Northwest **Power** and **Conservation** Council



April 4, 2017

**MEMORANDUM**

**TO:** **Fish and Wildlife Committee members**

**FROM:** **Leslie Bach**

**SUBJECT:** **Cold-water habitat overview**

## BACKGROUND:

**Presenter:** Leslie Bach

**Summary:** The importance of cold-water to salmon and steelhead is well-known and documented. Seasonal temperatures in both the mainstem and tributaries are often above optimal conditions for fish. In addition, climate change models predict general increases in stream temperature as well as shifts in the timing of streamflow. These changes could exacerbate the already challenging seasonal conditions for fish. Maintaining and enhancing cold-water habitats is critical to the conservation and long-term viability of salmonids in the Columbia River Basin.

Numerous efforts are underway to understand the distribution, processes and functions of cold-water habitats, and to identify measures to protect and restore them. The processes that form and maintain cold-water habitats, as well as the manner in which fish use these habitats, varies with location, landscape context and scale. A summary of the ongoing work on cold-water habitats; tools and methods to identify and map these habitats; and relationships to fish use will be summarized in this presentation. Gaps in existing knowledge and data will also be highlighted.

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**Relevance:** Actions related to cold-water habitat are identified in numerous locations in the 2014 Fish and Wildlife Program. Protecting and restoring habitat is a key sub-strategy in the Ecosystem Function section of the Program (page 41). An important aspect of this is ensuring that the habitats that are restored and protected are providing the appropriate thermal regimes for fish and other aquatic life. Specific to mainstem habitat measures, the Program states that "The Council will consider additional mainstem habitat actions including "identifying, protecting restoring and managing thermal refugia for salmonid use during high water-temperature periods" (page 43). Under the Climate-Change sub-strategy, the general measures call for the action agencies to "evaluate the effectiveness and feasibility of possible actions to mitigate effects of climate change…other actions to create or protect cool water refugia in mainstem reaches or reservoirs" (page 58).

The ISAB and ISRP's 2016 Critical Uncertainties Report extensively highlights the importance of thermal refuges. Some examples include the value of 1) understanding the locations of thermal refuges in the mainstem as temperatures increase with climate change, 2) securing thermal refuges and sufficient high quality water under predicted landscape-scale changes in hydrology, and 3) considering areas likely to provide thermal refuges for aquatic species when selecting areas for habitat restoration.

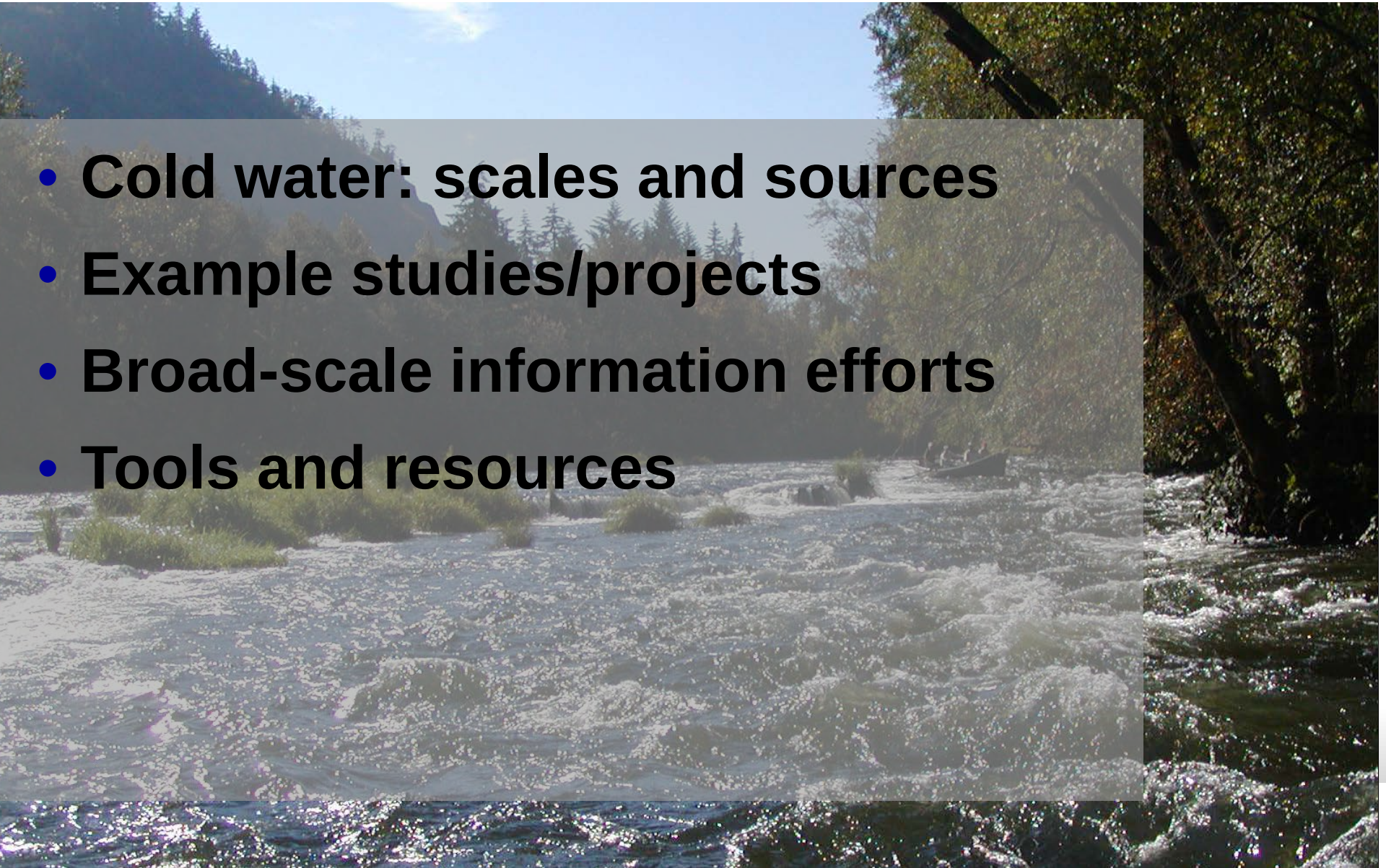
**Background**: Components of this topic have been addressed at previous Council meetings over the past several years. Information on cold-water refuges in the mainstem Columbia were presented at EPA's Columbia River Cold Water Refugia workshop in June, 2016. In addition, Stan Gregory provided an overview of cold-water habitats at the Future of our Salmon Conference in 2016. This overview will build on these past presentations to summarize the state of the science.

**More Info:**

- Nov 2015 presentation from Dan Isaak and Mike Young on Identifying, Protecting & Enhancing Climate Refugia for Salmonids
- January 2016 Council briefing on the Distribution and use of Cold Water Refuges in the Willamette
- August 2016 presentation from John Palmer and Matthew Keefer

# Cold-water habitat in the Columbia River Basin

# Presentation Outline



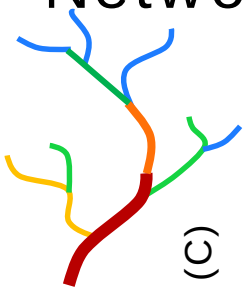
- **Cold water: scales and sources**
- **Example studies/projects**
- **Broad-scale information efforts**
- **Tools and resources**

# Spatial patterns

(of warm season mean/max)

