# Rising Water Temperature STAC workshop: Watershed Day 1 Summary

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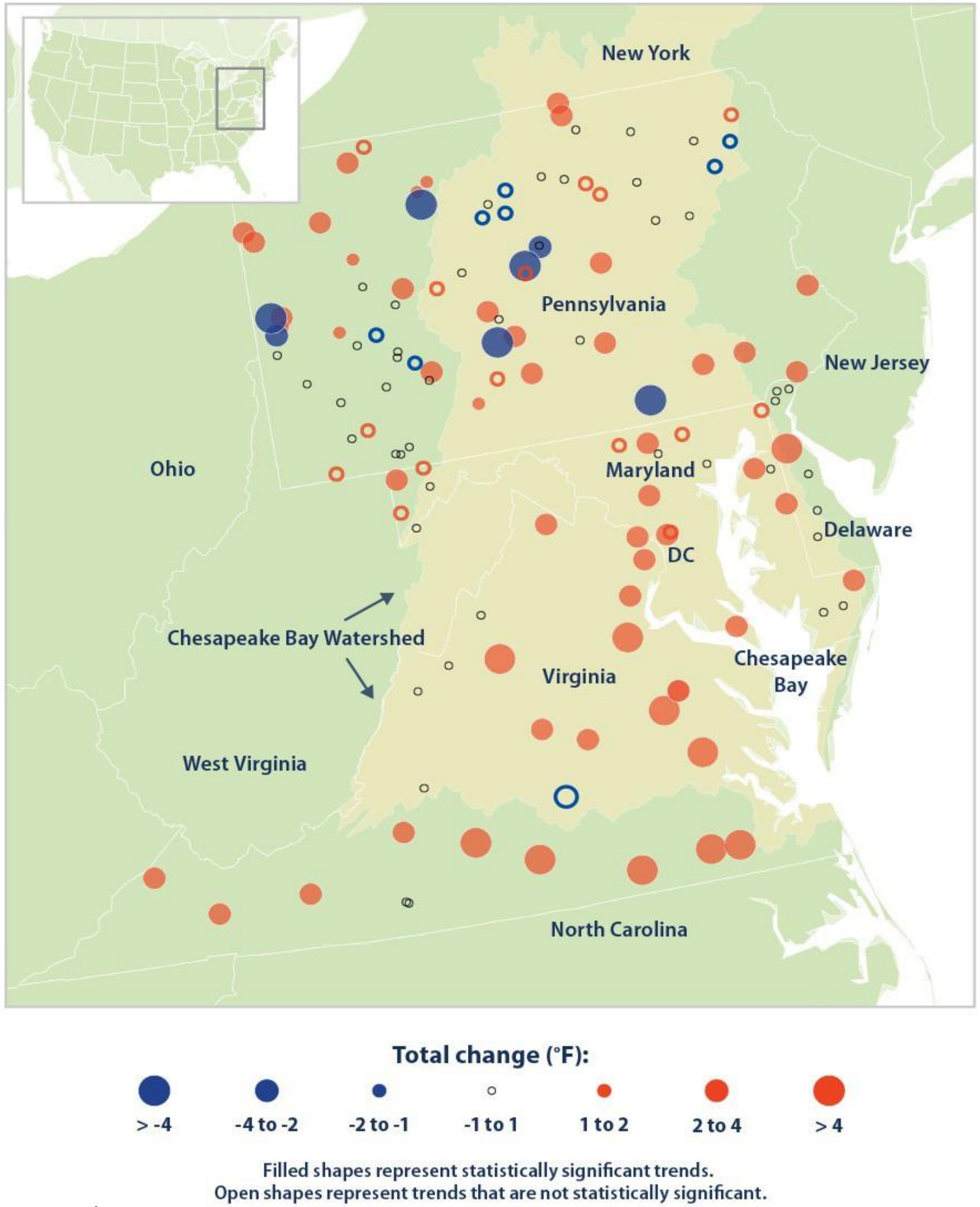
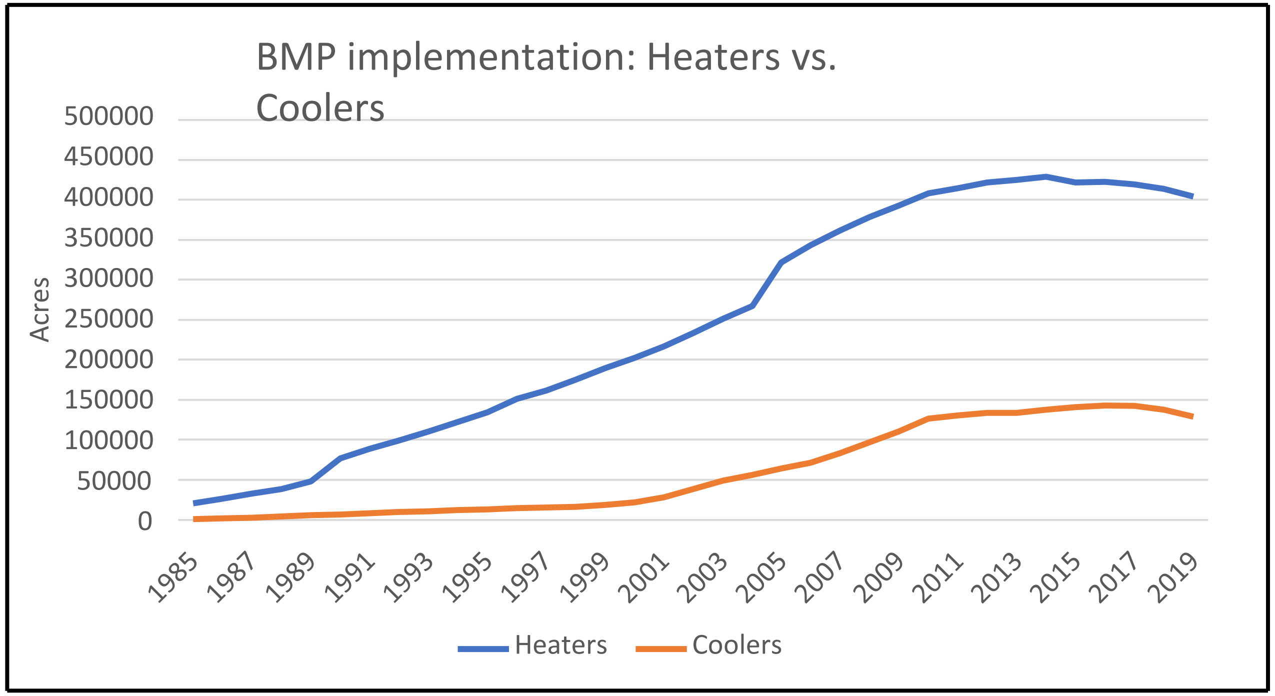
# Water temperatures have been increasing in streams and rivers of the Chesapeake Bay watershed – even more than in the Bay's tidal waters




