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Evaluating the Role of Aeolian Sand in the Preservation of Archaeological Sites, Colorado River Corridor, Grand Canyon, Arizona: 2003-2006 Results

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Erosion Destroys Archaeological Sites

DEFLATION

Wind removes sand grains holding sites together, uncovering buried materials. As sand is removed, artifacts from different levels become mixed together, destroying context.

INCISION

Precipitation run-off creates gullies that cut into archaeological deposits and undermine features

In a dynamic environment…

Rates of erosion reflect competition between processes that remove sediment and processes that retain or replace it, e.g.:

- **precipitation run-off** (creates gullies)
- **wind deflation** (removes sand grains)

vs.

- **growth of soil crusts** (holds sand in place)
- **deposition of sand by wind & water**

  (replaces sand, backfills gullies)

Gully at 24.5 mile

same gully backfilling with aeolian sand deposited by Nov 2004 BHBF

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Previous research re: aeolian sand & archaeological site preservation

- **Lucchitta (1991) observed that gullies did not persist in areas with abundant aeolian sand**
  - **loose sand absorbs more rainfall than hard packed soil, so less runoff**
  - **gullies rapidly backfill in active dune fields**

- Other studies:
  - Hereford and others 1989, 1993, 1995, 1996, etc.
  - Thompson and Potochnik 2000 – concluded that restorative potential of aeolian sand was important and undervalued; recommended further research

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2003-2006: Work by Draut and others (See bibliography)

Working Hypothesis: Reduction in open, dry sandbar area contributes to archaeological site erosion: dam operations limit open dry sand bars→ less sand available for aeolian redeposition → deflation by wind, unmitigated erosion by gullies.

River-level sand bar

Sand dunes above river

To understand erosion and deposition processes affecting cultural sites:

- Studied sedimentary history, geomorphology using vertical sediment exposures
- Collected weather data at 6 sites from Nov. 2003 to January 2006:
  - **Rainfall**
  - **Wind speed and direction**
  - **Aeolian sand transport**
- Established decision criteria for evaluating site sensitivity to dam operations
- All data sets used together to identify processes affecting archaeological areas, potential effects of dam operations

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Sedimentary and Geomorphic Studies

- Detailed evaluations of sediment in three areas (Palisades, Comanche, Arroyo Grande):
  - Evaluated evidence of aeolian activity, past and present
  - Evaluated other modern landscape processes, including potential sensitivity to dam operations

- Archaeological sites occur on/in fluvial, aeolian, slope-wash, distal debris-flow, and colluvial deposits

- Many covered by aeolian sand

Weather Stations at 6 locations, Nov 03 - Jan 06: Findings

- Rainfall HIGHLY variable by location
- Aeolian sand transport 10 x greater in dune fields without much vegetation or cryptogamic crust
- Wind speeds highest in spring (April - early June), when sand transport is 5-15 times greater than in other times of year (<u>implications for timing BHBFs</u>)
- Effects of 2004 BHBF: where some (dry, exposed) flood sand remained in spring 2005, and where wind direction was right, aeolian sand transport was significantly higher than pre-BHBF spring 2004

 

Malgosa

8 miles

Palisades

- Highest rainfall of any study site (2x as much as Palisades)
- Highest sand transport (10x as much as Palisades)
- NO GULLIES OR ARROYOS

- Low rainfall
- Low aeolian sand transport
- LARGE ARROYOS, GULLIES

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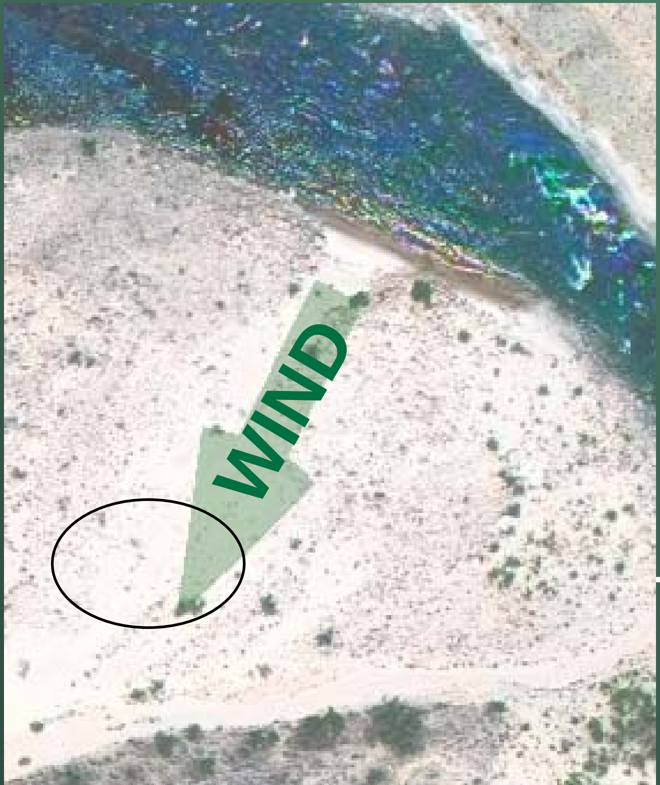
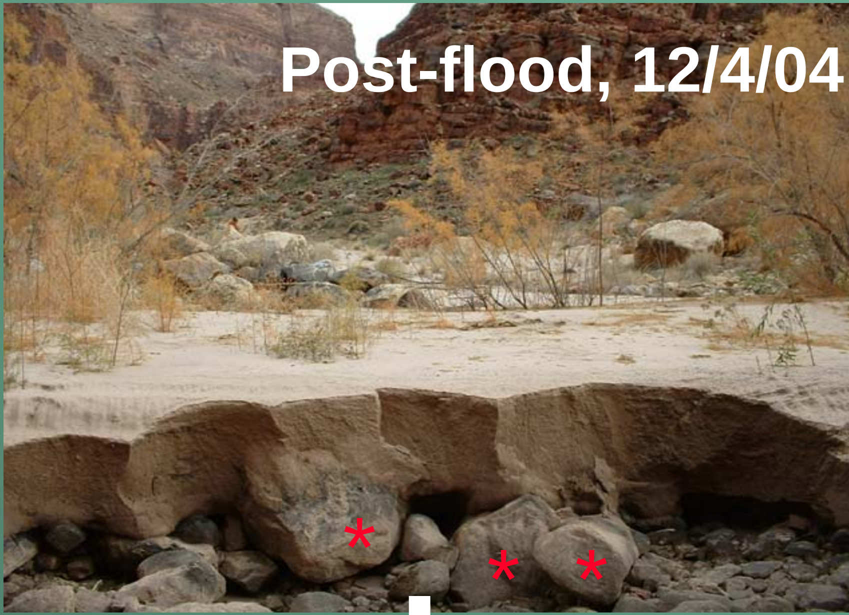
All aeolian deposits are not created equal
(in terms of origins or site preservation potential)

