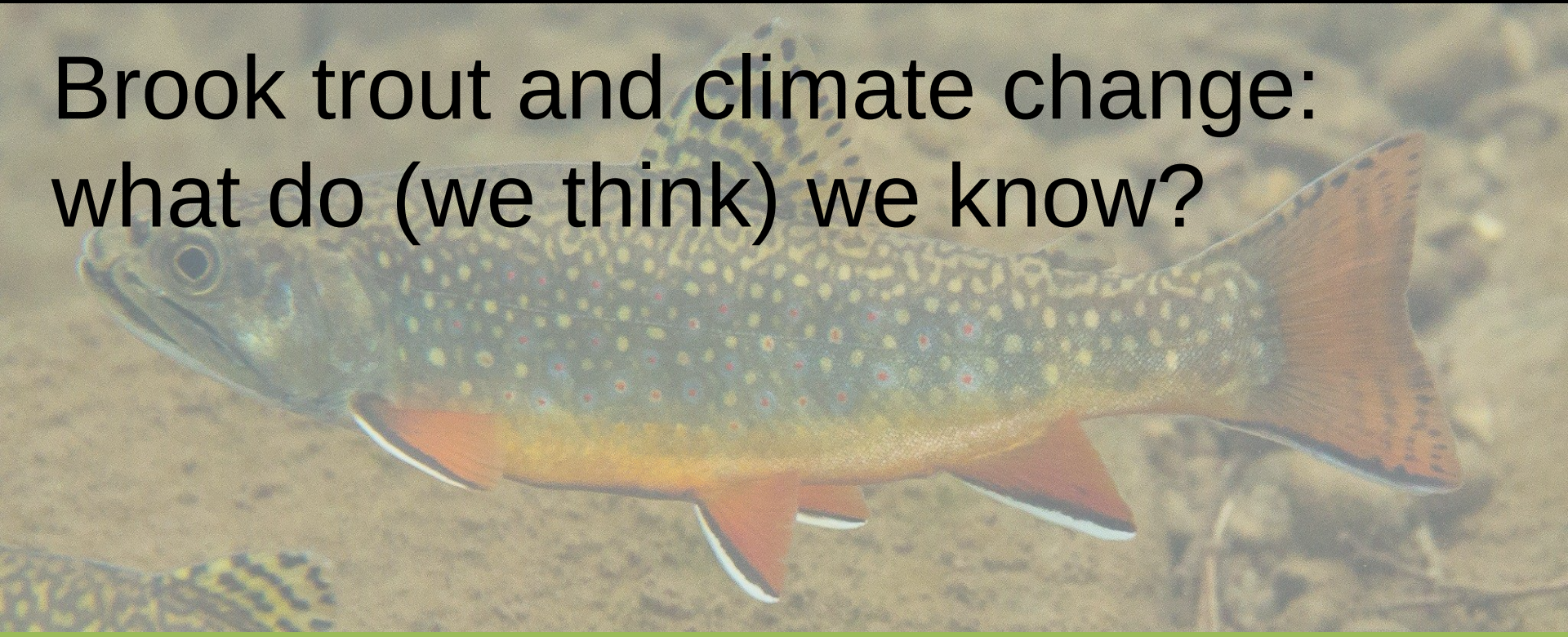
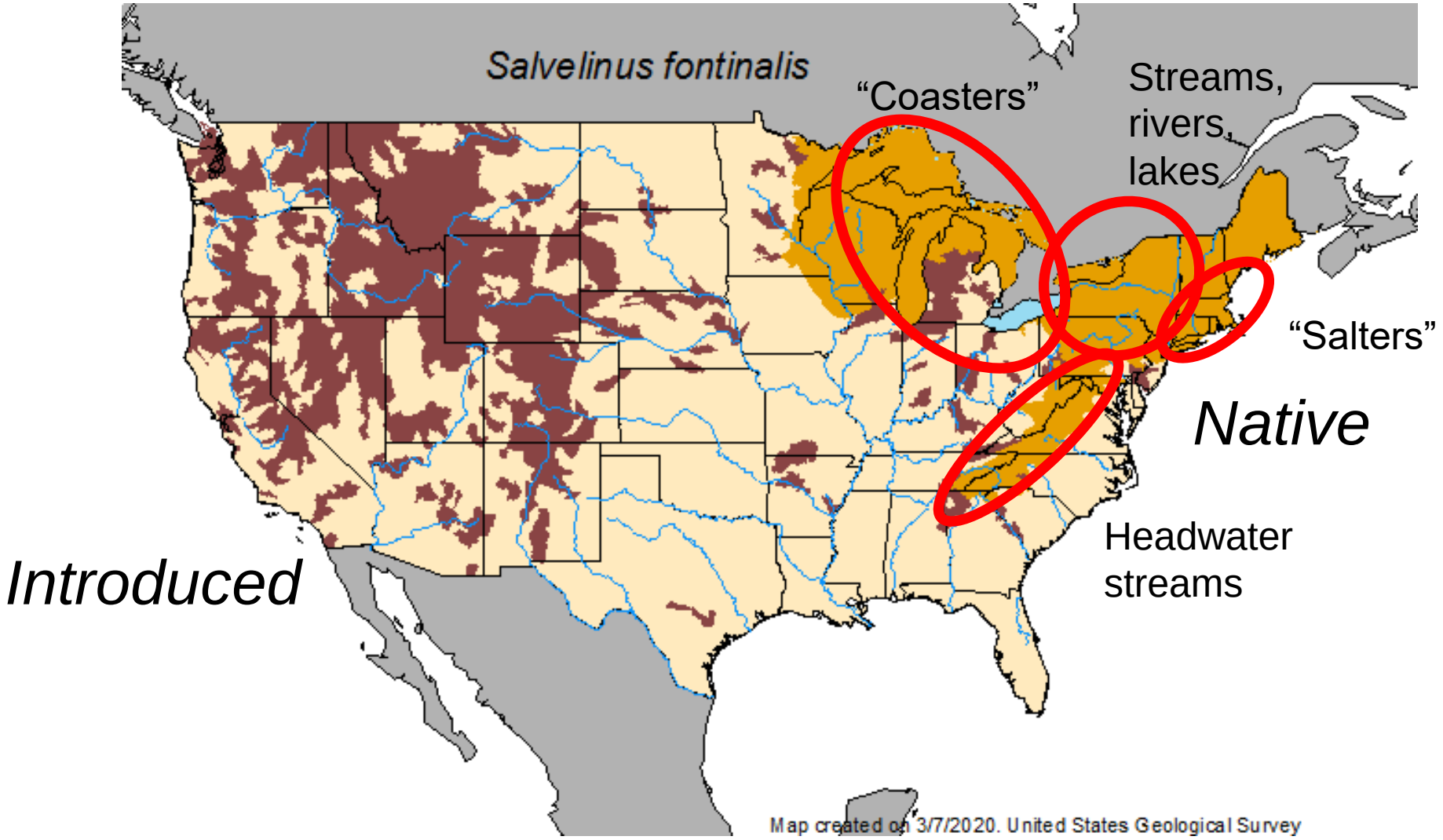
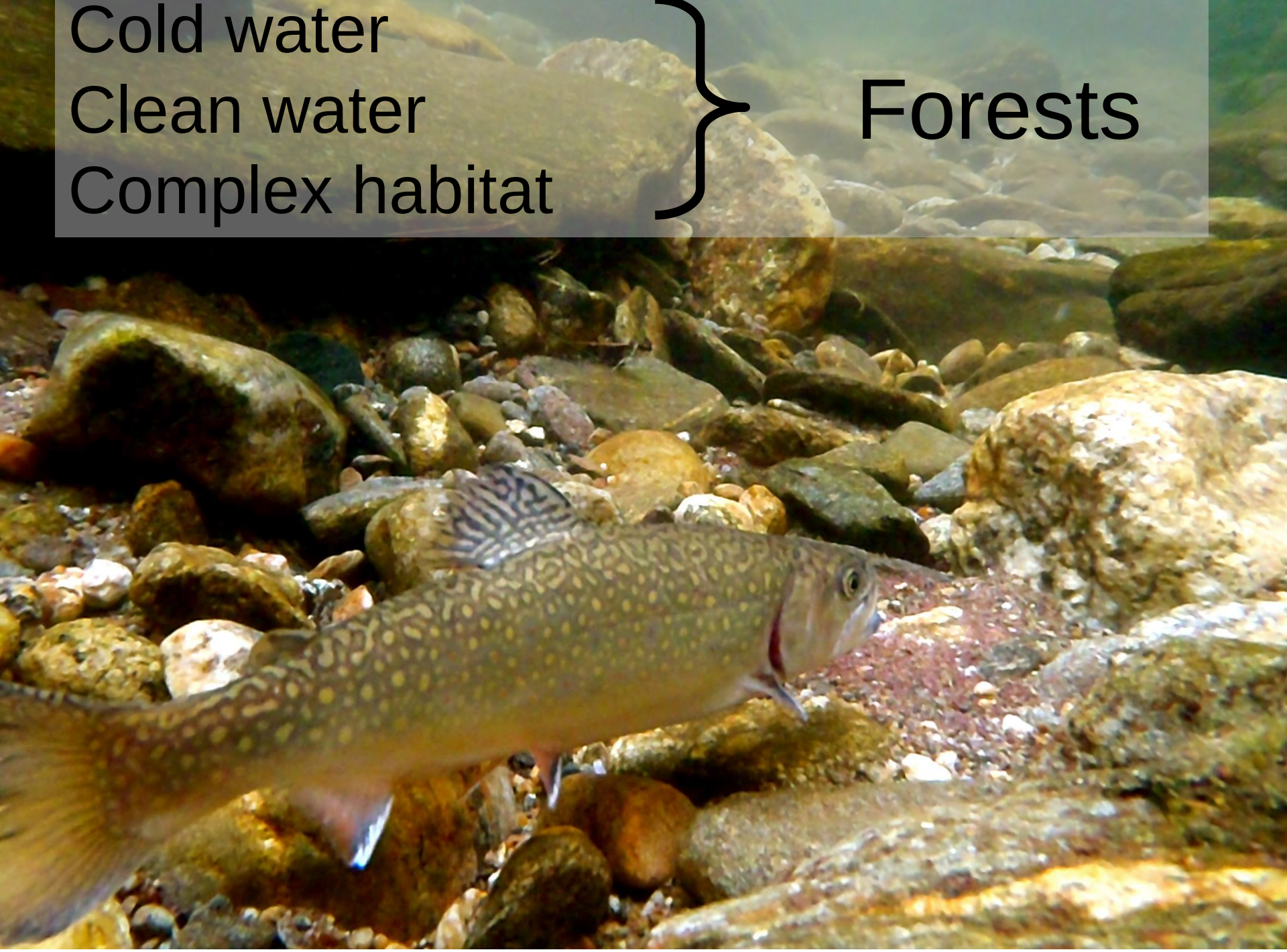


