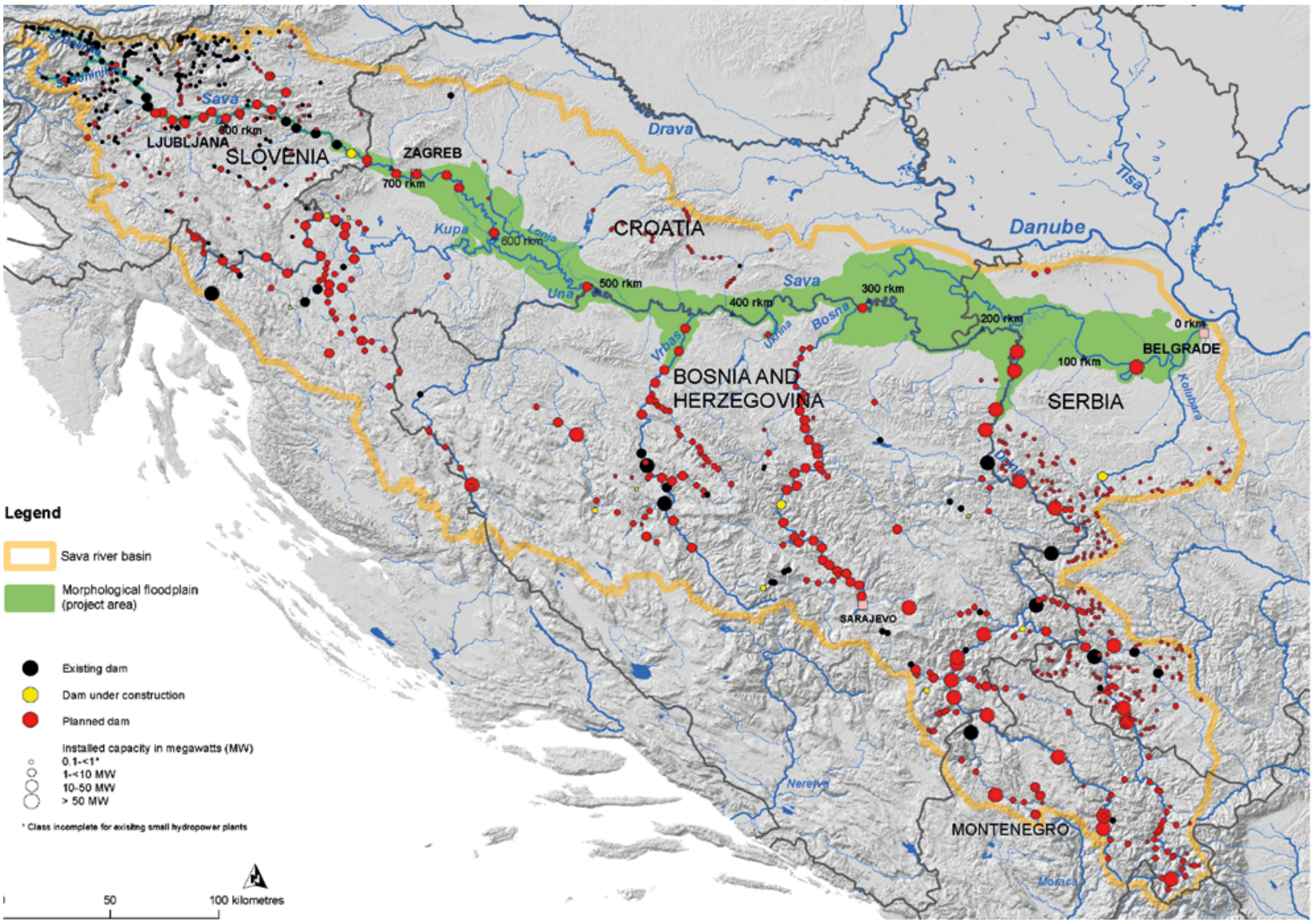

Figure 4. 582 hydropower plants are intended in the Sava basin.

