

Thermal Benefits of Restoration

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Manuscript Co-Authors

Phil Roni

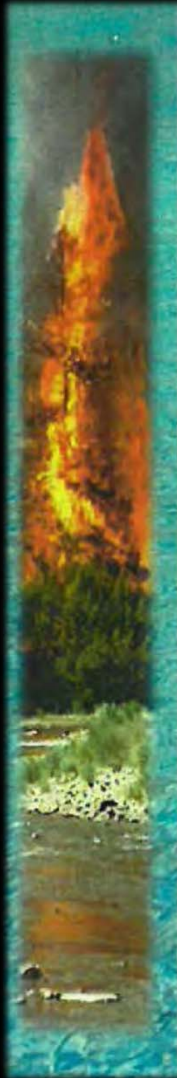
Ray Timm

Paul Anders

Presentation Overview

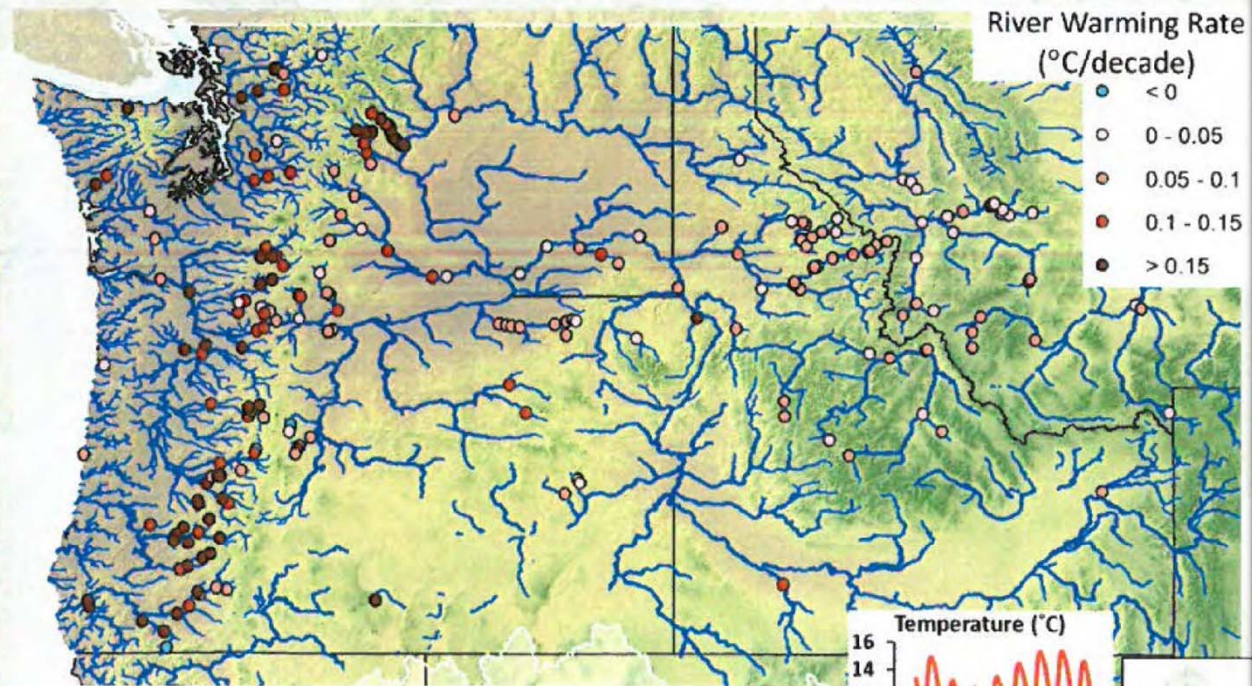
- Problem
- Mechanisms
- Factors
- Biological Context
- Complexity
- Data gaps
- Mitigation

Context

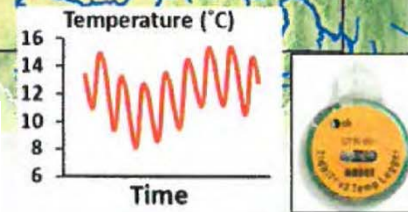


River Temp Trends (1968-2011)