Brook trout and climate change: what do (we think) we know?

Nathaniel (Than) Hitt, Benjamin Letcher, Stephen Faulkner
U.S. Geological Survey, Eastern Ecological Science Center, Kearneysville WV

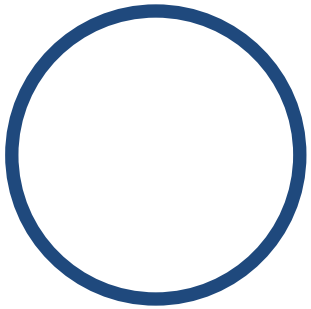

Salvelinus fontinalis
"Coasters"
Streams, rivers, lakes
"Salters"
Native
Headwater streams
Introduced
Map created on 3/7/2020. United States Geological Survey


Cold water
Clean water
Complex habitat
Forests

Conceptual model for brook trout + climate change

How and where will conditions change?

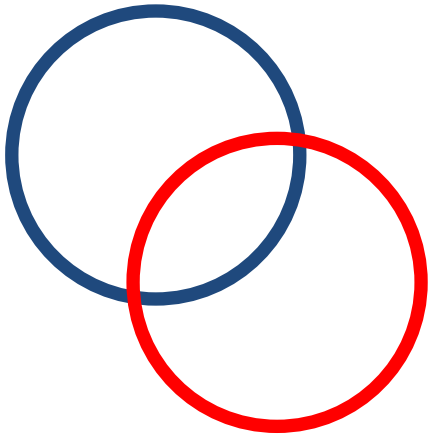
Exposure



Conceptual model for brook trout + climate change

How and where will conditions change?

Exposure



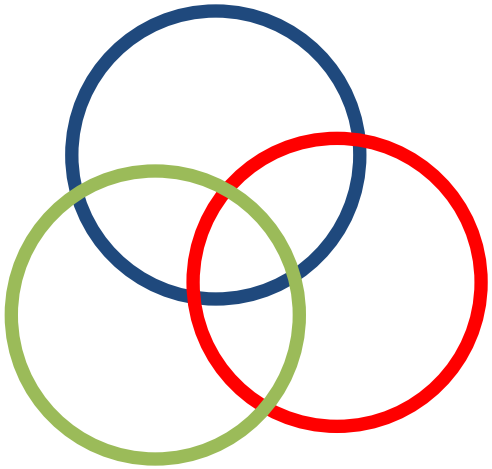
Which populations will respond?

Sensitivity

Conceptual model for brook trout + climate change

How and where will conditions change?

Exposure



Which populations will respond?

Sensitivity

Adaptive capacity

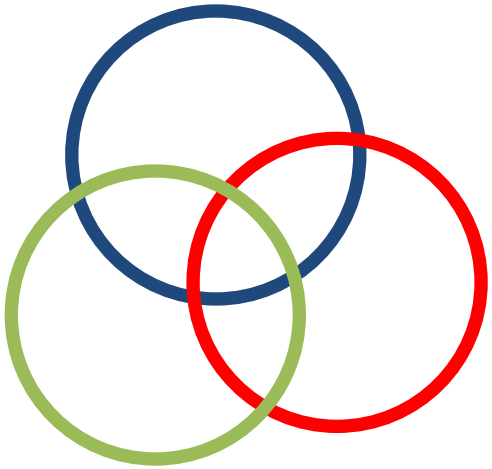
Will evolutionary change enable persistence?

