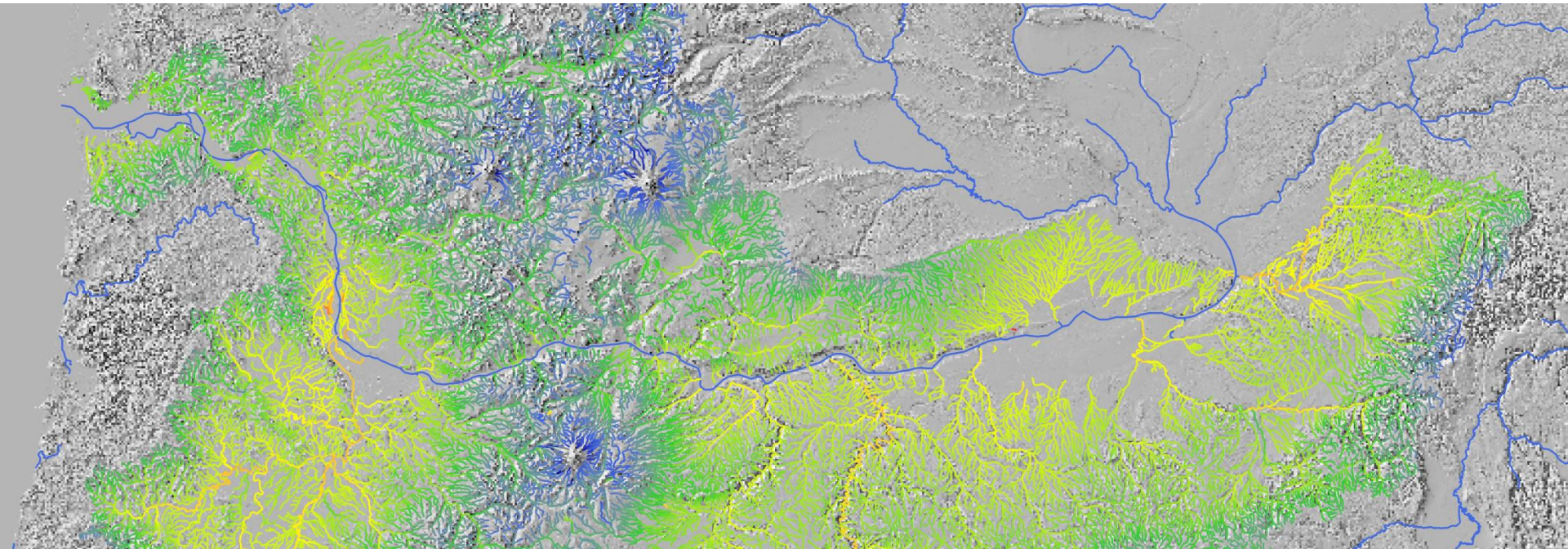


NorWeST and Columbia River tributary riparian shade restoration

SSN Workshop 2019

Session 2

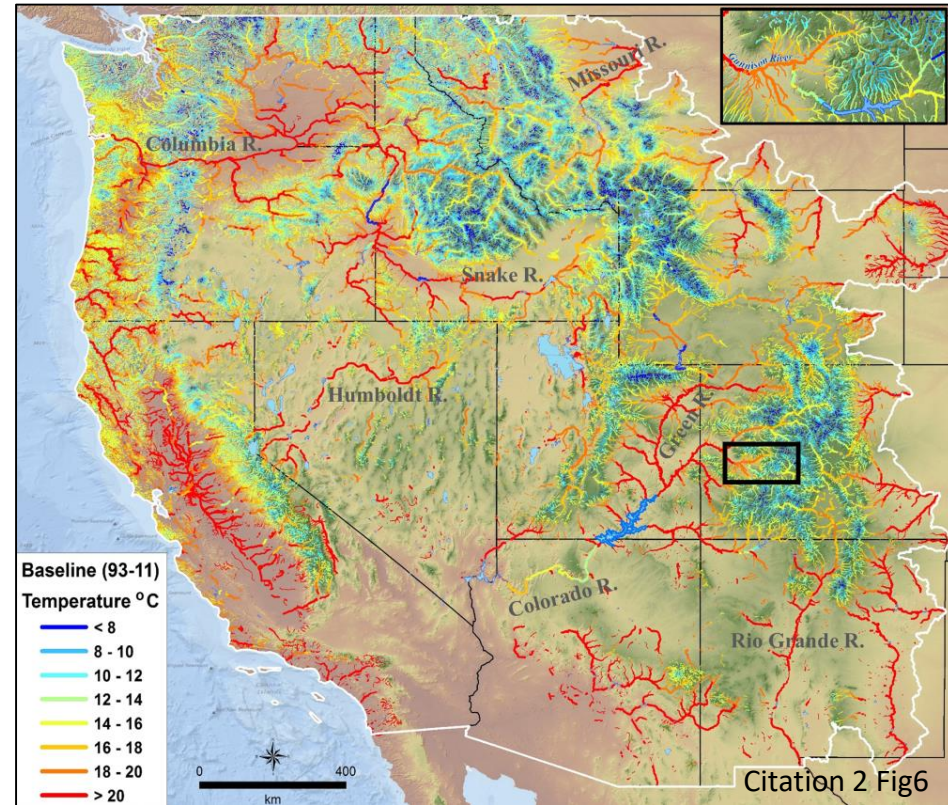


Overview

1. What is the NorWeST SSN temperature model?
2. How can it be applied to new projects?
3. Present riparian shade restoration case study.

1. NorWeST SSN Temp Model¹

- Western CONUS
- Mean August stream temperature
- 12 covariates
 - Elevation
 - Canopy
 - Slope
 - Precipitation
 - Drainage Area
 - Latitude
 - Below a Dam
 - Glacier Presence
 - Baseflow Index
 - Lake Presence
 - August Air Temp
 - August Discharge



¹ Isaak et al. 2017 WRR

1. NorWeST SSN Temp Model¹

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From: NorWeST Website

¹ Isaak et al. 2017 WRR

2. NorWeST Application: Products

~ 40 prediction scenarios

- Historical ranges or individual years
- Future decades under varying climate predictions

Table 1. Description of NorWeST historic and future stream temperature climate scenarios.

Scenario	Description
S1_93_11	Historical composite scenario representing 19 year average August mean stream temperatures for 1993-2011
S2_02_11	Historical composite scenario representing 10 year average August mean stream temperatures for 2002-2011
S3_1993	Historical scenario representing August mean stream temperatures for 1993

2. NorWeST Application: Products

Additional time periods June, July, Sept, and MWMT

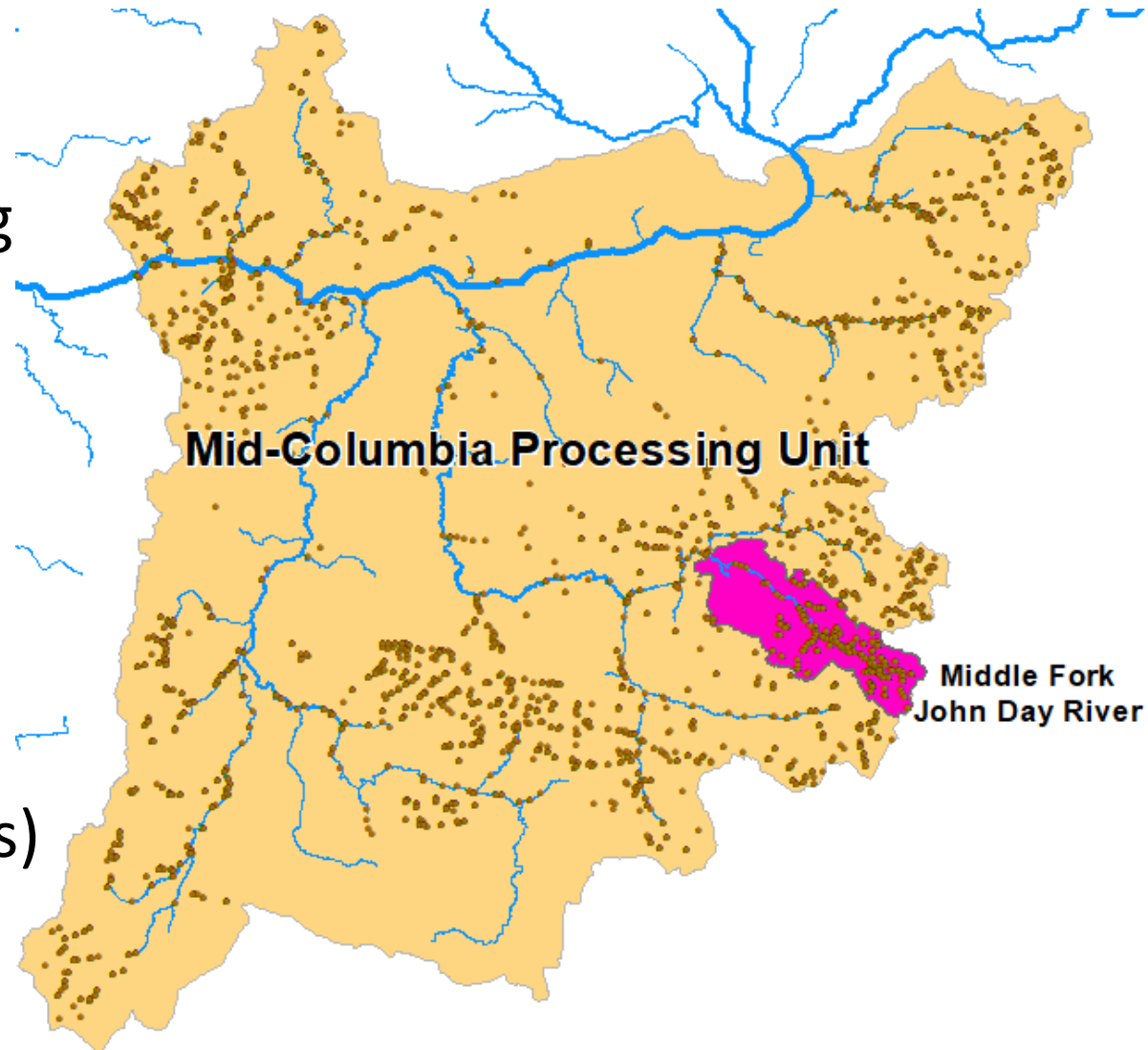
NorWeST Processing Units



2. NorWeST Application: Manipulate

Refit to focal area
within a processing
unit

Tailors model to
temperature data
specifically within
study basin
(pros & cons to this)



2. NorWeST Application: Manipulate

Adjust/Alternate/Additional covariates

NorWeST

Elevation

Canopy Cover

Reach slope

Precipitation

Drainage Area

Tailwater

Prop. Glacier

Base flow Index

Prop. Lake

Air Temp

discharge

Latitude

2. NorWeST Application: Manipulate

Adjust/Alternate/Additional covariates

NorWeST	Adjust
Elevation	Elevation
Canopy Cover	Canopy Cover
Reach slope	Reach slope
Precipitation	Precipitation
Drainage Area	Drainage Area
Tailwater	Tailwater
Prop. Glacier	Prop. Glacier
Base flow Index	Base flow Index
Prop. Lake	Prop. Lake
Air Temp	Air Temp
discharge	discharge
Latitude	Latitude

2. NorWeST Application: Manipulate

Adjust/Alternate/Additional covariates

NorWeST	Adjust	Alternate
Elevation	Elevation	Elevation
Canopy Cover	Canopy Cover	Canopy Cover
Reach slope	Reach slope	Reach slope
Precipitation	Precipitation	Precipitation
Drainage Area	Drainage Area	Drainage Area
Tailwater	Tailwater	Tailwater
Prop. Glacier	Prop. Glacier	Prop. Glacier
Base flow Index	Base flow Index	Cold H ₂ O springs
Prop. Lake	Prop. Lake	Prop. Lake
Air Temp	Air Temp	Air Temp
discharge	discharge	discharge
Latitude	Latitude	Latitude

2. NorWeST Application: Manipulate

Adjust/Alternate/Additional covariates

NorWeST	Adjust	Alternate	Additional
Elevation	Elevation	Elevation	Elevation
Canopy Cover	Canopy Cover	Canopy Cover	Canopy Cover
Reach slope	Reach slope	Reach slope	Reach slope
Precipitation	Precipitation	Precipitation	Precipitation
Drainage Area	Drainage Area	Drainage Area	Drainage Area
Tailwater	Tailwater	Tailwater	Tailwater
Prop. Glacier	Prop. Glacier	Prop. Glacier	Prop. Glacier
Base flow Index	Base flow Index	Cold H ₂ O springs	Base flow Index
Prop. Lake	Prop. Lake	Prop. Lake	Prop. Lake
Air Temp	Air Temp	Air Temp	Air Temp
discharge	discharge	discharge	discharge
Latitude	Latitude	Latitude	Latitude
			Groundwater use

2. NorWeST Application: Manipulate

Adjust/Alternate/Additional covariates

NorWeST	Adjust	Alternate	Additional	Combination
Elevation	Elevation	Elevation	Elevation	Elevation
Canopy Cover	Canopy Cover	Canopy Cover	Canopy Cover	Canopy Cover
Reach slope	Reach slope	Reach slope	Reach slope	Reach slope
Precipitation	Precipitation	Precipitation	Precipitation	Precipitation
Drainage Area	Drainage Area	Drainage Area	Drainage Area	Drainage Area
Tailwater	Tailwater	Tailwater	Tailwater	Tailwater
Prop. Glacier	Prop. Glacier	Prop. Glacier	Prop. Glacier	Prop. Glacier
Base flow Index	Base flow Index	Cold H ₂ O springs	Base flow Index	Cold H ₂ O springs
Prop. Lake	Prop. Lake	Prop. Lake	Prop. Lake	Prop. Lake
Air Temp	Air Temp	Air Temp	Air Temp	Air Temp
discharge	discharge	discharge	discharge	discharge
Latitude	Latitude	Latitude	Latitude	Latitude
			Groundwater use	Groundwater use

3. Case Study: Region 10 RARE Project Goals

Investigate Pacific Salmon habitat availability

- Current temperature status?
- Restoration potential?
- Future climate?

