PREDICTING MONTHLY FLOWS FOR CA STREAMS

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David Wolock
Mike Wieczorek
James Falcone

US Geological Survey*

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The Quality of Our Nation's Waters

Ecological Health in the Nation's Streams, 1993–2005

National Water-Quality Assessment Program

Circular 1391

U.S. Department of the Interior
U.S. Geological Survey

Questions:

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Questions:

* What are the expected natural flows?

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Questions:

* What are the expected natural flows?

* How do expected flows vary through time?

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Questions:

* What are the expected natural flows?

* How do expected flows vary through time?

* Which streams are affected by flow alteration?

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Monthly Flows

PROS:

Monthly Flows

PROS:

- Indicate seasonality, magnitude, frequency

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Monthly Flows

PROS:

- Indicate seasonality, magnitude, frequency
- Easy to communicate, measure, manage

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- Temporal synchrony with observed precip

Monthly Flows

PROS:

- Indicate seasonality, magnitude, frequency
- Easy to communicate, measure, manage
- Temporal synchrony with observed precip

CONS:

- Excludes extremes, durations, variability

Hydrologic Reference Sites

N=163

Regionalization

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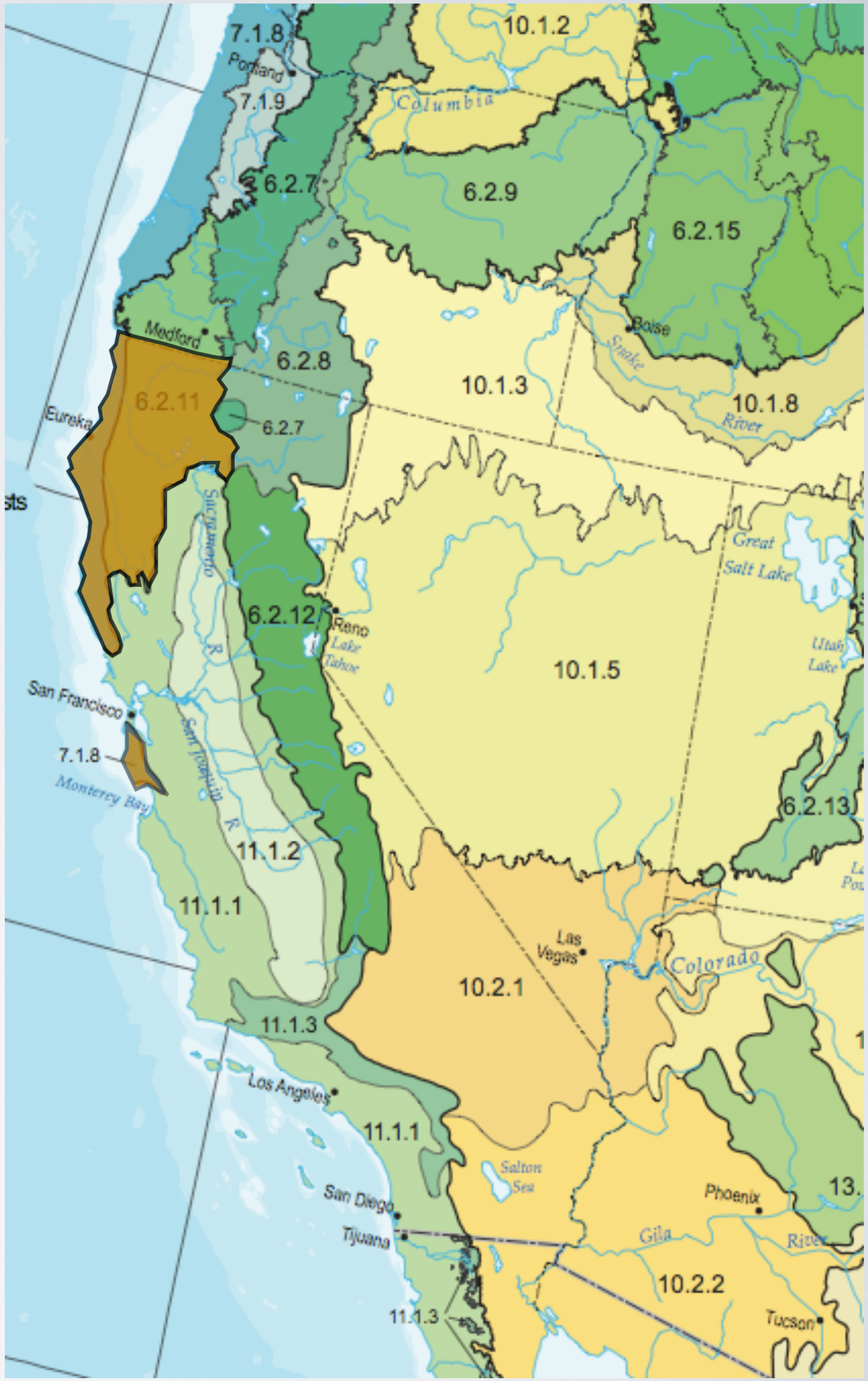
Regionalization

“North Coastal Mts”



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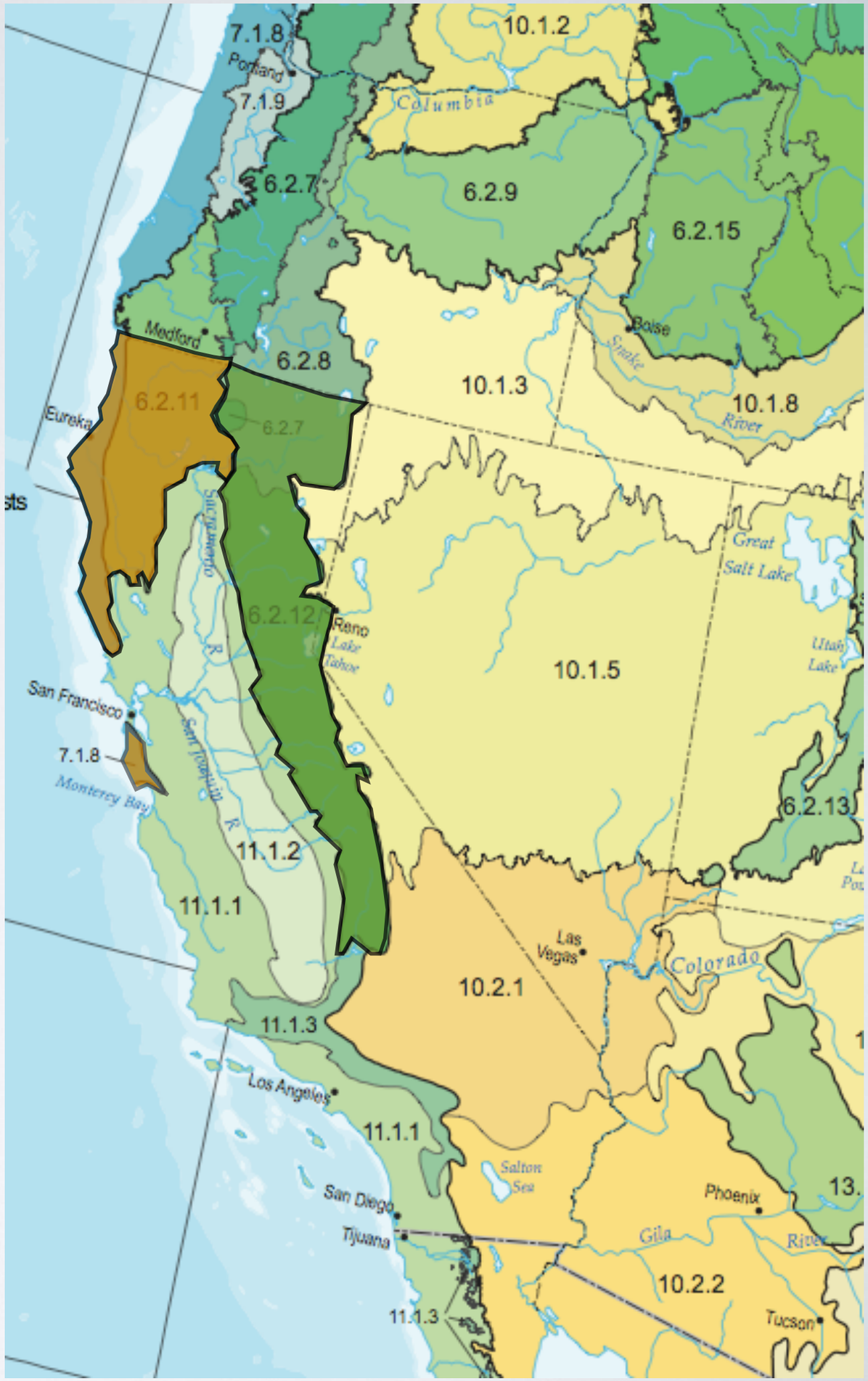
Regionalization

"North Coastal Mts"

"Interior Mts"



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Regionalization

"North Coastal Mts"

"Interior Mts"

"Xeric"

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Empirical Models of Natural Monthly Flows

monthly mean $Q_{\mathbf{yr}} =$

Empirical Models of Natural Monthly Flows

monthly mean Q_{yr} =

~ runoff (t-0...t-12)

Empirical Models of Natural Monthly Flows

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monthly mean Q_{yr} =

~ runoff (t-0...t-12)
~ precipitation (t-0...t-12)
~ temperature (t-0...t-12)

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Empirical Models of Natural Monthly Flows

monthly mean Q_{yr} =

~ runoff (t-0...t-12)
~ precipitation (t-0...t-12)
~ temperature (t-0...t-12)
~ 90 static predictors including

Empirical Models of Natural Monthly Flows

monthly mean Q_{yr} =

~ runoff (t-0...t-12)
~ precipitation (t-0...t-12)
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~ 90 static predictors including
soils, geology, topography, climate, etc.

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Empirical Models of Natural Monthly Flows

monthly mean $Q_{\mathbf{yr}}$ =

~ runoff (t-0...t-12)
~ precipitation (t-0...t-12)
~ temperature (t-0...t-12)
~ 90 static predictors including
soils, geology, topography, climate, etc.

yr = 1950-2012

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Random Forests

Random Forests

- Assumption-free

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Random Forests

- Assumption-free
- Nonlinear & interactions

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Random Forests

- Assumption-free
- Nonlinear & interactions
- Resists overfitting

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Assessing Model Performance

~ 50-70 reference sites/region
~ Jack-knife (leave-one-out)

Assessing Model Performance

~ 50-70 reference sites/region
~ Jack-knife (leave-one-out)

~ Normalized RMSE
~ Correlation Observed vs Predicted
~ Mean Observed/Predicted through time
~ SD of O/P through time

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Results

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Model Performance

r squared

Model Performance

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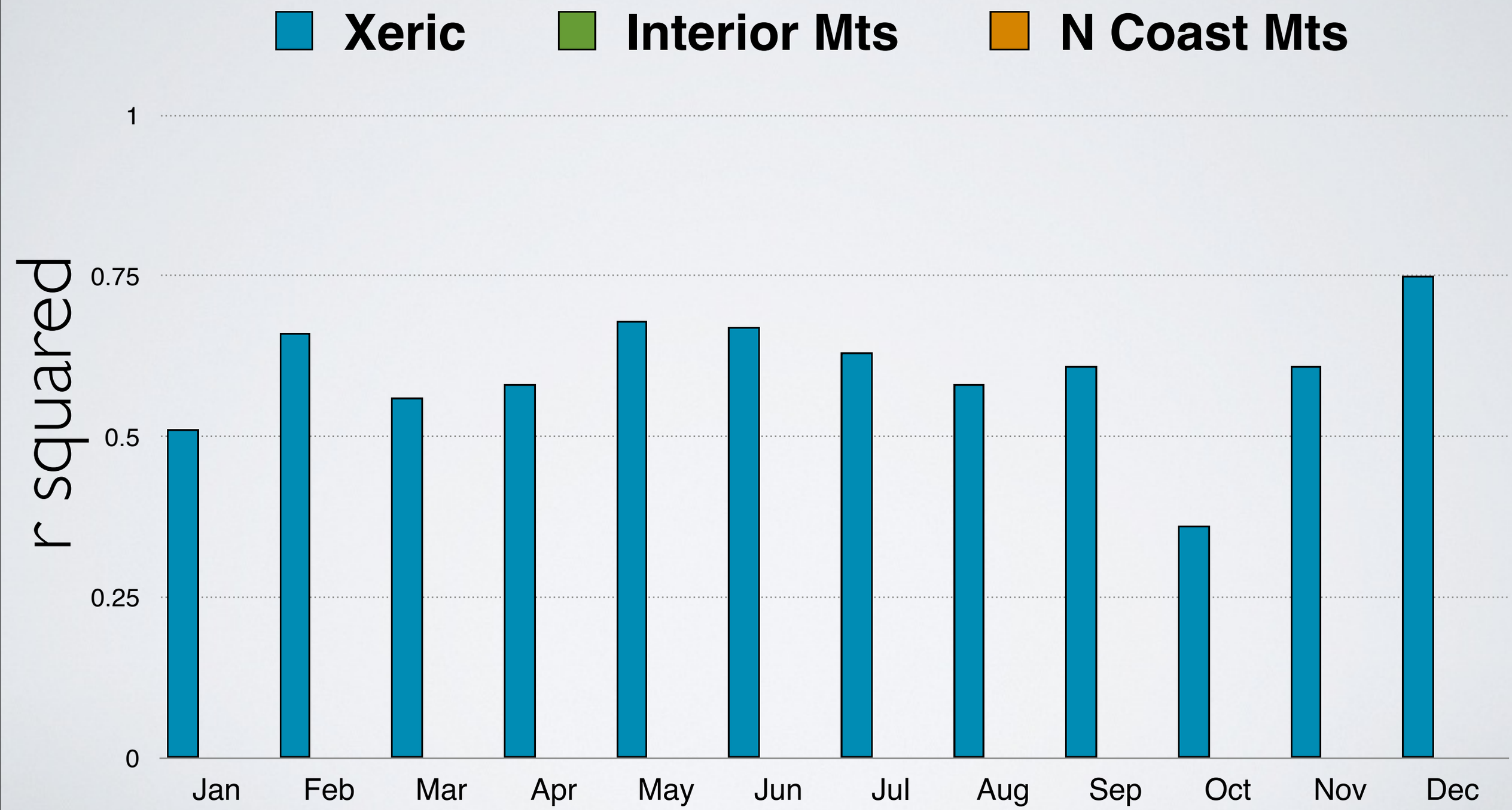
Model Performance



