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Capturing the effects of the Danube River incision on the potential natural vegetation of the Donau-Auen National Park

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Abstract

This study aims to investigate how the incision of the Danube has effected the potential natural vegetation (PNV) of the Donau-Auen National Park and its hydrological habitat parameters. It compares a mapping of the present PNV of a study site to a mapping from 1975. The change of flood characteristics and groundwater table is modelled in ArcGIS and R. The outcome of the study shows no habitat rejuvenation and only a minor change of PNV types. The hydrological regime, on the other hand, has changed distinctively.

Keywords

Terrestrialization, Hydrogeomorphology, Floodplain modelling, Disturbance regime

Introduction

Natural rivers are characterized by a dynamic disturbance regime. The varying water flow and sediment and woody debris load creates, in interaction with landscape and vegetation, an ever-changing mosaic of habitat patches (BEECHIE & BOLTON 1999). River-floodplain systems are hotspots of biodiversity (WARD 1998). Over the past centuries most Europe's rivers have been regulated and floodplains have been greatly reduced. The Donau-Auen National Park protects Austria's the largest remnant, located between Vienna and the Slovakian boarder. The pre-regulated state of the Danube featured a dynamic equilibrium between erosion and sedimentation. Historic maps show the Danube with braided and meandering channels, islands, gravel and sand bars and oxbow lakes (HOHNESINNER 2009). In the late 19th century the Danube was channelized. This led to the erosion of the river bed. The construction of several hydropower plants accelerated the incision rates, because sediments accumulate in the retention basins causing a deficit downstream (KLASZ et al. 2016). The floodplain is further disconnected from the river by the aggradation at the levees (KLASZ et al. 2014). This study investigates how river incision and levee aggradation have affected the inundation of the floodplain during flood events as well as the distance to groundwater during the vegetation period. It further assesses how the potential natural vegetation (PNV) has changed over the past 40 years. The outcome of this study was presented at the 6th Symposium for Protected Areas in the session theme 'Protected forest areas – lessons learned from long-term research'.

Methods

The study was conducted on an area of about 1 km², located between river-km 1899 and river-km 1898, on the left river bank of the Donau-Auen National Park (Fig.1). Polygons were identified based on homogeneity of topography, soil and vegetation during field assessments in 2015 and assigned to a PNV type. The polygons were mapped on an aerial photo and digitized in ArcGIS. The historic map by MARGL and MÜLLER (1975) was digitized as well. Using a digital elevation model (DEM), the delineation of the polygons was modified. The change of PNV types from 1975 to 2015 was calculated based on aerial balances. A floodplain age map was created based on historic maps. Landscape units were identified on the maps, digitized and intersected. The change of hydrological conditions in the floodplain was modelled based on river incision, floodplain aggradation and historic water levels of the Danube at the local gauging stations. The levee of the study site was modified with the site-specific aggradation rate of 7.5 mm/a by KLASZ et a. (2014).

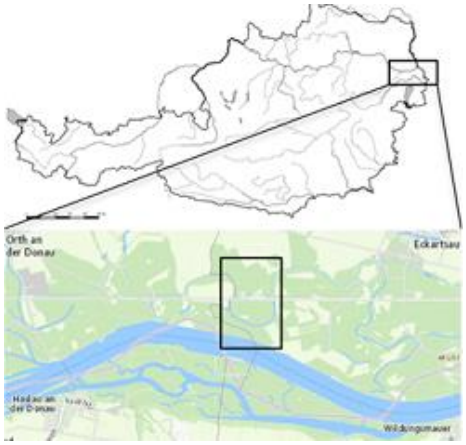

Figure 1: Study site (Geoland; modified)

The mean groundwater table for historic years was modelled based on a linear regression equation found between mean water level of the Danube in Hainburg and the groundwater level at the local gauging station Eckartsau, Bl 1897.3. (data source: via donau). The distance to groundwater was calculated for several historic years by subtracting the elevation of the groundwater table from the terrain elevation of the time-specific modified DEM. Annual incision rates were calculated from historic regulation low flow levels of Orth a.d. Donau. The water column of flood events of different annuity was modified for historic years by using the incision rates. The water column was projected onto the modified DEMs. Areas, which had a lower elevation than the water column but were isolated from the river by surrounding higher elevated areas, were redefined as non-flooded.

