Photo: E. Palmquist

Getting to know Colorado River riparian plant communities

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Why are riparian plant communities important?

- Alter river shape and sediment dynamics
- Supports migratory and resident animals
- Traditional plant resources
- Recreational impacts – positive and negative
- Increase regional biodiversity
- Mediate resources between rivers and uplands
- Improve water quality

Photo: E. Palmquist

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Photos: E.Palmquist

Species and characteristics determine function

- Species have different roles in the environment
- Roots, leaves, architecture, plant health form the basis for ecosystem function
- 'Riparian vegetation' differs greatly depending on the species

Importance of Cover vs. Composition

Goal 11. Riparian Vegetation. Maintain native vegetation and wildlife habitat, in various stages of maturity, such that they are diverse, healthy, productive, self-sustaining, and ecologically appropriate.

- Cover
  - How much space plants take up
  - Productivity, abundance
- Composition
  - Characteristics (e.g. trees, grasses, root depth, clonality, etc)
  - Diversity
  - Who's present, who's missing?

Photo: USGS GCMRC

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Photo: R.B. Stanton 1890

2016 Photo: Alan H. Fairley & Helen Fairley

Plant communities are capable of large changes when dam operations change.

- Little cover of riparian plants in predam era
- Increase in cover of woody and herbaceous plants
  - But species differ over time
- Period of riverine marshes associated with high fluctuating flows
- Tamarisk beetle leading to tamarisk death
- Losing Goodding’s willows

Bedford and others, 2018;
Brian, 1982;
Carothers and others, 1976;
Durning and others, 2021;
Kearsley and Ayers, 1996;
Palmquist and others, 2023;
Ralston, 2010;
Sankey and others, 2015;
Stevens and Waring, 1986;
Turner & Karpiscak, 1980

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Drivers of riparian plant communities

Climate: Temperature, precipitation, humidity

River Hydrology: HFEs, daily fluctuations, seasonality

Geomorphology: Channel shape, landforms

Biotic Interactions: Competition, herbivory

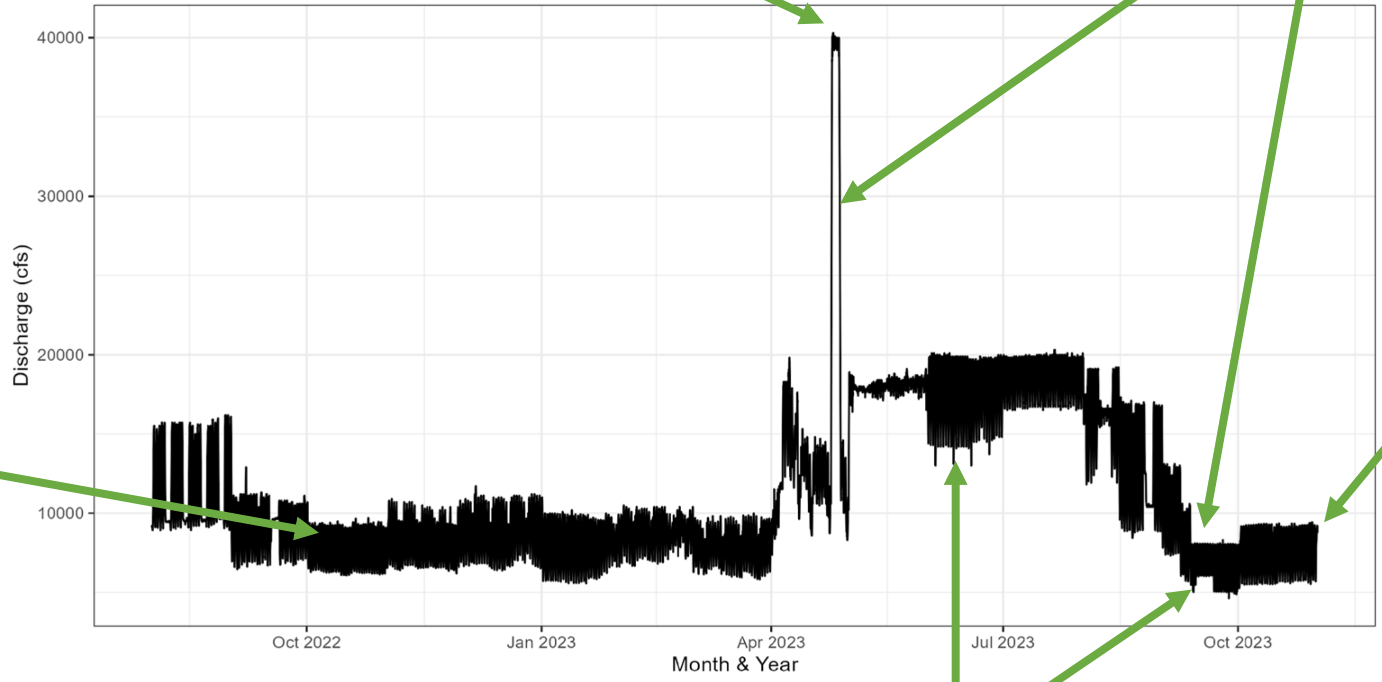
Riparian Plant Community: Cover, composition, diversity

River Flows

Mahoney and Rood, 1998;
Poff and others, 1997;
Butterfield and others, 2023;
Bejarano and others, 2018;

Flood timing, duration, frequency, magnitude
- Regeneration
- Disturbance

Drawdown/Rising rates and timing
- Flood attenuation
- Erosion



Variability
- Water reliability
- Predictability

Volume
- Riparian extent
- Species

- **High/low flow timing**
  - Water availability/stress during hot/cold periods

Plant – Sediment interactions

Butterfield and others, 2020;
Dean and others, 2019;
Dean and Topping, 2024 ;
Manners and others, 2014;
Palmquist and others, 2023;
Palmquist and others, in review;
Sankey and others, 2023

- The amount of sand vs. rock along river shorelines influences which plants grow where
- The kind and density of plants influences sediment deposition
- Tall, thick plant communities can reduce windblown sand
- Relationships between sand and plants can drive river ecosystem change

