



Using Repeat Photography to Document Dam Operation Effects on Sand Supply, Aeolian Landscapes, and Terrestrial Ecology in the Colorado River Ecosystem

GCDAMP Annual Reporting Meeting
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Project Background

■ FY18-20 TWP: Project D

- quantifies geomorphic effects of ongoing and experimental dam operations, as well as the geomorphic effects of riparian vegetation expansion and management, focusing on effects to the supply of sediment to cultural sites, dunefields, and terraces.

■ FY15-17 TWP

■ Project 4.1 (sub-element 2)

- “ascertain the degree to which environmental conditions at or near cultural sites have changed during the past >50 years . . . using qualitative visual comparisons of historical oblique imagery and current surface conditions”

■ Project 12

- “. . . how and in what respects have cultural resource values associated with the riparian landscape been altered, and how do perceptions of change vary across the different cultures that place value on these resources?”

LTEMP: Definition and Goals

- **CRE Definition:** “[T]he area potentially affected by implementation of the LTEMP primarily encompasses the Colorado River Ecosystem, which includes the Colorado River mainstream corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay of Glen Canyon Dam to the western boundary of Grand Canyon National Park (GCNP).]
- **LTEMP Goals**
 - **1. Archaeological and Cultural Resources.** Maintain the integrity of potentially affected NRHP-eligible or listed historic properties in place, where possible, with preservation methods employed on a site-specific basis.
 - **2. Natural Processes.** Restore, to the extent practicable, ecological patterns and processes within their range of natural variability, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems.
 - **6. Recreational Experience.** Maintain and improve the quality of recreational experiences for the users of the Colorado River Ecosystem. Recreation includes, but is not limited to, flatwater and whitewater boating, river corridor camping, and angling in Glen Canyon.
 - **7. Sediment.** Increase and retain fine sediment volume, area, and distribution in the Glen, Marble, and Grand Canyon reaches above the elevation of the average base flow for ecological, cultural, and recreational purposes.
 - **8. Tribal Resources.** Maintain the diverse values and resources of traditionally associated Tribes along the Colorado River corridor through Glen, Marble, and Grand Canyons.
 - **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.

