Colorado River plant communities in Glen, Marble, and Grand Canyons

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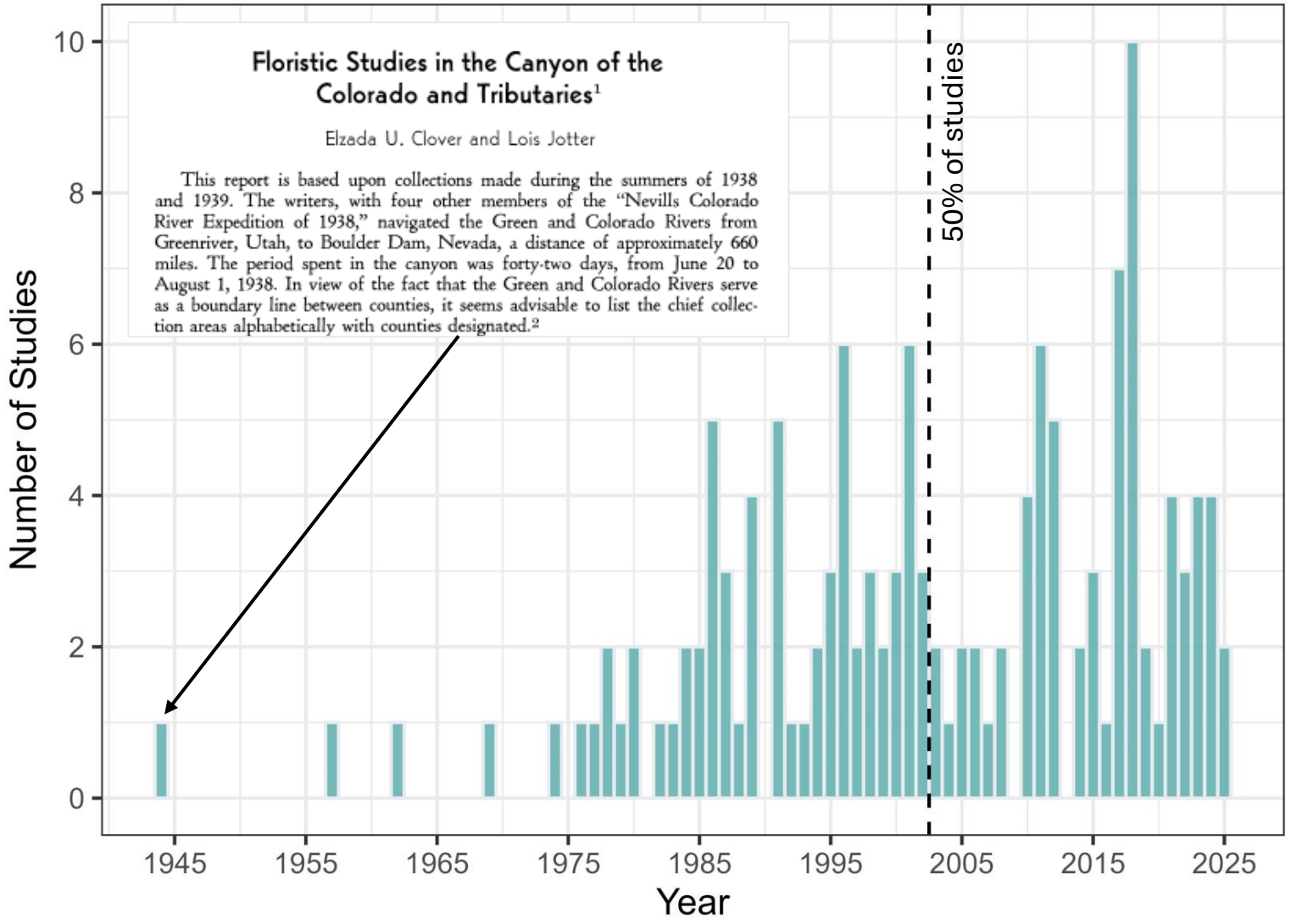
U.S. Department of the Interior
U.S. Geological Survey

Photo: E. Palmquist

We know quite a bit about riparian plant communities downstream of Glen Canyon Dam.