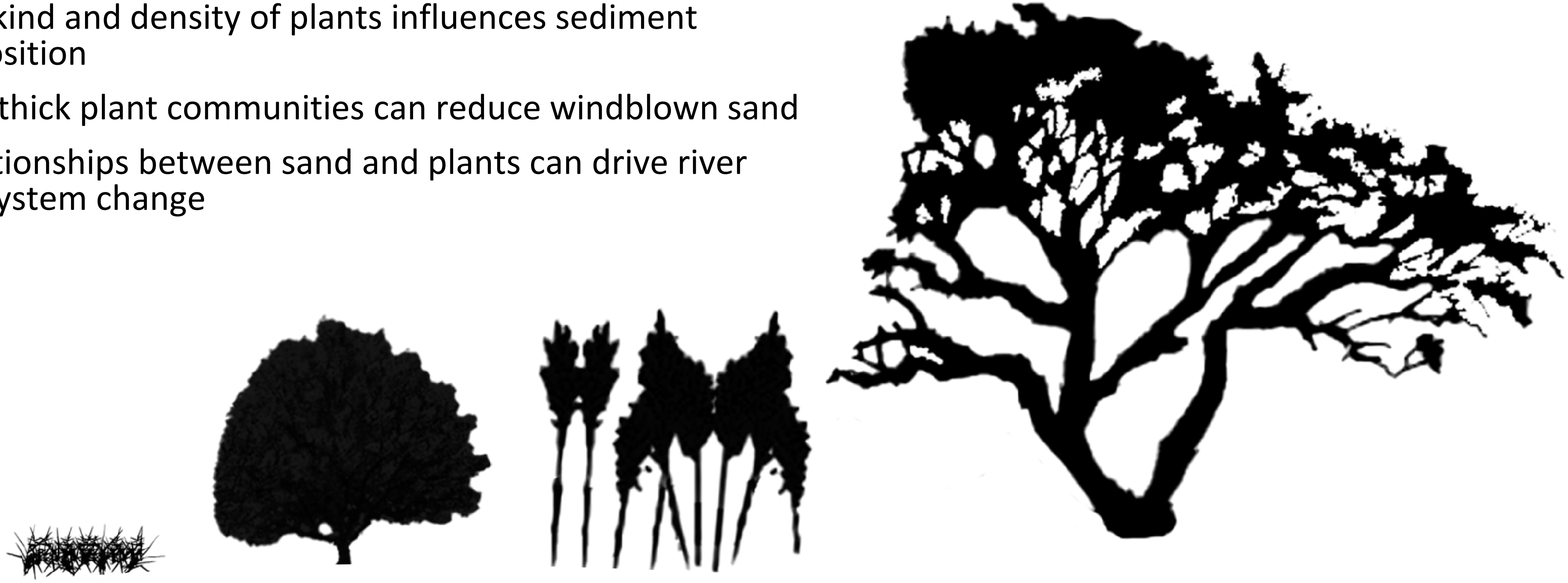


Image credit: E. Palmquist & V. Leshyk


Photo: USGS GCMRC

What do we want this community to look like?

- Plants are here to stay
- The water is there, and plants are already using it
- Already protected (proposed wilderness)
- Already being used by resident and migratory wildlife

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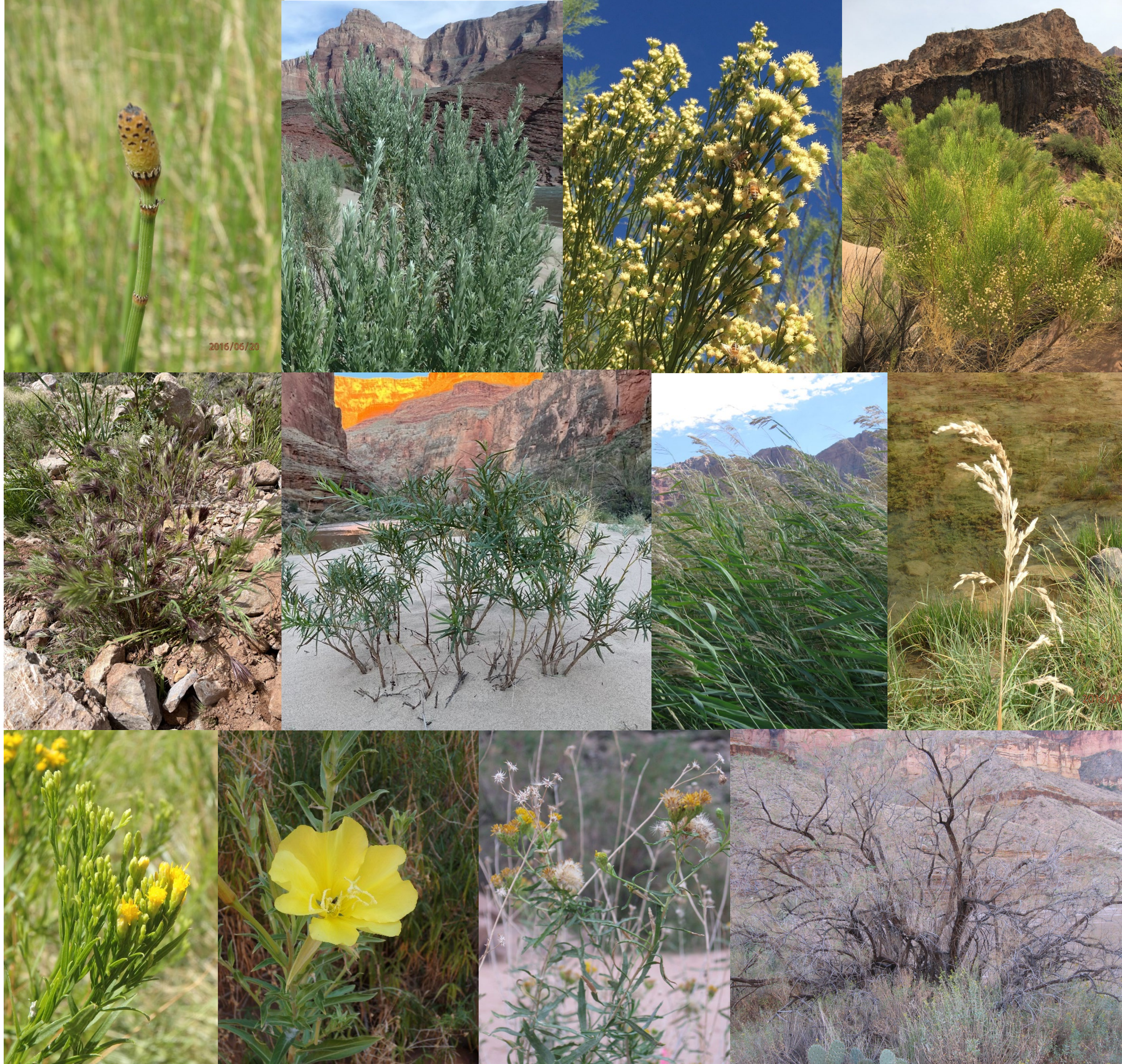
Photo: USGS GCMRC

