Mid-Coast Implementation Ready TMDL

Temperature
Technical Work Group

Thursday, March 9, 2017
Newport, Oregon

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State of Oregon Department of Environmental Quality

Today's Discussion Objectives

Yachats River model results
Sources of warming in the Yachats River
Watershed SSN temperature modeling
Next steps

Temperature Impaired Waterbodies 2010 Assessment - Category 5

Waterbody Name	River Mile	Season	List Date	Record ID
Carson Creek	0 to 2.9	Year Around (Non-spawning)	2004	24719
Depew Creek	0 to 1.5	Summer	1998	2937
Grass Creek	0 to 2.3	Year Around (Non-spawning)	2010	24698
Keller Creek	0 to 2.7	Year Around (Non-spawning)	2010	24707
Keller Creek	0 to 2.6	Year Around (Non-spawning)	2004	13271
North Fork Yachats River	0 to 6.3	Year Around (Non-spawning)	2010	13273
School Fork	0 to 3.2	Year Around (Non-spawning)	2004	13267
Stump Creek	0 to 2	Year Around (Non-spawning)	2010	13270
Williamson Creek	0 to 2.7	Year Around (Non-spawning)	2010	13272
Yachats River	0 to 13	Summer	1998	2729

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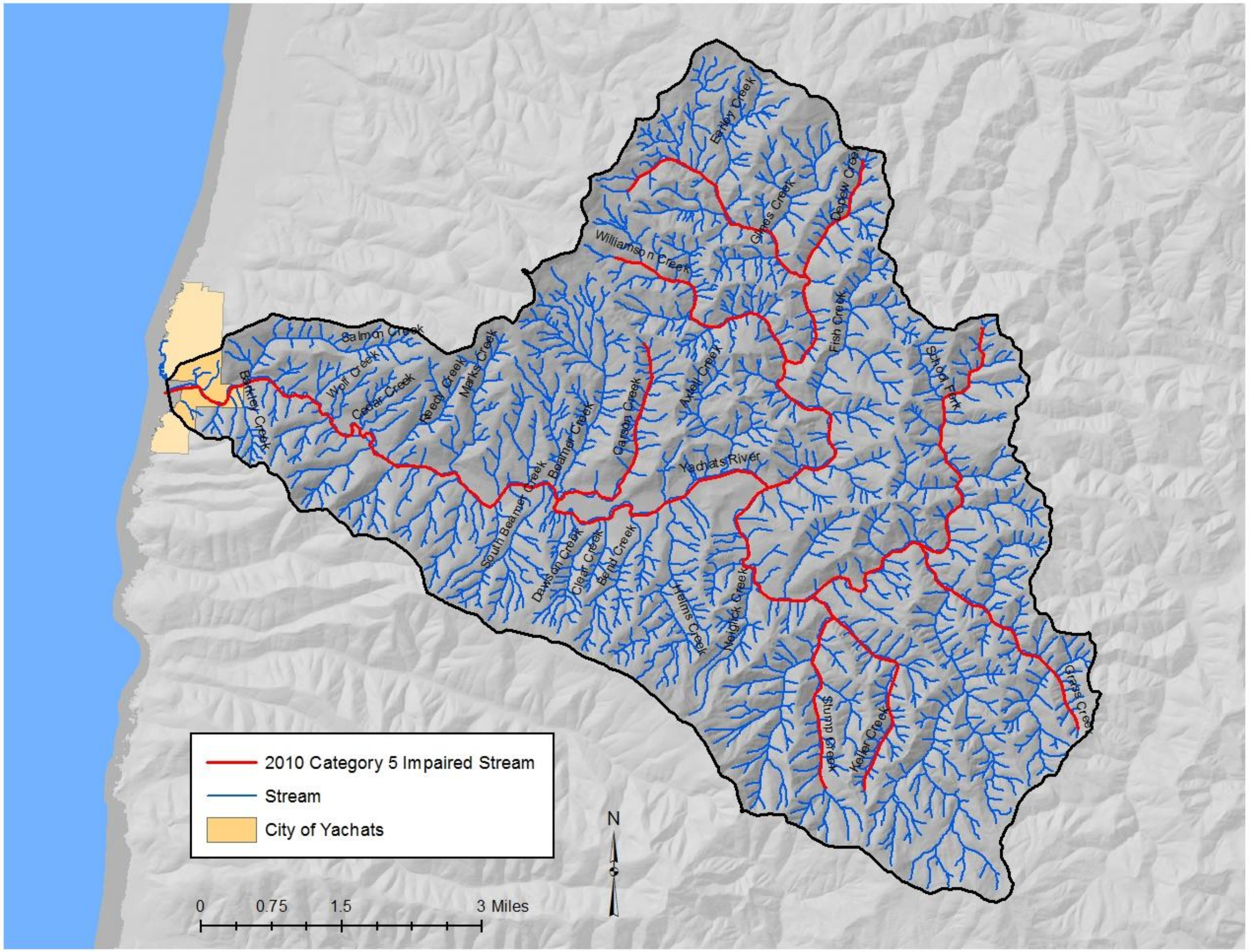
2010 Temperature Impaired waterbodies



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Waterbodies that exceed the criteria but are not identified as category 5 water quality limited

Station Name	Station ID	Numeric Criterion	Number of days exceeding Criterion
South Fork Yachats River at Yachats River Road	23746	18	154
Beamer Creek at Yachats River Road	23752	13	4
Carson Creek at RM 1 (Yachats)	34426	13	2
Grass Creek at mouth (Yachats)	33104	13	2
Helms Creek at mouth (Yachats)	26532	13	3
Keller Creek upstream of Stump Creek, at USFS picnic area	23751	13	6
Lower Carson Creek	28018	13	9
North Fork Yachats River approximately 0.1 mile upstream of Williamson Creek	23748	13	2
North Fork Yachats River at Yachats River Road (road mile 9)	23745	13	6
Reedy Creek 70 feet above drinking water intake (Yachats)	34413	13	1
Schoolfork Creek at Yachats River Road	23749	13	2
South Fork Yachats River at Yachats River Road	23746	13	5
Stump Creek upstream of Keller Creek	23750	13	6
Unnamed tributary to Yachats River at River Mile 3.3	26524	13	1
Williamson Creek at mouth, tributary to North Fork Yachats River	23747	13	2
Yachats River 100 feet upstream station 34385	34414	13	1
Yachats River above Grass Creek	33106	13	3
Yachats River at River Mile 4.9	23744	13	5
Yachats River at RM 3.5 ABV unnamed trib	34402	13	1
Yachats River upstream of Bend Creek	26531	13	2

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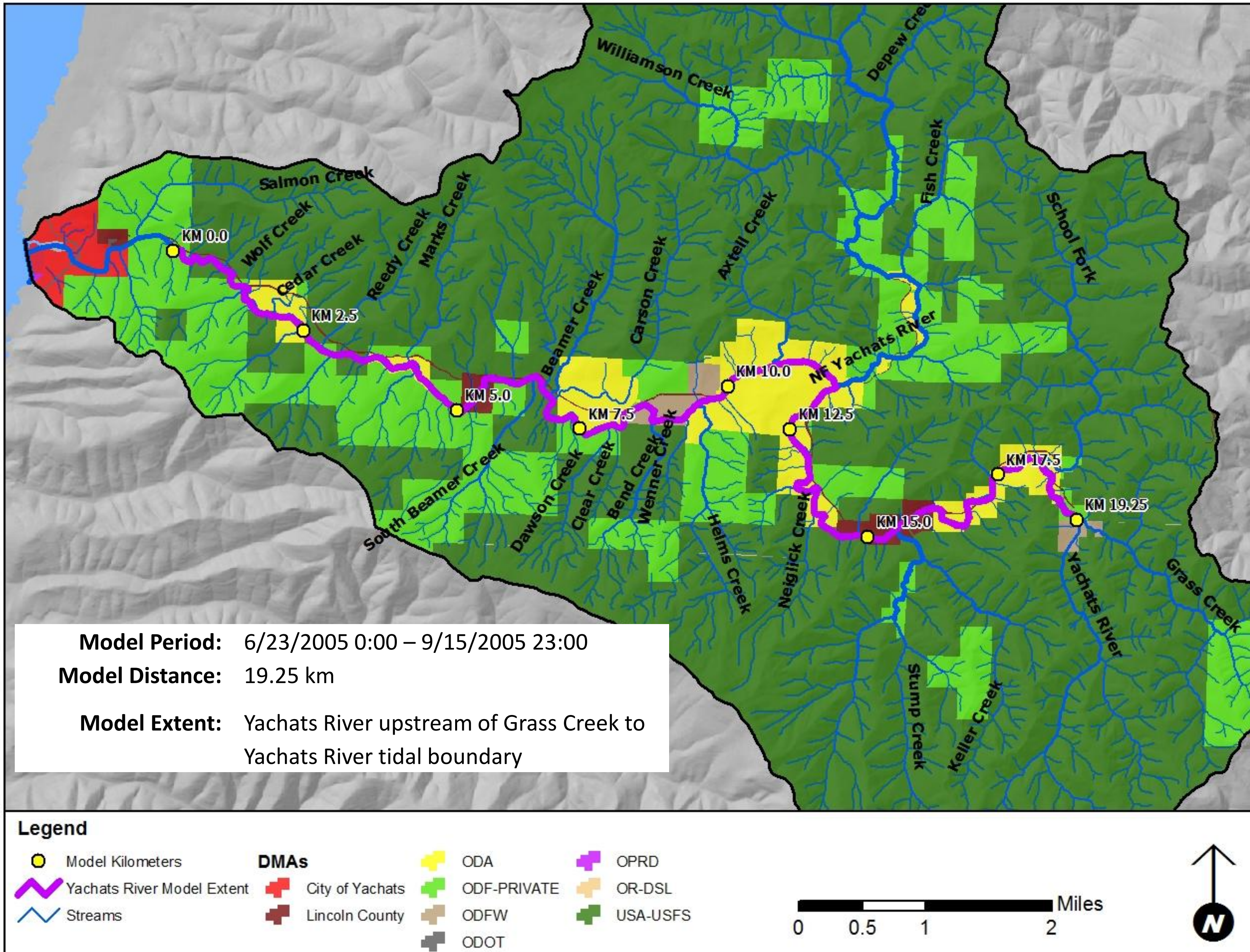
Yachats River Heat Source Model Extent



Model Period: 6/23/2005 0:00 – 9/15/2005 23:00

Model Distance: 19.25 km

Model Extent: Yachats River upstream of Grass Creek to Yachats River tidal boundary

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Model Inputs

Land Use/Land Cover

- Height / Elevation
- Canopy Cover
- Overhang
- Topographic Shade Angles

Stream Position

- Longitude
- Latitude

Channel Morphology

- Stream Elevation
- Gradient
- Bottom Width
- Channel Angle Z

Tributary/Boundary Conditions

- Stream Temperature
- Stream Flow

Meteorological Data

- Cloudiness
- Wind Speed
- Relative Humidity
- Air Temperature

Substrate

- Deep Alluvium Temperature
- Sediment Thermal Conductivity
- Sediment Thermal Diffusivity
- Hyporheic zone thickness
- Percent Hyporheic exchange
- Porosity

Model Outputs

Temperature

- Stream Temperature
- Sediment Temperature

Flux

- Streambed Conduction
- Convection
- Evaporation
- Solar Radiation (Above Topography)
- Solar Radiation (Blocked by LULC)
- Solar Radiation (Above Stream Surface)
- Solar Radiation (Penetrating Stream)
- Effective Shade
- Thermal Radiation (Total)

Hydraulics

- Flow Rate
- Hyporheic Exchange
- Flow Velocity
- Top Wetted Width
- Average Wetted Depth
- Maximum Wetted Depth

Others

- Hydraulic Dispersion (square meters/second)
- Evaporation Rate (mm/hour)
- View To Sky

