EMC-2015-001

Project 2 – "Longitudinal Trends in Stream Temperature in Contrasting Lithology"

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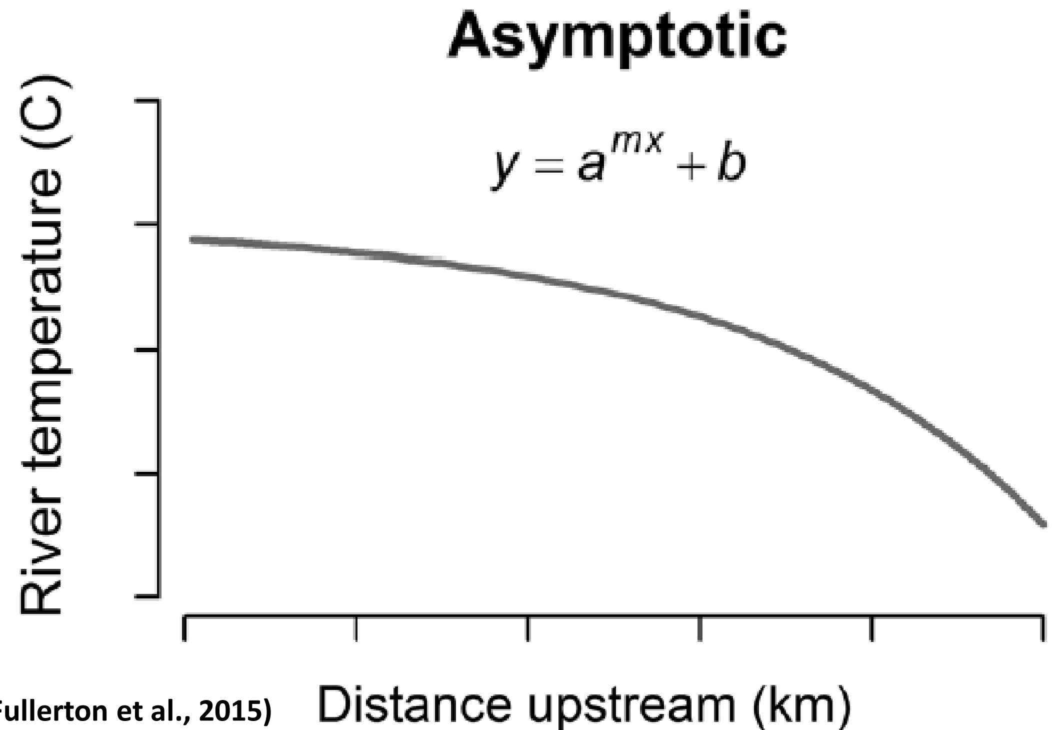
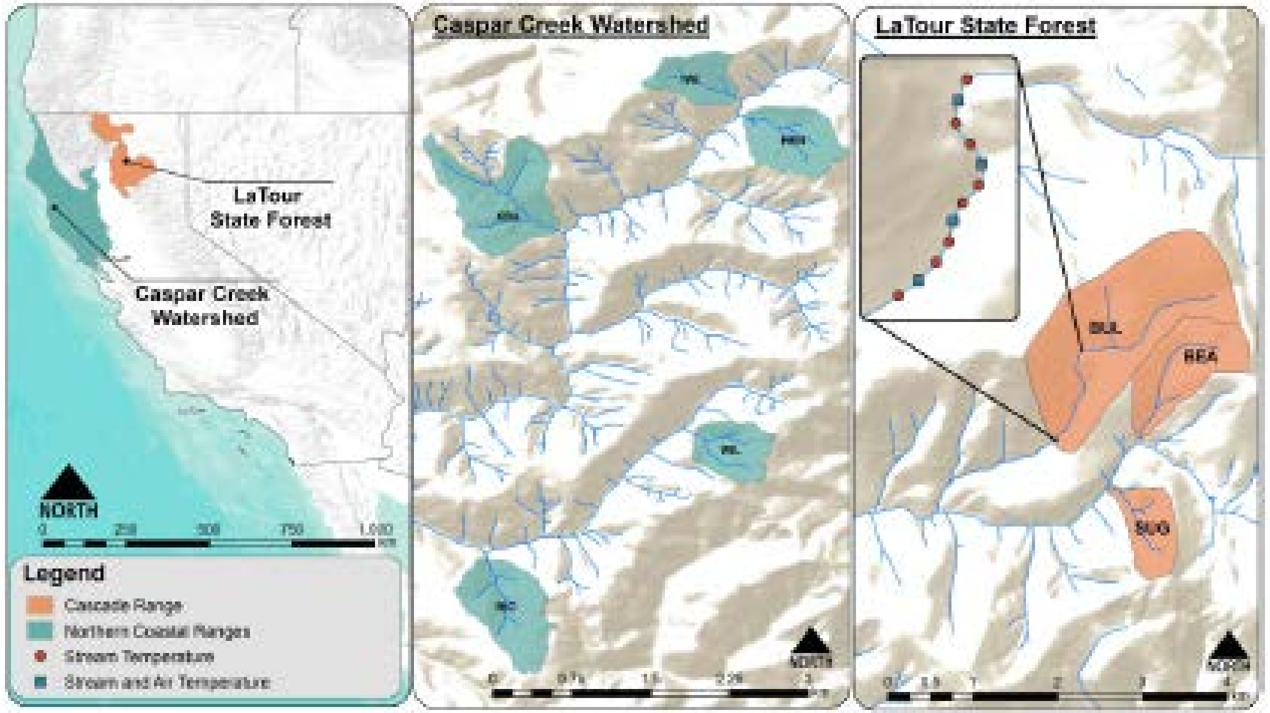
ASP Rule Assumptions - **916.9, 936.9, 956.9 (c)(4)**

