Project C.4: Vegetation Induced Declines in Channel Width with Implications for Eddy Sandbar Dynamics in the Colorado River in Marble and Grand Canyons

David Dean, Josh Caster, Joel Sankey, Paul Grams, Helen Fairley, Emily Palmquist
U.S. Geological Survey, Southwest Biological Science Center
Grand Canyon Monitoring and Research Center, Flagstaff, AZ

- Project Elements and Objectives
  - C.4.1 Biogeomorphic linkages between streamflow, sediment transport, and vegetation composition
- LTEMP Resource Goals:
  - Sediment
  - Riparian vegetation
- Multidisciplinary project integrating data from Projects B, C, D, and L

Presentation Outline

1. General discussion of how vegetation affects physical river change

2. Changes in channel width of the Colorado River in Marble and Eastern Grand Canyon (RM 0-74)
   a) Vegetation encroachment - effects on channel width
   b) Plant species responsible for narrowing

3. Vegetation induced changes in sandbar dynamics

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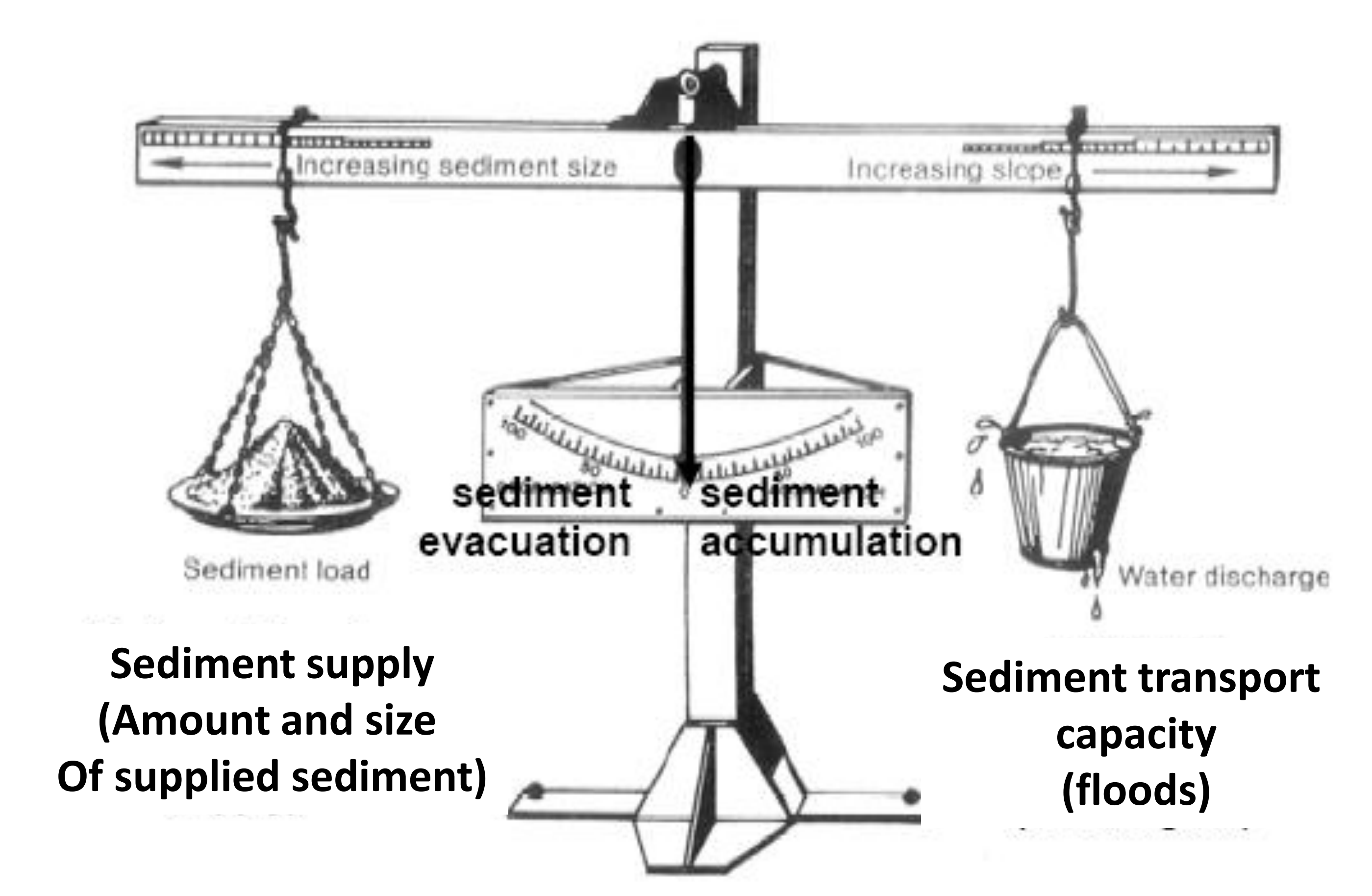
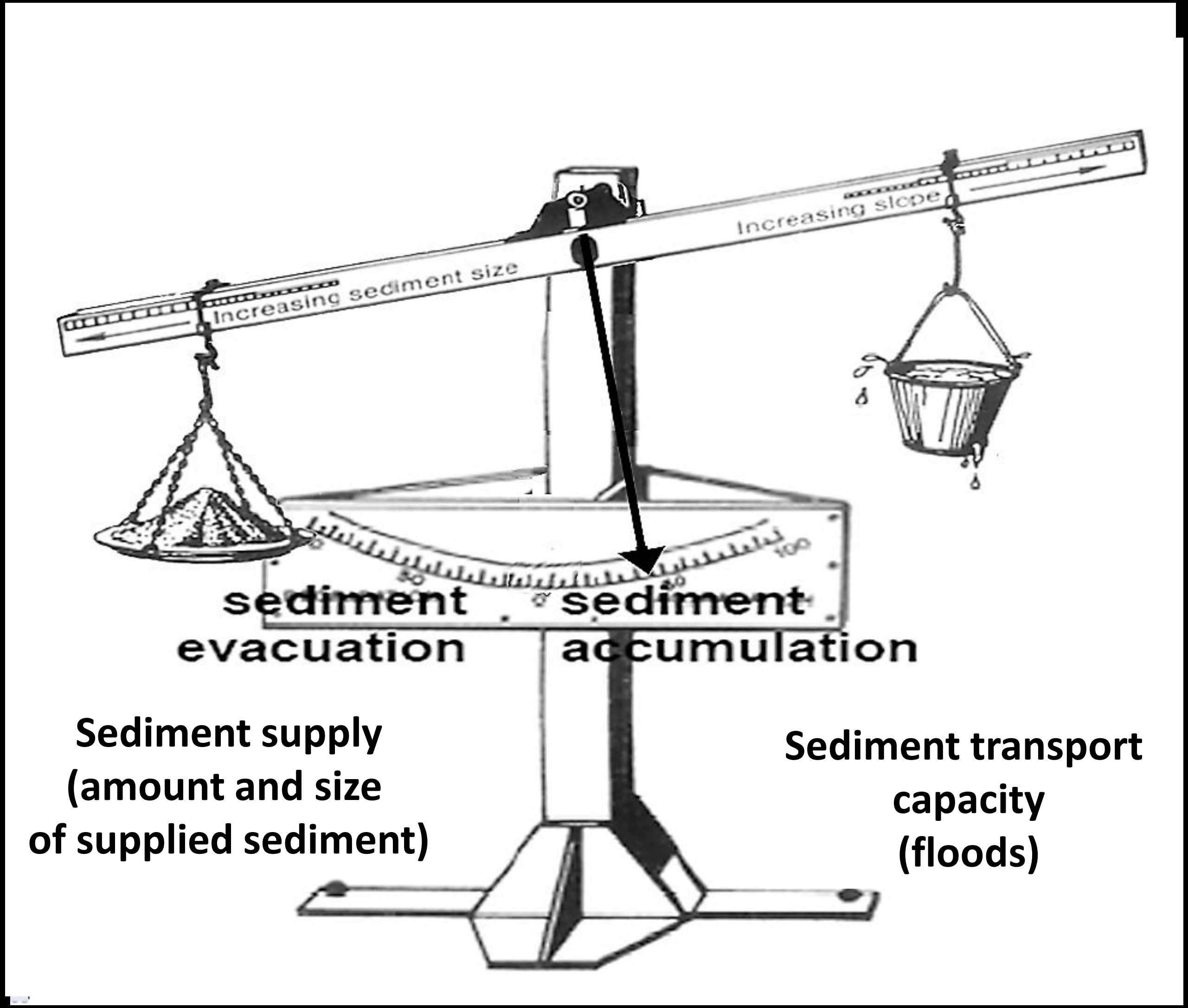
Why do channels change size and shape?

channels change in response to changes in the *balance* between water and sediment supply



Lane, 1955, modified by Borland (1960)

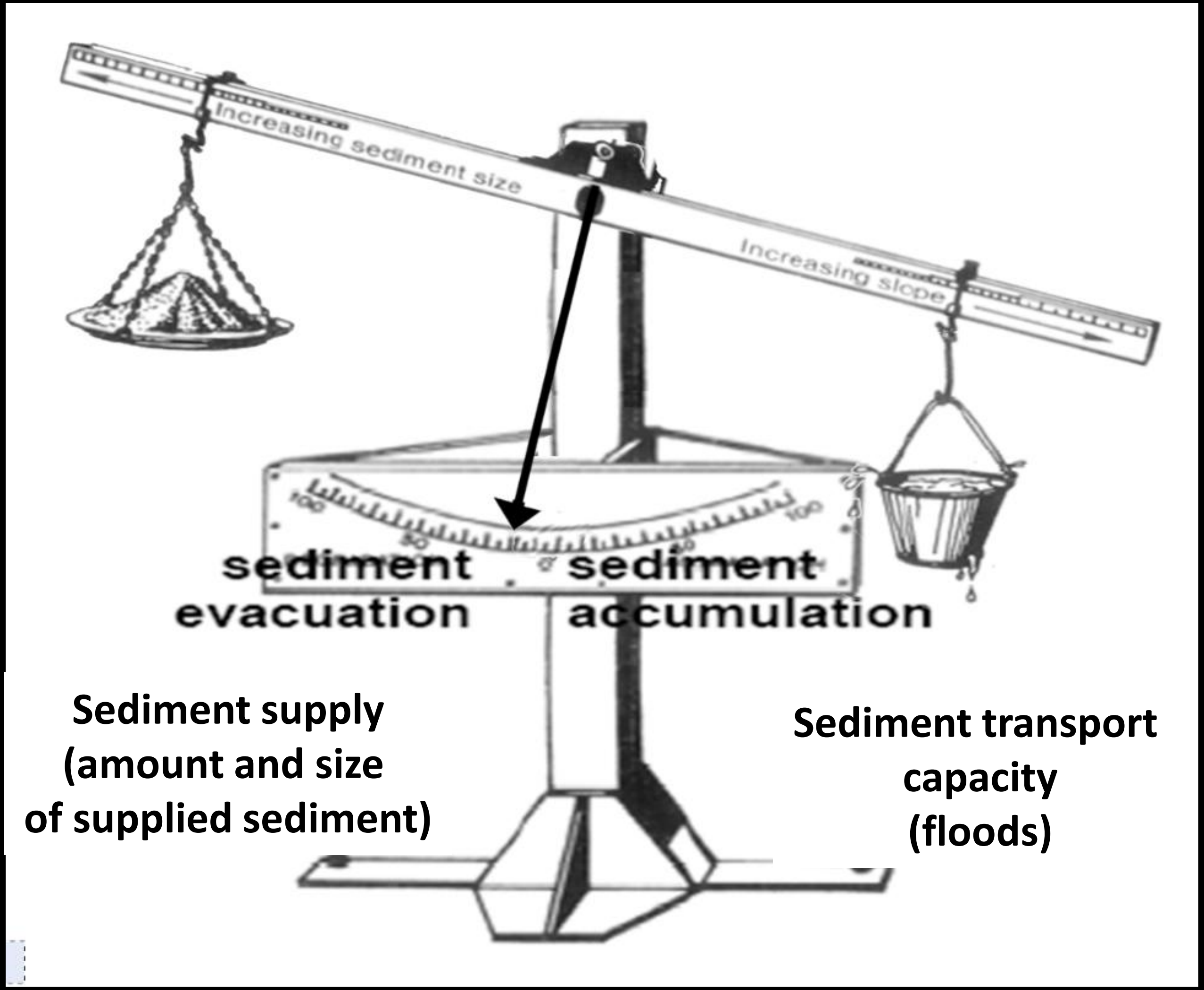
Water and Sediment Balance…



Lane, 1955, modified by Borland (1960)

Water and Sediment Balance…works well when you only have water and sediment

Shoshone Creek, NV, *Stanford Report*



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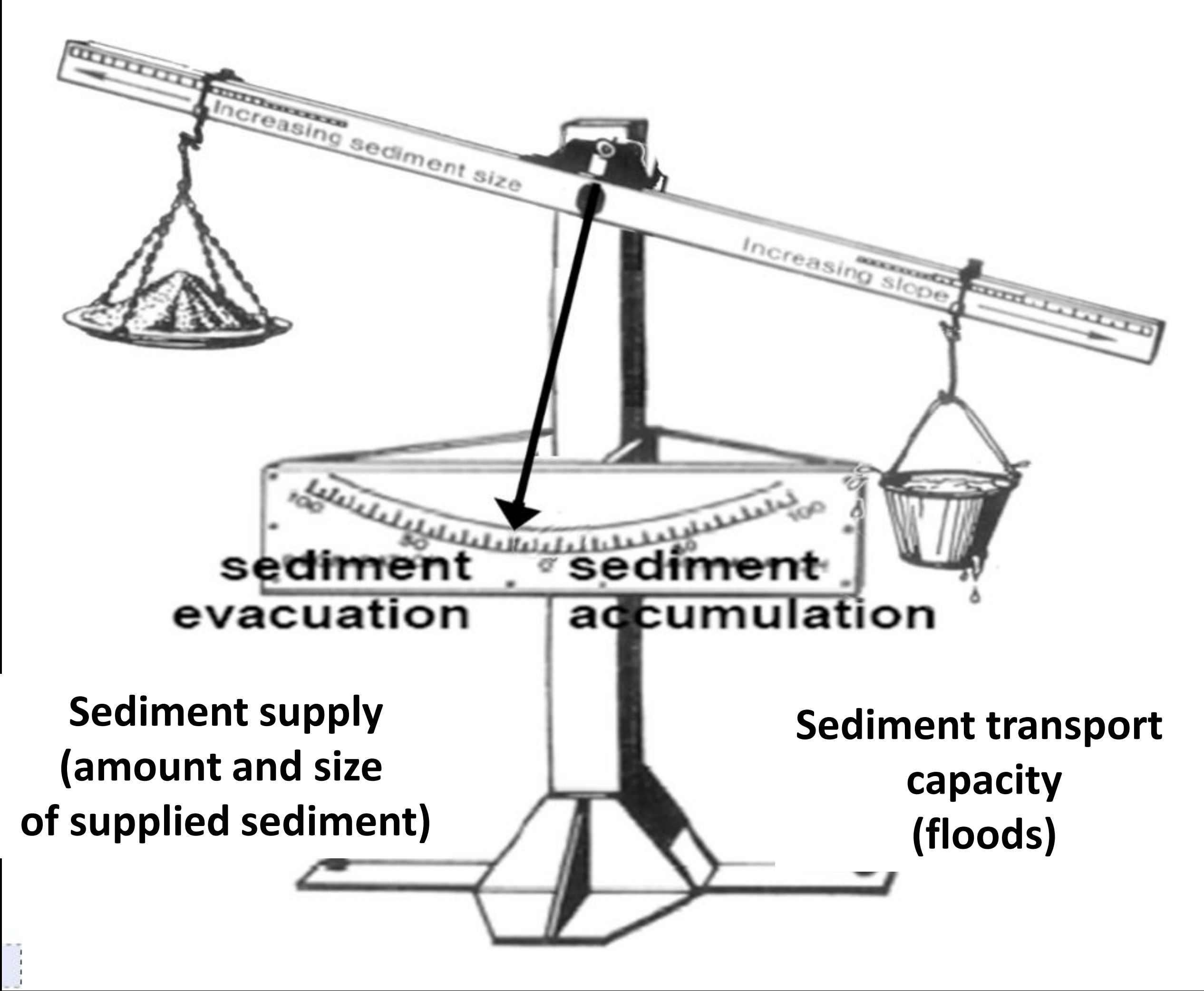
Water and Sediment Balance…gets messy when streamflow/sediment transport are modified by other processes (e.g. plants) – FEEDBACKS?

Little Colorado River, AZ

Dean and Topping, 2019, *GSA Bulletin*, Data Repository

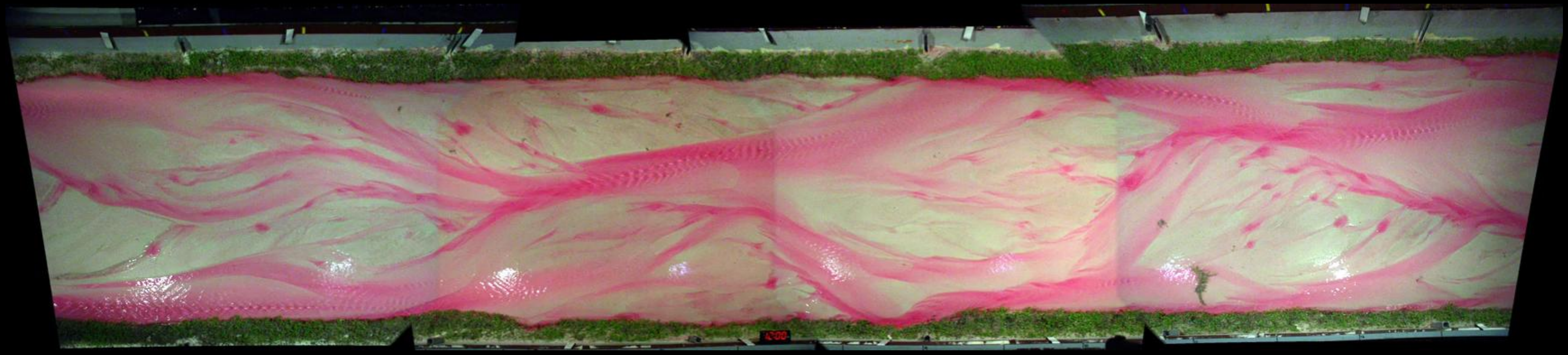


Sediment supply (amount and size of supplied sediment)

Sediment transport capacity (floods)

Flume Experiments:
Role of Vegetation on Channel Morphology

In this experiment, alfalfa sprouts were seeded and allowed to grow. Flow had simple hydrograph of low flow, and flood flow.



