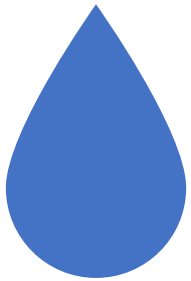
Developing ecological indicators for water planning



Laura Rack

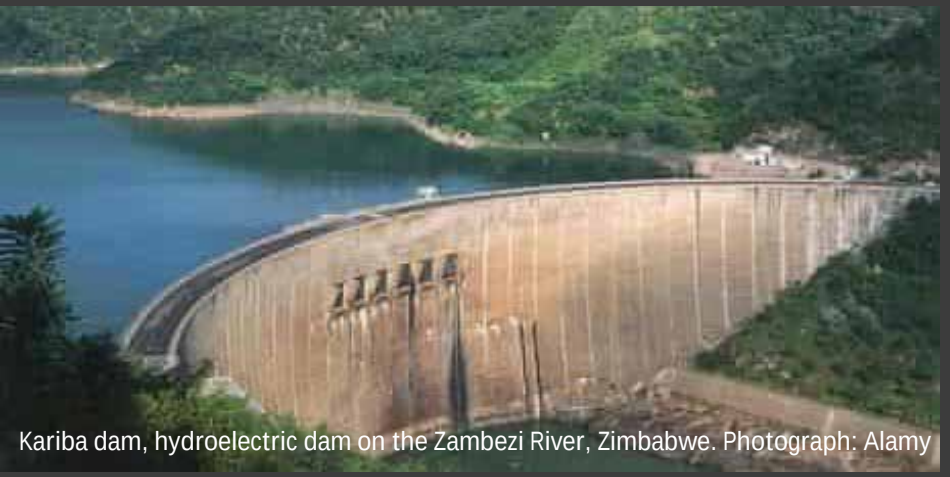
Odum School of Ecology and River Basin Center, University of Georgia

Rivers contribute in many ways to human wellbeing

These ecosystem services include:
Provisioning services (water and food)
Regulation services (water cleansing, flood reduction)
Cultural services (recreation, nature appreciation)

Output of the ESManage Project. This project was funded under the EPA Research Programme 2014-2020. The EPA Research Programme is a Government of Ireland initiative funded by the Department of the Environment, Climate and Communications. It is administered by the Environmental Protection Agency, which has the statutory function of co-ordinating and promoting environmental research.

https://www.cntraveler.com/activities/atlanta/atlanta/chattahoochee-river-national-recreation-area



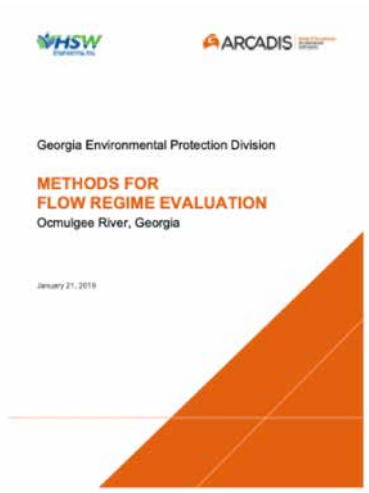
Kariba dam, hydroelectric dam on the Zambezi River, Zimbabwe. Photograph: Alamy

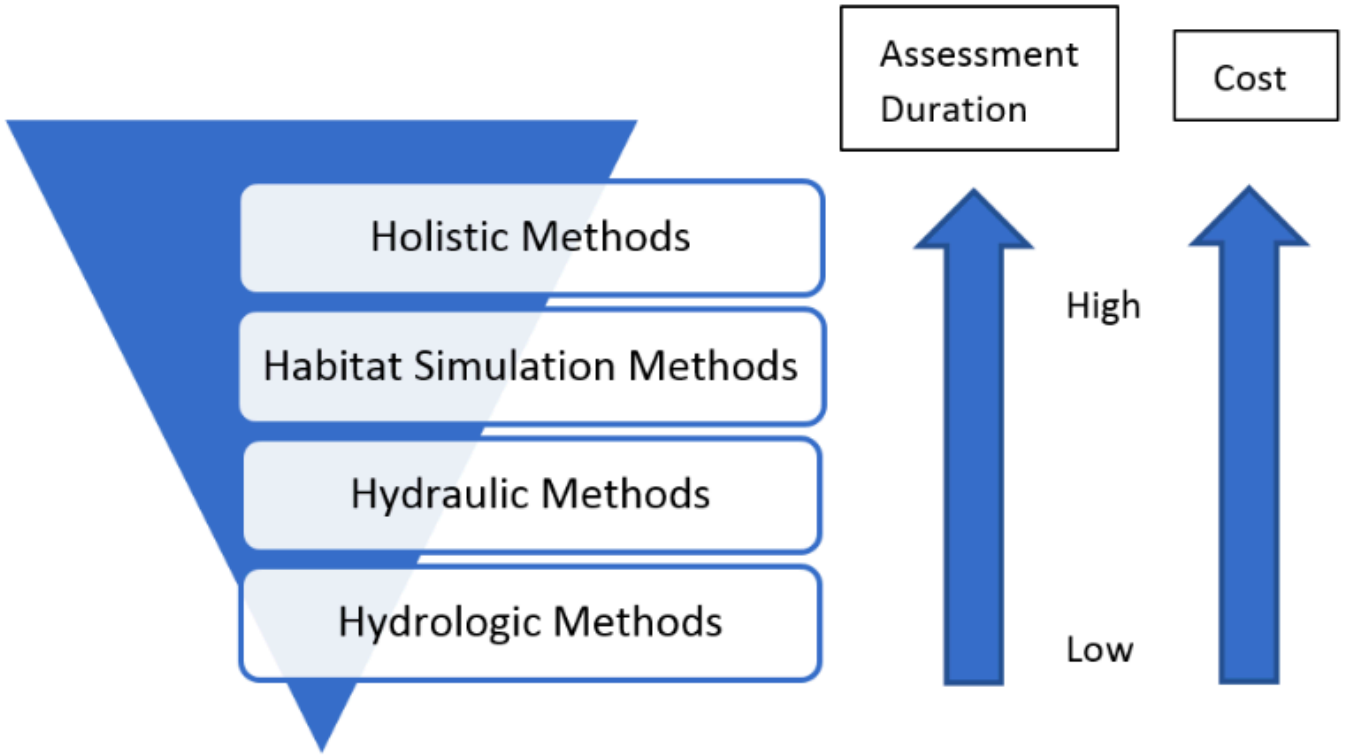
Austin from Tarrytown to West Lake Hills. Wikimedia Commons

We have altered river systems

But we still rely on them for multiple uses

Environmental flows





Arcadis. 2019. Methods for Flow Regime Evaluation Ocmulgee River, Georgia. Arcadis U.S., inc.