2. Threats

The many **hydropower** projects in the Sava river basin constitute one of the greatest sources of pressure on the river. Proposals for a total of up to 582 new dam projects have been identified *(figure 4).* Dams on the tributaries would have a severely negative impact on the Sava, where they would cause river bed incision by holding back sediments. A total of 88 hydropower projects are planned within stretches populated by huchen. If implemented, this would lead to a decline of the Balkan population by at least 70 %.

Twenty new hydropower projects are envisaged for the Sava alone, adding to the seven already existing (and one under construction). Most projects are located in Slovenia, however, there are also dams projected in the almost entirely free-flowing middle and lower Sava and in all major tributaries.

Dredging and sediment exploitation from the river channels is widespread; over the last decades, significant amounts were extracted: on average 950,000 m^3/year (m^3/a) from Sava channel and 1.29 million m^3/a from tributaries. Estimates based on the available dredging data show that the amount of material extracted from the river per year is up to ten times higher than the natural transport capacity for the Sava and more than four times higher for the tributaries. The impact of dredging on the sediment balances cannot be examined separately from the effects of trapping coarse material in the dam chains. The combination of dredging and trapping can lead to channel incision even in stretches that are not under serious pressure by dredging, particularly between the Sisak and Drina confluences. Hopefully, a preliminary legal decision in Croatia will drastically reduce the dredging amounts within the Natura 2000 sites. This law will require part of the material to be given back to the river, as practised in Germany and Austria, where sediment management has become an important tool for successfully stopping river incisions. More attention and monitoring should be given to potentially self-sustaining solutions in river stretches, such as the lower Drina along the Serbian-Bosnian border. This river is strongly impacted by dams in the upper and middle catchment, but just 20 km downstream of the last dam (hydropower plant (HPP) Zvornik) one of the most exciting and ecologically important river landscapes within the entire Danube basin can be found: the lower Drina. This river stretch is mostly free of riverbed- and bank fixation measures allowing for strong lateral erosion and a consequent loss of land, but the lateral movement of the river reduces the risks of dangerously big river bed incisions and as a consequence maintains natural groundwater tables in this fruitful landscape.

At the moment, **navigation** does not play a significant role in the economic development of the Sava river

Figure 5. The Sava River and its floodplains are a European lifeline and a natural flood prevention system (© Goran Šafarek).

basin, but the topic is on the political agenda at the national and European level. Navigation development, including the projected Sava-Danube canal through the Bosut-Spačva forest area, could cause serious changes of the river system. Regular maintenance dredging has a more severe impact if the extracted material is sold on the market – a common practice in the Sava river basin – as opposed to feeding the material back to the river. Proposals to improve the low water situation for navigation and river regulations include the construction of three ground sills, bank reinforcements (riprap and groynes) and further disconnection of river and floodplain (e.g. traverses to close side-channels). These constructions constitute the main impact on the river system by navigation. Major threats are new plans to raise the ECE (UN Economic Commission for Europe, Inland Water Transport) waterway class for the 594 km stretch between Belgrade and Sisak from III to IV (and on the Serbian part from IV to Va). This requires many significant river regulations, including 24 meander bend corrections and the stopping of nearly all lateral erosion by riprap and stabilising of the shipping channel. Necessary dredging is estimated at least at an initial 1.7 million m³ for the Croatian stretch, followed by continuous maintenance dredging. Another threat is the construction of new infrastructure, such as the proposed new harbour at Sisak, planned in an active floodplain area outside the town. These plans would have a huge deteriorating impact on the river and adjacent environment.

The following two maps *(figures 6 & 7)* summarize the current and potential future threats. Current threats *(figure 6)* cover nearly all activities that are threatening the ecological functionality of the river system: hydropower (impoundments, hydropeaking and sediment deficit), river regulation, frequent dredging and flood defence constructions. The second map *(figure 7)*, showing projected alterations, indicates that almost the entire length of all rivers in the morphological floodplain would be affected if hydropower and navigation projects were fully implemented.

3. Restoration potentials

The present study has attempted to identify the potentials for river and floodplain restoration along Sava River and the lower reaches of its tributaries. While river restoration means "giving more space to the river itself", the goal of floodplain restoration is "giving more space to floods".

