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science for a changing world

Changes in Riparian Vegetation in the Colorado River Corridor, 1965-present

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

2002

2009

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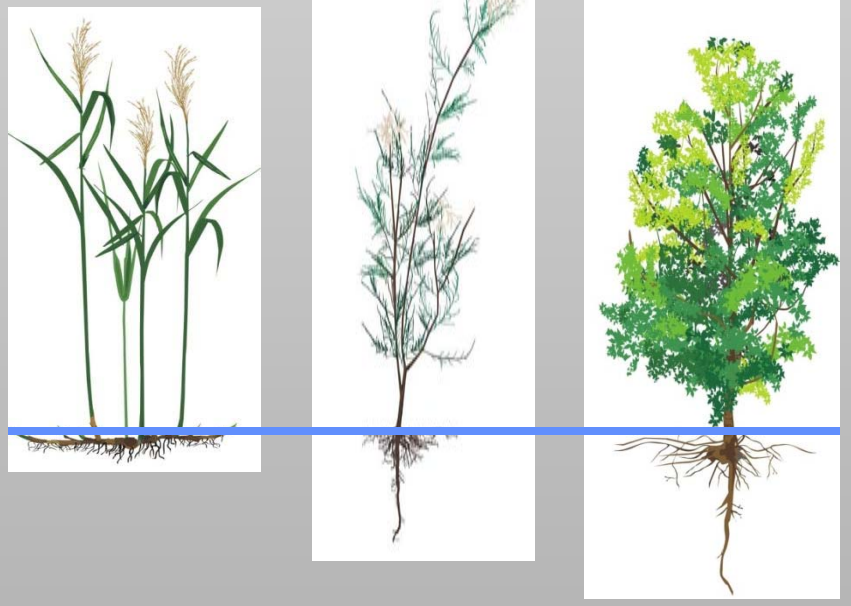
Drivers of Vegetation Change

Plant Traits

- Life history
- Morphology
- Fluvial disturbance
- Water balance

Phragmites australis *Tamarix spp* *Acer negundo/ Prosopis glandulosa*



Relevant Flow Component

- Magnitude & timing of high & low flow
- Mean discharge (1.5-2 yr recurrence)
- Flow permanence

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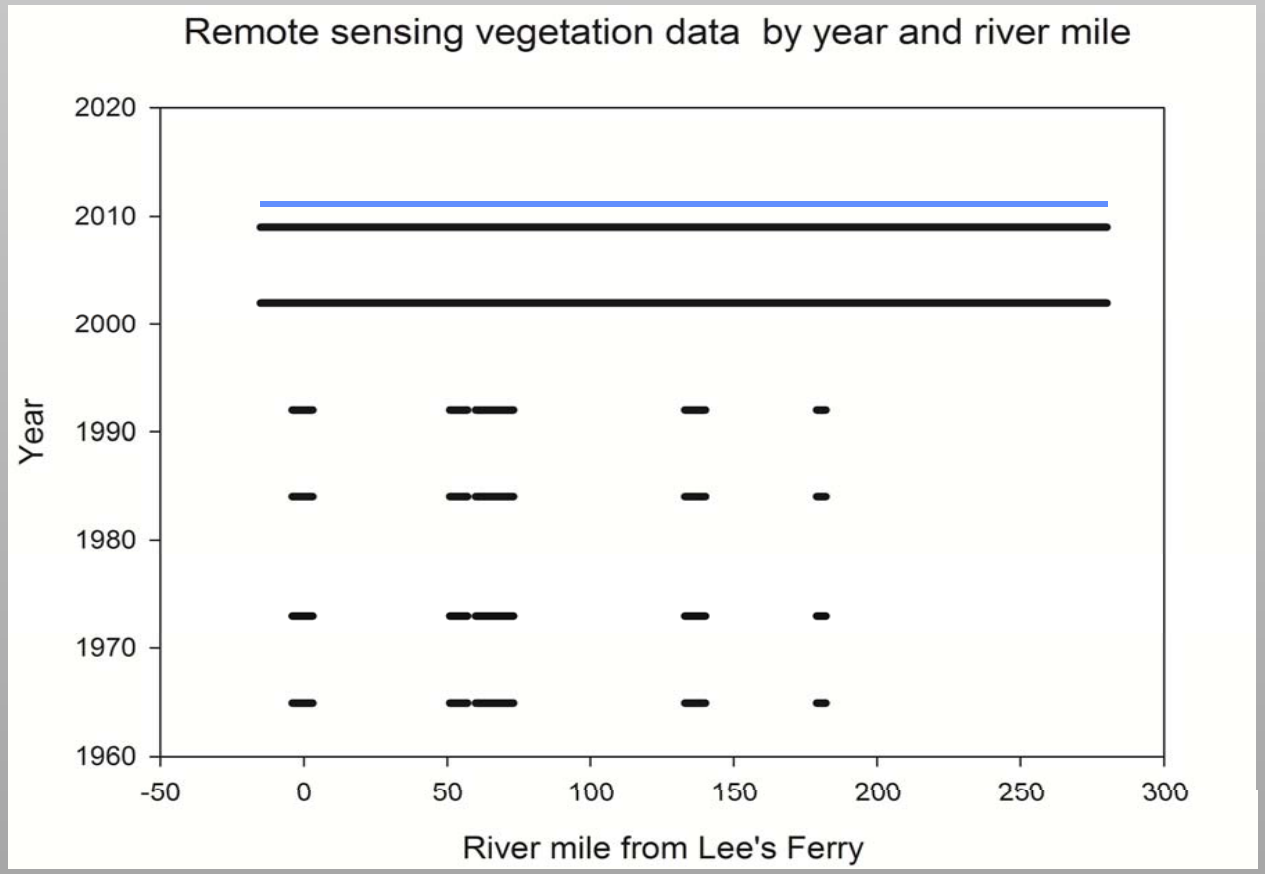
Available Data

- **Aerial and digital imagery-based vegetation maps**
  - **1965, 73, 84, 92, 2002, 2009**
    - **Total vegetation: segments '65-'92 (Waring, 1996); whole corridor '02, '09 (Davis, 2012) and 2013 (future – this summer's overflight)**



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Methods

- **GIS synthesis of the existing 5 decades of GCMRC remote sensing vegetation datasets by:**
  - **Vegetation maps 2002 (Ralston and others, 2008), 2009 (NPS, 2012)**
  - **Elevation Zones – 25k, 31k, 45k, 97k CFS virtual shorelines (Magirl and others, 2008)**
  - **Shoreline geomorphic units (eddies, debris fans, channel margins (Utah State data, unpublished))**
  - **Glen Canyon Dam hydrograph**
  - **Regional climate synthesis (Hereford and others, in review)**

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Questions for Remotely Sensed Data

- **Spatial and temporal dynamics**
  - **How does the composition of riparian vegetation vary spatially with river stage-elevation (elevation zones)?**
  - **How does the proportion of terrestrial area that is vegetated vary temporally (1965-present):**
    - **System-wide?**
    - **Among geomorphic units?**
    - **By proximity to the river channel?**
    - **By elevation zones?**
  - **What is the relationship of spatial and temporal variability relative to hydrology and regional climate?**

