Project D Update, Part II: Using Historic Photographs to Monitor Geomorphic Changes to the Colorado River corridor in Grand Canyon National Park, AZ

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Progress Matching Historical Photographs

- ~290 matches of pre-dam photographs (pre-1957) by E.C. LaRue [1923], R. B Stanton [1890], J.K. Hillers [1871]

- Additional ~200 matches of early post-dam [1973] color slides

River Mile 37.7L, Example of conditions in July 1973 (top photo) matched with identical view of 2022conditions. 1973 photos by unknown photographer; matched by A.H. Fairley. 5/1/22

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Photo Matching Objectives

Evaluate broad-scale changes in:

1) sand supply and storage

2) vegetation cover and composition

3) geomorphologic character of river corridor

To inform:

- Management of sand supply to source-bordering dunefields and archeo. sites
- Geomorphic responses to regulated flows, sediment supply, and riparian vegetation

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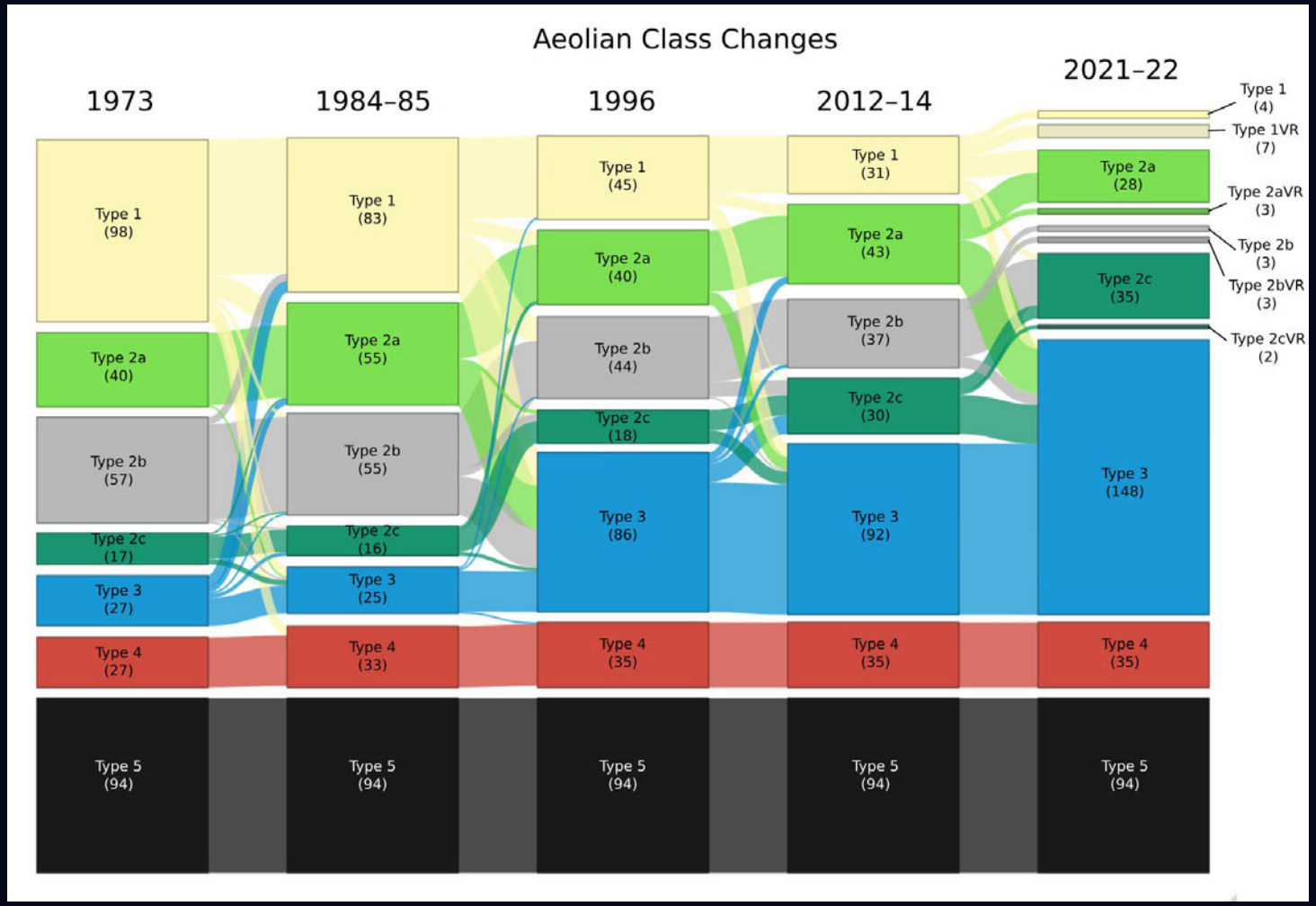
Fluvial Sand Connectivity Tied To Near Shore Vegetation Encroachment



Sankey, J.B., et al., 2023, https://doi.org/10.1016/j.jenvman.2023.118036.

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Preliminary Results*

- Sand erosion at ~56% of sites
- Sand deposition at ~37% of sites
- Spatial variability in sand transport and storage processes