What we have now

- Recorded over 300 species
- Tiny annual forbs to tall trees
- Native & nonnative species
- Lots of species in sunflower family (Asteraceae)
- Bloom in different seasons (spring, summer, fall)
- Annual, perennial, biennial
- Clonal or not

Photos: E. Palmquist



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Palmquist and others, 2018;
Palmquist and others, 2023

What we have now – grasses/forbs

Photo: E. Palmquist

Bromus rubens

red brome

Photo: E. Palmquist

Equisetum x *ferrissii*

horsetail

Photo: E. Palmquist

Sporobolus flexuosus

Mesa dropseed

Photo : E. Palmquist

Cynodon dactylon

Bermuda grass

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Palmquist and others, 2023

What we have now – trees/shrubs

Photos: E. Palmquist

Baccharis emoryi

Emory's baccharis

Photos: E. Palmquist

Baccharis sarothroides

desertbroom

Photos: E. Palmquist

Brickellia longifolia

Long-leaf brickellbush

Photos: E. Palmquist

Tamarix ramosissima x *chinensis*

saltcedar

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What we have now – hydrological zones

Butterfield and others, 2023;
Palmquist and others, 2023,
Butterfield and others, 2024,
Palmquist and others, in review

- Daily fluctuating flows, seasonal high and low flows, and HFEs form longitudinal strips of plant communities

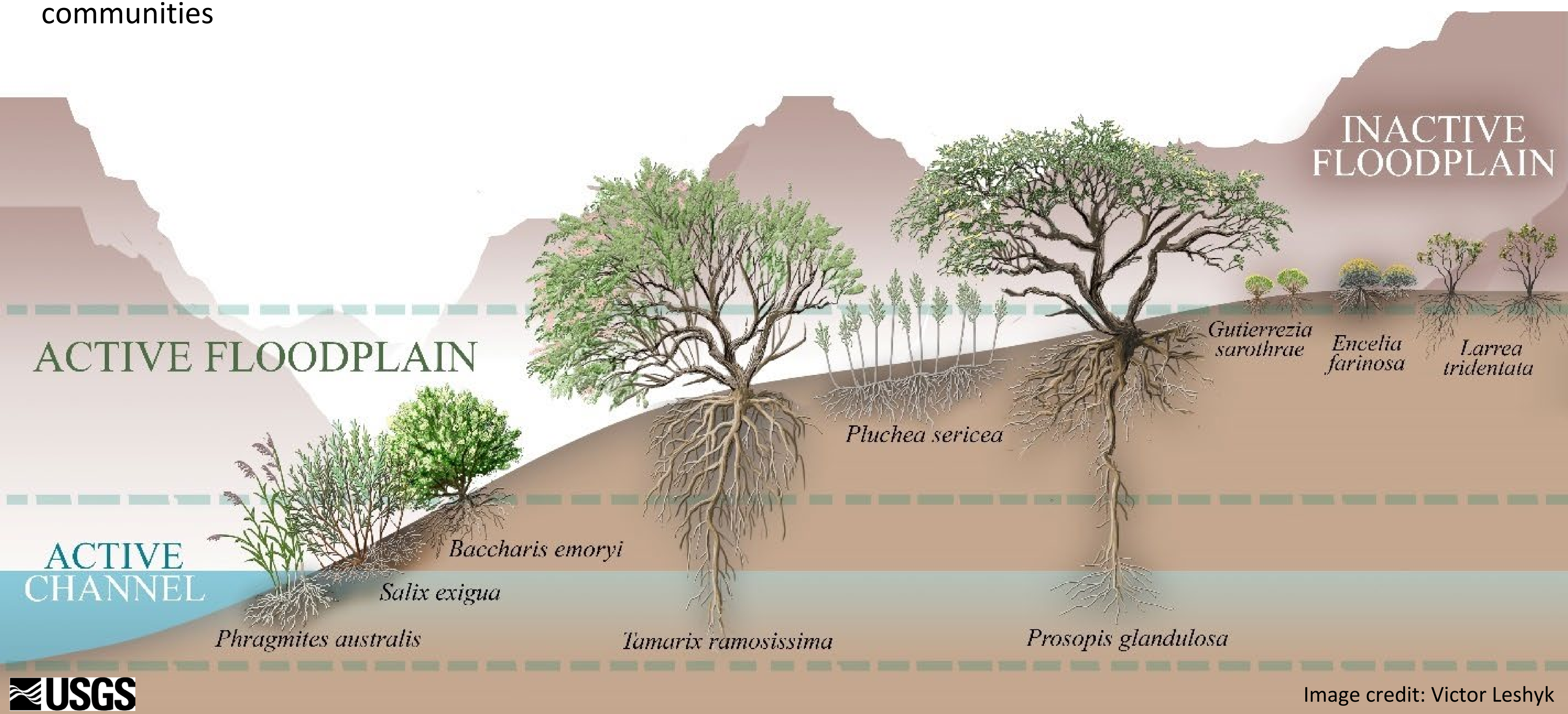
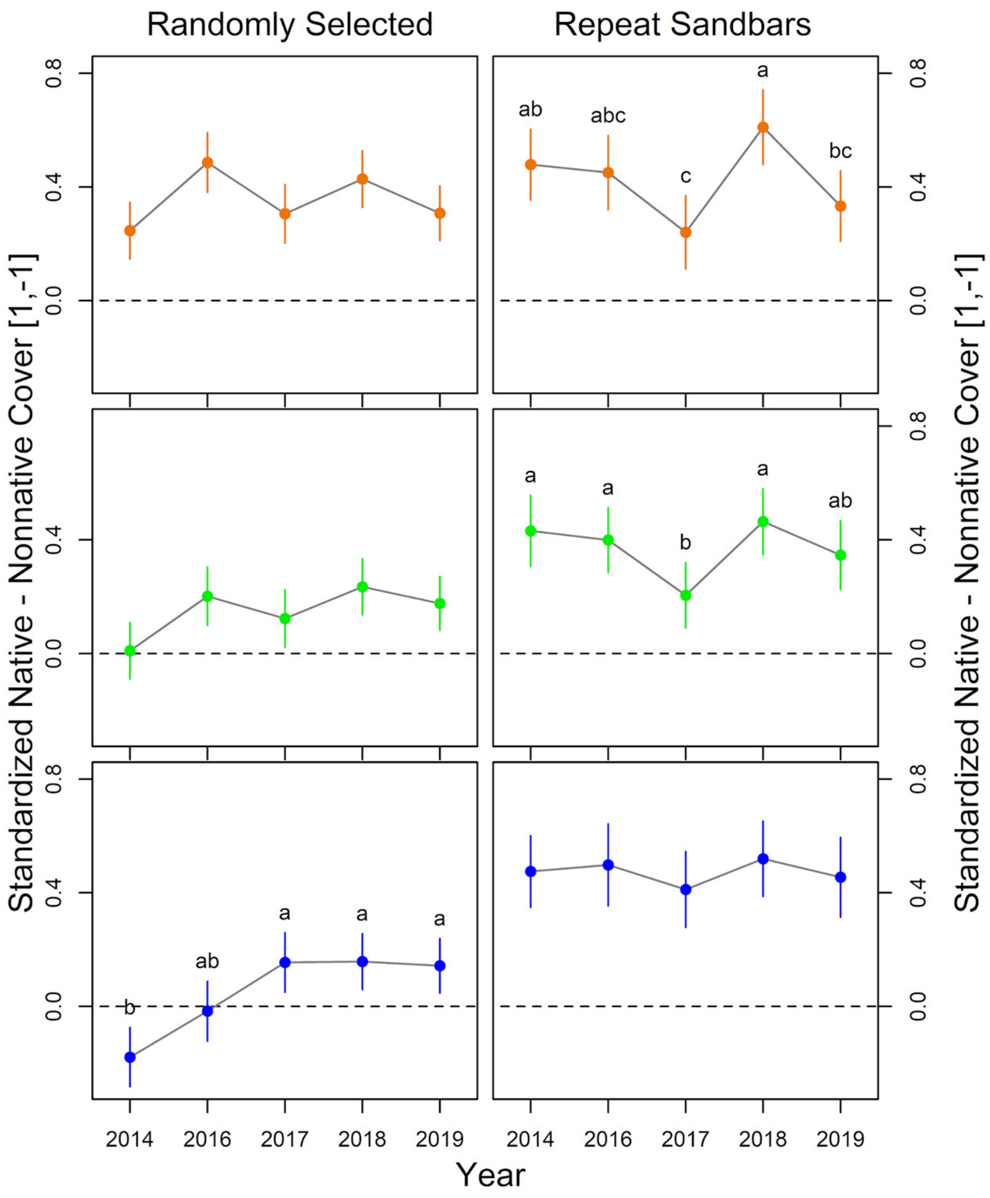


