Synthesis Element 1

# Water Temperature Effects on Fisheries and Stream Health in Non-Tidal Waters

**Contributors**: Steve Faulkner, USGS; Frank Borsuk, EPA; Kevin Krause, USGS; Rosemary Fanelli, USGS; Matthew Cashman, USGS; Than Hitt, USGS; Greg Pond, EPA; Benjamin Letcher USGS;

- Identify knowledge gaps, missing resources, and develop recommendations to mitigate detrimental impacts.

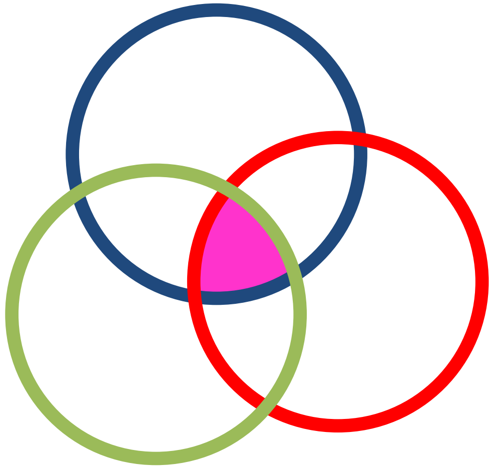
- Overview information
- Key findings
- Discussion Questions

# Conceptual model to assess effects of rising water temperatures on aquatic organisms

*Where will temperatures increase and by how much?*

Exposure

*Which populations will respond?*



Sensitivity

Adaptive capacity

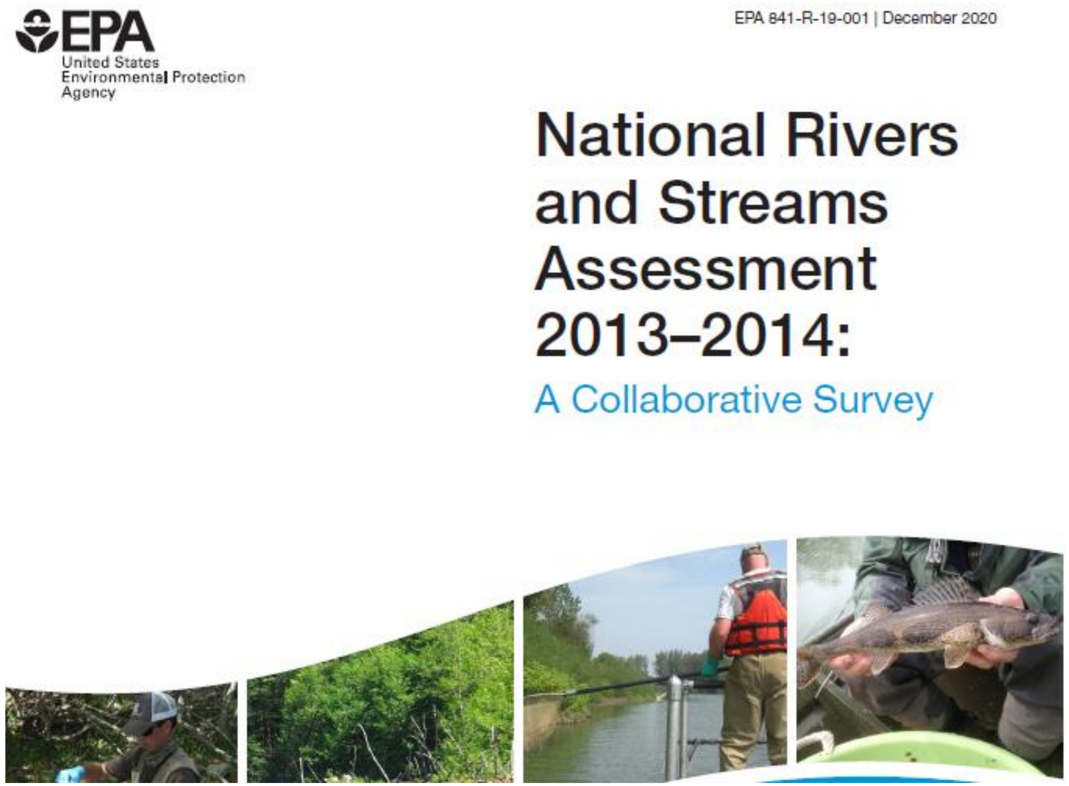
*Will evolutionary change enable persistence?*

*Adapted from Foden et al. 2013. PLOS One*

# Approach

- Initial literature review (not comprehensive)

