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Reconciling run-of-river hydropower with hydrological connectivity in river basins

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The international agenda and national strategies on renewable energy foster a further exploitation of river flows for hydropower production, especially by means of run-of-river technology. Planning and construction on new power plants, which often take place in pristine river catchments, raise conflicts among stakeholders and questions on the optimal allocation of a scarce resource between contrasting uses, such as energy production and the conservation of ecosystem services that might be relevant for the concerned regions. The variety of incommensurable interests at stake demands tools to guide water management choices and provide quantitative estimates of their effects.
In this work, such an analytical tool is applied to identify optimal environmental policies and design of small run-of-river power plants in streams that are important spawning sites for salmons. A stochastic description of streamflow and the concept of Paretian efficiency, which identifies options for which any improvement in one goal can only be obtained at the detriment of other objectives, are employed. A purely economic optimization of run-of-river power plants complying with current environmental regulation determines significant economic losses without effectively safeguarding hydrological connectivity and salmons' access to migration routes. On the contrary, considering the minimum flow discharge a design variable that can assume values higher than the one set by law, more economically appealing plant configurations which guarantee almost unaltered hydrologic connectivity between intake and outflow emerge. Results provide general indications on strategies to design small hydropower plants and preserve ecosystem services regulated by hydrological connectivity. The approach offers an objective basis to identify effective management and policy actions also when additional ecosystems services are considered, thus supporting the intensification of river flow exploitation for renewable energy production.