January 2016 Annual Reporting Meeting
Summary of Reports from Projects 2, 3, and 11

Project 2: Streamflow, Water Quality, and Sediment Transport

David Topping, Ron Griffiths, Nick Voichick, Tom Sabol, Dave Dean, Nancy Hornewer, Jon Mason, Joel Unema, Brad Garner, Dave Sibley, Megan Hines

Project 3: Bedload Sand Transport

Daniel Buscombe, Matt Kaplinski, Thomas Ashley, Paul Grams, Brandon McElroy, Robert Tusso

Project 3: Sandbars and Sediment Storage Monitoring

Paul Grams, Robert Ross, Robert Tusso, Joseph Hazel, Dan Hamill, Matt Kaplinski, Tim Andrews, Daniel Buscombe, Erich Mueller, Tom Gushue, Keith Kohl

Project 3&11 : Linkages Between Sandbar Dynamics and Riparian Vegetation

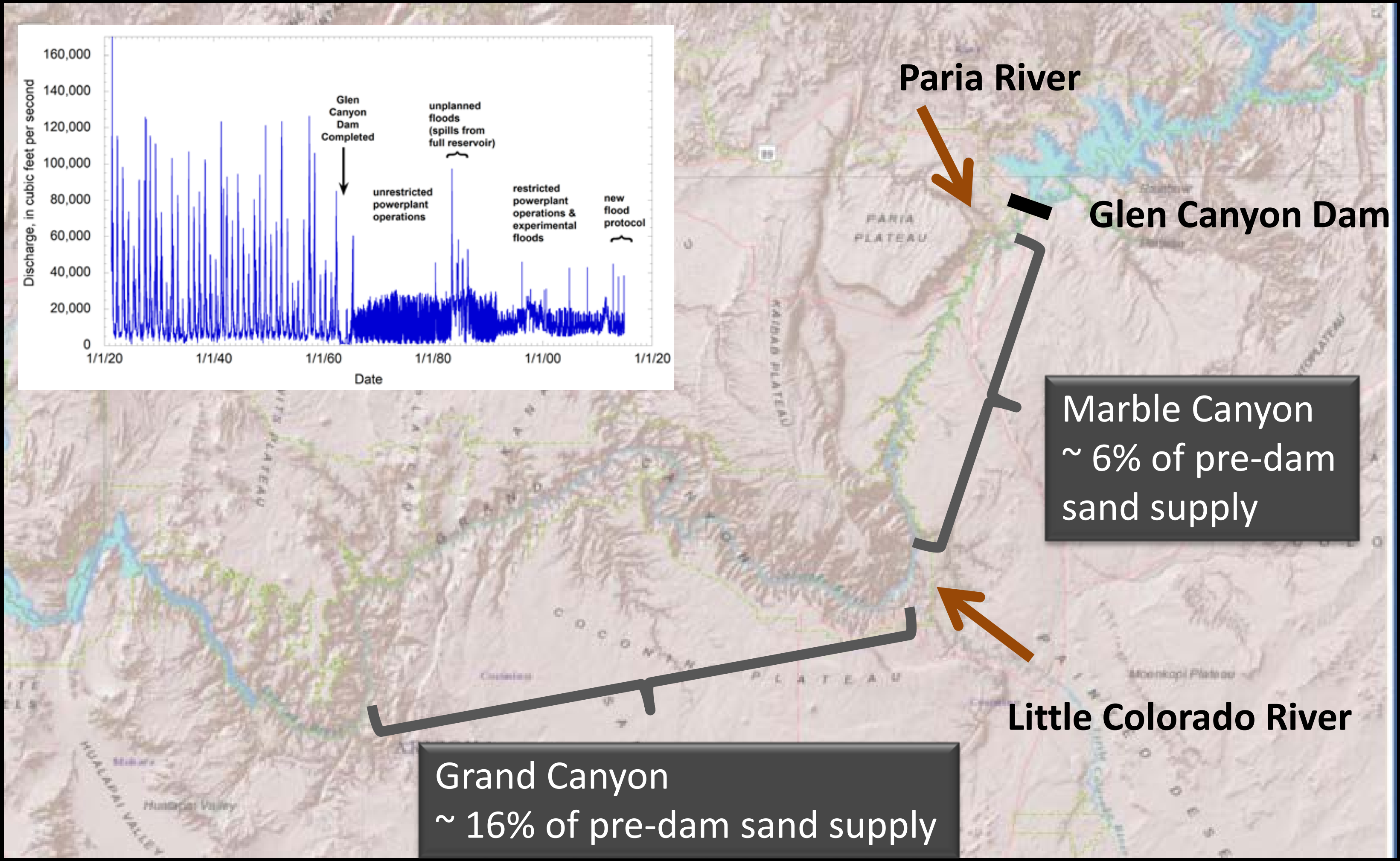
Erich Mueller, Paul Grams, Joseph Hazel, Daniel Sarr, Mark Schmeeckle

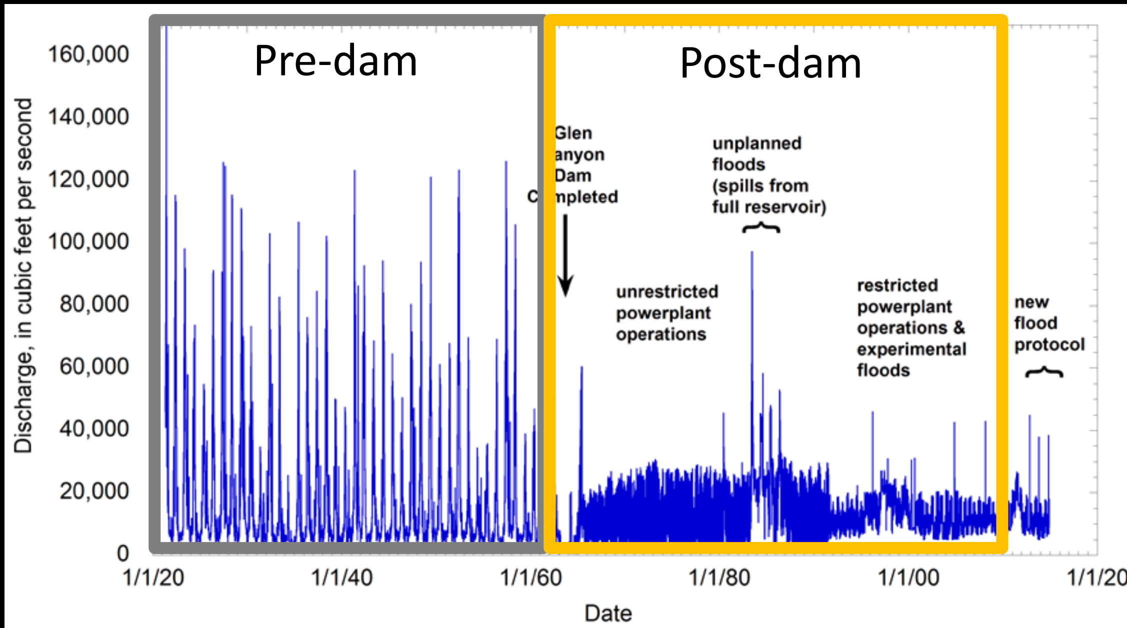
Projects 3&11: Riparian Vegetation Monitoring with Remote Sensing