- Sites differed, but across the watershed, water temperatures increased more than air temperatures
- USGS found an average increase of 1.98° F in air temperatures and 2.52° F in nontidal freshwater stream temperatures (from 1960 to 2010)
- Air to water temperature ratios at sites showed influence of land uses

**Source:** Rice and Jastrow 2015

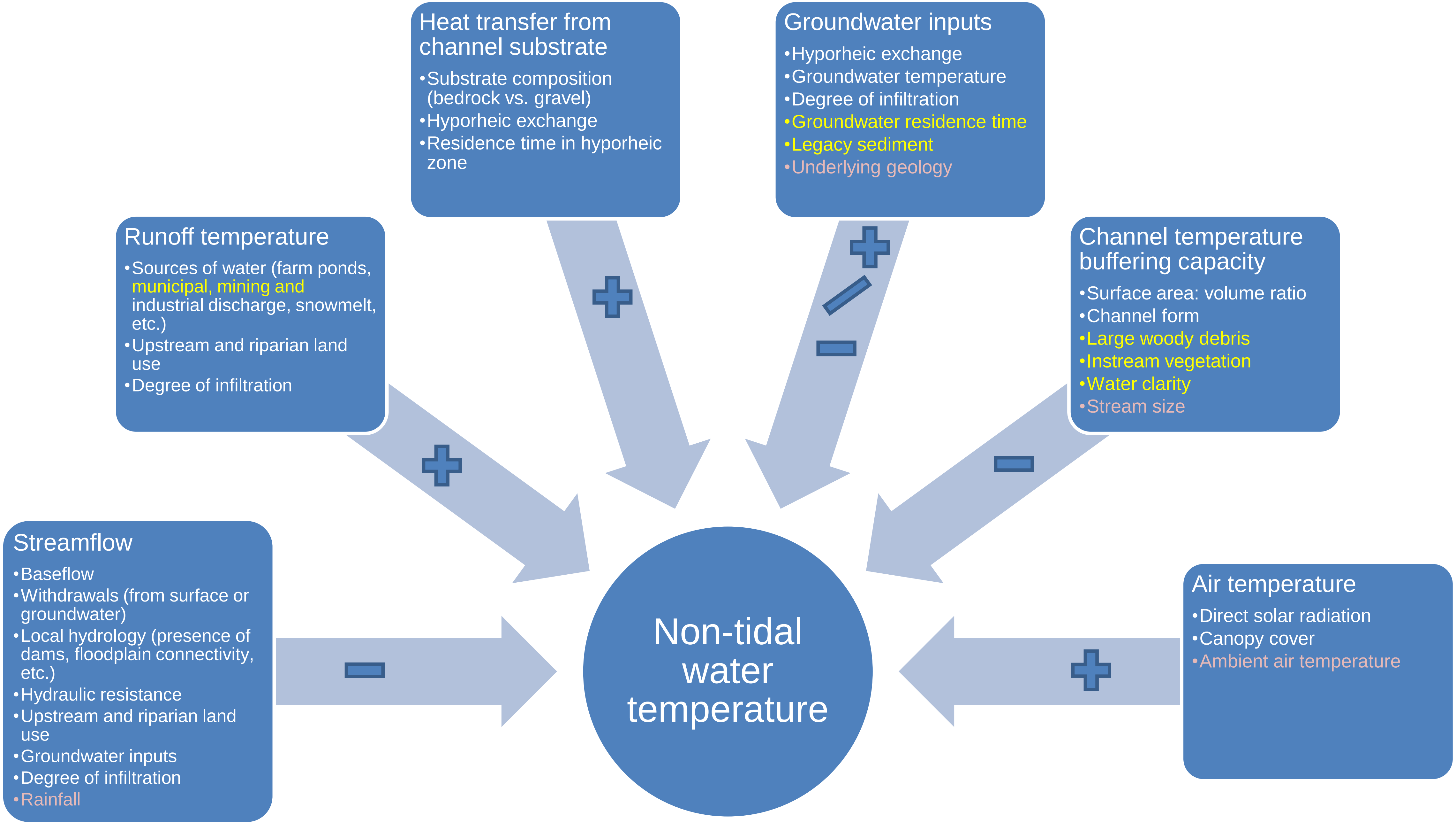
# Watershed-wide, there has been substantially greater implementation of "heater" BMPs as compared with "cooler" BMPs




In many years, there has been approximately 3x as much implementation of heaters as coolers