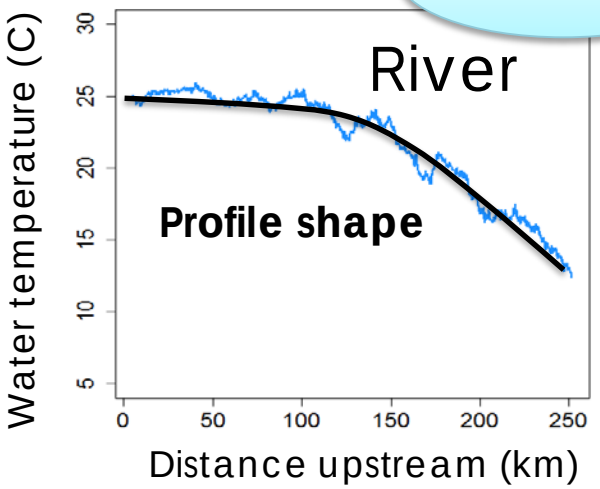
range

Network



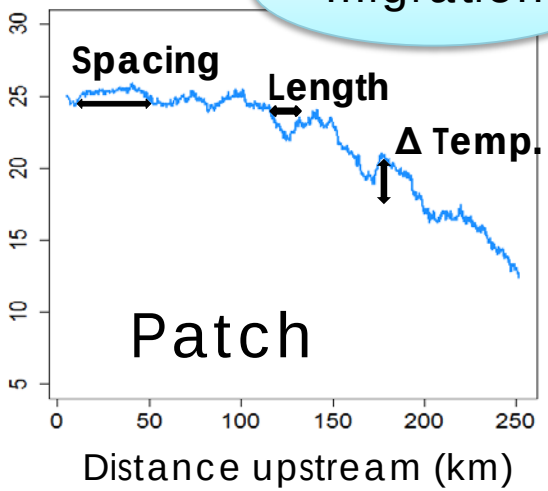
diversity

River



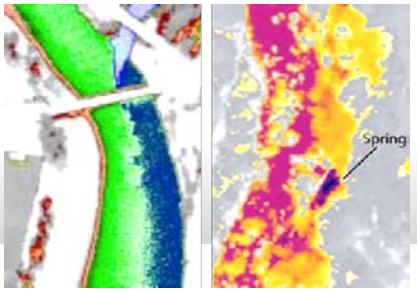

migration

Patch




refuge

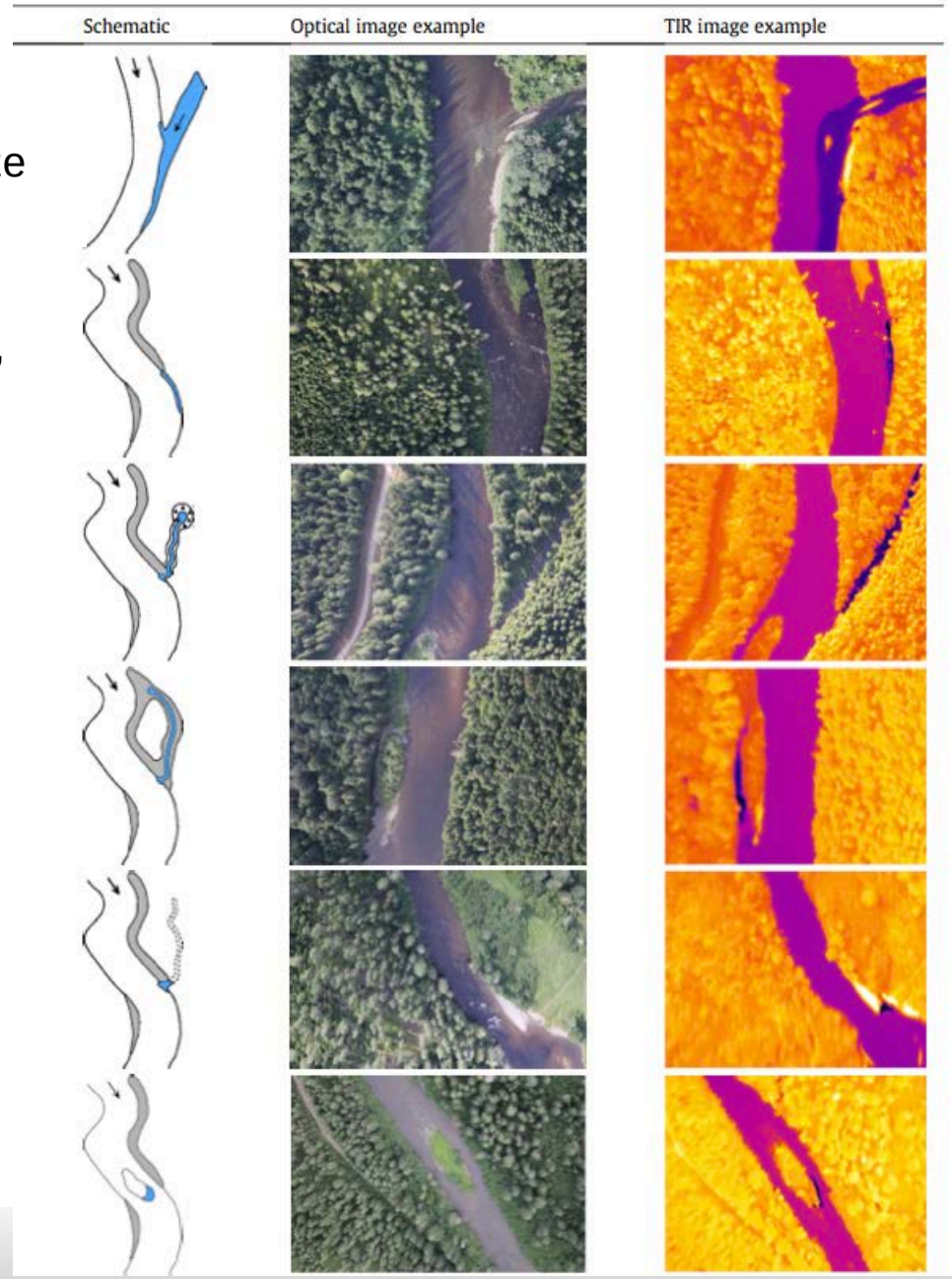
Microhabitat




Localized inputs

Source: Aimee Fullerton, NOAA-Fisheries

| Thermal Habitat | River Scale (Generalized) |
|---|---|
| Tributary confluence plume | Large - medium size rivers |
| Groundwater - seeps | Medium-size rivers, smaller streams |
| Groundwater - springs | Medium-size river, smaller streams |
| Cold side channel | Medium-size rivers |
| Cold alcove | Medium-size rivers |
| Hyporheic upwelling | Medium-size rivers, smaller streams |

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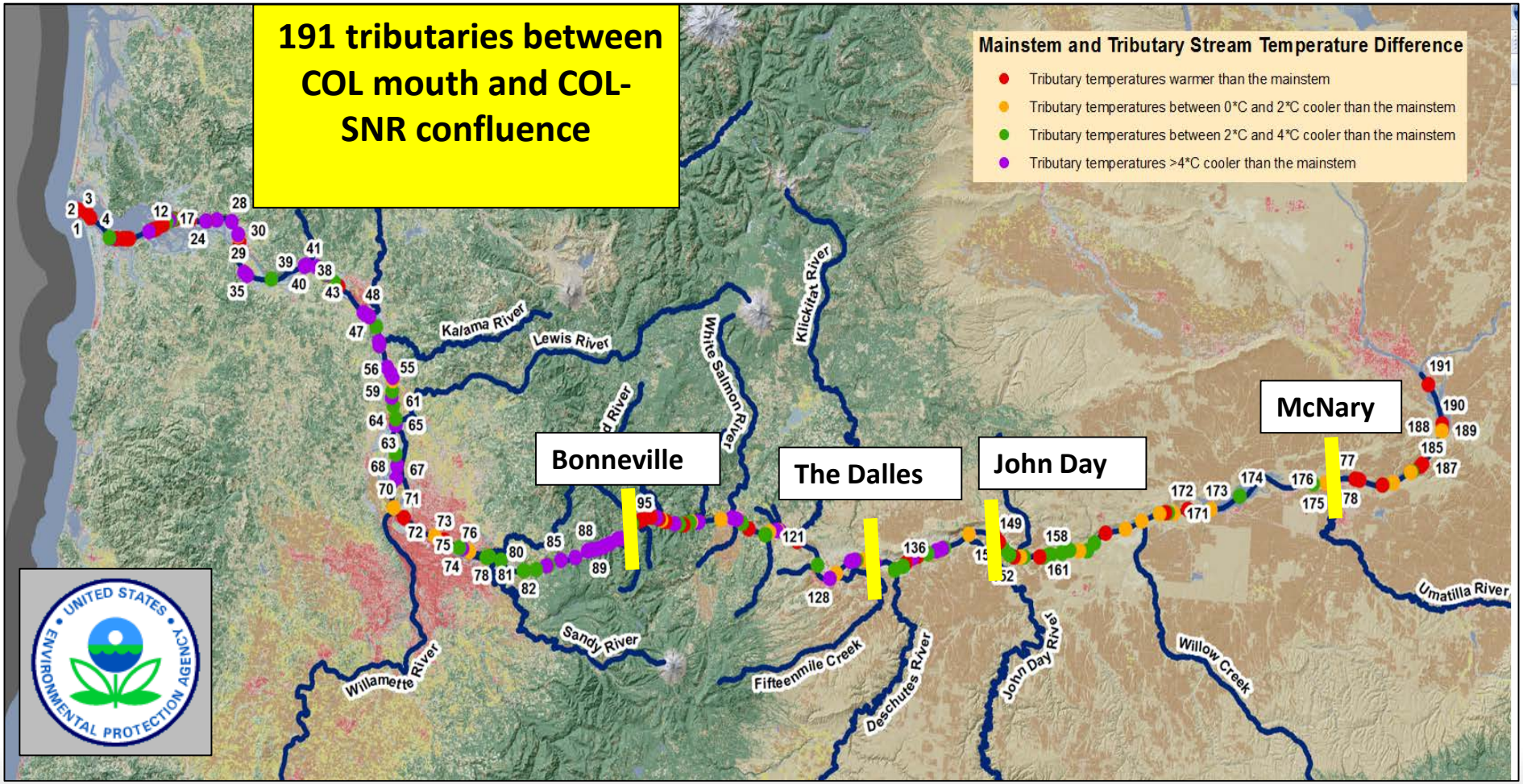
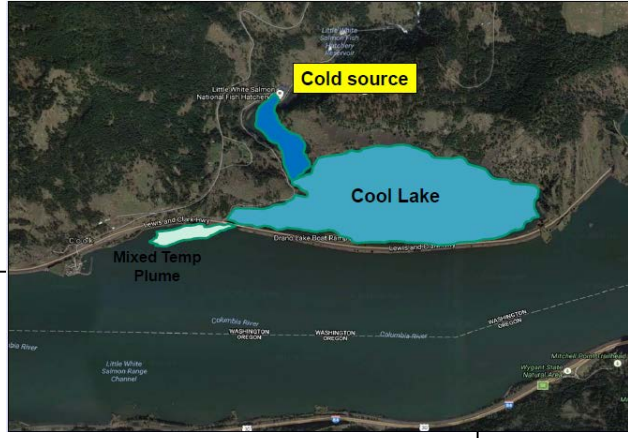
*Modified from*: Dugdale et al. 2013; *see also*: Torgersen et al. 2012