- ~80 years of accumulated knowledge
  - 50% published since 2002

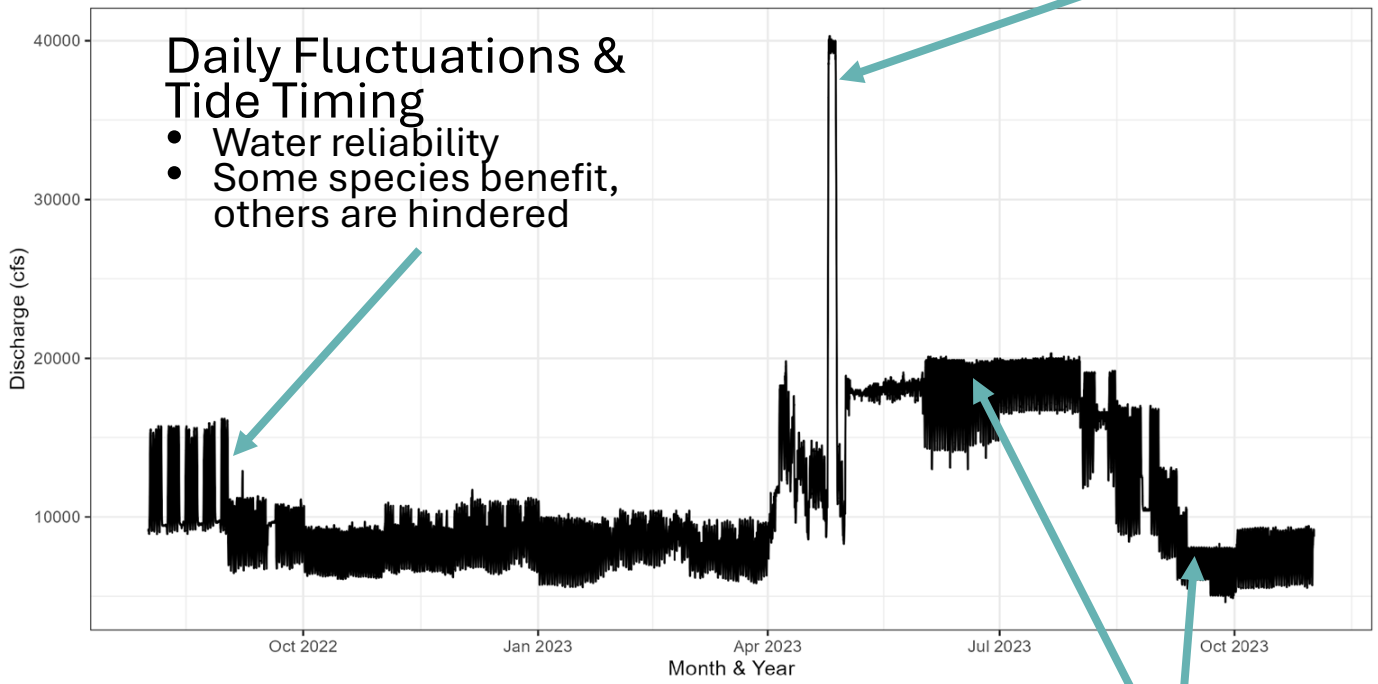


Plants are controlled by river flow

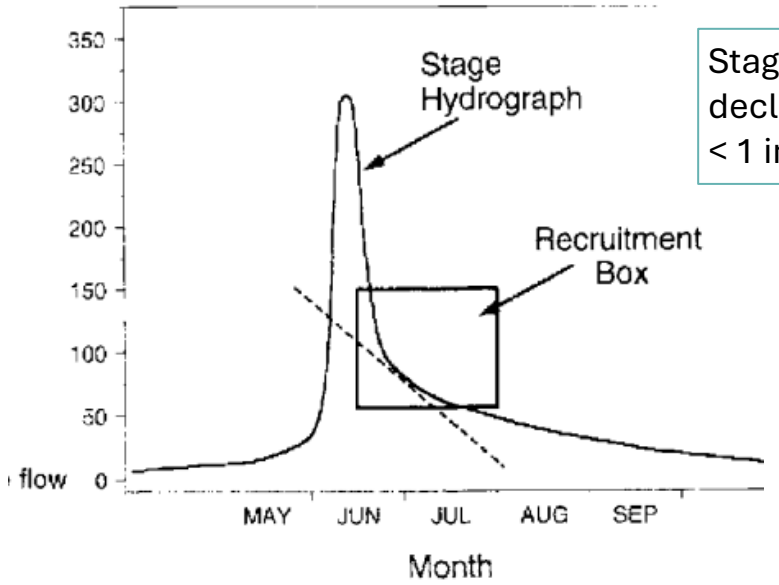
Butterfield and others, 2023;
Butterfield & Palmquist, 2025;
Mahoney and Rood, 1998;
Palmquist and others, 2025a;
Poff and others, 1997;
Discharge data from U.S. Geological Survey, 2026

