Evaluating Tradeoffs in Environmental Flows Using Optimization

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https://watershed.ucdavis.edu/eflows-optimization ← Learn More

https://github.com/ceff-tech/belleflopt ← Check out the code

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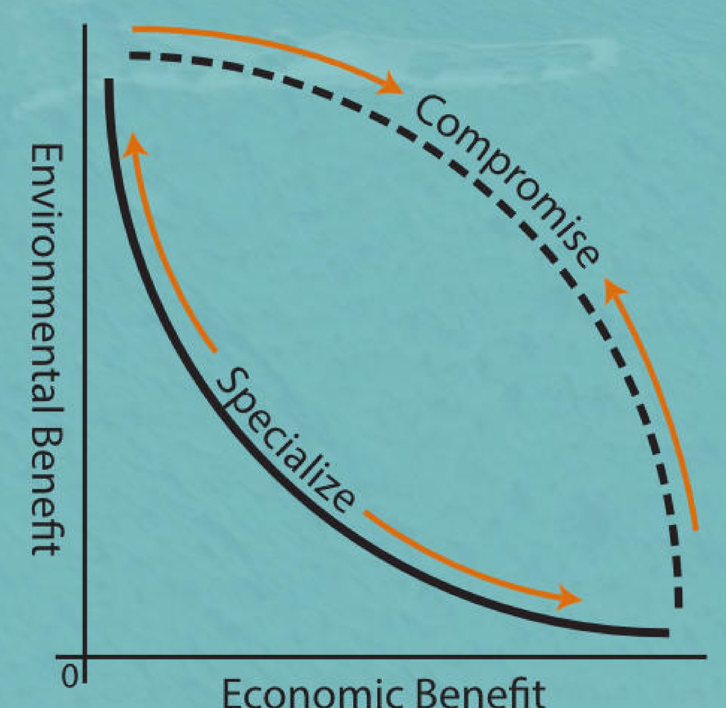
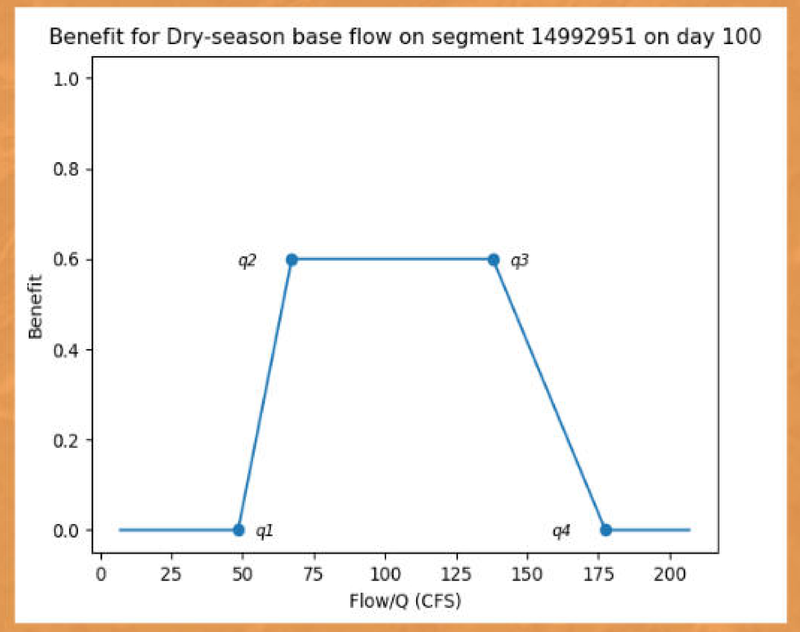
Competing Uses for Water

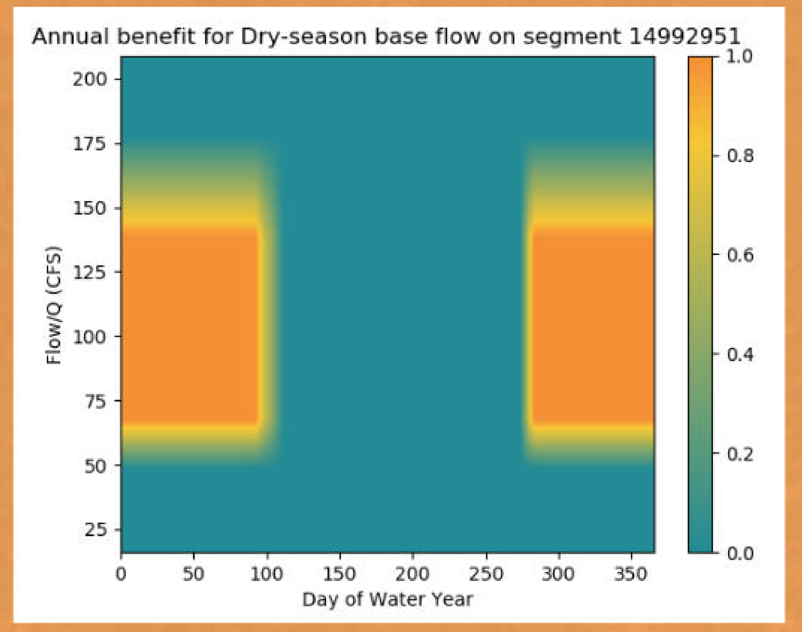


In California, where water is overallocated, water withdrawals represent a decision to prioritize one use over another at a place and time. Aquatic ecosystems are in heavy decline, in large part because of human alteration. The California Environmental Flows Framework (CEFF) is a new tool for managers to decide on instream flows to support aquatic ecosystems. As part of this large effort, we see an opportunity for an optimization approach that builds tradeoff curves (left) to provide additional information on strategies and consequences of decisions.