What are the challenges?

Holistic Environmental Flow challenges:

- Abundance of hydrologic metrics to evaluate
  - Lack of biological relevance
  - Redundancy
- Lack of consistency for flow-ecology relationships
- Empirical relationships are hard to develop
- Available data may not represent ecology of entire system

Yarnell and others, 2020

What are the challenges?

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Yarnell and others, 2020

Plus…

- Environmental metrics would be most helpful if they aligned with planning metrics

“Group members share a vision of a river system healthy enough to maintain the many social, ecological, recreational and economic values that the Flint River system provides -- values such as water supply, recreation, fisheries, property values, and a healthy river ecosystem.”

--Upper Flint River Working Group

American Rivers. 2019. Ensuring Water Security for People and Nature.

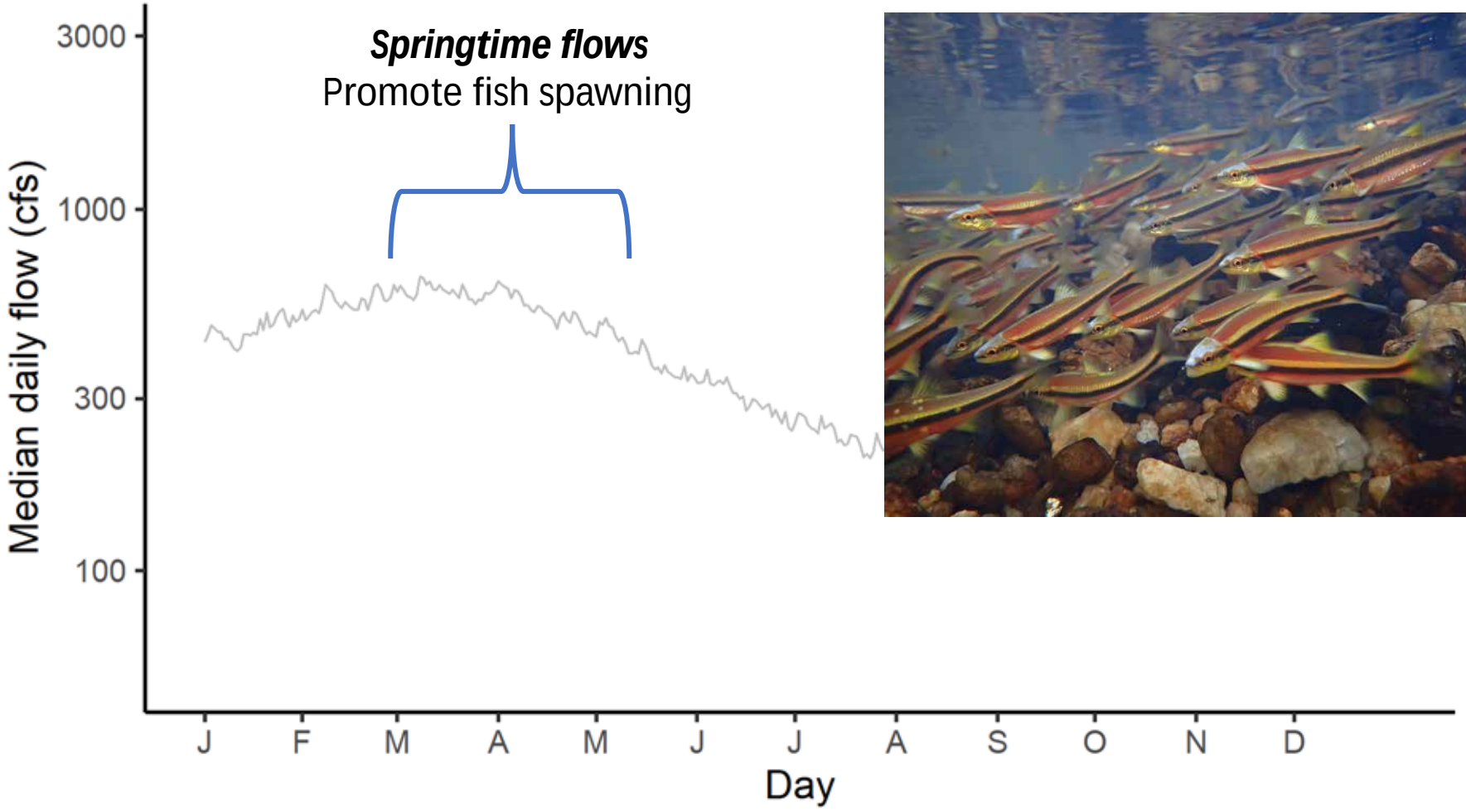
Flows for species and habitat

Based on an approach ecologists call “Functional Flows”