Flood magnitude, timing, and drawdown

- Germination, establishment



Cottonwood recruitment hydrograph



Mahoney & Rood, 1998

High/low flow timing

- Water availability/stress during hot/cold periods

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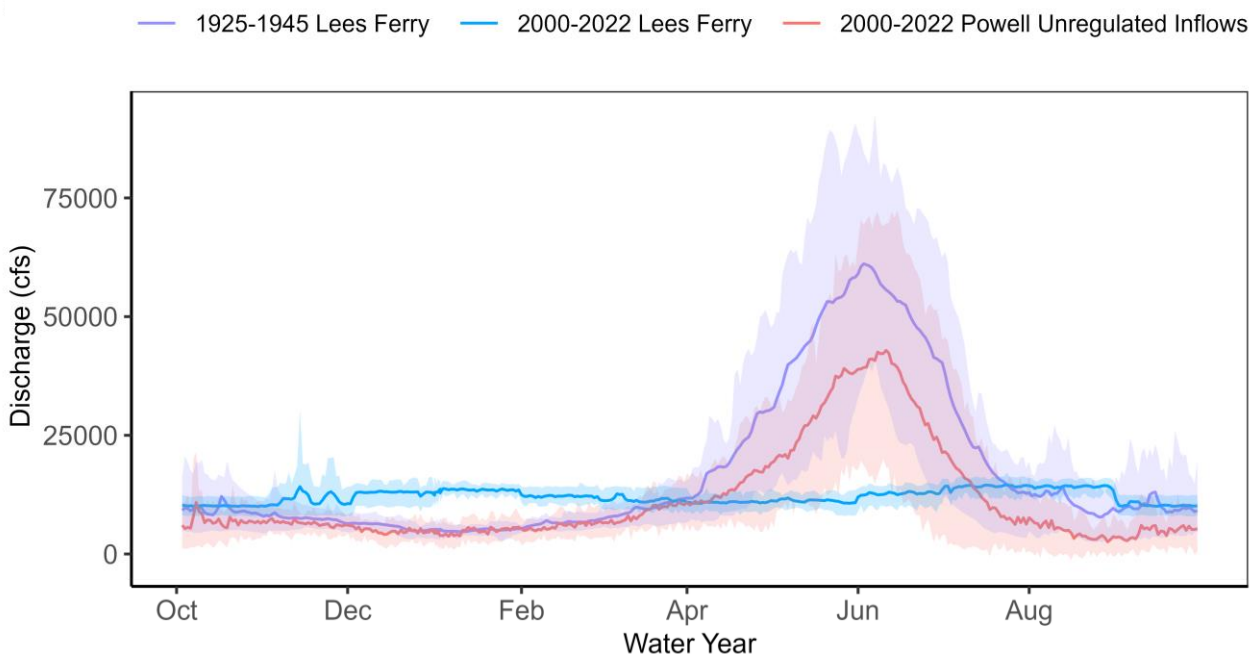
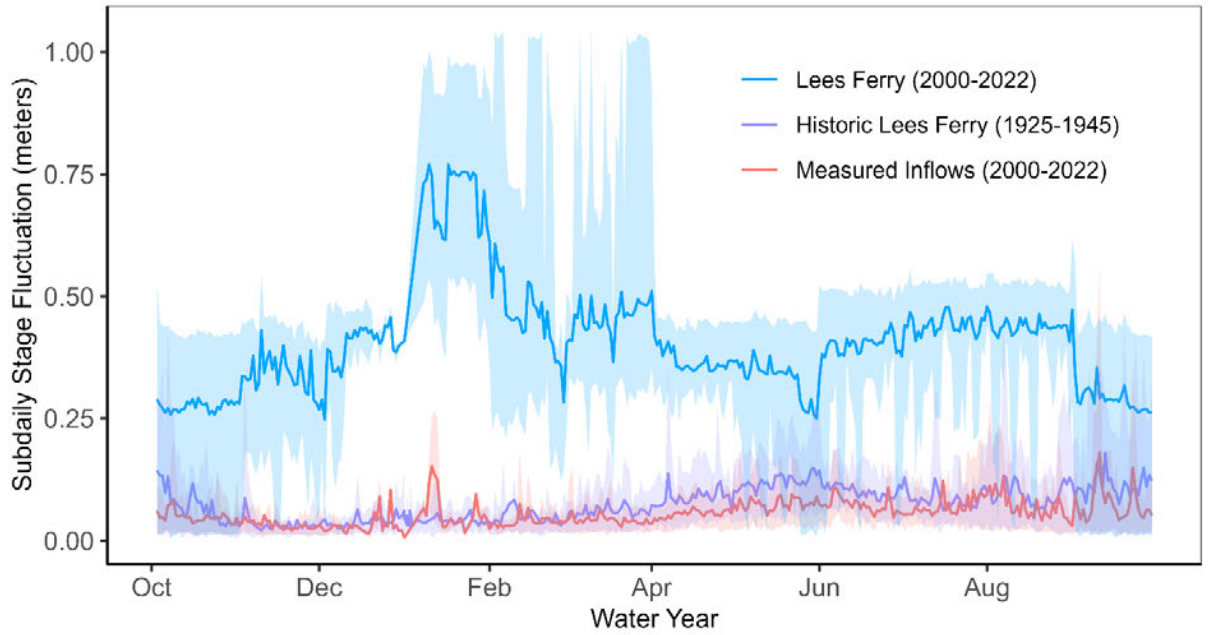
Key post-dam flow changes

