

Steelhead, Turtles, and Frogs: Temperature Dynamics of Stream Habitat

*Paul M. Rich, Stuart B. Weiss
Creekside Center for Earth Observation*

*Alan E. Launer
Stanford University*

*Ecological Society of America Annual Meeting
August 5-10, 2007, San Jose, CA, USA*

Stream Conservation



Key habitat characteristics:

- Water quality
- Flow pattern
- Solar exposure
- Water temperature

Issues:

- Development in watershed
- Riparian vegetation modification
- Stream channel modification
- Water quality degradation
- Runoff / flow changes
- Habitat loss



Species of Concern



Parr (juvenile steelhead)

Steelhead Trout

Oncorhynchus mykiss



An adult steelhead migrating upstream in San Francisco Creek



Northern Red-legged Frog (*Rana aurora*)

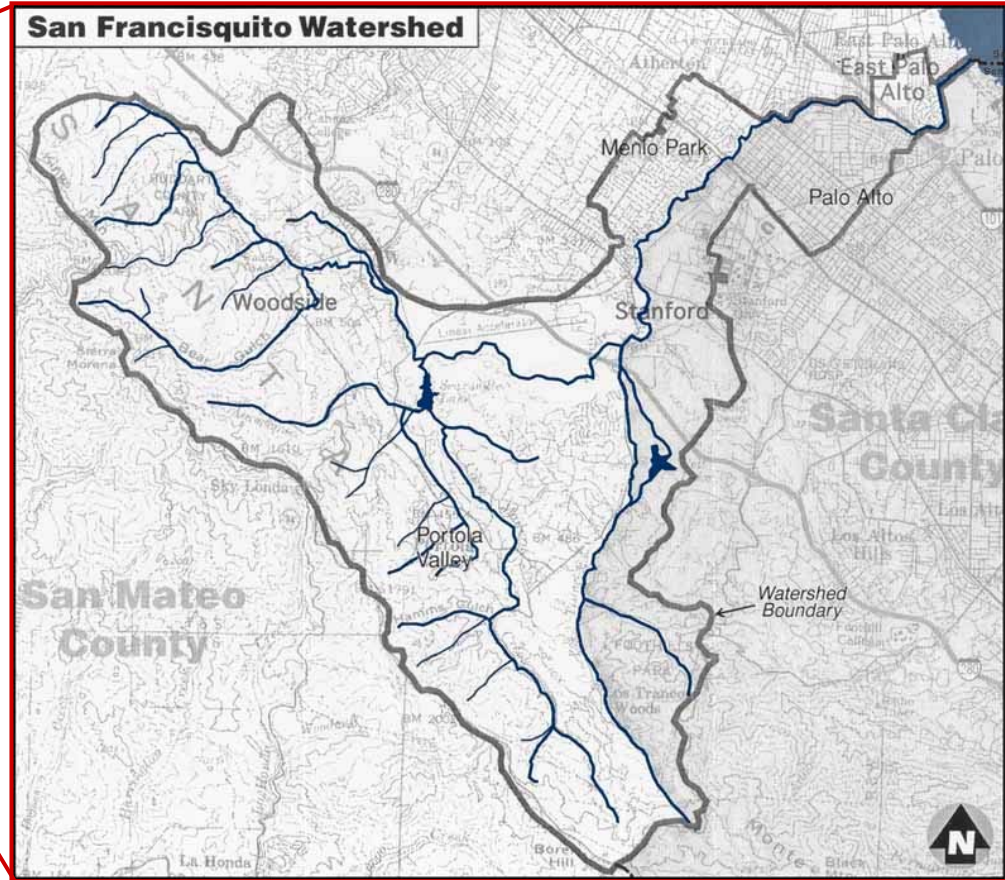
Photo Credit: James Bettaso
U.S. Fish & Wildlife Service



Western Pond Turtle (*Clemmys marmorata*)

Photo Credit: James Bettaso
U.S. Fish & Wildlife Service

Study Area: San Francisquito Creek



Methods

Long-term monitoring:

- Flow and water temperature from gauging stations
- Meteorology from nearby weather stations

Intensive field measurements:

- Solar exposure using hemispherical photography
- Water temperature using sensor network of iButton Thermochrons