245 sites with >10 year monitoring records

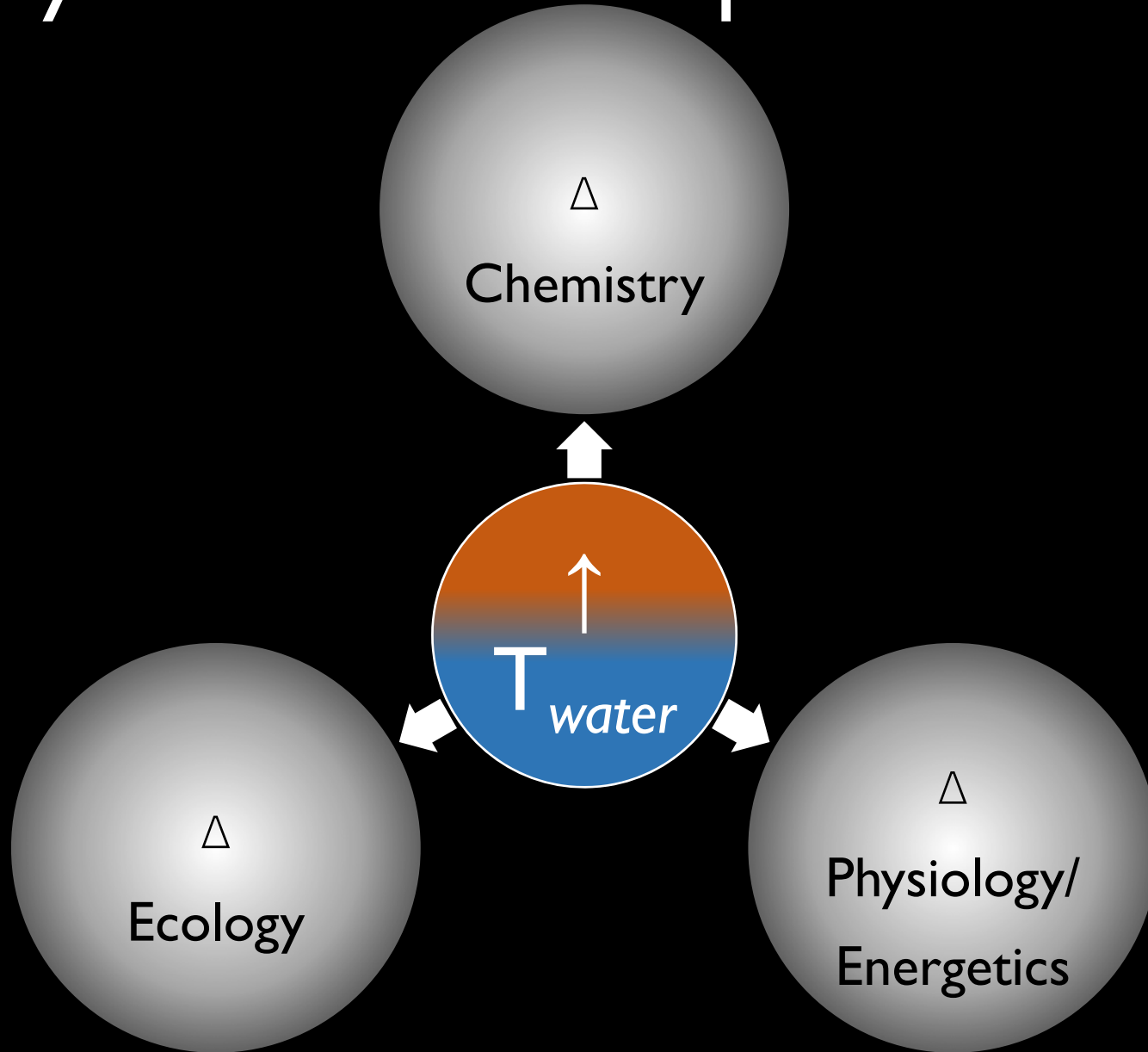


+0.11°C per decade
98.5% of sites are warming

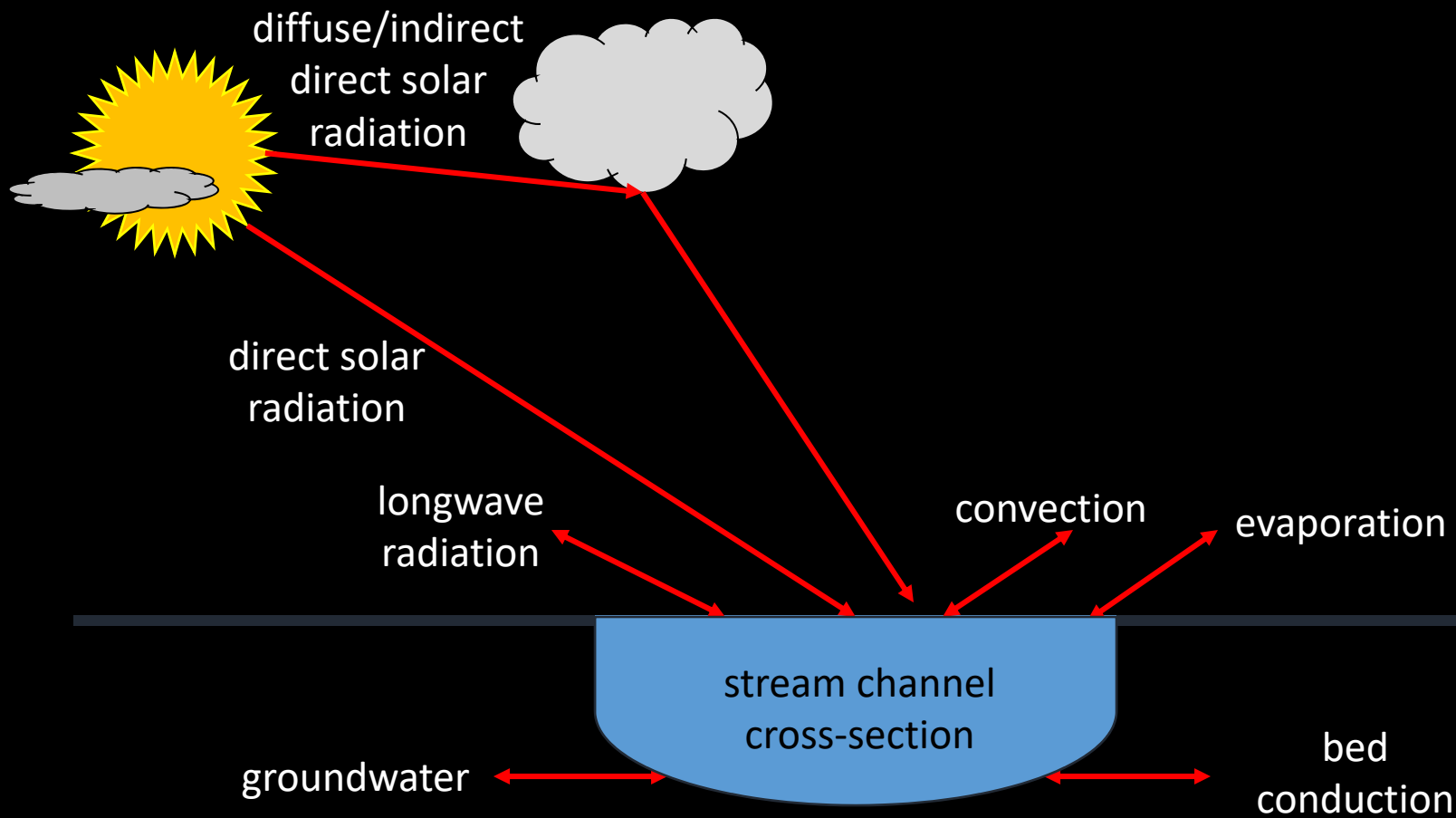


Isaak et al. In Prep.