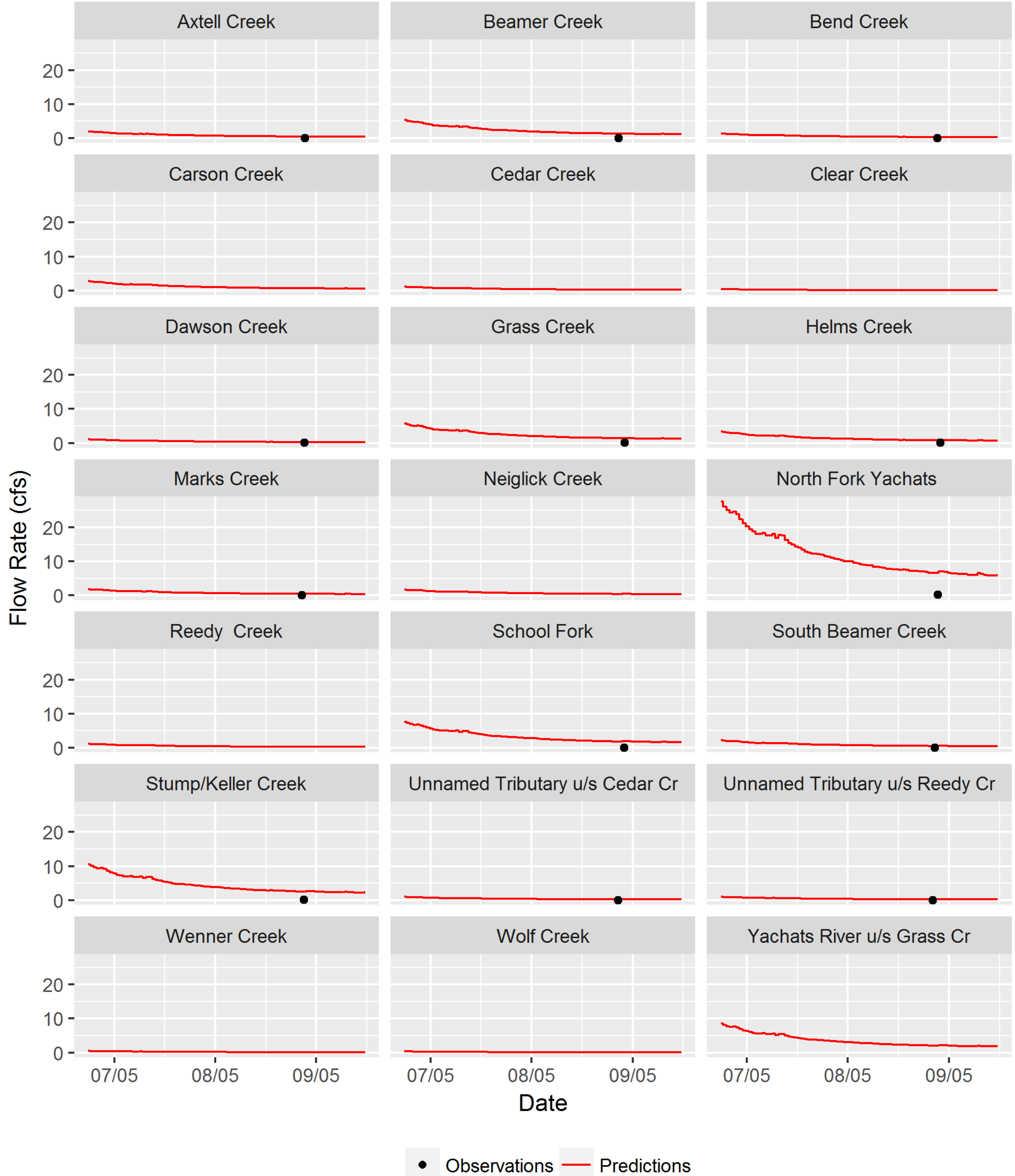
Temperature Inputs

- Measured data where available
- Unmeasured inputs used a nearby site with similar watershed

Measured	**Not Measured**
Grass Creek	Neiglick Creek
School Fork	Wenner Creek
Stump/Keller Creek	Clear Creek
North Fork Yachats	Carson Creek
Axtell Creek	Reedy Creek
Helms Creek	Cedar Creek
Bend Creek	Wolf Creek
Dawson Creek	
Beamer / Little Beamer	
South Beamer	
Marks Creek	
Unnamed Tributary u/s Reedy Creek	
Unnamed Tributary u/s Cedar Creek	

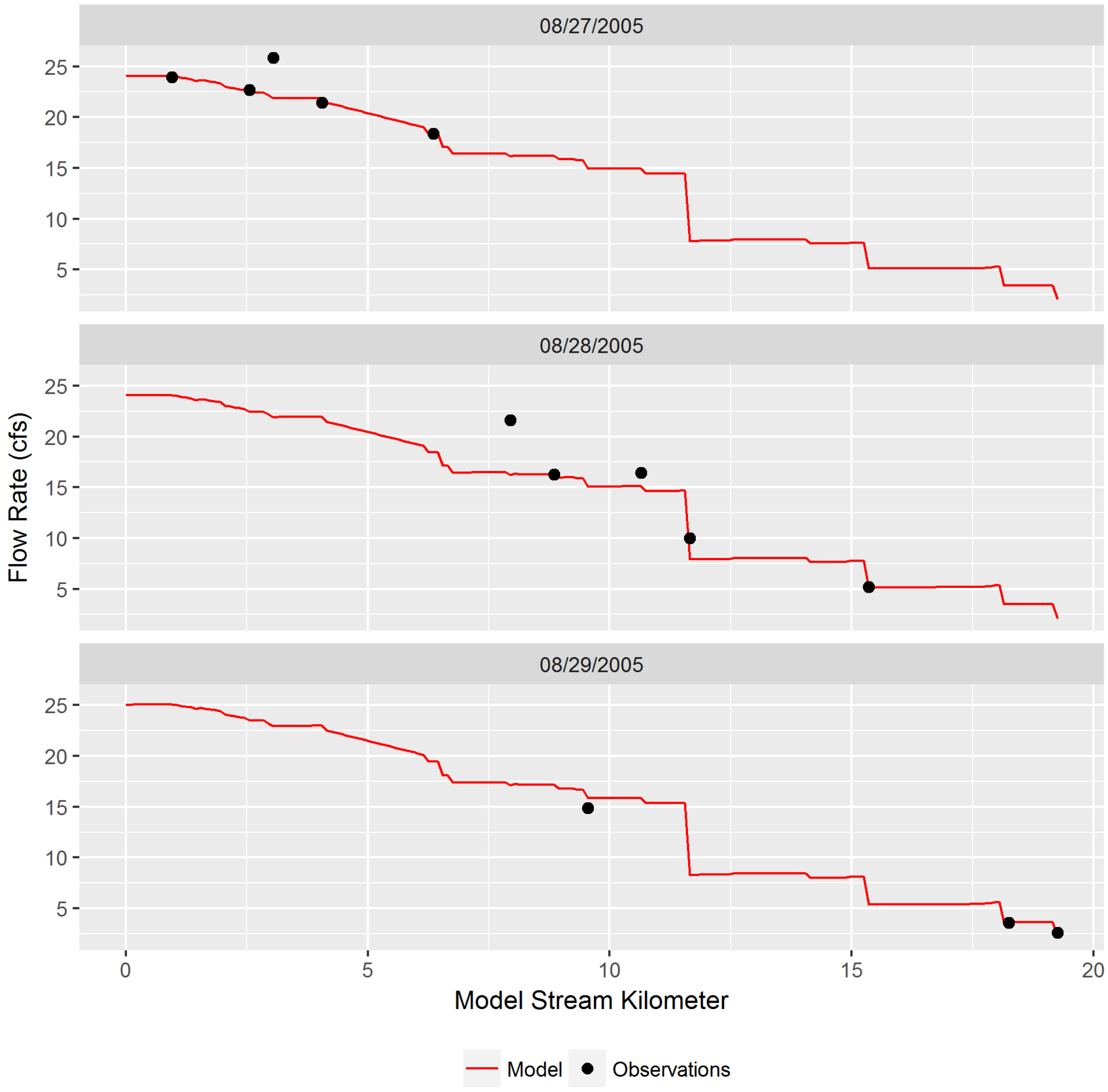
Flow Inputs

- Tributary inflows based on linear regression of Drift Creek gage (14306820) flows and adjustments based on watershed size
- Water right withdrawals assumed at 100% of permitted use
- Unbalanced flows attributed to groundwater or accretion