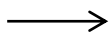


NorWeST Application

NorWeST Covariates

Elevation

Canopy



Riparian
shade levels

Slope

Precipitation

Drainage Area

Latitude

Below a Dam

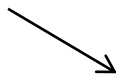
Glacier Presence

Baseflow Index

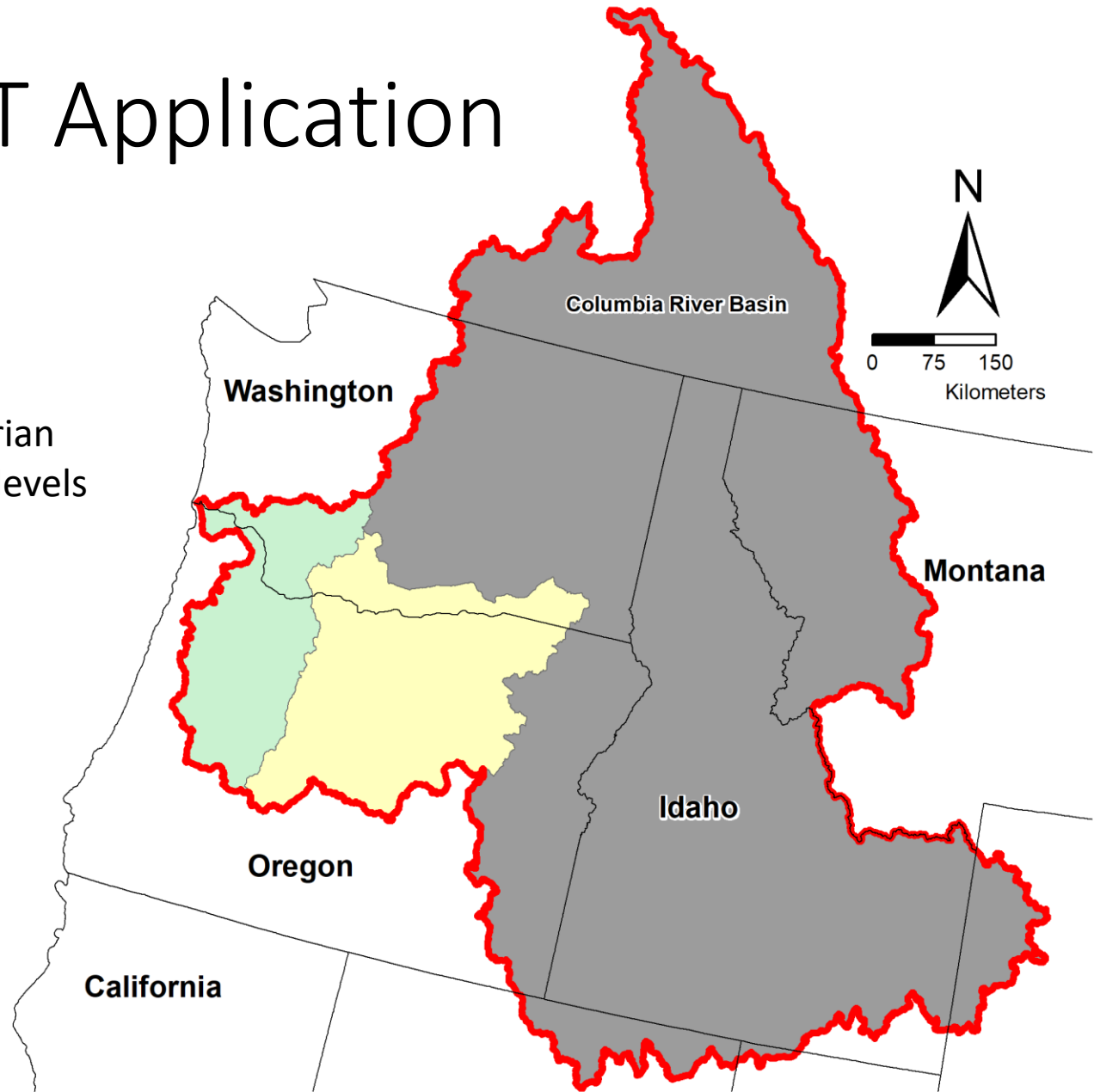
Lake Presence

August Air Temp

August Discharge



Climate
levels



Project goals

NorWeST	Elevation	Below a Dam
	Canopy	Glacier Presence
	Slope	Baseflow Index
	Precipitation	Lake Presence
	Drainage Area	August Air Temp
	Latitude	August Discharge

- Two factors affecting stream temperature:

CLIMATE ¹	Model Scenarios
	Present
	2040
	2080

¹ Isaak et al. 2017 WRR, ² data from Peter Leinenbach, US EPA

Project goals

NorWeST	Elevation	Below a Dam
	Canopy	Glacier Presence
	Slope	Baseflow Index
	Precipitation	Lake Presence
	Drainage Area	August Air Temp
	Latitude	August Discharge

- Two factors affecting stream temperature:

		RIPARIAN VEG. SHADE ²		
Model Scenarios		Topographic (no veg.)	Current Vegetation	Restored Vegetation
CLIMATE ¹	Present			
	2040			
	2080			

¹ Isaak et al. 2017 WRR, ² data from Peter Leinenbach, US EPA

Project goals

NorWeST	Elevation	Below a Dam
	Canopy	Glacier Presence
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- Two factors affecting stream temperature:

		RIPARIAN VEG. SHADE ²		
Model Scenarios		Topographic (no veg.)	Current Vegetation	Restored Vegetation
CLIMATE ¹	Present	Present/Topo.	Present/Cur.	Present/Res.
	2040	2040/Topo.	2040/Cur.	2040/Res.
	2080	2080/Topo.	2080/Cur.	2080/Res.

¹ Isaak et al. 2017 WRR, ² data from Peter Leinenbach, US EPA

Project goals

NorWeST	Elevation	Below a Dam
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Model Scenarios		Topographic (no veg.)	Current Vegetation	Restored Vegetation
CLIMATE ¹	Present	Present/Top.	Present/Cur.	Present/Res.
	2040	2040/Top.	2040/Cur.	2040/Res.
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CLIMATE ¹	Present	Present/Top.	Present/Cur.	Present/Res.
	2040	2040/Top.	2040/Cur.	2040/Res.
	2080	2080/Top.	2080/Cur.	2080/Res.

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CLIMATE ¹	Present	Present/Top.	Present/Cur.	Present/Res.
	2040	2040/Top.	2040/Cur.	2040/Res.
	2080	2080/Top.	2080/Cur.	2080/Res.

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Project goals

NorWeST	Elevation	Below a Dam
	Canopy	Glacier Presence
	Slope	Baseflow Index
	Precipitation	Lake Presence
	Drainage Area	August Air Temp
	Latitude	August Discharge

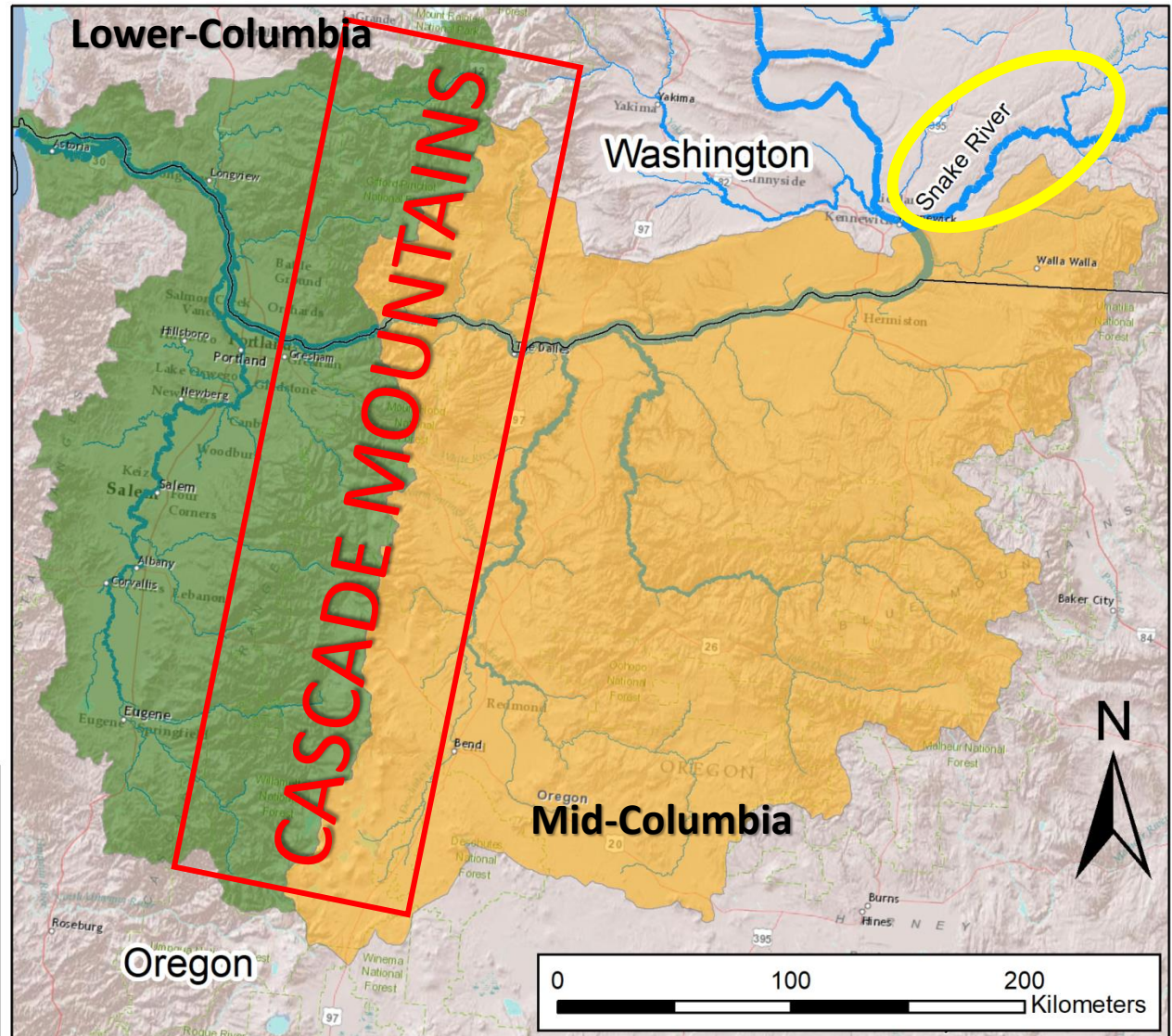
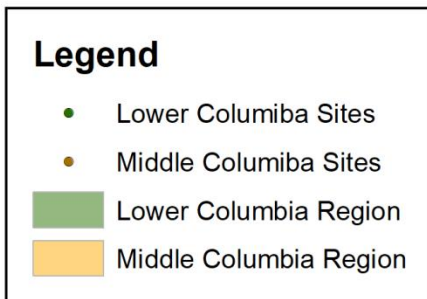
- Two factors affecting stream temperature:

		RIPARIAN VEG. SHADE ²		
Model Scenarios		Topographic (no veg.)	Current Vegetation	Restored Vegetation
CLIMATE ¹	Present	Present/Topo.	Present/Cur.	Present/Res.
	2040	2040/Topo.	2040/Cur.	2040/Res.
	2080	2080/Topo.	2080/Cur.	2080/Res.

