Rising Watershed and Bay Water Temperatures—Ecological Implications and Management Responses

May 2021 Forestry Workgroup update

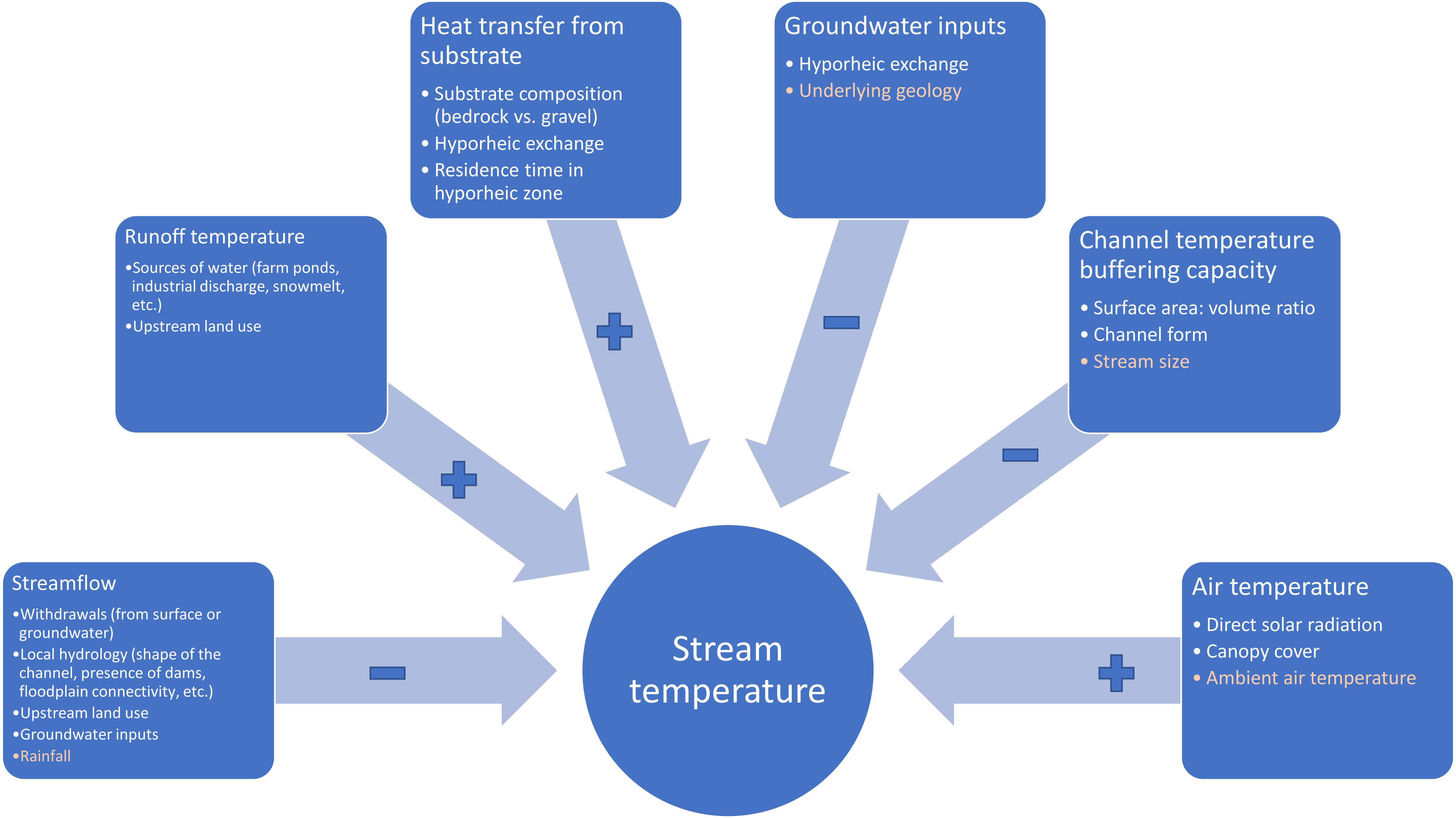
Katie Brownson, USFS

Workshop objectives

* Summarize major findings on the ecological impacts of rising water temperatures, including science-based linkages between causes and effects; and
* Develop recommendations on how to mitigate these impacts through existing management instruments, ranging from developing indicators, identifying best management practices, and adapting policies.