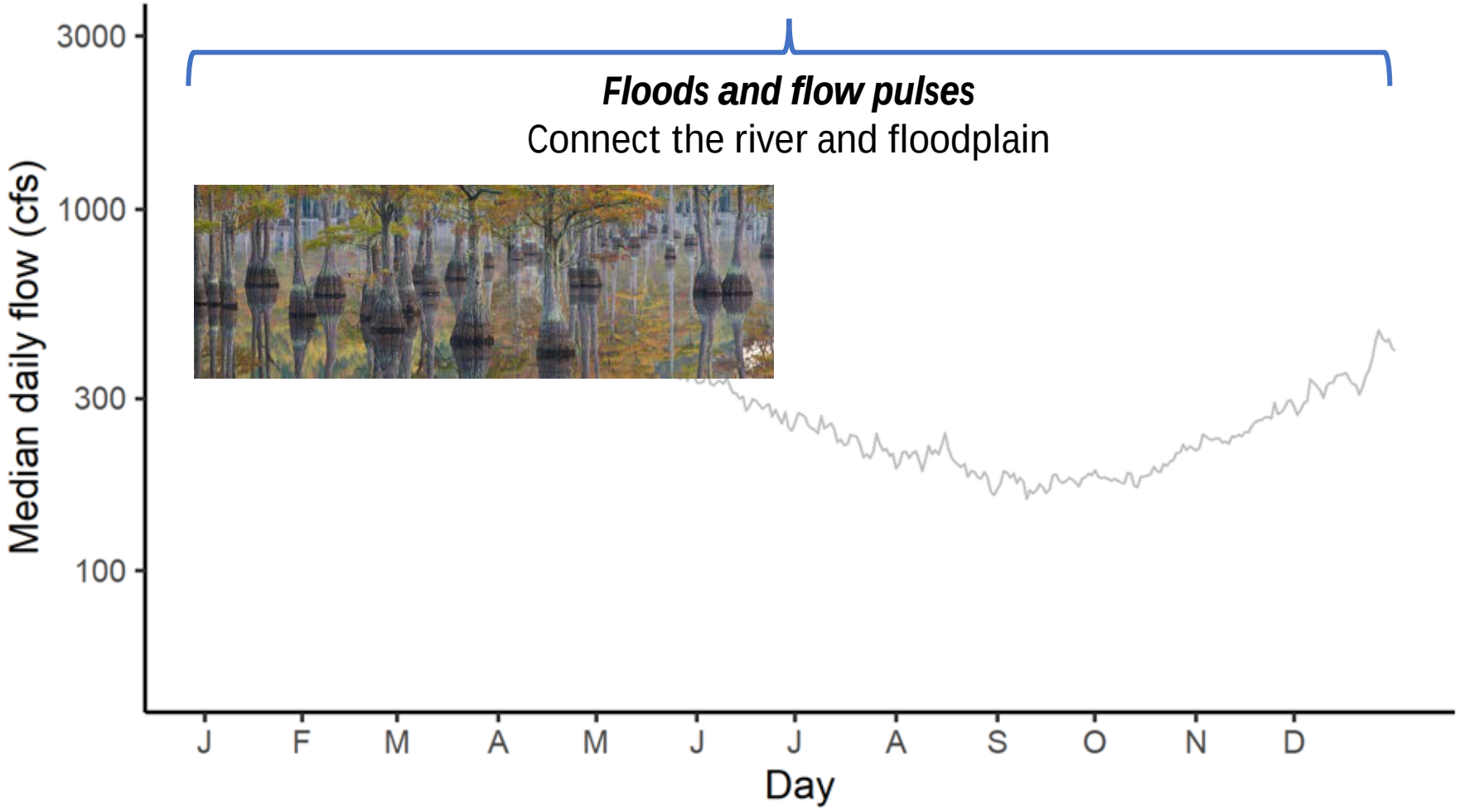
Identify a few dimensions of the natural flow regime that we can tie to support of riverine ecosystems