Image credit: Victor Leshyk

What we have now - composition

- Distinct floristic groups associated with Marble Canyon, eastern Grand Canyon, western Grand Canyon
- Diversity decreases with distance downstream
- Shift from more shrubs to more grasses with distance downstream
- Greater native cover and richness than nonnative



Palmquist and others, 2018;
Palmquist and others, 2023

Graph from Palmquist and others, 2023.

What we don’t have

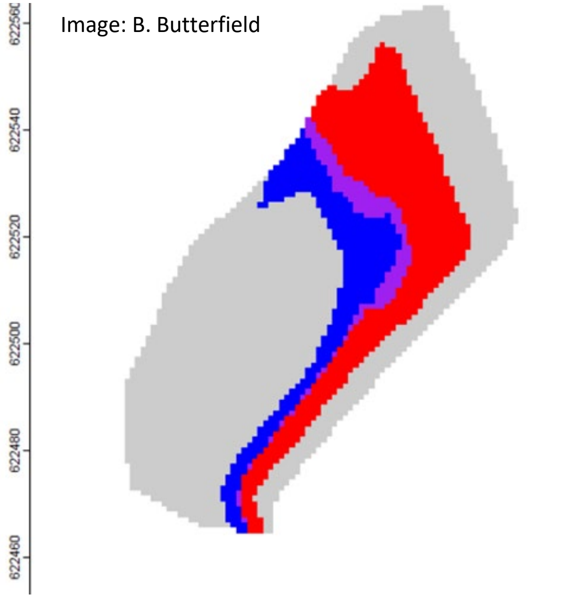
- Cottonwoods and tree willows
  - But in tributaries
- Only one species of shrub willow
- Few sedges, rushes

