Long-term trends in dissolved solids in the Upper Colorado River Basin, 1929-2017

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U.S. Department of the Interior Bureau of Reclamation

Colorado River Basin Salinity Control Forum

Value of the Colorado River

- The Southwestern US relies on Colorado River water to sustain ecosystems, communities, and economies
  - Economic benefit exceeds $1.4 trillion/year
  - Used by over 40 million people
  - Provides water for ag, municipalities, and industry

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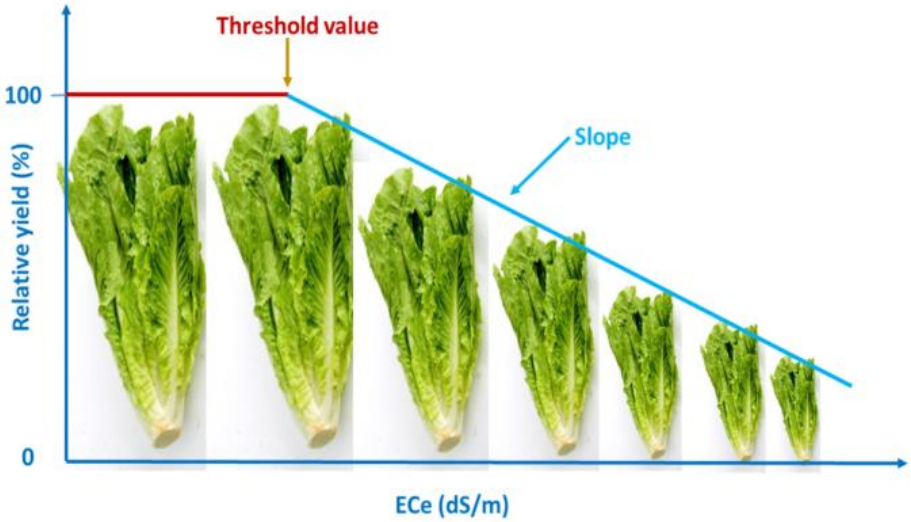
Salinity in the Colorado River

- Salinity is a major threat to water users
  - Quantified damages to U.S. users are ~$400 million/year
    - Decreased crop yields
    - Increased water treatment costs
- Water quality obligation to Mexico



- **Threshold: the EC of soil saturated extract (ECe) when yield starts decrease.**
- **Slope: % of yield decrease when ECe increased by 1 dS/m.**

English Text of Minute 242

INTERNATIONAL BOUNDARY AND WATER COMMISSION
UNITED STATES AND MEXICO

Mexico, D.F.
August 30, 1973

MINUTE NO. 242

PERMANENT AND DEFINITIVE SOLUTION TO THE
INTERNATIONAL PROBLEM OF THE SALINITY OF THE COLORADO RIVER

The Commission met at the Secretariat of Foreign Relations, at Mexico, D.F., at 5:00 p.m. on August 30, 1973, pursuant to the instructions received by the two Commissioners from their respective Governments, In order to incorporate in a Minute of the Commission the joint recommendations which were made to their

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Colorado River Salinity Control Forum

- 1973 - Colorado River Salinity Control Program was created to enhance and protect water quality in the Colorado River
  - Members include the 7 basin states; federal, state, and local agencies; public and private entities
  - Implement salinity control efforts
    - Irrigation upgrades
    - Vegetation management
    - Infrastructure improvements

Colorado River Basin SALINITY CONTROL FORUM

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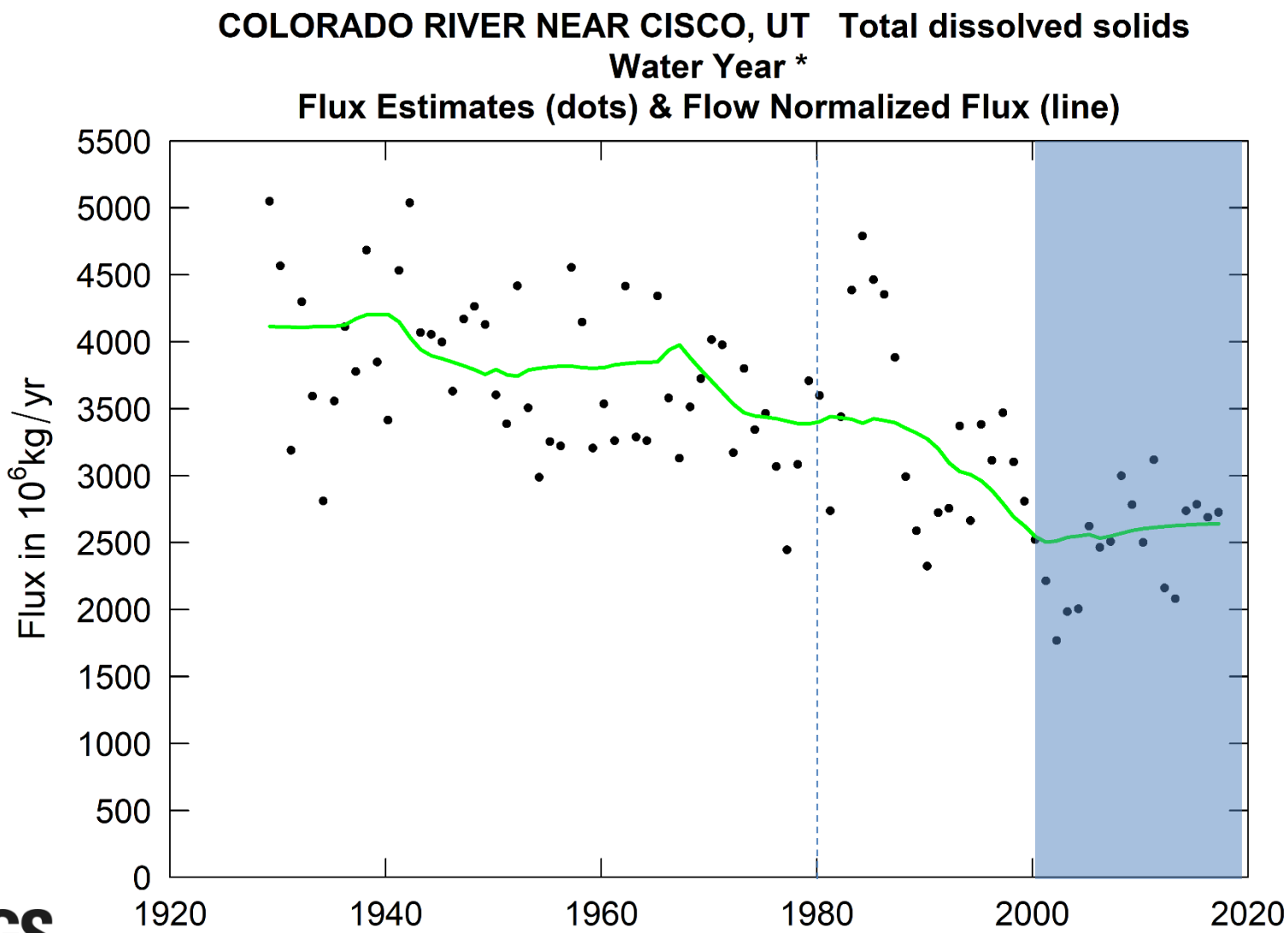
Long-term trends



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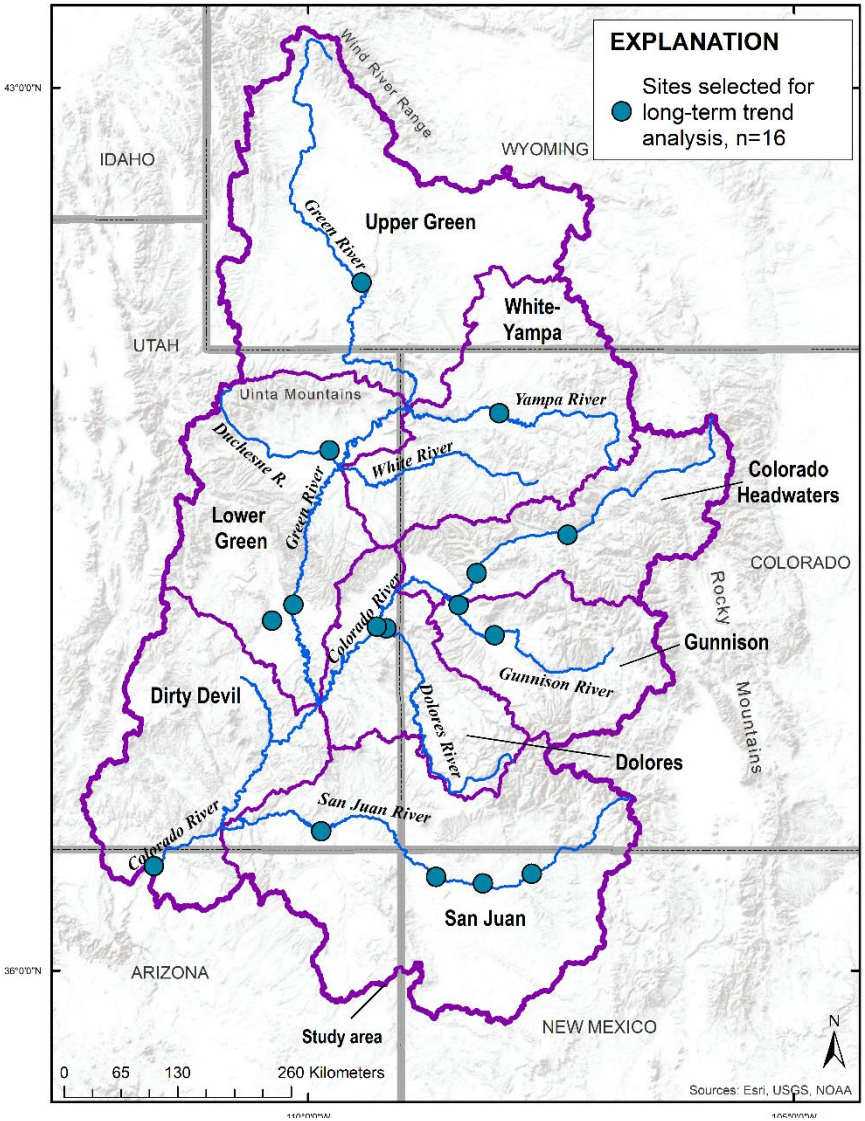
Salinity in the 20th and 21st centuries

- What are the long-term trends in salinity?
  - Calculate 50+ years of dissolved-solids trends
  - Understand how trends vary spatially across the UCRB
- What were salinity patterns prior to control projects?
- What are major forces driving long-term trends?
  - Correlate dissolved-solids trends to landscape and land-use change
- Can these processes help us understand how salinity will behave in the future?