With a view to achieving good ecological status as defined in the WFD, river restoration *(figure 8)* aims to prevent further deterioration and to improve the hydromorphologi-

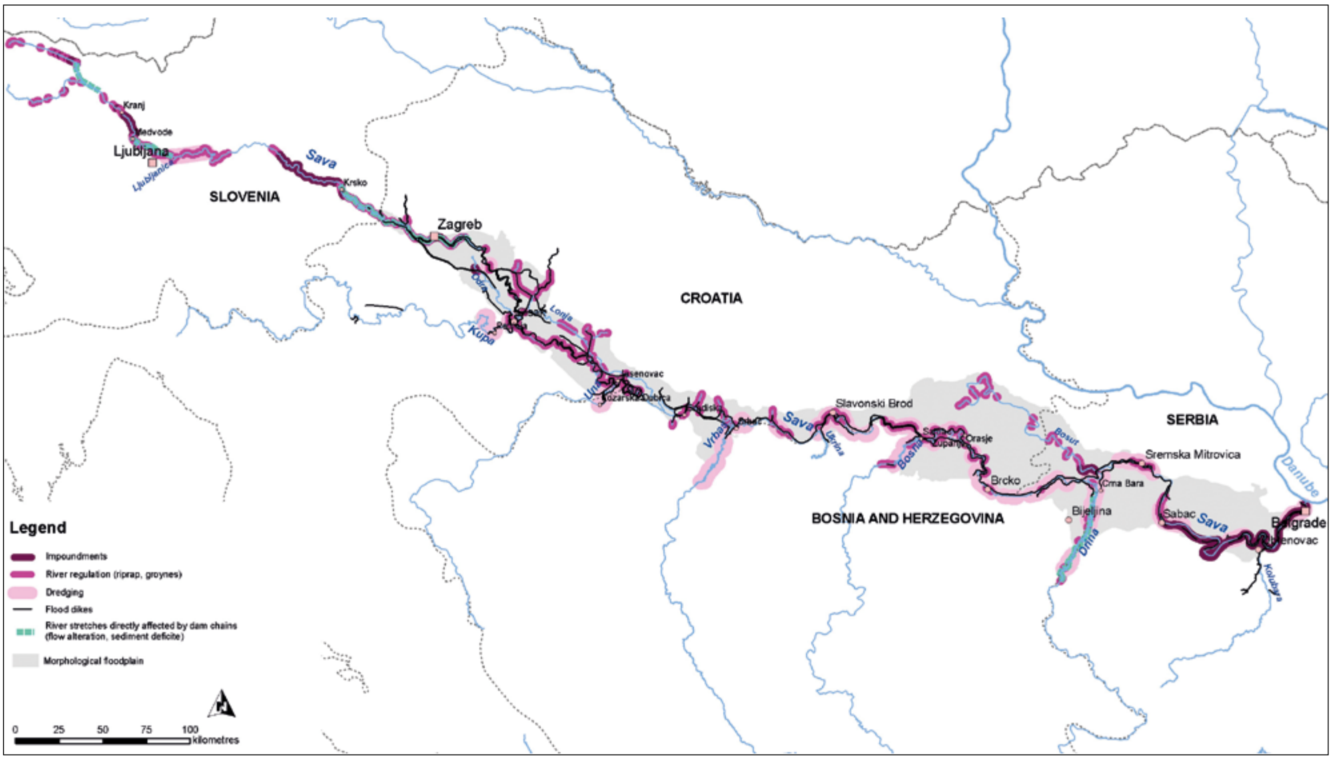

Figure 6. Current alterations and threats (impoundments, river regulation, dredging, flow alterations/sediment deficits and dikes) along the Sava and assessed tributaries.

