

Coldwater fishes and thermal refuges in hot water

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...and the field crews who risked life and limb to collect these data in rugged and remote locations.

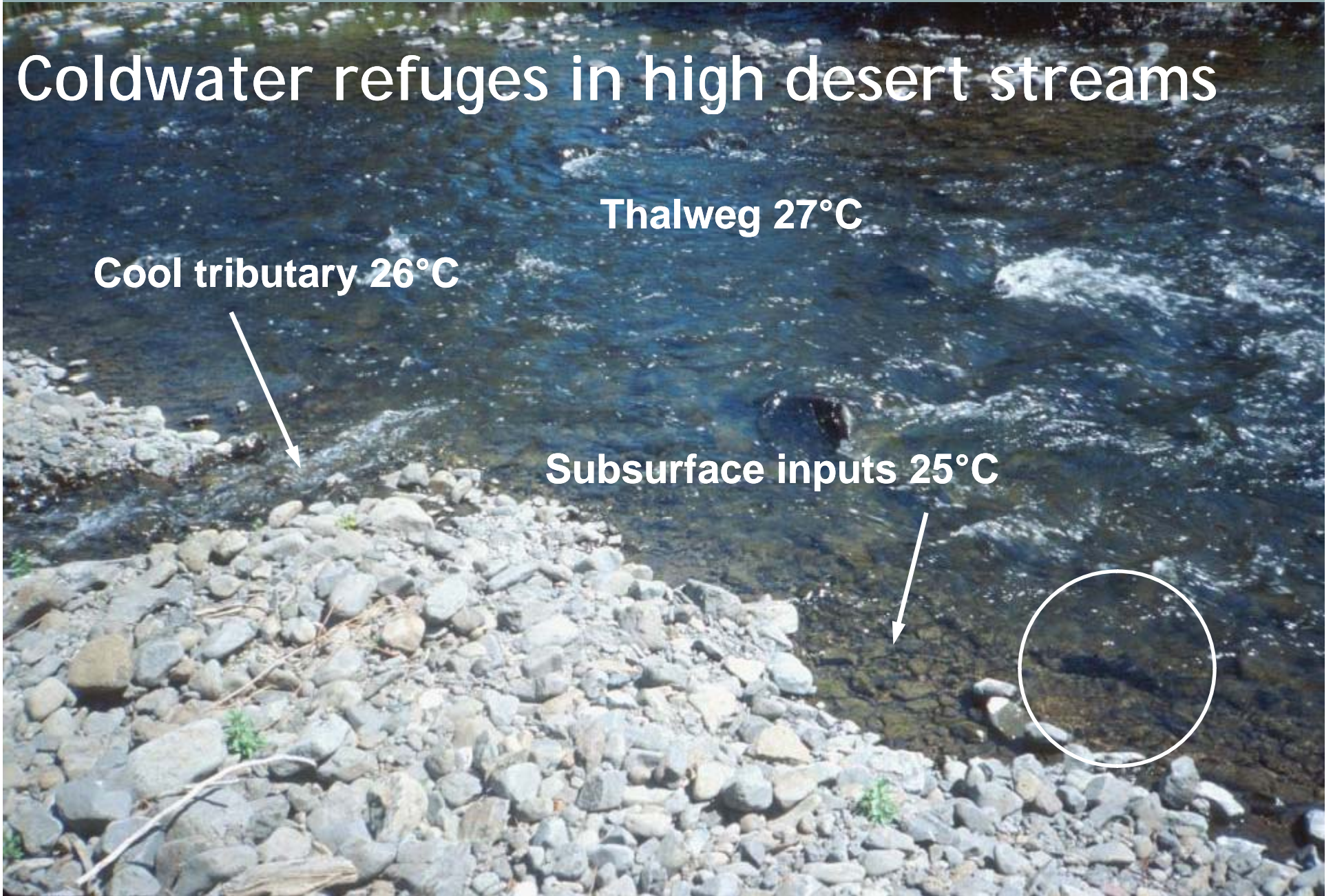


Coldwater refuges in high desert streams

Thalweg 27°C

Cool tributary 26°C

Subsurface inputs 25°C



A photograph of a rainbow trout in a shallow stream. The fish is dark with a lighter belly and is positioned horizontally across the frame. Below the fish, a white ruler is placed on the rocky stream bed for scale. The water is clear, and the rocks are dark and wet. The background shows more of the stream and surrounding vegetation.

Rainbow trout (*Oncorhynchus mykiss*)

Water temperature 25°C

Microhabitat coldwater refuge



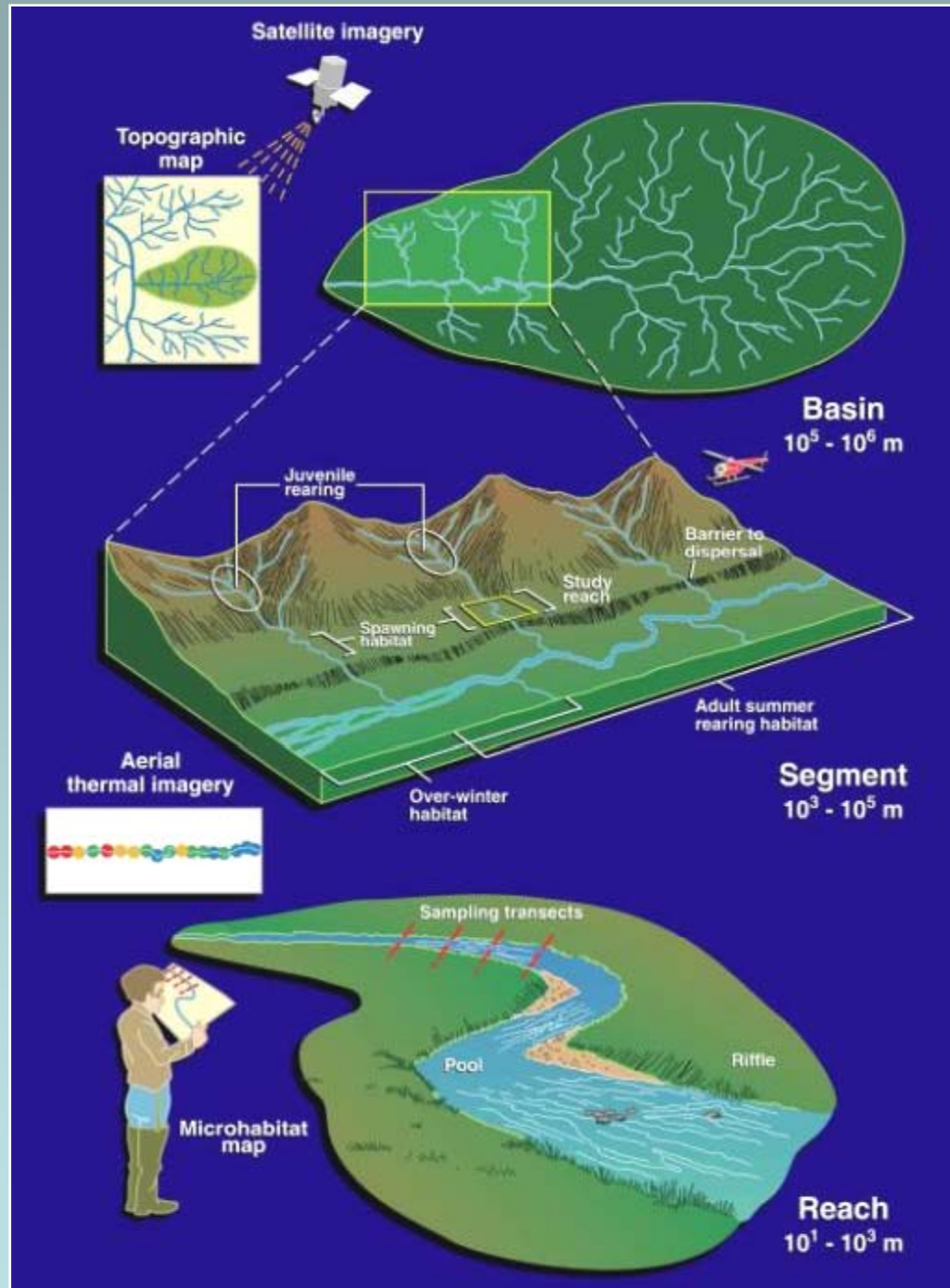
Adult chinook salmon
(*Oncorhynchus tshawytscha*)



Understanding Coldwater Refuges

- What role do they play in salmonid ecology?
- How can they be identified multiple spatial scales?
- Can their distribution be predicted based on hydrologic and geomorphic associations?
- How can they be protected and restored in degraded rivers?

Thermal refuges at multiple spatial scales



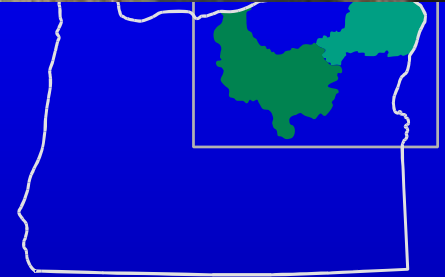
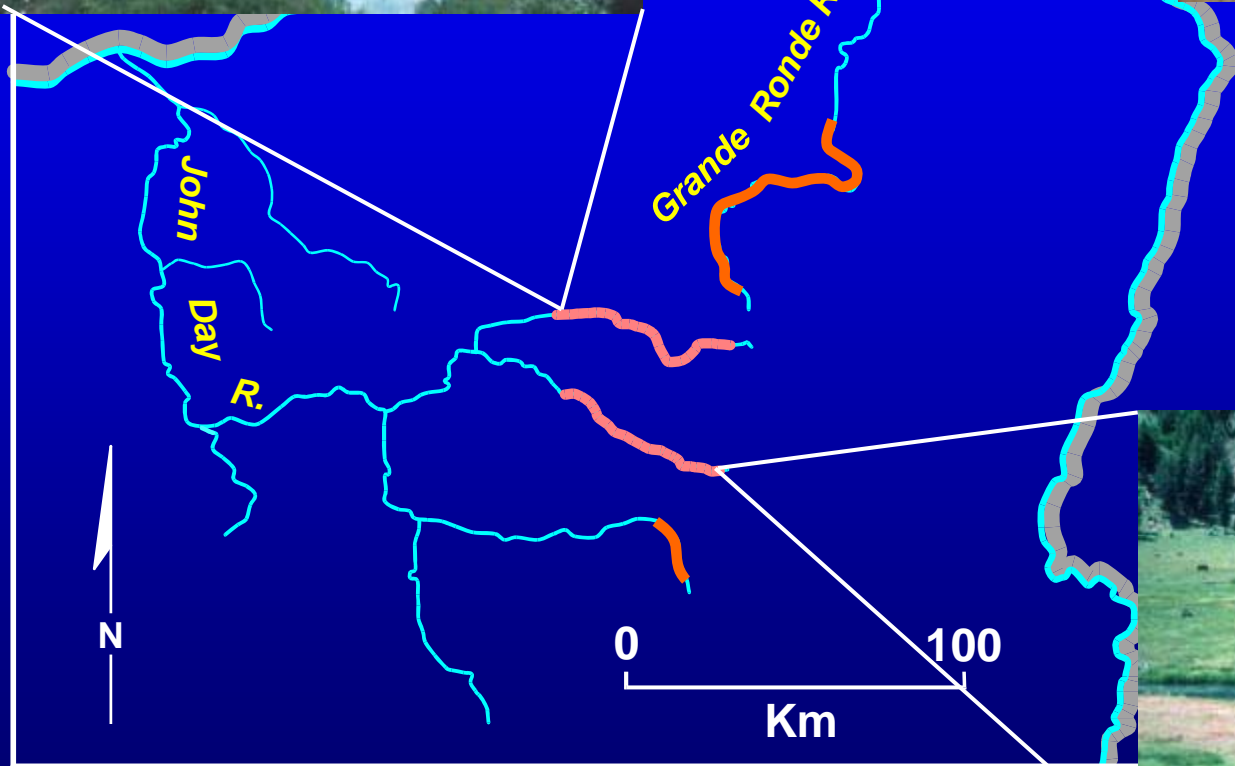
(Fausch et al. 2002)



Snake R.



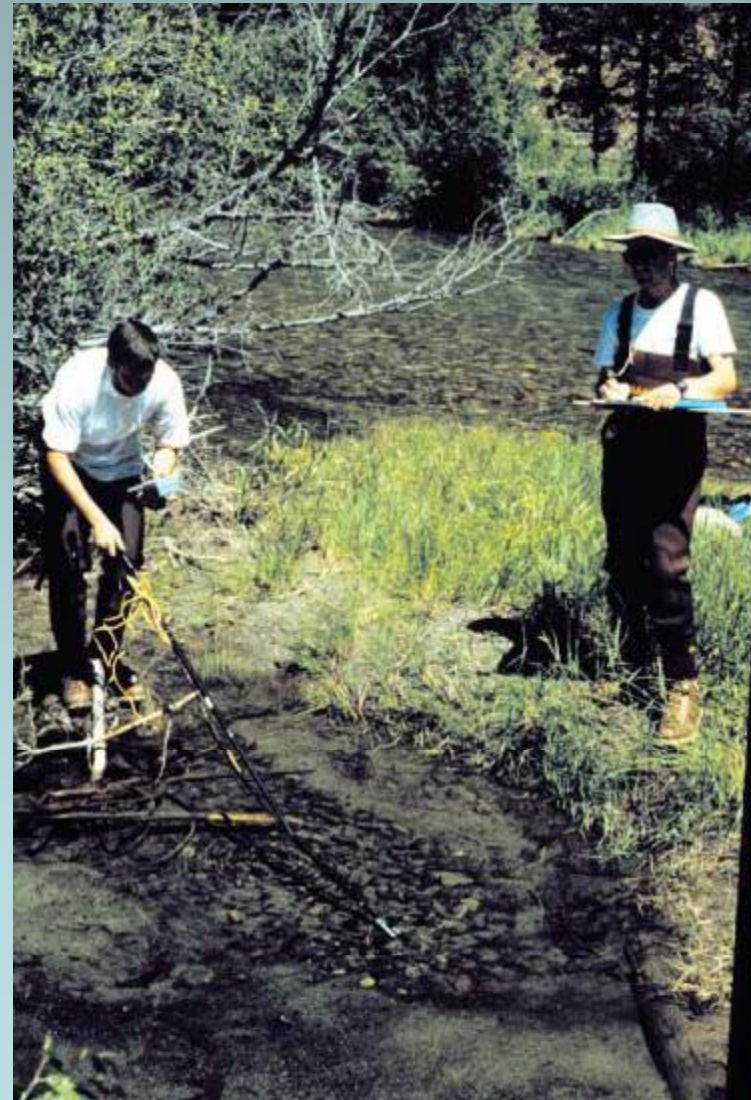
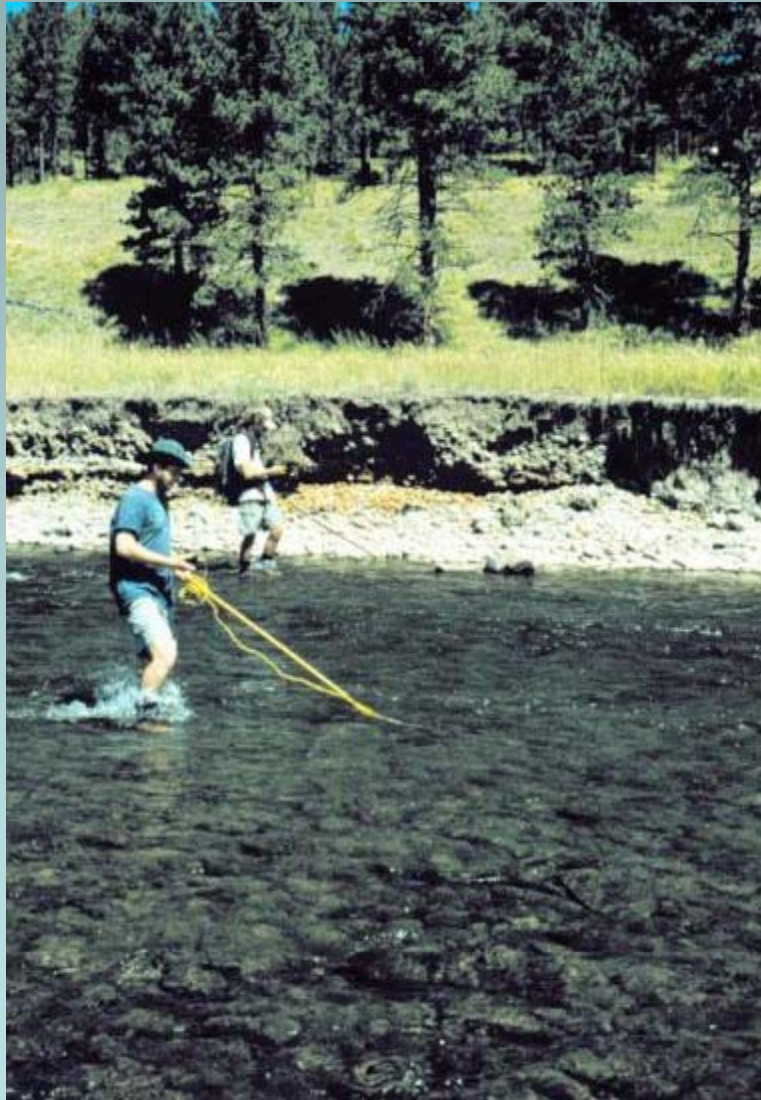
IN



