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An inverse technique to estimate the parameters of riparian marginal benefit functions

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Environmental flows variability has been shown to arise from the economical competition for water between traditional and non-traditional water uses (e.g., recreational activities, ecosystem services, etc.). To the purpose, the benefit function for non-traditional uses must also be known, which is currently a well-debated problem in relation to its actual existence and determination as far as the use of water in the riparian environment is concerned.

Based on the assumption that the system of all water uses (i.e. traditional and non-traditional) must work at the economical (unbounded) optimum, we formulate the competition between a run-of-the-river exploitation activity and the riparian environment in economic terms by means of marginal analysis. First, we assume a reasonable functional form (but with unknown parameters) to represent the beneficial use of water in the environment. Then, we use the principle of equal marginal utility in an inverse fashion together with suitable boundary conditions such the objective existence of minimal and maximal flows for the involved water uses and the knowledge of the benefit function for the exploitation use. This allows for an algebraic resolution of the unknown parameters for either linear or nonlinear environmental marginal benefit functions. Eventually, we show that such functions are indeed only meaningful in the specific economic context of the associated exploitation activity, which actually remains the true evaluator of the water value for both users. For all uses, we also obtain analytical expressions for the optimal water allocation rules and for the associated probability density function of the allocated flows.

We apply the resulting operational rules to both synthetic and real river hydrographs of run-of-the-river exploitation activity and show how this approach generates natural-like flow regimes in the impounded river reach in terms of timing, duration, frequency and magnitude of streamflow. Eventually, our approach can be considered as a further step to determine Environmental Flow Requirements in a quasi-objective way.