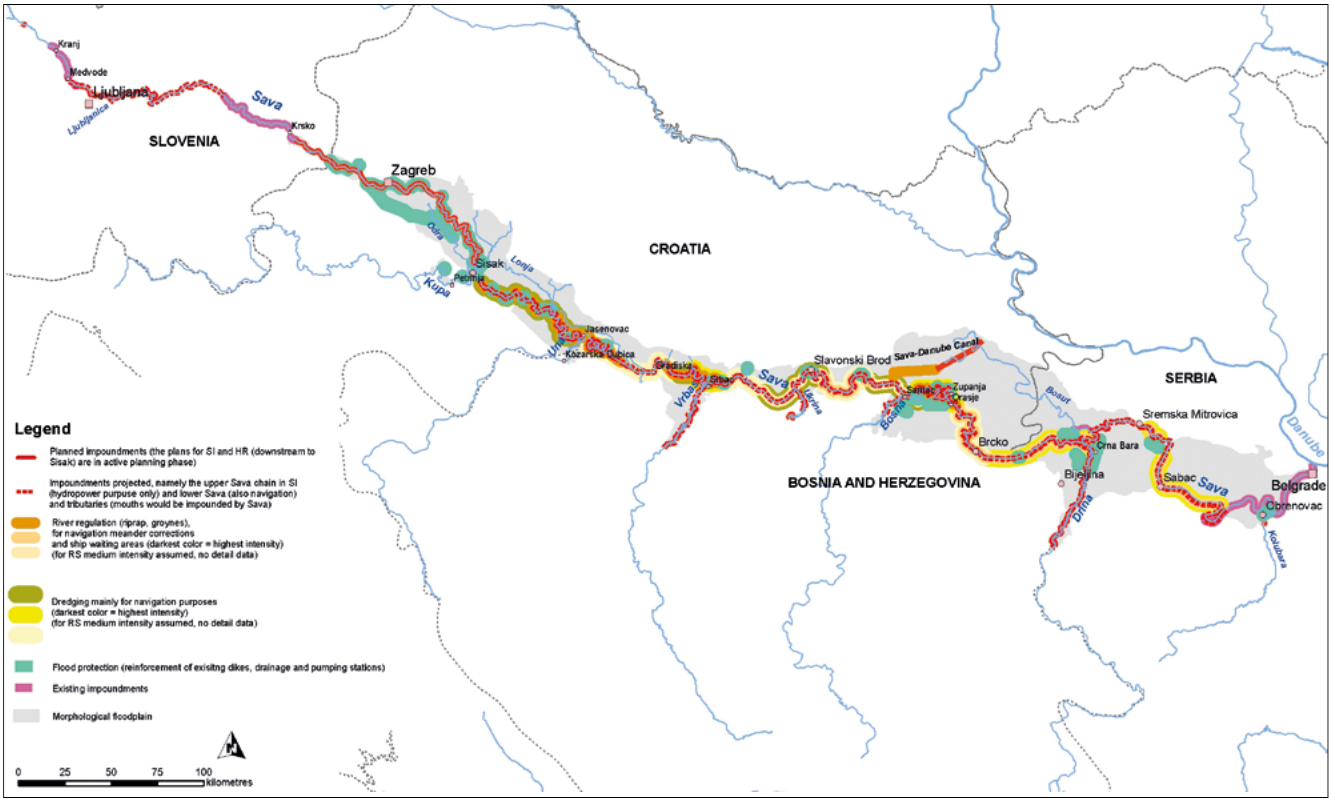

Figure 7. Projected alterations and threats (impoundments, river regulation, dredging, and technical flood protection). The entire Sava is at risk.

cal conditions. Altogether, 41 different river stretches with a length of 251 km have been identified (15 classified as highest, 22 as high and four as low priorities).

In terms of floodplain restoration *(figure 9),* an additional 143 potential areas have been delineated, covering a total area of 184,289 ha and reconnecting about 22 % of the floodplain area with the river. This would increase the overall flood retention capacity by approximately 3.1 billion m³. These areas have been evaluated and prioritized according to land structure, hydromorphology, protected area status, retention capacity and land ownership structure. Ten areas have come out with very high priority, 108 with *very high*