Trend analysis

- Conduct long-term trend analysis for 16 sites
  - Identify sites with robust records (50+ years)
  - Combine composited samples (pre-1960) with discrete samples (1960 – present)
  - Combine dissolved solids from multiple measurement methods (SC, ROE, SUM)



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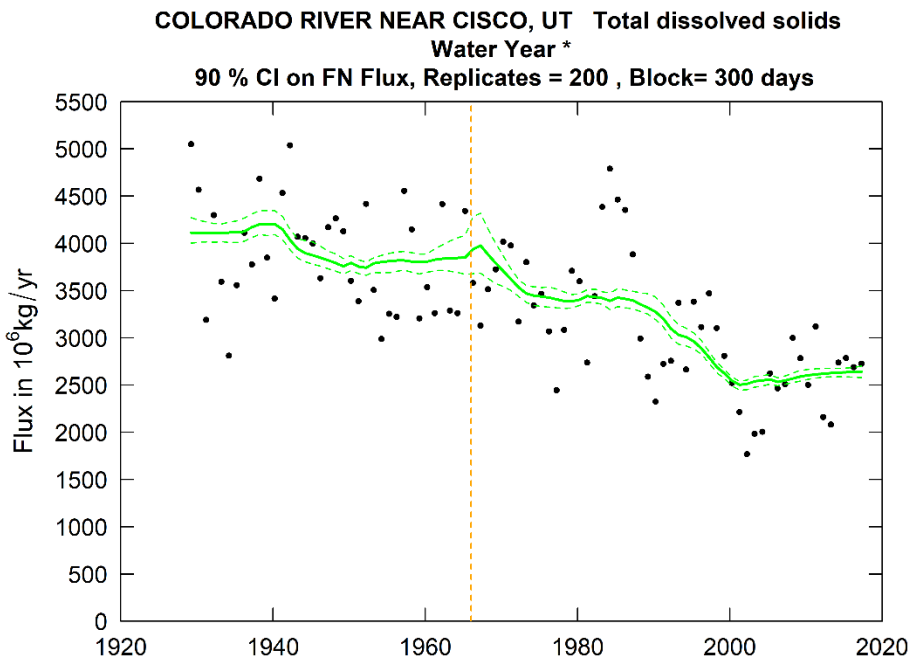
Trend analysis

- Analyze long-term (50+ year) dissolved-solids trends
  - WRTDS 3.0 - Weighted regressions on time, discharge, and season
  - Flexible flow-normalization
  - Uncertainty
  - The “wall”
  - CQTC vs. QTC



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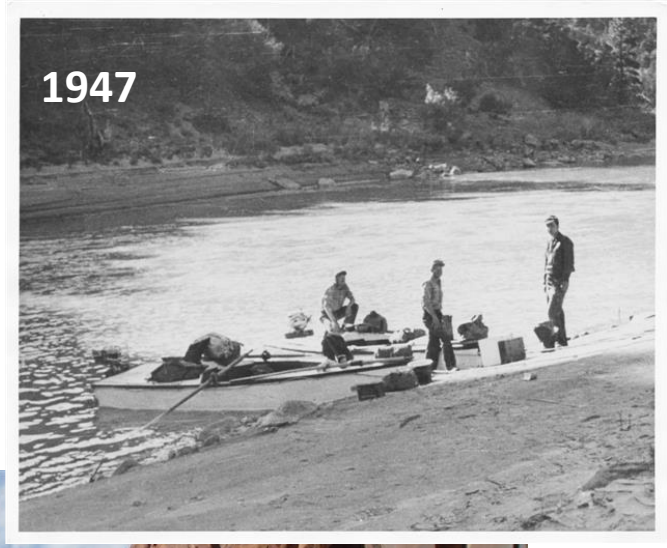
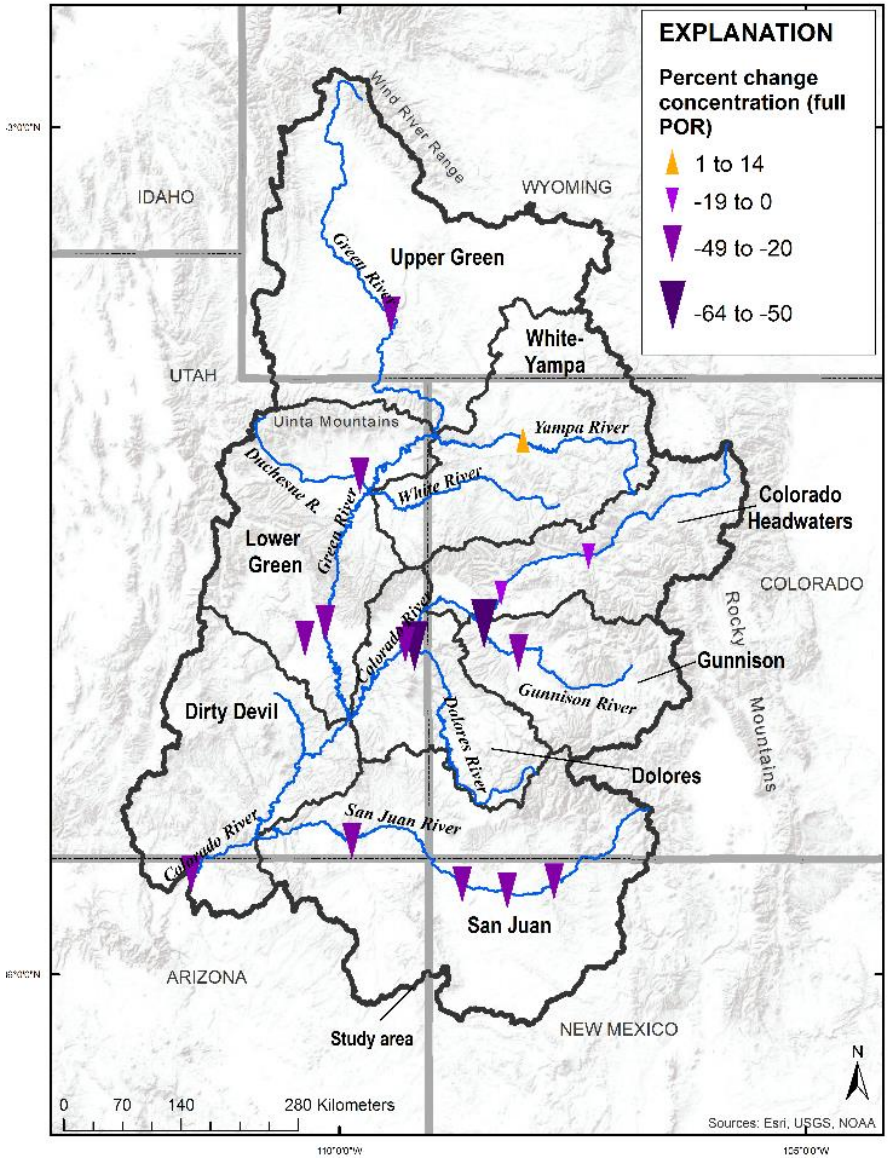
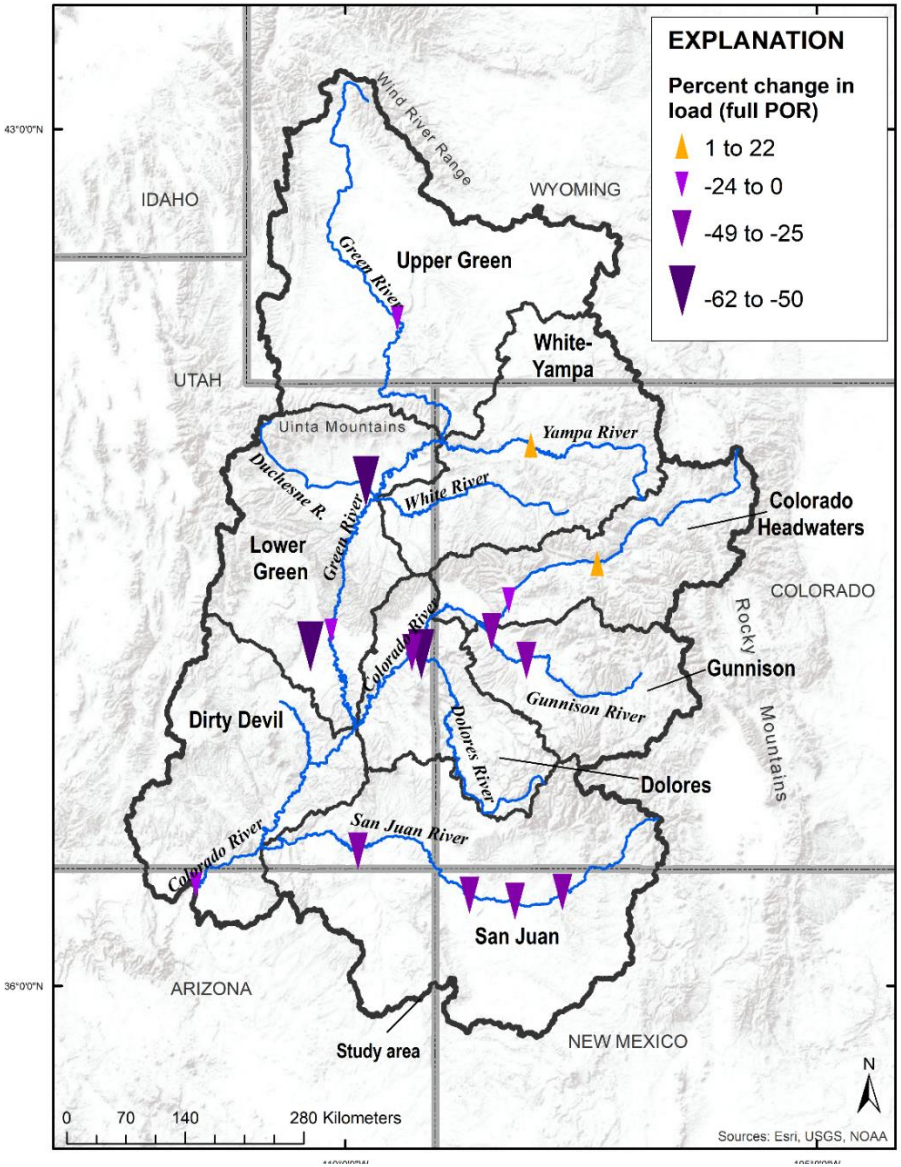
USGS long-term records

- This work is possible because of the availability of long-term discharge and water quality data collected by USGS
  - Data from pre-1960 to present