Analysis and modeling:

- Spatiotemporal patterns
- Temperature model



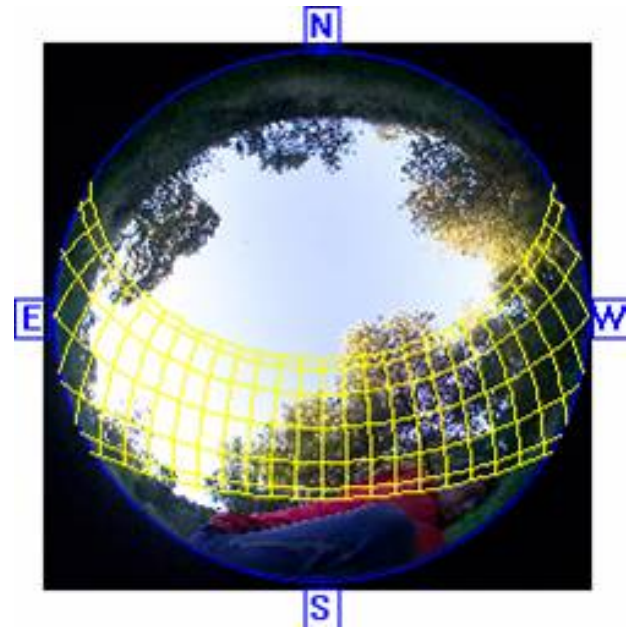
Water Temperature

Determinants:

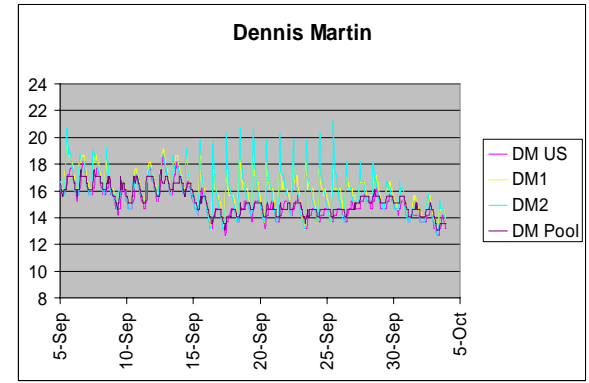
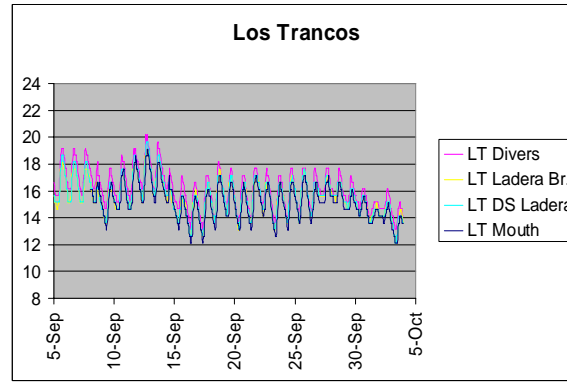
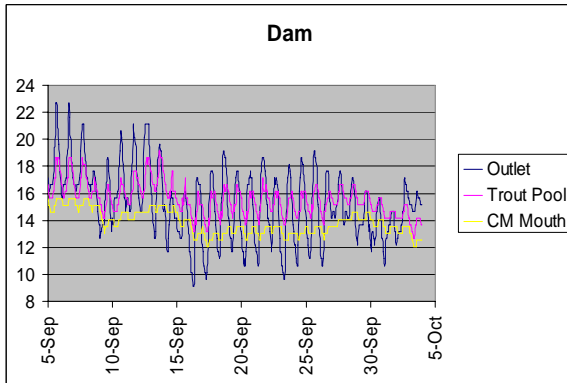
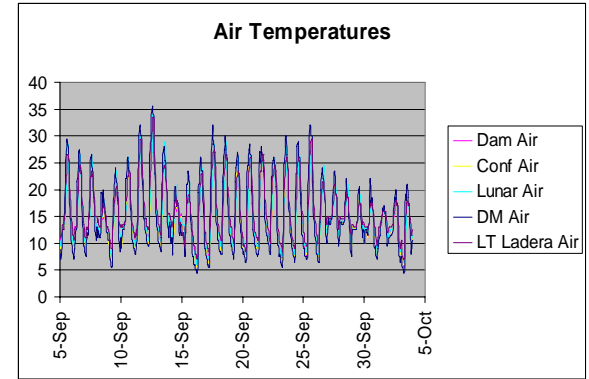
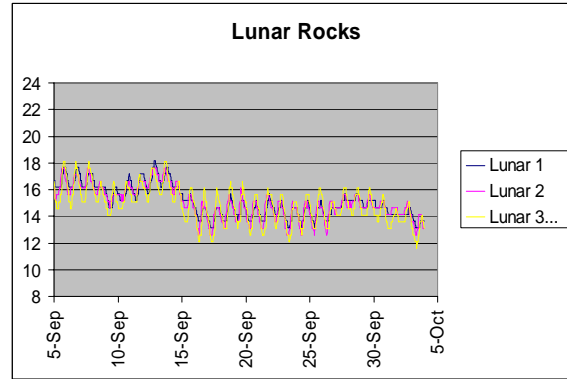
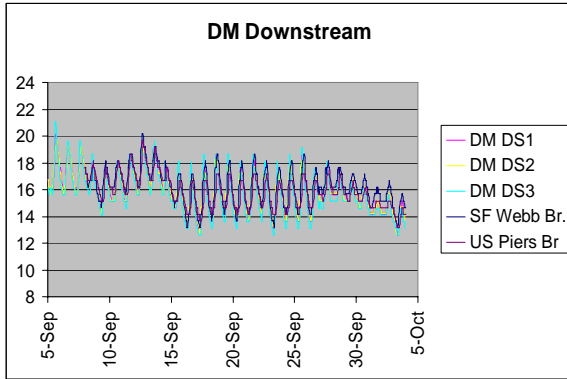
- Prevailing meteorology
- Local channel morphology and riparian canopy structure influences on solar exposure
- Surface and subsurface flow patterns

