Climate change impacts on thermal characteristics of freshwater fish habitats in a regulated river system

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Southeast United States (SEUS)

#AquaticBiodiversity

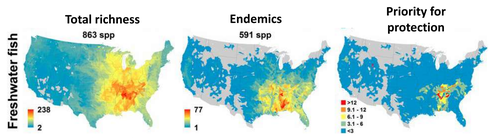


Figure source: Jenkins et al., 2015, PNAS

#Dams

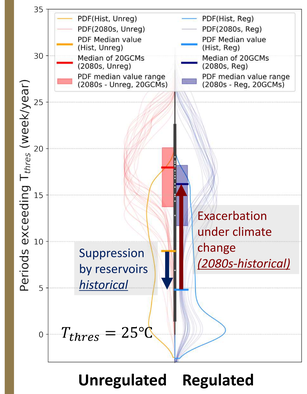
Over ***300*** major dams were constructed during the past century. Cold releases from reservoir hypolimnion change river thermal regimes and hence fish thermal habitats in the SEUS.

#ClimateChange

River temperature is projected to increase ***4***°C in SEUS by the 2080s under RCP8.5. During warm seasons, reservoirs can still release cold water downstream, but the cooling impacts dissipate faster.

River temperature

One of the leading physical drivers of ecosystem health and species persistence



- A physically-based modeling chain was established to simulate regulated river temperature, explicitly considering thermal stratification (*Cheng et al., Water Resources Research, in revision*)
- Calculate ***heat extremes*** as the periods that exceed a ***threshold temperature*** (T_{thres}, calculated based on the maximum weekly lethal temperature of three trout species)
- Downstream of large reservoirs, cold hypolimnetic releases suppress the extreme heat events.
- Under climate change, heat extremes will be exacerbated