# Lower Columbia: Cold water refuge tributaries identified in EPA catalog



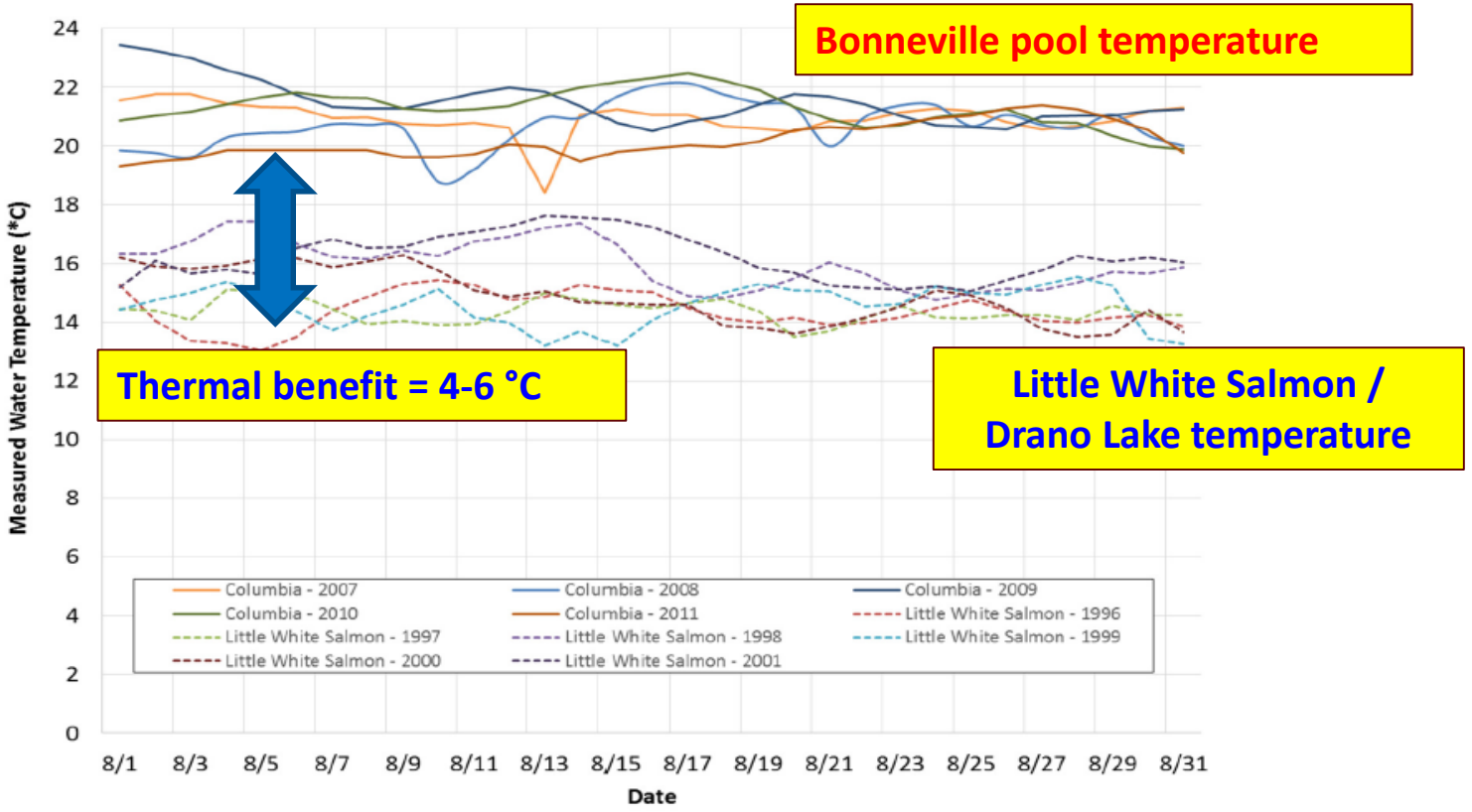

Data source: NorWest, USFS

# Example thermal refuge site in Bonneville pool




**Tributary #112 – Little White Salmon River**

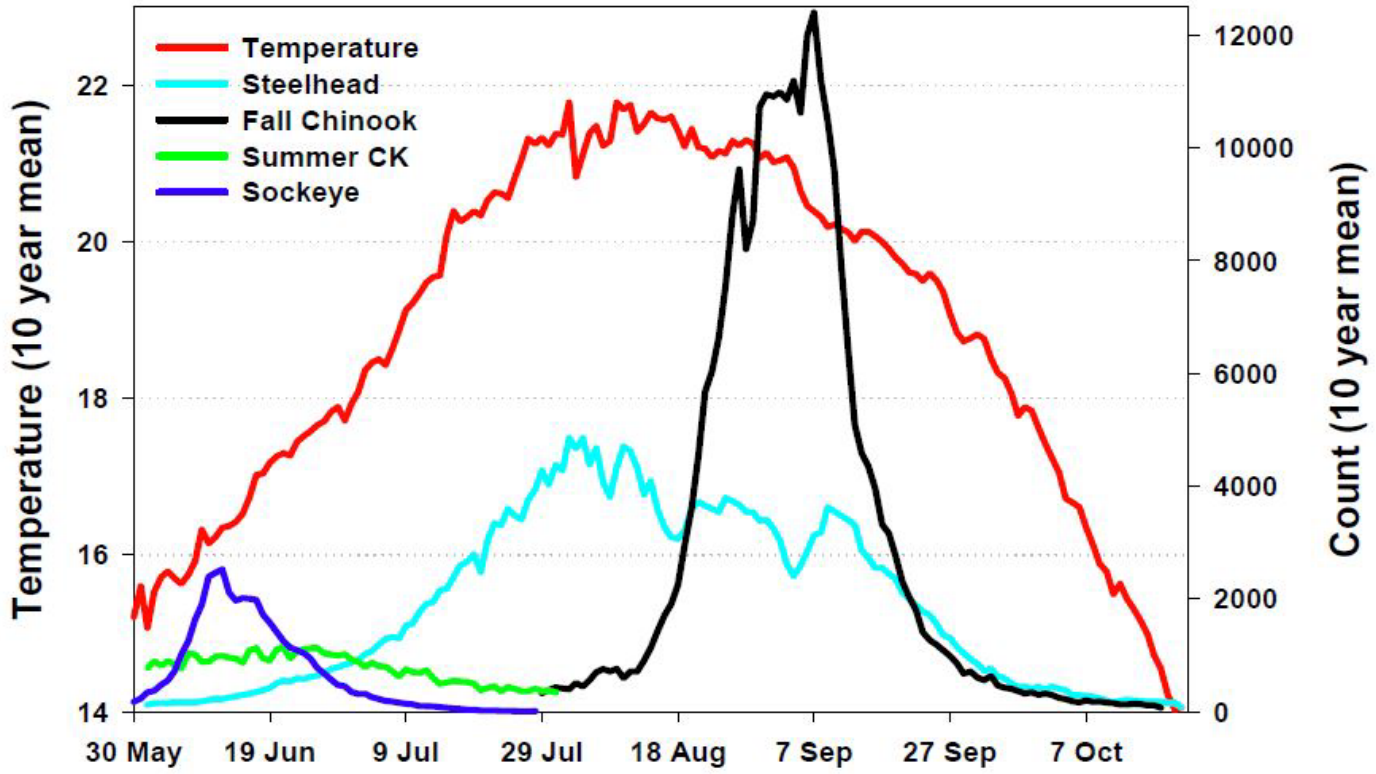
*Daily Average Water Temperature*




Source: Matthew Keefer, University of Idaho

Data source: NorWest, USFS

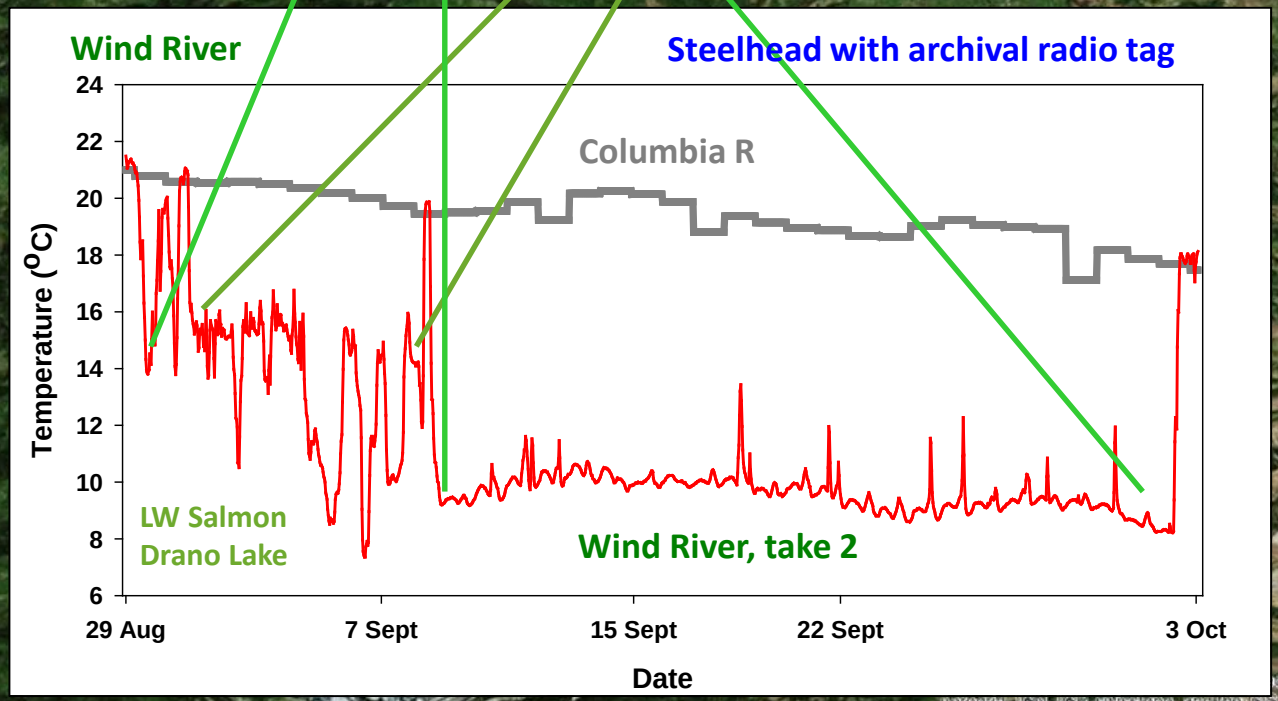
# Lower Columbia River Temperature and Salmon Use




