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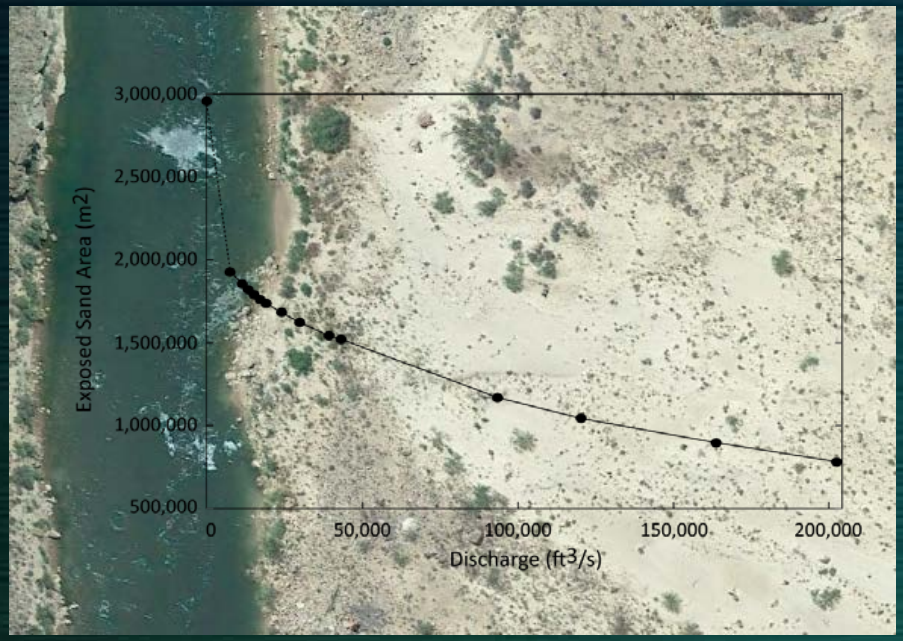
Grand Canyon Monitoring and Research Center

High Elevation Sand/Cultural Sites:
The response of source-bordering aeolian dunefields to the 2012-2016 High Flow Experiments of the Colorado River in Grand Canyon



Glen Canyon Dam Adaptive Management Program Annual Reporting Meeting,
March 13th, 2019, Phoenix, AZ

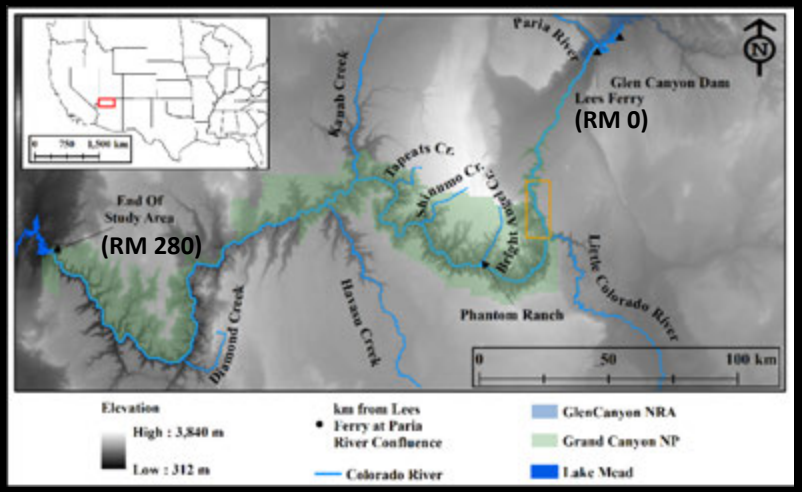
Joel B. Sankey (jsankey@usgs.gov)
US Geological Survey,
Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, Flagstaff, AZ

The response of source-bordering aeolian dunefields to the 2012-2016 High Flow Experiments of the Colorado River in Grand Canyon

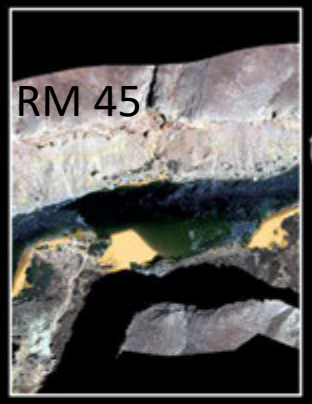
- Joel B. Sankey, US Geological Survey, SBSC, GCMRC, Flagstaff, AZ
- Alan Kasprak, US Geological Survey, SBSC, GCMRC, Flagstaff, AZ
- Joshua Caster, US Geological Survey, SBSC, GCMRC, Flagstaff, AZ
- Helen Fairley, US Geological Survey, SBSC, GCMRC, Flagstaff, AZ
- Amy East, US Geological Survey, CMSC, Santa Cruz, CA
- Jen Dierker, National Park Service, Grand Canyon, AZ
- Laura Durning, NAU, School of Informatics, Computing and Cyber Systems
- Ashton Bedford, NAU, School of Informatics, Computing and Cyber Systems
- Paul Grams, US Geological Survey, SBSC, GCMRC
- Dan Buscombe, NAU, School of Earth Science and Environmental Sustainability
- Temuulen T. Sankey, NAU, School of Informatics, Computing and Cyber Systems