OREGON

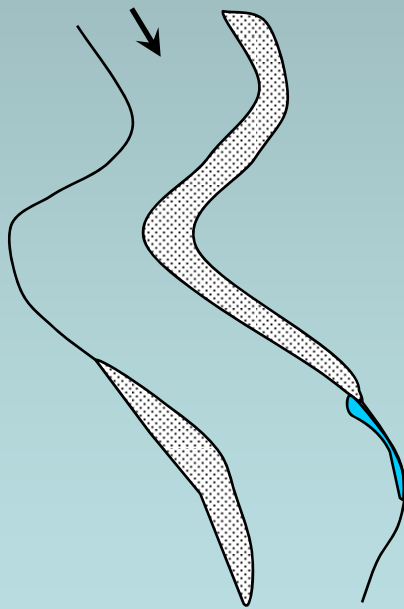


Micro- and Channel-Unit Scales



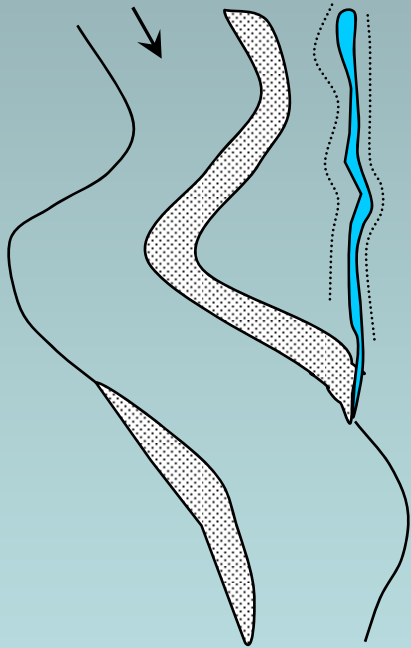
Coldwater Refuge Types

Lateral Seep



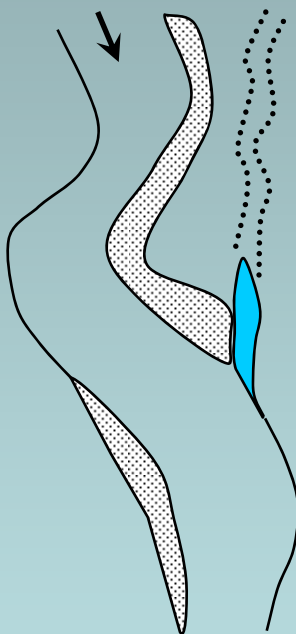
(Ebersole et al. 2003)

Cold Springbrook



(Ebersole et al. 2003)

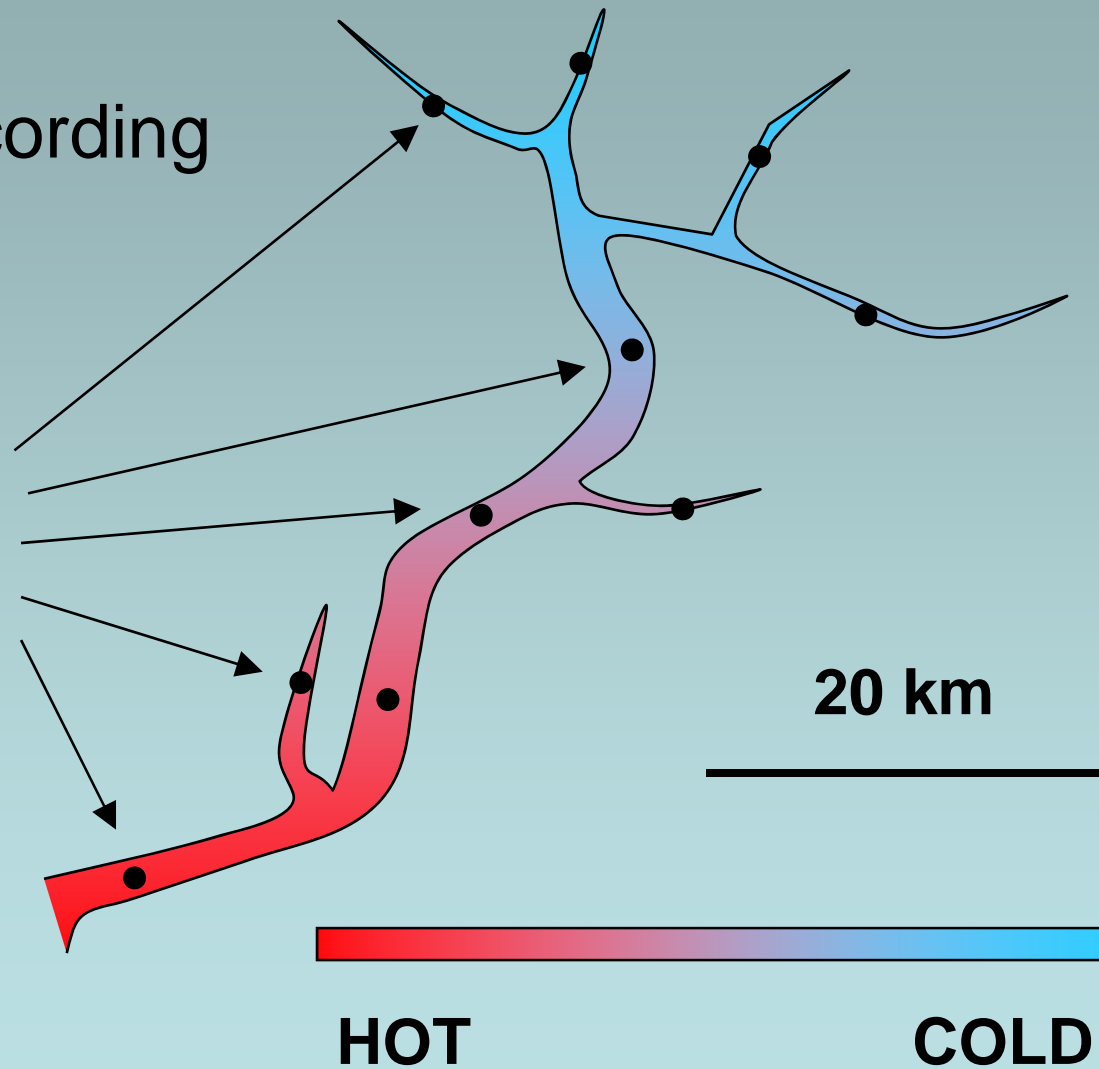
Cold Alcove



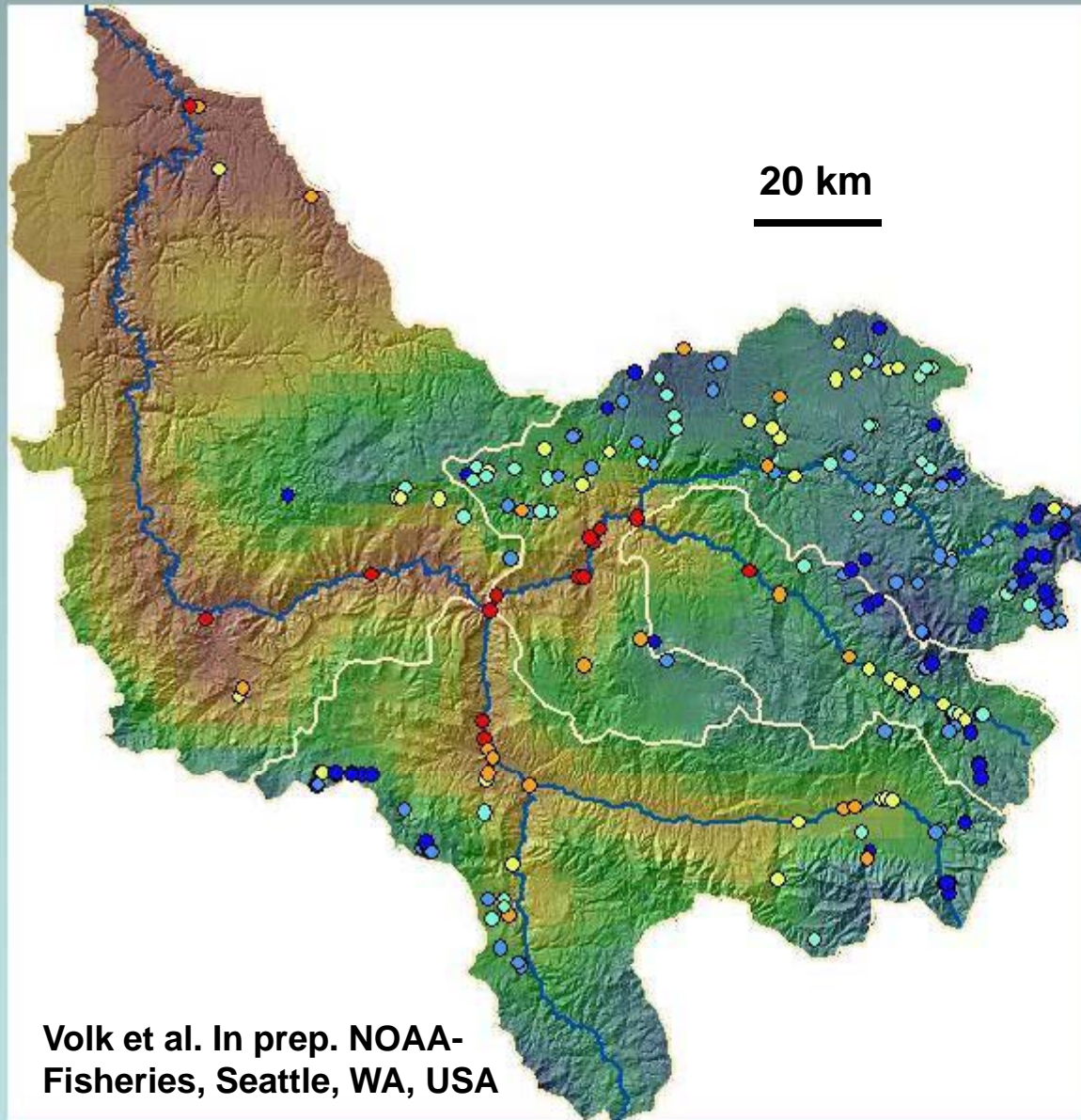
(Ebersole et al. 2003)