Tools:

- Hemispherical photography
- Sensor networks

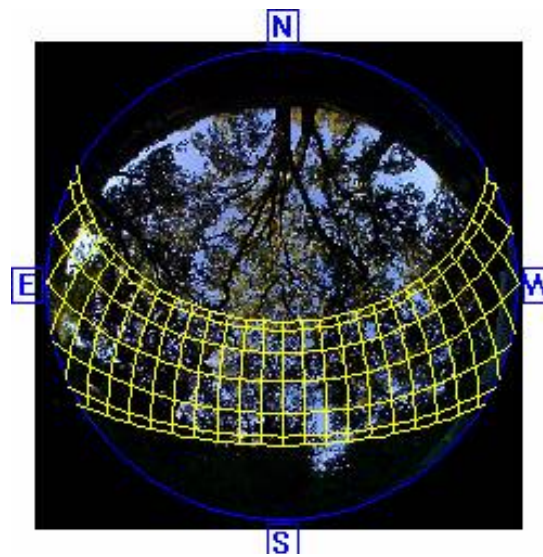
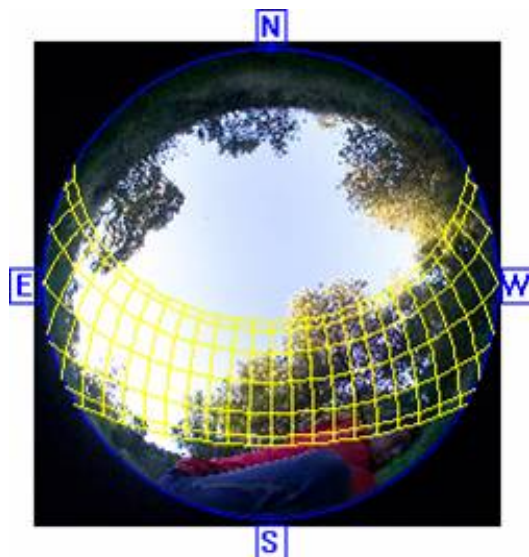