Dam-induced thermal regime alteration forces species redistribution

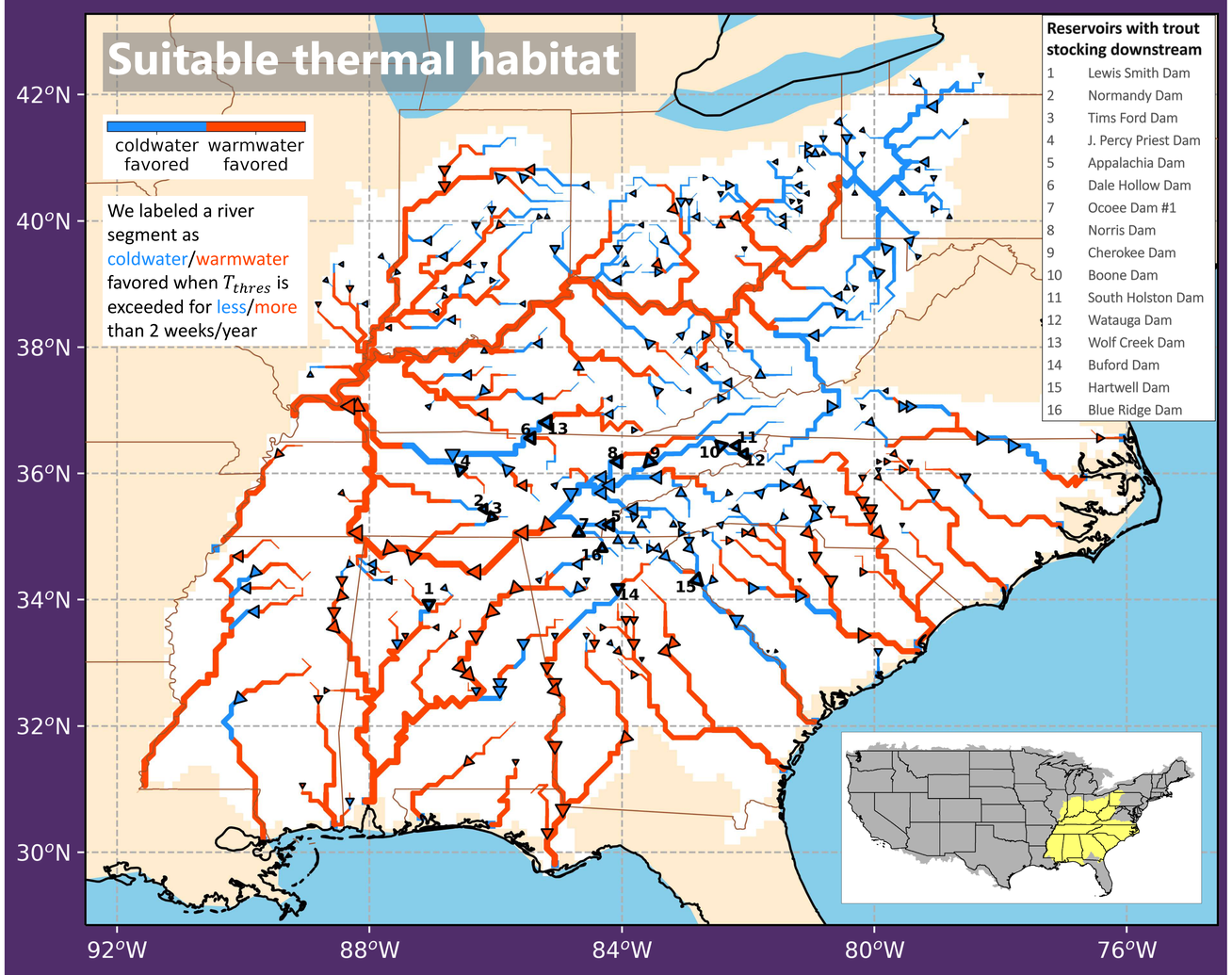
Pre-dam

- Southeastern United States is a place of great aquatic biodiversity, e.g., ***62*** percent of U.S. fish species and ***91*** percent of U.S. mussel species.
- Most of them are warmwater species and endemic.
- Coldwater species, e.g., rainbow and brown trout, only existed in the Appalachians and small headwater streams.

Post-dam

- Downstream of large reservoirs, cold hypolimnetic releases during warm seasons wipe out indigenous warmwater species. *Suitable habitats for warmwater species shrink.*
- However, the cold releases provide an ideal habitat for imported coldwater species downstream of reservoirs. At multiple dams, especially those operated by the Tennessee Valley Authority, trout are hatched and stocked downstream, bringing in significant economic benefits.

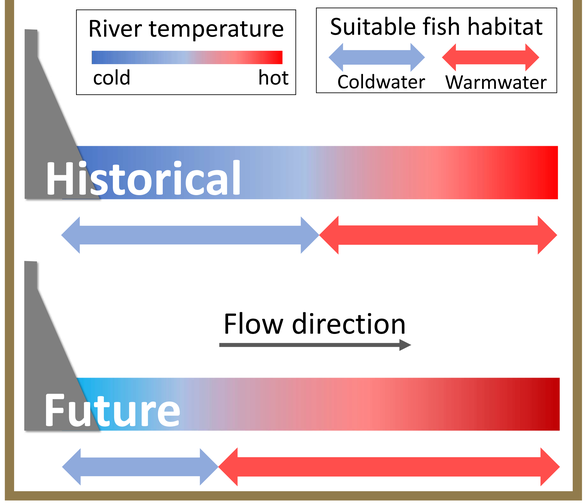
Suitable thermal habitat



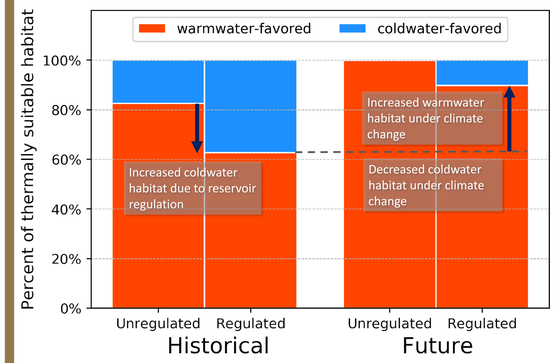
Main Takeaway

- **In the SEUS, cold hypolimnetic releases from thermally stratified reservoirs provide an ideal habitat downstream of reservoirs for imported coldwater fish species, i.e., trout.**
- **Under climate change, as river temperature increases, suitable habitat for the lucrative and recreational trout fishing will shrink while suitable habitat for indigenous warmwater fish species will increase, which might help restore the freshwater biodiversity in the SEUS.**

Projected change in fish thermal habitats



Decreasing trout habitat under climate change



- Historically, reservoirs in the SEUS convert 20% of regulated river segments from warmwater to coldwater favored.
- Under climate change, as river temperature increases, suitable habitat for coldwater species, i.e., trout, decreases from 37% to 10% while suitable habitat for warmwater species increases by 27%.

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