Project J Summary: Conditions and processes affecting sand resources at archaeological sites

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Project J: 2013-2014
Overview questions

- Do cultural sites erode or change faster or in a significantly different manner than they would if dam operations were different?

- How effective are HFEs at supplying aeolian sand to upland landscapes and archaeological sites?

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What happens to upland landscapes = what happens to archaeological sites

- To understand processes and risks of site erosion, Project J included both site- and landscape-scale studies
- Highly likely that yet-undocumented arch sites are within river-corridor sand deposits

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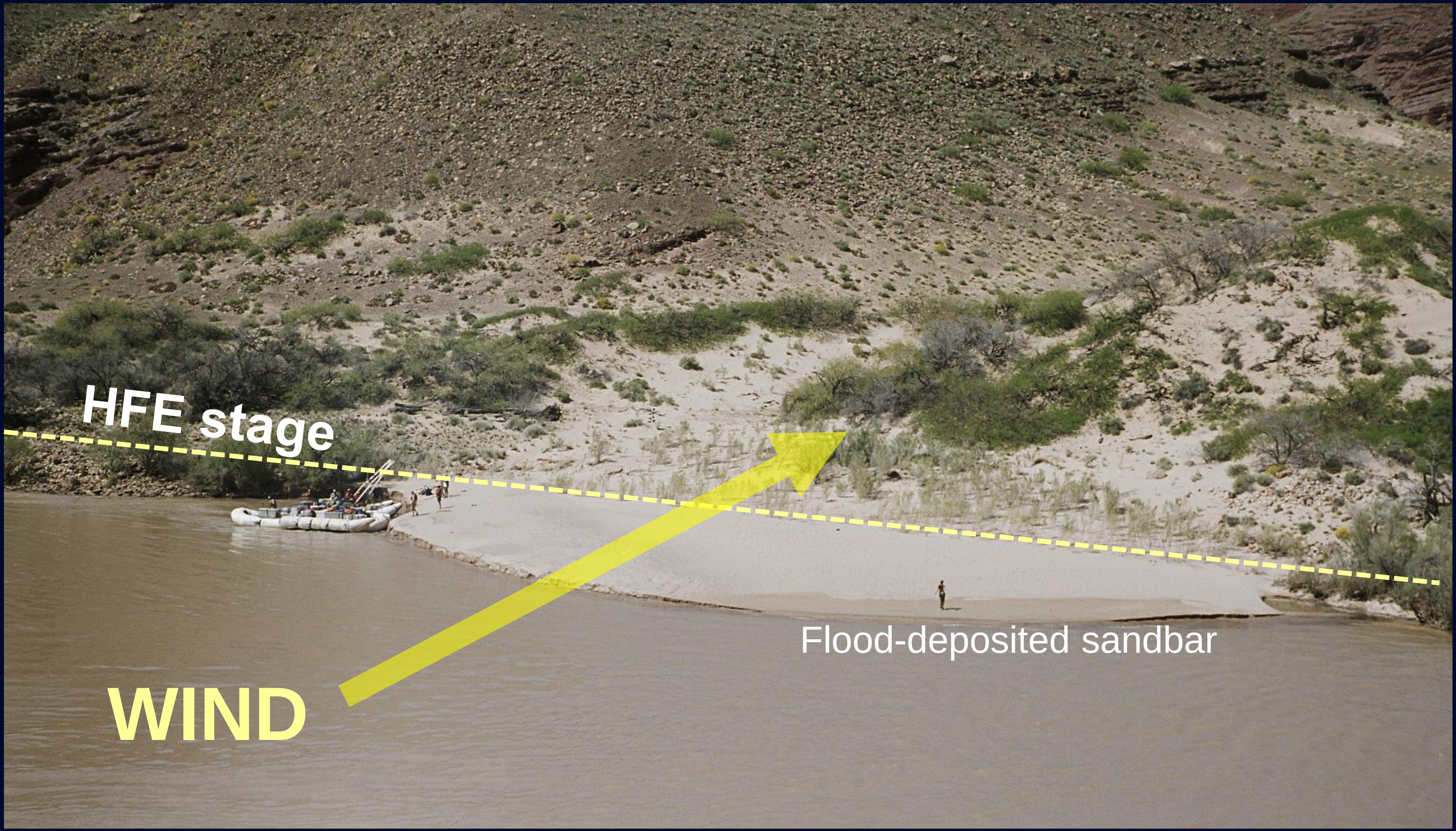
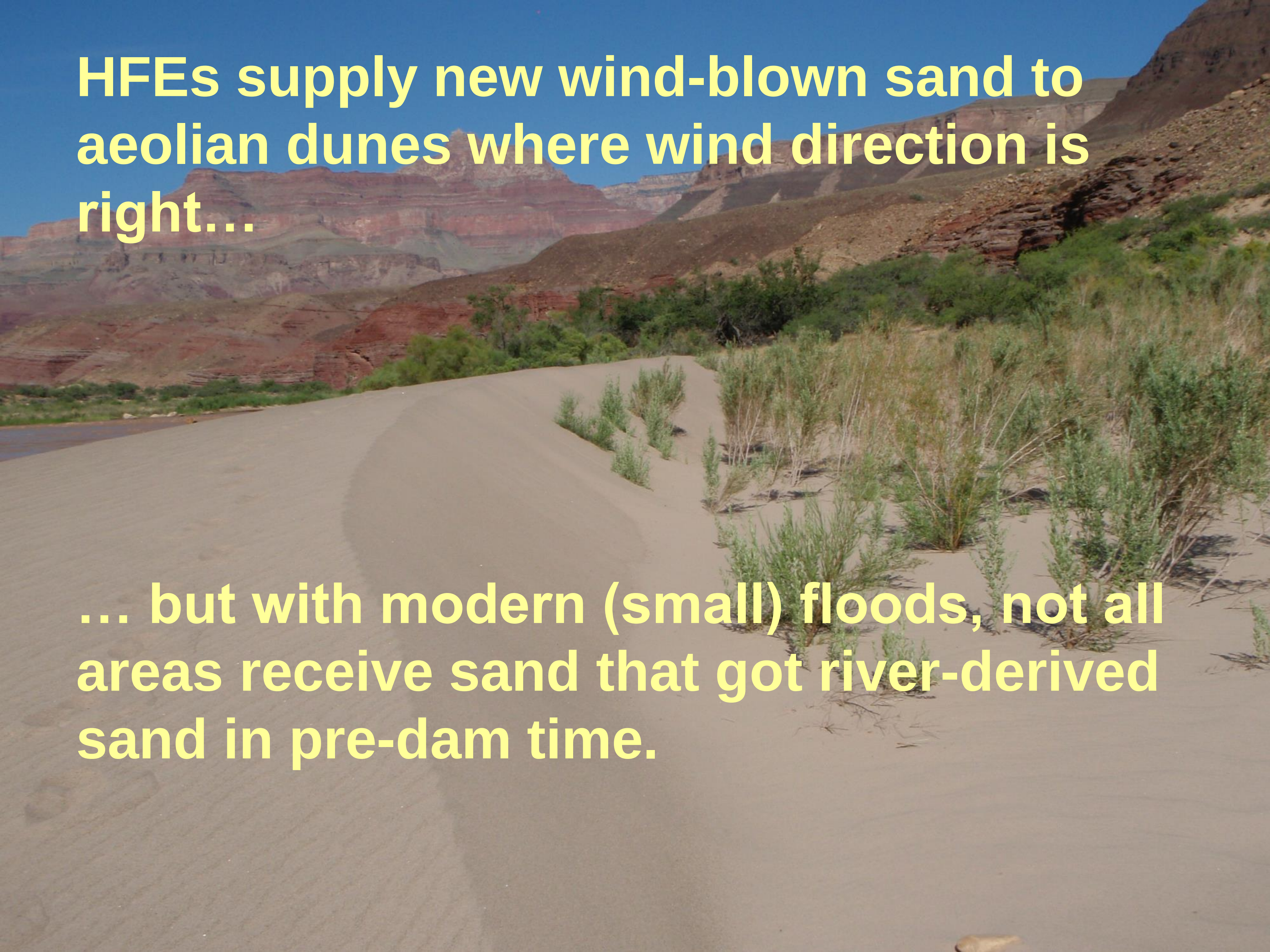
Aeolian landscapes form downwind of river sandbars: "source-bordering dunes"