Results: Temperature vs. Time

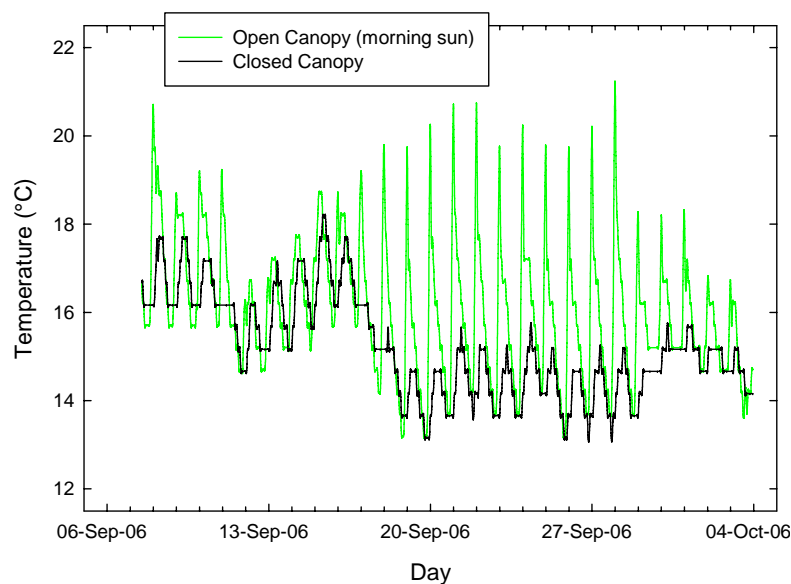


- *Water temperature co-varies with air temperature, with lags*
- *Variance explained by solar exposure and flow patterns*