*Very preliminary, based on partial analysis, n = 108 matches

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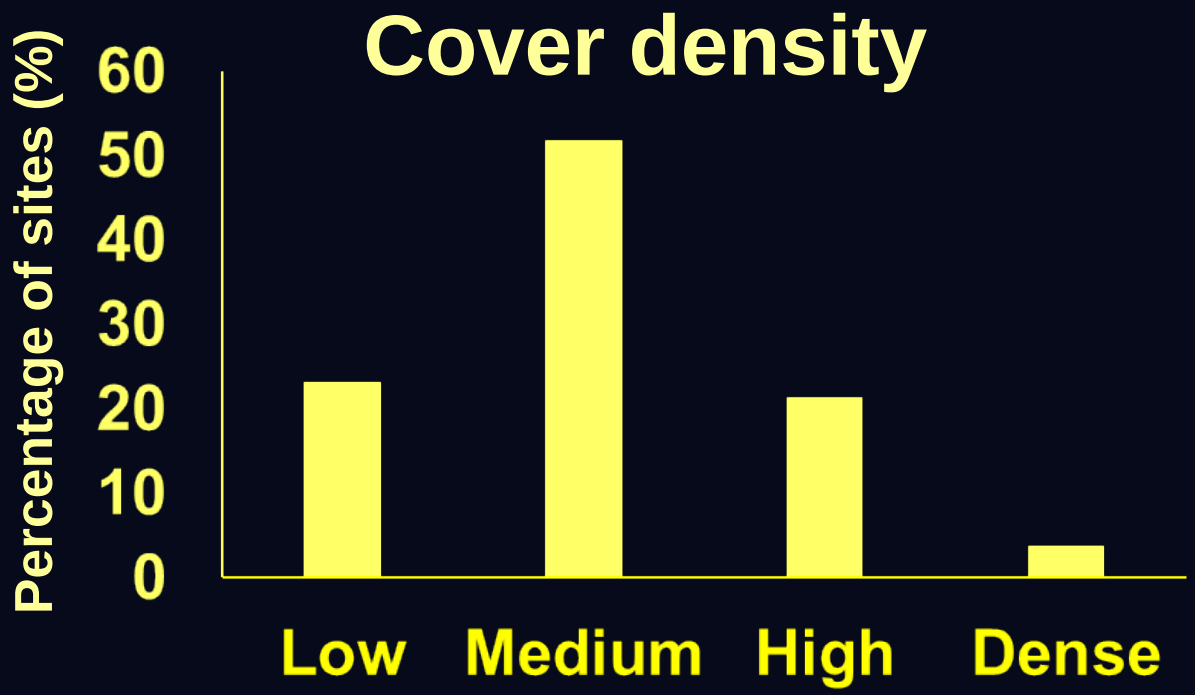
Preliminary Results

- Vegetation cover ↑ at 98% of sites
- Density of total covered varied



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Not for Citation or Distribution

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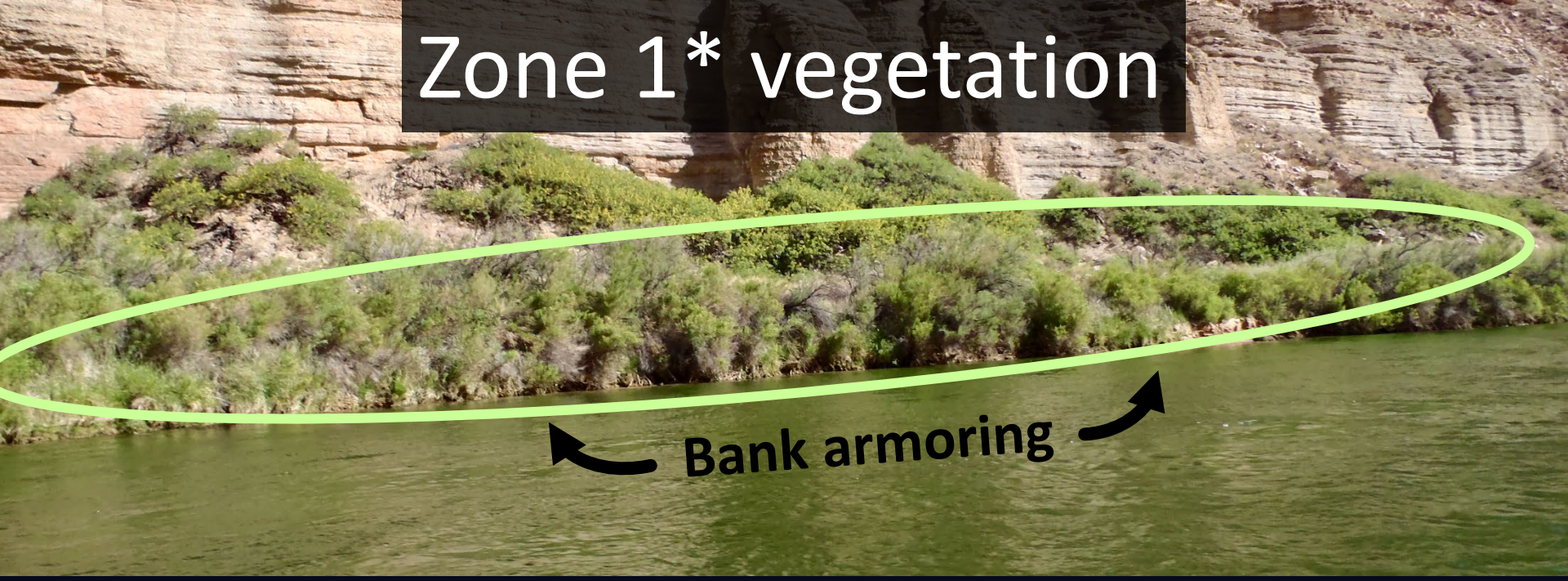
Zone 1* vegetation



- Zone 1 = baseflow to maximum power plant capacity under LTEMP (a.k.a., active channel)
- Discharge range = 8k – 25k cfs (226-708 m^3/s) (LTEMP restricted hydro-peaking flow regime)
- Obligate riparian shrubs (*Baccharis* spp., *Salix exigua, Pluchea sericea*)

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* Defined by Sankey et al. 2015

Results

- Zone 1 vegetation present at 92% of sites

(n = 108)