HFEs supply new wind-blown sand to aeolian dunes where wind direction is right…

… but with modern (small) floods, not all areas receive sand that got river-derived sand in pre-dam time.

Link between river sediment and upland aeolian landscapes

- Aeolian dunes get sand from fluvial (flood) sandbars
- Aeolian dunes without modern sand supply develop much more biologic soil crust, become less active
- River-derived sand (fluvial and aeolian) matters to hundreds of river-corridor archaeological sites

Project J: 2013-2014 Research questions

At landscape scale

- What number and proportion of arch sites potentially receive windblown sand from HFEs?
- Role of aeolian sand in limiting gully erosion?

At site scale

- At sites that receive HFE sand, does aeolian deposition sufficiently outpace erosion by rainfall and gullying? How well does HFE sand preserve sites?
- How do conditions in Glen Canyon compare with those in Marble-Grand Canyon?

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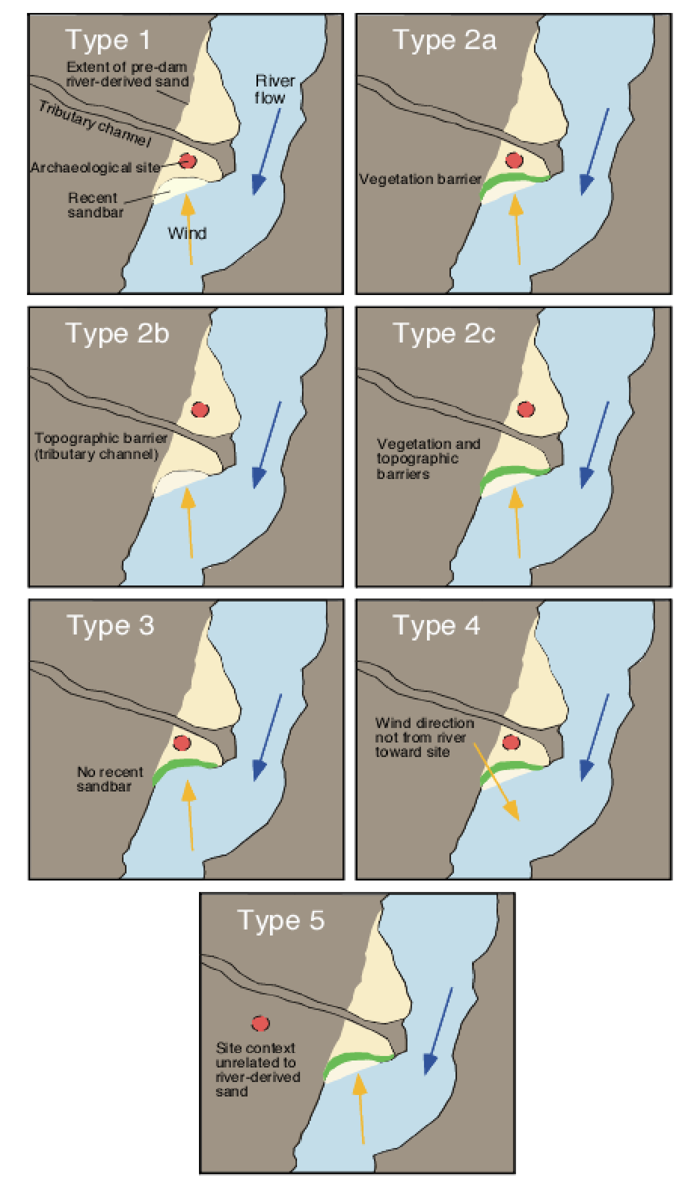
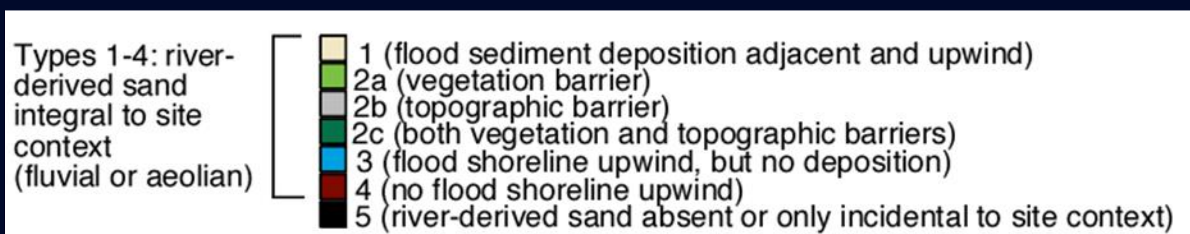
What number and proportion of arch sites potentially receive windblown sand from HFEs?

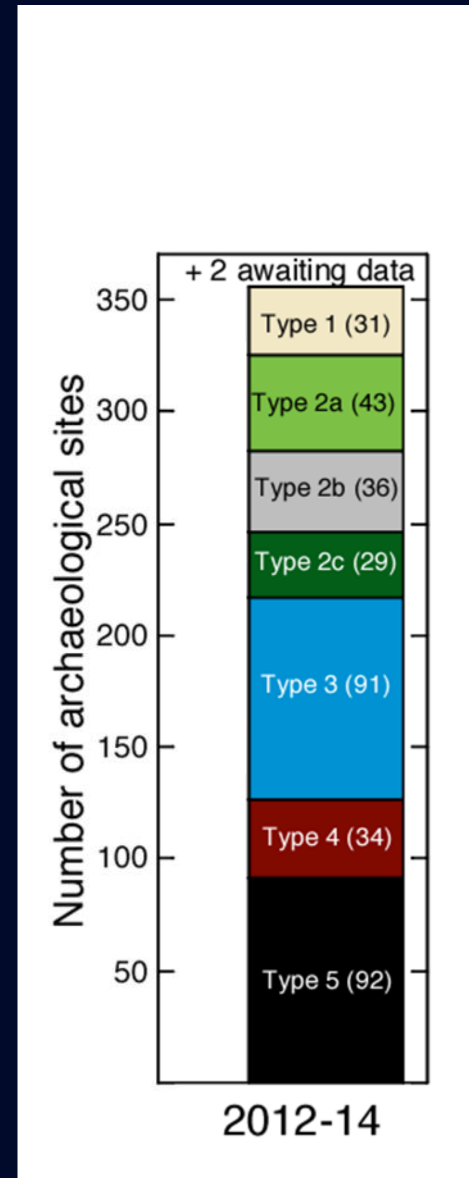


- 7-part classification system
- Evaluated 358 river-corridor arch sites, RM 0-240
- Types 1-4 have river-derived sediments as substrate
- Ranking means decreasing potential for aeolian sand supply from recent fluvial sandbars
- Modern evaluation from field data, 3 earlier time steps from aerial imagery

Preliminary results, do not cite (East et al., in prep.)

What number and proportion of arch sites currently have potential to receive windblown sand from HFEs?





