Thermal Benefits of Restoration

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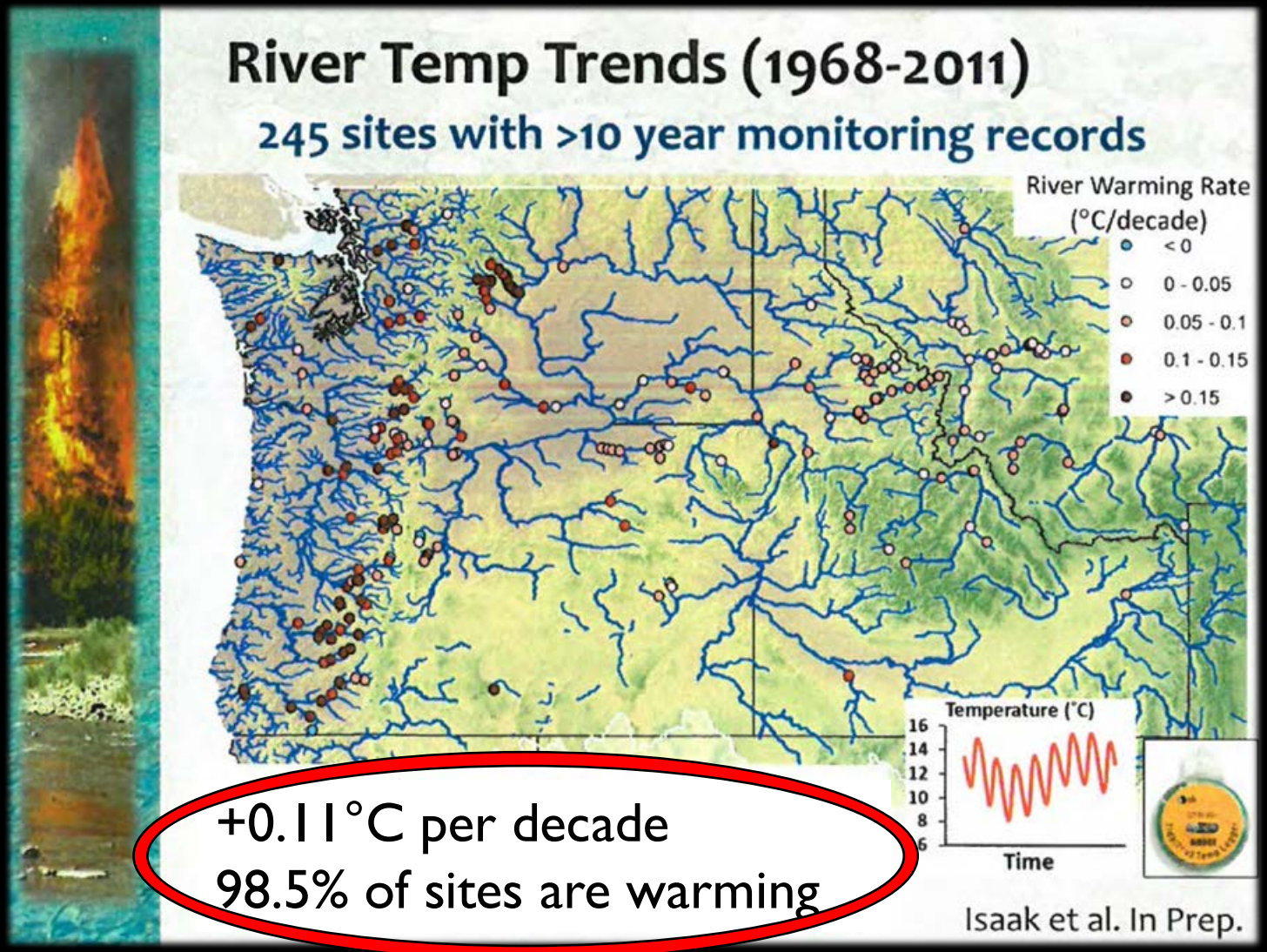
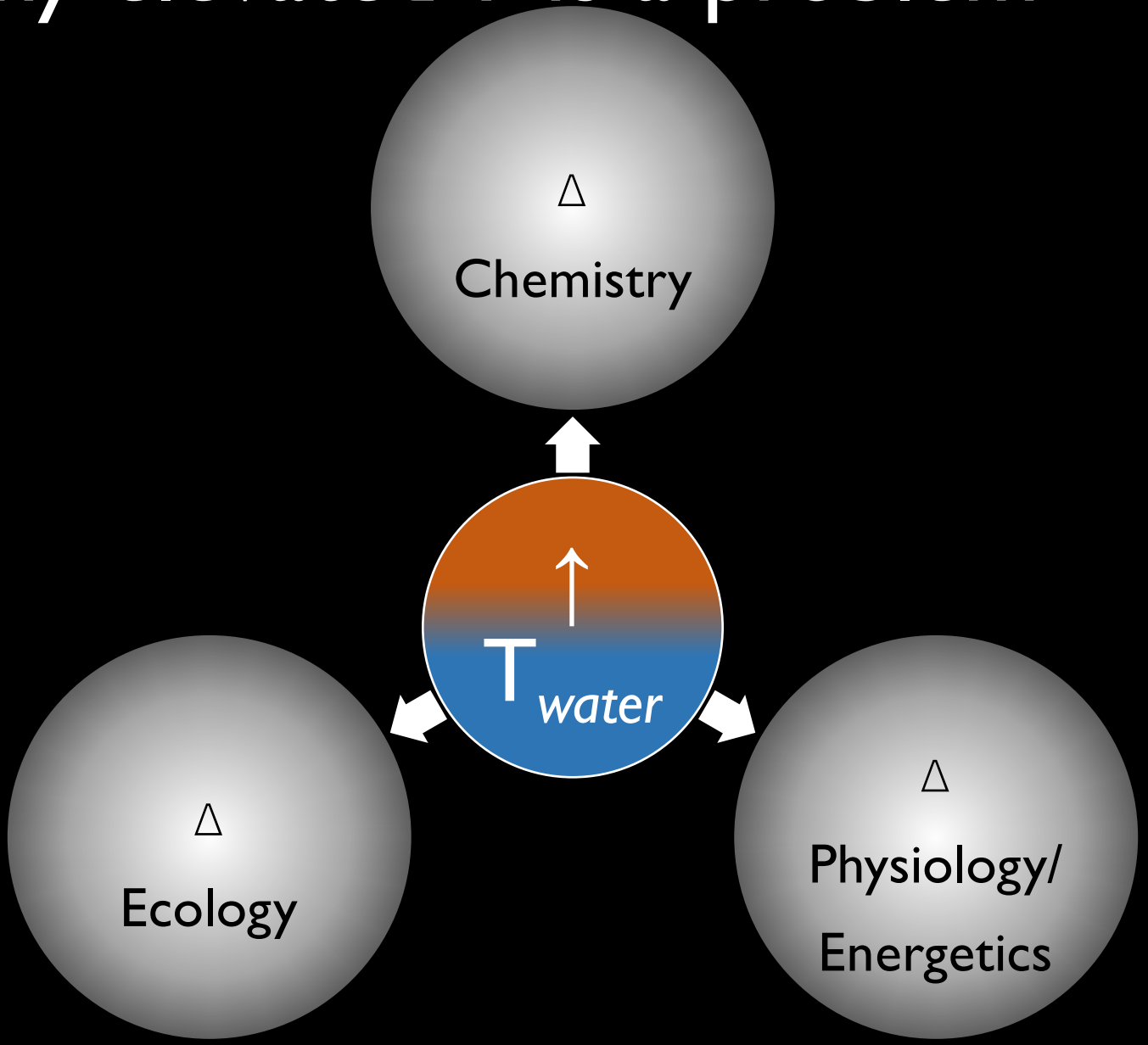
Presentation Overview

