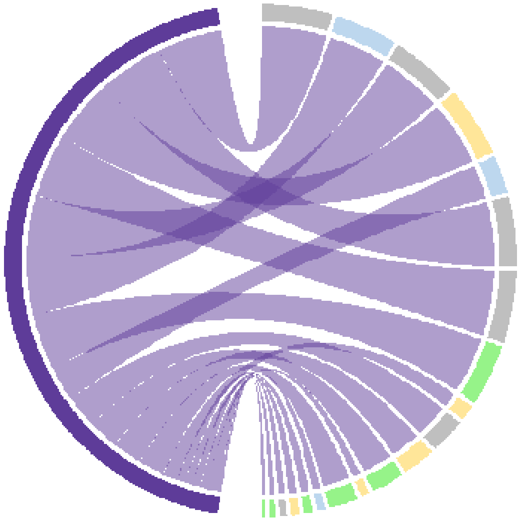
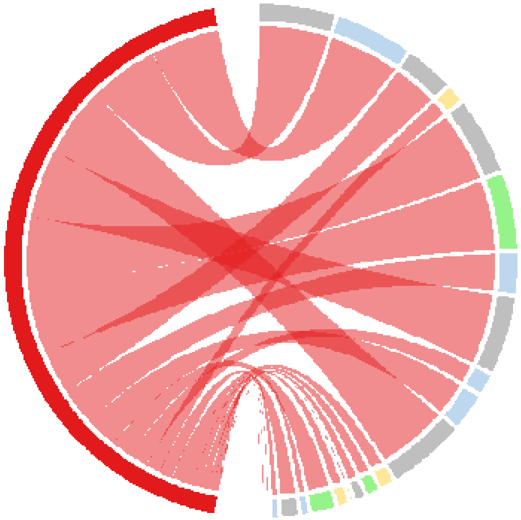
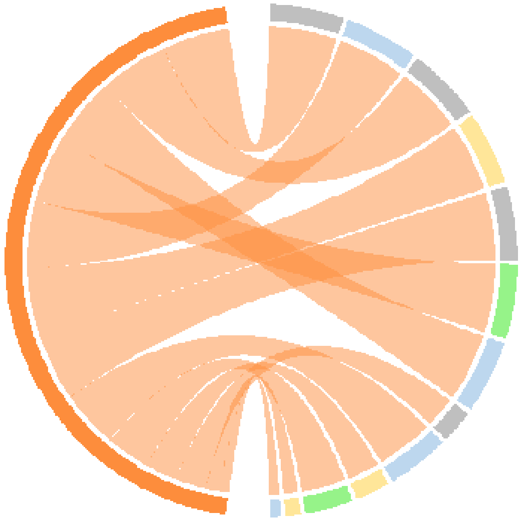
Introduction to R10 RARE temperature TMDL SSN models

SSN Workshop 2019

Session 3

Overview

1. R10 RARE Big Cold Small Cold Project temp. TMDL SSNs
2. Refit NorWeST with alternate and additional covariates
3. Present a model selection process for SSN
4. Explain model averaged predictions
5. Compare management scenario predictions

US EPA Region 10 R.A.R.E.[1]

Big Cold Small Cold Project

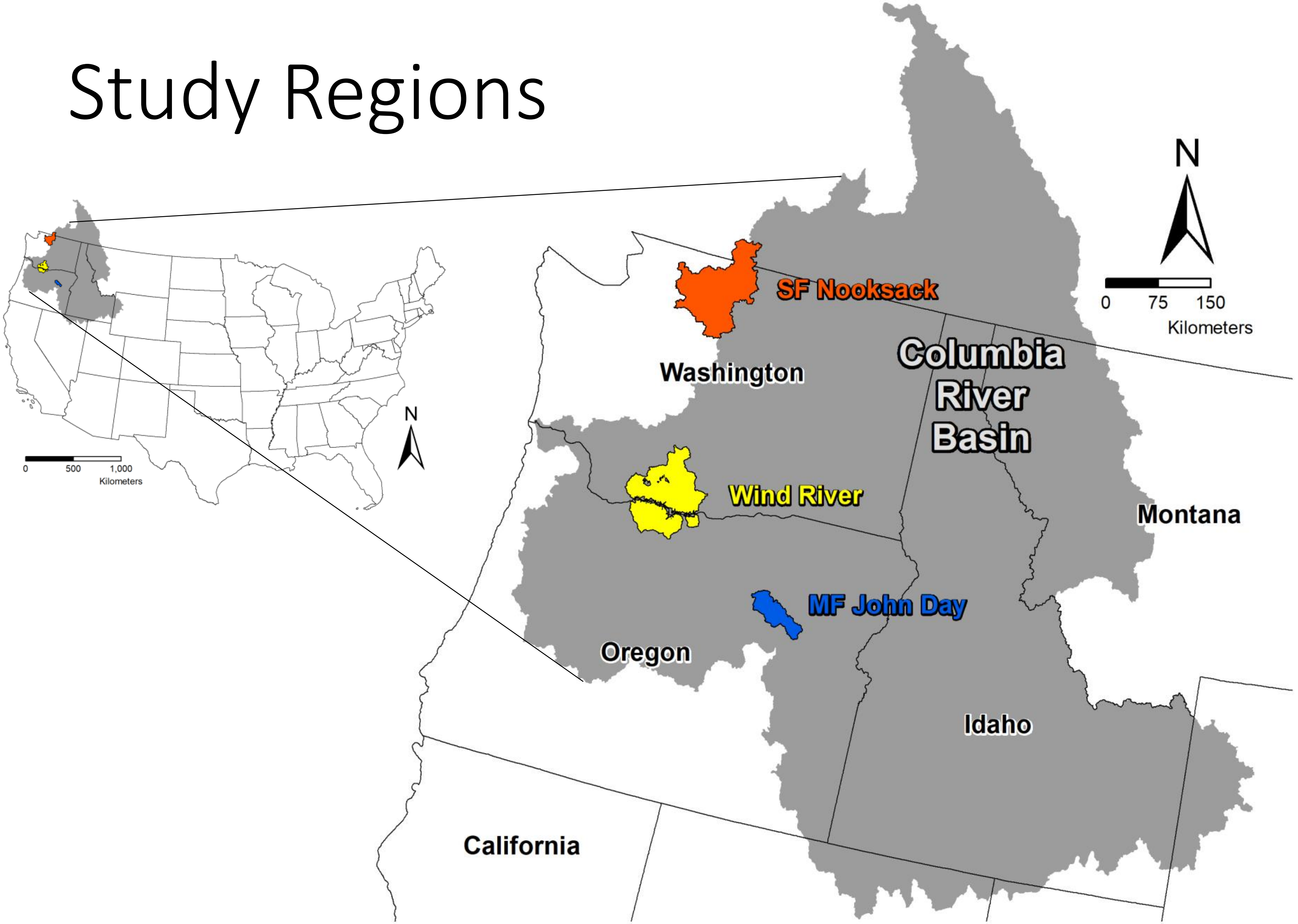
Proposal:

- To tailor the NorWeST August stream temperature SSN model[1] to small study regions

[1] Isaak et al. 2017 WRR

NorWeST website - https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html

Study Regions



Proposal and Products

Proposal:

- To tailor the NorWeST August stream temperature SSN model[1] to small study regions using additional and/or alternate covariates

Potential products from the research:

1. A more thorough understanding of local temperature controls

[1] Isaak et al. 2017 WRR

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Proposal and Products

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- To tailor the NorWeST August stream temperature SSN model[1] to small study regions using additional and/or alternate covariates and extend to May & September.

Potential products from the research:

1. A more thorough understanding of local temperature controls
2. Temporal differences in drivers controlling stream temperature

[1] Isaak et al. 2017 WRR

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Proposal and Products

Proposal:

- To tailor the NorWeST August stream temperature SSN model[1] to small study regions using additional and/or alternate covariates and extend to May & September.

Potential products from the research:

1. A more thorough understanding of local temperature controls
2. Temporal differences in drivers controlling stream temperature
3. More precisely inform local habitat restoration

[1] Isaak et al. 2017 WRR

NorWeST website - https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html

Model selection and fitting process

Fit NorWeST covariates

- Prop. Glacier
- Prop. Lake
- Elevation
- Drainage area
- Latitude
- Reach slope
- Base Flow Index
- Precipitation
- Discharge
- Tailwater

FORCED:
- Air temp
- Canopy

Fit all possible combinations

Substitute new covariates

NorWeST	New Alternates
Discharge	Area normalized discharge; Stream flow volume
Base Flow Index	Base flow recession coefficient; Avg. hydraulic conductivity; Prop. high hydraulic conductivity class; Cold water springs; Geothermal activity/Hot springs
Reach slope	Main channel slope

Add interactions

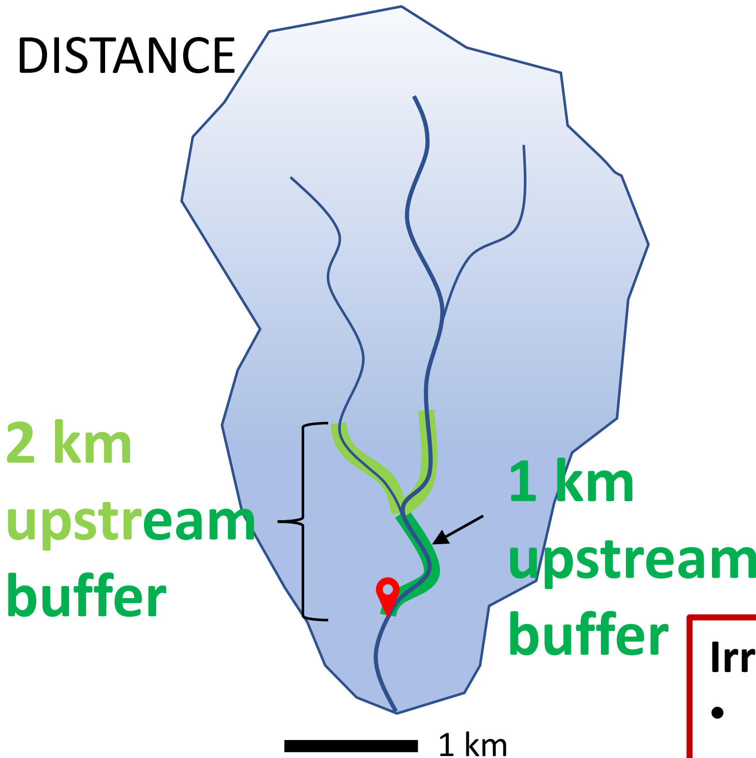
slope and GW influence covariate interaction examples