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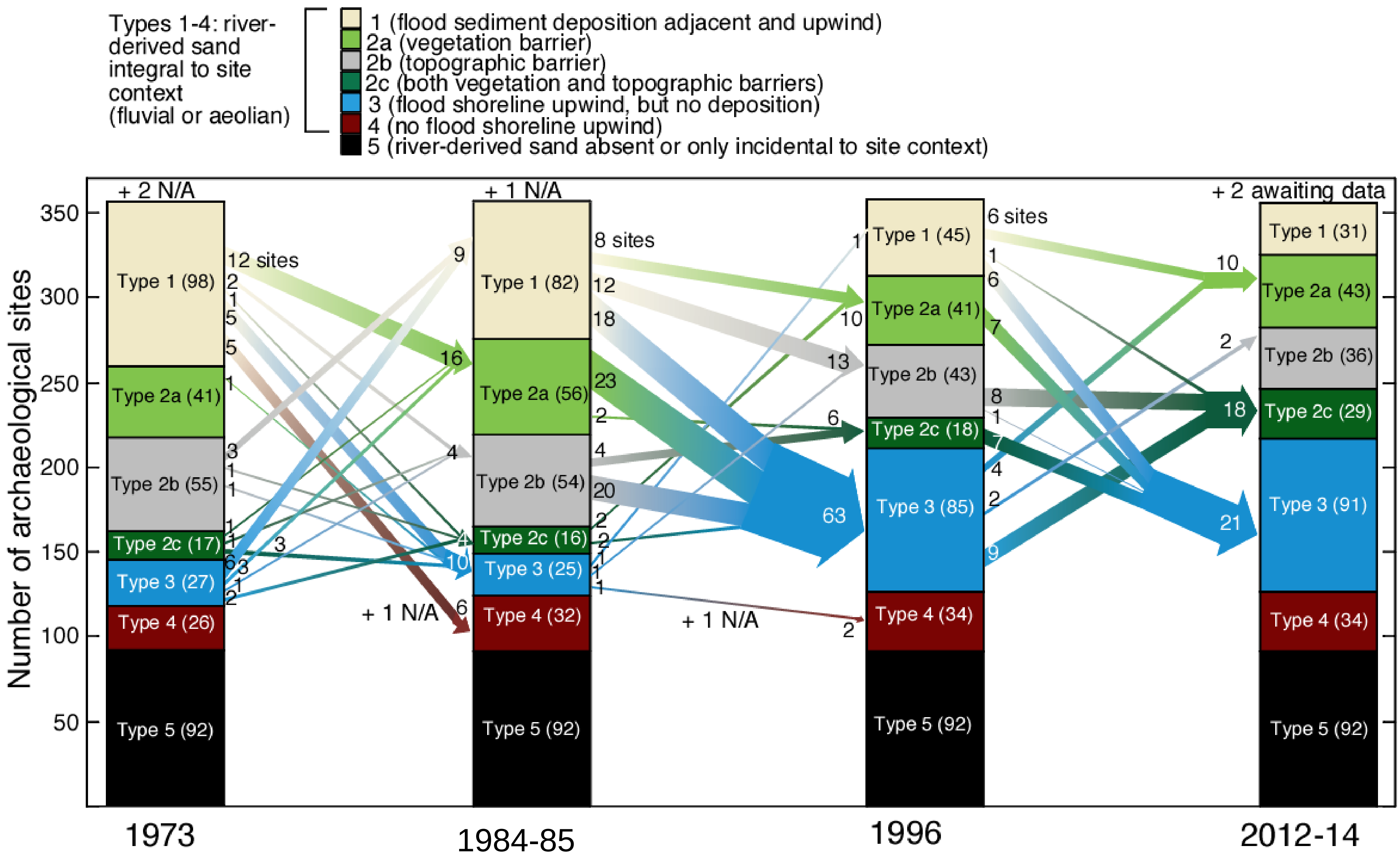
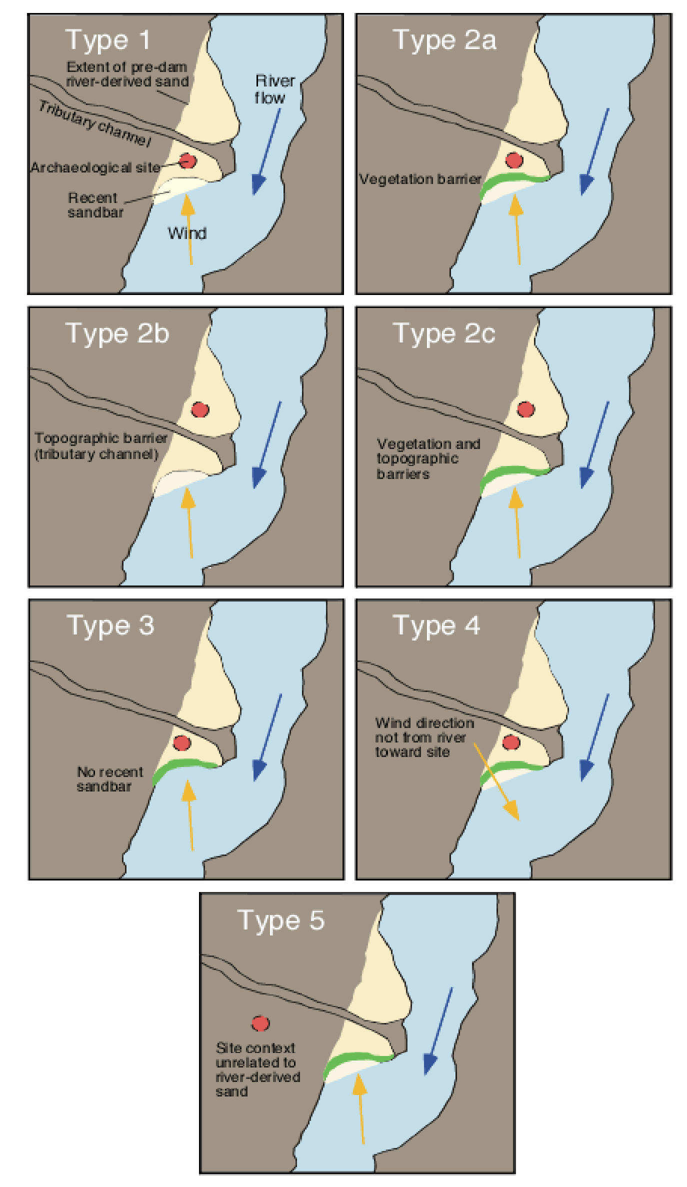


Preliminary results, do not cite (East et al., in prep.)