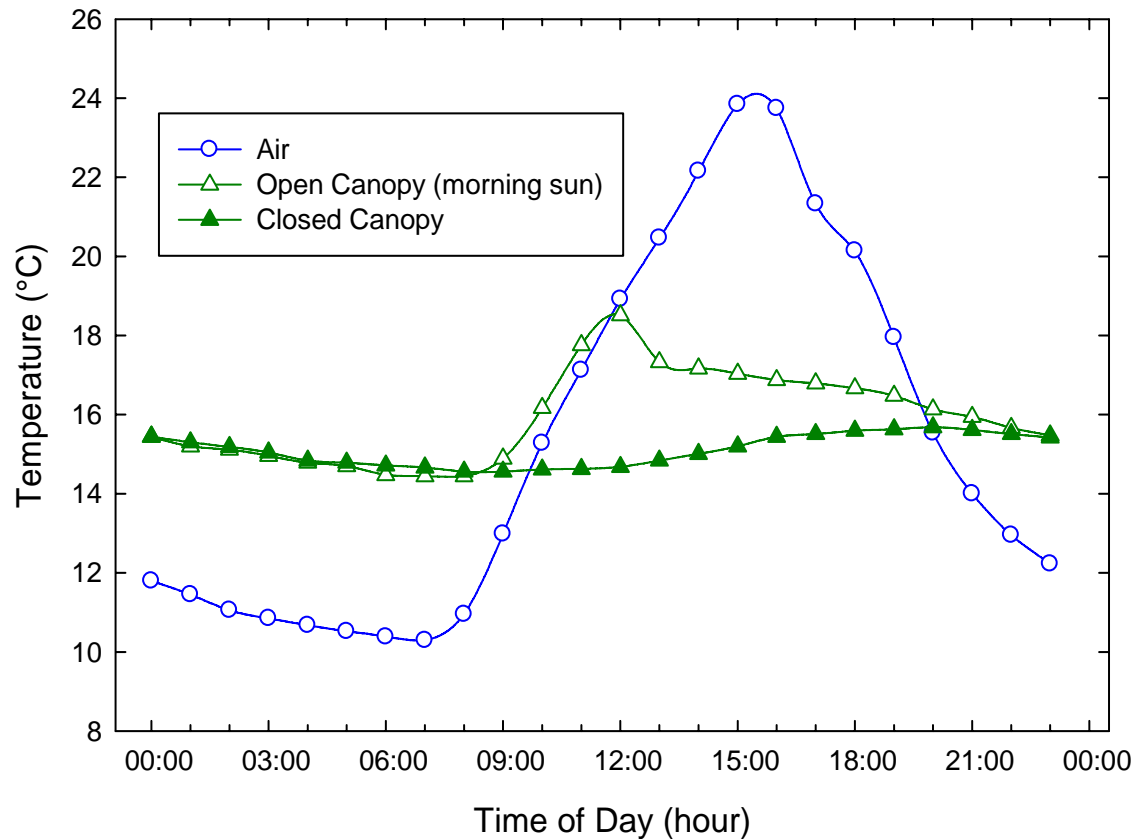
Results 2: Riparian Canopy Effects



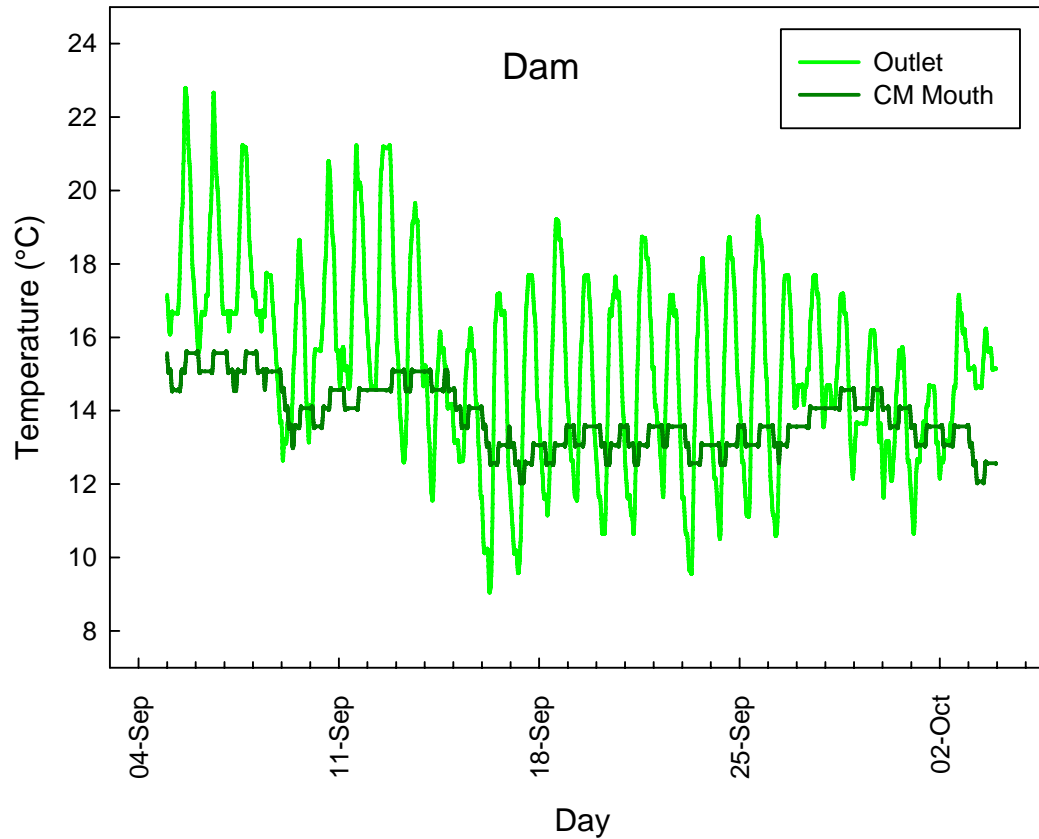
- *Stream reaches with high solar exposure display high temperature variability (up to 5 C° differential from baseline)*
- *Shaded reaches display modest temperature variability (0.5 – 1.0° C differential)*