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

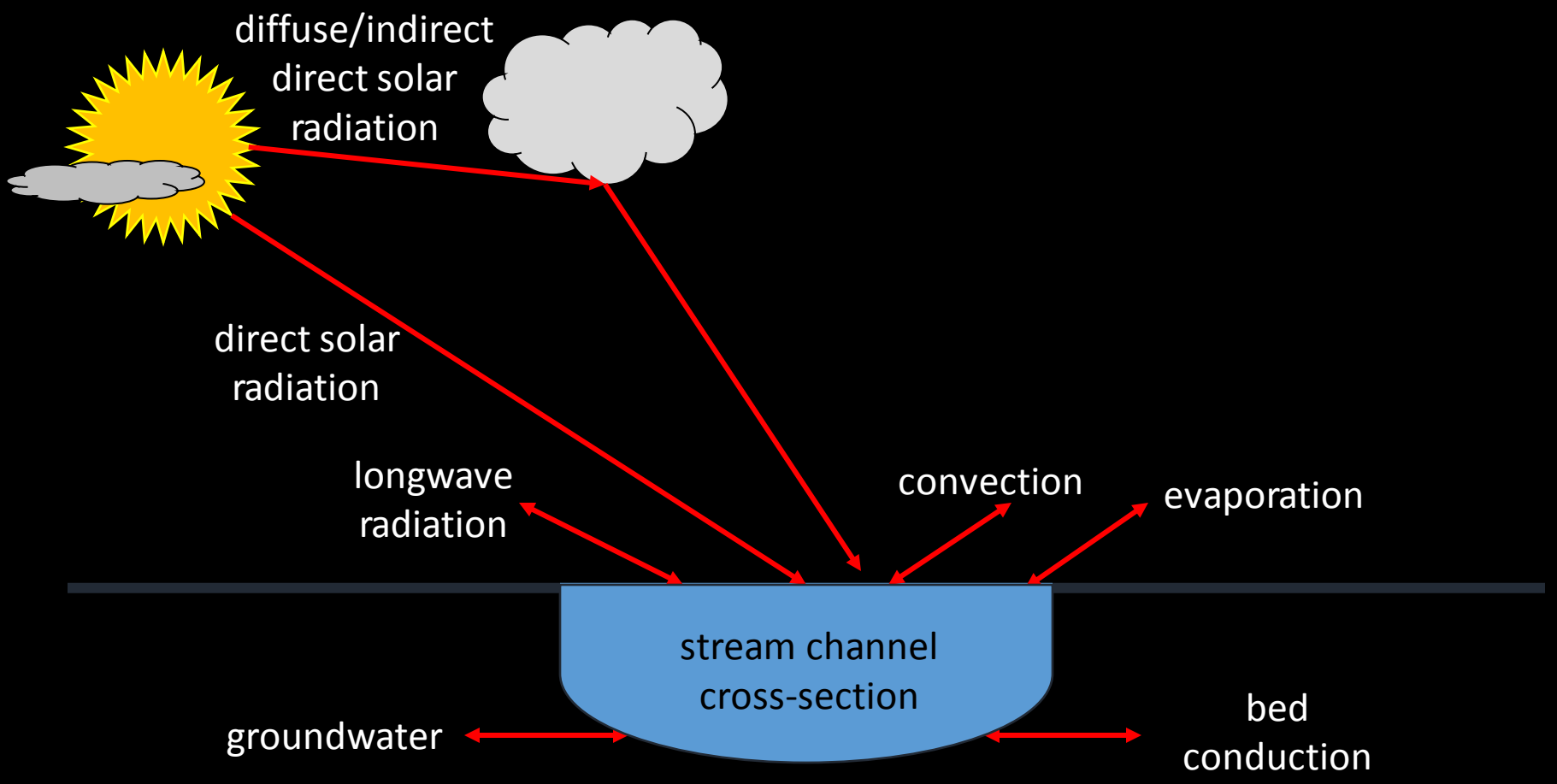
Context


River Temp Trends (1968-2011)
245 sites with >10 year monitoring records
River Warming Rate (°C/decade)
< 0
0 - 0.05
0.05 - 0.1
0.1 - 0.15
> 0.15
Temperature (°C)
16
14
12
10
8
Time
+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