Network and Basin Scales

Continuously recording temperature data loggers



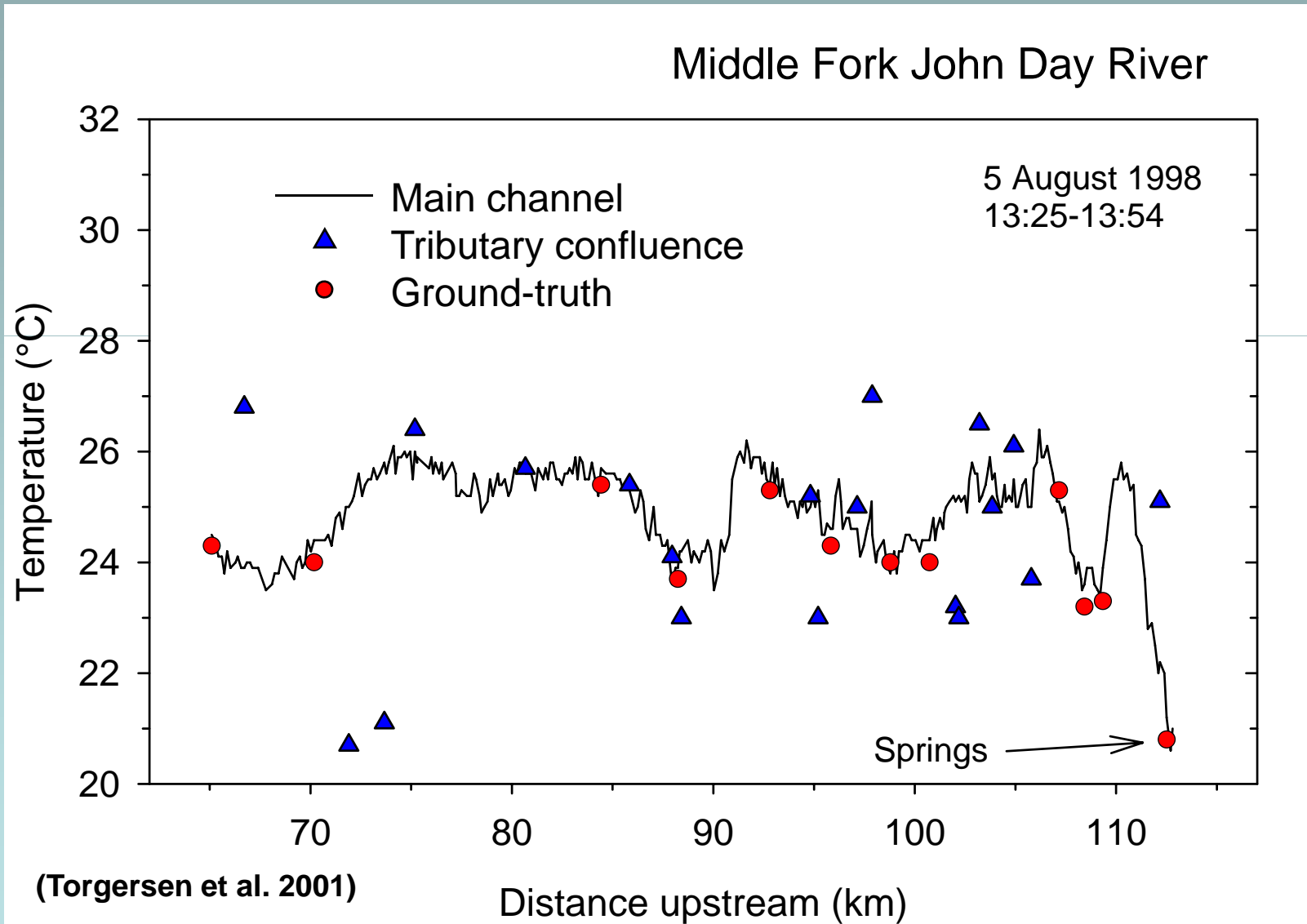
Multi-agency spatial databases



Reach and Section Scales

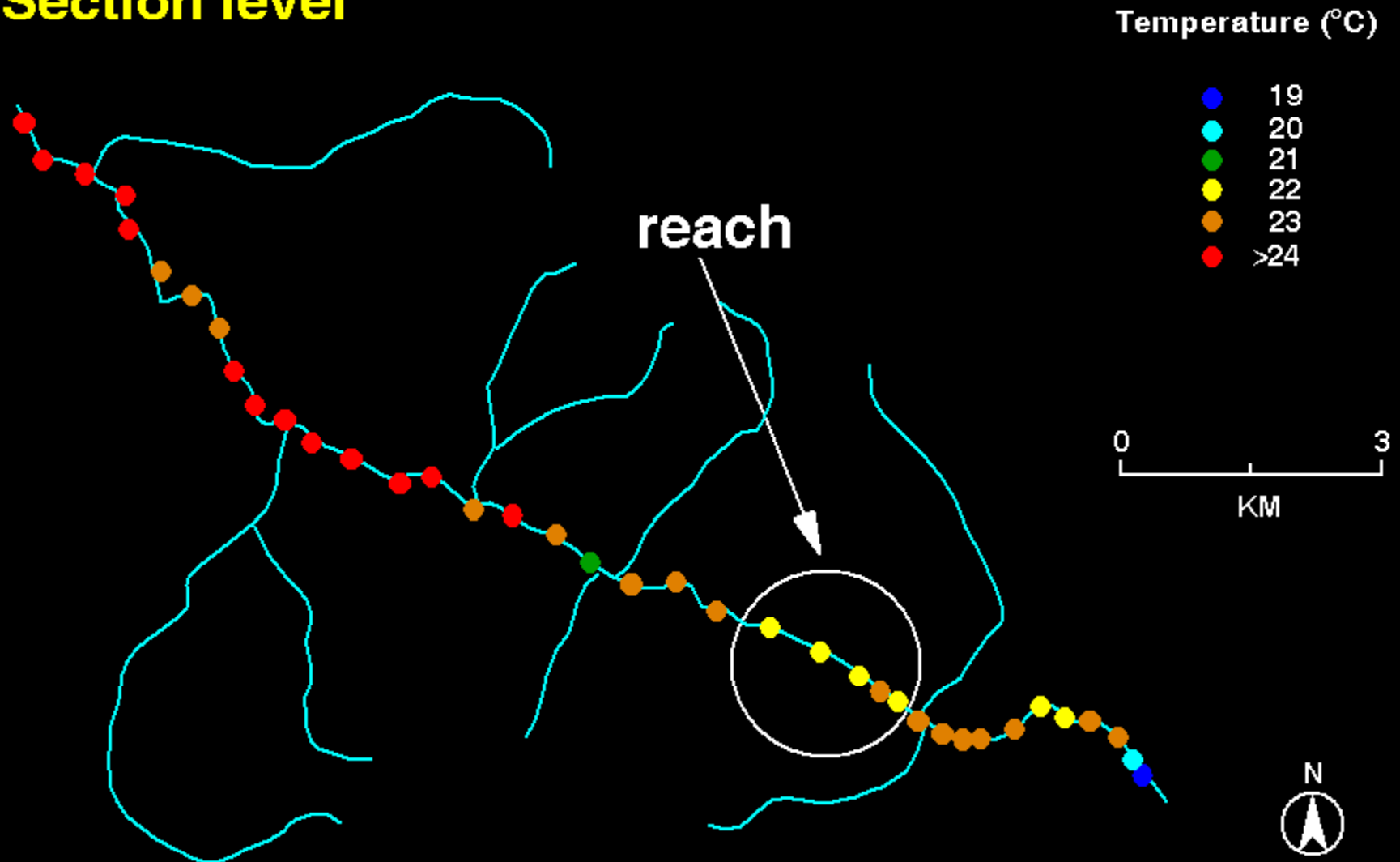


Airborne Thermal Remote Sensing



Middle Fork John Day River

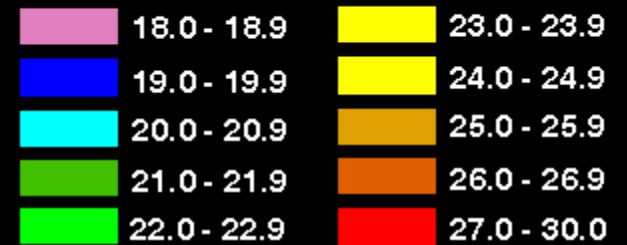
1) Section level



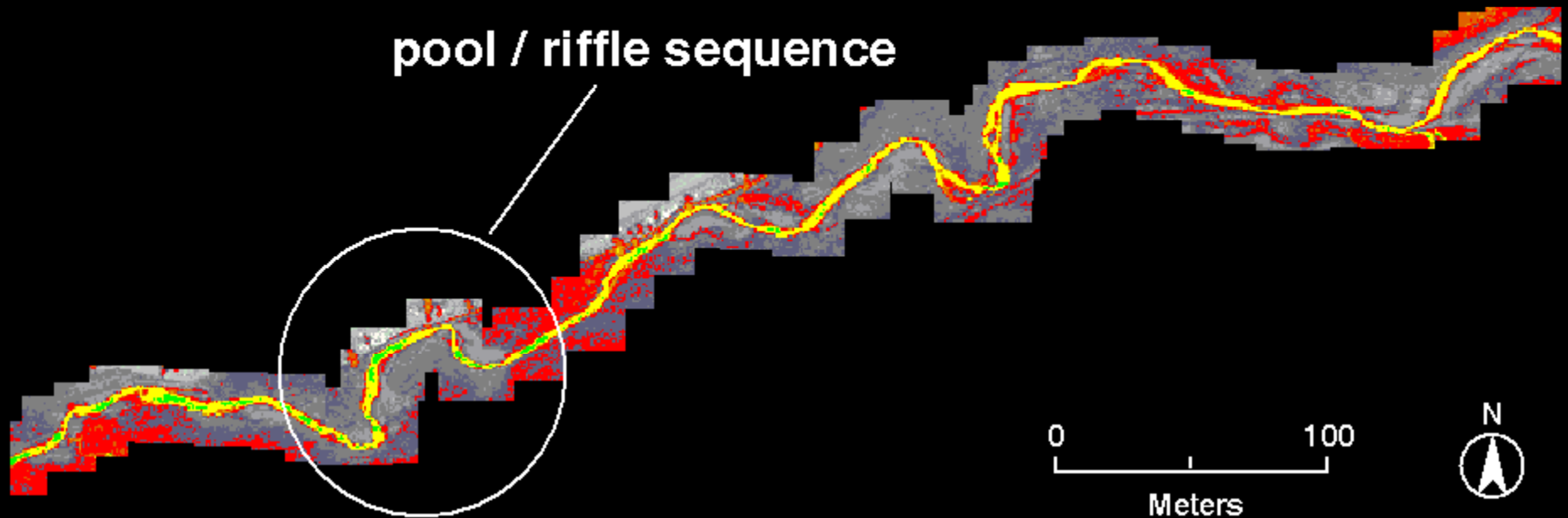
Middle Fork John Day River

2) Reach level

Temperature (°C)



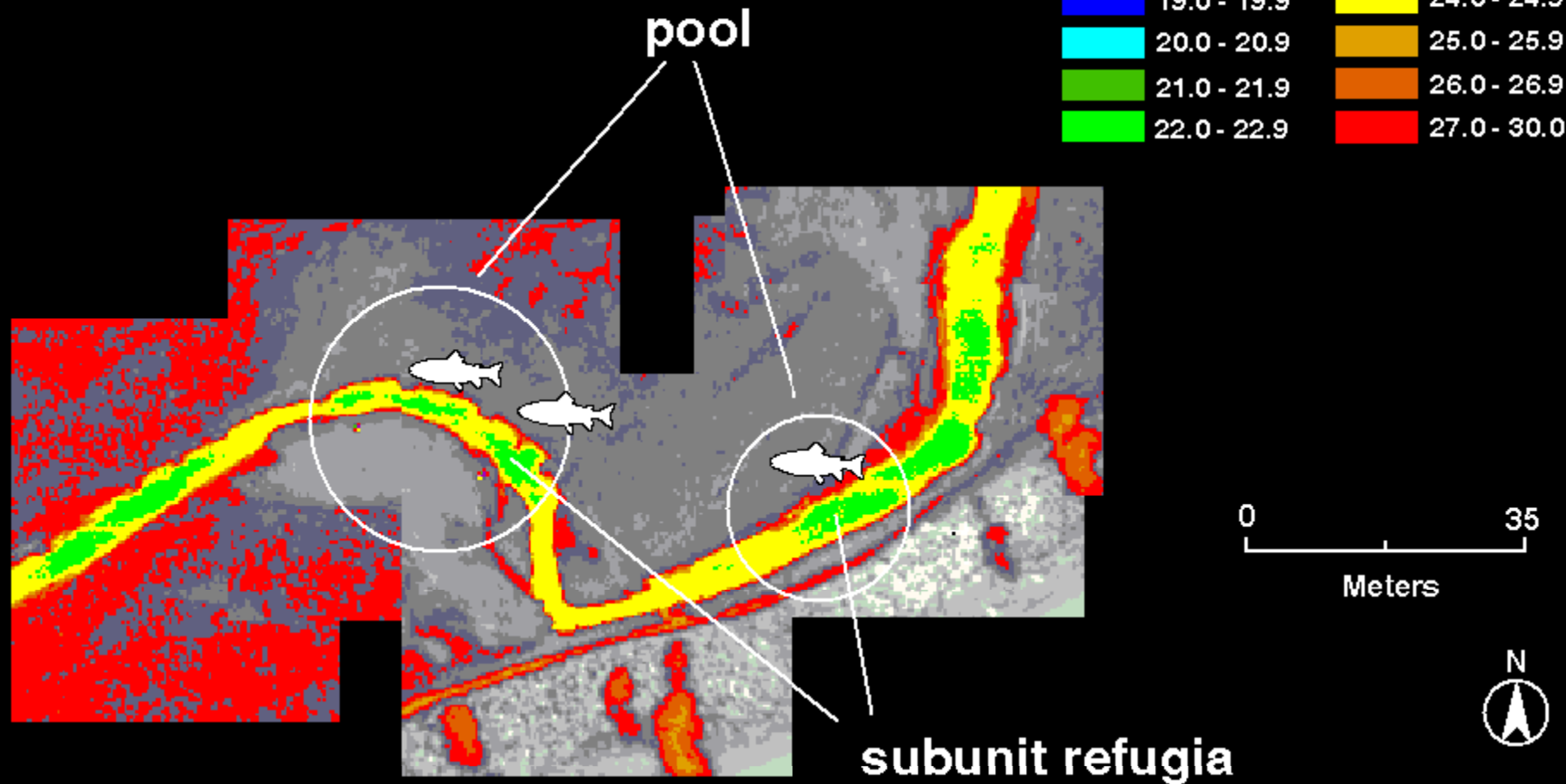
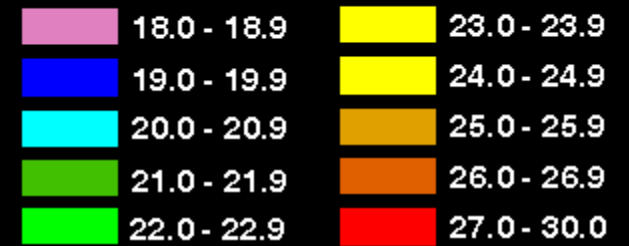
pool / riffle sequence



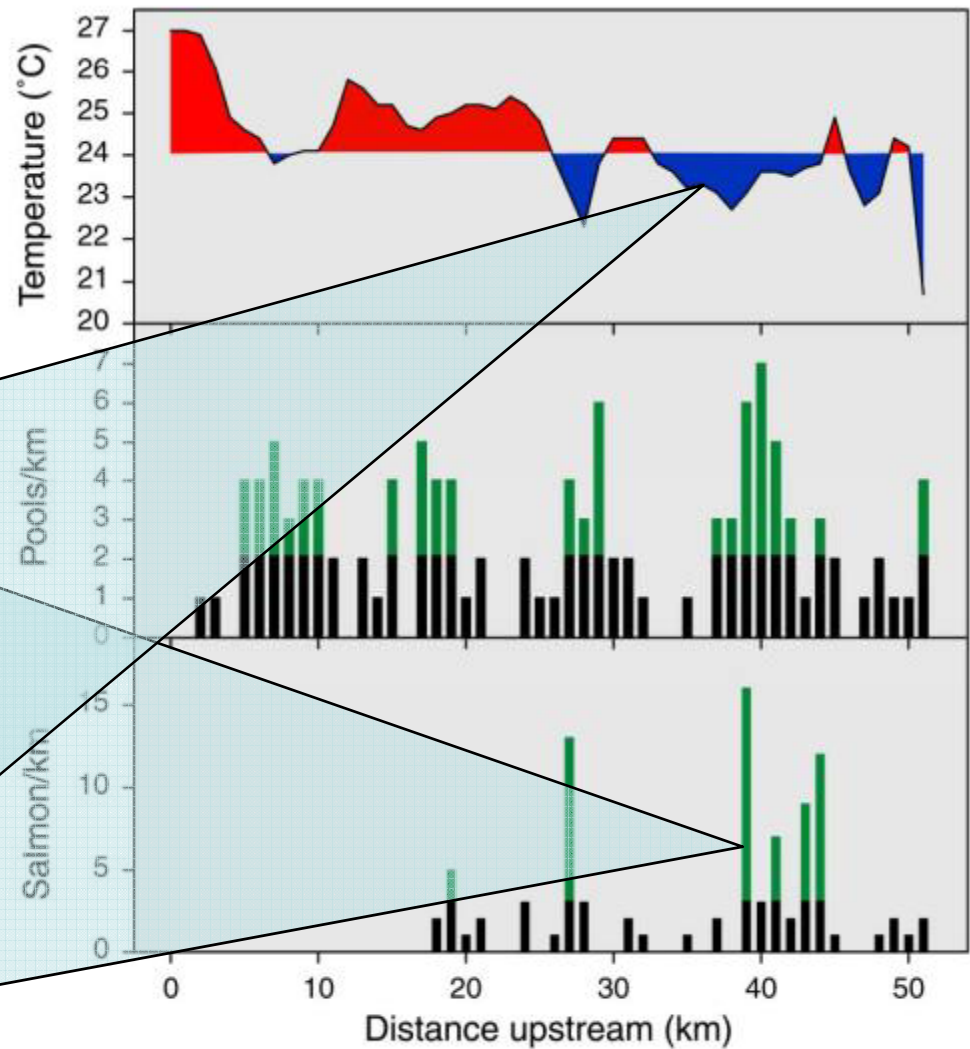
Middle Fork John Day River

3) Channel unit level

Temperature (°C)