- MFS (Modern Fluvial Sourced) deposits
- formed by sand transported from river-level sandbars
- 45,000 cfs floods can replenish source areas

- RFS (Relict Fluvial Sourced) deposits
- formed by *in situ* reworking of large pre-dam flood deposits
- much larger floods needed to replenish RFS deposits

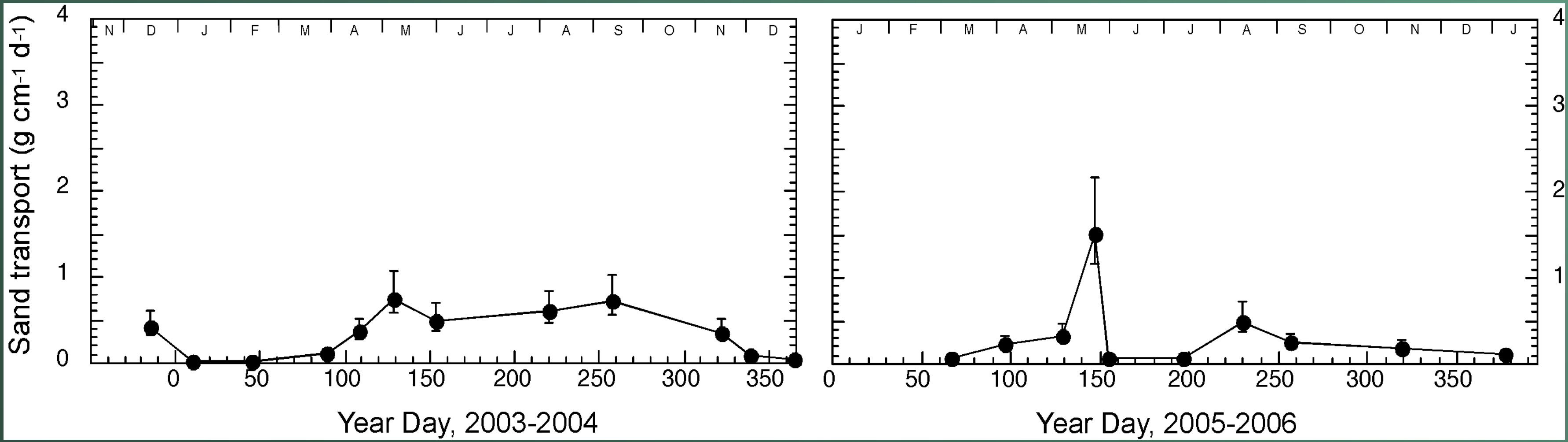


November 2004 BHBF at 24.5 mile



November 2004 BHBF at 24.5 mile

- Qp (proxy measurement for wind capacity to transport sand) was approximately 30% higher in April-May 2004 than April-May, 2005, <u>but</u>
- Sand transport DOUBLED at lower station in April-May 2005 compared to the same period in 2004
- Conclusion: increased sand transport in spring 2005 was due to increased sand supply after BHBF



24.5 mile, Lower station

SUMMARY OF KEY FINDINGS:

- High rates of aeolian sand transport appear to offset/limit gully erosion caused by rainfall
- If open, dry sandbar area can be enlarged (using BHBFs and normal dam ops), then aeolian transport of sand to MFS deposits should increase, especially during spring windy season
- All sites are not equally affected by aeolian processes; location of sediment supply in relation to predominant wind direction is key

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Next steps?

- Evaluate following hypotheses in conjunction with future BHBF tests:
  - Management policies/dam operations affect the amount of sand transported by wind upslope by controlling the availability of open sand source areas in the CRE
  - Greater availability of sand, deposited in appropriate locations by BHBFs, can enhance sediment transport to archaeological sites (and other high elevation areas in CRE), thereby offsetting erosion due to rainfall & deflation
- Systematically evaluate which/how many archaeological sites in CRE could potentially benefit from increased sand availability

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Decision criteria for evaluating site sensitivity to dam operations (re: aeolian sand transport):

1. What is the depositional context of sediment on which the site was formed? (Aeolian, or other?)
2. What is the depositional context of sediment that has buried the site? (Aeolian, or other?)

If aeolian sediment is determined to be relevant to this site:

3. Is there evidence for loss of aeolian sediment that previously covered the site? (yes/no)
4. What is the source of aeolian sediment covering the site?
5. Has that aeolian sand source declined? (yes/no)
6. Could renewed aeolian sand deposition have a significant restorative effect on this site? (yes/no)
7. How could that be accomplished? (Is wind direction right for a 45,000 cfs BHBF to put sand in upwind source areas?)

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