- Expert Opinion
  - Questionnaire
  - Arm-twisting

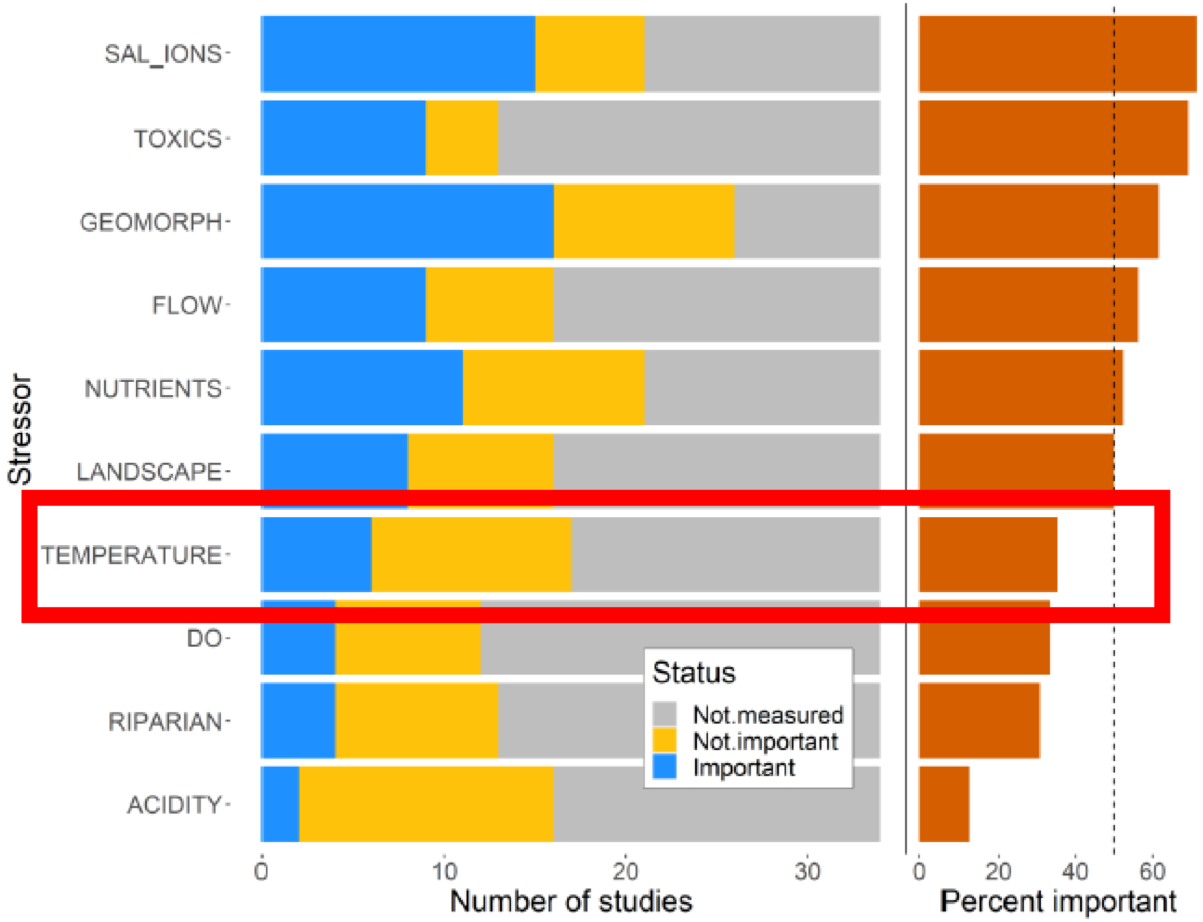


# Key Findings - Fish

**Lit review analysis results**

- Number of studies that measured the stressor
- Number of studies that reported the stressor as important
- Percent of studies that measured the stressor and reported it as important based on their statistical analysis

*Note: each study is weighed equally; may not reflect differences in study design and environmental conditions (# sites or presence of other stressors)*




*Provisional results, for feedback only*

Fanelli, Cashman, Porter, in prep

# Key Findings - Fish

U.S. Environmental Protection Agency. 2020. National Aquatic Resource Surveys. National Rivers and Streams Assessment 2013–2014.

| COM_NAME | TEMP_NRSA | | COM_NAME | TEMP_NRSA | COM_NAME | TEMP_NRSA |
|---|---|---|---|---|---|---|
| SLIMY SCULPIN | CD | | SHIELD DARTER | CL | SHORTHEAD REDHORSE | CL |
| BROWN TROUT | CD | | ROSYFACE SHINER | CL | POTOMAC SCULPIN | CL |
| BROOK TROUT | CD | | MOTTLED SCULPIN | CL | BLUE RIDGE SCULPIN | CL |
| RAINBOW TROUT | CD | | RAINBOW DARTER | CL | REDSIDE DACE | CL |
| BURBOT | CD | | LOGPERCH | CL | CHAIN PICKEREL | CL |
| CUTTHROAT TROUT | CD | | FANTAIL DARTER | CL | SWALLOWTAIL SHINER | CL |
| LONGNOSE SUCKER | CD | | TONGUETIED MINNOW | CL | ALLEGHENY PEARL DACE | CL |
| ATLANTIC SALMON | CD | | LONGHEAD DARTER | CL | STONECAT | CL |
| E. BLACKNOSE DACE | CL | | BLACKSIDE DARTER | CL | BLACKNOSE SHINER | CL |
| CREEK CHUB | CL | | W. BLACKNOSE DACE | CL | BROOK STICKLEBACK | CL |
| GREENSIDE DARTER | CL | | VARIEGATE DARTER | CL | AMERICAN EEL | CL |
| LONGNOSE DACE | CL | | BANDED DARTER | CL | YELLOW PERCH | CL |
| WHITE SUCKER | CL | | SILVER SHINER | CL | BANDED KILLIFISH | CL |
| COMMON SHINER | CL | | MIMIC SHINER | CL | WALLEYE | CL |
| CUTLIPS MINNOW | CL | | FALLFISH | CL | MUSKELLUNGE | CL |
| TESSELLATED DARTER | CL | | COMELY SHINER | CL | SEA LAMPREY | CL |
| SMALLMOUTH BASS | CL | | SPOTFIN SHINER | CL | NORTHERN PIKE | CL |
| RIVER CHUB | CL | | SPOTTAIL SHINER | CL | AMERICAN SHAD | CL |
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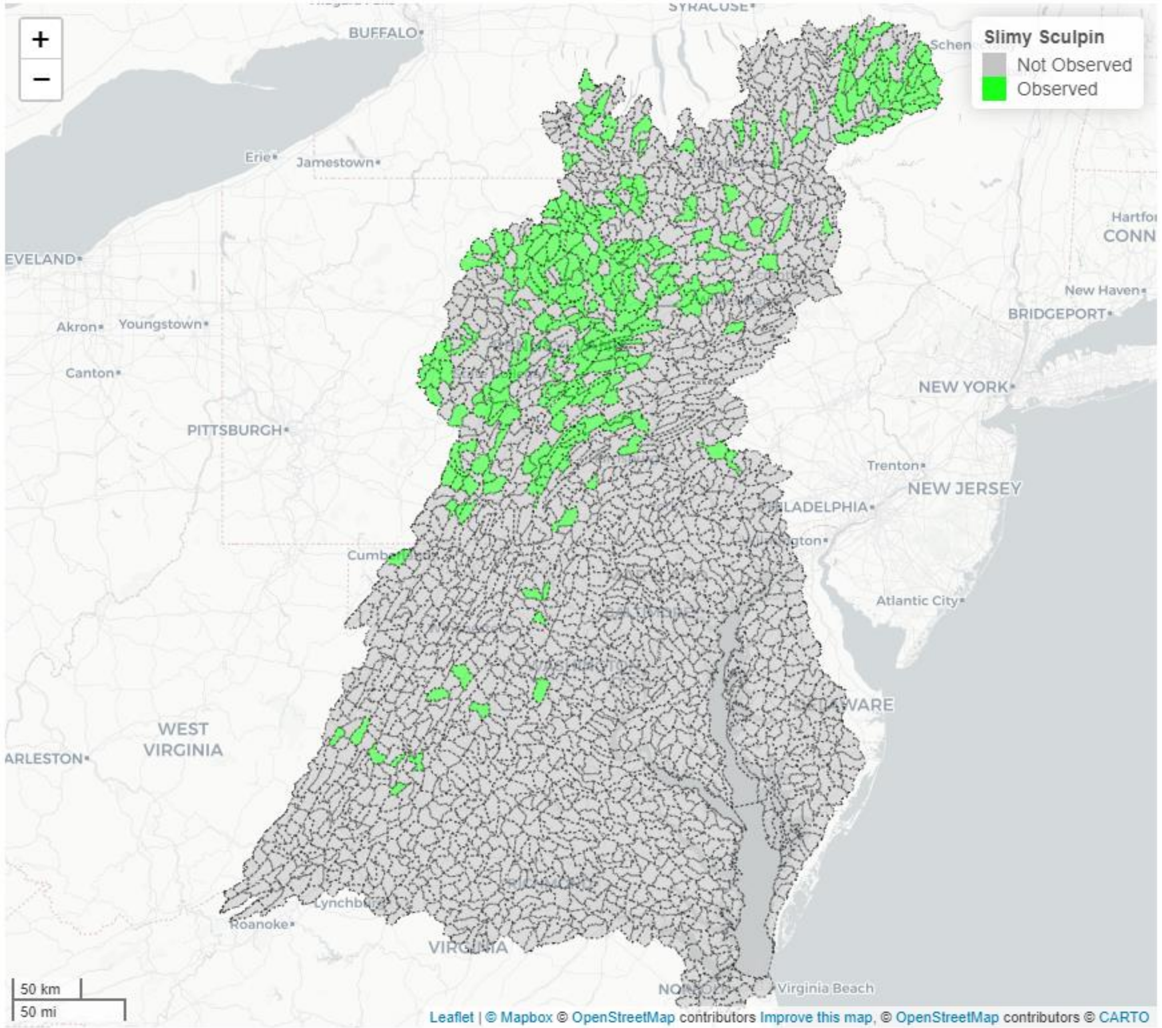
# Key Findings – Fish

