



Jun 27th, 9:00 AM - 10:20 AM

## Open models for dammed rivers: A New England case study for balancing social-ecological sustainability of riverine ecosystem services

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Roy, Sam; Uchida, Emi; Souza, Simone; Blachly, Ben; Fox, Emma; Gardner, Kevin; Gold, Arthur; Jansujwicz, Jessica; Klein, Sharon; McGreavy, Bridie; Mo, Weiwei; Smith, Sean; Vogler, Emily; Wilson, Karen; Zydlewski, Joseph; and Hart, David, "Open models for dammed rivers: A New England case study for balancing social-ecological sustainability of riverine ecosystem services" (2018). *International Congress on Environmental Modelling and Software*. 38.  
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## Open models for dammed rivers: A New England case study for balancing social-ecological sustainability of riverine ecosystem services

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**Abstract:** Dam removal is a cornerstone of environmental restoration practice in the United States. One positive outcome of dam removal is restored access to historic habitat for sea-run fish, providing a crucial gain in ecosystem resilience. But dams also provide stakeholders with valuable ecosystem services, such as municipal water storage, recreational use of lakes and rivers, property values, hydroelectricity generation, landscape nutrient and sediment flux, cultural attachments to dams, and many other river-based ecosystem services. Uncertain socio-ecological and economic outcomes can arise without carefully considering the basin scale trade-offs of dam removal.

Using a combined modeling approach at watershed scales, we quantify how different dam decisions, such as removal, infrastructural improvements, management changes, or repairs, can impact the productivity of riverine ecosystem services. We identify decision scenarios that provide efficient productivity across multiple ecosystem services using a multi-objective genetic algorithm (MOGA). Production possibility frontiers (PPF) are then used to evaluate trade-offs between ecosystem services across multiple different decision scenarios. Our results suggest that for many rivers, there is potential to dramatically increase productivity of ecosystem services that benefit from open rivers with a minimal impact on dam-related services. Further benefits are made possible for all ecosystem services by considering decision alternatives related to dam operations and physical modifications.

Our method is helpful for identifying efficient decisions, but a deep and mutual understanding of stakeholder preferences is required to find a true solution. We outline how to interpret these preferences in our framework based on participatory methods used in stakeholder workshops.

**Keywords:** ecosystem services, dams, rivers, multi-objective genetic algorithm, production possibility frontiers.