Tal and Paola, 2007
For other videos of their experiments, go to:
https://pubs.geoscienceworld.org/gsa/geology/article/35/4/347/129823/Dynamic-single-thread-channels-maintained-by-the

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Little Colorado River

Little Colorado River, AZ
Looking Downstream from
Highway 89 bridge
near Cameron, AZ

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Dean and Topping, 2019

Moenkopi Wash

Moenkopi Wash, AZ,
Looking upstream from
Old Hwy 89 bridge
Near Cameron, AZ

Dean and Topping, 2024

Colorado River RM 71.7

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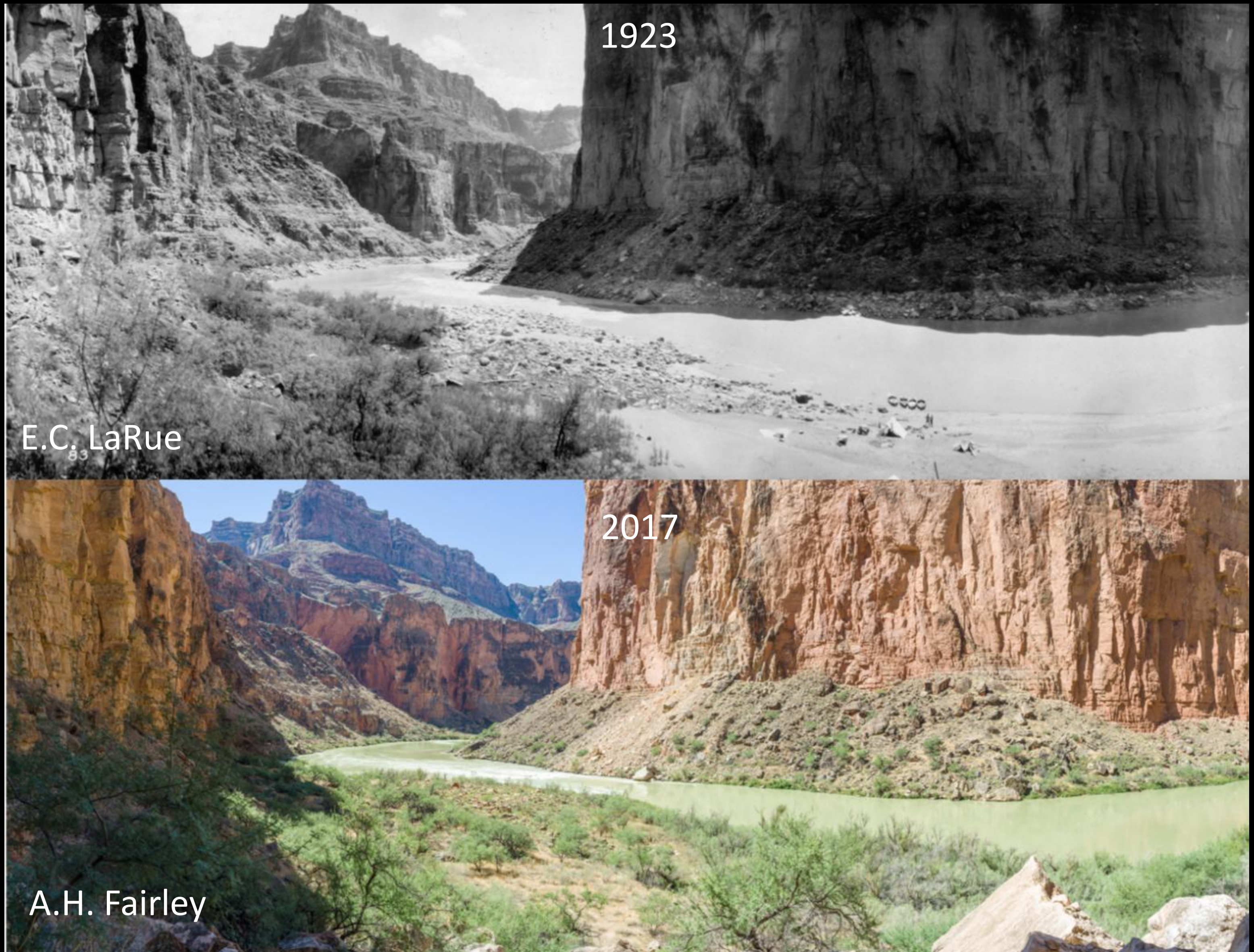
Colorado River RM 43.9



Why is bare sand important in Grand Canyon?

Natural part of the ecosystem

sand dunes (archeological sites)

shoreline habitat

campsites

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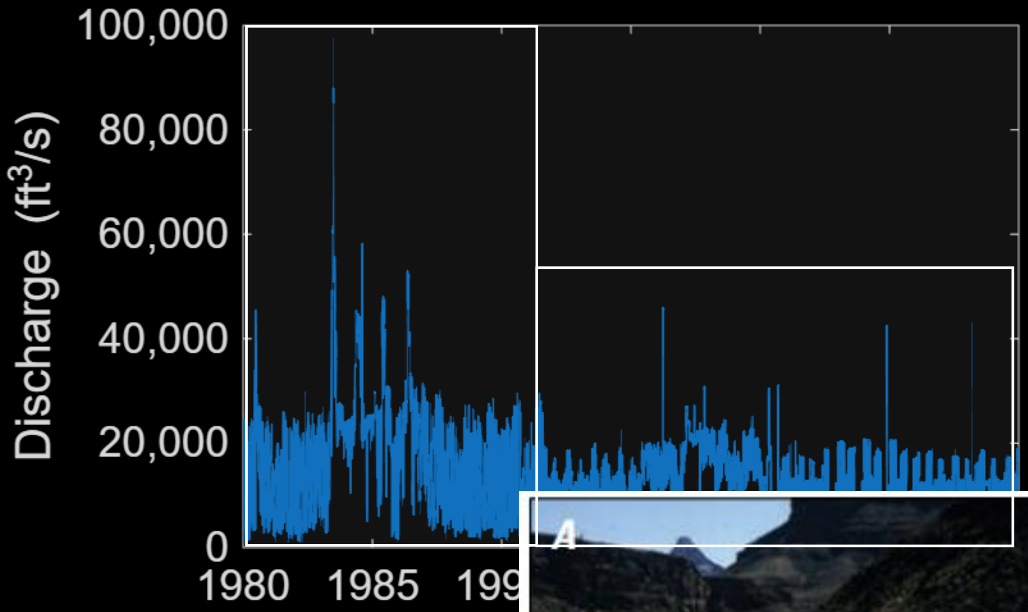
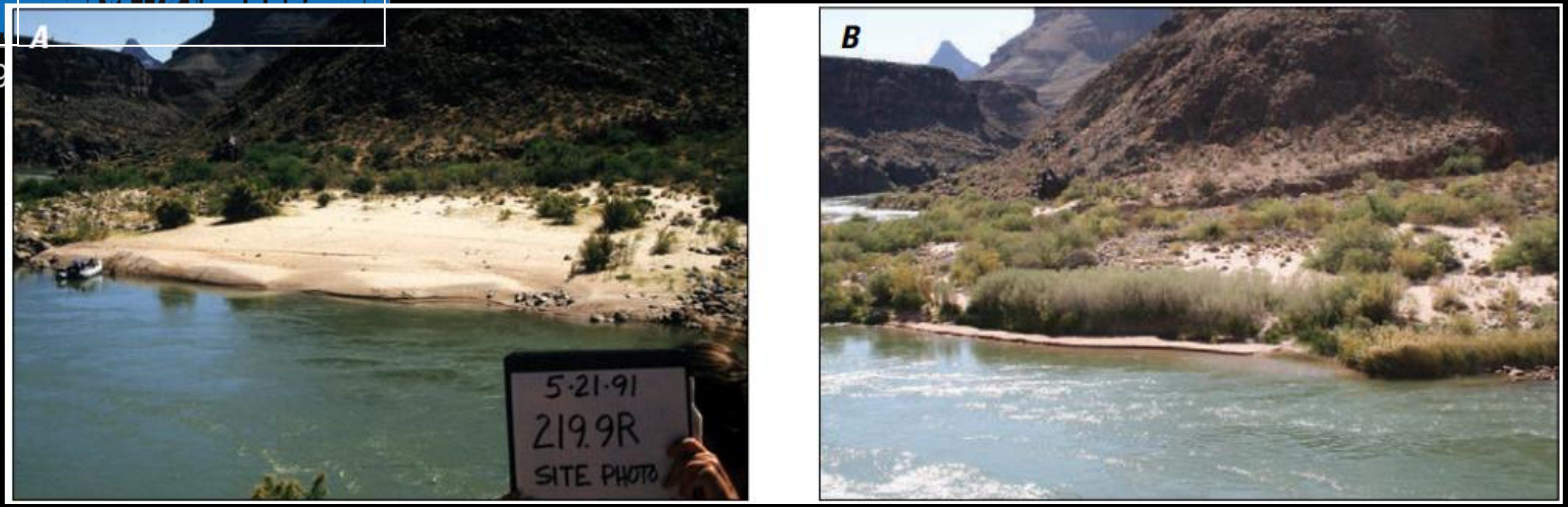
Vegetation will track large changes in river stage.



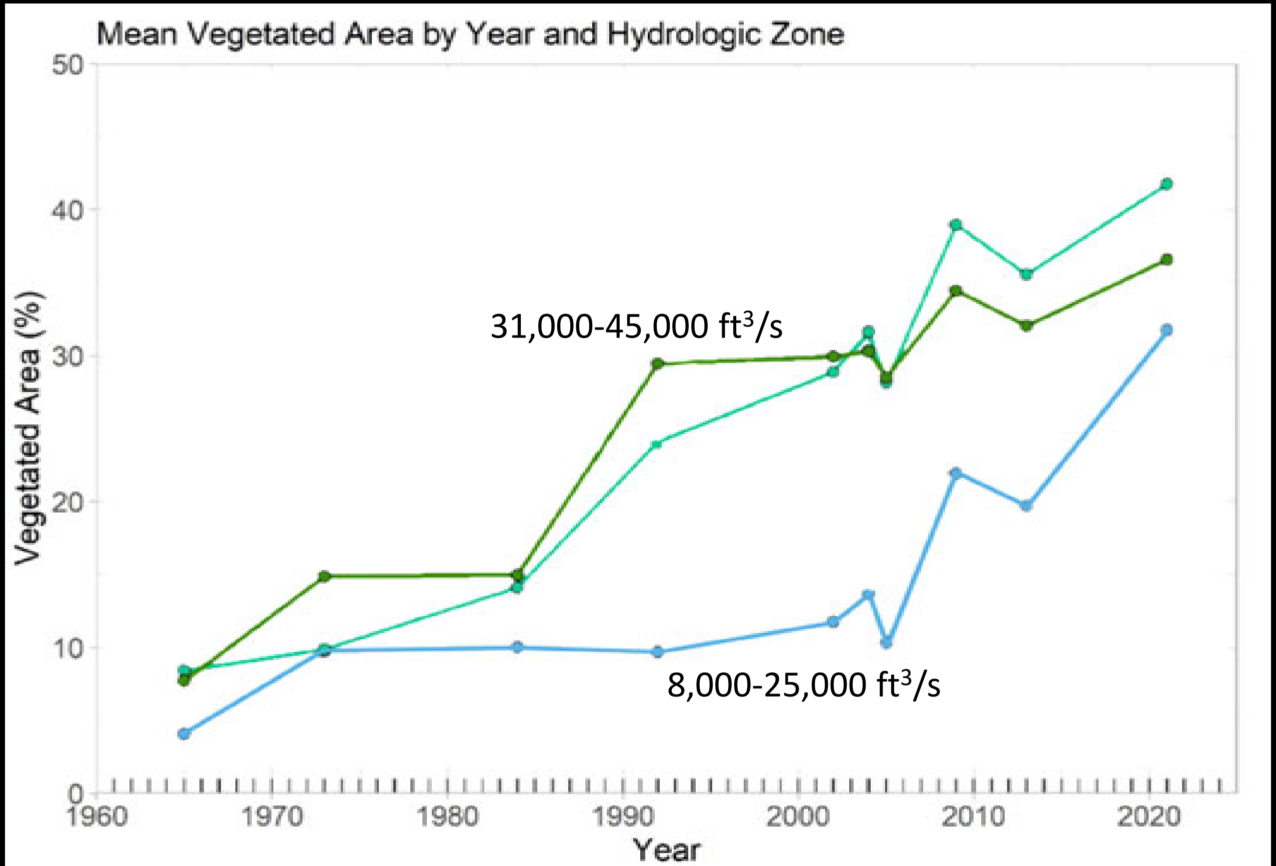
Riparian Zone will encroach upon the river IF
- Decrease in disturbance (e.g., decline in flood peaks)
- Increase in baseflow



Hazel et al., 2022, *USGS Professional Paper*

Vegetation will track large changes in river stage.

Increase in baseflows and lack of flood disturbance = vegetation expansion between 8,000 ft^3/s and 45,000 ft^3/s stages.



How has vegetation affected the Colorado River channel?

Has vegetation encroachment affected physical river dynamics?

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Modified from Sankey et al., 2015, *JGR Biogeosciences*; Durning et al., 2021, *Ecohydrology*

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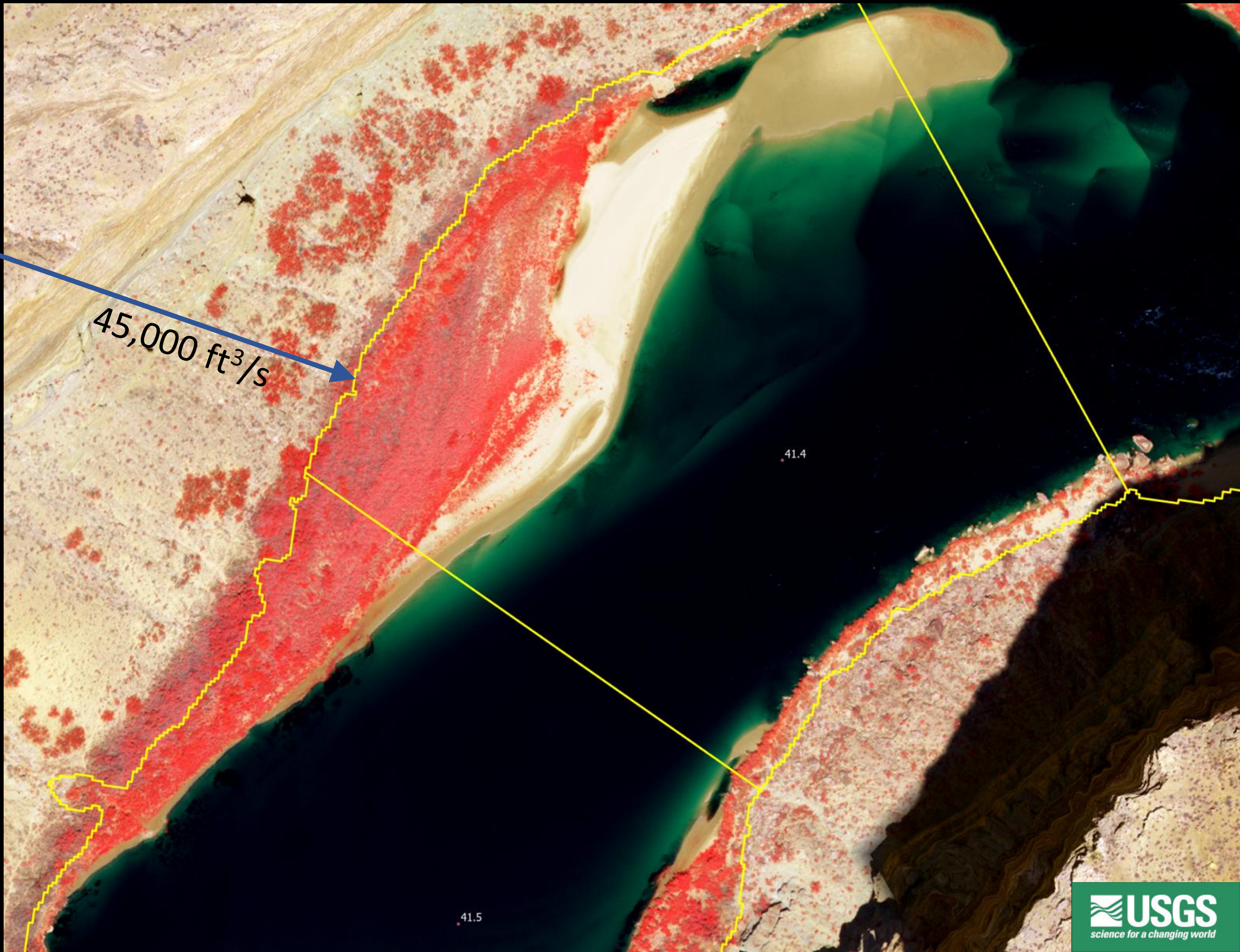
Calculations of Channel Width

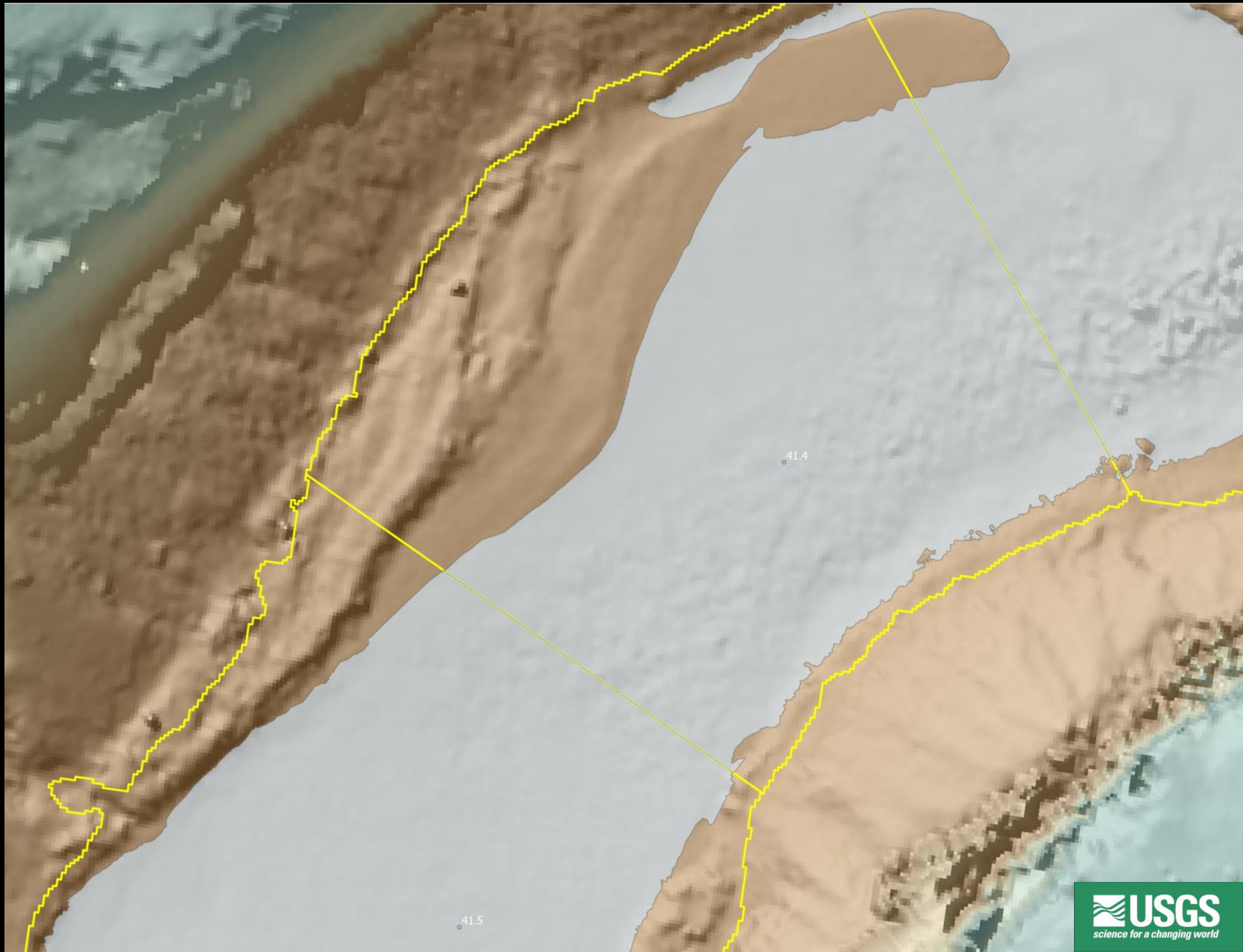
- Remote sensing datasets from overflights (2002, 2009, 2013, 2021) - Project L
  1. Modeled water surface extents (Magirl et al., 2008)
     a) Historic channel was very wide
     b) Modern channel can't exceed 45,000 ft^3/s boundary (last HFEs to reach 45k were 1996 and 2012)