Adapted from Foden et al. 2013. PLOS One

Conceptual model for brook trout + climate change

Meteorology
Hydrology
Geophysics

Exposure



Pop dynamics
Physiology
Ecology

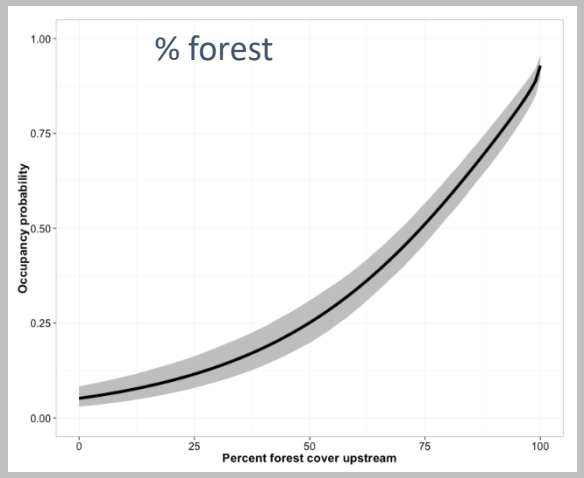
Sensitivity

Adaptive capacity

Evolutionary ecology
Genetics/genomics

Fundamental limits on Brook Trout

Landscape



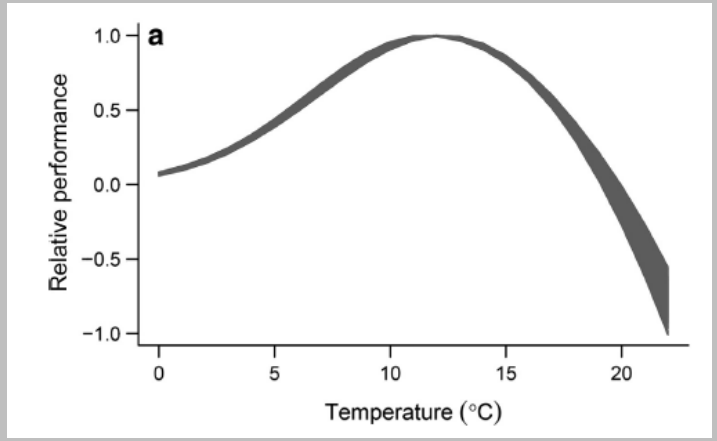
Kanno et al., 2015, TAFS

Water quality

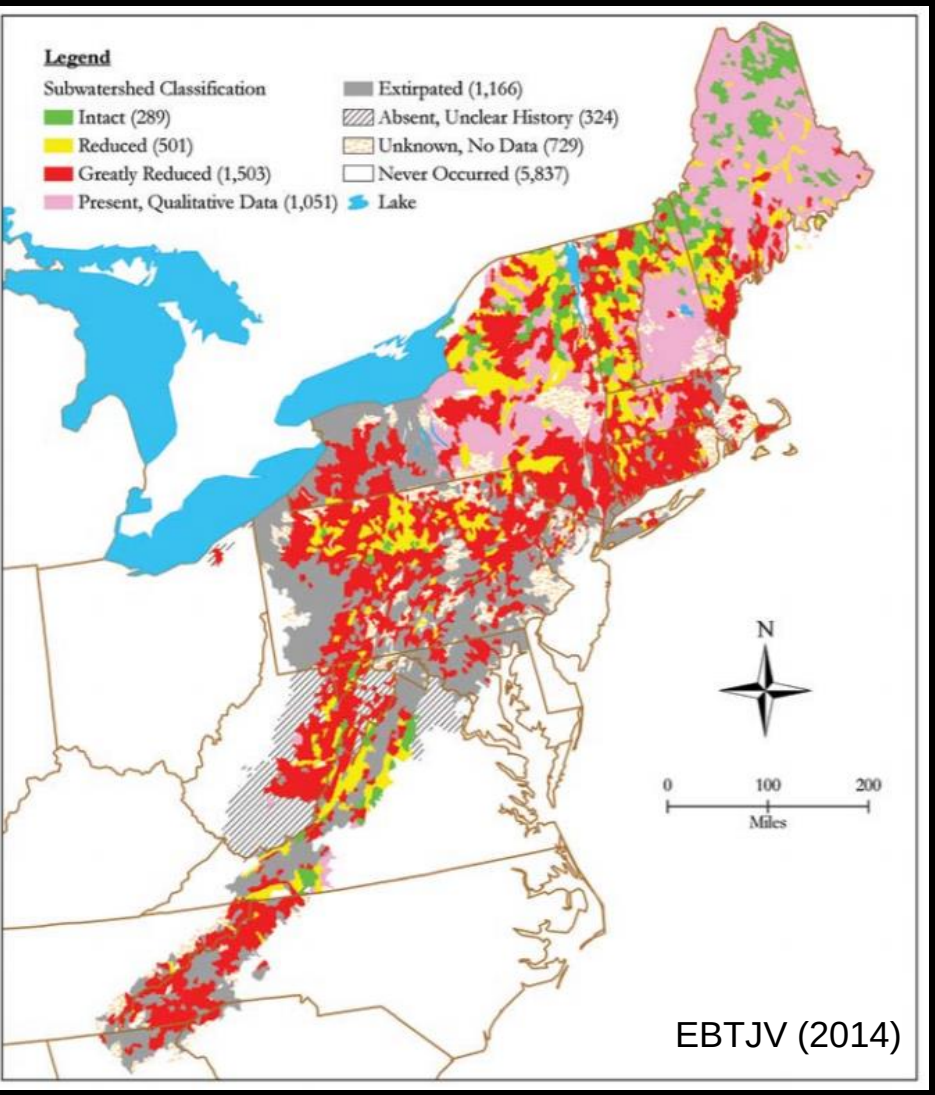
- Temperature
- Acid Mine Drainage (AMD)

Water quantity

- Flow; droughts and floods



Childress and Letcher, 2017, Ecology



Threats:

- Altered flows (flood/drought)
- Warming water
- Land use
- Groundwater withdrawal
- Habitat fragmentation
- Invasive/non-native species
- Acid rain/AMD