Results

The field assessment of the PNV identified the same PNV types as previously mapped by MARGL and MÜLLER (1975), except for one landscape unit located at a former point bar of the isolated meander bend. While the unit was mapped as the PNV type 'Black poplar woodland' 40 years ago, it has now progressed to the next stage of succession 'Dry poplar woodland'. The study site features predominately late stages of succession characterized by *Quercus robur* and *Fraxinus excelsior*. Earlier stages are found at the river bank ('Fresh willow woodland'), at the area between the Danube and a flood runner in the western proximate floodplain ('Fresh poplar woodland and Wet poplar woodland') and in depressions ('Reed and Wet willow woodland') (Fig.2). Historic maps of the Danube document the landscape dynamics over time. Whereas especially the right river bank is characterized by geomorphic dynamics such as channel migration and island formation, the study site has remained relatively stable. Most of its landscape is at least over 240 years old. Small areas, located on a former side arm and in the migration corridor of a meandering side arm are 142 – 240 years old (Fig.3). The hydrology of the study site shows distinct changes. The groundwater table lowered by about 40 cm in a 30-year period from 1970 to 2010. Modelled flood inundation maps show a reduction of flooded area and depth of inundation at the study site. In 1970 the 2-year flood inundates 67.12% of the floodplain, whereas only 12.89 % are inundated in 2010. The area inundated by water column of over 2 m also decreases from 19.04 % in 1970 to 9.02 % in 2010 (Fig. 4).

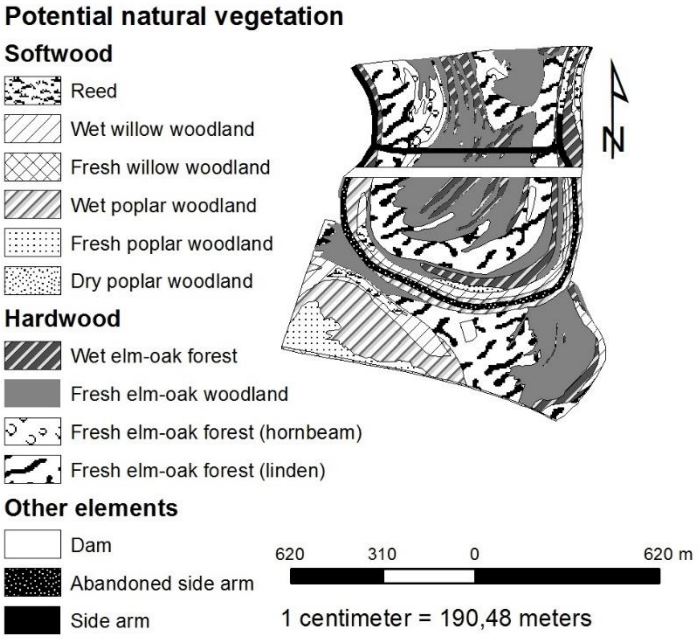

Figure 2: PNV map 2015

Discussion

Over the past 40 years no habitat rejuvenation has been initiated at the study site. In floodplains rejuvenation is driven by flood events, which act as mechanical disturbances and stress, as the impact the metabolism during the period of the flood inundation (EGGER et al. 2009). The modelled flood maps illustrate how the lowering of the Danube and the sedimentation at the levee mitigate the effect of flood events in the floodplain. Over the years the area of inundation as well as the depth of inundation strongly declined. This not only affects the habitat turnover but also decreases the transport of nutrients across the floodplain (JUNK et al. 1989). Groundwater level fluctuated with the water level of the Danube. Thus, distances to groundwater increase while river incision. Lotic water bodies and their species assemblages are especially sensitive to the river incision as they are less frequently recharged by flood water and the rising groundwater table (BAUMGARTNER 2014). Most of the floodplain forest of the study site is in a late successional stage. There is a lack of pioneer habitats, which feature particularly high biodiversity (EGGER et al. 2009). The floodplain age map shows that the study site has been comparatively stable even before the regulation of the Danube. Most of the floodplain is over 240 years old. Succession in established elm-oak forests is a slow process, compared to the quick progression of successional phases in the early willow and poplar stages (EGGER et al. 2009). The stable and old floodplain areas on the left river banks are characterized by thick layers of silty soil, with high nutrient and water holding capacities (MARGL 1973). This soil properties might buffer the effect of the hydrological changes on the floodplain vegetation.