Keefer et. al. 2011

# Refuge use: Steelhead

## Columbia River between Bonneville Dam and The Dalles Dam

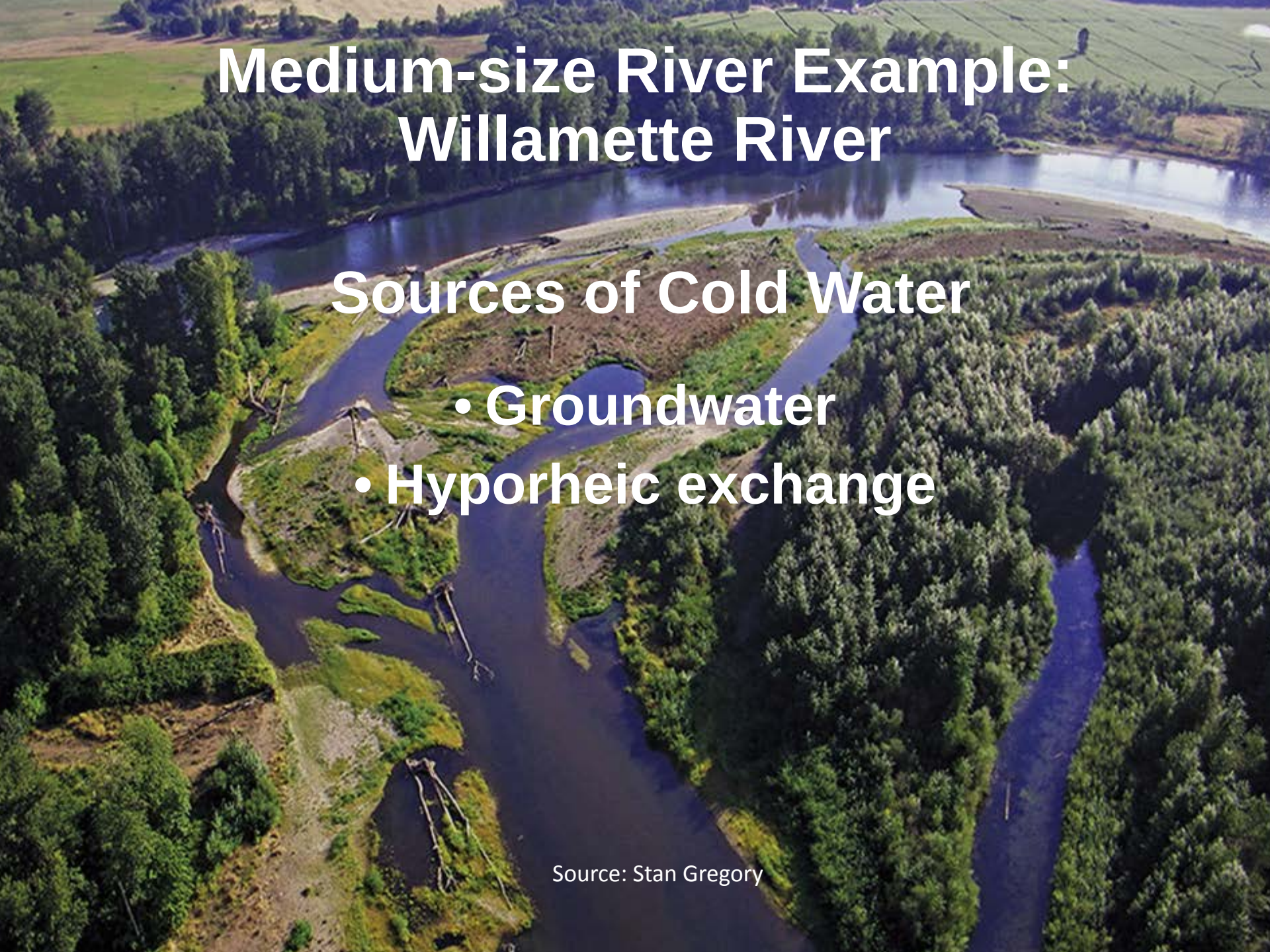



92 94 96 100 112 115 116 119 120 122 123 125 127 128 129

Source: Matthew Keefer, University of Idaho

# Gaps and Future Efforts

- Significant gaps in information along the mainstem Columbia (and Snake) Rivers
- EPA and LCEP studying tributaries below Bonneville Dam
- Developing a model to track fish and determine thermal exposure and effects



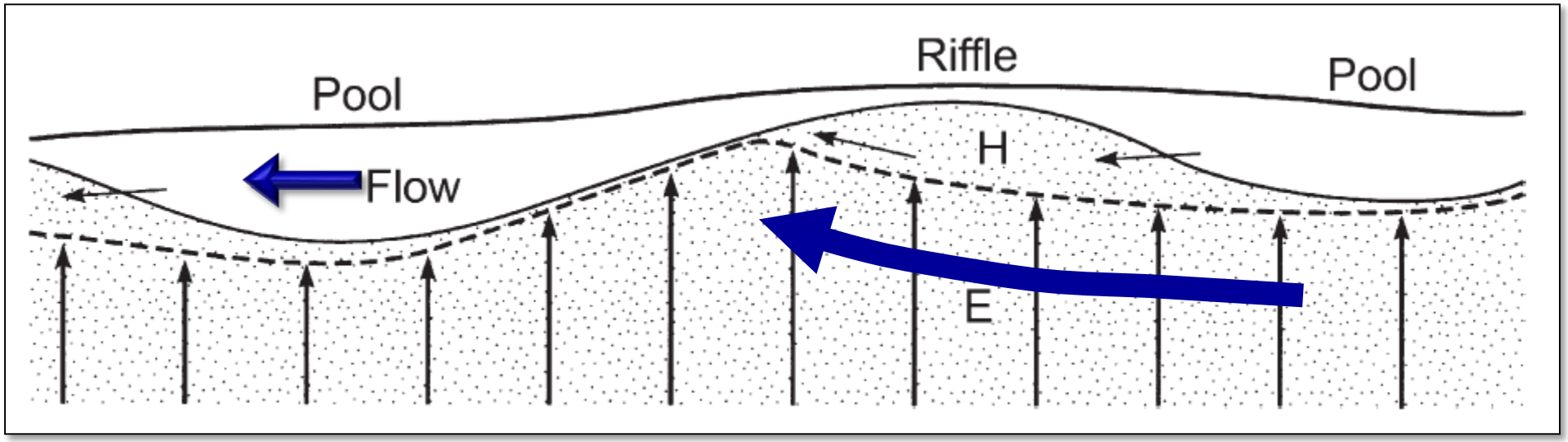
# Medium-size River Example: Willamette River

## Sources of Cold Water

- Groundwater
- Hyporheic exchange

Source: Stan Gregory

# Hyporheic Flow - side view




**Side Channel**:

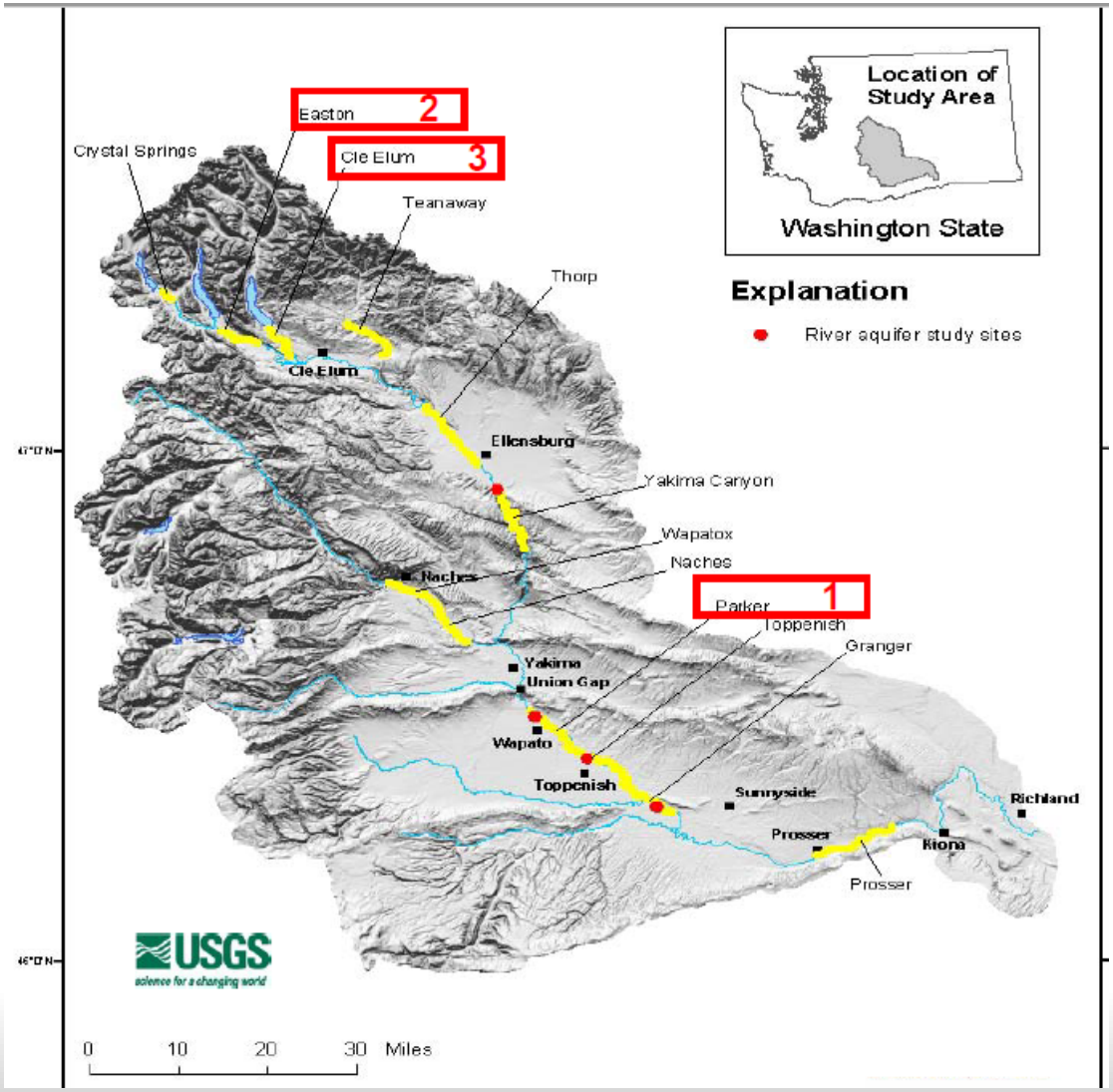
- 25% of side channel sites were colder than mainstem Willamette
- None were >2ºC colder than mainstem