- Decrease peak flows
- Increase base flows
- Less seasonal variation
- Increase daily fluctuations





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Palmquist and others, 2025b

Image credit: E. Palmquist & V. Leshyk

Riparian plants have complex feedback loops with sediment.

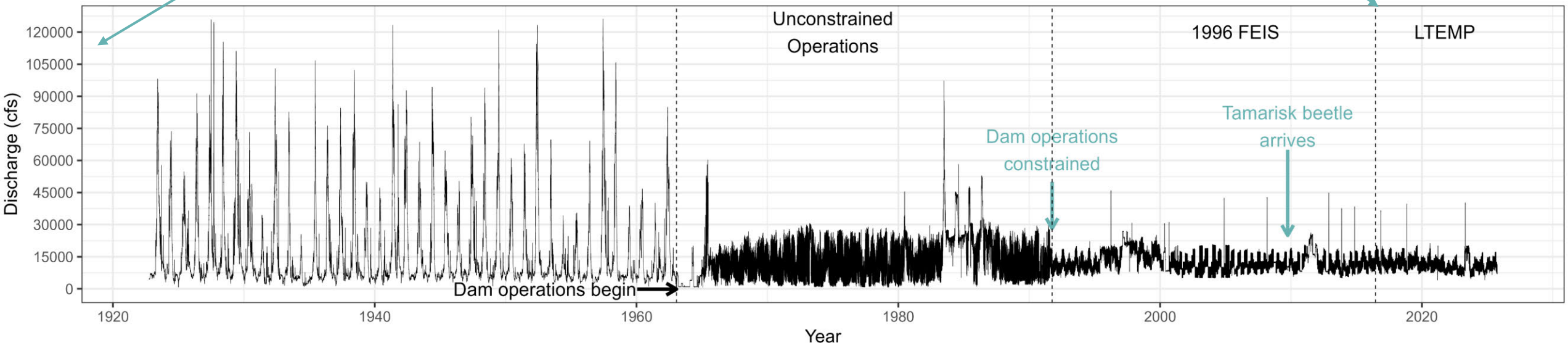
Photo: USGS GCMRC

- River-dependent species grow best in fine sediments (silts, clays, sands)
- Much lower fine sediment inputs
- River characterized by erosion

Butterfield and others, 2020;
Chapman and others, 2020;
Dean and Topping, 2019;
Hazel and others, 2022;
Manners and others, 2014;
Palmquist and others, 2025a;
Topping and others, 2000

Plant communities change when dam operations change.

Bedford and others, 2018;
Brian, 1982;
Carothers and others, 1976;
Durning and others, 2021;
Kearsley and Ayers, 1996;
Palmquist and others, 2023;
Ralston, 2011;
Sankey and others, 2015;
Stevens and Waring, 1986;
Stevens et al, 1995;
Turner & Karpiscak, 1980;
Discharge data from U.S. Geological Survey, 2026;
Photos from Repeat Photography Collection, H. Fairley.



Little cover of riparian plants

Increase in woody, herbaceous plants

Riverine marshes common

Tamarisk, coyote willow, arrowweed

Woody/herbs infill to daily flows

Decline in marshes

Tamarisk defoliation/death

Arrowweed, common reed, horsetail, Bermuda grass, seepwillows, mesquite

USGS

What styles of riparian vegetation do we have?