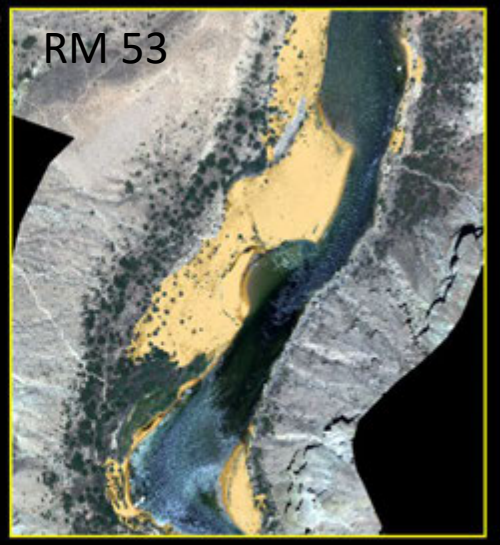
Bare, unvegetated sand is important for recreation, habitat, and cultural resources along the Colorado River in Grand Canyon

River Corridor Remote Sensing Assessment of Bare Unvegetated Sand

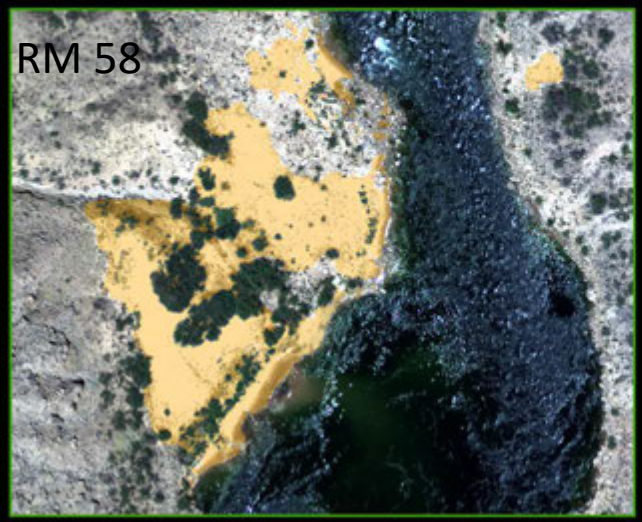


https://www.aopa.org/news-and-media/all-news/2015/march/10/pilot-getaways-mineral-canyon-utah





Sankey et al. 2018, Sand classifications along the Colorado River in Grand Canyon derived from 2002, 2009, and 2013 high-resolution multispectral airborne imagery: U.S. Geological Survey data release, https://doi.org/10.5066/P99TN424.



The Distribution of Colorado River Sand in Grand Canyon

~ 1/3 is almost always underwater

~ 1/6 is periodically underwater

~ 1/2 is above the HFE high water line

Baseflow Discharge

HFE Discharge

Bare, Unvegetated, Exposed Sand Area (m^2)

3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000

0
50,000
100,000
150,000
200,000

Discharge (ft^3/s)

Kasprak et al., 2018, Quantifying and forecasting changes in the areal extent of river valley sediment in response to altered hydrology and land cover. *Progress in Physical Geography, https://doi.org/10.1177/0309133318795846*