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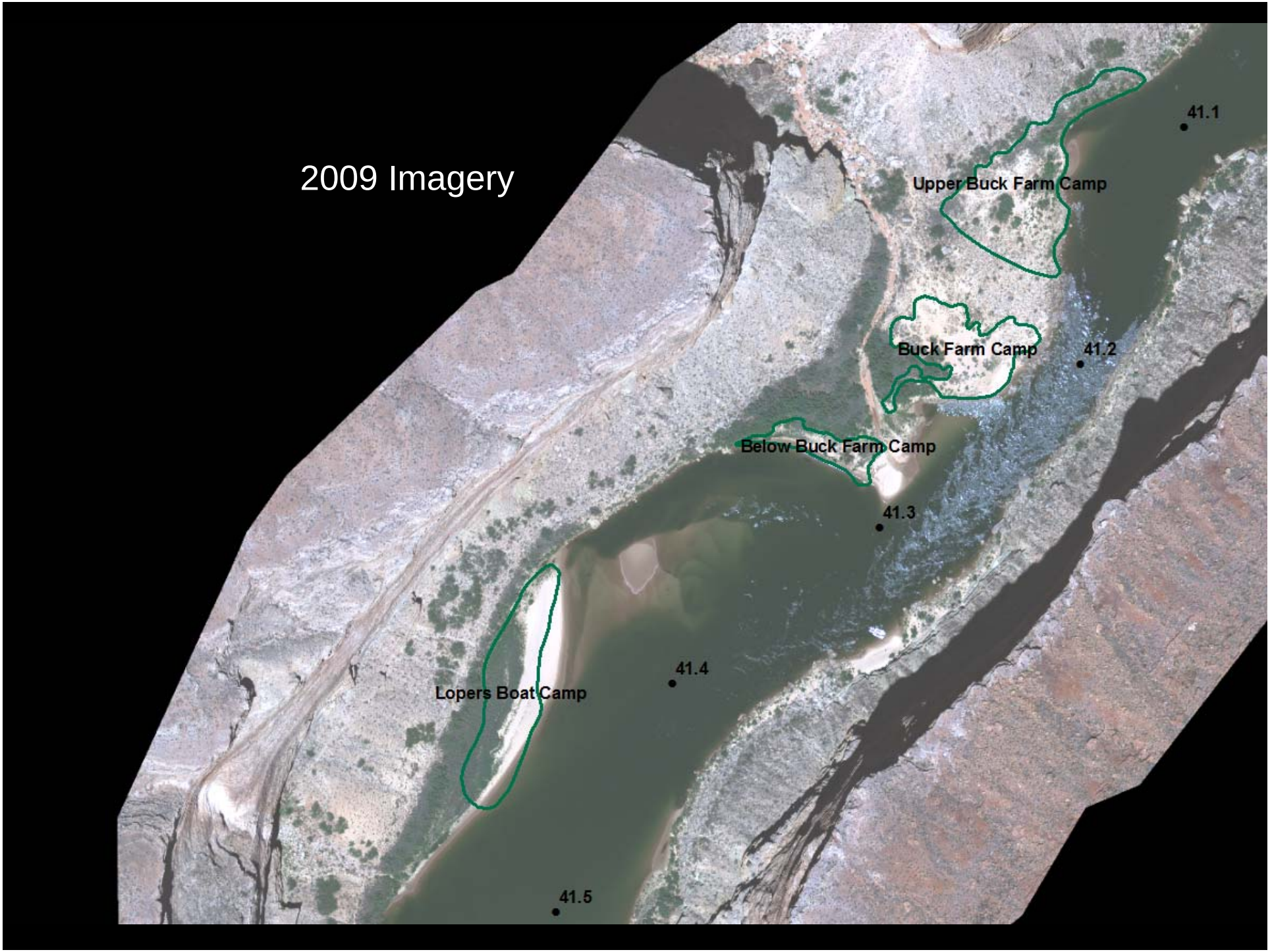
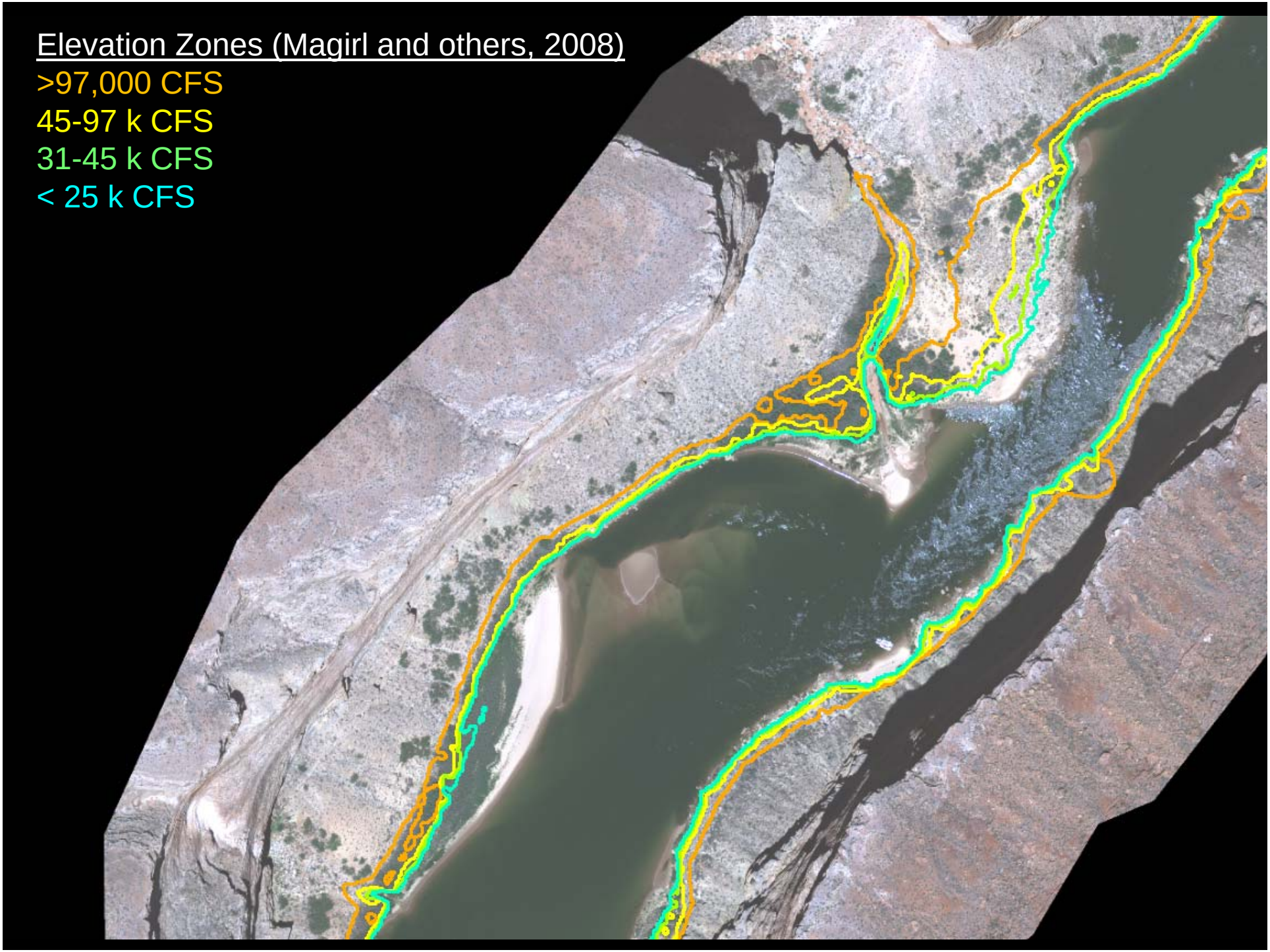
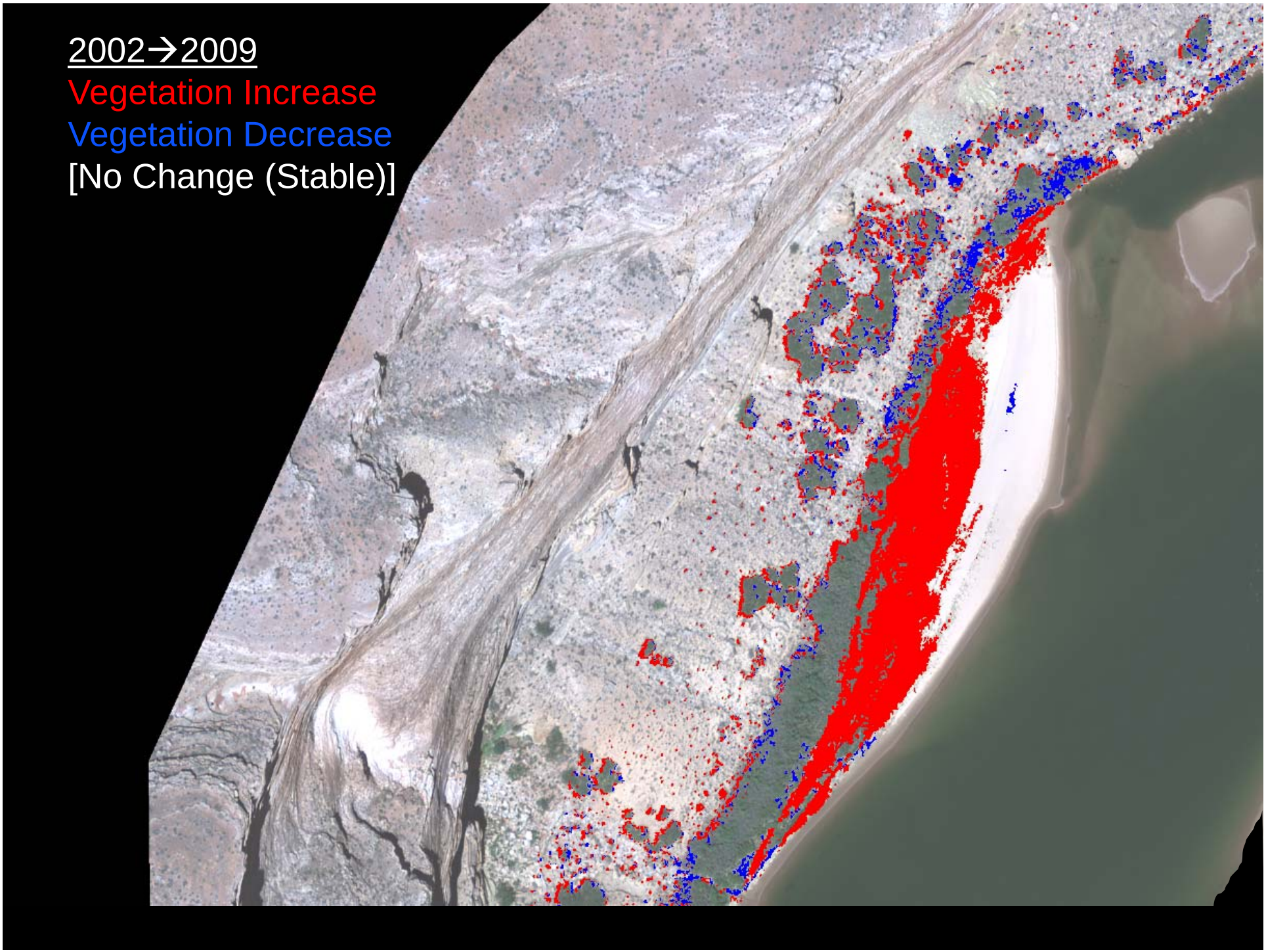

2009 Imagery
41.1
Upper Buck Farm Camp
Buck Farm Camp
41.2
Below Buck Farm Camp
41.3
41.4
Lopers Boat Camp
41.5


Elevation Zones (Magirl and others, 2008)
>97,000 CFS
45-97 k CFS
31-45 k CFS
< 25 k CFS

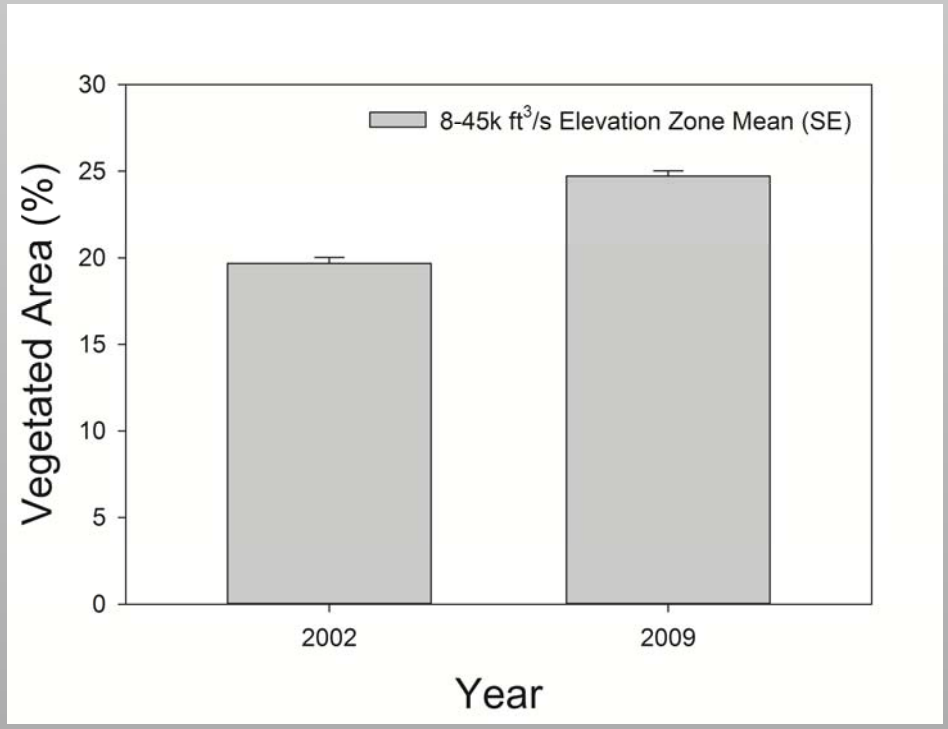

2002
Lopers Boat Camp


2009
Lopers Boat Camp


2002→2009
Vegetation Increase
Vegetation Decrease
[No Change (Stable)]

2002 → 2009

- **Riparian vegetation increased system-wide**
- **25% of the shoreline below 45,000 ft^3/s elevation zone was vegetated as of 2009**



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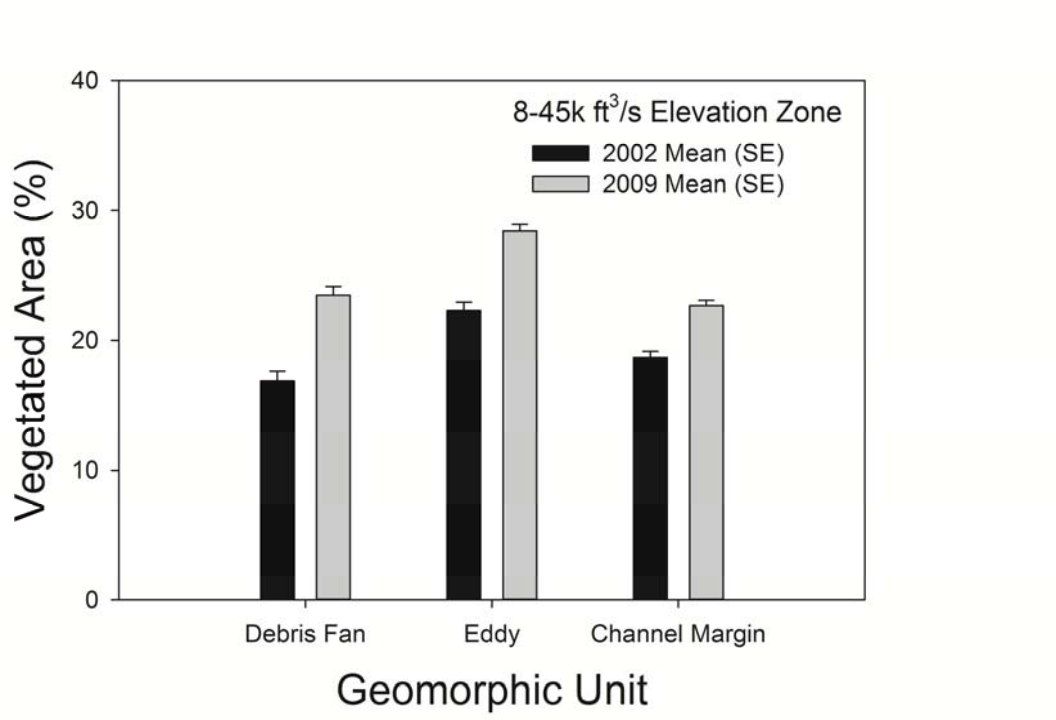
2002 → 2009