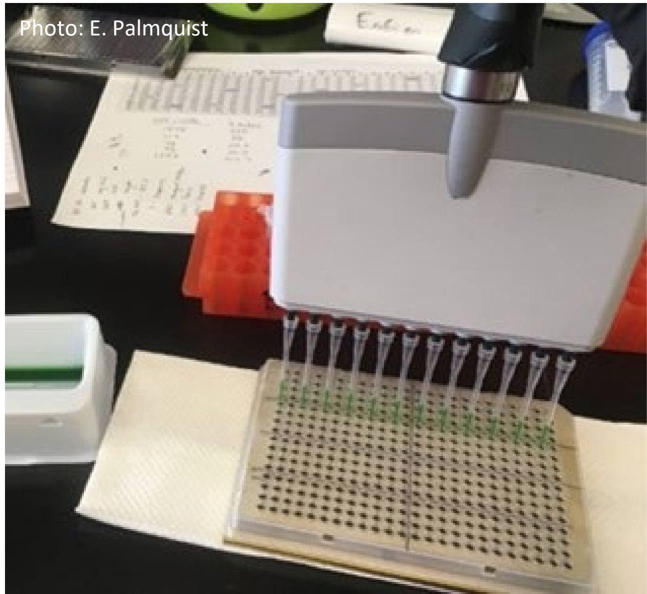
Photos: E. Palmquist

Palmquist and others, 2023

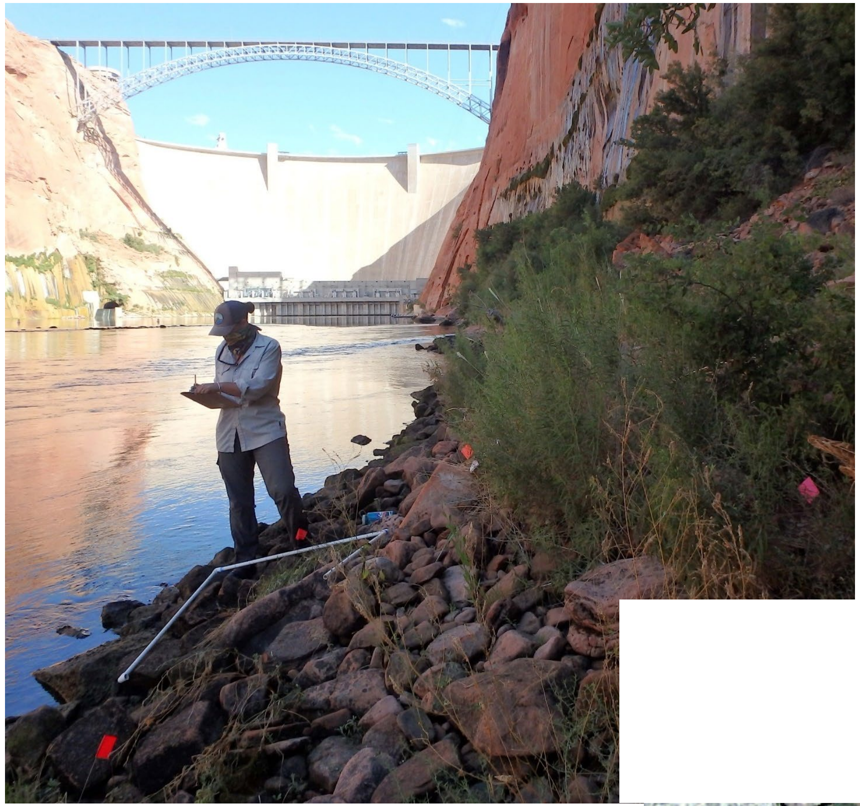
How are we studying plant community responses to dam operations?

- Annual monitoring (C.1)
- Manipulative experiments (C.2)
- Synthesis of multiple lines of evidence & predictive modeling (C.3)
- Management decision support (C.4)

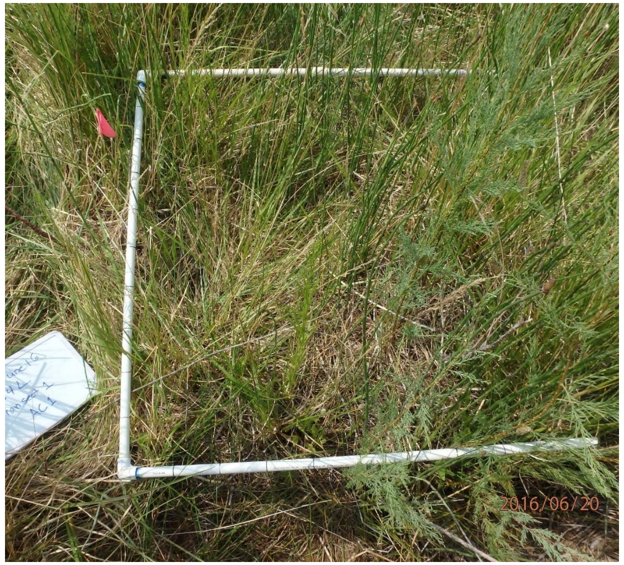


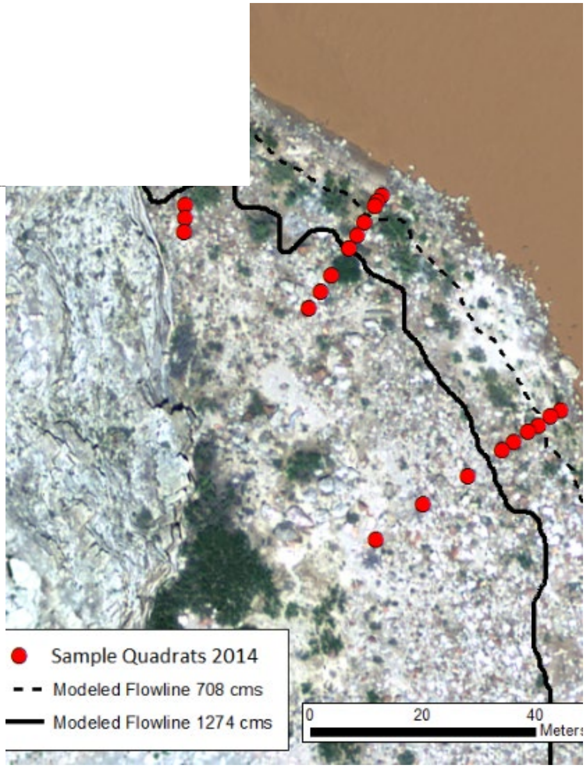


C.1 We record patterns annually



Photos: USGS GCMRC





- Tracking status and trends
  - Temporal shifts in metrics
  - Differences among geomorphic surfaces
    - e.g. Camping beaches are not representative
  - Trends in species of interest
    - e.g. *Baccharis* species are increasing
- Backbone for studying impacts of dam operations
  - Publications, Web Tool, SEIS, etc.
  - Impacts of dam operations vary throughout the canyon