Preliminary Information-Subject to Revision.
Not for Citation or Distribution

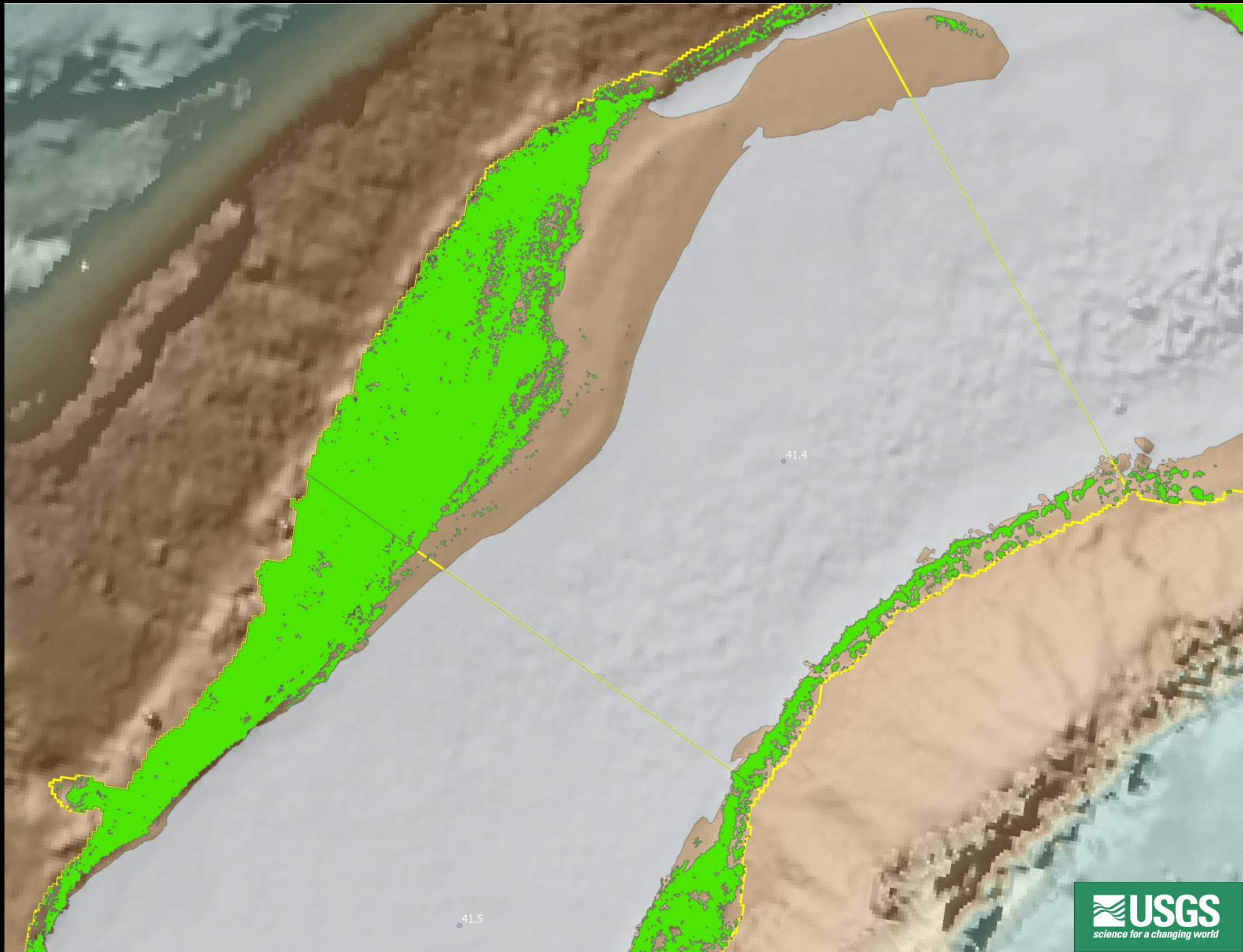
Calculations of Channel Width

- Remote sensing datasets from overflights (2002, 2009, 2013, 2021) - Project L
  2. Digital surface models (DSMs) – Elevation of ground and vegetation surfaces (Sankey and others, 2025)



Calculations of Channel Width

- Remote sensing datasets from overflights (2002, 2009, 2013, 2021) - Project L
  3. Vegetation Maps (Sankey and others, 2015; Durning et al., 2017)
     a. Use vegetation to add vertical offset to DSM
     b. Intersect 45k water surface elevation with the DSM
     c. Intersection gives approximate channel width
     d. Manually edit



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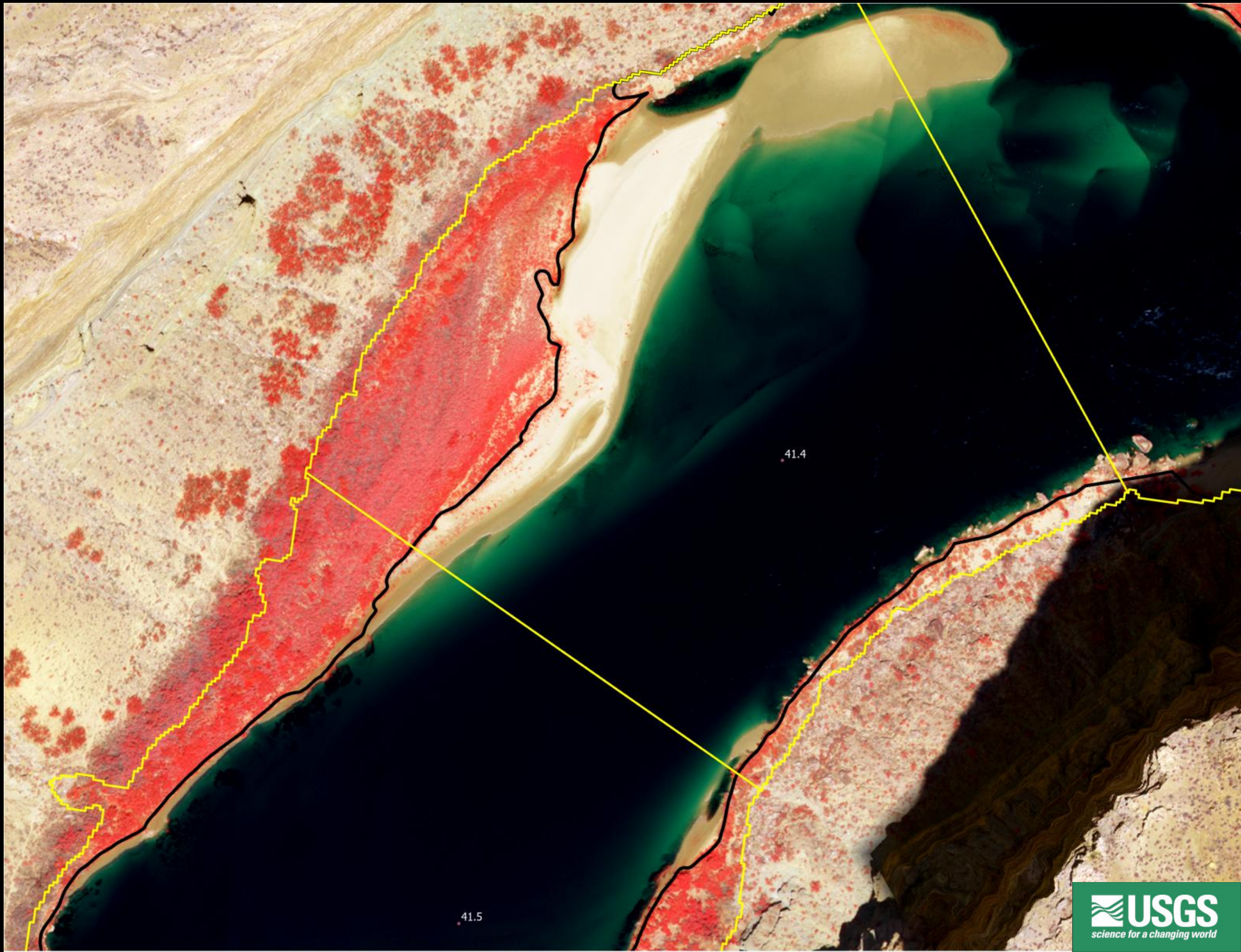

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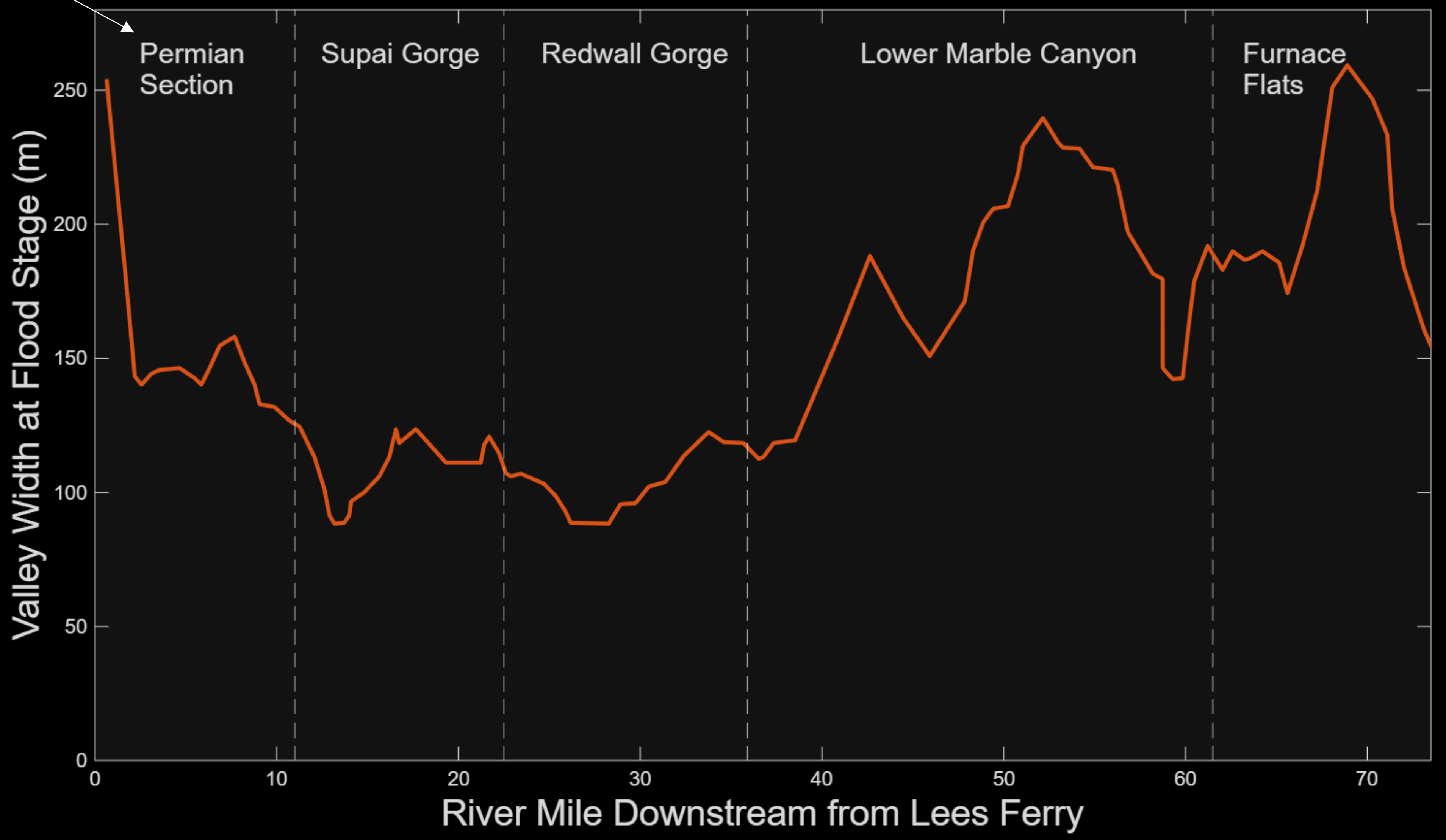
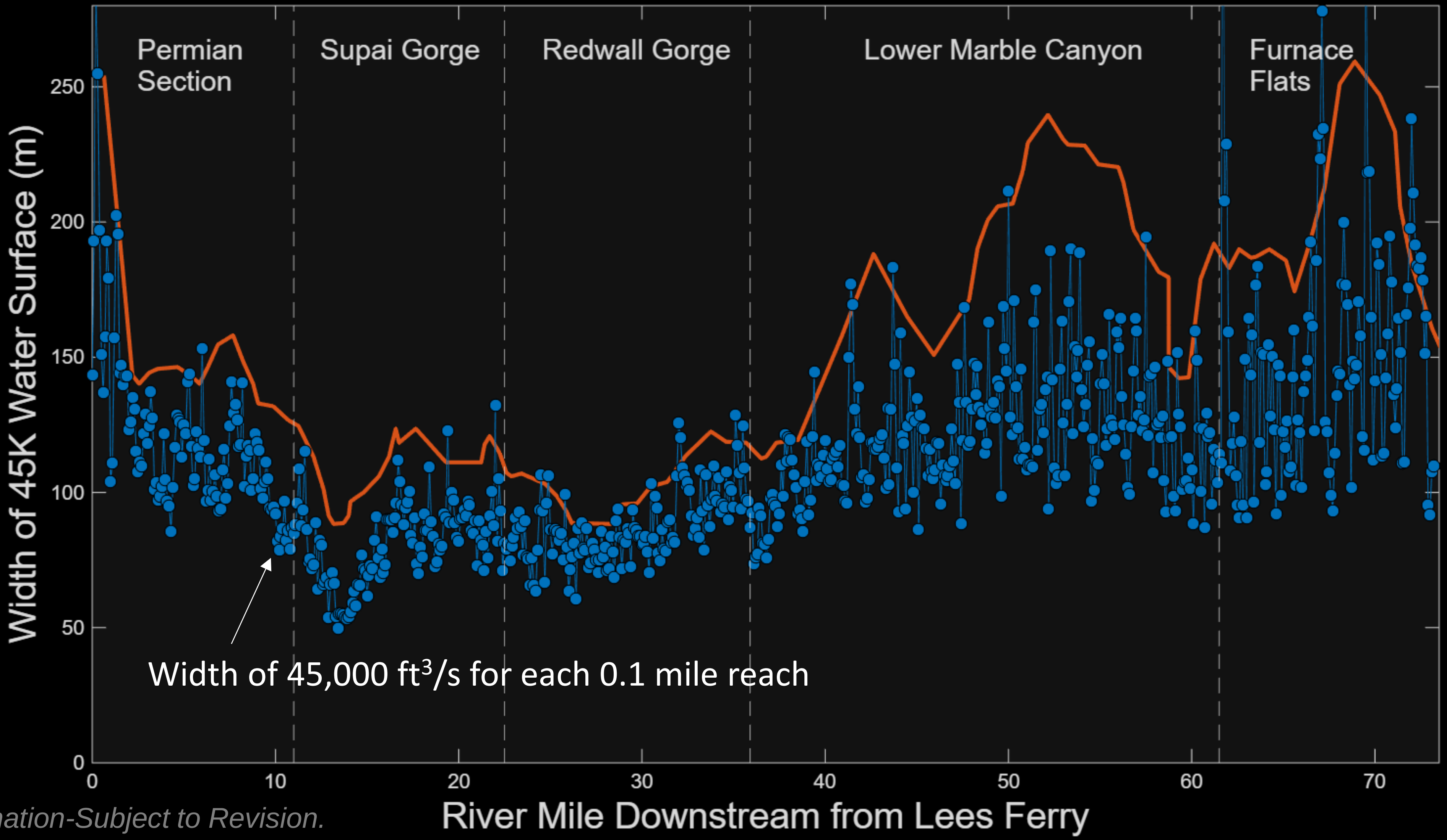
Changes in Channel Width (RM 0-74)

Segments from Schmidt and Graf, 1990



Changes in Channel Width (RM 0-74)



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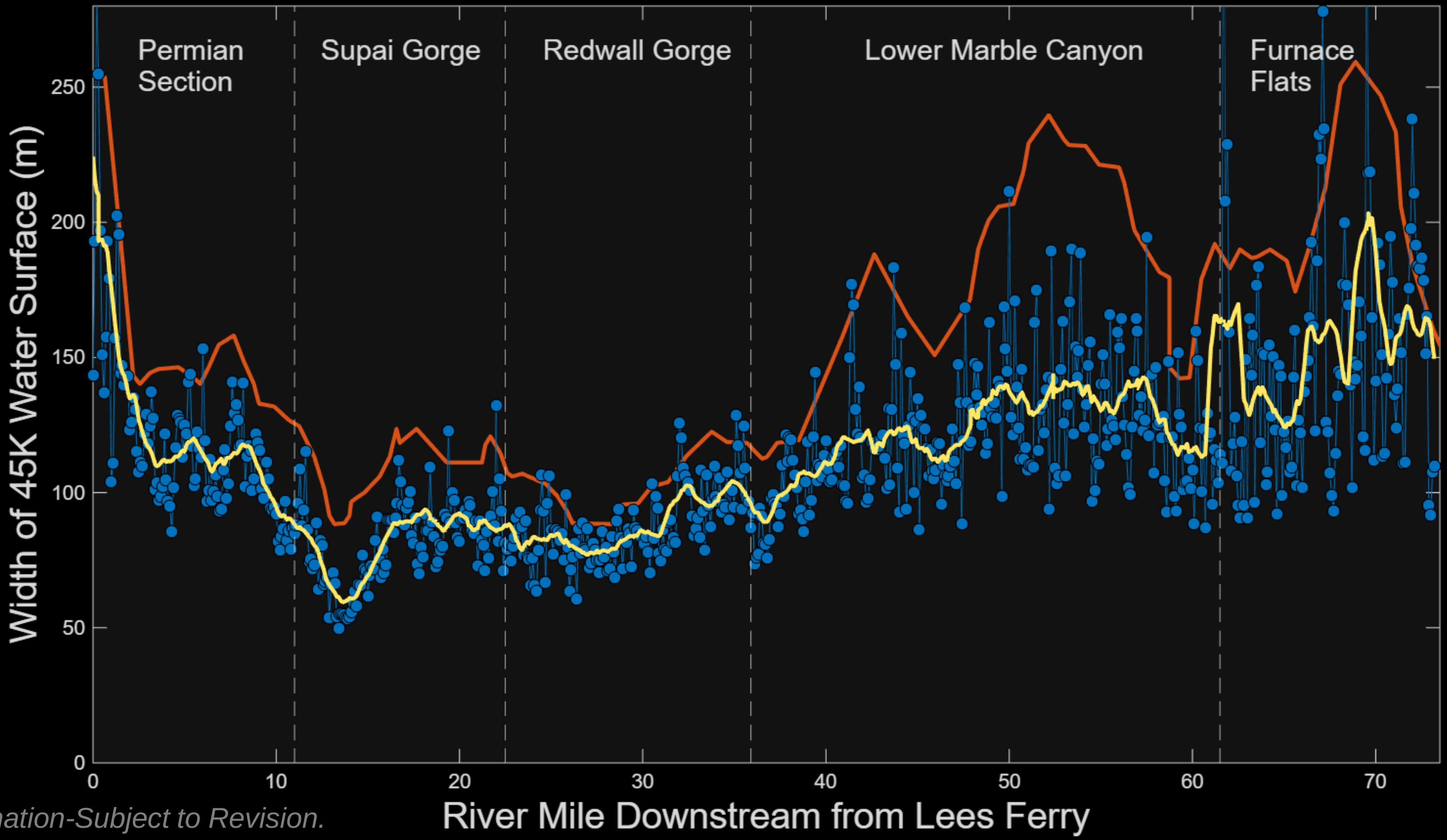