**Floodplain alcove:**

56% of the alcoves were more than 2°C colder than mainstem maximum

Source: Stan Gregory

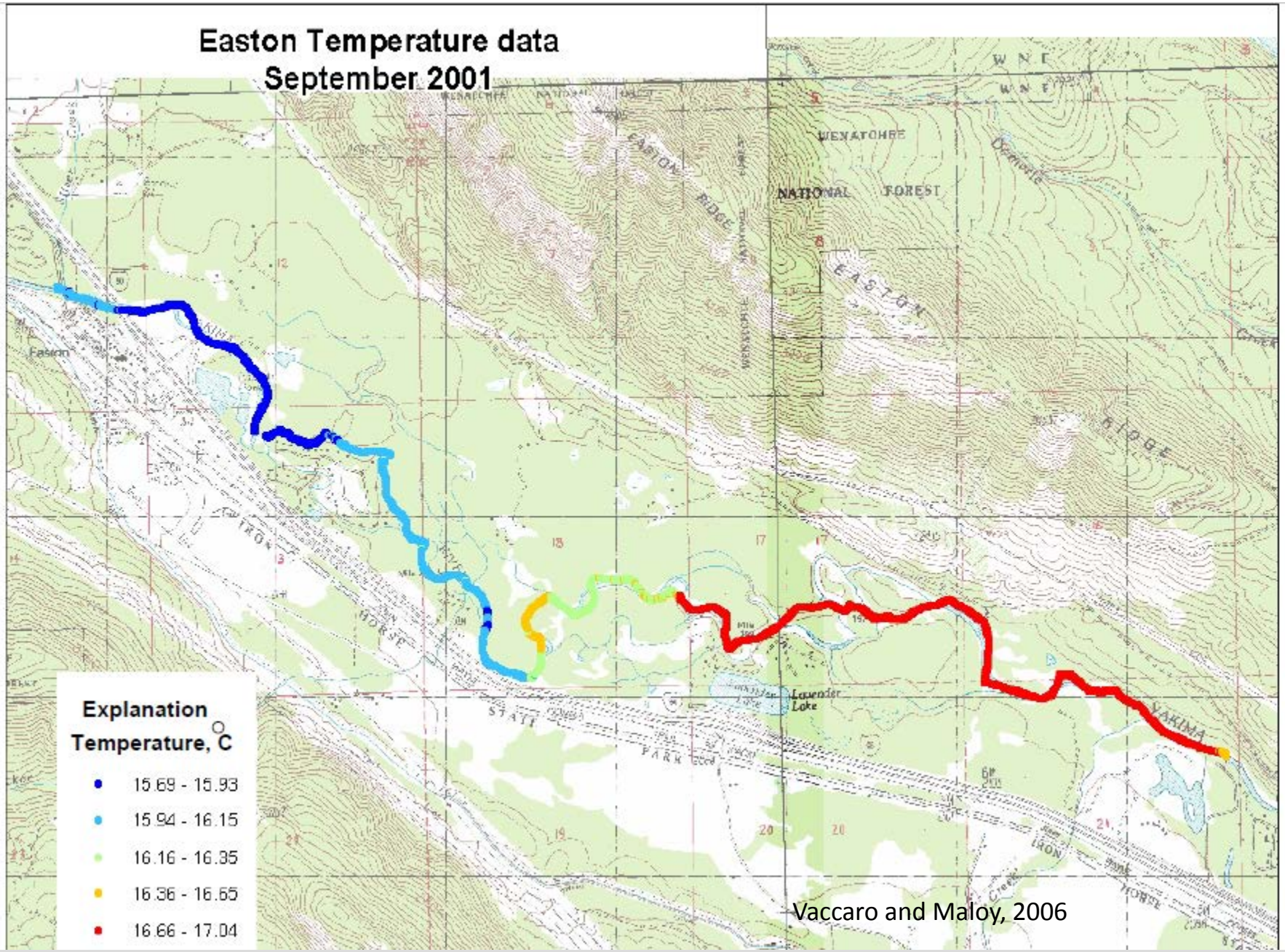
# Medium-size River Example: Yakama River




## Thermal Profiling Method

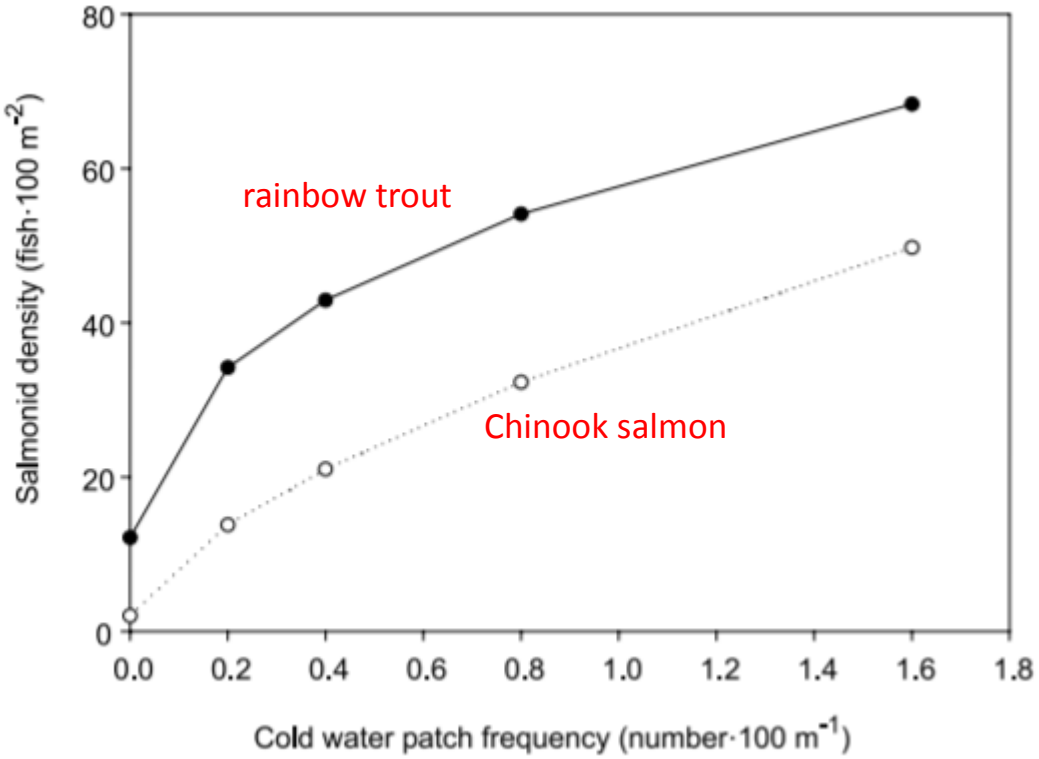
- Longitudinal profile of near-bottom water temperature, conductivity and depth
- Measured continuously while drifting at velocity of stream
- Long reaches: 5-25 km
- Tested in 11 reaches of Yakima River
- **Cold-water source is groundwater**

Vaccaro and Maloy, 2006


Easton Temperature data
September 2001
Explanation
Temperature, °C
15.69 - 15.93
15.94 - 16.15
16.16 - 16.35
16.36 - 16.65
16.66 - 17.04
Vaccaro and Maloy, 2006