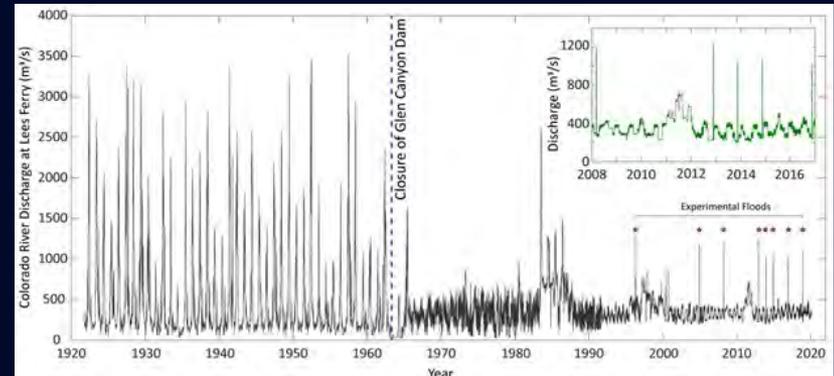
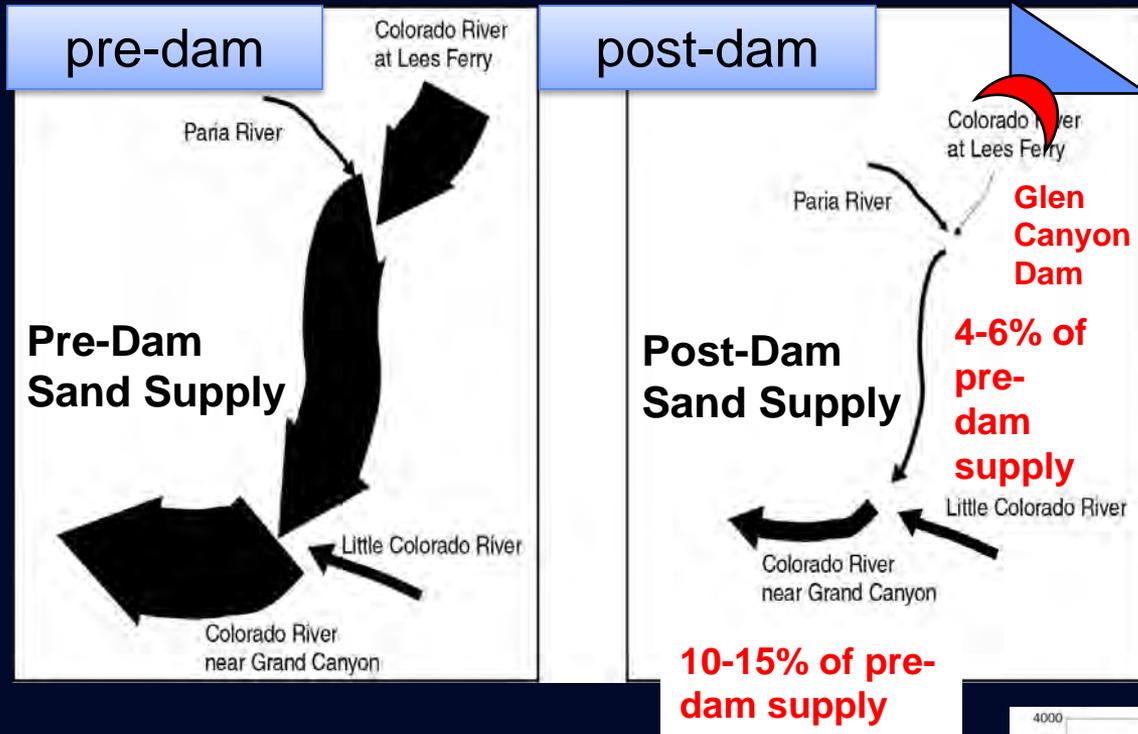
250+ archaeological sites are located in/on ancient & historic flood deposits



Wind-blown sand formerly covered many flood deposits and archeological sites



Reduced post-dam sediment budget and reduced flow magnitude and variability has disrupted sand supply, both in-channel and on-shore