Results 3: Diurnal Canopy Effects

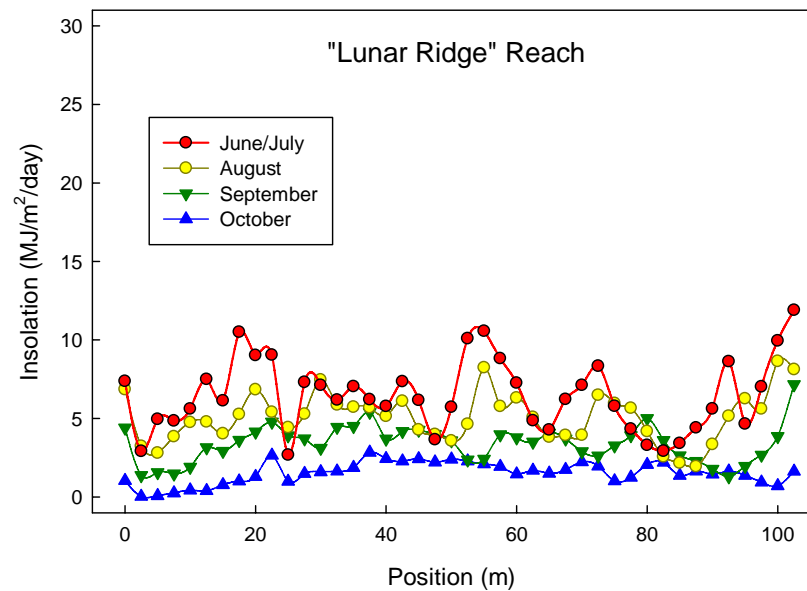
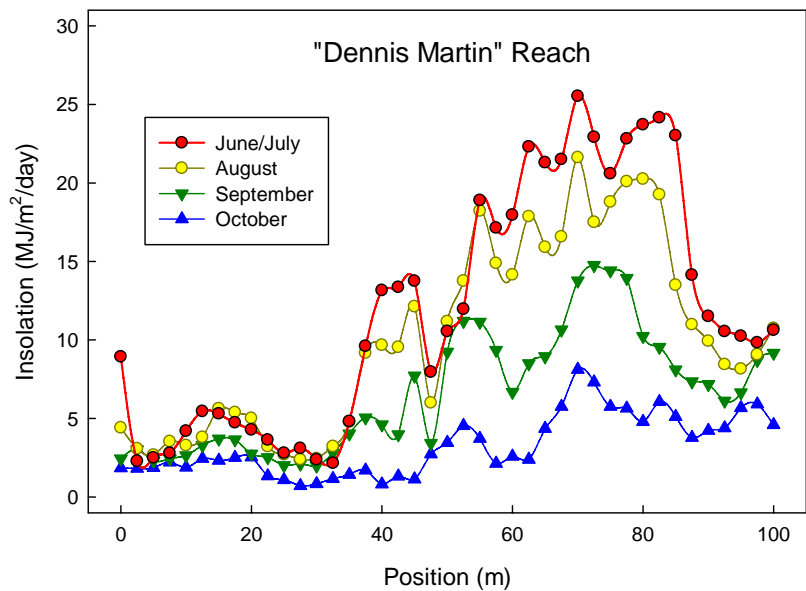