- For most species, general categorical data, little quantitative
- Further Exploration
  - Metrics – Critical thermal maxima (CTM) vs. more relevant ecological attributes
    - Both physiological stress and competitive stress increase with higher temps
  - Life stage – warmer water may help spawning/fry of coldwater species
  - Indirect Effects/Interactions – Loss of more sensitive prey species reduces predator population

# Geospatial Data – Fish Occurrence Maps

Slimy Sculpin

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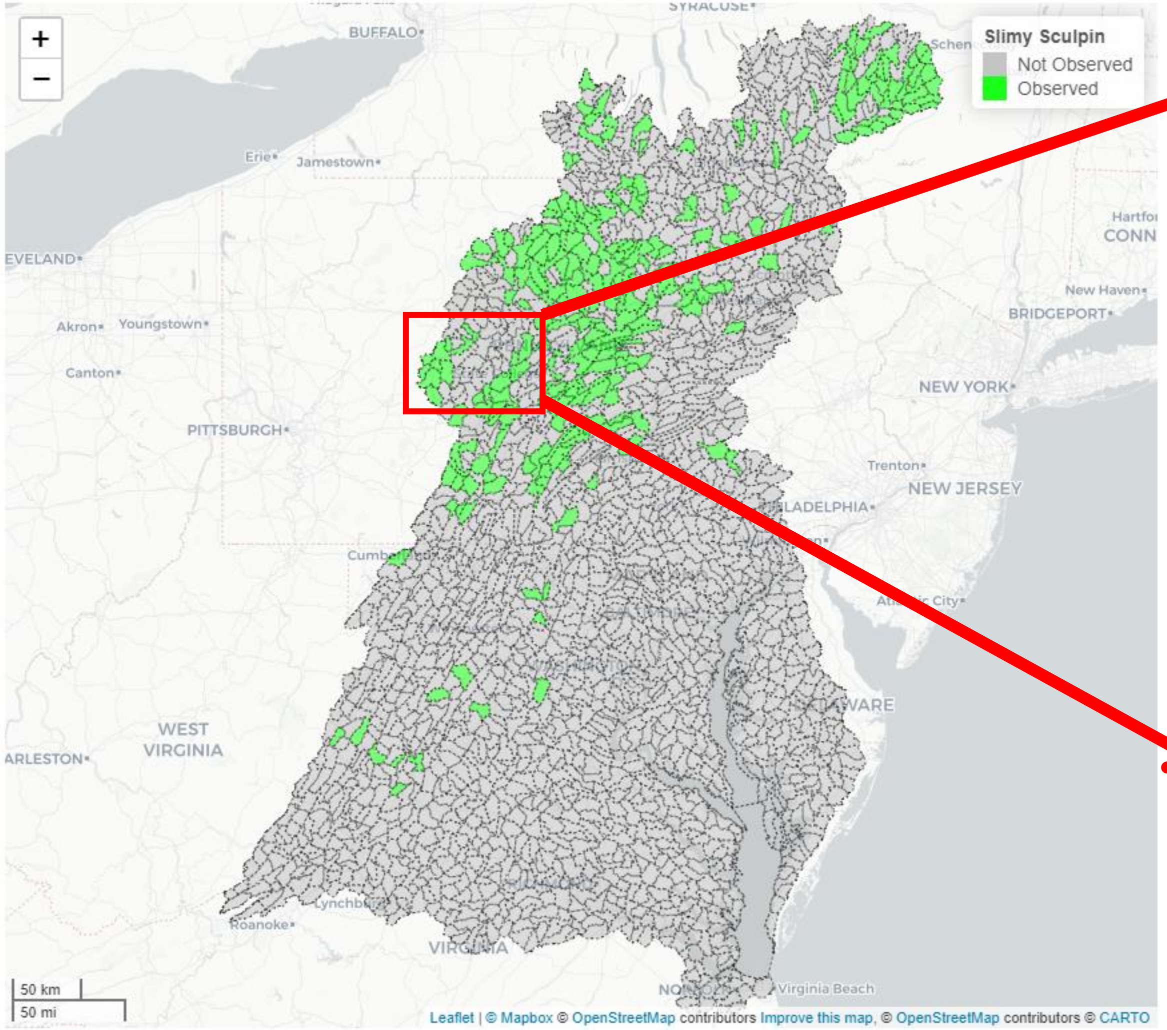


