Beavers and their influence on the structure and function of river systems (hydrology, geomorphology, water quality, ecosystems)

Annegret Larsen (1,2), Joshua R. Larsen (3), Thibault Lambert (2), Alexandre Luiset (2), Christopher Robinson (4,5), Andre Siebers (4), Pascal Schweizer (4,5), and Stuart Lane (2)

(1) Department of Geography, University of Manchester, Oxford Road Manchester, UK-M13 9PL (annegret.larsen@unil.ch), (2) Universite de Lausanne, Universite de Lausanne, Geopolis-Mouline, Lausanne, Switzerland, (3) School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, UK-B15 2TT, (4) Department of Aquatic Ecology, Eawag, 8600 Duebendorf, Switzerland, (5) Institute of Integrative Biology, ETH-Zürich, 8092 Zürich, Switzerland

Beaver (Castor fiber, Castor canadensis) are mammalian ecosystem engineers, modifying rivers and floodplains, and influencing local hydrology, geomorphology, carbon and nutrient cycling, and ecology. They construct dams, dig canals and burrows, fell trees and introduce wood into streams, which in turn impounds water and raises shallow water tables, altering the water balance, sediment transport, channel pattern, and biogeochemical cycling within aquatic-terrestrial habitats. In this cross-disciplinary study, we first synthesize beaver effects on the local hydrology, geomorphology and biogeochemistry of aquatic-terrestrial ecosystems. We then summarize results from four beaver sites in Switzerland and Germany in terms of hydrology, water biogeochemistry (nutrients, pH, dissolved oxygen, water temperature), geomorphology, dissolved/particulate organic matter concentration and composition (absorbance and fluorescence measures coupled with parallel factor analysis (PARAFAC) and RockEval-pyrolysis), macroinvertebrates (diversity, stable isotope analysis) during a complete hydrological cycle (all seasons). Results include a nitrate reduction of 17-23 % along beaver cascades, a DOC increase downstream of beaver reaches, a carbon storage increase in beaver sediments, and a spatial heterogeneity increase in macroinvertebrate food webs. Key feedbacks and overlaps among changes induced by beavers hint towards modifications in longitudinal connectivity (using drone-based remote sensing) that drive important process feedbacks. The magnitude of these feedbacks was heavily dependent on climate-landscape context as well as the ability to promote lateral connectivity determining the spatial extent of beaver effects with increasing stream order. We view these results in the context of stream management and restoration, and highlight the importance of a data-based, realistic approach towards using beavers for natural catchment management.