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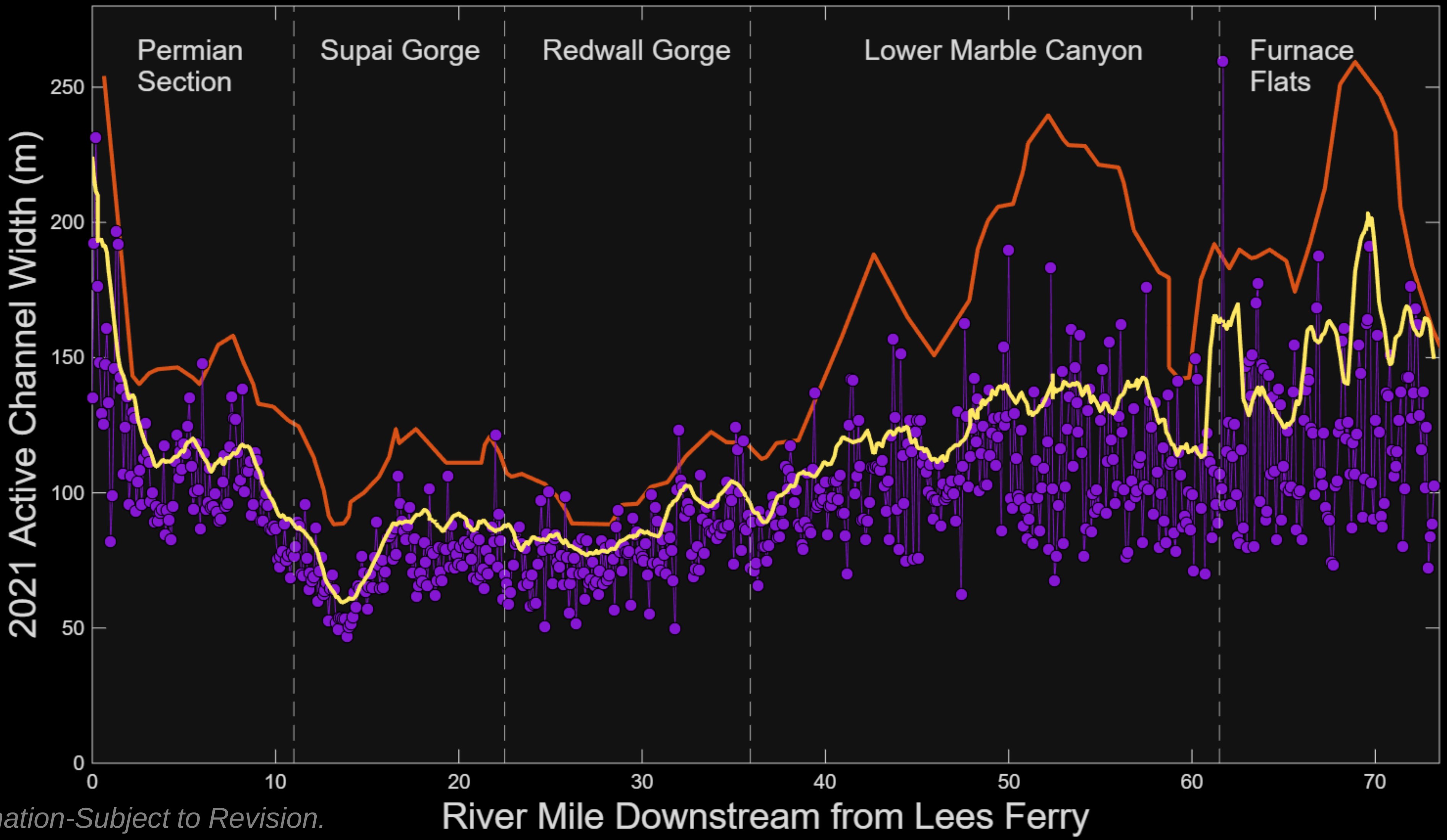

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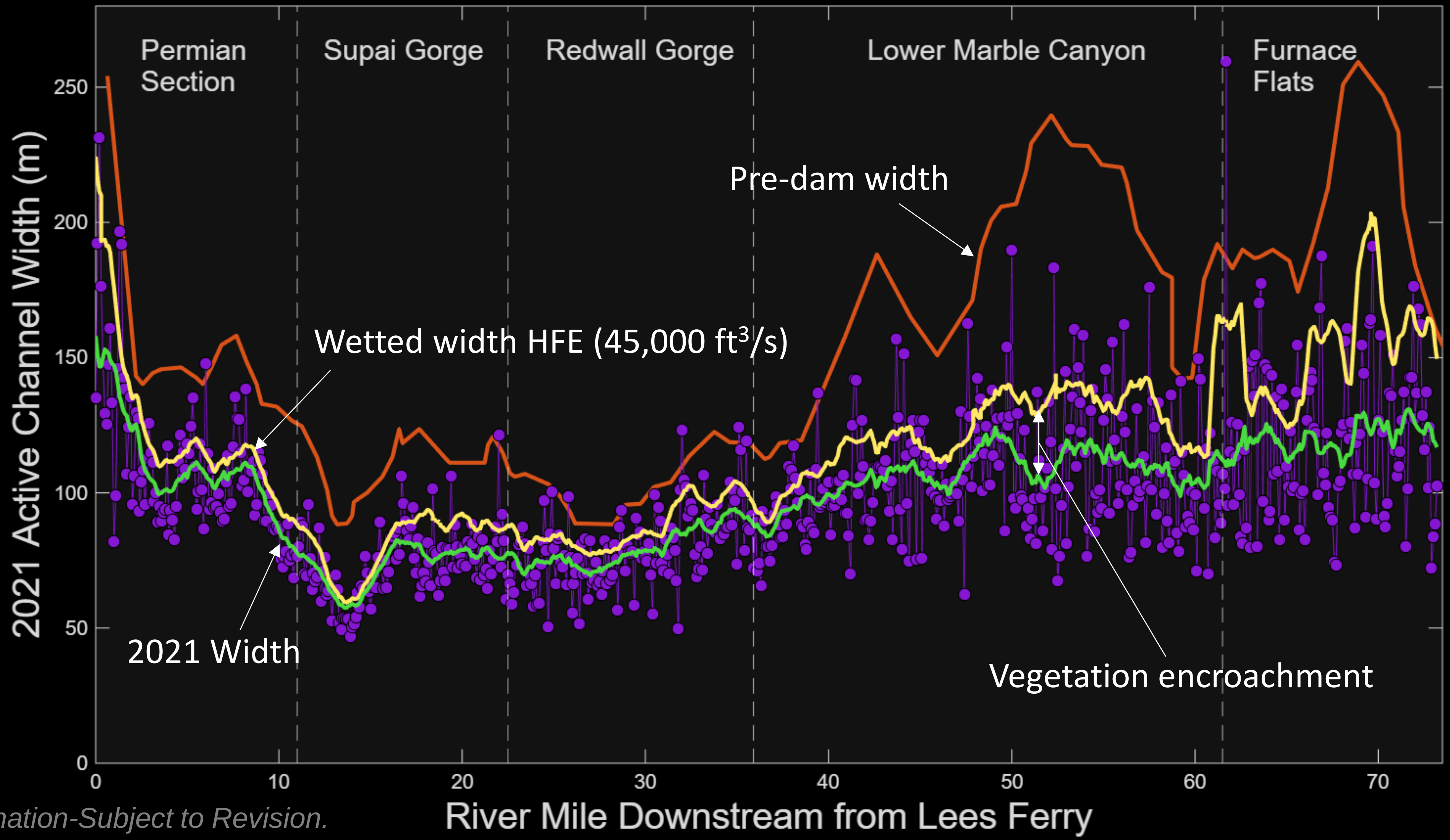

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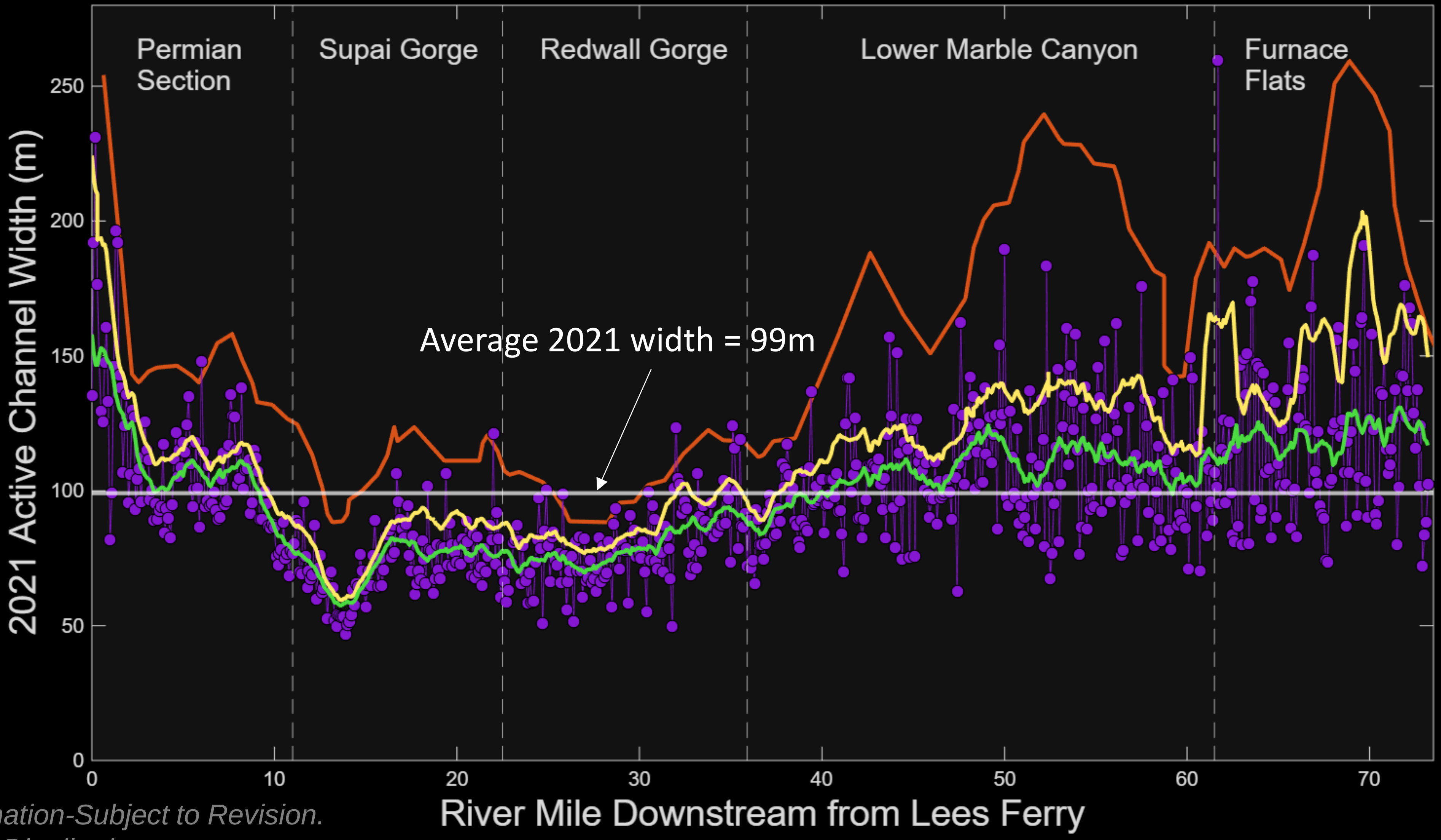

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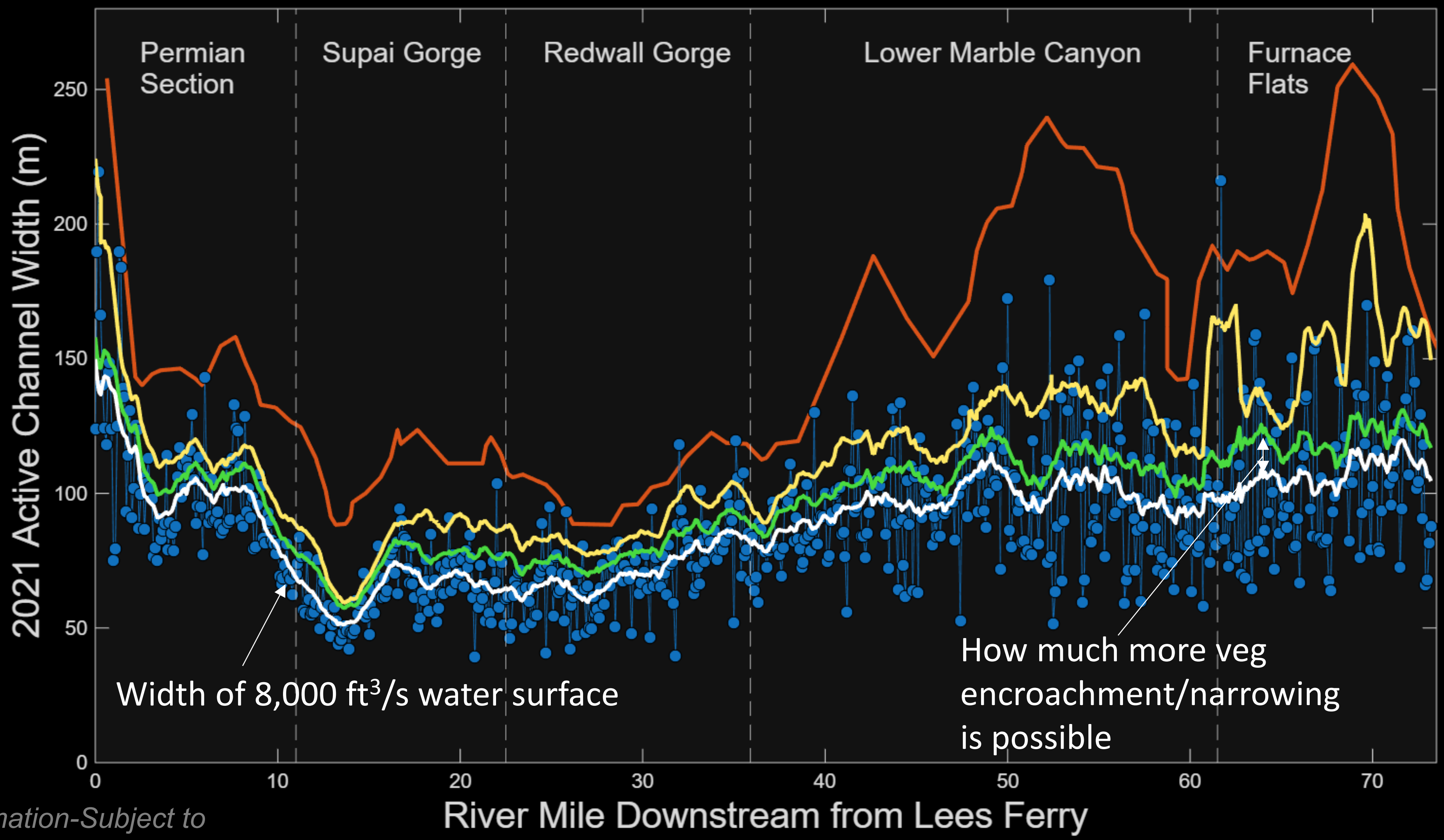

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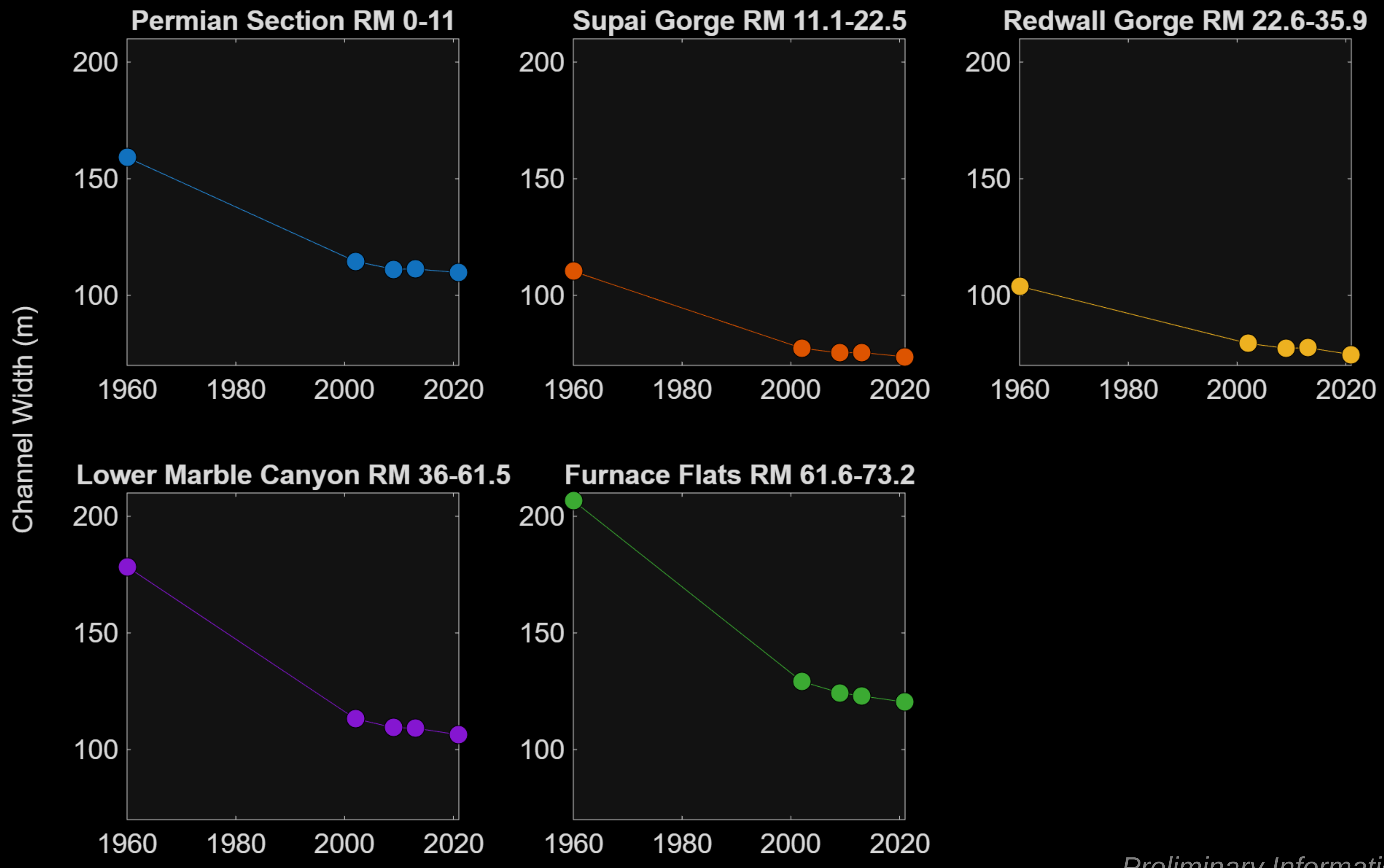
Changes in Channel Width 1963-2021, Segments



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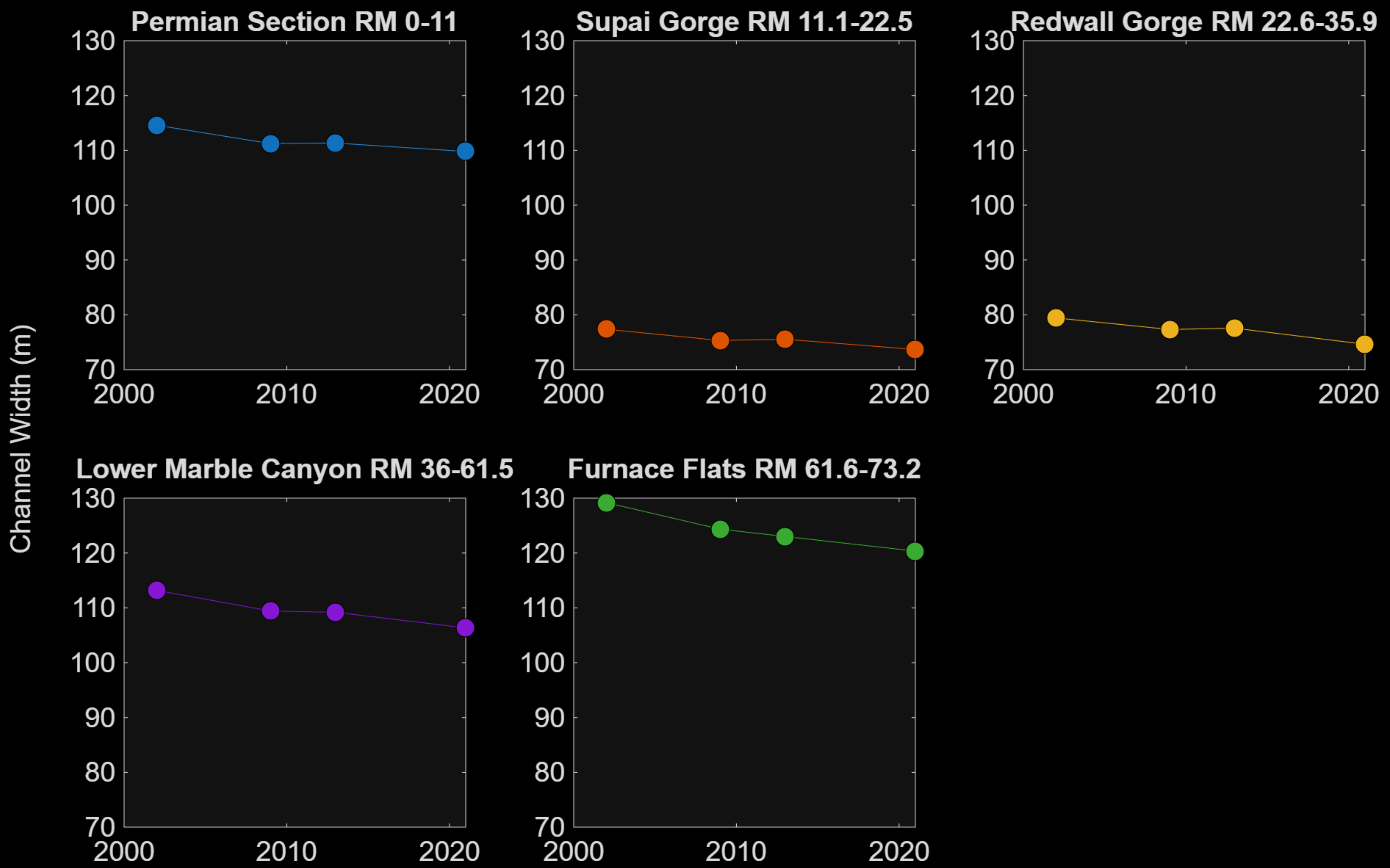