(4) Class II Large Watercourses (Class II-L): The primary objective is to maintain, protect or restore the values and functions of Class II-L type Watercourses described below. Class II-L Watercourses can have greater individual effects on receiving Class I Watercourse temperature, sediment, nutrient, and large wood loading than Class II standard (Class II-S) Watercourses due to larger channel size, greater magnitude and duration of flow, and overall increased transport capacity for watershed products. Other objectives stated in 14 CCR § 916.9 [936.9, 956.9] subsections (c)(1) and (2) above for the Core Zone and Inner Zone are also desired objectives for Class II-L type Watercourses.



(Fullerton et al., 2015)

- Assumes that Class II-L have more of an influence transmitting temperature increases to Class I watercourses
- Consistent with the dominant paradigm of asymptotic warming where stream temperature reaches equilibrium with meteorological conditions



Characteristic	Cascade Range	Coast Range	Reference
Mean T_a (°C, range)	10.9 (-6.0–29.2)	13.5 (1.6–28)	Measured herein
Precipitation (mm, Oct 2017–Sept 2018)	1,018	956	PRISM Climate Group, 2020
30-year mean precipitation (mm)	1,350	1,262	PRISM Climate Group, 2020
Mean stream elevation (m, range)	1,741 (1,576–1,912)	124 (52–189)	Measured herein
Mean watershed slope (%)	28	33	Measured herein
Mean canopy cover (%, range)	61 (54–66)	85 (78–91)	Oregon State LEMMA Database, 2020
Dominant forest cover	Sugar, ponderosa, and lodgepole pine	Coast redwood, Douglas-fir, and western hemlock	Observed herein
Dominant lithology	andesite, basalt	sandstone, mudstone	MacDonald, 1963; Amatya et al., 2016