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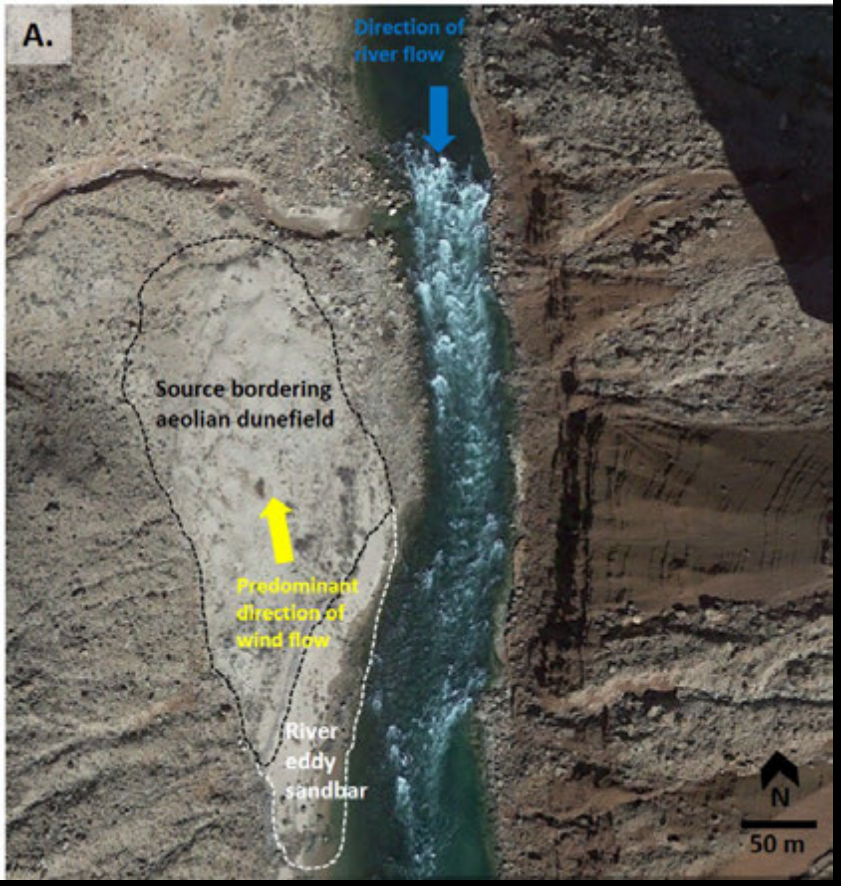
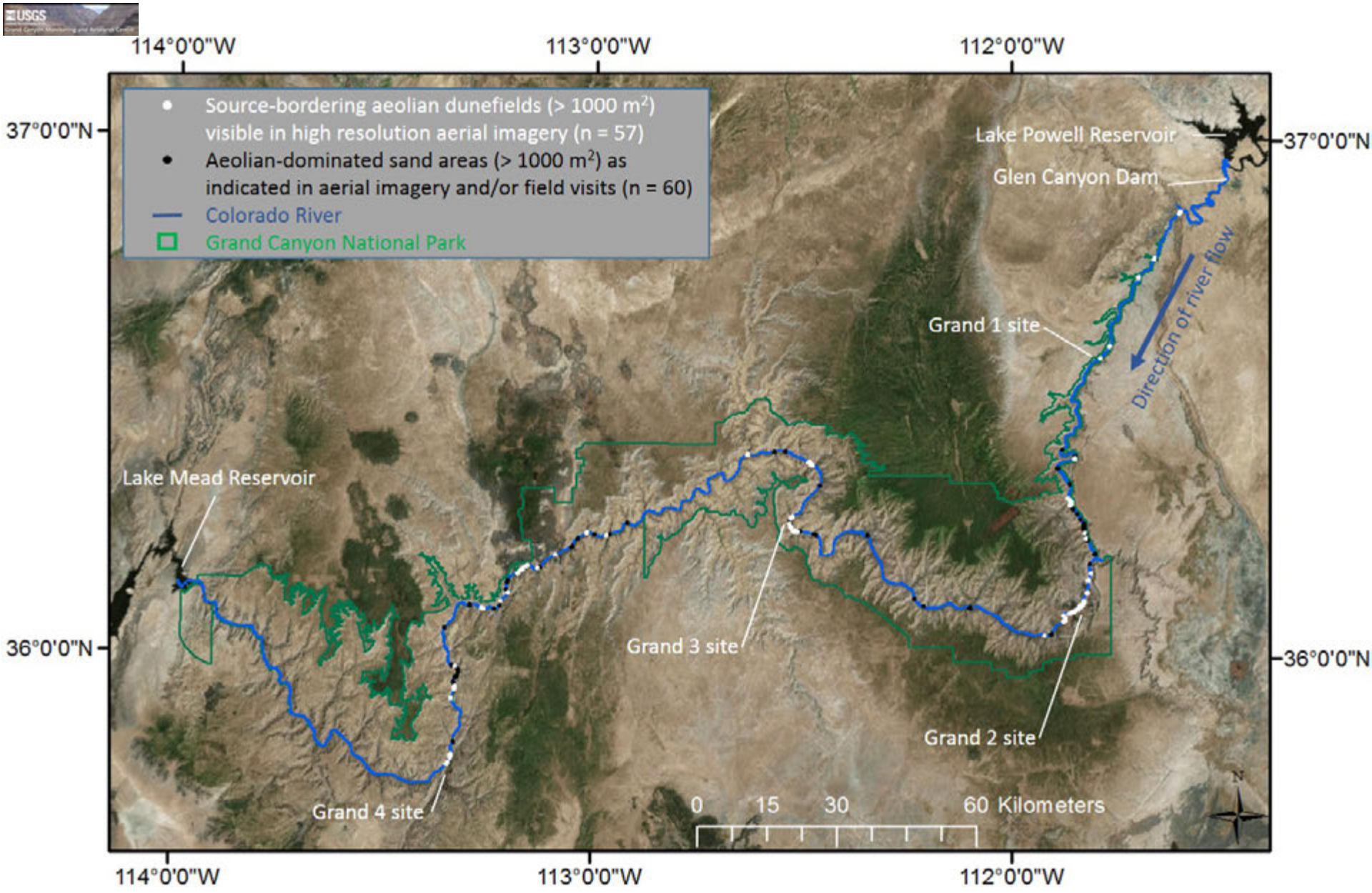

A.
Direction of river flow
Source bordering aeolian dunefield
Predominant direction of wind flow
River eddy sandbar
N
50 m


2017
Soap Creek


C.
Direction of river flow
River channel margin sand deposits
Source bordering aeolian dunefield
River eddy sandbar
Predominant (multimodal) directions of wind flow
N
50 m