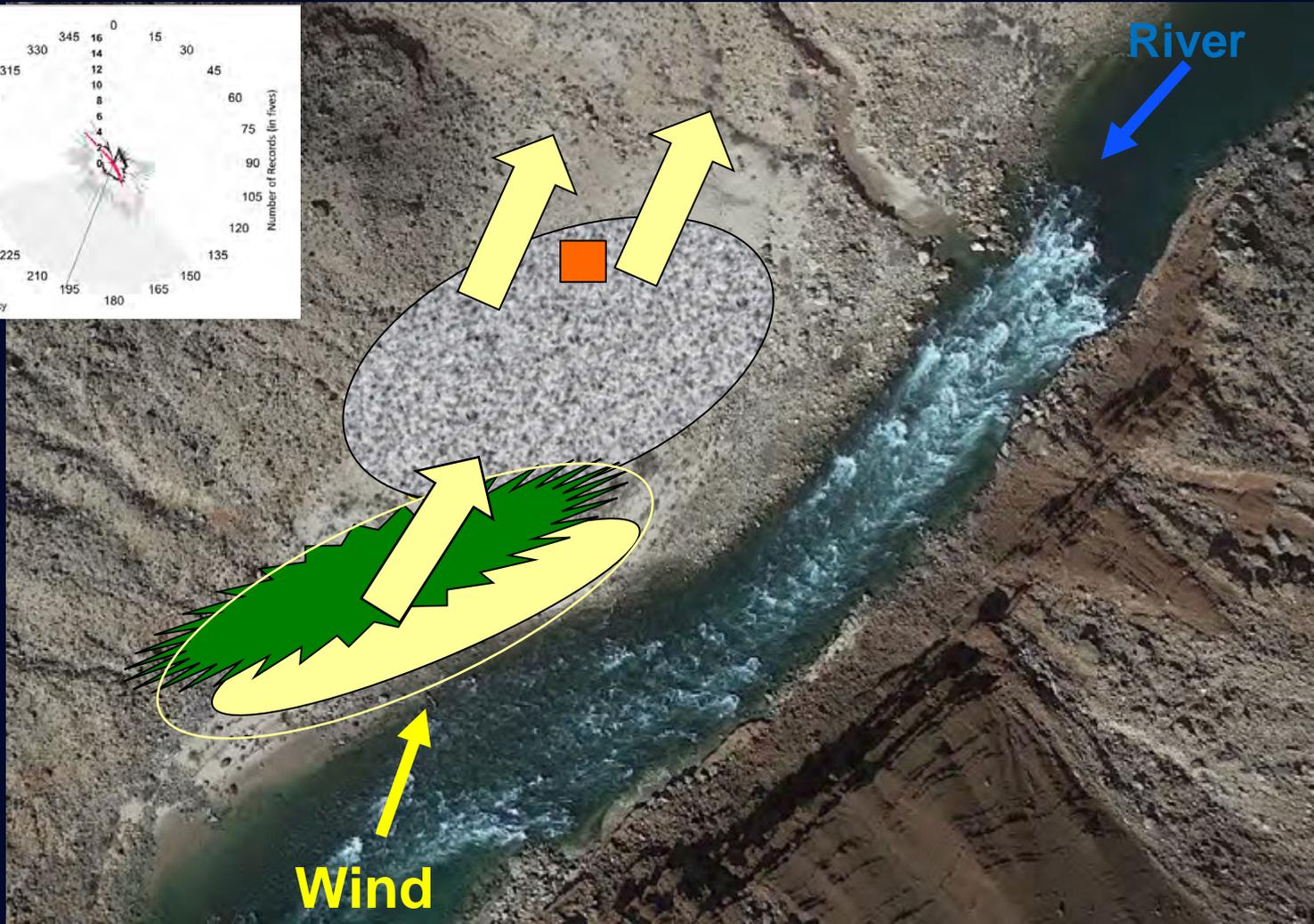
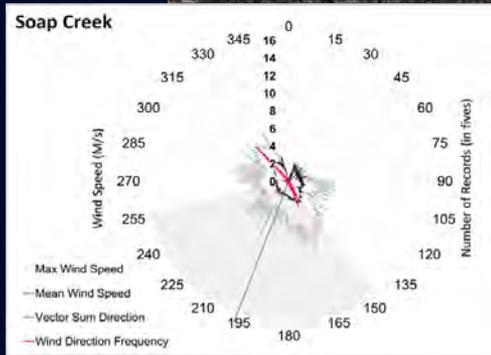
Regulated flows, lack of scouring floods, allowed riparian vegetation to colonize bare sand areas



Former camp at RM 74.7

Vegetation cover blocks wind, covers bare sand, reduces aeolian transport

What does aeolian sand have to do with dam operations?



Landscape processes are directly affected by aeolian sand replenishment

- Aeolian dunes without modern sand supply are less active, develop more biologic soil crust; once gullies form in this crust, they are likely to keep expanding
- Sites receiving river-derived sand (fluvial and aeolian) more resilient; annealing of small gullies can occur



Repeat Photography has a rich history in Grand Canyon and the Natural Sciences!