Results 4: Subsurface Flow Effects

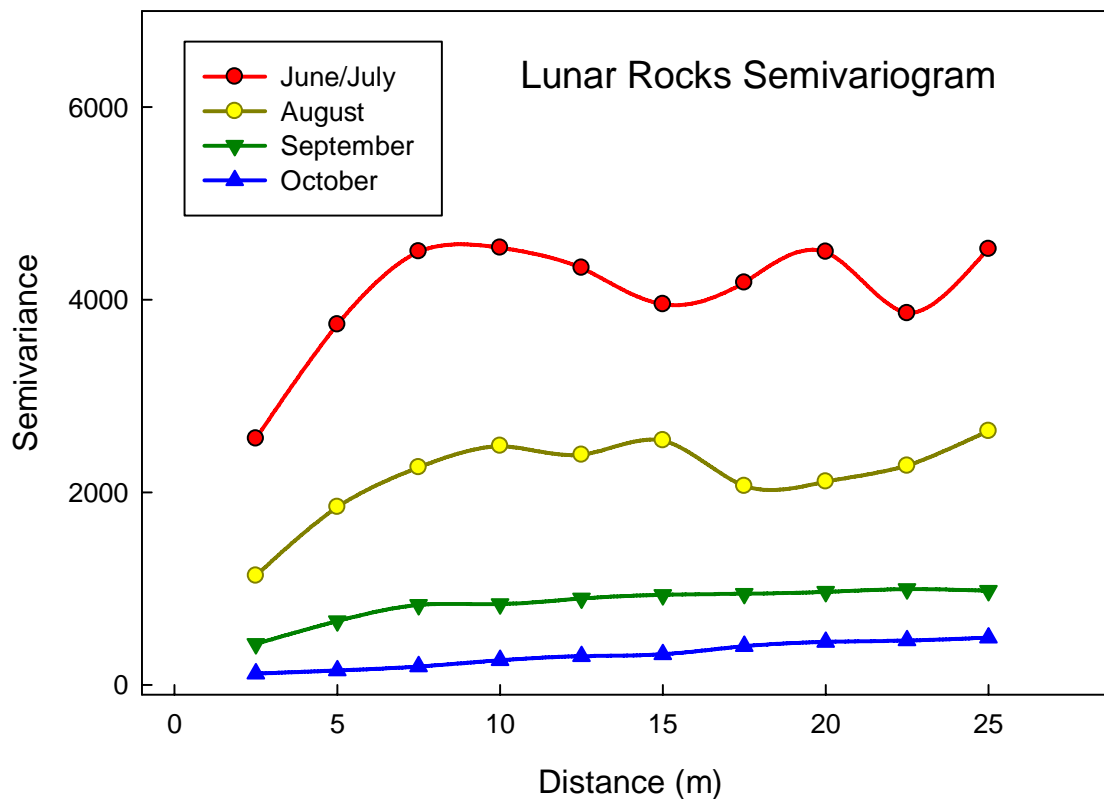


Subsurface flow through gravel beds can decrease temperature 2 - 3° C

Results 5: Solar Exposure

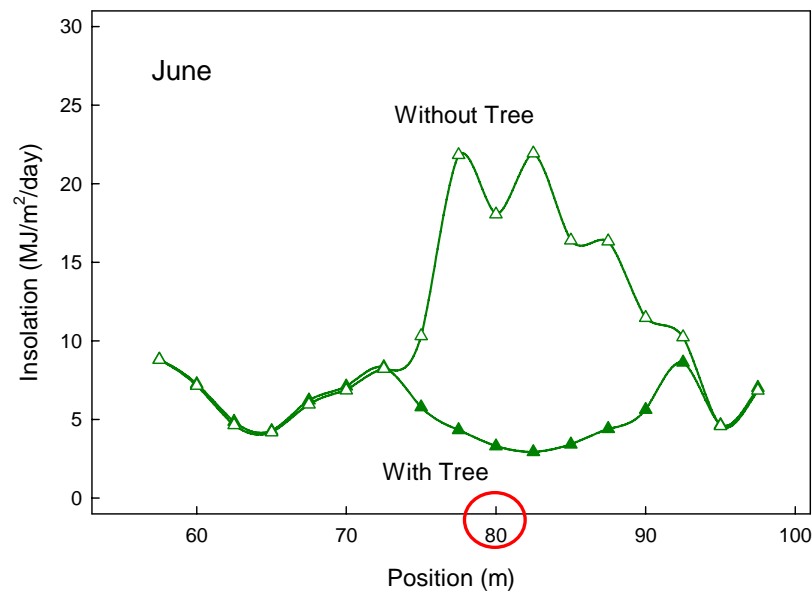
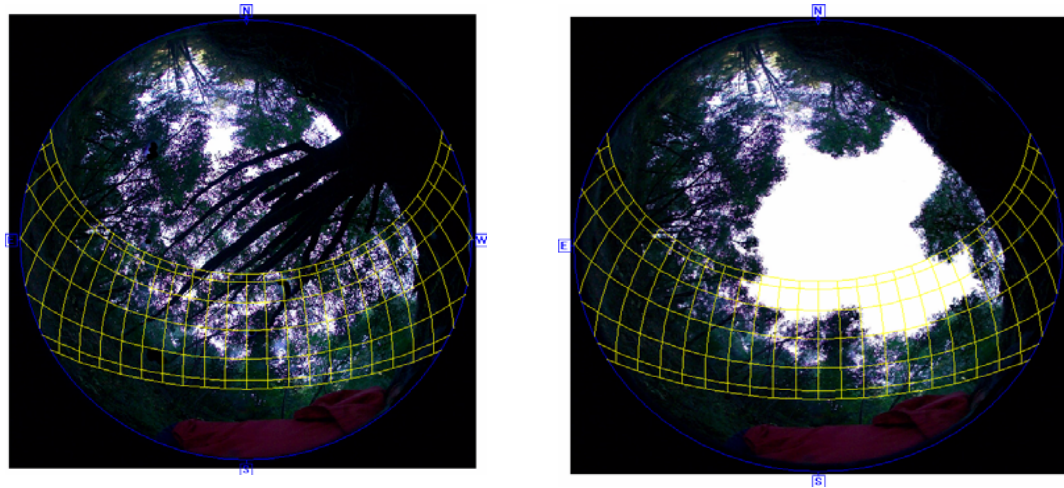