May be more practicable for water planning

Some examples of ecological functions



Some examples of ecological functions



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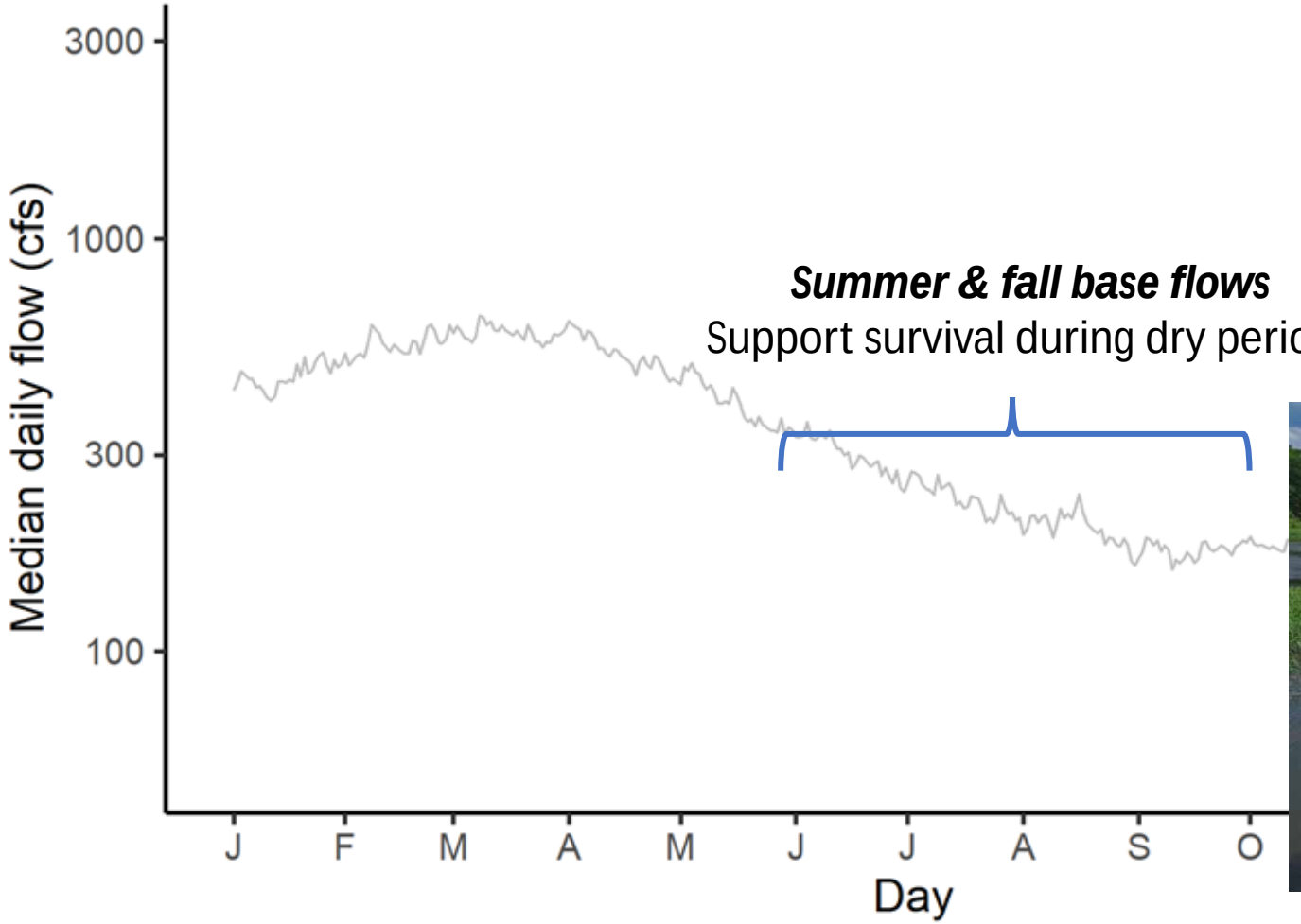
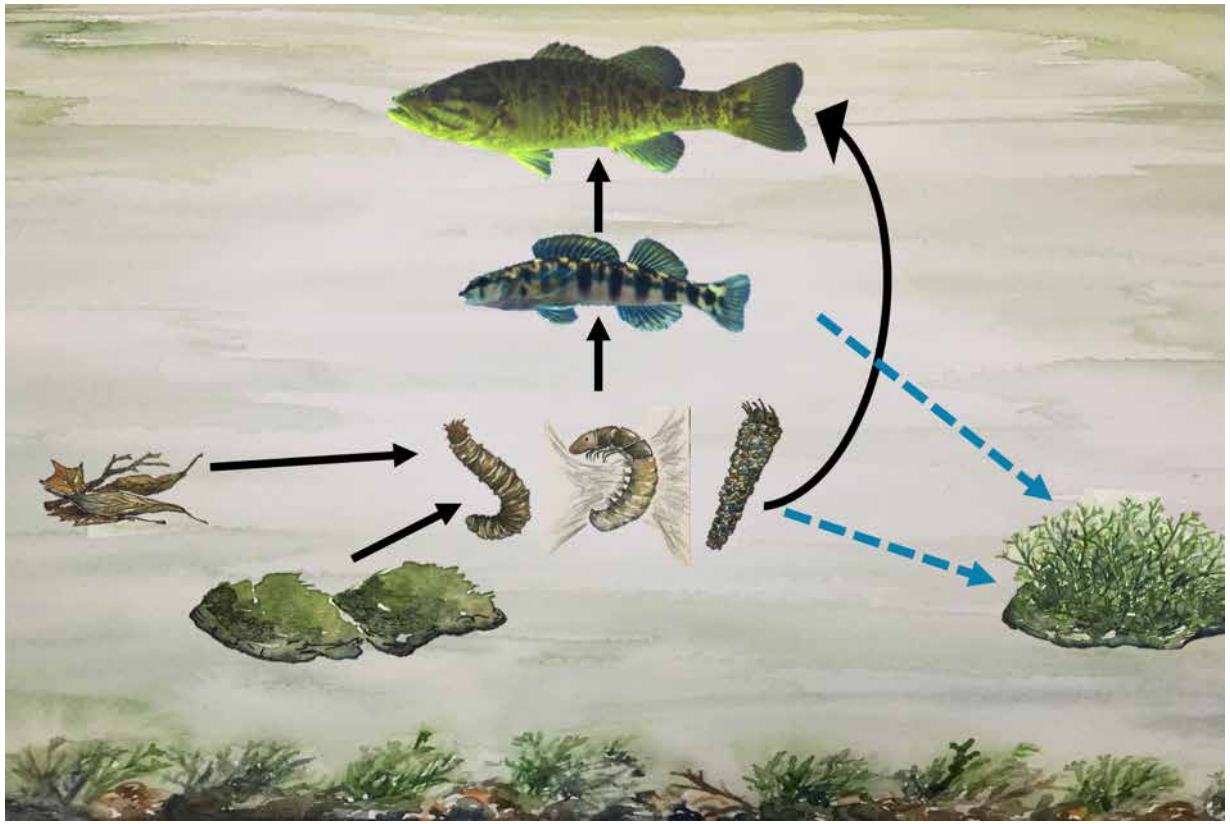


Summer & fall base flows

Support survival during dry periods

Developing flows for species and habitats in Flint River shoals



Review: Ecological studies of low-flow effects on riverine plants and animals

Riverweed -2

Algae - 19

Macroinvertebrates -18

Fish – 17

Review take-aways

Algae

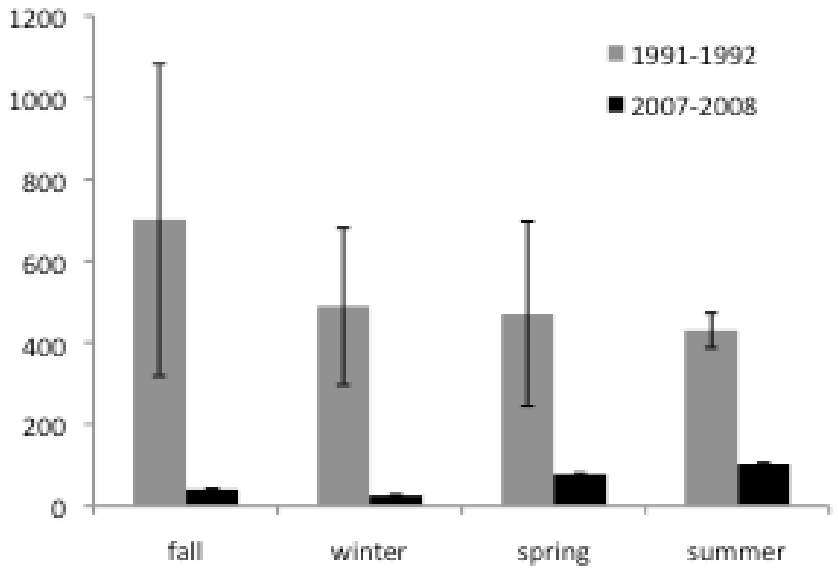
- Build-up during longer periods of low, stable flow conditions
- Depends on nutrient conditions

Aquatic invertebrates

- Decline in abundance when low-flows last 2 months or longer
- Filter-feeding invertebrates show most consistent declines

Fishes

- Generally, decreased abundance during low flows, but not always
  - Low-flows sometimes = better juvenile survival, or fish aggregation