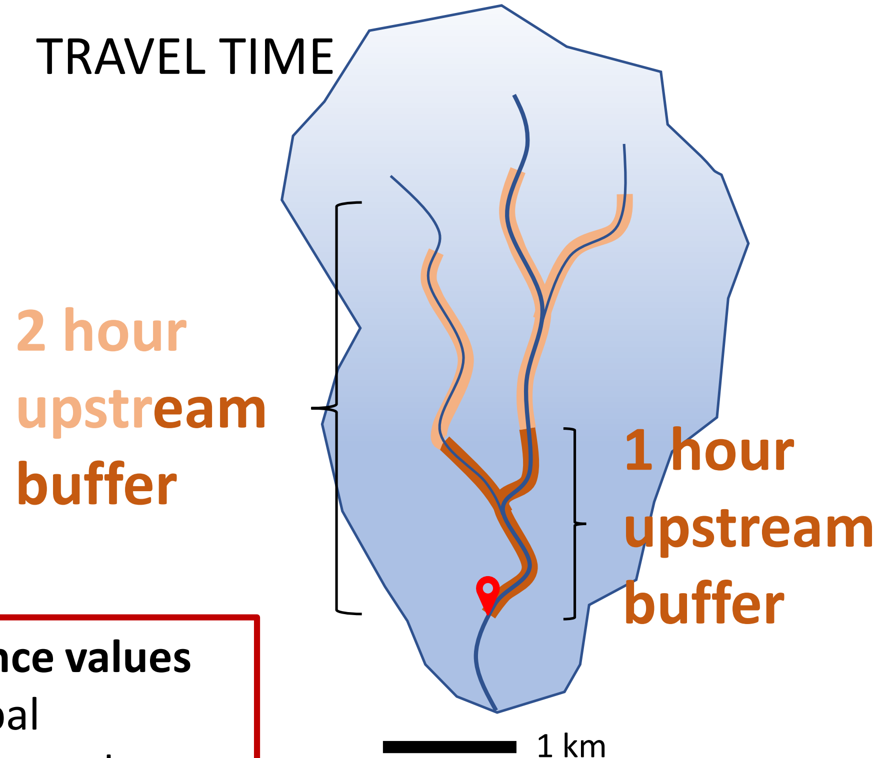
Reach slope : Base Flow Index or Main channel slope : Base Flow Index

Substitute shade

Canopy → 79 other shade/insolation covariates

Upstream Shade Buffers





Distance Buffers

- 1km
- 2km
- 3km
- 4km
- 5km
- 10km
- Full watershed

Irradiance values

- Global Horizontal Irradiance (GHI)
- Direct Normal Irradiance (DNI)
- Both GHI/DNI clear-sky and cloudy

Time Buffers

- 1hr
- 2hr
- 3hr
- 4hr
- 5hr
- 6hr
- 12hr
- 24hr

Model selection and fitting process

Fit NorWeST covariates

Prop. Glacier
Prop. Lake
Elevation
Drainage area

Latitude
Reach slope
Base Flow Index

Precipitation
Discharge
Tailwater

FORCED: Air temp, Canopy

Fit all possible combinations

Substitute new covariates

NorWeST	New Alternates
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Substitute shade

Canopy → 79 other shade/insolation covariates

Add management

Ground water use
Irrigated crop H_2O loss
Surface water use
Wastewater treatment plant surface water returns

Fit all possible combinations

Suite of best models

Model statistic to compare different model fits:
Akaike Information Criterion (AIC) – lower is better

Suite of models (All within 3 AIC units of the lowest AIC)

Suite of best models

Model statistic to compare different model fits:

Akaike Information Criterion (AIC) – lower is better

Suite of models (All within 3 AIC units of the lowest AIC)

Model 1 AIC=32
Model 2 AIC=32.25
Model 3 AIC=34
Model 4 AIC=35
~~Model 5 AIC=35.5~~
~~Model 6 AIC=35.6~~
~~Model 7 AIC=38~~
~~Model 8 AIC=38.25~~
~~Model 9 AIC=39~~
~~Model 10 AIC=41~~

Suite of best models

Model statistic to compare different model fits:

Akaike Information Criterion (AIC) – lower is better

Suite of models (All within 3 AIC units of the lowest AIC)

Model 1	AIC=32	OBS. TEMP ~ Prop. Glacier + Latitude + Precipitation + Reach slope
Model 2	AIC=32.25	OBS. TEMP ~ Prop. Glacier + Tailwater + Base flow Index : Reach slope
Model 3	AIC=34	OBS. TEMP ~ Latitude + Drainage area + Area norm. Q
Model 4	AIC=35	OBS. TEMP ~ Prop. Lake + Latitude + Precipitation + Ground water use
~~Model 5~~	~~AIC=35.5~~	OBS. TEMP ~ Prop. Lake + Latitude + discharge + surface water use
~~Model 6~~	~~AIC=35.6~~	OBS. TEMP ~ Shade 1km + Latitude + mc slope : Reach slope
~~Model 7~~	~~AIC=38~~	OBS. TEMP ~ Prop. Glacier + Tailwater + Precipitation + Reach slope
~~Model 8~~	~~AIC=38.25~~	OBS. TEMP ~ elevation + Drainage area + discharge
~~Model 9~~	~~AIC=39~~	OBS. TEMP ~ Prop. Lake + Tailwater + Precipitation + Ground water use
~~Model 10~~	~~AIC=41~~	OBS. TEMP ~ Shade 1hr + Latitude + Discharge + Surface water use

Suite of best models

Model statistic to compare different model fits:
Akaike Information Criterion (AIC) – lower is better

Suite of models (All within 3 AIC units of the lowest AIC)

Model 1 AIC=32 OBS. TEMP ~ Prop. Glacier + Latitude + Precipitation + Reach slope

Repeat selection process for each month in each basin

Model 4 AIC=35 OBS. TEMP ~ Prop. Lake + Latitude + Precipitation + Ground water use

~~Model 5 AIC=35.5~~ OBS. TEMP ~ Prop. Lake + Latitude + discharge + surface water use

~~Model 6 AIC=35.6~~ OBS. TEMP ~ Shade 1km + Latitude + mc slope : Reach slope

~~Model 7 AIC=38~~ OBS. TEMP ~ Prop. Glacier + Tailwater + Precipitation + Reach slope

Allowing covariates to “compete” with each other

~~Model 10 AIC=41~~ OBS. TEMP ~ Shade 1hr + Latitude + Discharge + Surface water use

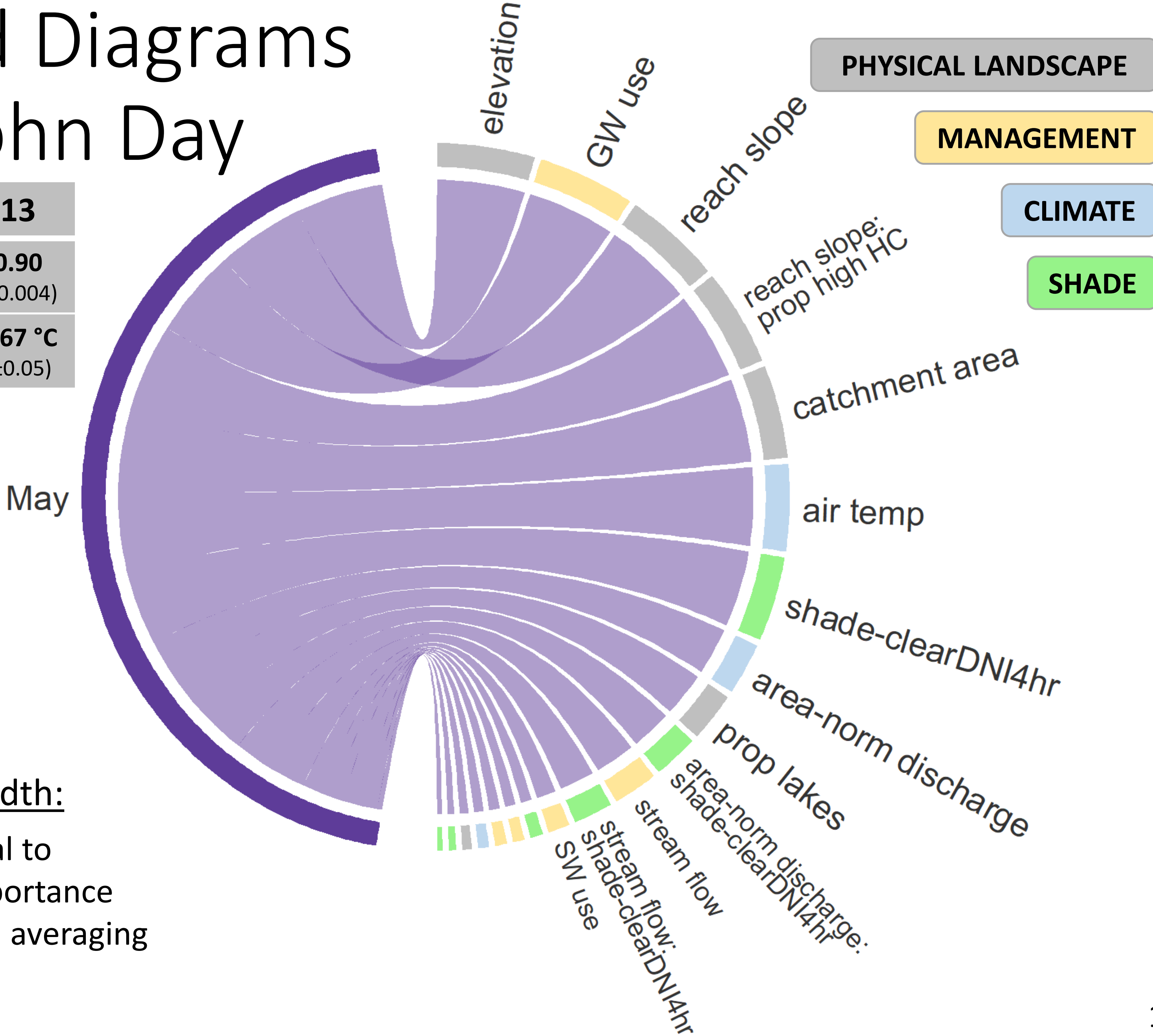
Fit Summary of Best Model Suites

Basin	Month	# models	Avg. Gen. R^2 (±SD)	Avg. RMSPE °C (±SD)
MFJD	**May**	13	0.90 (±0.003)	0.67 (±0.060)
	August	53	0.66 (±0.002)	1.02 (±0.008)
	September	15	0.75 (±0.014)	0.82 (±0.009)
SFNR	**August**	24	0.55 (±0.048)	1.44 (±0.212)
	September	14	0.92 (±0.017)	0.84 (±0.041)
WR	**May**	16	0.80 (±0.004)	0.89 (±0.010)
	August	20	0.49 (±0.020)	1.28 (±0.017)
	September	13	0.57 (±0.007)	1.17 (±0.006)

(Higher is better) (Lower is better)

Chord Diagrams
MF John Day

Models	13
Gen. R^2	0.90 (±0.004)
RMSPE	0.67 °C (±0.05)