IN THE FOOTSTEPS OF
**JOHN WESLEY
POWELL**
AN ALBUM OF COMPARATIVE PHOTOGRAPHS OF THE
GREEN AND COLORADO RIVERS, 1871-72 AND 196

Recent Vegetation Changes Along
Colorado River Between Glen Canyon
and Lake Mead, Arizona

GEOLOGICAL SURVEY PROFESSIONAL PAPER

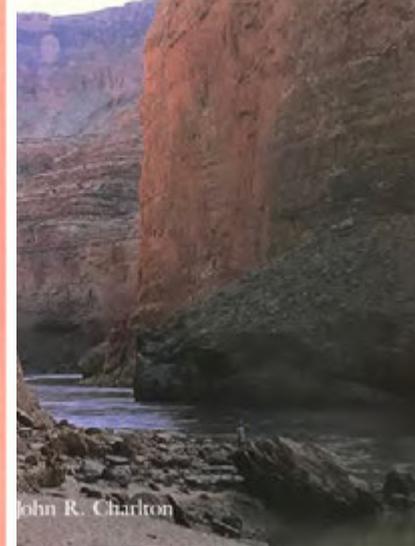
Grand Canyon a Century of Change

2nd Edition

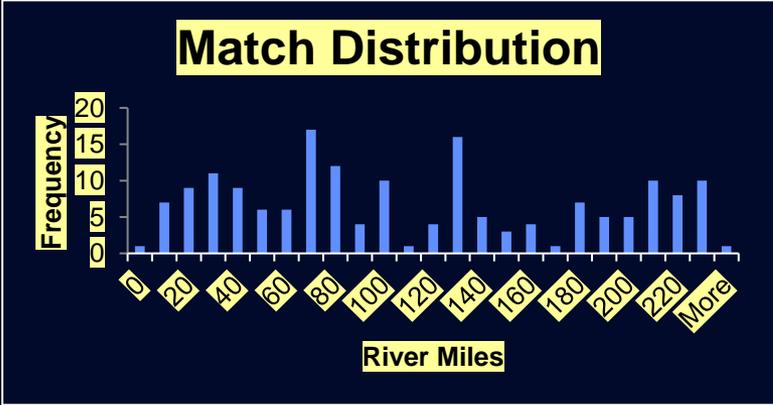
THE
GRAND CANYON REVISITED
A Rephotography of the
GRAND CANYON
1923/1991

REPEAT PHOTOGRAPHY
Methods and Applications in the Natural Sciences

edited by
ROBERT H. WEBB • DIANE E. BOYER • RAYMOND M. TURNER



Repeat Photography, FY16-20

- Relies on unpaid volunteers (photographer and riparian ecologist), personal equipment
 - All work performed in conjunction with other project elements and permitted river trips
 - ~200 matches so far
 - Focus on matching photos from 1923 USGS trip
 - Matches not evenly distributed
- 
- | River Miles | Frequency |
|-------------|-----------|
| 0 | 1 |
| 20 | 8 |
| 40 | 10 |
| 60 | 12 |
| 80 | 18 |
| 100 | 10 |
| 120 | 5 |
| 140 | 18 |
| 160 | 8 |
| 180 | 5 |
| 200 | 10 |
| 220 | 10 |
| More | 10 |
- Each panorama match requires 7 digital images
 - 1-3 hours required to complete each match
 - For each match, we also collect detailed info on plants in photo view (previous vs. present) plus any other visible changes

Some 1923 photos were matched in 1990s, allowing study of MLLF effects*

E. C. La Rue
08/02/1923



E. Hymans
Ca. 1991



A. H. Fairley
05/06/2017



Stake 1091, RM 11.5 R, Soap Creek



* Asterisk denotes photo match at or near a Project D monitoring site

Current digital images have very high resolution, allowing detailed analyses



Mouth of Little Colorado River from right side of Colorado River

Exact matches vs. “pseudo-matches”



E. C. La Rue
08/30/1923



A.H. Fairley
05/06/2018

Stake 2056, true match

RM 98.7 L, Crystal Camp



S2056x, pseudo match

Every match shows vegetation increase!