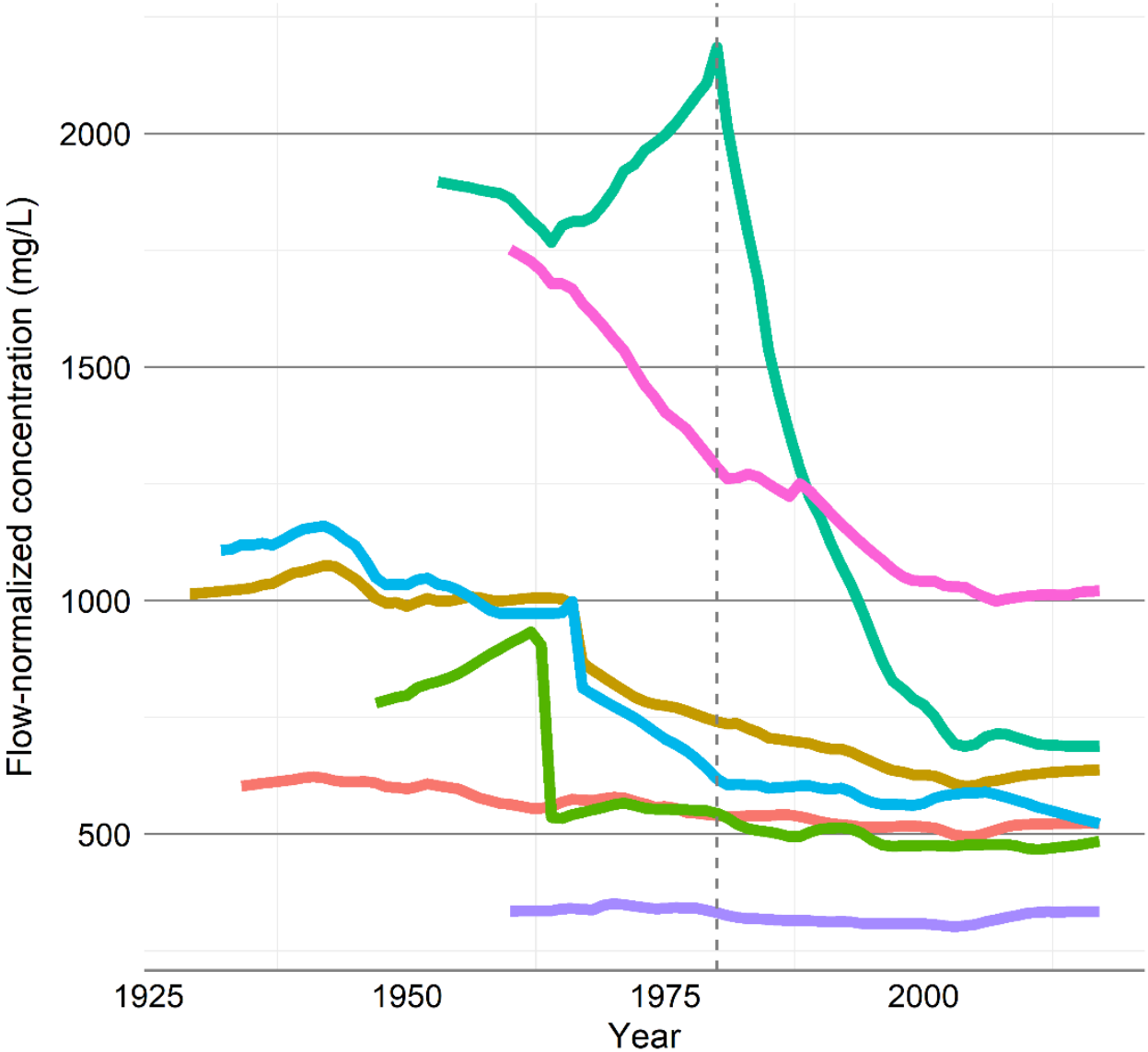


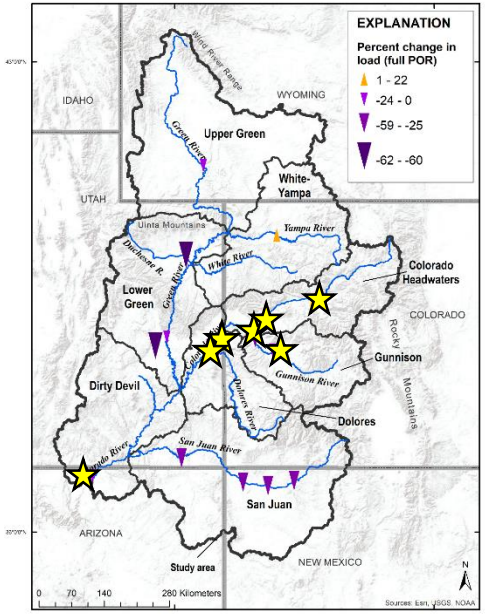
Widespread decreasing salinity trends





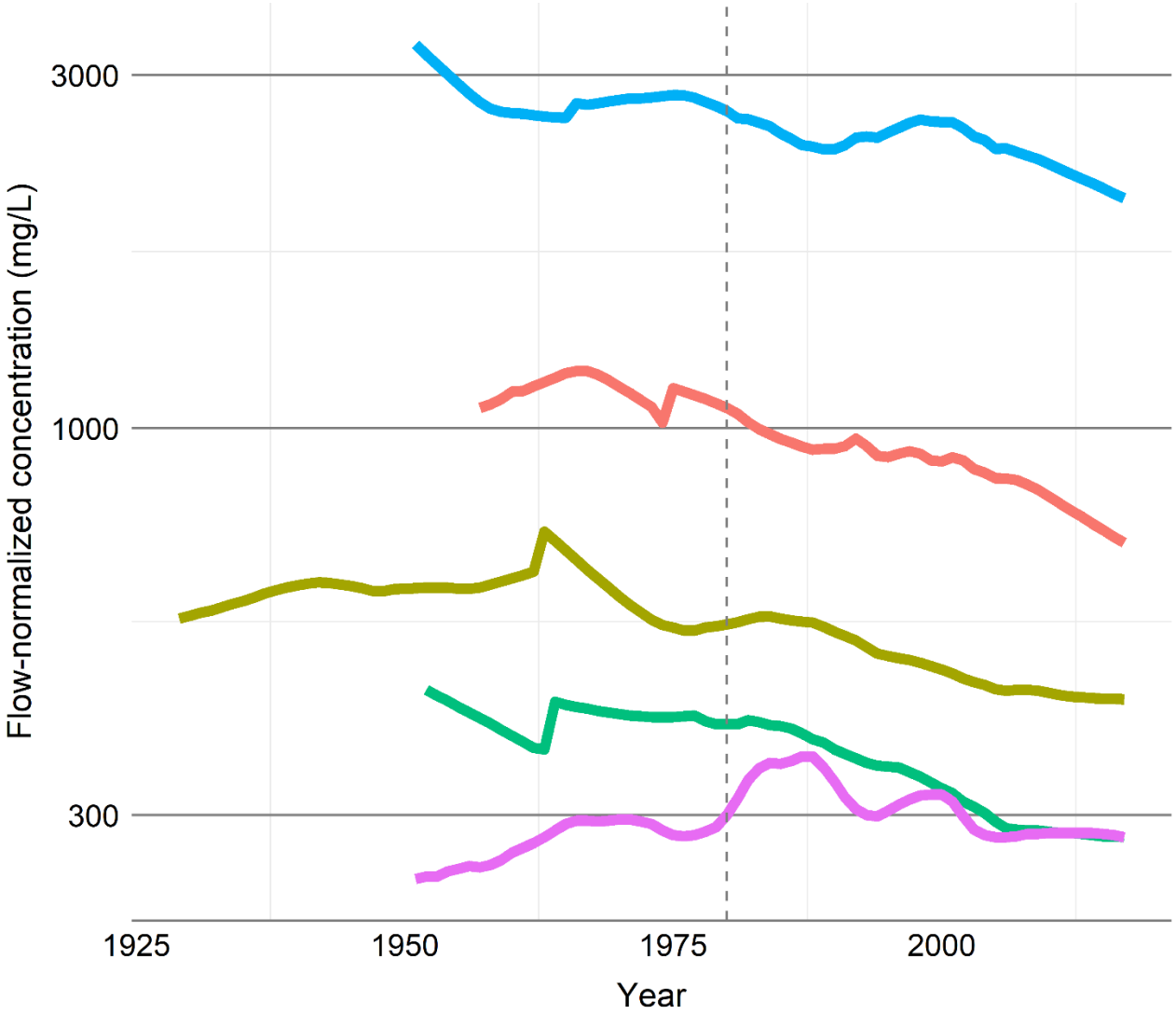
Concentration trends: Colorado Basin

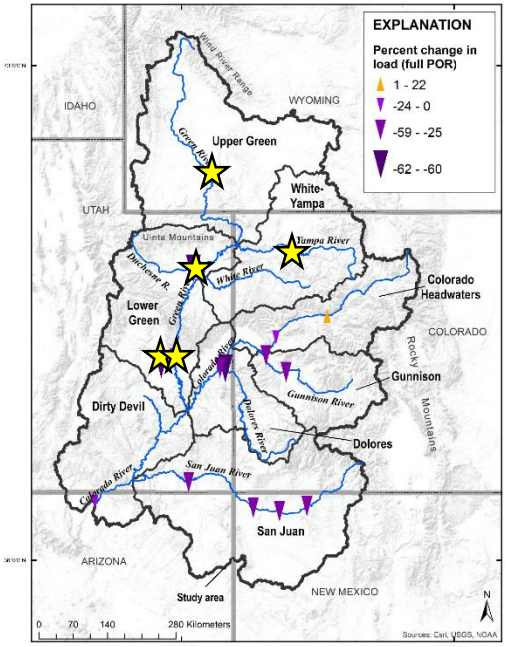




- CR - CAMEO
- CR - CISCO
- CR - LEES FERRY
- DOLORES - CISCO
- GUNN R - GRAND JUNCTION
- ROARING FORK - GLENWOOD SPGS
- UNCOMPAHGRE - DELTA