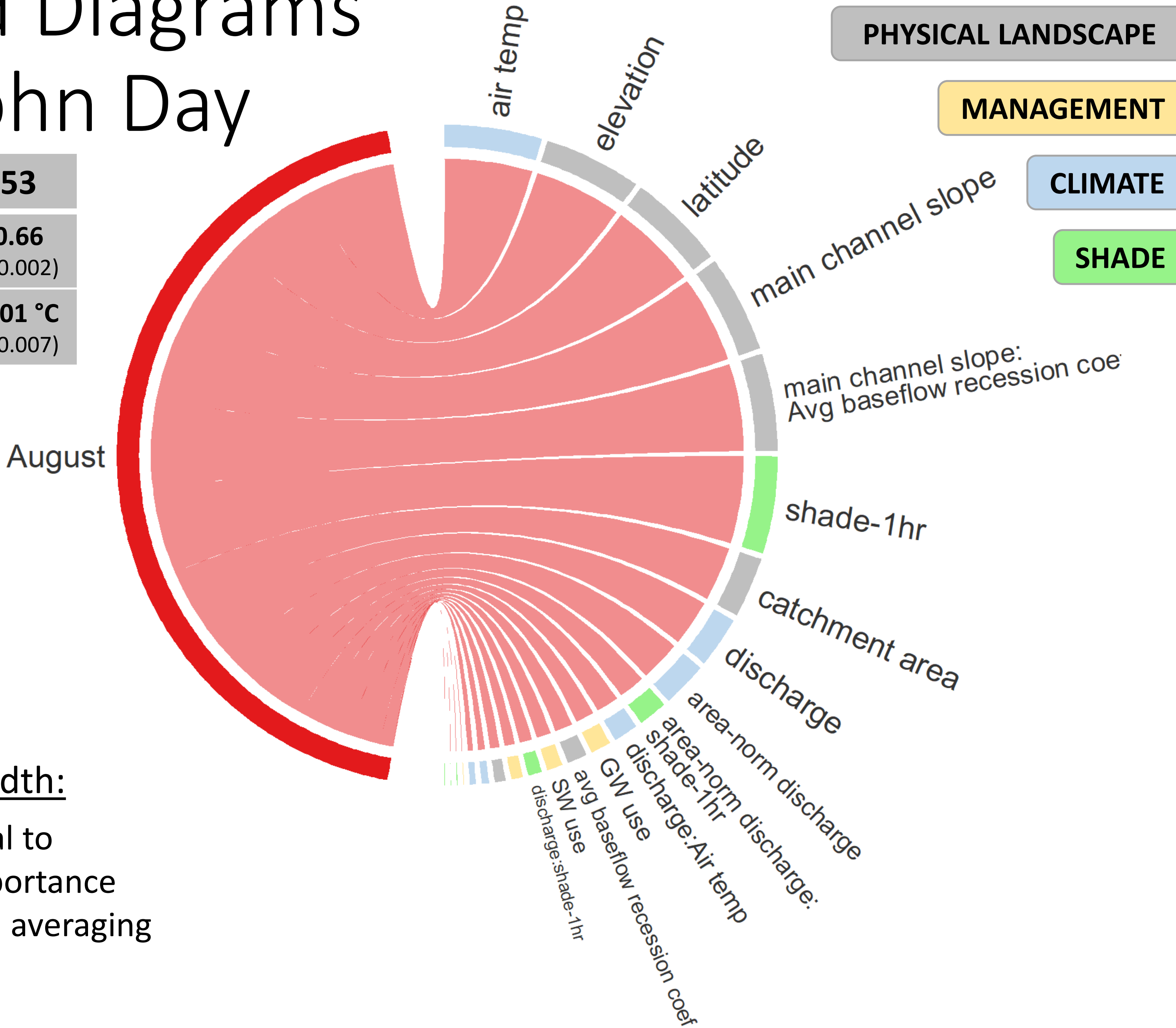


Ribbon Width:

Proportional to relative importance from model averaging AIC weights

Chord Diagrams
MF John Day

Models	53
Gen. R^2	0.66 (±0.002)
RMSPE	1.01 °C (±0.007)

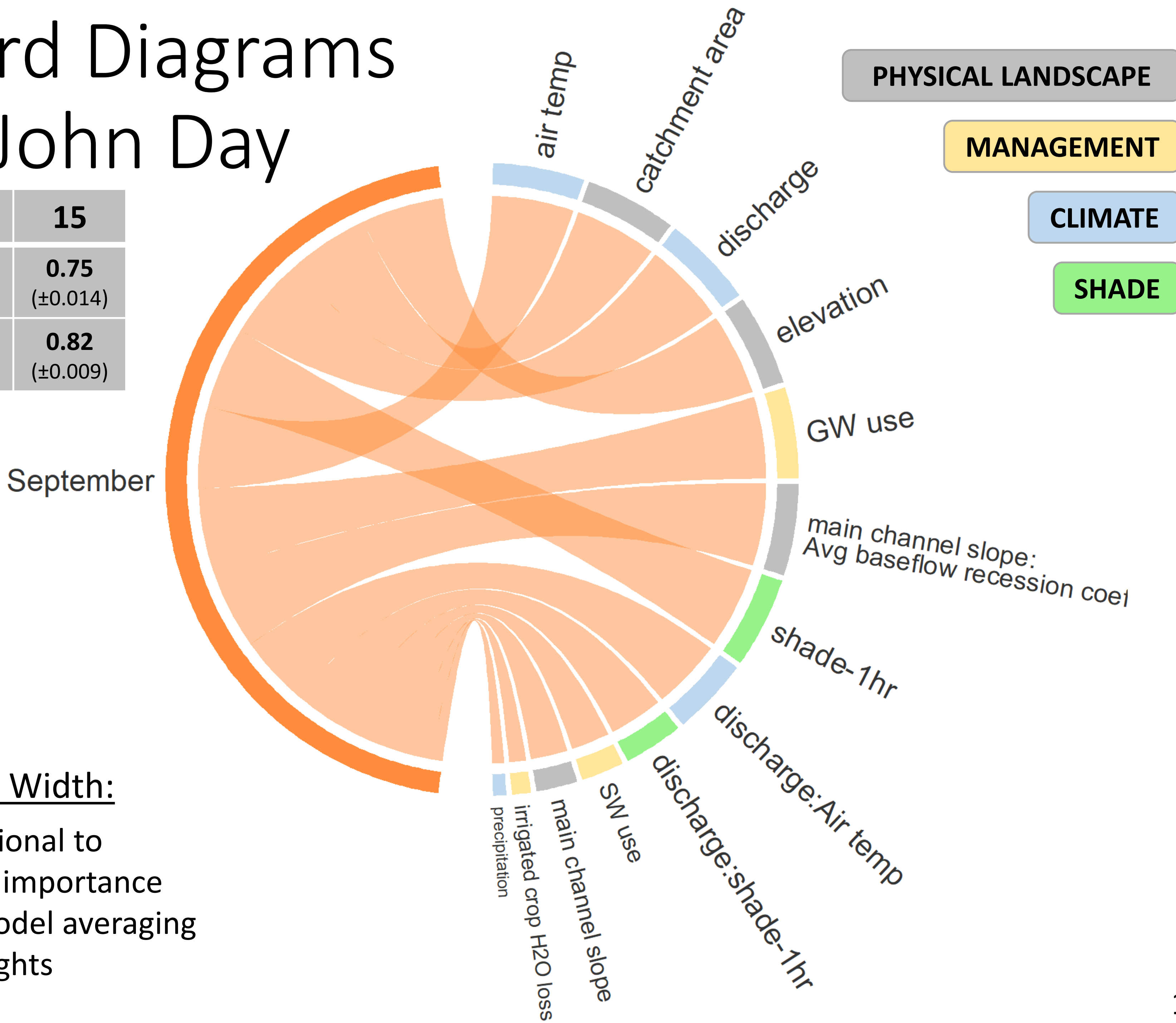


Ribbon Width:

Proportional to relative importance from model averaging AIC weights

Chord Diagrams MF John Day

Models	15
Gen. R^2	0.75 (±0.014)
RMSPE	0.82 (±0.009)



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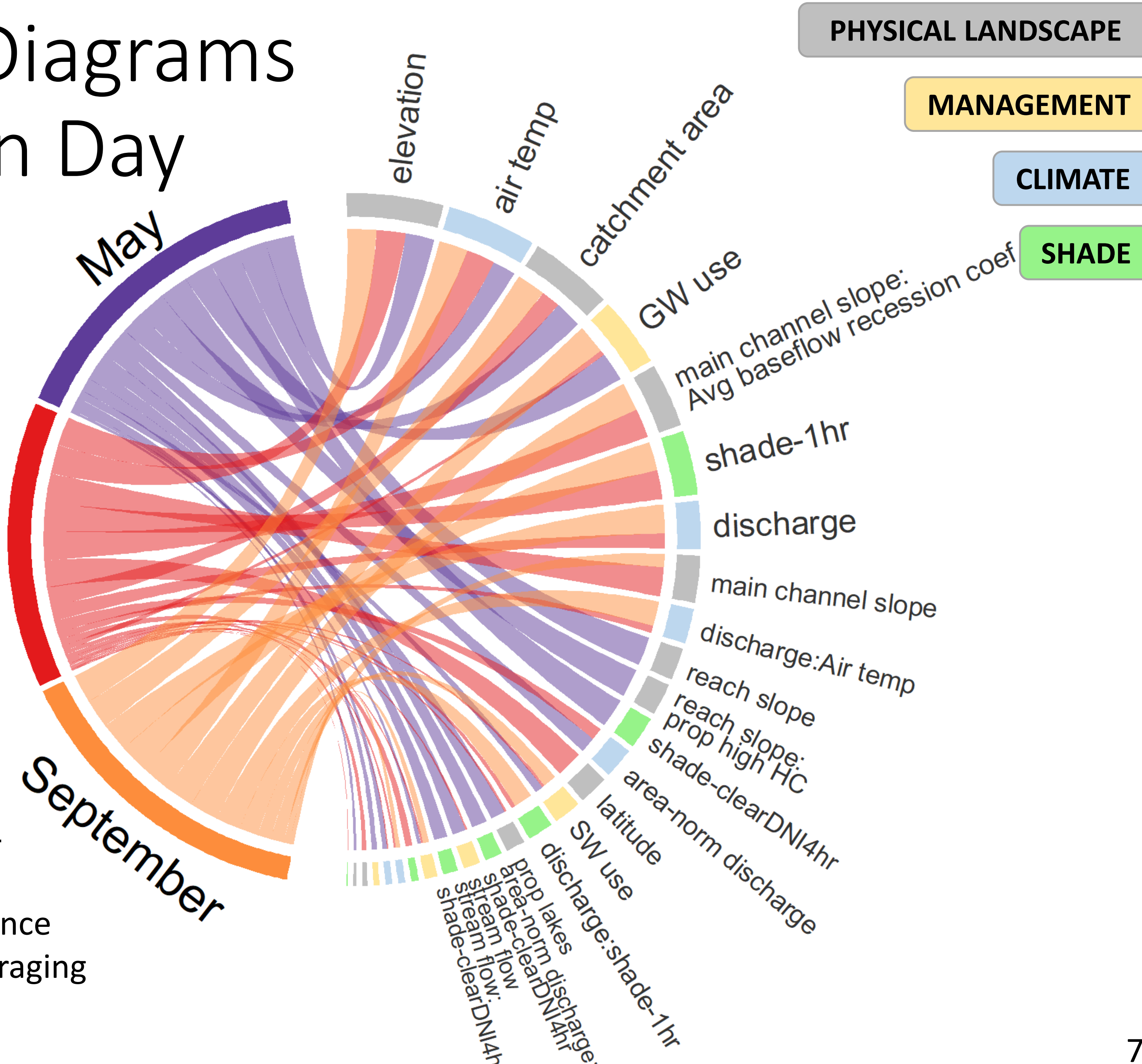
Chord Diagrams MF John Day



