Hydrobiologia (2013) 712:1–4
DOI 10.1007/s10750-013-1507-8

FORM AND FUNCTION

Preface: physical template and river ecosystem functioning: interdisciplinary feedbacks for improving rivers

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Published online: 10 April 2013

This special issue in *Hydrobiologia* comprises papers that were presented in 2011 during an oral and a poster session at the 7th Symposium for European Freshwater Sciences (SEFS) in Girona, Spain, entitled 'Form and function: channel morphology, hydraulic integrity and river ecosystem functioning', as well as selected articles on recent aspects of the subject. The aim of this session was to promote communication between hydrologists, geomorphologists and ecologists to improve the understanding of river forms and processes and associated ecosystems on the one hand, and to provide knowledge on river restoration as well as on benefiting ecosystem services on the other.

Guest editors: A. Elosegi, M. Mutz & H. Piégay / Form and function: channel form, hydraulic integrity, and river ecosystem functioning

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River ecosystems depend on the dynamic interplay between flow and channel morphology, which together set the physical template for fluvial communities, and ultimately for ecosystem functioning (Elosegi et al., 2010). There is still a need for research on the significance of hydromorphology on riverine communities, notably in terms of responses to restoration actions (Palmer et al., 2010). Further, research is needed on the effect of channel morphology and hydraulics on ecosystem functions, such as the transformation of organic matter or the maintenance of water quality, which are the basis for ecosystem services and of key importance for the human society (Palmer & Febria, 2012). Most river ecosystem functions are actually provided by coupled processes, which relate to river form on a wide range of temporal and spatial scales (Malard et al., 2002). Hence, focusing on ecosystem functions opens the perspective of hydromorphological integrity from a set of standard variables that are commonly assessed in river restoration and monitoring to a complex set of interacting multiple environmental drivers on these ranges of scales. River scientists are today equipped with a large toolkit of techniques, ideas and approaches to link hydromorphology with river functioning and ecosystem services, which should be regarded in assessment, management and restoration of riverine ecosystems. Rivers change over time, owing to a set of human drivers (e.g., embankment, damming, landuse change, discharge regulation…) (Kondolf & Piégay, 2003; Brierley & Fryirs, 2005), such that their biological communities and associated functions constantly evolve. As a consequence, rivers follow a complex temporal trajectory, adjusting their geometry to human pressures acting locally and upstream at different temporal scales (Dufour & Piégay, 2009). The main aim is, therefore, to understand such complex trajectories from physics to biology and identifying the best management solutions with the aim of maximising human benefits. The questions that are to be solved are of interdisciplinary nature and do not only concern the field of natural sciences. Ultimately, concepts such as river health and river integrity are not purely scientific, but also involve the relationships we humans want to maintain with the environment, what is usually called environmental ethics. Therefore, our value systems, driven by cultural and historical issues, are of no minor importance when managing and restoring river ecosystems (Gobster & Hull, 2000; Le Lay et al., 2012).

The nine papers collected in this special issue provide a first step to open this interdisciplinary debate, illustrating the wide range of what 'river form' actually means for hydrology, hydraulics, fluvial morphology and biology. The papers provide information on how to characterise river forms and associated biological assemblages and properties. The authors indicate, or directly demonstrate, how an impacted river form can affect river functions. Different spatial and temporal scales are considered, from the perspective of process-based local features up to regional perspectives and from instantaneous events to decades, combining past and future in a trajectory perspective. The selected case-studies focus on the characterisation of river forms as well as on the understanding of the underlying mechanisms and cover a large range of issues. It is precisely this diversity of approaches that shows the scientific and practical interest in the integration of hydromorphology and biology.

In addition to the pervasive effects of change in climate and sediment supply, many streams and rivers are affected by large dams, which in turn impact the geomorphic functioning of river channels, and hence result in modified river habitats. Ibisate et al. (2013) report the long-term hydromorphological changes induced by a reservoir as well as by a chain of small hydropower plants at the middle and lower reaches of the Aragón River in Spain. Channel migration and the width of the active channel were found to be reduced, and in the short-circuited reaches the river bed incised. Ibisate et al. (2013) conclude that these physical changes could in turn have important effects for river communities and ecosystem functioning.