Classifying 358 sites: takeaway points



- **266 sites (74%) have river-derived sand as substrate (Types 1-4)**
- **232 sites in Types 1-3 (65%) are downwind of HFE shorelines (45k and less), so are potentially influenced by sandbars from flows of that magnitude**
- **Type 1 sites have best chance of getting aeolian sand, but any of Type 1-3 could get some new sand (Collins measured new deposition at a 2b site)**
- **From 1973-2014, Type 1 sites decreased due to veg growth and non-deposition**

Preliminary results, do not cite (East et al., in prep.)

Limitations and caveats

- Some Type 1 sites “do better” than others; being Type 1 doesn’t guarantee the site will have new aeolian deposition or stay preserved well, only that it has a good sand-supply pathway (high connectivity) from HFE sandbars
- We did not quantify relative area or volume of sandbar sources and downwind sandy landscapes (sandbars can change a lot on short time scales)
- Classification is “living document” – historical variability warrants future investigations

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How effectively does aeolian sand counteract gully erosion?

- **Balance between forces forming gullies (rainfall, overland flow erosion, base level) and annealing them (aeolian sand) – our focus.**
- **Windblown sand fills topographic lows**

We mapped sand activity and gullies in 6 reaches, to test hypothesis that gullies would be less common in active sand

"Active" aeolian sand has wind-rippled surfaces, slip faces at angle of repose
(Lancaster, 1994)

"Inactive" sand (often areas without modern sand supply) gets covered with biologic crust, further decreasing its aeolian activity

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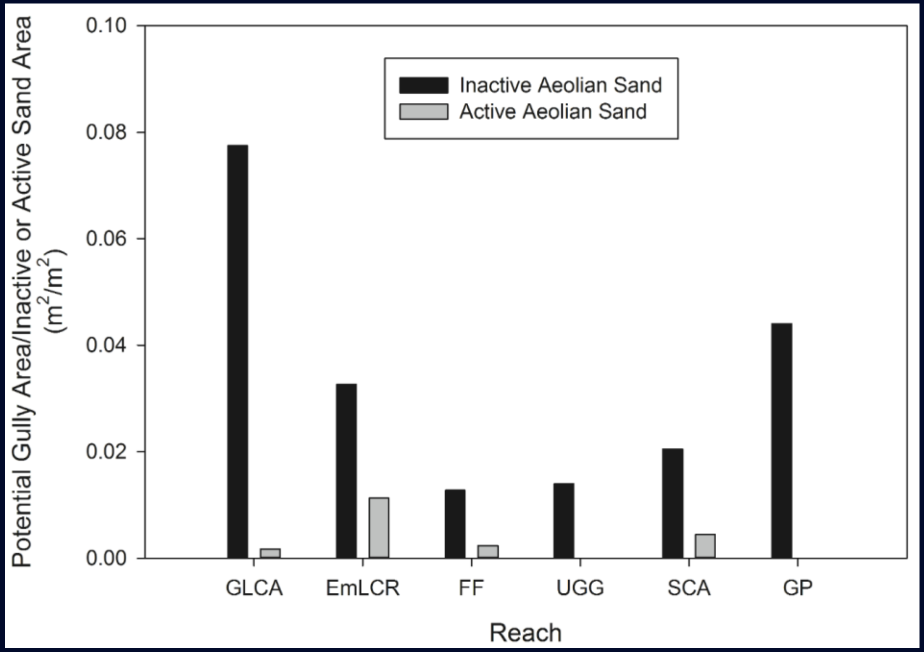
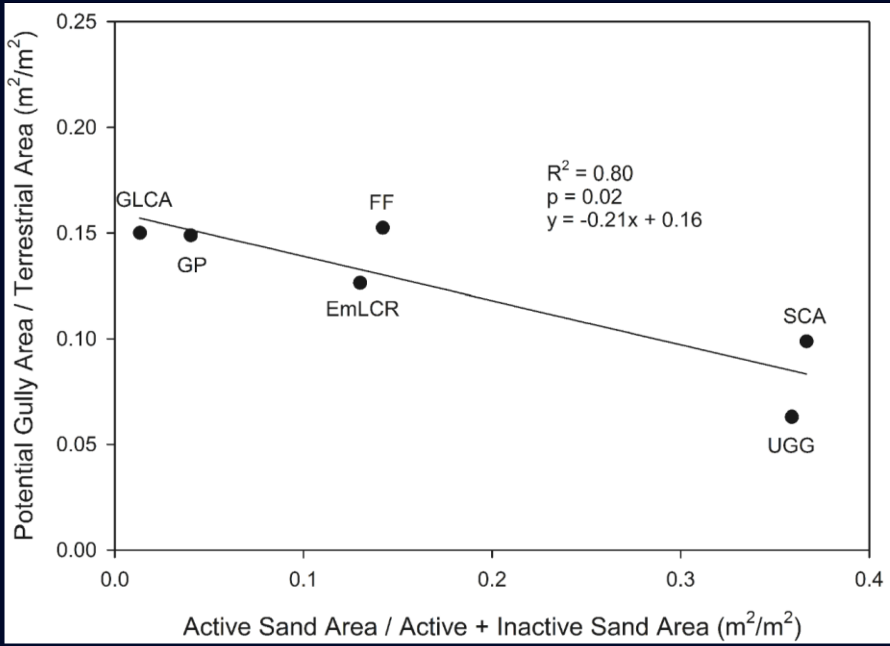
Aeolian sand activity anneals gullies