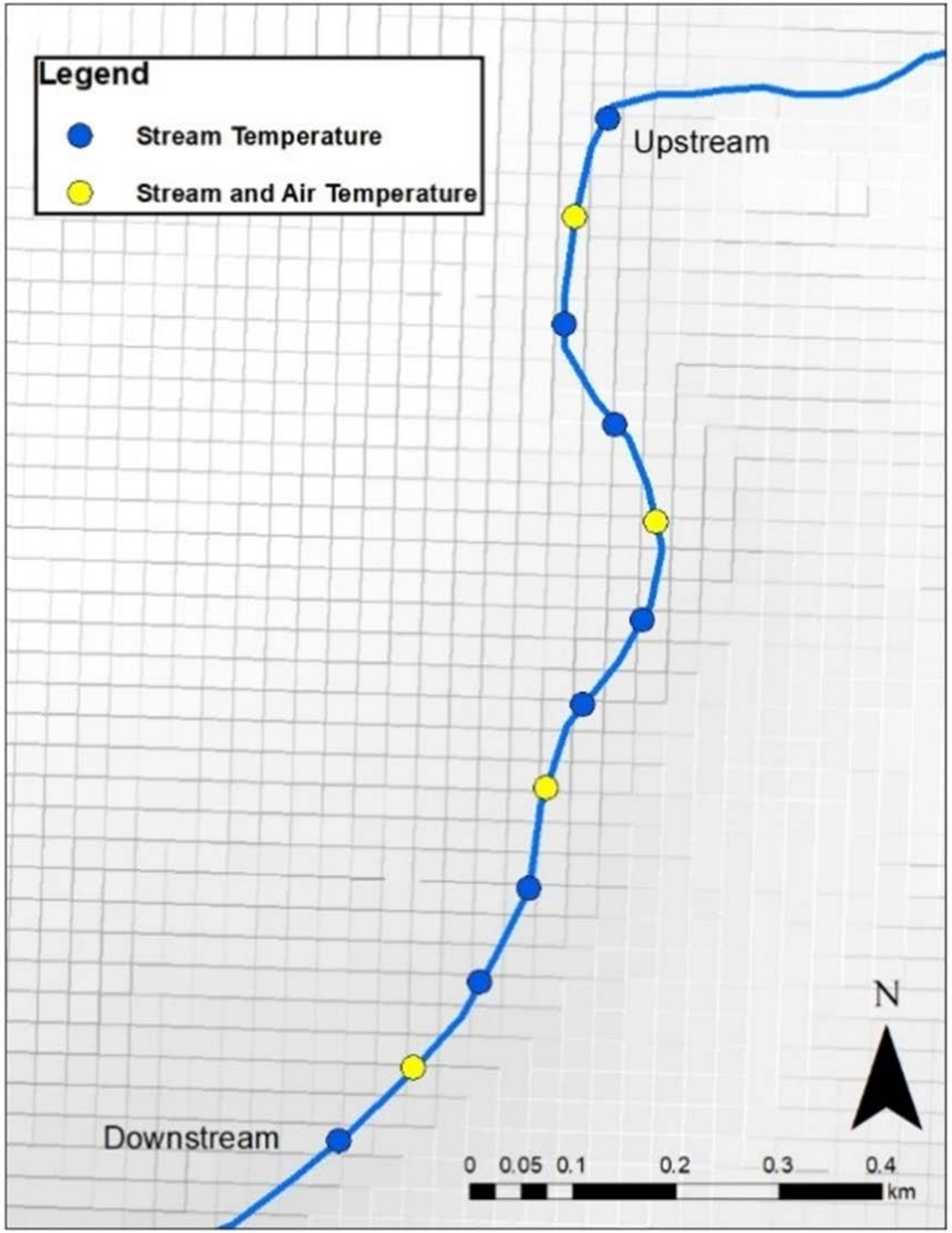


TABLE 2. Individual stream physical characteristics.

Characteristic	Cascade Range			Coast Range				
	BEA	BUL	SUG	HEN	IVE	RIC	WIL	XRA
Mean stream slope (%)[†]	19	17	24	21	23	27	19	25
Stream length (m)	880	1,078	902	418	418	550	308	770
Drainage area (km^2)[†]	1.07	3.13	0.58	0.38	0.23	0.47	0.26	0.62
Canopy cover (%)[‡]	66	54	62	92	78	88	80	87
T_s sensor spacing (m)	73	90	75	35	35	45	25	64
D_{50} (mm)[§]	60	51	46	24	13	17	16	21
Stream aspect[†]	S	S	NW	W	SE	SW	NW	SE
Elevation range (m)[†]	1,663–1,777	1,640–1,772	1,637–1,837	104–155	104–164	52–110	135–189	71–178

[†]Derived using ArcMap version 10.7 (ESRI, Redlands, CA)
[‡]Oregon State LEMMA Database (2020)
[§]From Pate et al. (2020)