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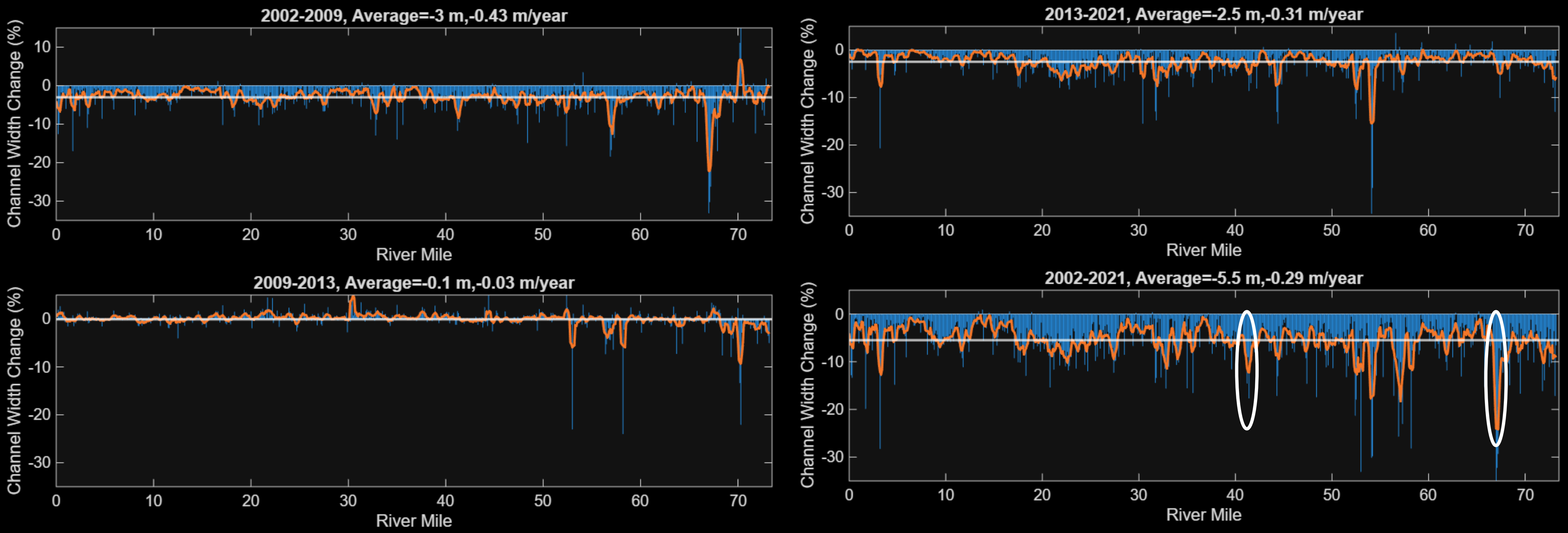
Width Change 2002-2021



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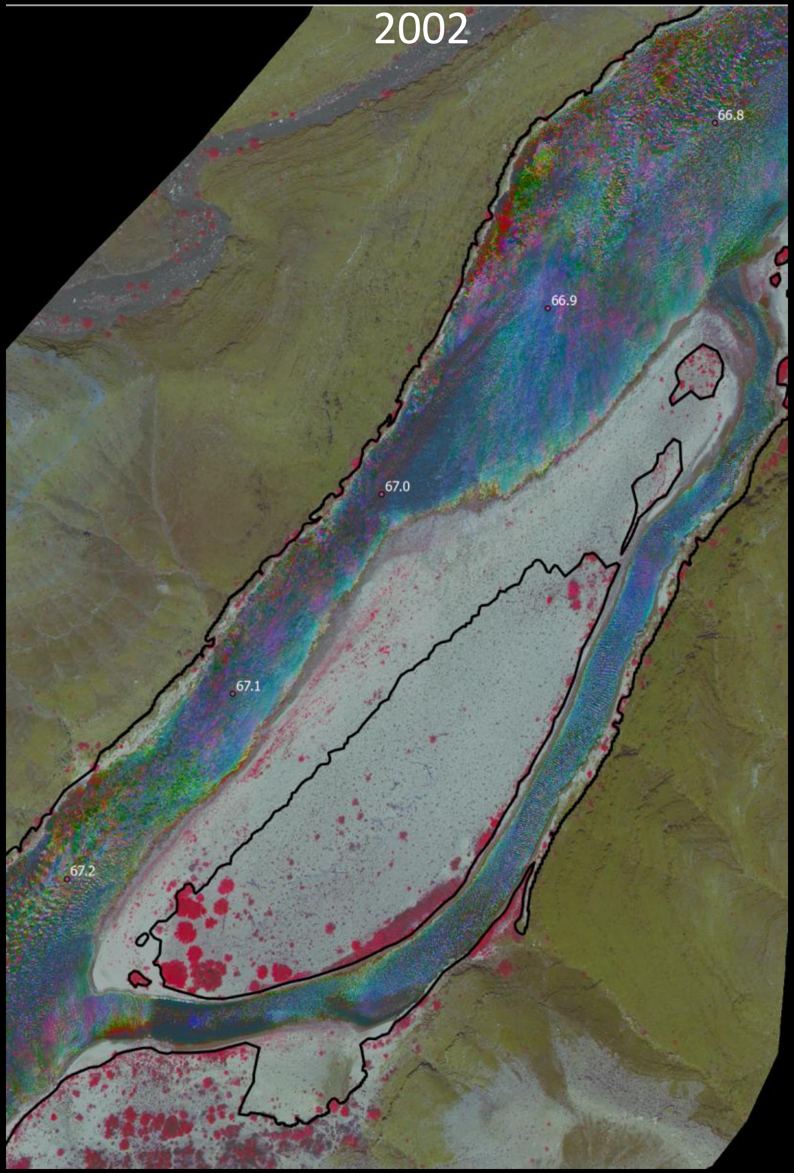
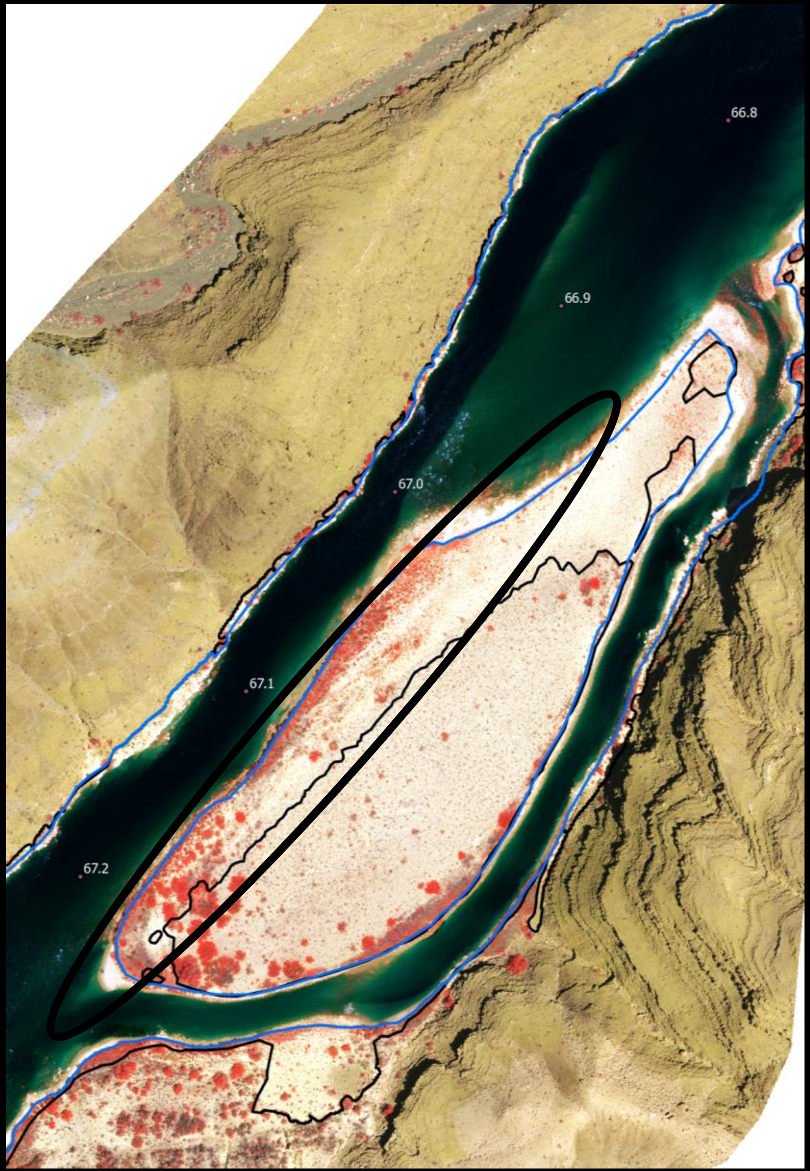
Width Change RM 67





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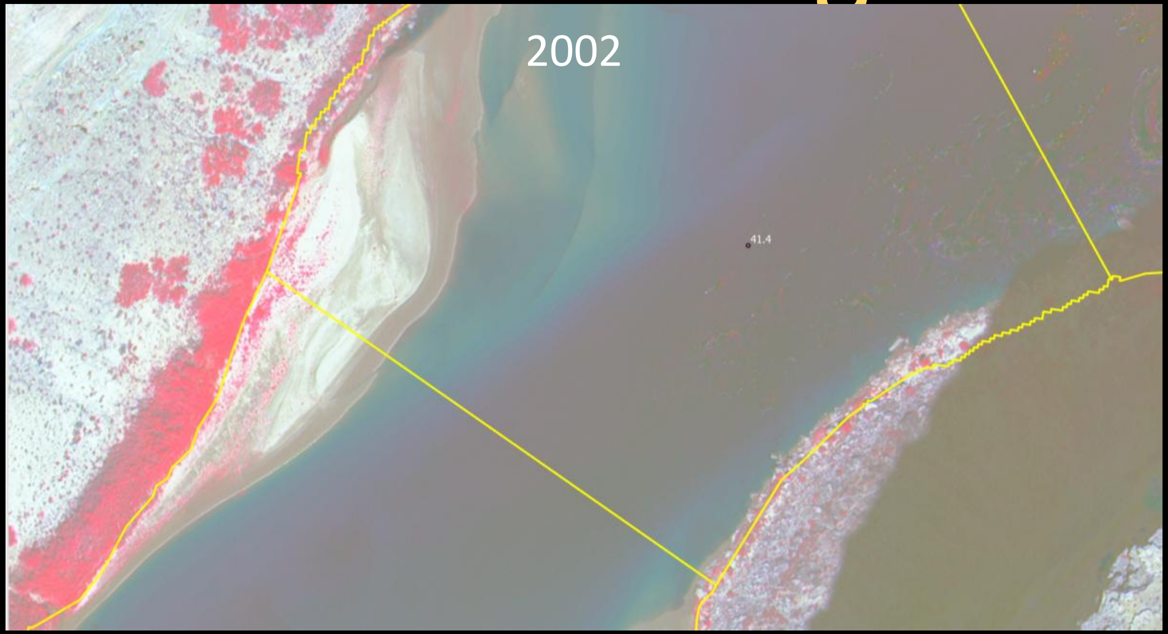
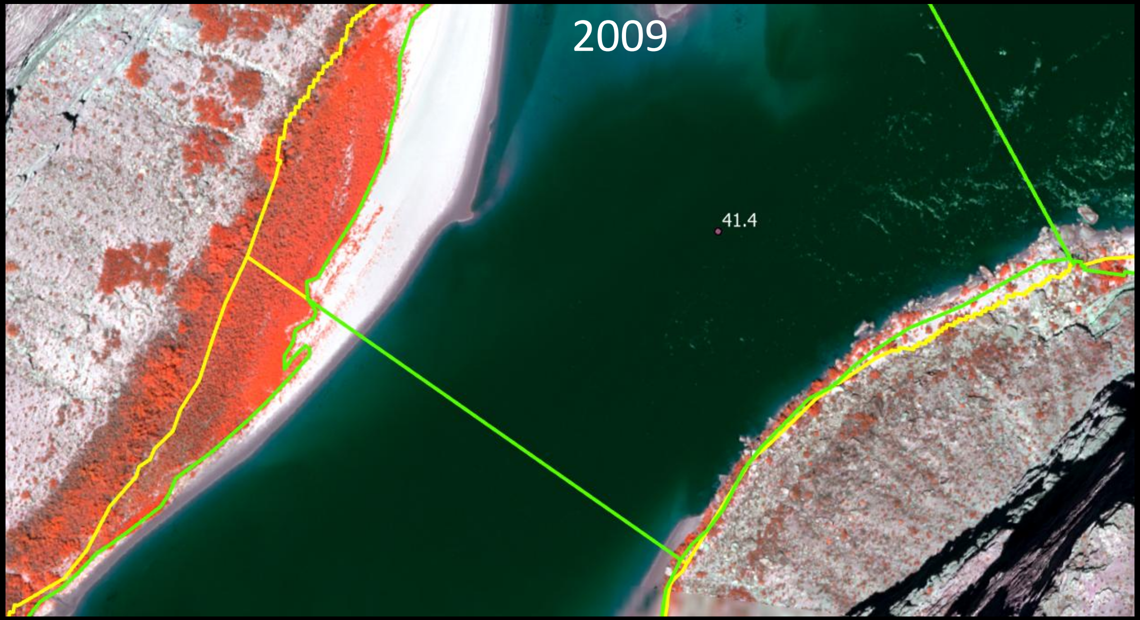
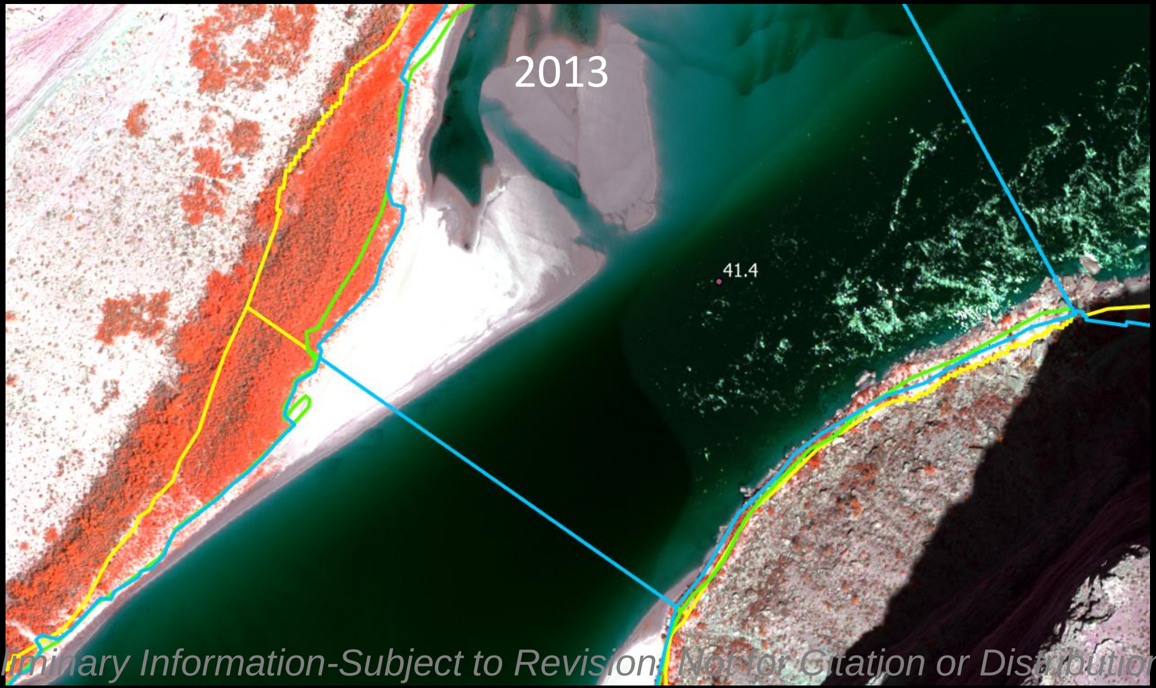
Colorado River RM 61.9

Width Change River Mile 41.4, Buck farm







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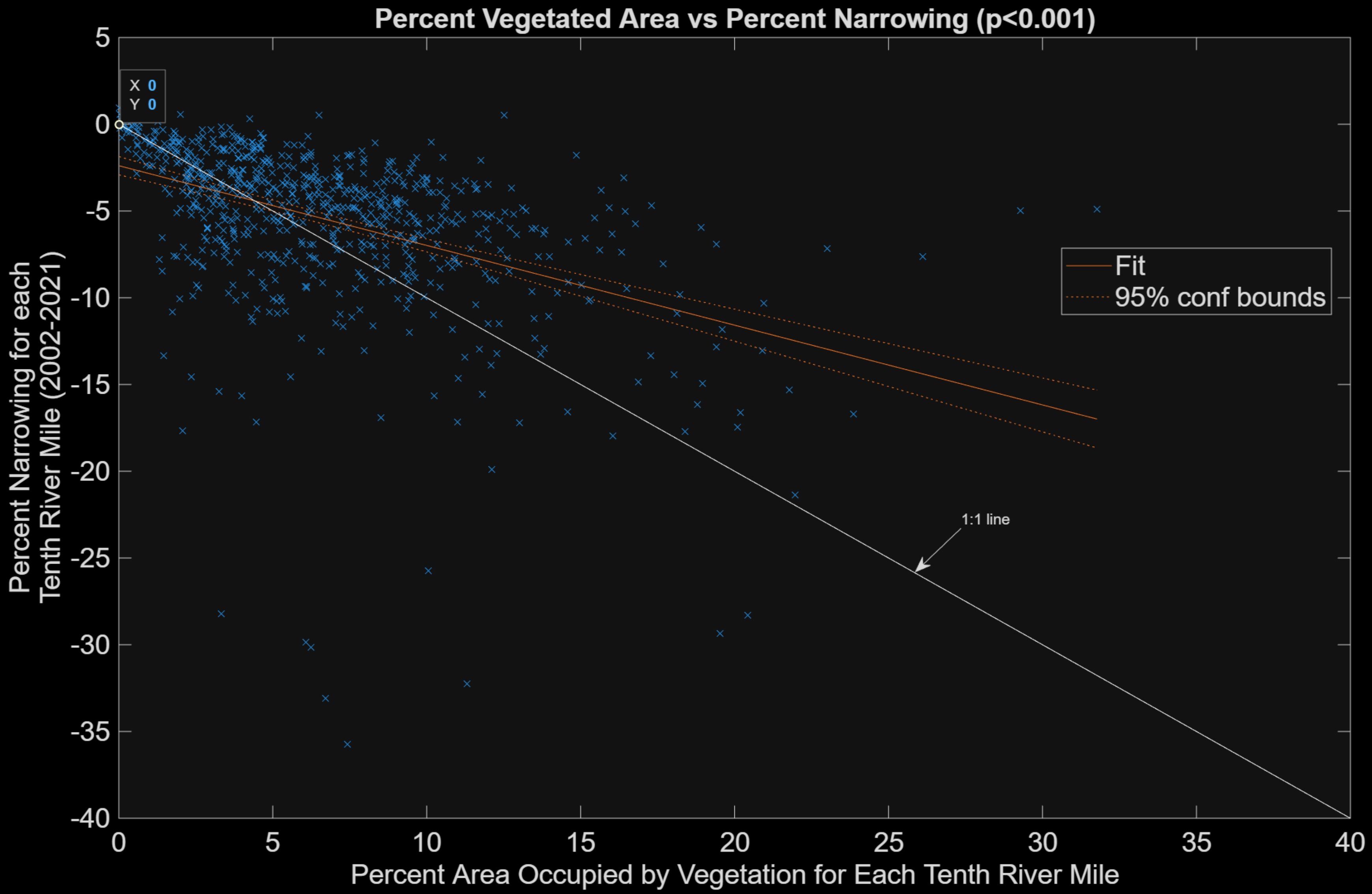
Plant Area vs. Channel Narrowing