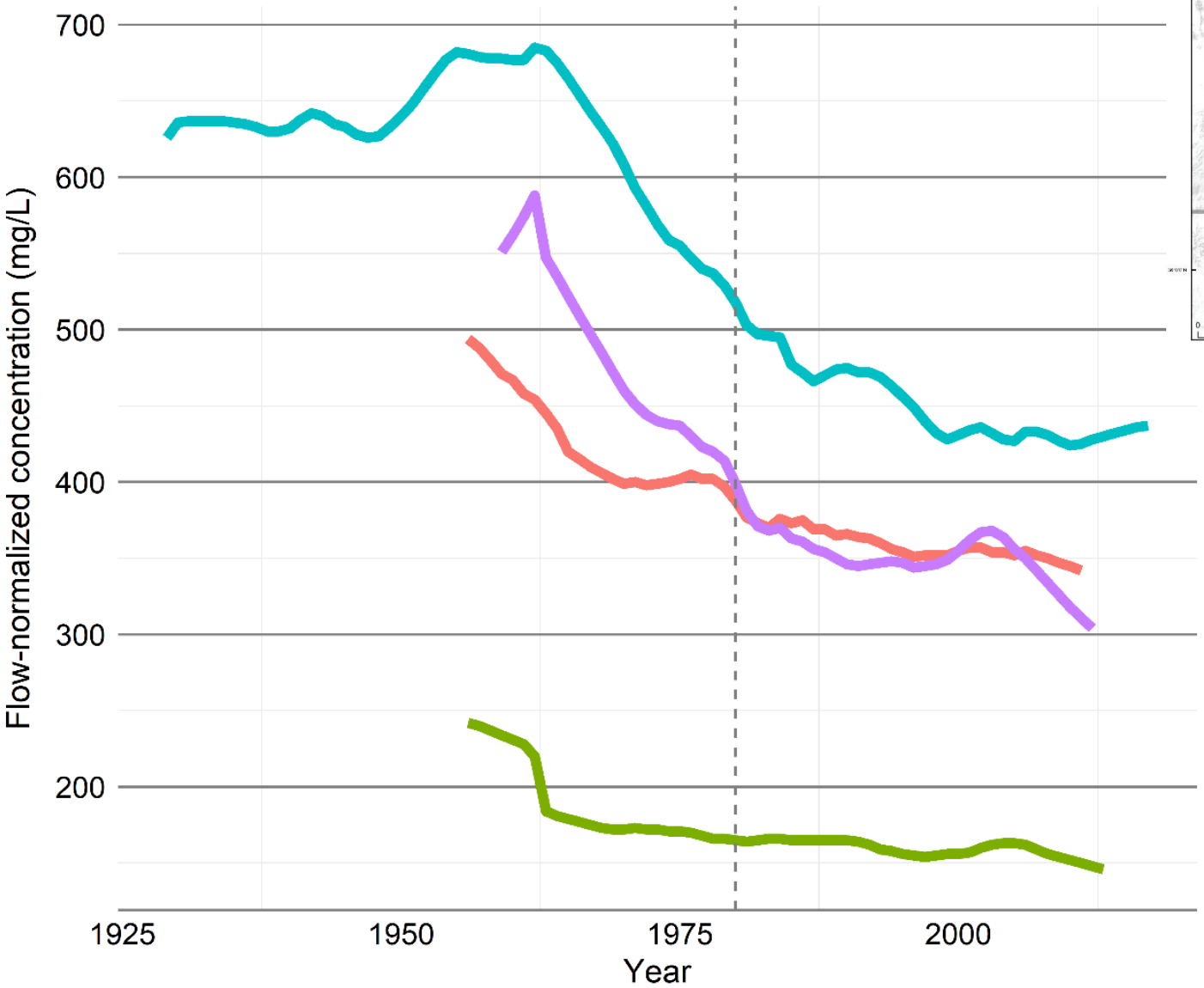
Concentration trends: Green River Basin

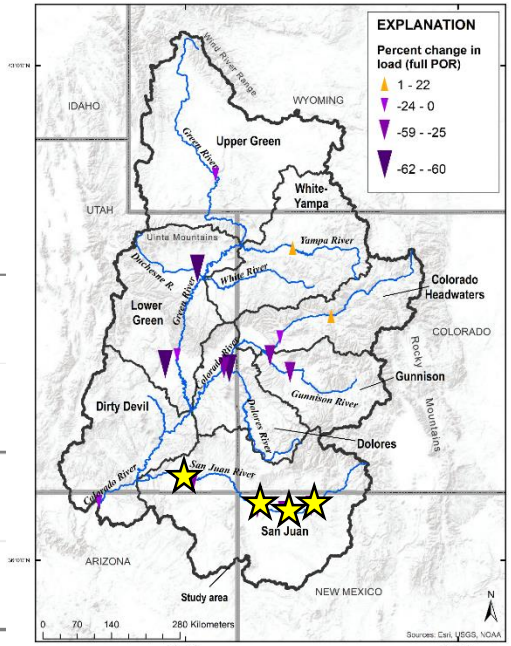




- DUCHESNE - RANDLETT
- GR - GREEN RIVER, UT
- GR - GREEN RIVER, WY
- SAN RAFAEL - GREEN RIVER
- YAMPA - MAYBELL

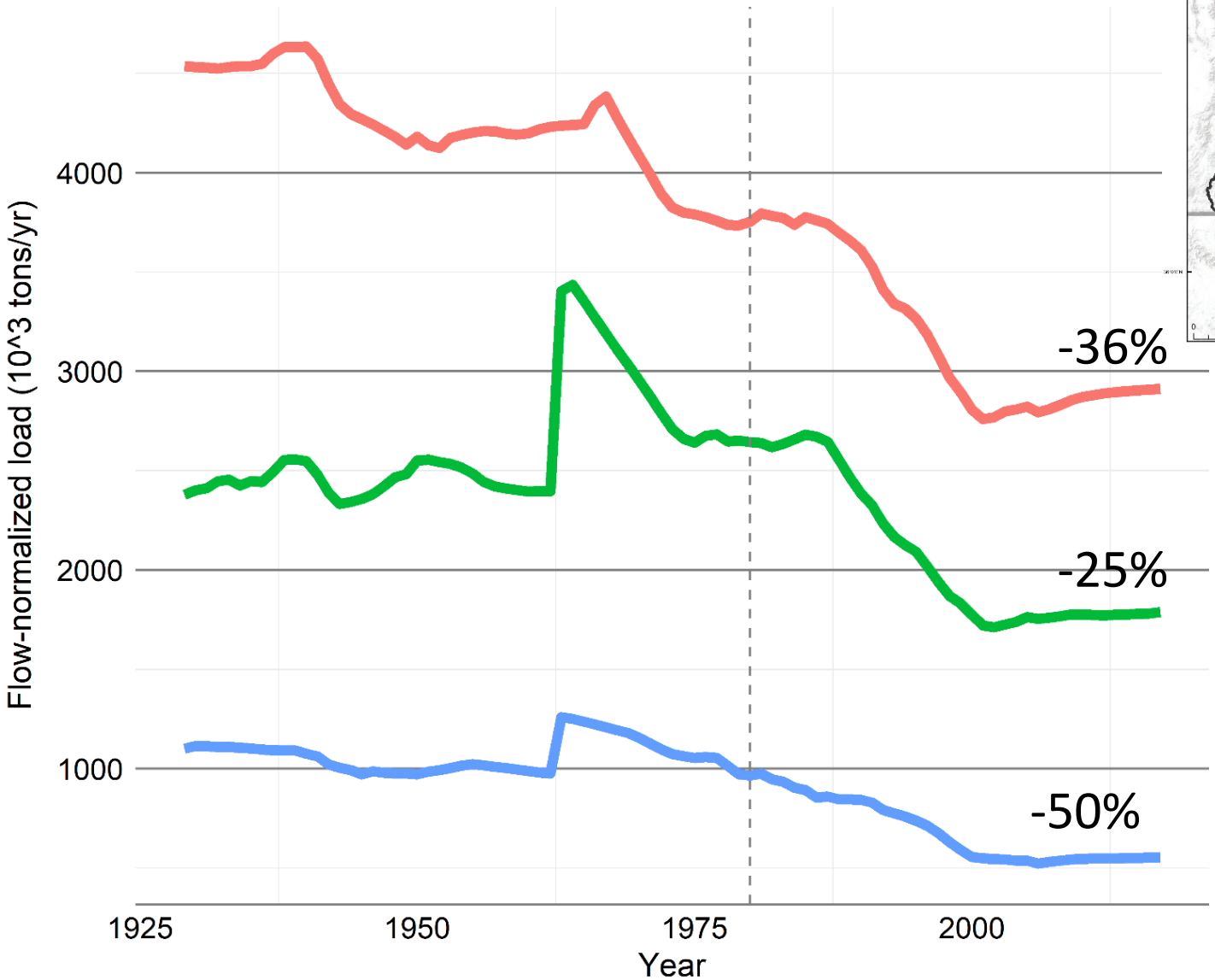
Concentration trends: San Juan Basin

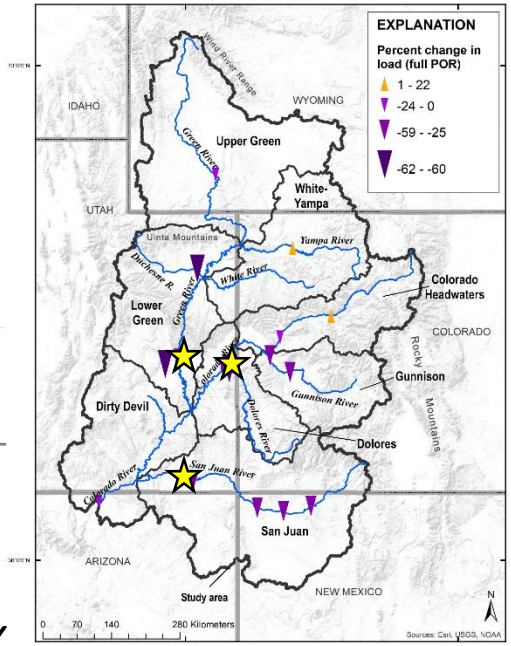




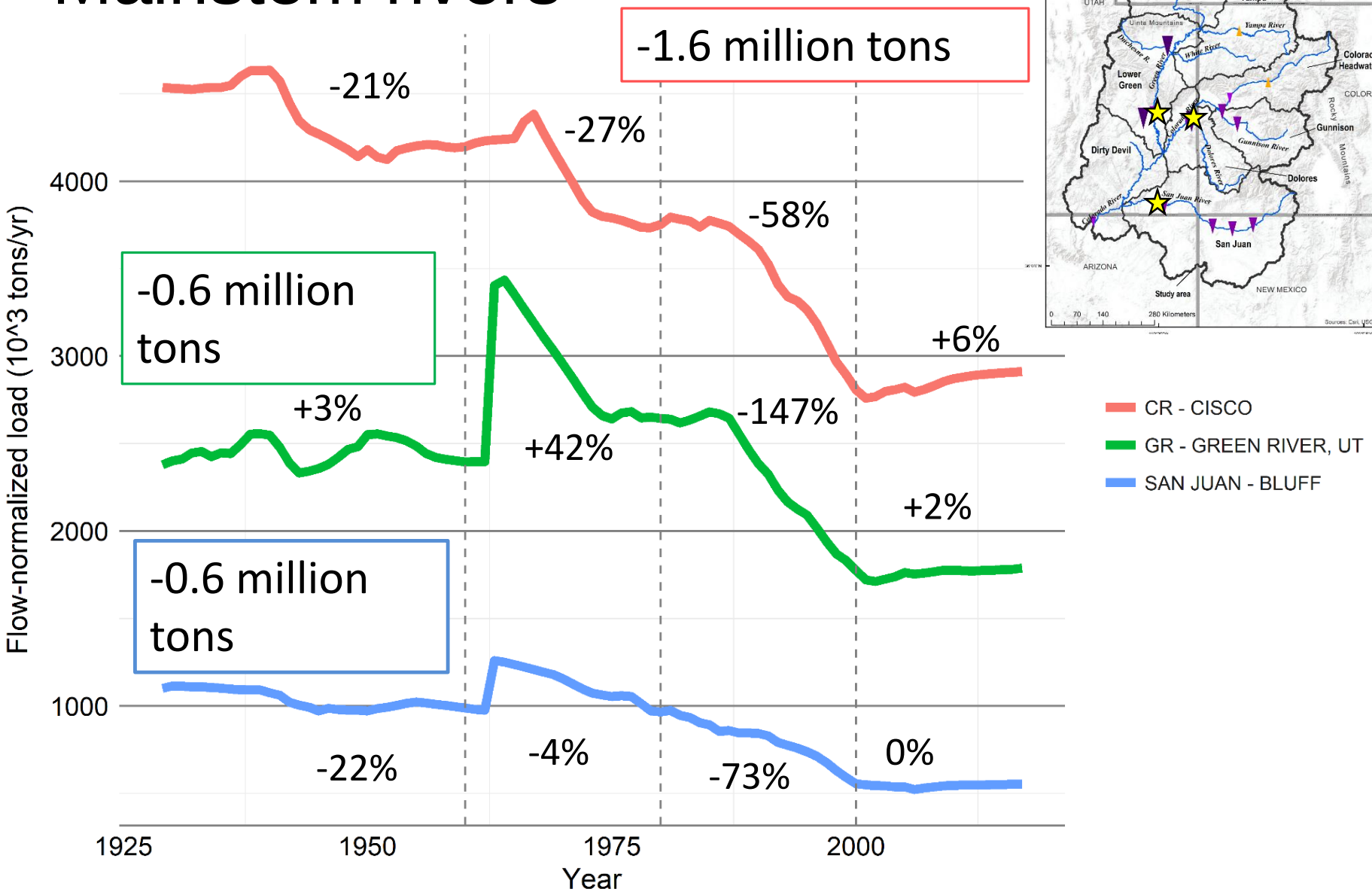
ANIMAS - FARMINGTON
SAN JUAN - ARCHULETA
SAN JUAN - BLUFF
SAN JUAN - SHIPROCK

Load trends: Mainstem rivers

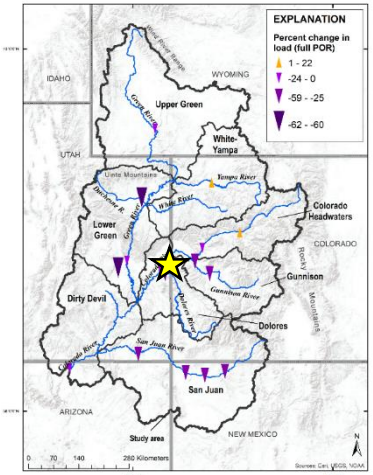


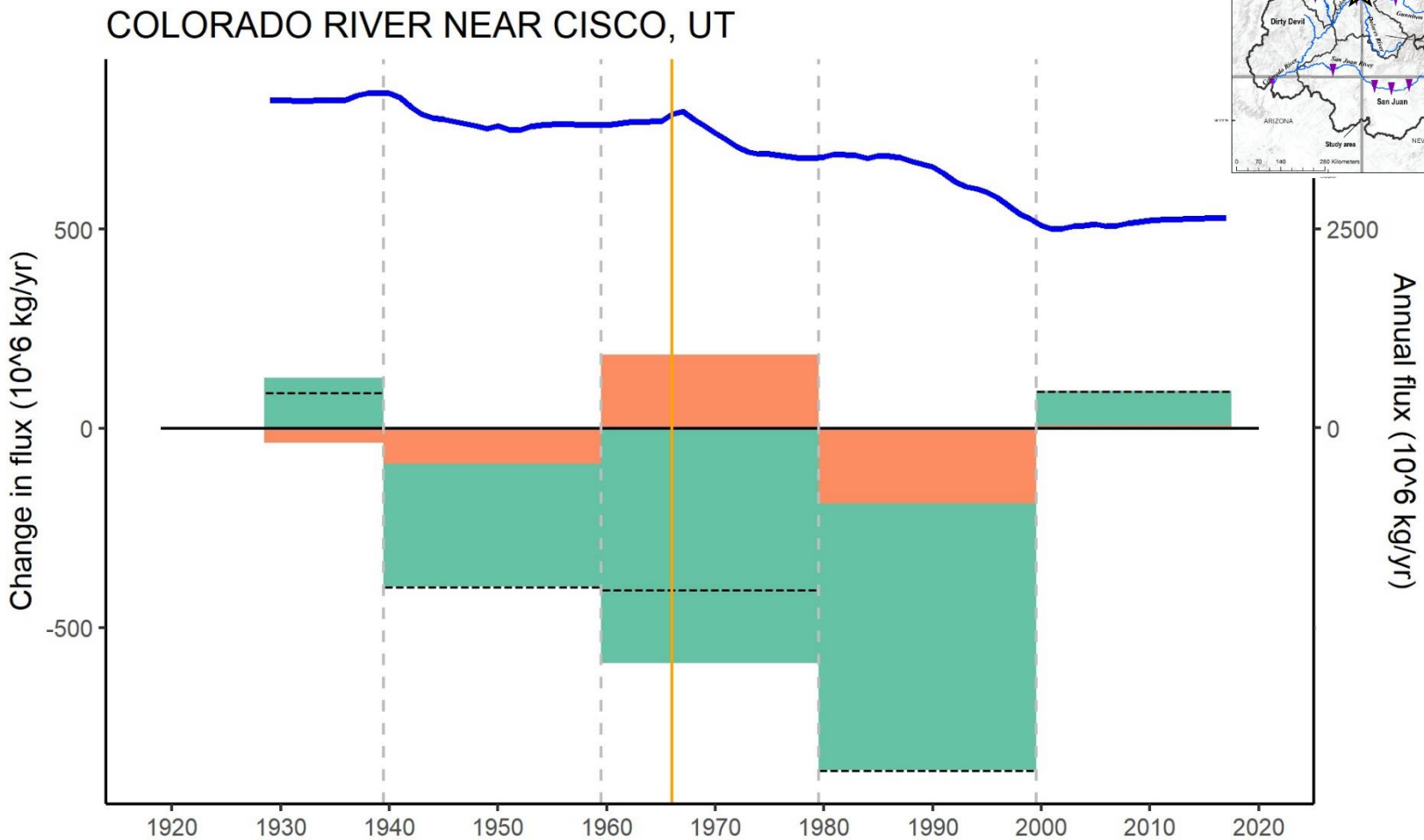


Load trends: Mainstem rivers



Are trends related to watershed processes or streamflow?





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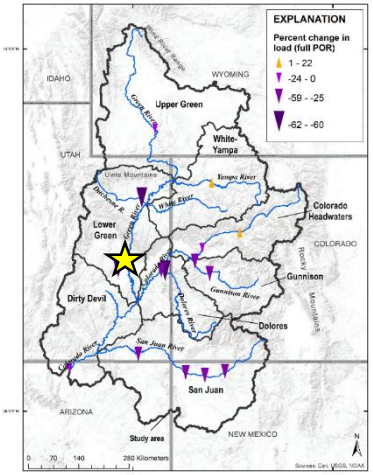