1.0 km^2 = 247 acres
0.4 km^2 = 100 acres
0.6 km^2 = 150 acres

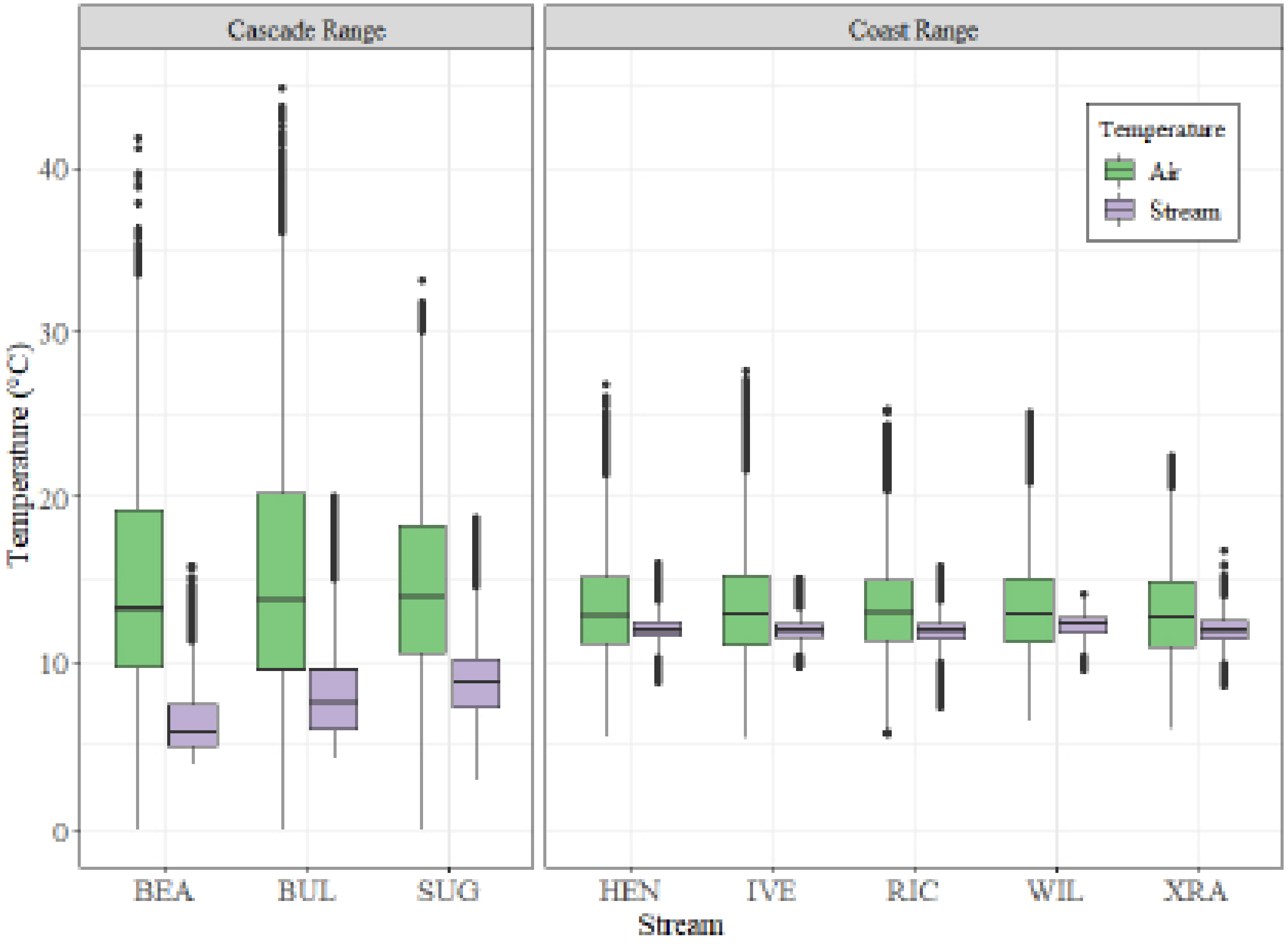
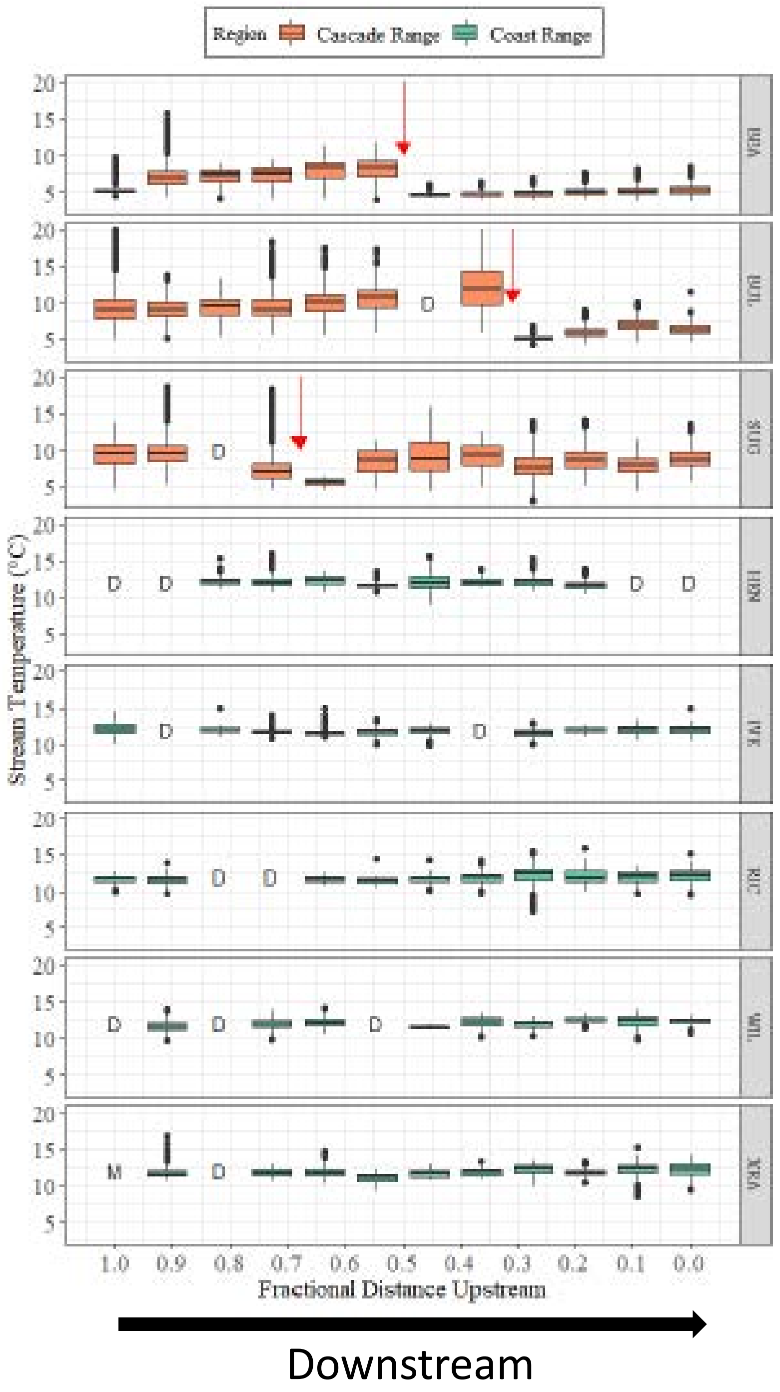


