Background: Web-based Dam Decision Support Tool

The Dam Decision Support Tool is a web app collaboratively developed by researchers on the NSF-EPSCoR Future of Dams project. The Tool was developed to be used in a Participatory Multi-Criteria Decision Analysis (MCDA) Workshop. The Dam Factsheets, information on Decision Alternatives and Decision Criteria, Decision Matrices, and Multi-Criteria Decision Analysis with Multi-Objective Genetic Algorithm (MCDA-MOGA) model are components of this Tool.

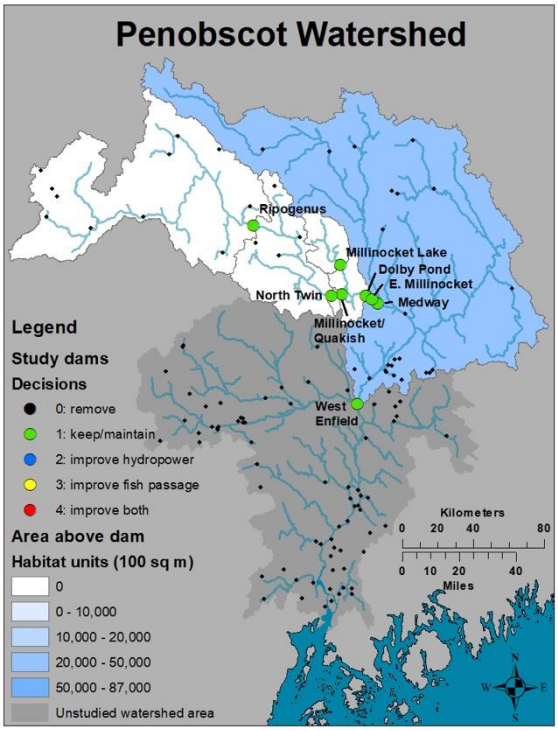

Figure 1 – Penobscot watershed dams up for relicensing within next decade

Research Goal

We created this tool to support parties interested in participating in or preparing for a Federal Energy Regulatory Commission (FERC) dam relicensing process; however, it is our hope that the tool will be useful in other contexts as well. We envision the tool supporting a group of multiple decision makers with different interests (e.g., regulators, municipal officials, dam owners, non-governmental organization representatives, etc.) considering a diverse set of goals in a participatory setting (e.g., regulatory agency working group, public meeting, internal preparatory meeting, etc.) to identify a shared set of priorities. We seek your input about how effective the Dam Decision Support Tool is in supporting decision processes, as well as how and when the Tool might be used in or to prepare for a FERC relicensing process to best support decision makers. Your participation and feedback will help us revise this Tool to better support decision makers like you in future dam decisions.

Dam Decision Support Tool Objectives

The Dam Decision Support Tool builds on the work of Roy et al. (2018)[1] and is designed to: a) capture decision maker preference information about decision criteria (e.g., cost, fish mortality, hydropower generation, etc) and alternatives (e.g., remove dam, increase hydropower capacity, etc); b) rank potential decision alternatives based solely on user-defined preferences; c) refine rankings with location-specific decision criteria data; d) support multi-dam decision scenarios; and e) visually represent the user's decision output with a map similar to Figure 1.

The Dam Decision Support Tool includes the following components, to be housed at the University of New Hampshire's Data Discovery Center after the workshop.

1) Dam Factsheets: a brief packet of information for each FERC-licensed hydropower dam project (4 documents total), including ownership history, site characteristics, and technical specifications.
2) Dam Decision Matrices, with baseline performance data for each decision alternative under every decision criterion at each dam.
3) Multi-Criteria Decision Analysis (MCDA) with Multi-Objective Genetic Algorithm (MCDA-MOGA): an interactive web-based application to support user preference ratings for of a set of decision criteria under a series of decision alternatives, pairing MCDA and MOGA. This is a hybrid MCDA model that calculates an optimum decision scenario (e.g., list of 8 dams within a watershed to be removed, kept, etc.) based on an internal set of site-specific decision criteria performance values and user-defined preference values elicited from the user.

The Dam Decision Support Tool provides a set of dam decision criteria and alternatives on which to base user preferences, the first step of an MCDA (a structured framework to help balance complex decisions). The tool asks the user to specify numeric preference values for each decision criterion at each individual dam site (8 total), where the sum of all preferences for any decision alternative must equal 1. Changes in one decision criterion preference value (e.g., increase preference for fish survival) must be compensated for by changes in another decision criterion preference value (e.g., decrease preference for hydropower generation). The MCDA-MOGA model generates an "efficient" combination of changes to a collection of dams in a given watershed, including removal of all dams and keeping and maintaining all dams (with a full spectrum of other options in between). The MOGA includes an algorithm that accounts for interaction between decision alternatives at individual dams for fish survival (i.e., fish survival at one dam depends on what happens at a dam upstream).

The MCDA-MOGA model then applies the user-defined preference values to the potential decision alternatives for each dam in the multi-dam set (which may include a few dams or all dams in a watershed) and selects outcomes that maximize a total score (sum of normalized decision criteria values multiplied by user-defined preference weights) for each decision alternative for each dam. The coordinated, multi-dam outcome is mapped to produce a figure similar to Figure 1, which shows which dams from the original set remain in the watershed after the simulated decision. The results of the tool include: (a) a graph of 'raw' user preference information for each dam; (b) a graph of decision alternatives for an individual dam broken down by decision criteria, based on user-defined preferences; (c) a graph of decision criteria for multiple dams, broken down by the top-ranked decision alternative; (d) a graph of the decision alternative rankings for all dams; (e) graphs of the final MCDA ranking for all dams with a map of the top-ranked multi-dam recommendation; (f) CSV downloads of the results.

We have compiled and defined a set of decision alternatives and decision criteria identified through interviews with decision makers and relevant to the set of 8 dams (4 hydropower projects) coming up for relicensing on the Penobscot River watershed. The

Dam Decision Matrices include site-specific data about the performance of each decision criterion under each decision alternative to help the user make choices in the Dam Decision Support Tool. We are interested in exploring the benefits and drawbacks of single-dam decision making versus coordinated, multi-dam decision making, given the potential advantages with the latter in terms of efficiency and ecological restoration opportunities. This Dam Decision Support Tool and the workshop focus on the West Enfield[2], Medway[3], Millinocket[4], East Millinocket[4], North Twin[4], Dolby[4], Millinocket Lake[4], and Ripogenus[5] dams, which are all coming up for relicensing in the next 10 years. However, these tools can be modified to consider the entire Penobscot River Watershed and dams in other watersheds (subject to data availability)[1]. The decision-making activity and supporting tools are intended to be site-specific and data-driven for realism.

References

[1]Roy, S.G., Uchida, E., de Souza, S.P., Blachly, B., Fox, E., Gardner, K., Gold, A.J., Jansujwicz, J., Klein, S., McGreavy, B., Mo, W., Smith, S.M.C., Vogler, E., Wilson, K., Zydlewski, J., & Hart, D. (2018). A multiscale approach to balance trade-offs among dam infrastructure, river restoration, and cost. *Proceedings of the National Academy of Sciences*, 201807437. doi:10.1073/pnas.1807437115.

[2]West Enfield Dam (FERC No. 2600) license

[3]Medway Dam (FERC No. 2666) license

[4]Penobscot Mills Project (FERC No. 2458) license

[5]Ripogenus Dam (FERC No. 2572) license