Longitudinal patterns and land use



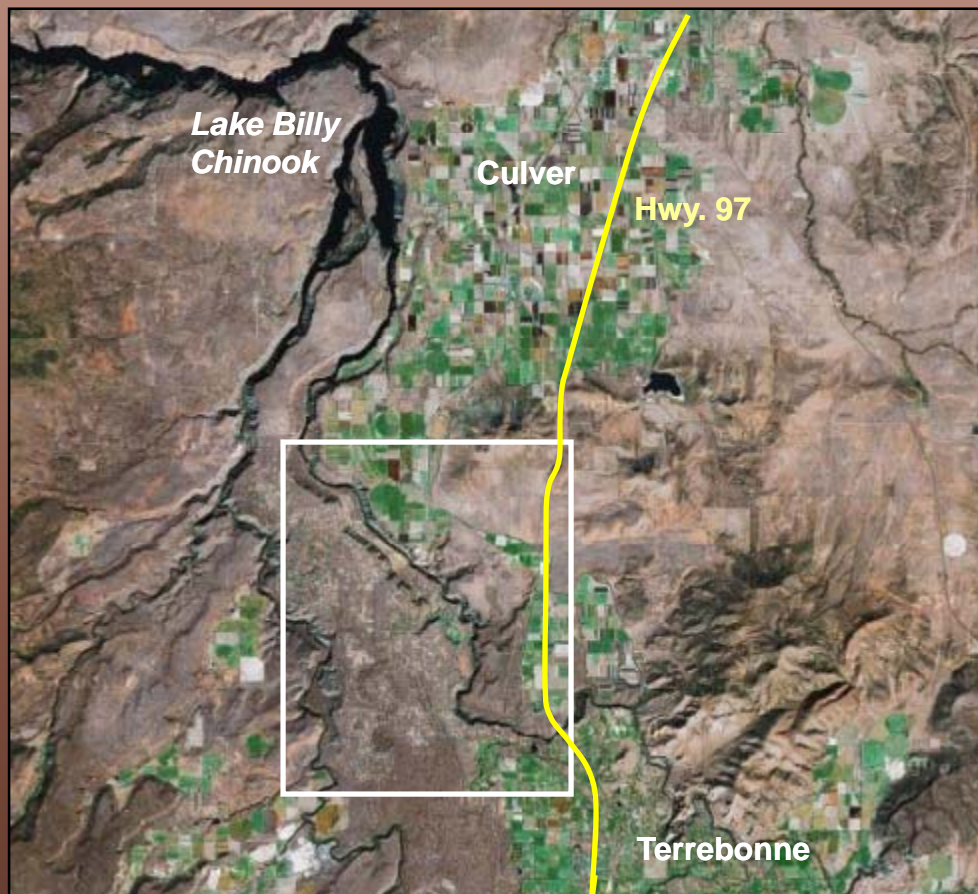
(Torgersen et al. 1999)



Fish assemblages and thermal heterogeneity



Lower Crooked River, Oregon



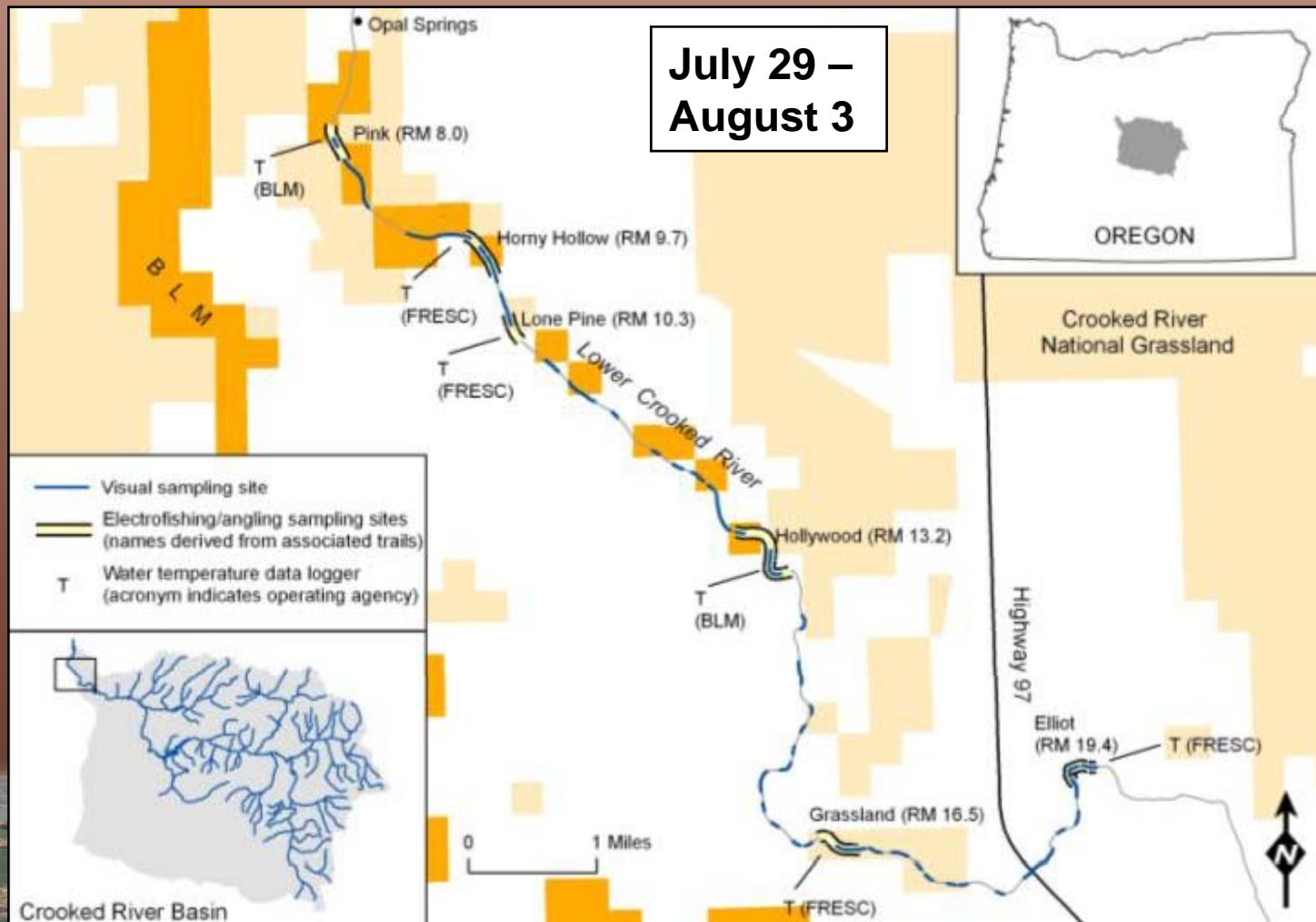
- 16 km in length
- Rugged, steep-walled basalt canyon
- Private (8 km), BLM, National Grasslands, and ODFW
- Limited access with development on cliff sides

A “riverscape” approach



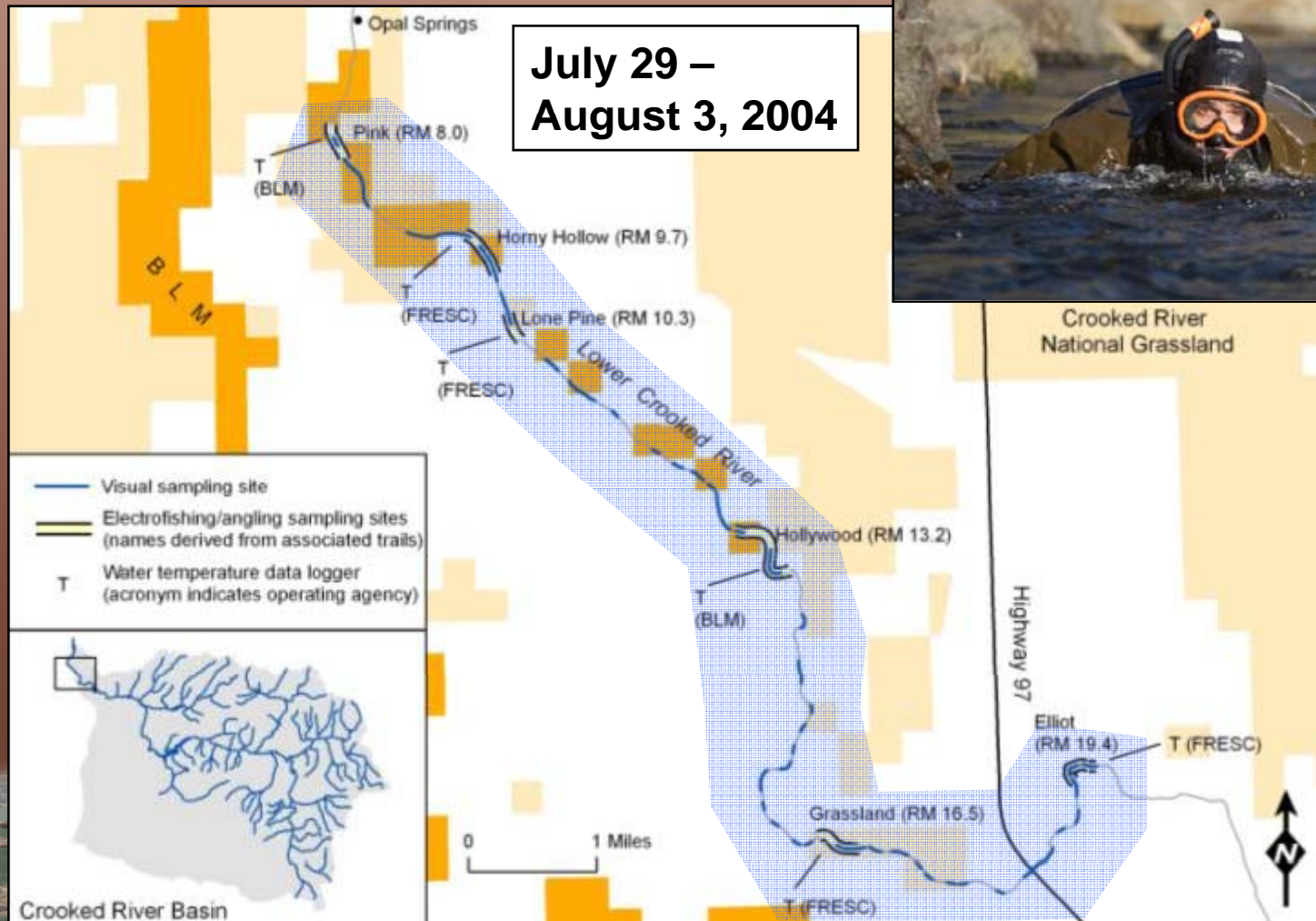
- Airborne thermal IR remote sensing (Watershed Sciences, Inc.)
- Reconnaissance with inflatable kayaks (May 2004)
- Snorkeling (aquatic habitat and fishes)
- Electrofishing
- Angling

Fish Survey 2004



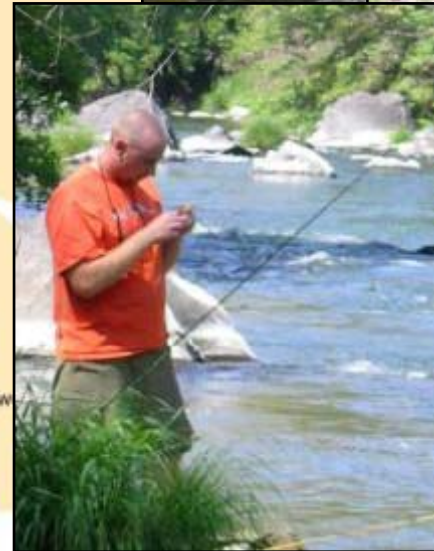
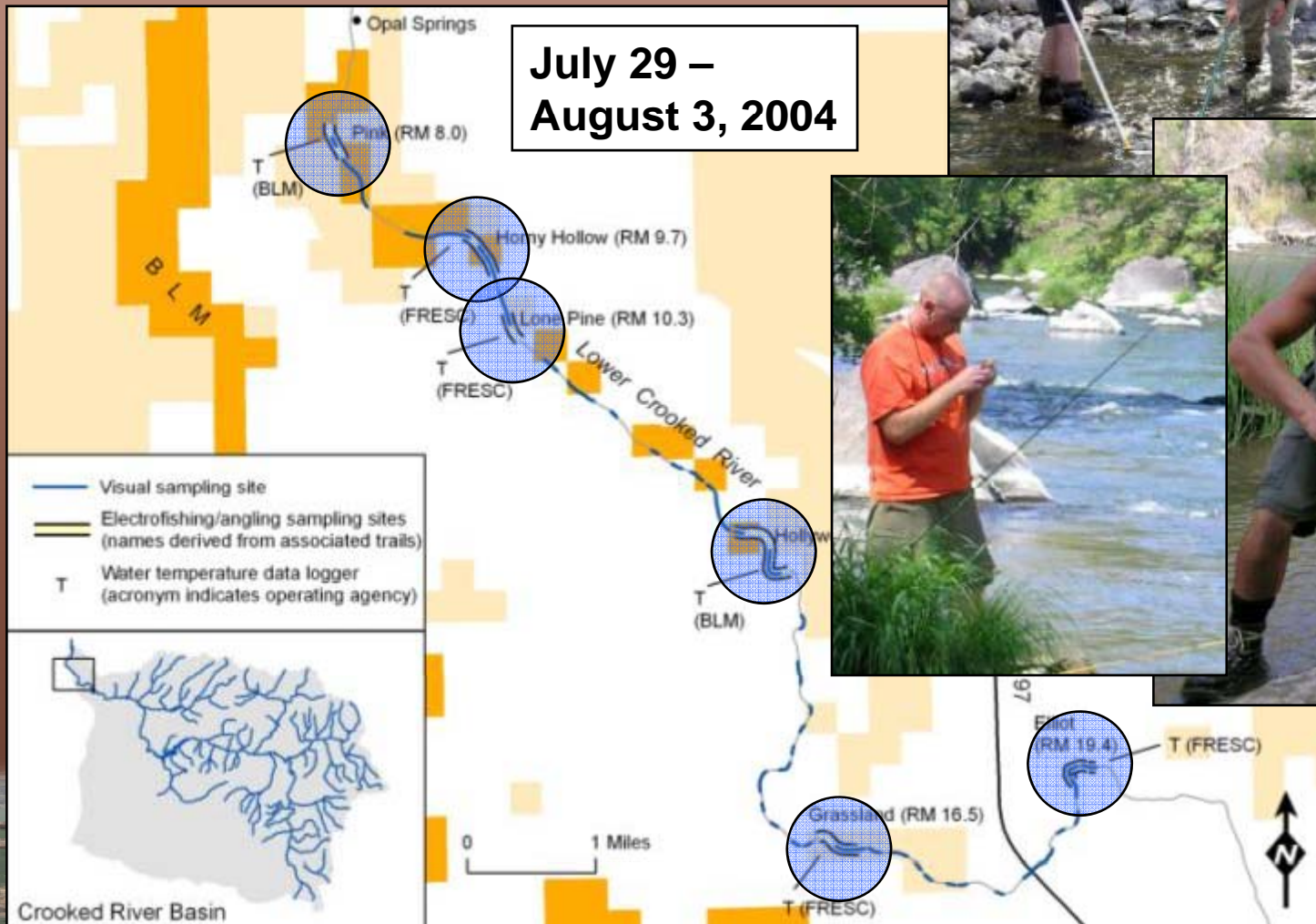
Snorkeling