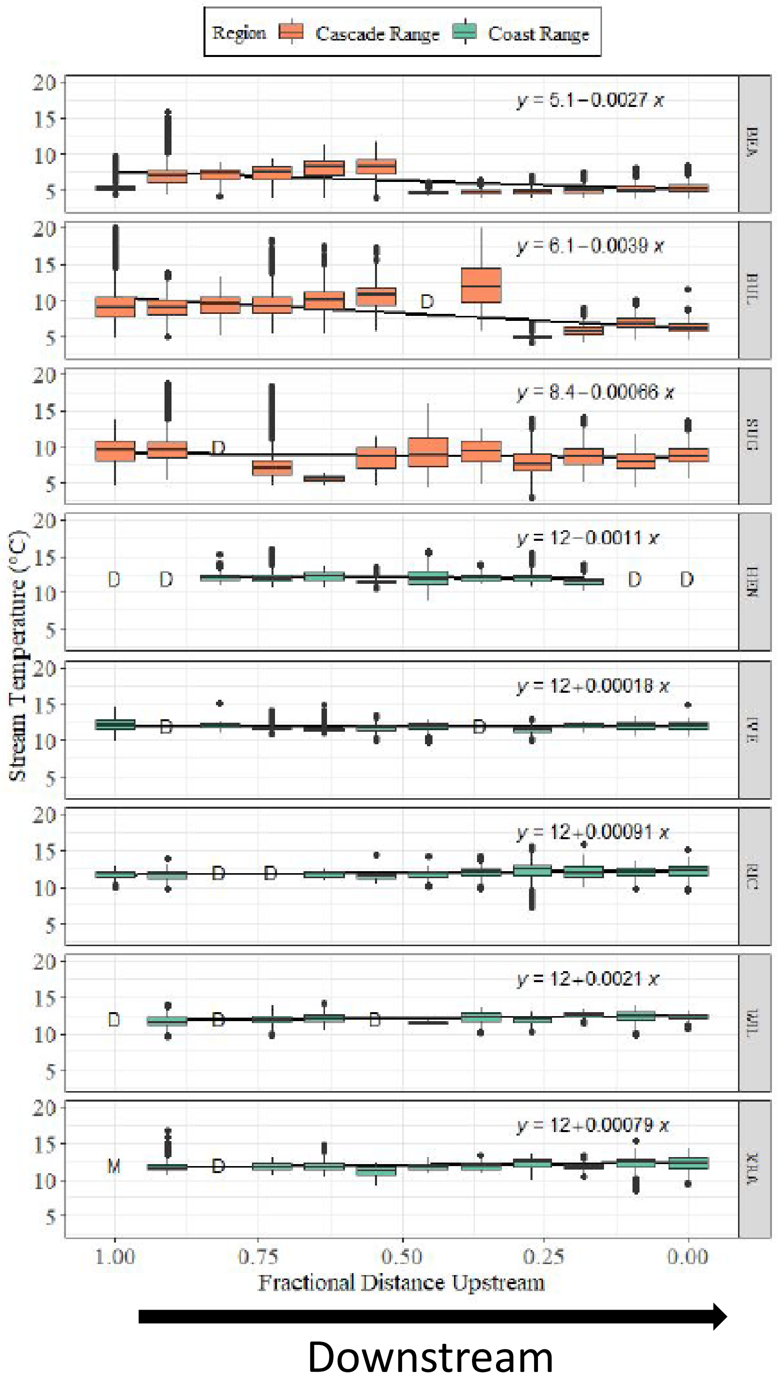
Figure 2. Comparison of air and stream temperature distributions among streams in the Coast and Cascade Ranges. Data were pooled from all temperature sensors within each stream. The boxplot central tendency line is the median, shaded boxes represent the interquartile range (IQR), whiskers represent the largest value up to 1.5-times the IQR, and the black dots indicate outliers beyond 1.5-times the IQR.

Stream and Air Temperature Statistics

Type	Region	Avg. Daily Mean (°C)	Avg. Daily SD (°C)	Avg. Daily Max (°C)	Avg. Daily Min (°C)	Avg. diel range (°C)
T_a	Cascade Range	14.73	5.48	26.22	8.49	17.73
	Coast Range	13.11	2.44	17.60	9.95	7.66
T_s	Cascade Range	7.30	0.68	8.77	6.53	2.24
	Coast Range	12.00	0.28	12.46	11.59	0.90