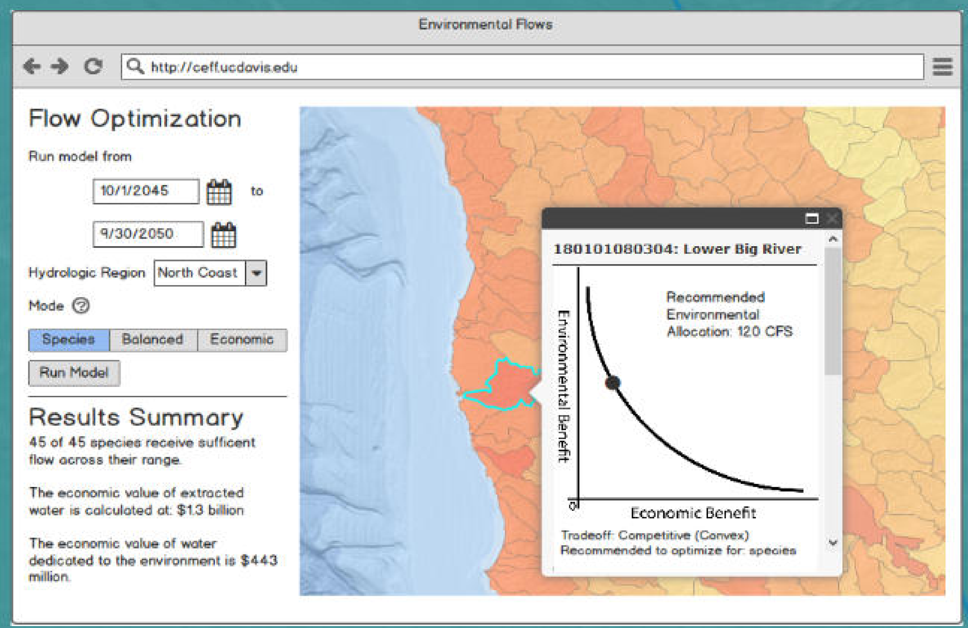
Benefit of Environmental Flows

How much benefit does an ecosystem get from a specific amount of water at a specific time? This question is critical to our optimization, and there are many potential answers. To start with, we built "fuzzy" flow component boxes based on modeled historical data from Zimmerman et al, 2018. They are fuzzy because the closer the flow is to historical timing and quantity of water, the more benefit we assign to the flow. As it strays further away, the model provides less benefit. The lefthand graph below shows the benefit we calculate for potential flows on a single day of the dry season for a segment of the North Fork American River, and the one on the right shows benefit across the entire dry season.