Pre-workshop synthesis topics

1. Identification of Where Rising Stream and River Water Temperatures will Have the Most Impacts on Watershed Fish Populations and Overall Stream Health Including Identification of Critical Temperatures/ Temperature Changes
2. Identification of the Where Rising Bay Water Temperatures will Have the Most Impacts on Bay Fish, Shellfish and Crab Populations and Their Prey Including Identification of Critical Temperatures/ Temperature Changes
3. Identification of Where Rising Bay Water Temperatures will Have the Most Impacts on Submerged Aquatic Vegetation Communities and Individual Species Including Identification of Critical Temperatures/Temperature Changes
4. Identification of the Characteristics of Watersheds Which May Make Them More Vulnerable or Resilient to Stream Temperature Changes in the Absence of Certain Key Landscape Factors
5. Past, Current and Projected Changes in Watershed and Tidal Water Temperatures and Implications for Ecosystem Processes Influencing Stream, River and Estuarine Health
6. Understanding the Factors and Geographies Most Influencing Water Temperatures in Local Waters Throughout the Watershed and Across all the Bay's Tidal Waters
7. **Identification of Where Habitat Restoration Can Mitigate Rising Water Temperatures and Where Rising Temperatures Can Impair Habitat Restoration**
8. **Identification and Characteristics (and Quantification, Where Possible) of BMPs Which Can Help Mitigate (or, Conversely Exacerbate) Rising Local Stream, River, Groundwater and Tidal Water Temperatures**
9. Synthesis of Information Supporting Development of and Options for a Tidal Bay Temperature Indicator
10. Identification of Any Needs for Enhancing the Partnership's Monitoring Networks as Needed to Support Reporting of the Water Temperature Indicator or Other Instruments


Heat transfer from substrate
• Substrate composition (bedrock vs. gravel)
• Hyporheic exchange
• Residence time in hyporheic zone
Groundwater inputs
• Hyporheic exchange
• Underlying geology
Runoff temperature
•Sources of water (farm ponds, industrial discharge, snowmelt, etc.)
•Upstream land use
Channel temperature buffering capacity
• Surface area: volume ratio
• Channel form
• Stream size
Streamflow
•Withdrawals (from surface or groundwater)
•Local hydrology (shape of the channel, presence of dams, floodplain connectivity, etc.)
•Upstream land use
•Groundwater inputs
•Rainfall
Stream temperature
Air temperature
• Direct solar radiation
• Canopy cover
• Ambient air temperature
+
+
−
−
−
+

$$A \quad + \quad B \quad + \quad C \quad + \quad D \quad + \quad E$$

$$\sum \; [\Delta \text{ Land Use }] + [\text{Upland BMP } \Delta\} + [\text{Stream Corridor } \Delta\} + [\text{Corridor BMP } \Delta]$$

A = *Land Use Temp Effect*: ambient stream temps influenced by heat island effect: Forest << Pasture/Crops << Suburban <<< Urban

B = *Upland BMP Effect:* reflects how the ponding, infiltration or filtration of runoff modifies baseflow temps (may + , - or have no change from the land use baseline)

C = *Stream Corridor Effect*: reflects the *current* presence or absence of riparian/floodplain cover along the corridor (i.e., + or -)

D = *Corridor BMP Effect*: Whether the installation of a new BMP in the corridor influences stream temps, relative to the historical corridor baseline. (i.e., + or -)

E = *Riverine/Reservoir Effect*: the increase in stream temp as it moves from headwaters thru rivers (and is warmed by reservoirs and impoundments, until it ultimately reaches head of tide

Classification of BMP Temp Effects

1. Known Heaters
2. Suspected Heaters
3. Shaders
4. Shade Removers
5. Known Coolers
6. Suspected Coolers
7. Thermally Neutral
8. Uncertain or Unknown

1. Known Heaters

- Upland BMPs that increase downstream temperatures due to surface ponding via detention or retention of runoff, to a depth of up to 10 feet (increase from 2 to 10 degrees F)
- Examples include wet ponds, created wetlands, dry ED ponds, farm ponds and CAFO lagoons
- No engineering techniques exist to mitigate heating, except for deep-water release from much deeper reservoirs and impoundments.