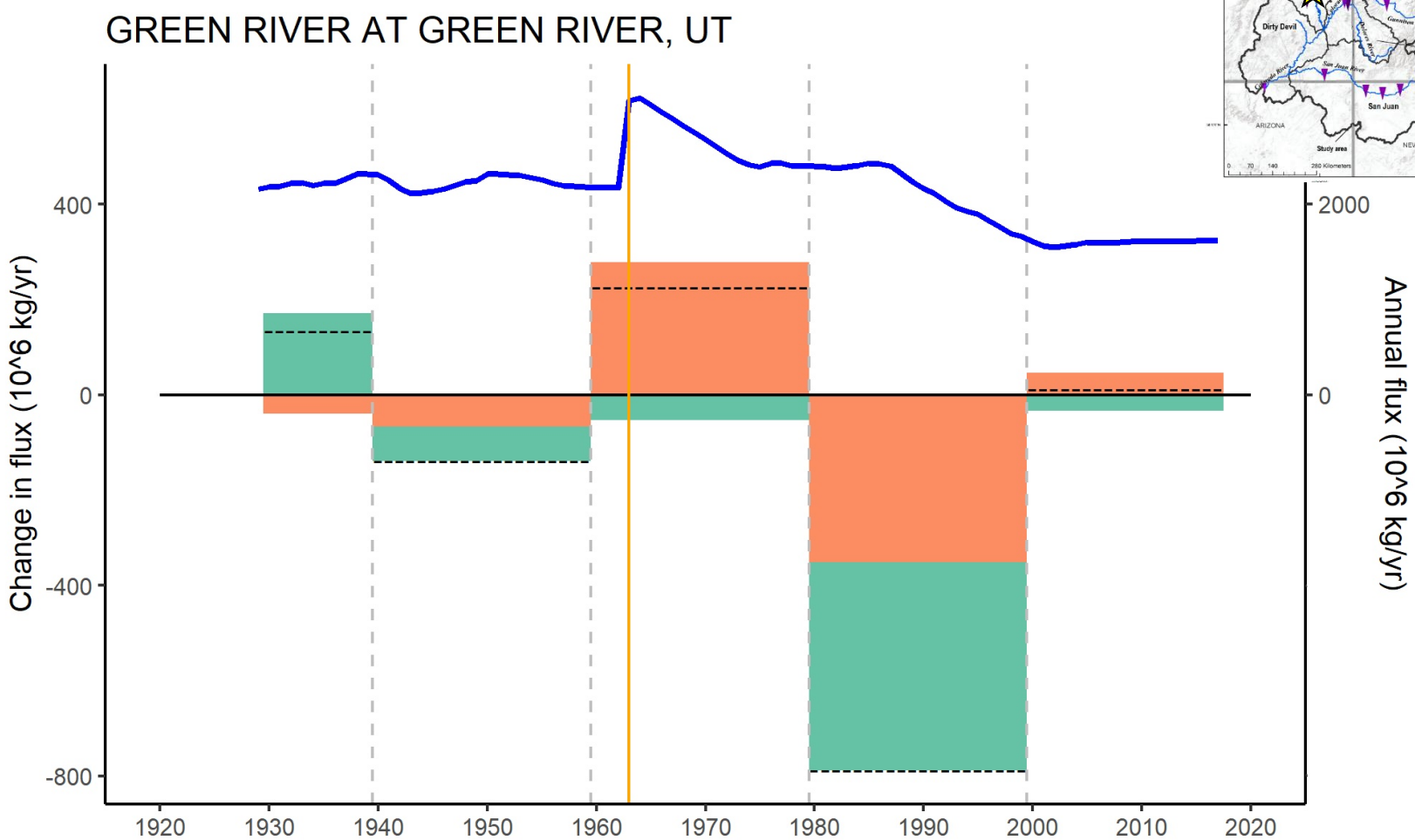

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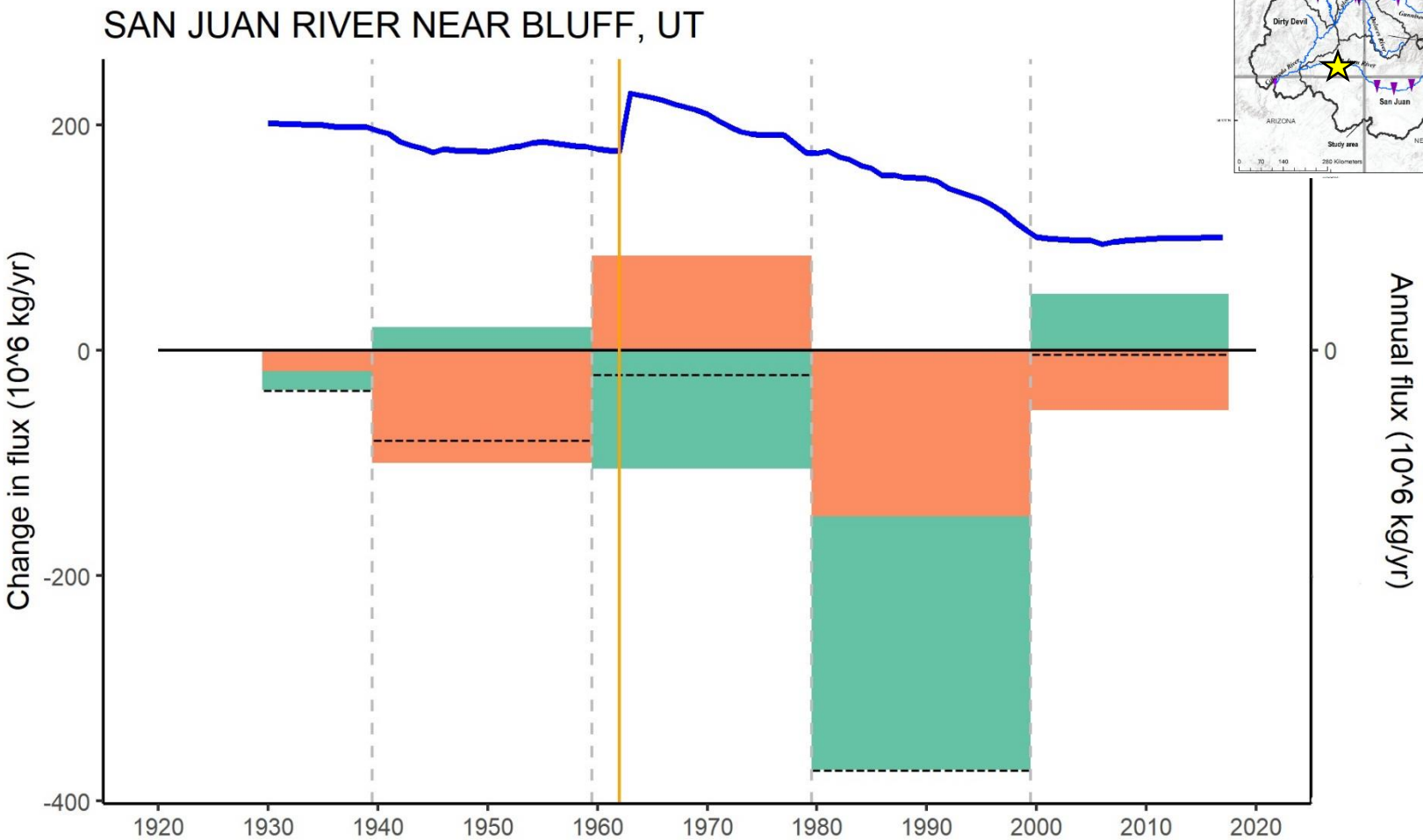

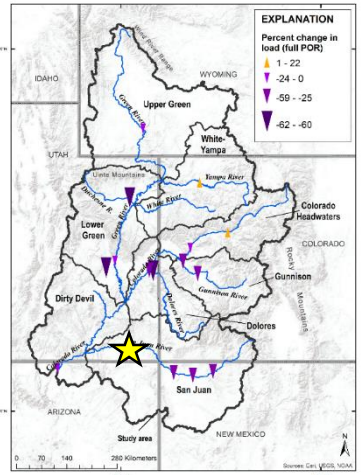

Major findings

- Widespread declines in salinity loads and concentrations
- Greatest rate of decrease occurred from 1980 to 2000
- Consistent flattening of salinity loads after 2000
- Decreasing trends related more to changes occurring in the watershed

What are drivers of multi-decadal changes in salinity?

- Changes in vegetation
  - recovery from grazing, fire, logging, climate, etc.
- Streamflow processes
  - arroyo cutting, dams, water use, climate
- Land use
  - resource extraction, grazing, agriculture, logging
- Salinity control projects
  - irrigation improvements, point-source mitigation

Questions/ideas?