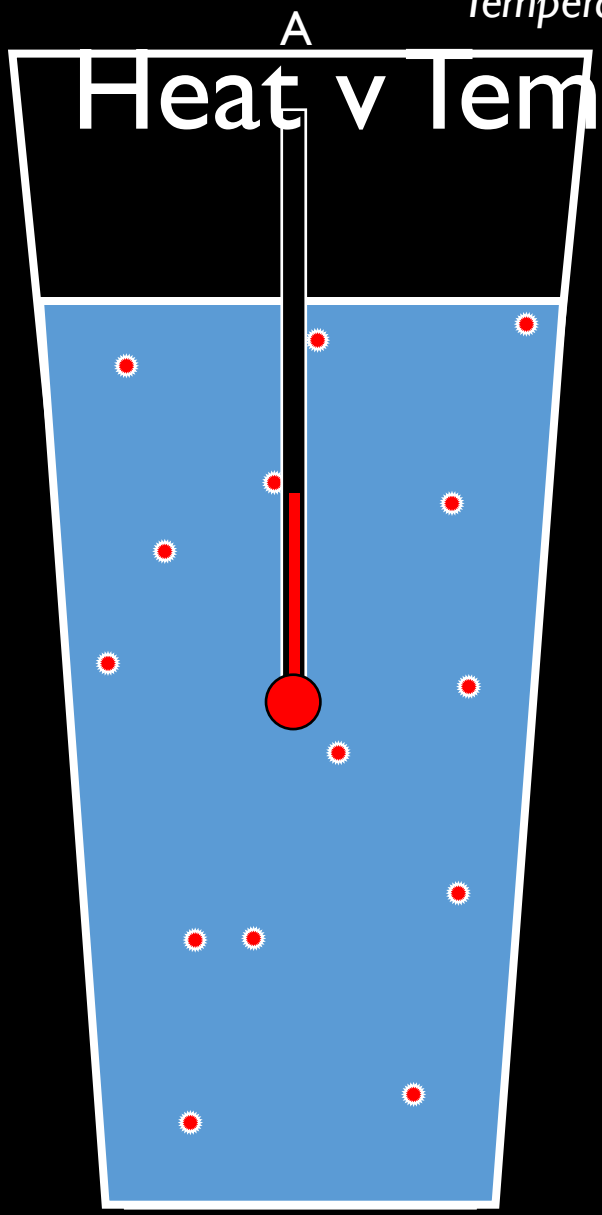


Redrawn, after Boyd and Sturdevant 1997

Heat is [total] energy

Temperature is a measure of [average] energy

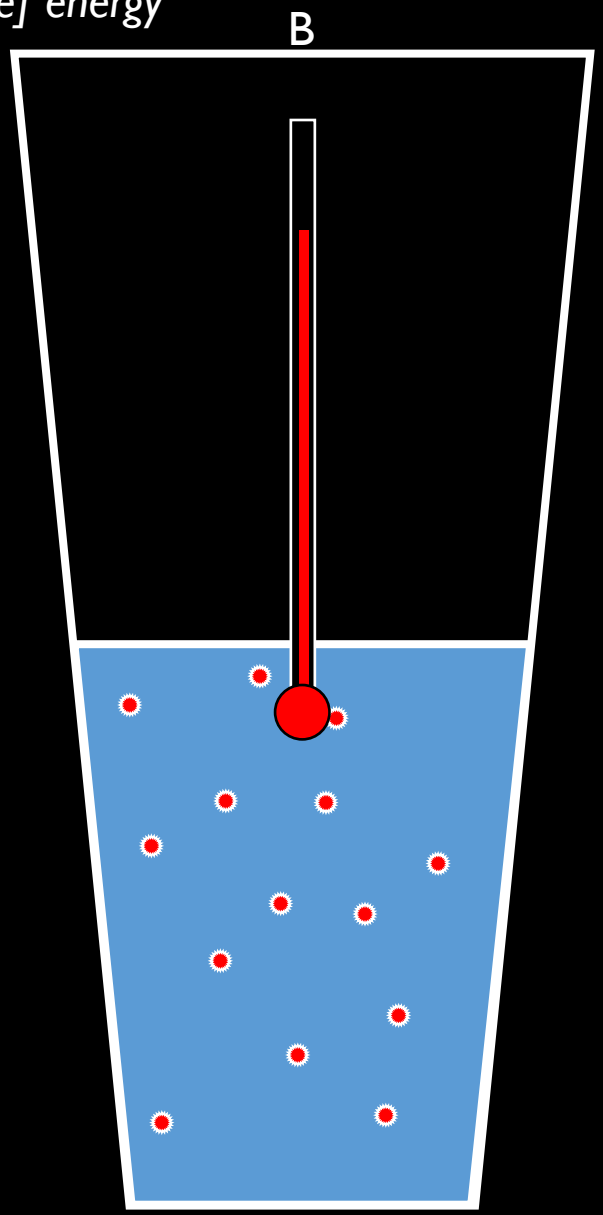
Heat v Temperature



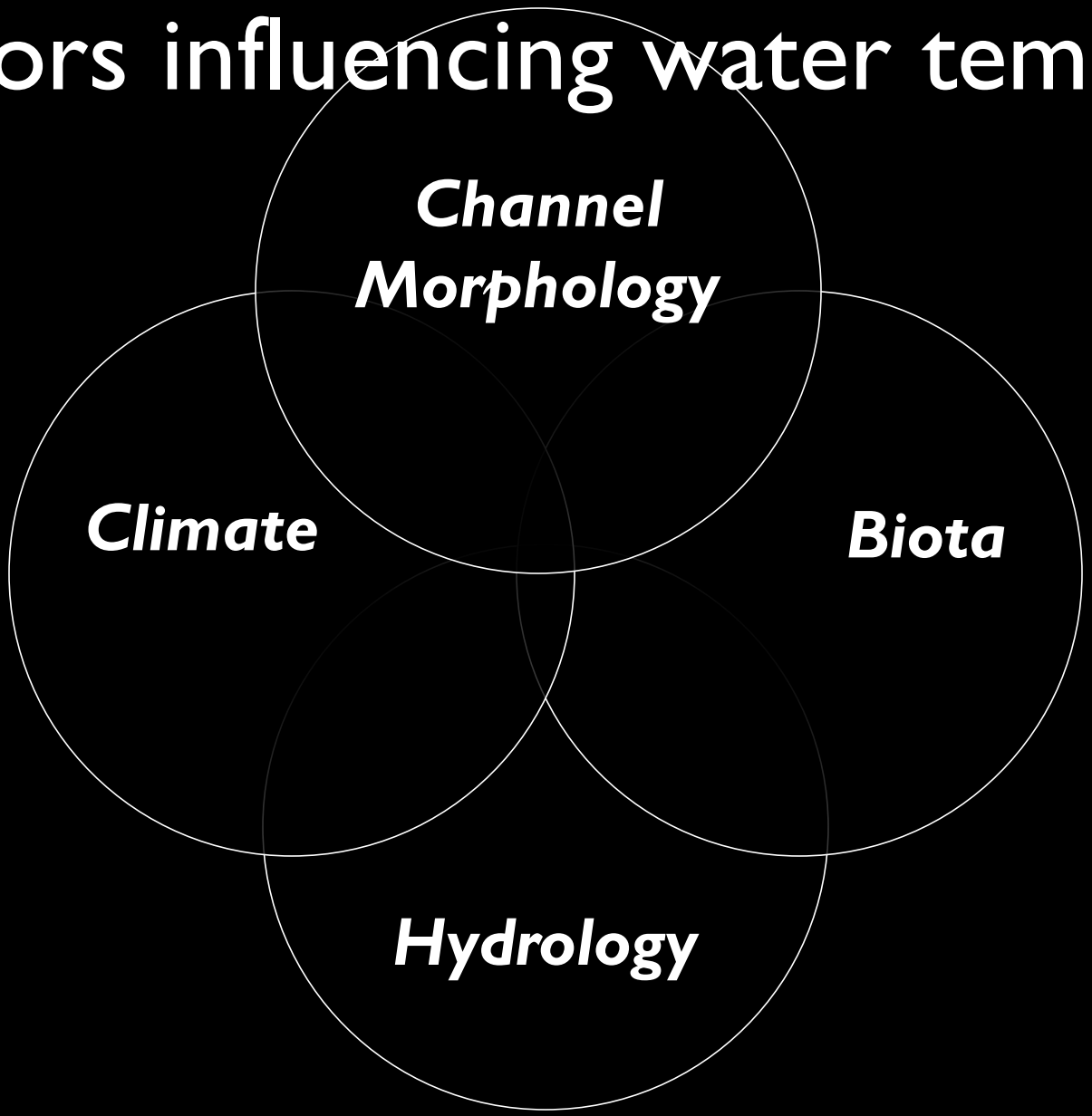
$Heat_A = Heat_B$

$Temp_A < Temp_B$

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



Factors influencing water temp

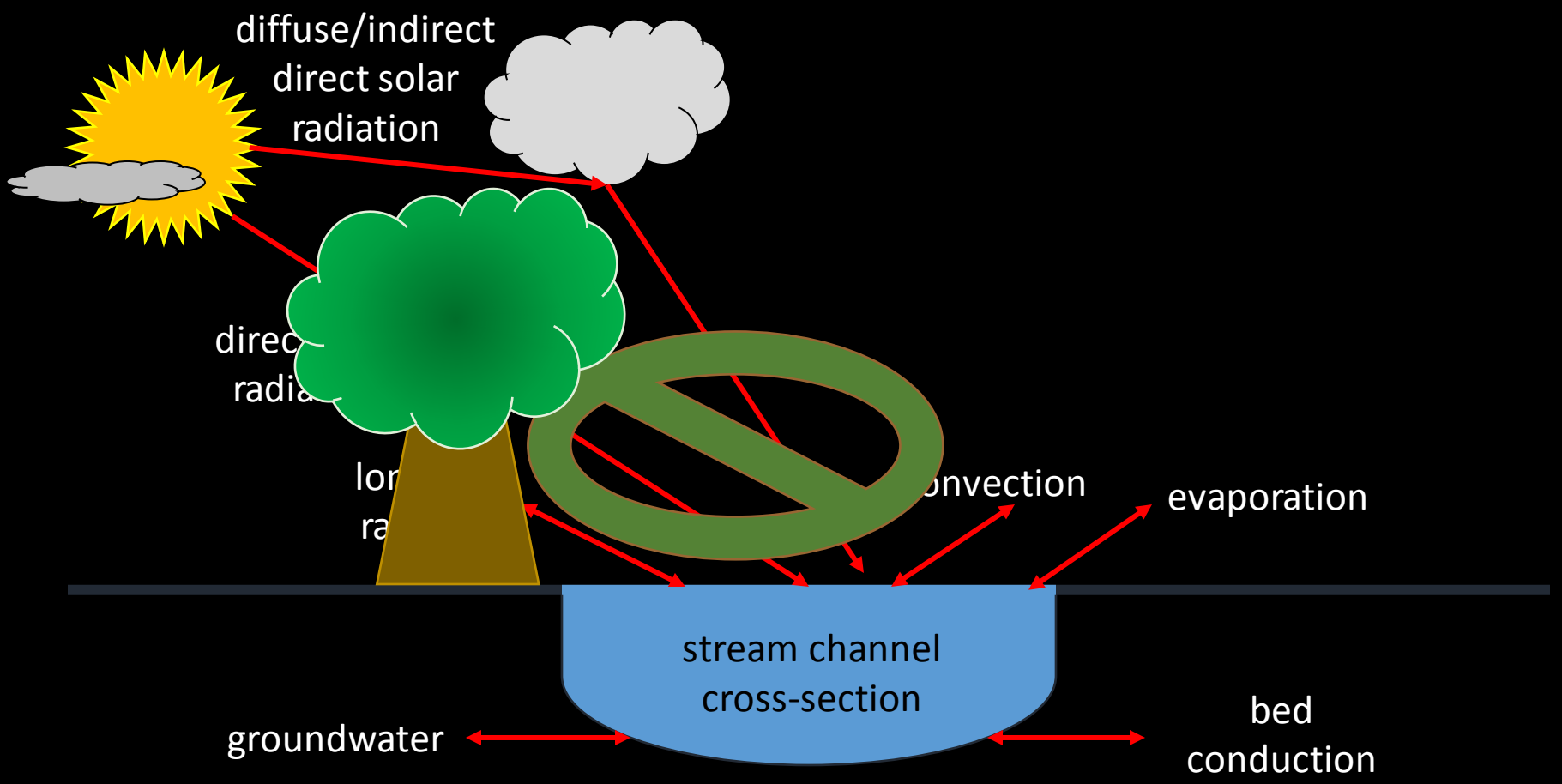


Redrawn, after Poole and Berman 2001, ODEQ 2008

What is the current restoration approach for T mitigation?