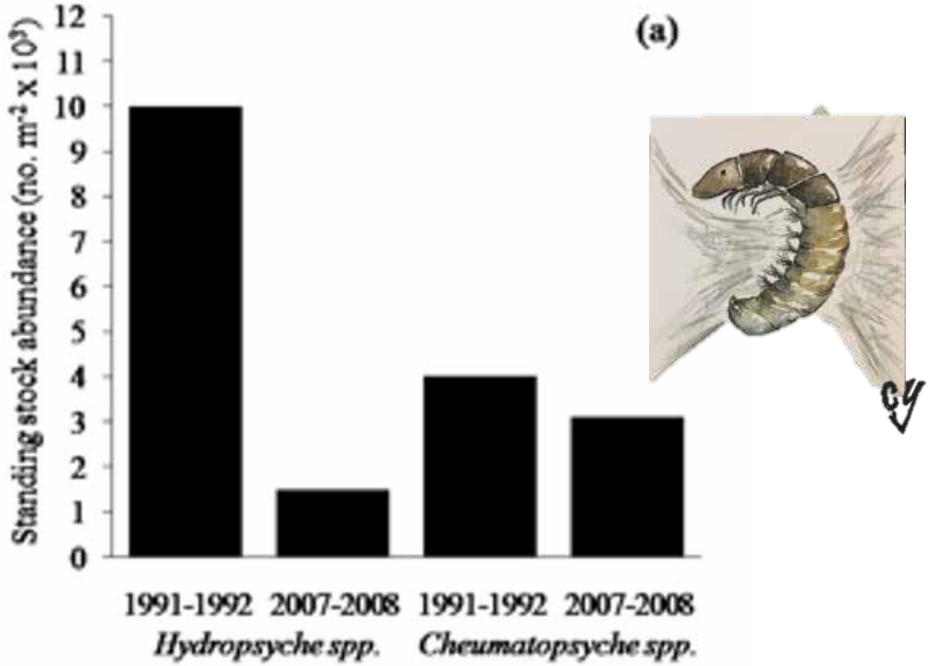


Riverweed biomass reduced during 2007-2008 drought

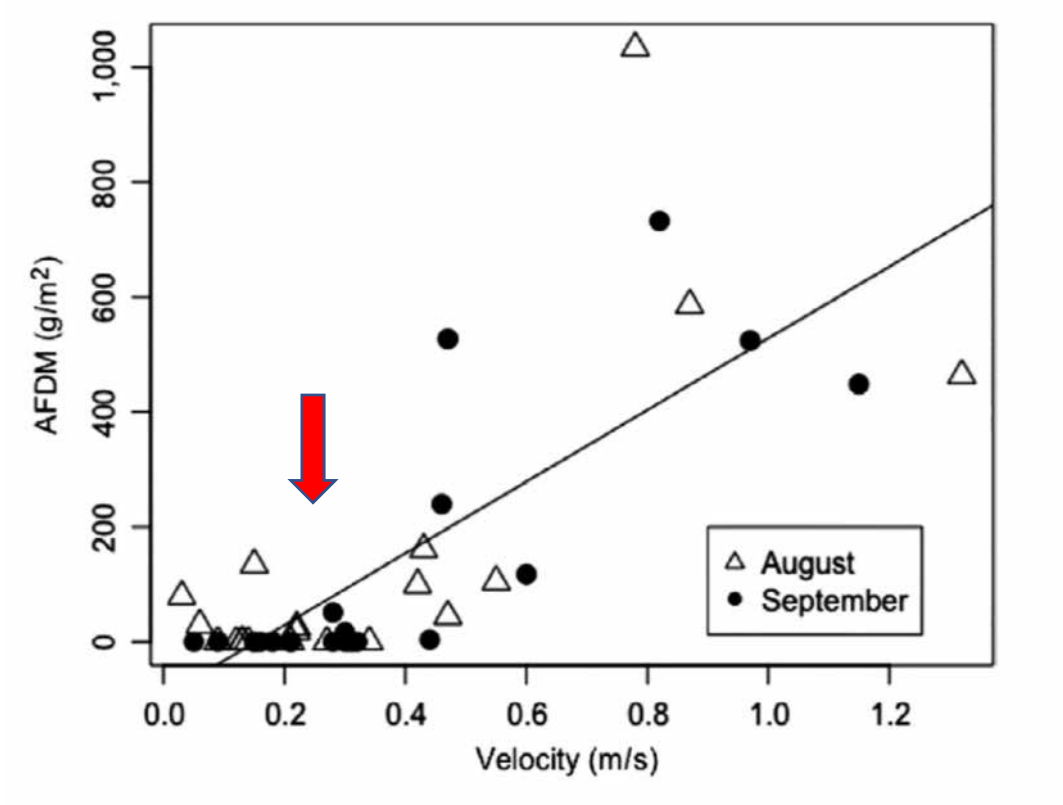
J. Pahl, UGA MS thesis

Caddisfly biomass reduced during 2007-2008 drought

R. Katz, UGA MS thesis



It’s not just low flow

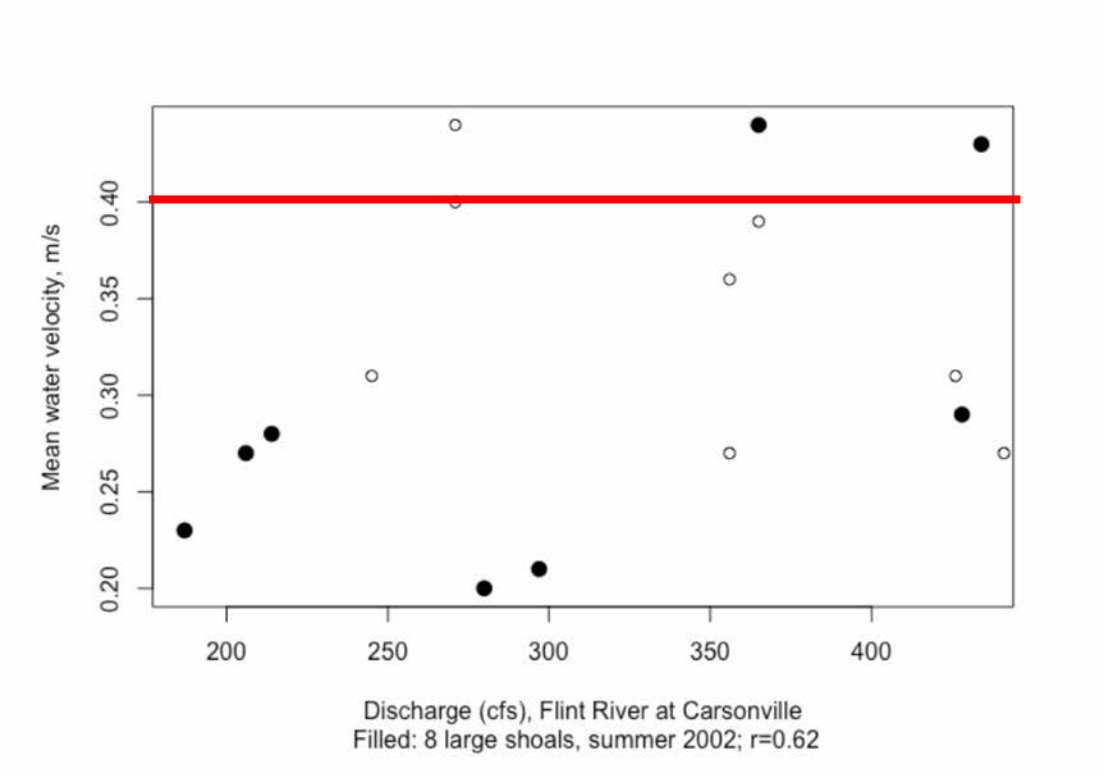


Wood et. al 2019, Freshwater Biology

Riverweed biomass lower in areas with slower flow in 2016 (low-flow summer)

…and consumed when transplanted to low velocities

Velocity in Flint River shoals



P. Marcinek, UGA MS Thesis

Summer flows for species and habitats