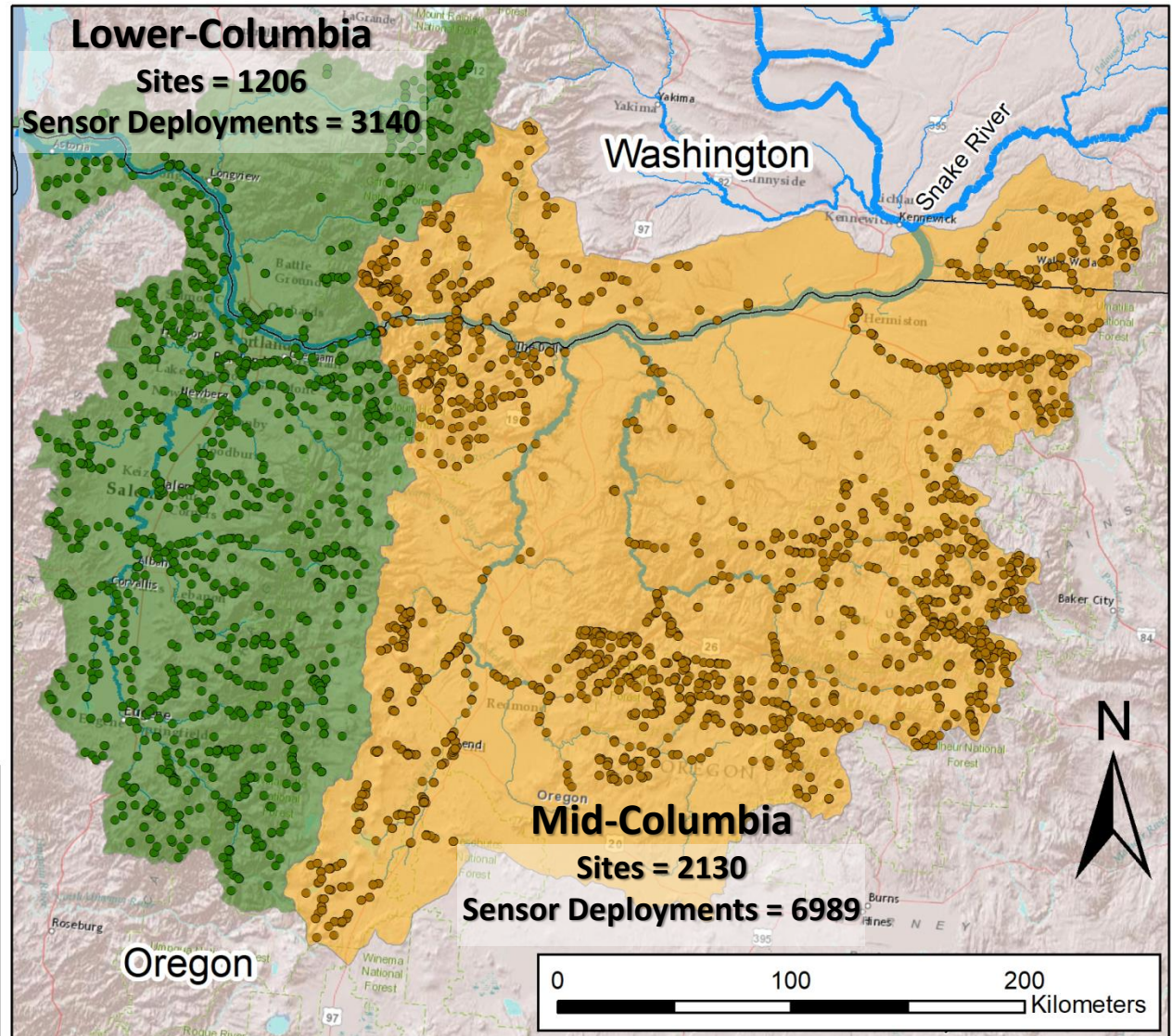
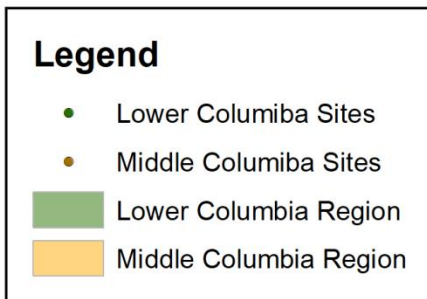
Mean August
stream temperatures

¹ Isaak et al. 2017 WRR, ² data from Peter Leinenbach, US EPA

The Study Region

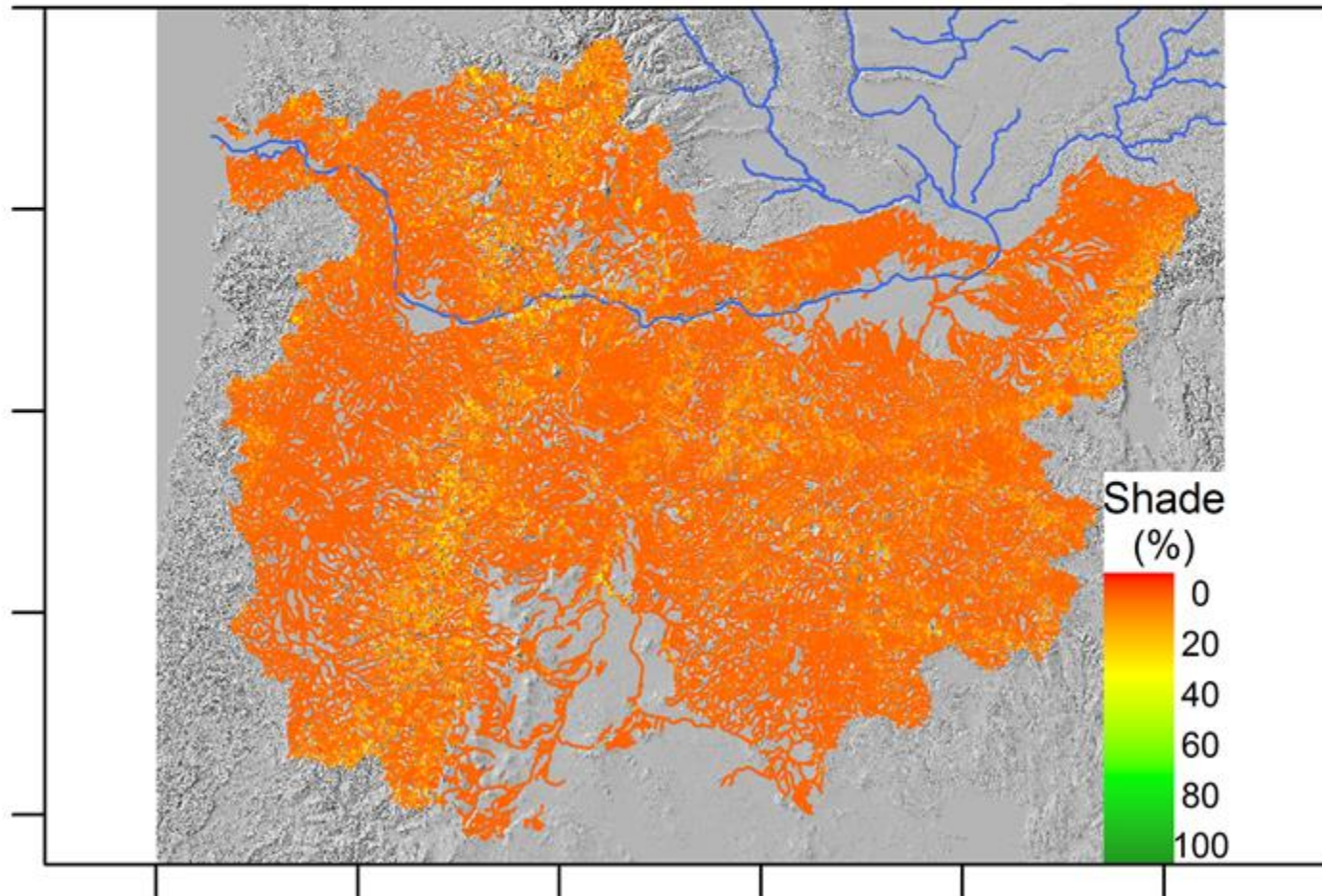


The Study Region



Shade Maps:

Topographic (no veg.)

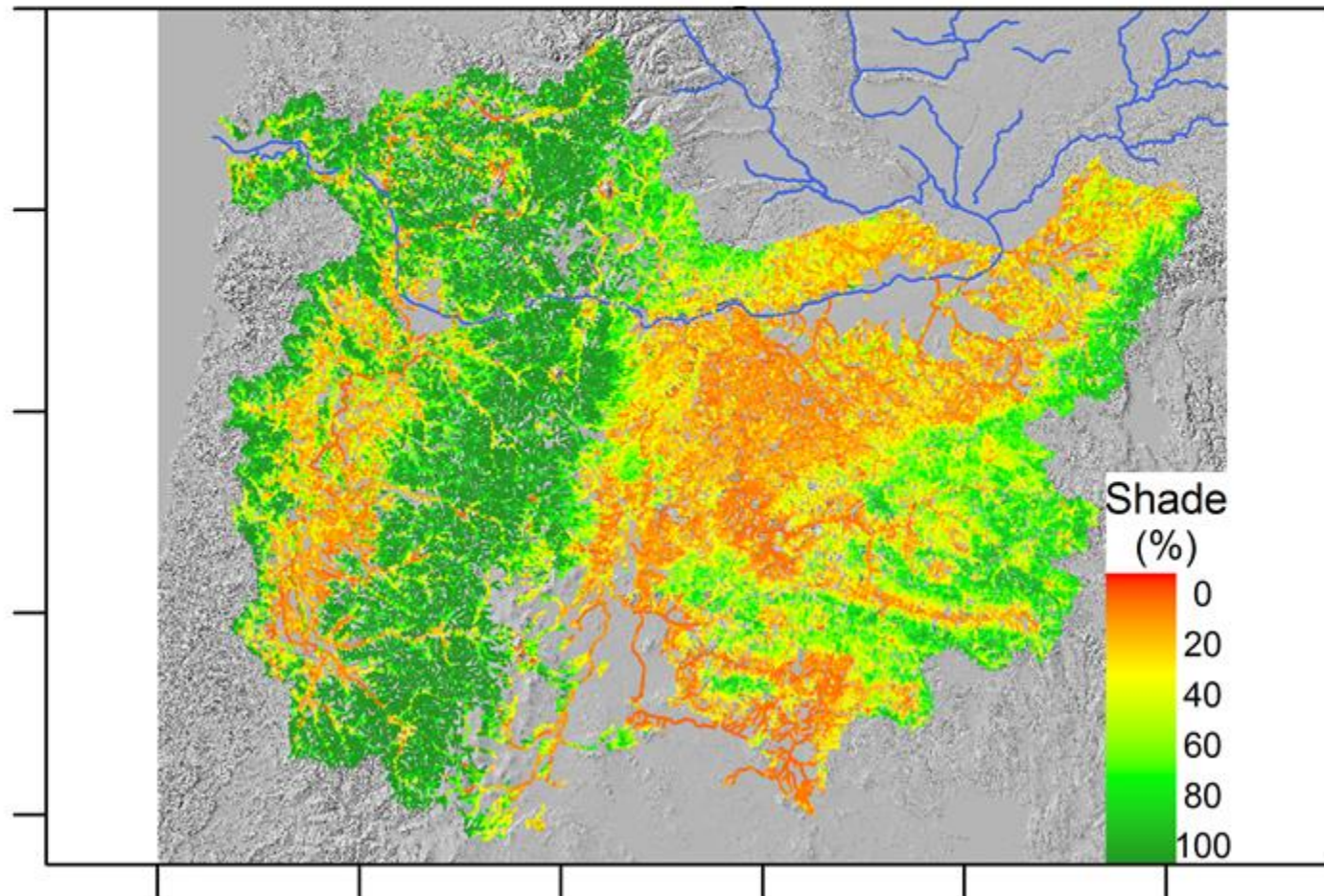


	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040 /Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Shade Maps:

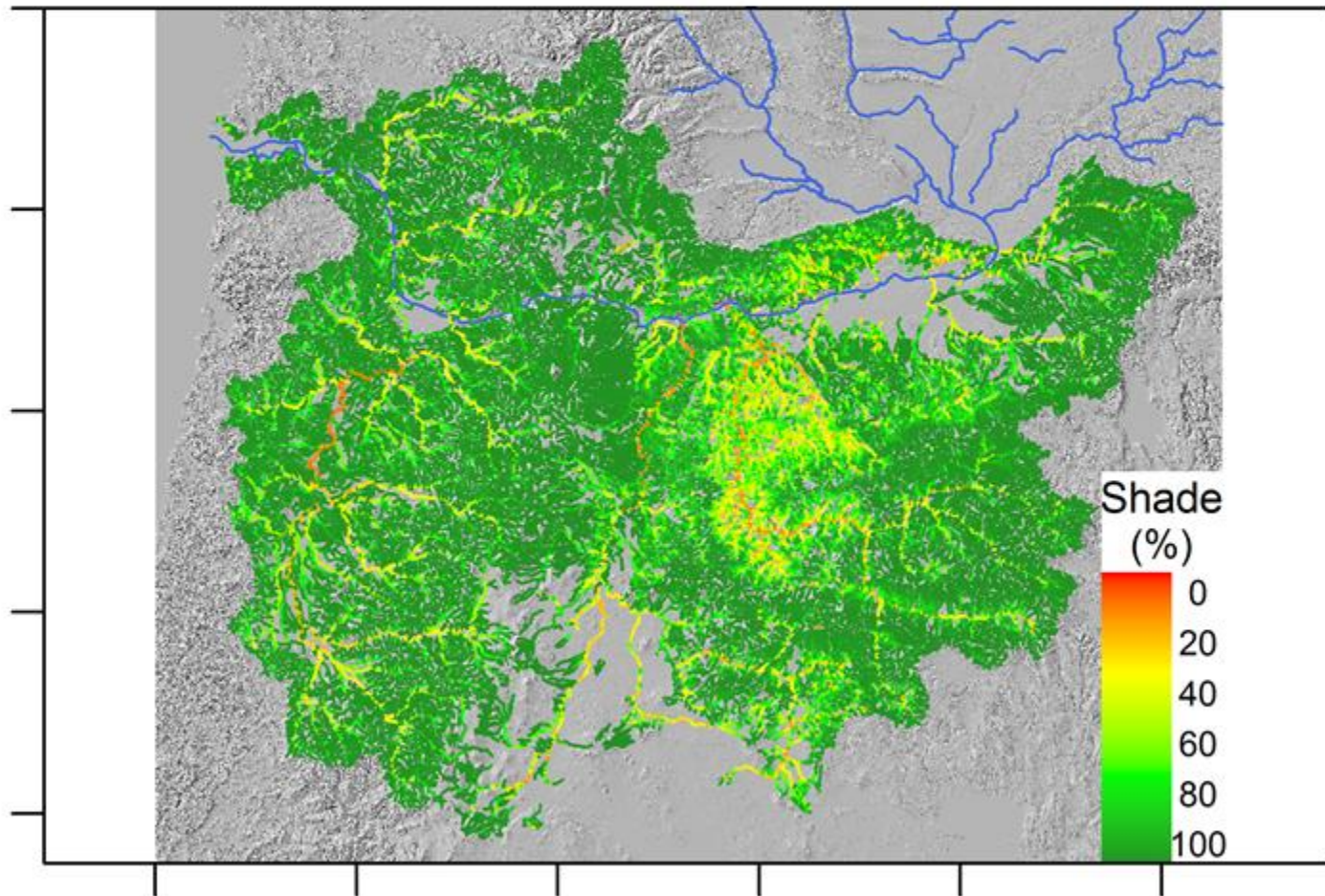
	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040 /Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Current Vegetation



Shade Maps:

Restored Vegetation

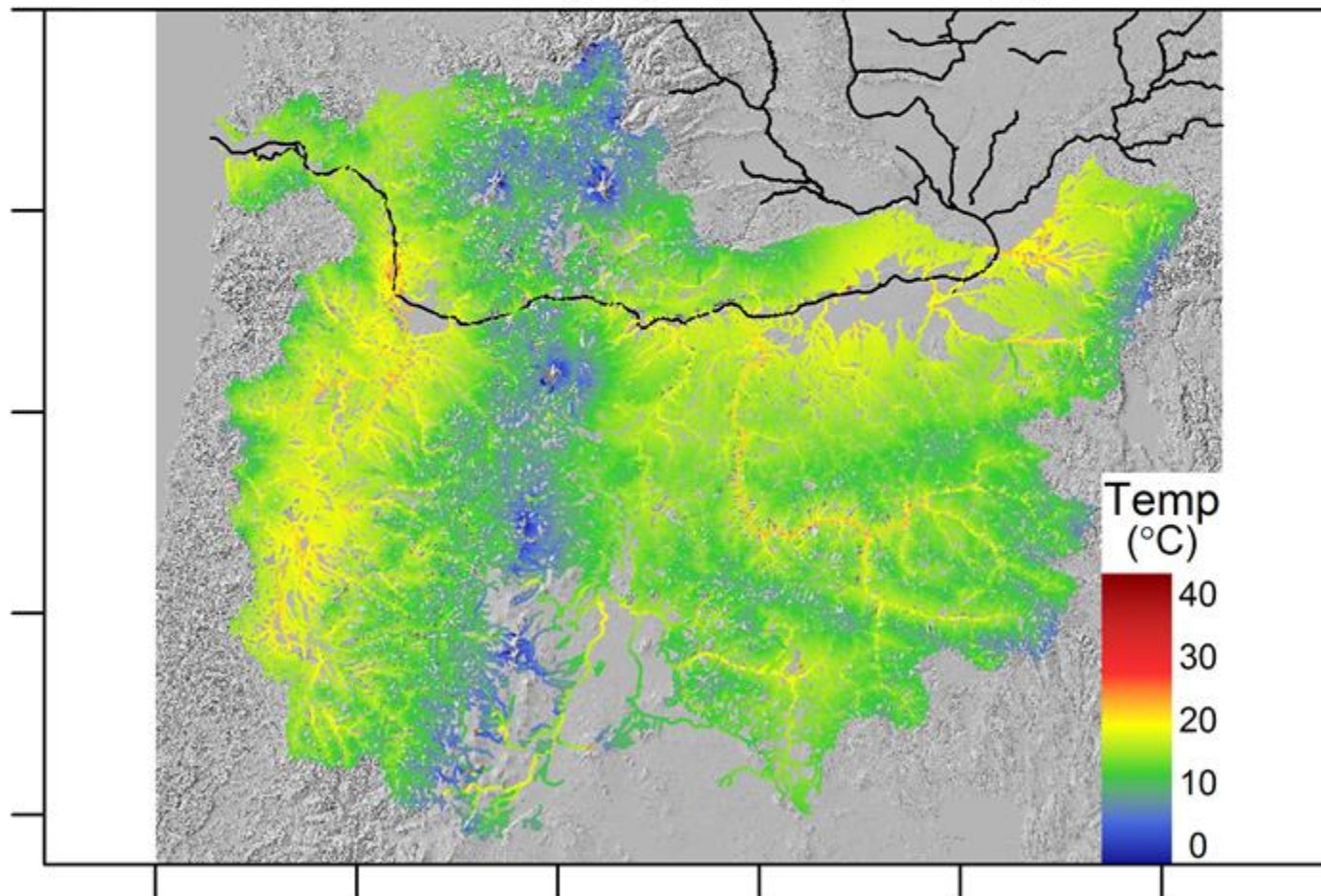


	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040 /Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Temp Change by Shade

How does altering riparian shade affect stream temperature?

Present Climate: Topographic (no veg.)

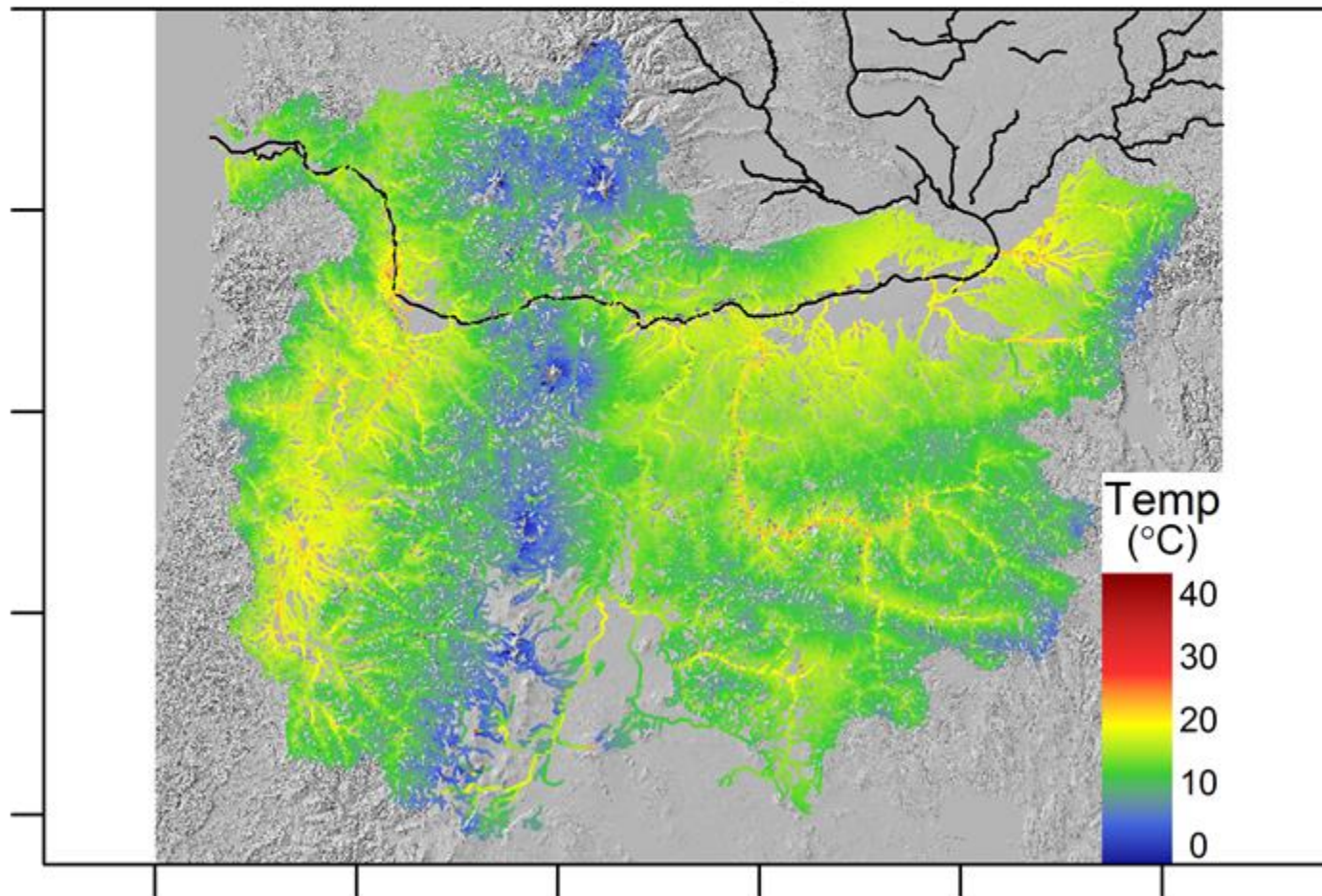


	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040 /Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Temp Change by Shade

How does altering riparian shade affect stream temperature?