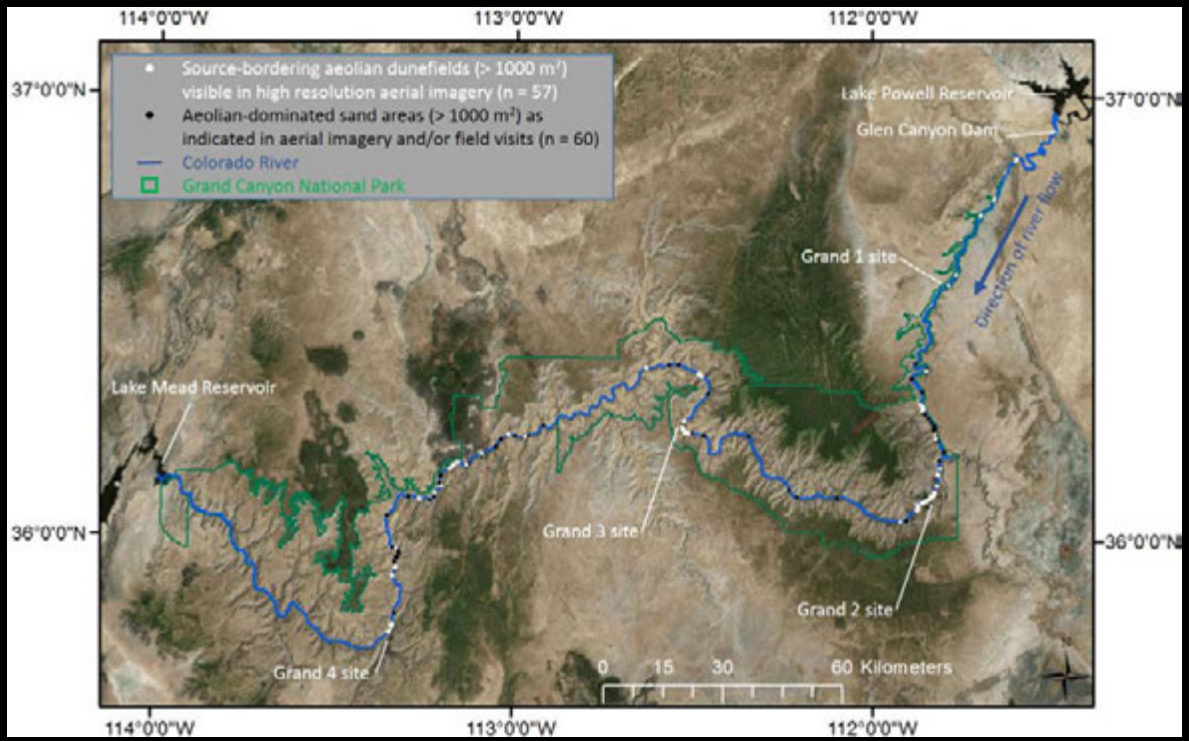

2017
Fossil Creek



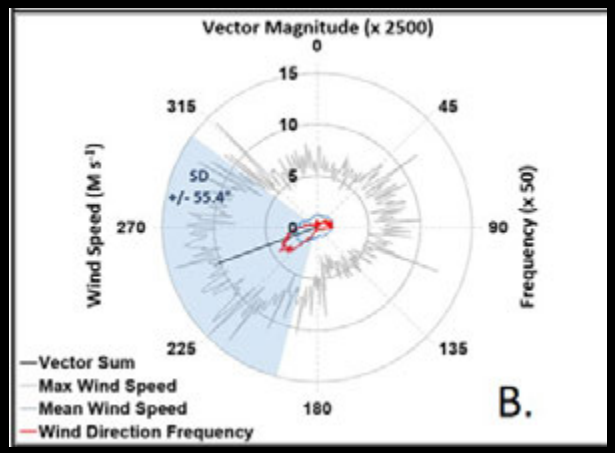
Sankey et al. (2018a) The response of source-bordering aeolian dunefields to sediment-supply changes 1: Effects of wind variability and river-valley morphodynamics. *Aeolian Research*, 32, pp.228-245.

Sankey et al. (2018b) The response of source-bordering aeolian dunefields to sediment-supply changes 2: Controlled floods of the Colorado River in Grand Canyon, Arizona, USA. *Aeolian Research*, 32, pp.154-169.