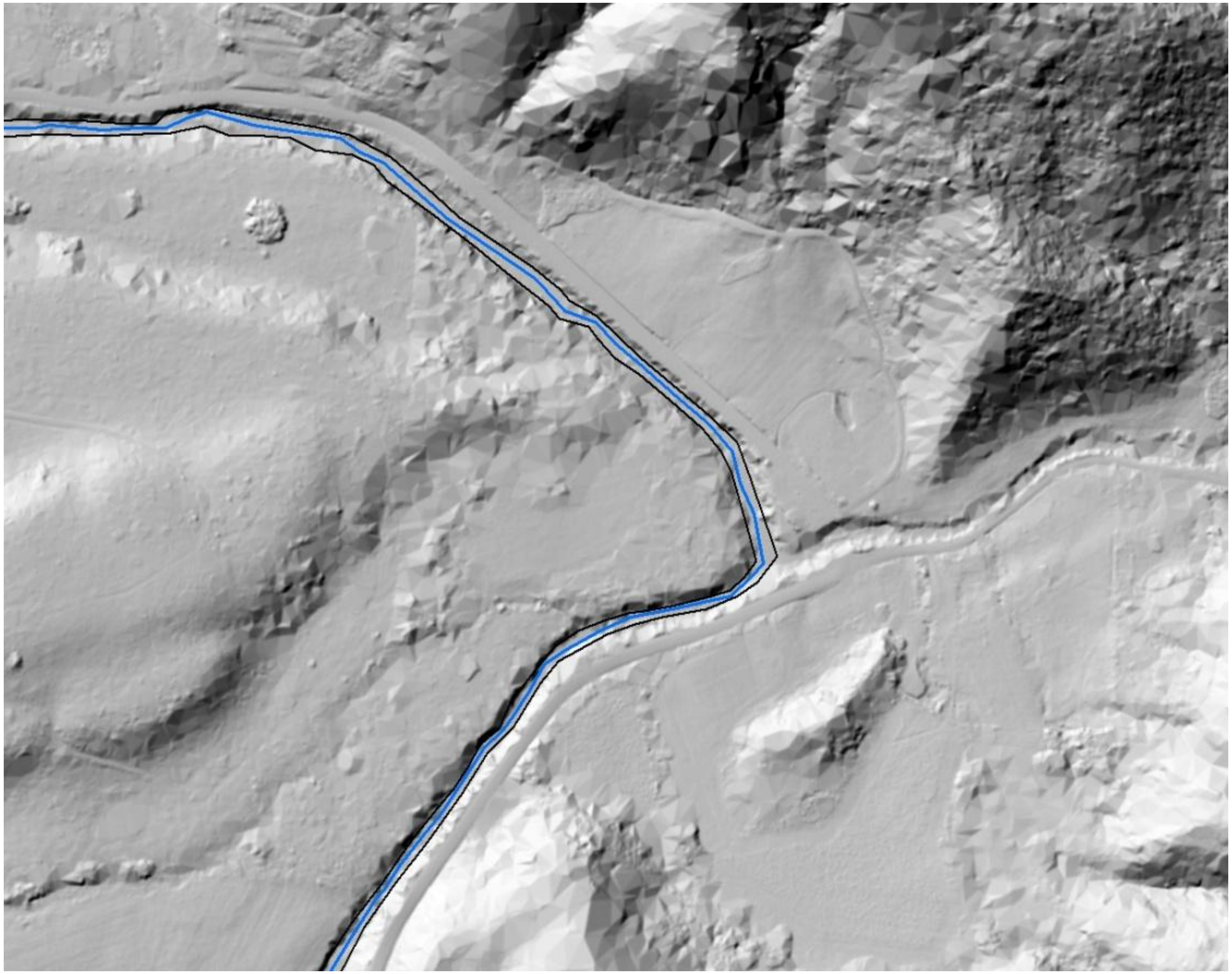


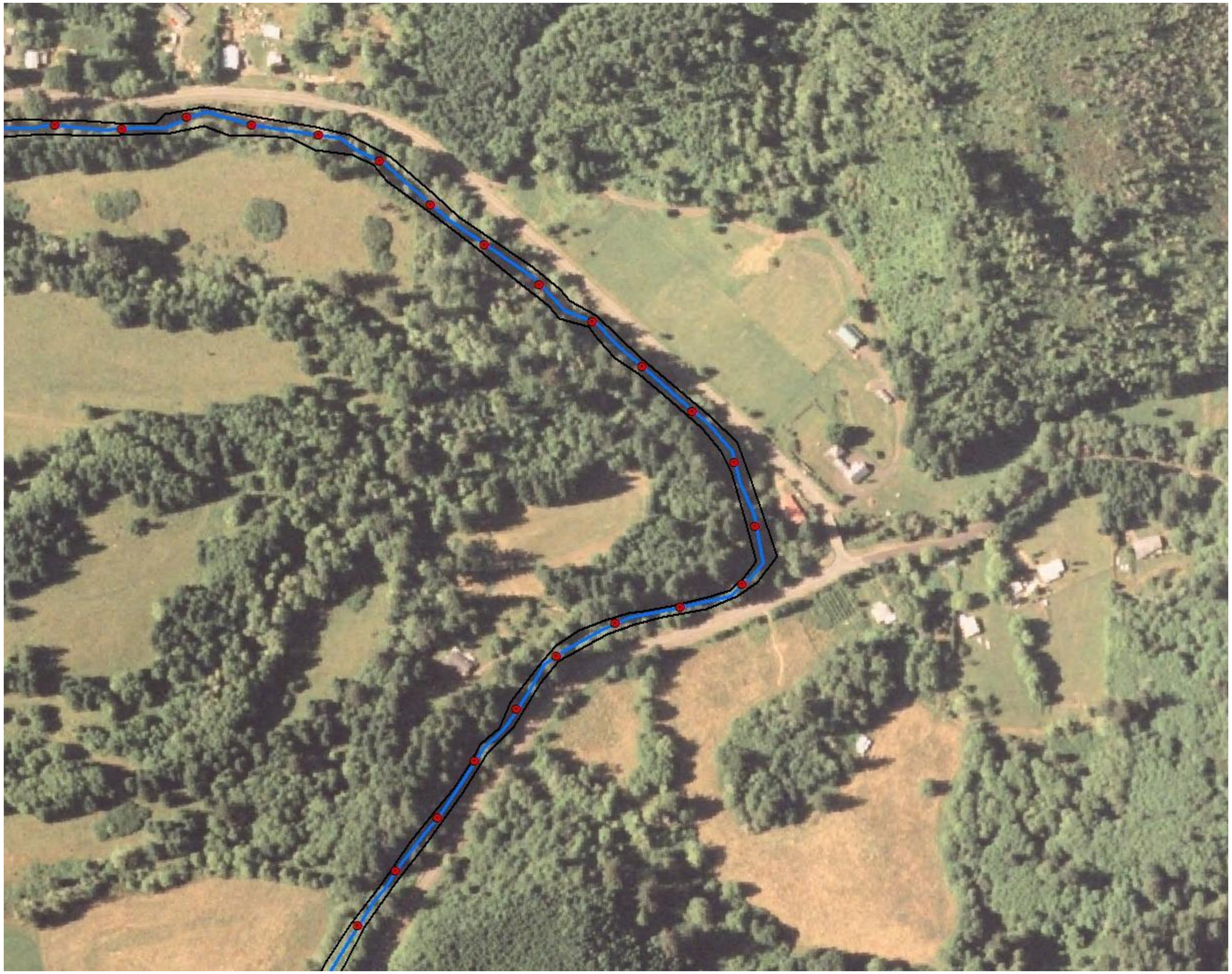
Axtell Creek
Beamer Creek
Bend Creek
Carson Creek
Cedar Creek
Clear Creek
Dawson Creek
Grass Creek
Helms Creek
Marks Creek
Neiglick Creek
North Fork Yachats
Reedy Creek
School Fork
South Beamer Creek
Stump/Keller Creek
Unnamed Tributary u/s Cedar Cr
Unnamed Tributary u/s Reedy Cr
Wenner Creek
Wolf Creek
Yachats River u/s Grass Cr
Flow Rate (cfs)
20
10
0
07/05
08/05
09/05
Date
Observations
Predictions