- Increase shade
  - Riparian planting

Mechanisms of heat transfer



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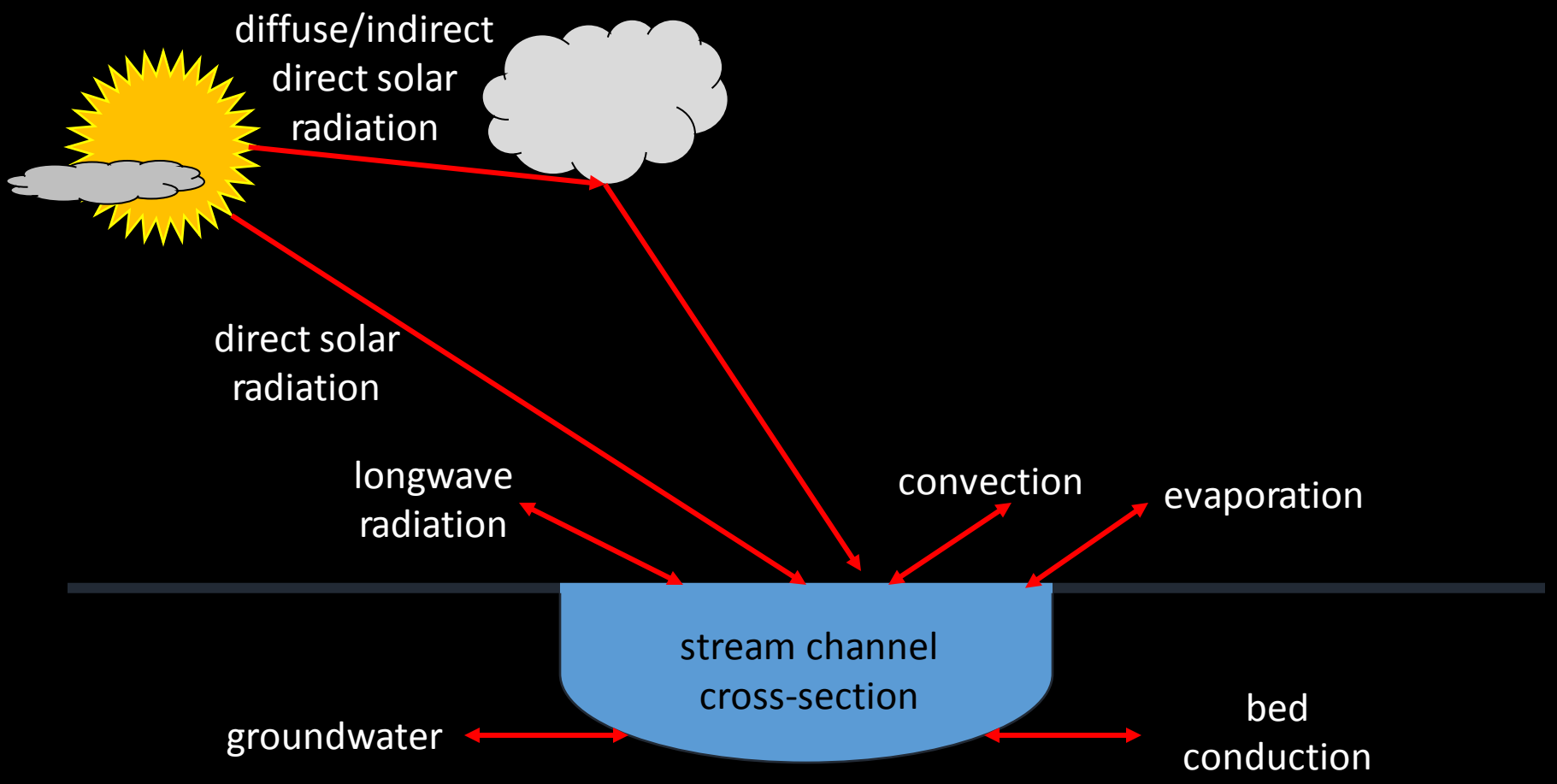
What is the current restoration approach for T mitigation?

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


PC: Angling for Conservation


PC: Pinterest

Mechanisms of heat transfer



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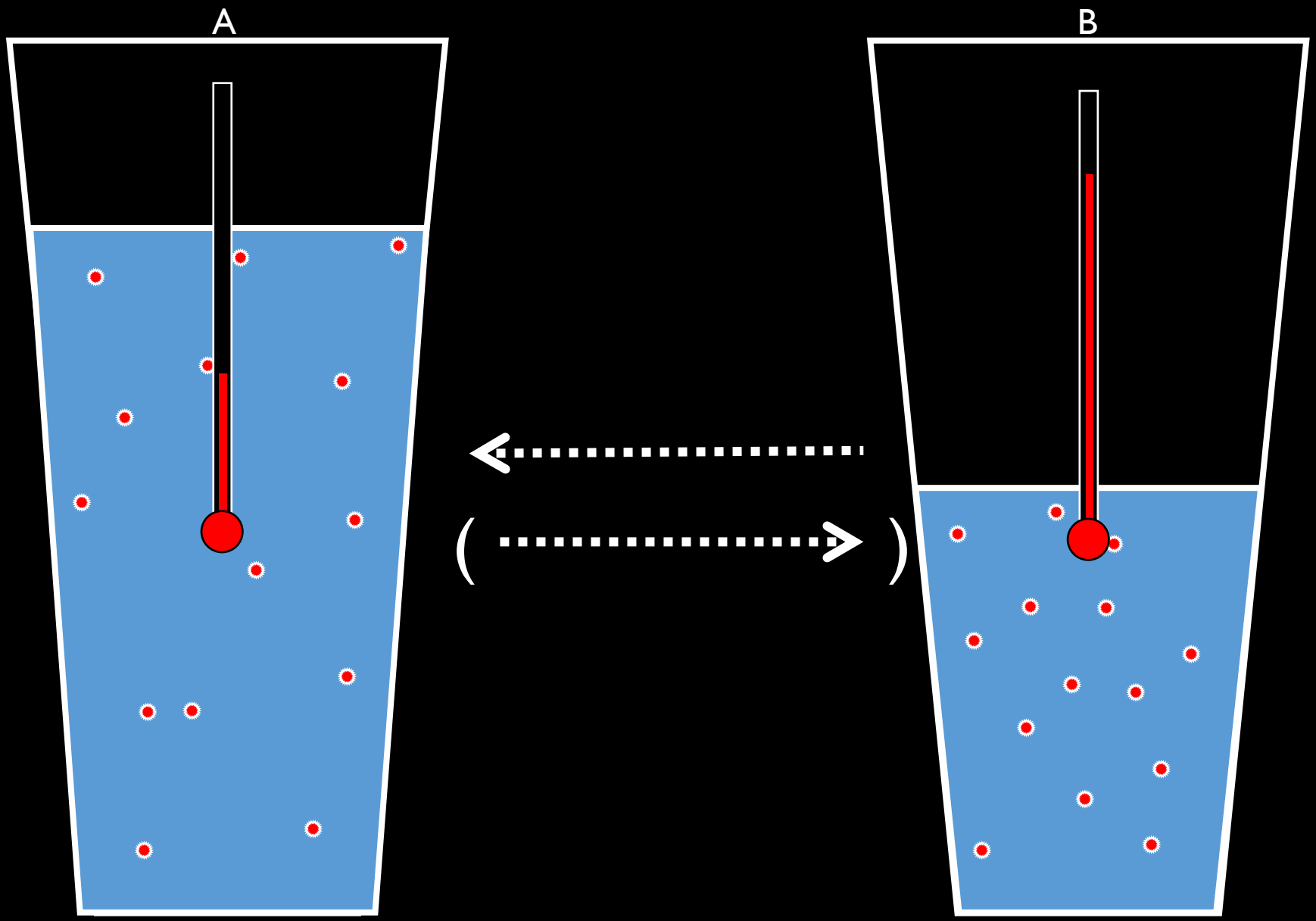