Present Climate: Current Vegetation

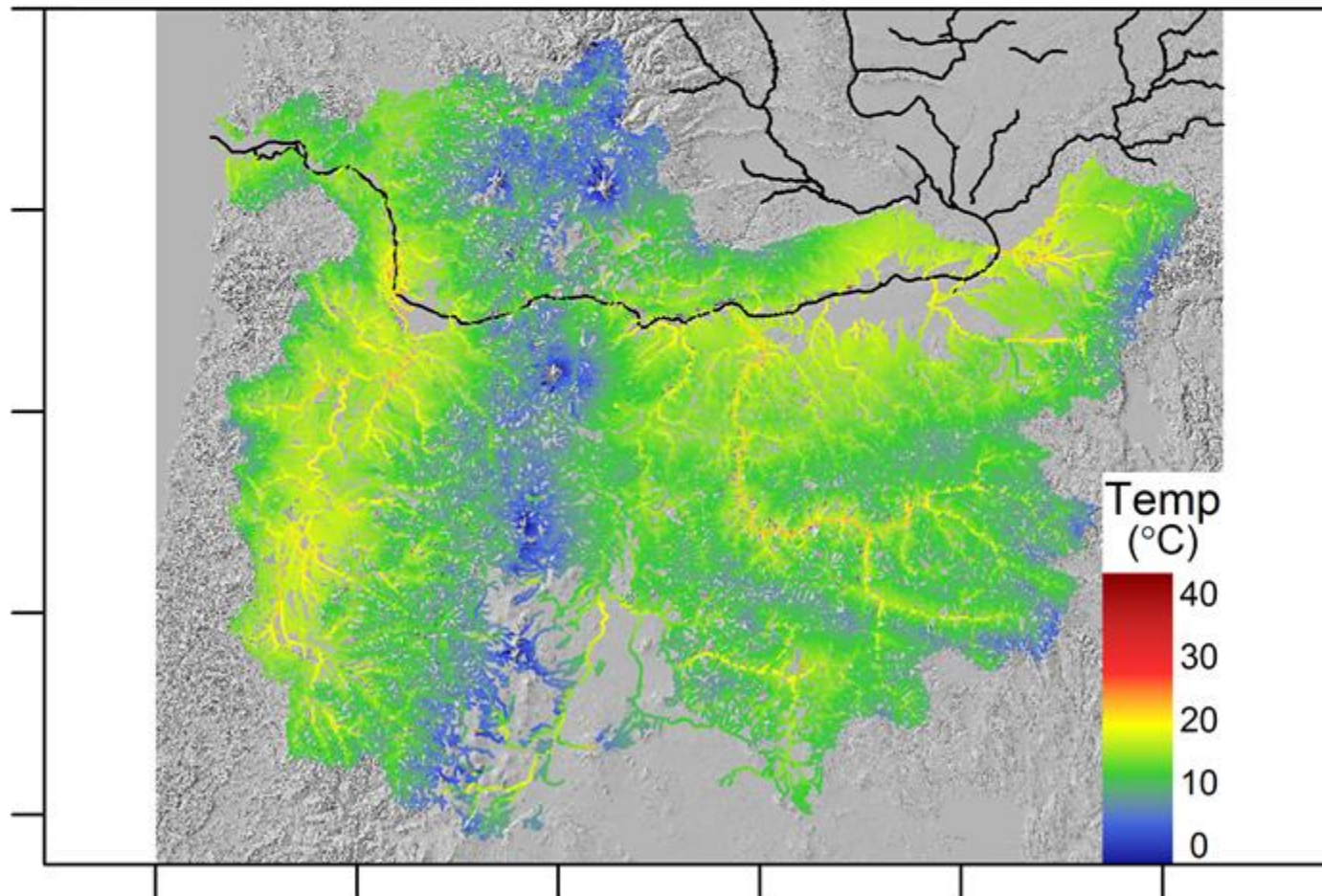


	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040/ Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Temp Change by Shade

How does altering riparian shade affect stream temperature?

Present Climate: Restored Vegetation



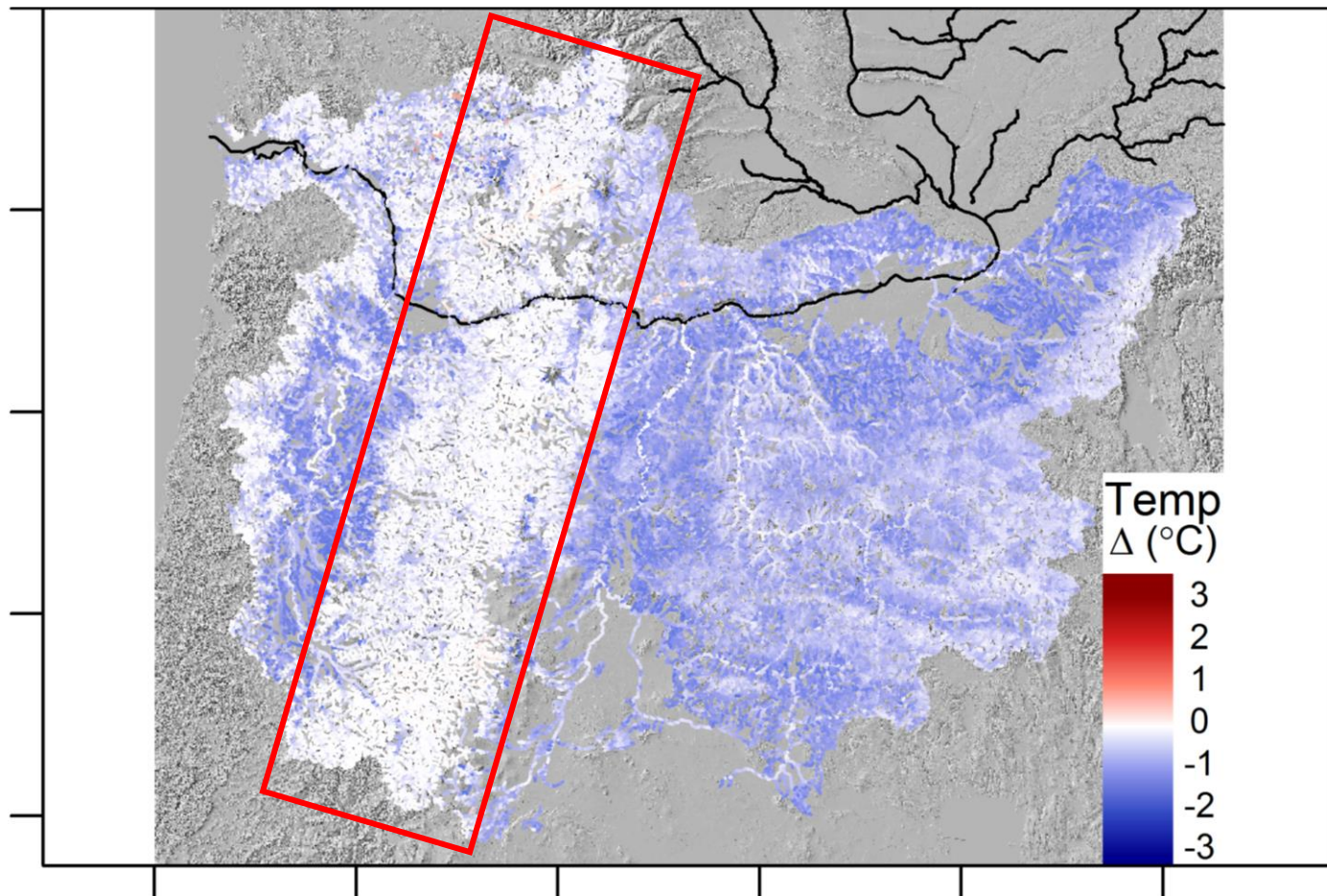
	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040 /Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Temperature Differences

Where does adding vegetation decrease stream temperature?

Difference between now and Present Restored shade

	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040 /Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

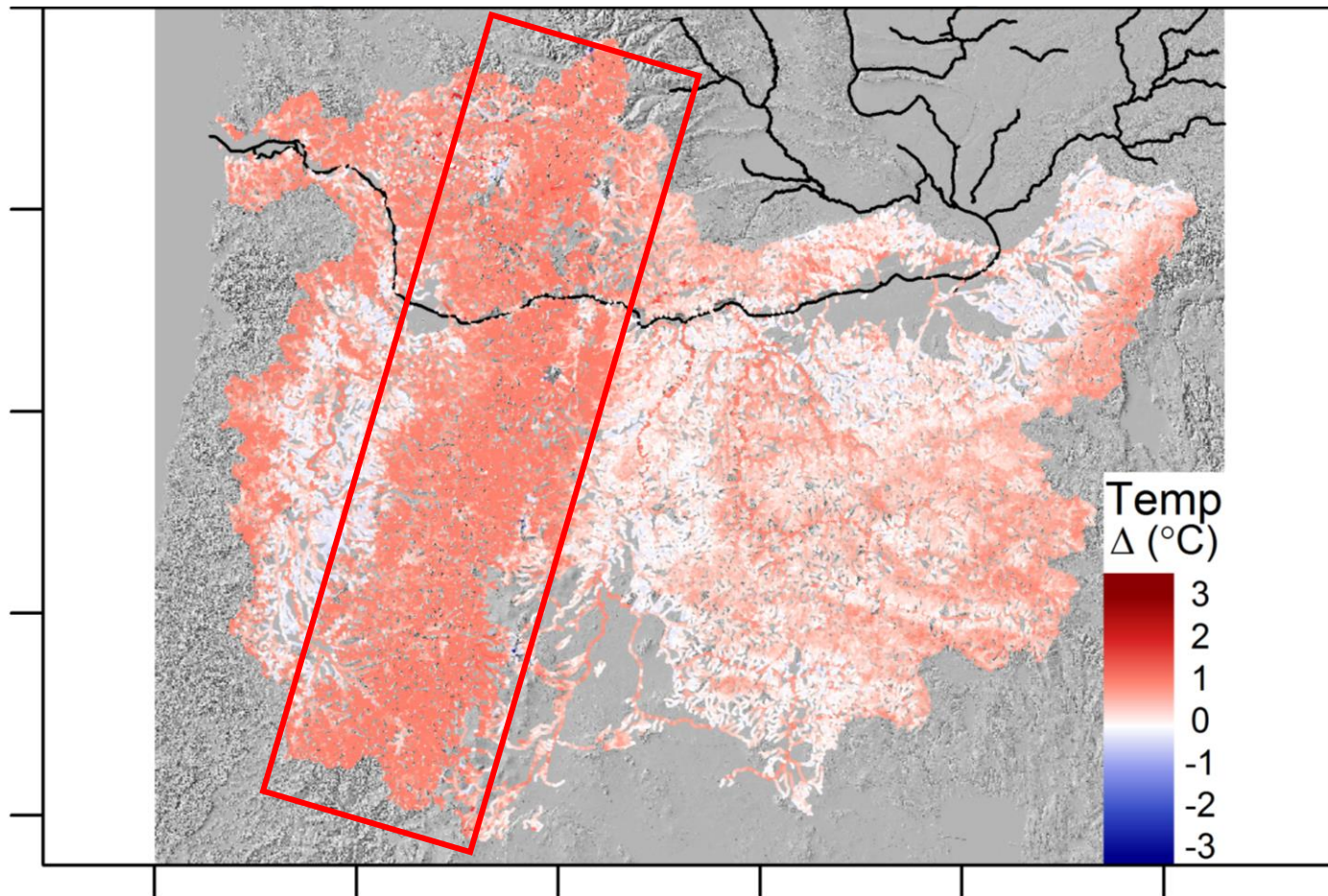


Temperature Differences

Where does adding vegetation decrease stream temperature?

	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040 /Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Difference between now and 2040 Restored shade

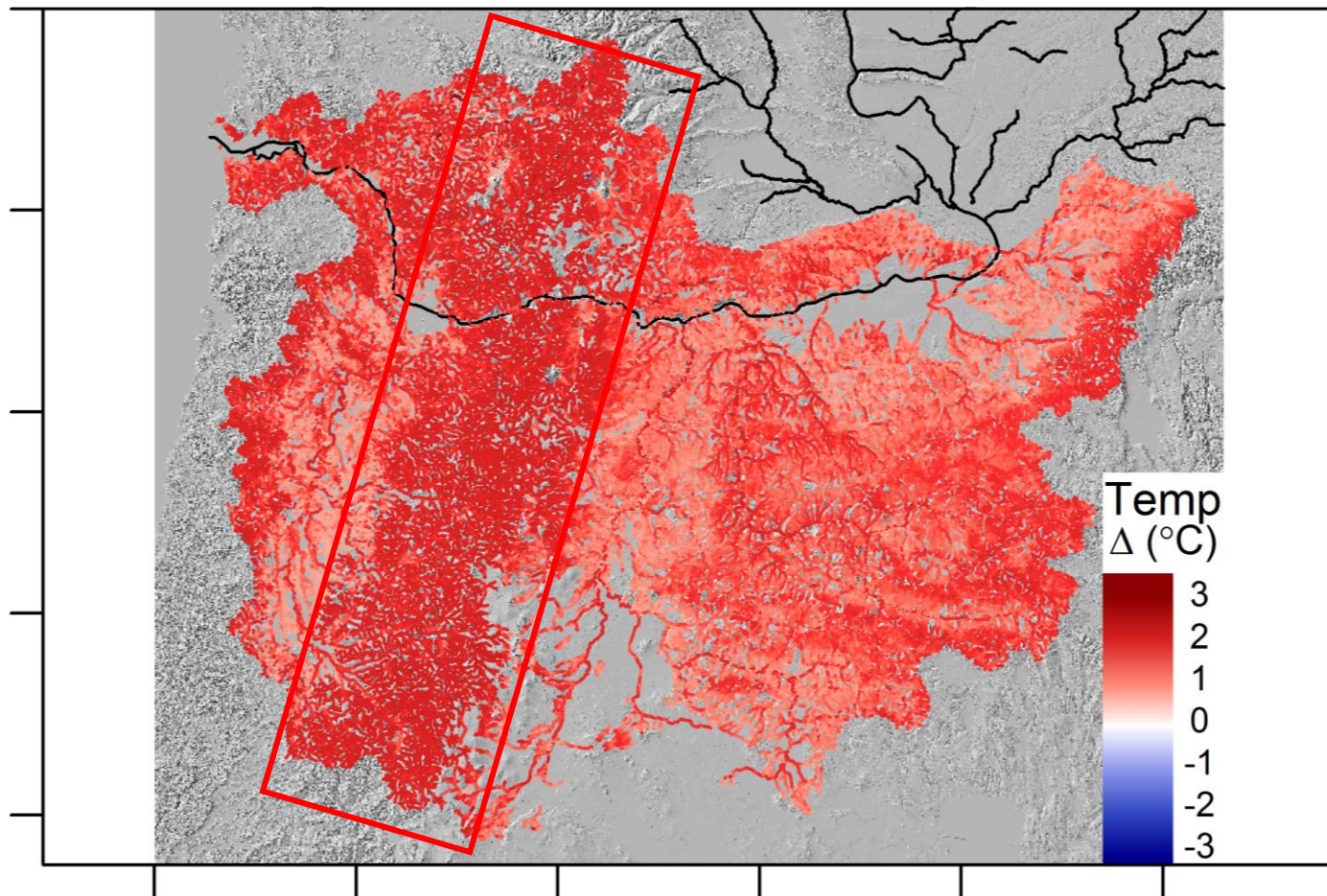


Temperature Differences

Where does adding vegetation decrease stream temperature?