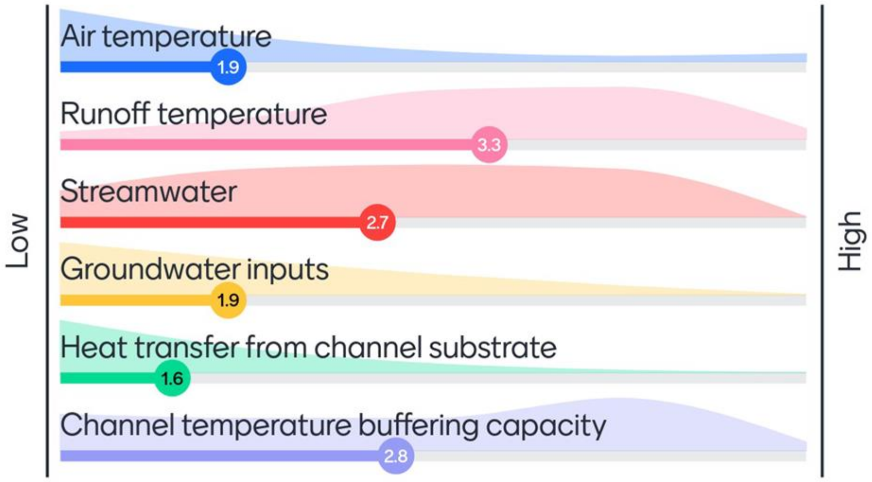
**"Heaters"** include stormwater retention ponds, floating treatment wetlands and vegetated open channels.
**"Coolers"** include riparian forest buffers, upstream tree planting, urban stormwater infiltration, and wetlands restoration, enhancement and rehabilitation.

# Increasing stream and river temperatures have been driven by rising air temperatures, but other drivers have a strong influence

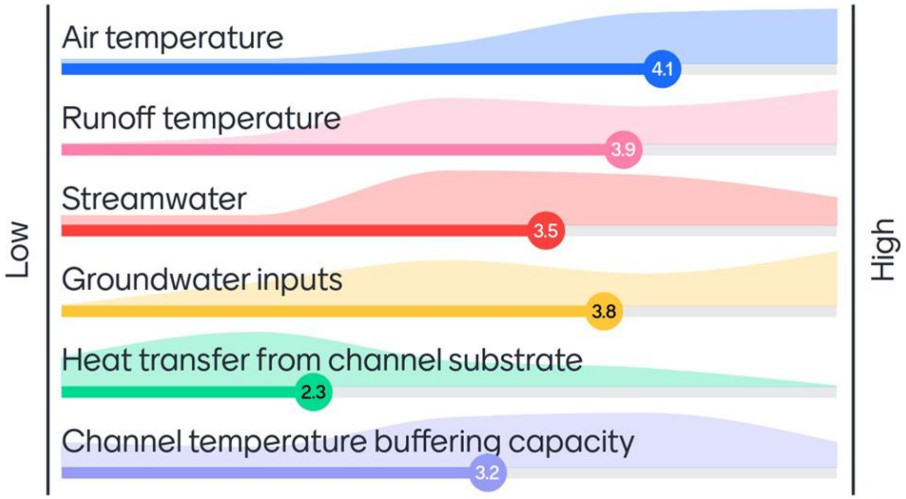


# Runoff temperature, stream flow, and channel buffering capacity are particularly relevant drivers to consider for management

## Rank drivers in terms of our ability to influence the driver




## Rank drivers in terms of their relative influence on water temperature



# Drivers of rising water temperatures: Key knowledge gaps

- Degree to which various drivers (and interactions between drivers) influence water temperature in specific sub-watersheds

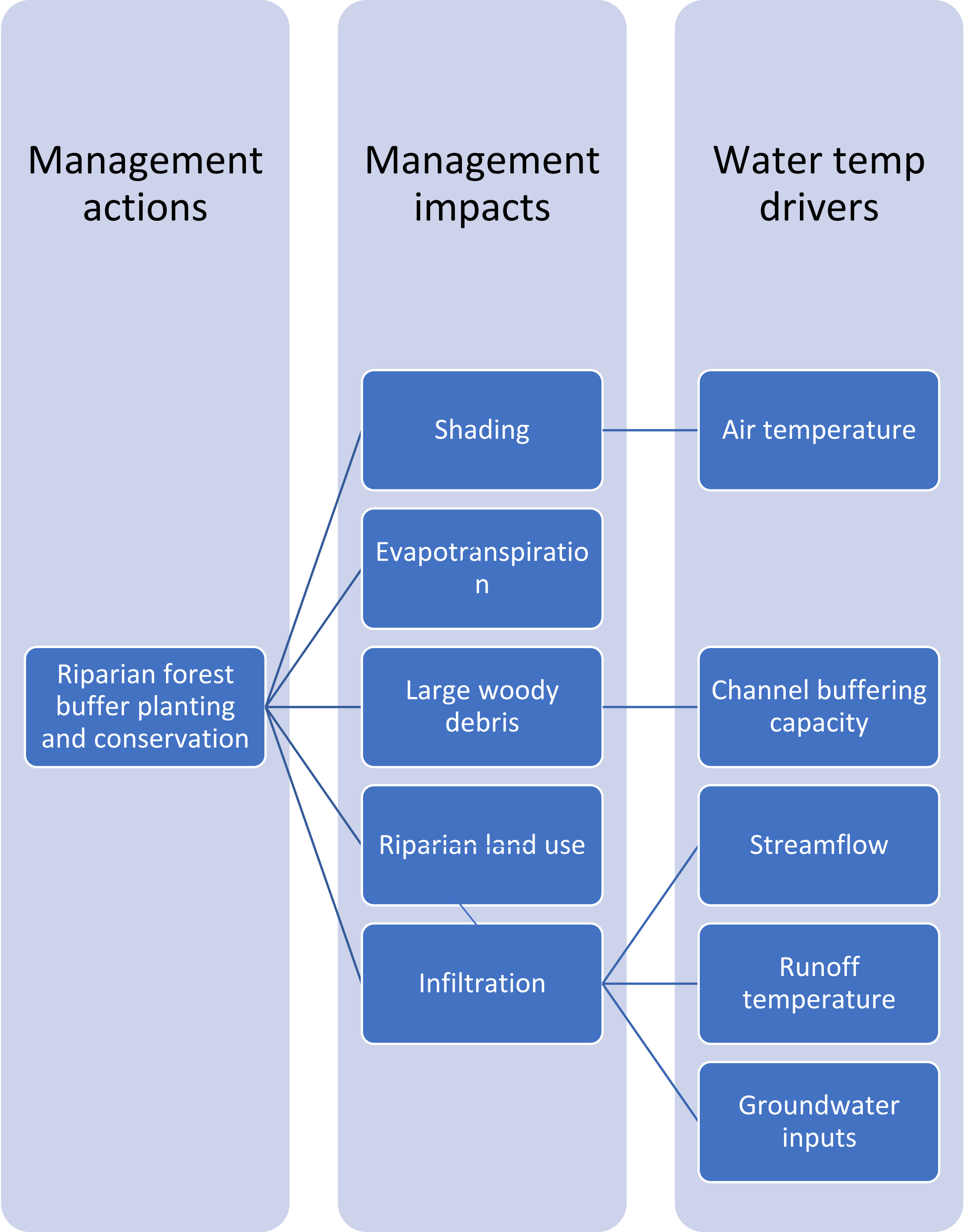
- The relative influence of BMPs on water temperature
  - Which BMPs are most effective at cooling temperatures? Can we derive temperature response curves for BMPs?
  - More information on the temperature of impacts of certain BMPs:
    - Agricultural infiltration and soil health practices
    - Stream restoration
    - Wetlands