E. C. La Rue
08/02/1923

Stake 672
RM 10.6 L



A. H. Fairley
05/05/2017



Even bedrock shorelines have increased vegetation

E. C. La Rue
09/29/1923



Stake 5315
RM 214.1 L

A. H. Fairley
09/05/2017



Vegetation increase is densest on bare sand

E. C. La Rue
09/30/1923



RM 217.9 L
Stake 703



A.H. Fairley
05/18/2017

In addition to covering bare sand, vegetation encroachment is leading to channel narrowing in some areas

E. C. La Rue
09/27/1923

Stake 1802
RM 204.5 R



A. H. Fairley
05/11/2018



Matches from early 1990s show less shoreline vegetation than today

E. C. La Rue
08/14/1923



E. Hymans
02/24/1993



A. H. Fairley
05/10/2017



Stake 1707a, RM 66.0 L

Another Example . . .

E.C. La Rue
09/13 /1923



E. Hymans,
Ca. 1991



A.H. Fairley,
5/16/2017



Many 1923 sand bar camps (aeolian sand sources) are unavailable today due to vegetation encroachment

E. C. La Rue
08/10/1923



Stake 678
RM 43.9 L

A.H. Fairley
05/06/2019



The original President Harding Camp

Repeat photographs of RM 43.9 L, stake 677

E. C. La Rue
08/10/1923



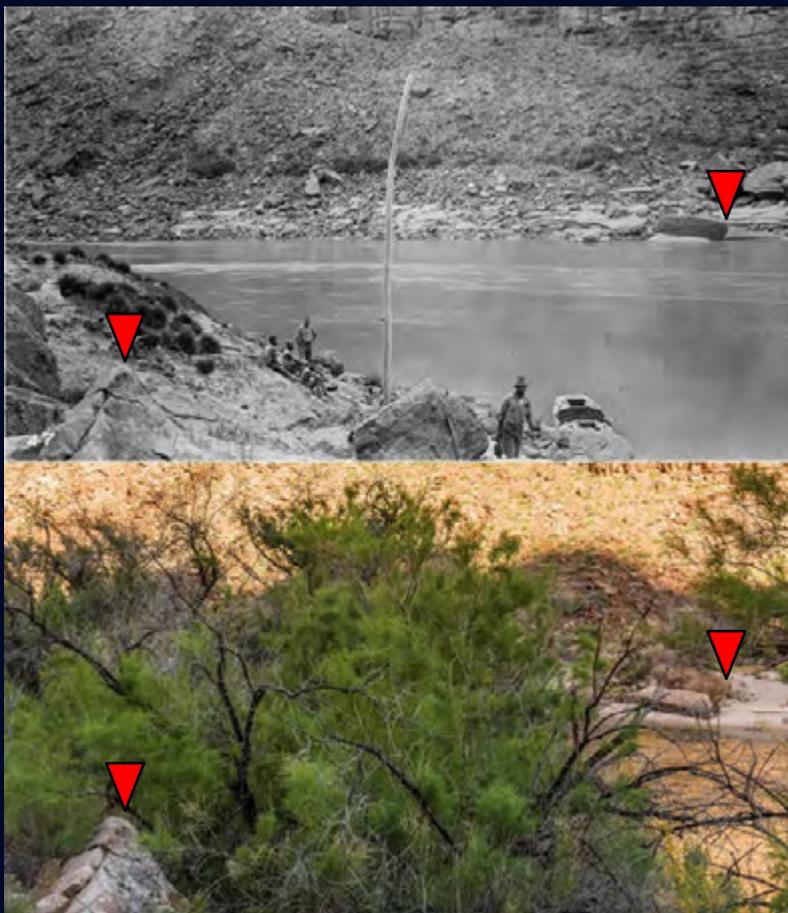
Stake 677
RM 43.9 L

A. H. Fairley
08/26/2017

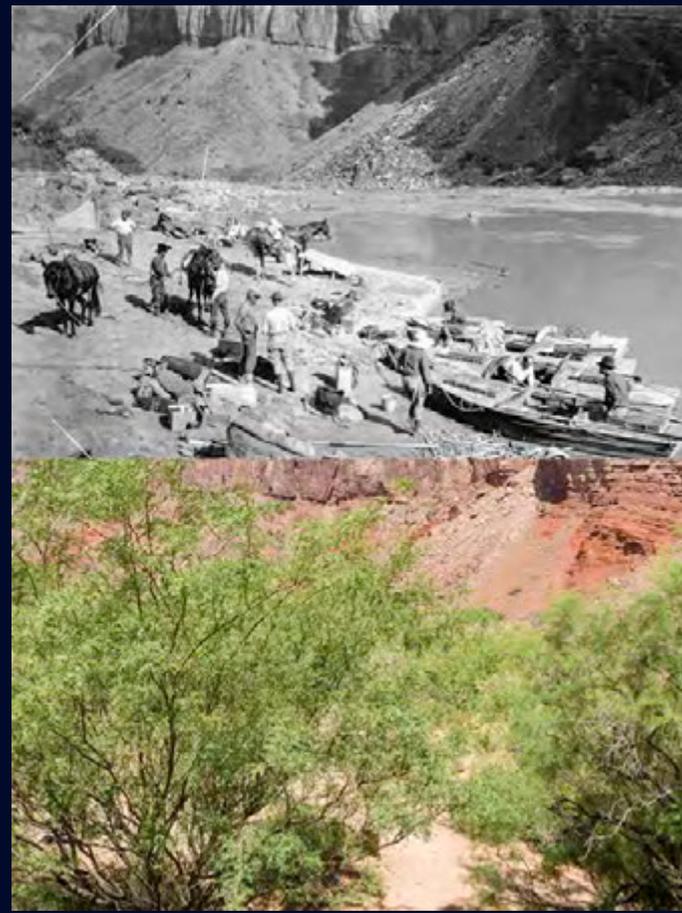


More 1923 camps

22-Mile Camp



Top of Hance Rapid



Stake 714: RM 22.1 R
Top: E. C. La Rue, 08/06/1923
Below: A. H. Fairley, 05/06/2017

Stake 715: RM 77.1
Top: L. Freeman, 08/1923
Below: A. H. Fairley, 05/10/2019

Another 1923 camp . . .

E. C. La Rue
09/25/1923



A. H. Fairley
05/17/2017



TRUE
MATCH



Stake 2839, RM 197 L

Same camp, slightly different view

A. H. Fairley
05/12/2016



E. C. La Rue
09/25/1923



Loss of aeolian sand has affected large portions of the bio-cultural landscape of the Colorado River ecosystem



Lower Unkar, RM 73.9 L. Top, S1575, looking upstream; Below, S1574, DS view. Left: R. B. Stanton, 01/24/1890; Right: A. H. Fairley, 08/23/2017