Yachats River Hydraulic Calibration

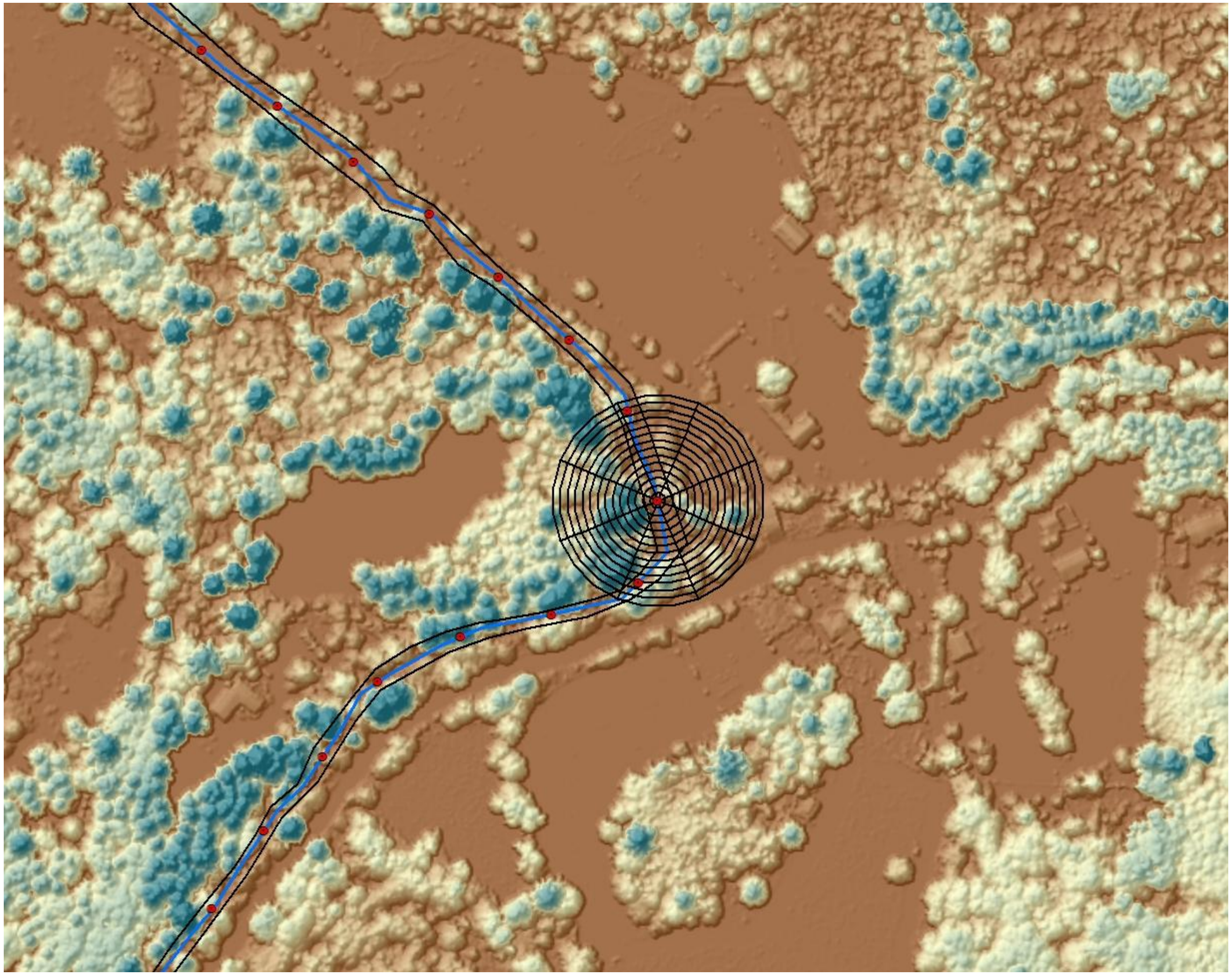


Stream Position, Elevation, Channel Width

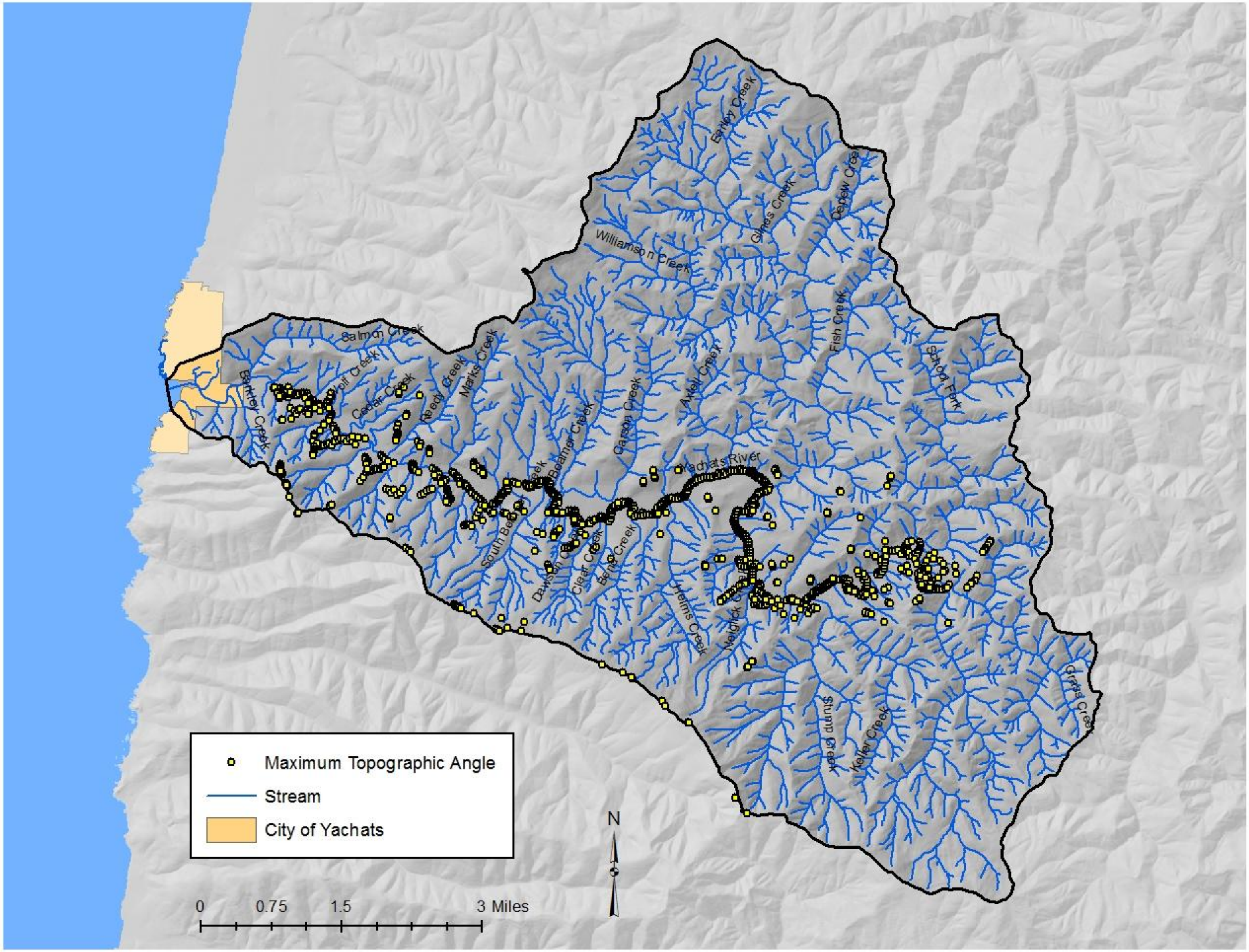




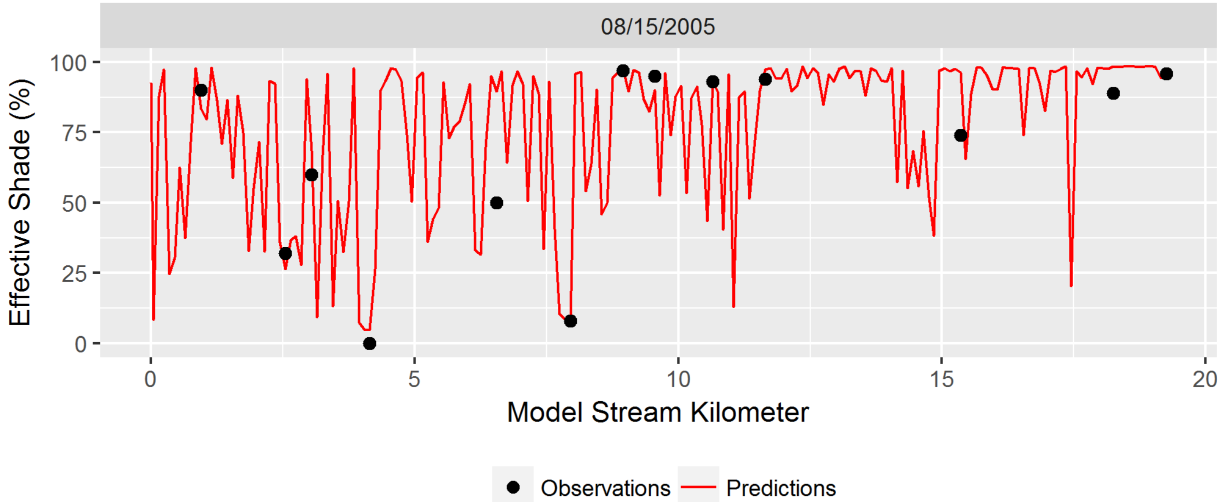
Land Cover Height



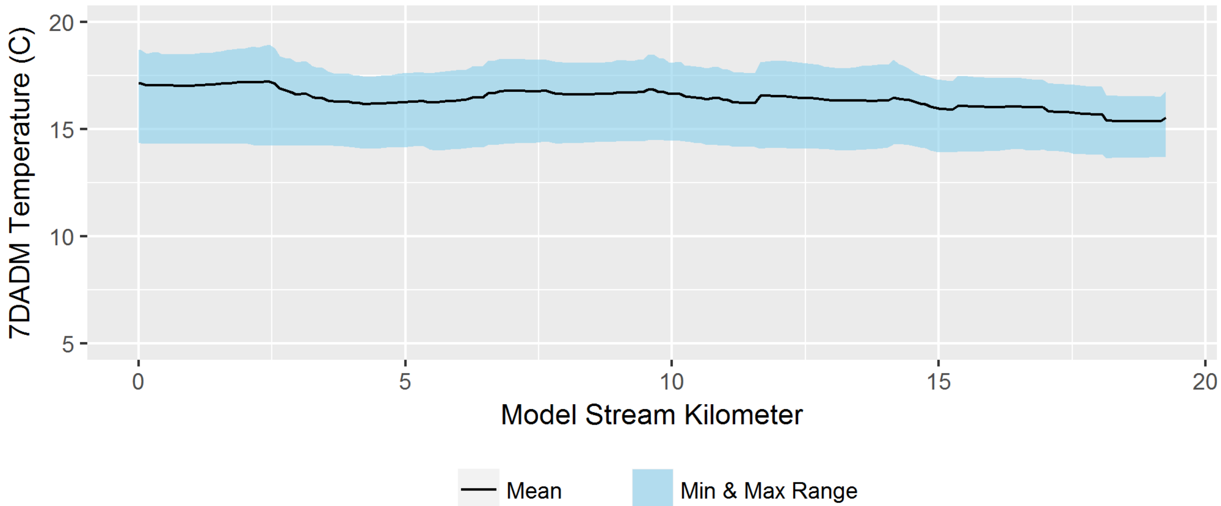
Topographic Shade Location



Yachats River Effective Shade Calibration

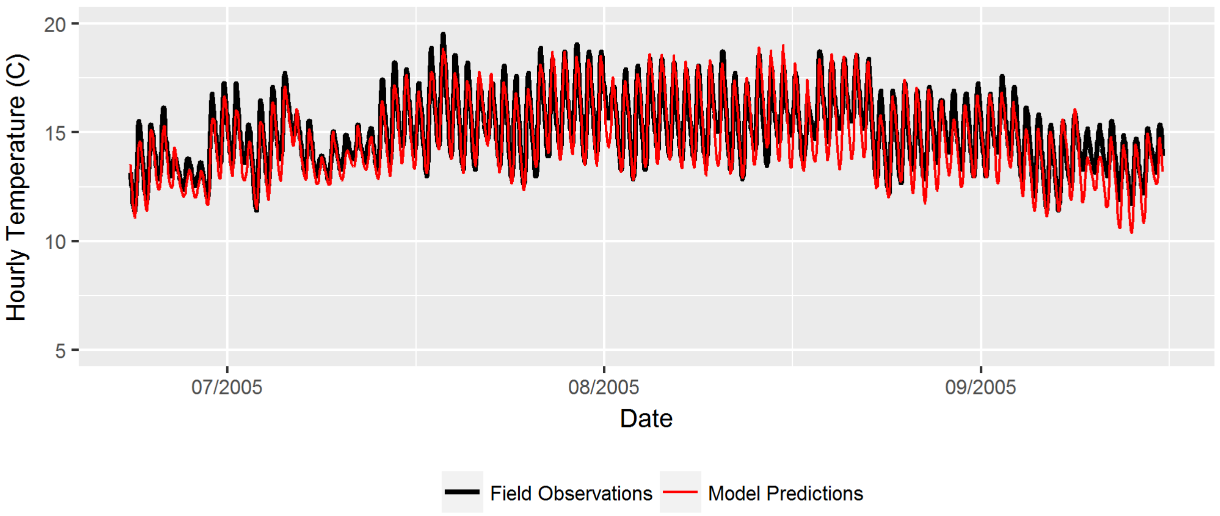


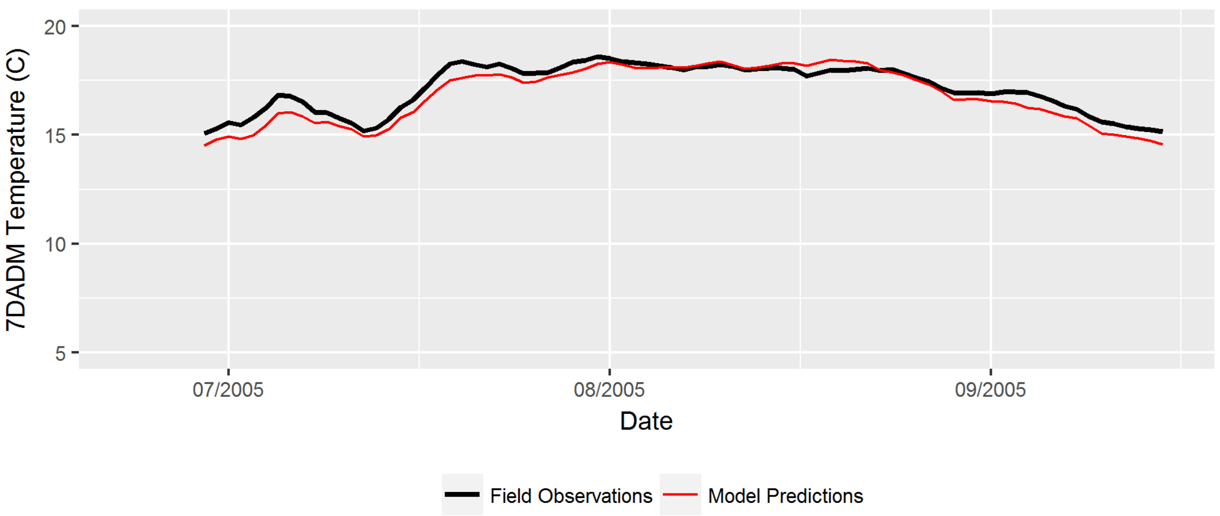
7-Day Average Daily Maximum Temperatures



Refer to handout for more results.

Yachats River upstream of Bend Creek - LASAR station 26531





Refer to write-up for more results.

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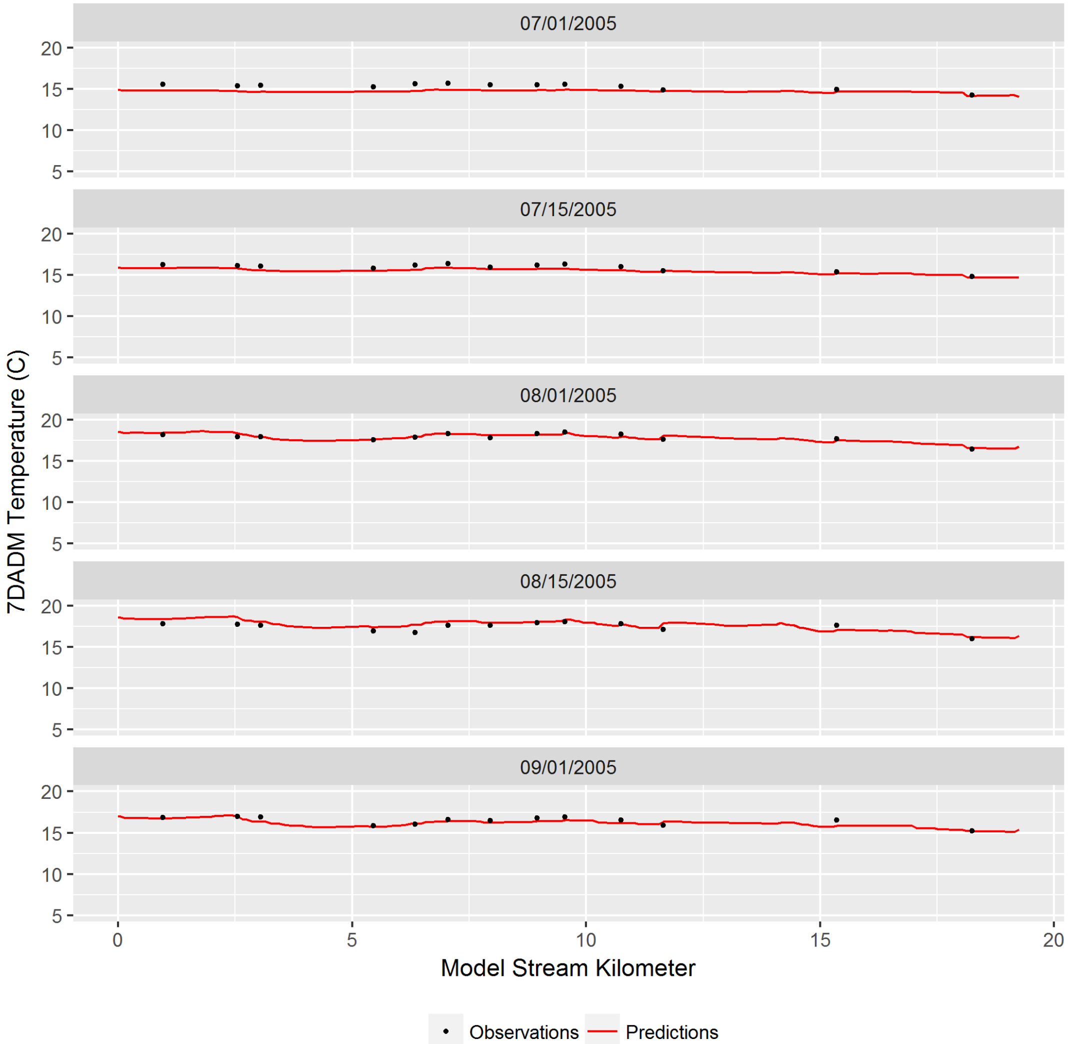
7-Day Average Daily Maximum Temperatures



Refer to write-up for more results.

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Model Fit Statistics

Hourly Data

Observations: 2040

Mean Errors -0.59 - -0.06

RMSE: 0.29 – 0.75 ^{o}C

Nash Sutcliffe: 0.58 – 0.95

7DADM

Observations: 79

Mean Errors -0.43 – 0.27

RMSE: 0.12 – 0.57 ^{o}C

Source Assessment and Cumulative Effects Questions

1. What is causing stream temperature warming and where are anthropogenic sources located?

2. How much stream warming comes from anthropogenic sources?

3. Where along the stream is anthropogenic warming occurring?

Yachats River Temperature Standard

OAR 340-041-0028

- $18^{o}C$ 7DADM during salmon and trout rearing and migration use
- $13^{o}C$ 7DADM during salmon and steelhead spawning use (Oct 15 – May 15)
- Anthropogenic sources are limited to $0.3^{o}C$ of warming.

TMDL allocations must be set at a level that will achieve these criteria.

Anthropogenic sources are only responsible for their own warming.