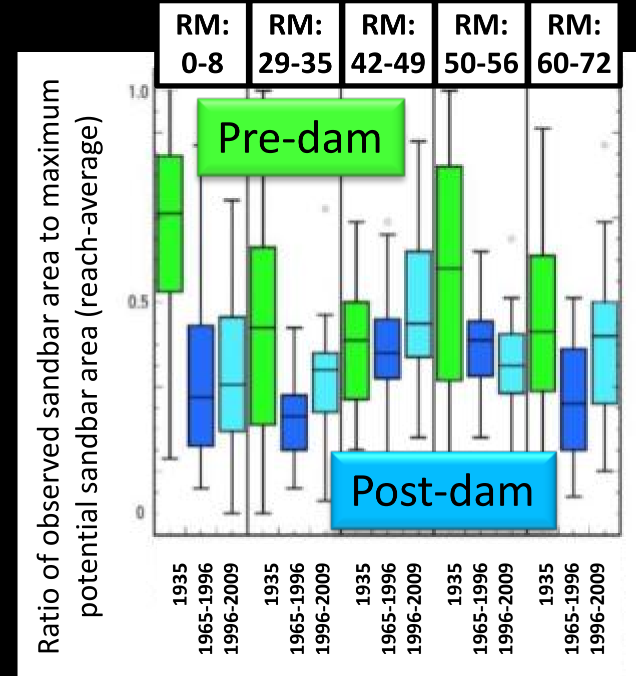
Joel Sankey, Laura Cagney, Temuulen Sankey, Ashton Bedford, Rene Horne, Phil Davis, Joshua Caster, Paul Grams, Barbara Ralston

USGS

Review of Problem: Sediment budget affected by disruption of sand supply and change in flow regime







Pre-dam:

- Annual floods
- Low base flows
- Abundant sand supply
- Large sandbars

Post-dam:

- Rare floods
- Daily fluctuations
- Limited sand supply
- Diminished sandbars

85 to 95% reduction in supply coupled with ~20% reduction in mean annual flow → sediment deficit

About 25% reduction in sandbar area in Marble Canyon (Schmidt et al., 2004; Ross and Grams, 2015)

USGS

Project 2: Streamflow, water quality, and sediment transport

- The basic physical data that support other projects:
  - Stage
  - Discharge
  - Water temperature
  - Salinity (specific conductance)
  - Turbidity
  - Dissolved Oxygen
  - Suspended- and bed-sediment data
  - Sediment loads (silt and clay loads and sand loads)
  - User-interactive sand budgets in 6 reaches from Lees Ferry to Lake Mead
- Continued development of database and website with tools for data visualization and downloading:
  - http://www.gcmrc.gov/discharge_qw_sediment/
  - http://cida.usgs.gov/gcmrc/discharge_qw_sediment/
- Results:

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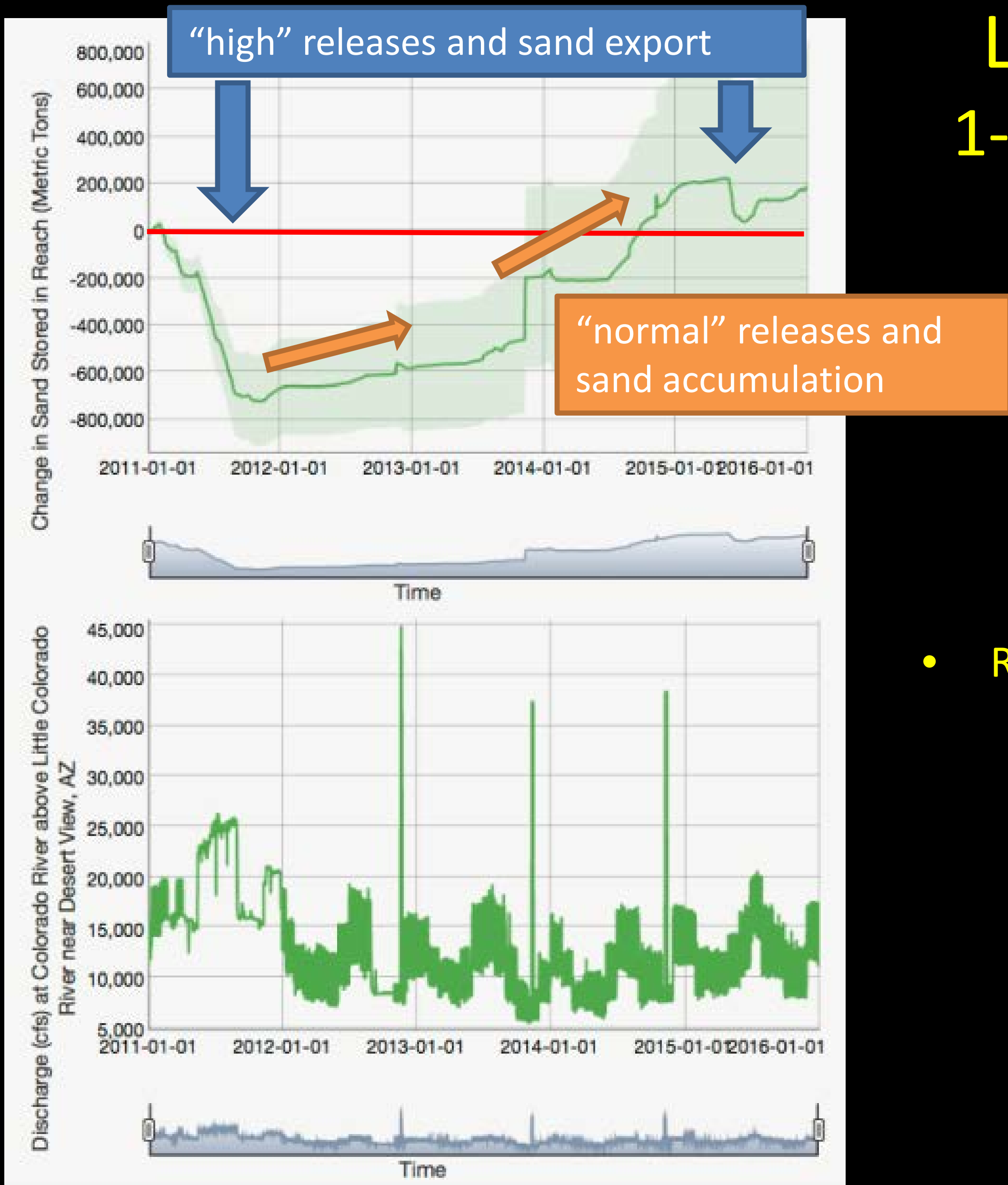
Lower Marble Canyon
1-1-2011 through 1-6-2016



Change in Sand Mass

- Zero Bias Value: **190,000 Metric Tons**
- Upper Uncertainty Bound: 770,000 Metric Tons
- Lower Uncertainty Bound: -390,000 Metric Tons

- Results:
  - Sand evacuation occurs during periods of sustained high releases (equilization flows) and sand accumulation during periods of sustained low/normal releases
  - Sand resources (amount) appear to be sustainable over the long-reach scale except in higher release years