Results 6: Spatial Autocorrelation



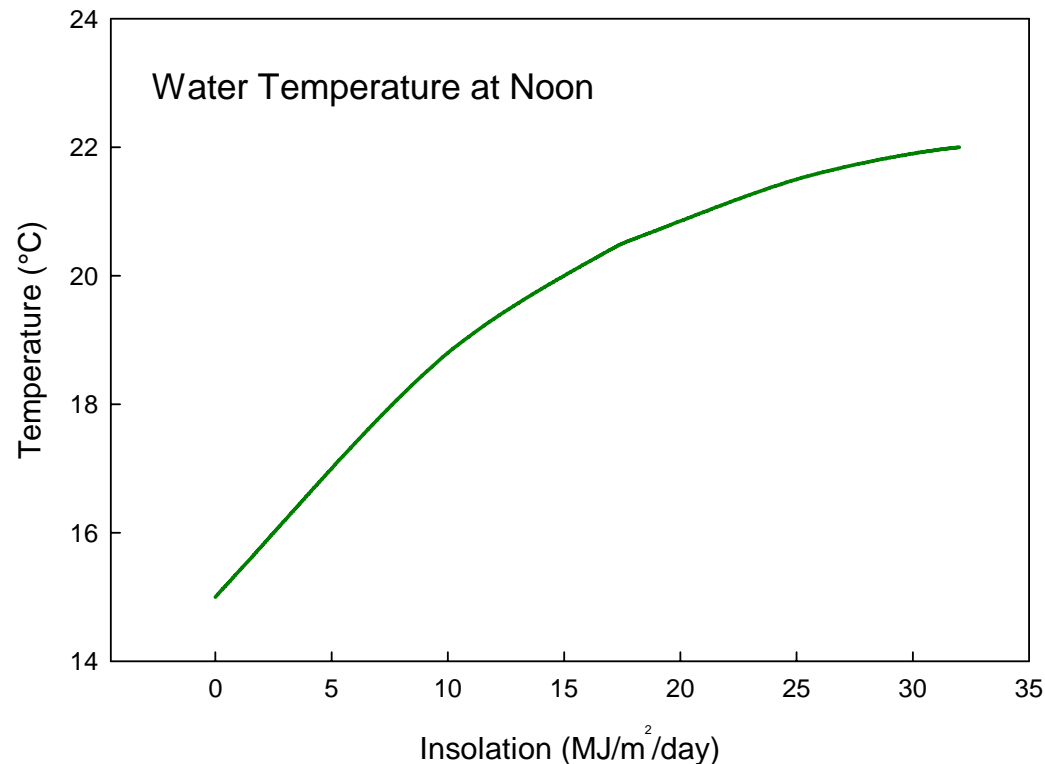
Semivariance peaks at 10-15 m, with pseudoperiodicity => sample interval of 10-20 m

Results 7: Simulated Tree Removal



Temperature Model

- Stream temperature model integrates interplay of prevailing meteorology, solar exposure as determined by stream channel morphology and riparian canopy structure, and surface and subsurface flows.



Perspective

- Water temperature limits distribution of aquatic organisms:
 - Steelhead Trout prefer cooler habitat
 - Red-Legged Frogs and Western Pond Turtles prefer warmer habitat
- Synthetic approach:
 - flow, water temperature, meteorology, geomorphology
 - solar exposure from hemispherical photographs
 - temperature from Thermochron sensor network
- Applicable for broad spectrum of streams



Acknowledgements

- Nina Allmendinger
- Linda Chamberlin
- Ryan Navratil
- Bijan Osmani
- Brian Scoles
- Pam Sturner
- Jasper Ridge Biological Preserve
- National Fish and Wildlife Foundation
- San Francisco Watershed Council
- Stanford University, Land Use and Environmental Planning



Stream monkeys