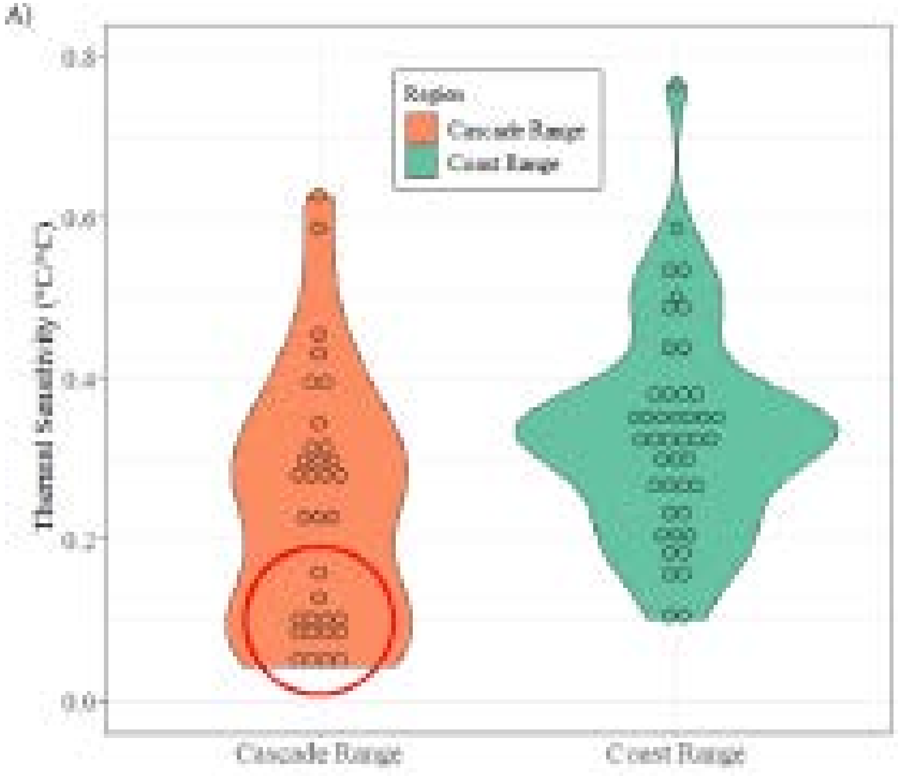


Region
Cascade Range
Coast Range
Stream Temperature (°C)
BEA
BUL
SUG
HEN
IVE
RIC
WIL
XRA
1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0
Fractional Distance Upstream
Downstream

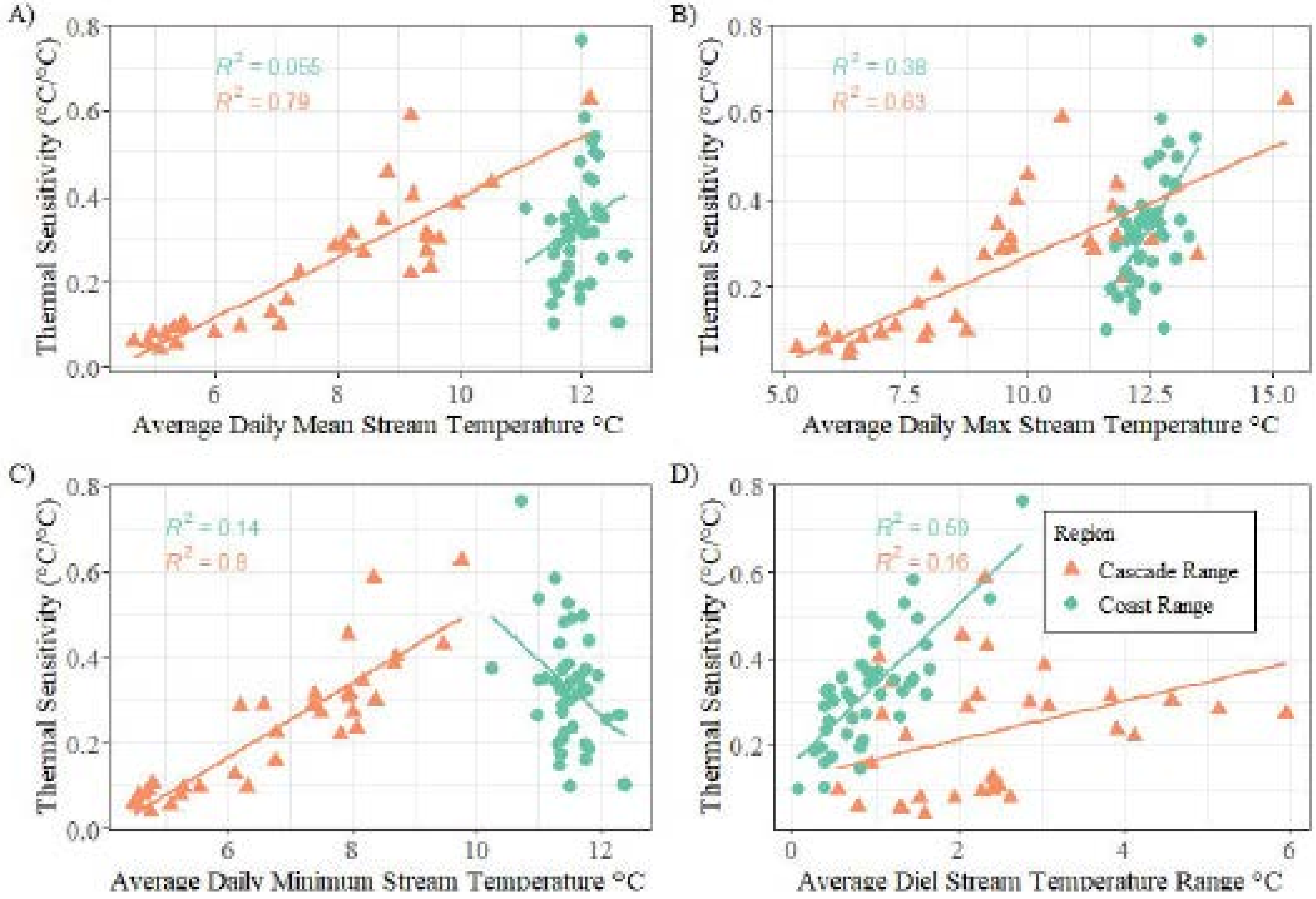


Region
Cascade Range
Coast Range
Stream Temperature (°C)
y = 5.1−0.0027 x
y = 6.1−0.0039 x
y = 8.4−0.00066 x
y = 12−0.0011 x
y = 12+0.00018 x
y = 12+0.00091 x
y = 12+0.0021 x
y = 12+0.00079 x
BEA
BUL
SUG
HEN
IVE
RIC
WIL
XRA
1.00 0.75 0.50 0.25 0.00
Fractional Distance Upstream
Downstream