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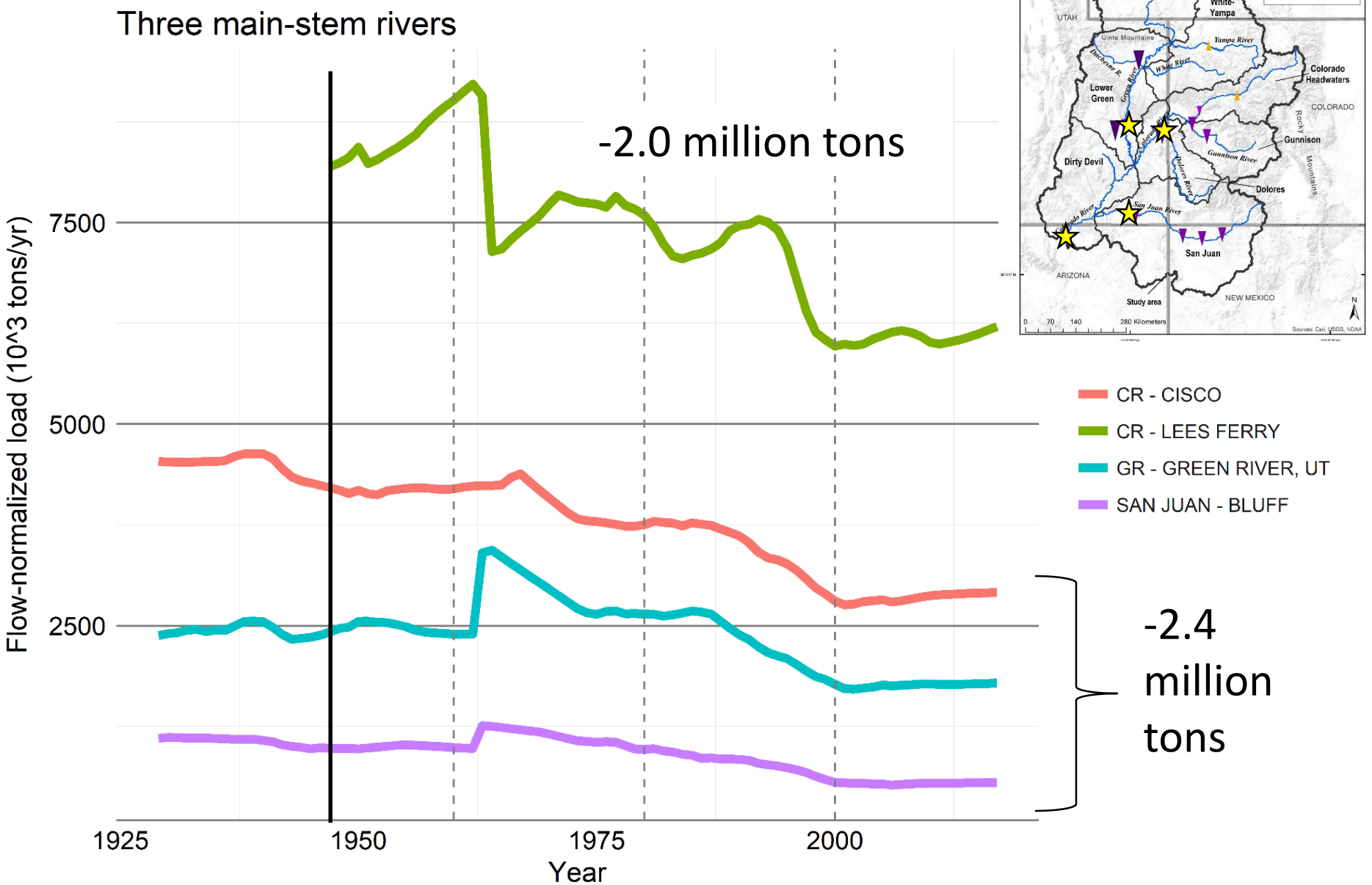
Trend analysis



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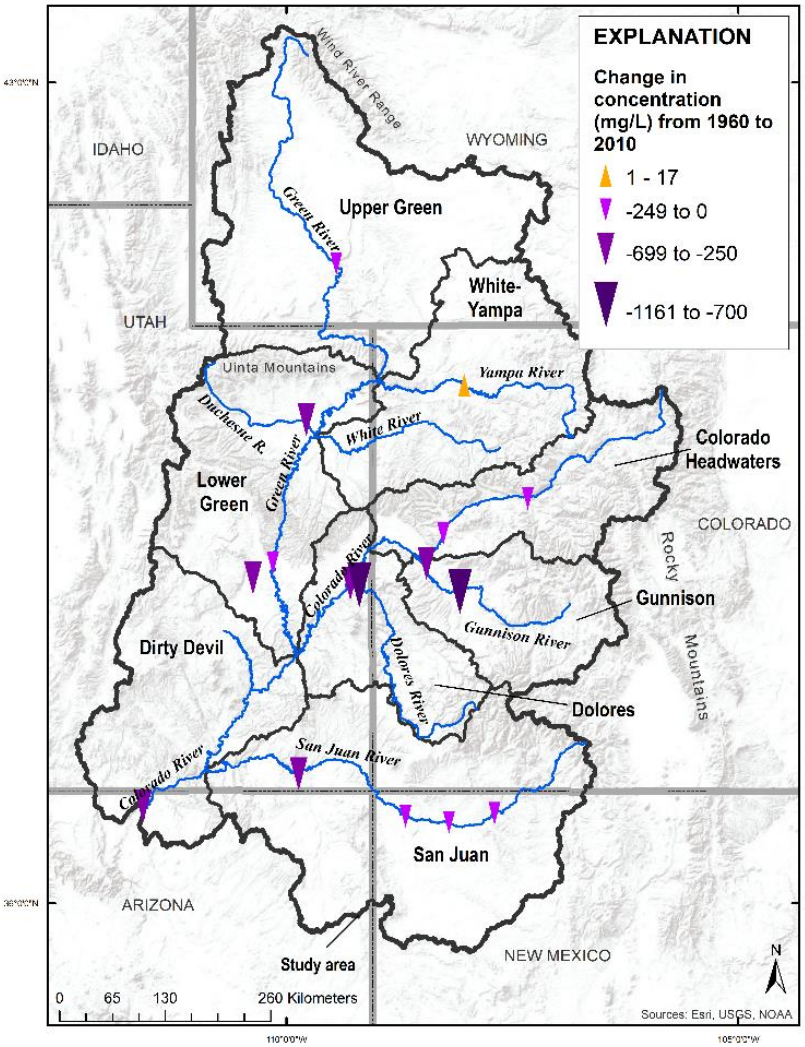
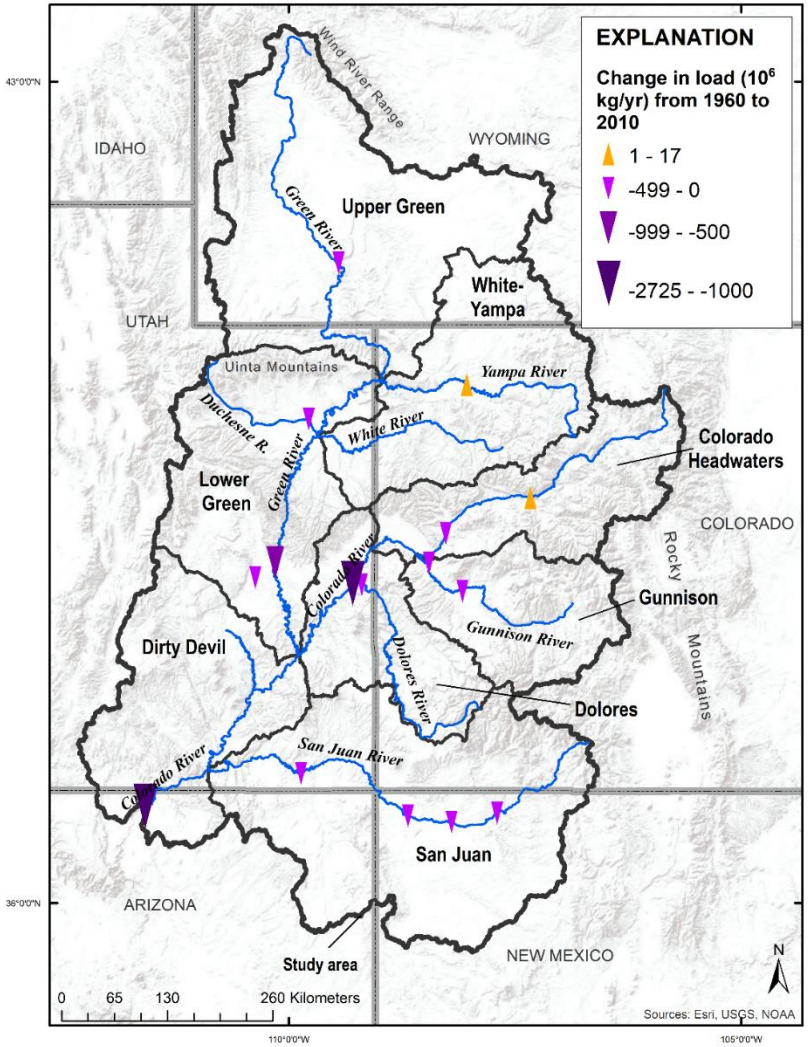