- **Riparian vegetation increased system-wide for each major geomorphic unit below 45,000 ft^3/s elevation zone**



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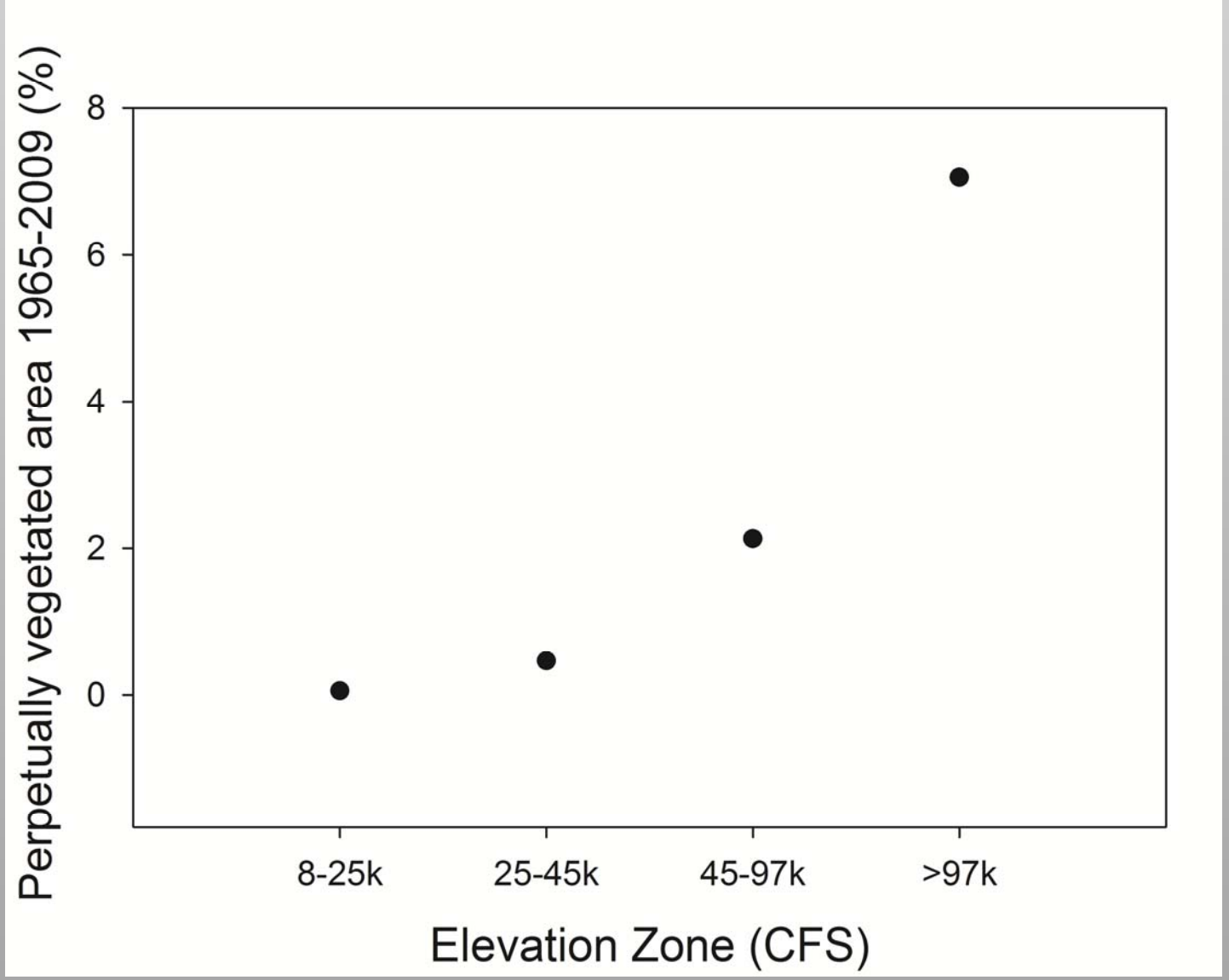
1965 → 2009

- **Vegetation was less stable at lower elevation zones**



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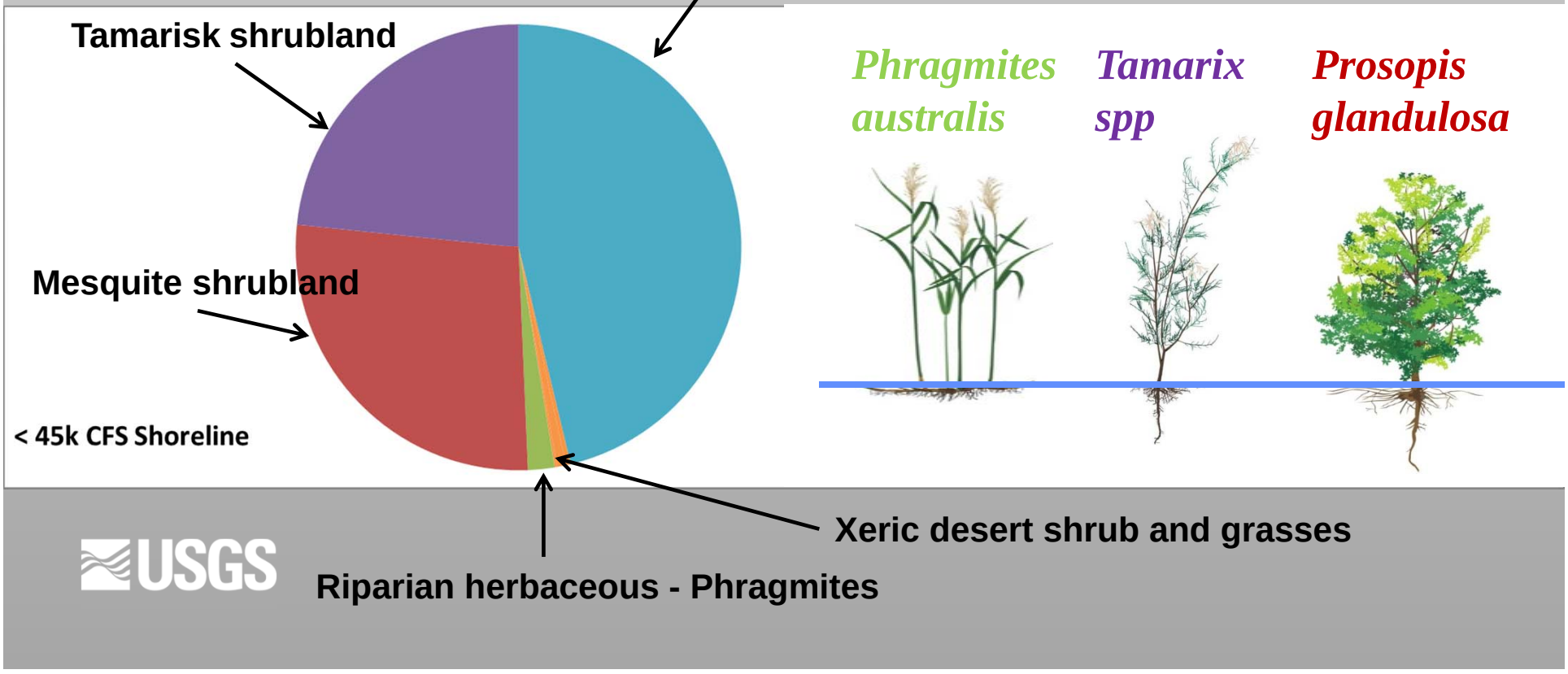
1965 → 2009: Vegetation composition by elevation zone

- **Below 45,000 ft^3/s**



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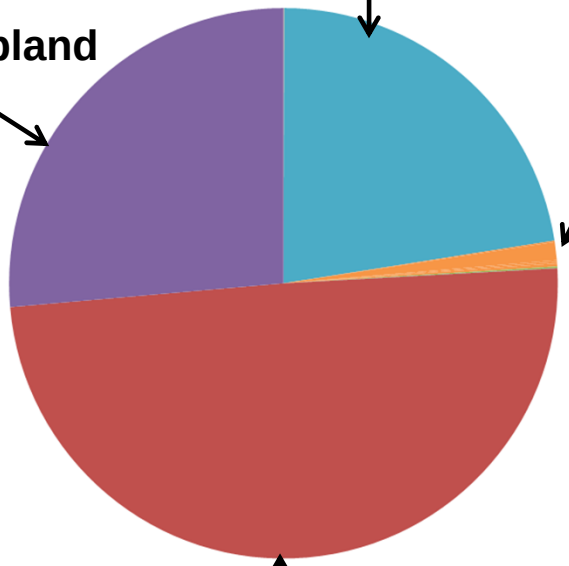
45,000-97,000 ft^3/s elevation zone

- Riparian herbaceous < 1%
- Riparian shrubs < 25%
- Tamarisk ~ comparable to lower elevation zones