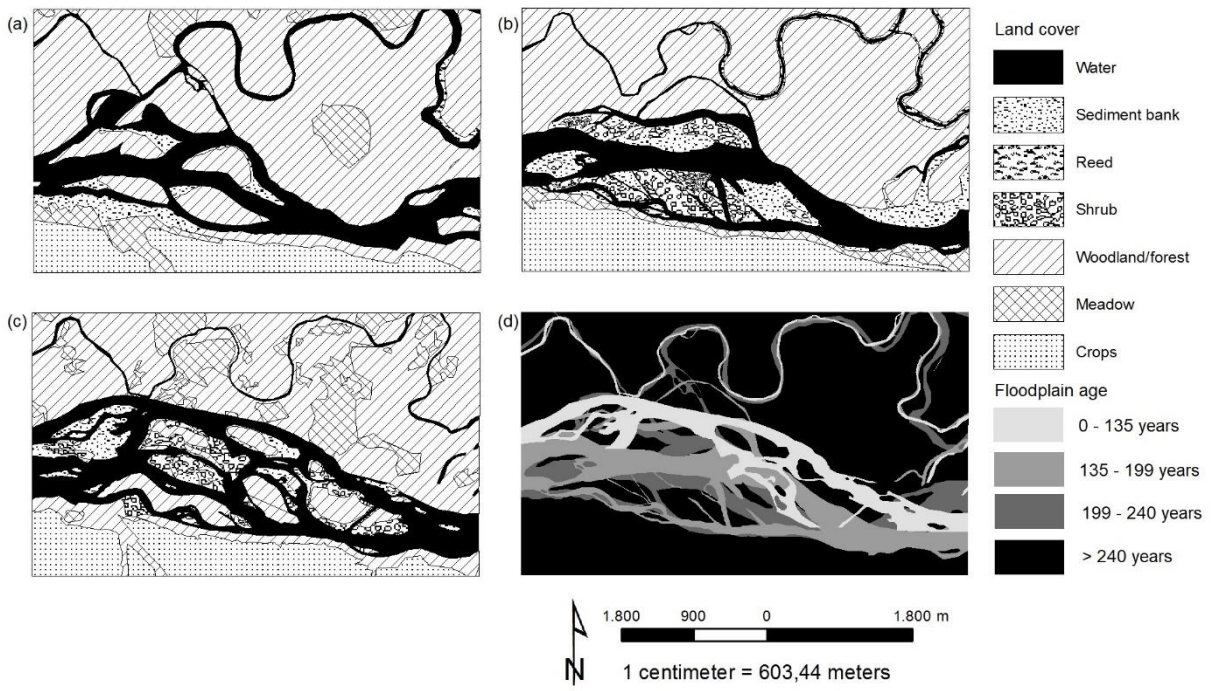

Figure 3: Historic maps of the study site (a) 1778, (b) 1816, (c) 1873, (d) floodplain age

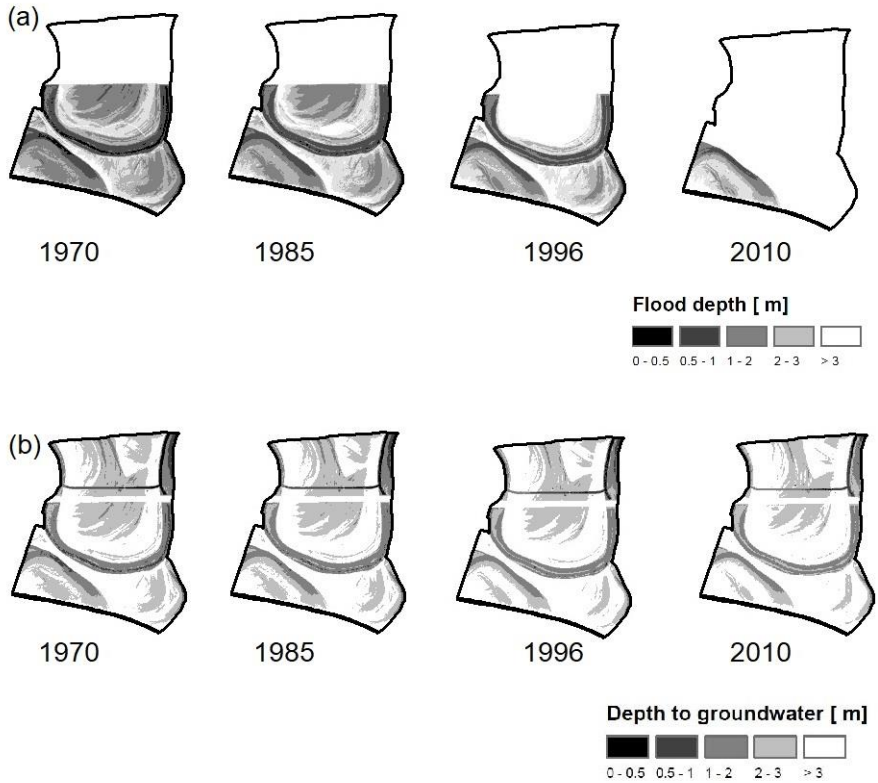

Figure 4: Modelled maps (a) 2-year flood, (b) groundwater

Conclusion

River incision accelerates the trajectory towards terrestrialization in the floodplain of the Donau-Auen National Park. Pioneer vegetation and lotic water bodies are particularly threatened by this development.

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