- Regional/subwatershed models of groundwater inputs

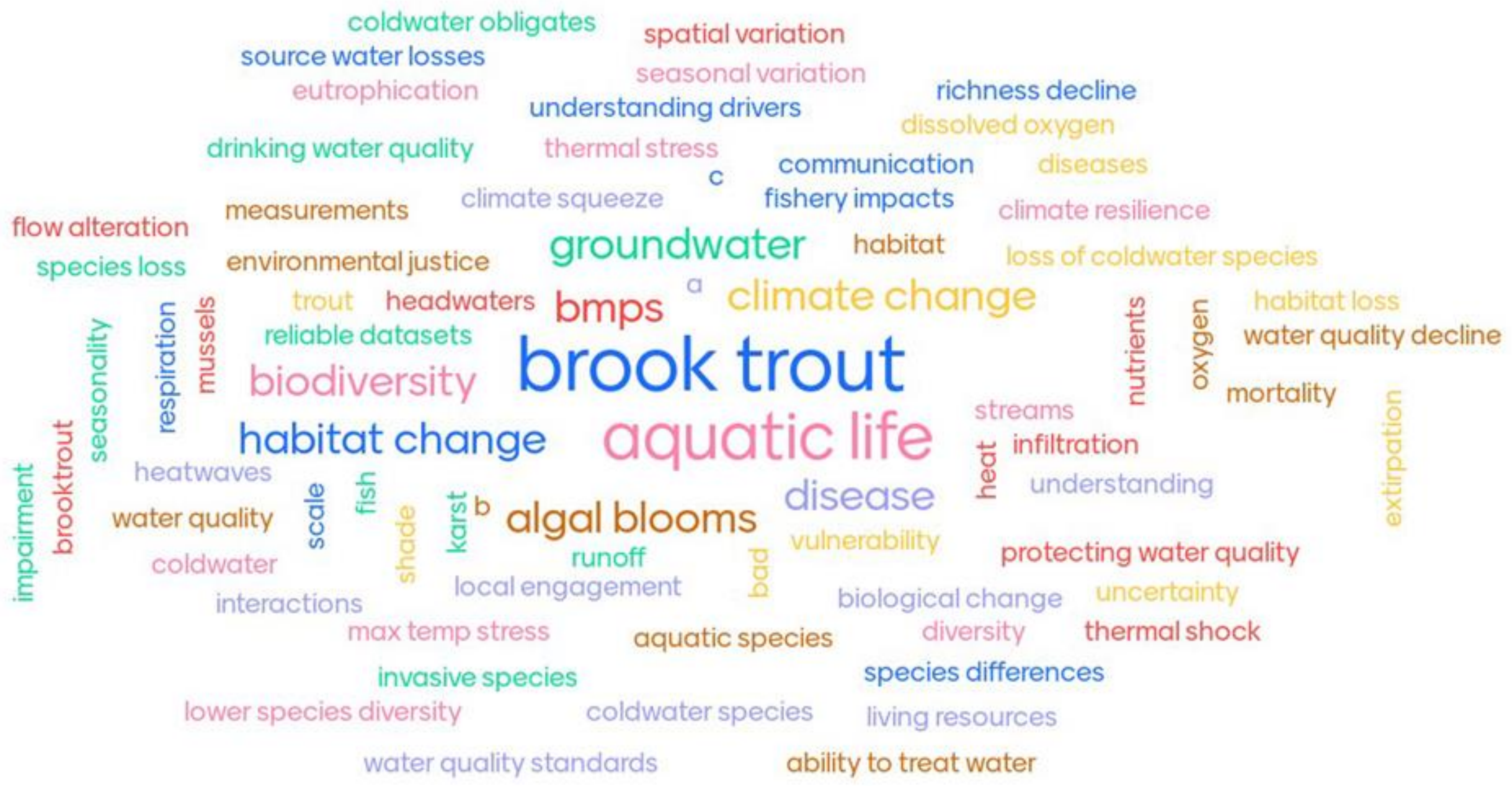
# Issues with the conceptual model

- Accounting for variation in the importance of drivers depending on location within the watershed and the dominant land use
- Addressing issues of scale (both spatial and temporal)
- Avoiding oversimplification- how to account for interrelationships and complex biological factors
- Connecting drivers with management activities and land use decisions