Riparian shrubs - Baccharis, Sand-bar Willow, Arrowweed

Xeric desert shrub and grasses

Tamarisk shrubland

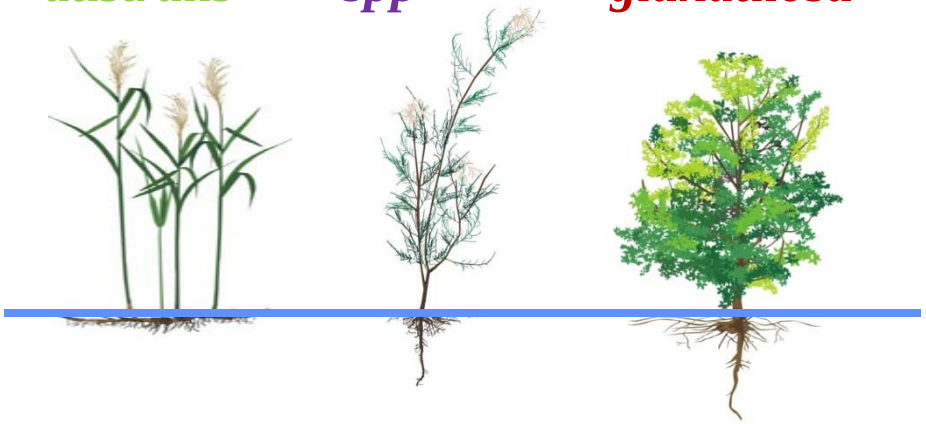


45-97k CFS Shoreline

Phragmites australis

Tamarix spp

Prosopis glandulosa



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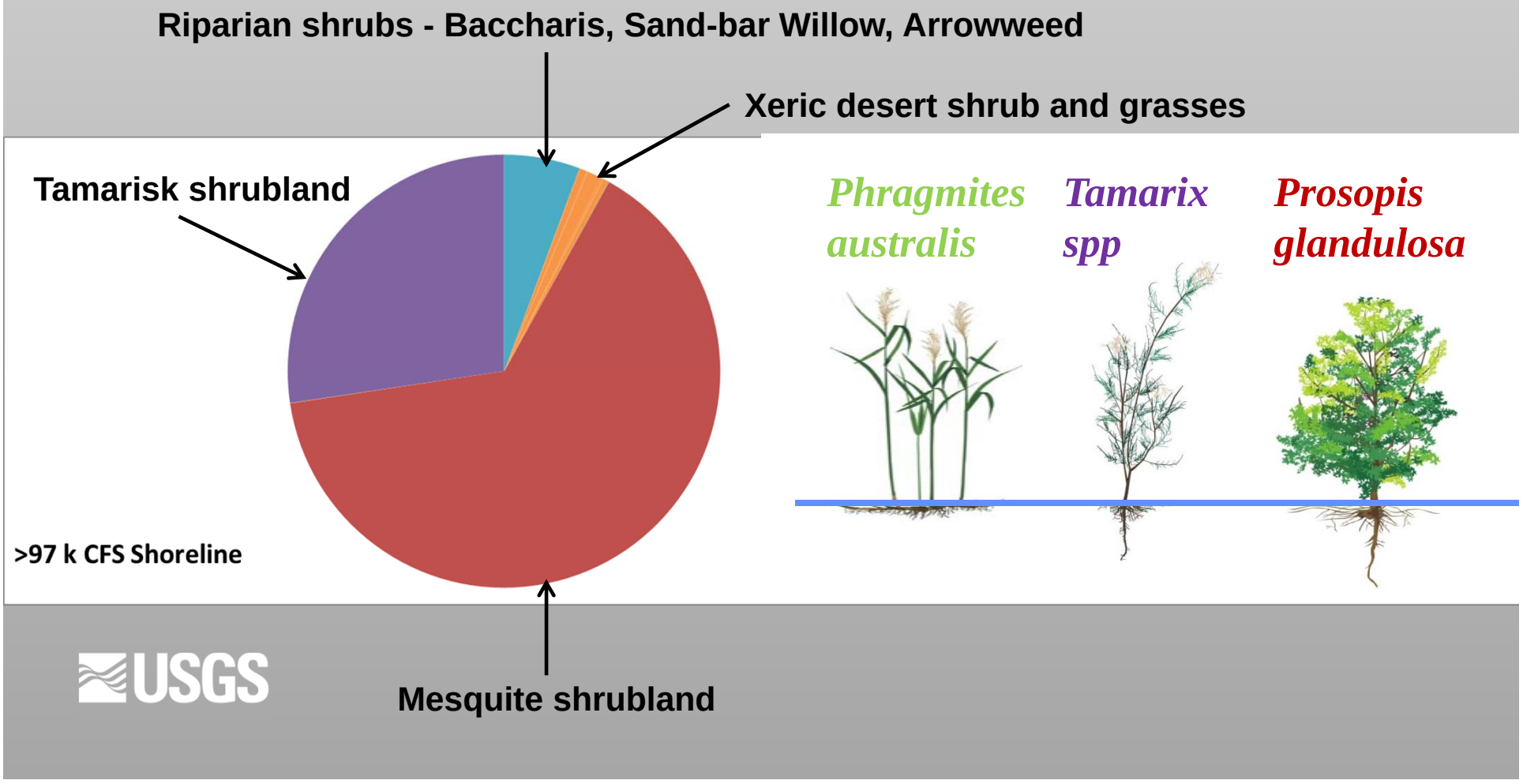
Mesquite shrubland

Above 97,000 ft^3/s elevation zone

- **Riparian shrubs < 10 %**
- **Tamarisk ~ comparable to lower elevation zones**



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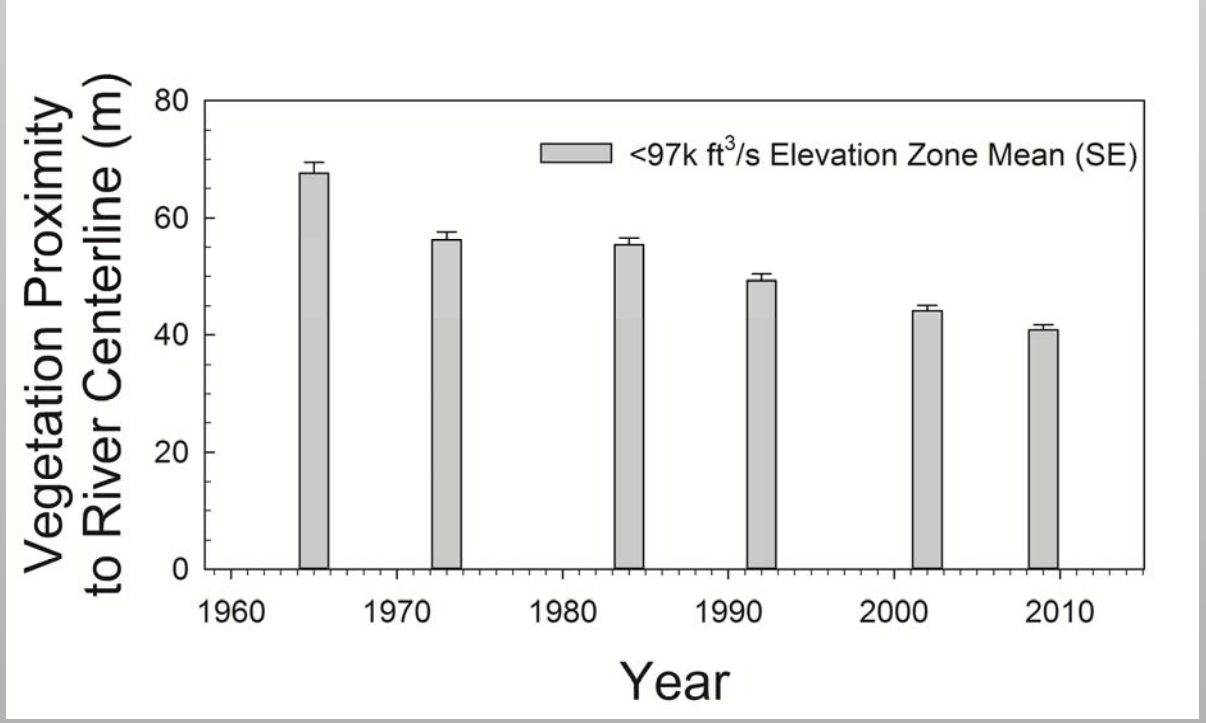
1965 → 2009

- **Riparian vegetation expanded shoreward**



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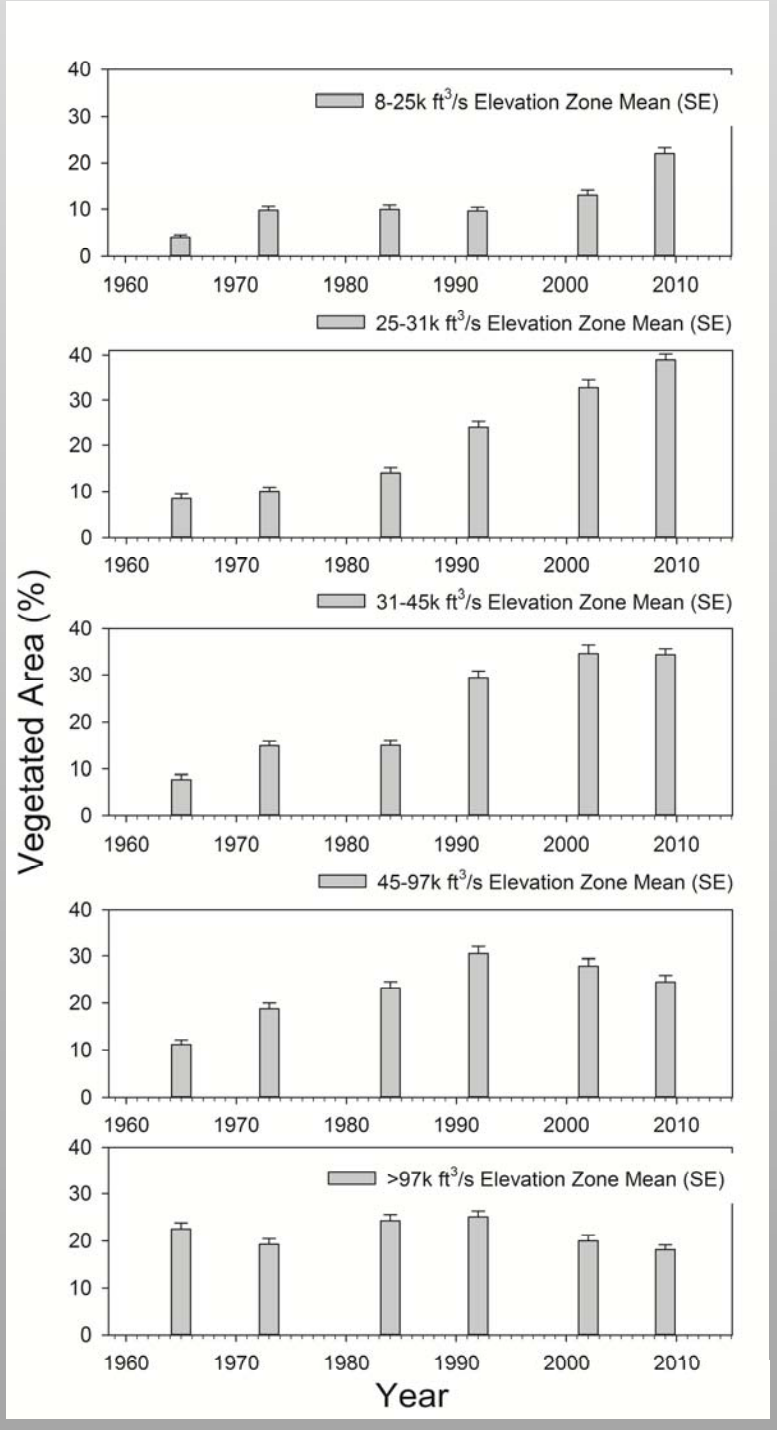
1965-2009

- **Long-term vegetation changes vary by elevation zone**



Lowest elevation zone - river

Highest elevation zone - xeric

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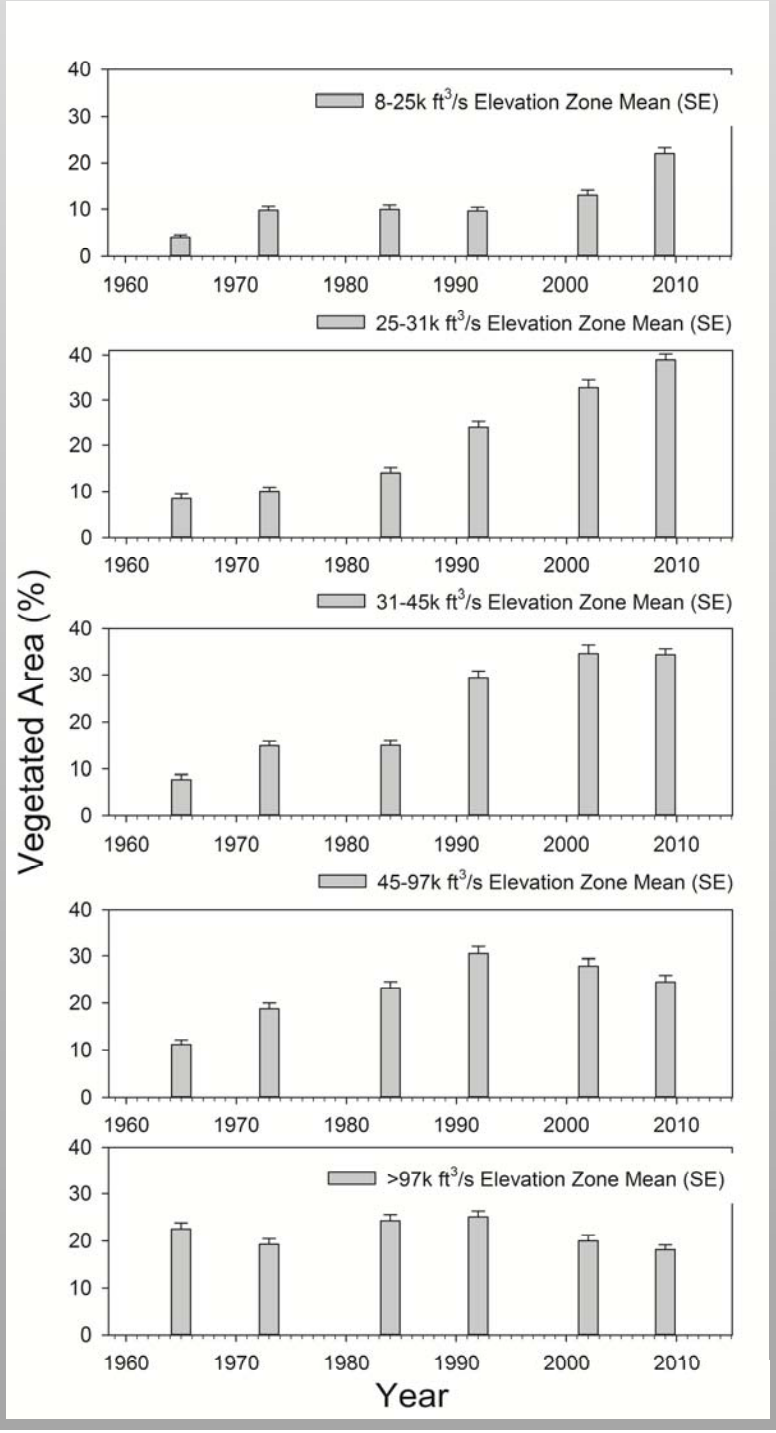
1965-2009