Belletti et al. (2012) analyse the braiding pattern of multiple reaches in the Rhône basin and measure several variables describing the physical characters of channel habitats. They found that discharge appears to be less relevant than sediment supply or groundwater level in structuring the braided geometry and the channel habitat pattern in natural braided rivers at a regional scale. The implications for ecosystem functioning are potentially large, as channel form drives river communities and their role in the ecosystem.

Based on extensive hydraulic and geomorphic data collected in alpine rivers, Gostner et al. (2012) present a new hydromorphological index based on the coefficient of variation of the flow velocity and the water depth. It can be linked to standard modelling and is especially designed to enable the prediction and comparison of different alternatives in river engineering projects to support decision making processes towards an enhancement of habitat heterogeneity. This sort of tools are important to effectively integrate channel form in river management.

Arismendi et al. (2012) analyse changes in hydrology resulting from climate change. They report on a shift in the timing of low flow and summer high temperatures in North American streams, both important biological stressors. The authors argue that increased climatic variability results in a shorter lag between the two stressors, and thus potentially reduce the time needed for the recovery from successive environmental stress. This type of hydrological impact affects already a large number of natural streams on regional scale and it will become of increasing importance in the future.

The significance of hydromorphological factors for stream organisms is confirmed by Wyżga et al. (2012), showing that the Biological Monitoring Working Party score system, when used in a gravel bed river in Poland, responds more to the channel characteristics (either channelized or not) than to water quality. These results have important implications for projects attempting to restore channel morphology.

In this same context, Jähnig et al. (2012) compare habitat diversity and morphodynamics in actively and passively restored reaches with non-restored control reaches in mountain streams. They found an increase in habitat richness, diversity and habitat dynamics within the restored reaches. The analysis of discharge data support that floods that exceed the critical shear stress of the bed material and the time span since restoration, determine the potential for morphological changes.

An example of how flow diversion at small hydropower plants affects nutrient retention is given by the research undertaken by Izagirre et al. (2012). The authors measured nutrient retention at the stream channels and compared it to the diversion canals. The strong morphological contrast between different types of reaches did not result in consistent differences in transient storage and nutrient uptake efficiency. Uptake rates for phosphate remained similar, whereas ammonium retention was found to be even higher in the diversion canals. The authors conclude that effects of hydropower plants on nutrient retention depend on the proportion of flow diverted, and hence on operational decisions.

Dealing with the impacts of river regulation as well, González et al. (2012) show several effects from river regulation on ecosystem functioning, and more specifically on the degradation of organic matter, a pivotal function of headwater streams (Gessner & Chauvet, 2002). They report reduced leaf litter breakdown rates downstream of small dams, even if the dams did affect neither the water temperature nor nutrient concentrations. The authors explain lower breakdown rates by differences in the community structure, in particular by the absence of shredding limnephilid caddisflies below the dams. This type of impact, which is mediated by groups of organisms and their respective differences in tolerance towards a modified hydrology, is expected to be common in many rivers of the world.

Elosegi & Sabater (2012) review the literature linking river regulation and channel modification with ecosystem functioning. They show some functional variables to respond in very consistent and thus, predictable ways, other functions of the ecosystem to be more context dependent, and that there is still little information available on some important functional attributes of river ecosystems. The published information shows that even light modifications of hydrology and channel form can have severe effects, and that effects are very specific to different functional variables. More importantly for managers, the authors propose a set of criteria for the selection of relevant functional variables to evaluate the ecological impacts of hydromorphological modifications.

The range of the research papers in this special issue reflects the interdisciplinary nature of the theme among hydrology, hydraulics, fluvial morphology and biology. We hope that the special issue can stimulate further work in the complex interplay of form and function across disciplines. We wish to thank all the authors for contributing their research, as well as to *Hydrobiologia* for giving us the opportunity to arrange this special issue. The help of many reviewers largely enhanced the quality of the papers.