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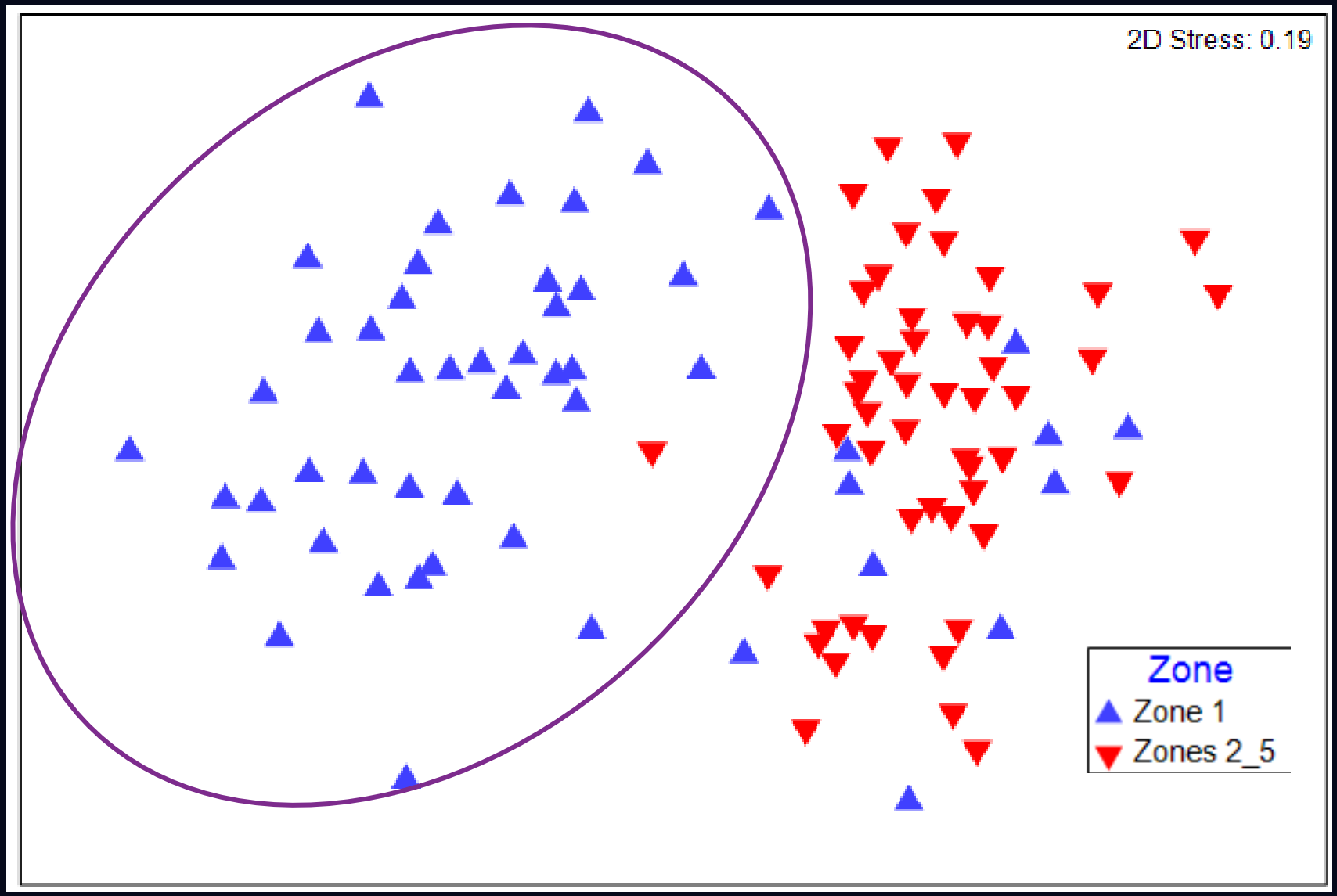
Results: Zone 1

NMDS ordination, Bray-Curtis similarity



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

Results: Zone 1

- 139 total species, 26 unique to Zone 1
- 6 of 10 most abundant species: non-natives
- 6 of 10 most abundant species: Facultative
- or Obligate Wetland species

- Example …. *Schedonorus arundinaceus*

- Present at 80% of sites
- Robust, non-native perennial; invasive
- Participating in bank armoring

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

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Zone 1 Vegetation Encroachment is Leading to Widespread Shoreline Steepening

River mile 179.2 L (Stake No. 697ab). Top photo E.C. LaRue, 9/19/1923; Bottom photo A.H. Fairley, 5/19/2021

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Zone 1 Vegetation Encroachment is Leading to Widespread Shoreline Steepening, cont.

River mile 74. 6 (Stake No. 2505): Top photo E.C. LaRue, 8/15/1923; Bottom photo A.H. Fairley, 5/4/2016

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Another example of shoreline steepening

John K. Hillers photo, August 21, 1872, left; H.C. Fairley photo, Sept 15, 2024 right. River mile 34.2, right bank.

Steeper shorelines, vegetation barriers limit sand deposition at elevations >25k cfs, except during high flow experiments (HFEs)

River mile 46.8 (Stake No. 798): Top photo E.C. LaRue, 8/11/1923; Bottom photo A.H. Fairley, 8/26/2017

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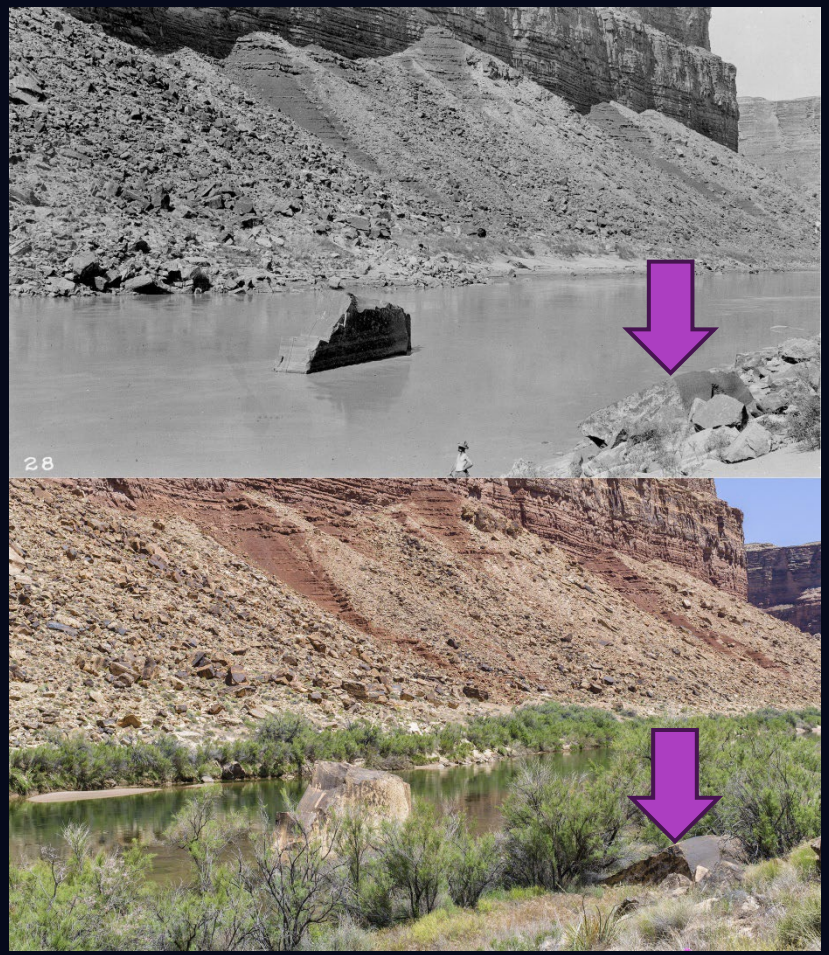
During HFEs, sand is deposited in and adjacent to Zone 1 vegetation