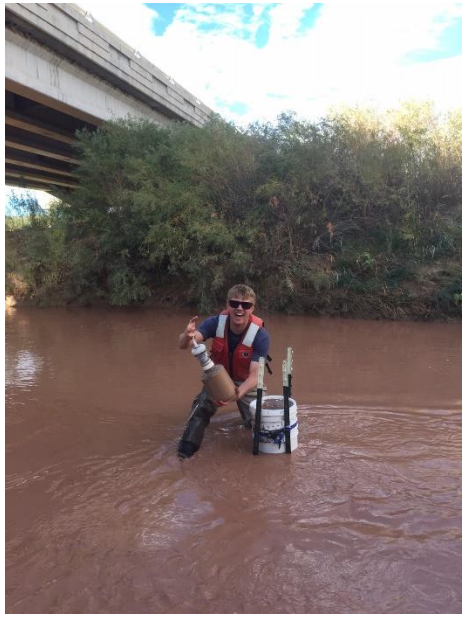


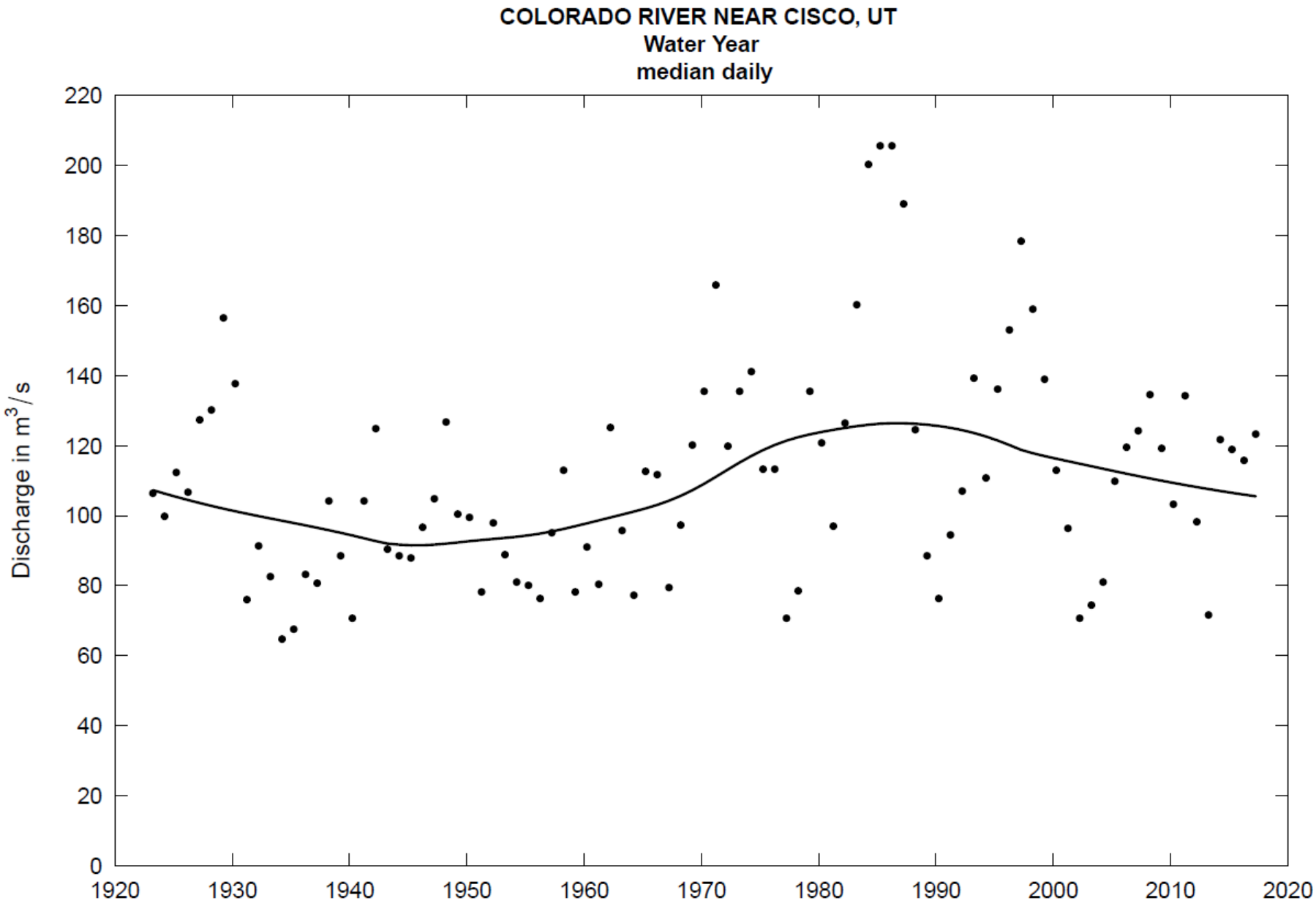
Relevance and Benefits

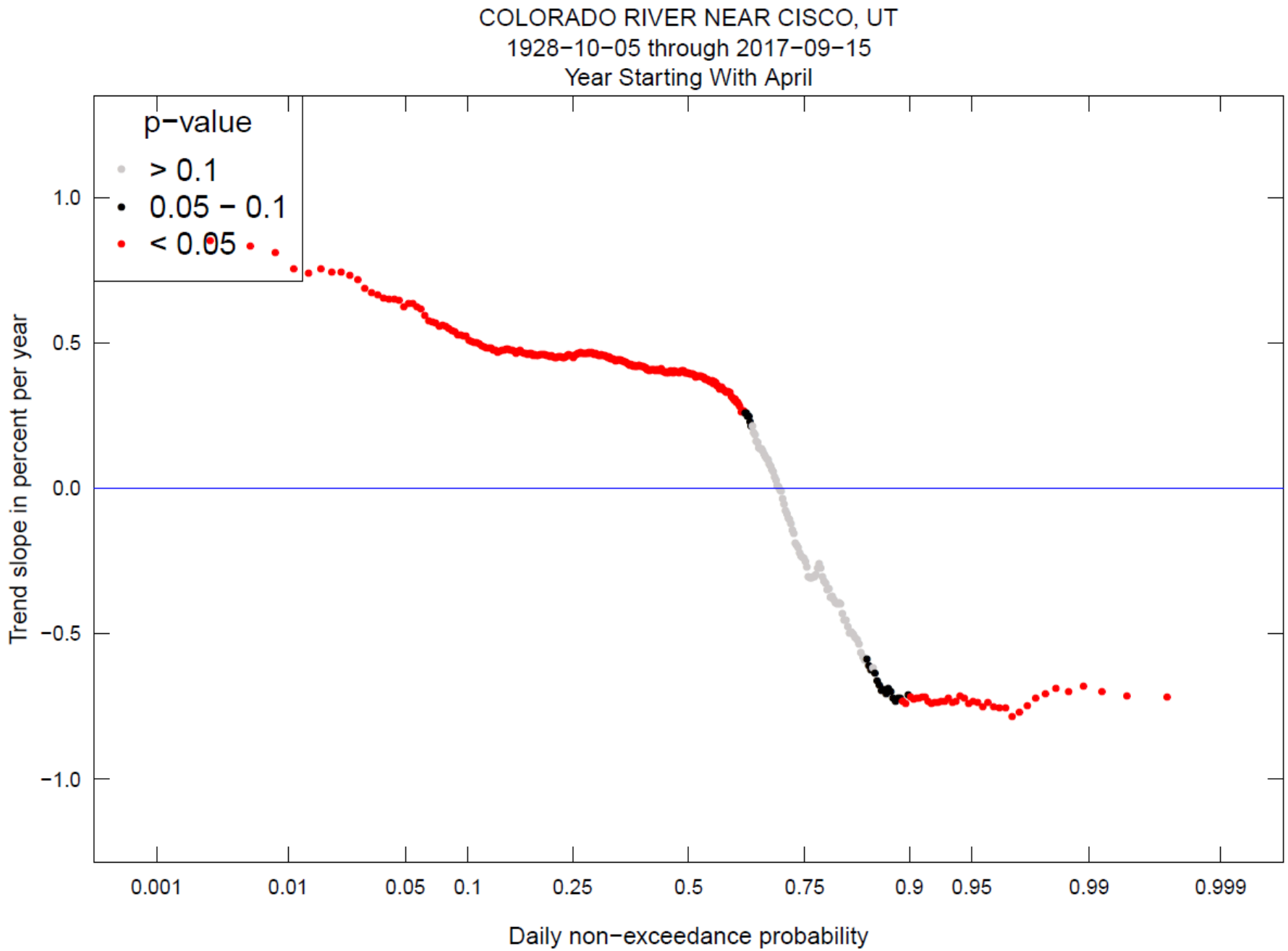
- Need to minimize salinity generated in the Upper Basin for downstream users and to meet international treaty obligations
- Identifying processes affecting salt transport informs and improves how we manage salinity in the future
- There may be natural processes that land/water managers can capitalize on to more efficiently reduce salt loads

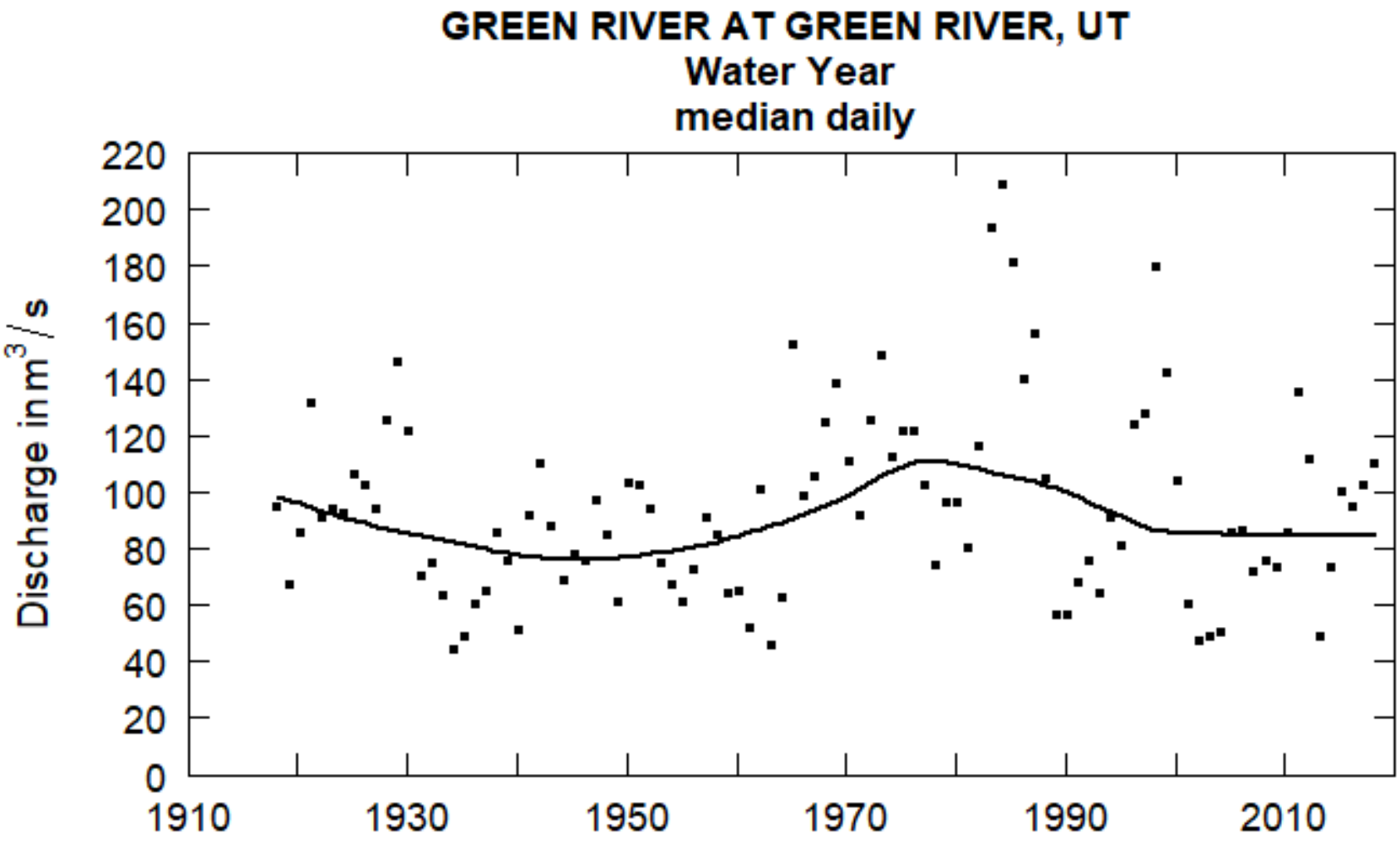
USGS partnership with Salinity Control Forum