Thermal Sensitivity



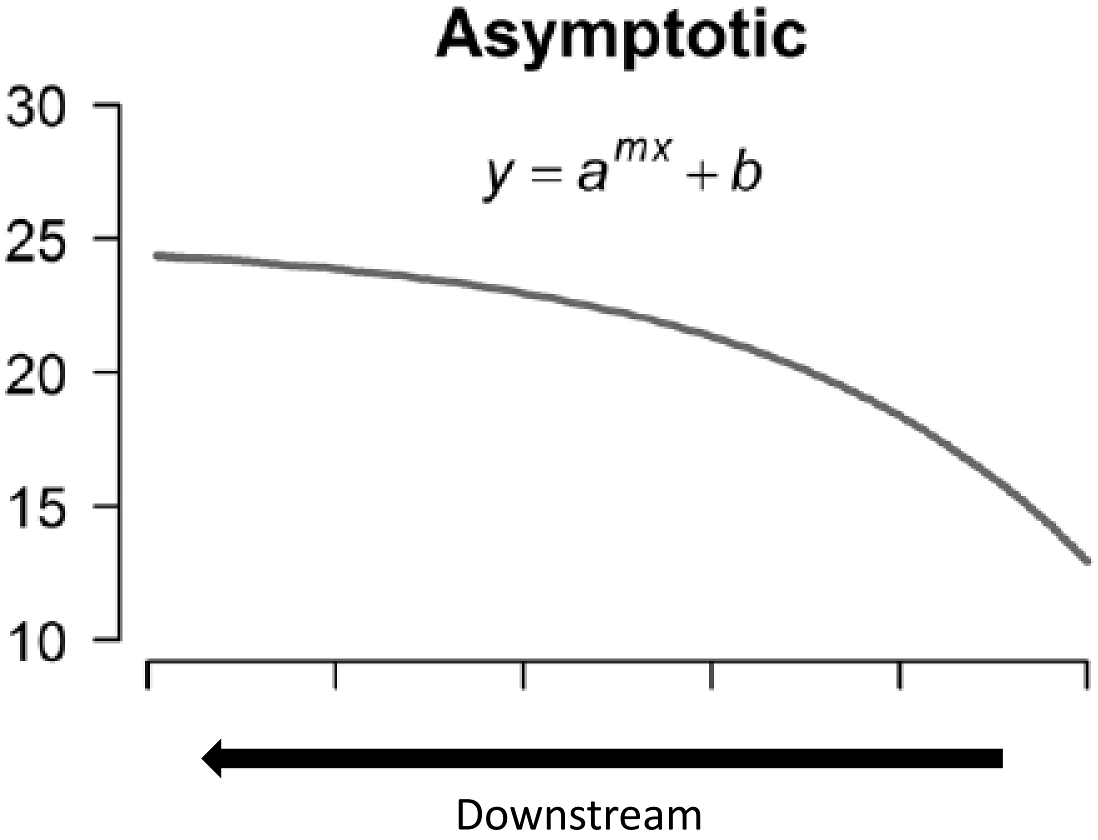
Region	Stream	# of T_s sensors	Mean R^2 (range)	Mean (°C °C^{-1})	Median (°C °C^{-1})	SD (°C °C^{-1})	Minimum (°C °C^{-1})	Max (°C °C^{-1})
Cascade Range	BEA	12	0.55 (0.11–0.85)	0.13	0.09	0.09	0.05	0.31
	BUL	11	0.64 (0.48–0.84)	0.26	0.23	0.18	0.04	0.63
	SUG	10	0.55 (0.30–0.71)	0.33	0.31	0.13	0.10	0.59
	Sub-totals	33	0.58 (0.11–0.85)	0.24	0.23	0.16	0.04	0.63
Coast Range	HEN	8	0.60 (0.44–0.93)	0.36	0.32	0.19	0.18	0.77
	IVE	10	0.60 (0.32–0.78)	0.27	0.25	0.10	0.15	0.44
	RIC	9	0.55 (0.28–0.75)	0.39	0.37	0.14	0.20	0.59
	WIL	9	0.48 (0.11–0.65)	0.28	0.33	0.11	0.10	0.37
	XRA	8	0.66 (0.35–0.78)	0.37	0.35	0.09	0.27	0.50
	Sub-totals	44	0.58 (0.11–0.93)	0.33	0.33	0.13	0.10	0.77