Summer and fall (dry season) baseflow	Support growth and survival of aquatic organisms Sustain higher velocity habitats Maintain habitat connectivity	# days with flow < 500 & 100 cfs June-October	Mega-shoals observed to have mean velocities < 40 cm/s at flows <500 cfs (Carsonville gage), potentially leading to loss of riverweed and invertebrate productivity. Sprewell Bluff shoals approach 'more rocks than water' at lows <100 cfs (Carsonville gage).

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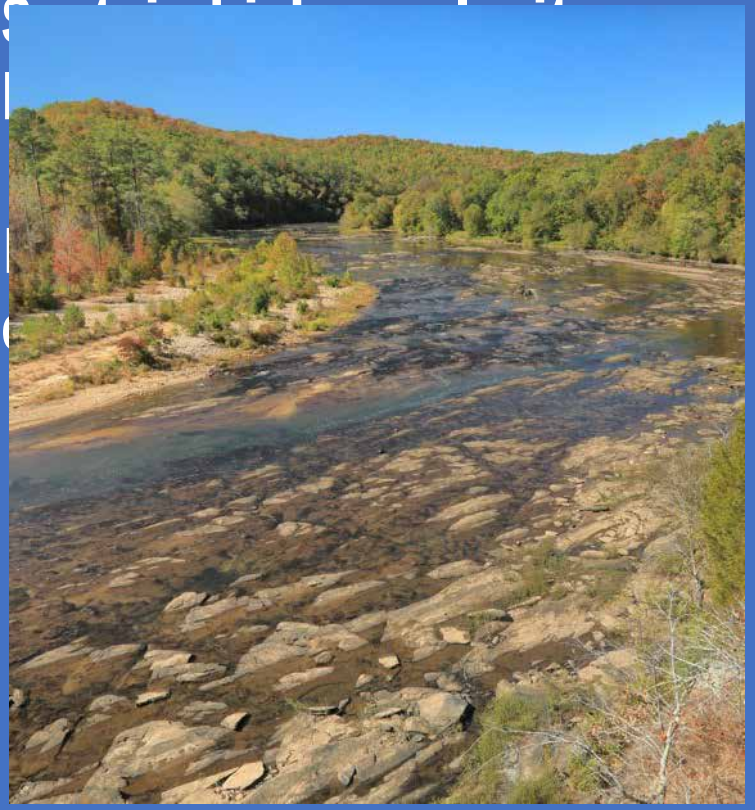
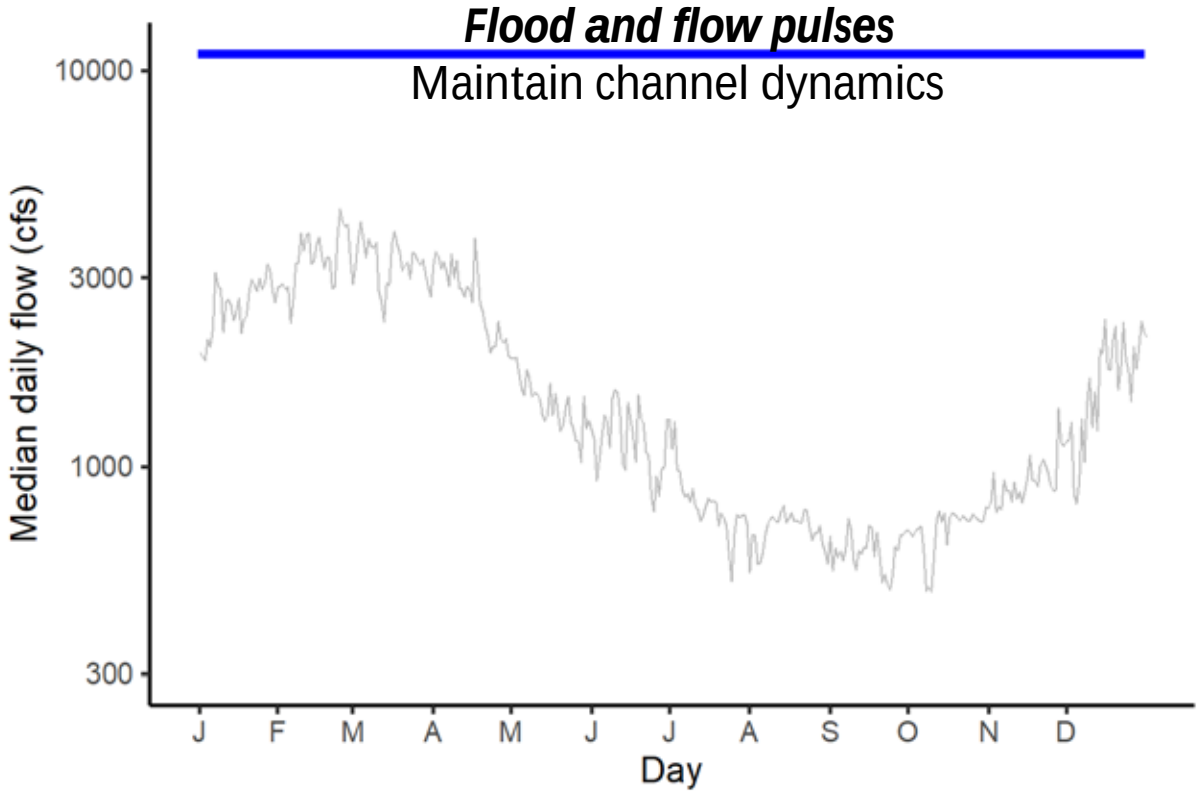