- **Long-term vegetation changes are associated with distinct hydrology of elevation zones**



Current Operations **(<25k ft³/s)**

Powerplant Operations **(25-31k ft³/s)**

Recent HFE's **(31-45k ft³/s)**

Rare post-dam Floods **(45-97k ft³/s)**

Never inundated post-dam **(>97k ft³/s)**

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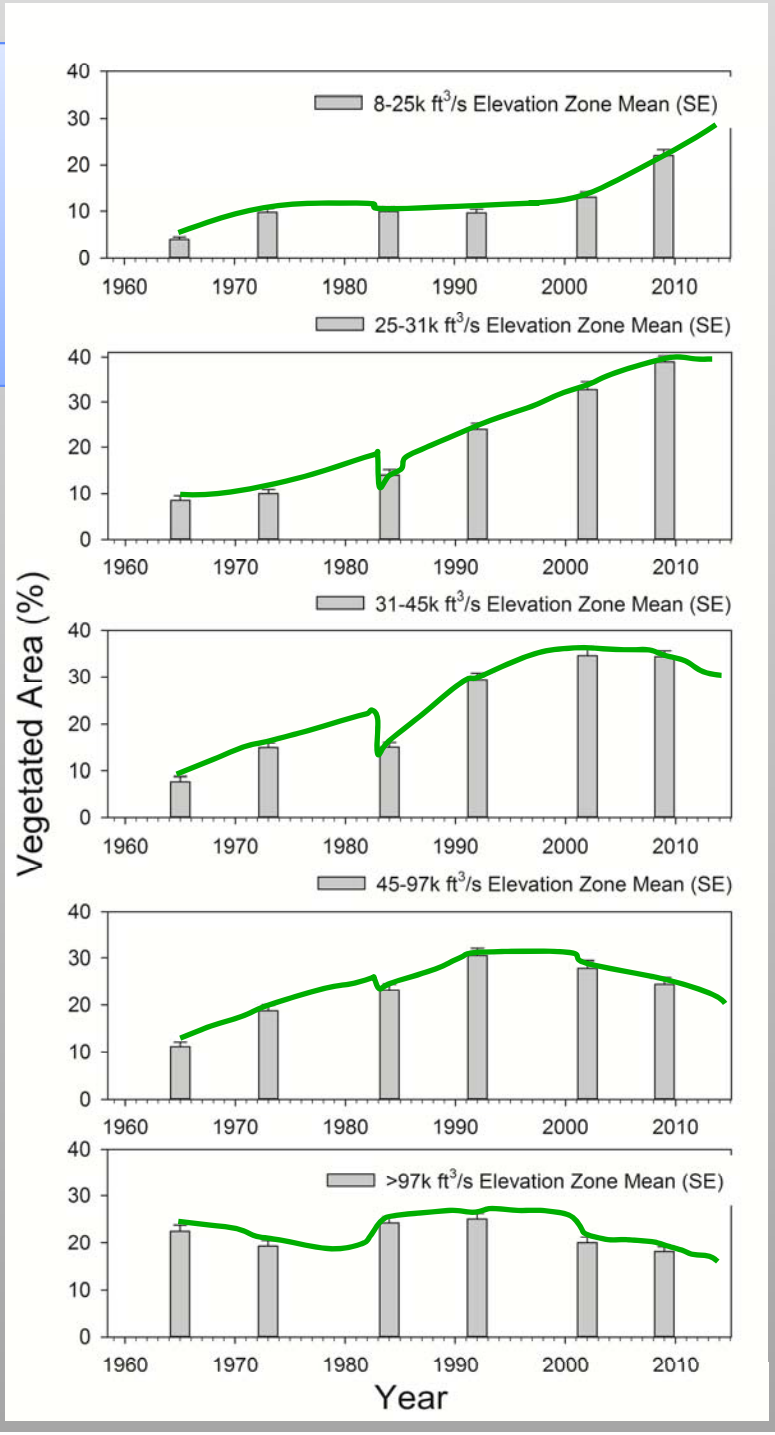
More variability likely exists than is captured at the temporal resolution of available data



Current Operations
(<25k ft³/s)

Powerplant Operations
(25k-31k ft³/s)

Recent HFE's
(31k-45k ft³/s)

Rare post-dam Floods
(45k-97k ft³/s)

Never inundated post-dam
(>97k ft³/s)

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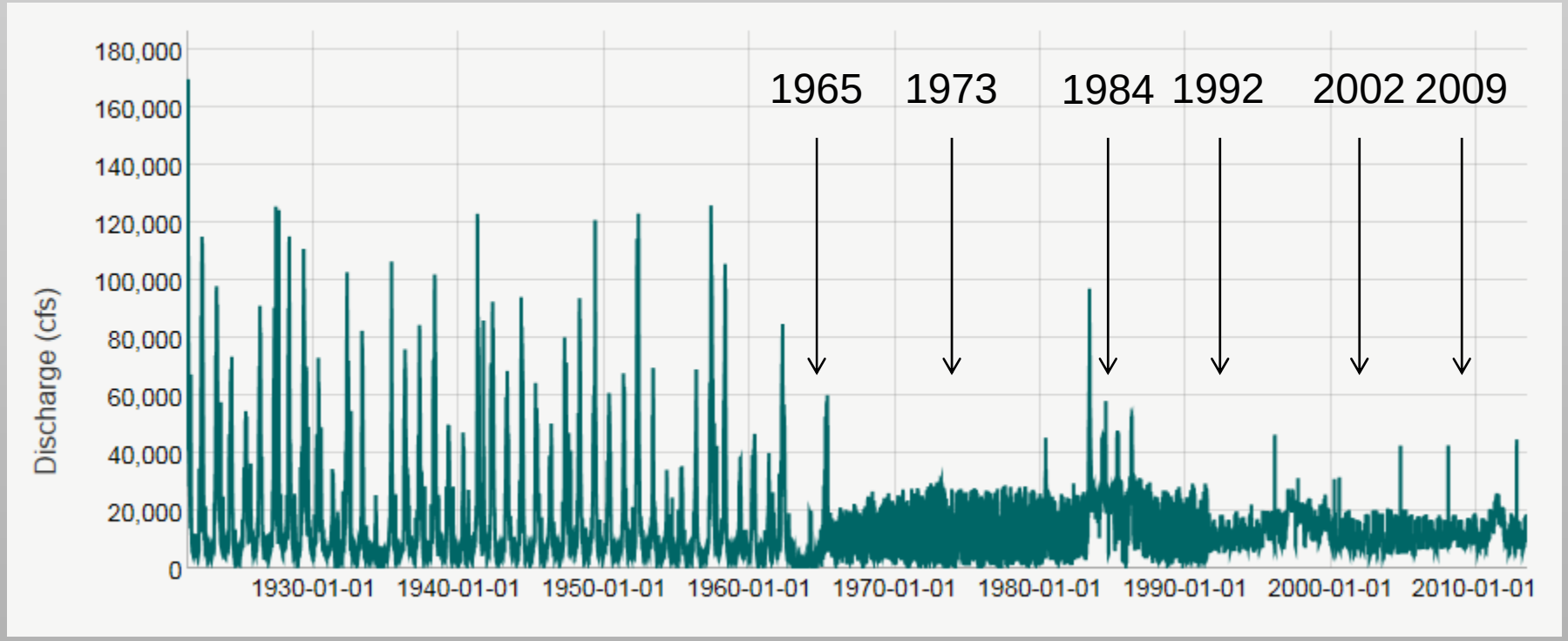
1965
1973
1984
1992
2002
2009
Discharge (cfs)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1930-01-01
1940-01-01
1950-01-01
1960-01-01
1970-01-01
1980-01-01
1990-01-01
2000-01-01
2010-01-01

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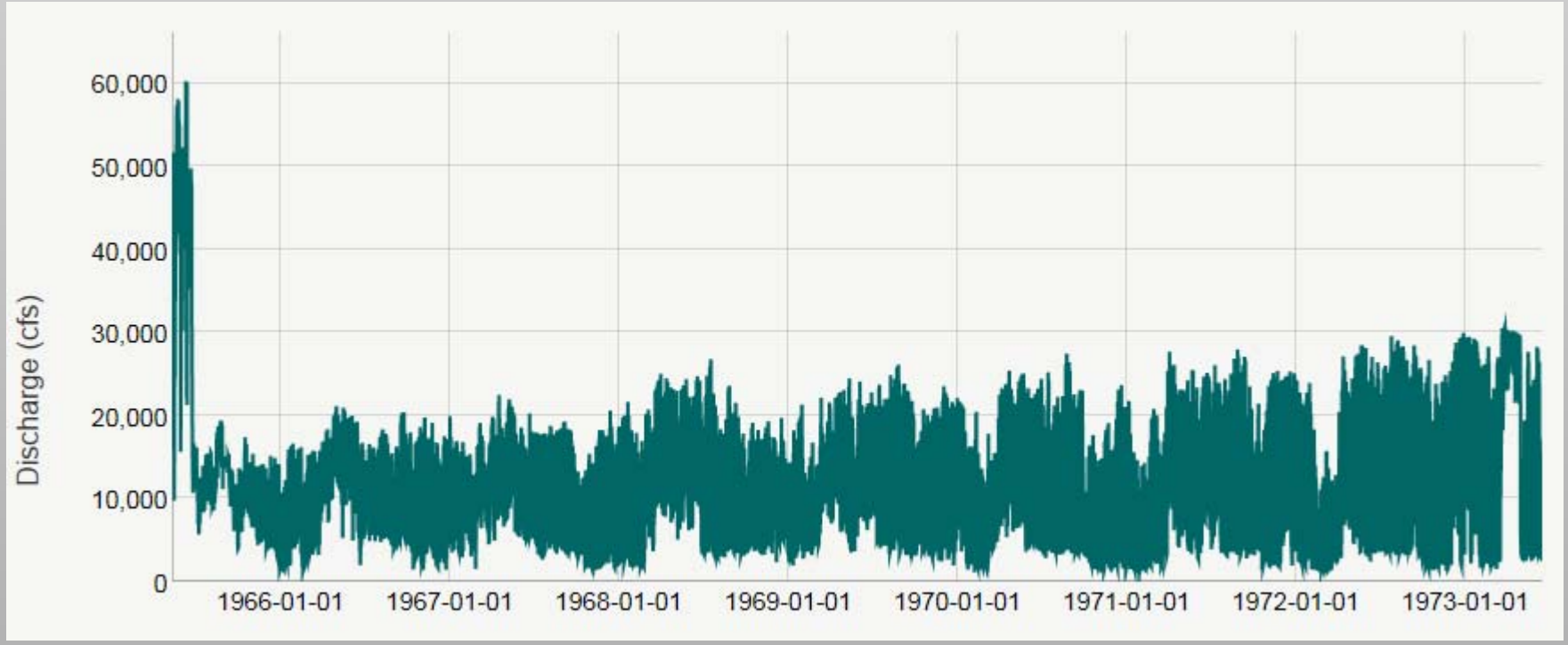
1965-1973