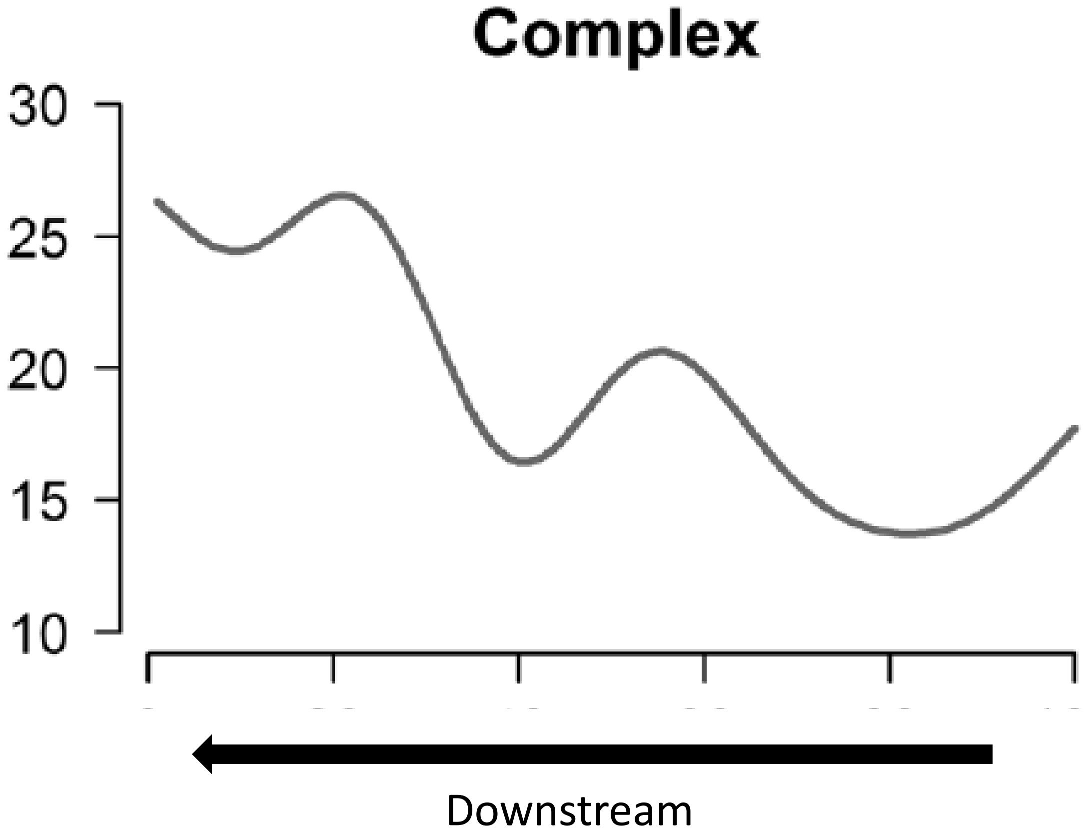

A)
B)
C)
D)
R^2 = 0.055
R^2 = 0.79
R^2 = 0.38
R^2 = 0.63
R^2 = 0.14
R^2 = 0.8
R^2 = 0.59
R^2 = 0.16
Thermal Sensitivity (°C/°C)
Average Daily Mean Stream Temperature °C
Average Daily Max Stream Temperature °C
Average Daily Minimum Stream Temperature °C
Average Diel Stream Temperature Range °C
Region
Cascade Range
Coast Range

Thermal Sensitivity Range (°C °C^{-1})	Location	Temporal Resolution	Reference
0.04–0.77	8 streams in Northern California, US	Daily	Present study
0.19–0.67	12 sites in a Pennsylvania watershed	Weekly	O'Driscoll & DeWalle, 2006
0.39–0.61	6 sites across northern latitudes of the US	Daily	Simmons et al., 2014
0.35–1.09	43 streams internationally	Daily, Weekly	Morrill et al., 2005
0.20–0.65	80 boreal streams in SW Alaska	Daily	Lisi et al., 2015
0.02–0.93	57 sites across Pennsylvania	Daily, Weekly	Kelleher et al., 2012
0.10–0.82	78 sites in Shenandoah National Park, Virginia, US	Daily	Snyder et al., 2015
0.10–0.81	74 sites in the Columbia River Basin, US	Daily, Weekly	Chang & Psaris, 2013
0.13–1.25	157 sites across US, Air Temp > 0 °C	Weekly, Monthly	Segura et al., 2015
0.20–1.14	104 sites across US PNW	Weekly	Mayer, 2012
0.02–1.09	43 sites across the Oregon Cascades	Daily	Tague et al., 2007
0.13–0.79	46 sites across Maryland, US	Daily	Hilderbrand et al., 2014
0.01–0.58	43 coastal streams in SW Alaska	Daily	Winfree et al., 2018
0.49–1.08	61 sites across the Southeast US	Monthly	Caldwell et al., 2015

Ranged from small to large in drainage area

What Should Our Assumptions for Class IIs Be in ASP?





Study Validates Concepts in 14 CCR § 916.9 [936.9, 956.9] (v)

(v) Site-specific measures or nonstandard operational provisions

(1) In consideration of the spatial variability of the forest landscape, the RPF may propose site-specific measures or nonstandard operational provisions in place of any of the provisions contained in this section. Site specific plans may be submitted when, in the judgment of the RPF, such measures or provisions offer a more effective or more feasible way of achieving the goals and objectives set forth in 14 CCR § 916.9 [936.9, 956.9], subsections (a) and (c), and would result in effects to the beneficial functions of the Riparian zone equal to or more favorable than those expected to result from the application of the operational provisions required under 14 CCR § 916.9 [936.9, 956.9].

“Option V” is not widely used