Intact

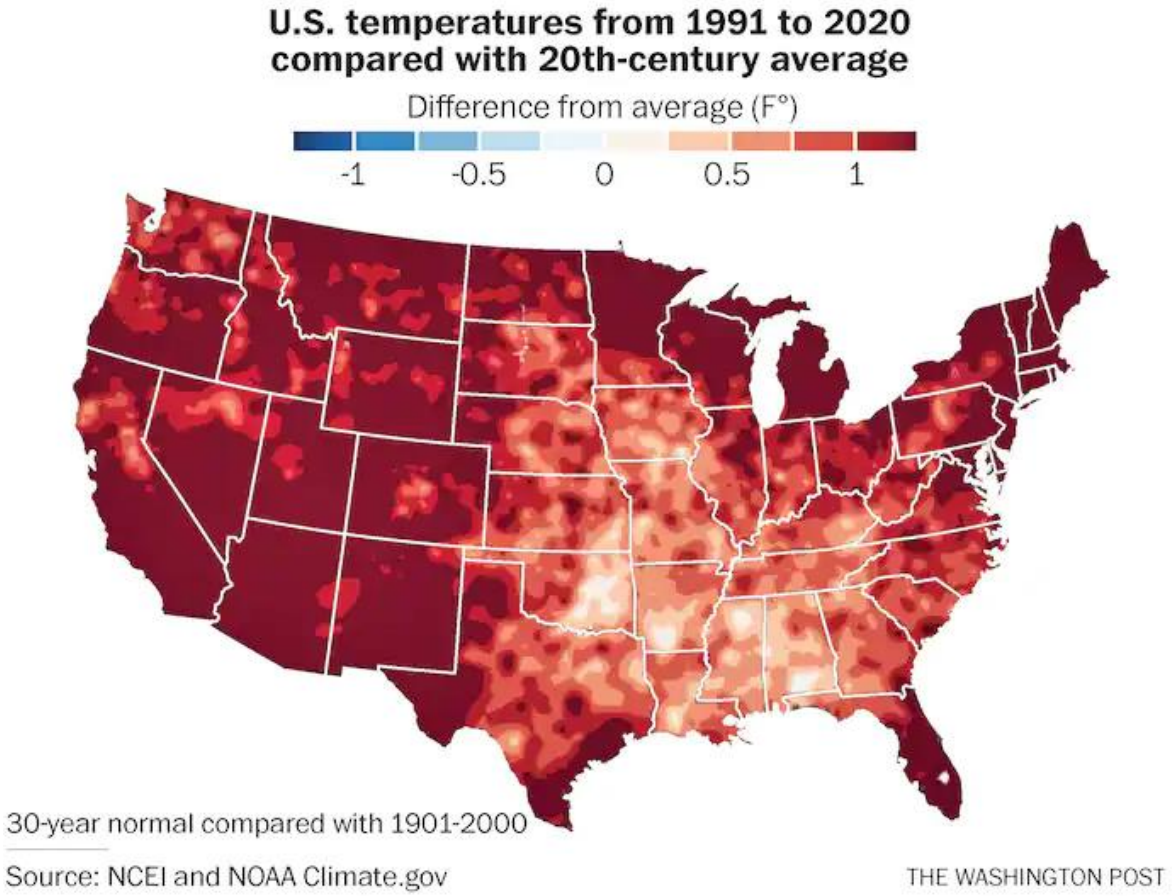
Reduced

Greatly reduced

Extirpated

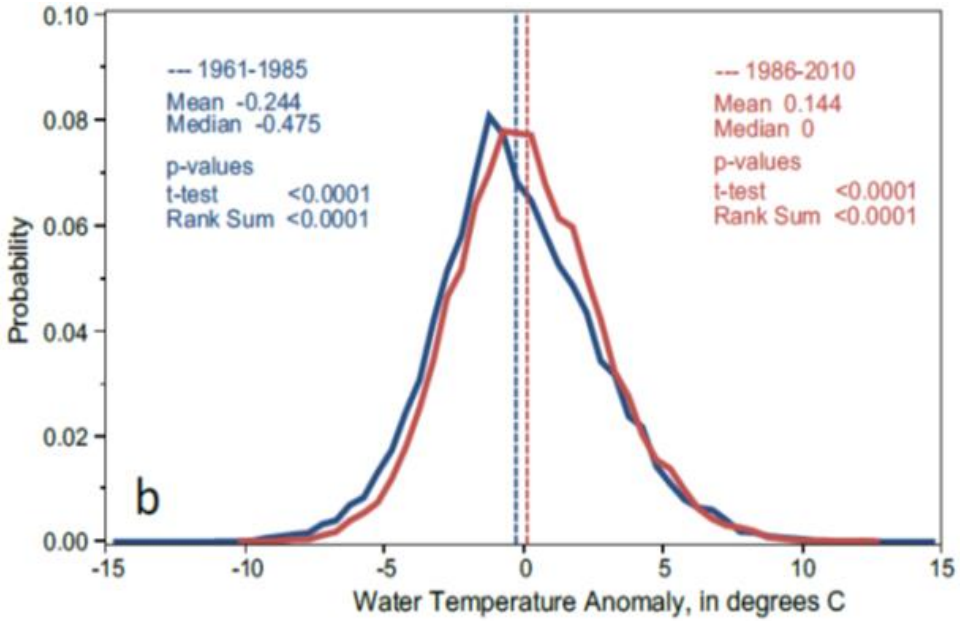
Exposure:
Stream temperature

Warming air temperatures



Exposure:
Stream temperature

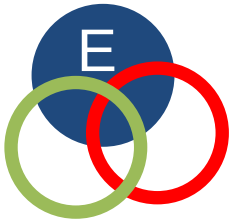
Warming stream temperatures



Rice and Jastram 2014
Climatic Change

Heat response thresholds

20 ºC: physiological stress
23 ºC: occupancy
25 ºC: lethal limit

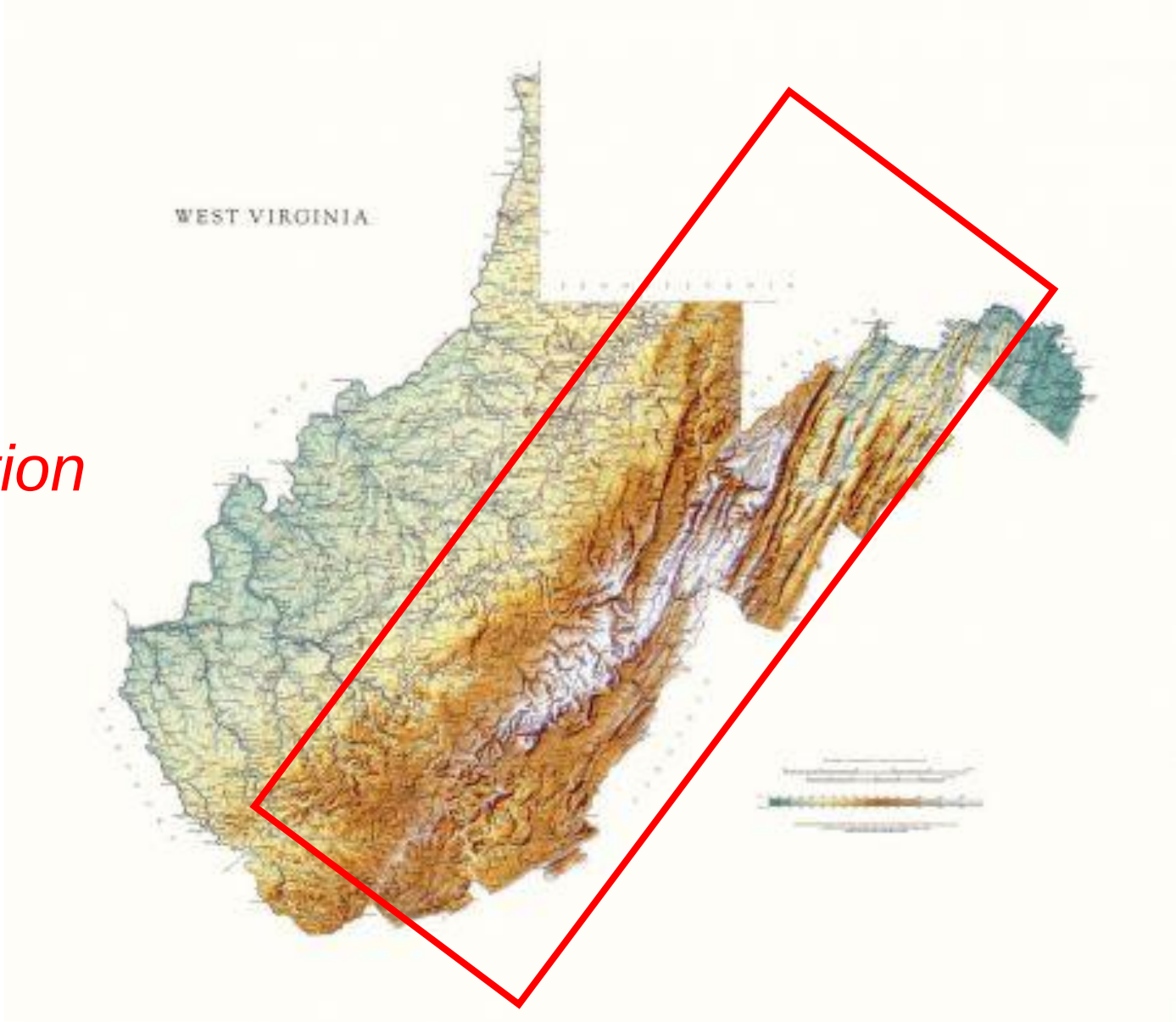


Exposure:
Stream temperature

Prior assumption:
Elevation drives stream warming via air temperature

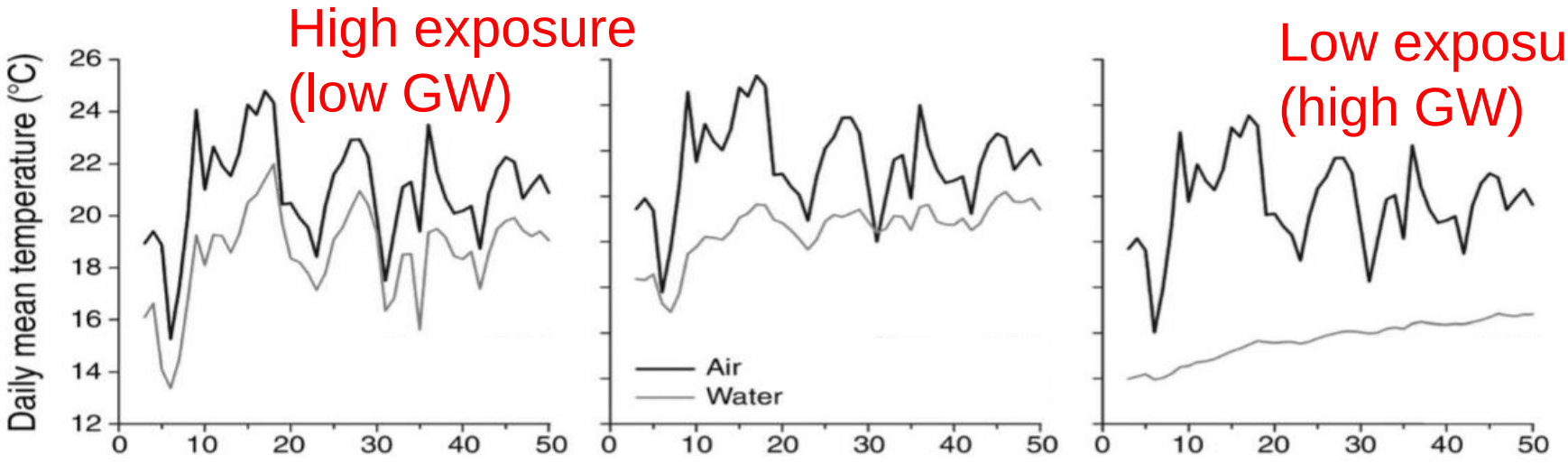
…but groundwater (GW)
can buffer air temperature effects and
is spatially and temporally complex

Elevation



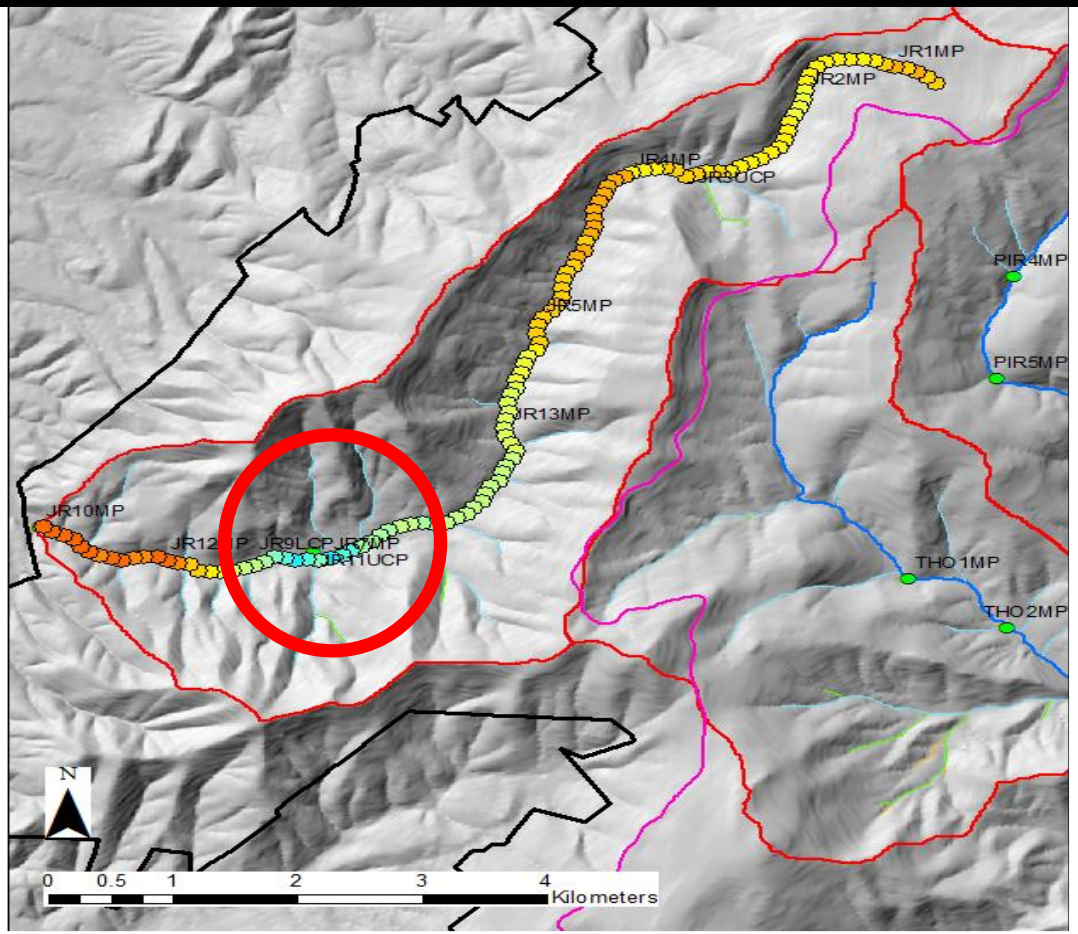
Shavers Fork of the Cheat River

Stream temperature data can predict GW buffering



Snyder et al. (2015)

Landform features predict GW in streams



Johnson et al. (2017)

- Bedrock depth
- Stream gradient
- Lateral hillslopes
- GW recharge areas
- Vegetation

Exposure:
Accounting for GW in climate change forecasts

USGS science for a changing world

Brook Trout Thermal Habitat Forecasts

Catoctin Mountain Park, Maryland & Shenandoah Valley, Virginia

Air Temperature Increase (°C): 1.5 3.0 5.0 GW Sensitivity to Air Temperature: 0.5 0.75 1.0

1. Select current or future conditions (below).
2. For future conditions, select Air Temperature Increase and Groundwater (GW) Sensitivity scenarios (above right).

Current Future

Maximum Weekly Average Temperature (MWAT)

Click on site to view data

- 23.3°C - 27.5°C
- 20.1°C - 23.2°C
- 17.6°C - 20.0°C
- 12.5°C - 17.5°C

Brook Trout thermal habitat suitability forecasts for 3 scenarios of mean annual air temperature increase (1.5, 3, and 5°C) and 3 scenarios of groundwater sensitivity to air temperature (0.5, 0.75, 1.0). Red circles indicate thermal unsuitability for Brook Trout based on maximum weekly average temperature (MWAT > 23.3°C). Current conditions represent sampled data during summer 2016.