January 22, 2016 from: http://www.gcmrc.gov/discharge_qw_sediment/

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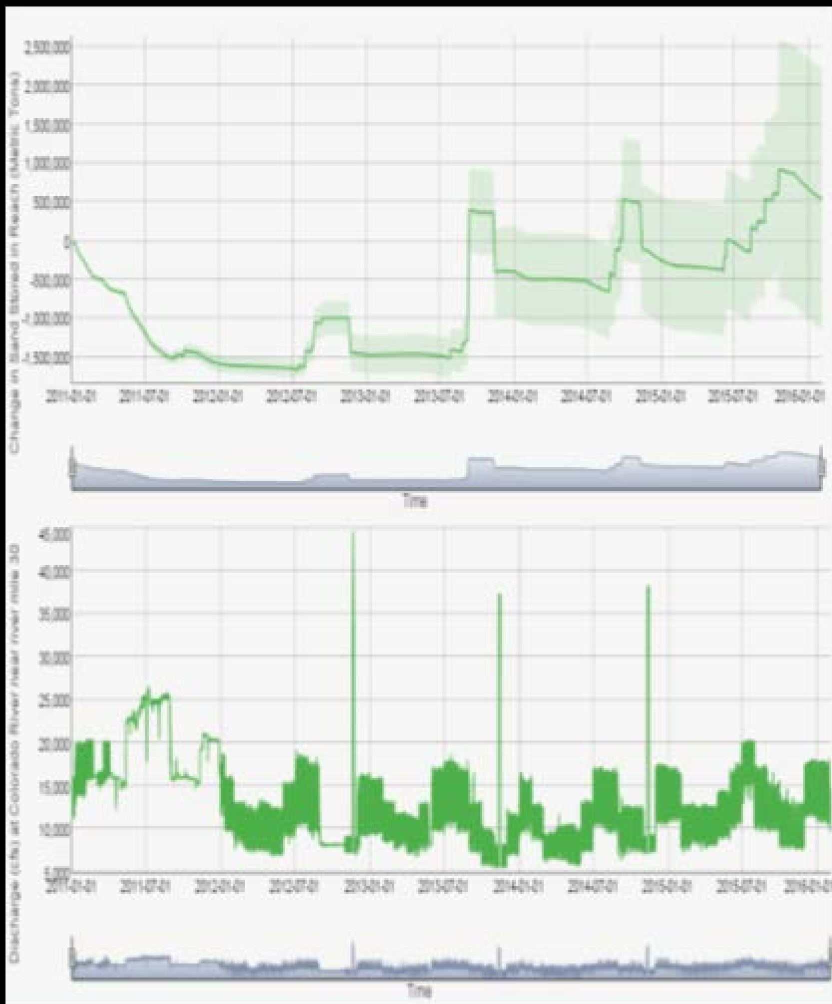
Sand budgets: 2011 - present

Upper Marble Canyon



Lower Marble Canyon

February 24, 2016 from: http://www.gcmrc.gov/discharge_qw_sediment/

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Sand budgets: 2011 - present

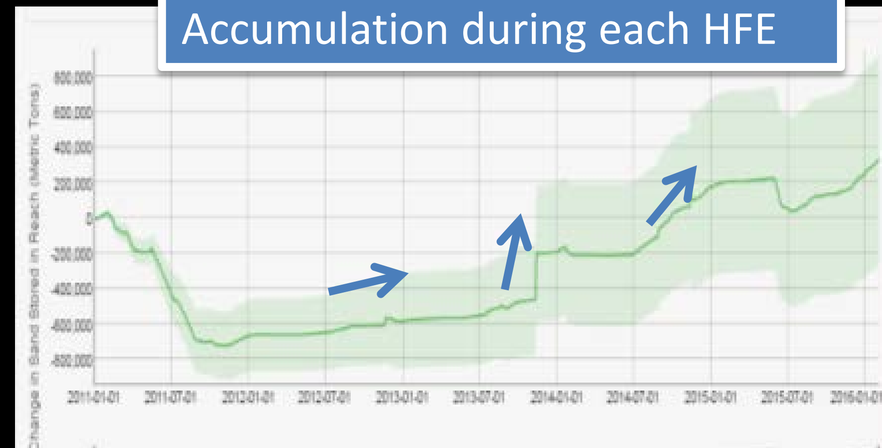
Upper Marble Canyon

Accumulation before and export during each HFE

Consistent with objective to “use” Paria sand without causing depletion from bed

Lower Marble Canyon

Accumulation during each HFE



- Results:
  - Systematic response of reach-scale sand budgets during HFEs appears to be emerging under the HFE Protocol
  - different from that observed during the 2004 and 2008 HFEs likely because of the differing longitudinal distribution of the antecedent sand supply (large supply all in upper Marble Canyon under HFE protocol, either smaller supply or further downstream in previous high flows)

February 24, 2016 from: http://www.gcmrc.gov/discharge_qw_sediment/

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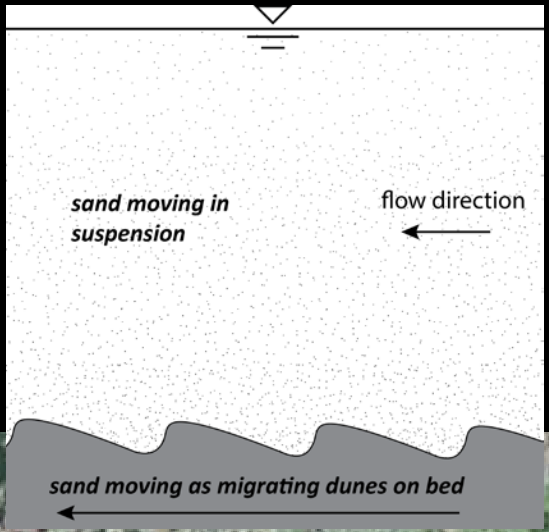
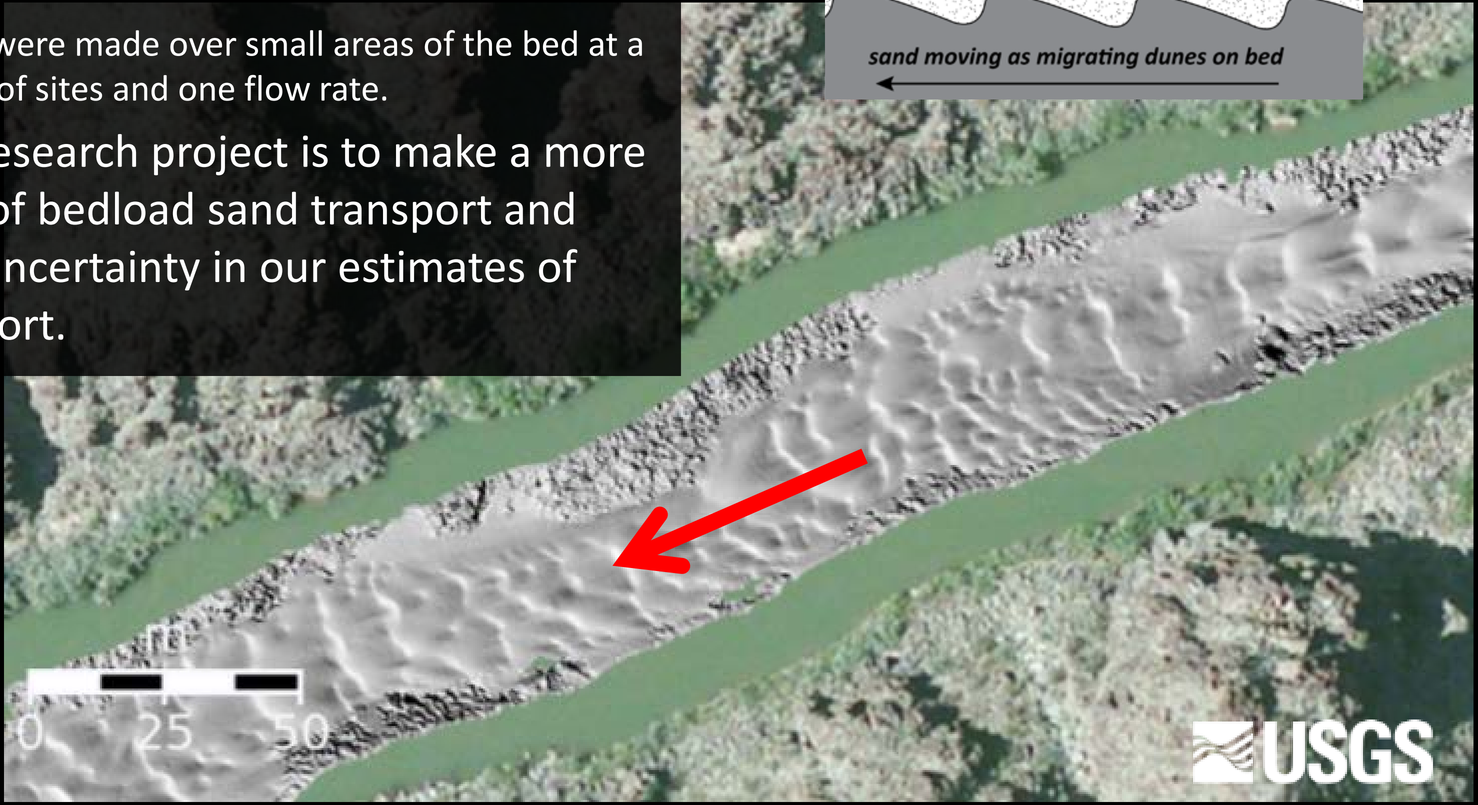
Project 3: Bedload Sand Transport