July 29 –
August 3, 2004

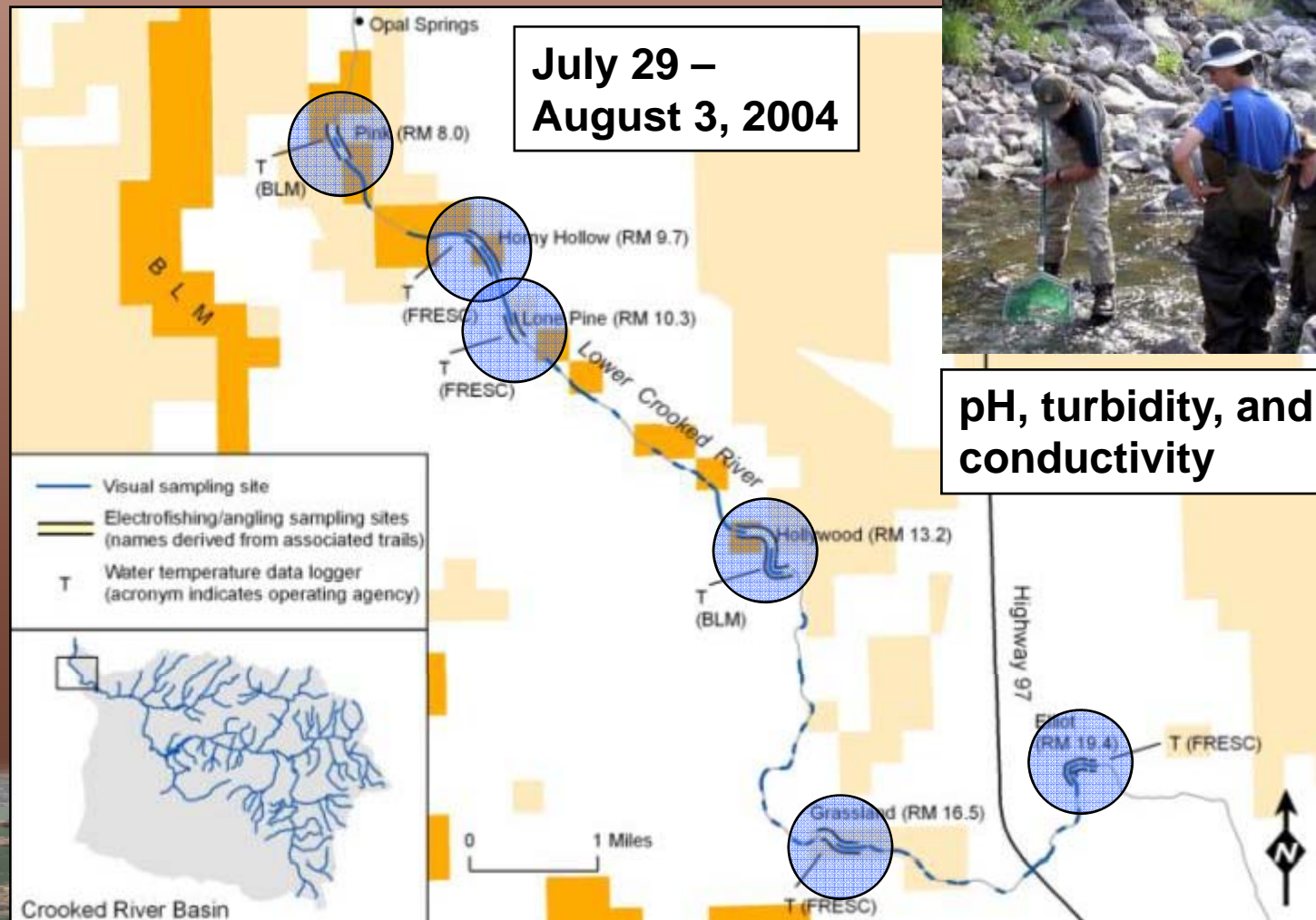


Electrofishing and angling

July 29 –
August 3, 2004

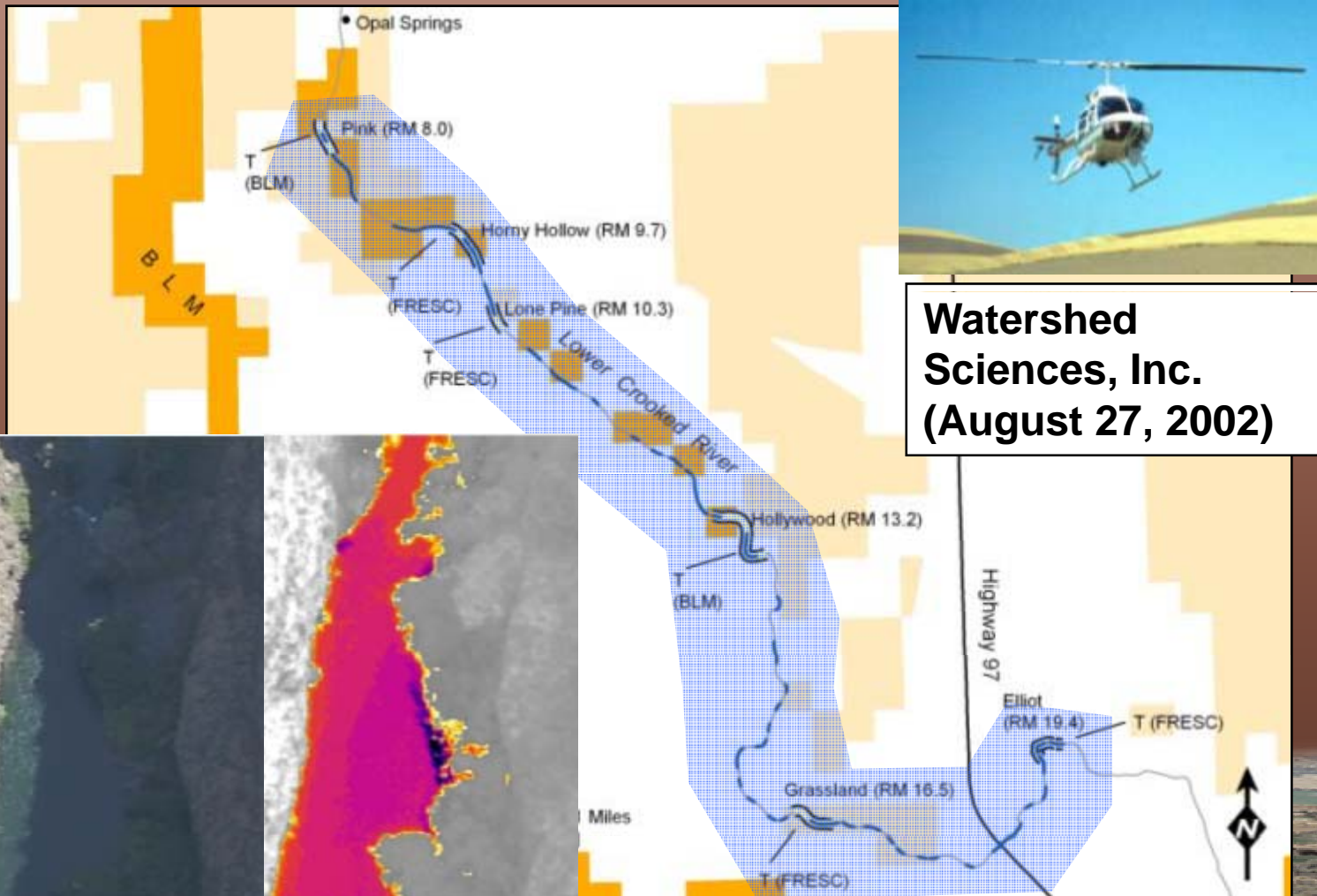


Stream temperature and water quality



pH, turbidity, and conductivity

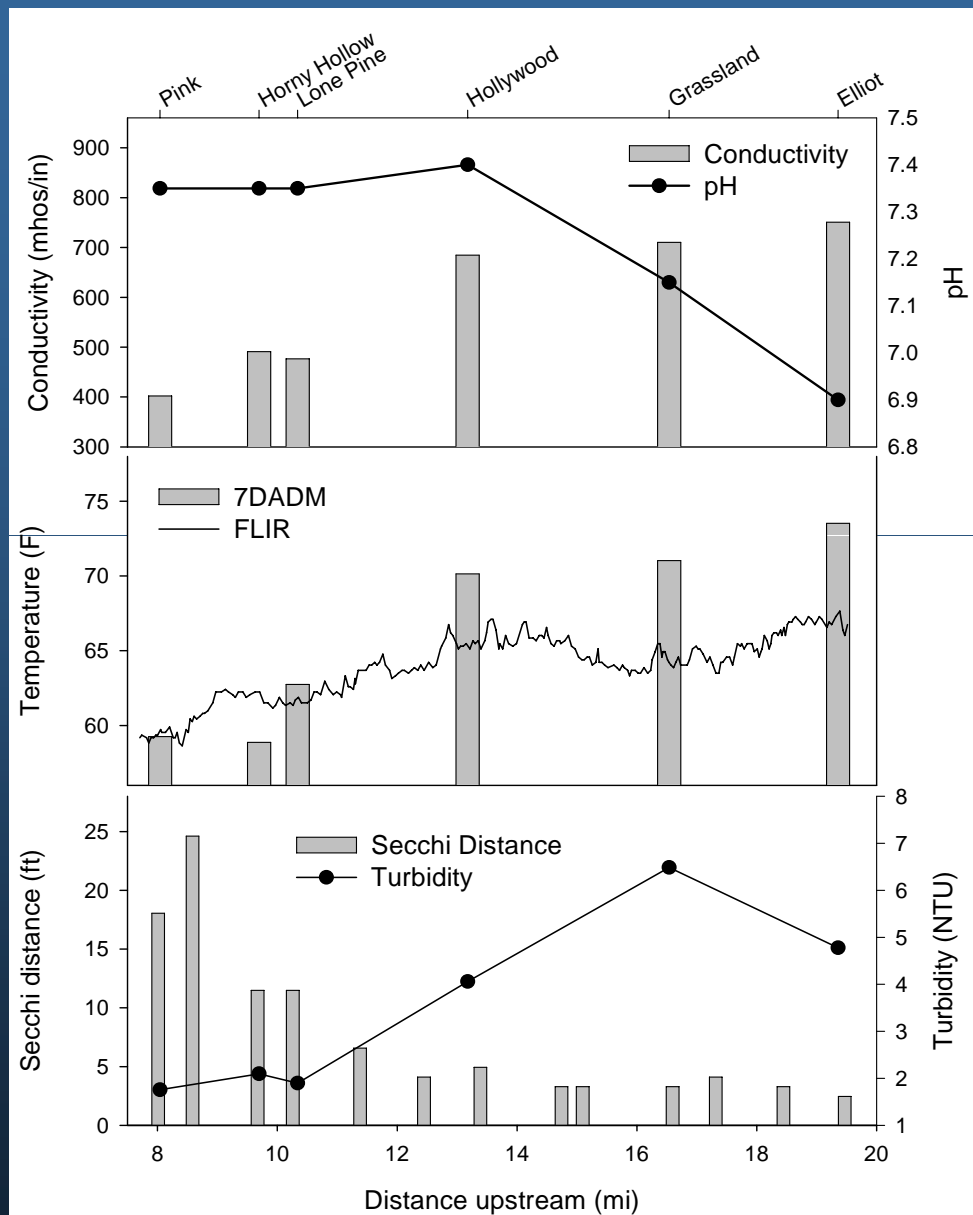
Airborne thermal IR remote sensing



**Watershed
Sciences, Inc.
(August 27, 2002)**

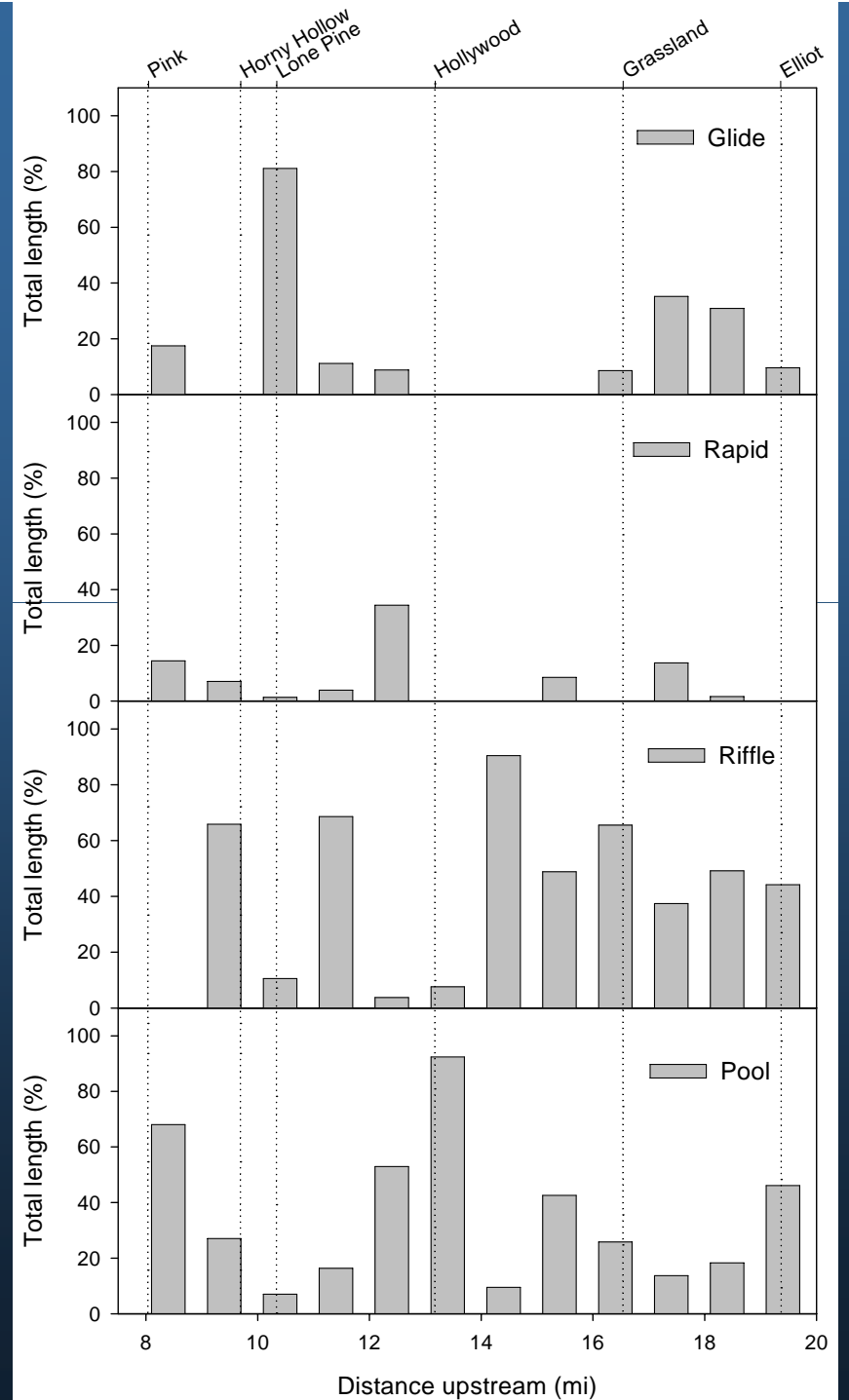