Potential anthropogenic sources of warming

1. Lack of streamside vegetation

2. Water withdrawals

3. Channel morphology changes
   - Loss/change in hyporheic flow
   - Loss/change in floodplain storage
   - Loss of cold water refuges

Source Assessment Model Scenarios

1. Streamside Vegetation
2. Instream Flows

Yachats River Vegetation Model Scenario

Model Scenario Elements

- Restoring streamside vegetation in areas along the Yachats River to minimize anthropogenic loading of solar radiation.

- Protecting existing streamside vegetation and actively managing it to a mature stand in order limit new anthropogenic loading of solar radiation.

Yachats River Vegetation Model Scenario

Model Scenario Elements

<u>Restoration Areas</u>
Locations with bare ground, grass, short shrubs
<= 0.9 meters (3 feet) of height

<u>Protection Areas:</u>
Locations with existing vegetation > 0.9 m (3 feet)
Assumed managed and protected to achieve conditions
similar to restored vegetation.

Yachats River Vegetation Model Scenario

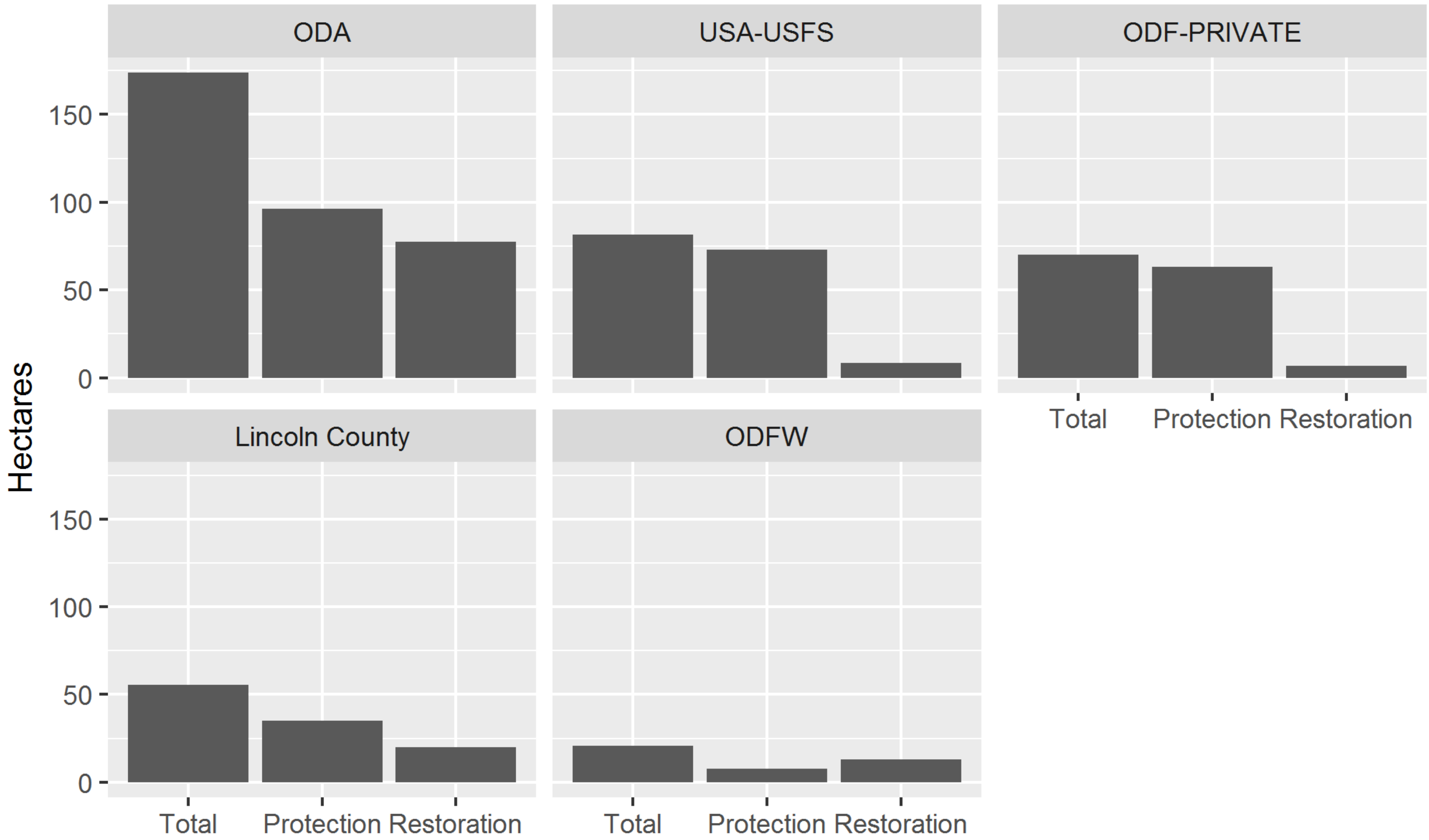
Restored/Protected Vegetation Assumptions

- Hardwood/Conifer mix
- Mid seral stage (65 years old)
- Height estimate based on growth curves from literature
- Consistent with PNV regions developed by USFS
- Canopy cover is 91% (same as current condition model)
- Applied within the entire model extent

Species	Height (m)	Stand Percent
Red Alder	33.5	60%
Western Hemlock	39.4	30%
Sitka Spruce	43.8	10%
Composite	**36.6**	100%