References

Arismendi, I., M. Safeeq, S. L. Johnson, J. B. Dunham & R. Haggerty, 2012. Increasing synchrony of high temperature and low flow in western North American streams: double trouble for coldwater biota?. Hydrobiologia. doi:10.1007/s10750-012-1327-2.

Belletti, B., S. Dufour & H. Piégay, 2012. Regional variability of aquatic pattern in braided reaches (example of the French Rhône basin). Hydrobiologia. doi:10.1007/s10750-012-1279-6.

Brierley, G. J. & K. A. Fryirs, 2005. Geomorphology and River Management: Applications of the River Styles Framework. Wiley-Blackwell, Chichester.

Dufour, S. & H. Piégay, 2009. From the myth of a lost paradise to targeted river restoration: forget natural references and focus on human benefits. River Research and Applications 25(5): 568–581.

Elosegi, A. & S. Sabater, 2012. Effects of hydromorphological impacts on river ecosystem functioning: a review and suggestions for assessing ecological impacts. Hydrobiologia. doi:10.1007/s10750-012-1226-6.

Elosegi, A., J. Dìez & M. Mutz, 2010. Effects of hydromorphological integrity on biodiversity and functioning of river ecosystems. Hydrobiologia 657: 199–215.

Gessner, M. O. & E. Chauvet, 2002. A case for using litter breakdown to assess functional stream integrity. Ecological Applications 12: 498–510.

Gobster, P. H. & R. B. Hull (eds), 2000. Restoring Nature. Perspectives from the Social Sciences and Humanities. Island press, Washington, DC.

González, J. M., S. Mollá, N. Roblas, E. Descals, O. Moya & C. Casado, 2012. Small dams decrease leaf litter breakdown rates in Mediterranean mountain streams. Hydrobiologia. doi:10.1007/s10750-012-1144-7.

Gostner, W., M. Alp, A. J. Schleiss & C. T. Robinson, 2012. The hydro-morphological index of diversity: a tool for describing habitat heterogeneity in river engineering projects. Hydrobiologia. doi: 10.1007/s10750-012-1288-5.

Ibisate, A., E. Díaz, A. Ollero, V. Acín & D. Granado, 2013. Channel response to multiple damming in a meandering river, middle and lower Aragón River (Spain). Hydrobiologia. doi: 10.1007/s10750-013-1490-0.

Izagirre, O., A. Argerich, E. Martí & A. Elosegi, 2012. Nutrient uptake in a stream affected by hydropower plants:

comparison between stream channels and diversion canals. Hydrobiologia. doi:10.1007/s10750-012-1354-z.

Jähnig, S. C., A. W. Lorenz, R. R. C. Lorenz & J. Kail, 2012. A comparison of habitat diversity and interannual habitat dynamics in actively and passively restored mountain rivers of Germany. Hydrobiologia. doi:10.1007/s10750-012-1264-0.

Kondolf, M. G. & H. Piégay (eds), 2003. Tools in fluvial geomorphology. Wiley-Blackwell, Chichester.

Le Lay, Y.-F., M. Cottet, H. Piégay & A. Rivière-Honegger, 2012. Ground Imagery and Environmental Perception: Using Photo-questionnaires to Evaluate River Management Strategies. In Carbonneau, P. & H. Piégay (eds), Fluvial Remote Sensing for Science and Management. Wiley, New York: 405–430.

Malard, F., K. Tockner, M.-J. Dole-Olivier & J. V. Ward, 2002. A landscape perspective of surface-subsurface hydrological exchanges in river corridors. Freshwater Biology 47: 621–640.

Palmer, M. A. & C. Febria, 2012. The heartbeat of ecosystems. Science 336: 1393–1394.

Palmer, M. A., H. L. Menninger & E. Bernhardt, 2010. River restoration, habitat heterogeneity and biodiversity: a failure of theory or practice? Freshwater Biology 55: 205–222.

Wyżga, B., P. Oglęcki, H. Hajdukiewicz, J. Zawiejska, A. Radecki-Pawlik, T. Skalski & P. Mikuś, 2012. Interpretation of the invertebrate-based BMWP-PL index in a gravel-bed river: insight from the Polish Carpathians. Hydrobiologia. doi:10.1007/s10750-012-1280-0.