- Gullies are more prevalent in inactive sand
- More gullies terminate in active aeolian sand

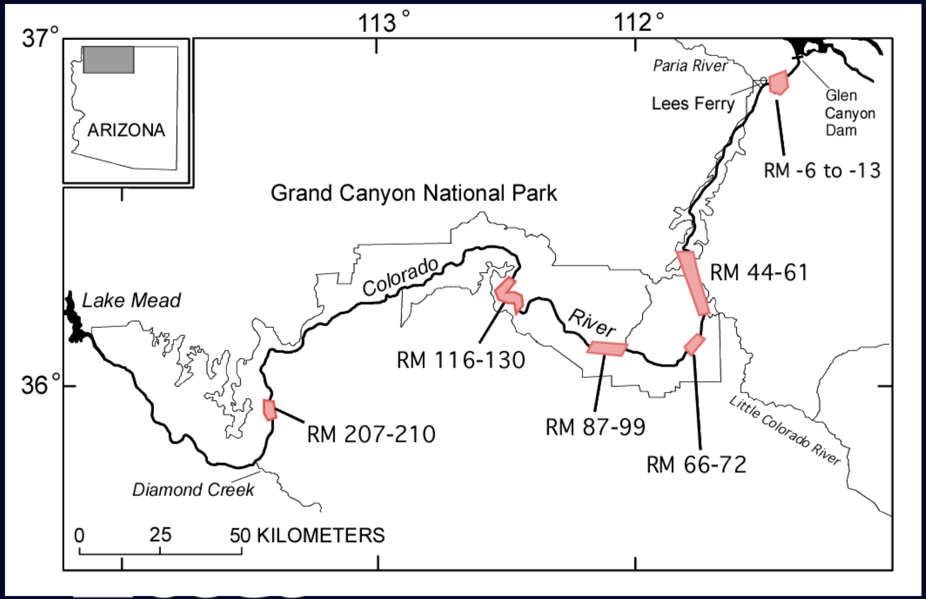


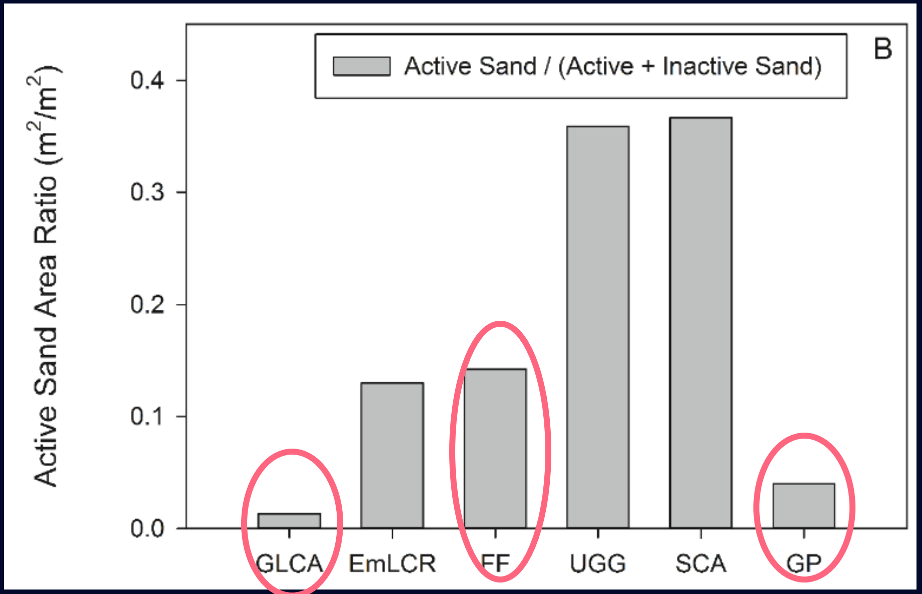


From Sankey and Draut, 2014 (*Geomorphology*):
gullies occupy much less proportion of the sand area in active sand deposits

Relative abundance of active and inactive sand

- **Major differences, by reach, in the proportion of active aeolian sand**
- **Greatest arch-site concentrations also occur in places with greatest % inactive sand, so greatest susceptibility to gully erosion** (see also Pederson and O'Brien, 2014)





From Sankey and Draut, 2014 (*Geomorphology*)