Strength of cooling effect- High
Certainty- High

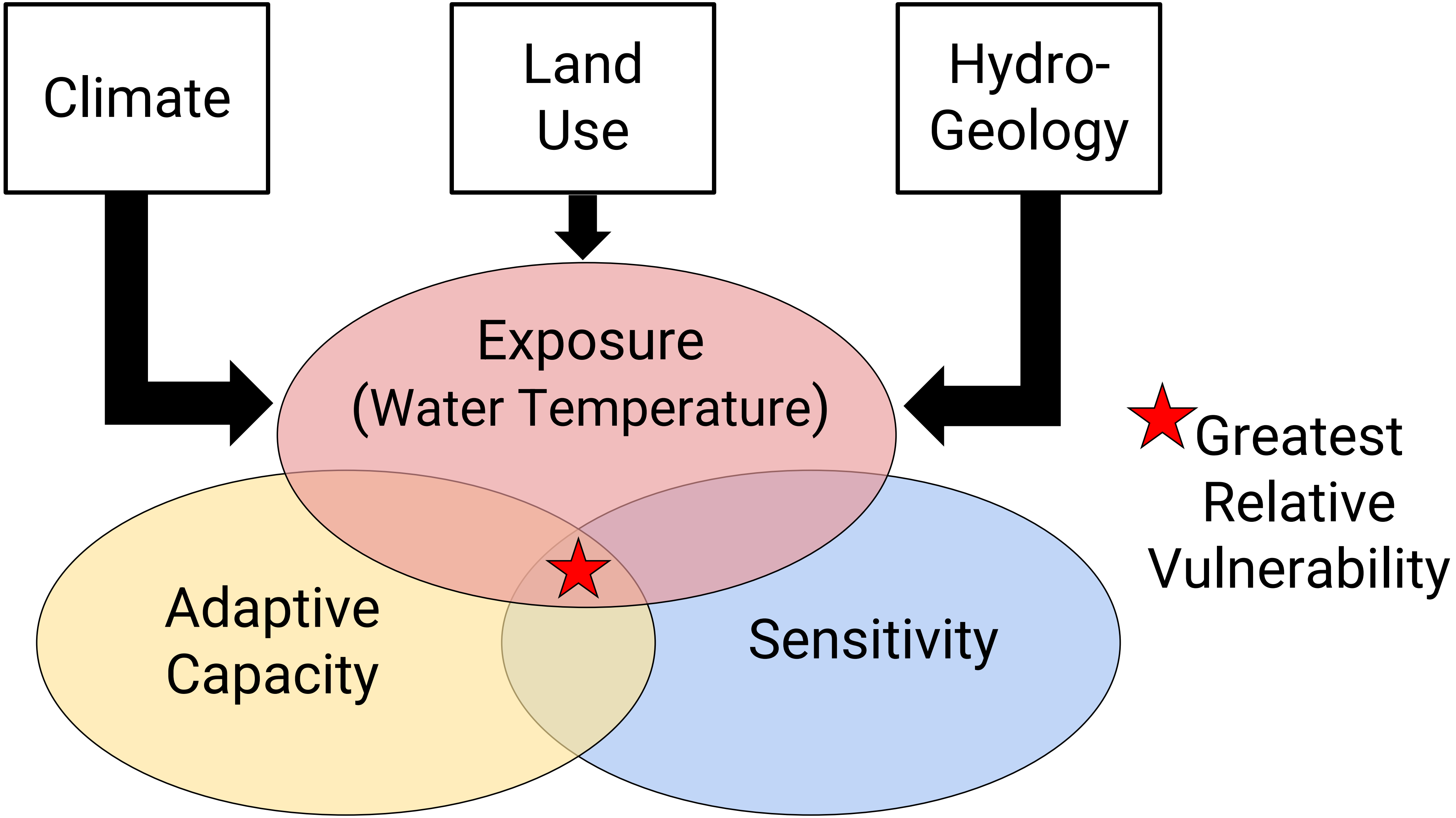


# What is your biggest concern or focus with regard to rising non-tidal water temperatures?



# Species & Habitat Vulnerability

Integration of **Exposure**, **Sensitivity**, & **Adaptive Capacity**



# Rank species in terms of their relative exposure to rising water temperatures

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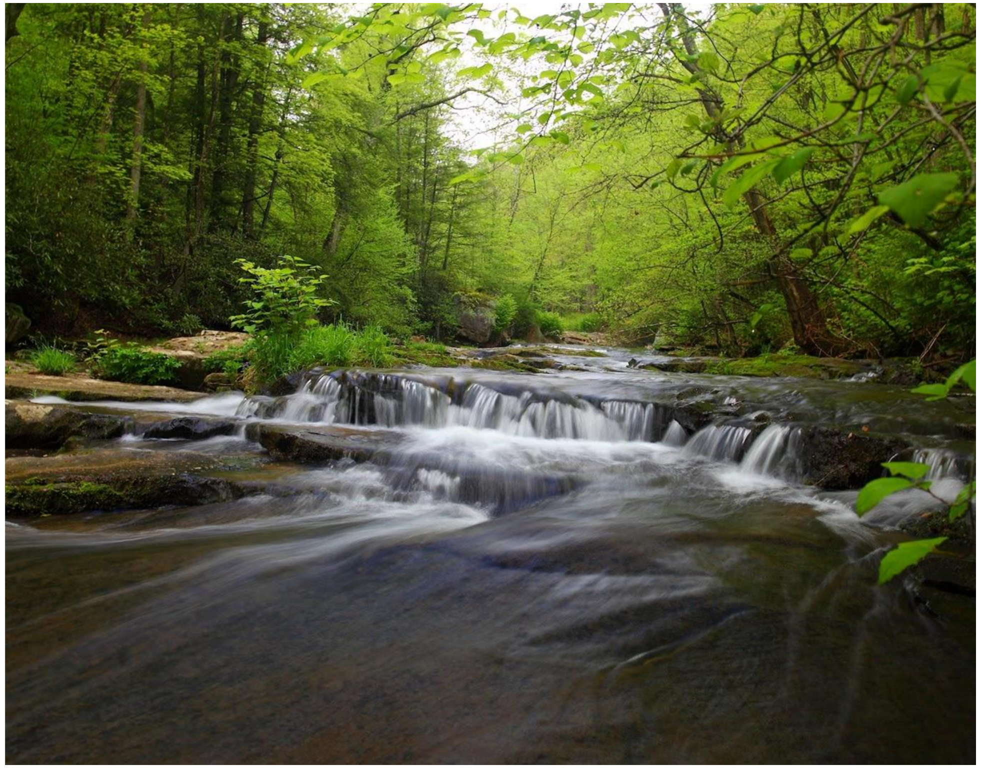
# Ecological Impacts - Species