A
B

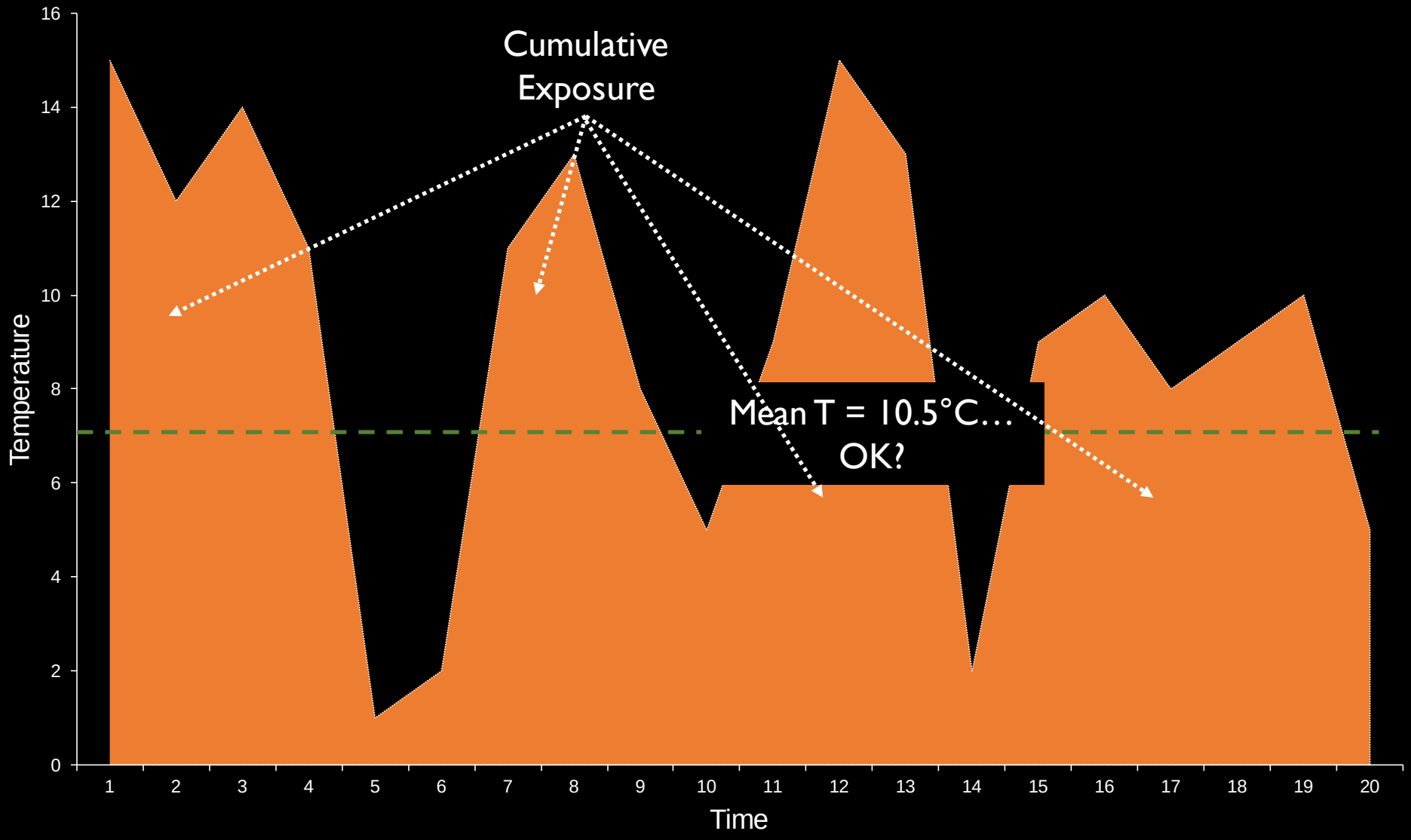
What is the current restoration approach for T mitigation?

- 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 t
  - What else can we do to *improve* c