With loss of sand supply, dunes have become less active, more vegetated*

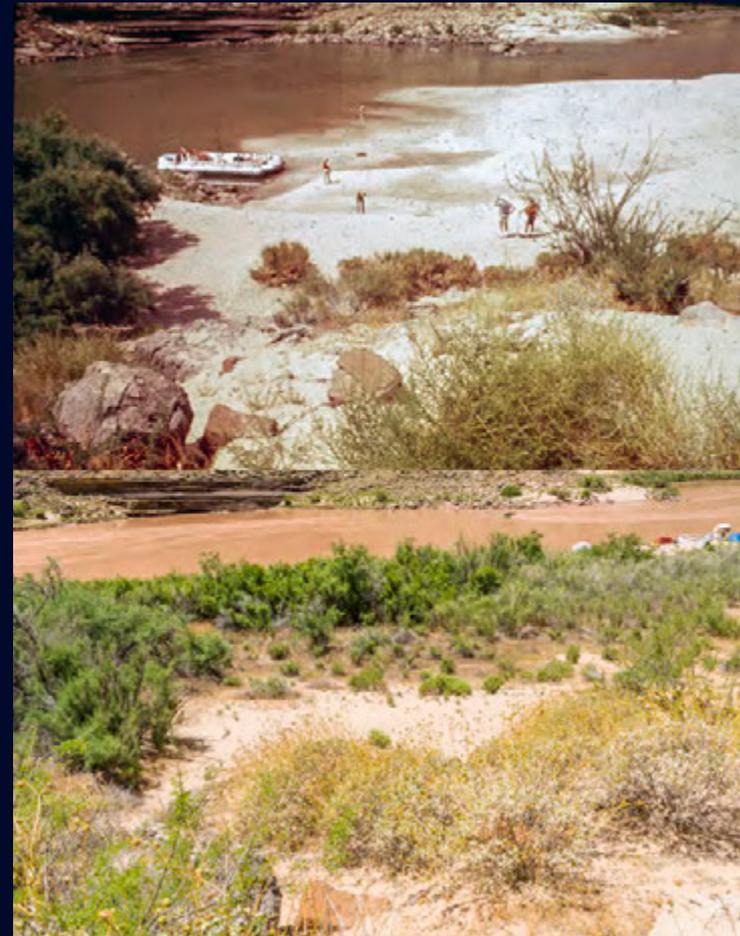
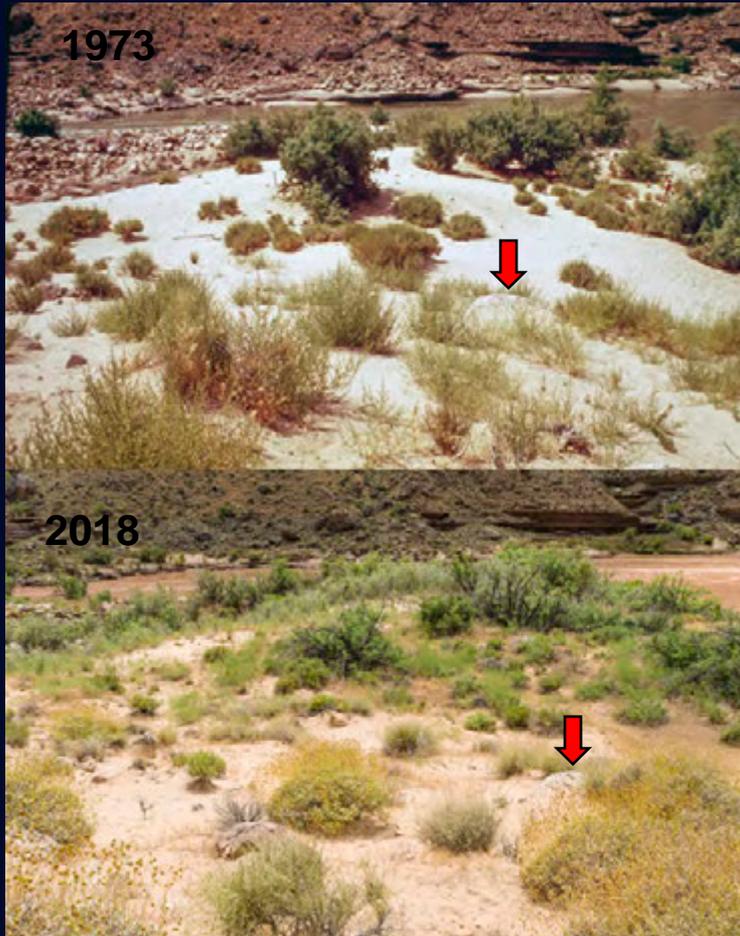
River Mile 24.7 L
Left: R.B. Stanton
07/14/1889,
Right: A.H.Fairley,
05/07/2017



River Mile 125.6 L
Left: R.B. Stanton
02/21/1890,
Right: A.H. Fairley,
08/31/2017