	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040 /Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Difference between now and 2080 Restored shade



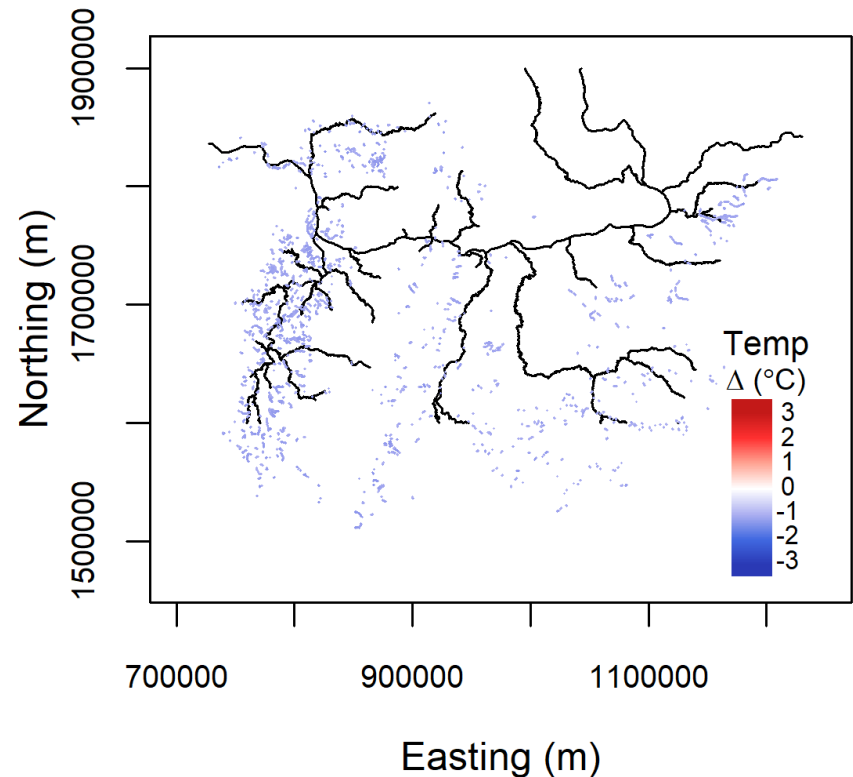
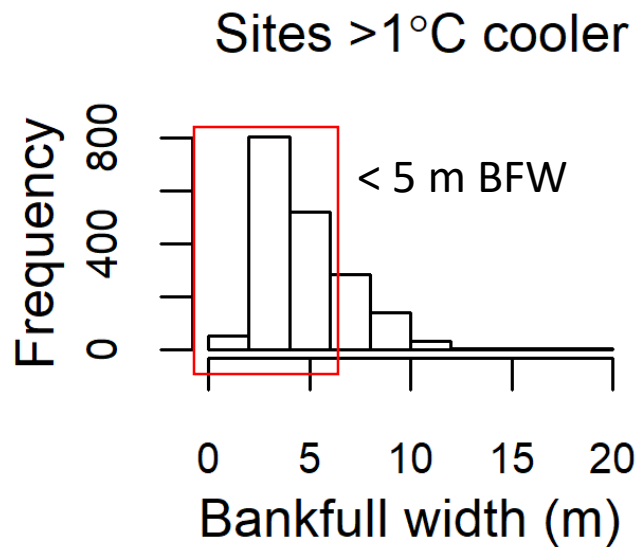
	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040/ Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Best restoration sites?

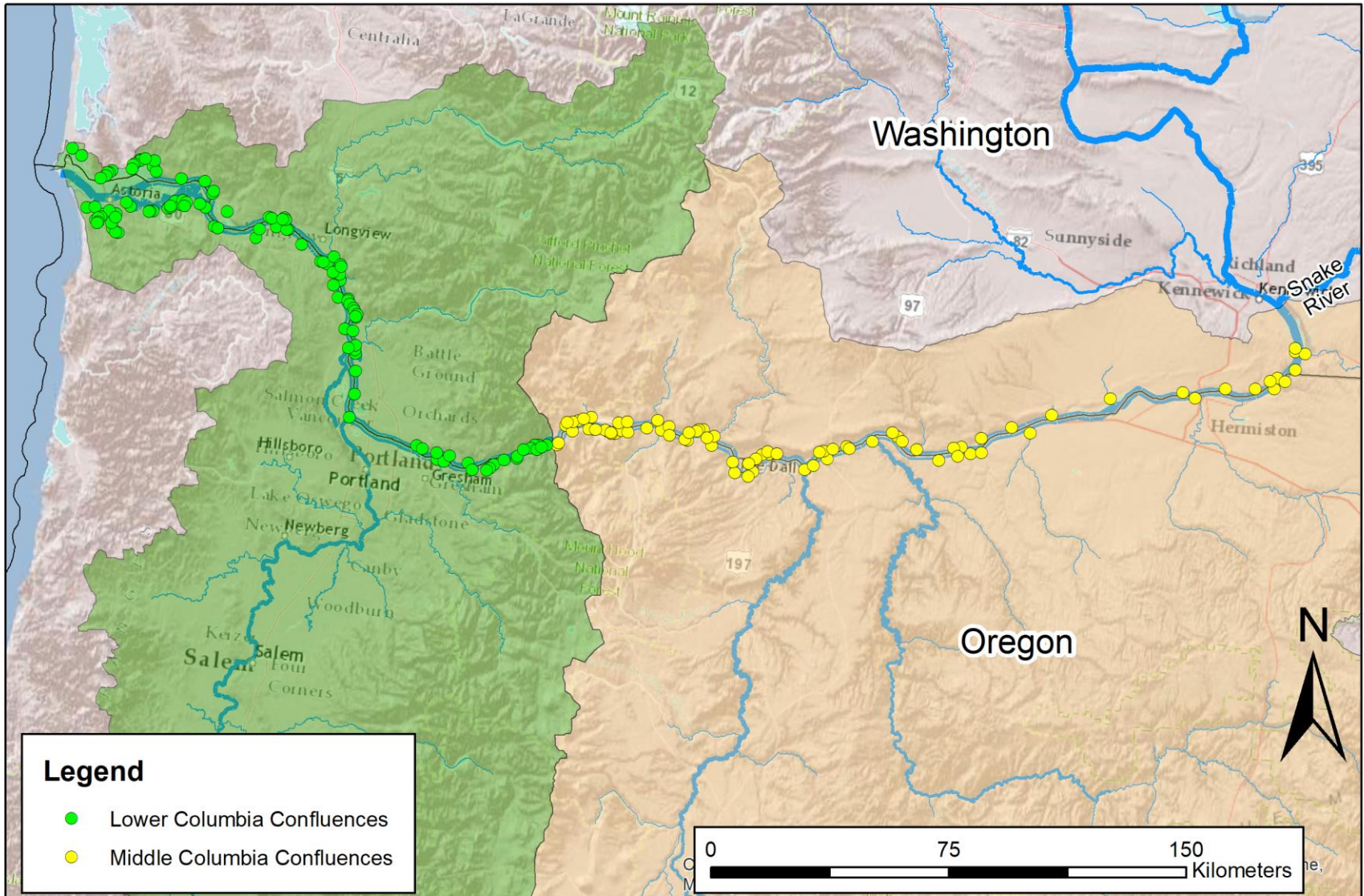
What size stream benefits most from riparian shade restoration?

- Bank full width for reaches w/ $> 1^{\circ}\text{C}$ temp. decrease

Reaches $> 1^{\circ}\text{C}$ cooler



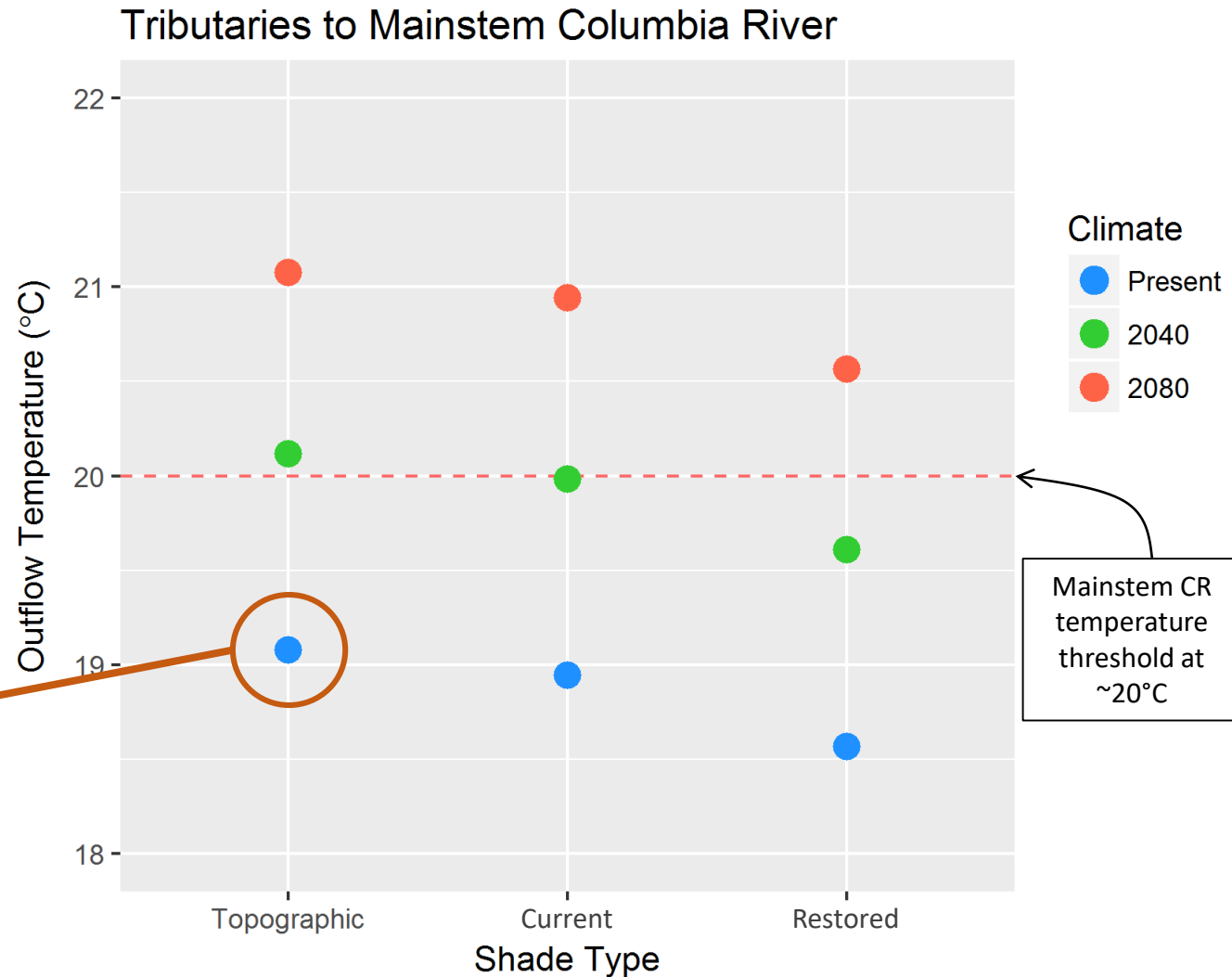
Tributary outflows



Cold Water Refugia: Mainstem CR

- 198 tributaries to mainstem Columbia Riv.
- Flow weighted mean tributary temperature