1.5 y recurrence ~ 26,600 ft^3/s



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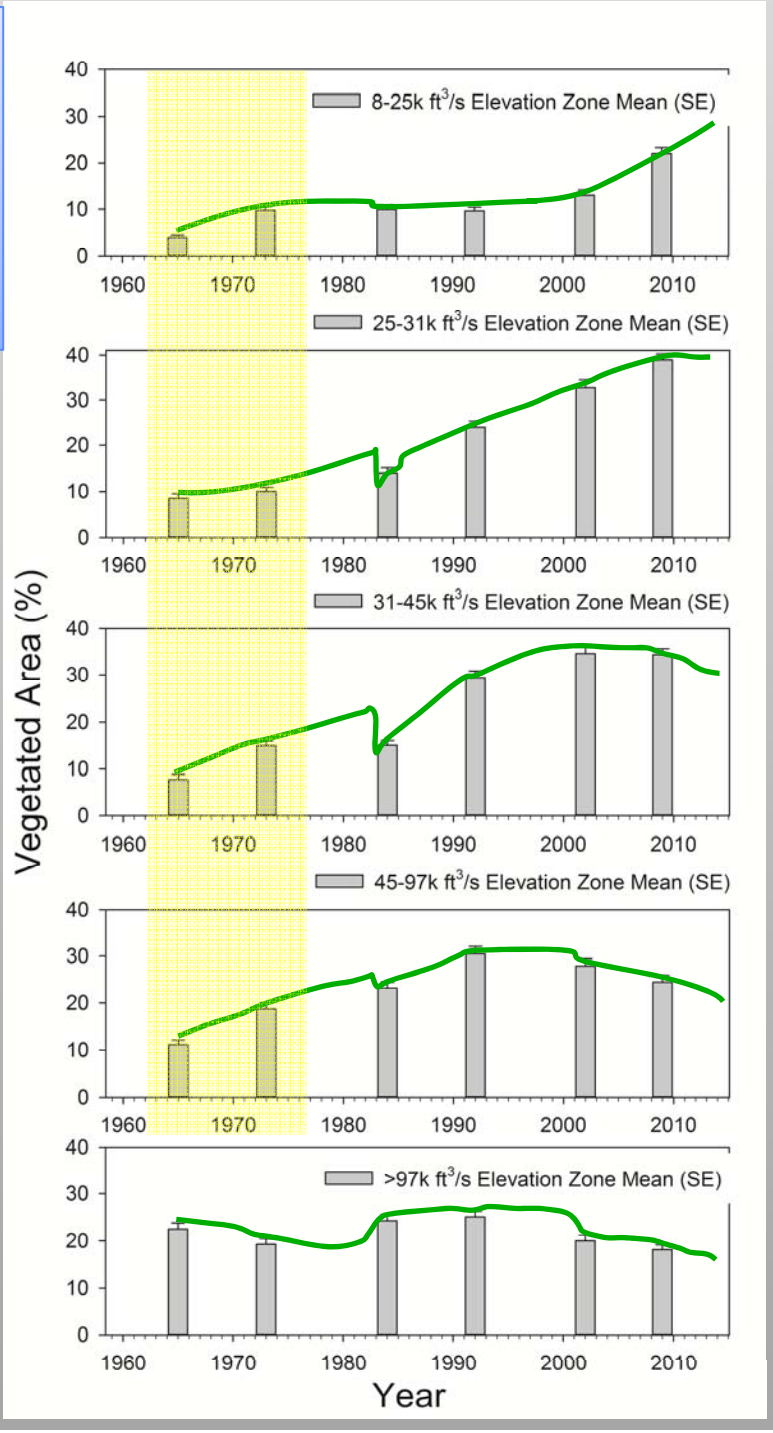
1965-1973:

- **Vegetation expansion below 97,000 ft³/s**



Current Operations
(<25k ft³/s)

Powerplant Operations
(25k-31k ft³/s)

Recent HFE's
(31k-45k ft³/s)

Rare post-dam Floods
(45k-97k ft³/s)

Never inundated post-dam
(>97k ft³/s)

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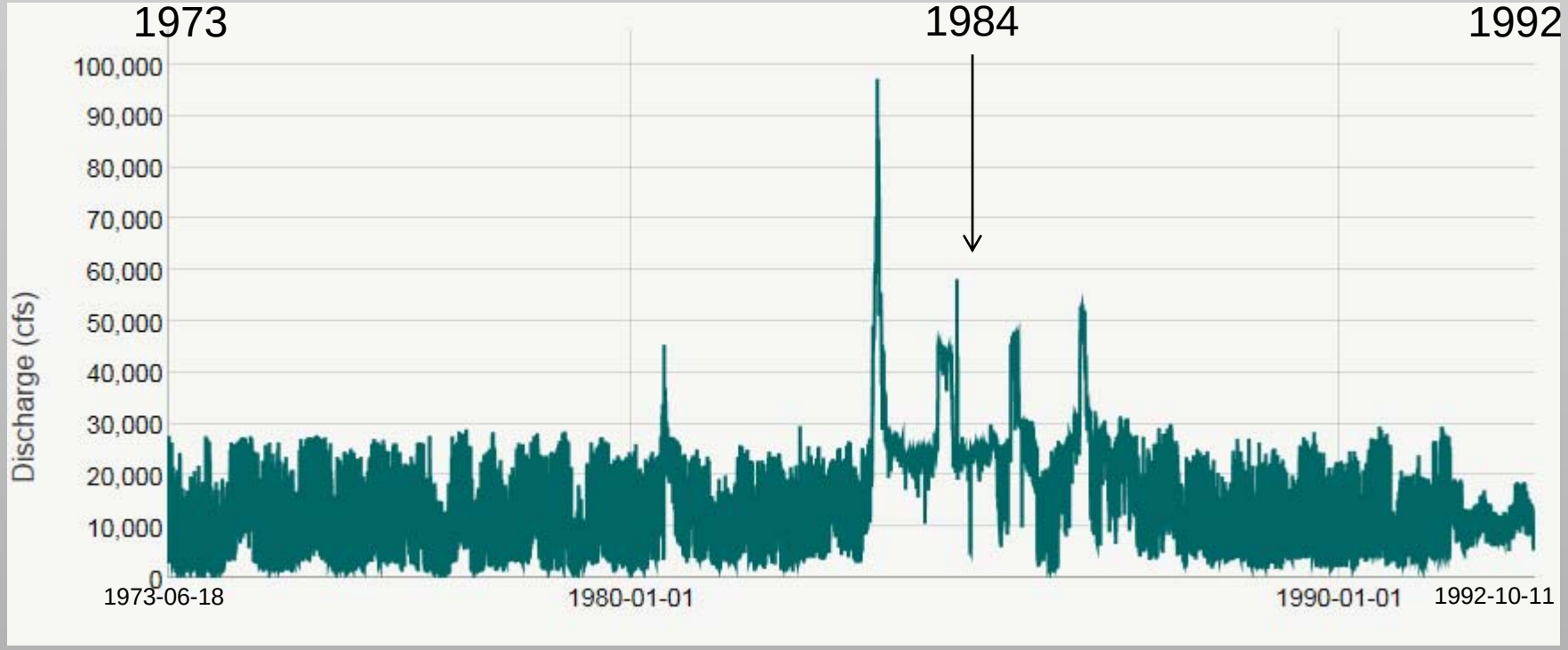
1973-1984-1992

1.5 y recurrence ~ 28,400 ft^3/s (‘73-’84)
1.5 y recurrence ~ 29,100 ft^3/s (‘84-’92)



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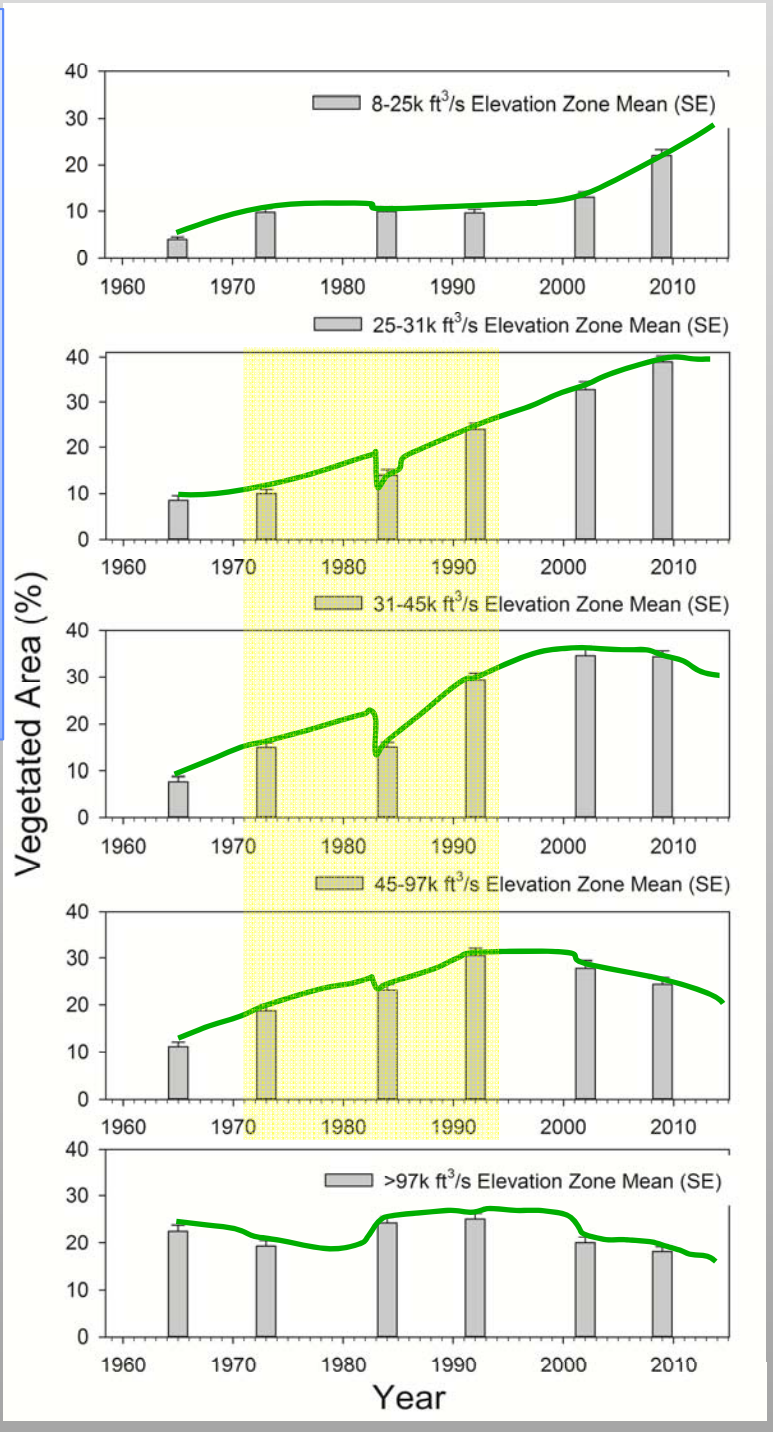
1973-1992:

- **Vegetation expansion 25-97 k ft³/s elevation zones**
- **Rapid decrease and then increase in riparian vegetation in response to large floods**



Current Operations
(<25k ft³/s)

Powerplant Operations
(25k-31k ft³/s)

Recent HFE's
(31k-45k ft³/s)

Rare post-dam Floods
(45k-97k ft³/s)

Never inundated post-dam
(>97k ft³/s)