Get Publication
Get Catoctin Data and Metadata
Get Shen Valley Data and Metadata

Acknowledgements

- USGS Leetown Science Center and Natural Resource Preservation Program (NRPP) for funding
- Catoctin Mountain Park for collaboration
- D. Strong and J. Wolf (USGS) for webmap creation

Thermal habitat fragmentation

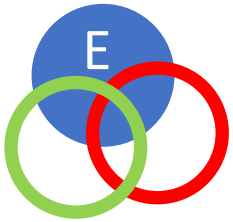
https://chesapeake.usgs.gov/fishforecast

Frederick County, WashCo MD, Esri, HERE, Garmin, INCREMENT P, NGA, USGS

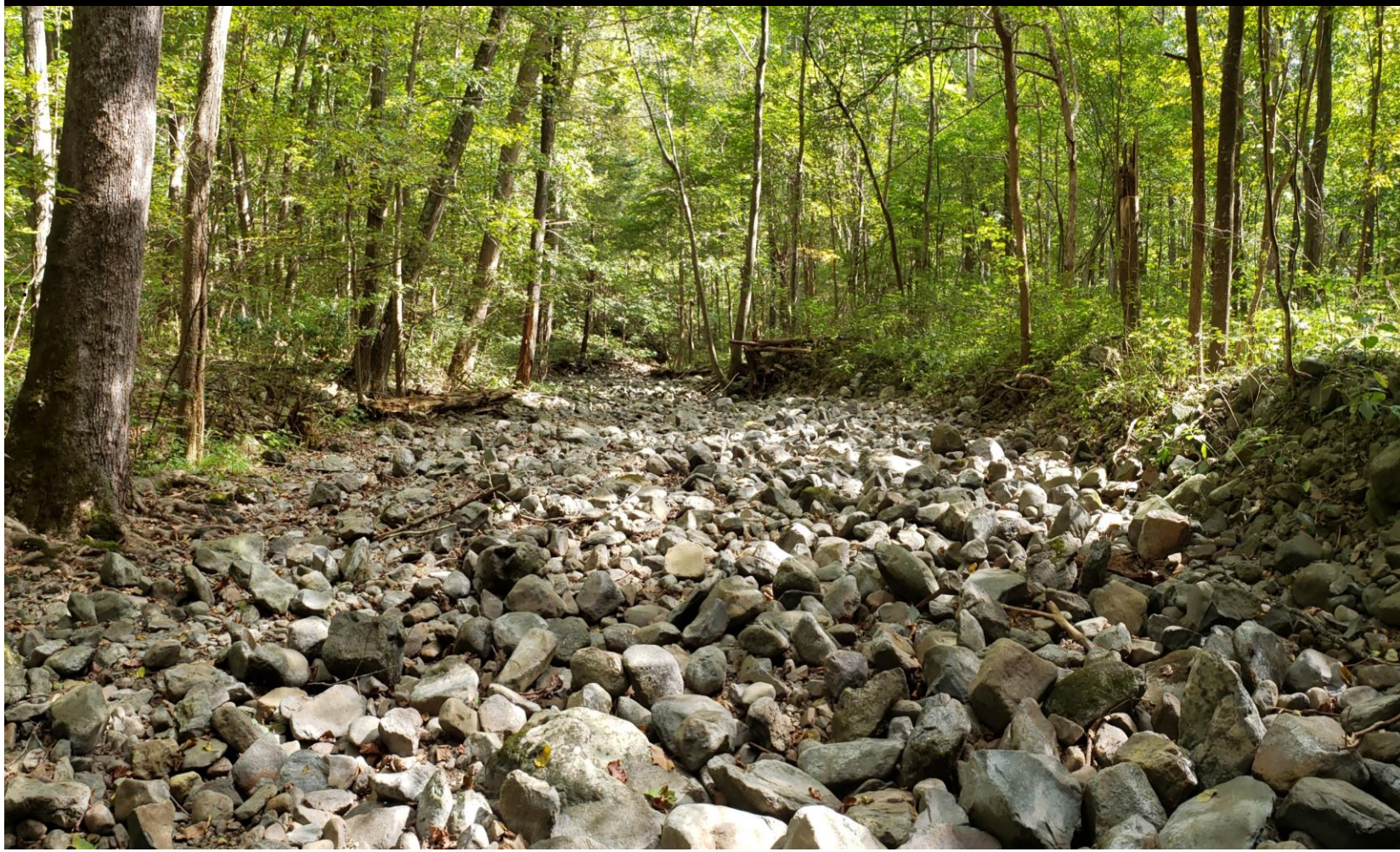
DOI Privacy Policy | Legal | Accessibility | Site Map | Contact USGS