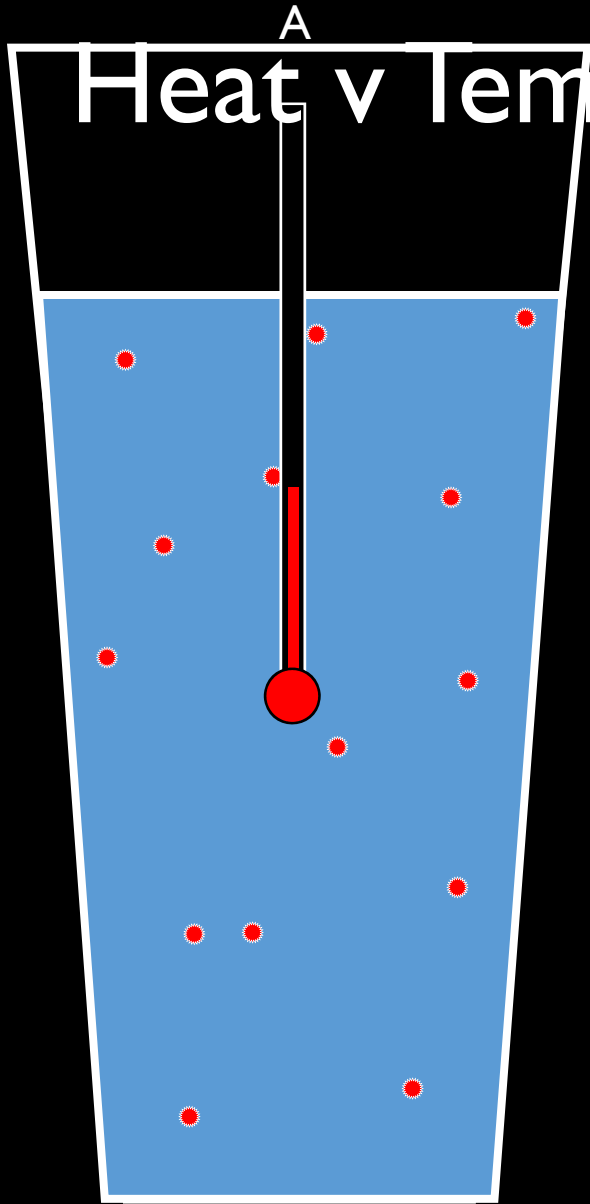
Why elevated T is a problem



Mechanisms of heat transfer

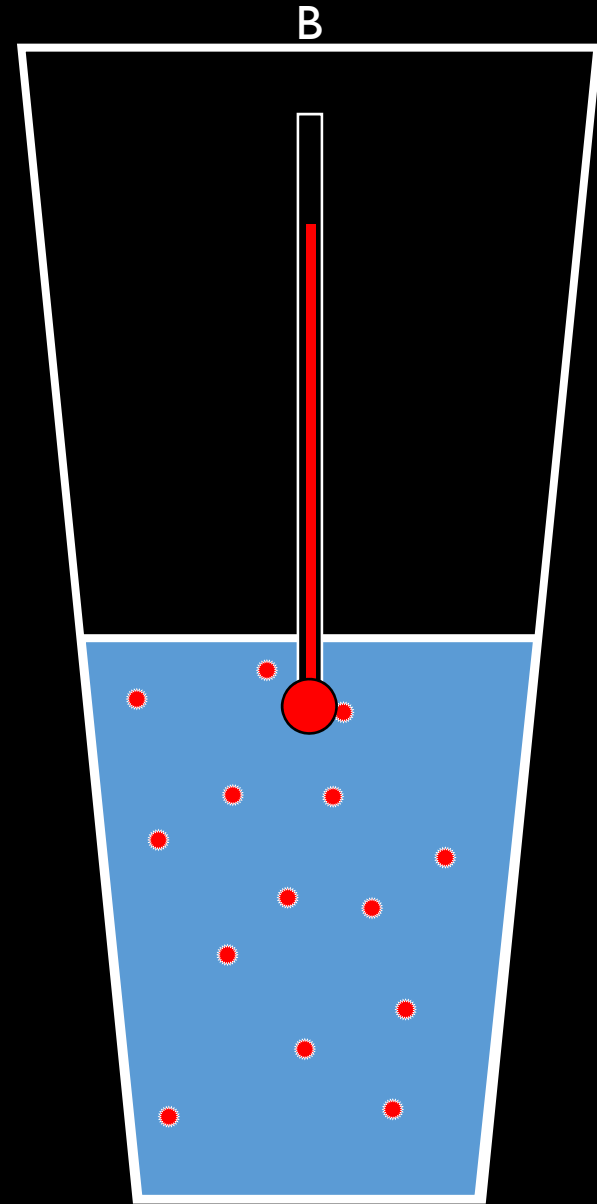


Heat v Temperature

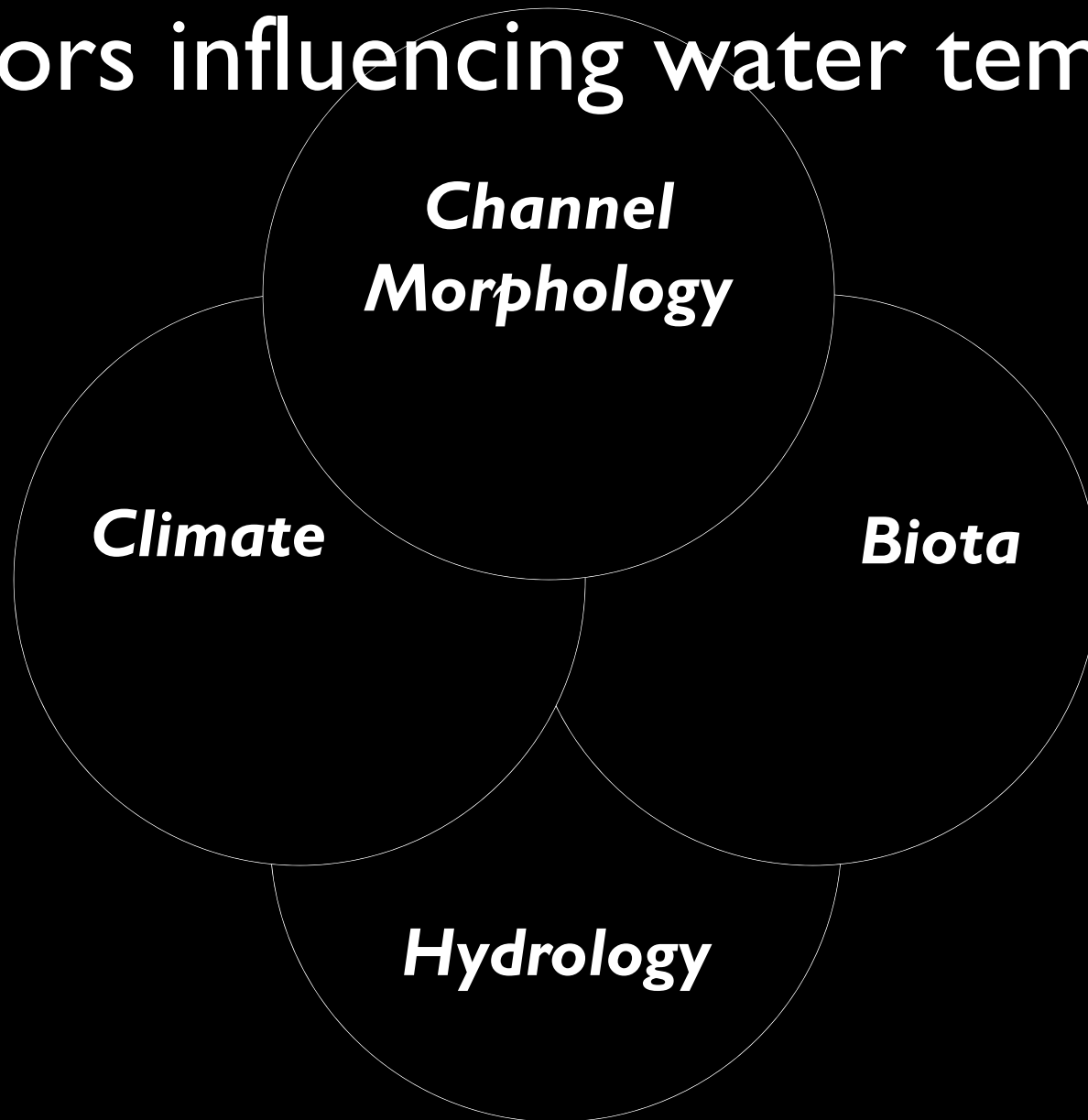


$$\text{Heat}_A = \text{Heat}_B$$
$$\text{Temp}_A < \text{Temp}_B$$

• 1 unit of heat
(calorie,
Joule, etc.)