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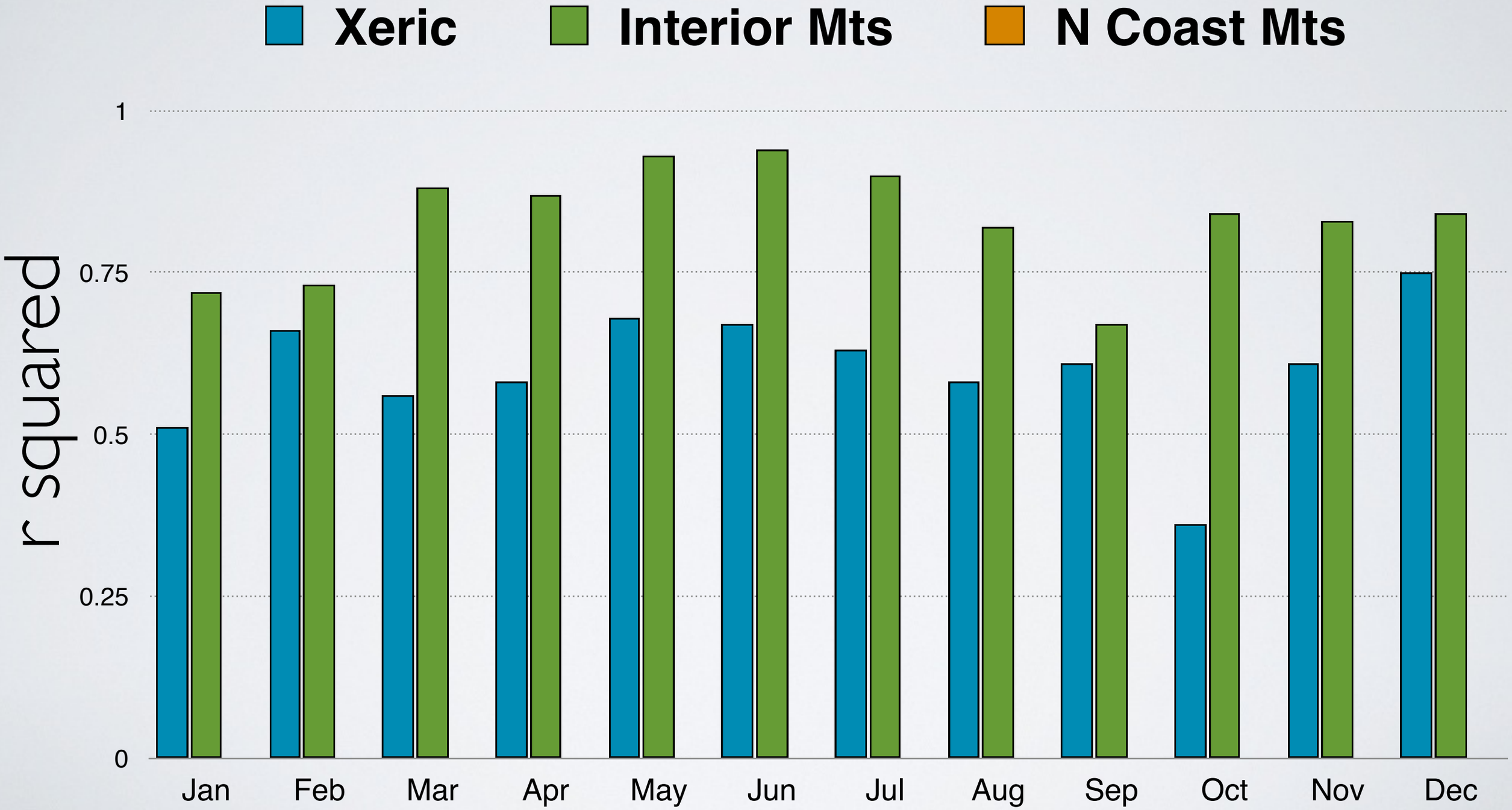
Model Performance



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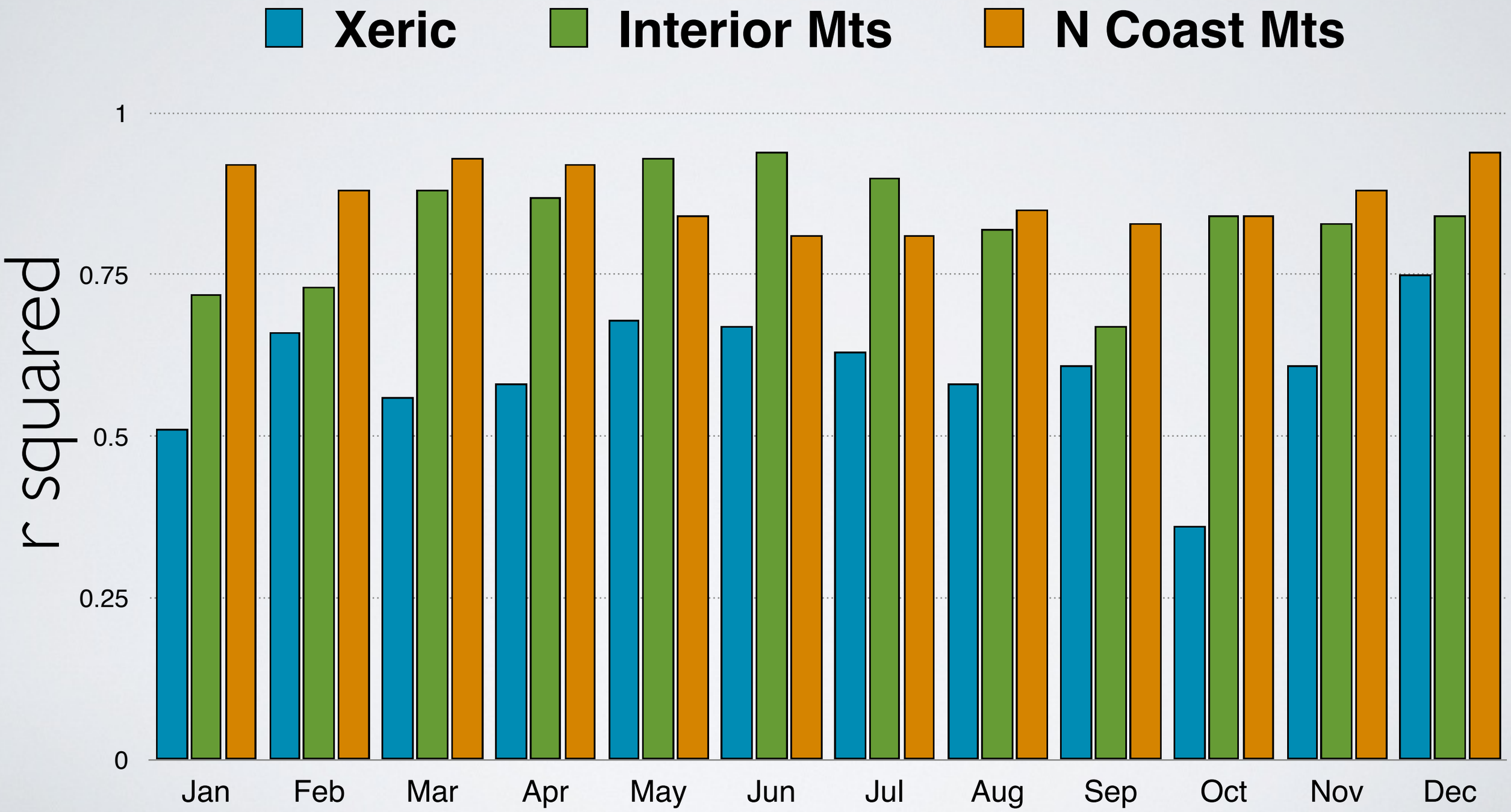
Model Performance



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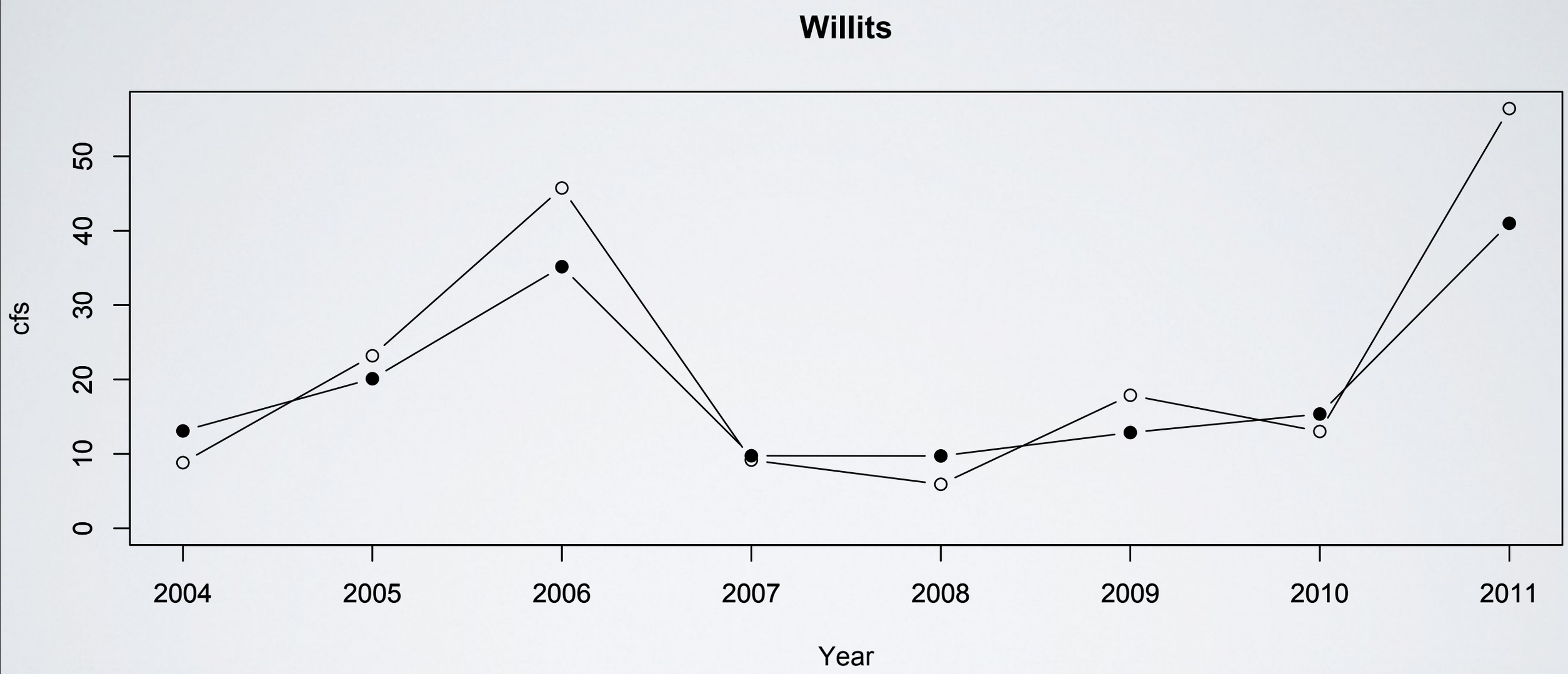
observed

predicted



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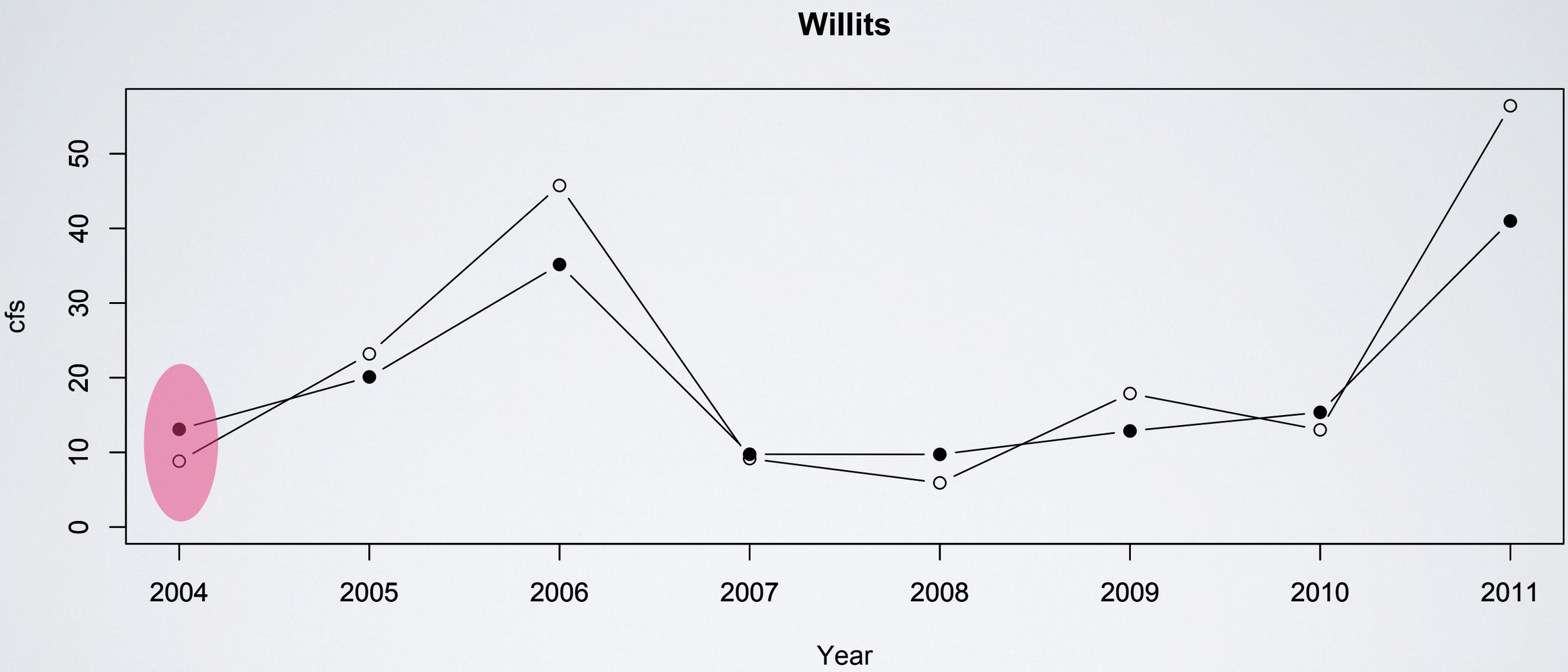
observed