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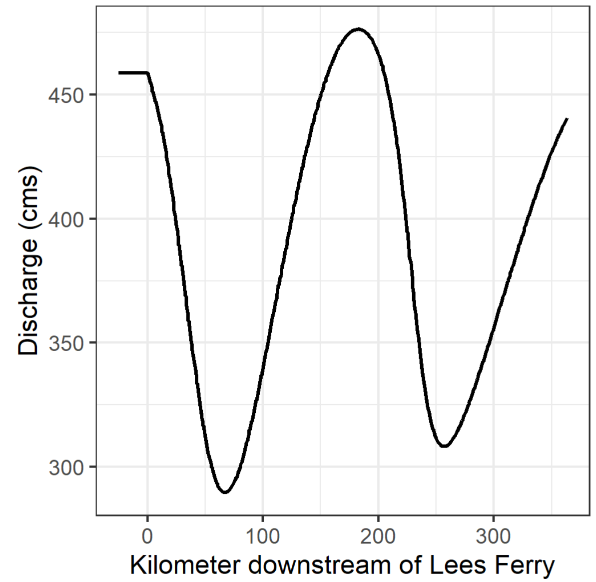
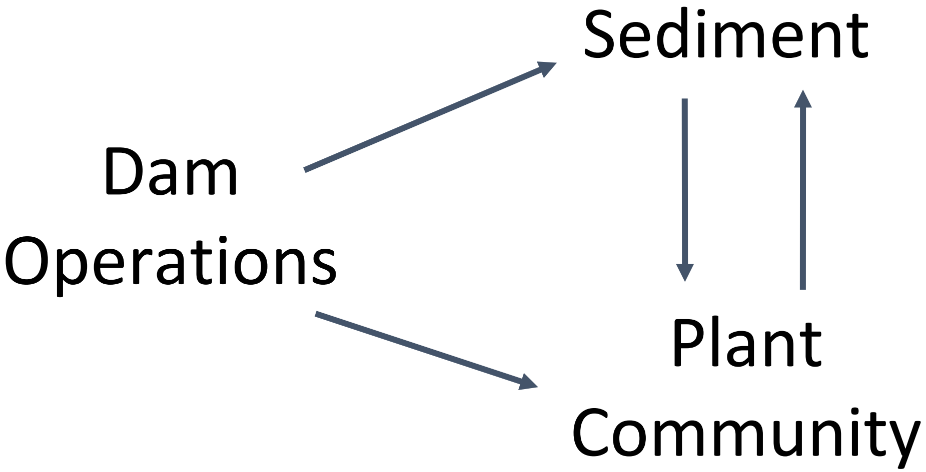
Palmquist and others, 2023

C.1 Many factors interact with dam operations to impact riparian plant communities

- Where you are matters: some species do better with high daily flows at night, others during the day!
- Responses to dam operations depend on temperature, which increases downstream
- Amount of sand is almost as strong of an environmental driver as water availability/inundation





Palmquist and others, in review

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

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Correlation is not causation

Hydrograph has been fairly invariant over our recent monitoring period

Many factors co-vary in space

There are factors we do not or cannot measure that may be influential

One solution: Experiments! We manipulate water availability in a controlled setting in ways that we cannot in the field

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C.2 Take-homes from past experiments

- Inundation tolerance is predictable from habitat preferences in the field
- Drought tolerance is not, suggesting species-specific responses to drawdowns in river stage
- Clonal species (e.g. arrowweed), which are generally understudied in this region, behave much differently than the well-studied trees (e.g. cottonwoods)
- Cottonwoods and tree willows are less tolerant of both inundation AND drought than common species in CRe

Photo: E. Palmquist

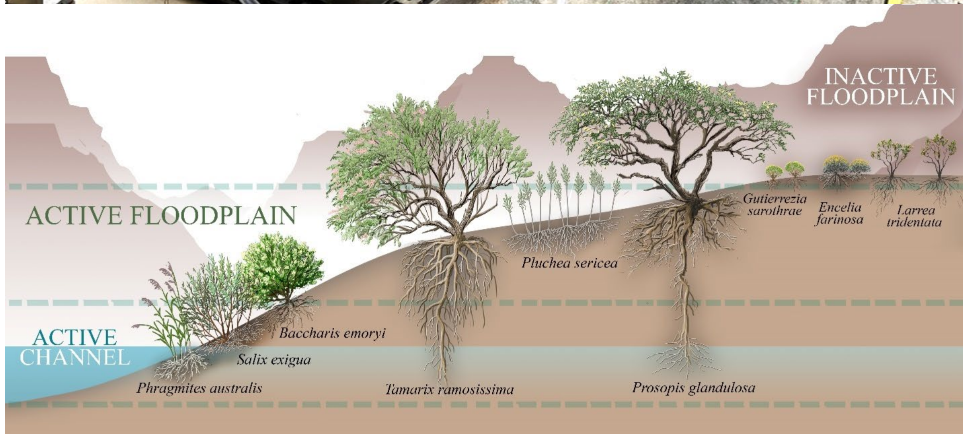
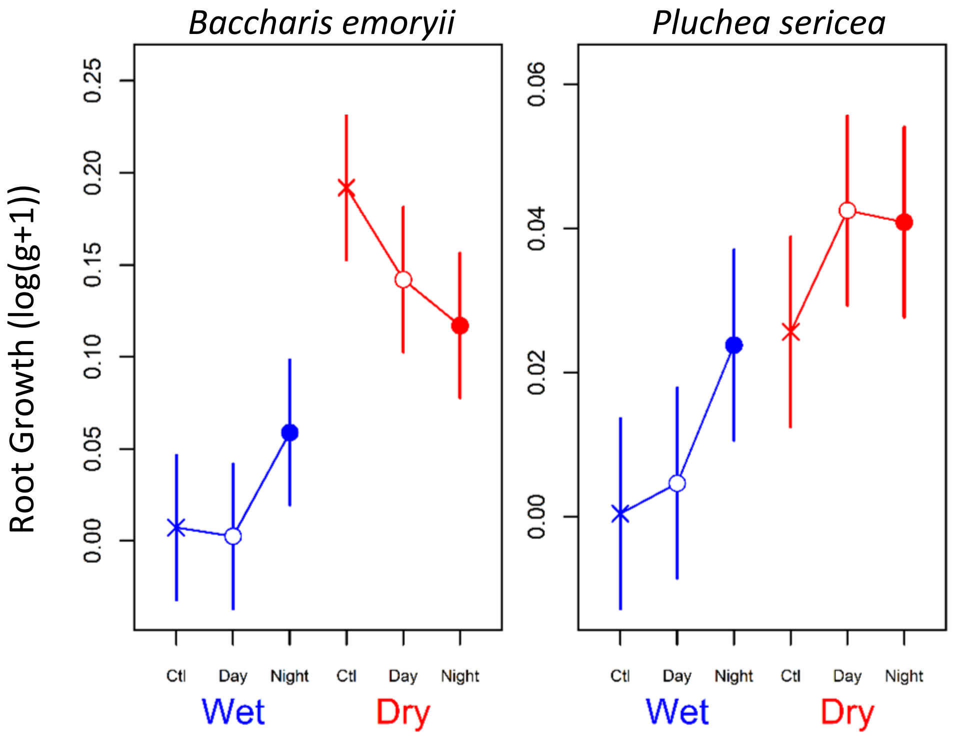