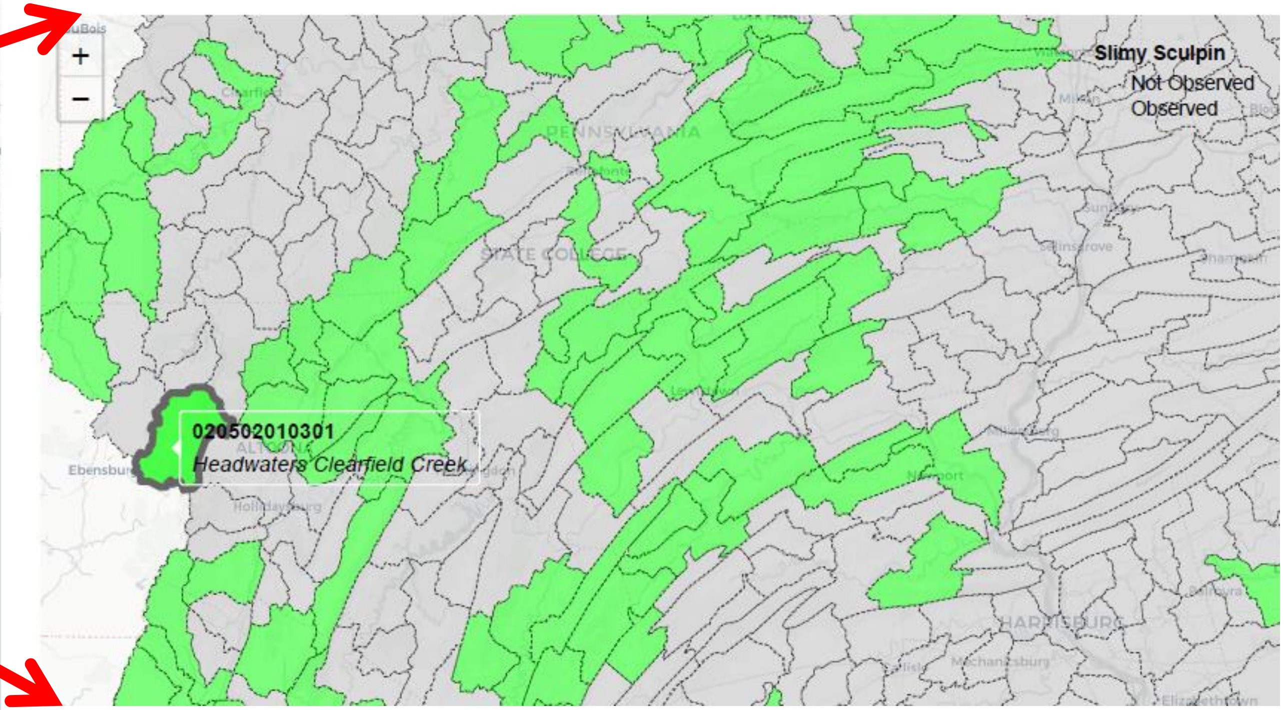


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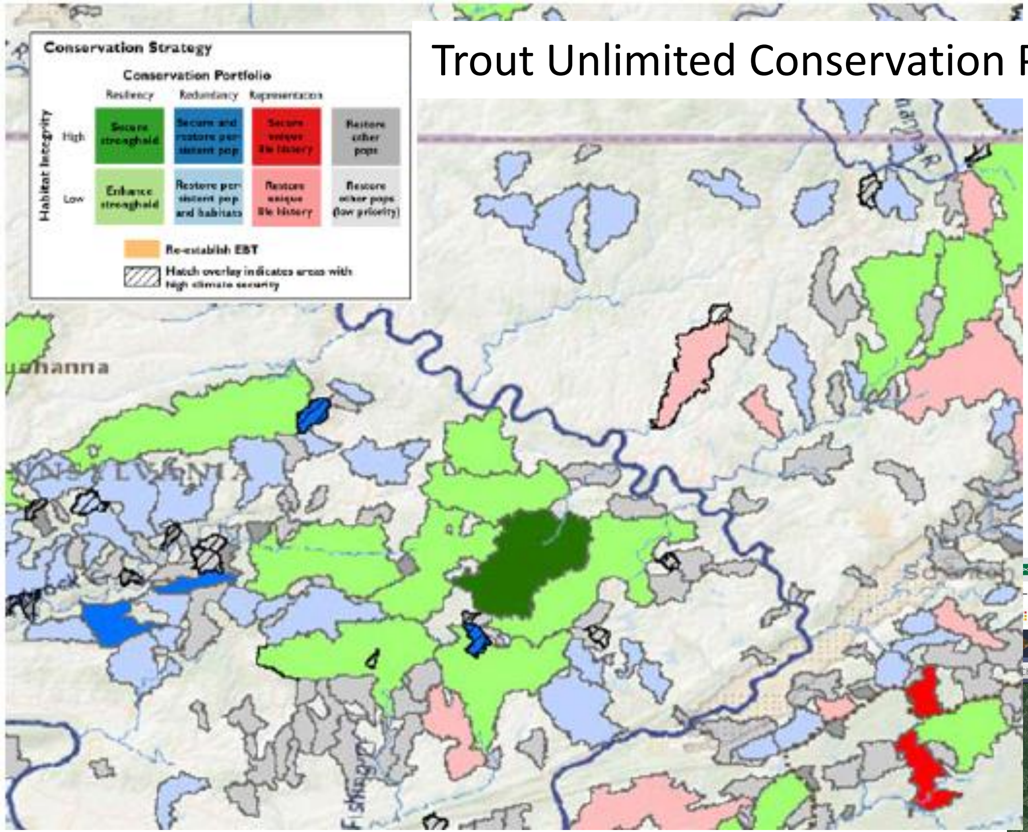
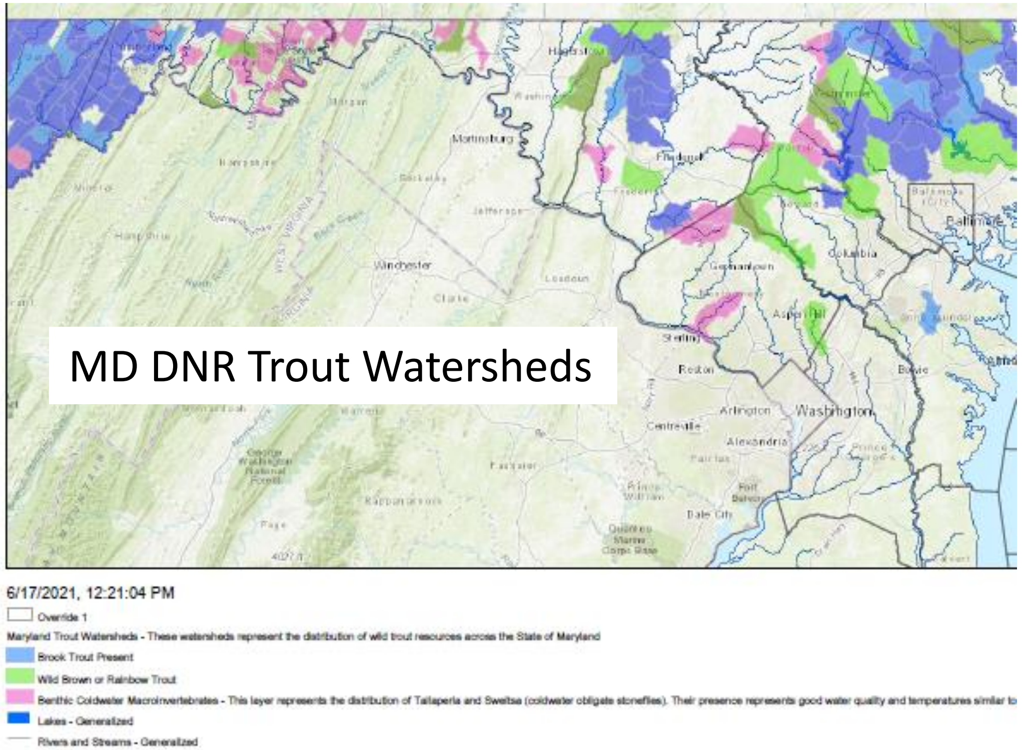
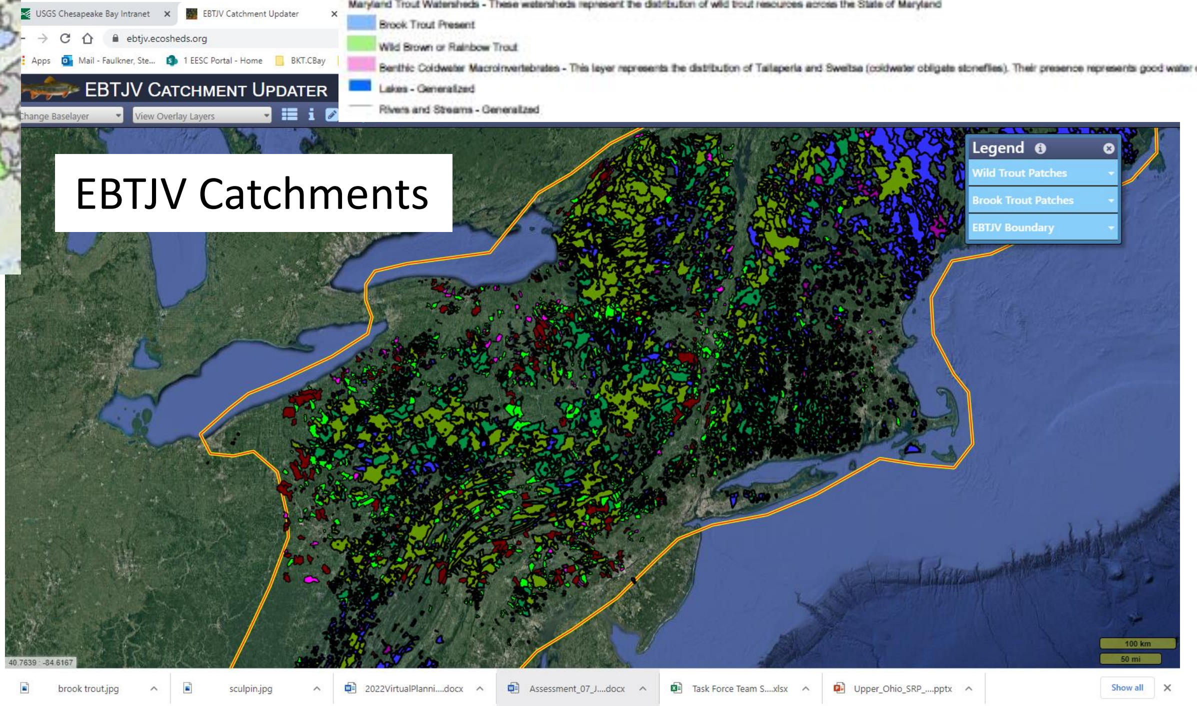
# Geospatial Data – Brook Trout




Trout Unlimited Conservation Portfolio




MD DNR Trout Watersheds




EBTJV Catchments

# Geospatial Data – Stream Temperature, Brook Trout Occupancy

https://ecosheds.org/models/stream-temperature/latest/

Bayesian model predicts daily stream temperature based on catchment characteristics and climate conditions