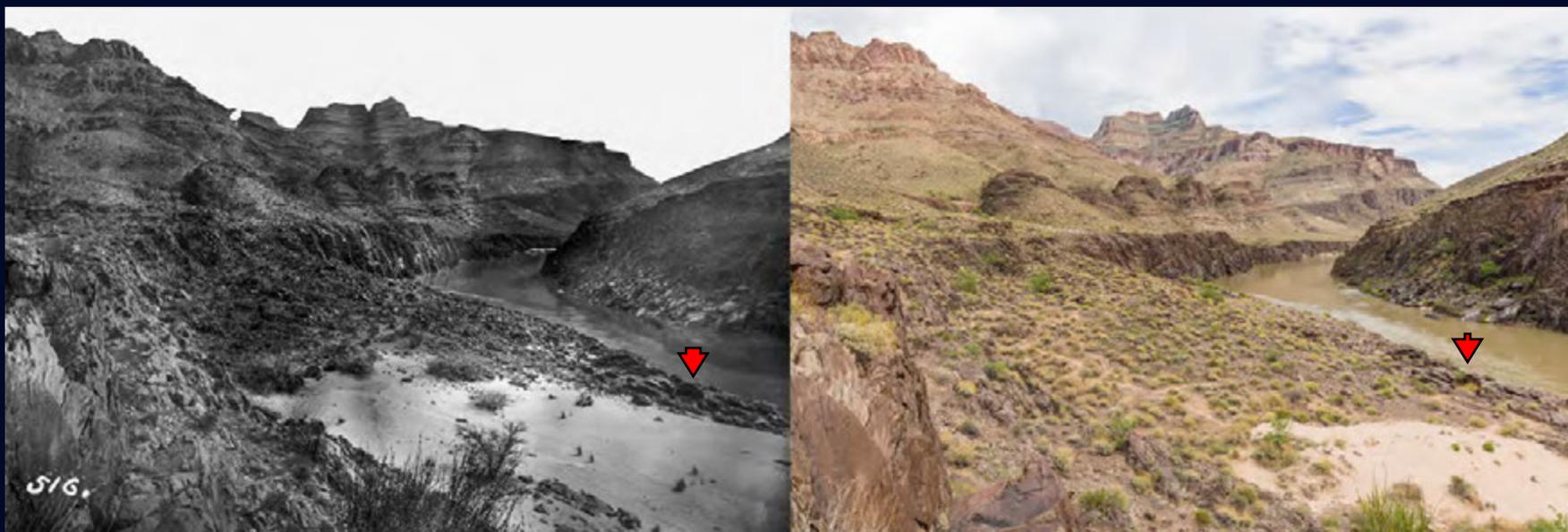


Loss of fluvial-aeolian connectivity impacts area and quality of campsites as well as archaeological site integrity*



122 Mile Camp (Project D Study Site)
Top: Borden-Weeden photos, July 1973
Bottom: A. H. Fairley, May 12, 2019

Bass Camp: an example of how aeolian sand contributes to camp site area . . .



R. B. Stanton, 02/17/1890

A.H. Fairley, 05/11/2019

RM 109 R, Bass Camp, upper half (Stake 1580)

... and quality! As aeolian sand deflates and is not replenished, rocky substrate becomes increasingly exposed

July 1973



May 2019



Upper camp

Middle camp

Bass Camp, River Mile 108.9

Loss of aeolian sand has implications for the plants and animals that need or prefer aeolian sand habitats*

Lower Granite Camp, River mile 93.9 L



This photo match shows how perennial shrubs (mostly *Isocoma acradenia*) have largely replaced the bunch grasses (mostly *Achnatherum hymenoides*, a.k.a. Indian Rice Grass) which formerly grew abundantly on the dunes at lower Granite Rapids

Dam-induced ecological changes affect locations of traditional cultural significance, not just camps and archaeological sites*

E.C. La Rue
09/18 /1923



Stake 2239x
RM 171.9



A.H. Fairley
05/15/2019

Questions?



Tad Nichols, 07/13-14/1958

A. H. Fairley, 05/15/2019



Left Photo: Mexican Hat Expeditions boats parked at mouth of Mohawk Canyon; river flow ~65,000-70,000 cfs