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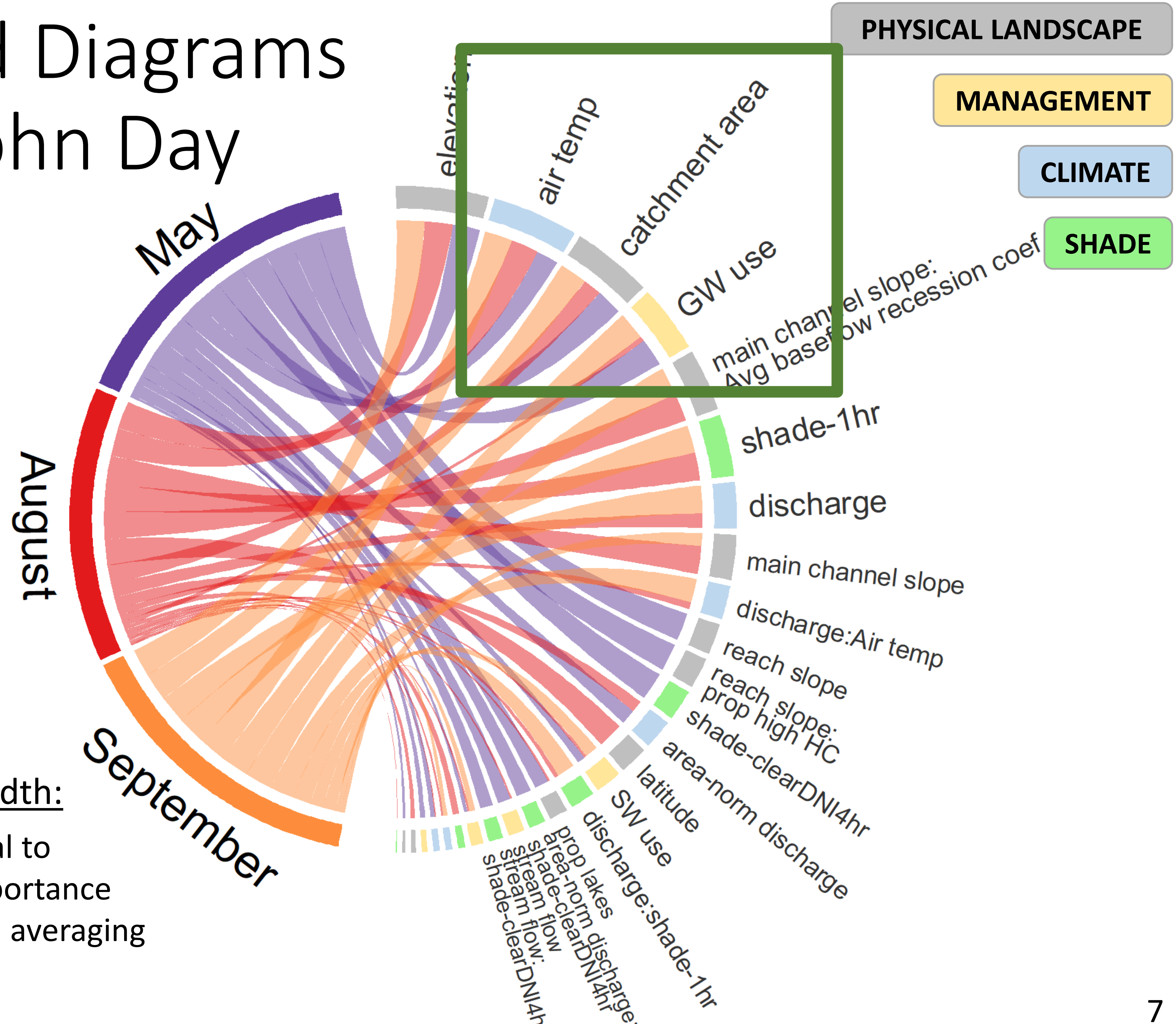
Chord Diagrams MF John Day



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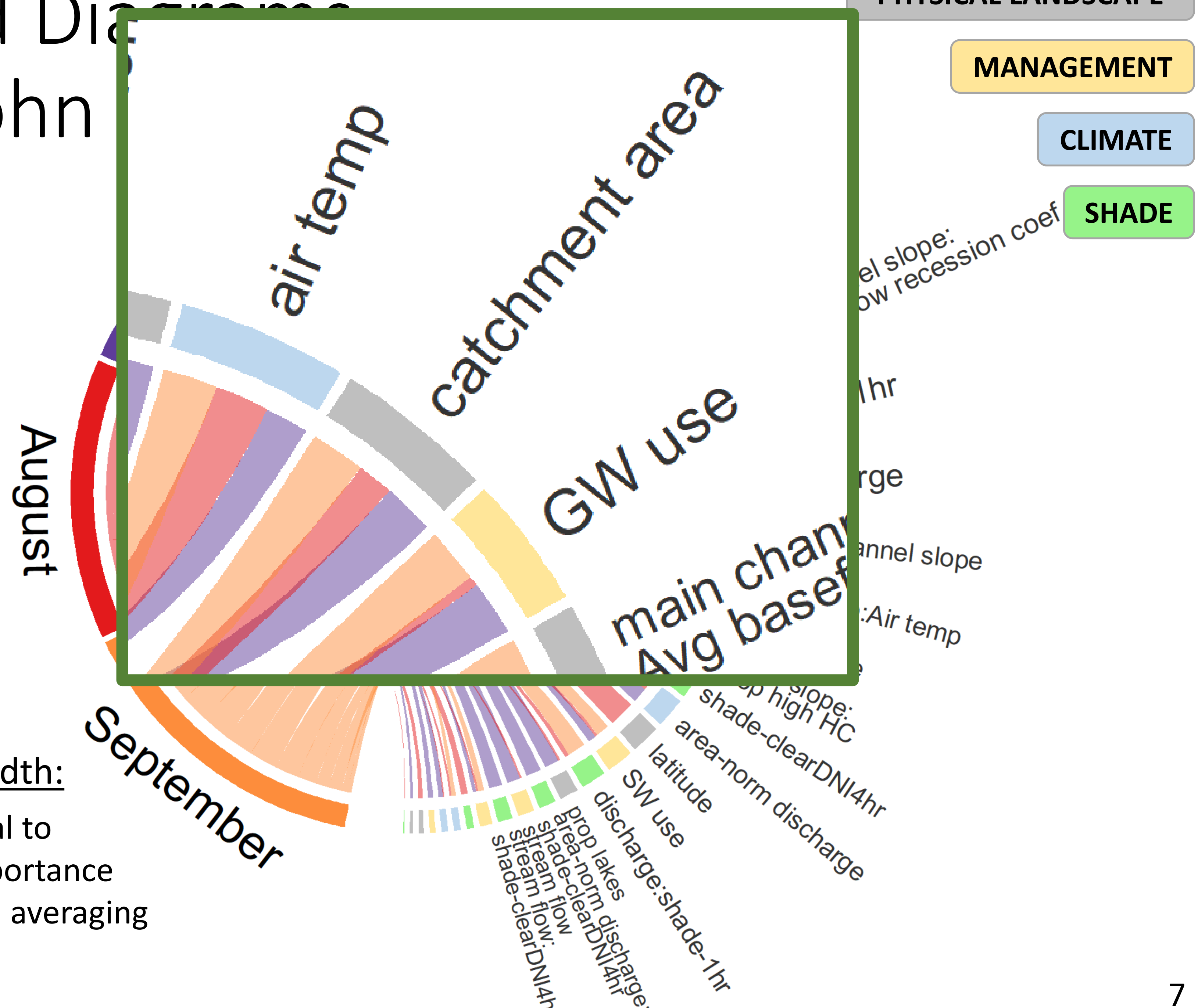
Chord Dia
MF John