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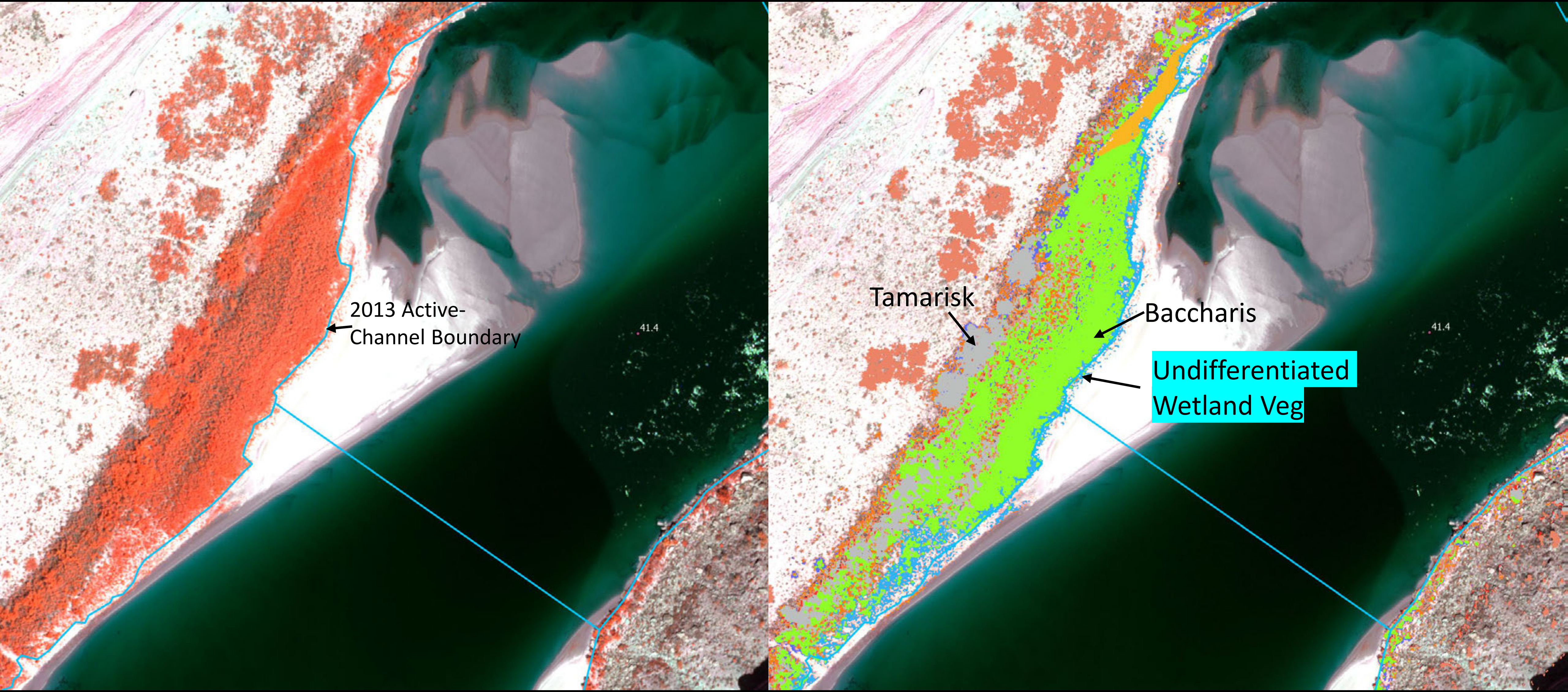
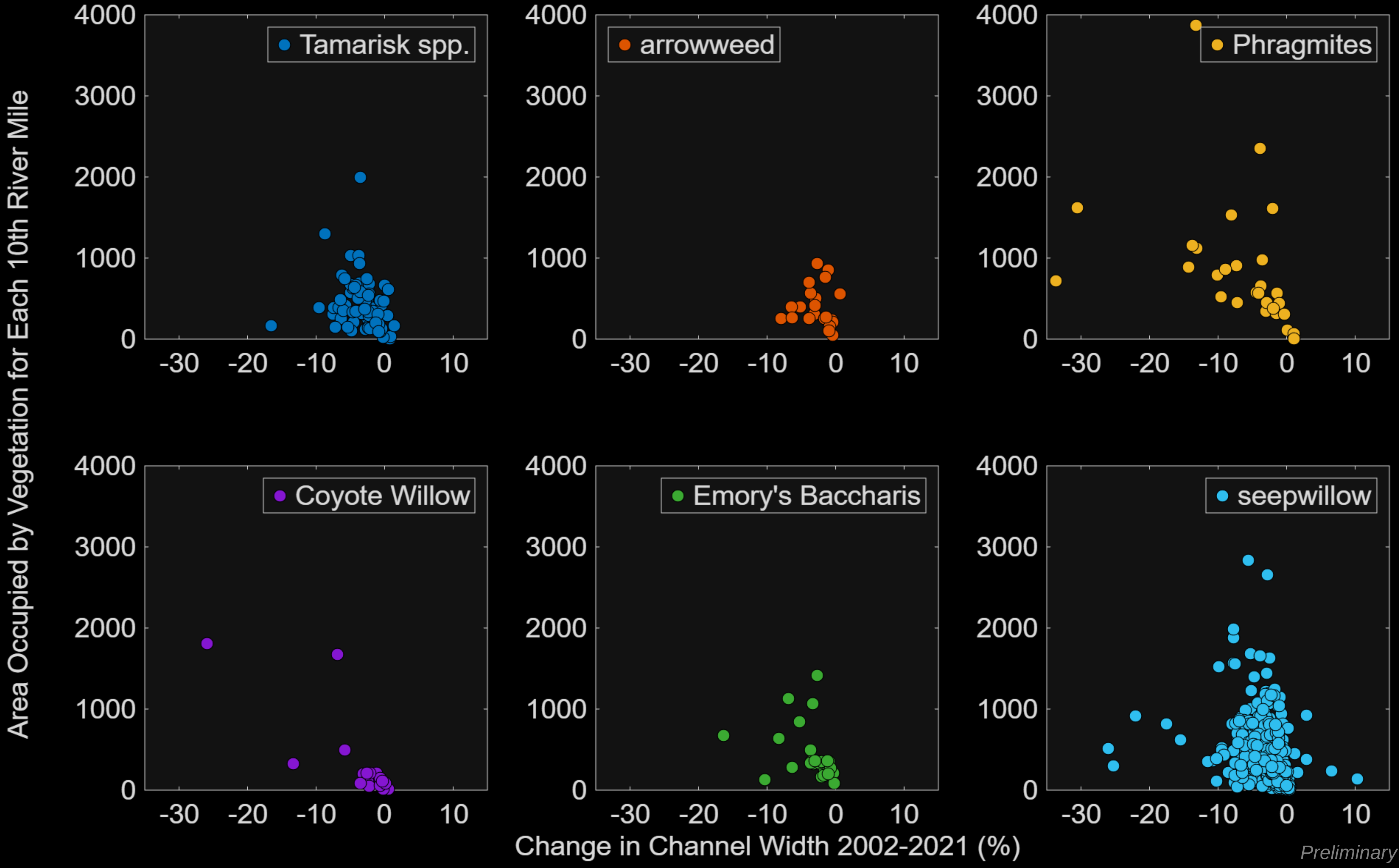
What Types of Plants Cause Narrowing?



Durning et al., 2021, *Ecohydrology*, Project L

Plant Species vs. Channel Narrowing



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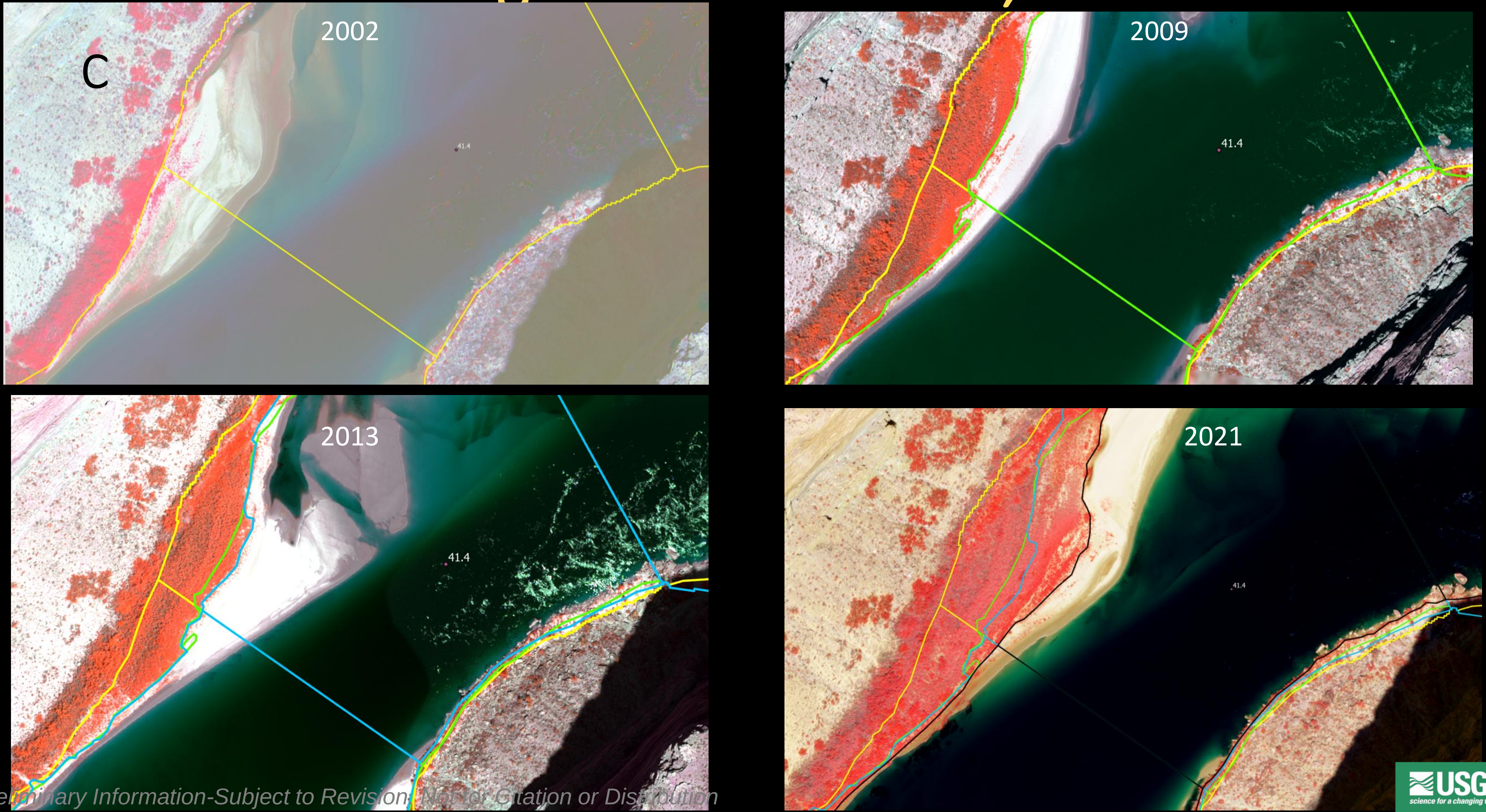
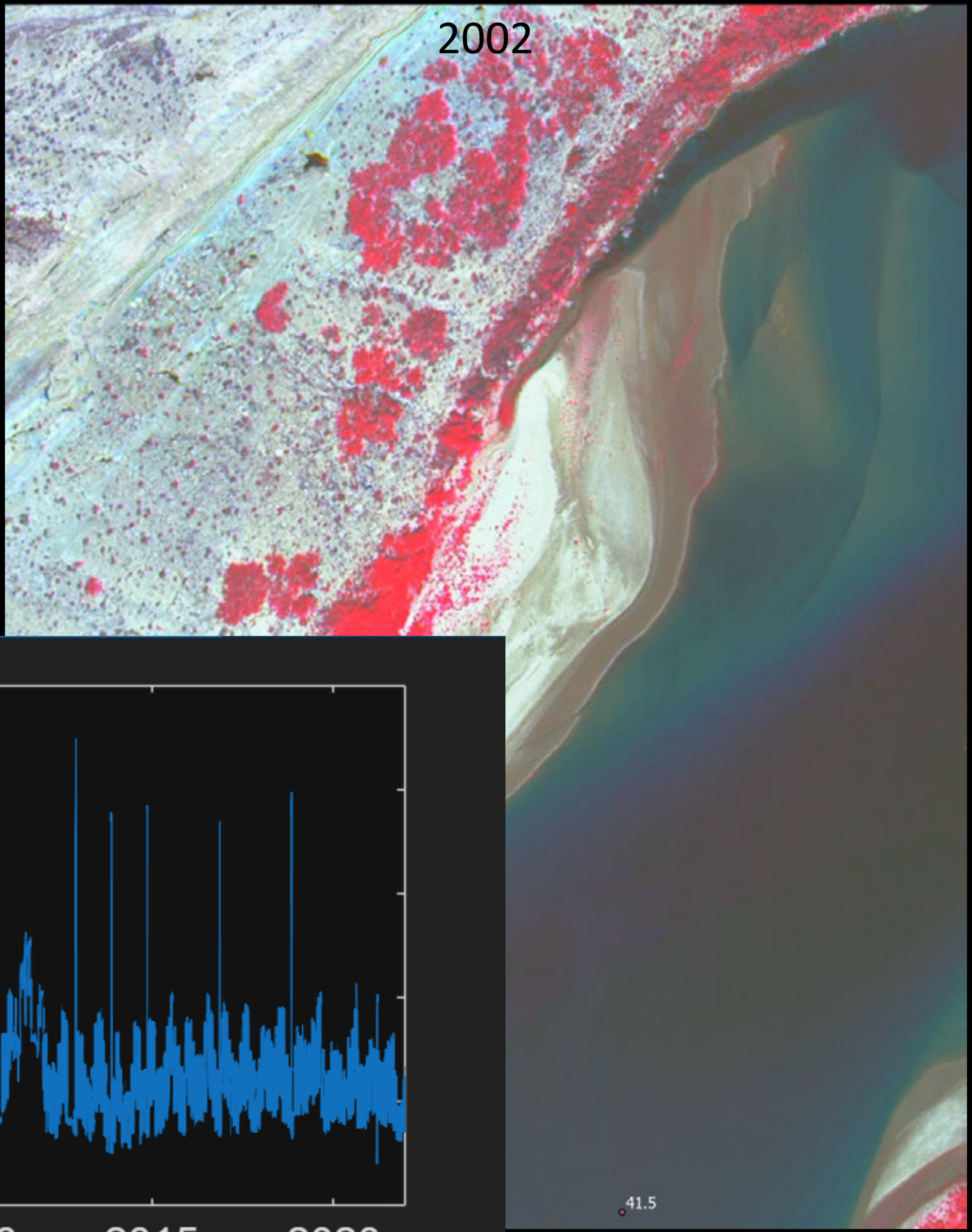
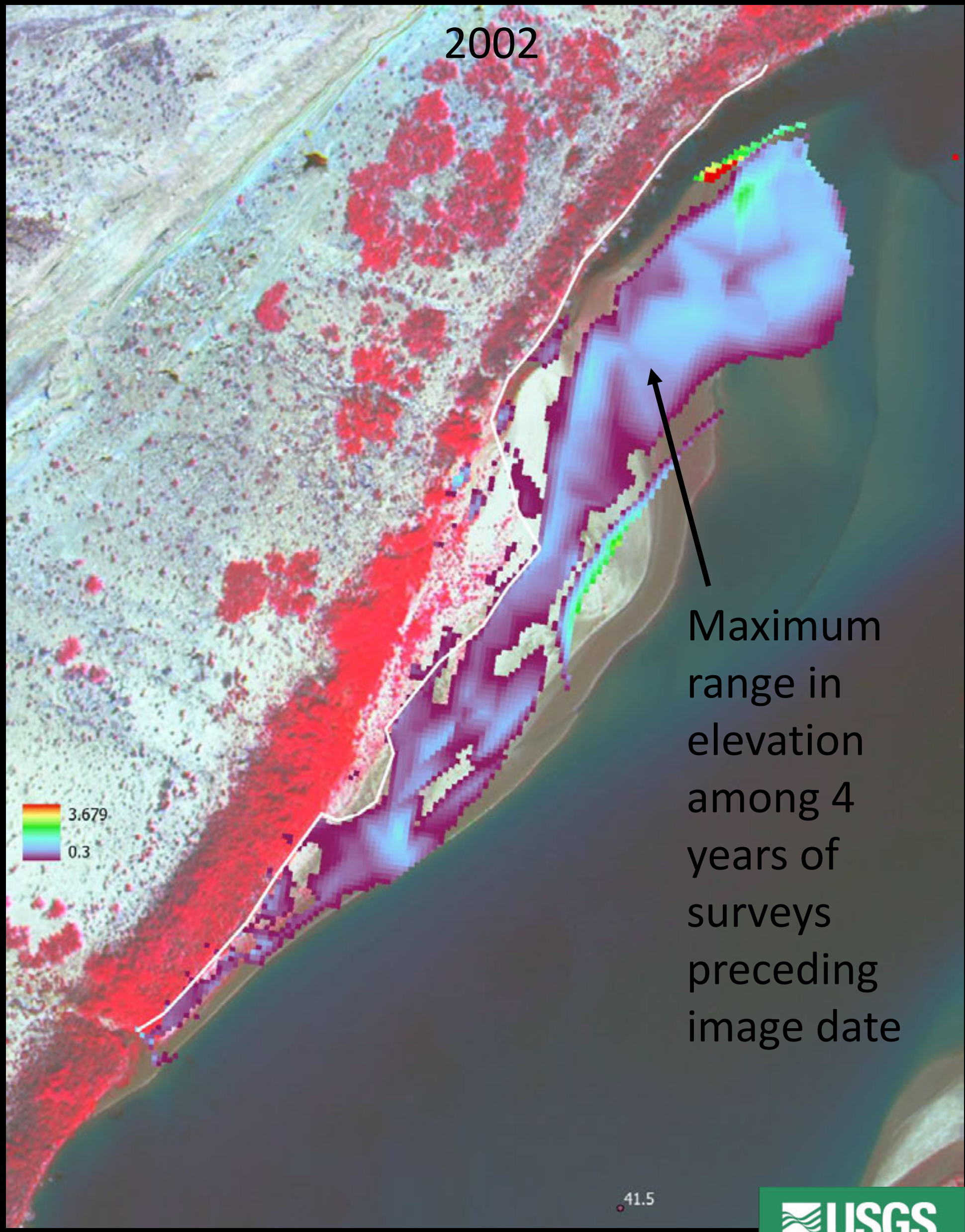
Width Change River Mile 41.4, Buck farm