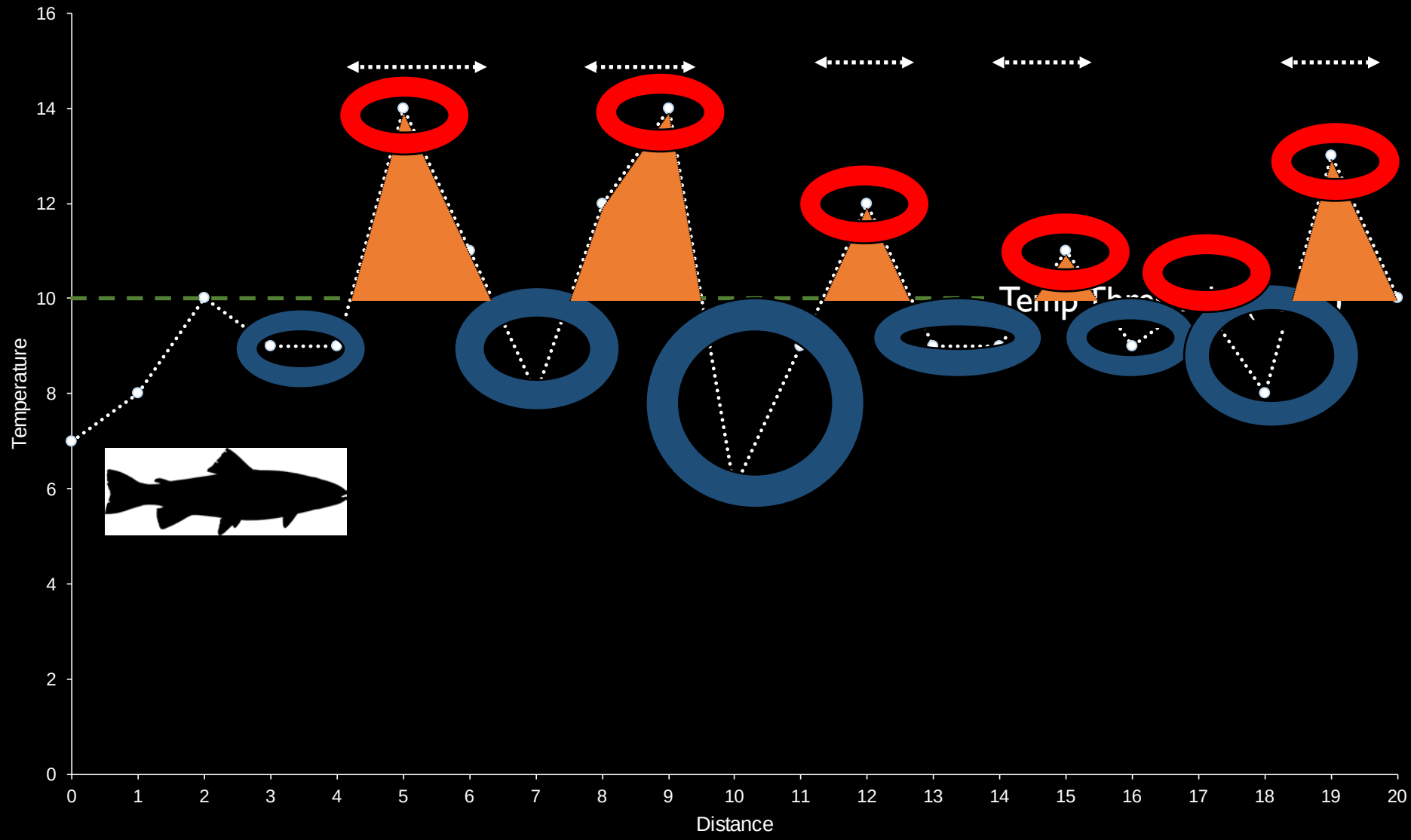
PC: Angling for Conservation

PC: Pinterest

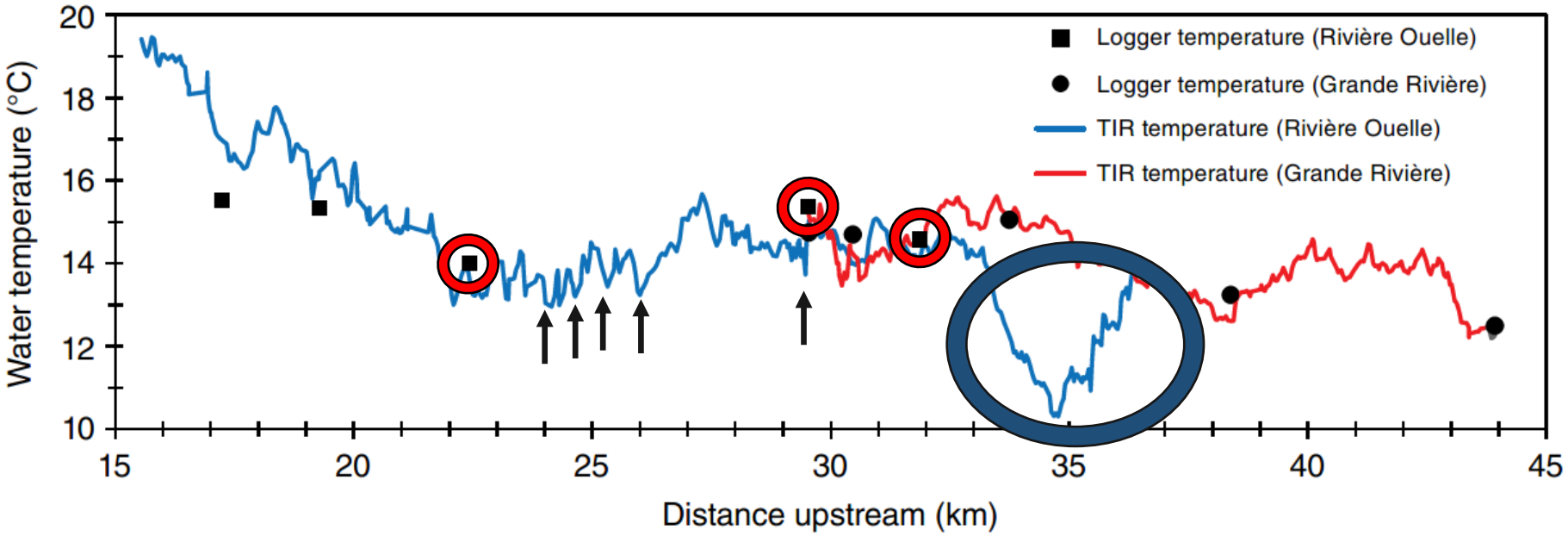
What matters for fish? Exposure



What matters for fish? Patches

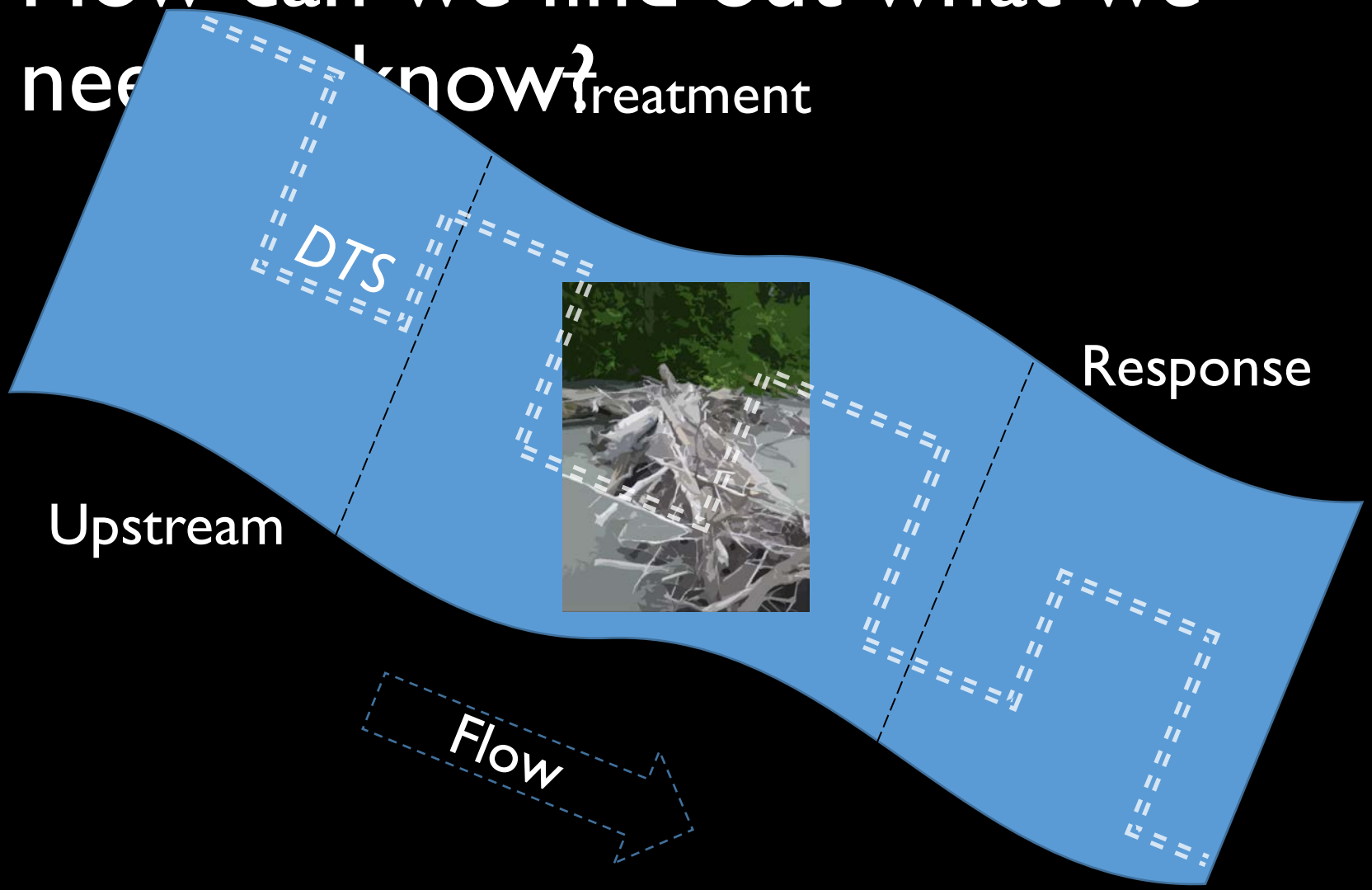