Factors influencing water temp

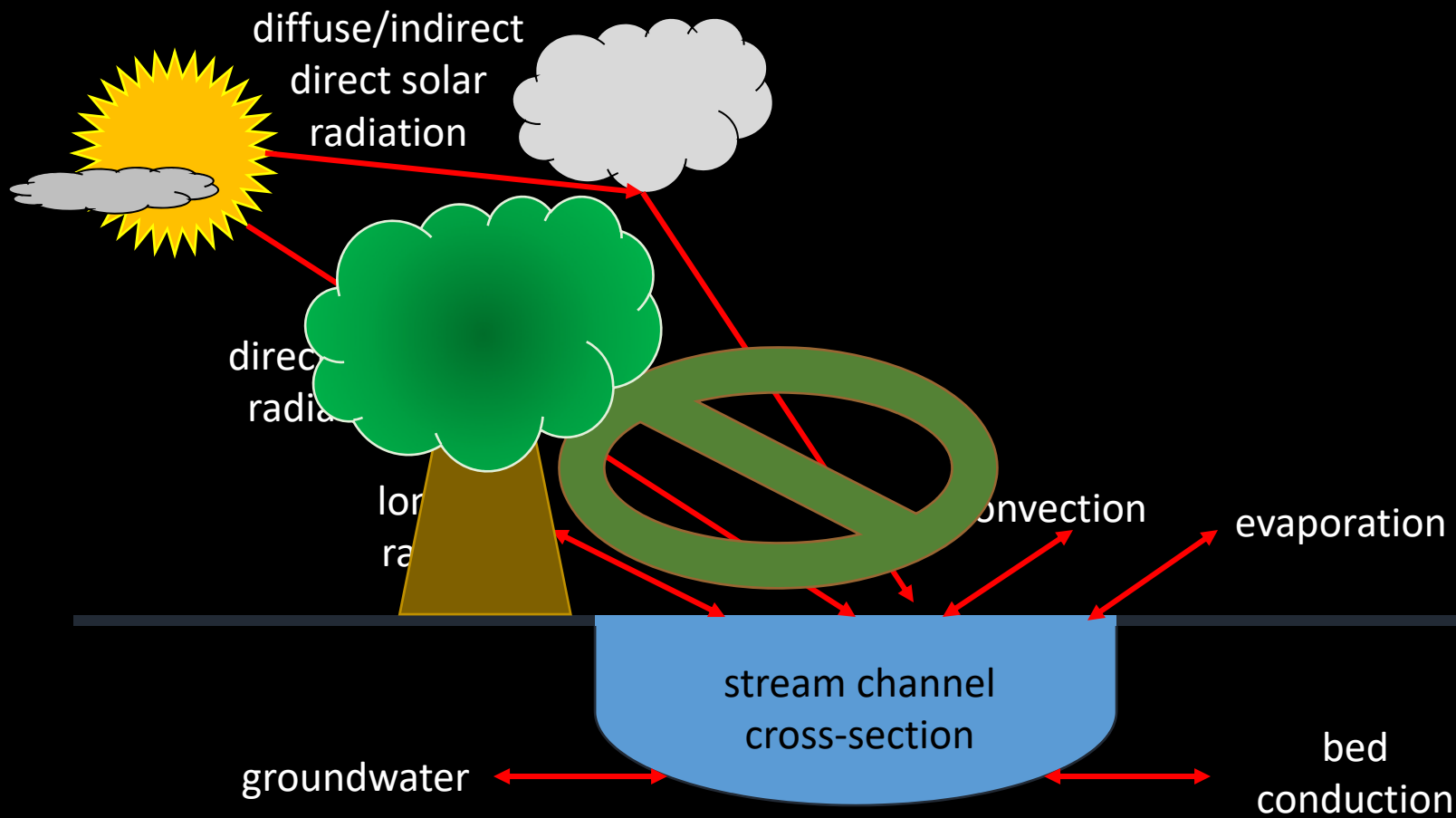


What is the current restoration approach for T mitigation?

- Increase shade
 - Riparian planting



Mechanisms of heat transfer



Redrawn, after Boyd and Sturdevant 1997

What is the current restoration approach for T mitigation?

- Increase shade
 - Riparian planting
- Increase in-stream flow
 - Reduce usage
 - Improve efficiency of diversions