We could build these out to more than just low flows

Oconee Basin Project



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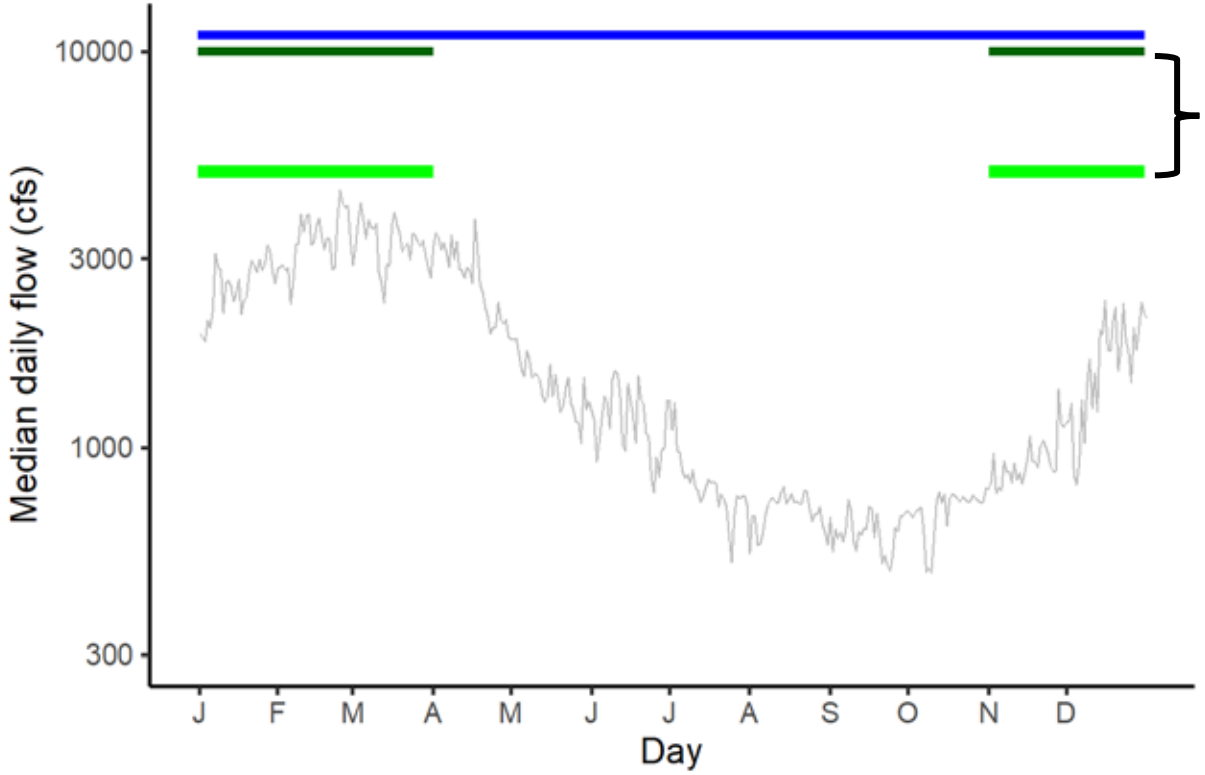
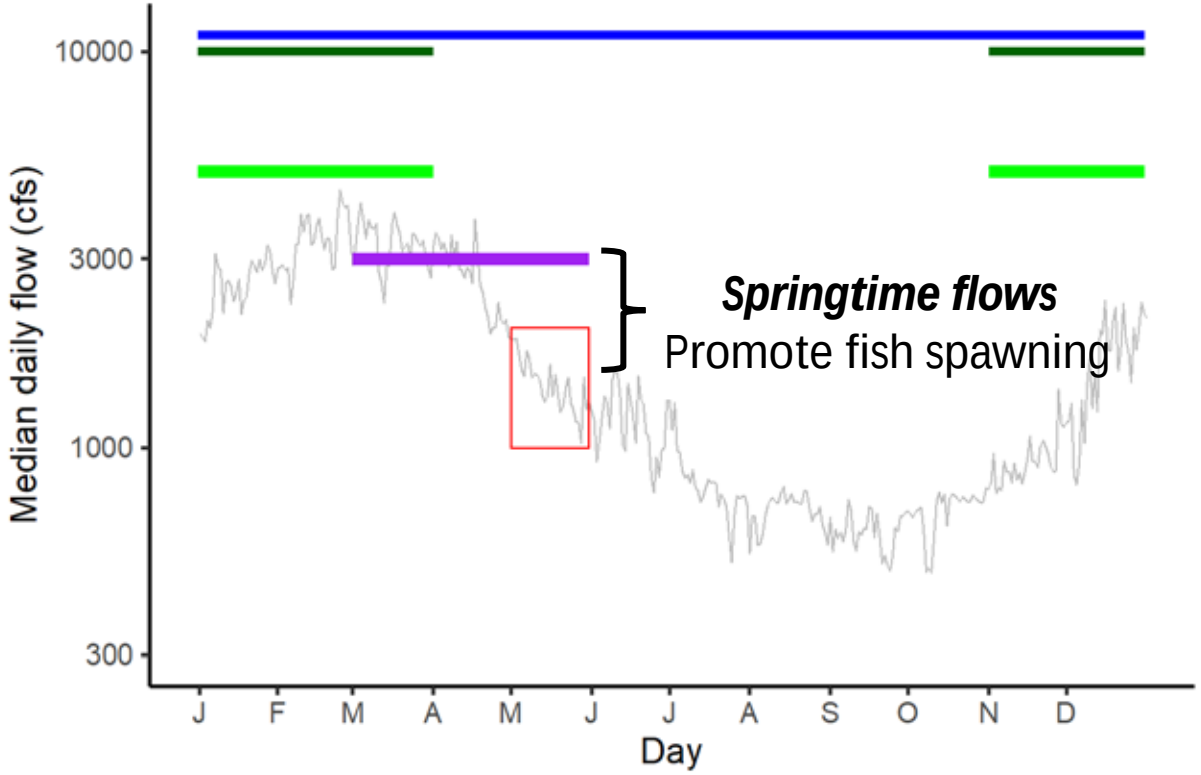