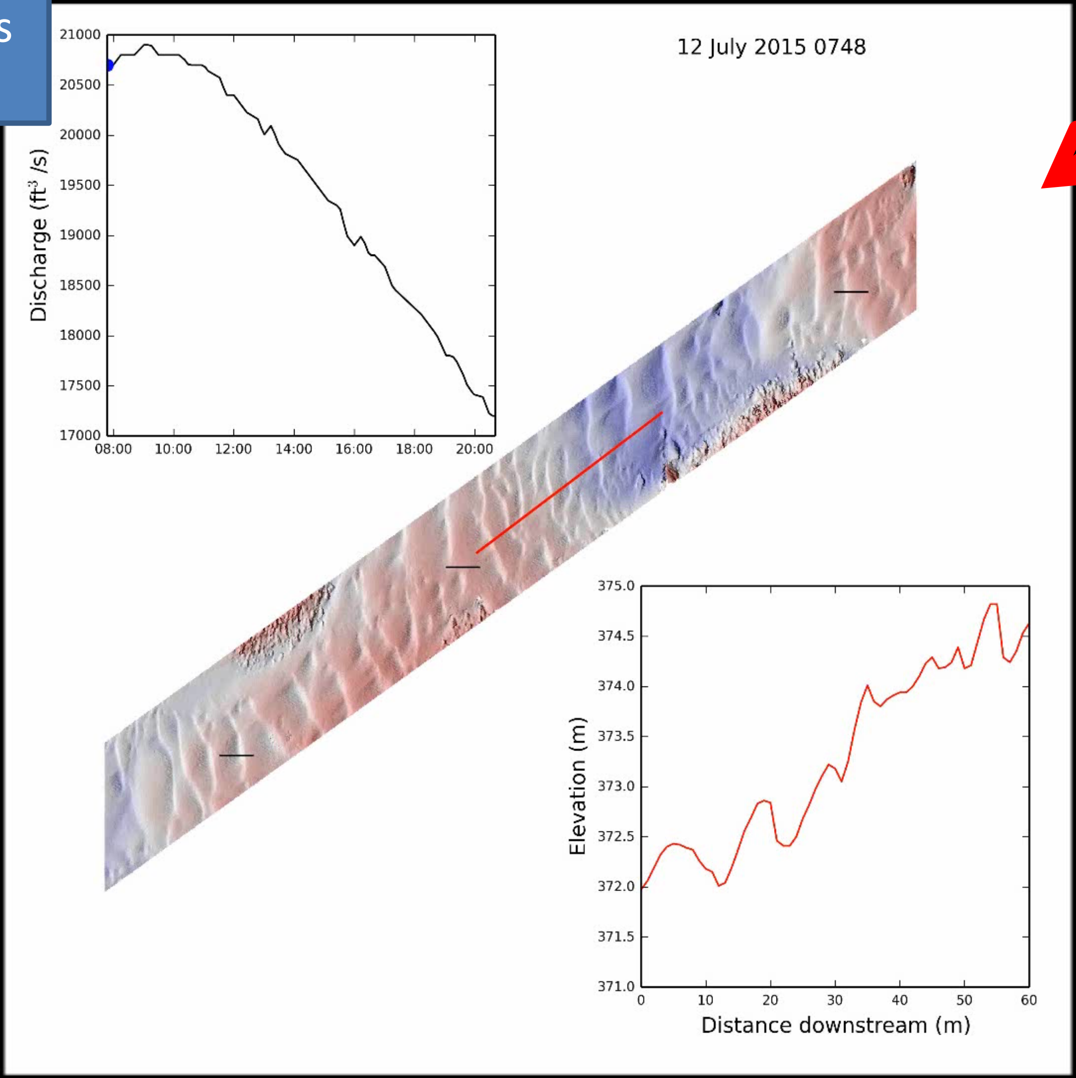
- Sand moves both on the bed and in suspension in the water.
- The relative proportions moving by each process depends on grain size and flow strength.
- Measurements made in 1998 indicated that only about 5% of the total sand load moved as "bedload."
  - Measurements were made over small areas of the bed at a limited number of sites and one flow rate.
- Purpose of this research project is to make a more robust estimate of bedload sand transport and thereby reduce uncertainty in our estimates of total sand transport.





Video of sand dunes migrating on bed of Colorado River near Diamond Creek stream gage

Blue dot shows discharge



Direction of flow and dune migration

Vertical profile showing moving sand dunes

Bedform Dimensions:

Height: ~ 1 m

Length: ~ 10 m

Speed: ~ 4 m/hr

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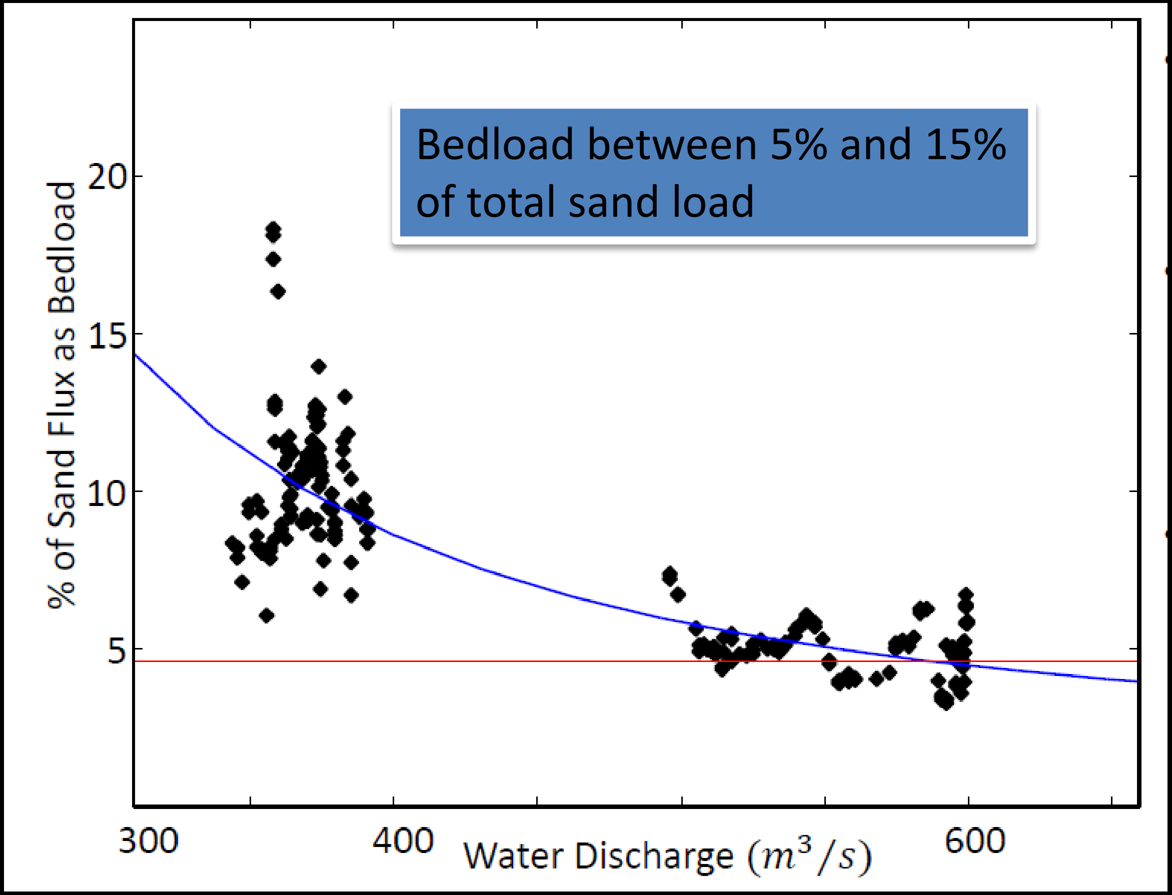
Relation between Bedload and Suspended Sand load