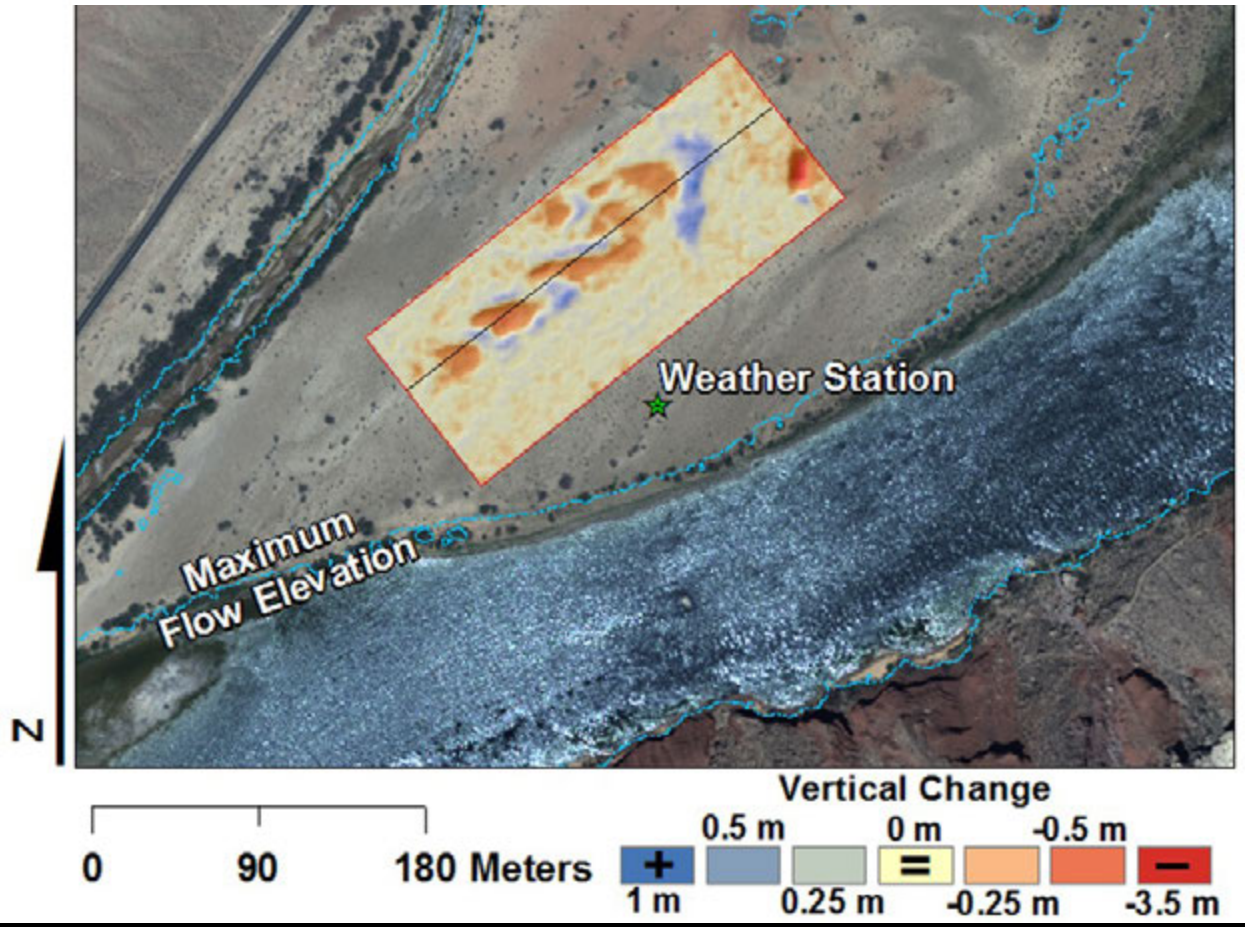
- Dunefields aren't inundated by contemporary discharges from GCD, and they are located above the stage of HFEs.
- Are they affected by dam operations?



