# Impact of hydrological connectivity on primary production patterns of large river floodplains

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## Introduction

Floodplains connected to the main stem of the river are important areas for the biogeochemical cycling in fluvial landscapes (Robertson *et al.* 1999; Van der Lee *et al.* 2004). The hydrological retention in such areas is associated with lower flow rates and increased transparency of the water column (Newbold *et al.* 1989) and, combined with high nutrient contents, exhibits higher rates of carbon processing compared to the main channel (Tockner *et al.* 1999; Hein *et al.* 2004). The distribution of pelagic algae, periphyton and macrophytes, the availability of resources and therefore the potential productivity in floodplain waters are determined by the frequency and intensity of surface water connectivity. Variable future management alternatives within the broad hydrological range from disconnected backwaters to a fully integrated side-arm system are discussed for the Danube floodplain Lobau near Vienna (Austria).

Main focus of the study is to depict the relevance of hydrological connectivity to the spatial and temporal distribution of aquatic primary producers in the Lobau. Therefore, basic information on habitat structure, surface and groundwater dynamics, and estimates of nutrient and light availability will be combined and related to the present distribution of aquatic primary producers. Based on the modelling of hydrology, nutrient and suspended solids contents of possible management alternatives future primary production patterns can be estimated.

## Study area

The Lobau is a large floodplain area right at the eastern border of the city of Vienna. During the regulation of the Danube in the late 19$^{th}$ century, this former dynamic floodplain was disconnected from the main channel by the construction of a flood protection dam. Lateral embankments along the main river channel severely altered the geomorphic and hydrologic dynamics and impeded the natural sequence of erosion and sedimentation (Hohensinner *et al.* 2004). During the last decades vertical erosion in the main river bed (incision), in concert with ongoing aggradation in the floodplain, have further decoupled the wetland from the river, both hydrologically and ecologically (Reckendorfer *et al.* 2005). Today, the Lobau represents a groundwater-fed and back-flooded floodplain lake system (Schiemer 1999), where sedimentation and terrestrialisation processes prevail (Kirschner *et al.* 2001). Thus, within the scope of the research project "OptimaLobau" multiple future management scenarios are discussed, based on state-of-the art ecosystem models.

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## Approach

The distribution of aquatic primary producers is determined by the morphological structure, hydrological patterns and the availability of nutrients and light. The hydrology within the floodplain depends on the connectivity with the main channel of the river and is determined by the management scheme and the main channel water levels. A 2d coupled groundwater-surface water model of the floodplain hydrology will be the basis for the calculation of the suspended solids and nutrient concentrations. The suspended matter inputs from the River Danube will be calculated via a correlation of the suspended solids load with the water level of the main channel. Sedimentation rates, which are depending on the flow velocity and the particle size of the suspended material, will be computed to estimate fine sediment distribution and turbidity within the floodplain. Light availability will be calculated via turbidity-light attenuation correlations.

The hydrological regime (and associated the disturbance frequency) is the main factor controlling the establishment of macrophytes (Biggs 1996; Riis and Biggs 2003). Because macrophyte immigration and growth rates are relatively slow, successful development of macrophytes is primarily controlled by the frequency of hydrological disturbances, which are defined as situations where significant altered conditions prevail, compared to the mean annual situation. For example a hydrological disturbance can be the change from surface disconnection to connection of the floodplain with the main channel or current velocities exceeding 0.8 m $s^{-1}$ (Riis and Biggs 2003) in an area. At hydrological stable phases current velocity can affect macrophyte production in different ways. While low current velocities within a range of 0 – 0.3 m $s^{-1}$ (Madsen *et al.* 2001; Riis and Biggs 2003) can increase photosynthetic rates of macrophytes by controlling the thickness of the diffusive boundary layer and increasing resource supply, higher flow velocities ( > 0.4 m $s^{-1}$) can result in biomass losses and reduction in abundance (Riis and Biggs 2003). In addition, production rates of macrophytes decline due to the increased turbidity and in consequence the lower light availability.