# Smaller Stream Examples

Grande Ronde and tributaries



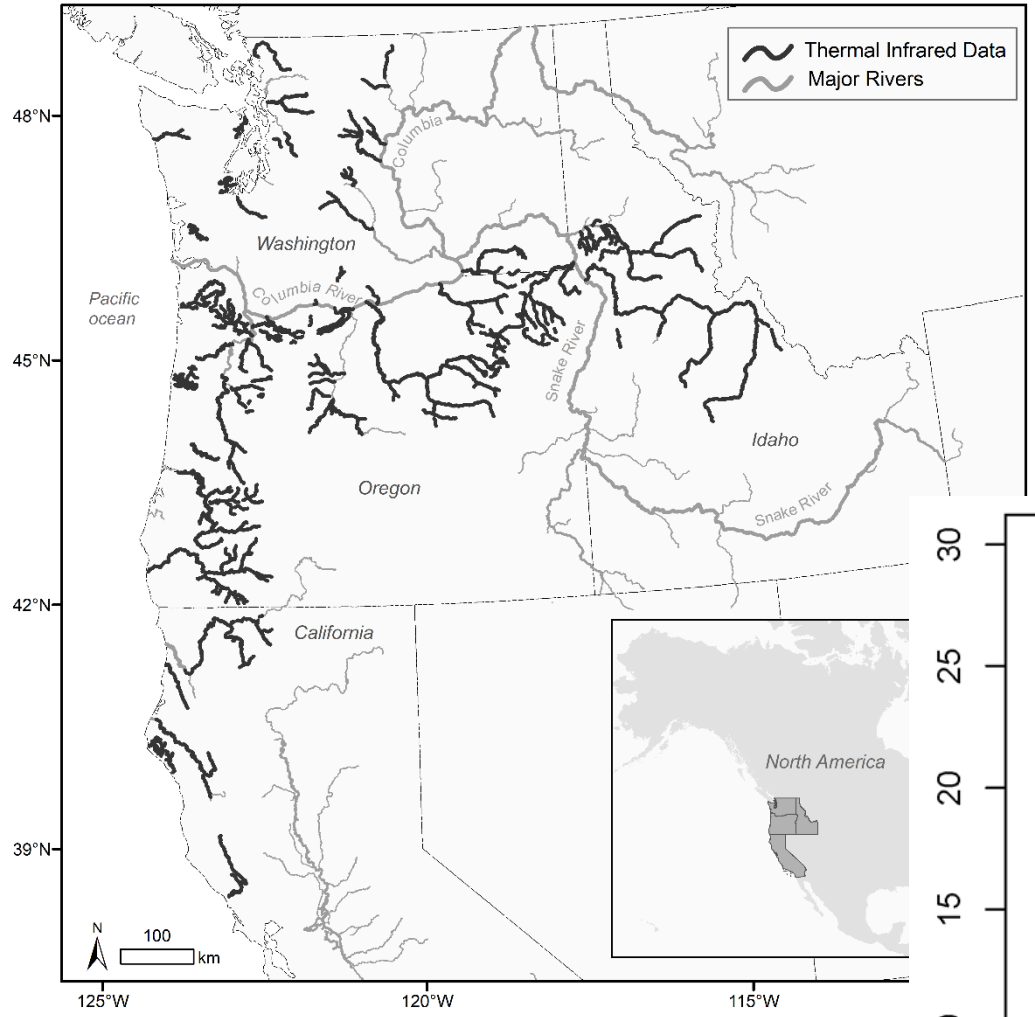

Ebersole et al., 2003

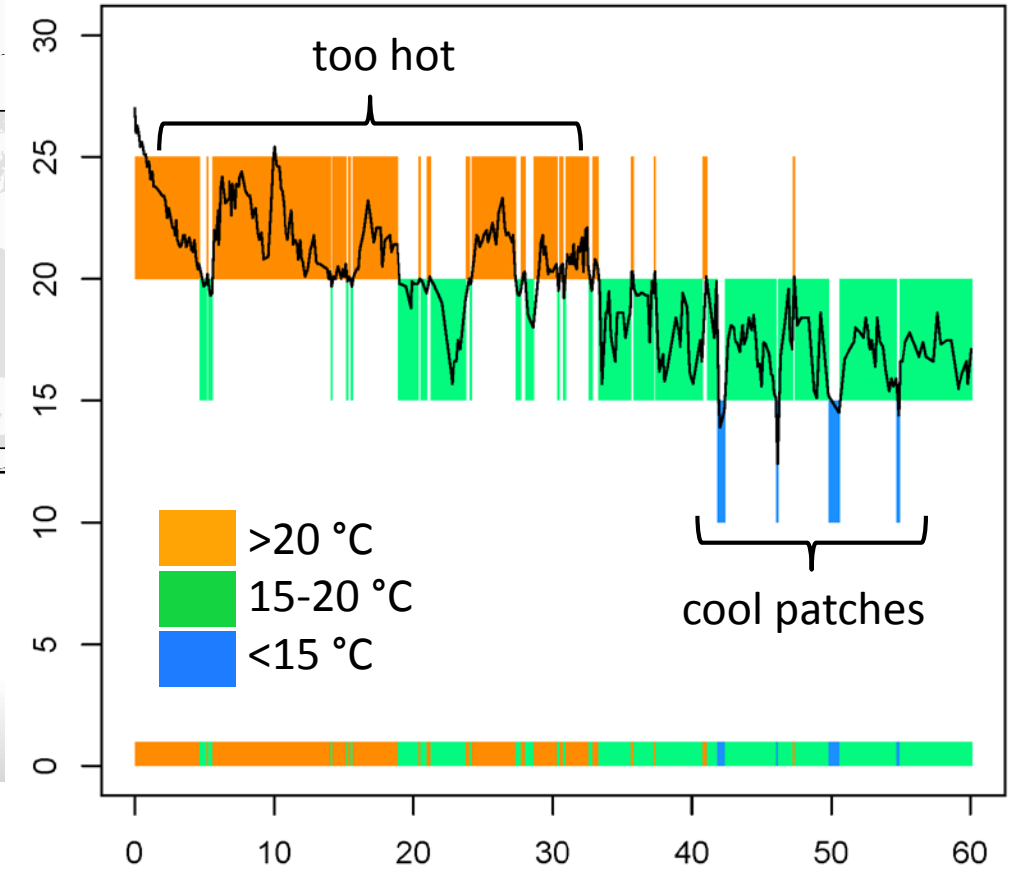
Grande Ronde, South Fork John Day and Middle Fork John Day

- Intermittent and ephemeral streams provided cold-water patches at confluences
- Demonstrated the importance of groundwater to stream temperature

Ebersole et al., 2015

# Airborne thermal infrared (TIR) remotely sensed data




Fullerton et al., 2017 In review

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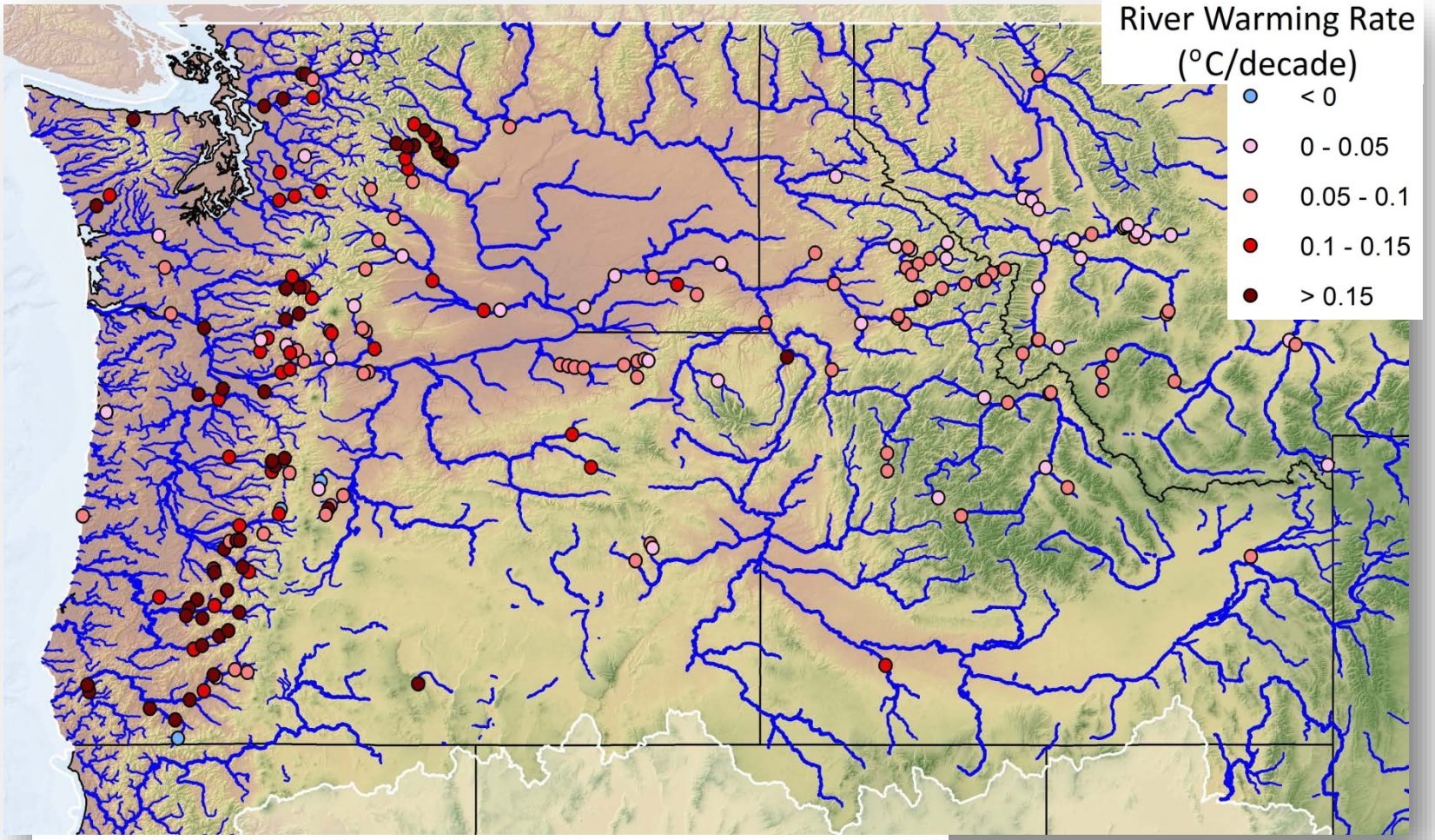
# Summer River Temp Trends (1968-2011)

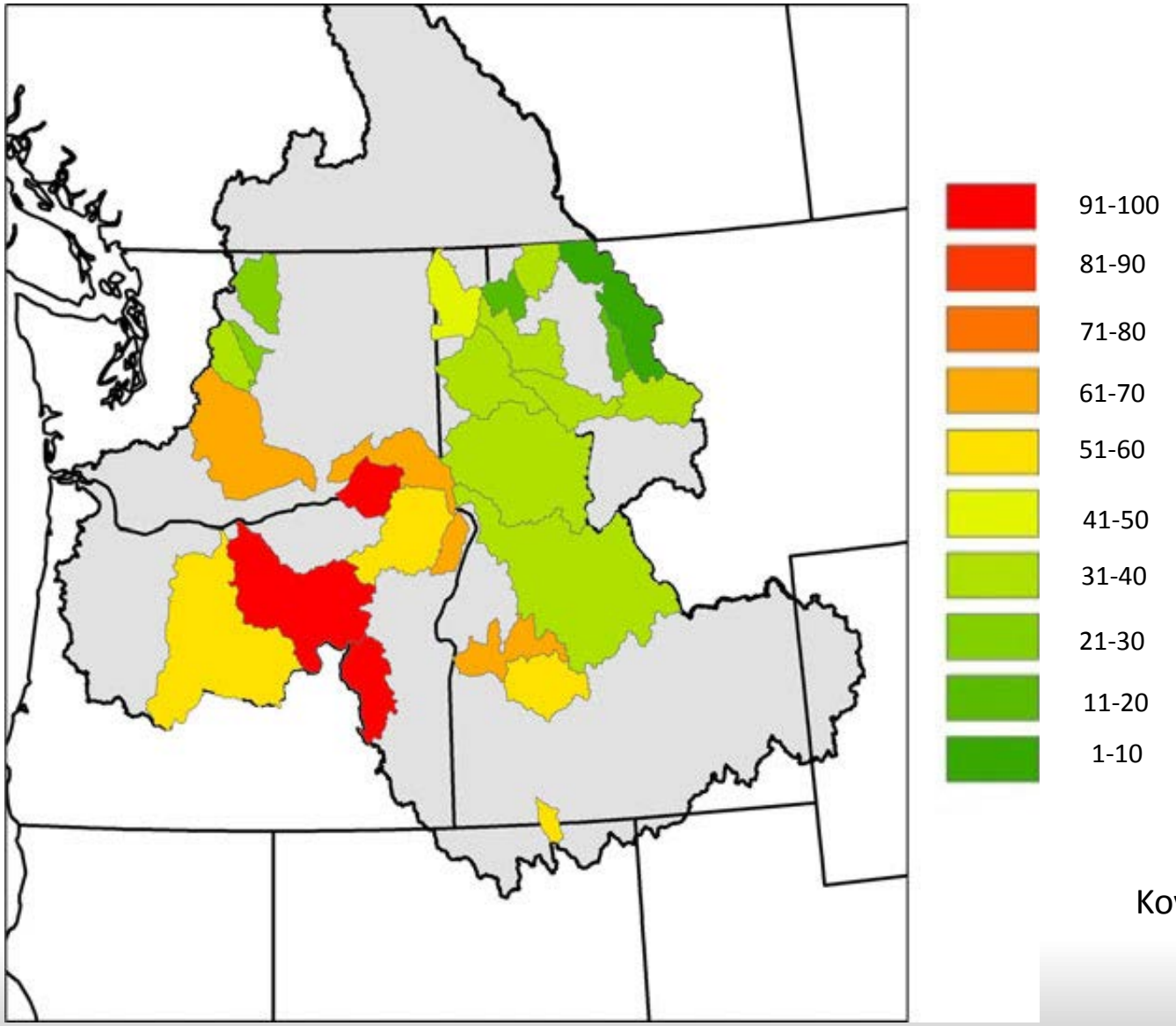
245 sites with >10 year monitoring records