RM 10.2, Left
(Stake 2758)

E.C. LaRue, 8/2/1923

A.H. Fairley, 5/5/2017

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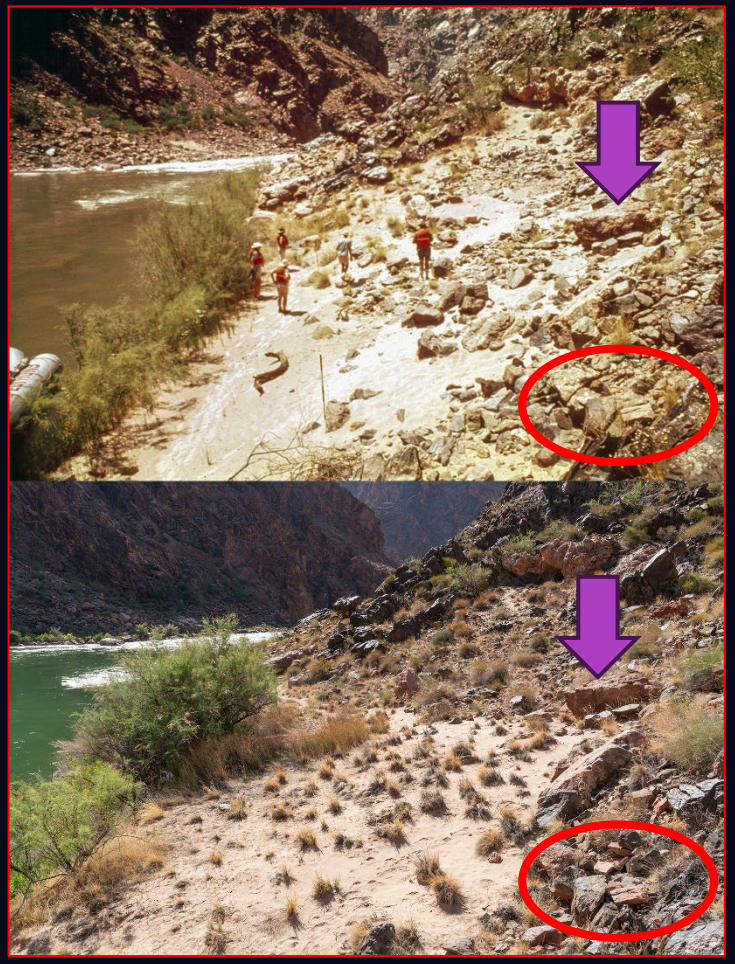
Another example of sediment build-up next to Zone 1 vegetation



River mile 99. 6, right
Stake No. 5509

NPS photo, July 1973

A. H. Fairley, 5/14/2021

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Beach Erosion At Lower Elevation with Sediment Accumulation At Higher Elevation

River mile 124. 2, left
Stake No. 5561

NPS photo, July 1973

A.H. Fairley, 5/11/2022

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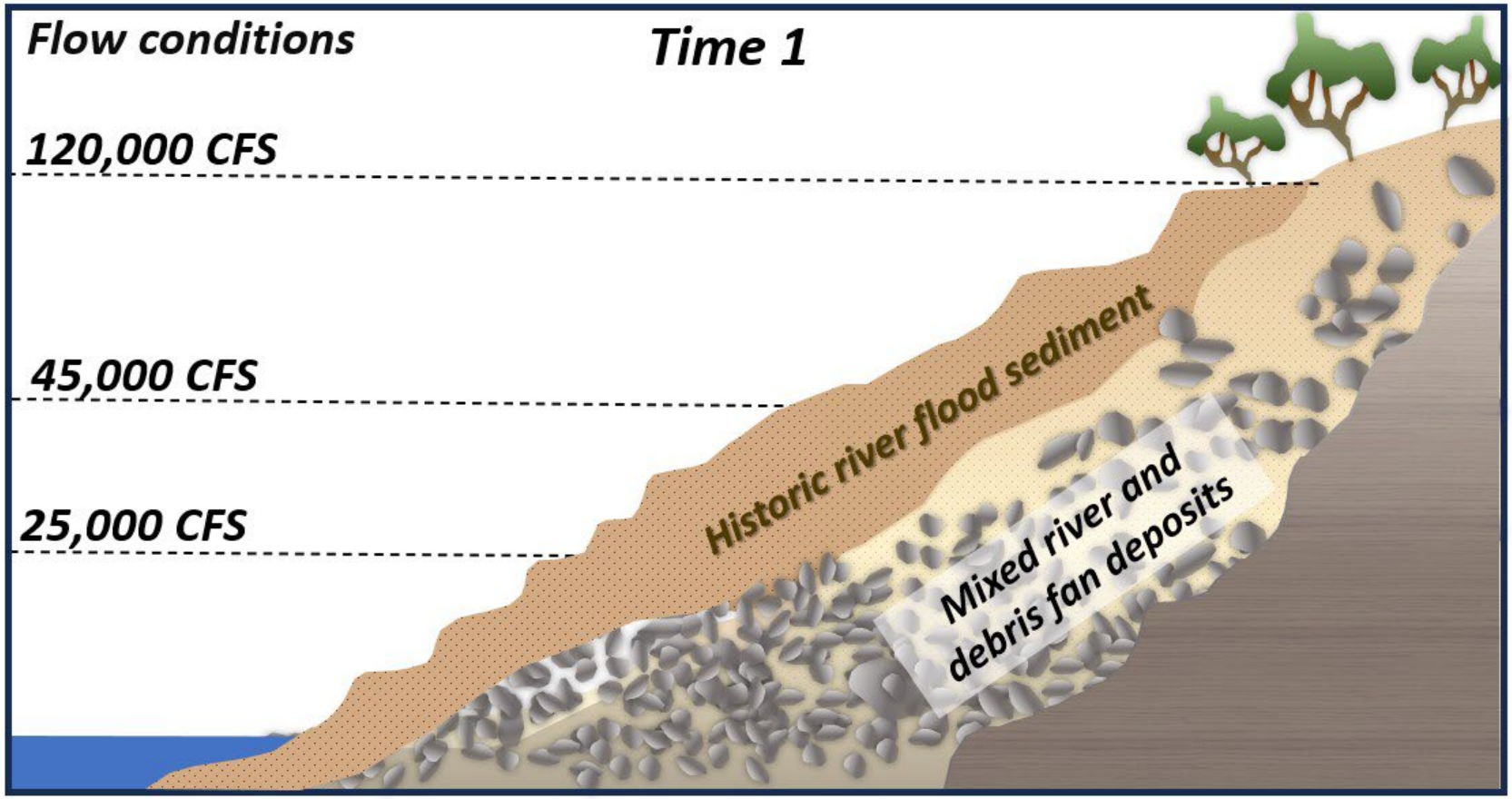
Schematic representation of river bank evolution under dam regulated flows