predicted



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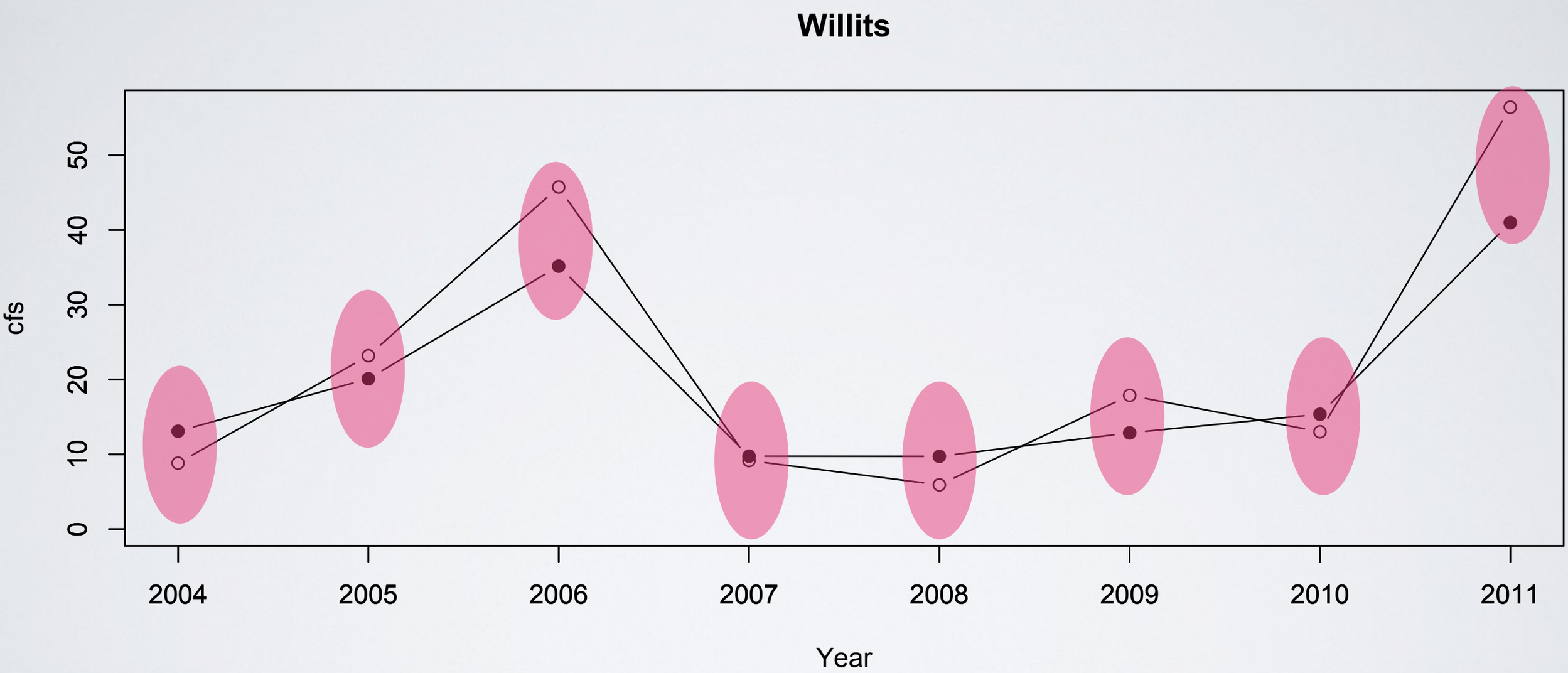
observed

predicted



mean O/P= 1.04

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Model Performance

Mean O/P

Model Performance

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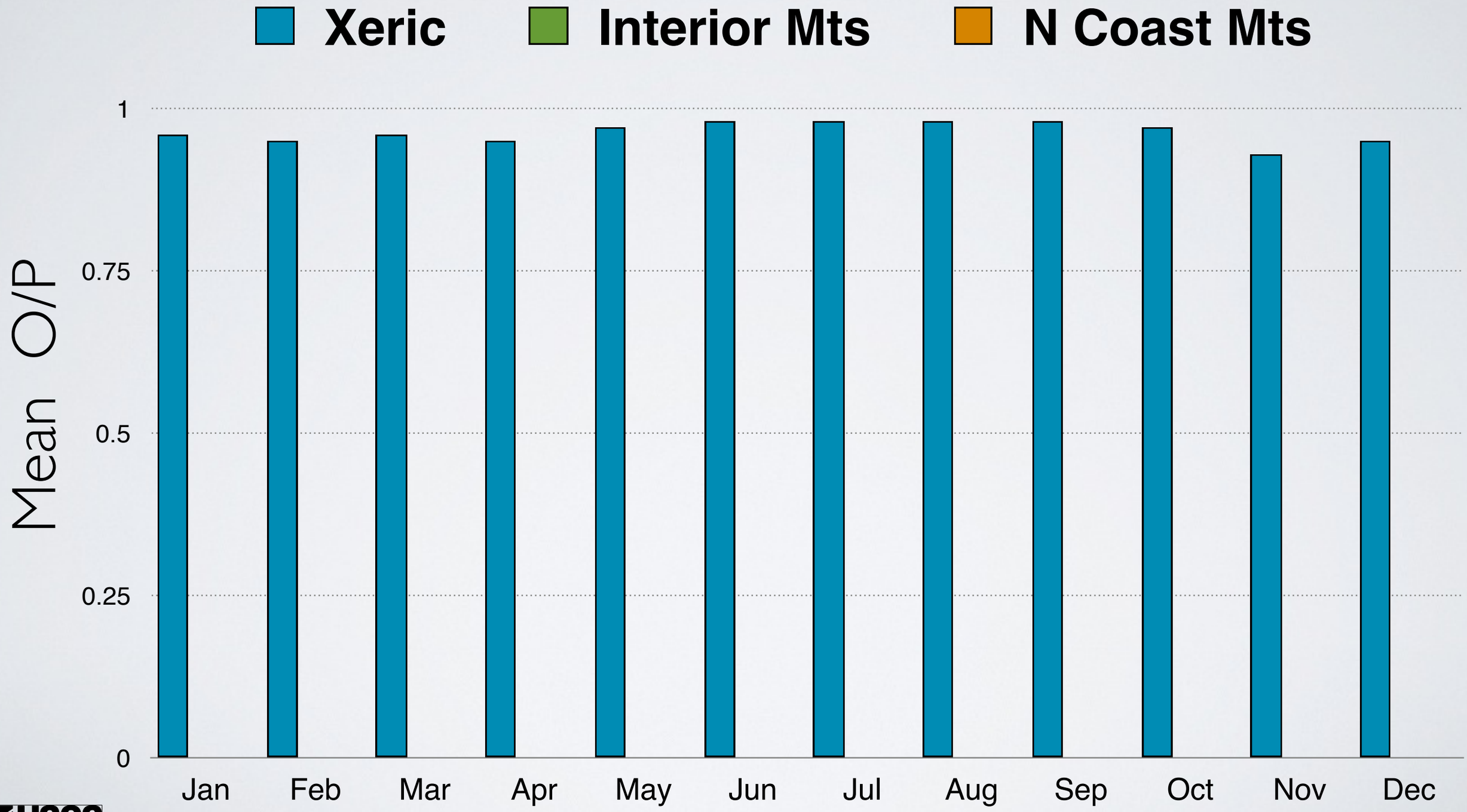
Model Performance



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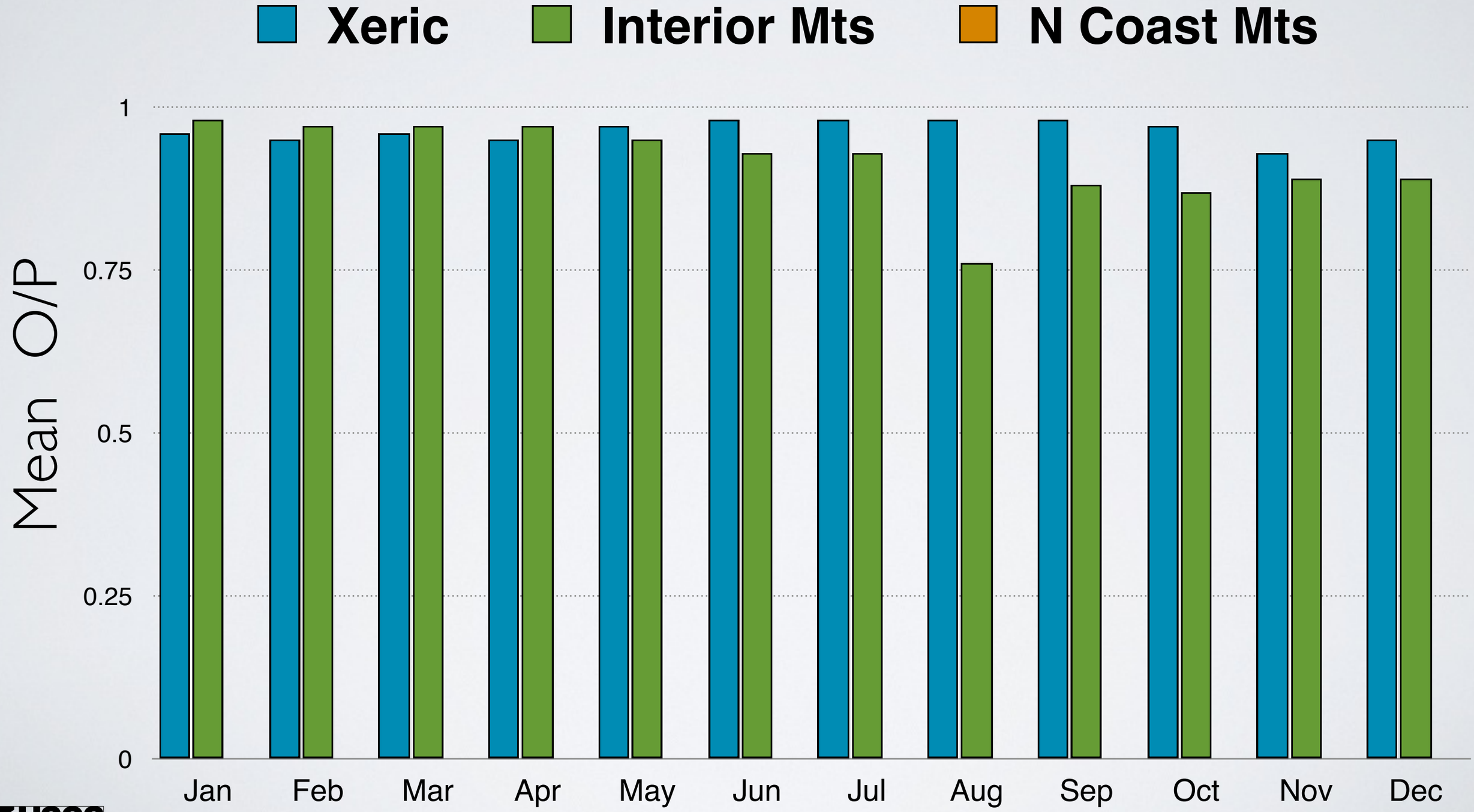
Model Performance



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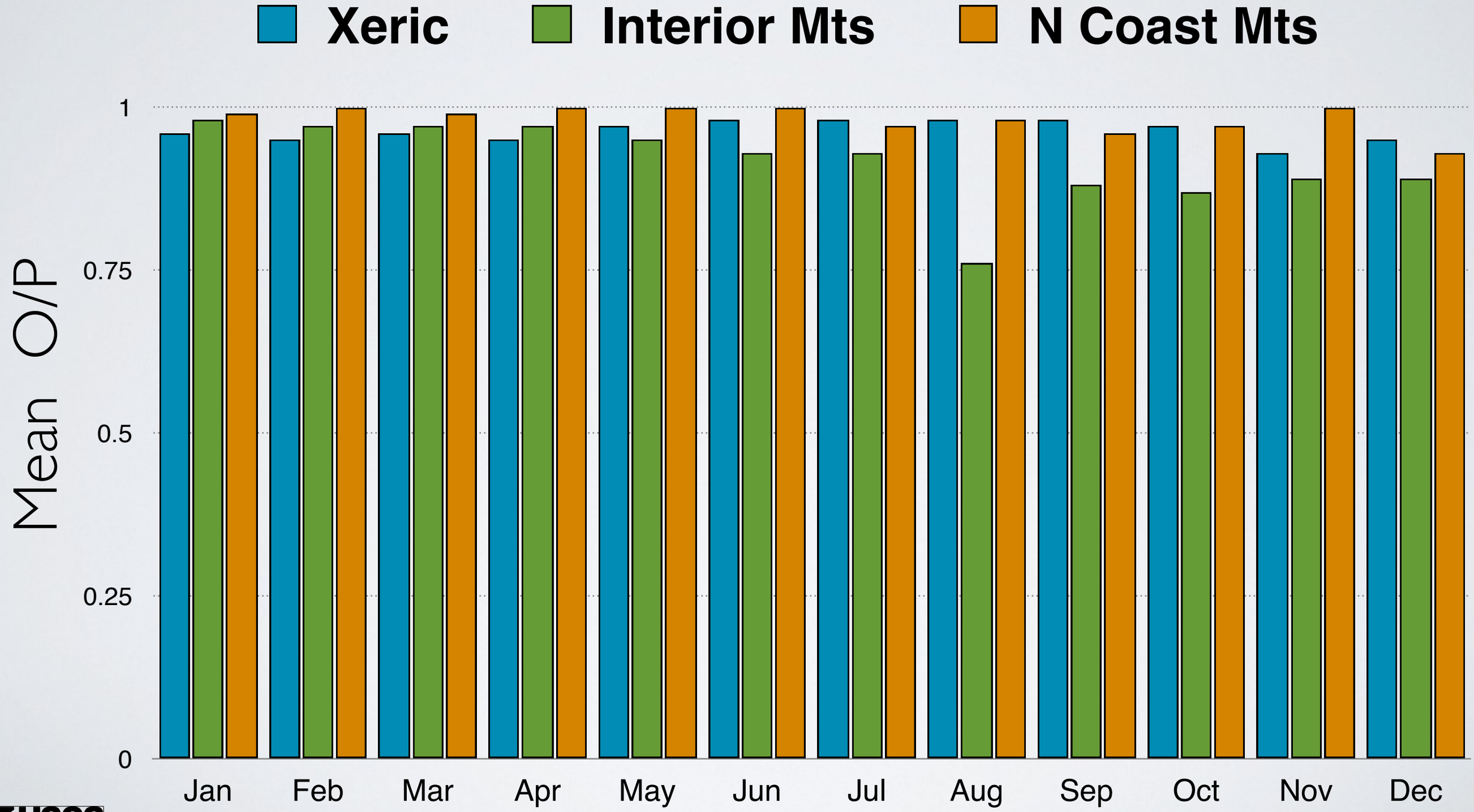
Model Performance