Preliminary Conclusions:

- New estimate of bedload consistent with earlier estimates
- But shows variation with discharge

Future work:

- Additional measurements at higher and lower discharges
- Measurements at additional sites

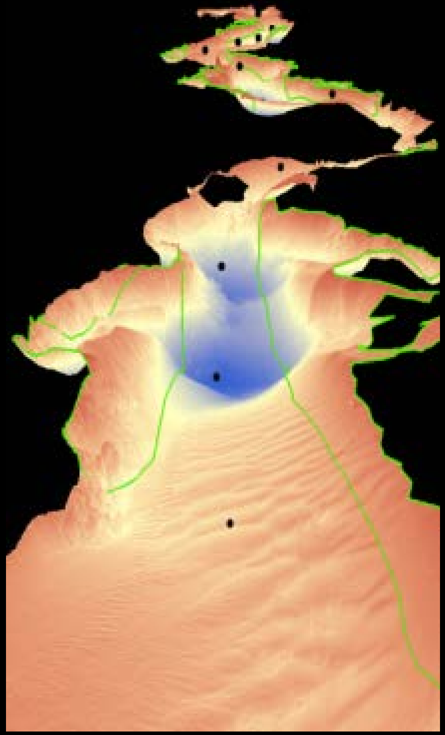


preliminary data, do not cite

USGS

Project 3: Sandbars and In-channel Sand Storage

- HFEs in 2012, 2013, and 2014 built sandbars
  - Bars eroded between HFEs
  - Greater erosion in years of higher release volumes
  - Bars larger now than at start of HFE protocol and periods with no HFEs, but no evidence for "progressive" increases in sandbar size
- High-elevation Campsite area (above 25,000 cfs stage)
  - No net change in non-critical reaches
  - Increase from 2012 to 2014 in critical reaches
- First three years of HFE protocol were a period of low annual release volumes and good tributary sand supply
  - Bar deposition without depleting sand from storage
  - Sand accumulated in Marble Canyon, replenishing sand evacuated during 2011 equalization



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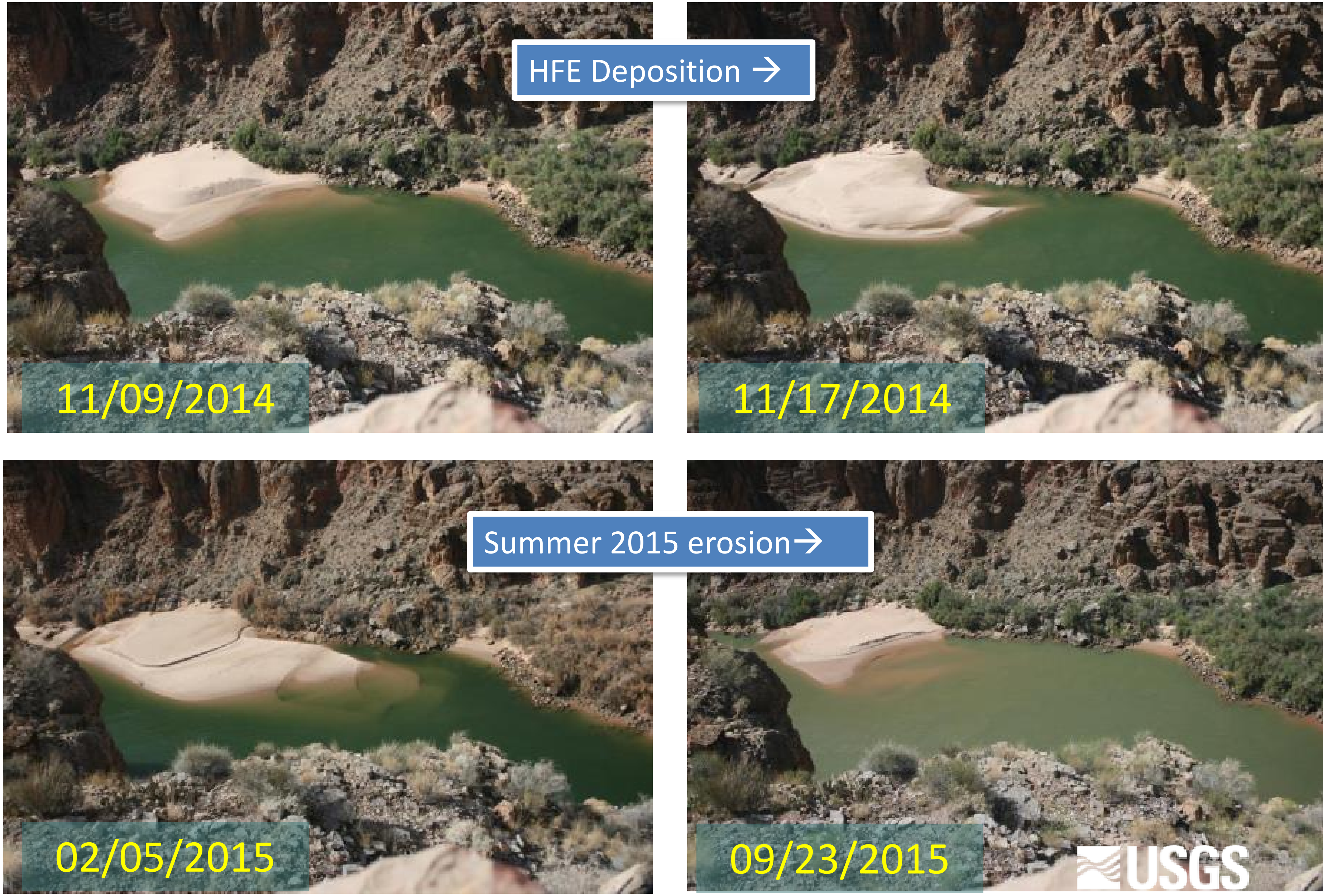
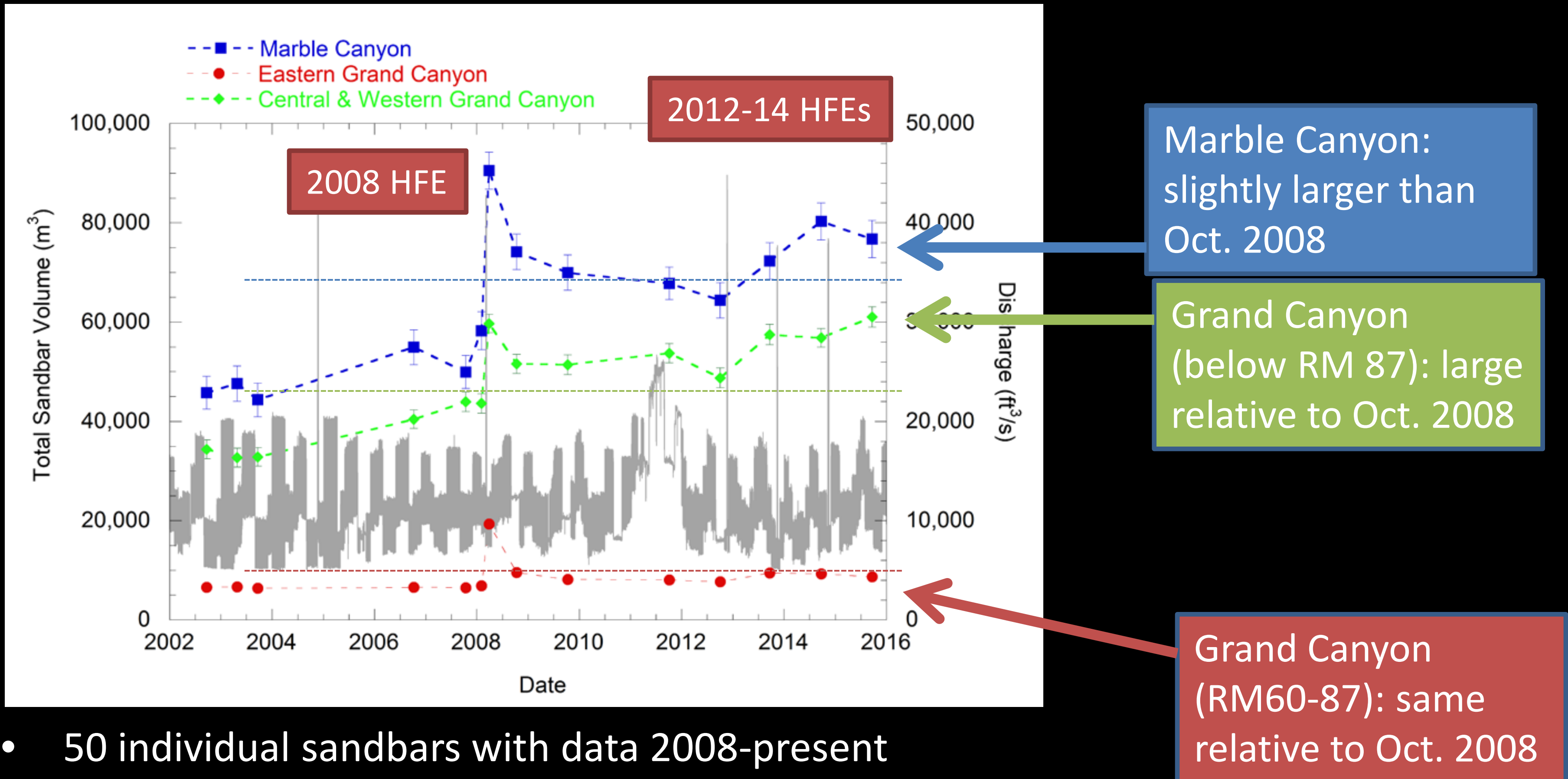
River Mile (RM) 30 R