- **Strongest negative impacts** on coldwater species (e.g., trout, sculpin)

- Watershed-wide, warmwater aquatic species are most common. Although more tolerant to temperature increases, they are **sensitive to extreme temperatures** including rapid changes and to indirect effects (e.g., invasives, pathogens) from higher temps.

- **More study needed** of temperature effects on lower foodweb
    - Algae, biofilms, zooplankton
    - Macroinvertebrates
    - Freshwater mussels & host species
  - Life stages, & predator/prey interactions

# Ecological Impacts - Habitats



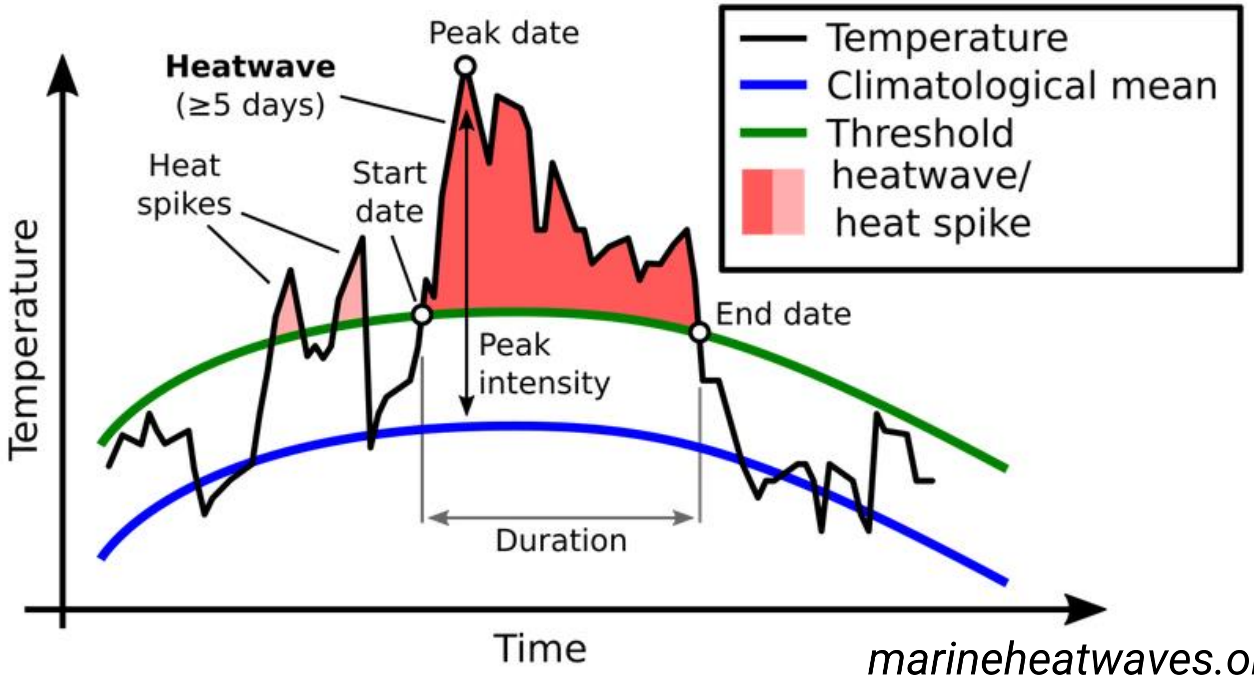
- **Strongest negative impacts** on small, coldwater streams not driven by groundwater due to relatively low heat capacity

- Protecting native brook trout habitat, including watershed, is urgent priority

- Larger waterways with low forested watershed cover, riparian cover, heated urban runoff, and many “heater” BMPs likely vulnerable as well

# Ecological Impacts - Temperature Aspects

- Temporal Characteristics
  - Seasonality (e.g., warmer winters, shift in season length)
- Spatial Characteristics
  - Aquatic connectivity interacting w/temp.
  - Landscape (e.g., forest cover, buffers, dams, urbanization, BMPs)
- Event Characteristics
  - Long-term press (e.g., annual increase in water temp. trend)
  - Pulsed extreme warm water events (heatwaves)
    - Frequency, duration, intensity, onset rate