Water quality

Conductivity, pH, temperature, and turbidity



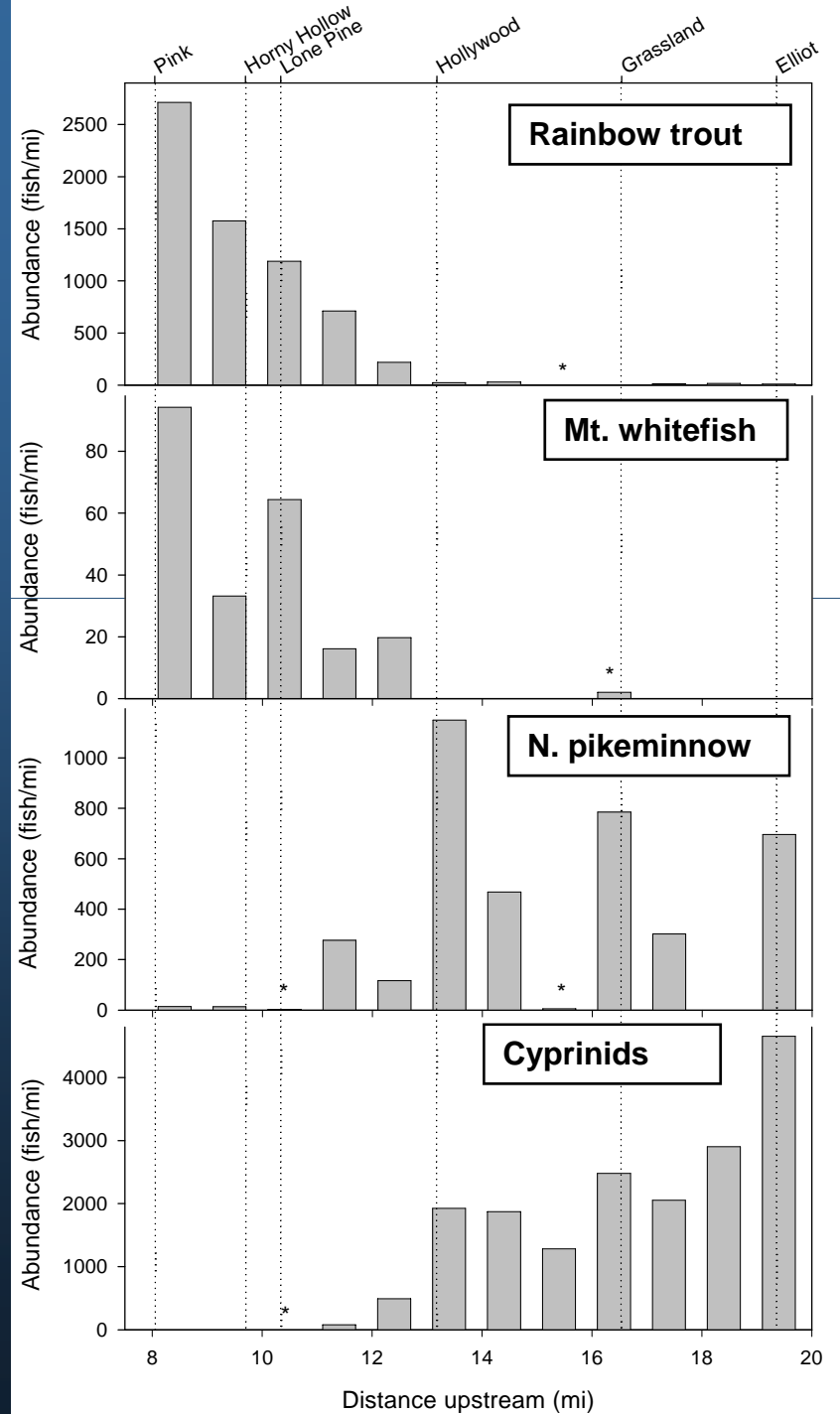
Aquatic Habitat

Habitat type



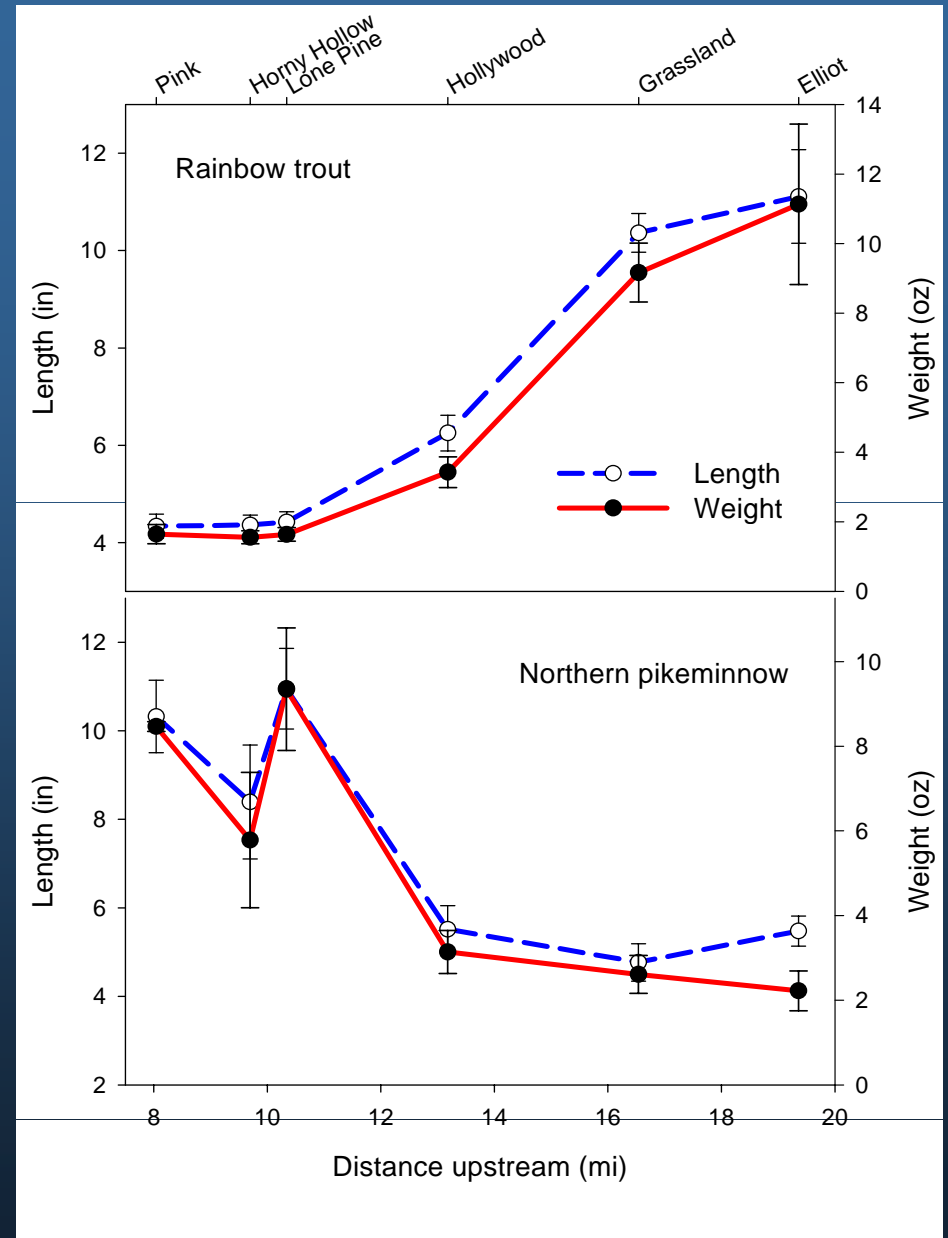
Fish assemblage

Relative abundance



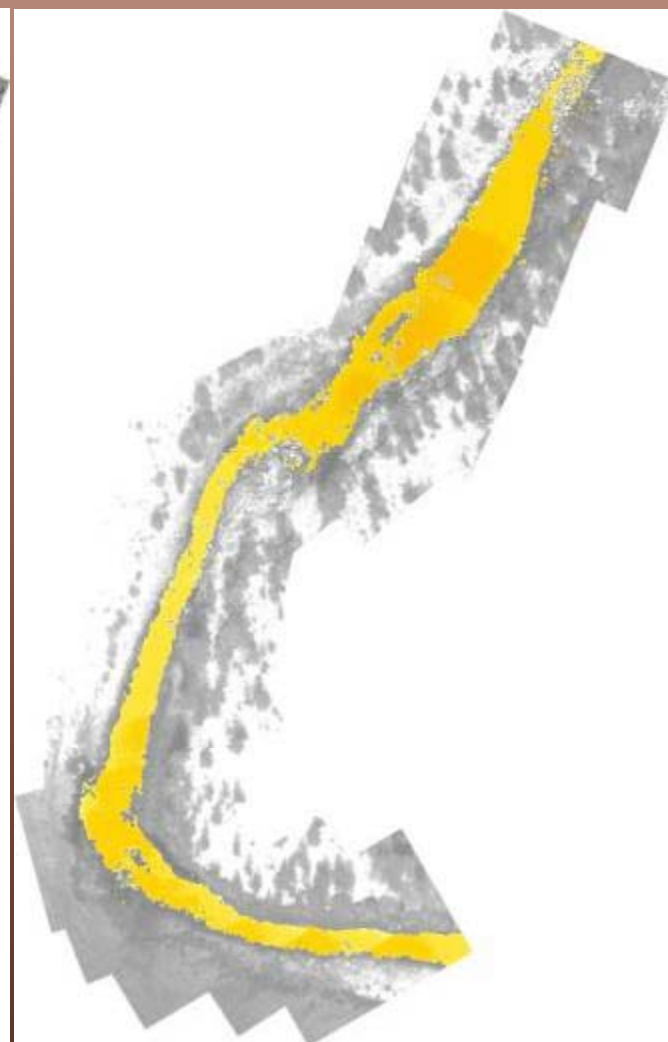
Fish size

Mean length and weight



Thermal homogeneity...

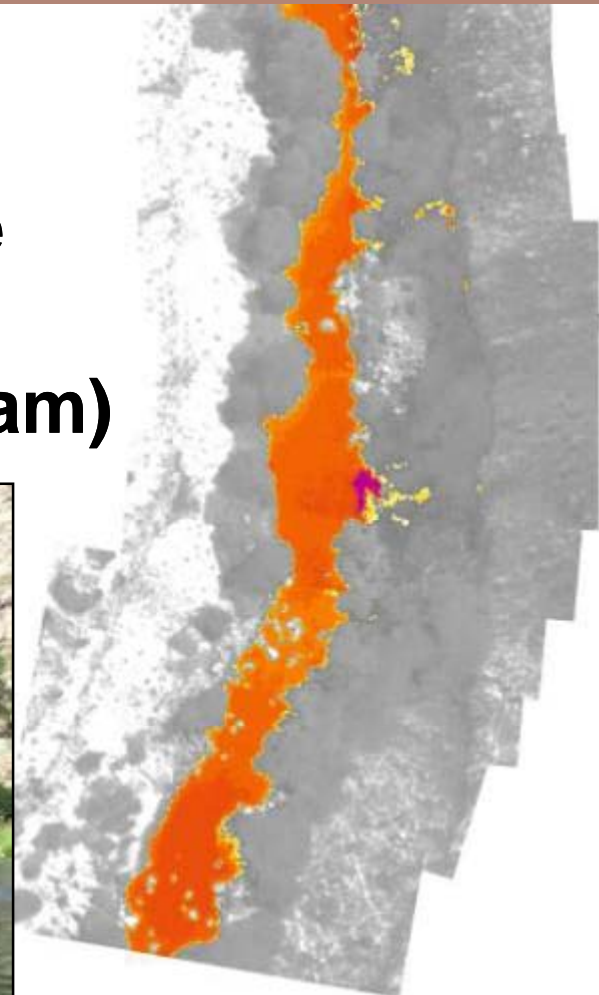
Elliot (warm, upstream)



Thermal heterogeneity...