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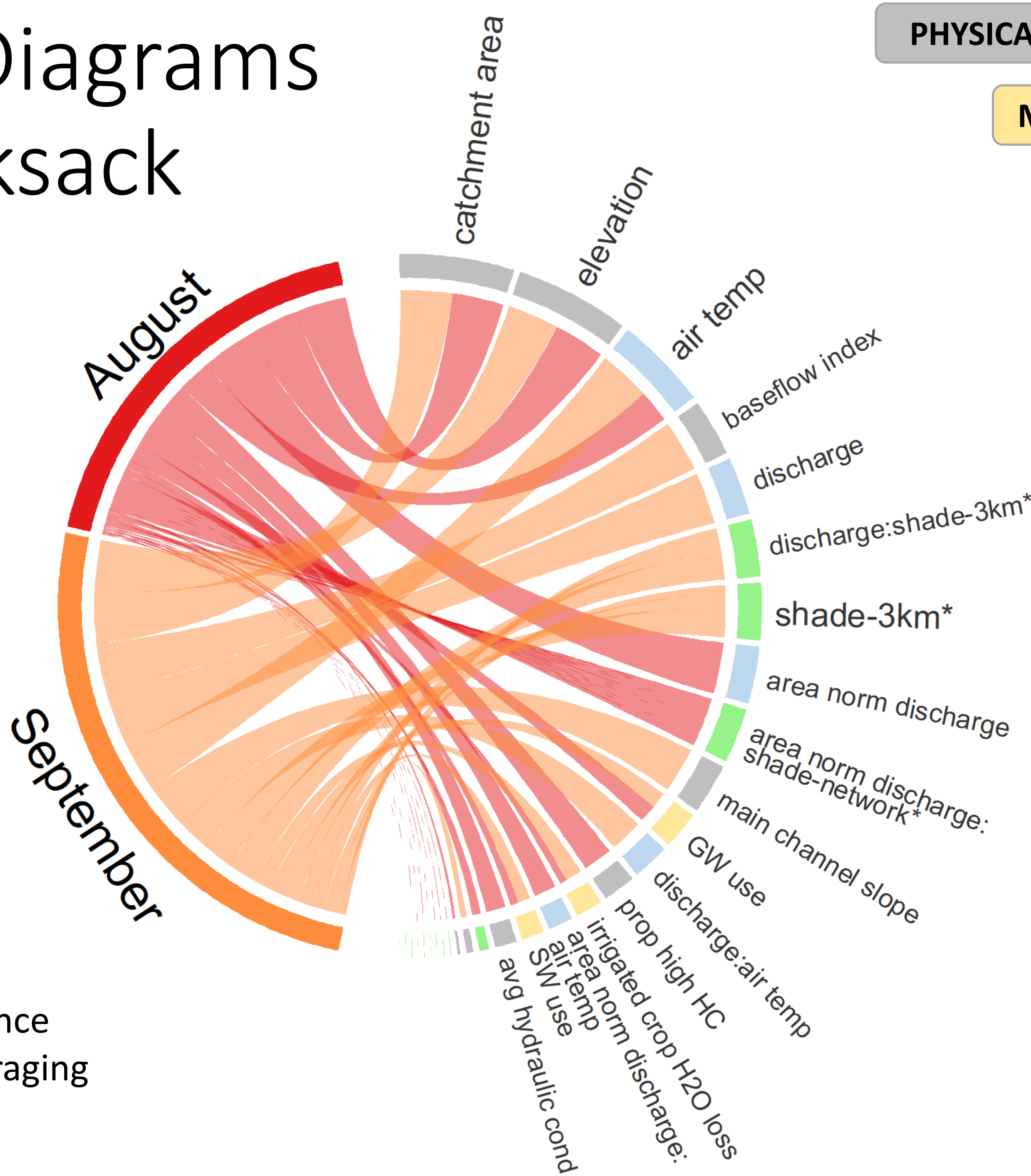
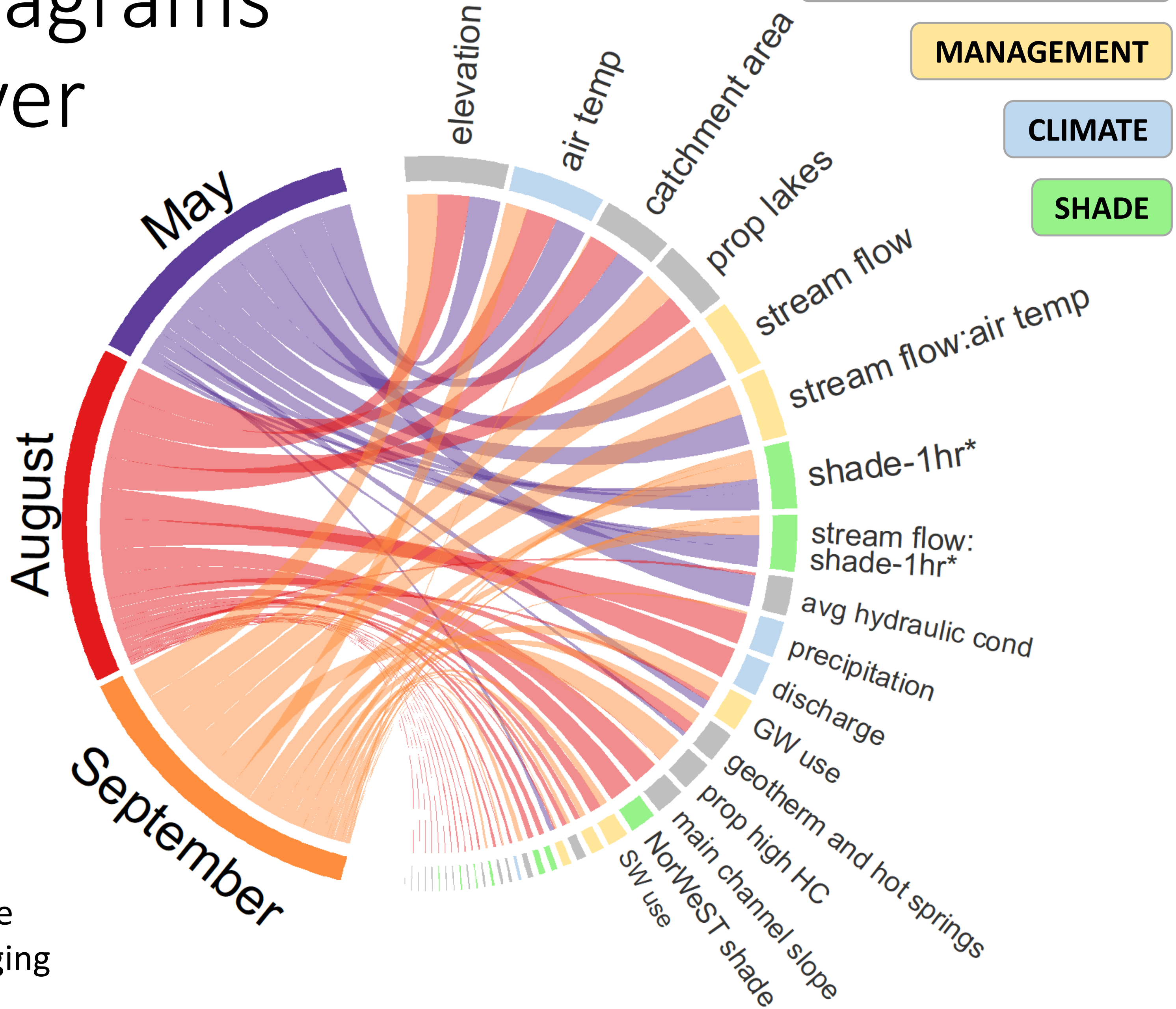
Chord Diagrams
SF Nooksack



<u>Ribbon Width:</u>

Proportional to relative importance from model averaging AIC weights

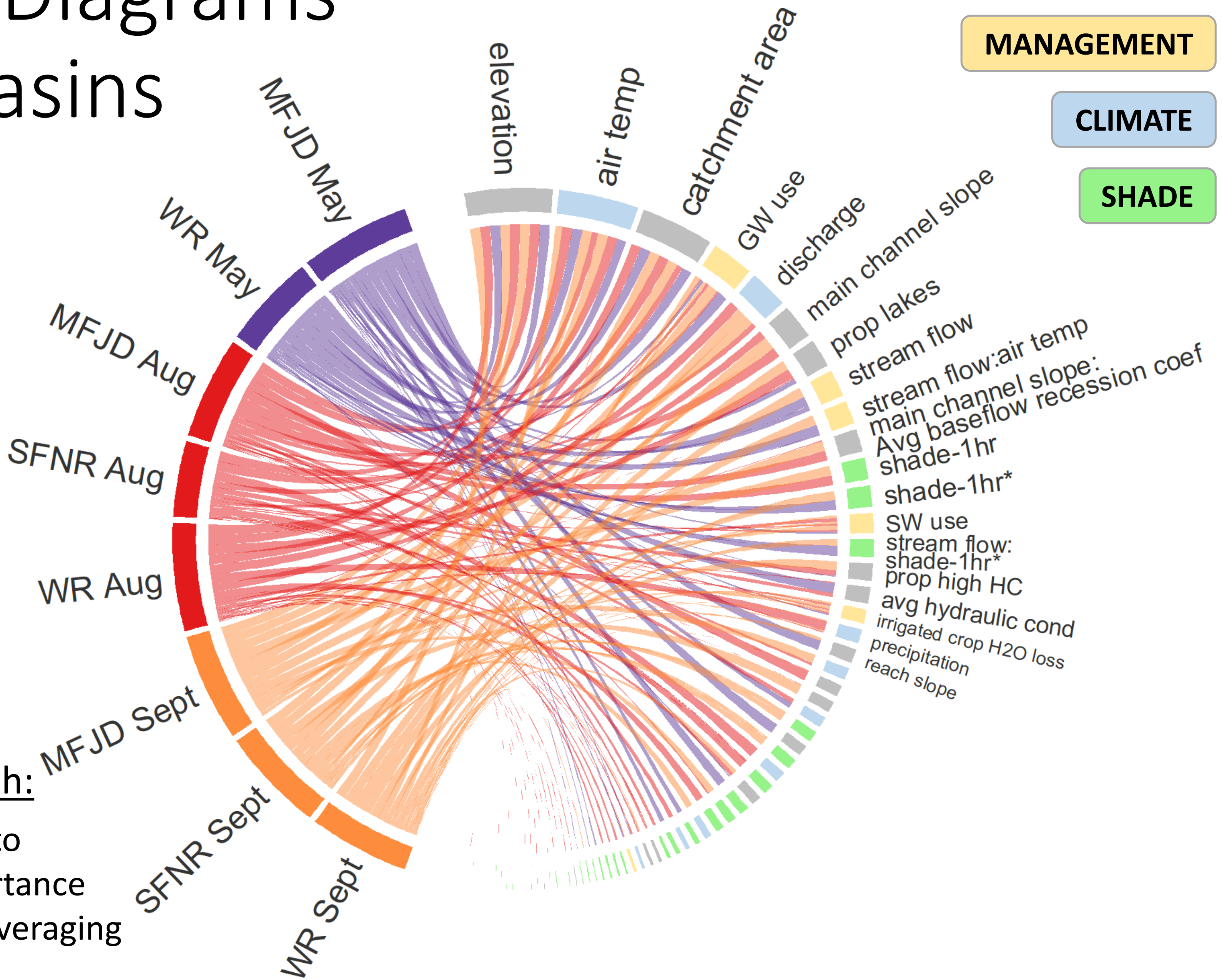
Chord Diagrams
Wind River



Ribbon Width:

Proportional to relative importance from model averaging AIC weights

Chord Diagrams All 3 Basins



Ribbon Width:

Proportional to relative importance from model averaging AIC weights

Summary of chord diagrams

Relatively Important covariates:

In ALL three study areas:

Elevation | Air temp | Drainage area → NorWeST

Shade of some kind

Flow of some kind

MF John Day	SF Nooksack	Wind River
Shade – 1hr or Shade – 4hr	Shade – 3km or Shade – 12hr	Shade – 1hr or Shade – 2km or Shade – Clear-sky DNI
Discharge or Area normalized discharge or Stream flow	Discharge	Discharge or Stream flow

UNIQUE to each area:

MF John Day	SF Nooksack	Wind River
Ground water use	Base Flow Index	Geothermal/Hot Springs

Model Averaging Predictions

glmssn_object	AIC	AIC_weight_i
best_model_1	114.6	0.1874
best_model_2	115	0.1474
best_model_3	115.9	0.09677
best_model_4	116.1	0.08532
best_model_6	116.4	0.07492
best_model_5	116.5	0.0692
best_model_12	117	0.05612
best_model_8	117	0.05528
best_model_10	117	0.05526
best_model_11	117.1	0.05138
best_model_9	117.4	0.04597
best_model_7	117.7	0.03928
best_model_13	117.9	0.03571