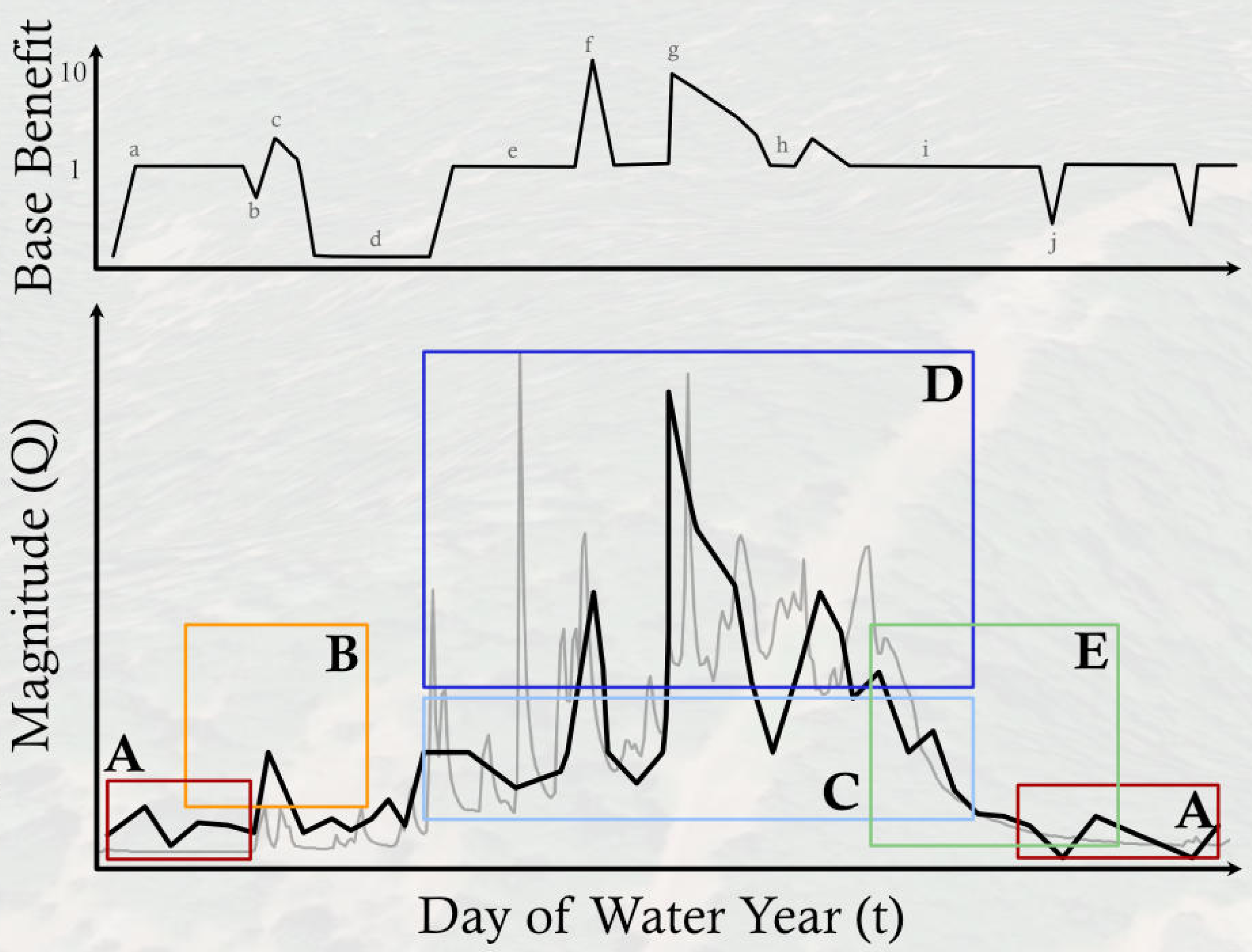
Decision Support



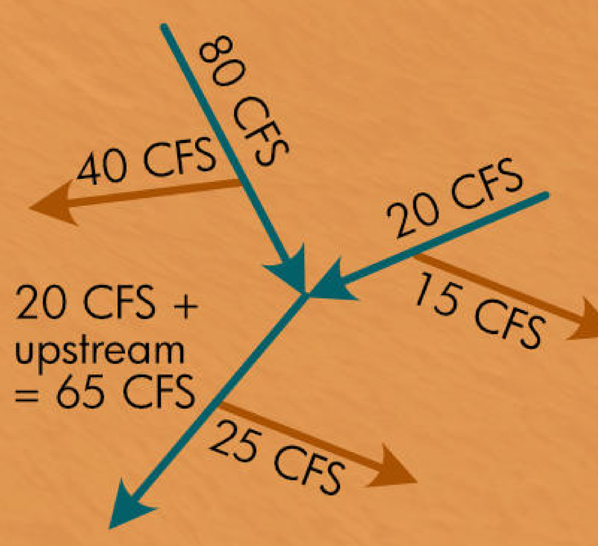
To make the model results available, we want to build a web interface that allows a user to run the model and view flow allocations and tradeoff curves by segment. It could initially provide results generated by our team, but ultimately we aim for visitors to change parameters, run the model, and view outputs in the browser to support decisions.

Finding Environmental Flow Regimes

CEFF guides managers in developing *functional flows* (Yarnell et al, 2015), or flows that support key ecosystem and geomorphic processes. For the optimization portion of the project, a computer randomly builds millions of hydrographs (line bottom right) for each stream segment, and we evaluate them (top right) by how well they support each component of flow (boxes).



Assessing the region



After establishing the benefit of flows for single components and segments, we combine these together into a stream network in order to assess the least harmful locations to withdraw water. The path to establish the withdrawal amounts may be more important, though, because it builds tradeoff curves (see first figure, top left), which tell us and managers how environmental impacts change when we withdraw water from the system.

Funders

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References

Yarnell, Sarah M., Geoffrey E. Petts, John C. Schmidt, Alison A. Whipple, Erin E. Beller, Clifford N. Dahm, Peter Goodwin, and Joshua H. Viers. "Functional Flows in Modified Riverscapes: Hydrographs, Habitats and Opportunities." BioScience 65, no. 10 (2015): 963–72. https://doi.org/10.1093/biosci/biv102.

Zimmerman, Julie K. H., Daren M. Carlisle, Jason T. May, Kirk R. Klausmeyer, Theodore E. Grantham, Larry R. Brown, and Jeanette K. Howard. "Patterns and Magnitude of Flow Alteration in California, USA." Freshwater Biology 63, no. 8 (August 1, 2018): 859–73. https://doi.org/10.1111/fwb.13058.