**98.5% sites are warming**

Isaak et al. 2016

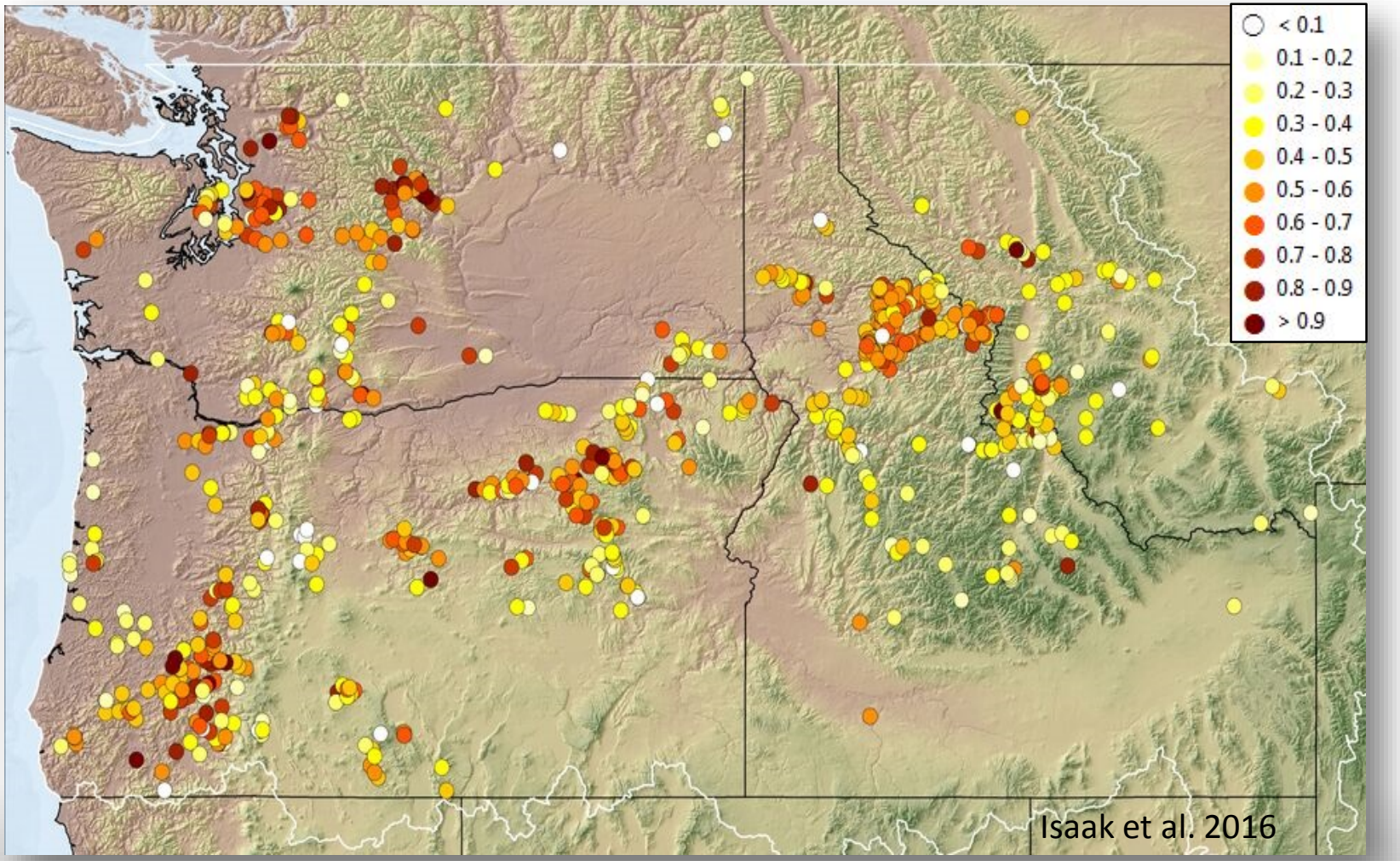
# Projected (2040s) climate vulnerability of bull trout