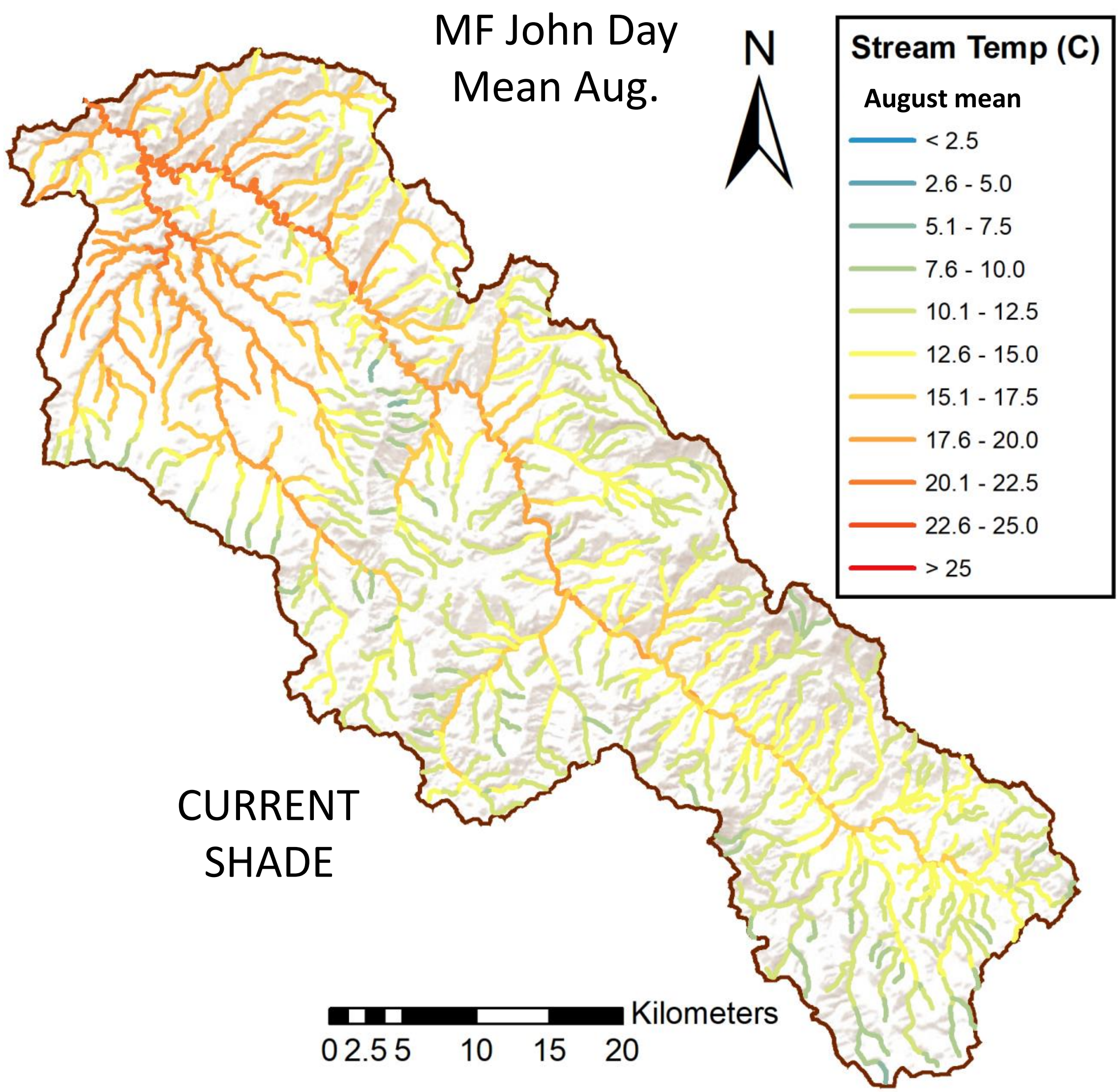
For model averaging details see:
Burnham and Anderson 2002

Model Averaging Predictions

MF John Day

Mean August

Historical average
(1990-2015)



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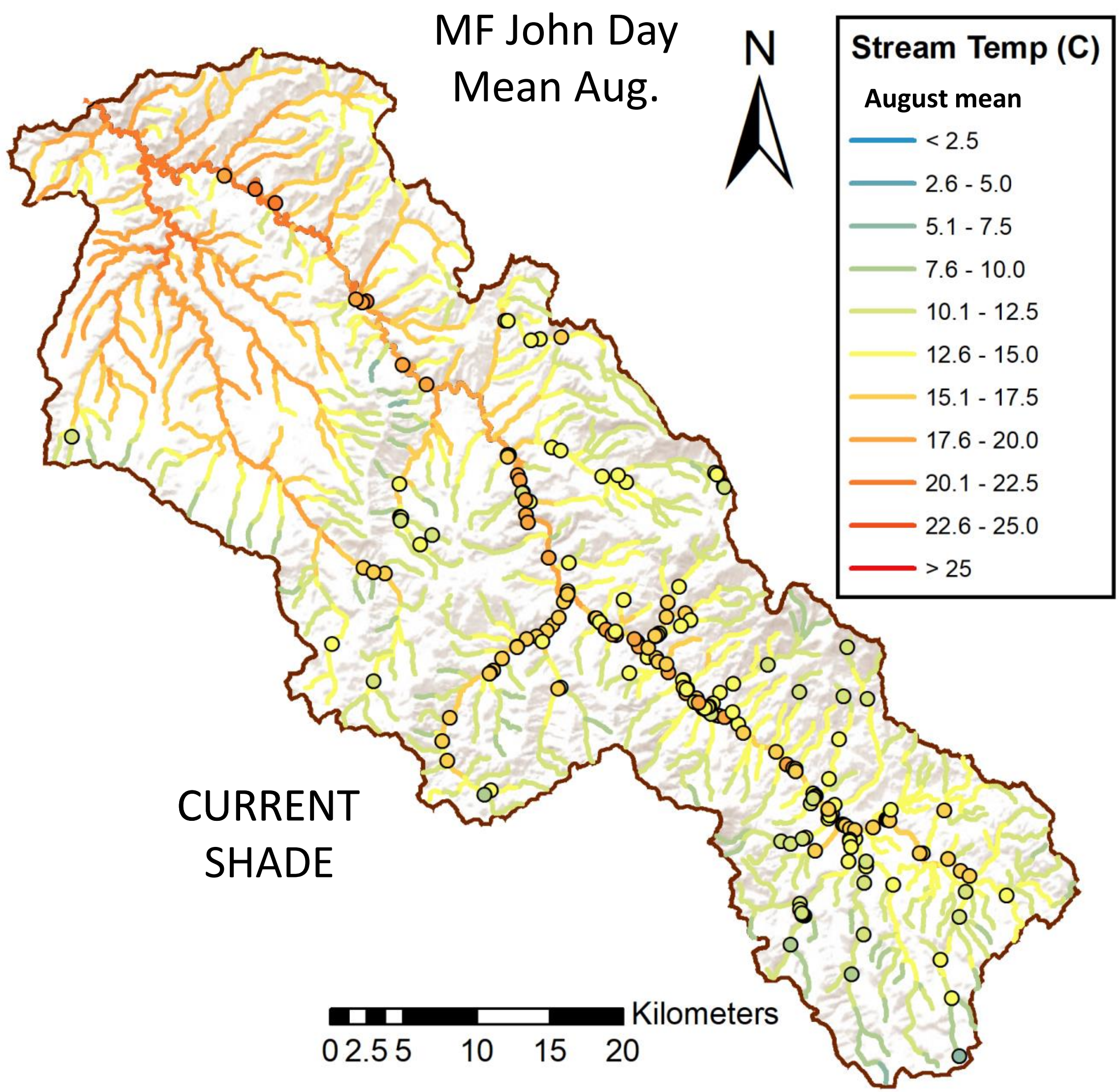
How good are these predictions?



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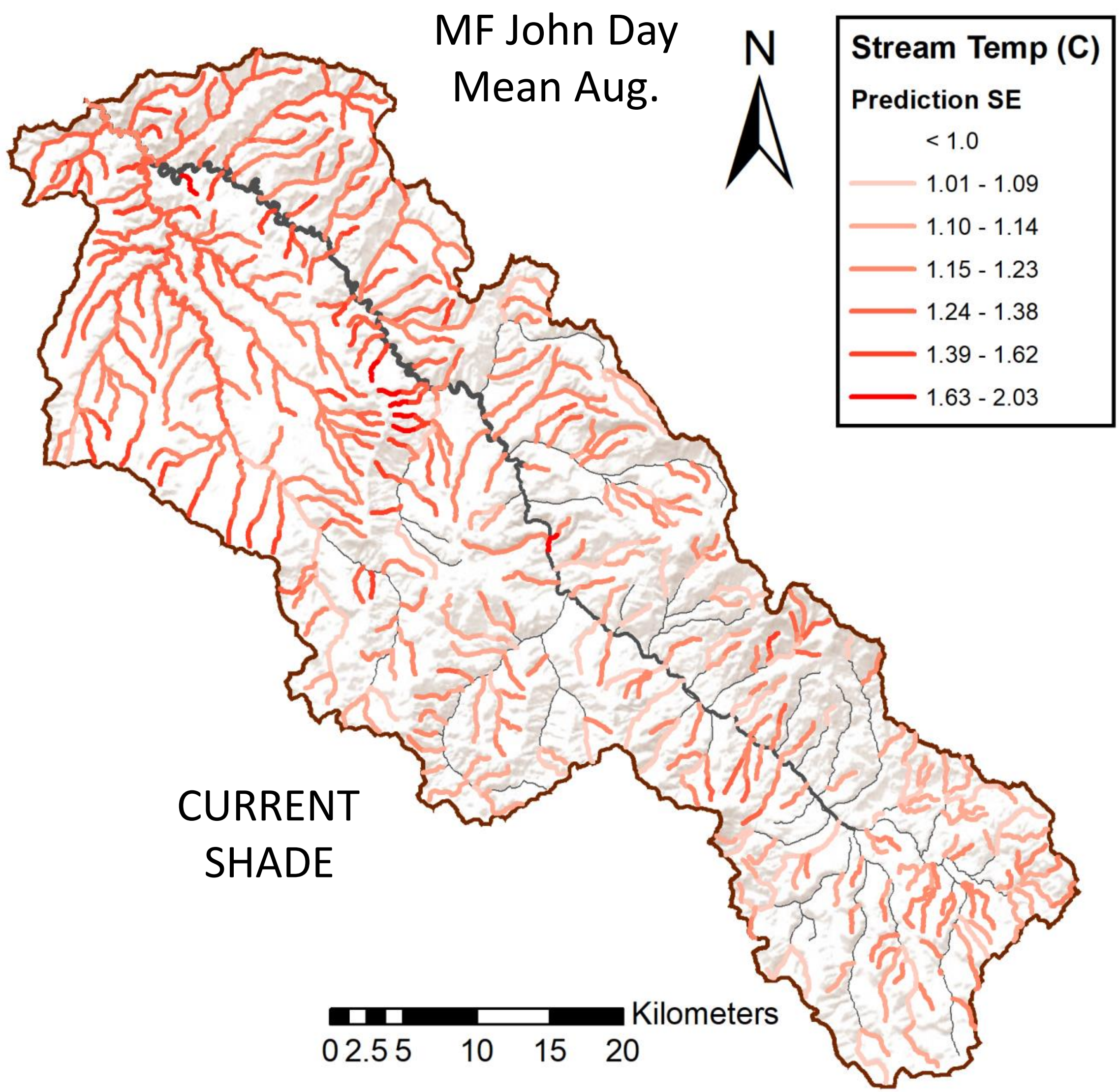