Flood and flow pulses
Connect the river and floodplain

We could build these out to more than just low flows

Oconee Basin Project



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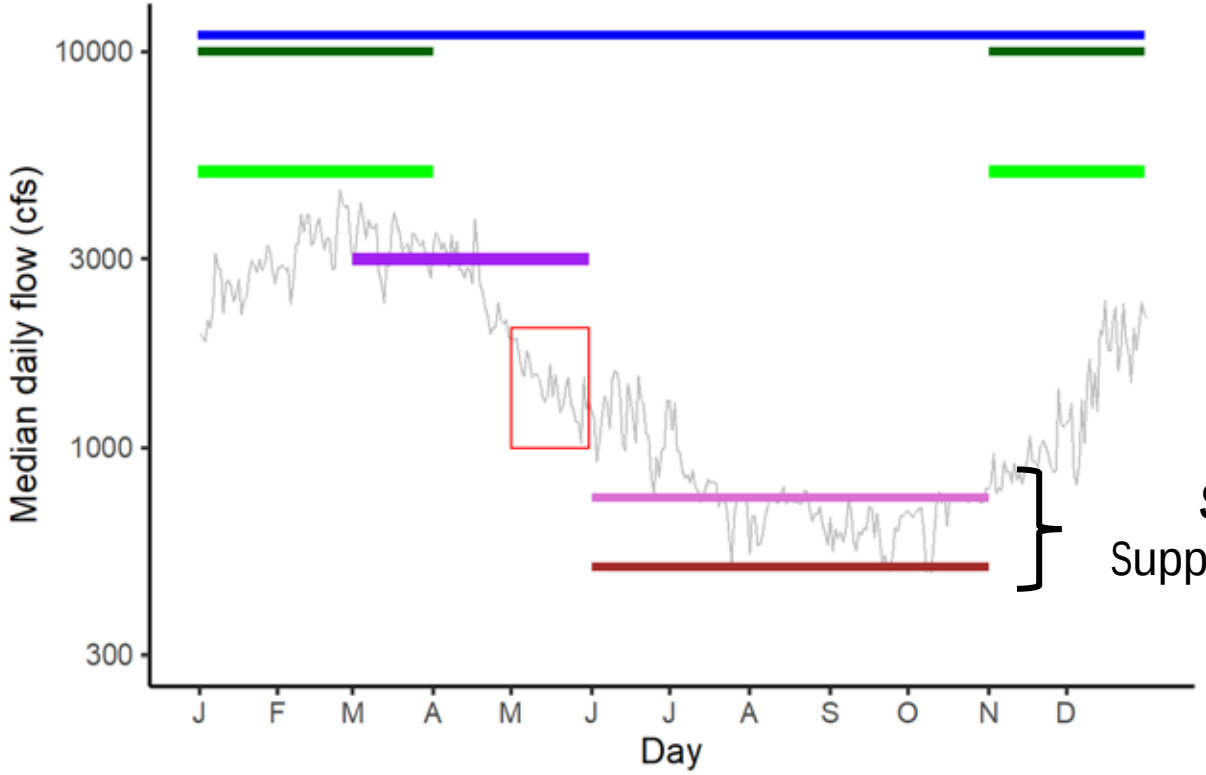
Oconee Basin Project



Summer & fall base flows
Support survival during dry periods

Next steps

- Targeted studies to fill data gaps
- Identifying metrics that transfer well between systems
  - Is there a percentile of flow that generally supports dry season survival in Georgia Rivers
- What are the flow sensitive species and habitats across river basins in Georgia
  - Opportunity for larger scale approach
  - Leverage area that have data available

Acknowledgments

People

- Mary Freeman
- Seth Wenger
- Laura Craig
- Steve Golladay
- Carol Yang
- RBC – labmates
- Gail Cowie

Funding

- Butler Fellowship
- American Rivers
- River Basin Center
- UGA Graduate School

Graduate School
UNIVERSITY OF GEORGIA

UNIVERSITY OF GEORGIA
Odum School of Ecology

UNIVERSITY OF GEORGIA
River Basin Center

Summer flows for species and habitats

Summer and fall (dry season) baseflow	Support growth and survival of aquatic organisms Sustain higher velocity habitats Maintain habitat connectivity	Annual frequency, periods of >=60 days with flow <dry season threshold, June-October	Low-flow durations that exceed ~60 days are associated with measurable declines in invertebrates

Monitoring at Still Branch

- Algae
  - We analyzed 10 years of data between 2008-2019 collected annual in late fall (except for 2010 and 2011) provided by Brant Keller
  - The Still Branch Reservoir Project monitoring observations provided qualitative evidence of algal buildup or more extensive filamentous algae during the lowest-flow years (2008, 2011, 2012, 2016).

- Fishes
  - This pattern suggested that fish were more concentrated in the shoal (i.e., there were more fish or less habitat, or both) during lower-flow years. However, fish counts were not elevated in the two years with the greatest number of extreme low-flow days (<95% exceedance flow; Figure 5). This suggested that although lower flow years may have concentrated fish, years with many days of extremely low flows resulted in fewer fish in the monitored shoal.
  - The data from the Still Branch monitoring effort show evidence that although fish densities can increase in a shoal during years with lower flows, fish numbers may also decline if flows are extremely low (e.g., <95% exceedance flow) for extended periods. This observation is based on a limited data set but may provide a starting point for hypothesizing that avoiding prolonged durations of extreme low-flows could benefit shoal-fish populations.

- Aquatic Invertebrates
  - compute a multimetric Benthic Index of Stream Integrity, with the monitoring site scoring “good” or “excellent” in most years. Because the data are numbers of individuals composing a fixed-count of organisms, they cannot be used to estimate variability in invertebrate densities or abundances.
  - The number of filter-feeding insects in the annual fixed-count samples in the Still Branch data set was not strongly correlated with low-flow metrics,