Image credit: Victor Leshyk

Palmquist and others, 2022;
Butterfield and others, 2024



C.2 New for 2023: Daily fluctuations

- Pilot experiment with three species simulating active channel and active floodplain habitats
- Water level held constant, or fluctuating, with both day and night peak treatments
- Null hypothesis: If daily fluctuations do not impact plant performance, then control and fluctuating conditions should produce similar responses
- Preliminary results reject this null hypothesis, and provide some support for differences in responses to day/night timing

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Limitations of experiments

- Greenhouse setting
- Small plants
- Need to assess relevance to natural systems and scales

Photos: B. Butterfield

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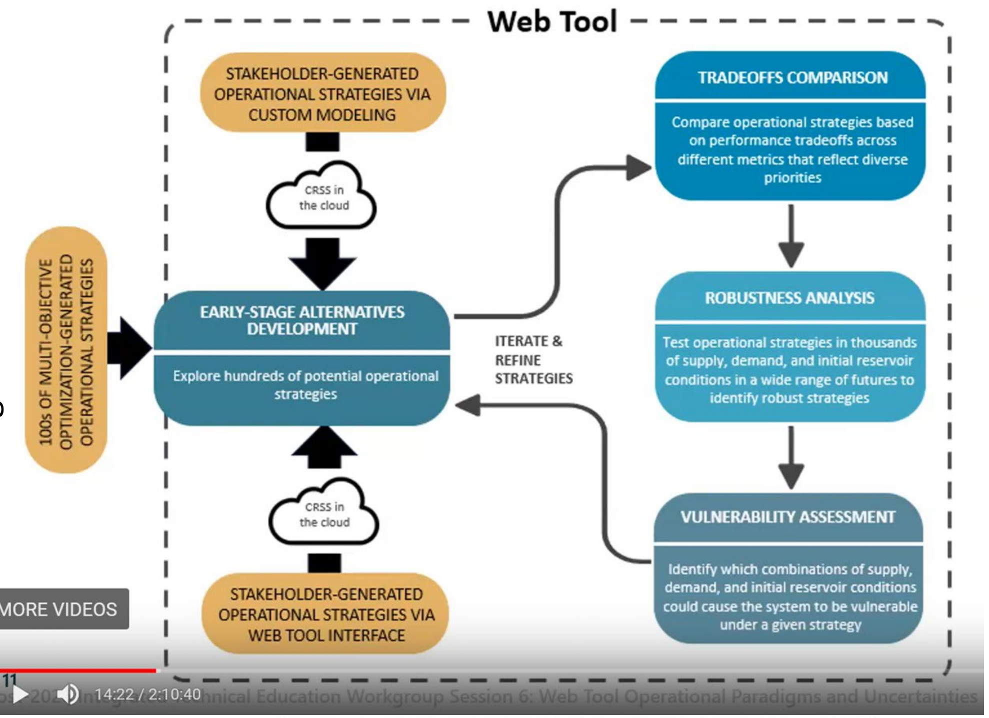
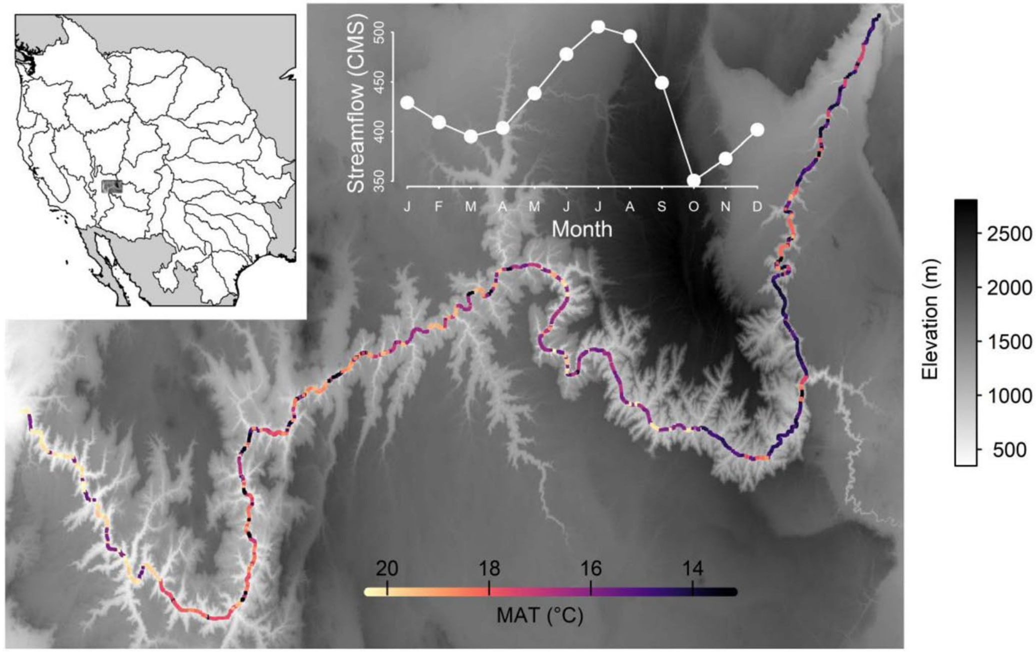
C3. Predictive modeling and synthesis

- Webtool, SEIS, etc.
  - Response to flow alterations
  - Rapid model prediction for many scenarios
- Regional context
  - How does the CRe compare to other riparian plant communities across the region?
  - How might different hydrographs, <u>outside those observed in the CRe</u>, impact community composition?