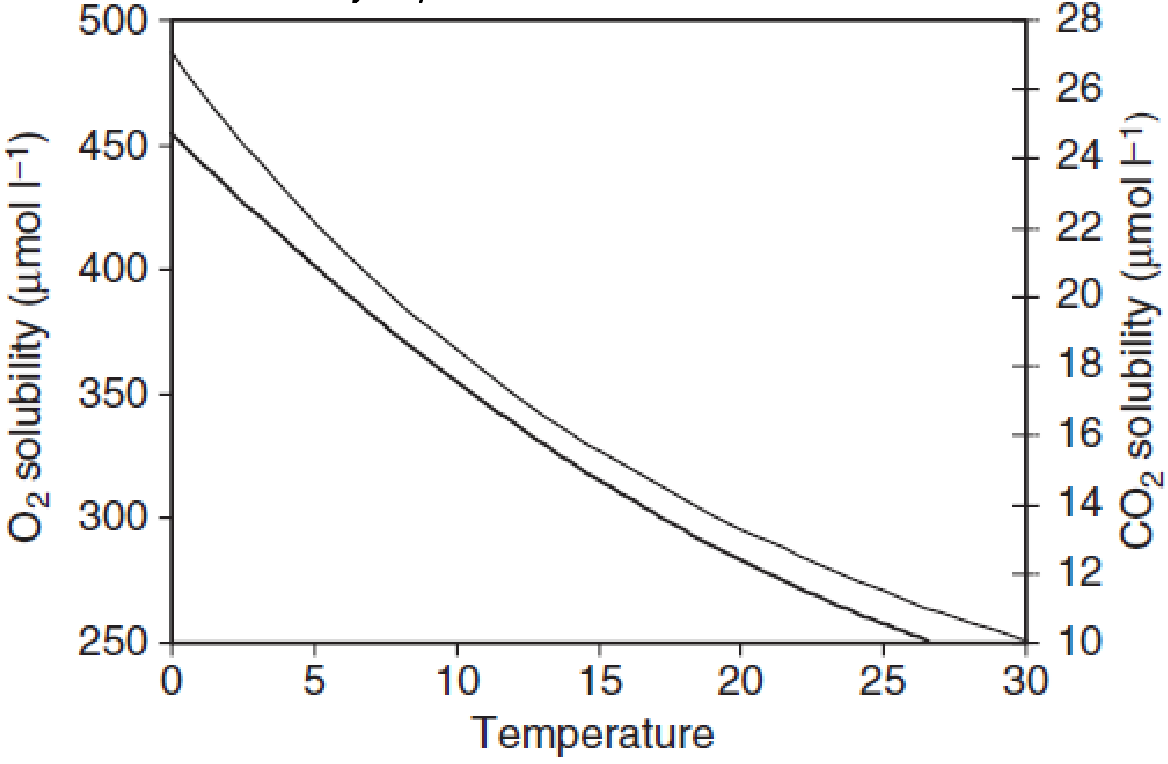



marineheatwaves.org

# Ecological Impacts - Other Stressors

- Co-occurring Stressors
  - Low dissolved oxygen
  - Low pH
  - Invasive species
  - Algal blooms
  - Bacterial/viral outbreaks
  - Distribution & toxicity of other pollutants (e.g., heavy metals, pesticides, ammonia, etc)

*Encyclopedia of Inland Waters 2009*



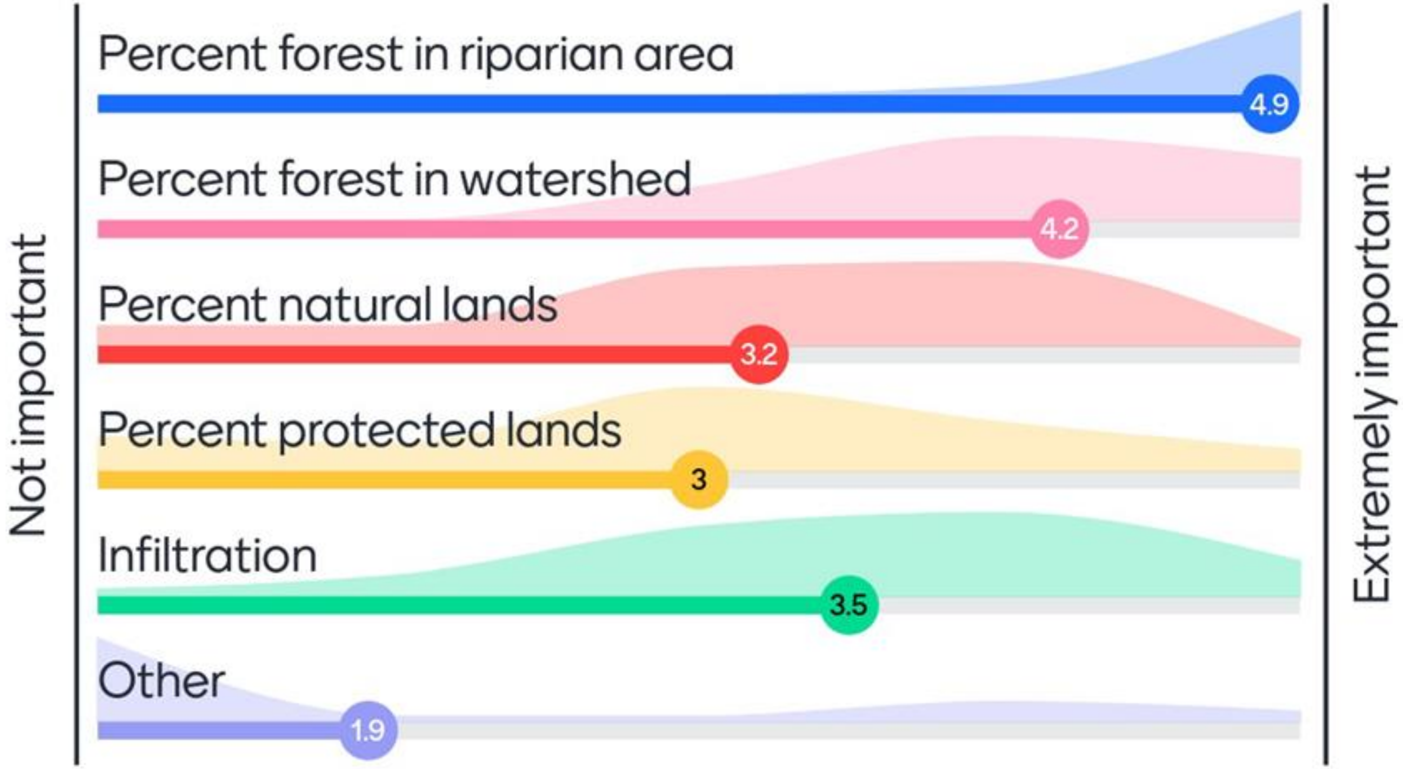

- Ecosystem Shifts
  - Diatom to green algae or cyanobacteria dominated
  - Species assemblages (e.g., expansion of invasives)
  - Predator/prey interactions