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Predictors

No. models

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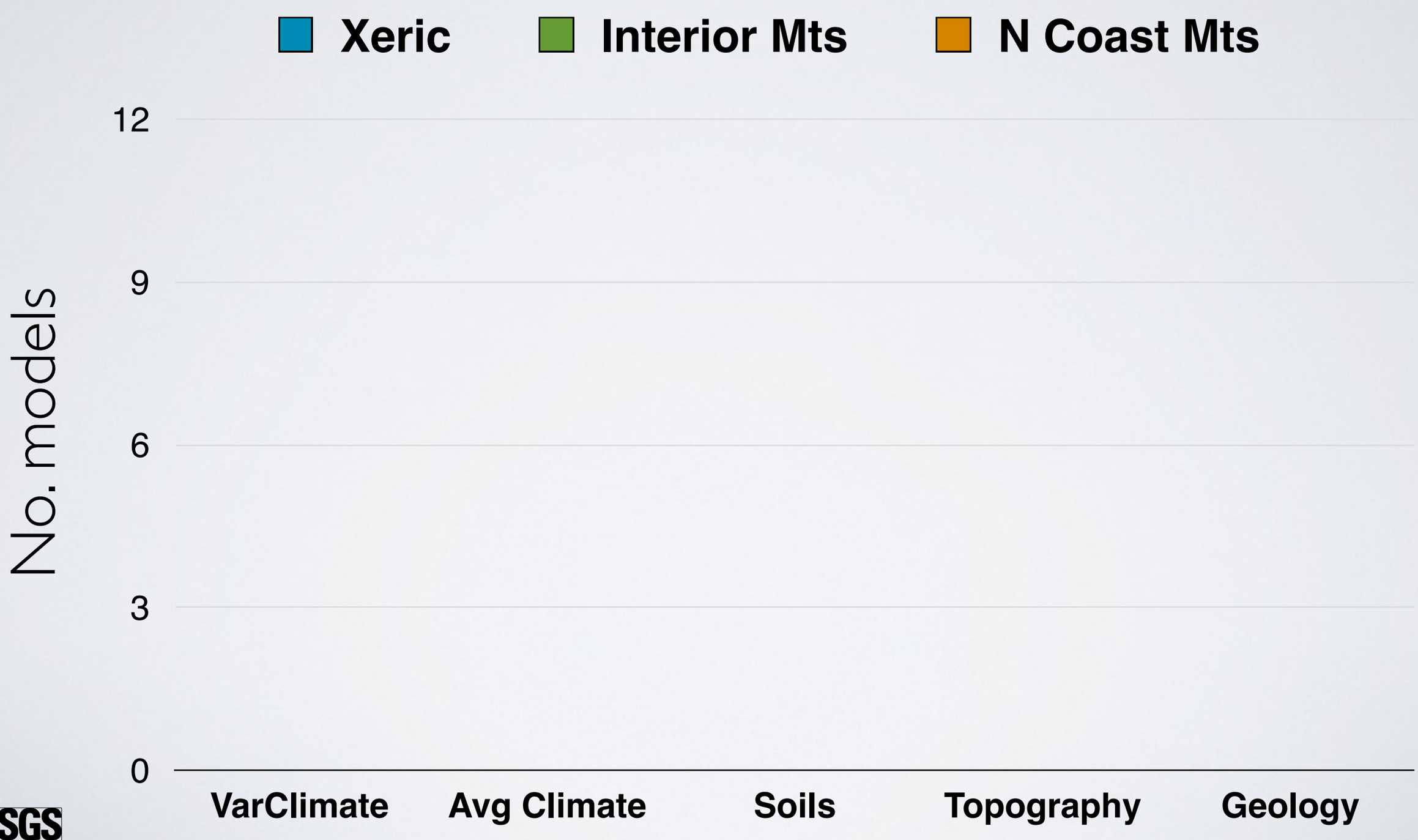
Predictors



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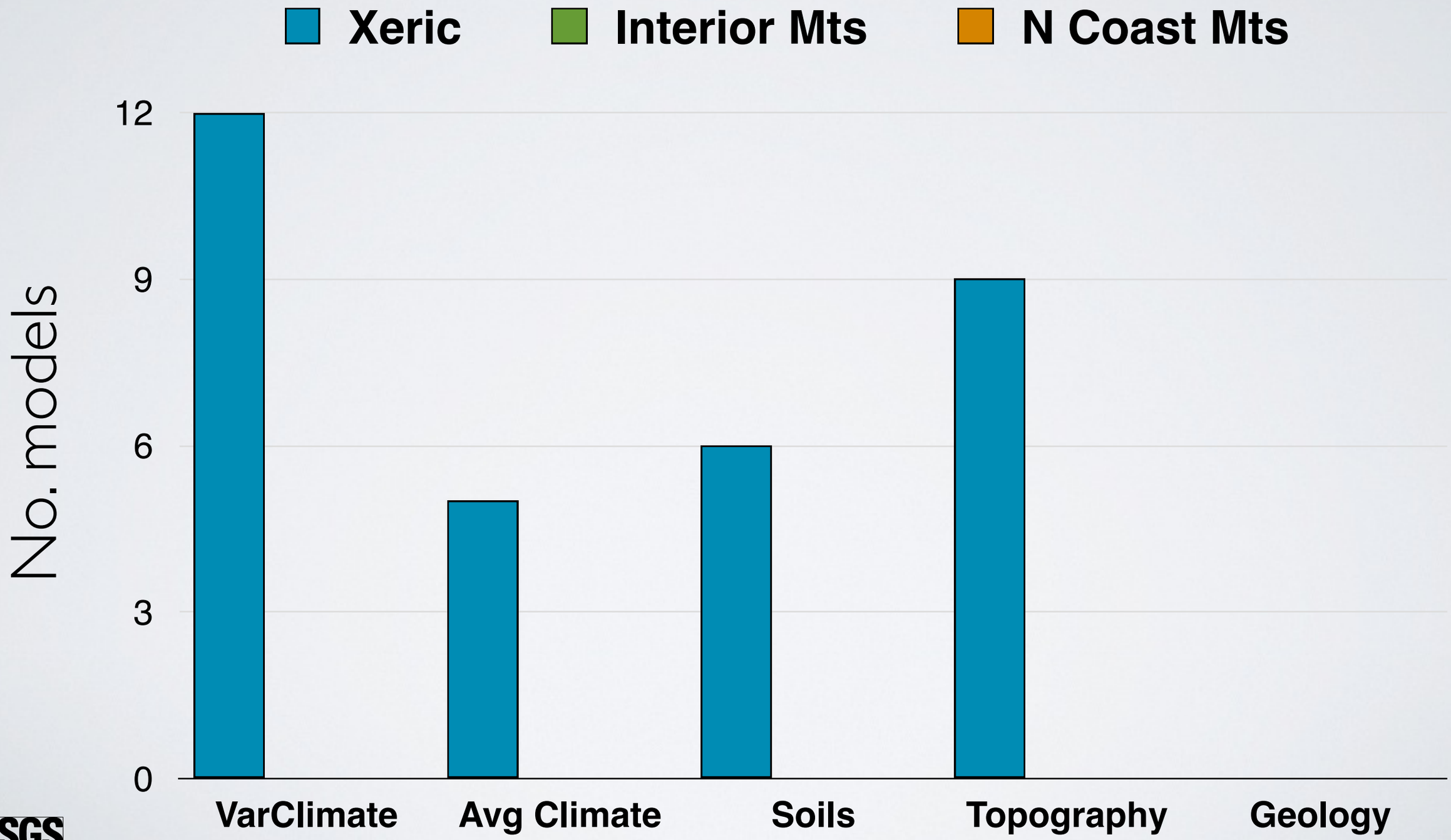
Predictors



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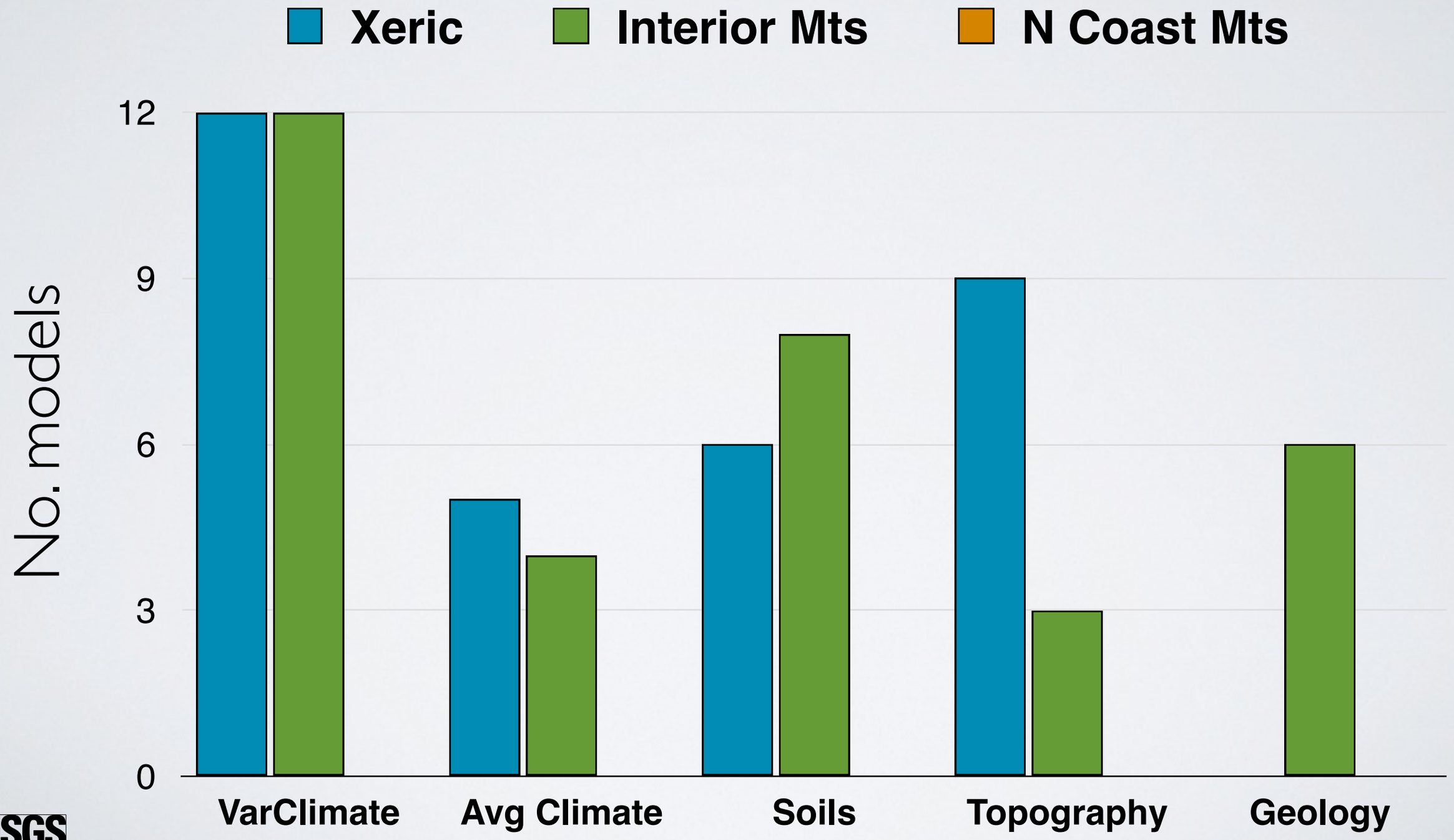
Predictors



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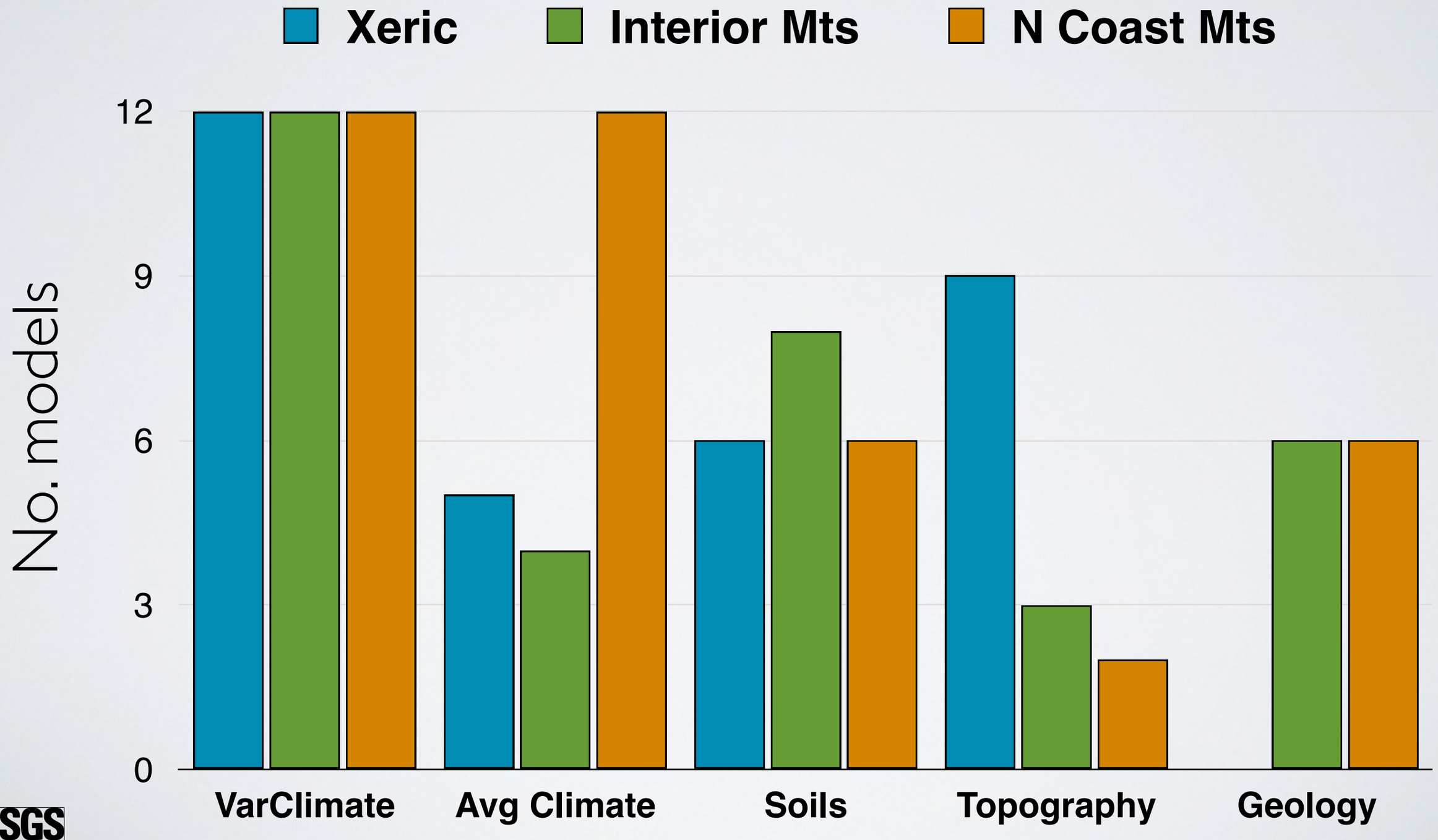
Predictors



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How do expected natural flows change through time?