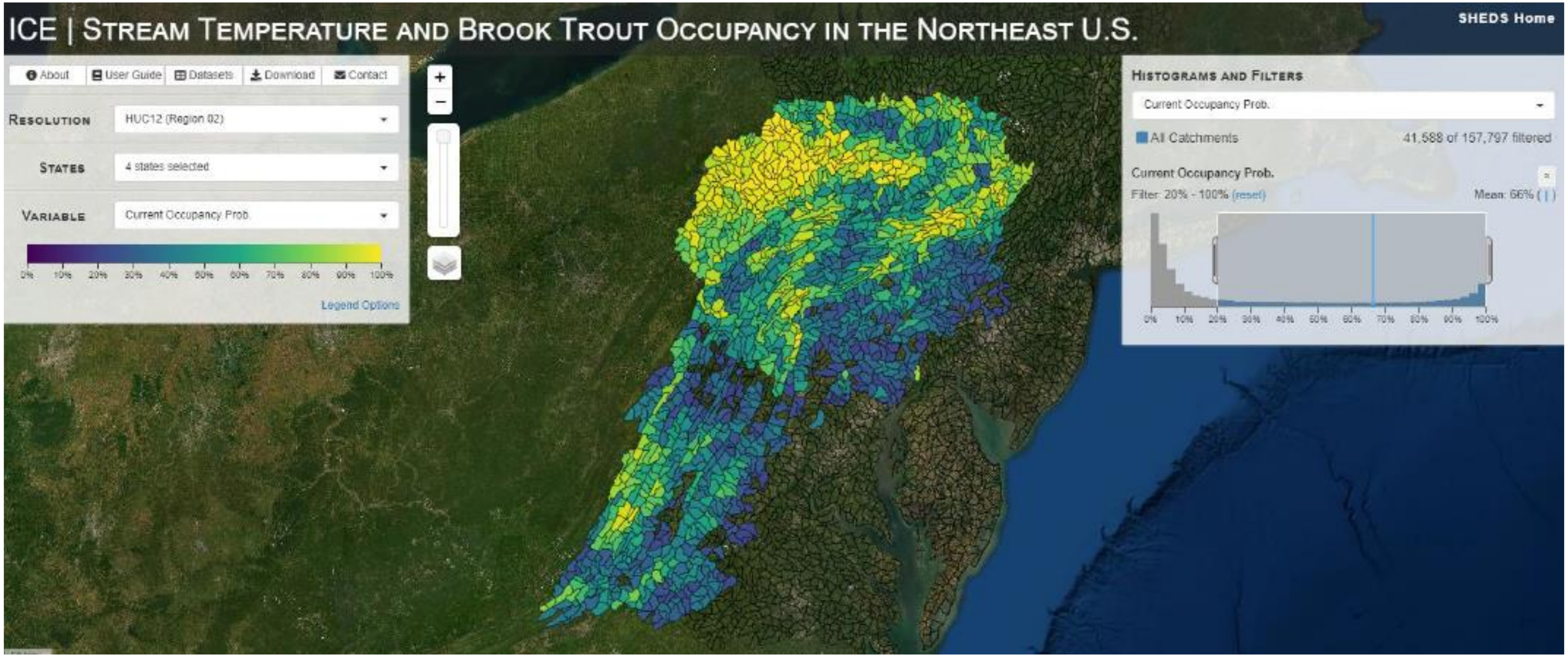
| Variable | Description |
|---|---|
| intercept | Intercept |
| AreaSqKM | Total Drainage Area (km2) |
| impoundArea | Impounded Drainage Area (km2) |
| agriculture | Agricultural Land Cover (%) |
| devel_hi | High Development Land Cover (%) |
| forest | Riparian (200 ft Buffer) Forest Cover (%) |
| prcp2 | 2-day Precipitation (mm) |
| prcp30 | 30-day Precipitation (mm) |

Letcher, et al. 2016. “A Hierarchical Model of Daily Stream Temperature Using Air-Water Temperature Synchronization, Autocorrelation, and Time Lags.” *PeerJ* 4: e1727. https://doi.org/10.7717/peerj.1727.

# Interactive Catchment Explorer (ICE)

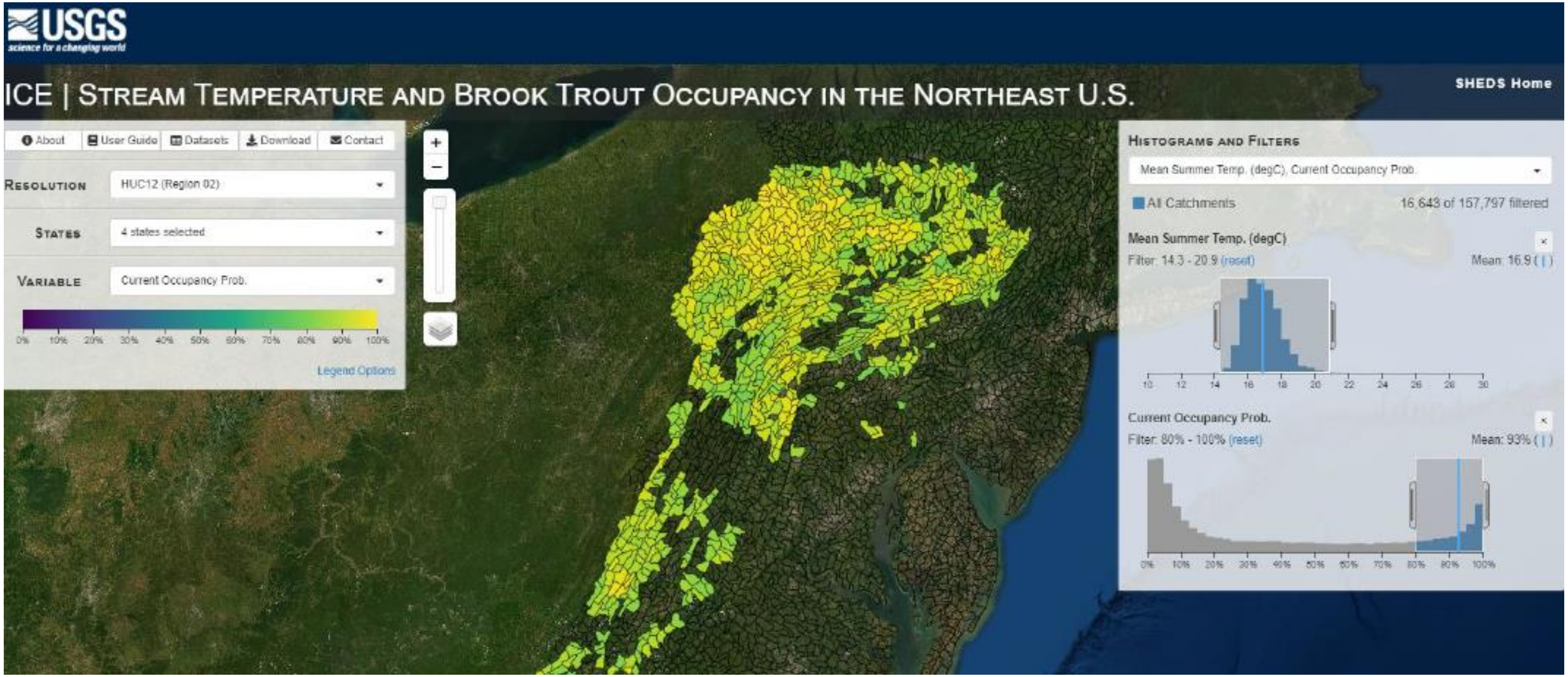
www.usgs.gov/apps/ecosheds/ice-northeast