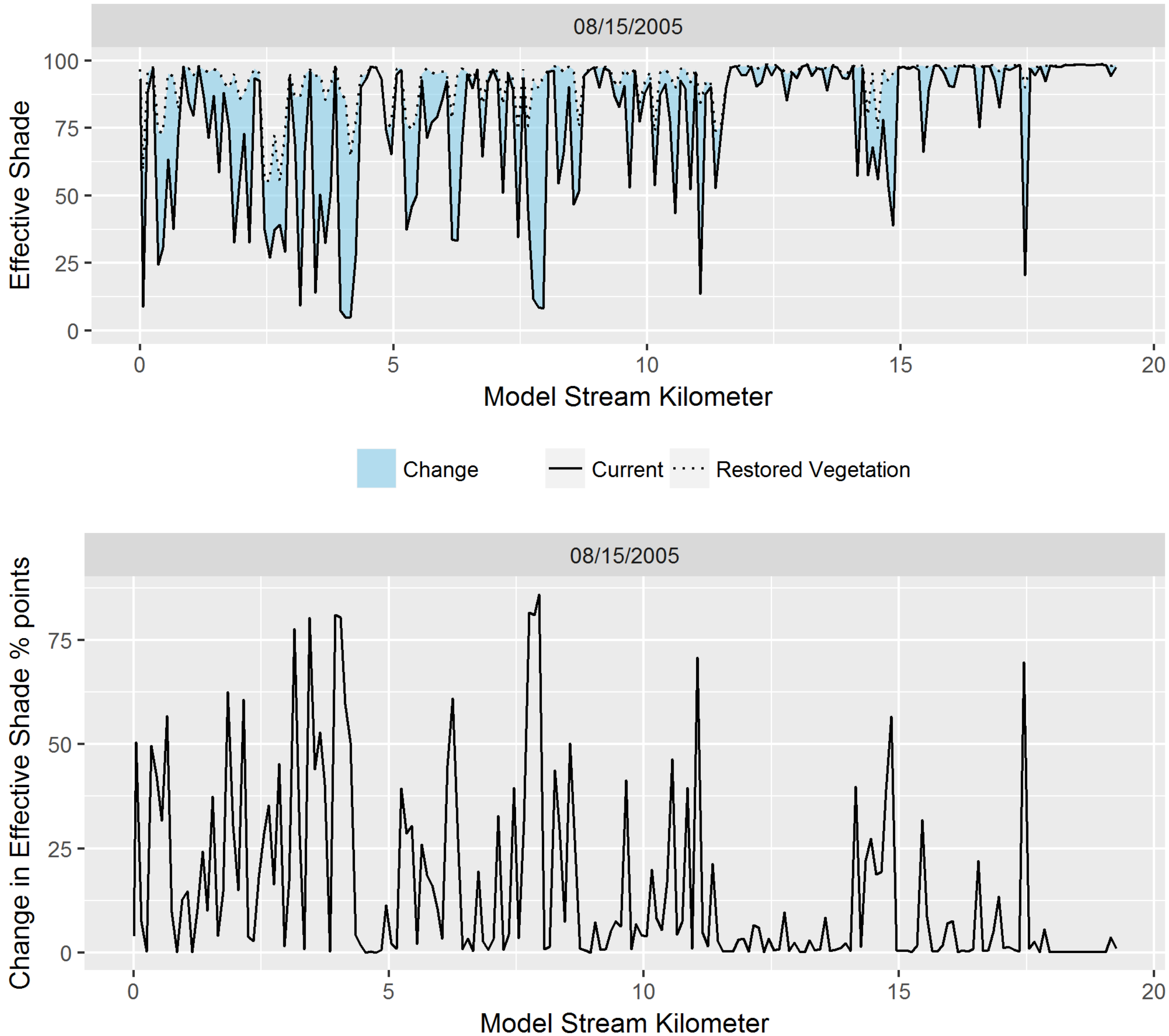
Yachats River Vegetation Model Scenario

Summary of Restoration/Protection Area for each DMA



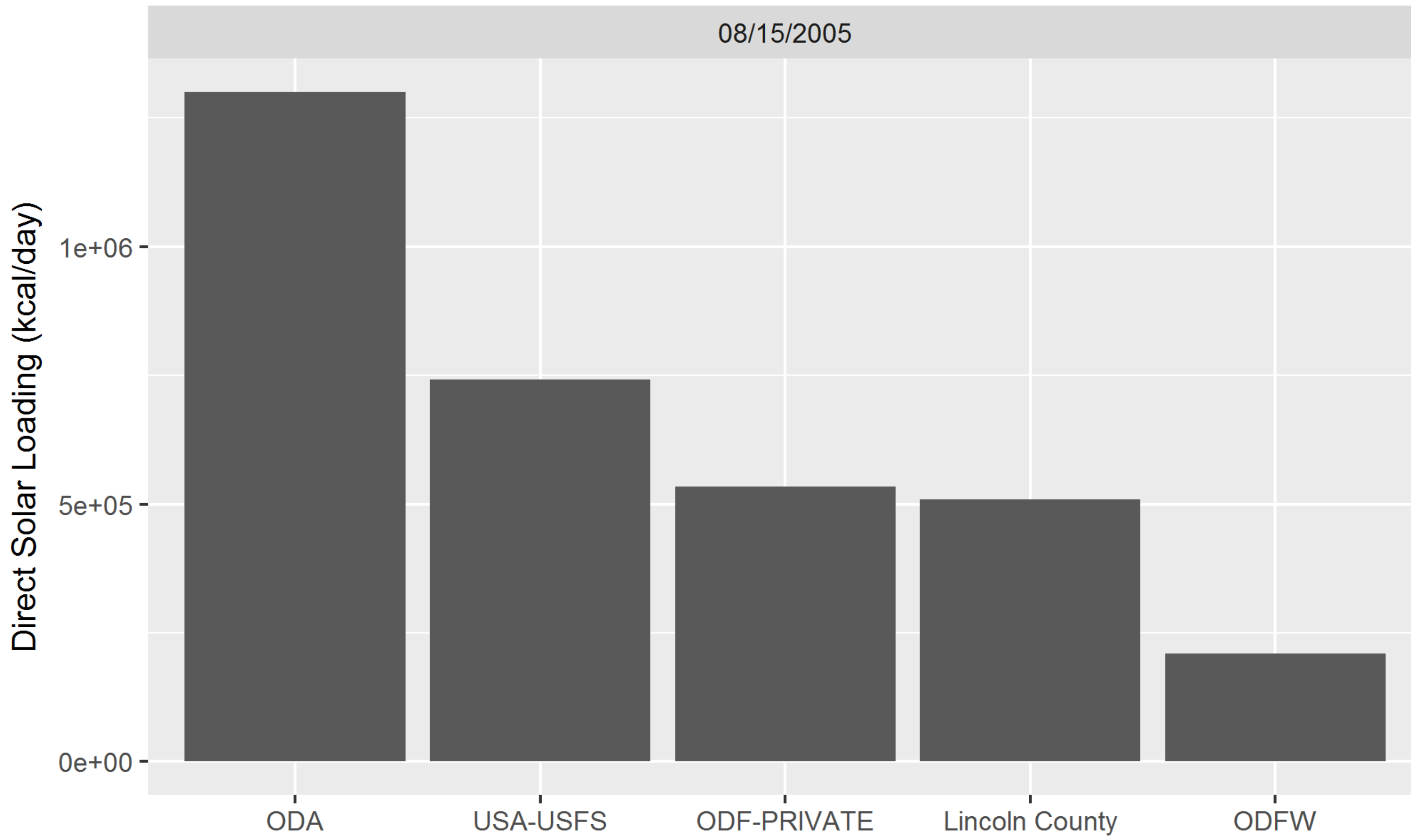
Yachats River Vegetation Model Scenario

Change in Effective Shade



Yachats River Vegetation Model Scenario

Direct Solar Loading by DMA



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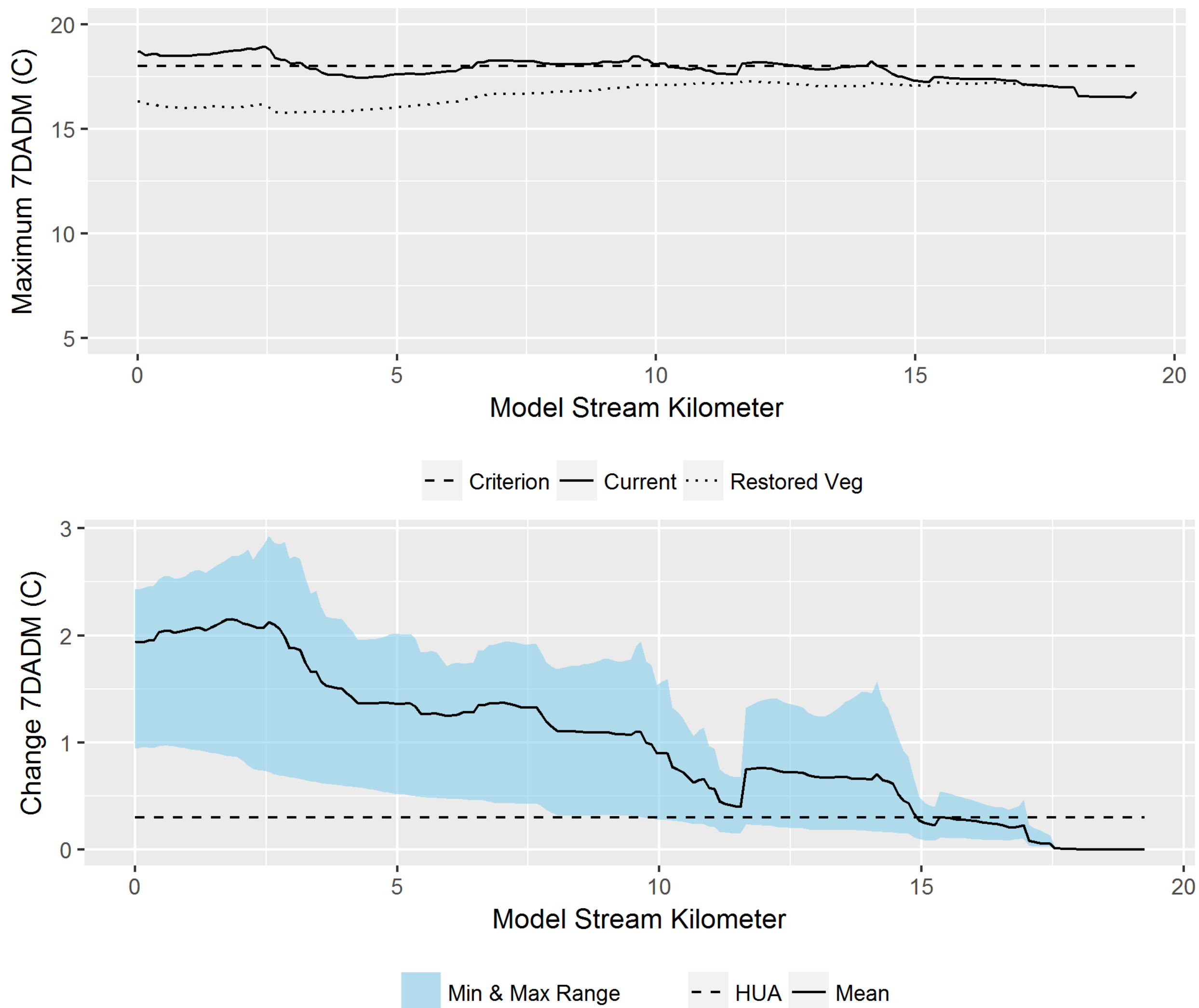
Yachats River Vegetation Model Scenario

Change in 7DADM Stream Temperature



Yachats River Vegetation Model Scenario Results

- Restoration and protection management strategies will increase effective shade above current conditions by as much as 90 percentage points in some locations (**Figure A64**).

- Restoring and protecting streamside vegetation will achieve the 18^{o}C applicable temperature standard in the Yachats River (**Figure A65**).

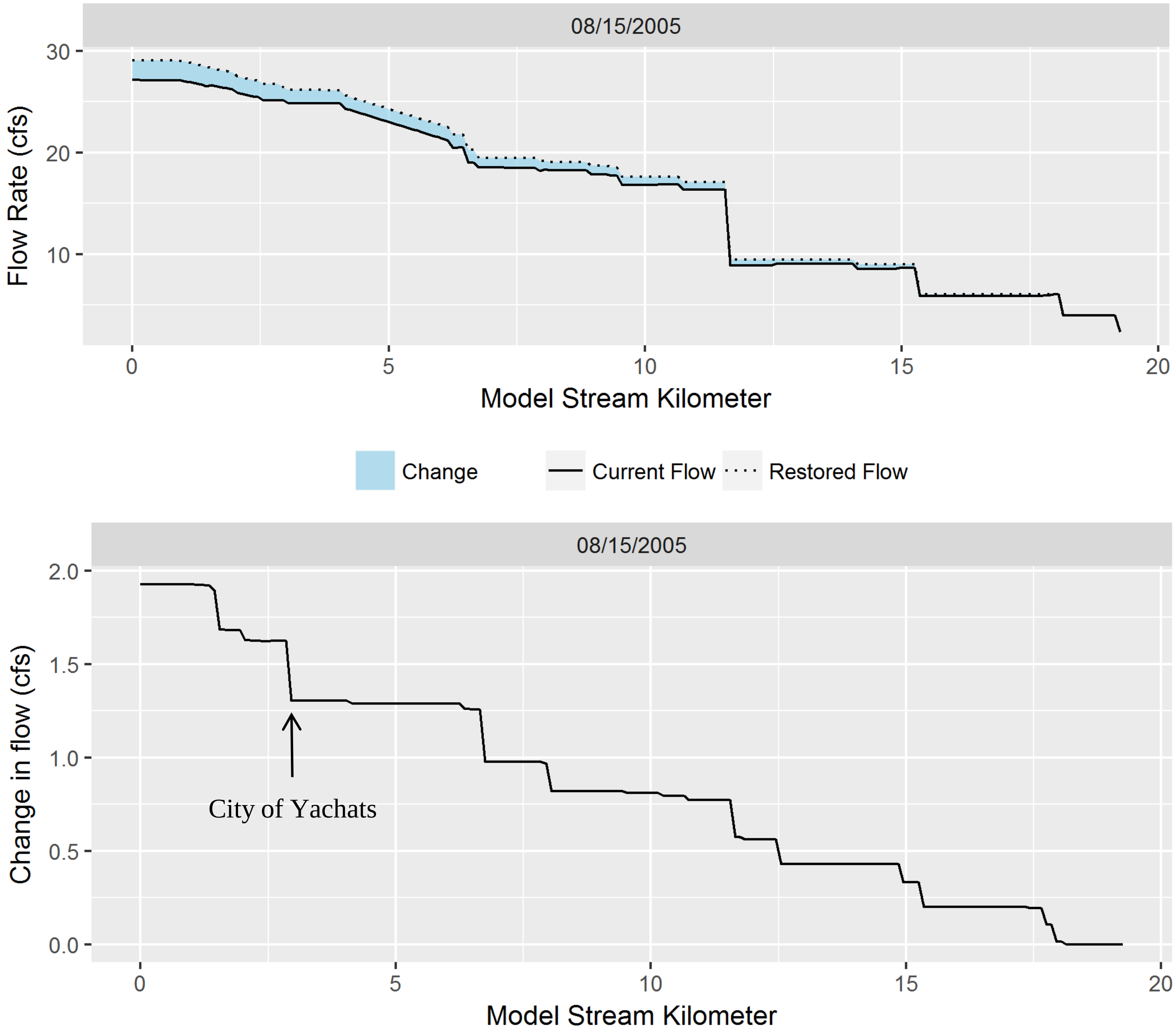
- The largest mean warming of 7DADM stream temperatures are in the Yachats River reaches between head of tide (model kilometer zero) and Reedy Creek (model kilometer 2.85) (**Figure A66**). The mean warming in these reaches range from 1.9 ^{o}C – 2.1 ^{o}C with the maximum mean warming occurring just downstream of Cedar Creek at about model kilometer 1.85

- The maximum warming in 7DADM stream temperatures is 2.8^{o}C and occurs just upstream of an unnamed tributary upstream of Cedar Creek at model kilometer 2.55 (**Figure A66**). This location is the point of maximum impact on the Yachats River.

Instream Flow Scenario

- No water withdrawals (including tributaries)
- All other variables are the same as current

Instream Flow Model Scenario Results



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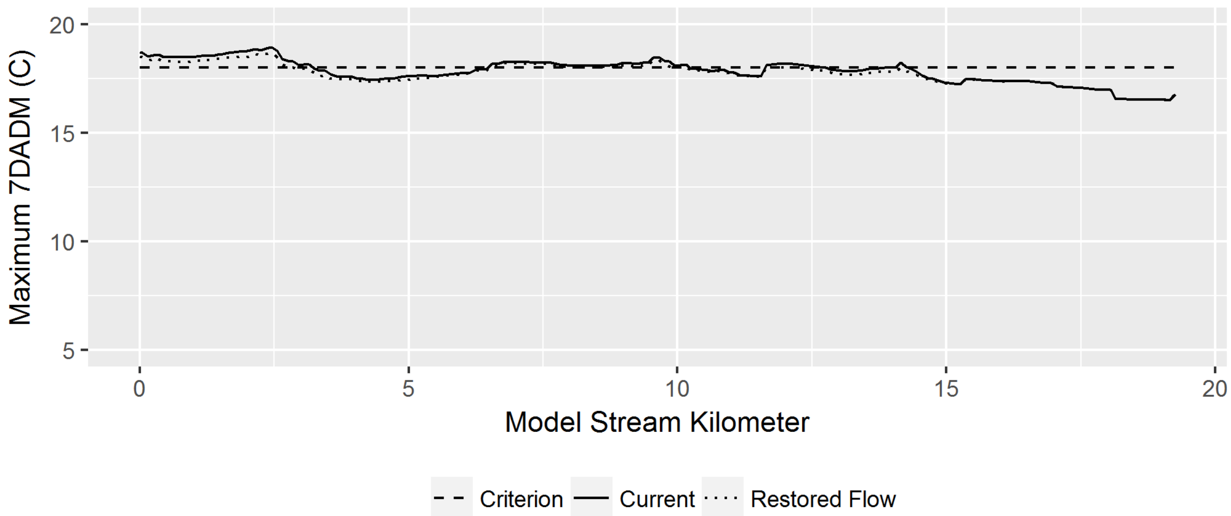
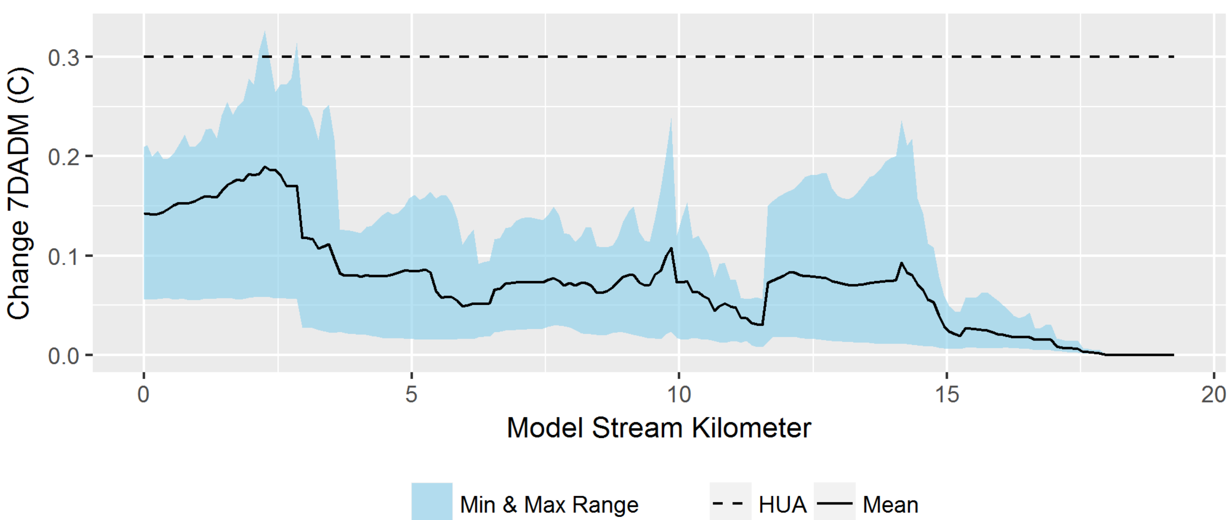
Instream Flow Model Scenario Results