Only in restoration areas

mostly

some

Cottonwood/willow gallery forest

Photo: E. Palmquist

Mixed riparian shrubs/grasses

Photo: E. Palmquist

Mesquite/tamarisk forest

Photo: USGS GCMRC

Dead tamarisk with little regrowth

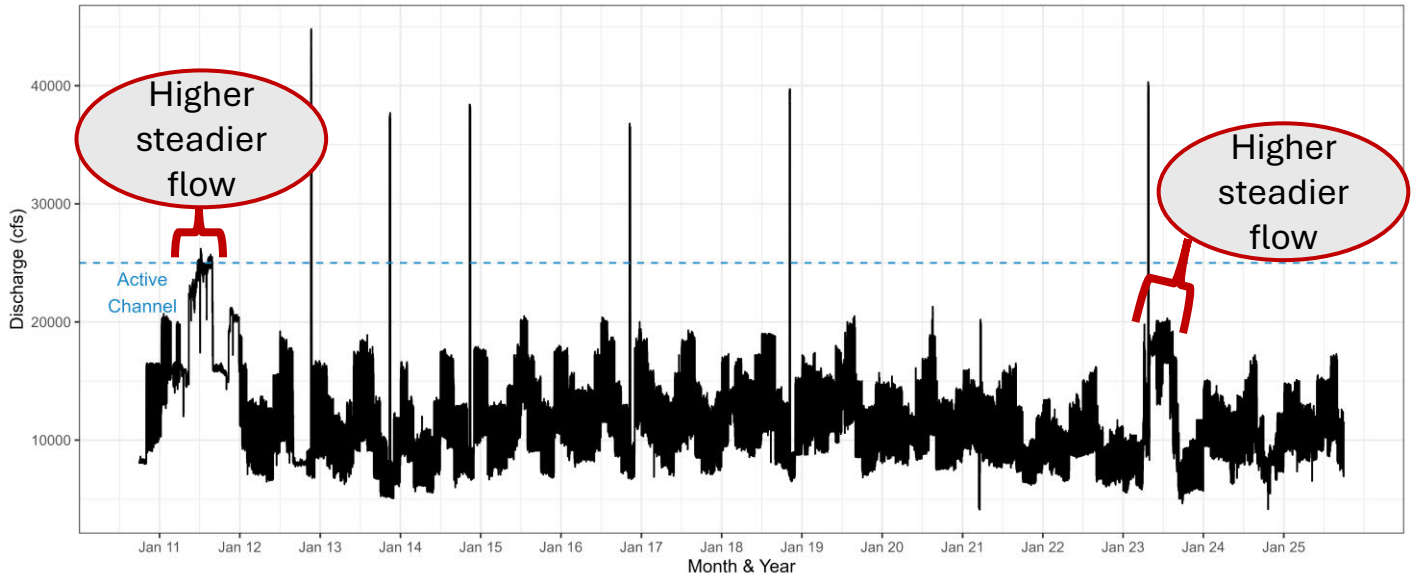
Photo: E. Palmquist

USGS

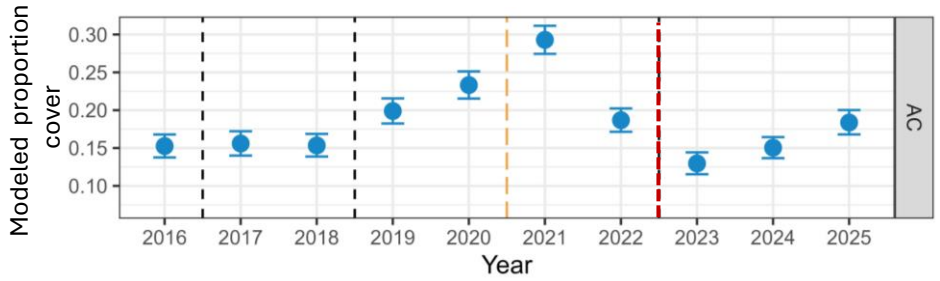
Palmquist and others, 2023

Recent patterns

- Vegetation increases during periods with average daily peak flows and without high flow experiments
- Declines with longer periods of higher, steadier flows



Living Plant Cover



See the Goal 11 metrics poster for more info.