ICE is a dynamic visualization tool for exploring catchment characteristics, model predictions, and identifying priority catchments



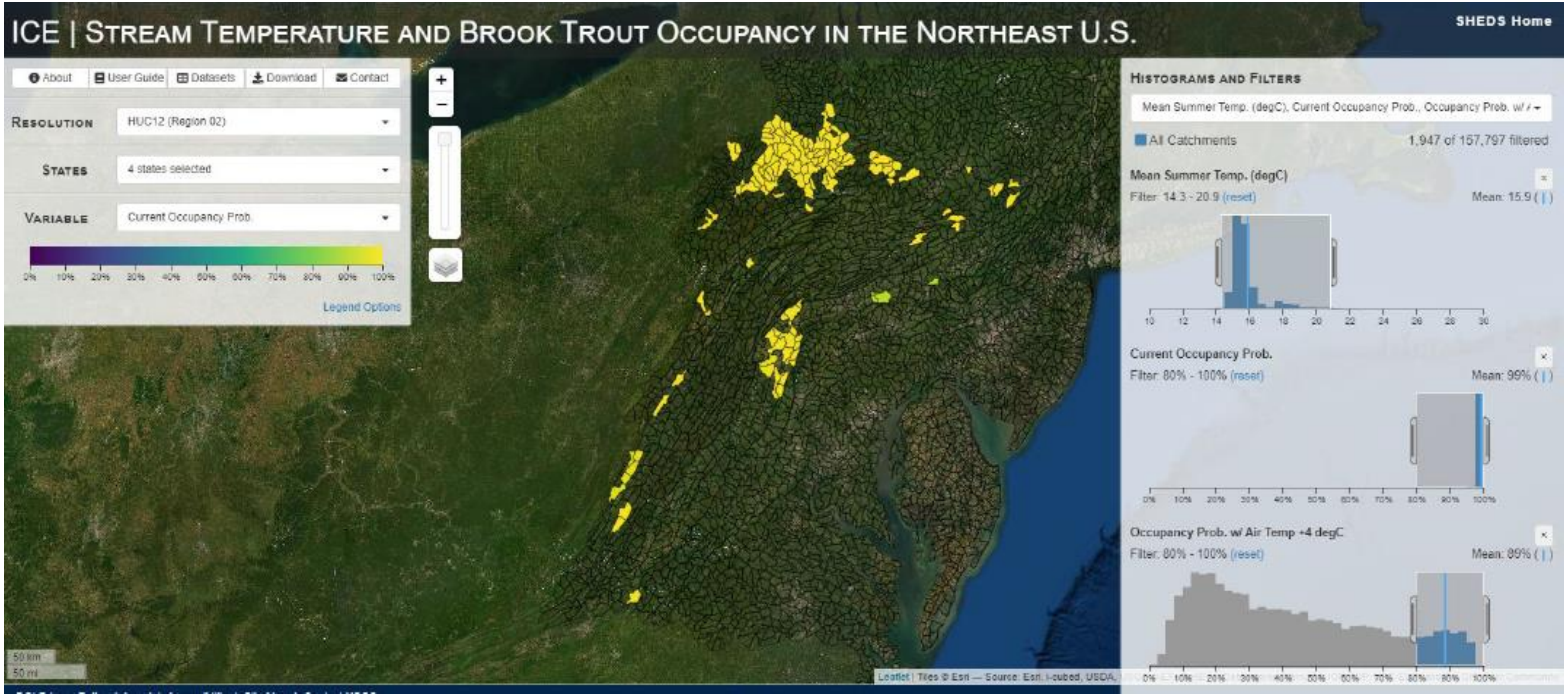
# Interactive Catchment Explorer (ICE)