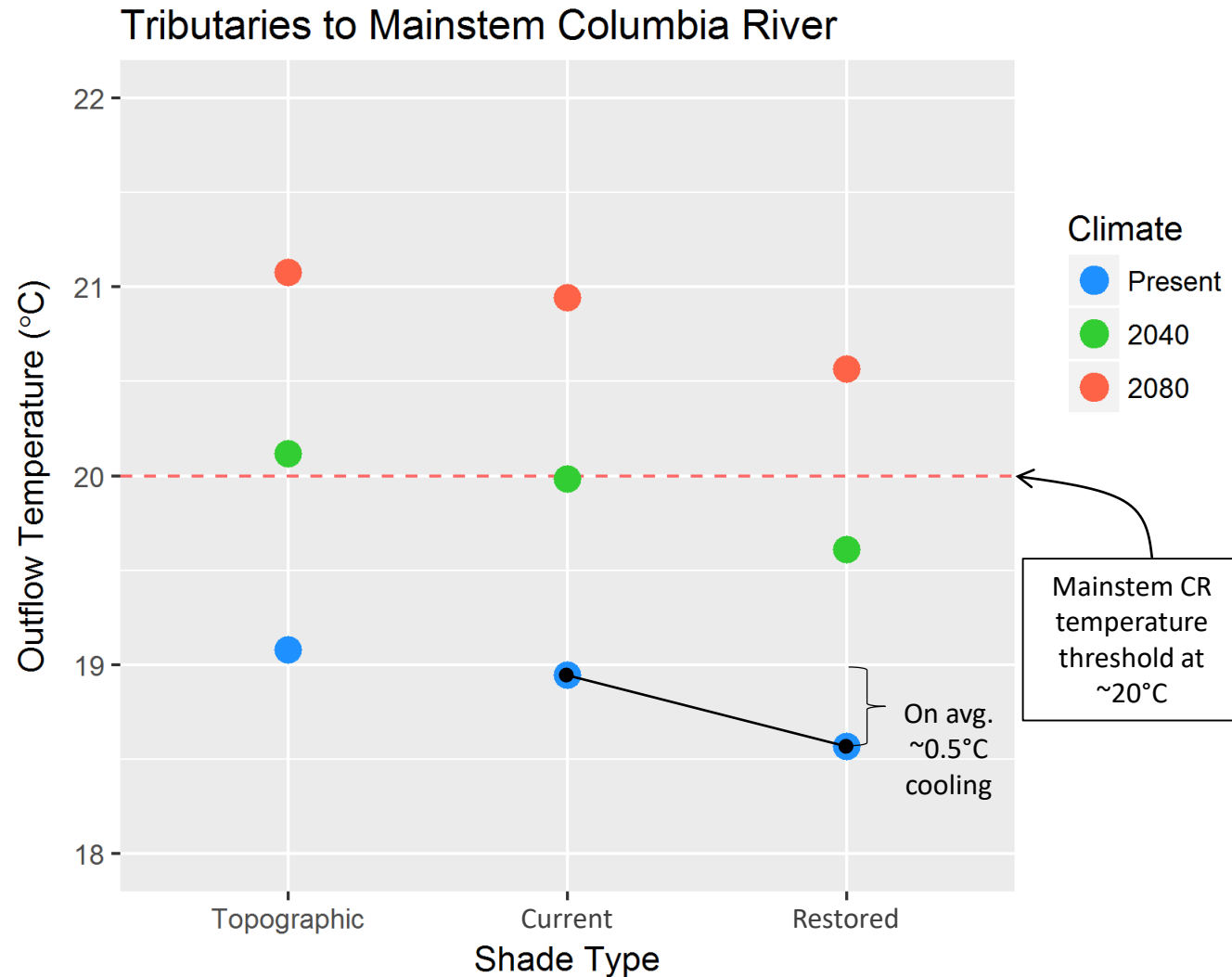
	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040/ Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.



Cold Water Refugia: Mainstem CR

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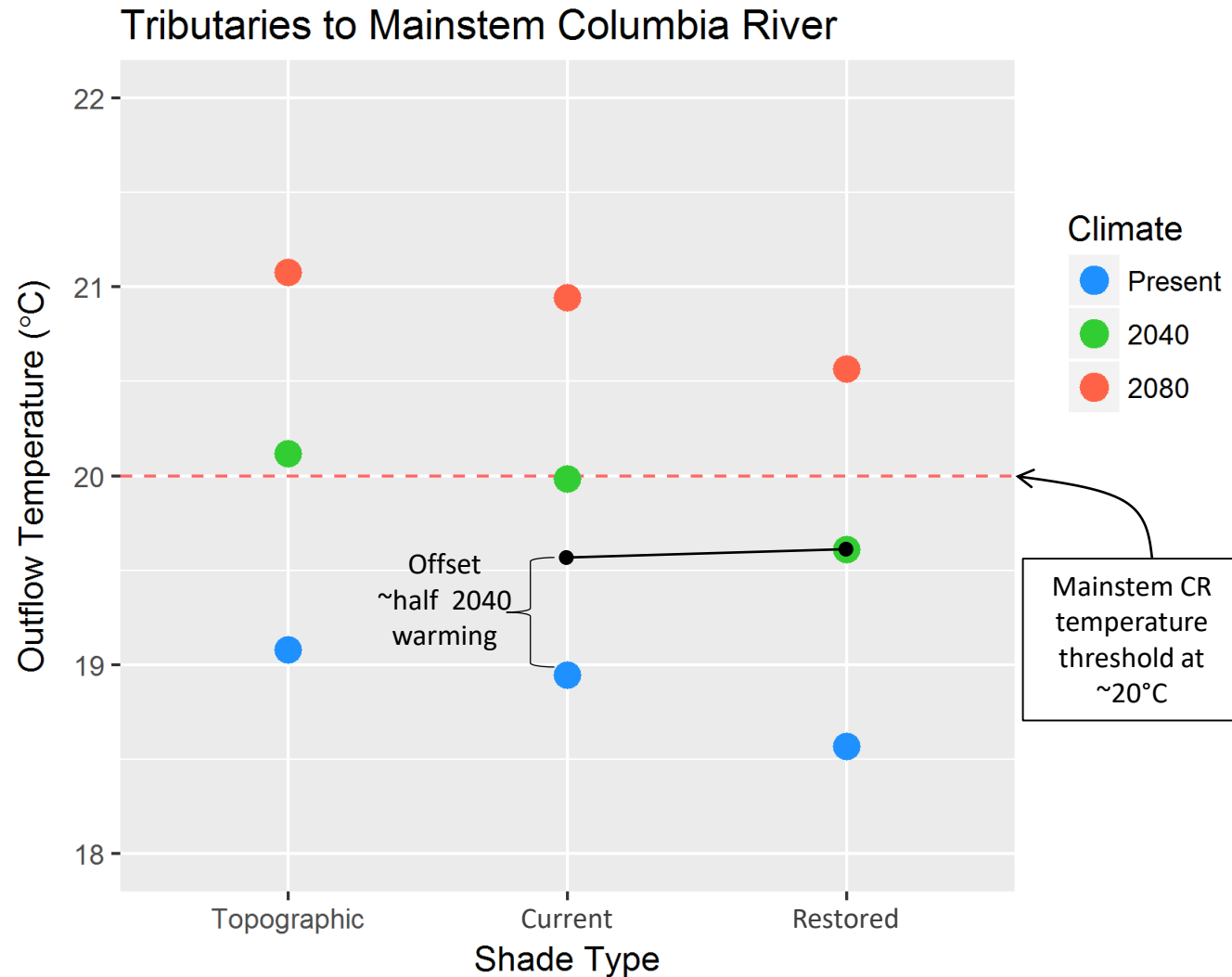
	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040/ Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.



Cold Water Refugia: Mainstem CR

- 198 tributaries to mainstem Columbia Riv.
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	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040/ Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

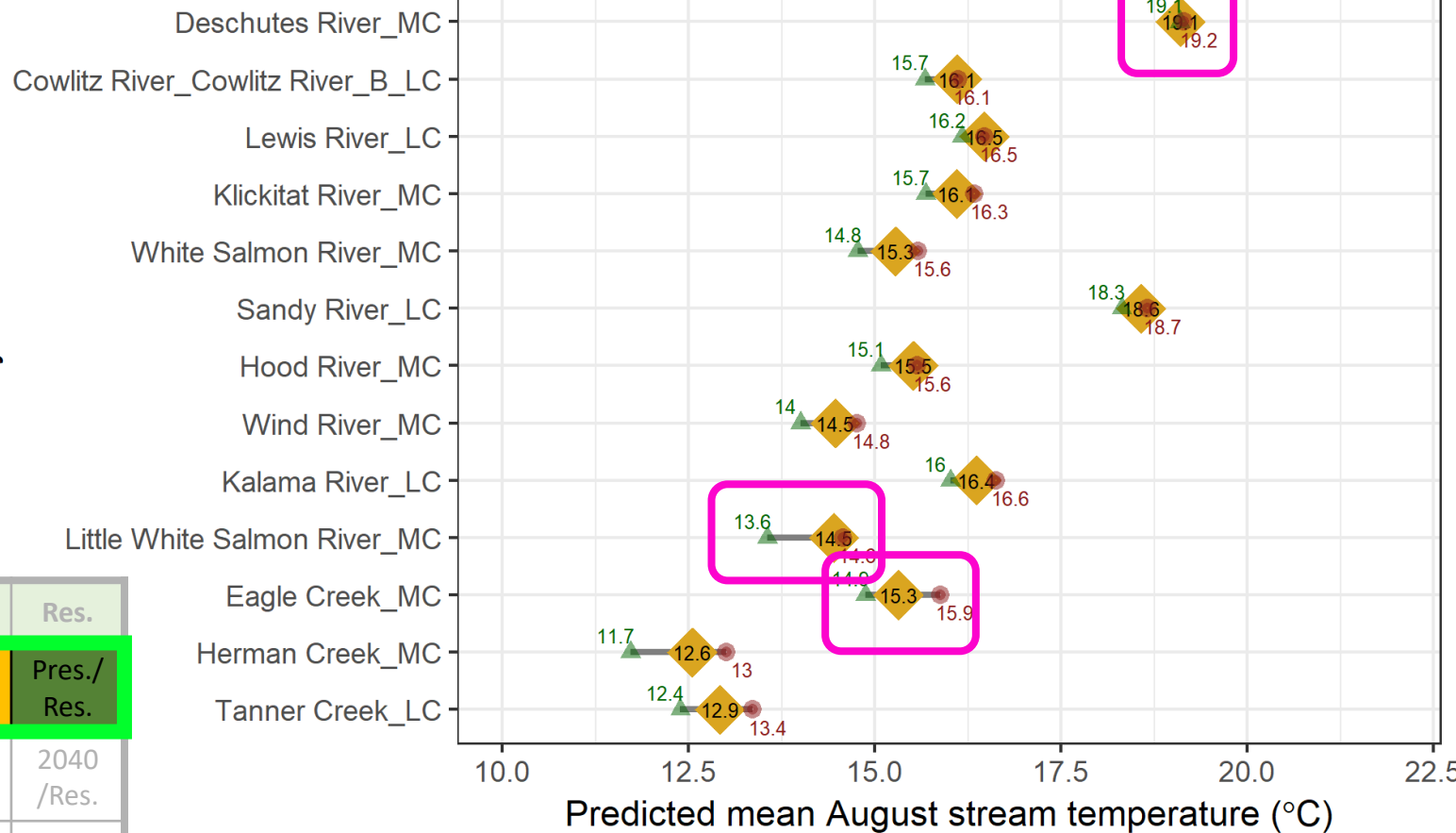


Individual Tributary Management

Present climate tributary outflow temperatures

13 focal tributaries ordered by Aug. discharge (large to small)

Tributary Name



Shade symbols: topographic (circles), current vegetation (diamonds), and restored vegetation (triangles)

	Topo.	Cur.	Res.
Pres.	Pres./Topo.	Pres./Cur.	Pres./Res.
2040	2040/Topo.	2040/Cur.	2040/Res.
2080	2080/Topo.	2080/Cur.	2080/Res.