Detecting Complexity

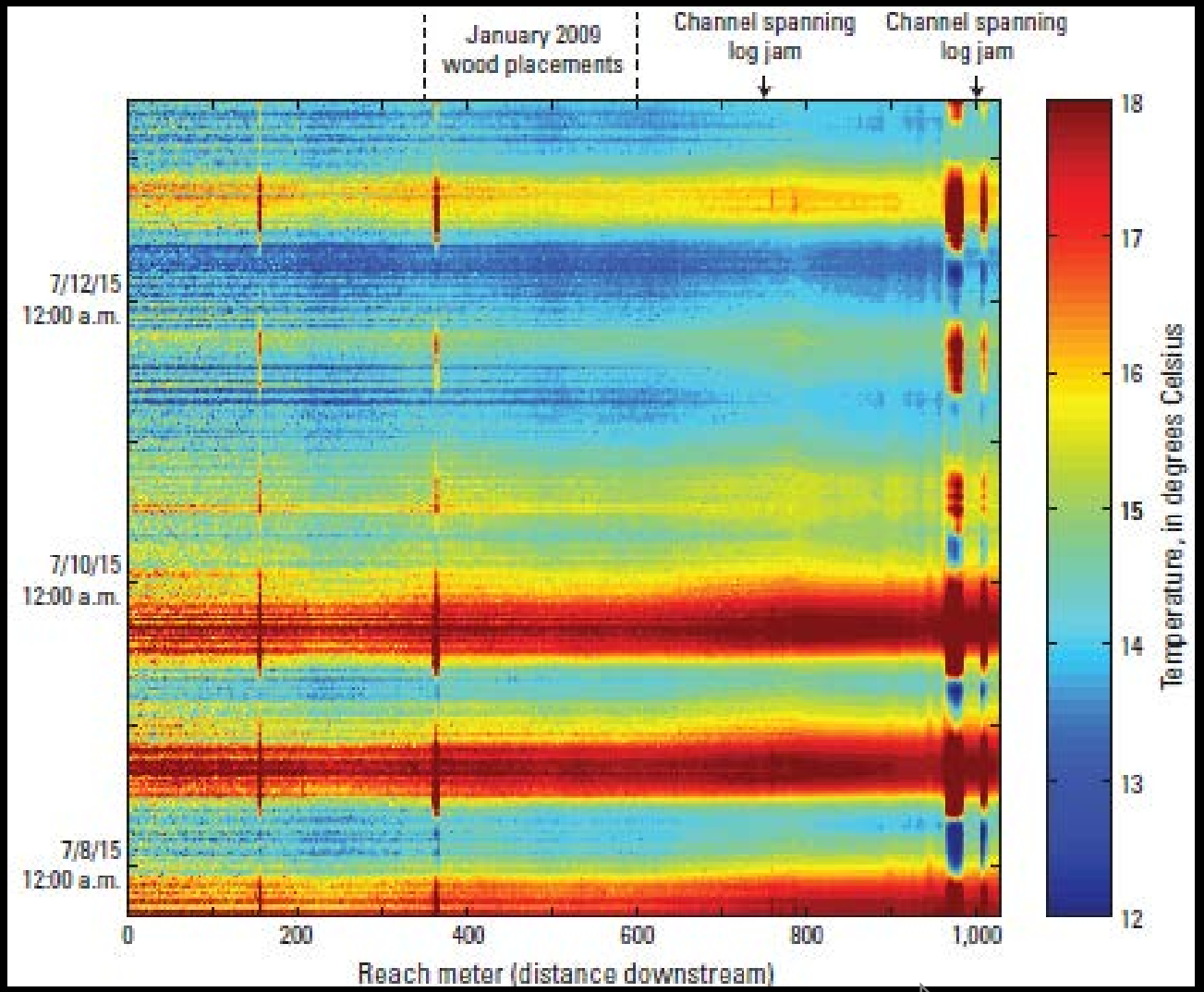


Dugdale et al 2016

How can we find out what we nee know?



Sample DTS profile

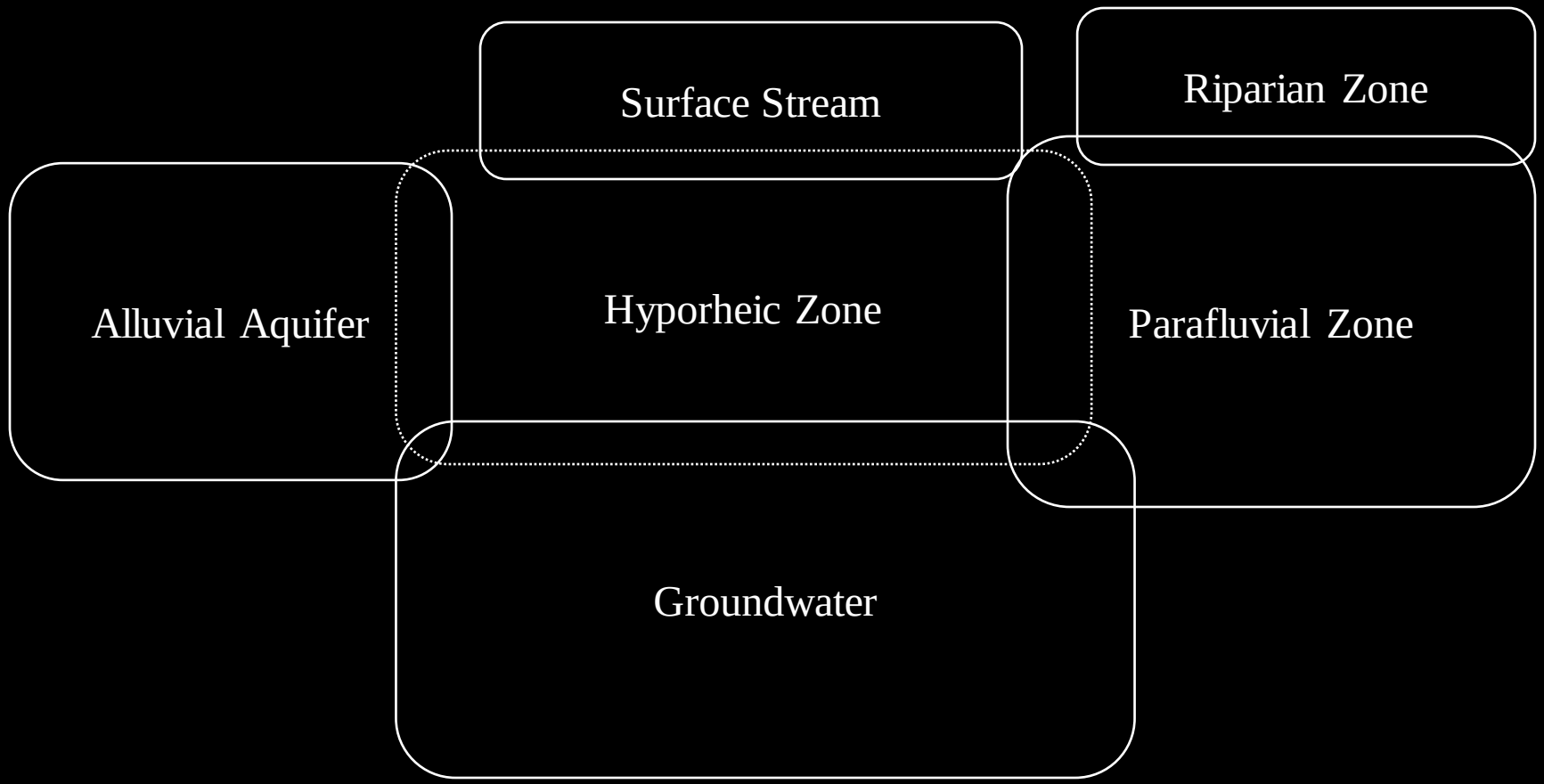


Macneale et al., in prep

What restoration approaches offer promise?