Instream Flow Model Scenario Results

- Maintaining instream flows results in marginally cooler 7DADM stream temperatures compared to current conditions
- Maintaining instream flows (alone) will not achieve the 18^{o}C applicable temperature standard in the Yachats River (**Figure A67**).
- The largest mean warming of 7DADM stream temperatures are in the Yachats River reaches between head of tide (model kilometer zero) and Reedy Creek (model kilometer 2.85) (**Figure A68**). The mean warming in these reaches range from 0.11 ^{o}C – 0.15 ^{o}C with the maximum mean warming just upstream of an unnamed tributary upstream of Cedar Creek at model kilometer 2.55.
- The maximum increase in 7DADM stream temperatures is 0.22^{o}C and occurs just upstream of an unnamed tributary upstream of Cedar Creek at model kilometer 2.55 (**Figure A68**). This location is the point of maximum impact on the Yachats River.

TMDL Allocations

- Waste Load Allocations will be set to zero (there are no point sources)

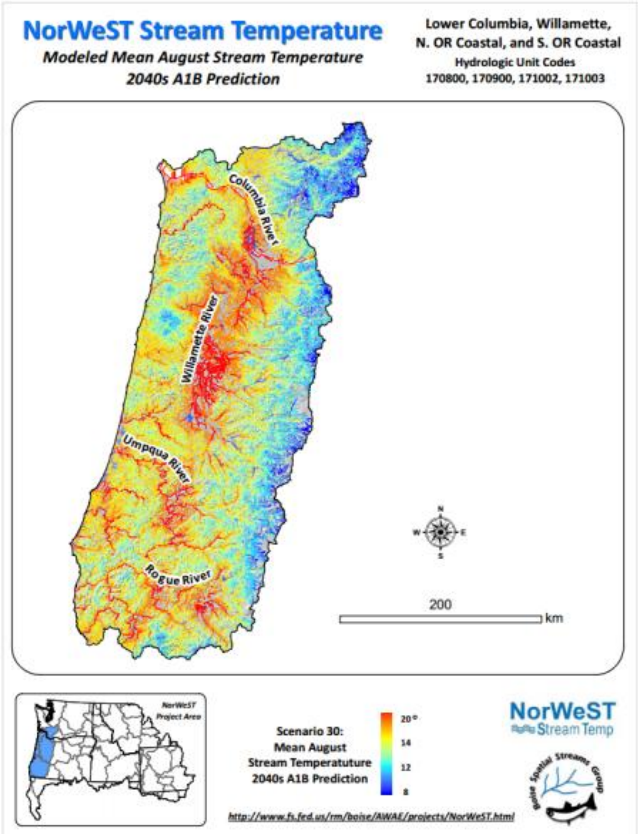
- Load allocations will be provided to each DMA

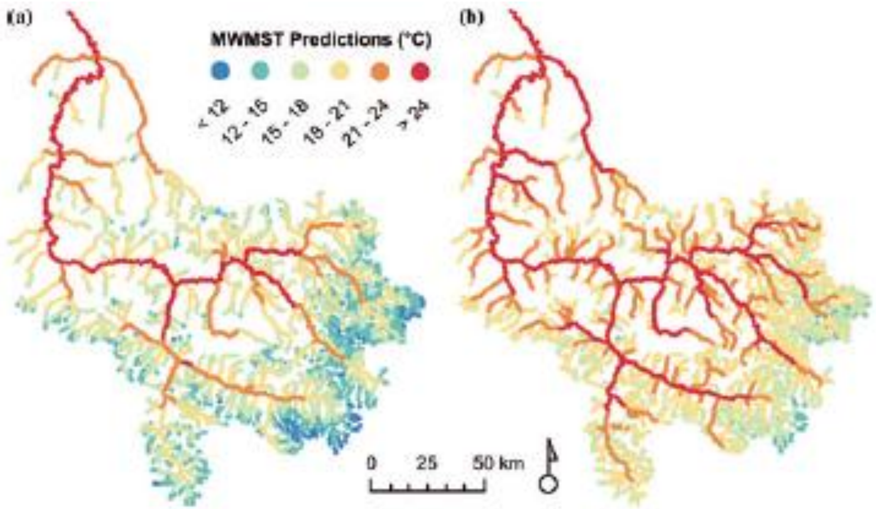
- The amount of load allocated is based on the amount of allowed stream warming (human use allowance) for each source.

Implementation Planning

- DMAs may propose implementation scenarios to achieve allocations
- DEQ will evaluate if the implementation scenarios achieve the allocations and applicable temperature criteria
- DEQ will consult with TWG, LSAC, and DMAs on distribution of the human use allowance and timelines and milestones for achievement of allocations
- DEQ will consult with TWG, and DMAs on identification of priority implementation areas

Spatial Statistical Model on Stream Networks (SSN)





Isaak et al. 2011. NorWeST: An interagency stream temperature database and model for the Northwest United States. U.S. Fish and Wildlife Service, Great Northern Landscape Conservation Cooperative Grant. Project website: www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html

Ruesch, et al. 2012. Projected climate-induced habitat loss for salmonids in the John Day River network, Oregon, U.S.A. Conservation Biology 26(5), 873–882.

Detenbeck et al. 2016. Spatial statistical network models for stream and river temperature in New England, USA. Water Resources Research 52(8), 6018-6040.

Steel et al 2016. Spatial and temporal variation of water temperatures regimes on the Soqualmie River Network. JAWRA. 52(3) 769-787.

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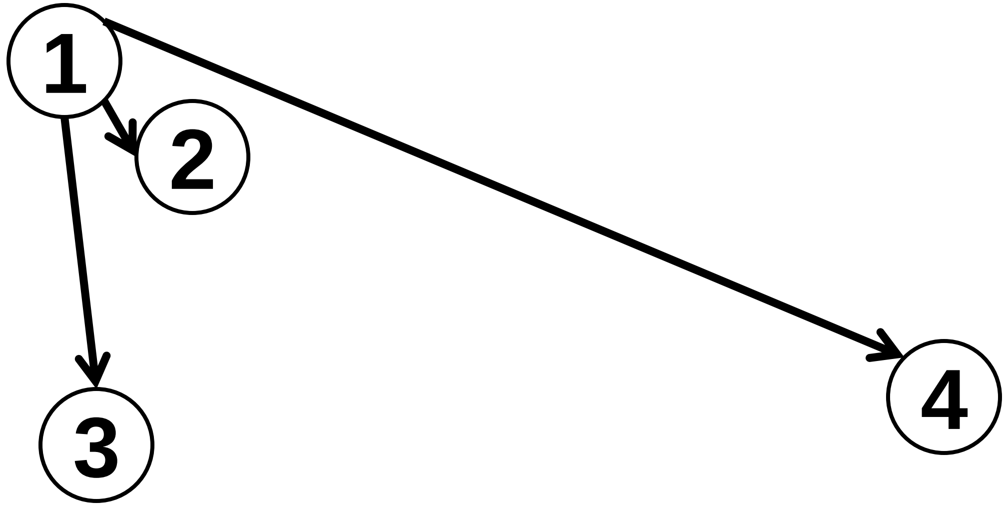
Spatial Statistical Model on Stream Networks (SSN)

- Empirical (vs. mechanistic)
- General linear mixed effects model
- Incorporates geostatistical autocovariance functions (autocorrelation)
- Distance is measured along the stream network

SSN Model

What is spatial autocorrelation?

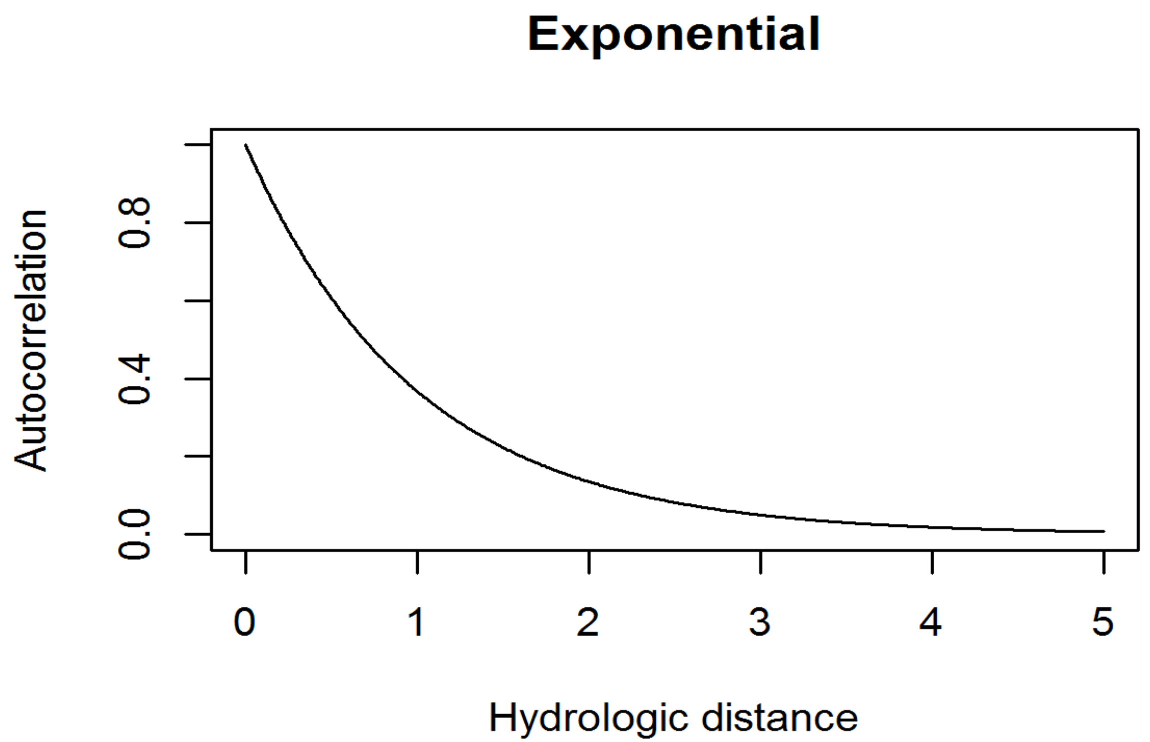
How similar we would expect the Temperature to be at two stations just because they are close to each other



SSN Model

How is it used?