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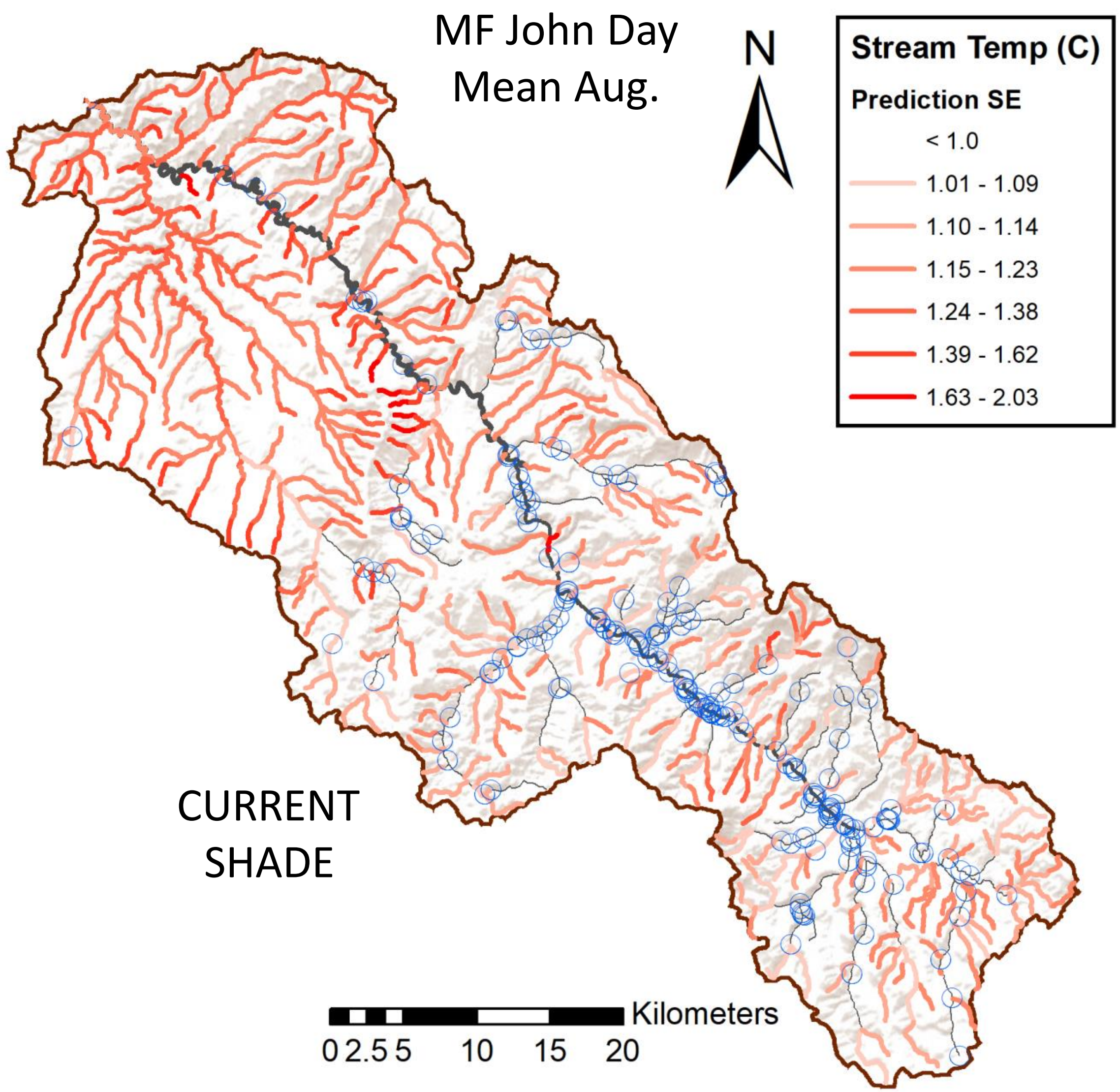

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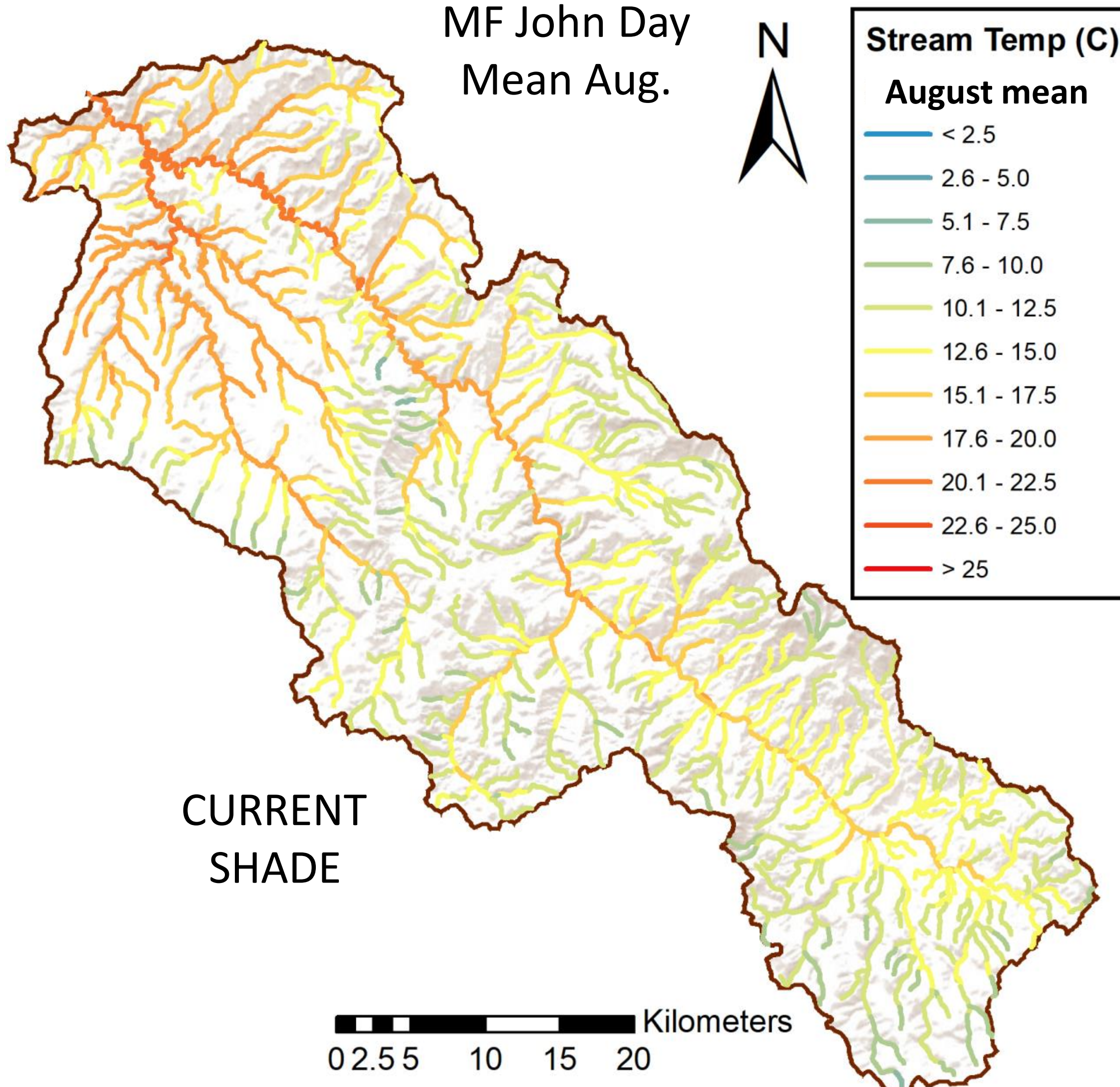

Management Scenarios:

- Riparian shade

For model averaging details see:
Burnham and Anderson 2002

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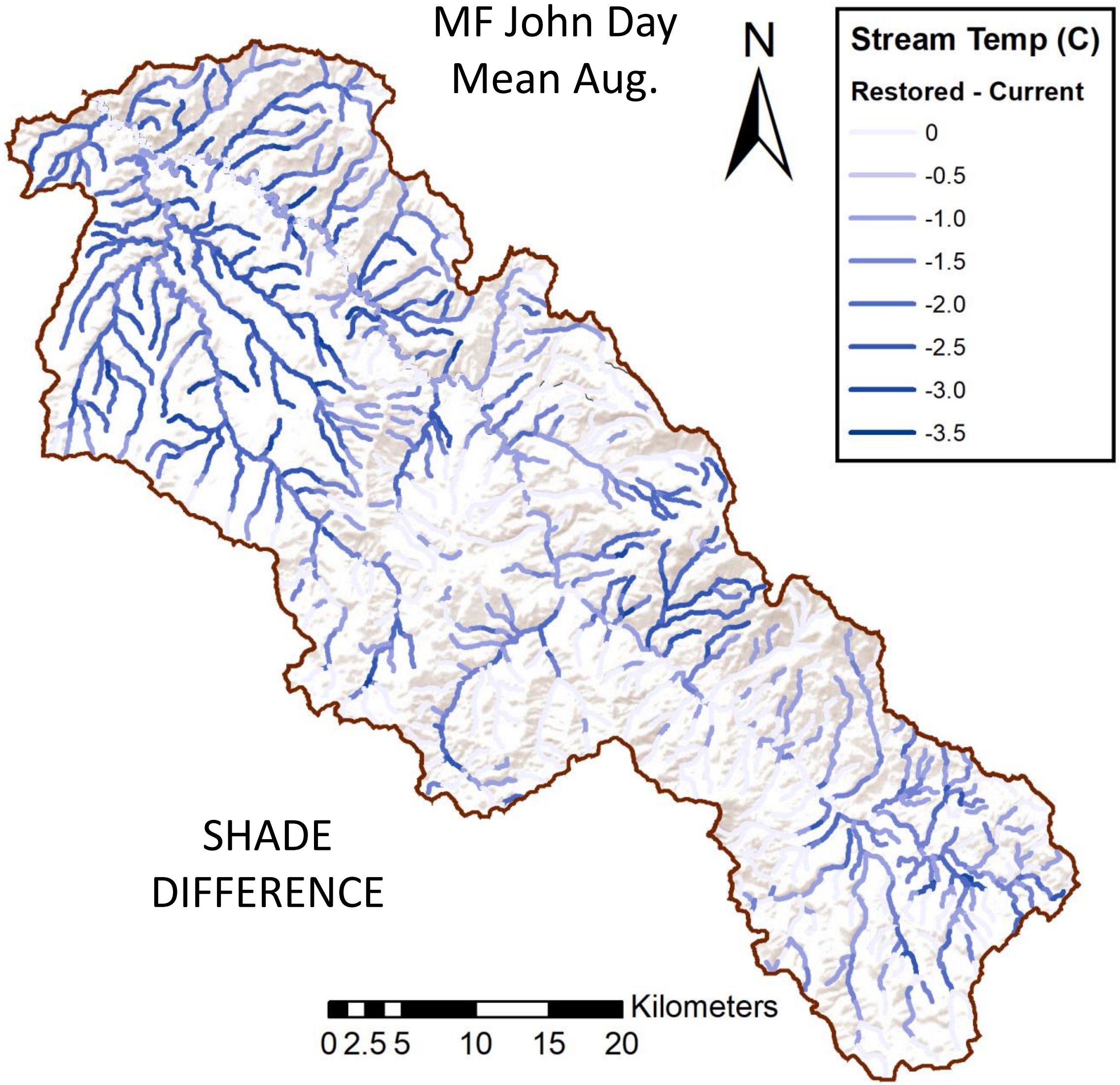
Historical average (1990-2015)