**Lone Pine
(cool,
downstream)**



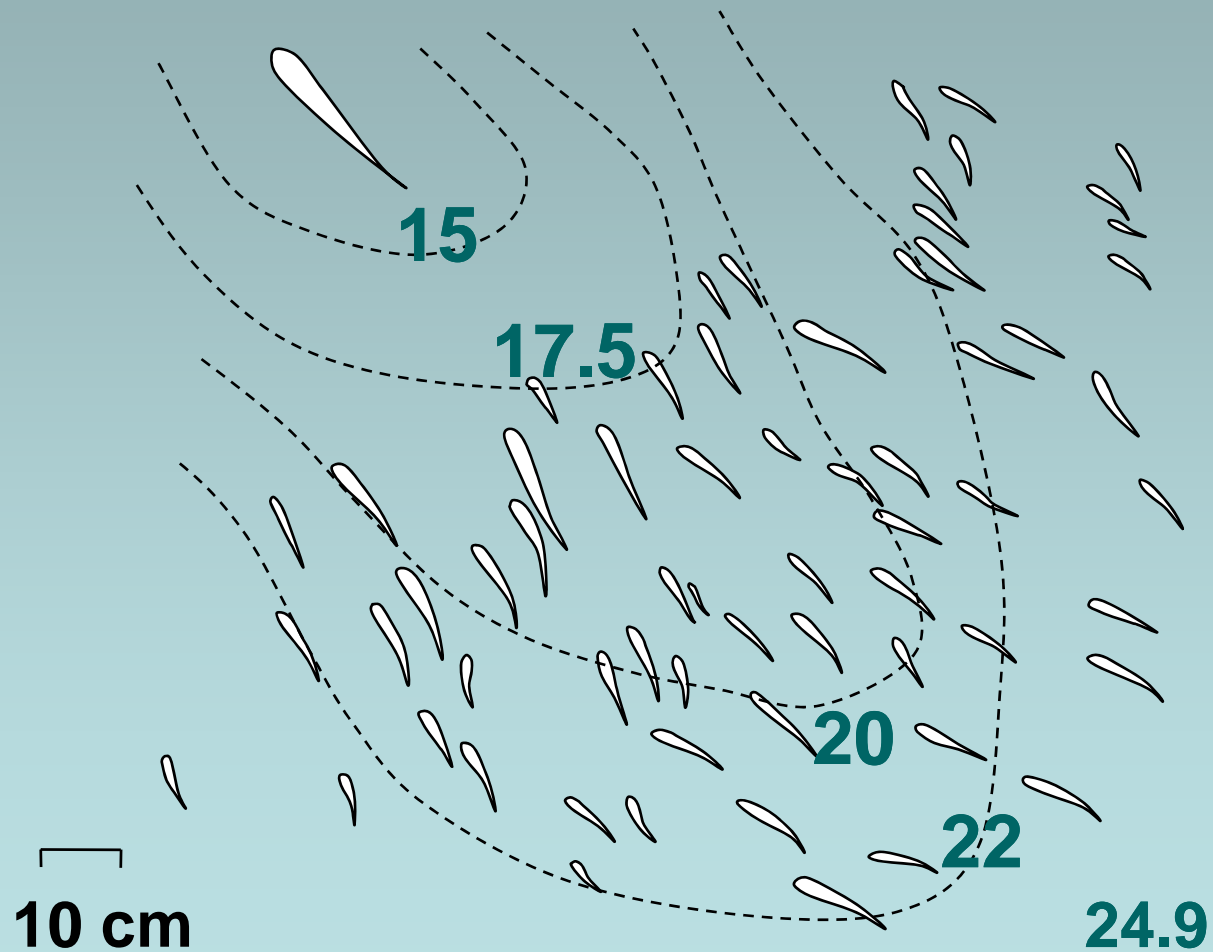
More questions...

- Behavior and movement patterns (refuge use by large and small individuals)
- Physiological consequences: **thermal tolerances** and growth
- Genetic differences in thermal tolerances: redband vs. rainbow trout



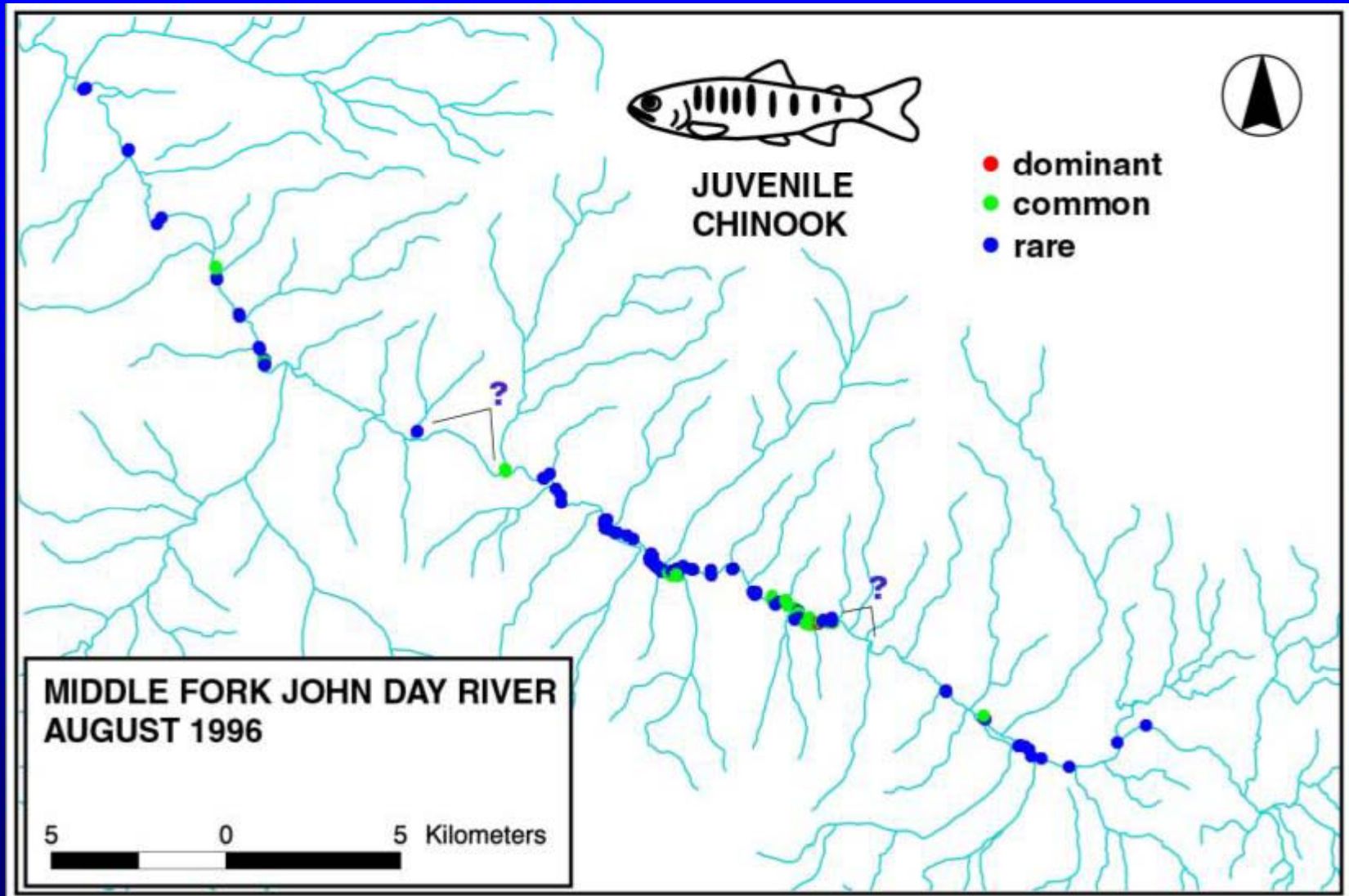
Fish Behavior and Distribution

Species interactions and habitat use



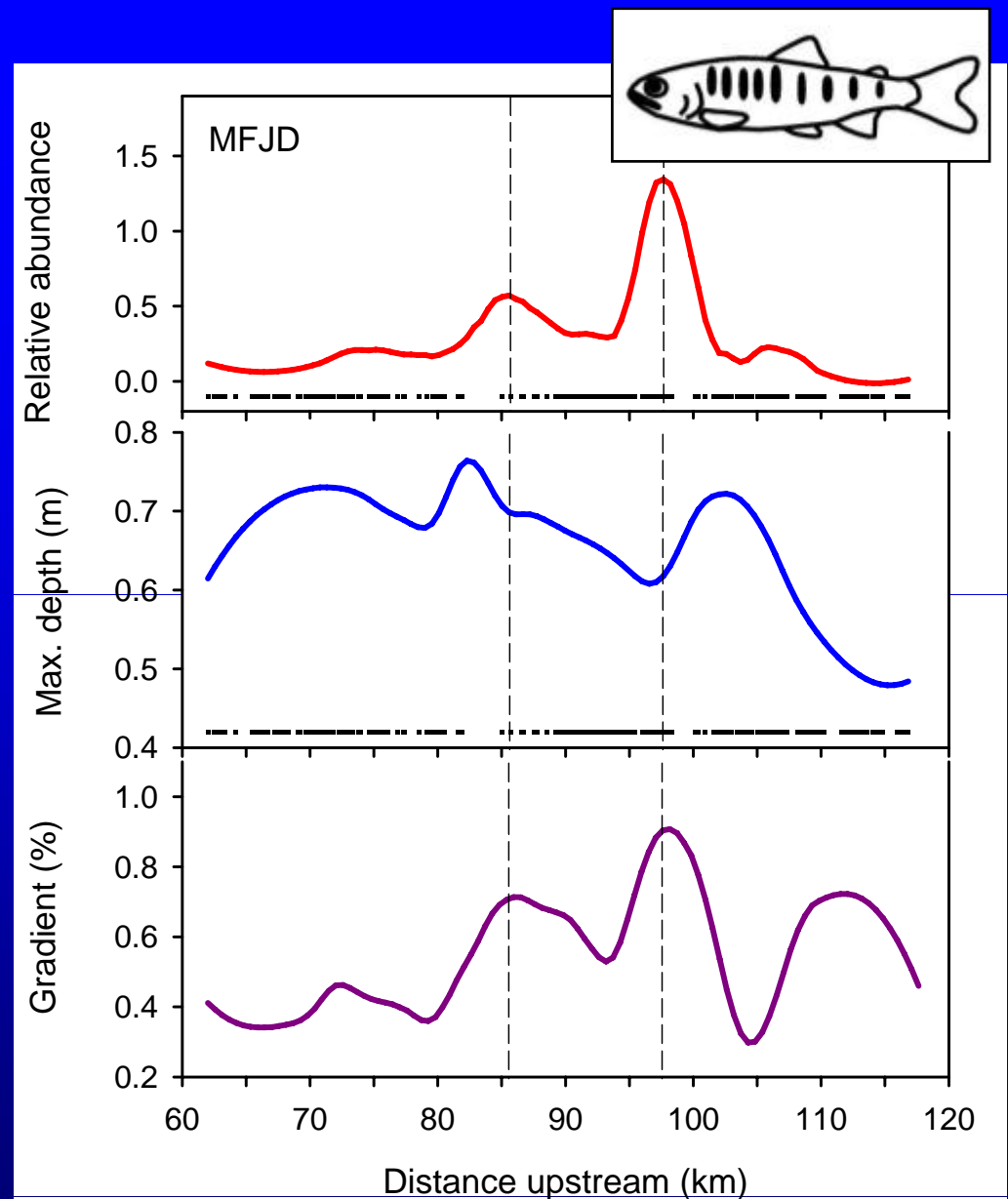
(Ebersole et al. 2001)

Patchiness in fish distribution



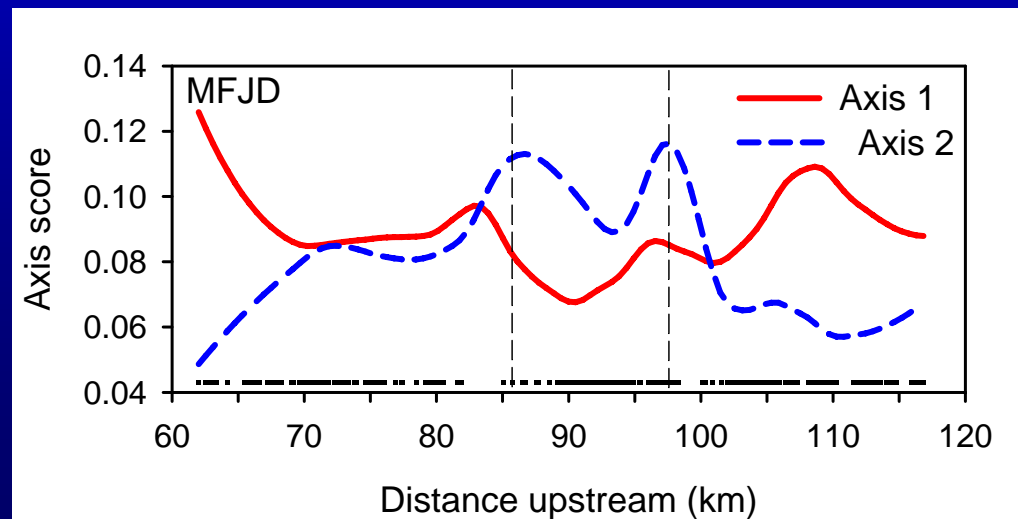
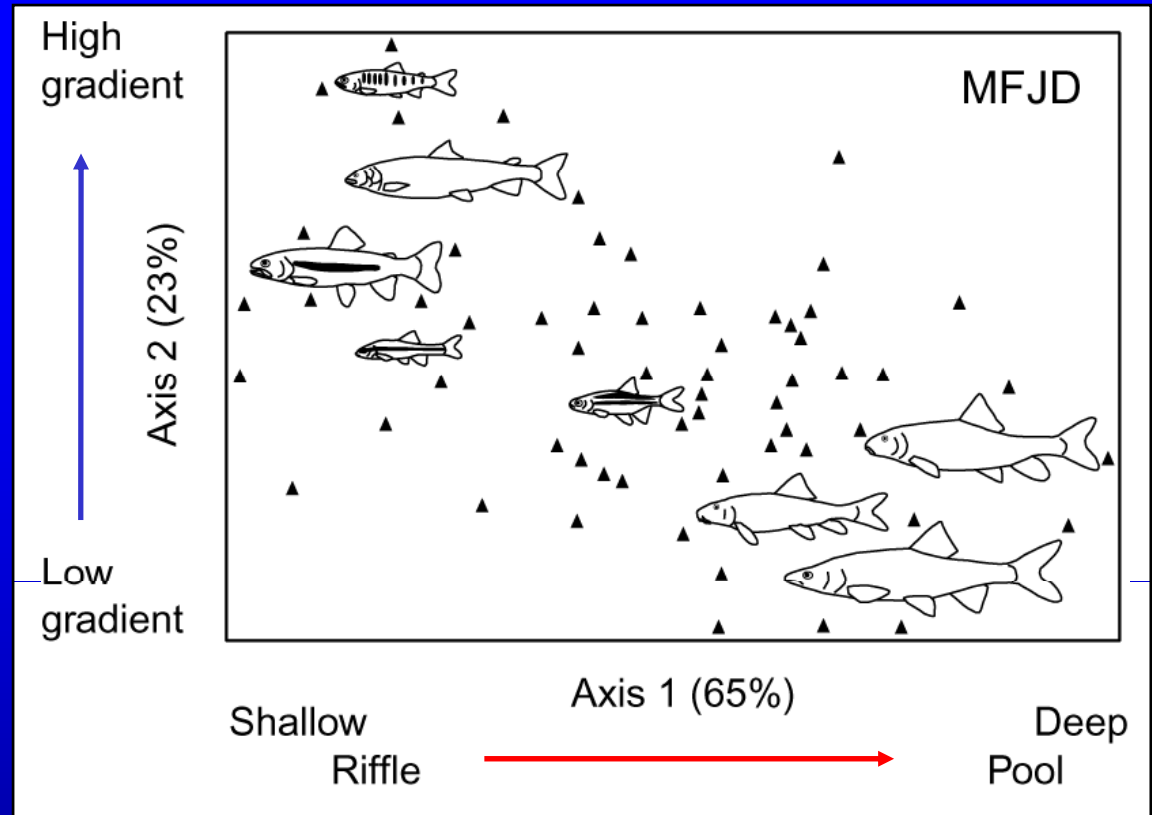
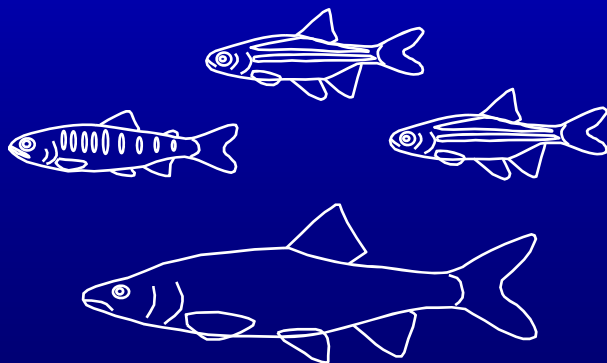
Spatial variability in physical habitat and fish distribution

