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Original Research Article

Building an eco-hydrological framework for the management of large river systems☆

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ABSTRACT

1. Rehabilitating degraded riverine landscapes in order to restore their ecosystem services require a scientific approach. The tasks include the development of methods for the assessment of ecological conditions and trends, for benchmarking of management alternatives and for the definition of ecological goals.
2. The central challenge is to develop a coherent eco-hydrological research protocol analyzing the causal effects of hydrology on geomorphic processes and ecology.
3. A major aspect is the formulation of ecological targets: historical reference conditions can be used to illustrate ecological deficiencies. However, at the planning and operational levels, they have to be substituted by a set of models which predict the responses towards management measures.
4. Large scale restoration programmes should be accompanied by hypothesis-based research in order to analyze the effects of engineering measures and advance our understanding of river-floodplain ecology.
5. A focus has to be the promotion of comprehensive management concepts, taking into account all concerned parties and assuring their active involvement. It is important to take advantage of management initiatives of various stakeholders, because governmental water policies rarely promote ecological improvement as a goal in itself.
6. Institutional frameworks should be established with the mandate to develop large-scale and comprehensive rehabilitation concepts and guaranteeing transparent planning and decision processes. It is imperative that expert panels comprising of scientists, river-engineers, planners and managers are installed, with long-term mandates, clearly defined responsibilities and authority for decision making.

1. Scope

Large river restoration has become a global issue in terms of ecology, geomorphology, hydrology and socio-economics. Enhancing degraded river habitats and improving the wider river landscape are essential in order to secure sustainable aquatic ecosystems and their multiple ecosystem services. Water authorities, river managers and scientists are facing the challenge to incorporate the various stakeholder interests (ecology, conservation, navigation, hydropower, flood control, drinking & irrigation water supply) in the conception and implementation of management programmes.

My comments are based on experiences gained from my involvement in applied issues of the Austrian Danube over the past thirty years and from the simultaneous development of large river and floodplain ecology as an academic field. This involvement in applied aspects meant a phase of

☆ This opinion paper is based on 30 years experience with remediation programmes at the Austrian Danube.

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continuous learning about the functioning of river-floodplain systems, the need for interdisciplinary research as well as for transdisciplinarity in decision processes.

There has been a strong mutual stimulation between "river science" and management (Decamps et al., 2004; Ormerod, 2004; Nilsson et al., 2007). Although our understanding has advanced considerably over the last decades, there is yet a challenge to further improve an integrated scientific basis for river administration and to develop standardized operational procedures.

The following comments address:

- the multiple requirements for science in river management,
- the imperative to develop a functional – eco-hydrological – understanding of river-floodplain systems, and
- the required interdisciplinarity between ecology, hydrology and fluvial morphology to achieve this goal.

They suggests avenues:

- to defining ecological targets for restoration by substituting guiding images with a set of functional models which predict trajectories of ecological response towards management,
- to defining hypothesis-based research programmes for analyzing the effects of engineering measures,
- to approaching transdisciplinarity in planning and decision making, and
- to improving legislative tools in order to achieve these goals.

2. The multiple requirements for science in river management

A scientific approach is significant in several phases of management. The tasks include the formulation and calibration of tools for the assessment of the status quo and the analysis of trends, the formulation of ecological goals, the benchmarking of optional scenarios and the assessment and prediction of effects (Stanford et al., 1996; Vaughan et al., 2009; Arthington et al., 2010).

Our involvement and learning process began in 1983 and 1984 with the discussion on the possible effects of a projected hydropower dam in the large alluvial floodplains of the Austrian Danube at Hainburg downstream of Vienna. Based on the restricted knowledge on the significance of hydrological connectivity and dynamic geomorphological processes and their ecological consequences (Amoros et al., 1987; Naiman et al., 1988; Junk et al., 1989; Gregory et al., 1991) available at that time, scientists expressed warnings about the negative environmental consequences of the dam on the river- floodplain ecosystem. In a concerted action we criticized the plan. This action and the critical reports in the media, led to a strong public intervention which stopped the execution of the project in December 1984.

In order to discuss alternative options for the future management of this section of the Danube an "Ecology Commission" was installed by the Austrian government.

This commission, which initiated a well-structured discussion process over several years, was a turning point in river administration and led to a growing mutual understanding between the involved authorities, stakeholders, engineers, hydrologists and ecologists. In the course of this discussion the indispensable necessity for an interdisciplinary scientific approach for large river management became apparent.

It became clear that the existing knowledge on the ecology of river-floodplain systems was insufficient and more research was required. It also made decision makers aware that scientists had to be included in the future planning of management programmes.

The Danube, like all the other major river systems in Europe, has been strongly changed by regulation schemes starting in the second half of the 19th century. The fluvial processes of the braided river course were drastically reduced by channelization, causing serious ecological problems both in the main channel and its alluvial zones. The main concerns were the continued trends in riverbed incision, the quality of the riverine inshore zones, the declining lateral integration between river and floodplain and its increasing aggradation. An assessment of the historical landscape development and the status of bioindicator groups, especially rheophilic fish guilds (Schiemer and Waidbacher, 1992), indicated the ecological deficiencies of the present day situation. The assessment, however, also made clear that – although strongly impacted – there was still a high potential for remediation in the form of re-establishing the ecological integrity between the river and the remaining floodplain areas (Schiemer et al., 1999).

Based on the recommendation of the "Ecology Commission", the political decision was reached after a process of negotiations over more than 10 years to conserve the Danubian floodplains between Vienna and the Slovakian border, by creating an "Alluvial Zone National Park" in 1996. This decision underlined the ecological and socio-economic importance of the area and hence led to a continued public interest regarding the protection of this river section. The National Park administration and the "Waterway Authority" took responsibility of improving the ecological conditions. A large-scale pilot project was planned for one of the floodplain segments of the National Park with the central goal of enhancing the integration with the river.

Scientists played a significant role in the promotion of the project and were responsible for the formulation of environmental targets, the benchmarking of technical measures and the planning and execution of a comprehensive pre- and post-monitoring programme. For lack of a detailed understanding of the floodplain systems response to enhanced connectivity with the river, the historical, pre-industrial riverine landscape functioned as a guiding image. The decisions on the quantitative extent of side-arm reconnections and the allowed lateral flow regime were largely a matter of "let's try and see".

However, significant achievements were the initiation of a of science-guided long-term pre- and post- assessment programme (e.g. Hein et al., 1999; Schiemer et al., 1999; Tockner et al., 1999) and the general acceptance of the role of scientists in the planning process.

This first large-scale programme with an exclusively ecological orientation was – despite many shortcomings – a