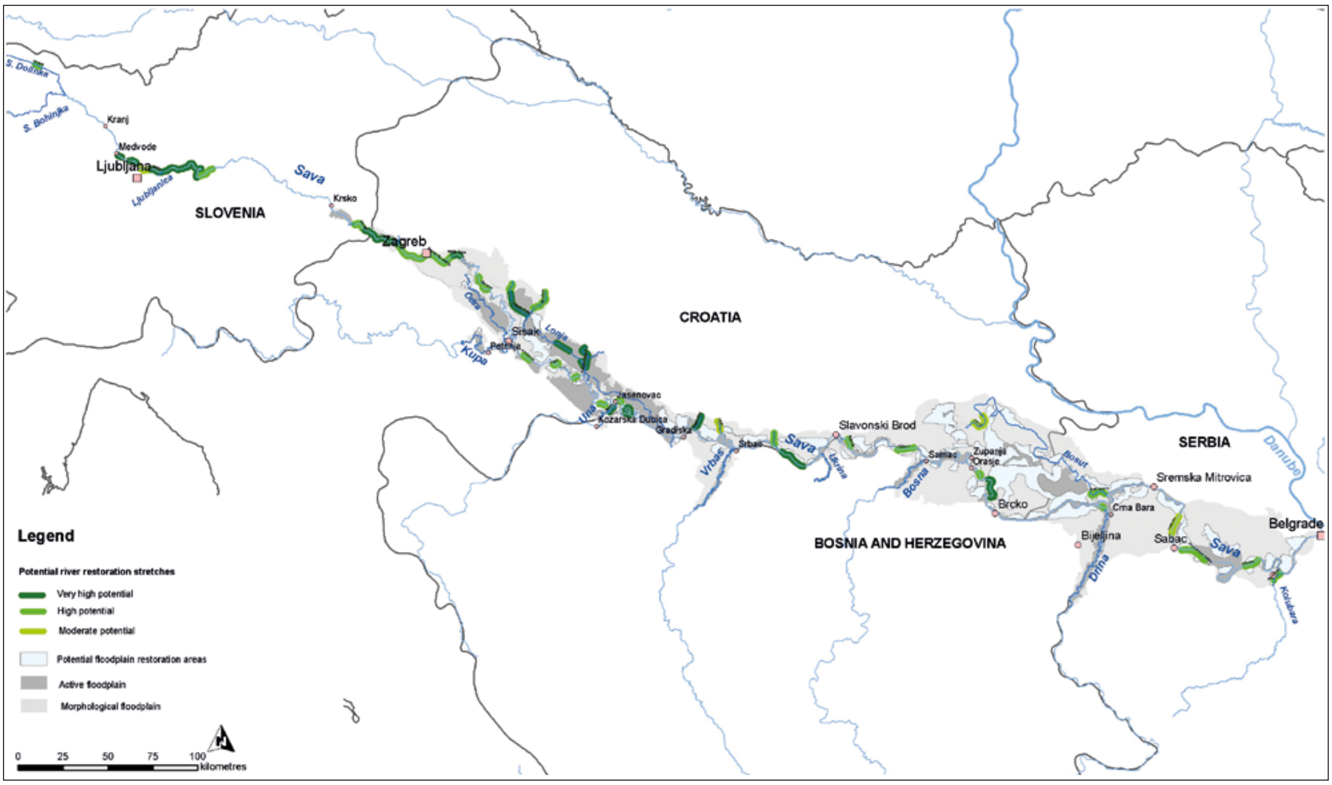

Figure 8. Potential river restoration stretches and their prioritisation. 41 river stretches with a total length of 251 km could be restored.