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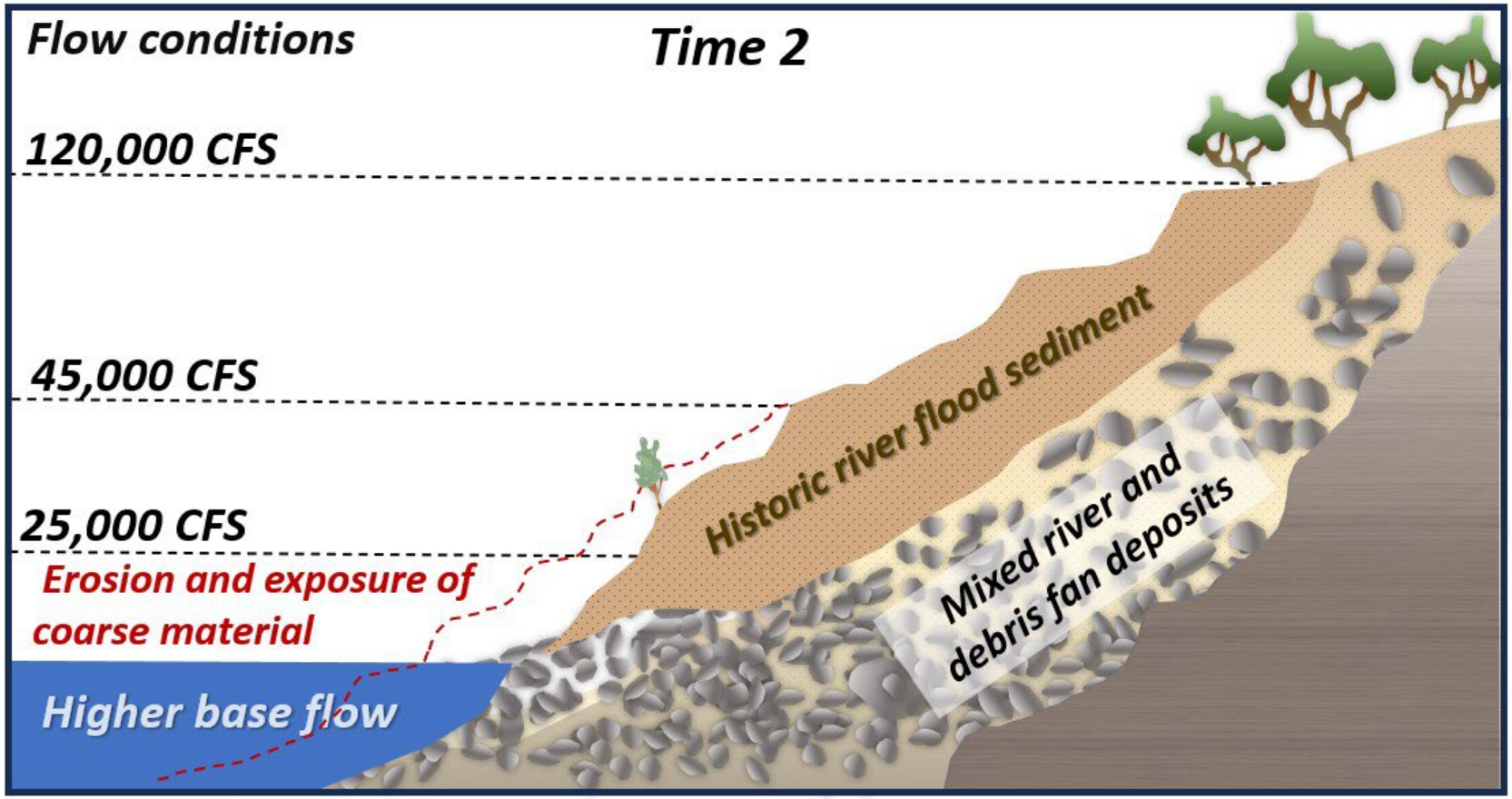