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Cucamonga Creek

Sept. mean flow (cfs)

1968 → 2010

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Cucamonga Creek

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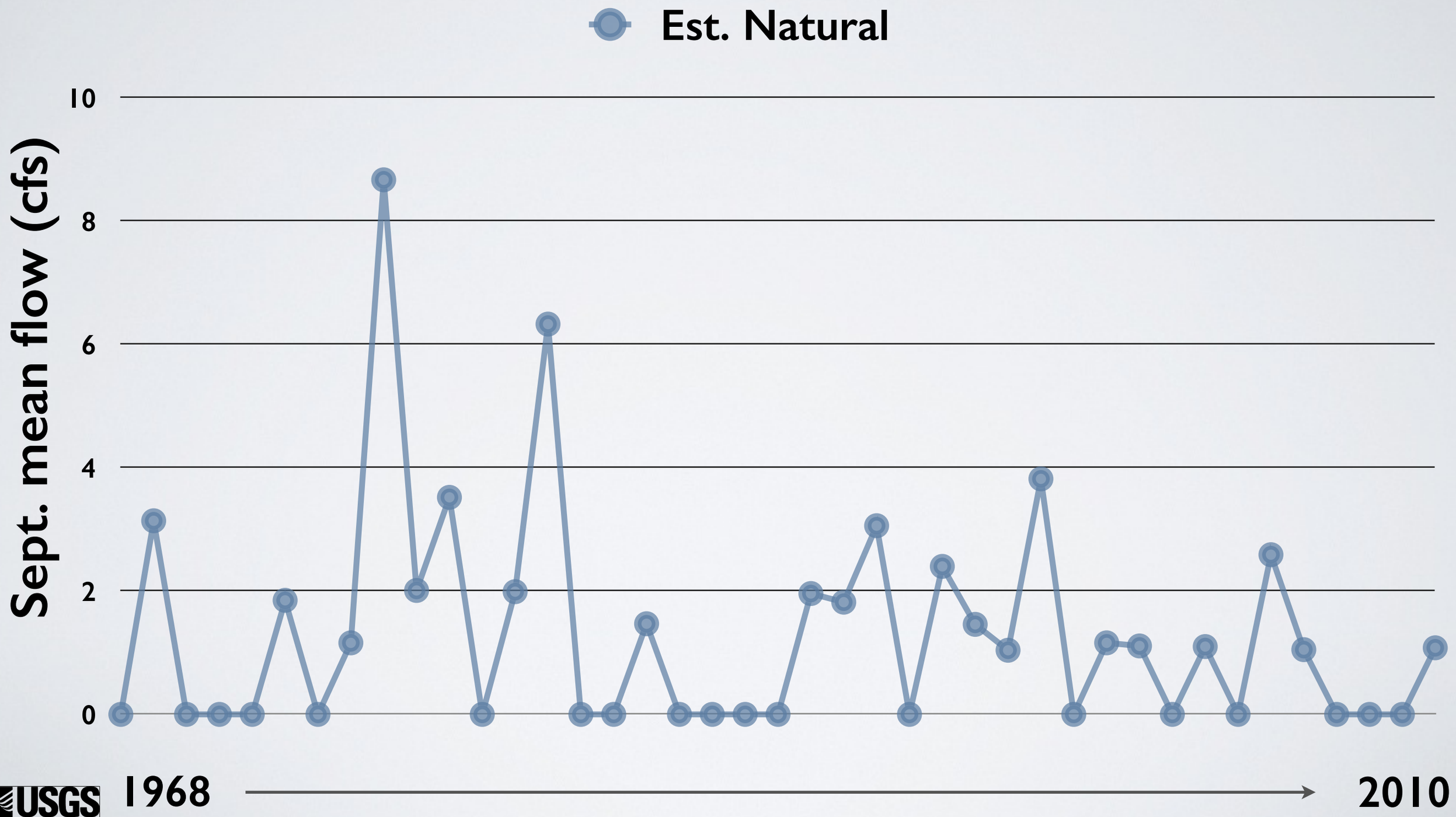
Cucamonga Creek