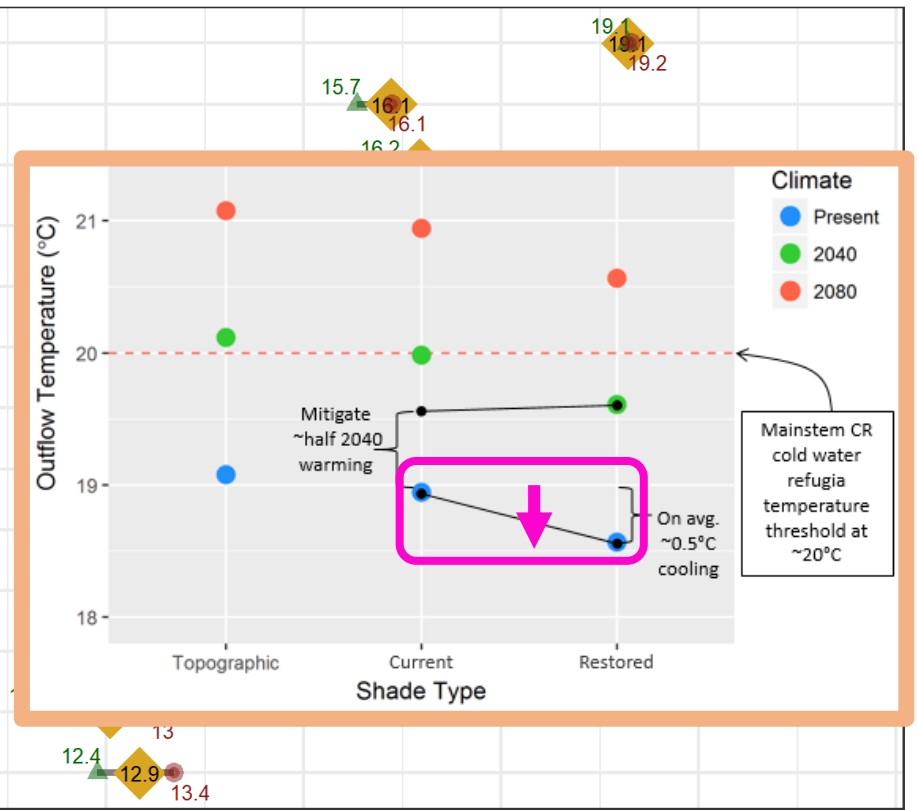
Individual Tributary Management

Present climate tributary outflow temperatures

13 focal tributaries ordered by Aug. discharge (large to small)

Tributary Name

Deschutes River_MC	0.6%
Cowlitz River_Cowlitz River_B_LC	18.1%
Lewis River_LC	5%
Klickitat River_MC	4.2%
White Salmon River_MC	4.1%
Sandy River_LC	1.4%
Hood River_MC	1.9%
Wind River_MC	1.6%
Kalama River_LC	1.1%
Little White Salmon River_MC	0.9%
Eagle Creek_MC	0.4%
Herman Creek_MC	0.4%
Tanner Creek_LC	0.2%



Predicted mean August stream temperature (°C)

Shade symbols: topographic (circles), current vegetation (diamonds), and restored vegetation (triangles)

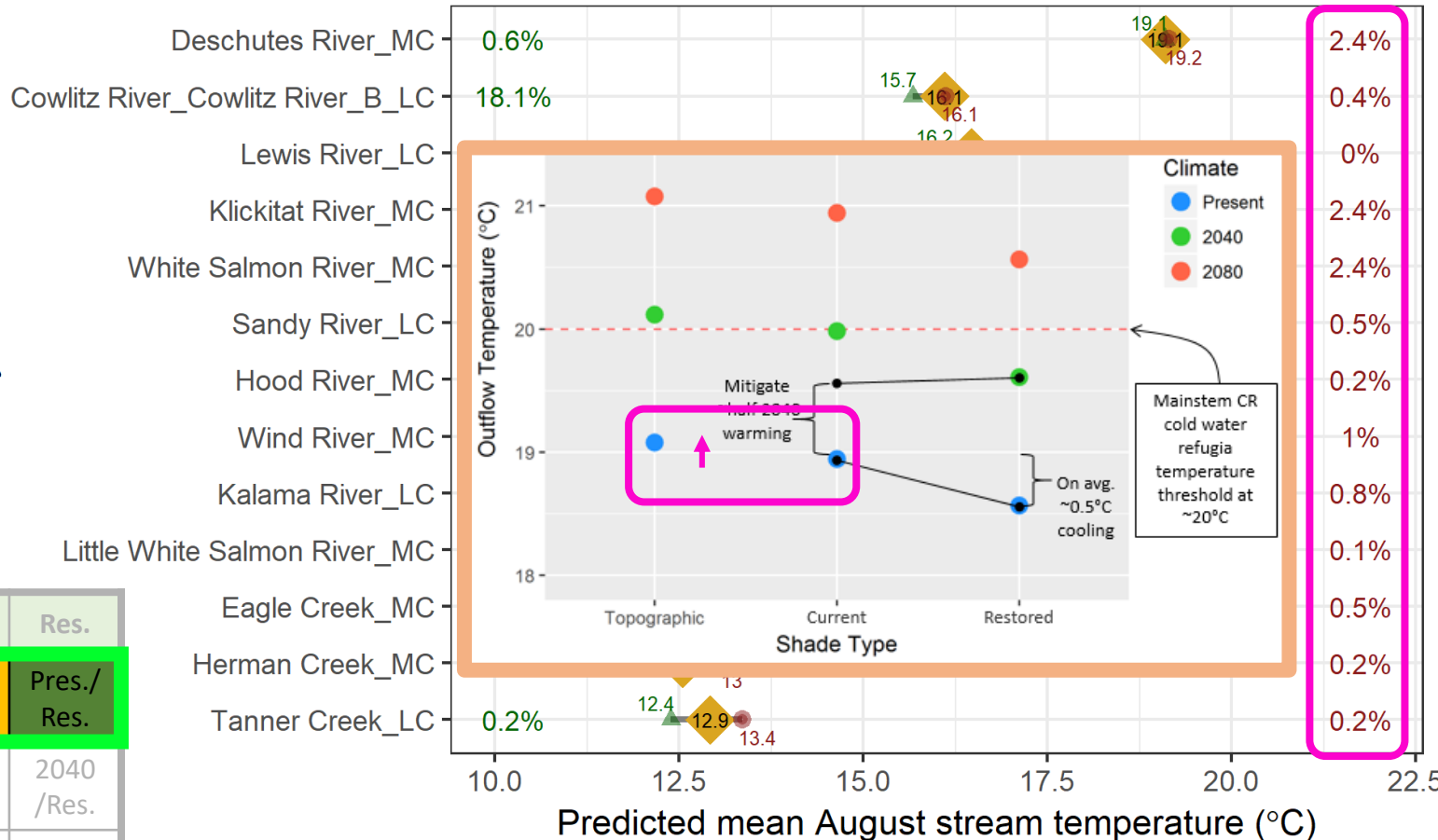
	Topo.	Cur.	Res.
Pres.	Pres./Topo.	Pres./Cur.	Pres./Res.
2040	2040/Topo.	2040/Cur.	2040/Res.
2080	2080/Topo.	2080/Cur.	2080/Res.

Individual Tributary Management

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	Topo.	Cur.	Res.
Pres.	Pres./Topo.	Pres./Cur.	Pres./Res.
2040	2040/Topo.	2040/Cur.	2040/Res.
2080	2080/Topo.	2080/Cur.	2080/Res.

	Topo.	Cur.	Res.
Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
2040	2040/ Topo.	2040/ Cur.	2040 /Res.
2080	2080/ Topo.	2080/ Cur.	2080/ Res.

Conclusions

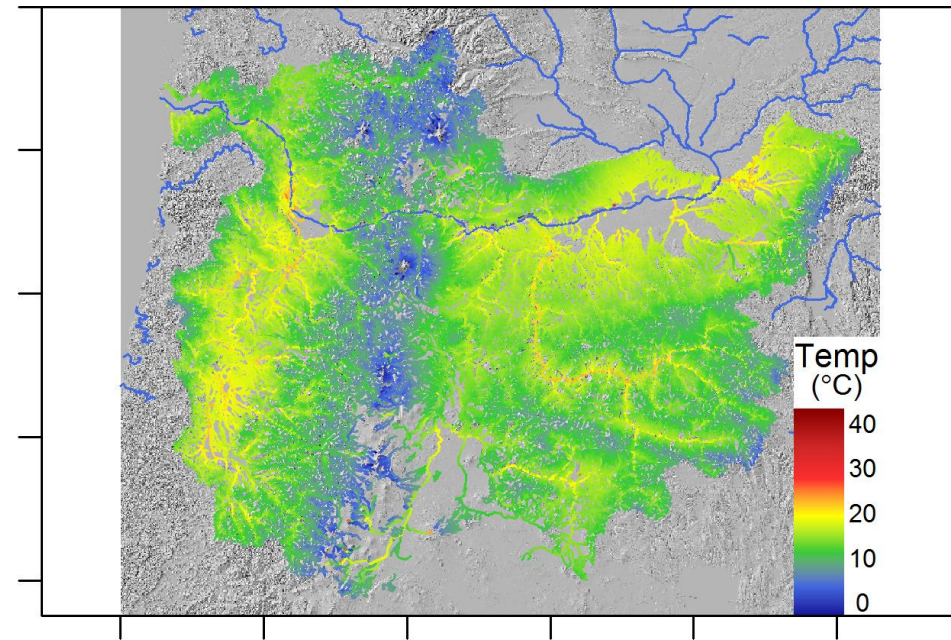
- Can riparian shading reduce tributary temperatures?
 - ~0.5°C of cooling for ***tributary outflows*** (on avg.)
- Can riparian shading restoration mitigate climate shifts?
 - Offset ~ ½ expected warming in ***tributary outflows*** (on avg.)
- What size systems should be restored first?
 - Smaller reaches w/ BFW < 5m show most improvement
- Some tributaries respond more than others.

Recap

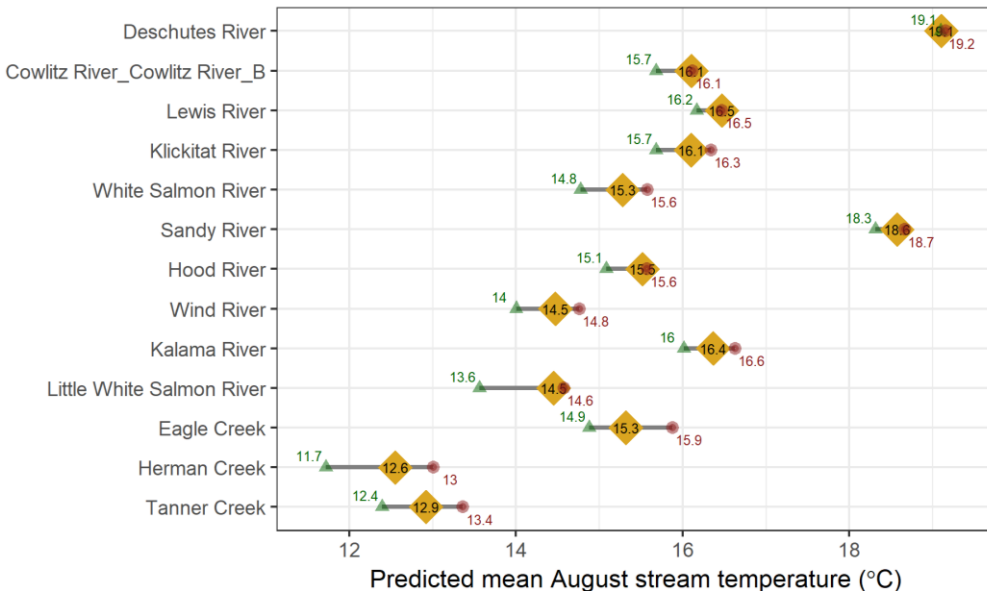
1. Details of the NorWeST SSN temperature model
2. The NorWeST SSN can be applied to new projects
3. Demonstrate how riparian shade restoration can be modeled using NorWeST and new SSN models

Break for Qs...

		Shade		
		Topo.	Cur.	Res.
Climate	Pres.	Pres./ Topo.	Pres./ Cur.	Pres./ Res.
	2040	2040/ Topo.	2040/ Cur.	2040/ Res.
	2080	2080/ Topo.	2080/ Cur.	2080/ Res.



Present climate tributary outflow temperatures
13 focal tributaries



Shade symbols: topographic (circles), current vegetation (diamonds), and restored vegetation (triangles)

Tributaries to Mainstem Columbia River