Management implications…

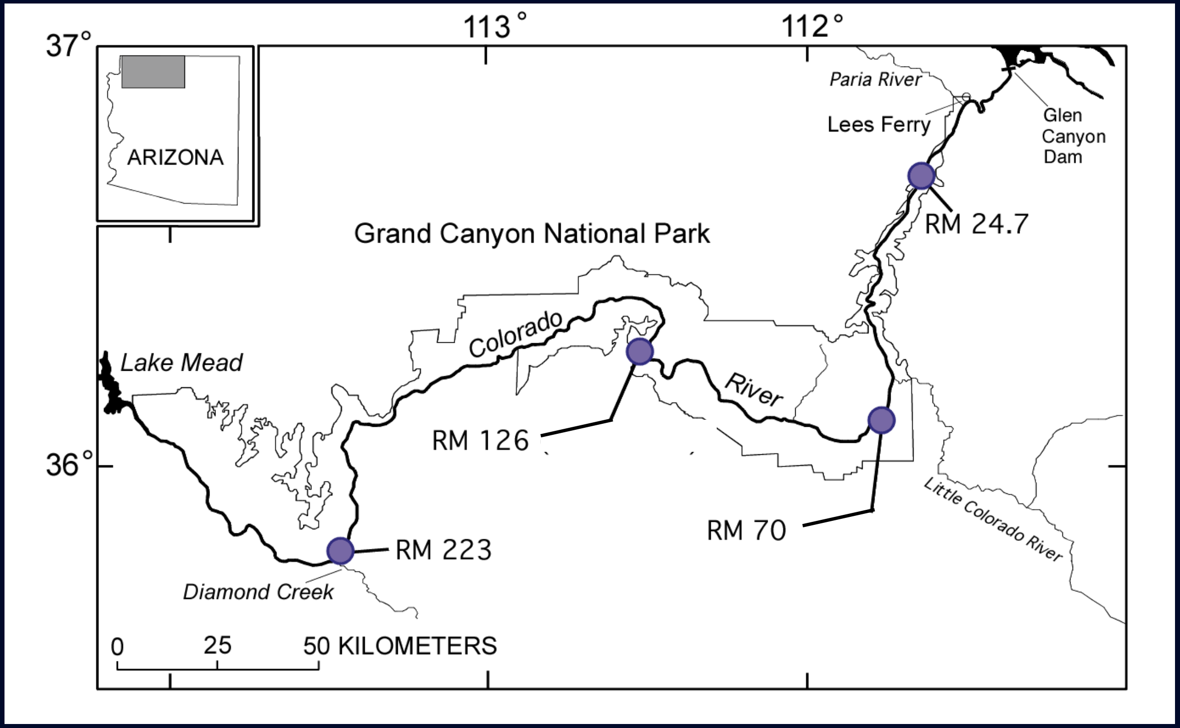
- HFE sand sources mean greater aeolian sand activity in dune fields immediately downwind of sandbars (Draut, 2012)
- Gullies can form in active sand, but are more likely to anneal instead of getting progressively larger
- So, yes, HFEs can reduce gully extent in areas with upwind sandbars

Management actions that increase deposition of active aeolian sand area can limit/reduce gully erosion.

← Gullies will not last long in places like this.

At site scale, for Type 1 sites:
Is aeolian sand supply enough to outpace erosion and enhance site preservation?

- Measure rainfall, wind at weather stations at 4 sites
- Terrestrial lidar scanning in 2013-14 (and 2006-10)
- Stationary cameras for daily record of site conditions



At four Type 1 “best case scenario” sites, what processes contribute to site stability or erosion, and at what rates?

Site C:05:0031 - Gullies from monsoon storms (rainfall as intense as 75 mm/hr)

8/22/2013, 3 p.m.

8/23/2013, 7 a.m.

9/11/2013, 3 p.m.

9/12/2013, 7 a.m.

Preliminary results, do not cite (J. Caster)

At four Type 1 "best case scenario" sites, what processes contribute to site stability or erosion, and at what rates?

Site C:05:0031 - Gullies that formed in monsoon season 2013 partially annealed during the spring 2014 windy season.

3/9/2014, 1 p.m.

5/1/2014, 1 p.m.

Preliminary results, do not cite (J. Caster)

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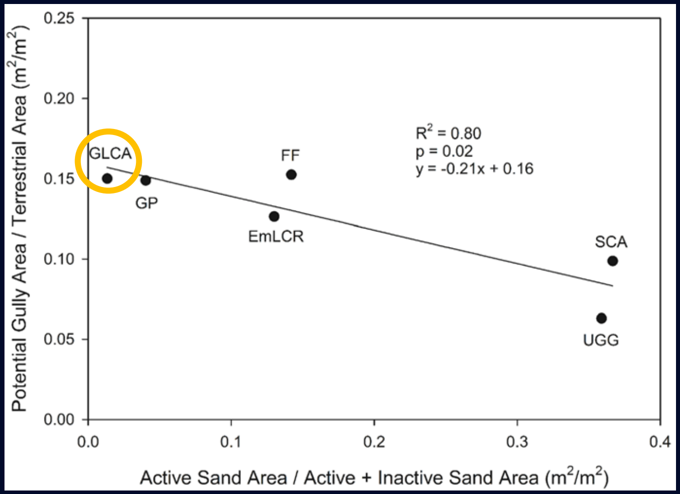
Are Glen Canyon sites significantly more eroded than those downstream from Lees Ferry where sand supply is greater?

- Measure site topography with lidar (airborne & terrestrial), compare with previous data in Marble-Grand Canyon
- Compare weather records – does Glen Canyon get more rain?