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1992-2002

1.5 y recurrence ~ 21,600 ft^3/s

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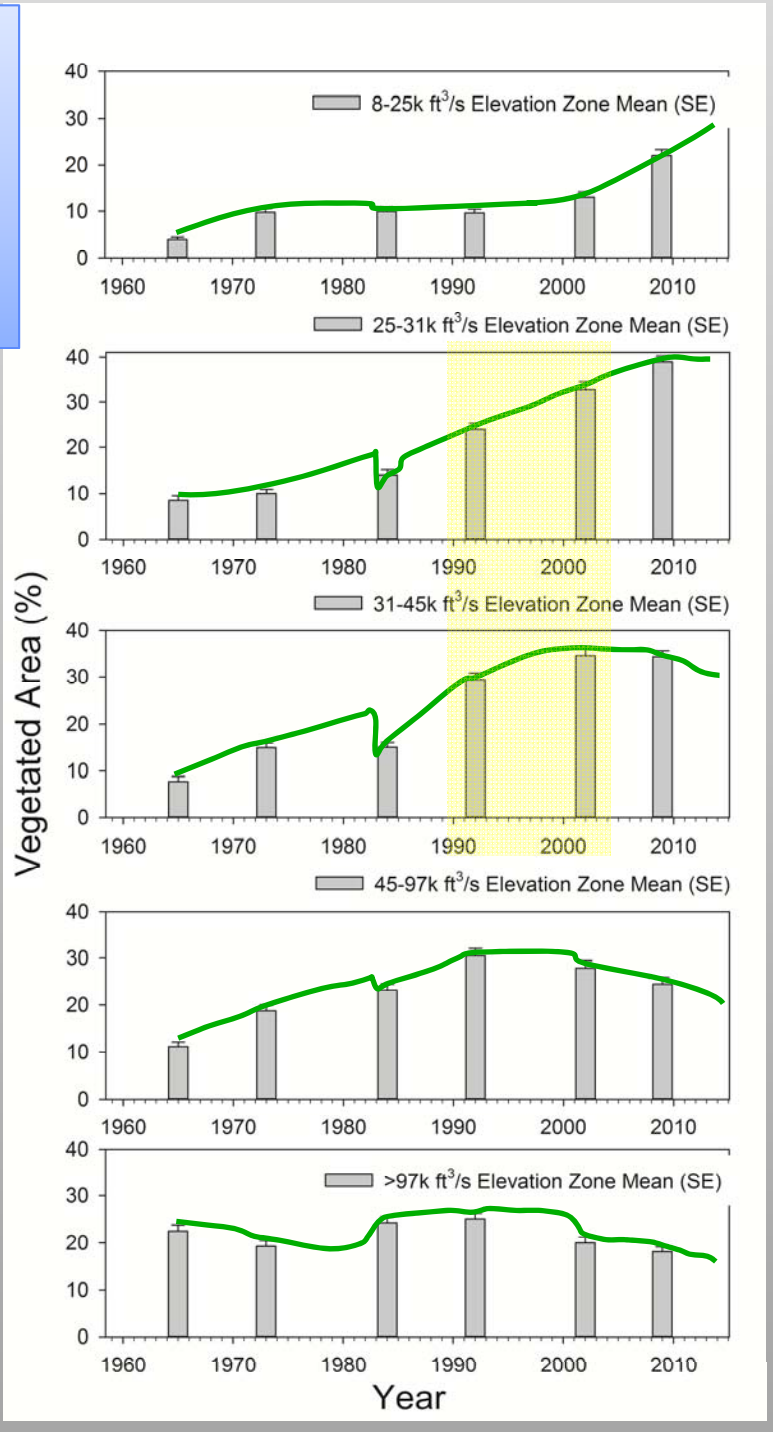
1992-2002:

- **Vegetation expansion 25-45 k ft³/s elevation zones**



Current Operations
(<25k ft³/s)

Powerplant Operations
(25k-31k ft³/s)

Recent HFE's
(31k-45k ft³/s)

Rare post-dam Floods
(45k-97k ft³/s)

Never inundated post-dam
(>97k ft³/s)

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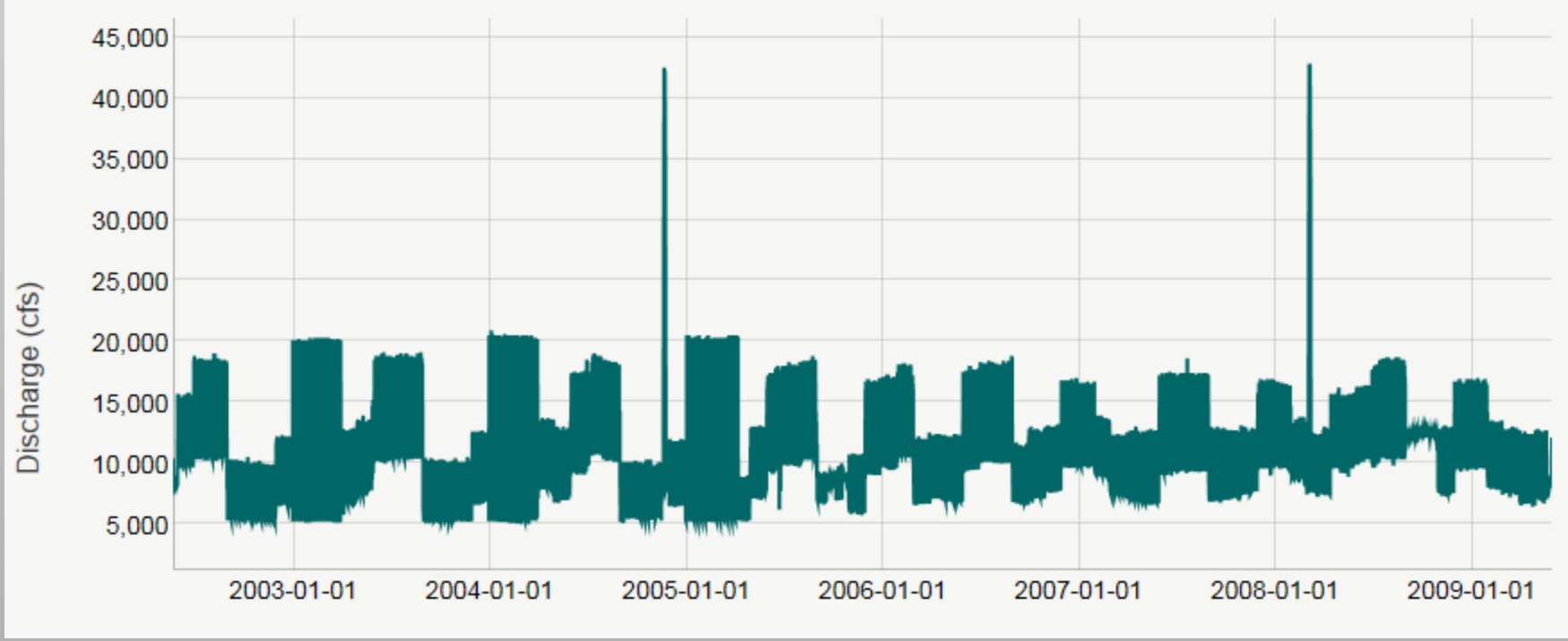
2002-2009

1.5 y recurrence ~19,000 ft^3/s



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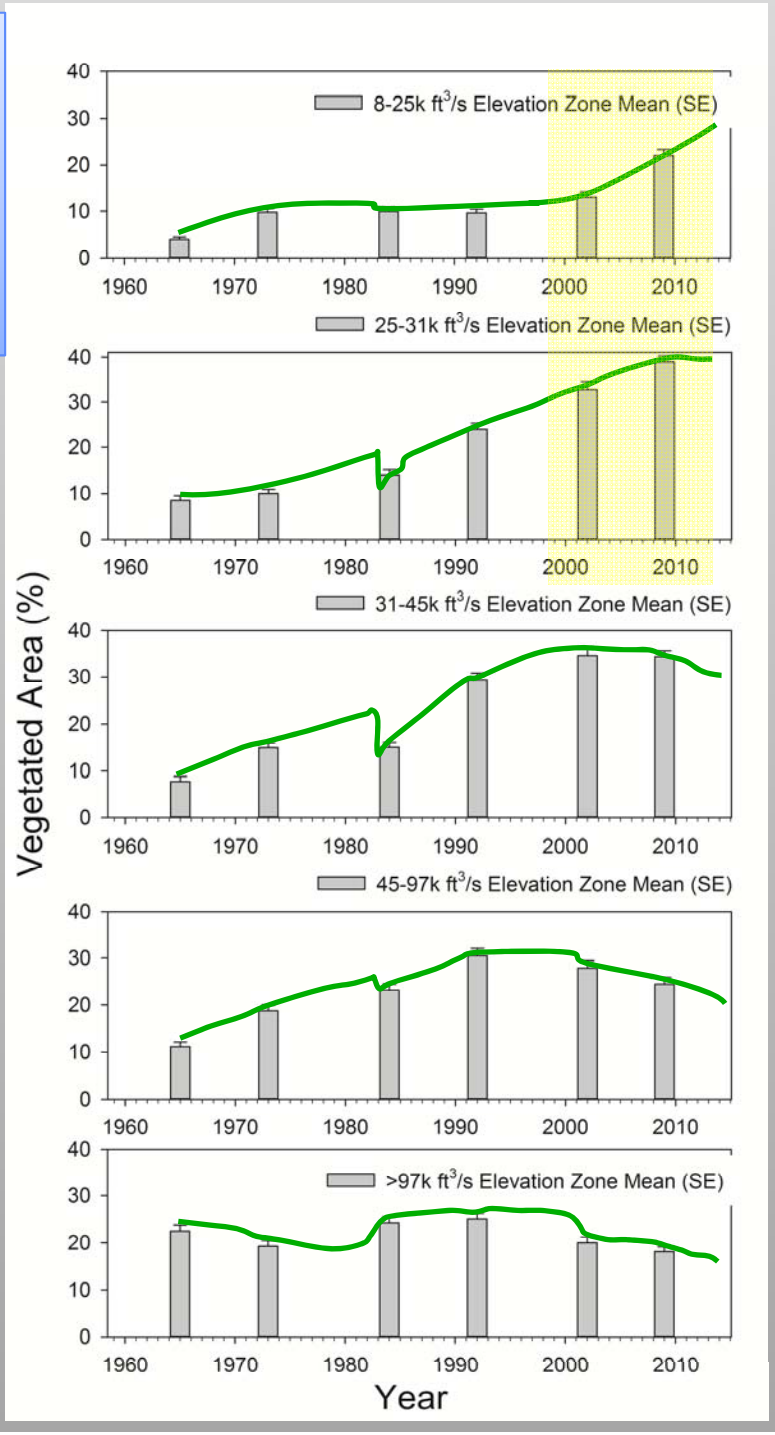
2002-2009:

- **Vegetation expansion below 31k ft³/s elevation zone**



Current Operations
(<25k ft³/s)

Powerplant Operations
(25k-31k ft³/s)

Recent HFE's
(31k-45k ft³/s)

Rare post-dam Floods
(45k-97k ft³/s)

Never inundated post-dam
(>97k ft³/s)

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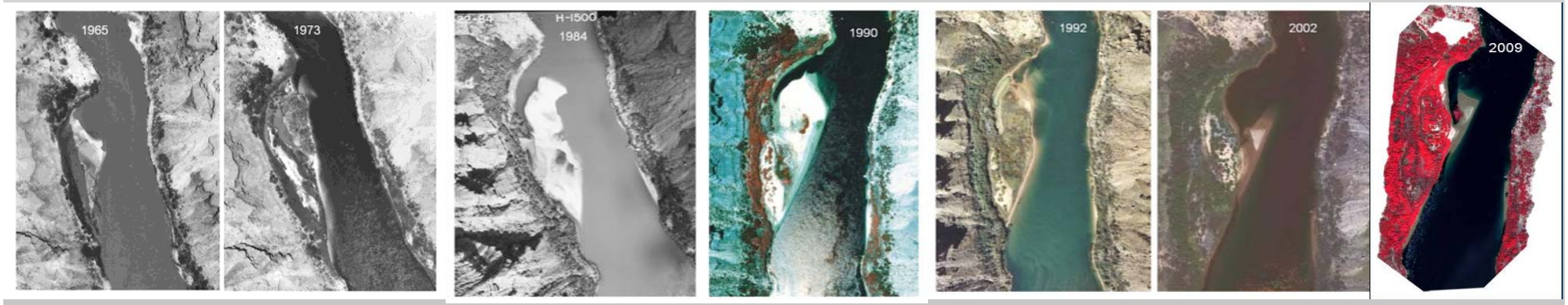
Summary



- More riparian vegetation exists than in previous 5 decades at the lowest elevation zones (<45k ft^3/s)
- Riparian woody vegetation expanded shoreward
- HFEs of present magnitude/duration do not appear to affect the longer term trend of expansion
- Vegetation change is significantly related to river hydrology at lower elevation zones (<45k ft^3/s) and regional climate at higher elevations (>97k ft^3/s)
- Remote sensing datasets allow both large-scale change detection and local-scale analysis to quantify plant response to changing dam operations.