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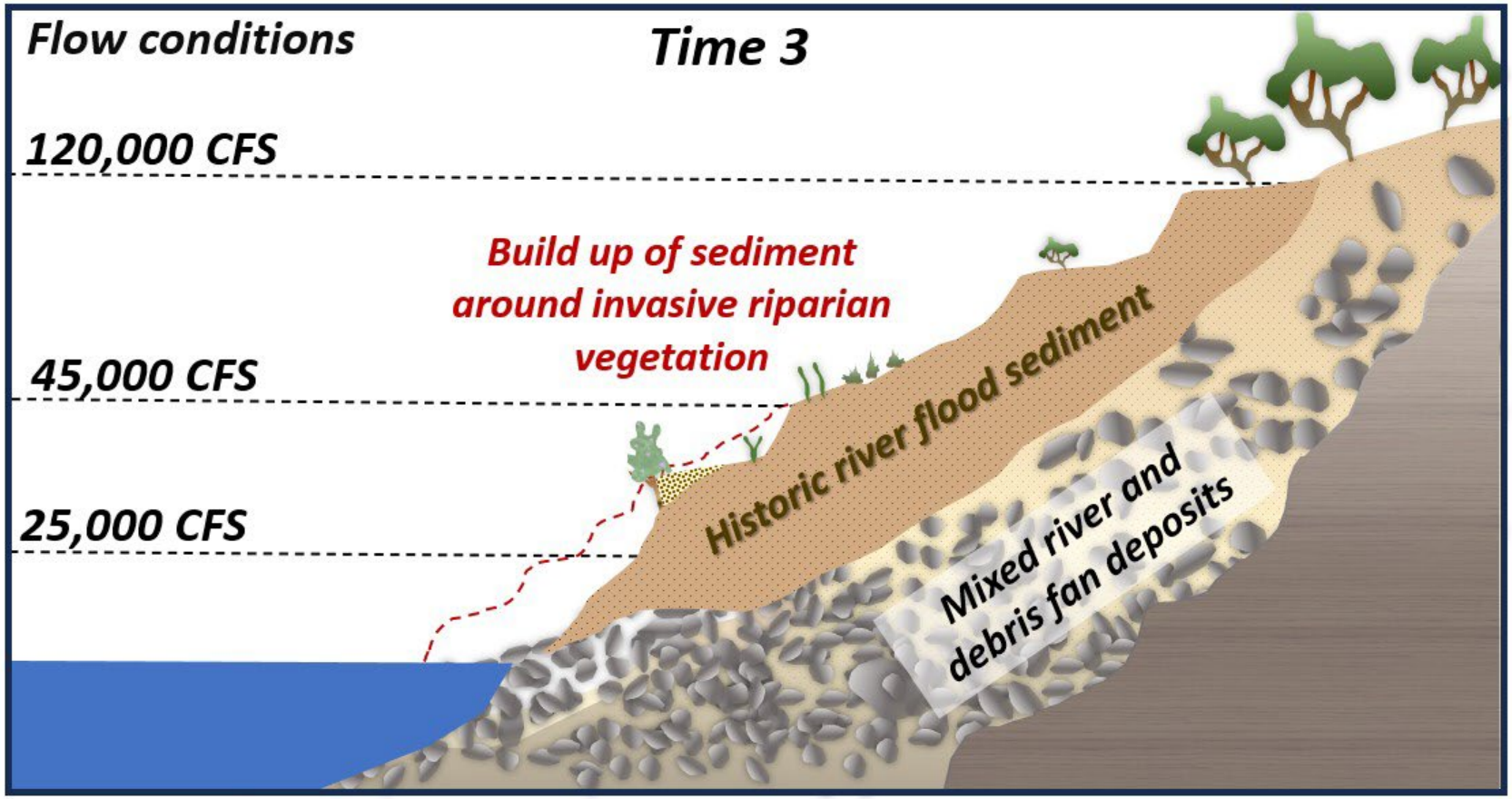

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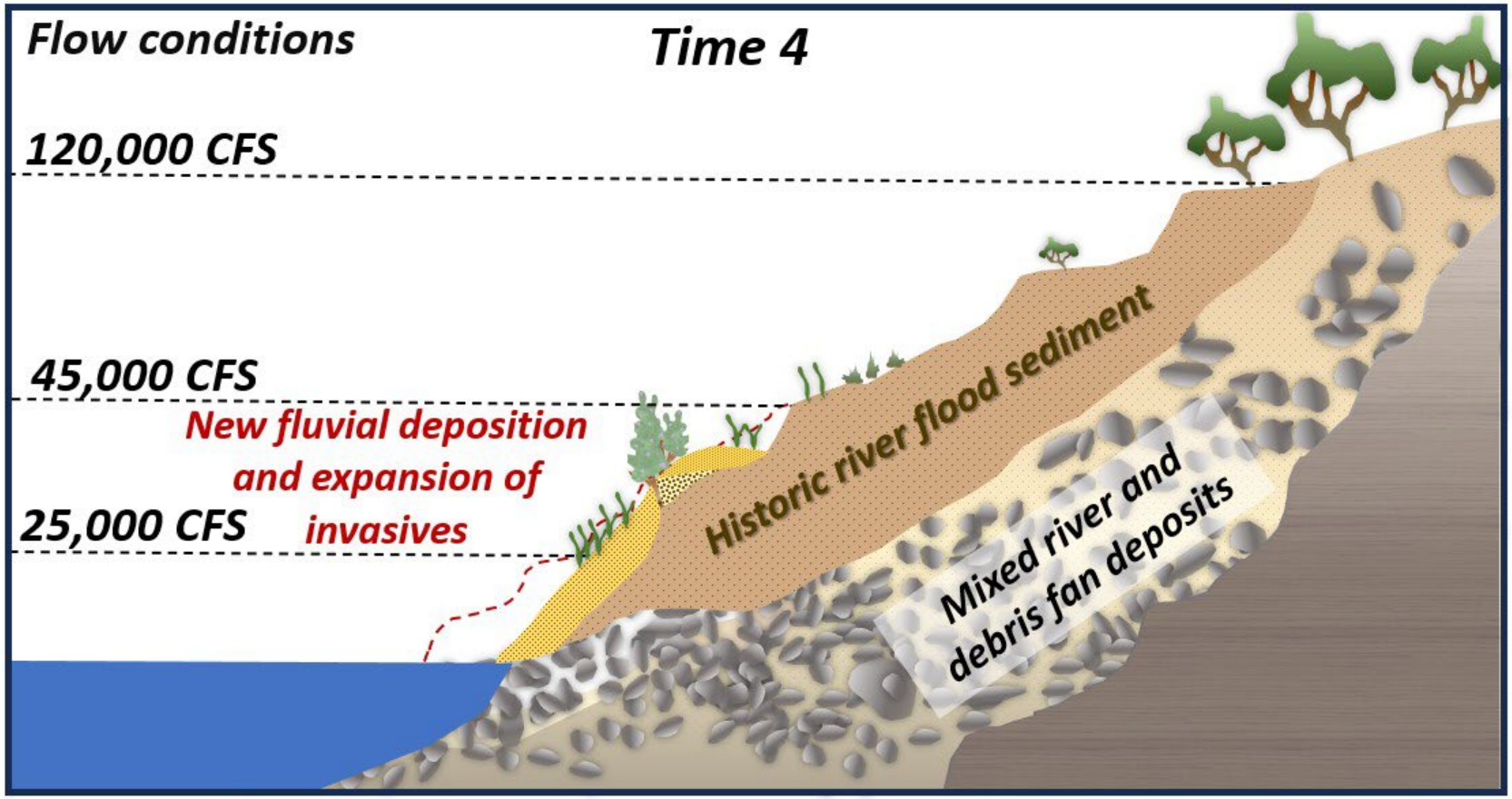