## Catchments in MD, PA, WV, VA with 80-100% Occupancy Probability

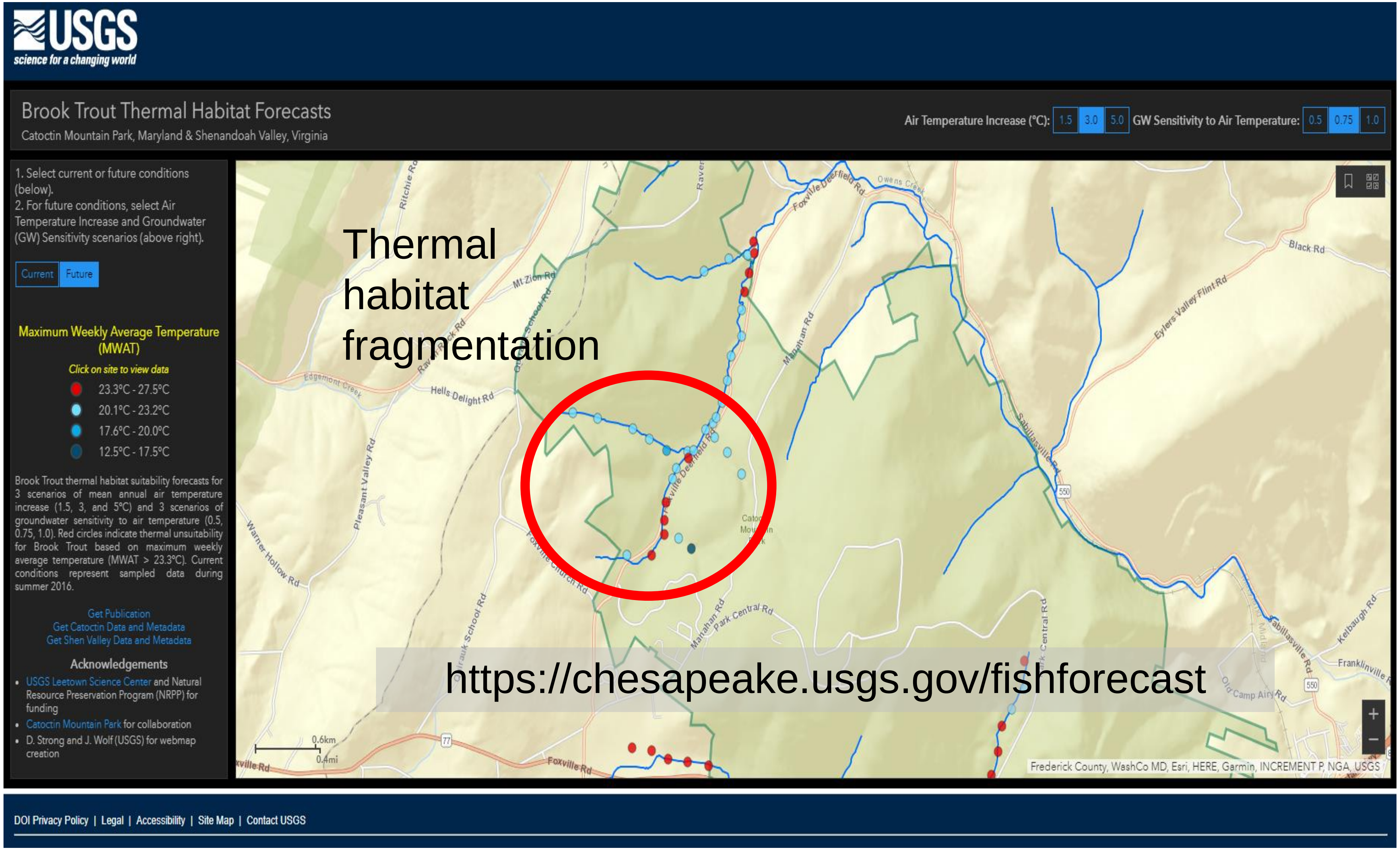


# Interactive Catchment Explorer (ICE)

## Occupancy Probability with +4 $^{o}$C Air Temperature



# Accounting for groundwater effects on brook trout habitat




Unsuitable

Suitable

# Key Findings - Macroinvertebrates/Mussels

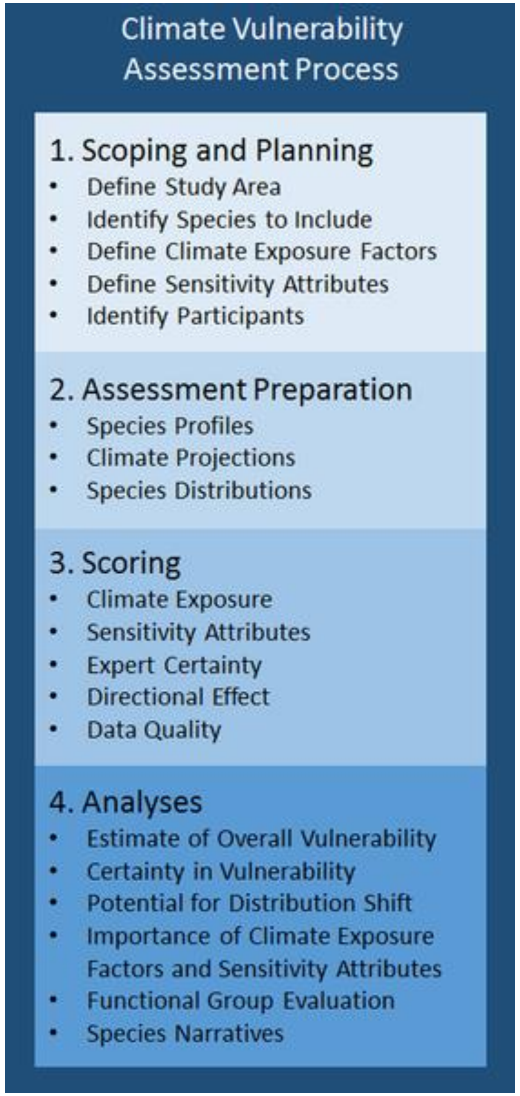
- Recent findings suggest that many freshwater mussel species in the southeastern United States are already living close to their upper thermal tolerances (Kwak 2012).

- A need exists to develop a strategy to obtain and classify the thermal tolerance information on the resident freshwater mussels within the Chesapeake Bay watershed as this information is currently limited.

- Recent findings suggest that the thermal tolerance information on the benthic macroinvertebrates is limited and unknown. Currently, the benthic macroinvertebrate are broadly classified in coldwater, coolwater and warmwater categories. However, these classifications are limited due to it being based on Genus-level identification data.

- Need to develop a strategy to obtain and classify the thermal tolerance information on the resident freshwater benthic macroinvertebrates within the Chesapeake Bay watershed as this information is currently limited. Relevant literature on the topic includes Poff et al (2006), Vieira et al. (2006) and Fritz et al (2020).

# Many Approaches to Vulnerability Assessment




Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE 11(2): e0146756. https://doi.org/10.1371/journal.pone.0146756
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146756

# Mentimeter Discussion Questions

How should we prioritize our efforts (rank in order of higher to lower preference)?

a. Fill knowledge gaps (e.g., better understanding of temperature sensitivities) to identify at-risk species/habitats

b. Identify most effective mitigation actions/strategies

c. Pursue both a and b simultaneously