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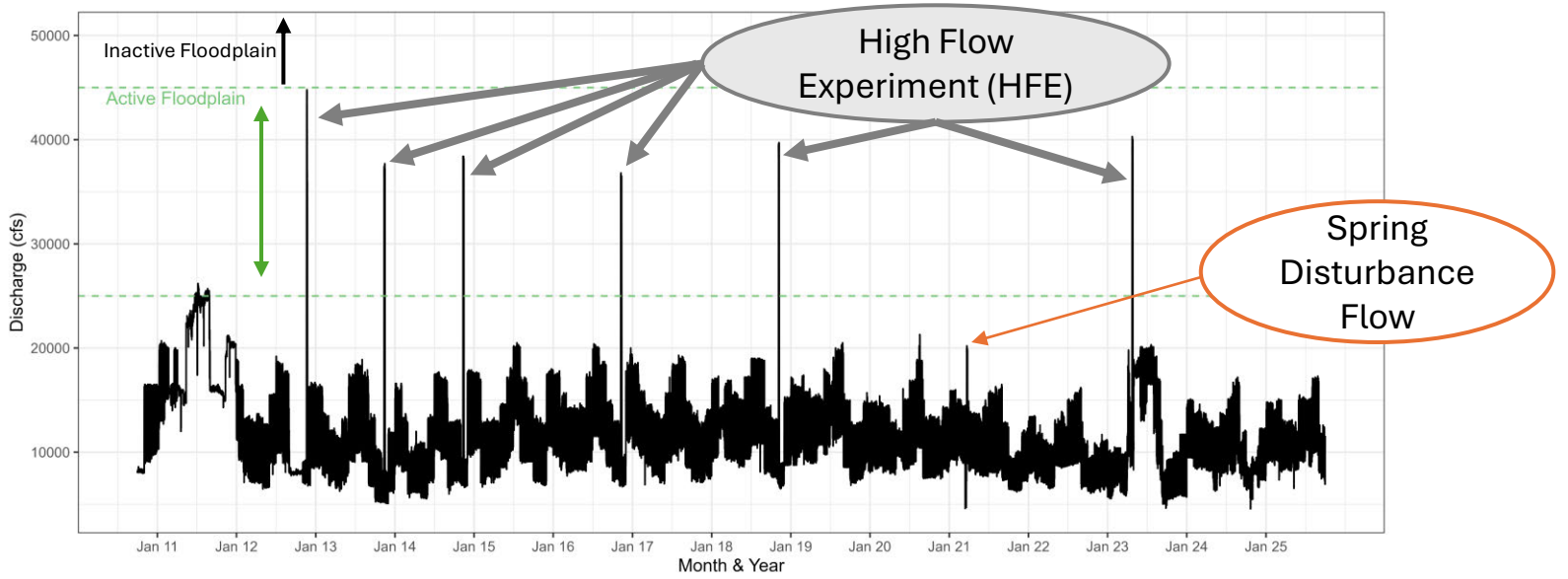
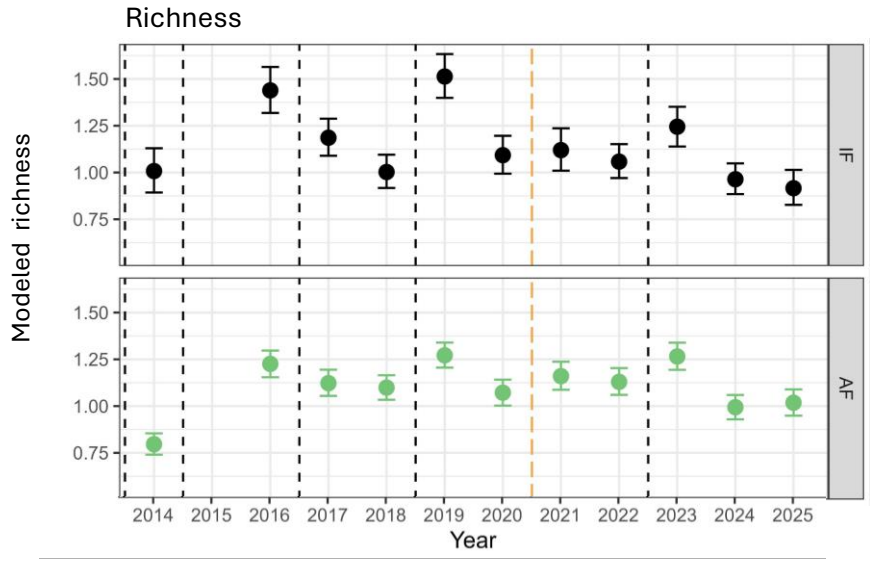
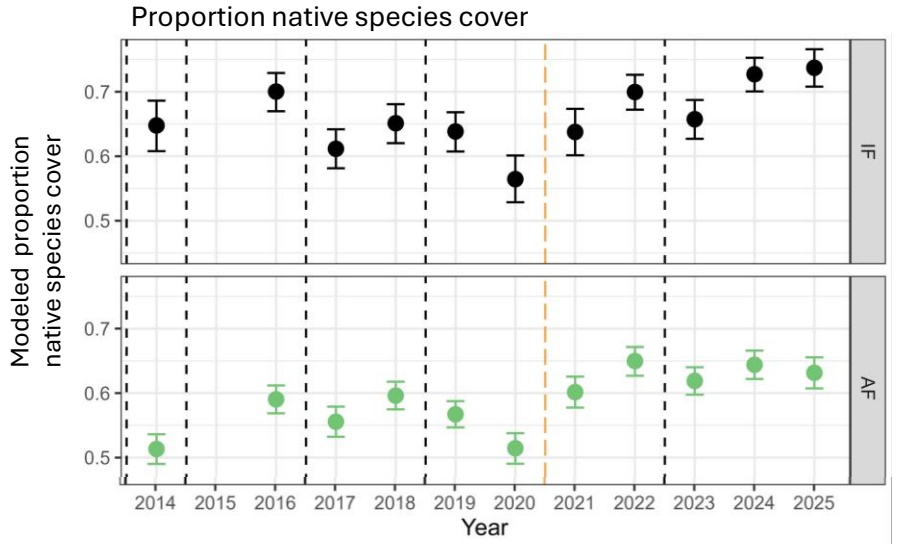
Recent Patterns