# Ecological Impacts - Key Knowledge Gaps

- Species
  - Impact to non-trout poorly known
  - Impact to prey/food, life cycles, and interactions w/ other stressors
- Habitats
  - Unclear which places are most susceptible to pulsed heating
  - Unclear how BMPs/stream restoration impacting temp

# Which landscape characteristics are more important to emphasize as potential management targets in the report and during Day 2 of the workshop?

Mentimeter

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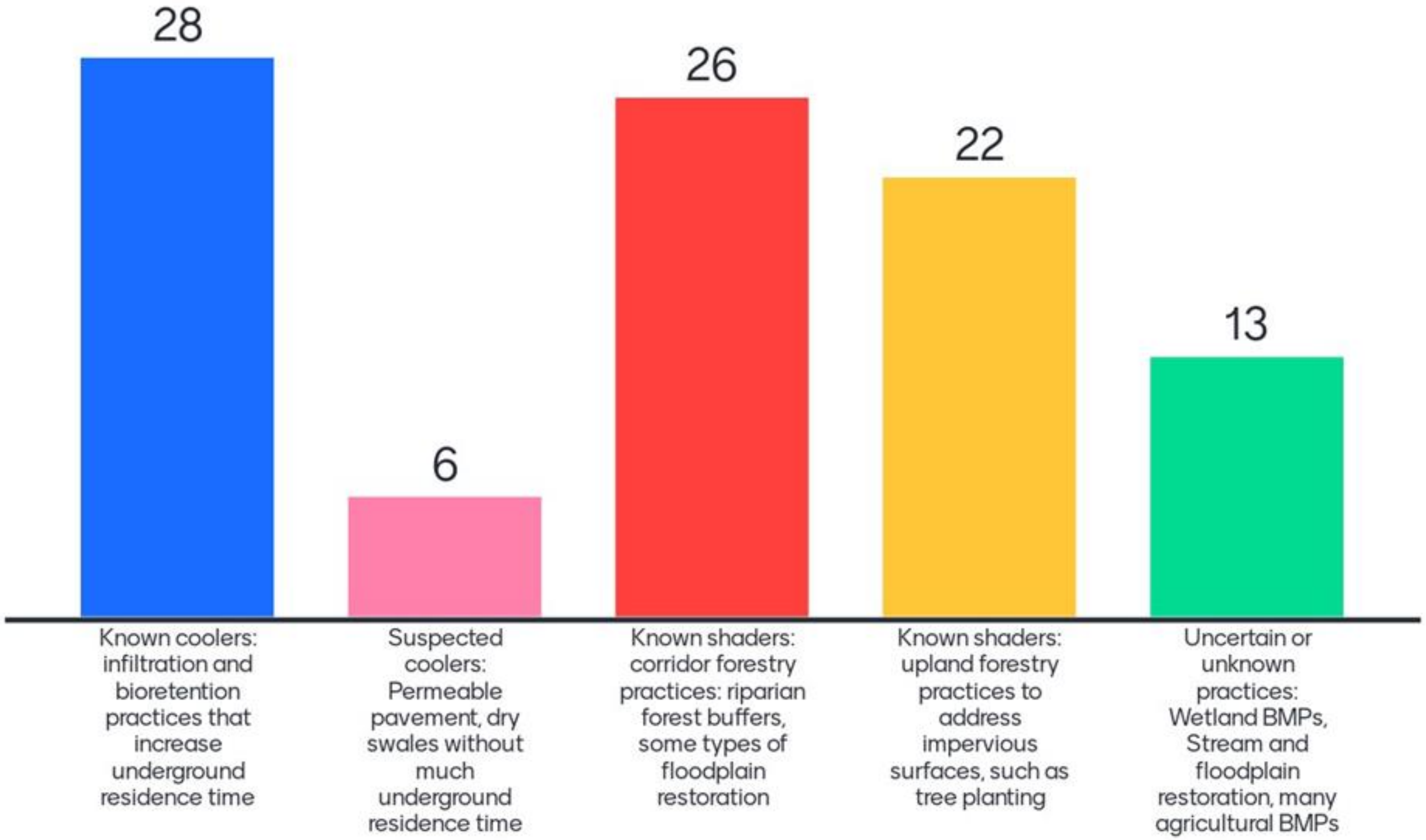
# Which 3 BMP categories are most important to emphasize as potential recommendations in the report and during Day 2 workshop?



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# Overarching themes: management practices

- Ensure rivers and streams are well buffered
- Encourage implementation of “coolers” and “shaders” upstream
- Minimize loss of existing forests
- Discourage implementation of heating BMPs, especially in watersheds with coldwater habitats
- Use habitat restoration to improve connectivity between suitable habitat patches and improve access to thermal refugia

# Overarching themes: Science support

- Improve understanding of the temperature impacts of BMPs
- Improve understanding of the ecological impacts of incorporating temperature refugia into stream restoration design
- Improve water temperature monitoring
  - Need higher-frequency continuous monitoring
  - Need monitoring at the air/water interface
  - Improve understanding of ecological implications of rising water temperature
- Improve modeling and decision support tools
  - Incorporate temperature into the CHWA
  - Improve capability to model local water temperature and water temperature impacts of BMPs