Comparing headwater stream thermal sensitivity across two contrasting lithologies in Northern California

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Abstract

Understanding drivers of thermal regimes in headwater streams is critical for a comprehensive understanding of freshwater ecological condition and habitat resilience to disturbance, and to inform sustainable forest management policies and decisions. However, stream temperatures may vary depending on characteristics of the stream, catchment, or region. To improve our knowledge of the key drivers of stream thermal regime, we collected stream and air temperature data along eight headwater streams in two regions with distinct lithology, climate, and riparian vegetation. Five streams were in the Northern California Coast Range at the Caspar Creek Experimental Watershed Study, which is characterized by permeable sandstone lithology. Three streams were in the Cascade Range at the LaTour Demonstration State Forest, which is characterized by fractured and resistant basalt lithology. We instrumented each stream with 12 stream temperature and four air temperature sensors during summer 2018. Our objectives were to compare stream thermal regimes and thermal sensitivity—slope of the linear regression relationship between daily stream and air temperature—within and between both study regions. Mean daily stream temperatures were ˜4.7 °C warmer in the Coast Range but were less variable (SD = 0.7 °C) compared to the Cascade Range (SD = 2.3 °C). Median thermal sensitivity was 0.33 °C $°C^{-1}$ in the Coast Range and 0.23 °C $°C^{-1}$ in the Cascade Range. We posit that the volcanic lithology underlying the Cascade streams likely supported discrete groundwater discharge locations, which dampened thermal sensitivity. At locations of apparent groundwater discharge in these streams, median stream temperatures rapidly decreased by 2.0 °C, 3.6 °C, and 7.0 °C relative to adjacent locations, approximately 70–90 meters upstream. In contrast, thin friable soils in the Coast Range likely contributed baseflow from shallow subsurface sources, which was more sensitive to air temperature and generally warmed downstream (up to 2.1 °C km^{-1}). Our study revealed distinct longitudinal thermal regimes in streams draining contrasting lithology, suggesting that streams in these different regions may respond differentially to forest disturbances or climate change.