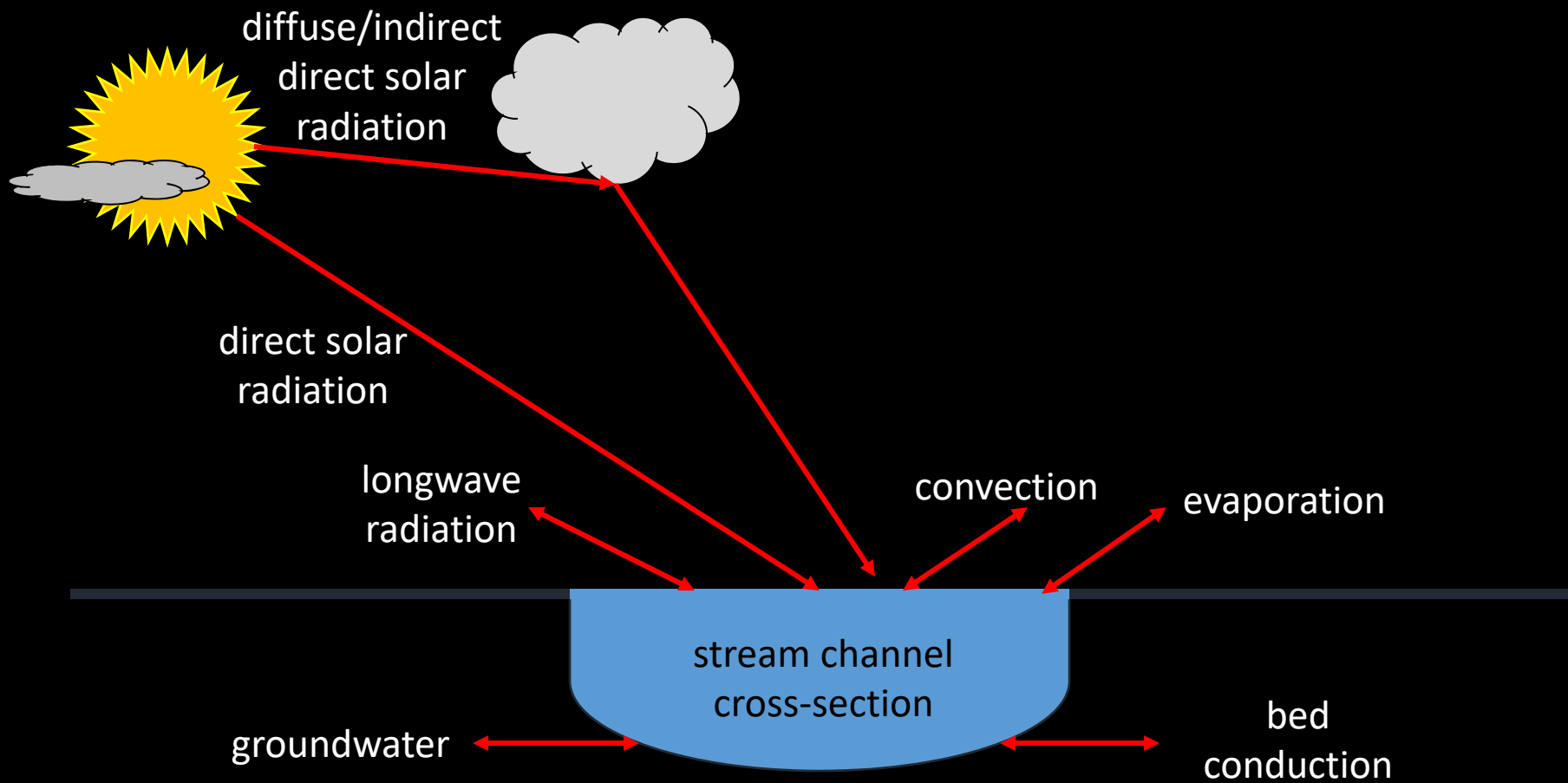


PC: Angling for Conservation



PC: Pinterest

Mechanisms of heat transfer

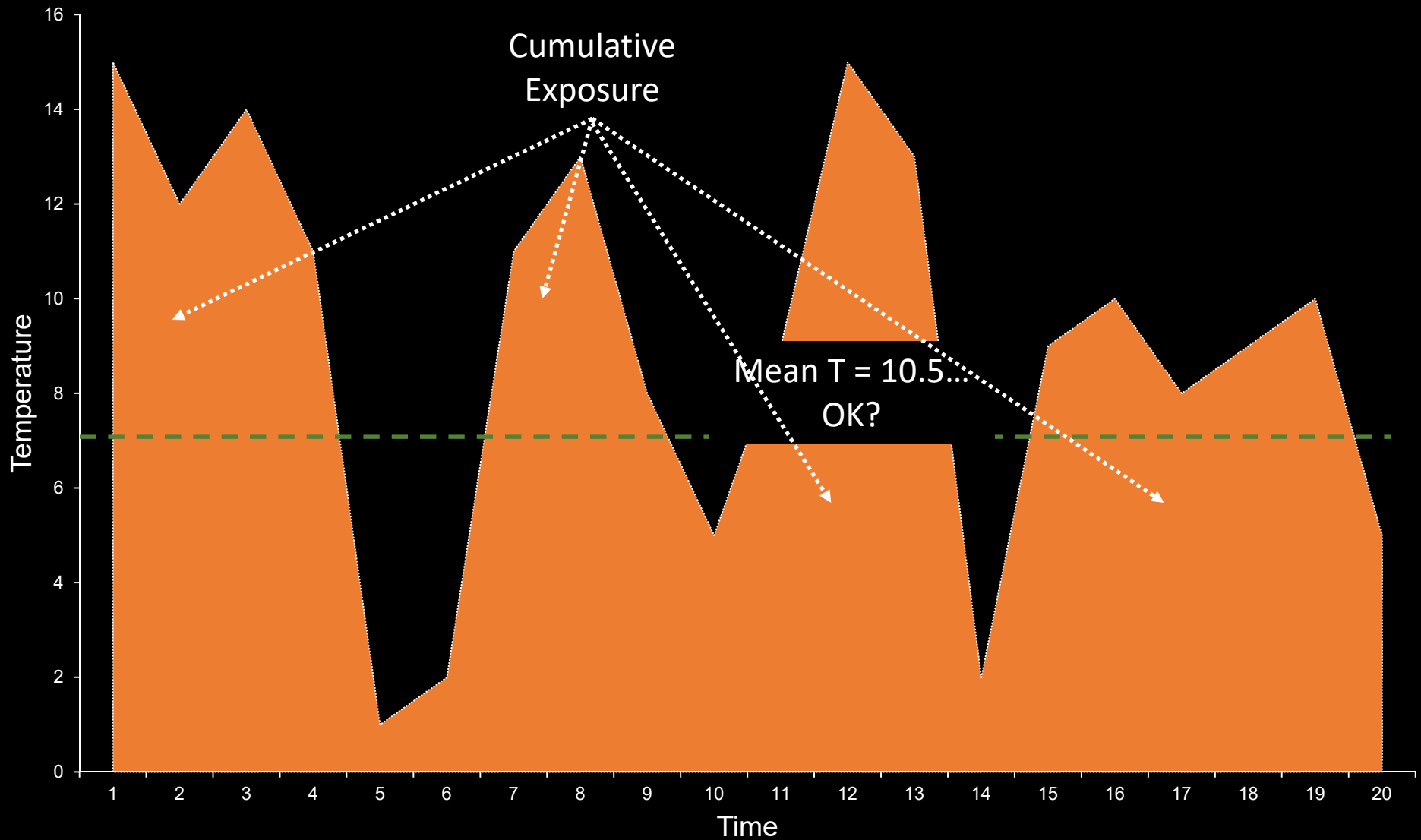


What is the current restoration approach for T mitigation?

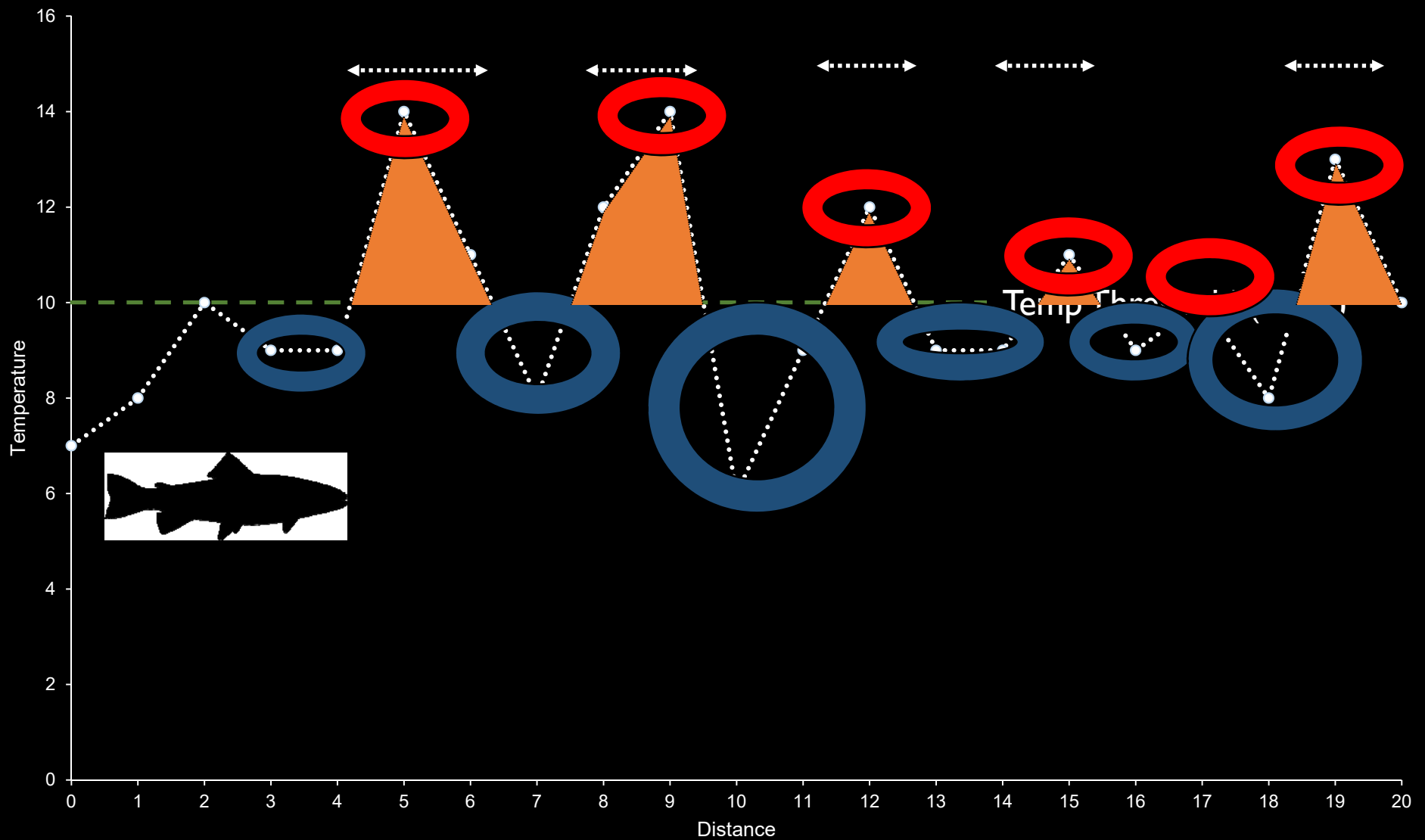
- Increase shade
 - Riparian planting
- Increase in-stream flow
 - Reduce usage
 - Improve efficiency of diversions
- These prevent warming...
 - What if stream is already hot?
 - What if mean T is less important than range?
 - What else can we do to *improve* c...