Sandbars: 2008-present

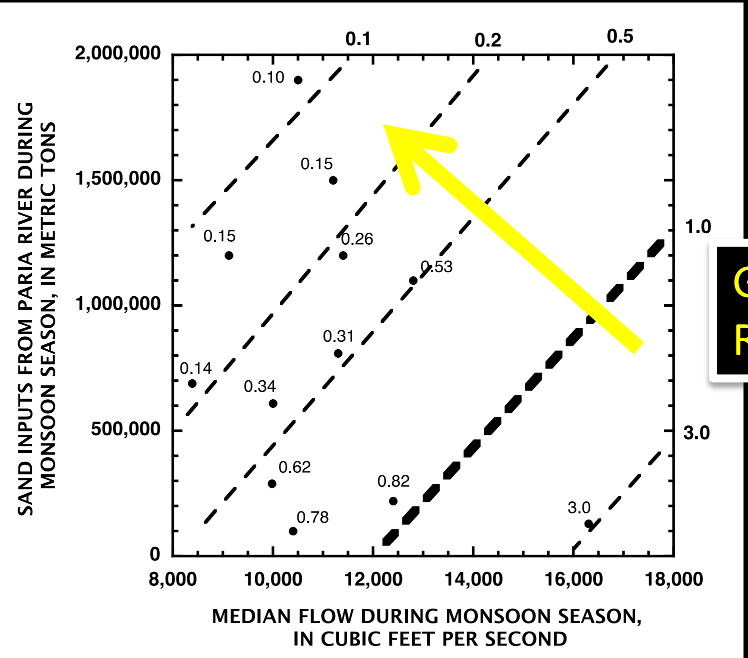


- 50 individual sandbars with data 2008-present
  - 25 in Marble Canyon
  - 7 in Grand Canyon (RM 60-87)
  - 18 in Grand Canyon (below RM 87)
- With October 2008 as reference (8-month post-HFE)
  - Increase in Marble Canyon and Grand Canyon (below RM 87)
  - No change in Grand Canyon (RM60-87)

preliminary data, do not cite

USGS

Relation between Dam Releases and retention of Paria sand inputs and sandbar response

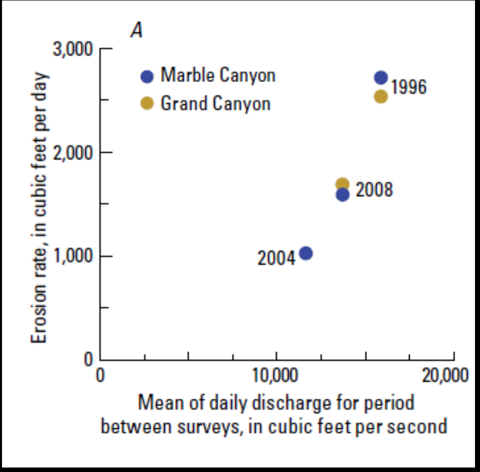


value at each data point is the proportion of the total Paria River, monsoon-season sand input that was exported from Upper Marble Canyon during the same period

Greater retention of Paria River sand inputs

Larger average release volumes result in greater export of sand inputs (*Jack Schmidt plot of data from GCMRC web site*)

preliminary data, do not cite



Larger average release volumes result in greater rates of sandbar erosion following HFE's (*Hazel et al., 2010*)

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Projects 3&11: Linkages between controlled floods, eddy sandbar dynamics, and riparian vegetation

- Spatial variability in eddy sandbar response to floods
  - Challenge for monitoring
  - Difficult to characterize “average” response
- Although variability has long been recognized, it has not been fully explained
- Because extent of riparian vegetation has varied in time and varies among sites, we are investigating the linkage between vegetation and changes in sandbar morphology