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Model Averaging Predictions

MF John Day

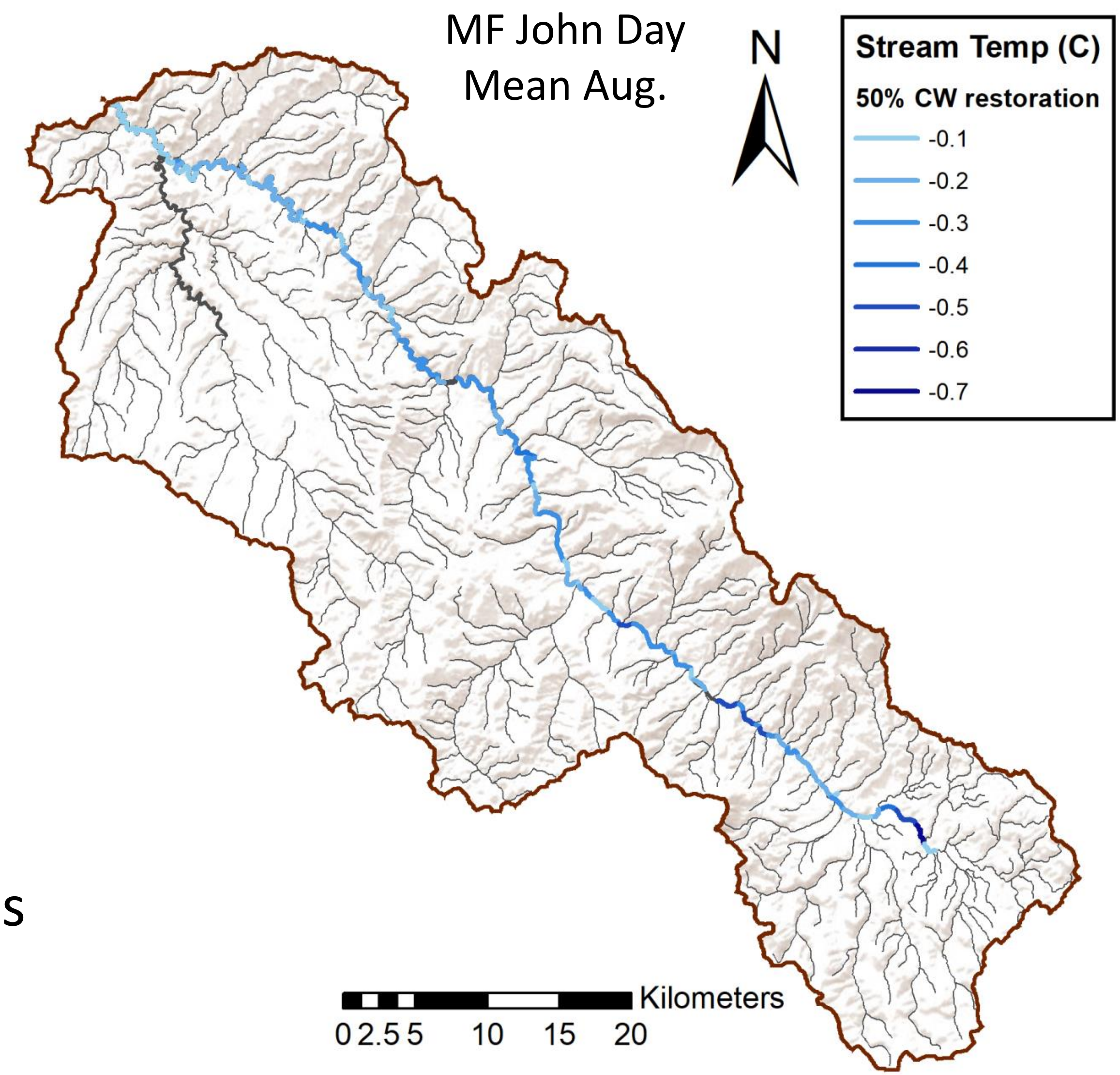
Mean August

Historical average
(1990-2015)

Management Scenarios:

- Riparian shade
- Channel width
- Irrigated crop water loss
- Dam removal

For model averaging details see:
Burnham and Anderson 2002



Management Scenarios: MFJD

Month	Summary Extent	Shade Difference	Channel Width	Crop H_2O loss	Management Combination
May	Watershed	3.41	-0.02	-0.02	3.38
	Mainstem	2.29	0.15	-0.18	2.5
	Outlet	3.68	0.18	-0.48	3.86
August	Watershed	1.51	-0.01	0	1.55
	Mainstem	1.03	0.27	0	1.69
	Outlet	0.72	0.2	0.01	1.29
September	Watershed	1.27	-0.05	-0.01	1.23
	Mainstem	0.87	0.13	-0.09	1.12
	Outlet	0.43	0.04	-0.24	0.36

Values = mean °C cooling attained from management scenario

Management Scenarios: SFNR

Month	Summary Extent	Shade Difference	Crop H_2O loss	Management Combination
August	Watershed	0.36	0.01	0.37
	Mainstem	0.33	0.03	0.35
	Outlet	0.28	0.13	0.39
September	Watershed	0.48	-0.01	0.47
	Mainstem	0.15	-0.03	0.12
	Outlet	-0.5	-0.19	-0.69

Values = mean °C cooling attained from management scenario

Management Scenarios: WR

Month	Summary Extent	Shade Difference	Crop H_2O loss	Management Combination	Dam Removal
May	Watershed	0	0.82	0.82	
	Mainstem	0	-0.08	-0.08	
	Outlet	0	-0.48	-0.48	
August	Watershed	0.63	0.02	0.64	
	Mainstem	0.69	0	0.69	
	Outlet	1.84	0.01	1.85	
September	Watershed	0.76	0.03	0.85	
	Mainstem	0.97	0	0.97	
	Outlet	2.34	0	2.34	

Values = mean °C cooling attained from management scenario

Recap

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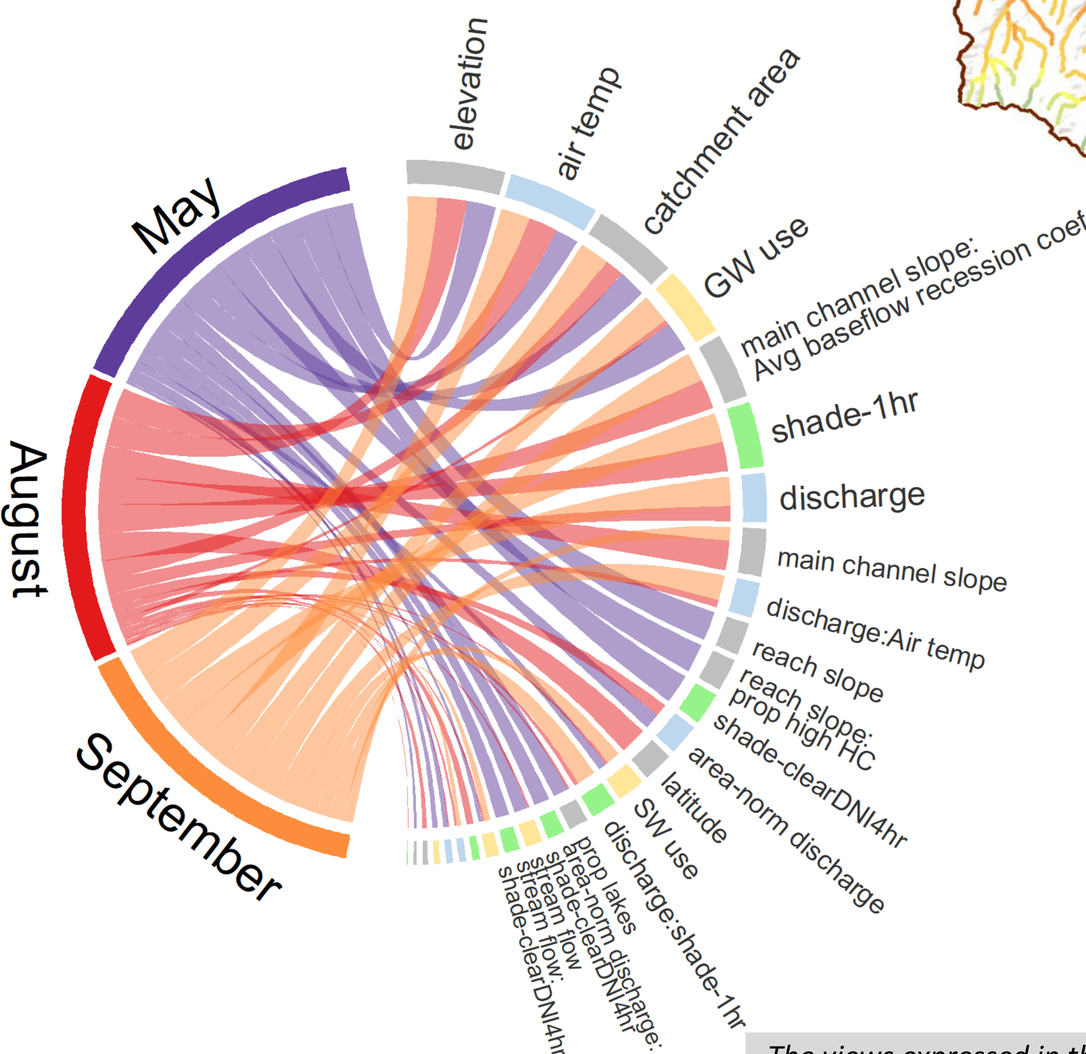
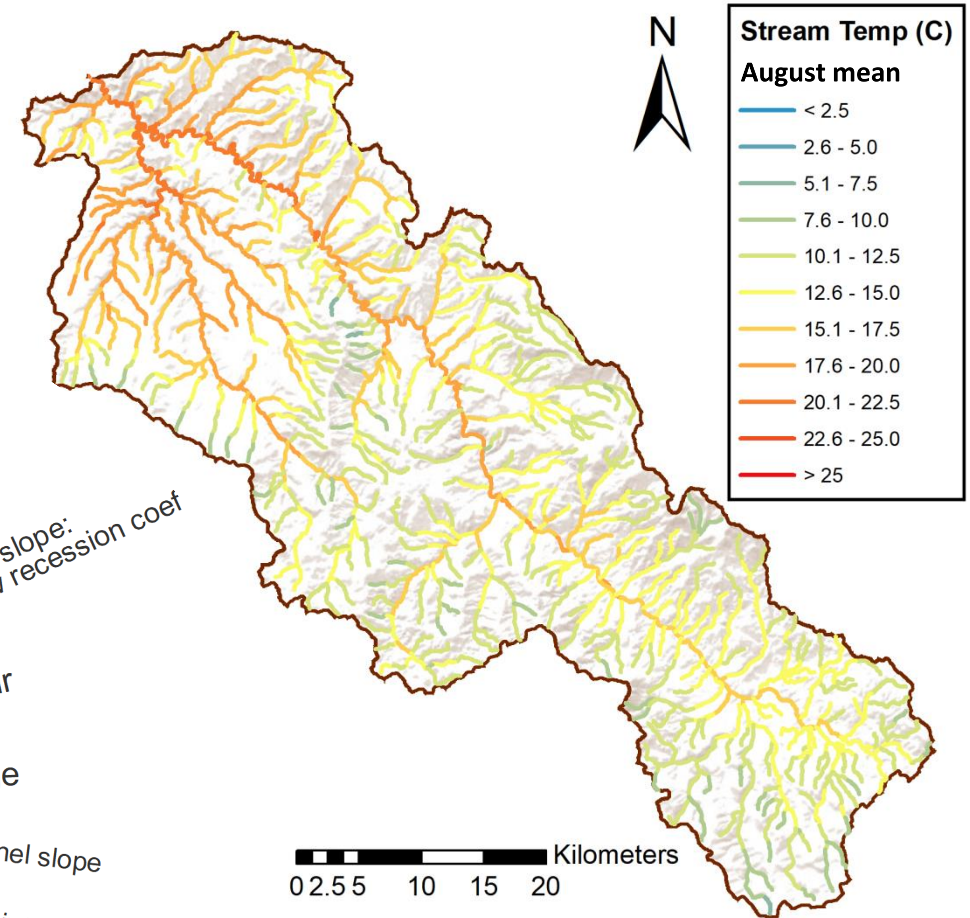
Questions?





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