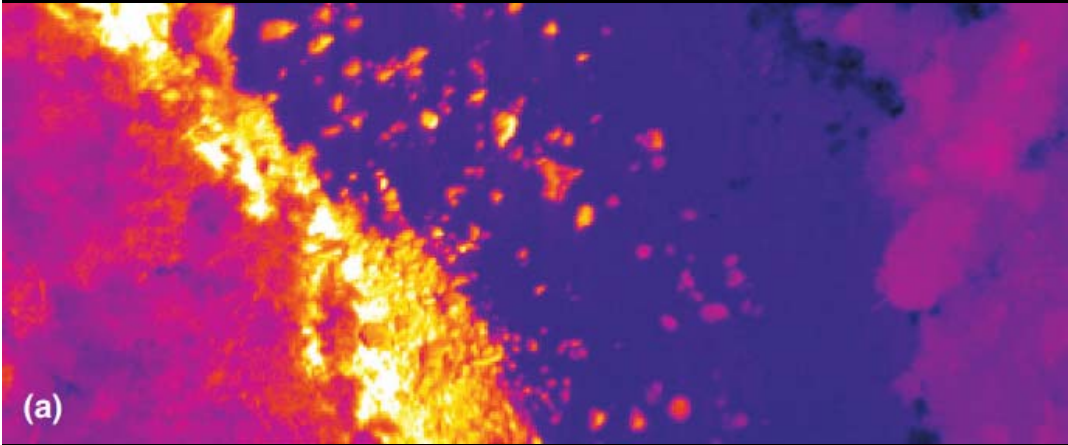
What matters for fish? Exposure



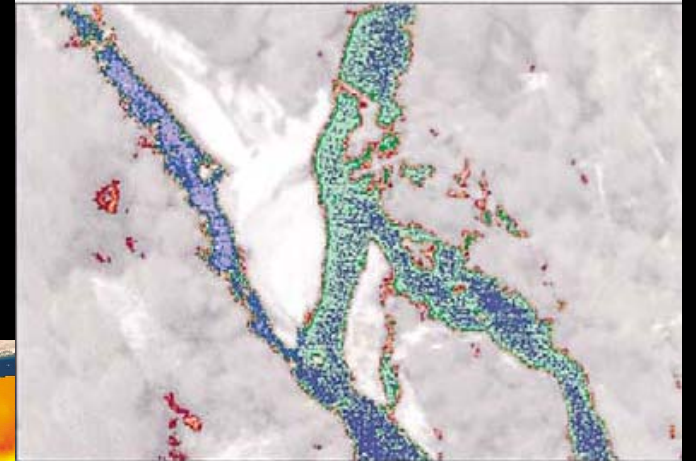
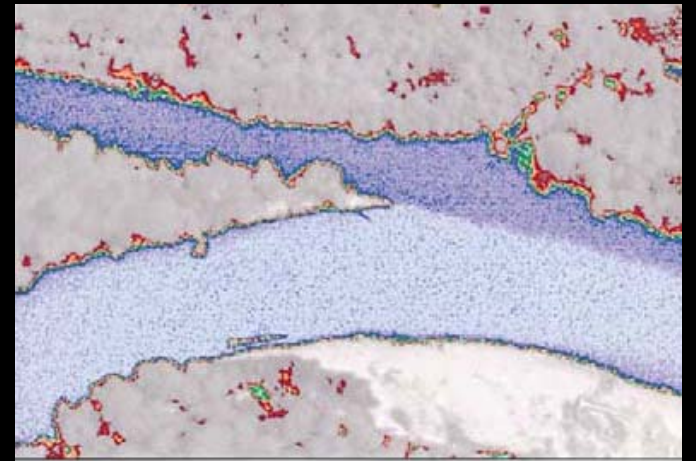
What matters for fish? Patches