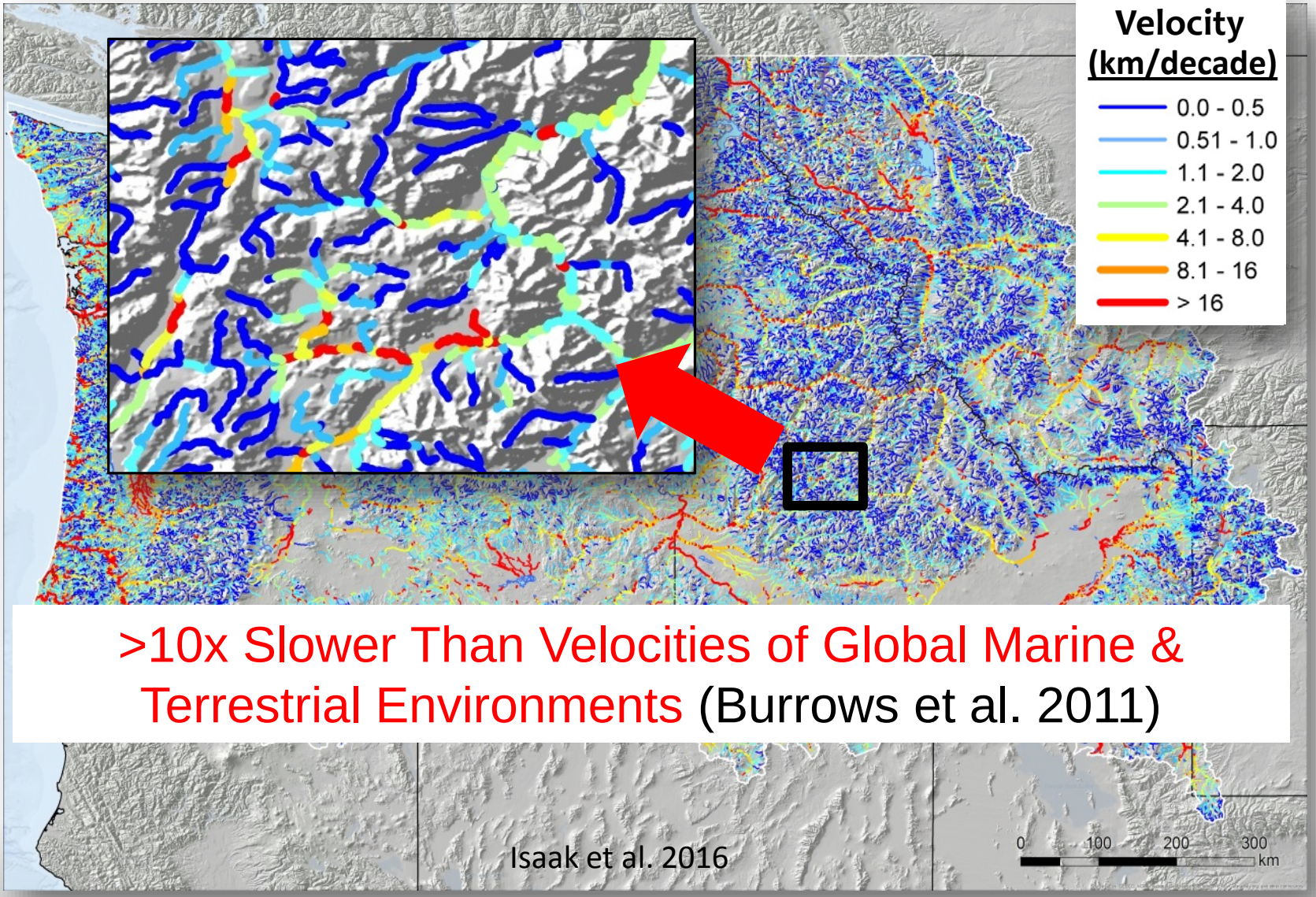

Kovach et al., 2015

# Stream Warming Rates 1968-2011

923 sites in NorWeST database with >10 year records

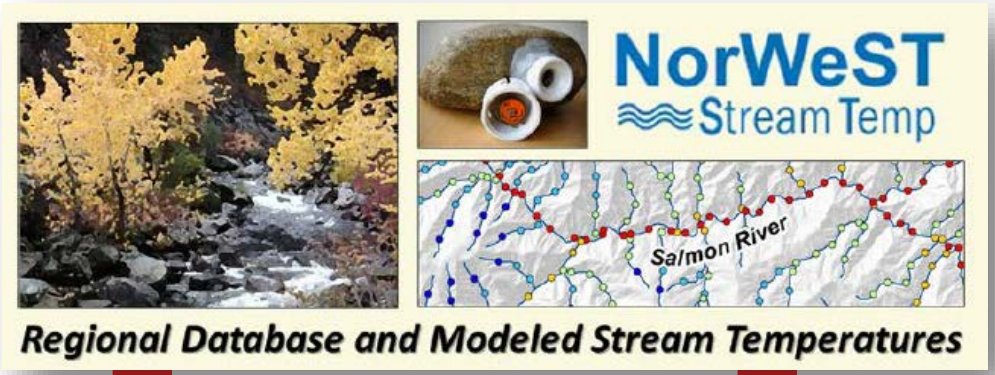


# Climate Velocity Map for Regional Network

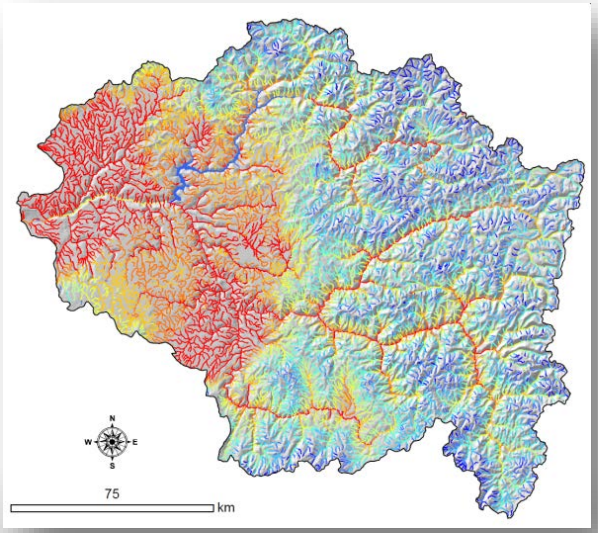



>10x Slower Than Velocities of Global Marine & Terrestrial Environments (Burrows et al. 2011)

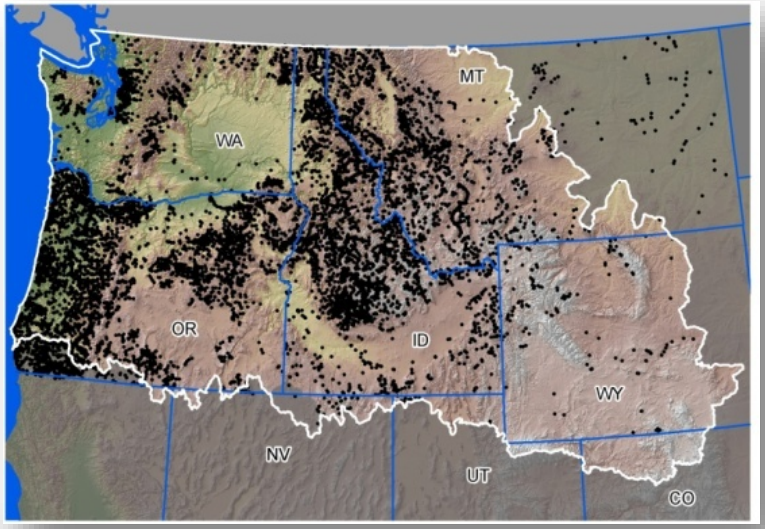
# Tools and Resources



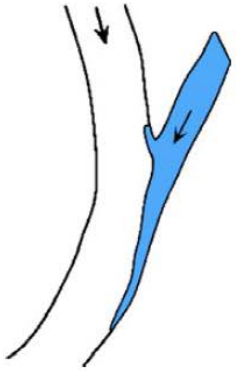
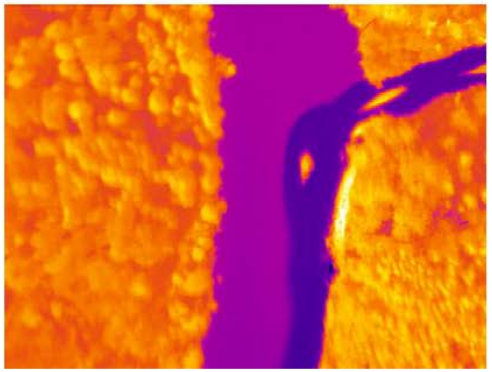

**GIS shapefiles of stream temperature scenarios**




**Temperature data summaries**



# Temperature Monitoring

| Schematic | Optical image example | TIR image example |
|---|---|---|
|  |  |  |

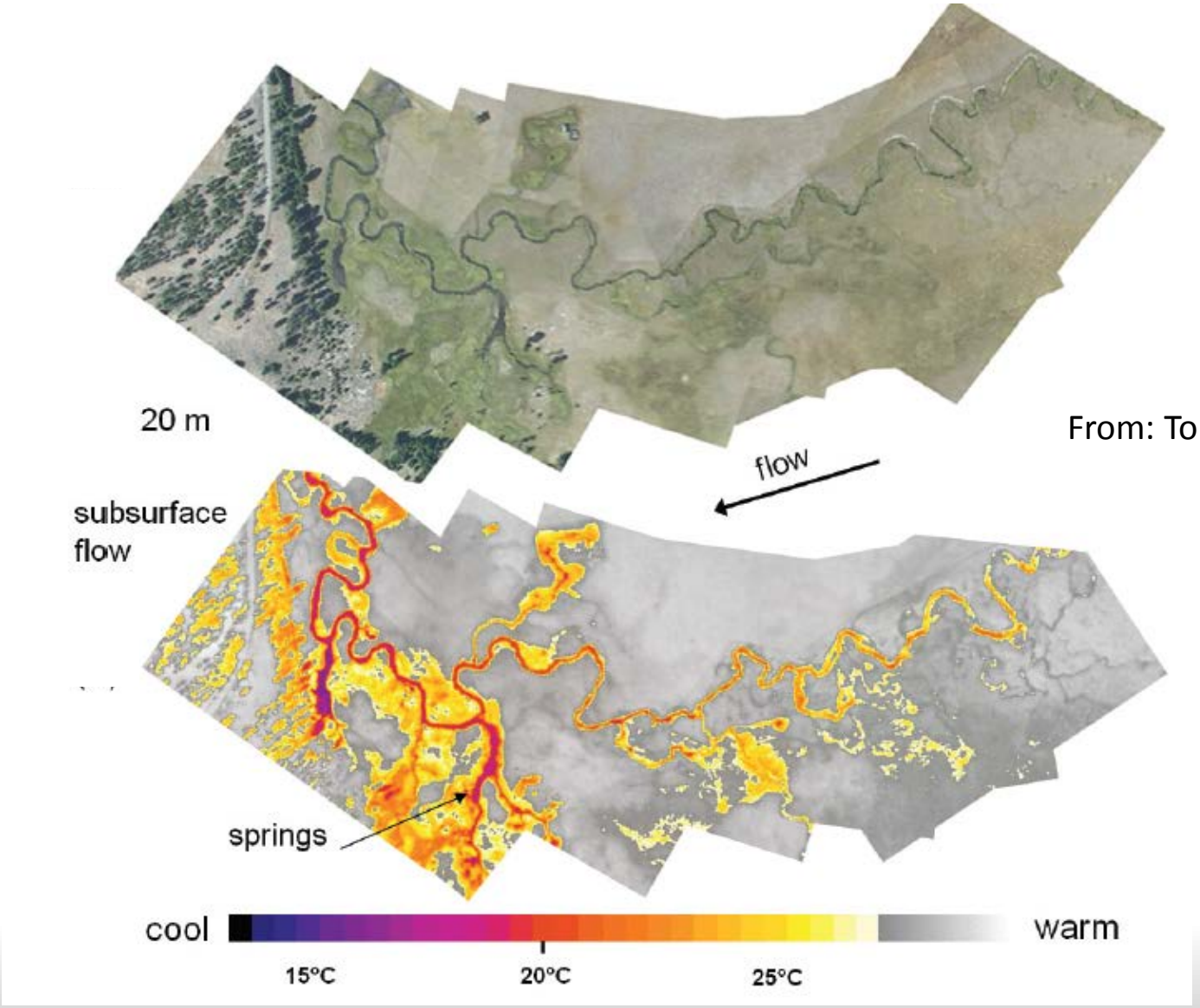
**In-channel**


**Thermal Infrared**

From: Torgersen et al. 2012

**Drone mounted cameras**

# Example Aerial Images – MF John Day River




From: Torgersen et al. 2012

# Cold-Water Habitats in the 2014 Program

Mainstem Habitat Actions:

- The Council will consider additional **mainstem** habitat actions including "identifying, protecting, restoring and managing thermal refugia for salmonid use during high water-temperature periods".

Climate Change:

- "…evaluate the effectiveness and feasibility of possible actions to mitigate effects of climate change...other actions to create or protect cool water refugia in **mainstem reaches or reservoirs**".

ISAB/ISRP Critical Uncertainties Report:

- How can habitat restoration activities or hydrosystem operations modify groundwater-surface water interactions and floodplain habitats to provide refuges during extreme events and improve overall survival, productivity, distribution, and abundance of anadromous and resident native fish populations?
- Where, when, and at what frequency under different conditions do salmonids and other native species use coldwater thermal refuges in the lower Columbia and Snake rivers?

Tributary Habitat 3.1. How can habitat restoration activities or hydrosystem operations modify groundwater-surface water interactions and floodplain habitats to provide refuges during extreme events and improve overall survival, productivity, distribution, and abundance of anadromous and resident native fish populations?

## Mainstem habitat

1. Where, when, and at what frequency under different conditions do salmonids and other native species use coldwater thermal refuges in the lower Columbia and Snake rivers?