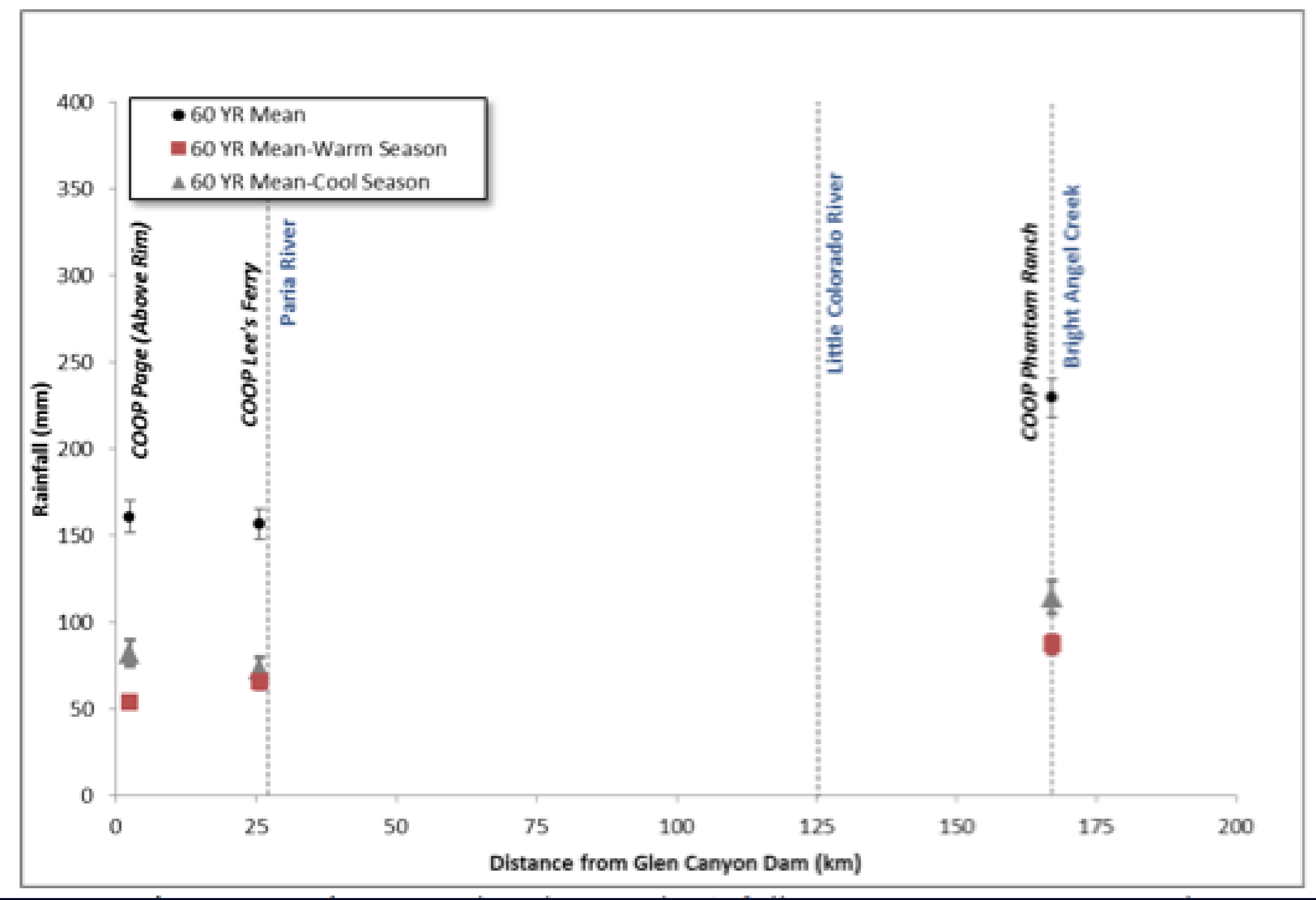


Sankey and Draut, 2014 (*Geomorphology*)

Glen Canyon vs. Marble-Grand Canyon

- **Glen Canyon area gets similar or slightly less rain, and less intense rain, compared to Marble-Grand Canyon**
- **Rainfall differences cannot explain the major gullying there**

60-year record (1952-2012), NOAA stations



Preliminary results, do not cite (Caster et al., in prep.)

Why such intense gullying in Glen Canyon?

- Glen Canyon morphology promoted formation of large, predam flood terraces and does not include large fan/eddy complexes to store modern sandbars (aeolian sand sources)
- Dune fields were apparently not well-developed even predam – few dunes, wind scoured river terraces today
- Substantial incision of bed (lowering of base level; Paul Grams' work) would exacerbate gully formation
- Near-absence of tributary sediment supply would discourage annealing
- So arch sites in GLCA seem at exceptional risk of gully erosion, very low potential for aeolian annealing

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Summary – Project J Findings

- There are individual reaches with particularly high density of archaeological sites that are especially susceptible to gullying (Furnace Flats, Granite Park). These are large, old flood deposits with little modern sand supply (little active aeolian sand)
- Glen Canyon is especially susceptible to gullying due to unique geomorphology, where aeolian processes are not a major player and there is little modern sand supply
- Among Project J reaches, the proportion of active aeolian sand area is lower than in less-regulated Cataract Canyon
- So, we infer that gully development and the risk of gully erosion exceeds what would occur without river regulation

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Summary – Project J Findings

- The number of sites with potential to receive windblown sand decreased from 1973 to 2014.
- Management actions that increase deposition of active aeolian sand area can limit/reduce gully erosion.
- HFEs can reduce gully extent in areas with upwind sandbars.
- Sites with greatest potential to receive windblown HFE sand still undergo gully erosion on seasonal time scales. In the next talk, Brian will show examples of how this translates into changes at individual sites.