Estimate the relationship using a function



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SSN Model

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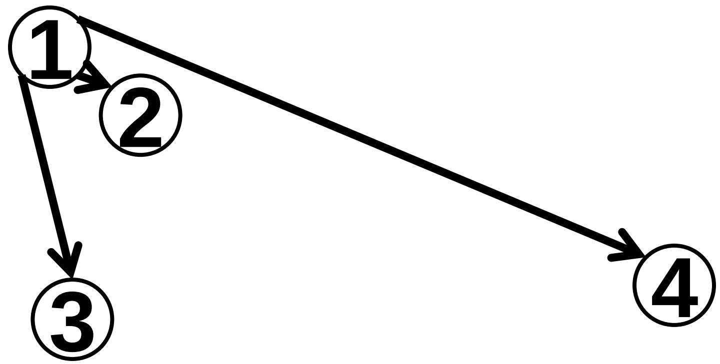

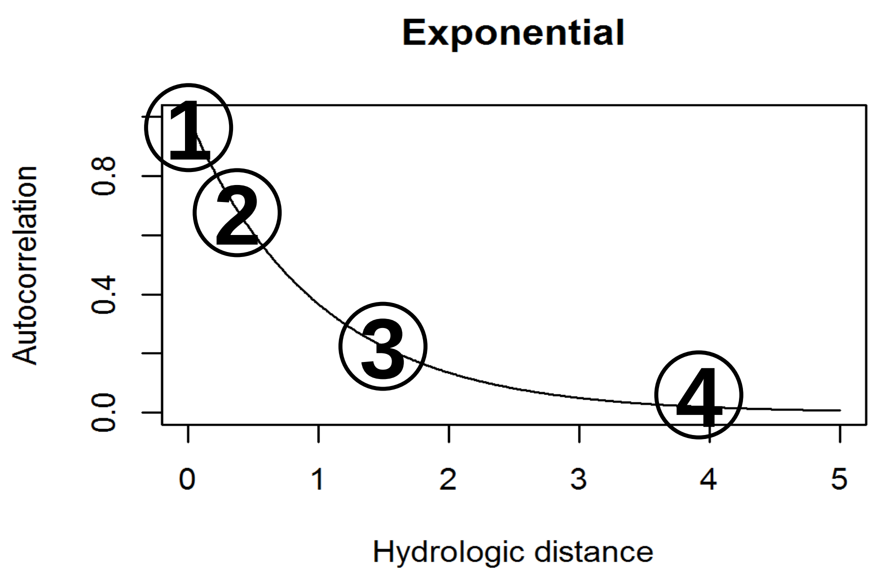

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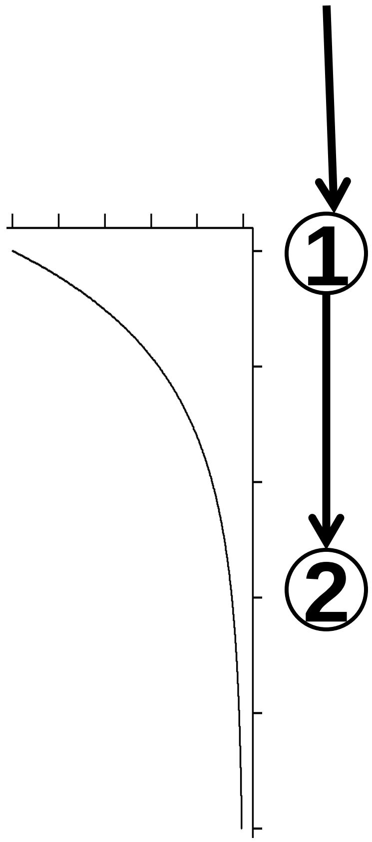
SSN Model

How is it used?

Apply the function in 3 contexts for stream networks and combine with within site variability

- **Tail down**
- Tail up



SSN Model

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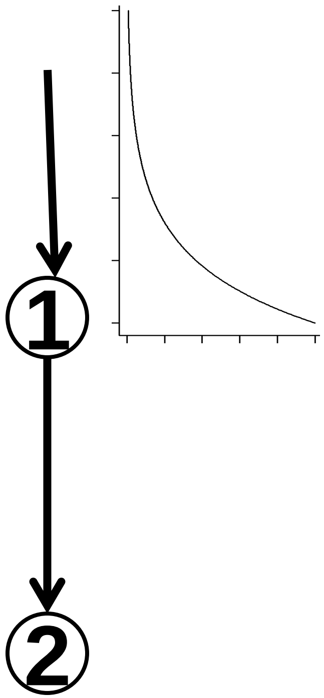


SSN Model

Response variables:

- Mean Monthly Daily Maximum Temperature
- Mean Monthly Daily Minimum Temperature
- 327 stations

Candidate explanatory variables:

- Elevation
- Drainage Density
- Stream Slope
- Watershed Area
- Base Flow Index
- Mean Monthly Flow
- Daily Solar Flux
- Area Disturbed (%)

SSN Model

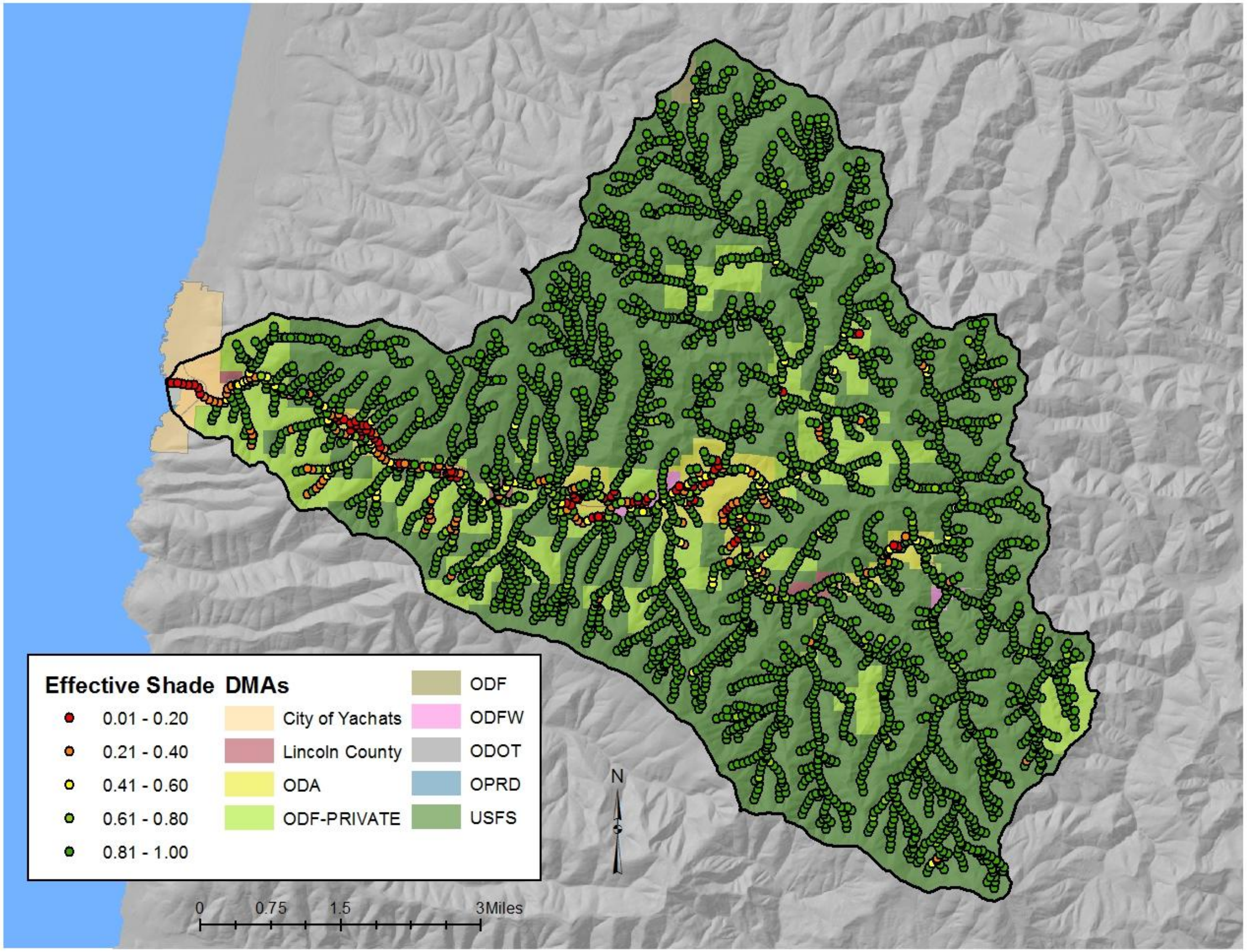
How will the SSN model be used?

- Identify sources of warming in the Tributaries
- Evaluate management scenarios and temperature response
- Estimate tributary temperatures for Yachats River

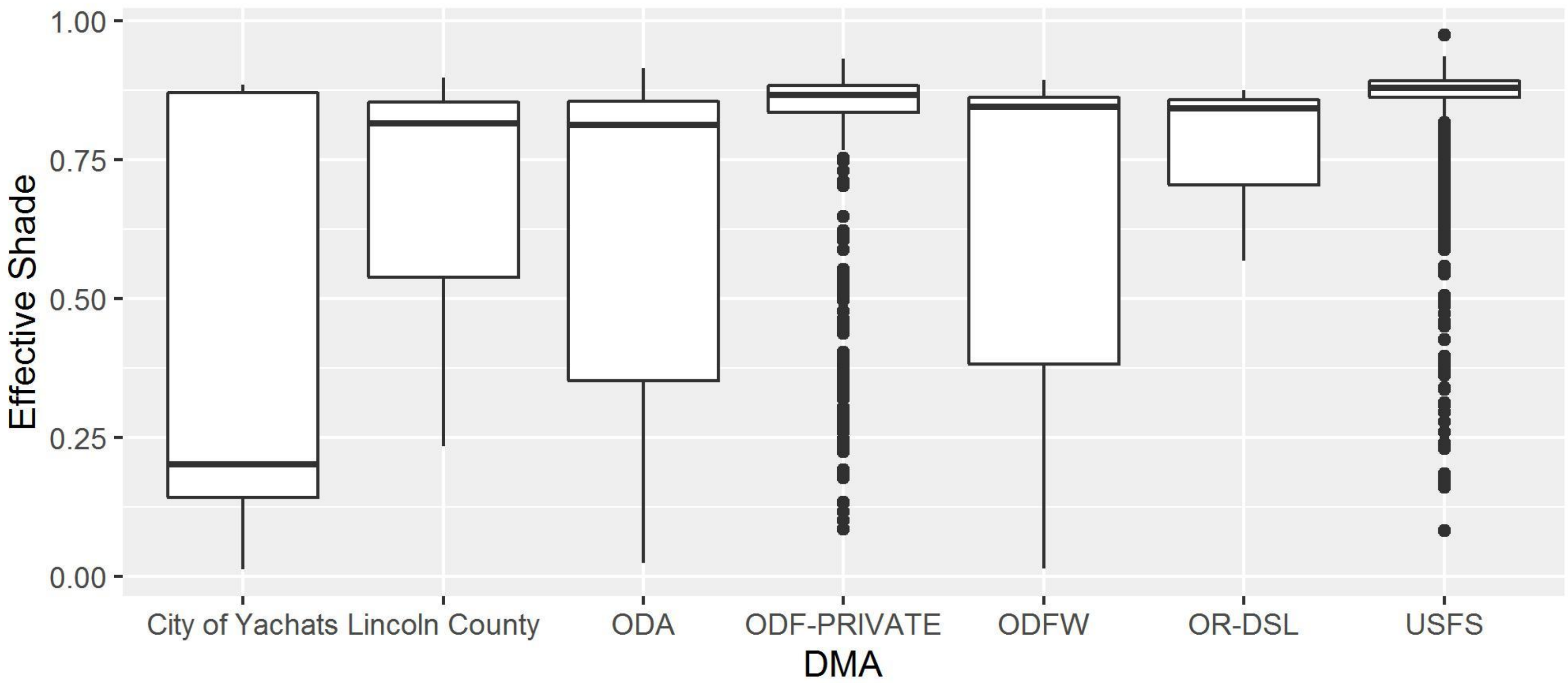
Also:

Characterize Solar Flux and Effective Shade in tributaries

Solar Flux / Effective Shade Modeling



Yachats River Watershed Current Effective Shade



Next Steps

Starting now through summer 2017

- TWG feedback on the Calibration and Scenario Report
- DEQ will contact DMAs to discuss implementation planning
- DEQ will distribute a draft of the TMDL allocation approach and distribution of human use allowance
- DEQ will complete SSN model and documentation

Feedback on the Report

Missing Data: Is there currently available data that is missing from the model calibration?

Withdrawals: Based on your understanding of the system is the rate and timing of the water withdrawals accurately represented?

Restored Vegetation: Is a hardwood/conifer mix and the resulting composite height (36.6 m) appropriate restored vegetation along the Yachats River?

Documentation: What can be improved with the plots or narrative to help the reader more clearly understand the methods, data used, or the results?

Thank You!

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