- Flood disturbance can increase richness
- Spring disturbance may increase proportion native species



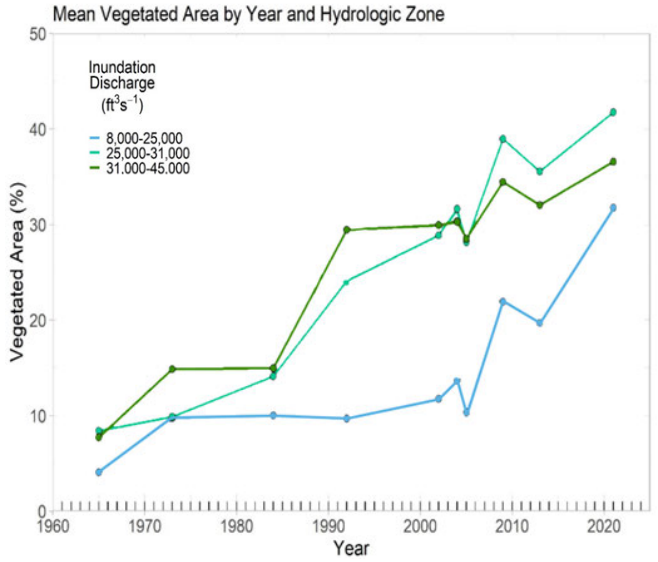




See the Goal 11 metrics poster for more info.