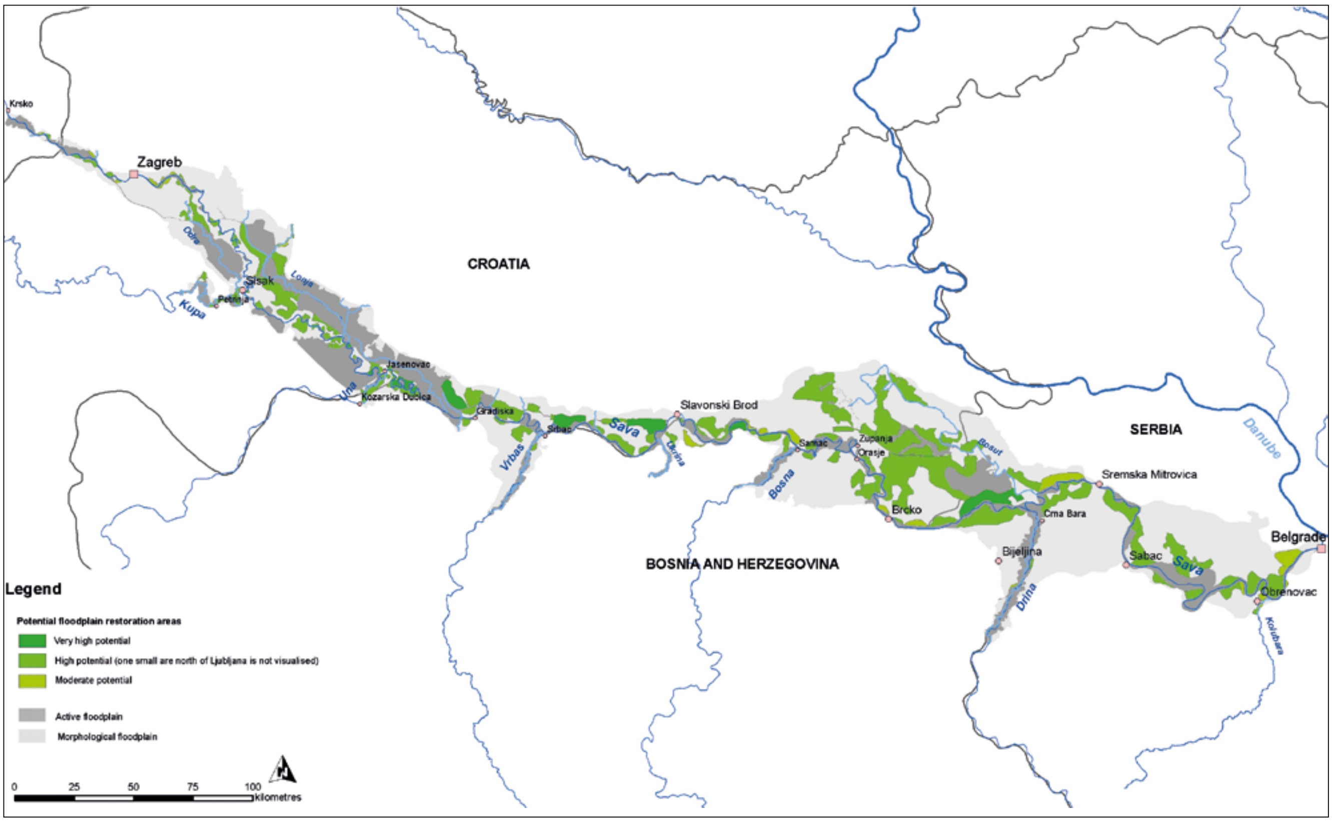

Figure 9. Potential river restoration stretches and their prioritisation. 41 river stretches with a total length of 251 km could be restored.

priority and 26 with *moderate* priority. The study also includes detailed proposals for several pilot restoration sites and areas.

References

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Wood resources in dynamic Danube floodplains – historical reconstruction and implications for management and restoration

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What do we know about the natural productivity of riparian forests prior to river regulation and about their function as a source of raw materials and renewable energy? Can we draw conclusions for today´s sustainable resource management using historical vegetation models?

An interdisciplinary research team consisting of river morphologists, vegetation/forest ecologists, and environmental historians investigated the Viennese Danube river landscape around 1825. The main research goal was to reconstruct the potential annual timber yield prior to river channelization. The riparian vegetation models and the historical research show that the natural wood productivity in the pre-channelization Danube floodplain was higher than in comparable near-natural riparian forests today. In comparison, current commercial forests with hybrid poplars yield higher amounts of wood. However, they do not meet sustainable forestry standards because of nature conservation concerns. Our study results call for the partial re-dynamization of embanked river reaches. This would also comply with the requirements of the EU Habitat Directive, EU Water Framework Directive and the EU Directive for Renewable Energy Sources.

Introduction

Forests in general and riparian forests in particular face an area of conflict – that between forestry revenue maximization and ecological, nature conservation-oriented forest management. Many of the remaining riparian forests along large European rivers were designated as protected areas according to the Flora-Fauna-Habitat Directive (NATURA 2000, 92/43/EWG). In addition, consideration must