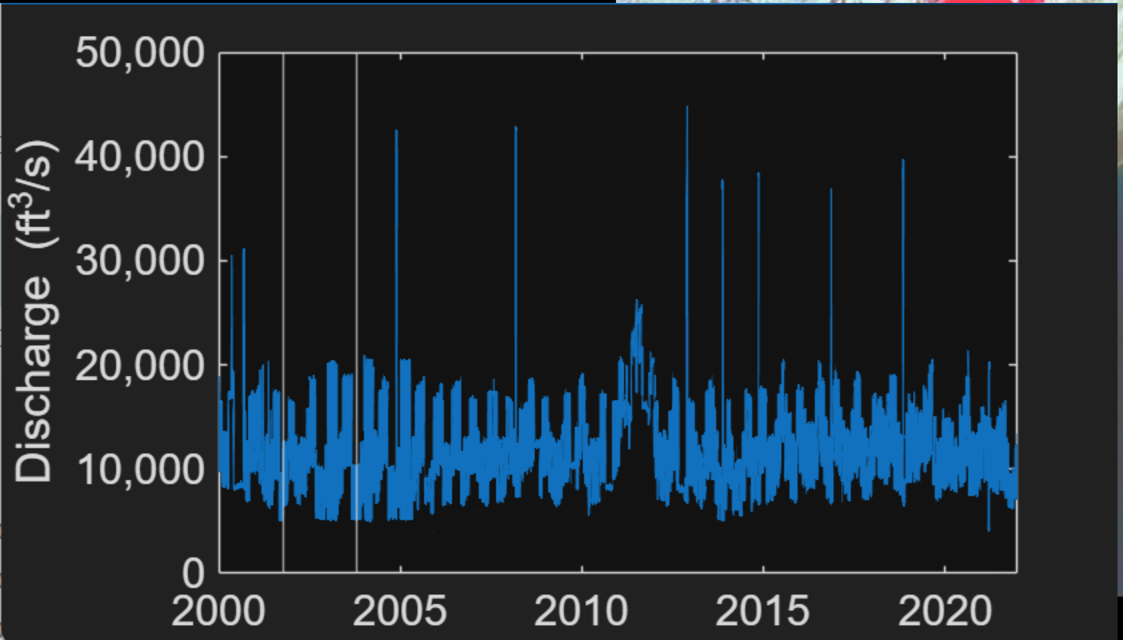


Change in Bar Dynamics – RM 41.4, Buck farm

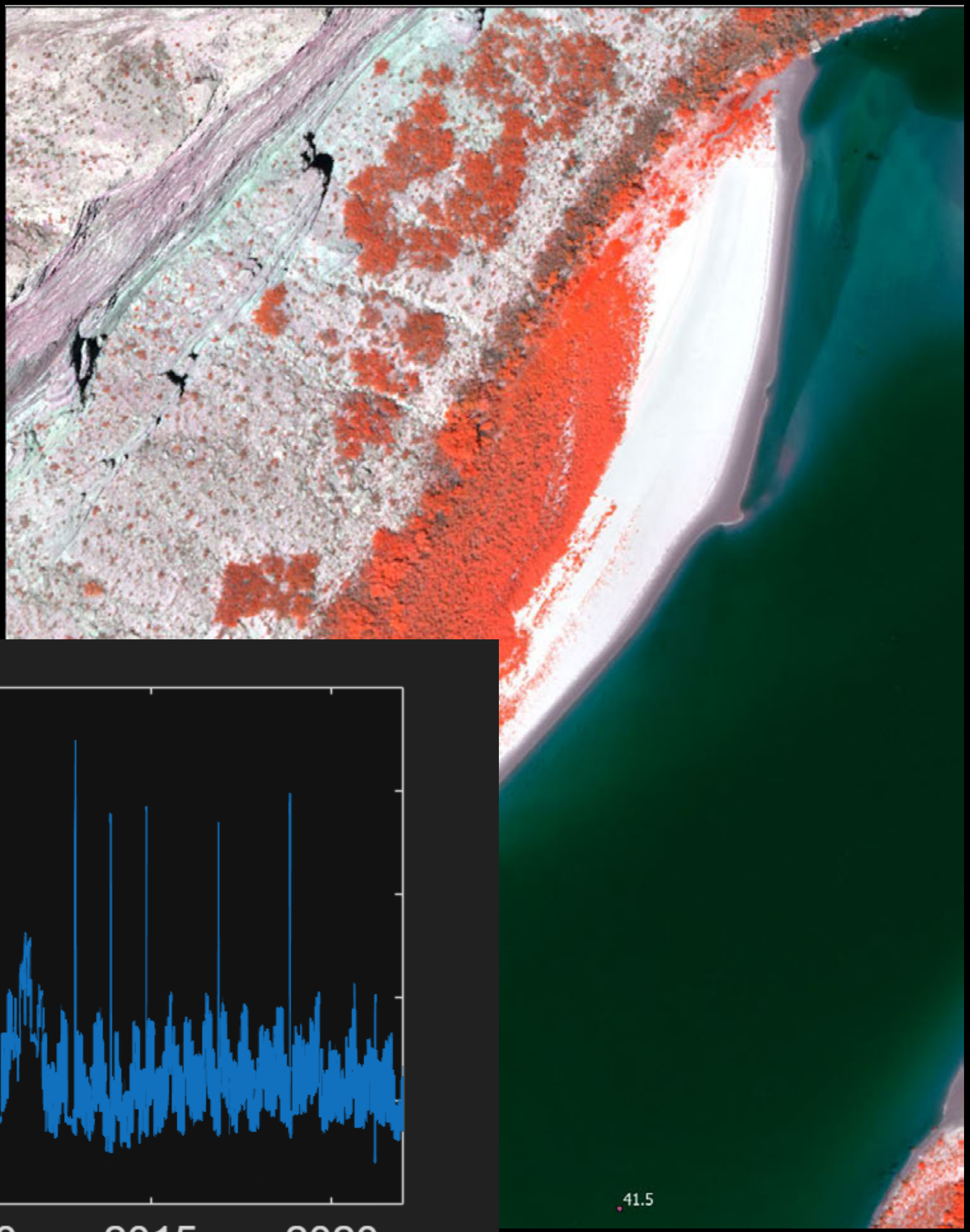
- Use survey data to evaluate sandbar activity (Project B)
- What parts of the sandbars were active over the periods prior to the imagery?

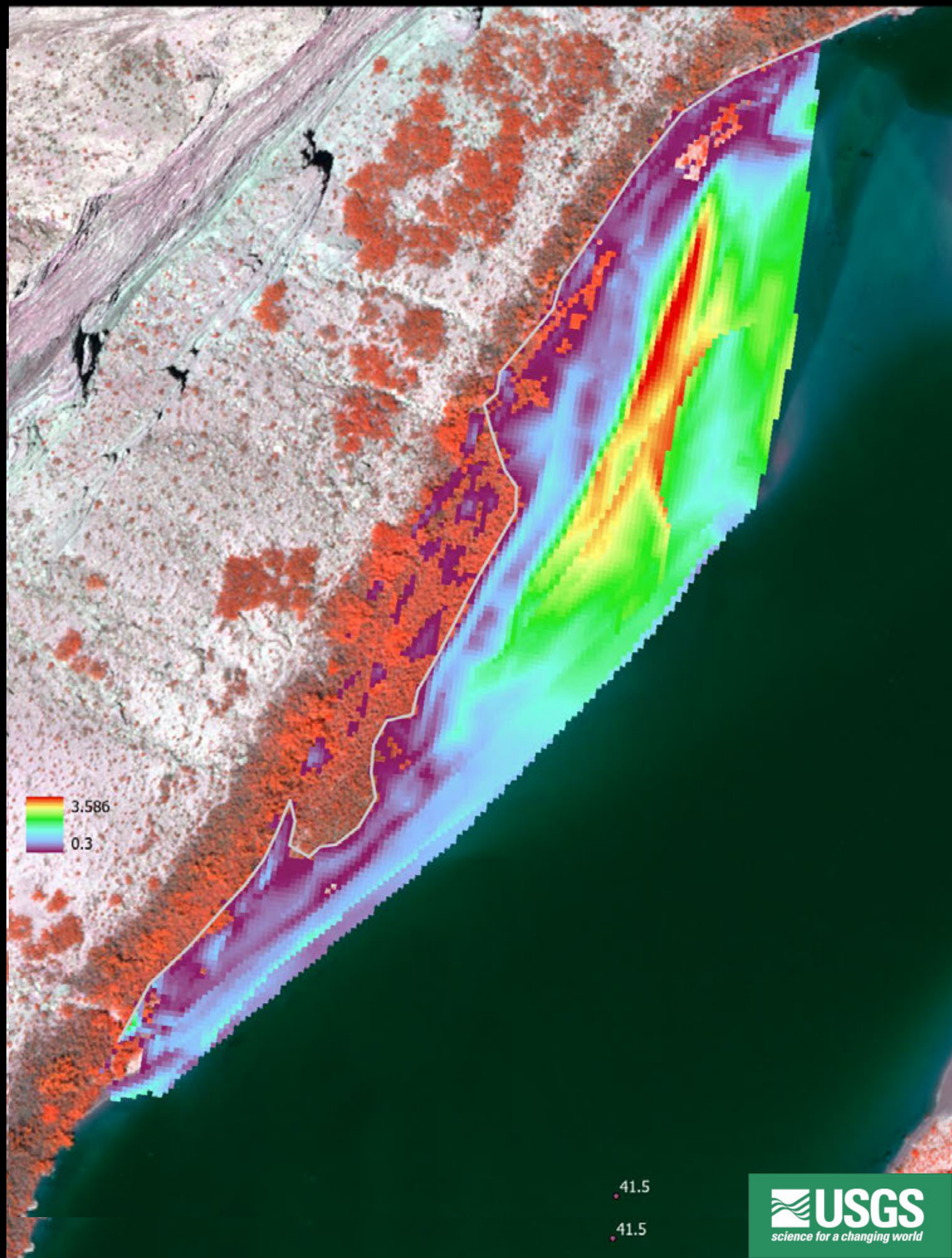


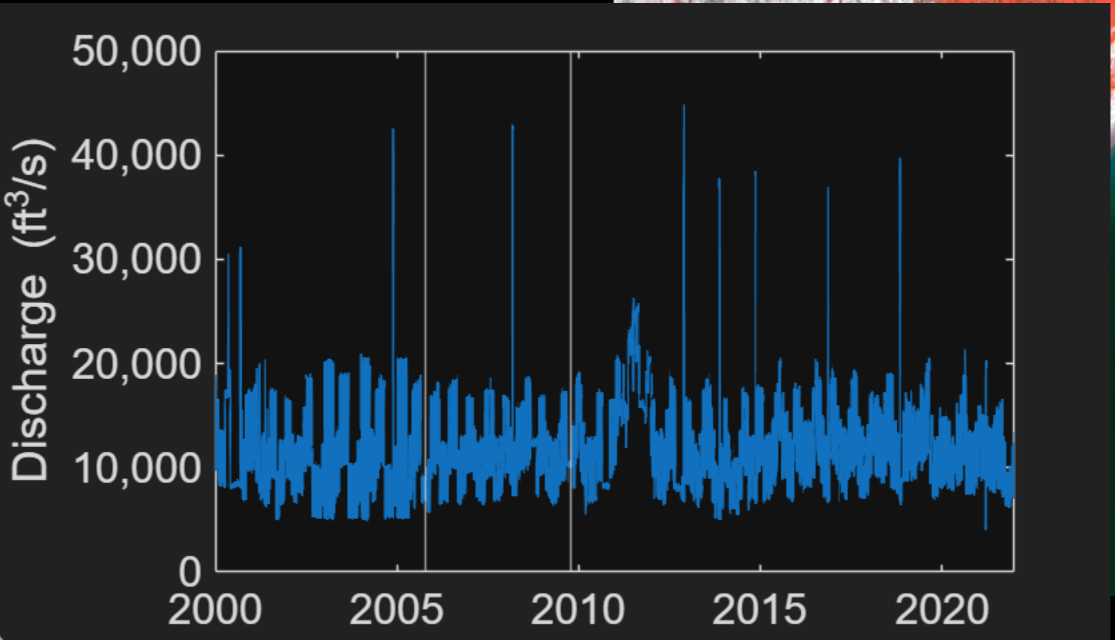




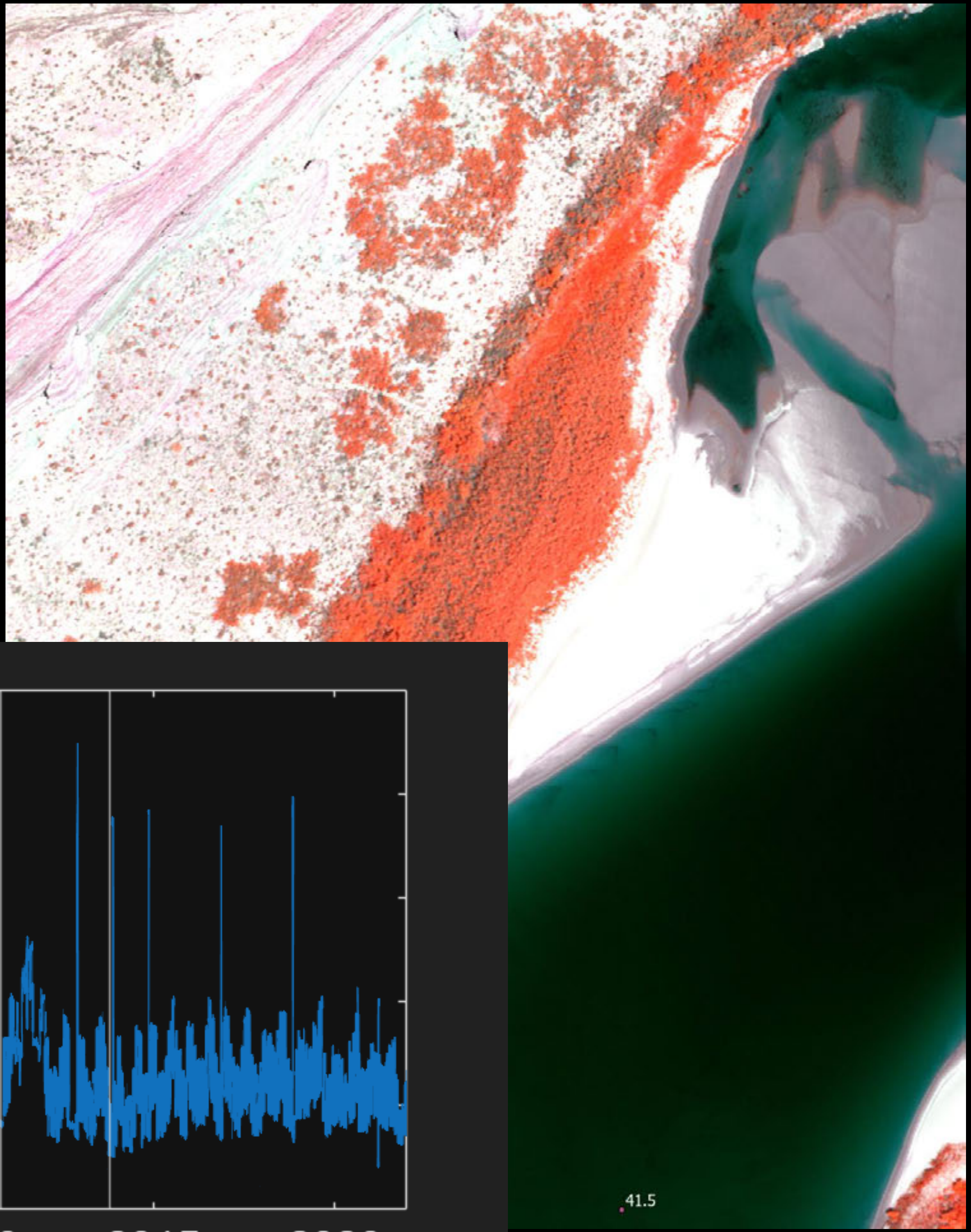
Change in Bar Dynamics – RM 41.4, Buck farm