Unsuitable

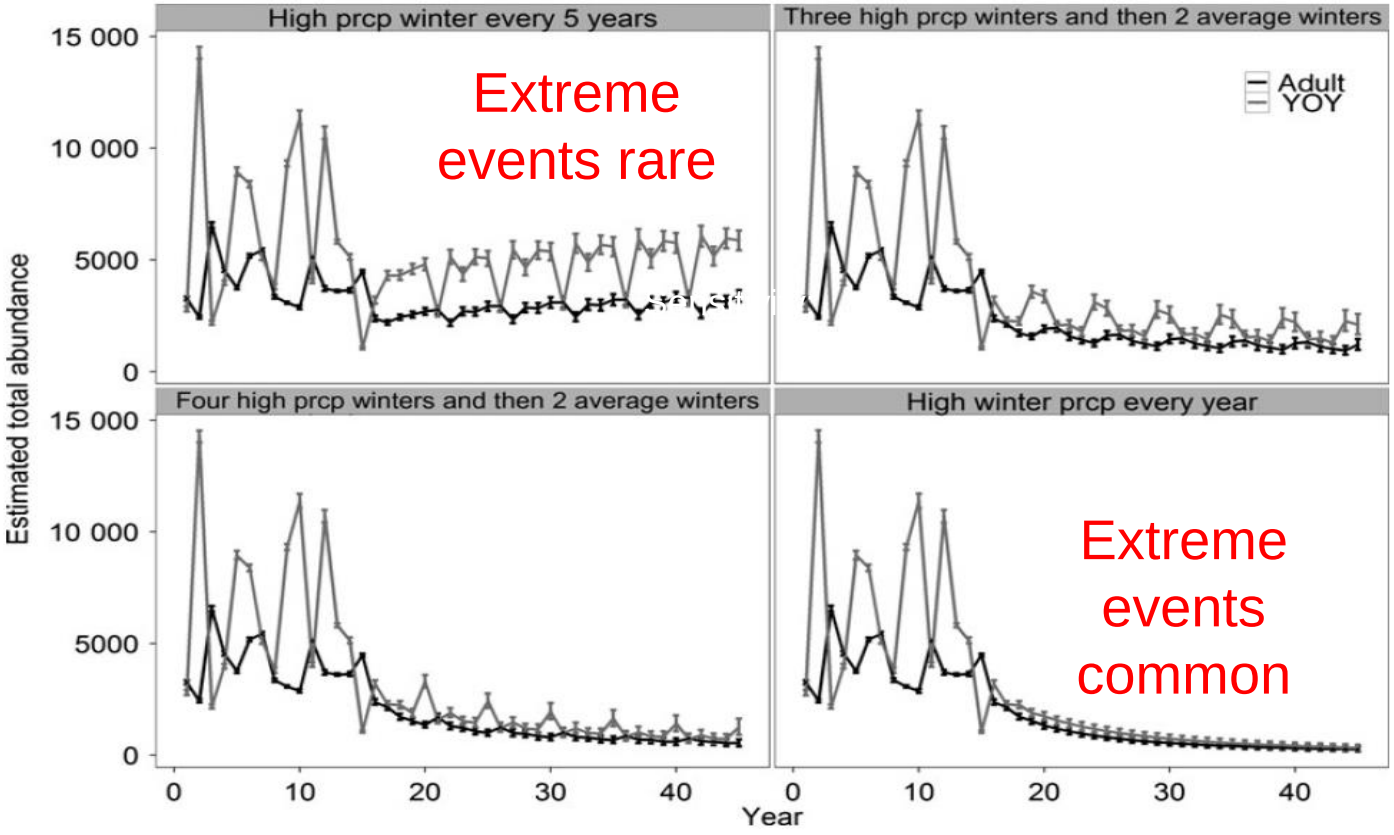
Suitable



Exposure:
Stream dewatering



Sensitivity:
Importance of multi-year flows

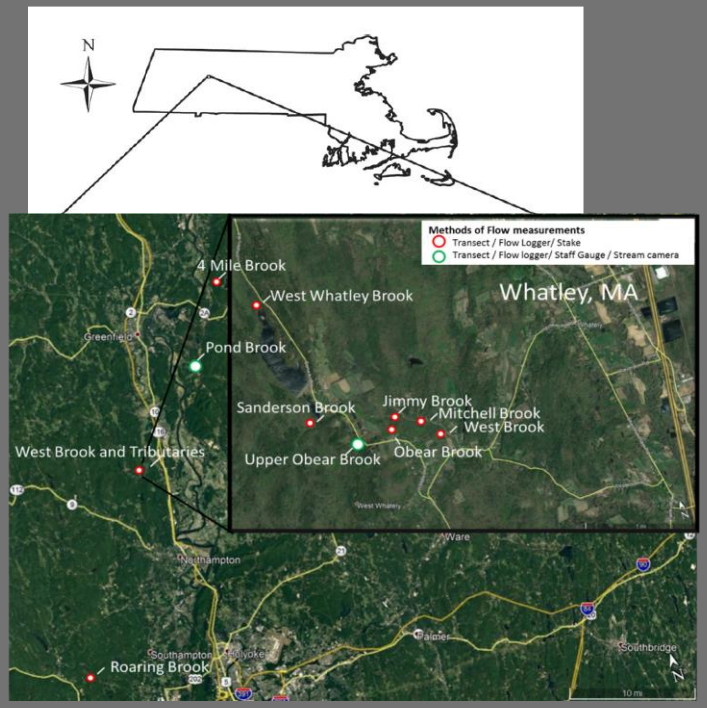


Sensitivity:
Invasive species x thermal stress

- Brook trout can use warmer water when brown trout are absent
- Effects of climate change depend on community structure

Hitt et al. (2017) CJFAS

Letcher et al. West Brook, MA Objectives



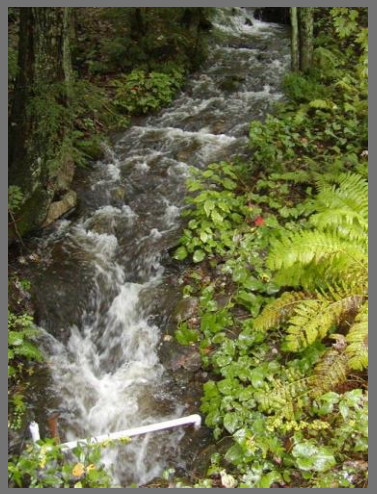
1. Quantify effects of environmental drivers on body size and trout population dynamics

2. Understand how stream flow affects early life of Brook Trout

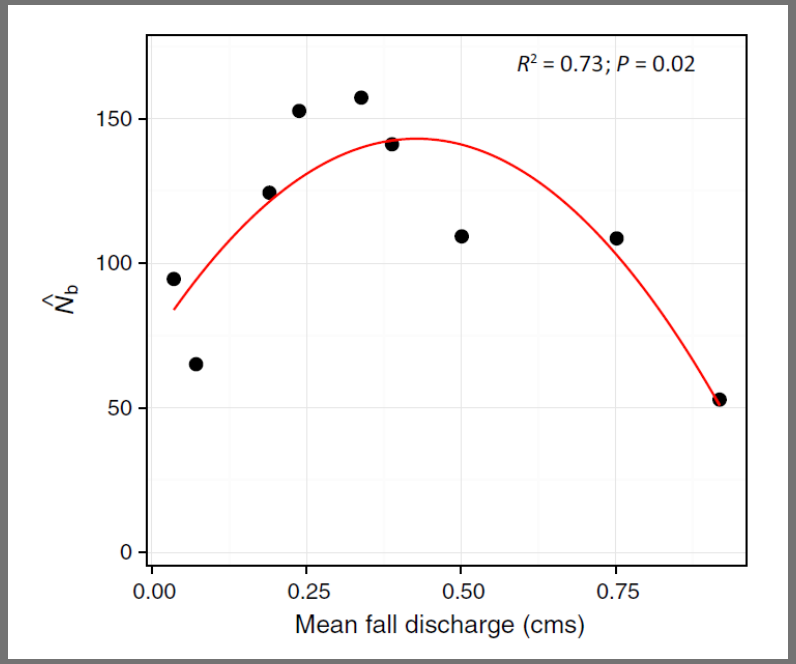
Demographic model results

2/3 of variation in abundance is due to flow and temperature (other 1/3 is fish density)

- Decreased survival from warmer temperatures
- Lower abundance → larger fish
- Higher flow in summer and fall → larger fish