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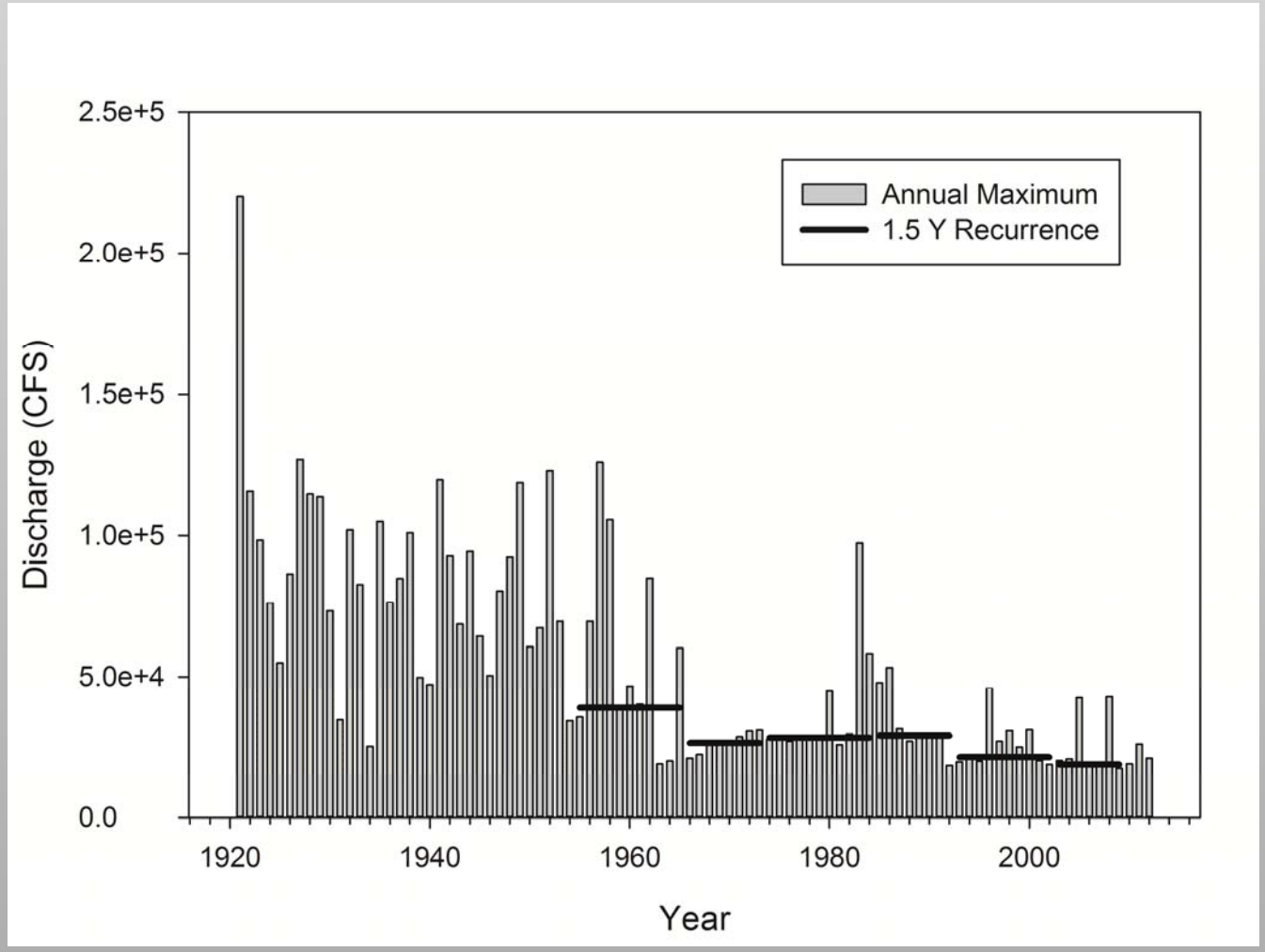
Changes in Riparian Vegetation in the Colorado River Corridor, 1965-present

Stanton Photo 1890, Cardenas Creek, Natl. Archives

Repeat photograph 2003, Cardenas Creek, USGS

Joel Sankey and Barbara Ralston, US Geological Survey, Grand Canyon Monitoring and Research Center

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


2.5e+5
2.0e+5
1.5e+5
1.0e+5
5.0e+4
0.0
Discharge (CFS)
1920
1940
1960
1980
2000
Year
Annual Maximum
1.5 Y Recurrence

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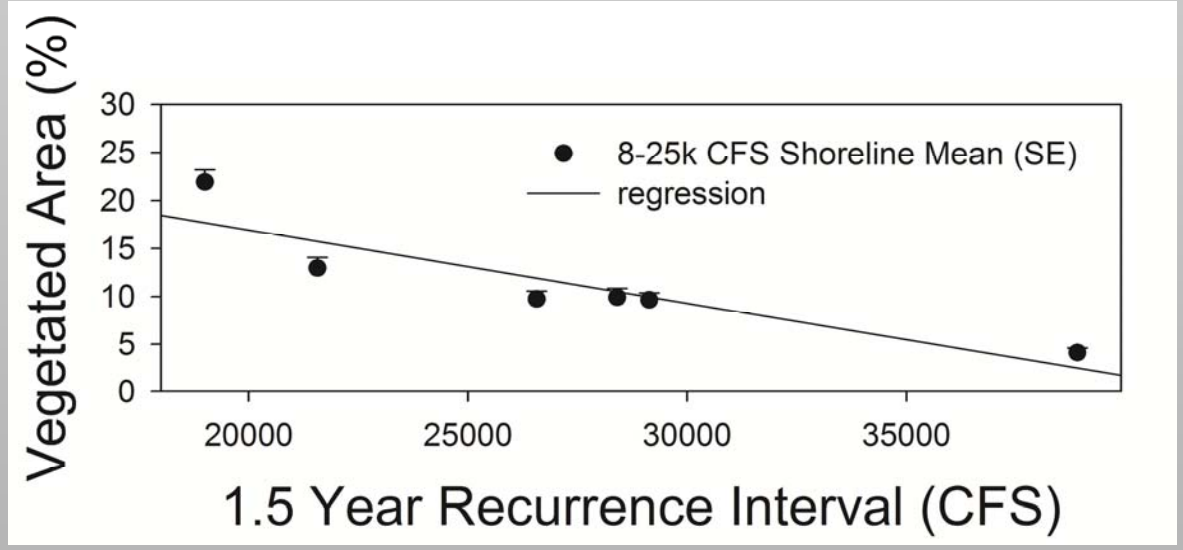
Vegetated Area (%)
30
25
20
15
10
5
0
8-25k CFS Shoreline Mean (SE)
regression
20000
25000
30000
35000
1.5 Year Recurrence Interval (CFS)

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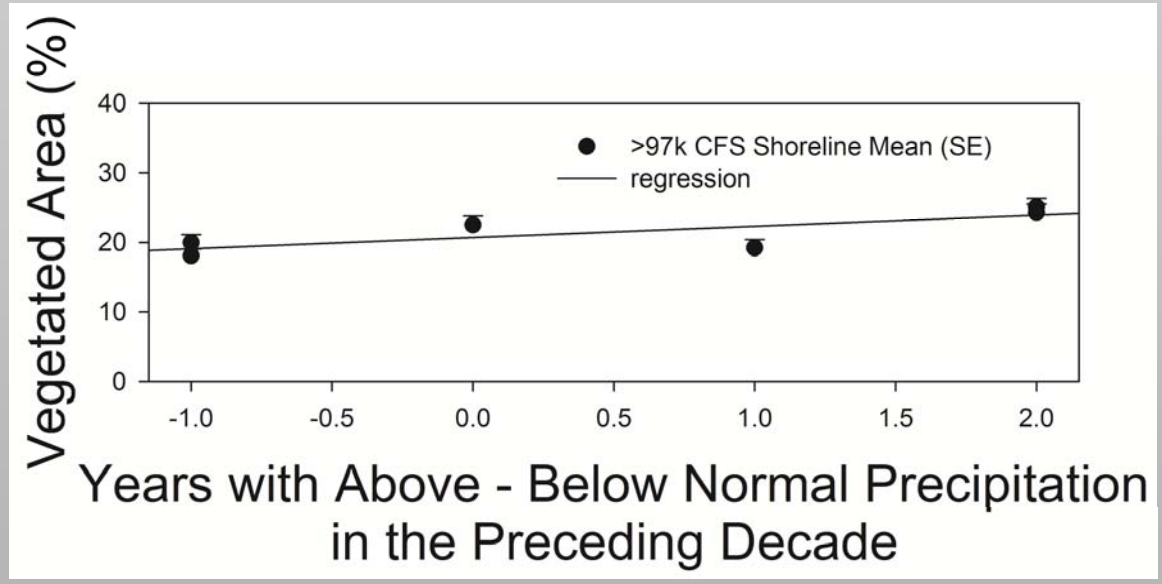
Vegetated Area (%)
40
30
20
10
0
>97k CFS Shoreline Mean (SE)
regression
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Years with Above - Below Normal Precipitation
in the Preceding Decade

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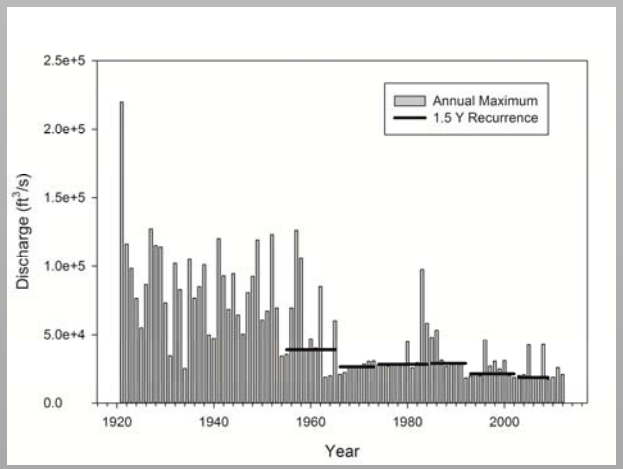
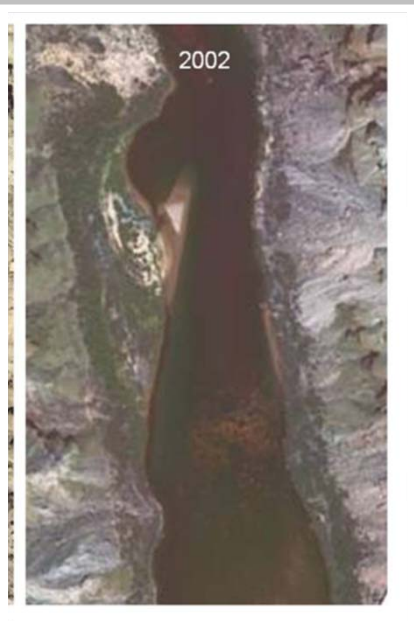
Overview

- Drivers of vegetation change
- Remotely-sensed data and questions
- Methodology
- Preliminary results





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