2. Suspected Heaters

- Have some, but not all, of the characteristics of known heaters, but are not well studied from a temperature standpoint.
- Examples include sand filters, submerged gravel wetlands, underground vaults and MTDs w/closed bottoms and longer runoff detention times.
- May also include urban and ag drainage systems, such as grass channels, bio-swales, ditches and crop tile drains.

3. Shaders

- Upland or corridor forestry practices that maintain or increase forest canopy/forest cover
- Upland BMPs: tree planting, tree pits, foundation planters -- greatest cooling effect occurs over impervious cover.
- Corridor BMPs: riparian forest buffers and some forms of floodplain restoration

4. Shade Removers:

- Land development activities, farming and stream corridor practices that remove riparian forests from the stream corridor, relative to the historic baseline year for actual cover.
- Examples may include: farm buffers that have expired, some forms of stream channel restoration, and construction site clearing during new land development

5. Known Coolers

• Urban BMPs designed to move surface runoff back into shallow groundwater, where it may reside for several days before reaching the headwater stream network.
• Good examples include infiltration and bioretention practices <u>that lack underdrains.</u>
• Limited research suggests the cooling effect can range from 2 to 5 degrees F, depending on site soils and hydro-geology

6. Suspected Coolers:

- Urban BMPs such as infiltration, permeable pavement, dry swales and bioretention that are located in tight soils, and therefore require underdrains.
- Not sure about green roofs and floating treatment wetlands?
- Could well be some research data out there on these suspected coolers

7. Thermally Neutral:

- Urban and Ag BMPs that do not change stream temps, one way or the other. However, there is not a lot of monitoring data
- Urban: street sweeping, urban nutrient management plans, IDDE
- Ag: farm nutrient management, various tillage practices

8. Uncertain Thermal Impacts

- Practices that may increase or decrease temperature via multiple mechanisms and the net impact is uncertain.
- Examples of these BMPs include stream restoration and wetland creation/restoration, some ag BMPs

1	*+/- reflects hypothesized increase or decrease in stream temperature resulting from BMP implementation at scale*										
2	*++: Strong effect increasing temp, +: Weak increasing effect, +/-: Indeterminate effect, -: Weak decreasing effect, --: Strong decreasing effect, Blank= No expected effect*										
3			**Streamflow effects**							**Runoff Temperature effects**	
4	**BMP Category**	**Description**	**Baseflow**	**Withdrawals**	**Local hydrology**	**Hydraulic resistance**	**Upstream land use**	**Groundwater inputs**	**Infiltration**	**Sources of water**	**Upstream land use**
5	Known Heaters	Upland BMPs that have been shown to increase downstream temperatures due to surface ponding via detention or retention of runoff, to a depth of up to 10 feet. Examples include wet ponds, created wetlands, dry extended detention ponds, farm ponds, reservoirs, and CAFO lagoons. Increase from 2 to 10 degrees F from the land use baseline.		++ Upland water capture can reduce streamflow						++ Upland water capture can increase warm water inputs to streams	
6	Suspected Heaters	These BMPs have some, but not all, of the characteristics of known heaters, but have not been well studied from a temperature standpoint. Examples include shallow sand filters, submerged gravel wetlands, underground vaults/manufacture practices that have closed bottoms and short runoff detention times. Other potential examples include “improved” urban and ag drainage such as grass channels, bio-swales, ditches, tile drains and the like.		+						+	
7											

Preliminary review of "shaders" research

- Riparian forests effectively cool streams by reducing incoming shortwave radiation, reducing maximum temperatures and overall temperature variability
  - Greatest cooling benefits are for smaller, narrower streams
  - Type and structure of riparian forest can influence cooling benefits
  - Even relatively small areas of riparian forest (300M-1km) can provide local cooling benefits and act as thermal refugia for coldwater species
  - Newly planted trees will require a decade or more to effectively shade streams -> Very important to conserve mature forests!
- Floodplain forests can also help reduce water temperature via reductions in ambient air temperature
- Upland forests can help cool runoff, especially when located over impervious surfaces

Questions for Forestry Workgroup

- Any comments on overall approach?
- Are there additional ways in which forestry BMPs and forest conservation influence water temperature?
- Is there other research we should draw from?