- Increase hyporheic exchange

Hyporheos



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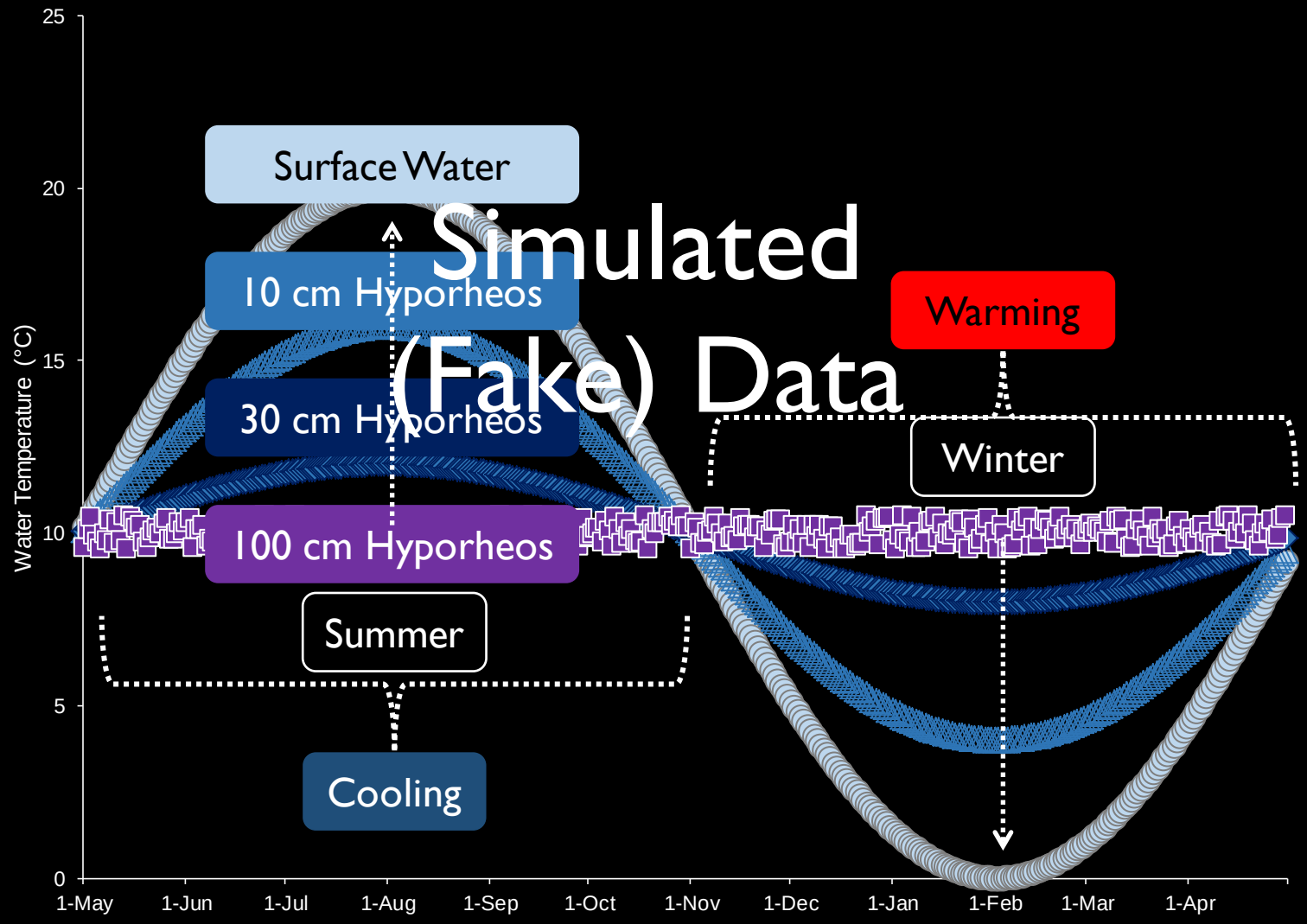
What restoration approaches offer promise?

- Increase hyporheic exchange
    - Increasingly stenothermic profile at increasing depth

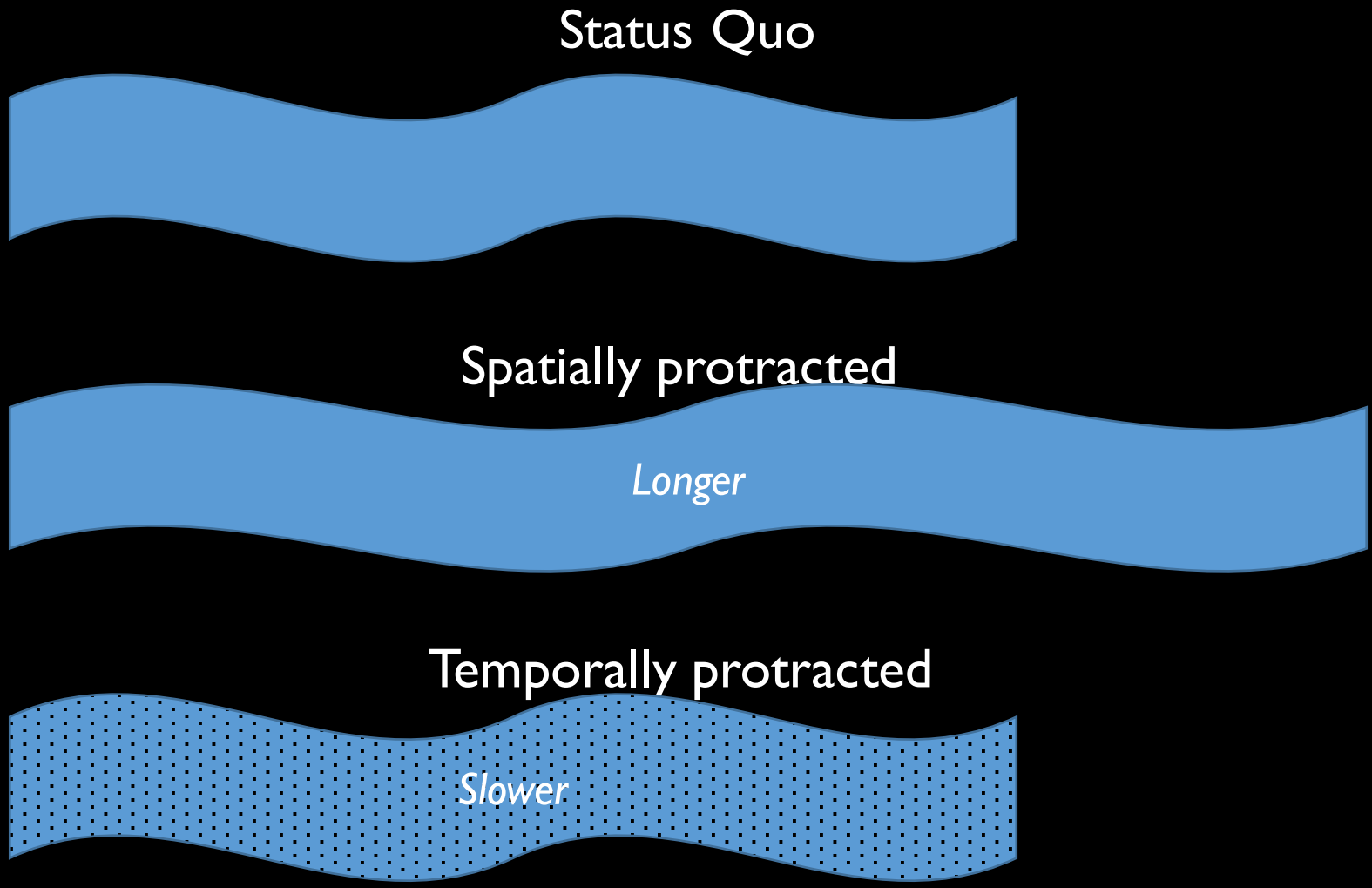
How does hyporheic exchange influence T?



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

How does hyporheic exchange influence T?



What restoration appro offer promise?

- Techniques that alter hydraulics
  - Large wood, boulders
    - Hydraulic forcing
  - Beaver centric and beaver
- Techniques that alter substrate porosity
  - Gravel augmentation
  - Other substrate remediation
  - Altered flow regimes

Increased Hyporheic Exchange

- Increased head
- Head heterogeneity
- Floodplain reconnection

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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