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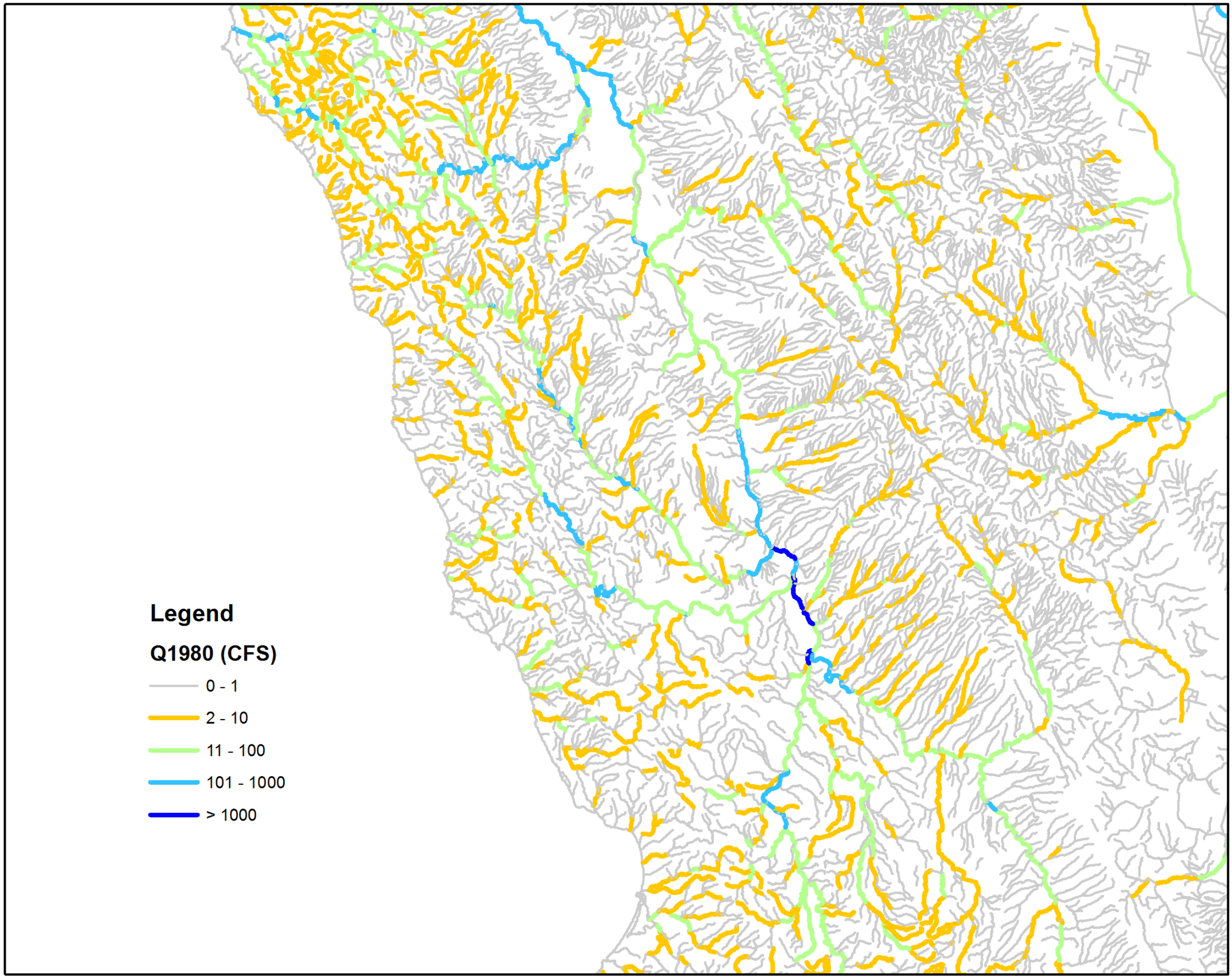
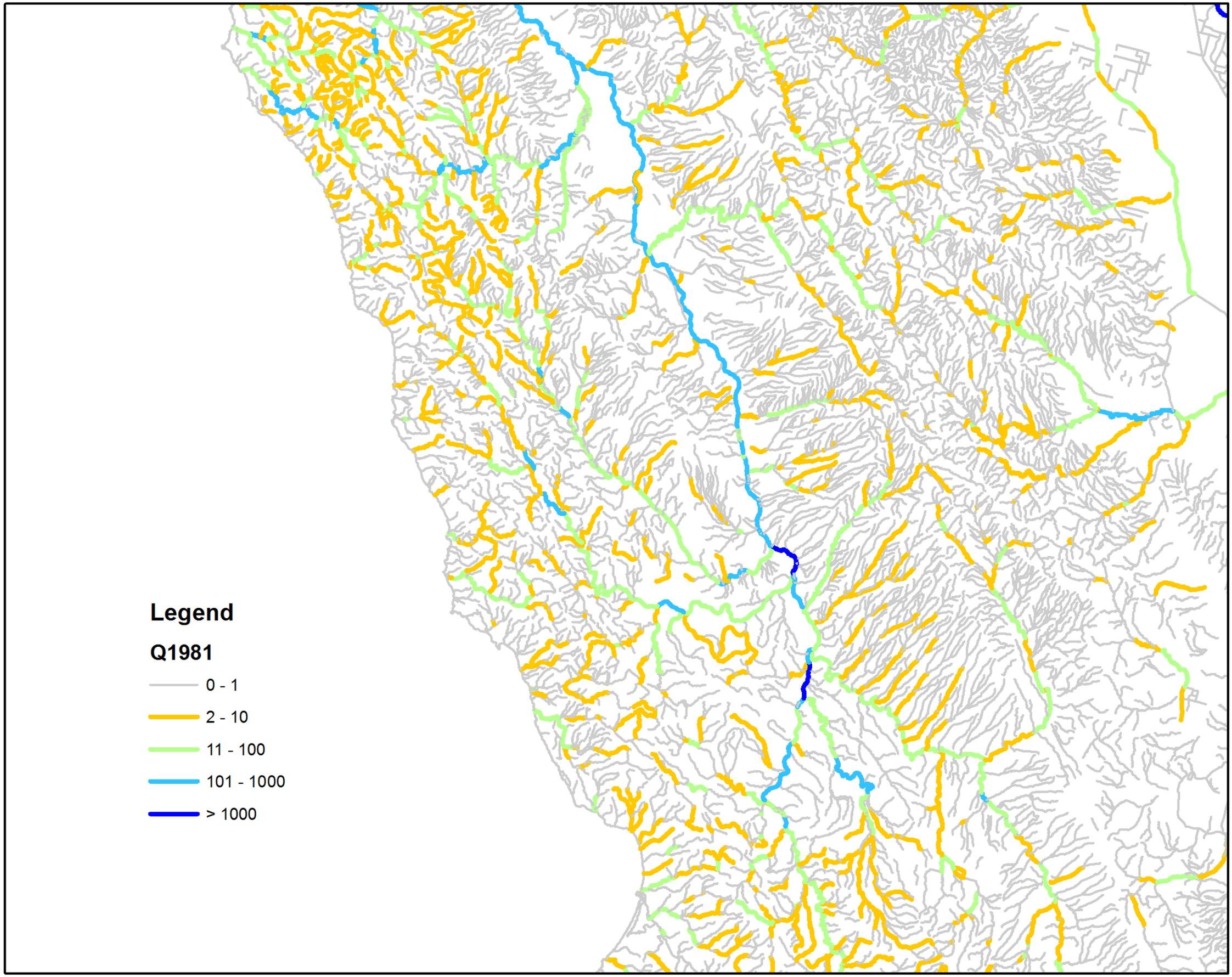
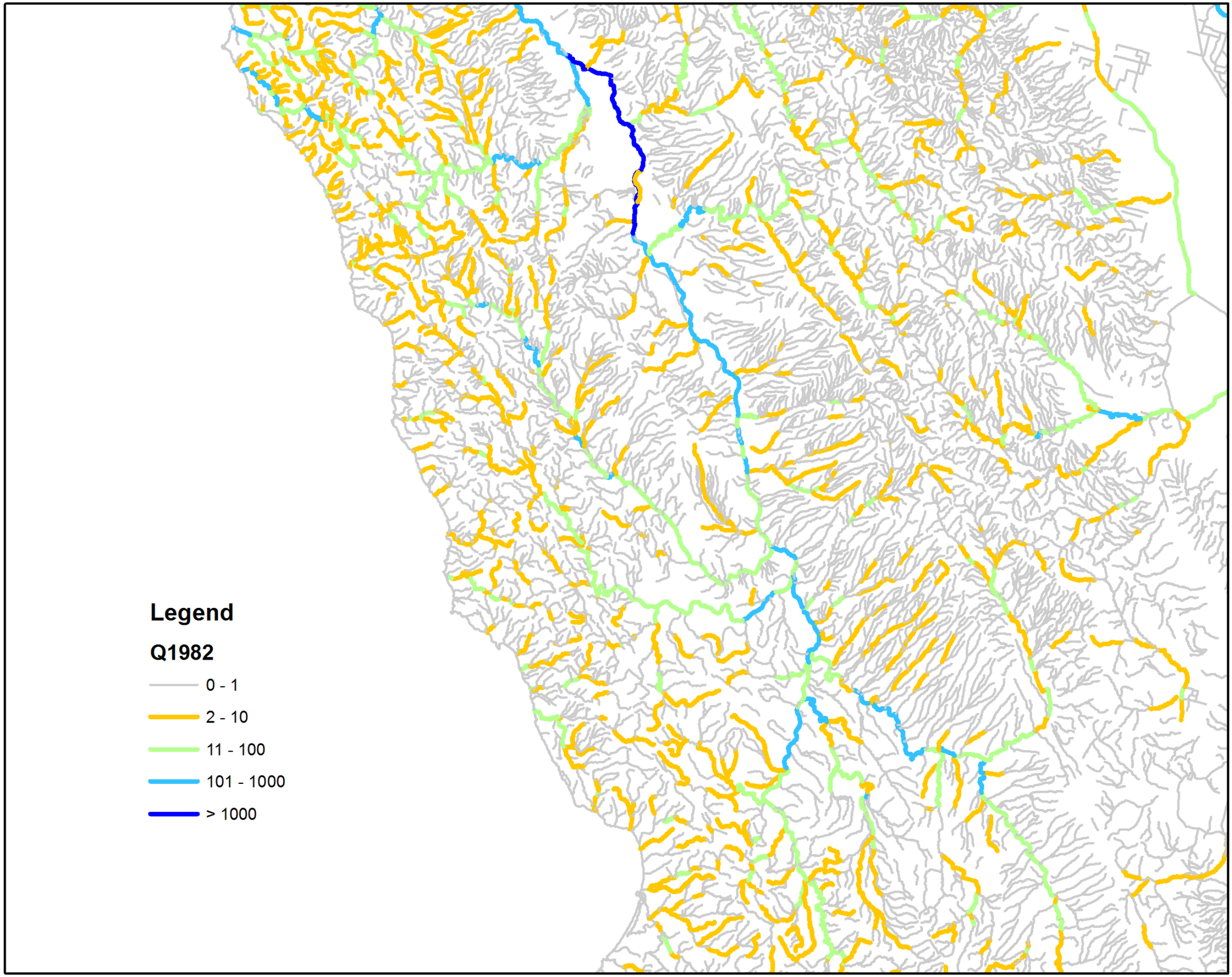
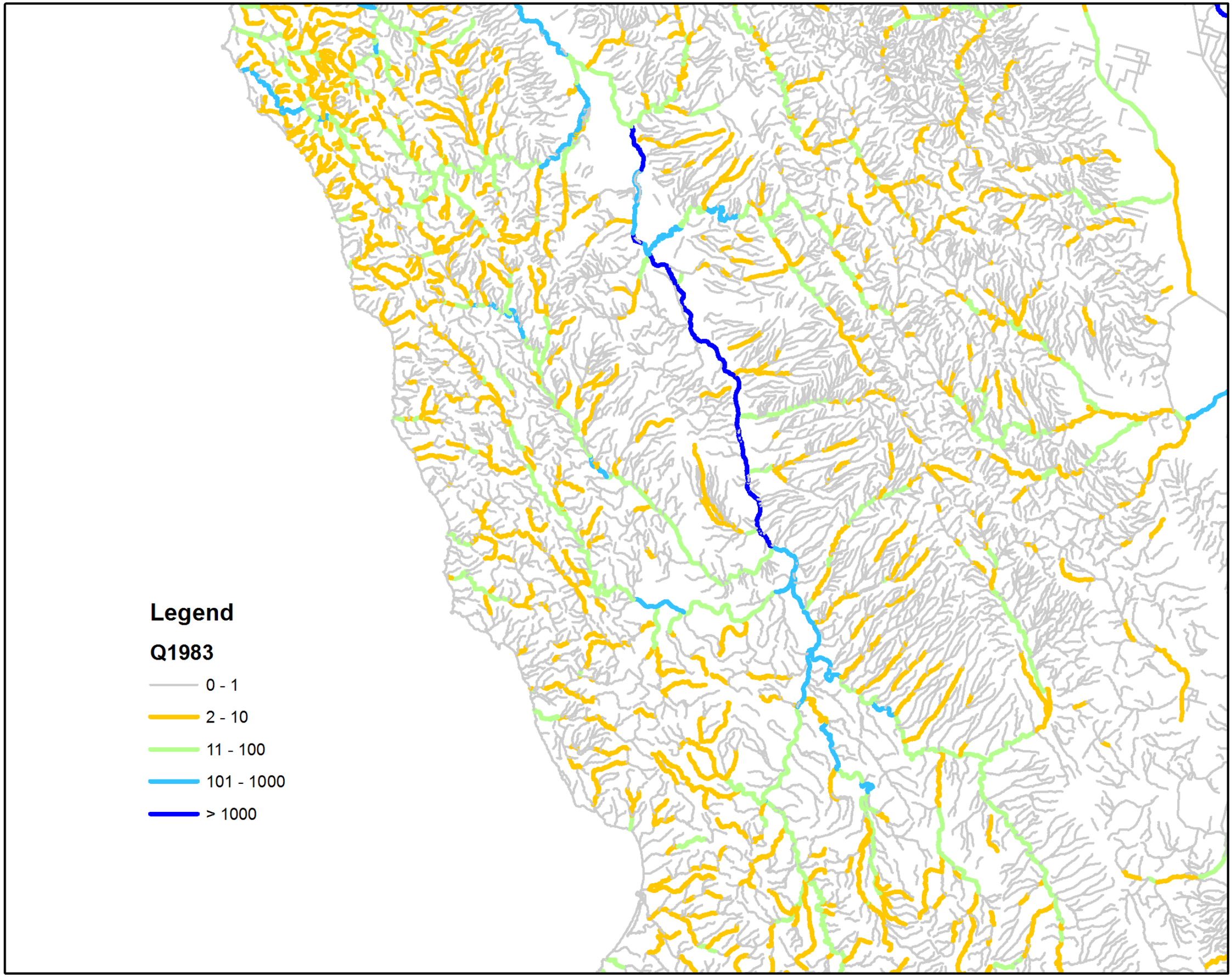
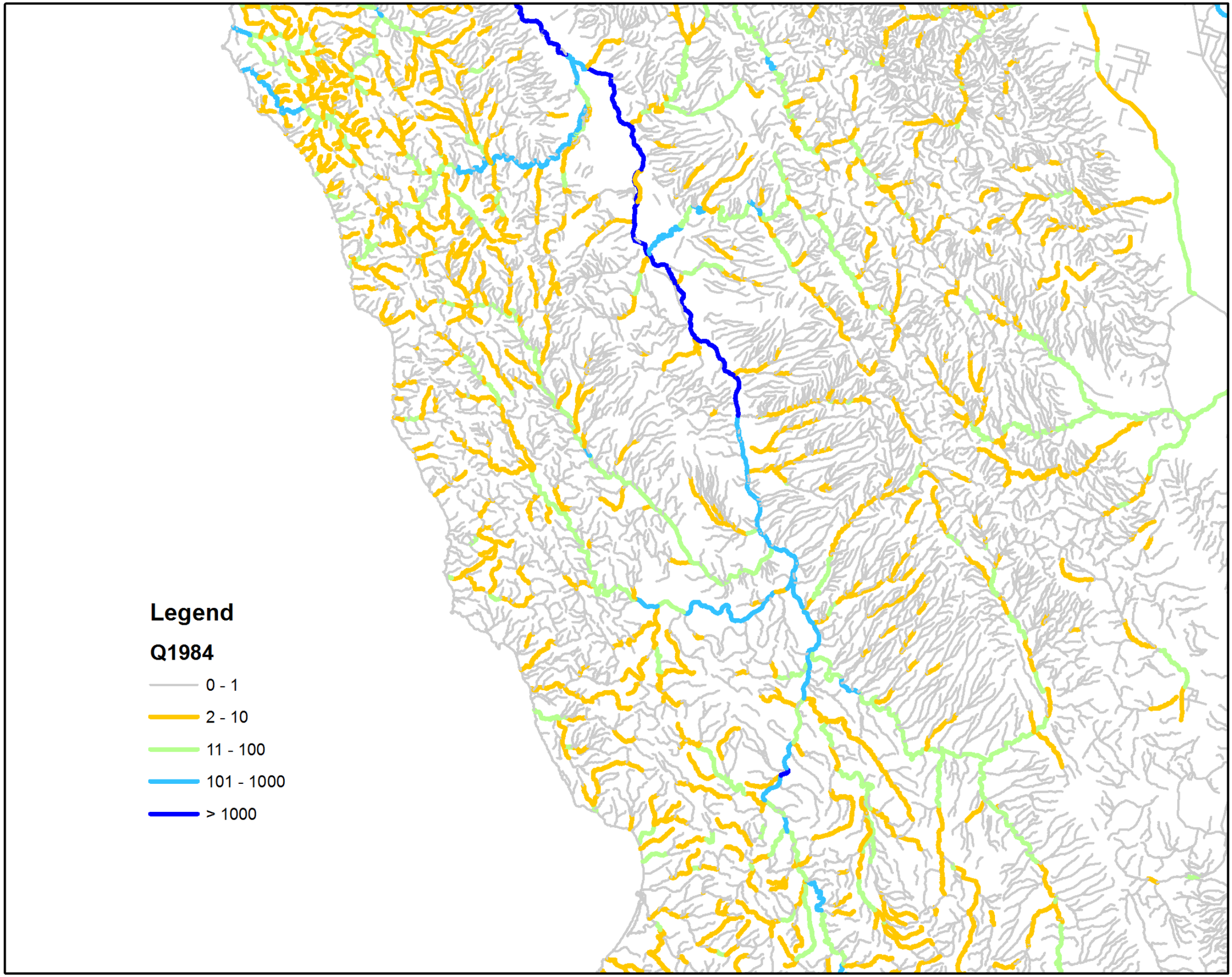
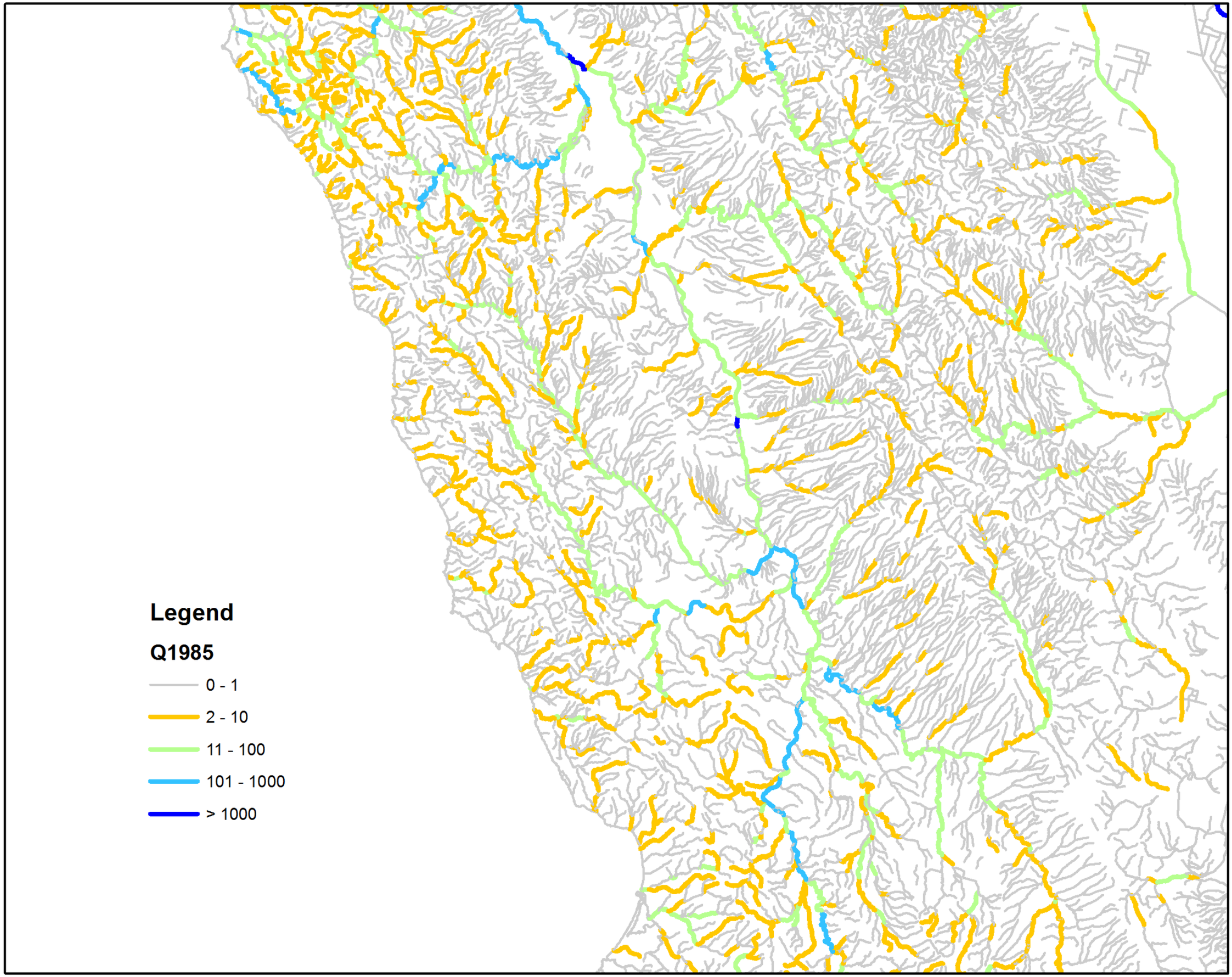