Lees Ferry Dunefield – Relict River Sediment Supply Example



Remote sensing topographic change detection 2002-2013



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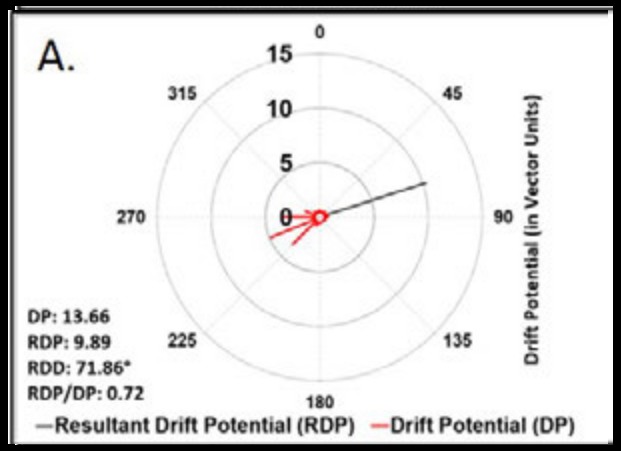
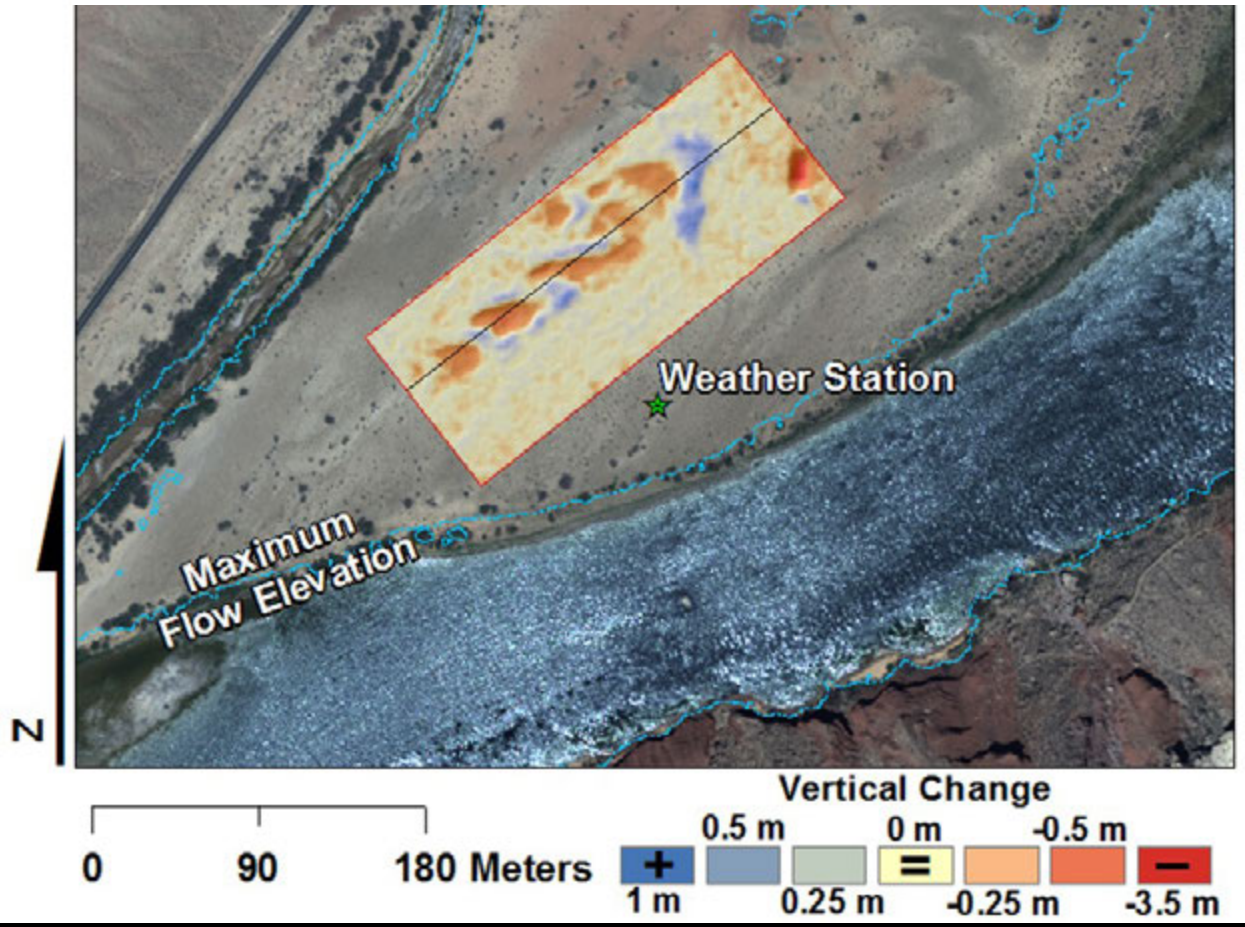


Remote sensing topographic change detection 2002-2013



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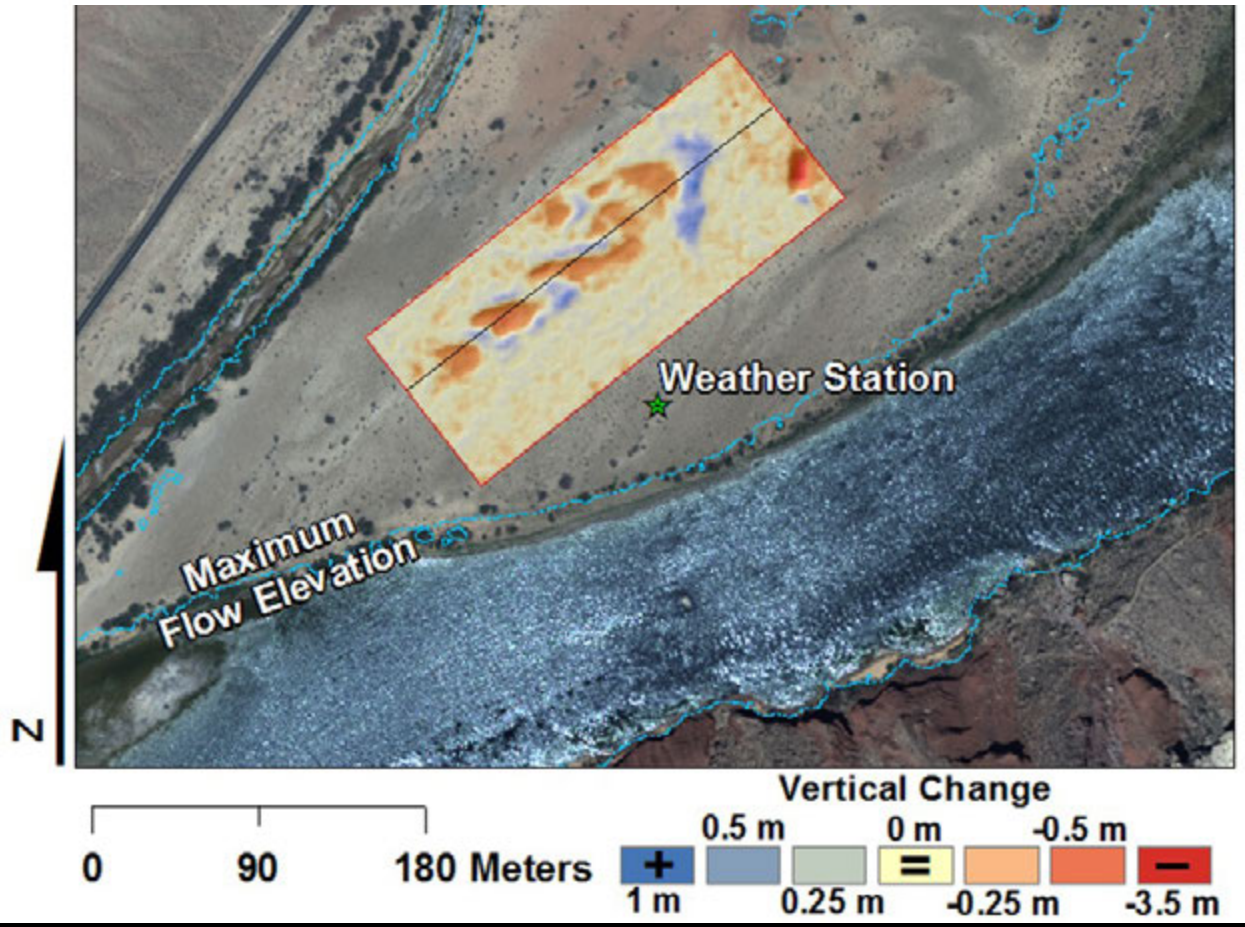
Lees Ferry Dunefield – Relict River Sediment Supply Example