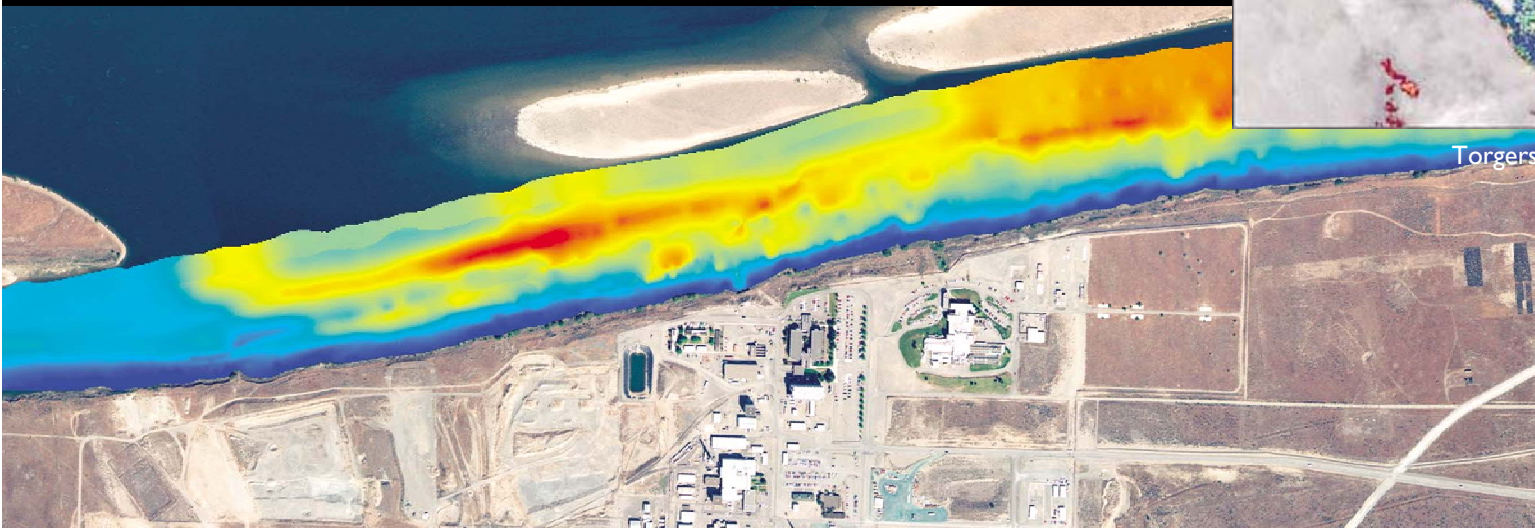
Complexity



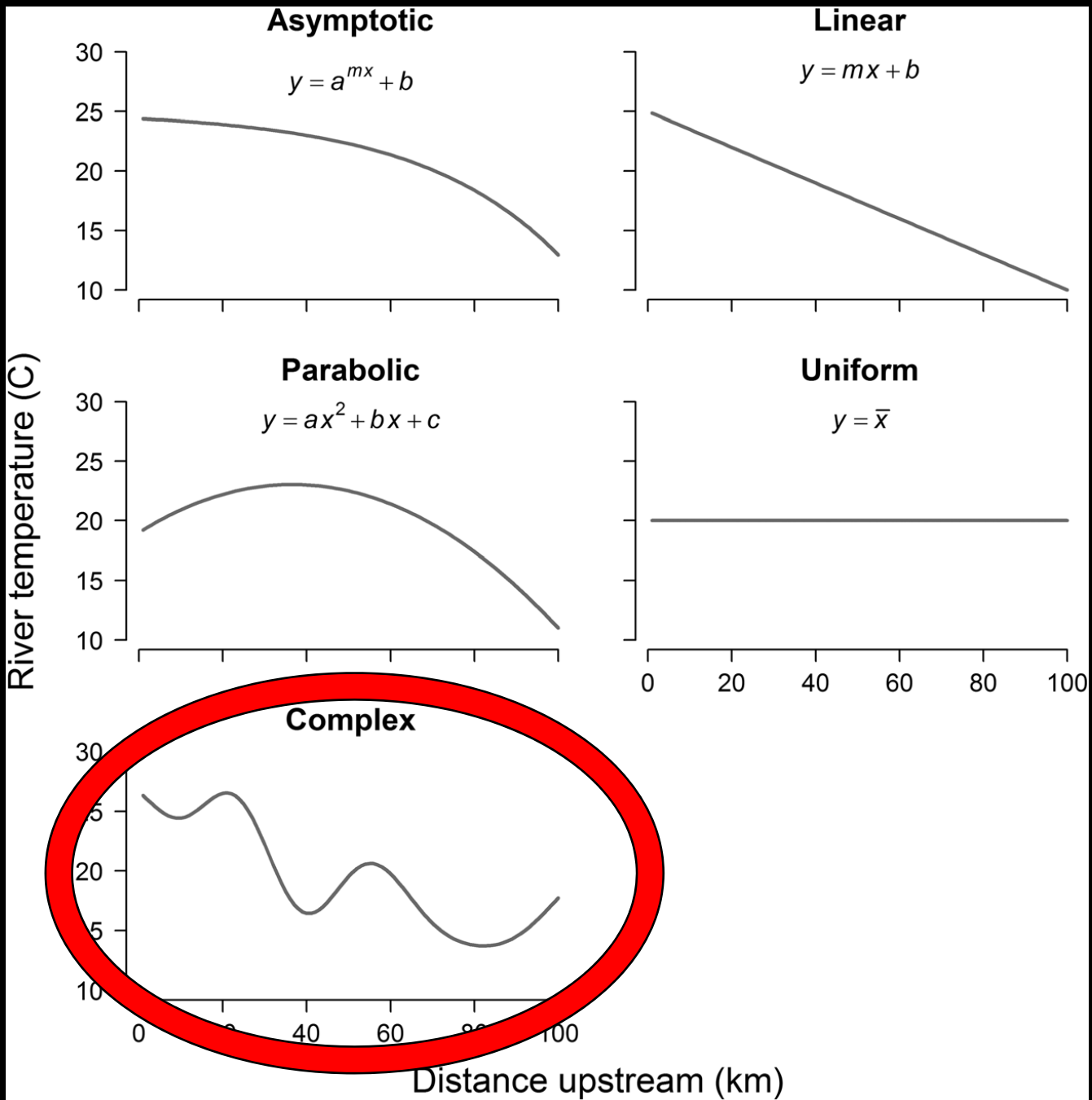
Dugdale et al 2016



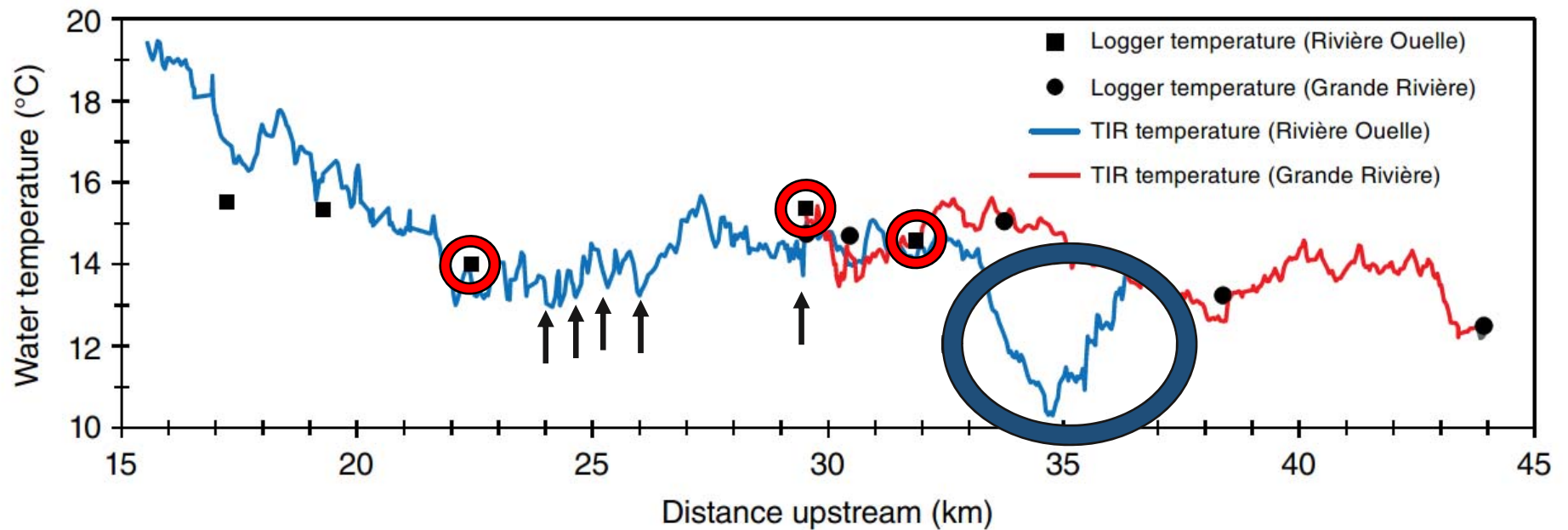
Torgersen et al 2001



Slater et al 2010

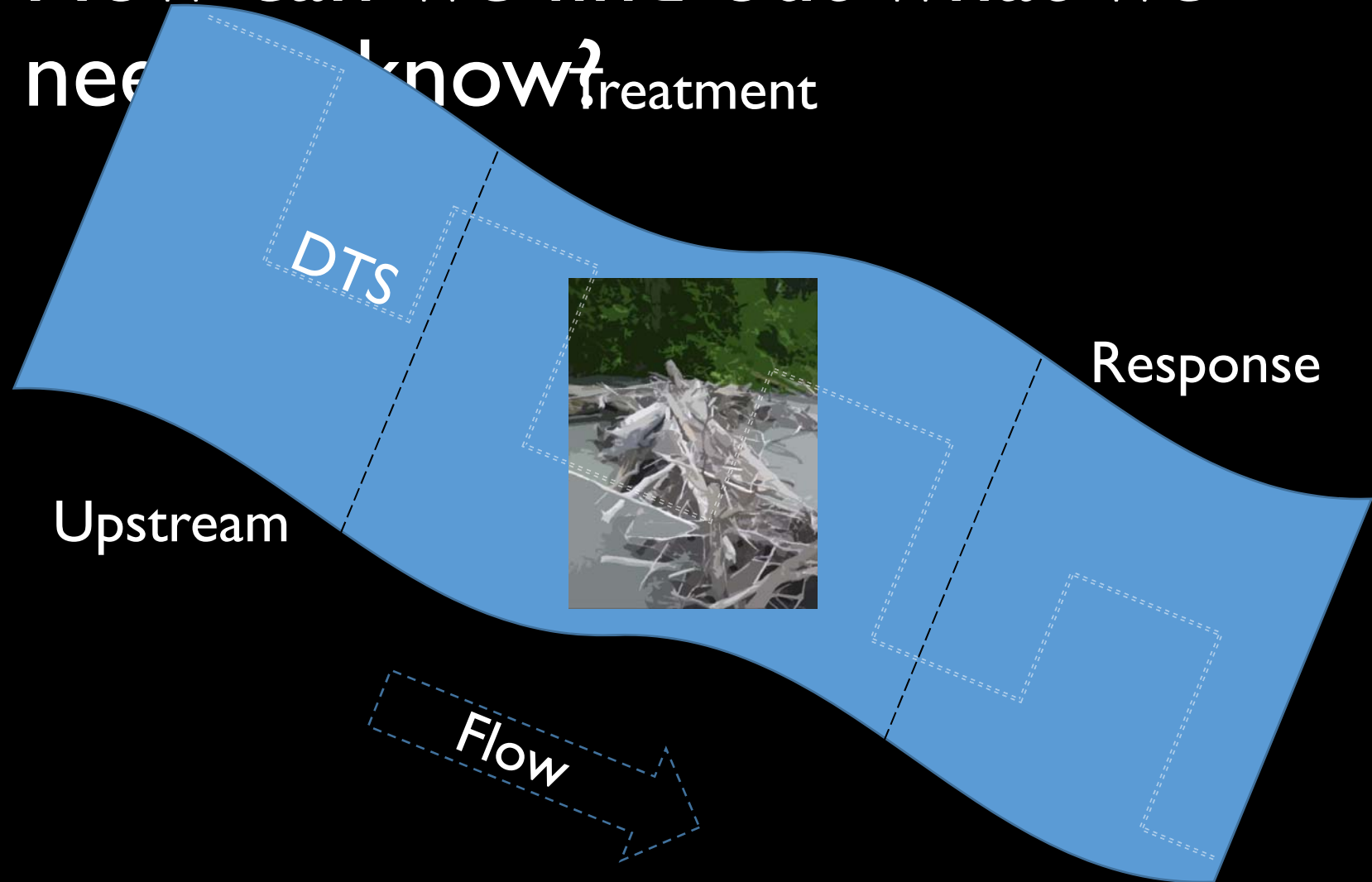


Detecting Complexity

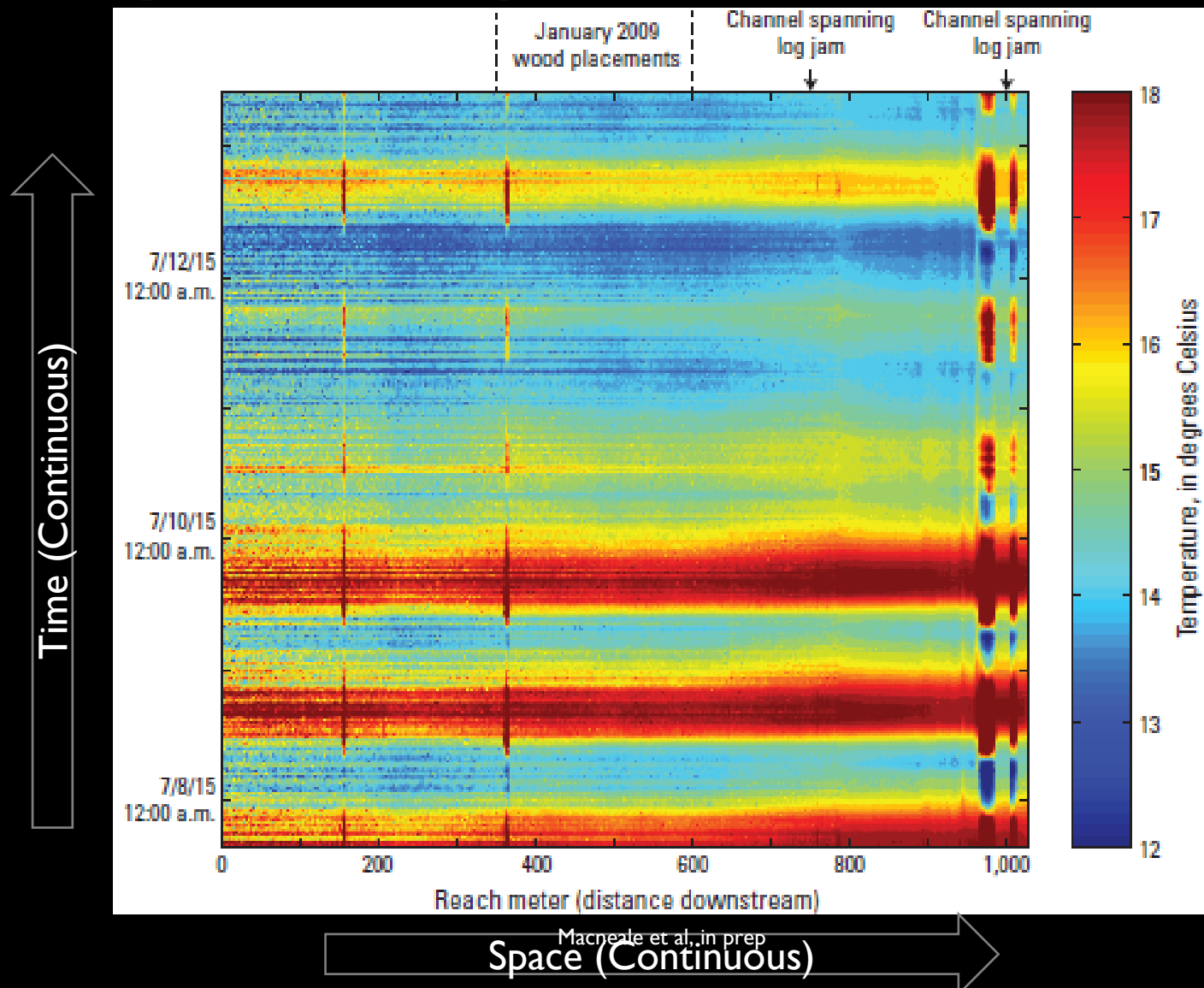


How can we find out what we need to know?

treatment



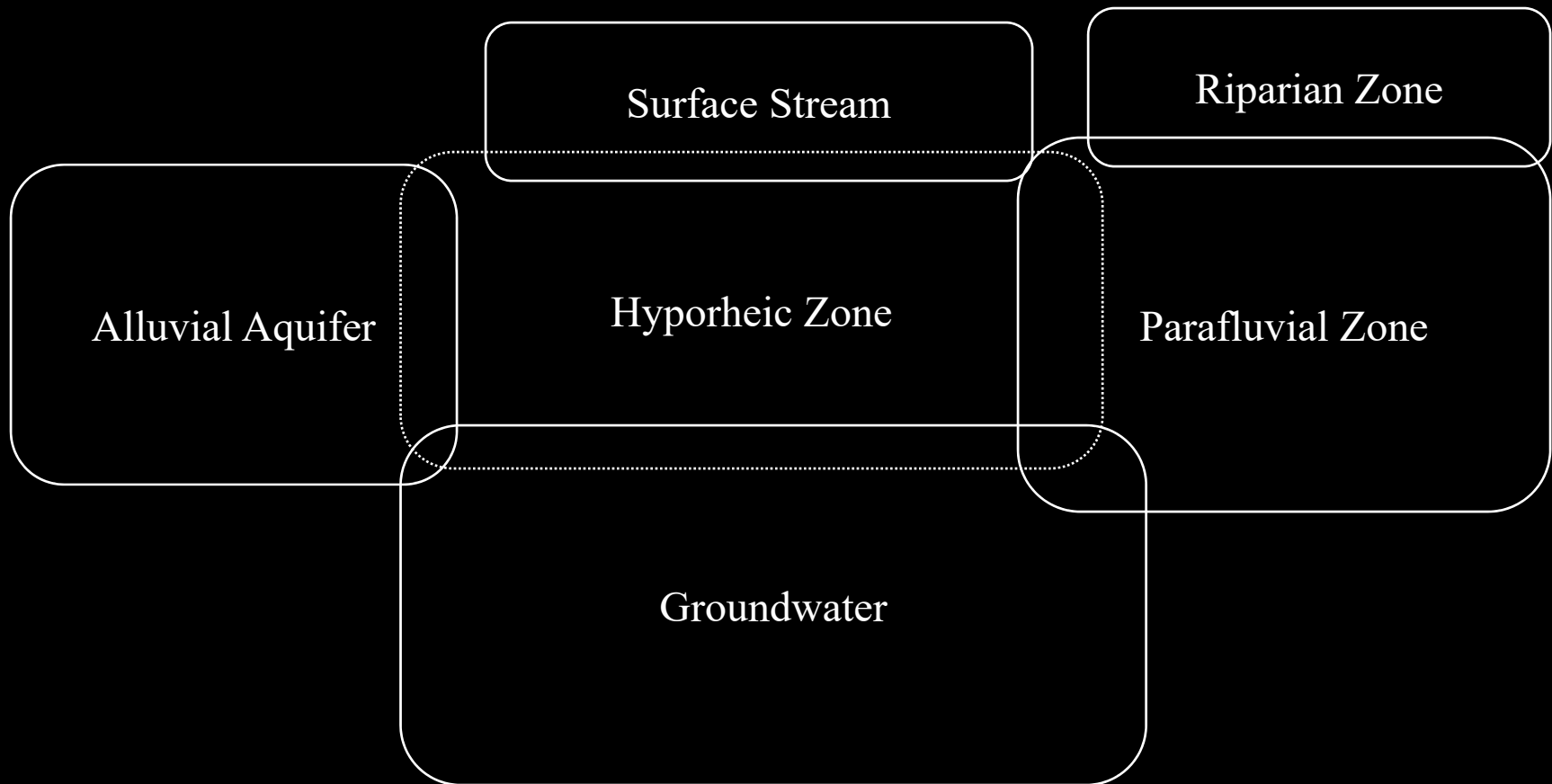
Sample DTS profile



What restoration approaches offer promise?

- Increase hyporheic exchange
 - Increasingly stenothermic profile at increasing depth
 - Spatially & temporally protracted interactions with cool substrate can reduce water temperature at upwelling locations

Hyporheos



What restoration approaches offer promise?

- Techniques that alter hydraulics

- Large wood, boulders
 - Hydraulic forcing
- Beaver-centric and beaver

Increased Hyporheic Exchange

- Increased head
- Head heterogeneity
- Floodplain reconnection

- Techniques that alter substrate porosity

- Gravel augmentation
- Other substrate remediation
- Altered flow regimes



Summary

- Elevated water T is a multifarious problem
- Few known options for *reducing* water T
 - Increasing shade & increasing flow reduce additional thermal accrual, but do not reduce T of water that is already warm
- Spatially resolute temperature monitoring (DTS, TIR) can reveal cold patch emergence resulting from restoration
- Certain combinations of techniques offer promise

Questions?

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