Legend
Q1980 (CFS)
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000

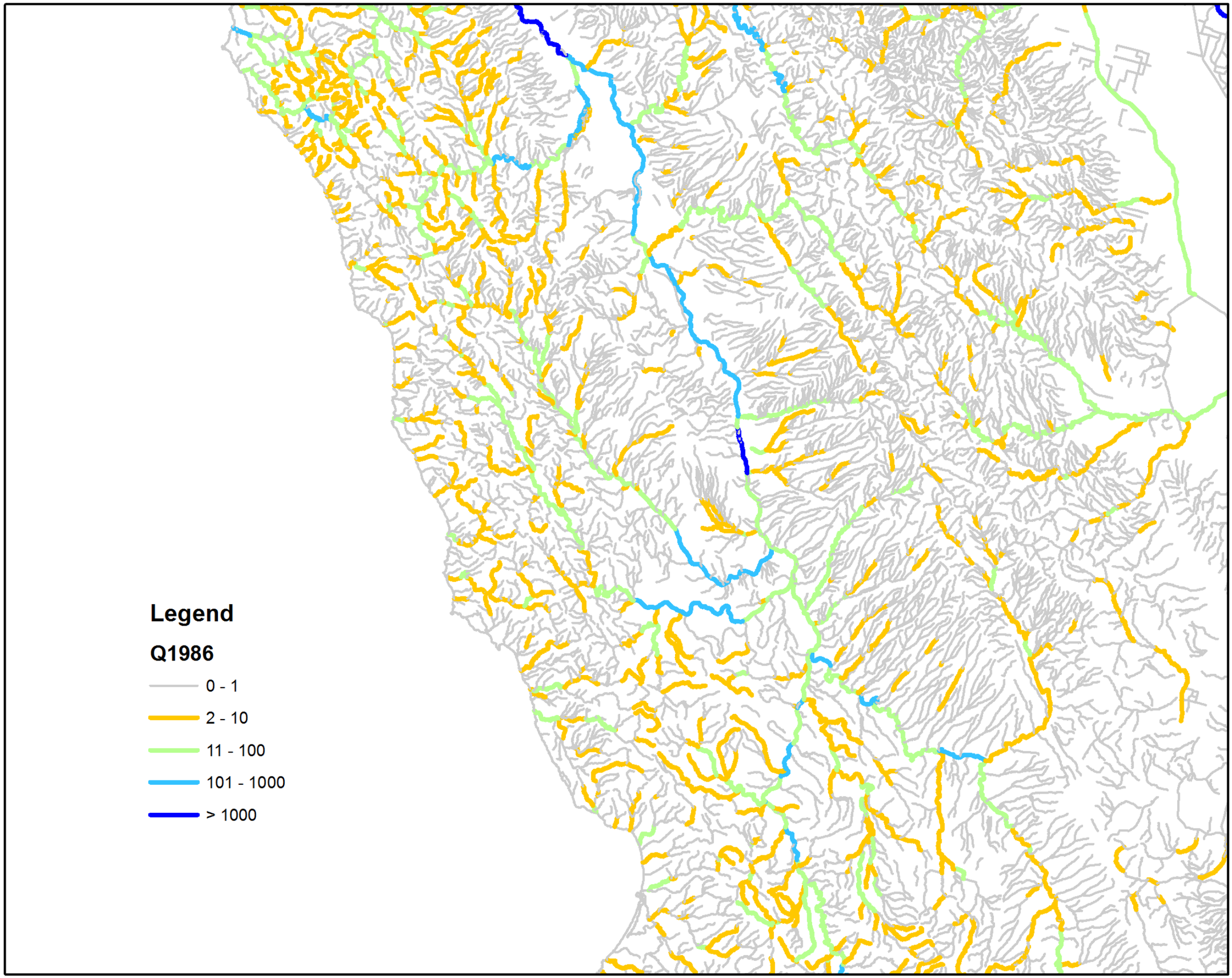

Legend
Q1981
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000

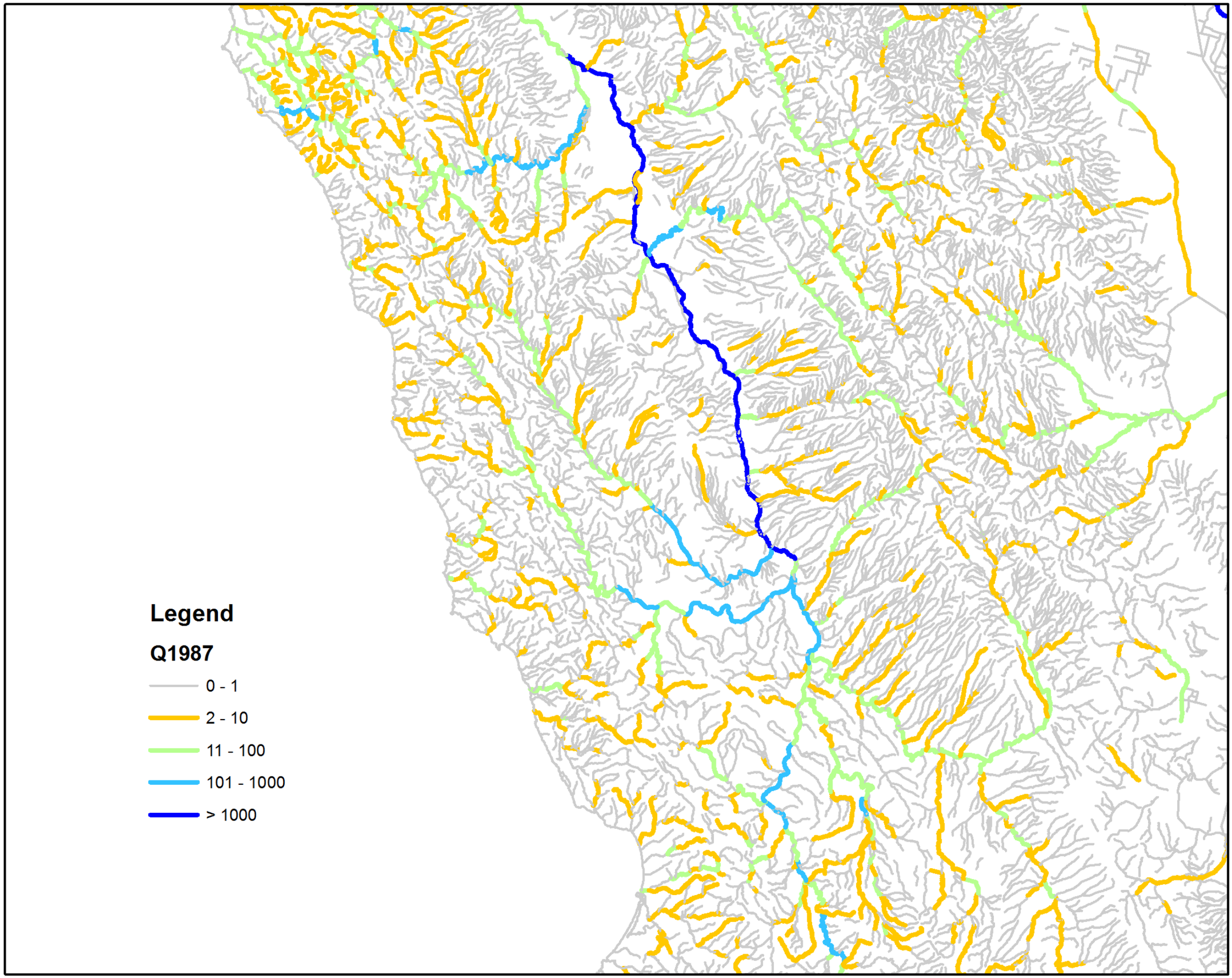

Legend
Q1982
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000

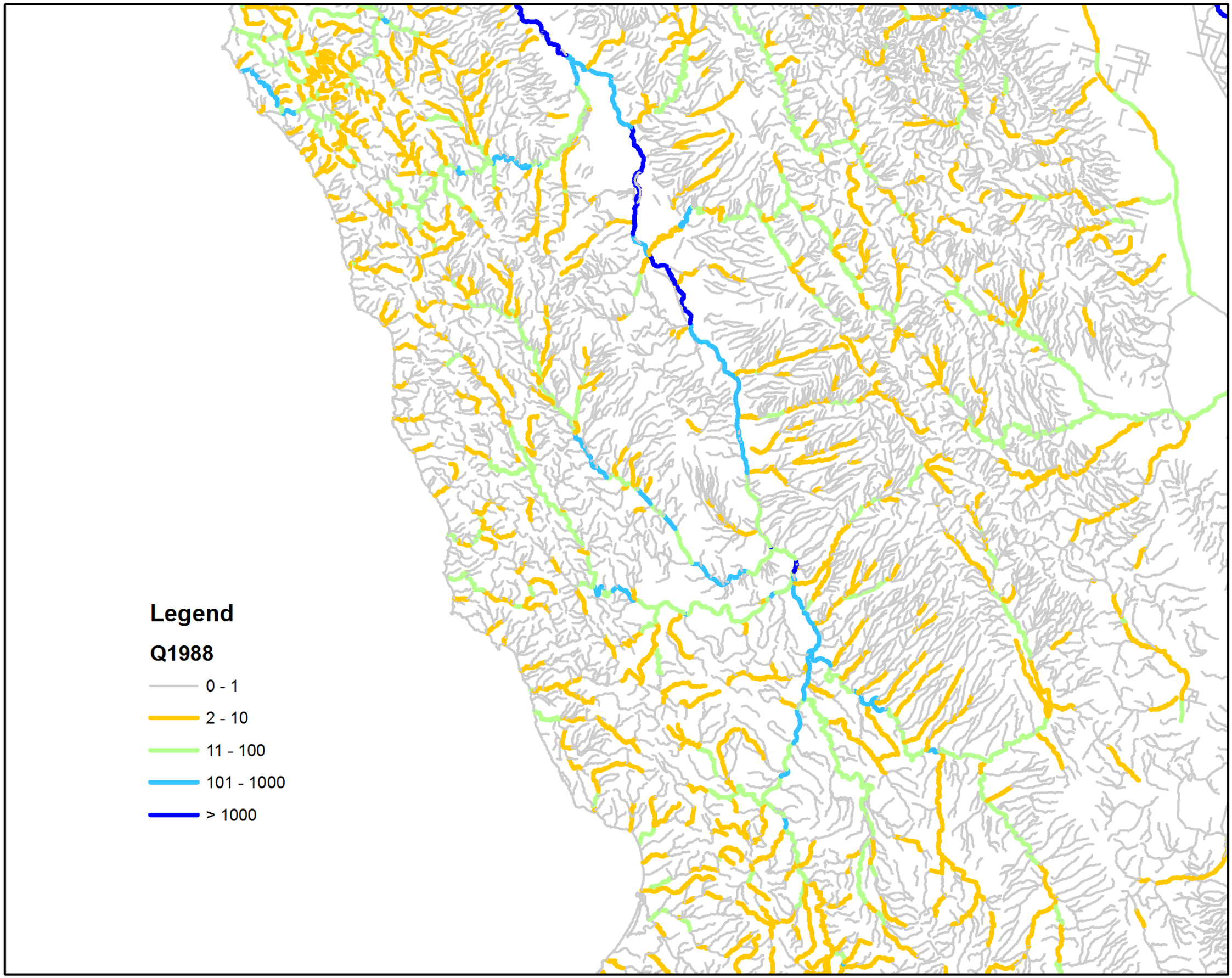

Legend
Q1983
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000

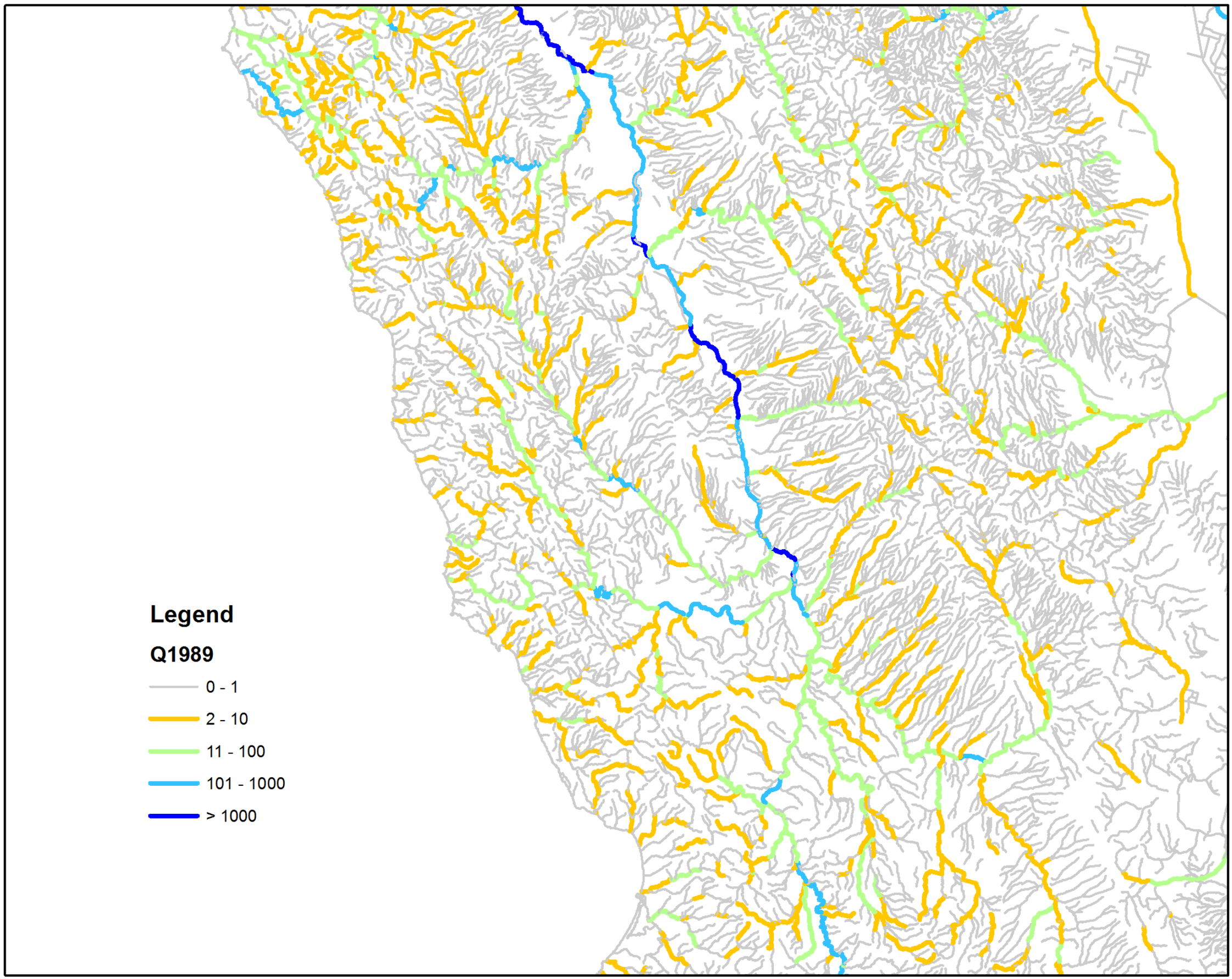

Legend
Q1984
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000

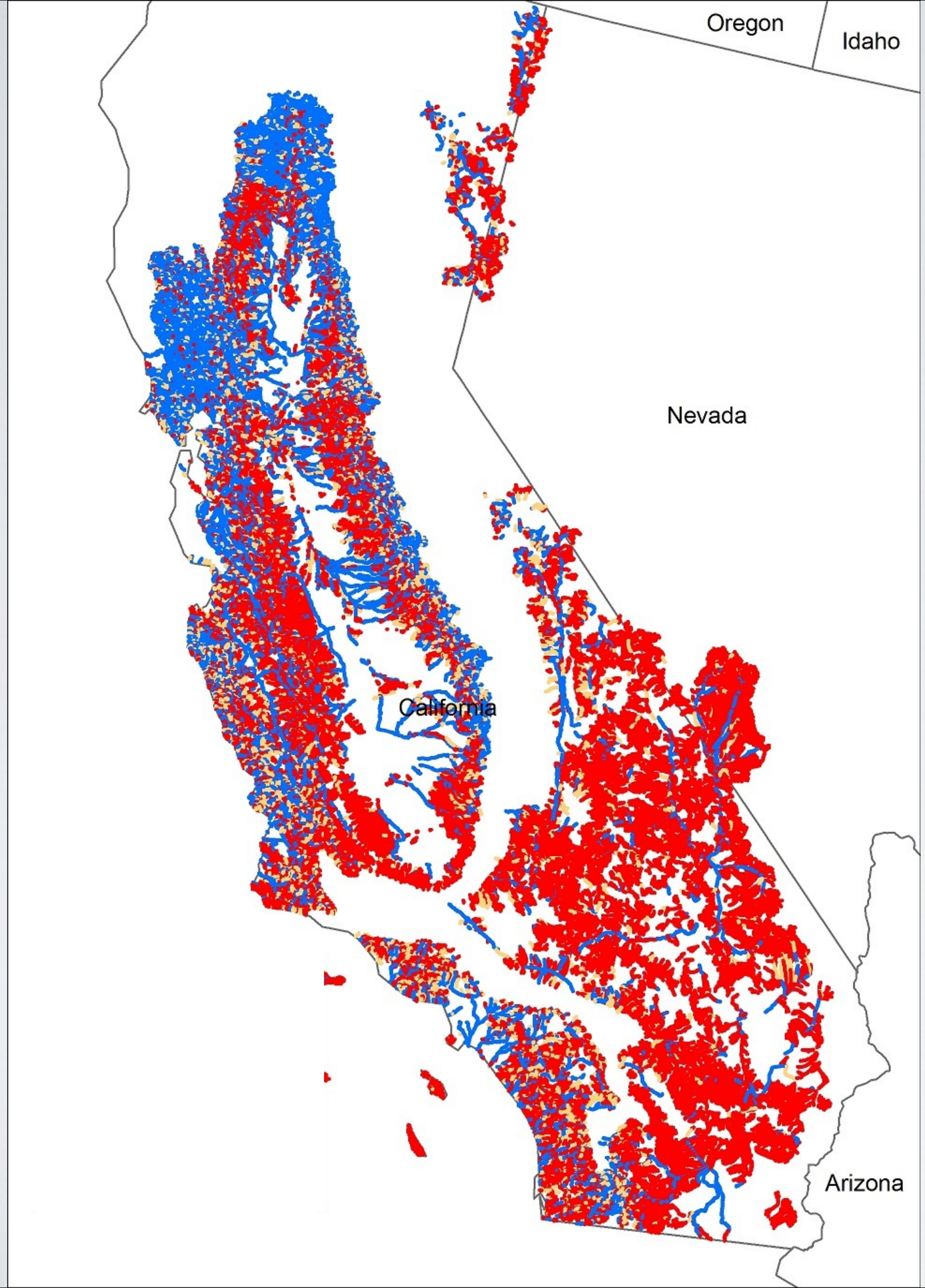

Legend
Q1985
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000


Legend
Q1986
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000


Legend
Q1987
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000


Legend
Q1988
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000


Legend
Q1989
0 - 1
2 - 10
11 - 100
101 - 1000
> 1000



Probability of April flow > 0

- 0 to 0.33
- 0.34 to 0.66
- 0.67 to 1

Which streams experience flow alteration?