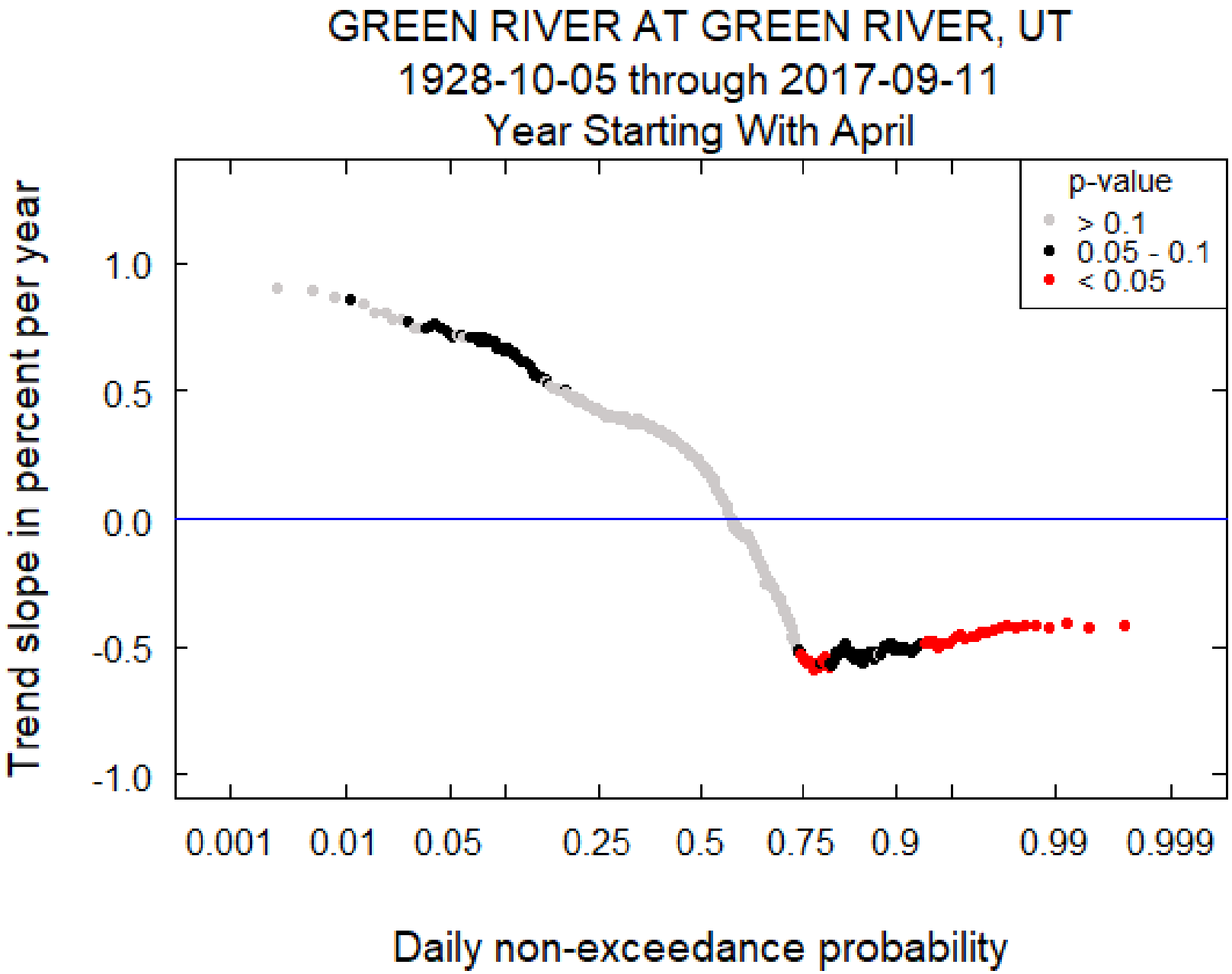
- USGS conducts scientific research of salinity loading, sources, and transport
- Science advisors to Forum
- Effective salinity mitigation requires monitoring and improved understanding of salinity distribution and processes

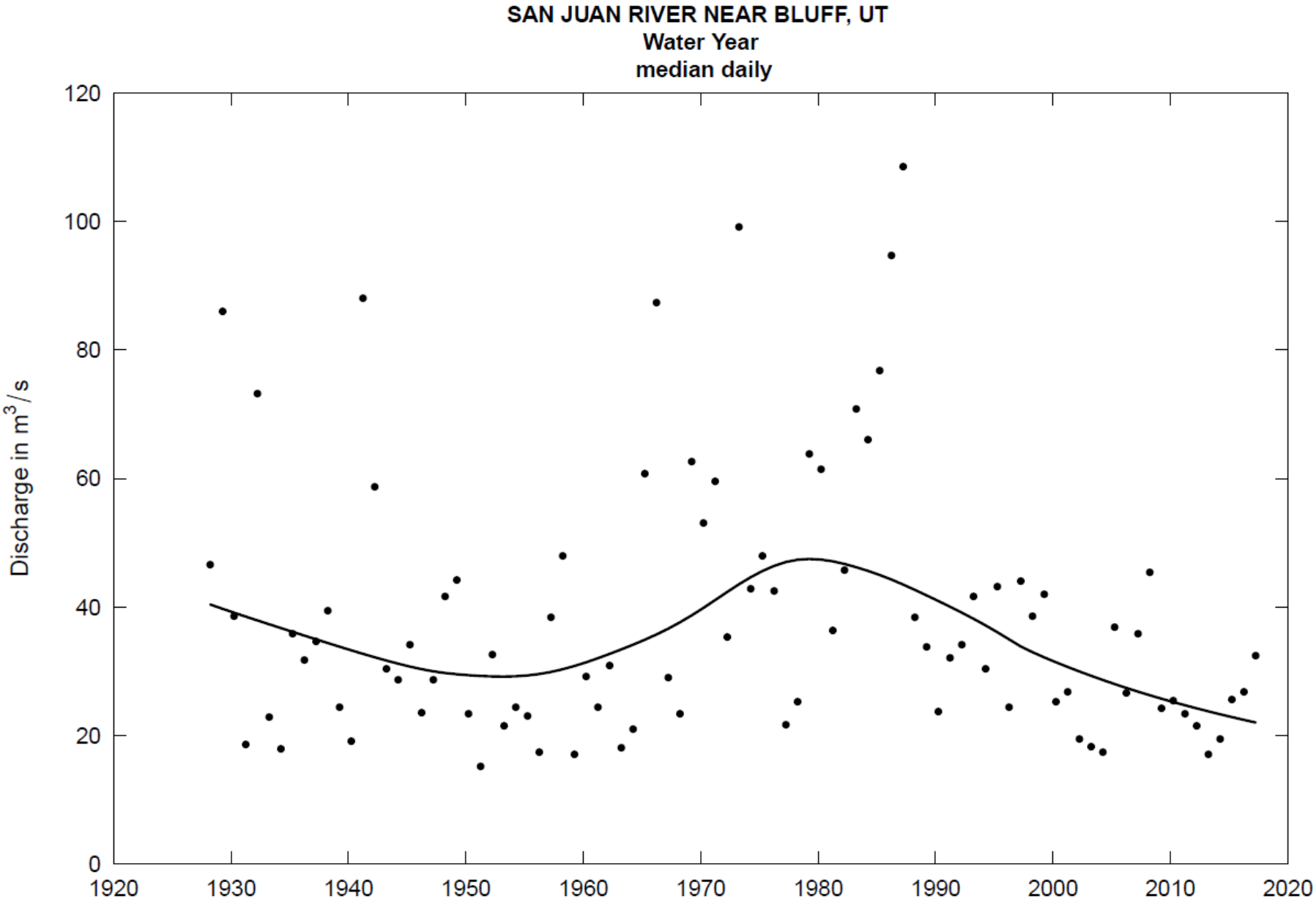


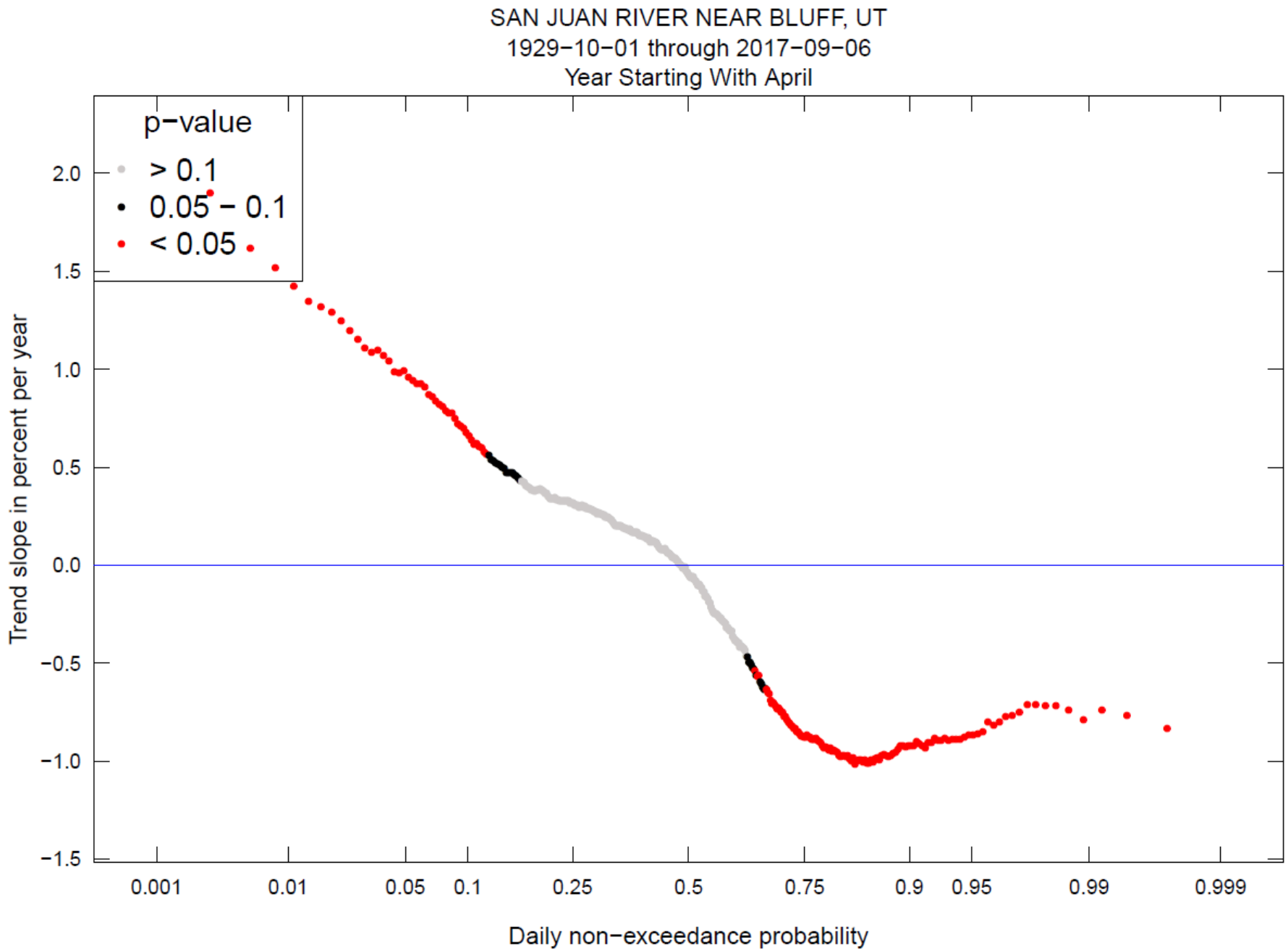

COLORADO RIVER NEAR CISCO, UT
Water Year
median daily
Discharge in m3/s
0
20
40
60
80
100
120
140
160
180
200
220
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020


COLORADO RIVER NEAR CISCO, UT
1928−10−05 through 2017−09−15
Year Starting With April
p−value
> 0.1
0.05 − 0.1
< 0.05
1.0
0.5
0.0
−0.5
−1.0
Trend slope in percent per year
0.001
0.01
0.05
0.1
0.25
0.5
0.75
0.9
0.95
0.99
0.999
Daily non−exceedance probability


GREEN RIVER AT GREEN RIVER, UT
Water Year
median daily
Discharge in m3/s
220
200
180
160
140
120
100
80
60
40
20
0
1910
1930
1950
1970
1990
2010


GREEN RIVER AT GREEN RIVER, UT
1928-10-05 through 2017-09-11
Year Starting With April
p-value
> 0.1
0.05 - 0.1
< 0.05
Trend slope in percent per year
1.0
0.5
0.0
-0.5
-1.0
0.001
0.01
0.05
0.25
0.5
0.75
0.9
0.99
0.999
Daily non-exceedance probability


SAN JUAN RIVER NEAR BLUFF, UT
Water Year
median daily
Discharge in m3/s
0
20
40
60
80
100
120
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020


SAN JUAN RIVER NEAR BLUFF, UT
1929−10−01 through 2017−09−06
Year Starting With April
p−value
> 0.1
0.05 − 0.1
< 0.05
Trend slope in percent per year
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
0.001
0.01
0.05
0.1
0.25
0.5
0.75
0.9
0.95
0.99
0.999
Daily non−exceedance probability