Middle Fork
John Day River
WARM



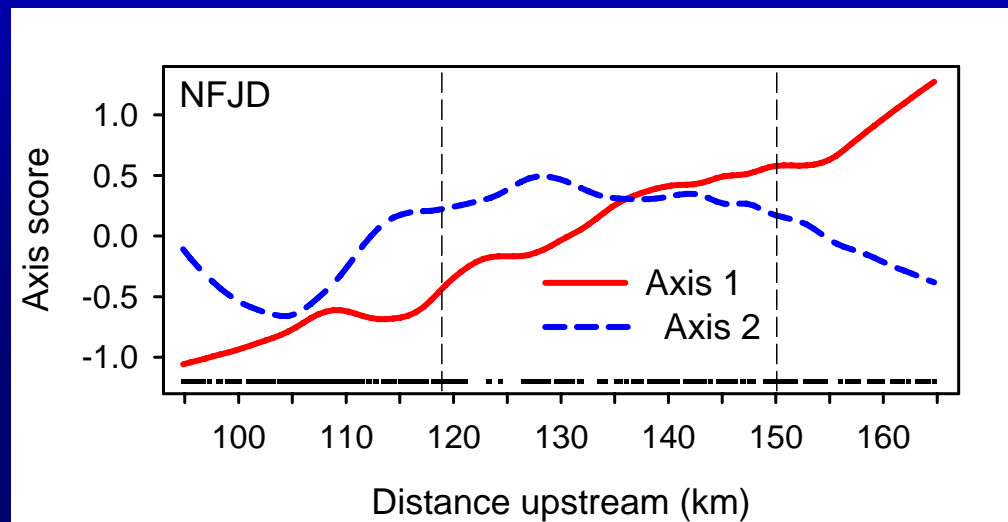
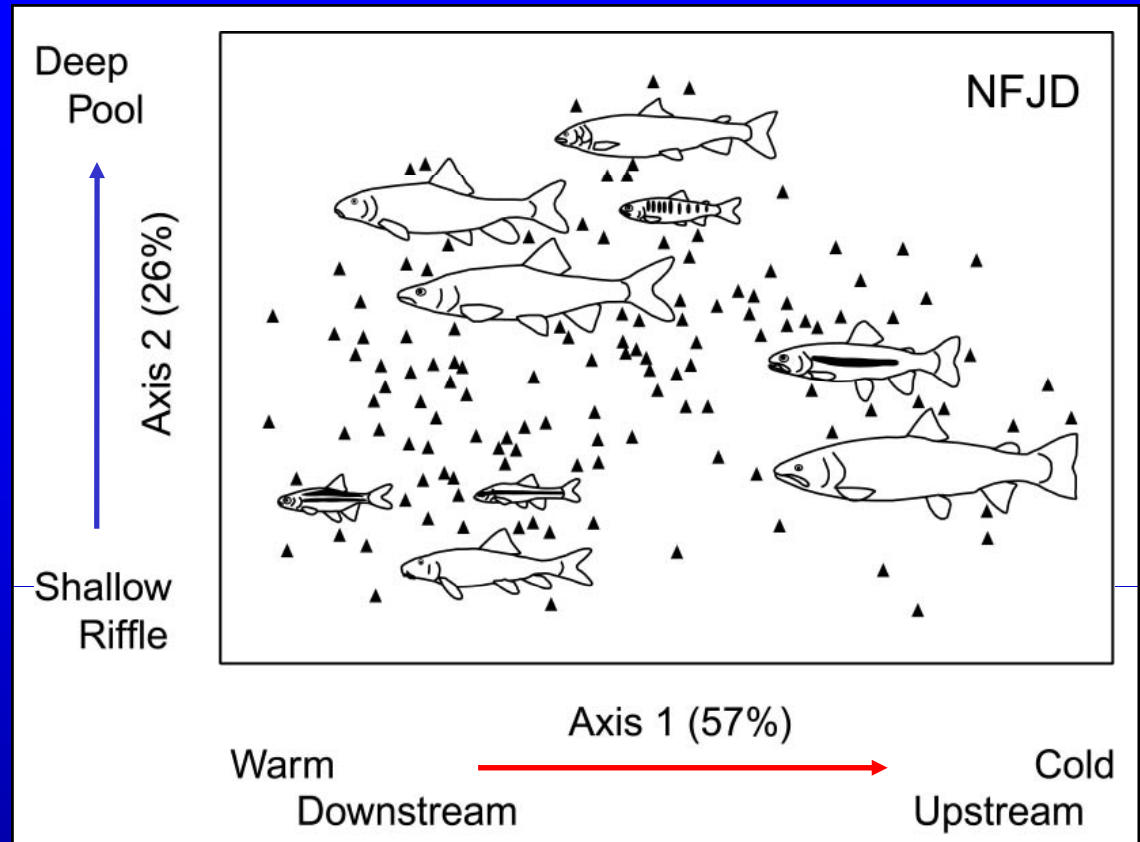
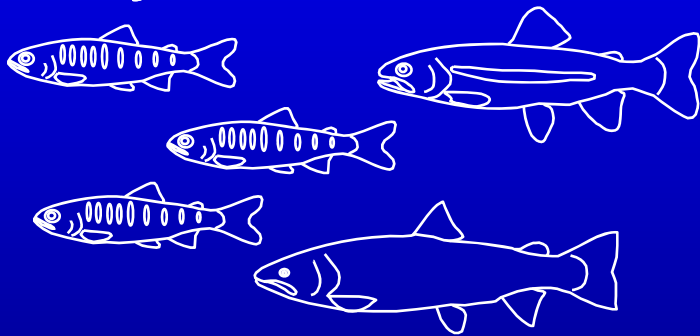
Habitat segregation at the channel-unit scale

Middle Fork
John Day River
WARM



Fish assemblage structure in a COOL stream

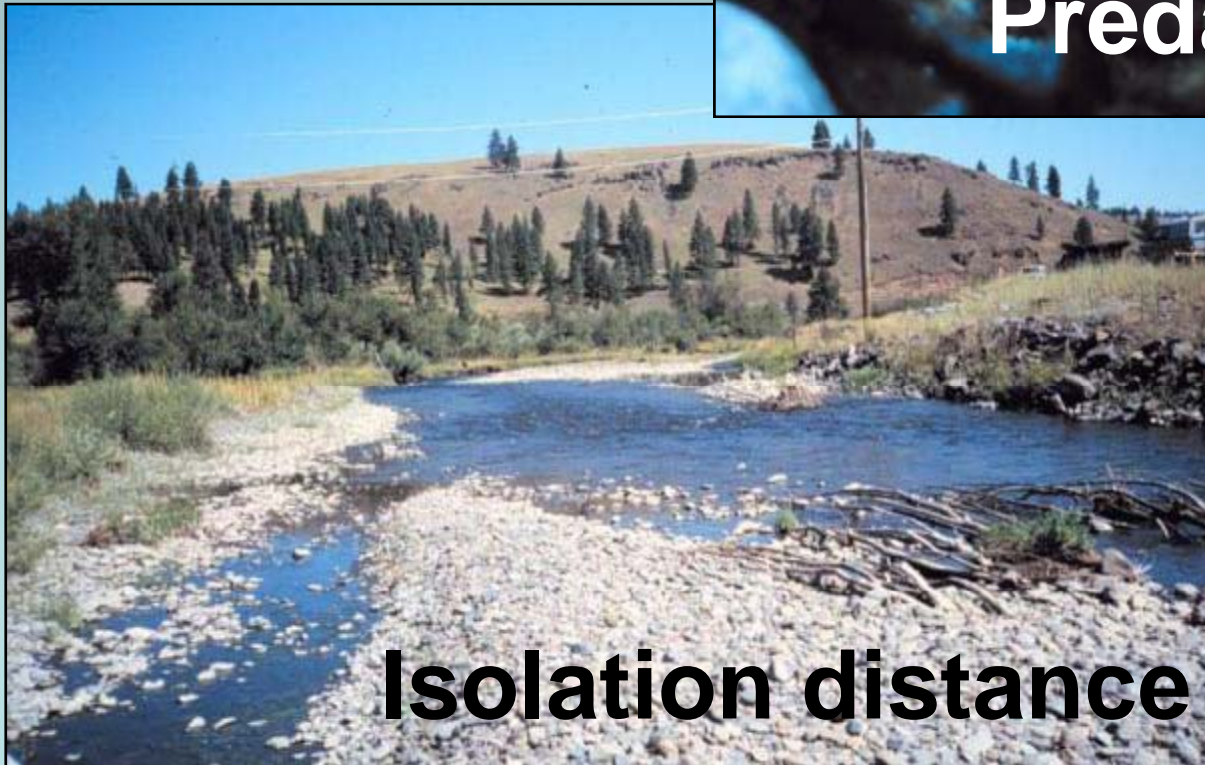
North Fork John Day River



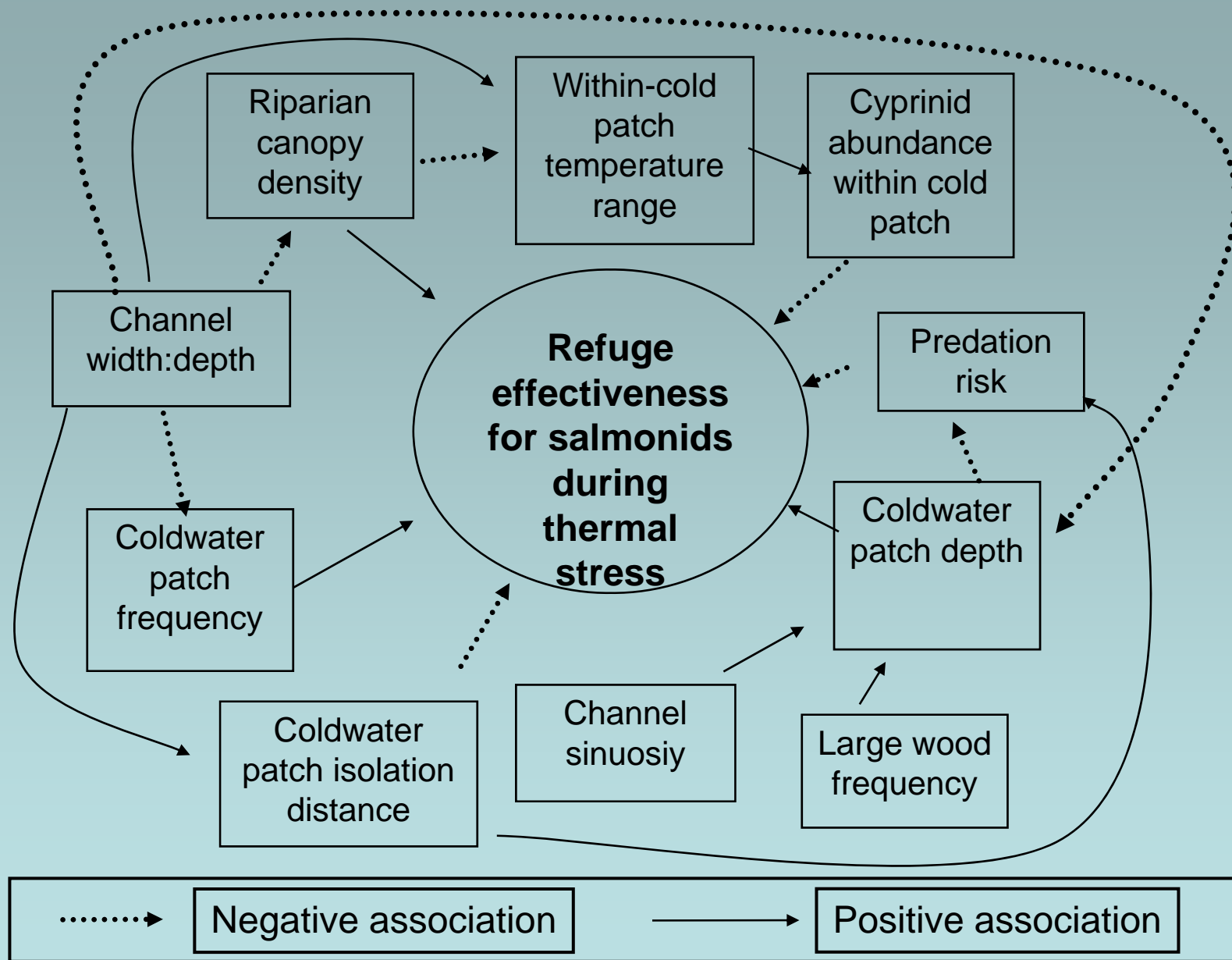
Potential tradeoffs



Predation risk



Isolation distance



Conclusions

- **Temperature alone can seldom explain fish distribution**
 - **Habitat structure**
 - **Microhabitat, channel unit, reach, network and basin scales**
 - **Biotic factors (predation and foraging)**
 - **Human impacts**
- **A refuge is not a home**



Future directions

- **What is a thermal refuge anyway?**
 - Provide scientific guidance for policy definitions
- **Temperature alone does not a refugium make.**
 - Differentiate between thermal anomalies and “refugia”.
- **Shifting mosaic of thermal landscapes**
 - Dynamics and floodplain complexity in conservation and restoration.
- **Predicting in time and space**
 - Refine, test, and unify predictive models based geomorphology/hydrology at multiple scales.



New challenges

- Experimentation and manipulation at “riverscape” scales
- Bridging the technology gap between the “**Haves**” and “**Have nots**”
 - Applying appropriate technology through extension and technology transfer.
- “**Space Invaders**”: Exotic species and climate change in thermal refuges.