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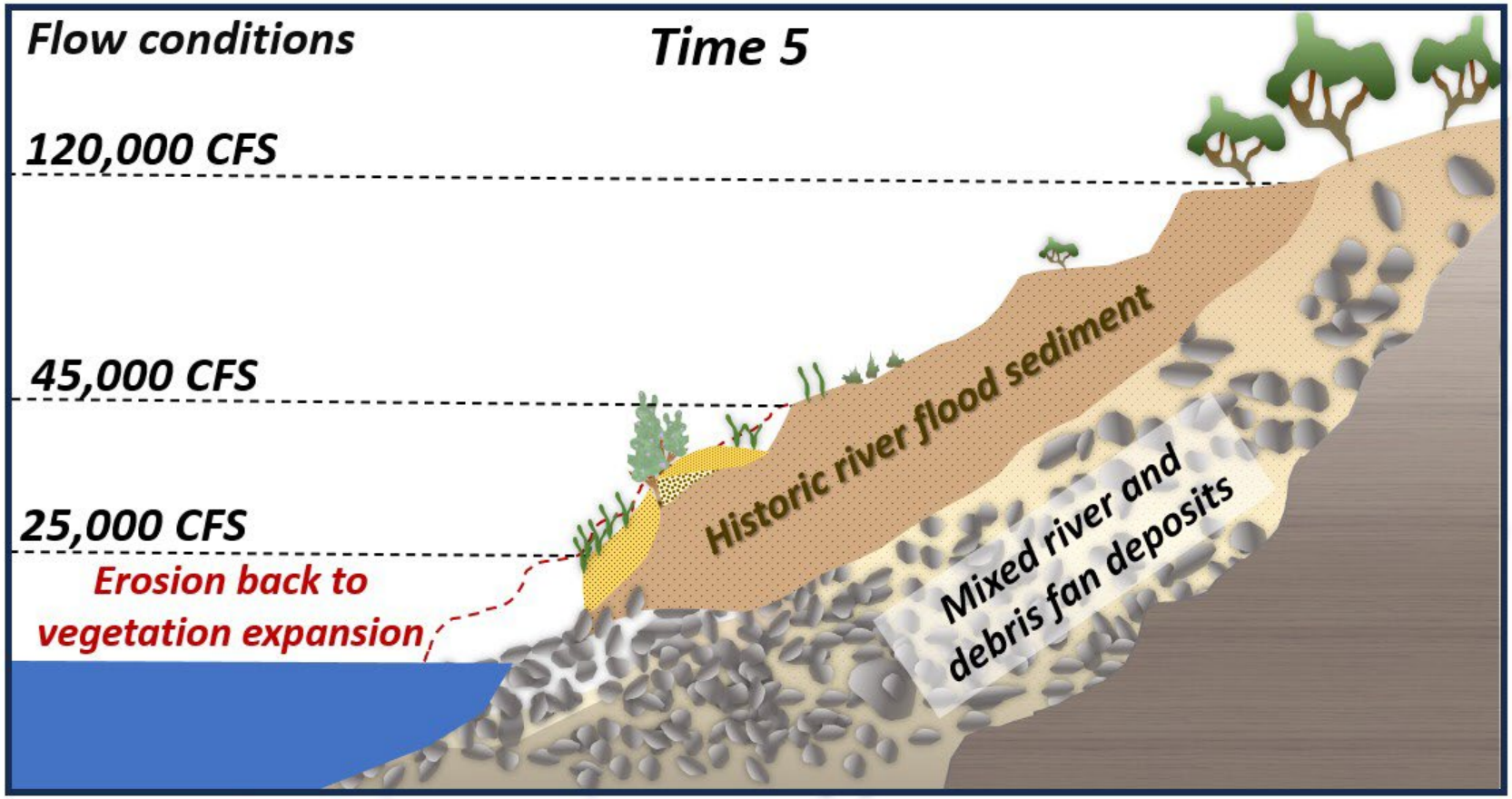

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Infrequent HFEs and vegetation encroachment is also leading to channel narrowing, with implications for future sediment deposition and habitat quality

River mile 204.8, right, looking upstream (Stake No. 1802):
Top photo E.C. LaRue, 9/27/1923; Bottom photo A.H. Fairley, 5/11/2018

Another Example of Channel Narrowing

River mile 204.8, right, looking downstream (Stake No. 1796):
Top photo E.C. LaRue, 9/27/1923; Bottom photo A.H. Fairley, 5/11/2018

Another Example of Channel Narrowing

Nankoweap, River mile 53.2, right, looking downstream (Stake No. 1424a):
Left photo R.B. Stantion, 1/18/1890; Bottom photo A.H. Fairley, 5/7/2019

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Another Example of Channel Narrowing

Cardenas, River mile 70.2, left, looking upstream (Stake No. 1440):
Left photo R.B. Stantion, 1/23/1890; Bottom photo A.H. Fairley, 5/4/2016