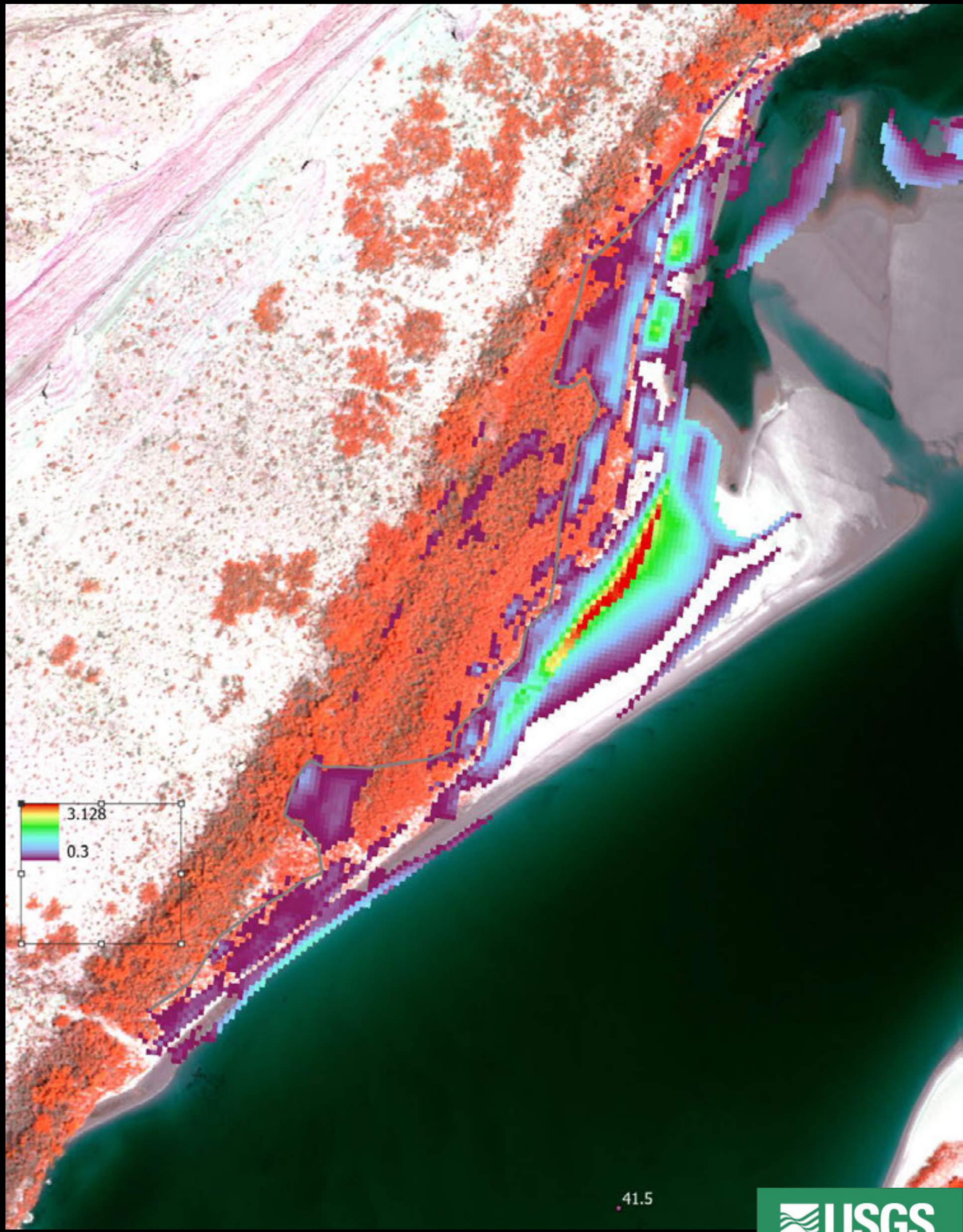


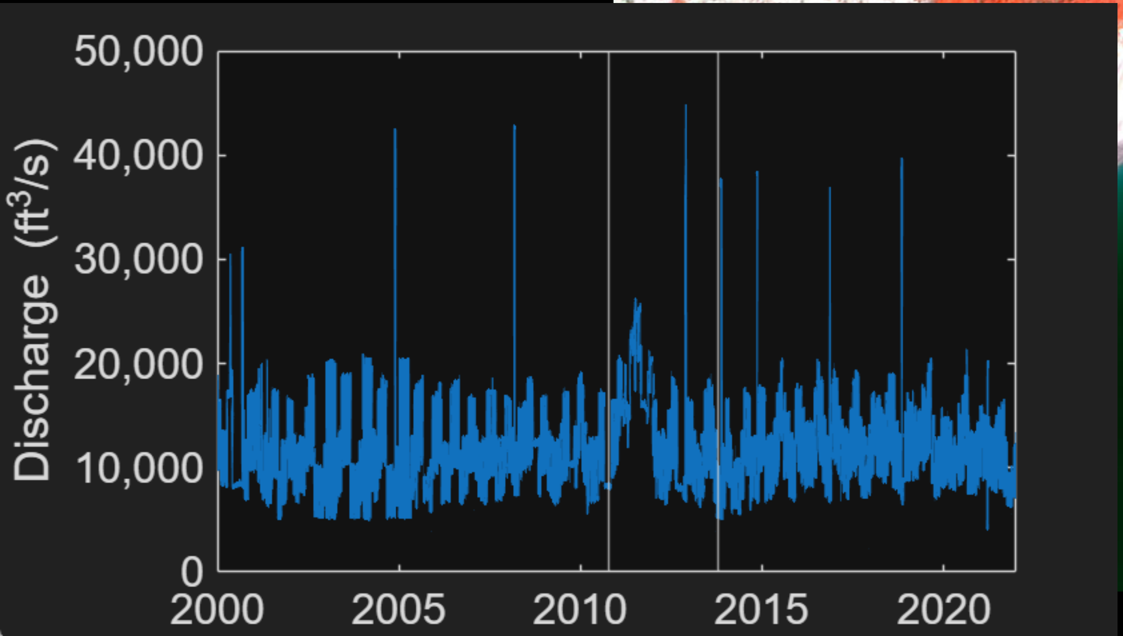




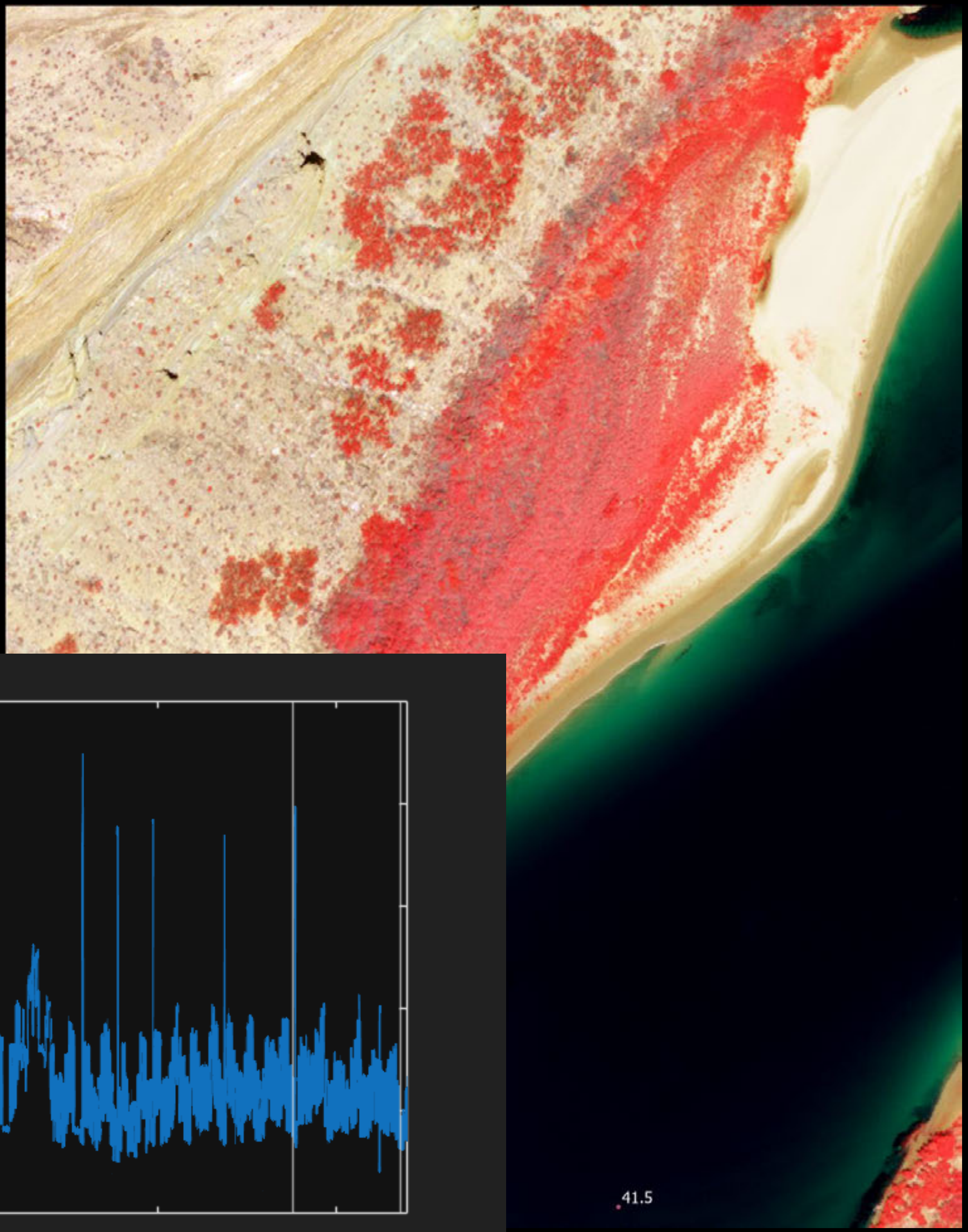
Change in Bar Dynamics – RM 41.4, Buck farm

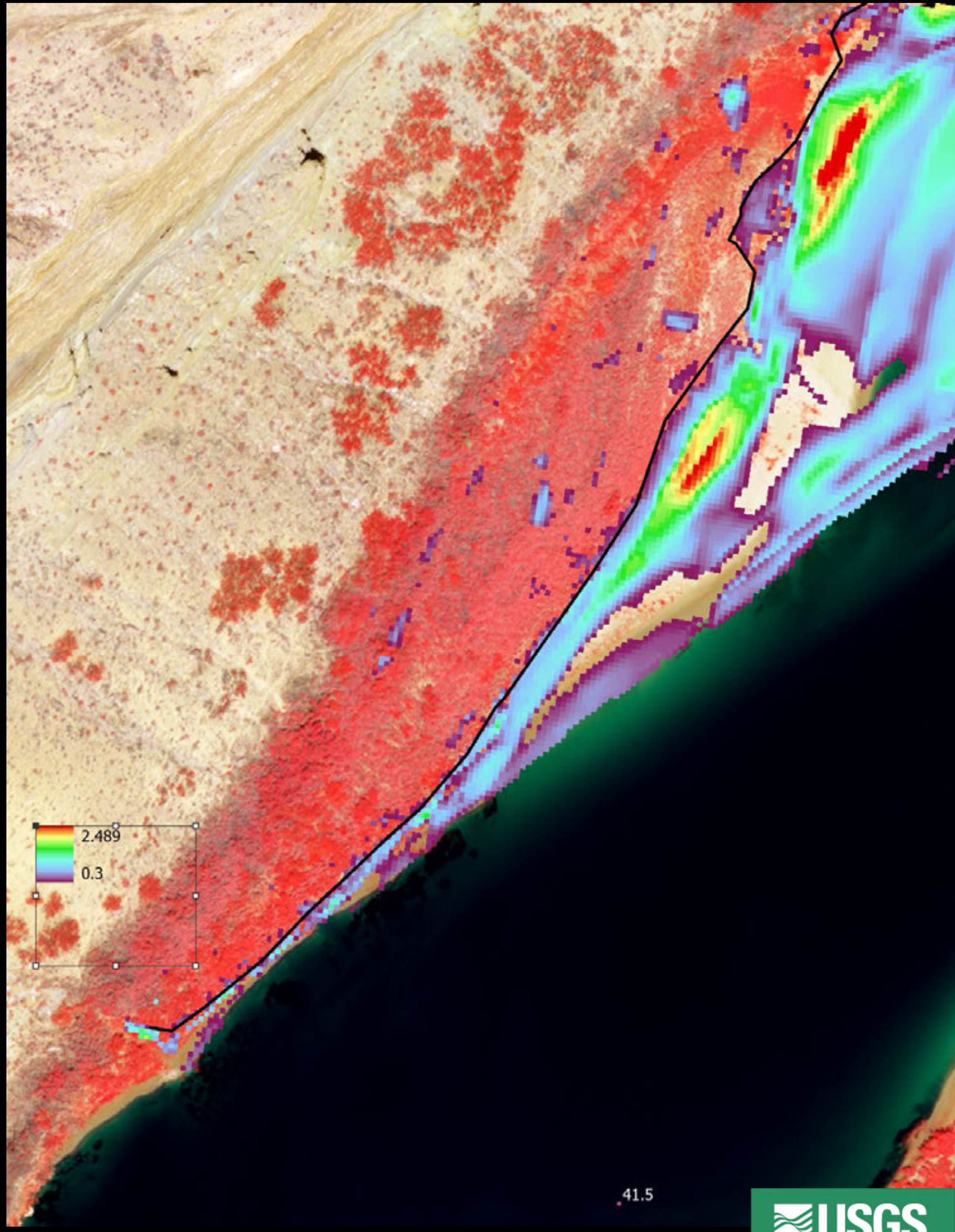


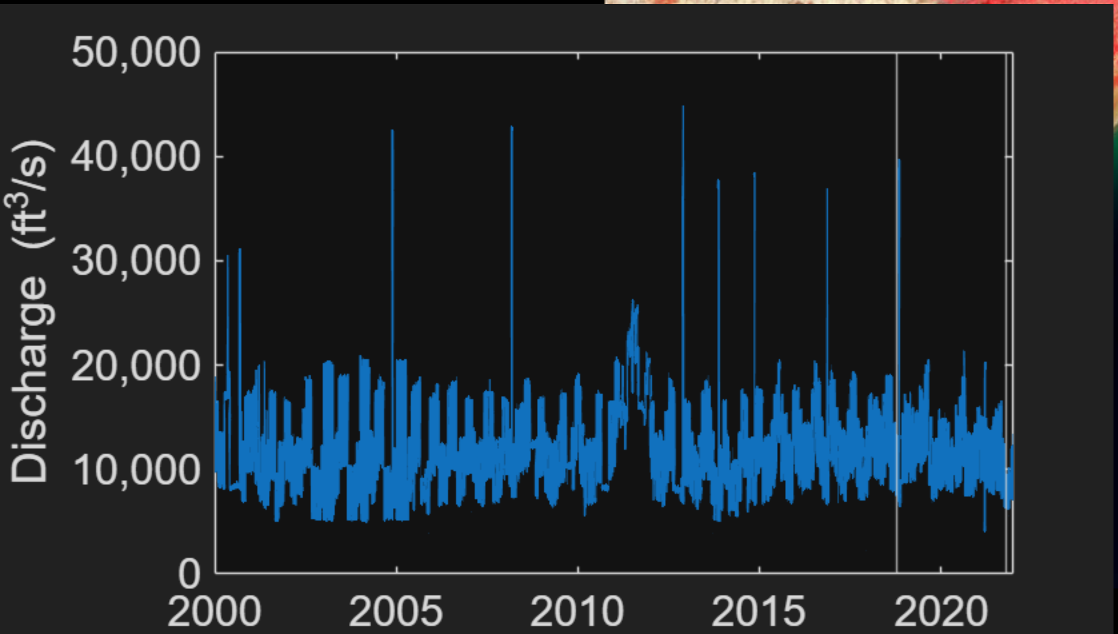




Change in Bar Dynamics – RM 41.4, Buck farm

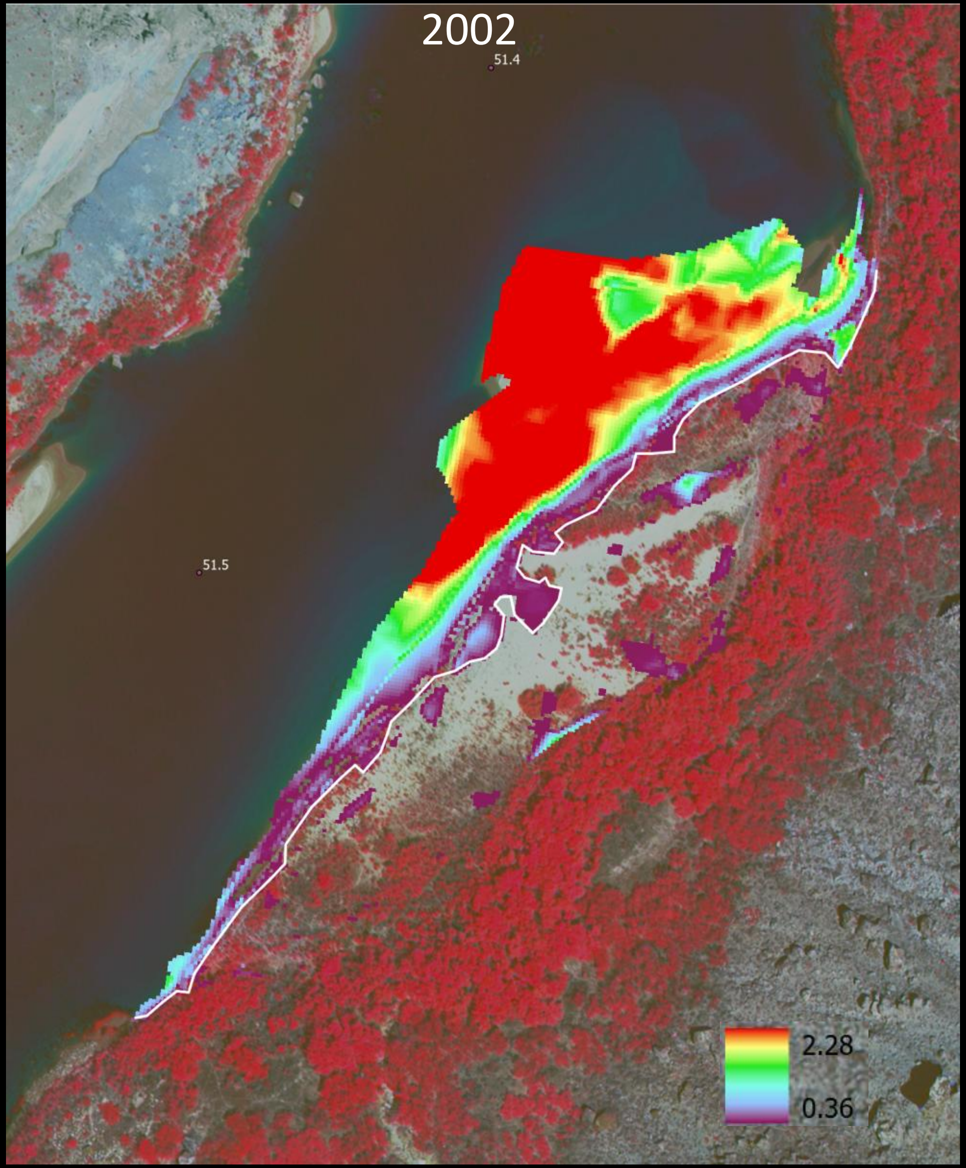






Change in Bar Dynamics – RM 41.4, Buckfarm

Change in Bar Dynamics – RM 51.5



Change in Bar Dynamics – RM 51.5

Change in Bar Dynamics – RM 51.5

Summary

Reduced peak flows (loss of disturbance) + Increased baseflows

=

Vegetation encroachment and channel narrowing

1963 – 2002 – narrowing of ~20m or ~23%

2002 – 2009 - narrowing of ~3m or ~2.9%

2013 – 2021 - narrowing of ~2.5m or ~2.5%

Further narrowing is likely; additional ~10m or ~10% is possible.

Loss of eddy sandbar dynamics – Implications for riverine habitat?

Implications for current/future sand bar responses to HFEs?

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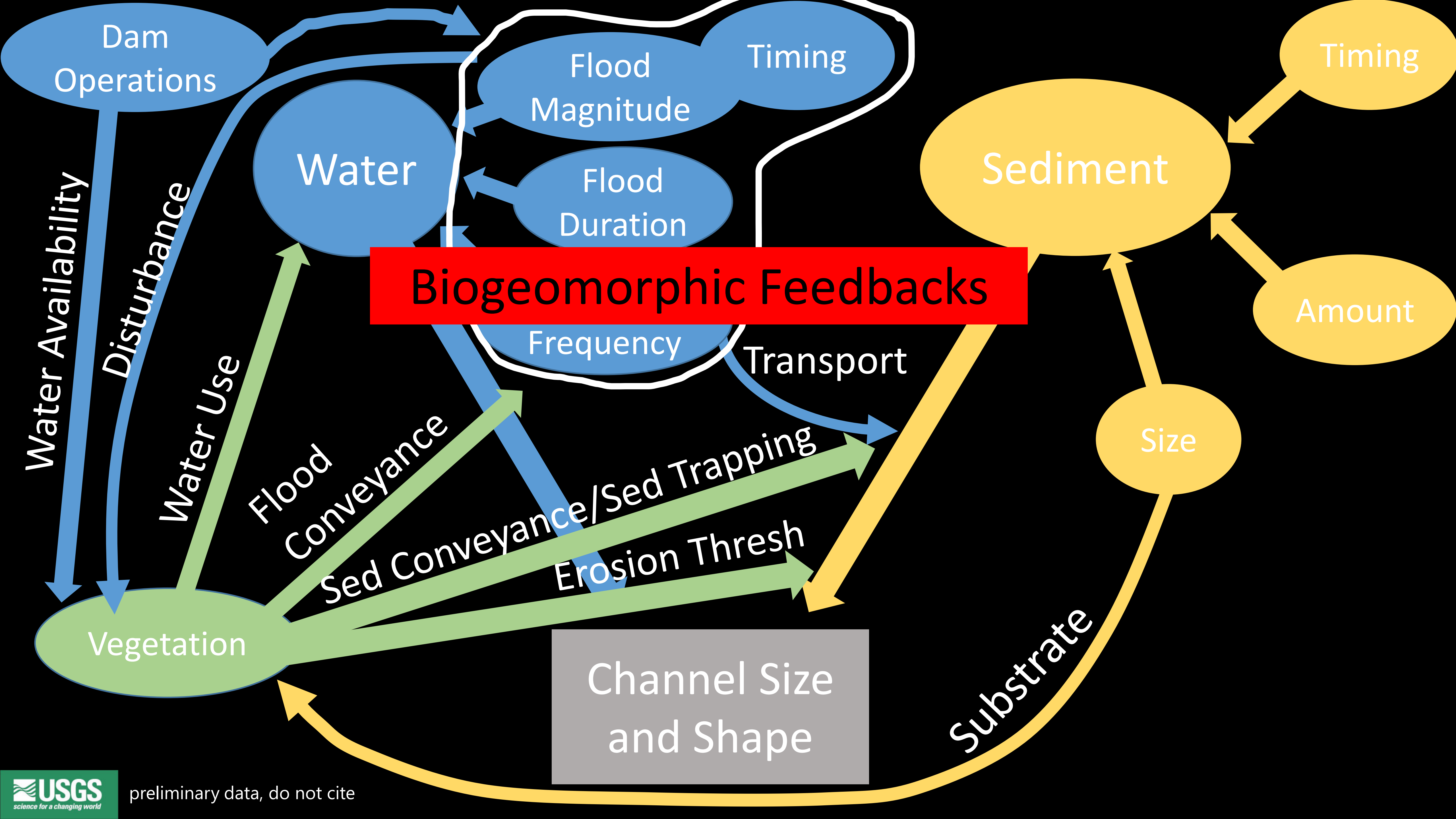

preliminary data, do not cite