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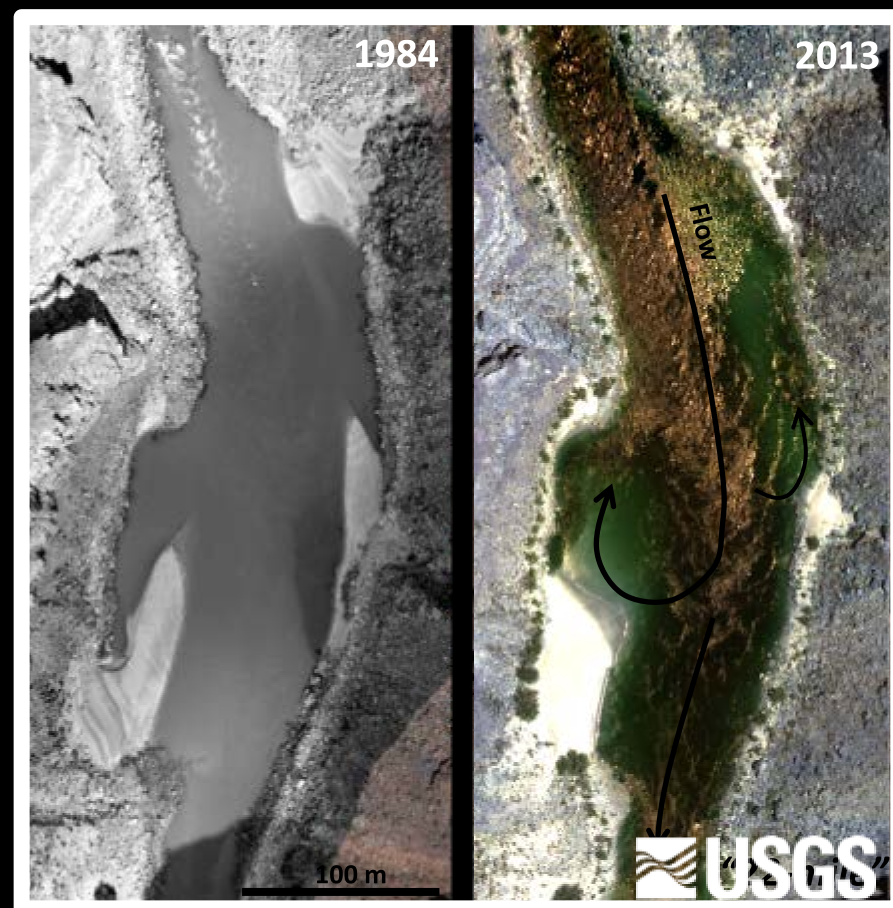
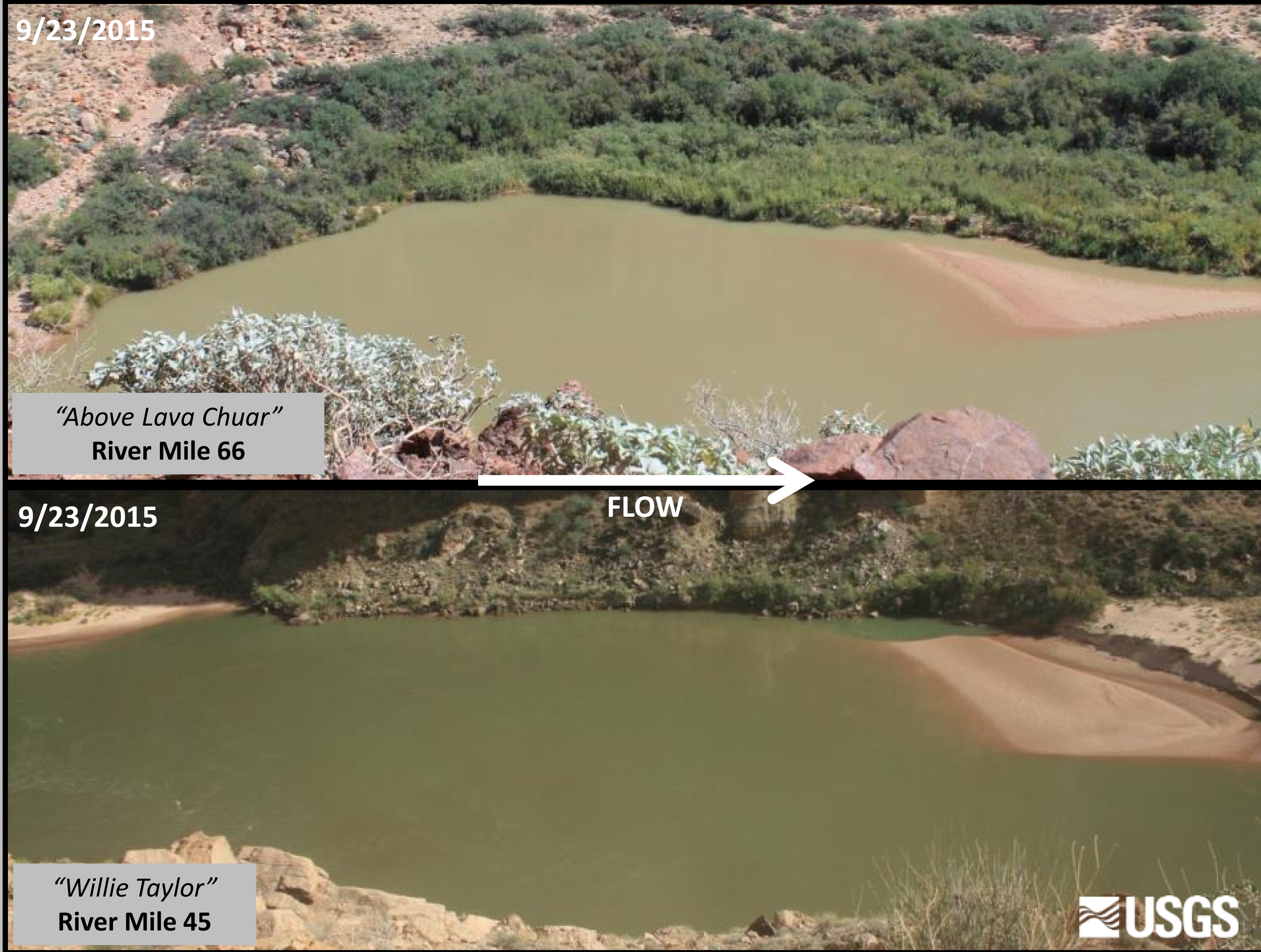
Background

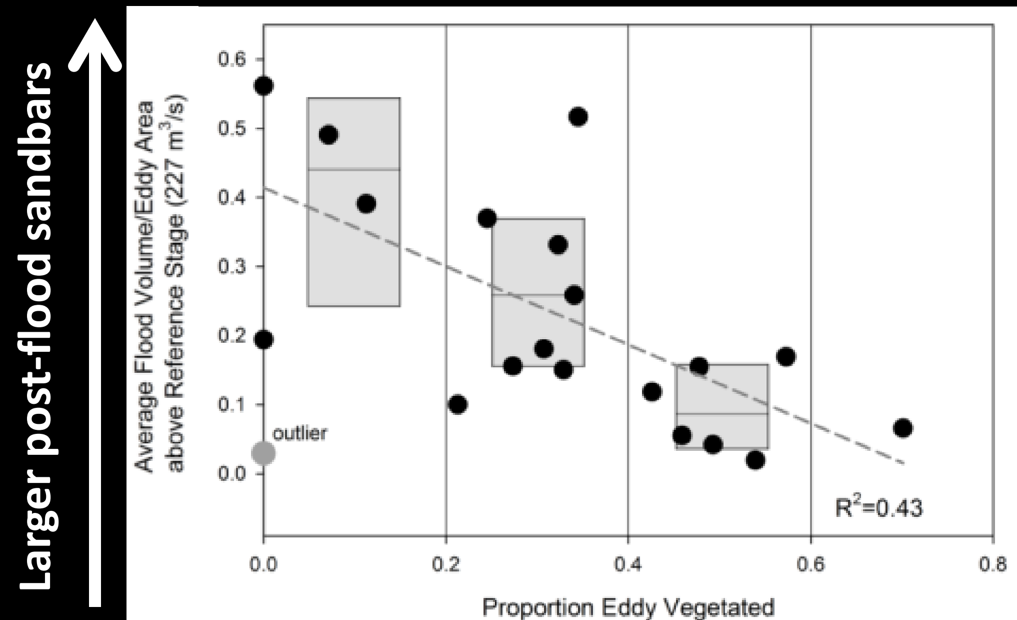
- The 1980s floods were the largest post-dam floods, approximately double recent controlled floods
- Many long-term monitoring sites were still relatively free of vegetation in the early 1990s
- Vegetation establishment on bars has varied between sites, influencing controlled flood response