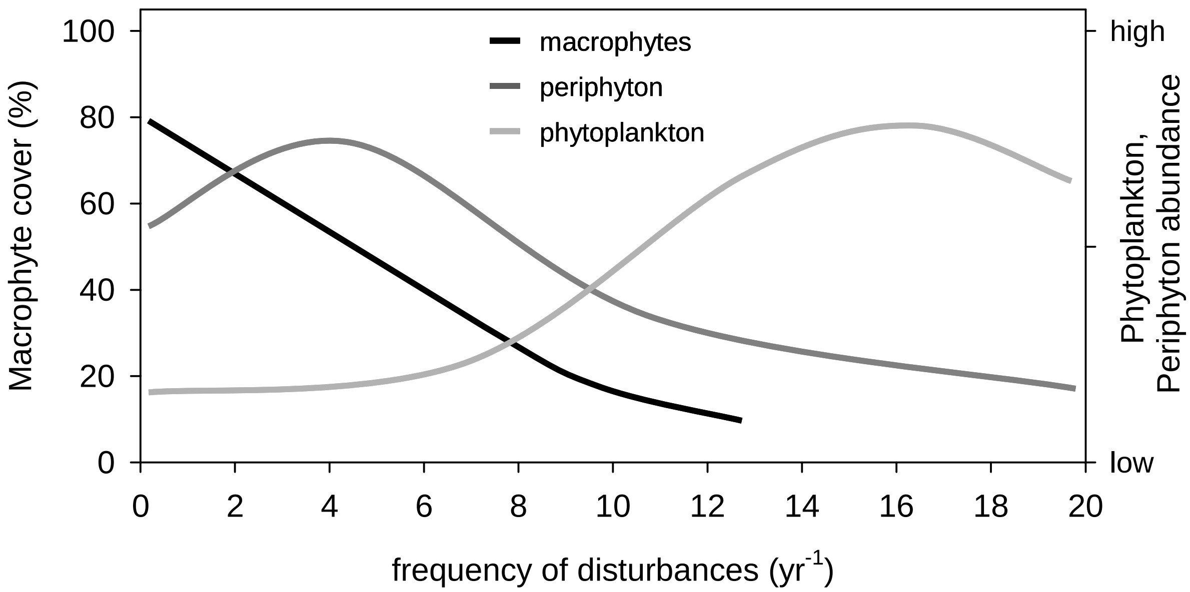


Figure 1. Relation of disturbance frequency to macrophyte cover (Riis and Biggs 2003 mod.) and periphyton and phytoplankton abundance.

A shift to a more turbid state can as well be caused by higher nutrient contents. The stimulation of phytoplankton growth leads to shading of macrophytes and a decline of macrophyte cover and biomass (Jones *et al.* 2002). Gonzales Sagrario *et al.* (2005) specified the threshold to a shift to a turbid state for mean total nitrogen in the range of 1.5 - 2 mg N $l^{-1}$ and for mean total phosphorus at 0.2 mg P $l^{-1}$ in shallow lakes.

As for macrophytes, a similar relationship between disturbance rate and biomass was found (Biggs 1995) for periphyton. Despite low biomass, periphyton was still present at higher frequency of disturbances (> 15) because of the more rapid colonization rate (Stevenson 1996) compared to macrophytes.

In the project "OptimaLobau" five hydrologically based management scenarios with different connectivity, resulting in variable patterns of water areas with different hydrological conditions, will be considered. We hypothesize that macrophytes will dominate in the most isolated segments of the floodplain and will be well abundant in areas with reduced flow velocity, for example at low connectivity levels and in shallow areas. The relative contribution of pelagic algae to the total aquatic production will be increasing with higher hydrological connectivity and after flood events. Possible management alternatives of the Lobau implicating higher nutrient inputs like, for example, increased agricultural utilization or extended residential areas can cause a change in the state of aquatic environments.

Benthic and attached algae should be abundant over a wide range of hydrological conditions and reach maximum production at lower levels of connectivity and in shallow areas.

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