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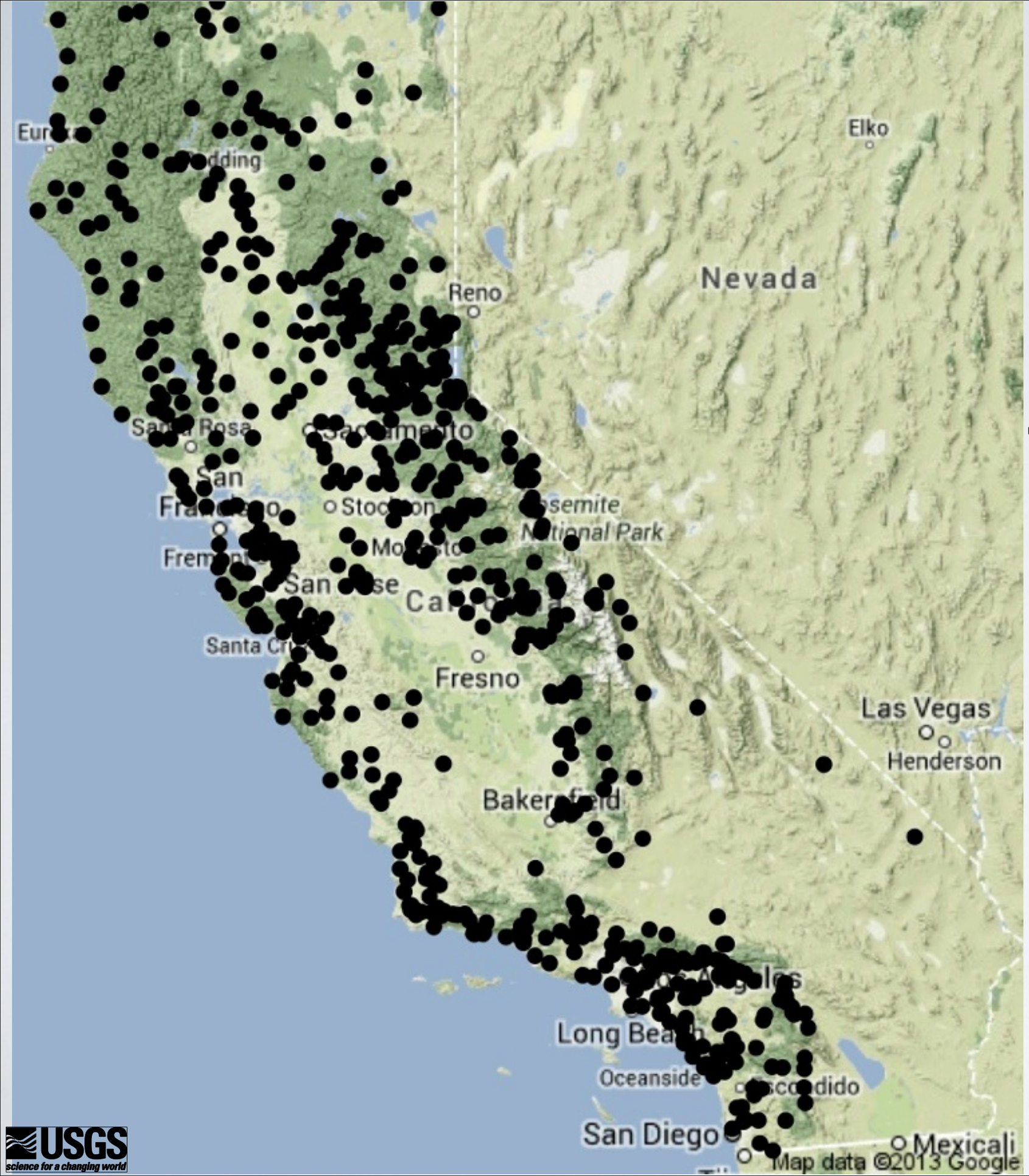

~700 USGS gages
>10yrs post 1990

Cucamonga Creek

Sept. mean flow (cfs)

1968 → 2010

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Cucamonga Creek

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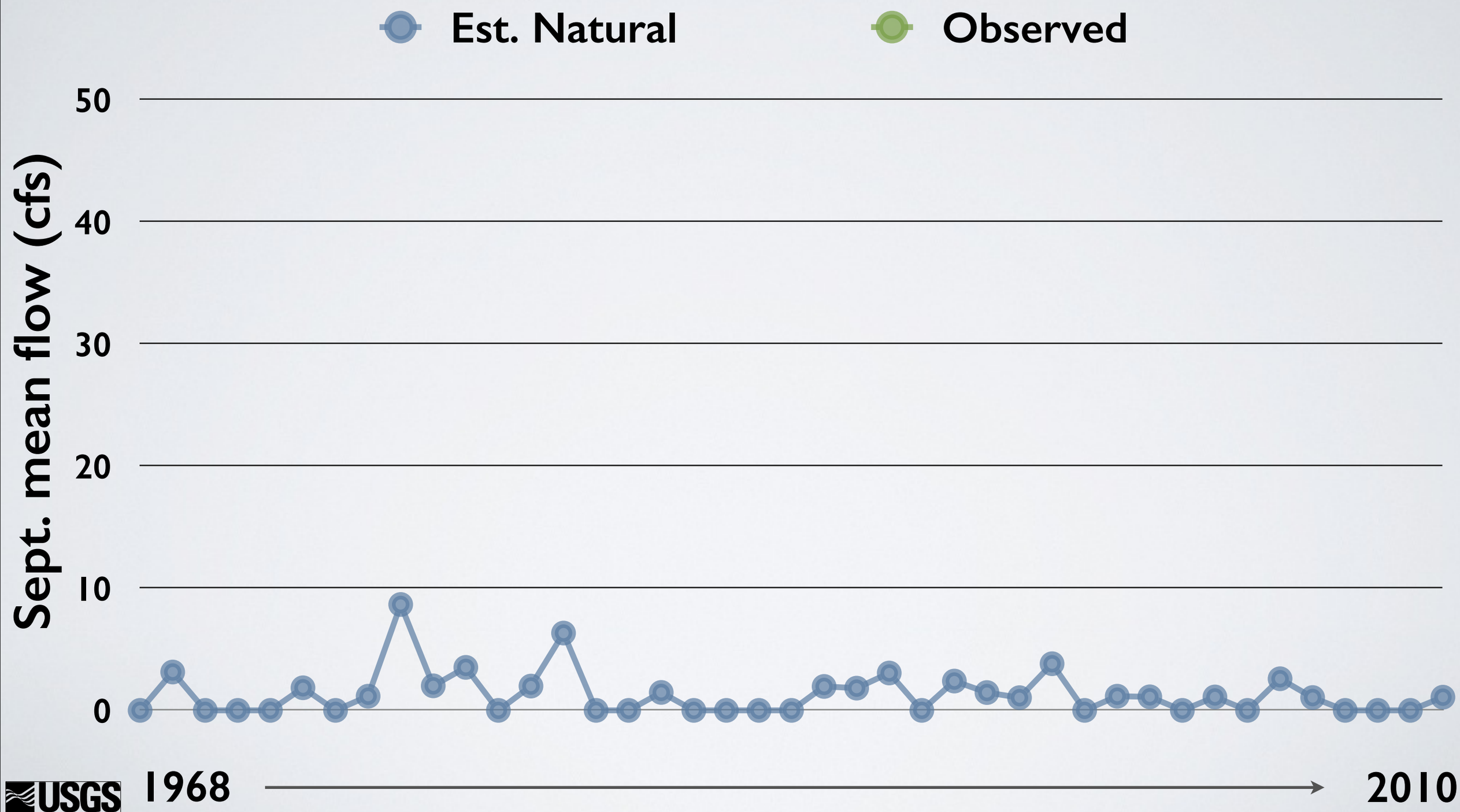
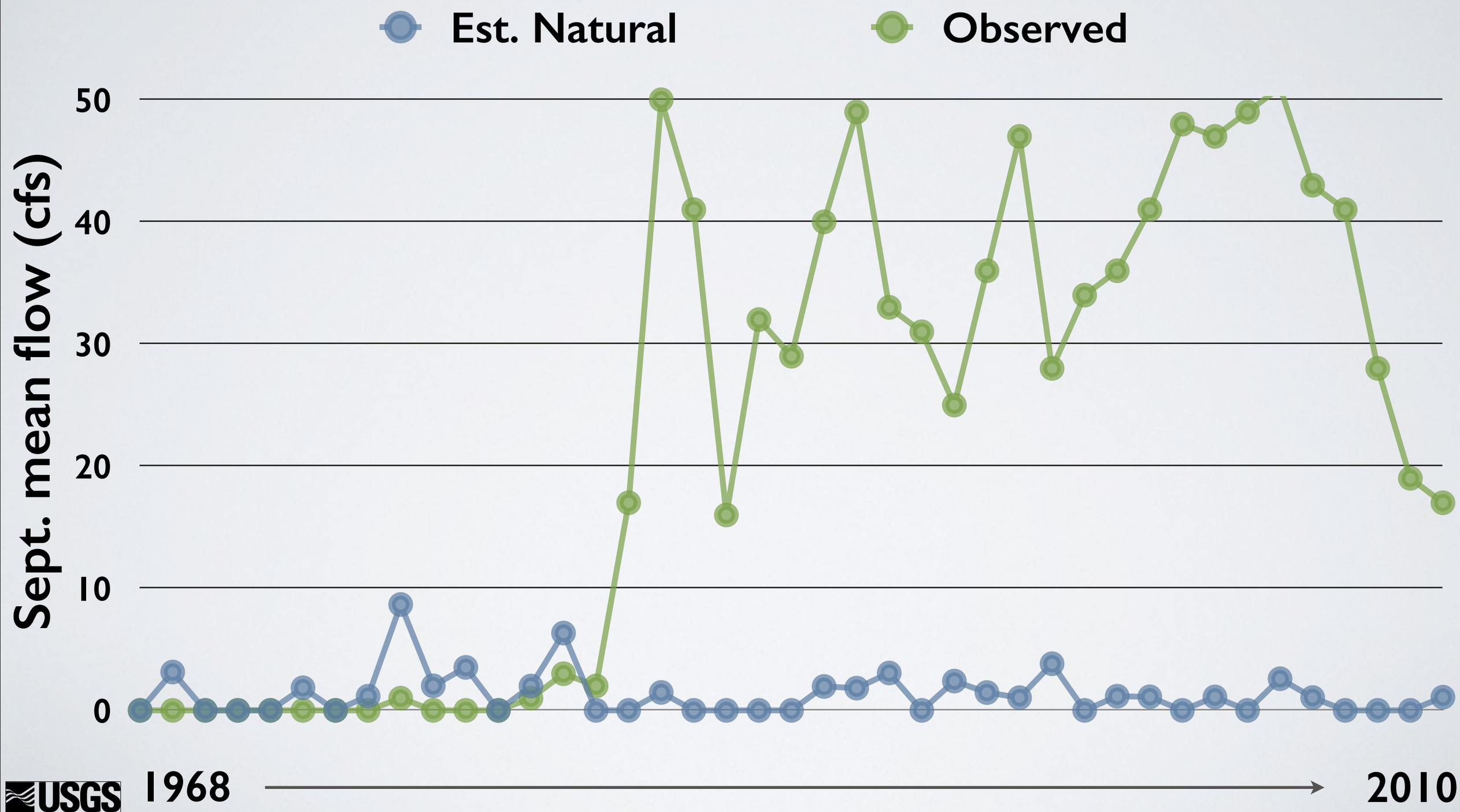
Cucamonga Creek



Cucamonga Creek



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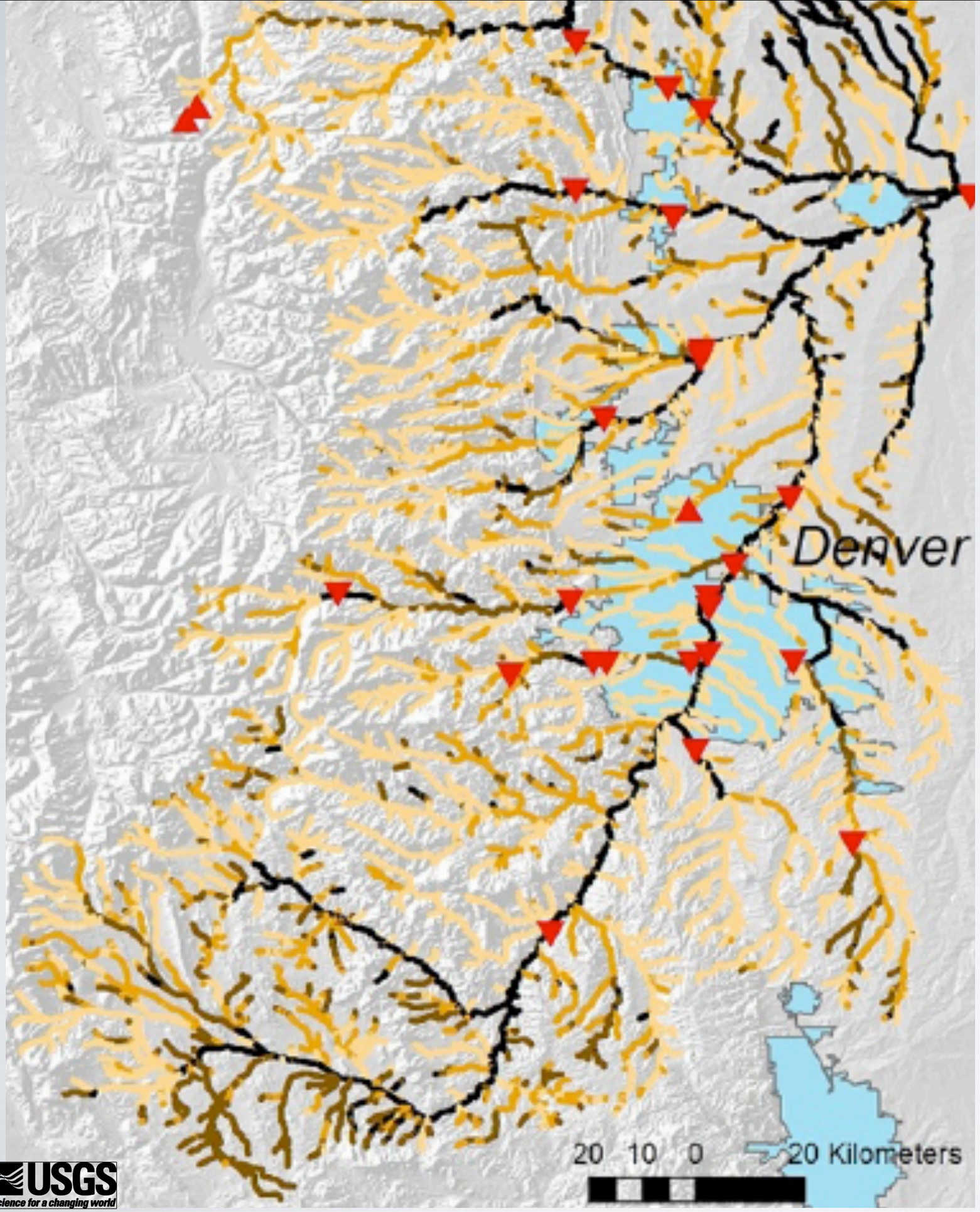

Increasing likelihood
of flow depletion

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Thank You

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