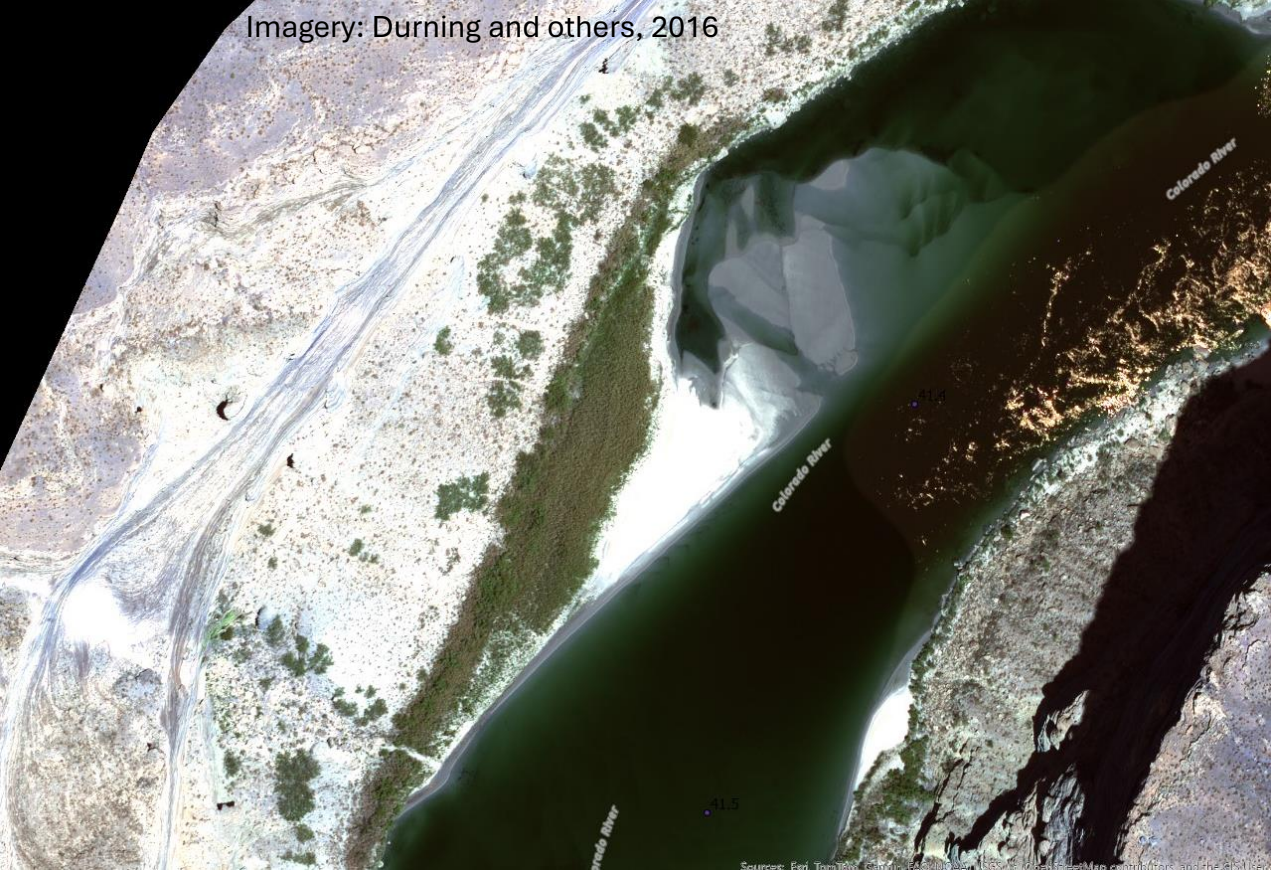
Plant change affects other resources

- Traps sand
- Decreases camping
- Creates bird/wildlife habitat
- Coarse estimate of plant water use 2021
  - 4,708 (3,629 – 6,048) acre ft yr^{-1}



Photos from Repeat Photography Collection, H. Fairley.
Photo Above: Weeden Campsite Inventory Survey
Photo Below: A.H. Fairley

Butterfield and others, 2020;
Dean and others, 2019;
Holmes and others, 2005;
Manners and others, 2014;
Palmquist and others, in press;
Sankey and others, 2023;
Spence, 2006



Future Possibilities – Lower annual releases

Lower, predictable max flows	Erratic, periodic low flows
Further expansion lower on the shoreline	Potential loss of drought-intolerant species
Plant death higher on shoreline	Potential declines in vegetation in general

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Durning and others, 2021;
Palmquist and others, 2023;
Palmquist and others, 2025a

Photos: E. Palmquist

Future Possibilities – loss of high flow experiments

Lose sandy habitats
Lose species unique to rivers
Riparian plants will continue to colonize fresh sand habitat
Existing sand stabilized, covered by plants, unless outside forces*

*camping, removal, decreased water availability

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Hazel and others, 2022; Palmquist and others, 2025a

Photo: E. Palmquist

Photo: USGS GCMRC

Future Possibilities – loss of flood pulses

Predictable maximum flows
Decline in species richness
More plant colonization close to the river
May disadvantage native species

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GCDAMP, 2025;
Butterfield & Palmquist, 2026;
Garssen and others, 2015;
Greet and others, 2015

Photos: E. Palmquist

Future Possibilities – changes to daily fluctuations

Smaller fluctuations	Shifts in tide timing (duck curve)
Increases in nonnative grasses	Possible drying during hot periods
Increases in species disadvantaged by daily fluctuations	Shifts in species distributions

USGS

Butterfield & Palmquist, 2024;
Butterfield & Palmquist, 2025;
Palmquist and others, 2025a

There’s a lot to know about riparian plants

- Knowledge gaps we’re working on:
  - Monitoring how compressed daily fluctuations, overall lower flow volumes, and infrequent HFEs change plant communities (C.1.1)
  - How river flows are interacting with tamarisk decline to reshape plant communities (C.3.1)
  - Changes to the shape of the riparian corridor (C.4.1)
  - Effectiveness of individual plant species at altering hydraulics and sediment transport (C.4.2)
  - Managing interactions between plants and wind-blown transport of river sand (D.3)

Photo: E. Palmquist

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Many colleagues, collaborators, boat operators, students, and volunteers assisted with these projects -

Thank you!

Photo: E. Palmquist

Further questions?

Contact us:

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or Search “Emily Palmquist USGS”

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Interested in our program?

Check out our websites:

https://www.usgs.gov/centers/southwest-biological-science-center/science/overview-riparian-vegetation-grand-canyon

https://www.usgs.gov/centers/southwest-biological-science-center/science/terrestrial-riparian-vegetation-monitoring-how

or Search “GCMRC riparian vegetation”

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