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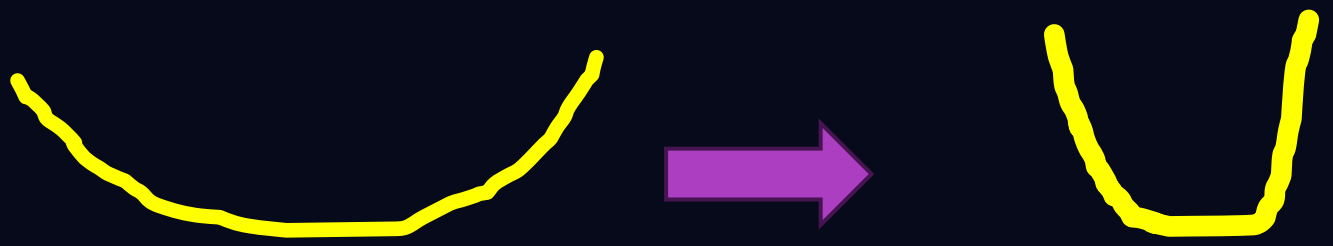
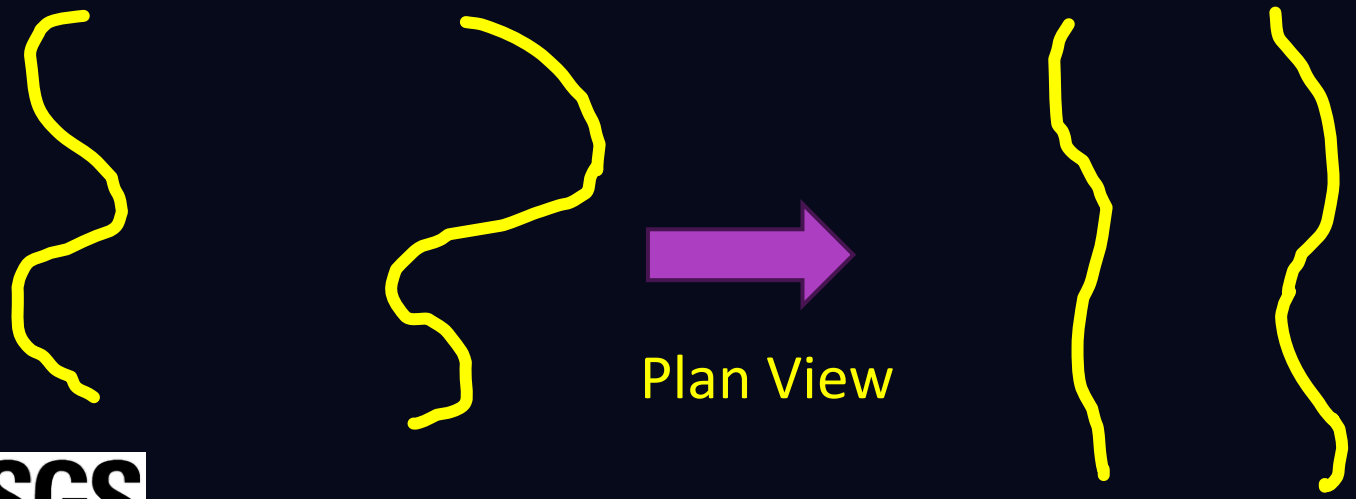
Progressive evolution of channel shape?



Cross-section



Plan View

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Conclusions

- Regulated flows have eroded sand from the lower elevations of sandbars/channel margins
- Sand deposition is predominantly occurring next to/immediately above Zone 1 vegetation
- Establishment of dense Zone 1 vegetation, in combination with low elevation sand erosion, is leading to bank steepening, channel narrowing, and other significant geomorphic changes
- Low frequency, low magnitude, and short duration of HFEs is contributing to changes in channel morphology
- GCDAMP decisions are driving these changes
- **Is this the environment we want to create?**

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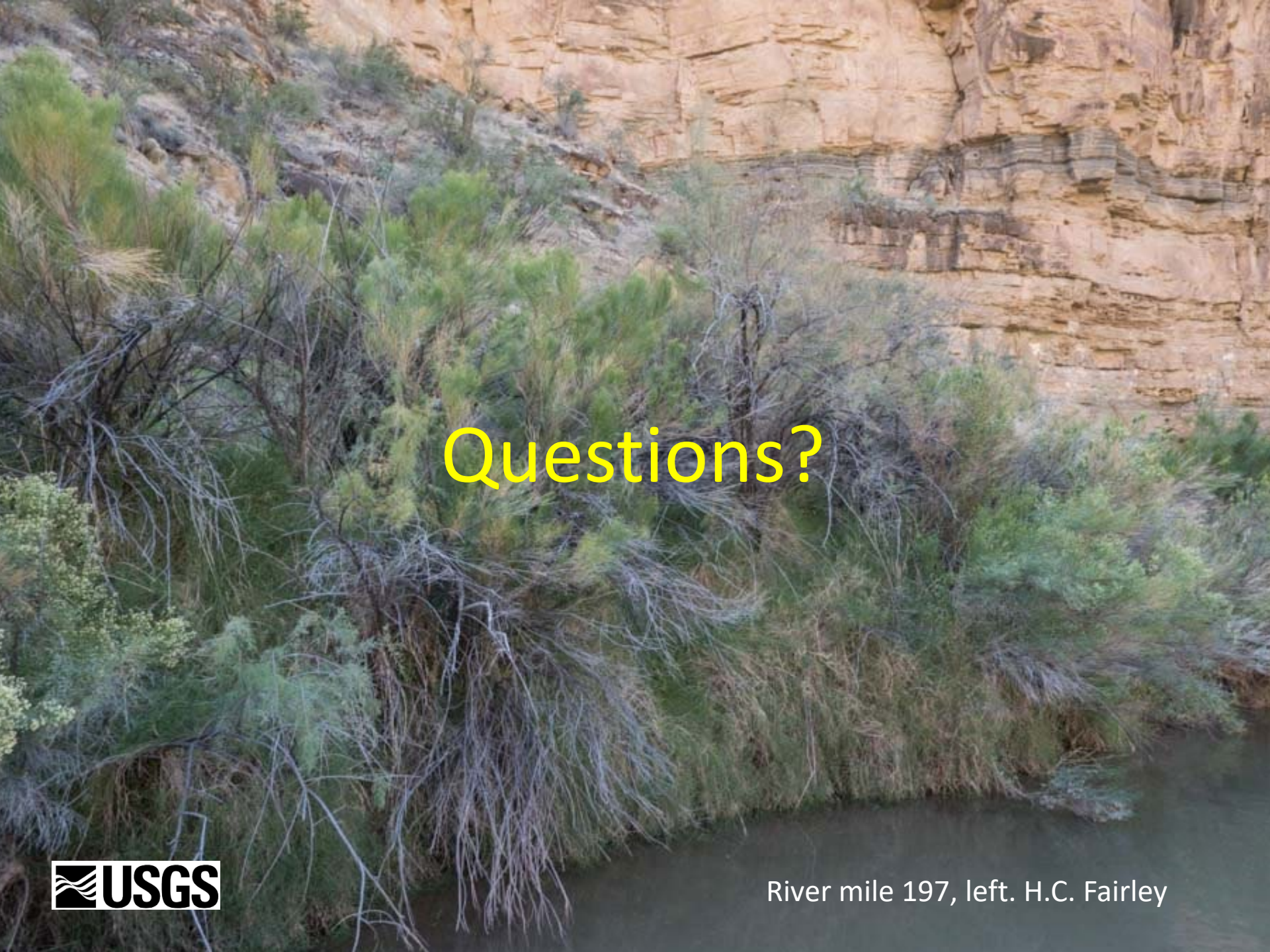
Questions?
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River mile 197, left. H.C. Fairley