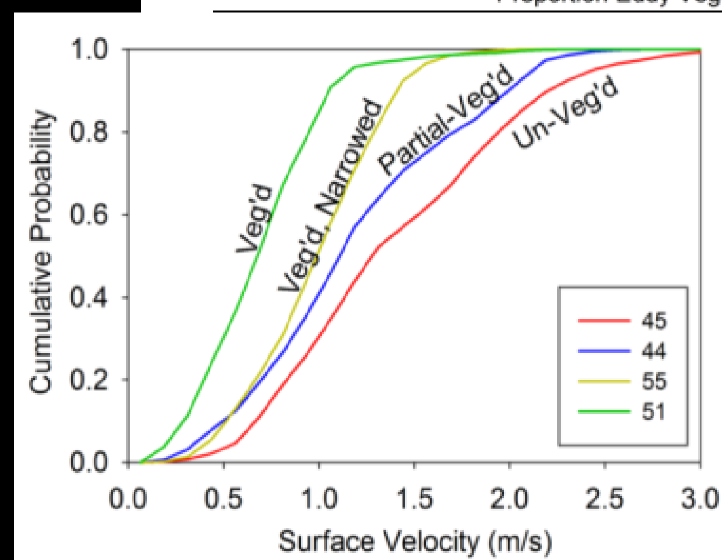



9/23/2015
"Above Lava Chuar"
River Mile 66
FLOW
9/23/2015
"Willie Taylor"
River Mile 45
USGS

The Proportion of Vegetation Cover and HFE Response are Related

- Sites with less vegetation
  - Changes in sediment storage occur in eddy
  - More HFE deposition on sandbar
  - Greater surface flow velocities
- Sites with more vegetation
  - Changes in sediment storage occur in channel
  - Less HFE deposition on sandbars
  - Lower surface flow velocities





preliminary data, do not cite

Project 3&11: Riparian Vegetation Monitoring With Remote Sensing

- Incorporation of the 2013 overflight images to analyze long-term riparian vegetation changes 1964 to 2013
  - Area covered by riparian vegetation increased between 1964 and 2009 (Sankey et al., 2015)
  - No change or decrease in riparian vegetation between 2009 and 2013
- Remote sensing of tamarisk and tamarisk beetle impacts: 2009 to 2013
  - Defoliation varies from approximately 10 to 30 % of total tamarisk vegetation area in different reaches of the river in the 2013 imagery

2013 image mosaic now available. Publication in review.

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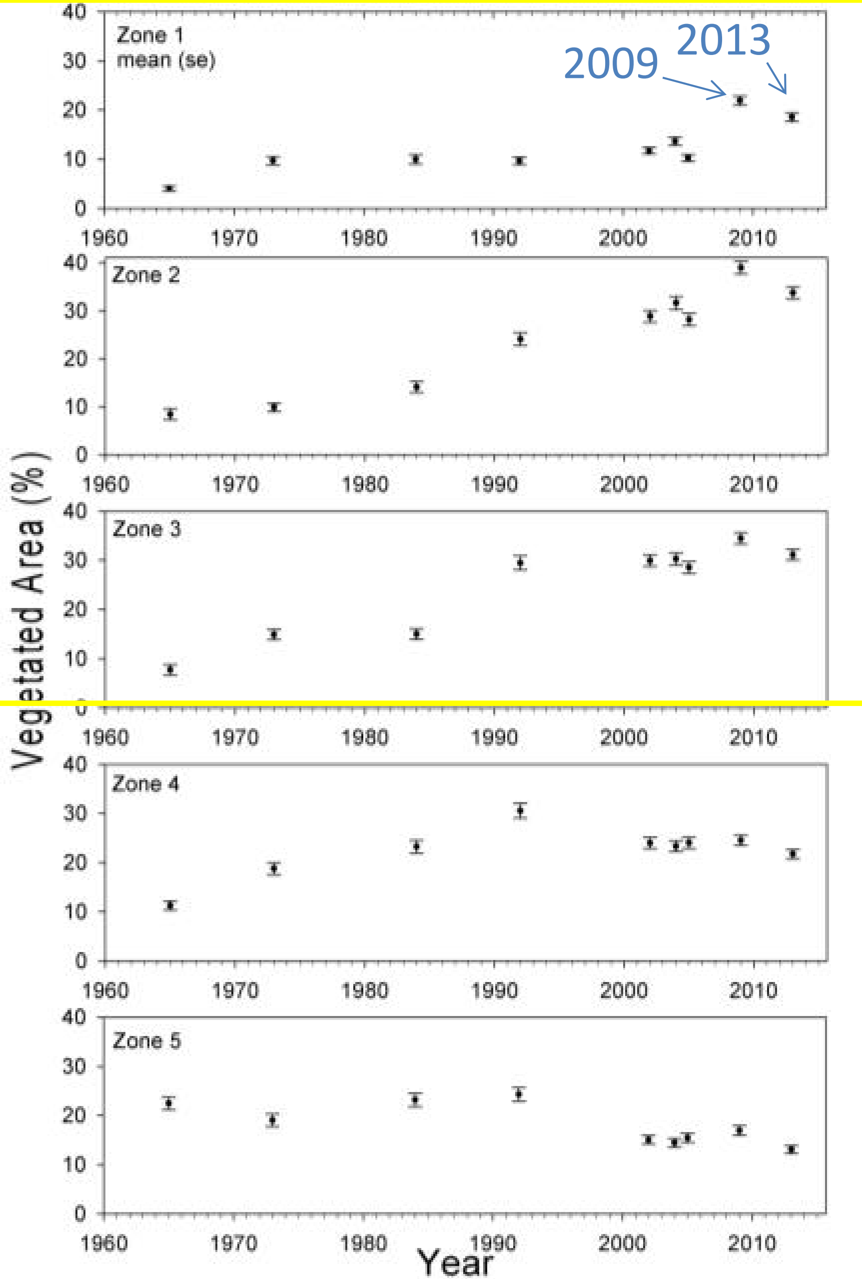
Long-term riparian vegetation changes 1964 to 2013

- Long-term increase in vegetation in zones inundated by discharges less than 45,000 ft^3/s
  - Elevated baseflows that increase water table
  - Reduced frequency and magnitude of flood flows



Zone 1: 8,000 to 25,000 ft^3/s

Zone 2: 25,000 to 31,000 ft^3/s

Zone 3: 31,000 to 45,000 ft^3/s

- No change or decrease in vegetation in zones inundated by discharges greater than 45,000 ft^3/s
  - Decoupled from river hydrology
  - Changes associated with regional precipitation

Zone 4: 45,000 to 97,000 ft^3/s

Zone 5: 97,000 to 210,000 ft^3/s

Sankey et al. (2015)

USGS

What percent of green tamarisk in 2009 was defoliated in 2013?

(Bedford, M.S. Thesis)

Reach	Percent of Tamarisk Vegetation	Total Area (m^2)
Glen Canyon (Glen Canyon Dam to Lees Ferry)		
Green	69 %	200,055
Defoliated	31 %	90,535
Kanab (RM 134.6 to 155.7)		
Green	79 %	40,470
Defoliated	21 %	10,948
National (RM 158.6 to 180.5)		
Green	88 %	217,275
Defoliated	12 %	28,927

preliminary data, do not cite

Acknowledgements

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