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Rule Curve Deviation Associated with Multifunctionality in USACE Dams

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Rule Curve Deviation Associated with Multifunctionality in USACE Dams

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Research Question

Rules vs. Discretion in the environmental management context: How does additional variety in dam purposes influence operational target attainment of federally managed dams?

Motivation

- Dam managers face complex tradeoffs when storing versus spilling water (Figure 1).
- Rule curves are developed to pre-commit them to providing services that are important to stakeholders including flood control, hydropower, and recreation.
- Most U.S. Army Corp of Engineer (USACE) dams have more than one officially designated purpose. The maximum number is 9 and mean number is 4.
- River system complexity means that rule curves are inherently incomplete contracts, which introduce discretion due to unforeseen states-of-the-world. Should dam managers adhere to rule curves no matter what? Or, should they more freely adapt to unexpected events and new knowledge albeit increasing uncertainty for stakeholders.
- Our motivation is to reveal under which conditions dam managers are more likely to use discretion versus less.

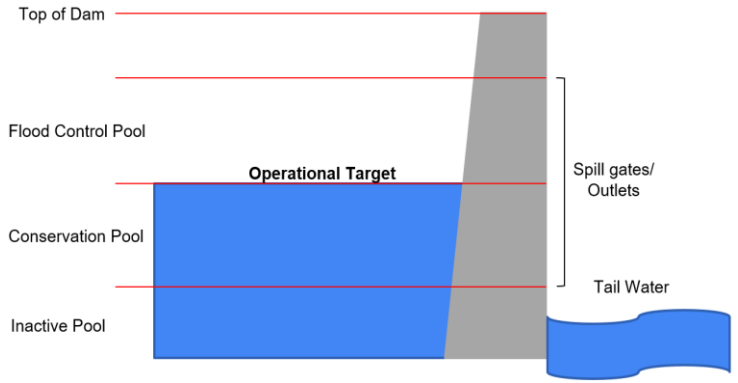


Figure 1. Schematic of dam structure and function.

Data

- 261 dams of 538 total USACE dams with incomplete data
- 1973 Average start of time series
- Source: https://nicholasinstitute.duke.edu/reservoir-data/

Types of targets

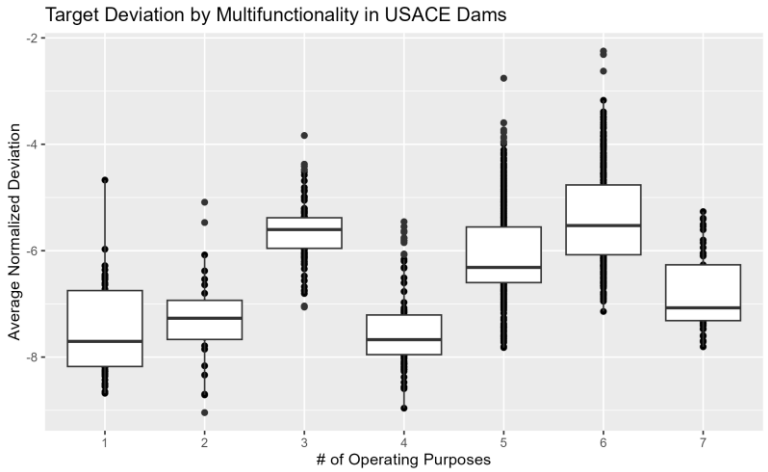
- Uniform – same every day of the year.
- Variable – variable over calendar day, but the same from one year to the next.
- Dynamic – functional relationship based on current and forecasted conditions.

Variables

- OT - Operational Target
- E - Elevation
- N - # of Operating Purposes

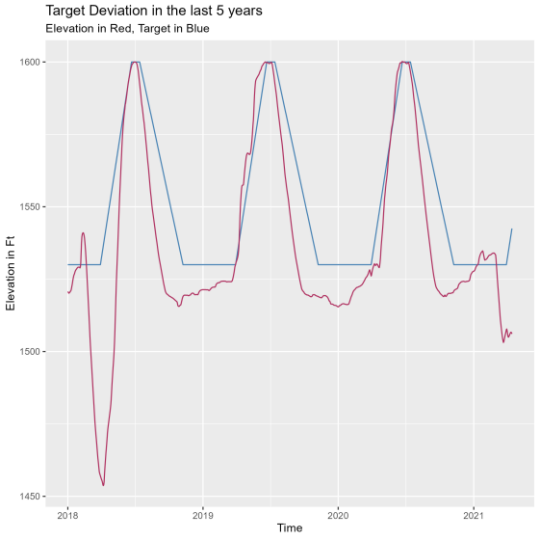
Base Regression

Log(Abs((E-OT)/OT)) = ß1*(N)



Results/Methodology

We aggregate daily data on deviations over all days by dam and control for seasonality, geography, management, and specific purposes. We find a positive relationship between deviation from targets and the number of operating purposes. Operating purposes are closely tied to USACE management branches, for example endangered fish migrate throughout basins, navigable waterways are oriented through connected lock systems, and flood control schemes coordinate storage to prevent catastrophes. Our next step is to incorporate forecast and inflow data to comprehensively understand management decisions under different scenarios.



Example of target and outcomes for Dworshak Dam in Idaho. Peak targets are almost always met but target deviations are large and variable for minimum pool height. This dam provides recreation and cooling of rivers for fish migration.