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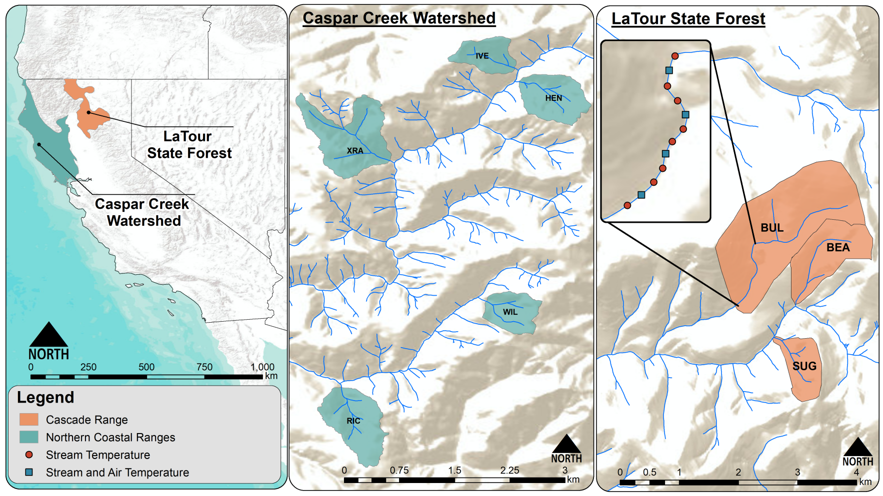
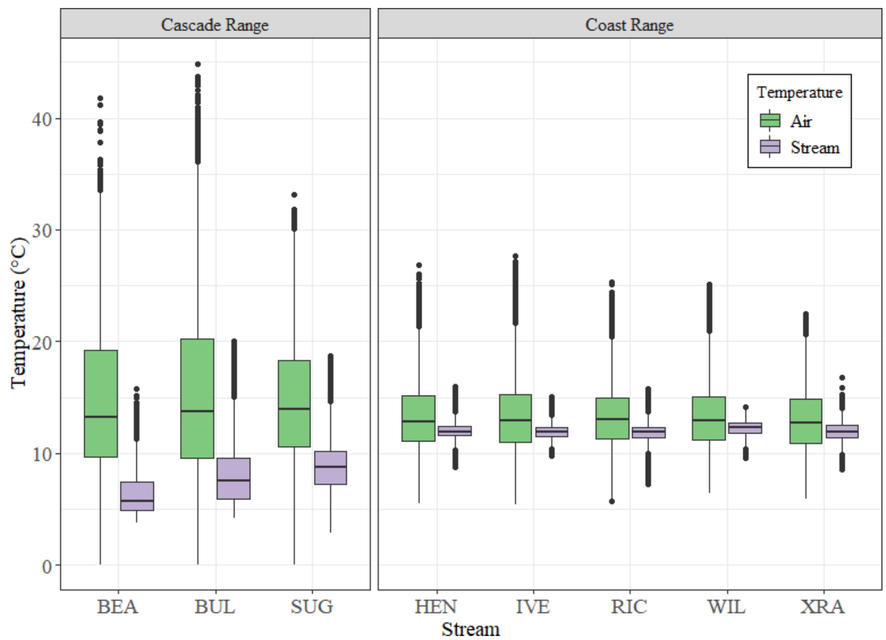
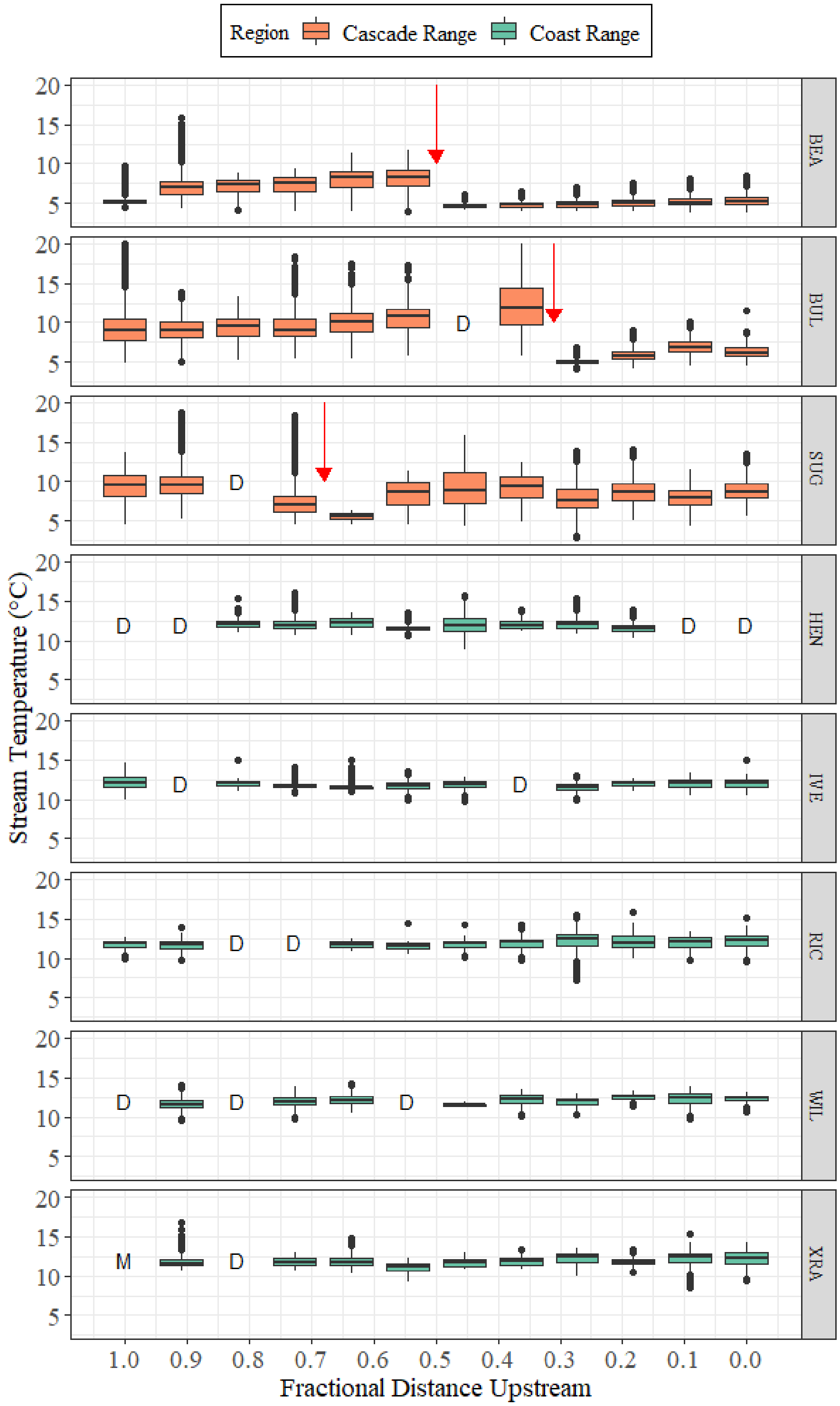
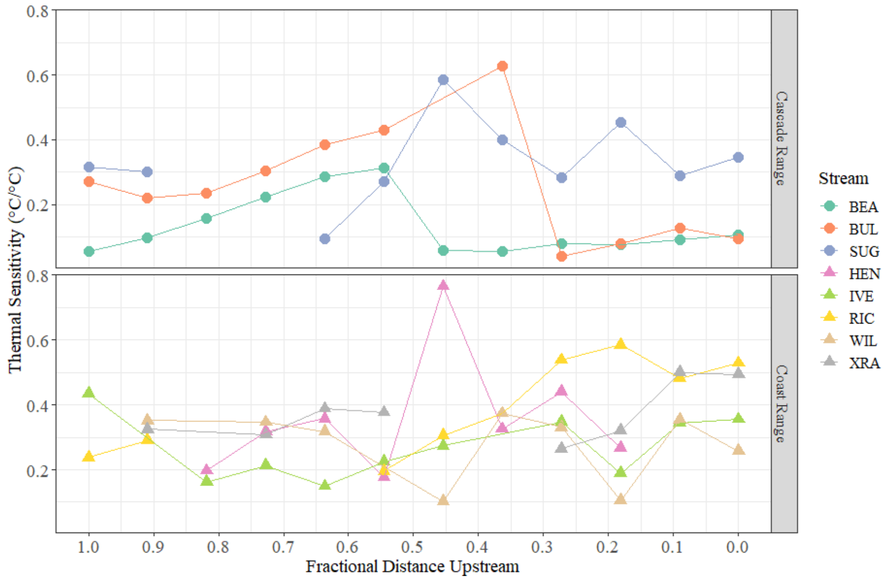
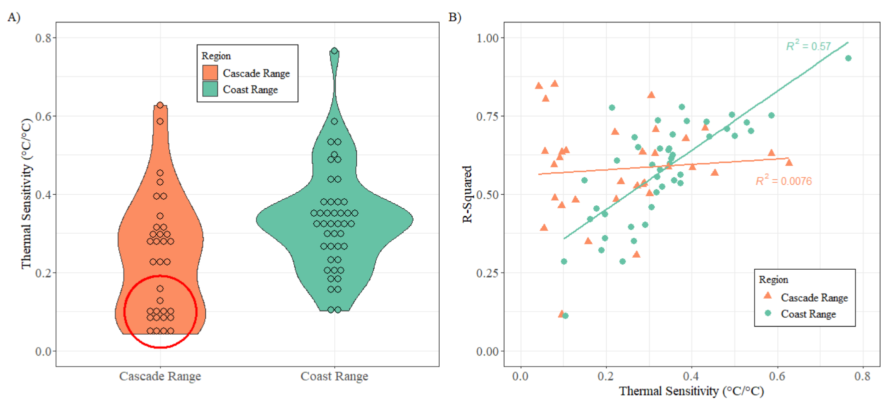

LaTour State Forest
Caspar Creek Watershed
NORTH
0 250 500 750 1,000 km
Legend
Cascade Range
Northern Coastal Ranges
Stream Temperature
Stream and Air Temperature
Caspar Creek Watershed
IVE
HEN
XRA
WIL
RIC
0 0.75 1.5 2.25 3 km
LaTour State Forest
BUL
BEA
SUG
0 0.5 1 2 3 4 km


Cascade Range
Coast Range
Temperature
Air
Stream
Temperature (°C)
0
10
20
30
40
BEA
BUL
SUG
HEN
IVE
RIC
WIL
XRA
Stream


Region
Cascade Range
Coast Range
Stream Temperature (°C)
Fractional Distance Upstream
BEA
BUL
SUG
HEN
IVE
RIC
WIL
XRA
D
M


Thermal Sensitivity (°C/°C)
Fractional Distance Upstream
Cascade Range
Coast Range
Stream
BEA
BUL
SUG
HEN
IVE
RIC
WIL
XRA


A)
B)
Thermal Sensitivity (°C/°C)
Region
Cascade Range
Coast Range
R-Squared
$R^2 = 0.57$
$R^2 = 0.0076$
Thermal Sensitivity (°C/°C)