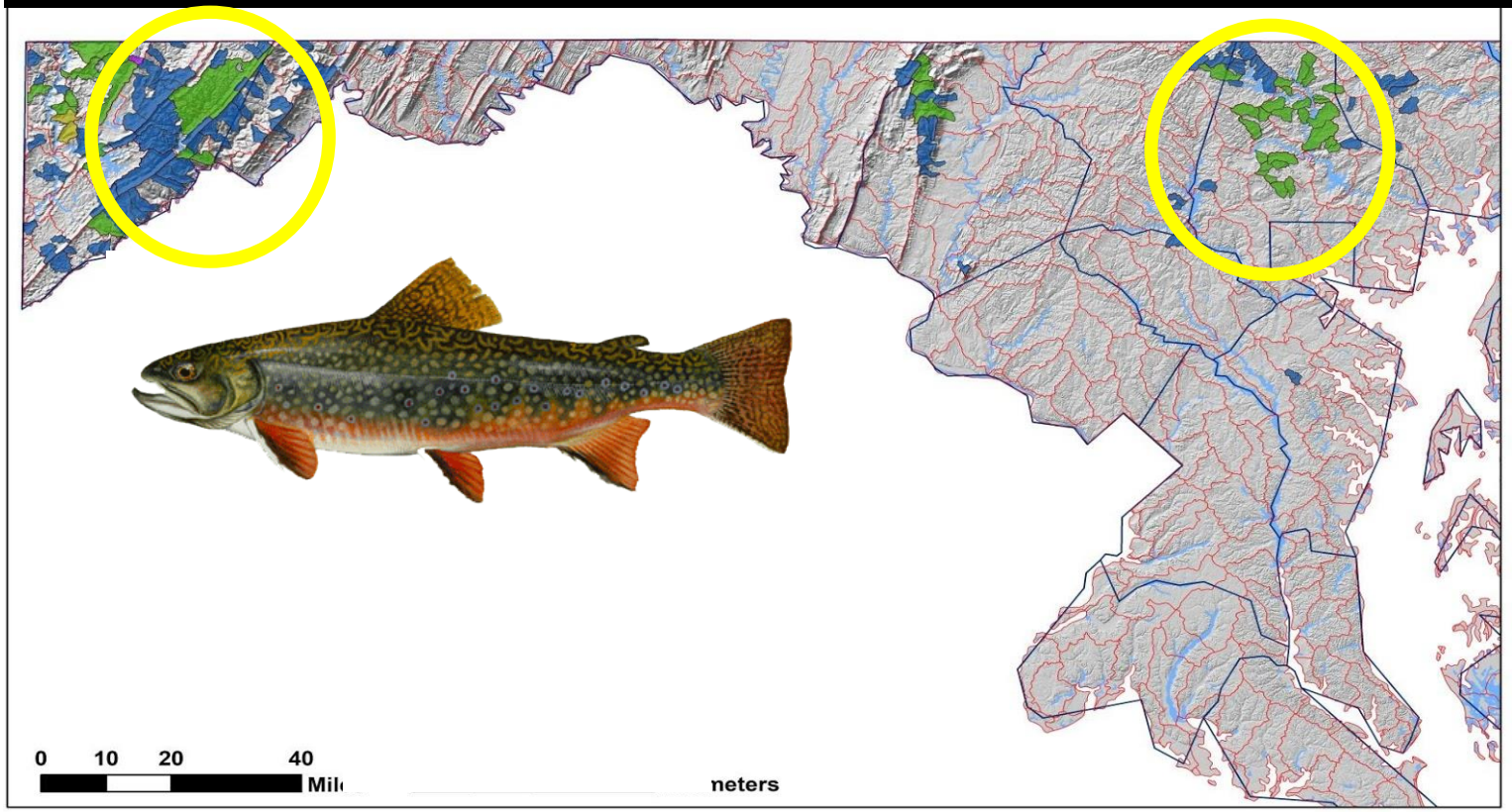


Number of breeders N_b

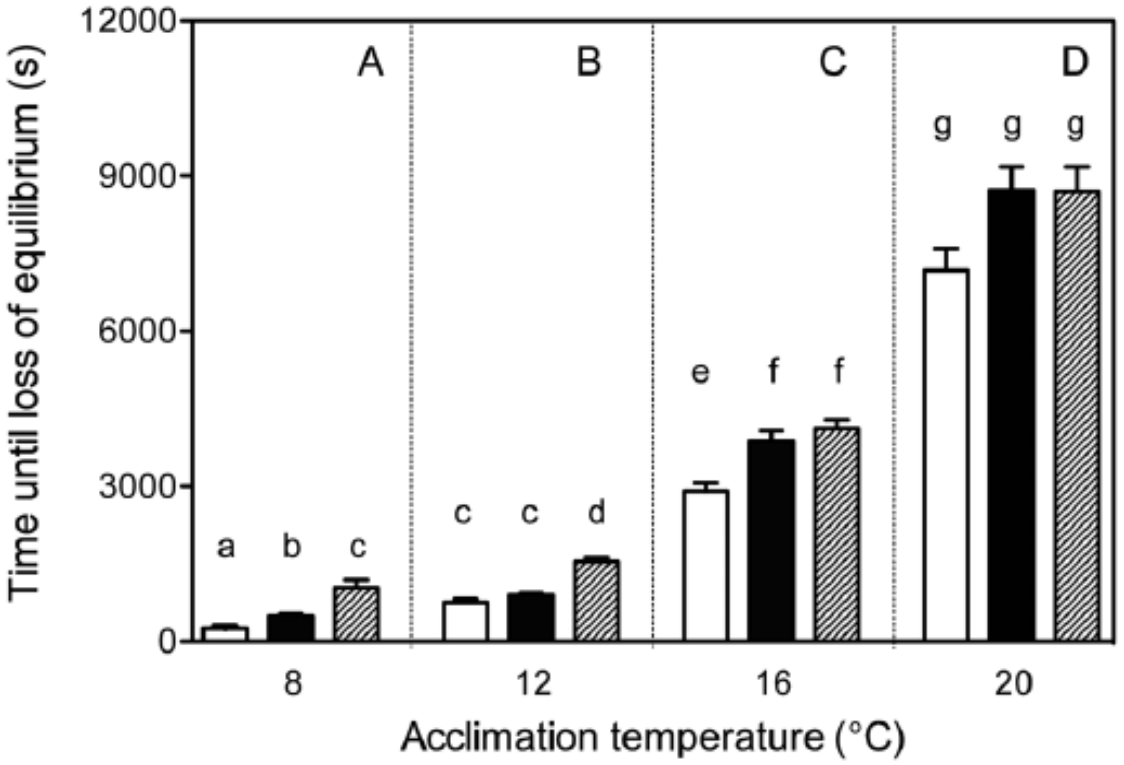


Kanno et al. 2014

Adaptive capacity:
Potential for local adaptation?



Adaptive capacity:
Potential for local adaptation?

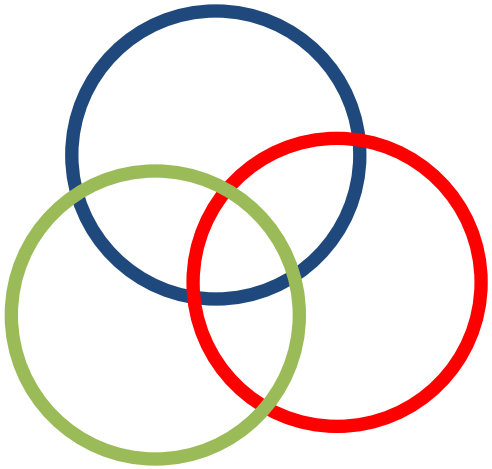


Stitt et al. 2014
Phys. Biochem. Ecol.

Conceptual model for brook trout + climate change

How and where will conditions change?

Exposure



Which populations will respond?

Sensitivity

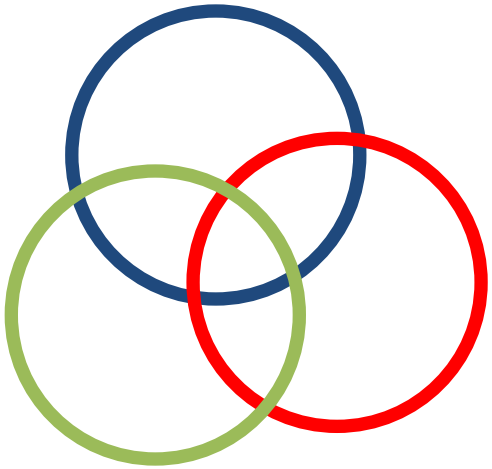
Adaptive capacity

Will evolutionary change enable persistence?

Where are we most/least confident?

Exposure

- *High certainty at landscape level*
- *Low certainty in GW-influenced streams*



Sensitivity

- *High certainty for single-year effects*
- *Low certainty for multi-year effects*

Adaptive capacity

- *Low certainty*


Questions?
faulkners@usgs.gov