Image credit: BOR



From: Butterfield and others, 2022

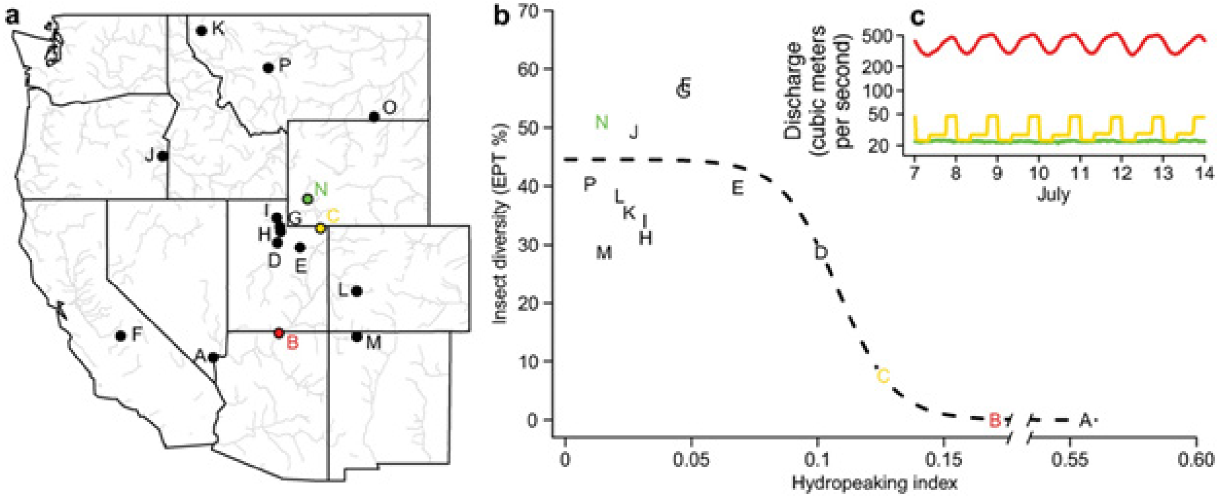


C3. Predictive modeling and synthesis

- Who do we have, who do we not have, and WHY?
  - Previous work (Butterfield and others, 2022) suggests some intriguing patterns
  - Regional perspective, similar to Kennedy and others, 2016
- Integration of multiple lines of evidence into our models
  - e.g. daily fluctuations
    - greenhouse experiments
    - field observations
    - regional analysis

Climate niche model (Regional Data) says CRe is:

Survey (Local Data) says CRe is:	Suitable	Unsuitable
Suitable		?
Unsuitable	?	



From: Kennedy and others, 2016

Next Steps

- Effects of daily fluctuations
  - Regional context
  - Greenhouse experiments
  - Plant traits
- Impacts of plant communities on wildlife
- Mechanistic models
  - Soil moisture dynamics
  - Sediment feedbacks
- Flipping the script
  - Previously: Given these flows, what plant communities do we get?
  - Proactive: **Given these plant community objectives**, what flows would we need?

Photos: J. Scott

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Photo: E. Palmquist

Plant community responses to dam operations are influenced by external changes

- Tamarix die-back
- *Phragmites australis*
- Arrival of new nonnative species
- Future flows uncertainty
- LTEMP plant management

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

Thank you!

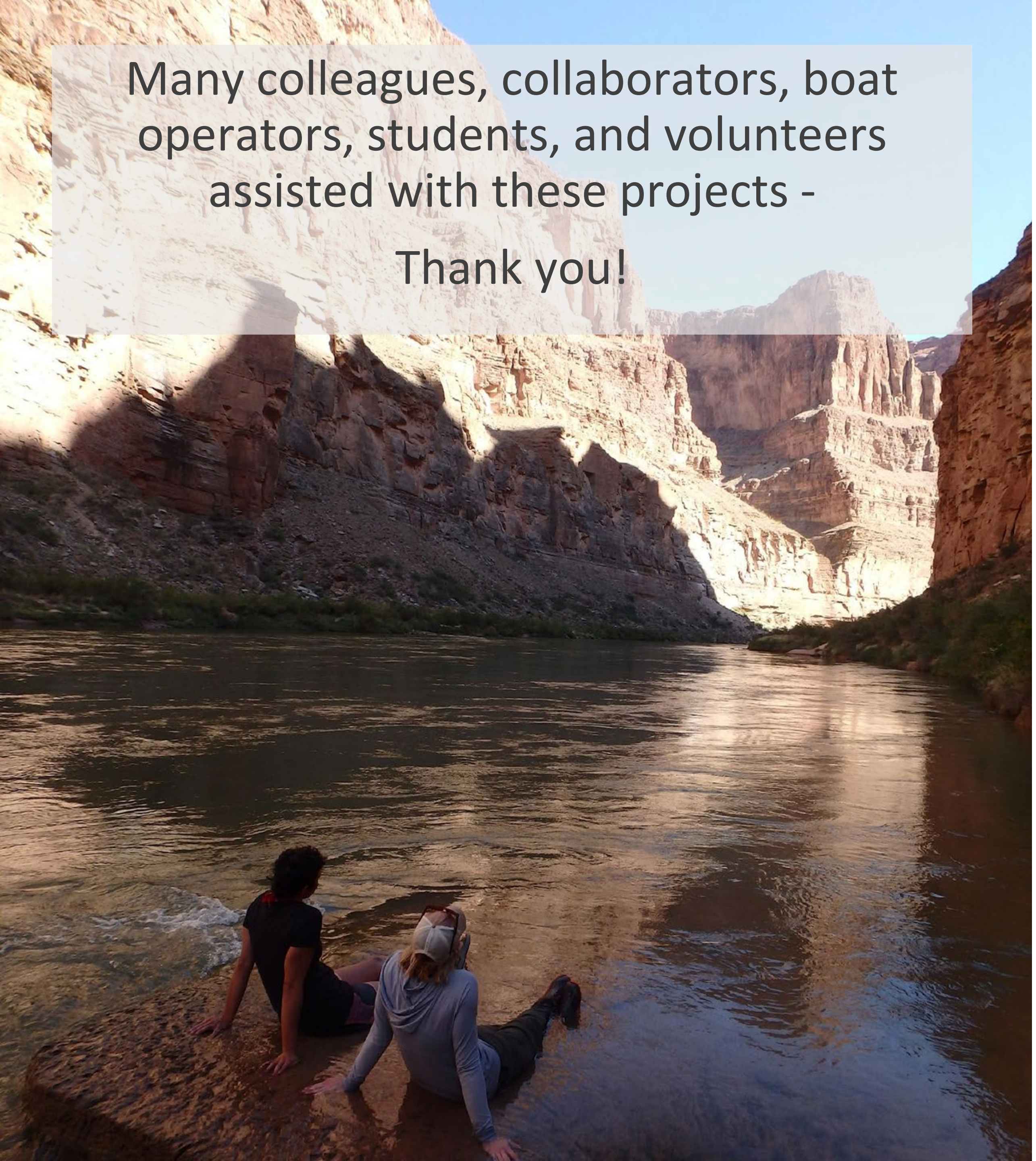

Photo: USGS GCMRC

Further questions?

Contact us:

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or Search "Emily Palmquist USGS"

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Interested in the riparian vegetation 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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