1923 (La Rue)

2017 (Fairley)

Remote sensing topographic change detection 2002-2013



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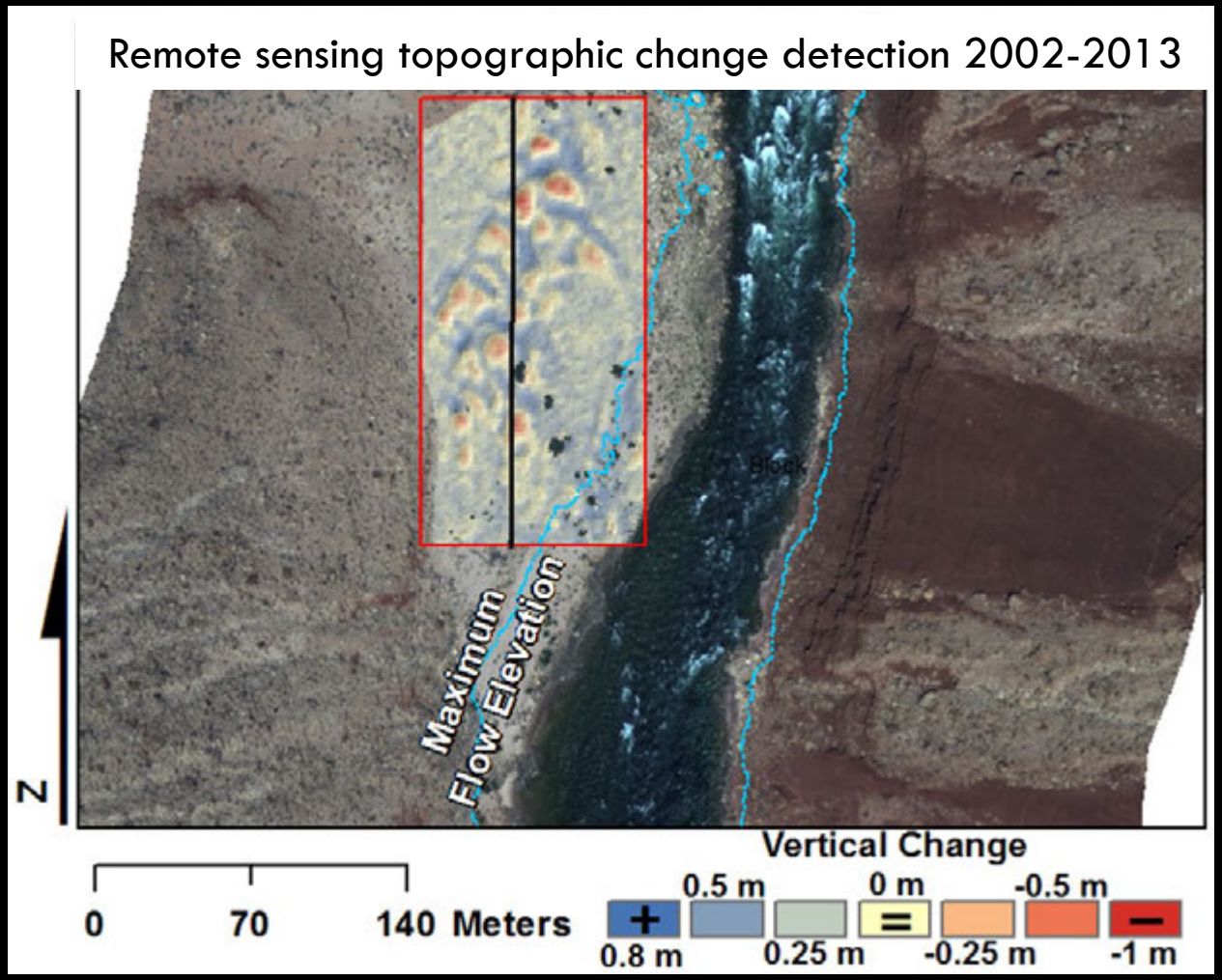
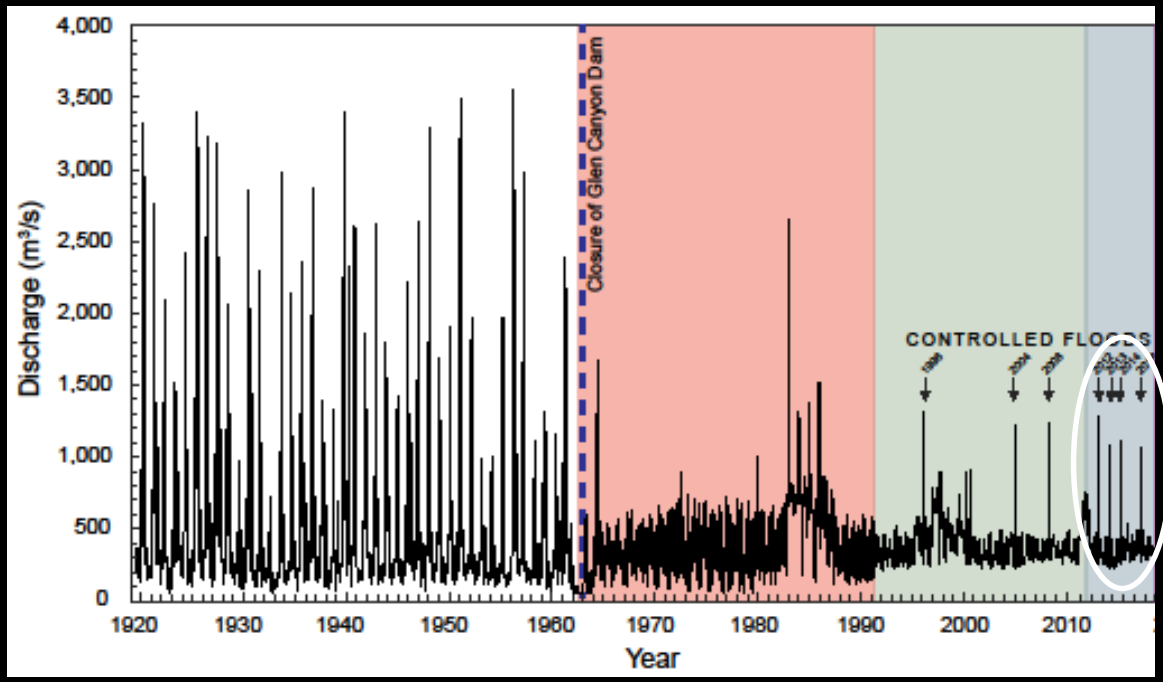
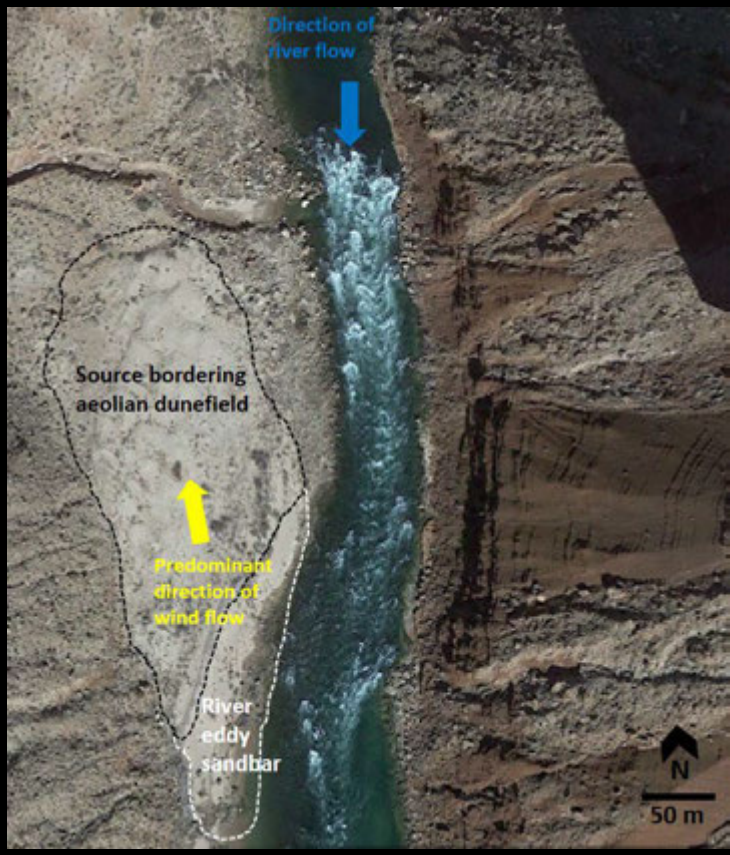
Soap Creek Dunefield – Modern River Sediment Supply Example

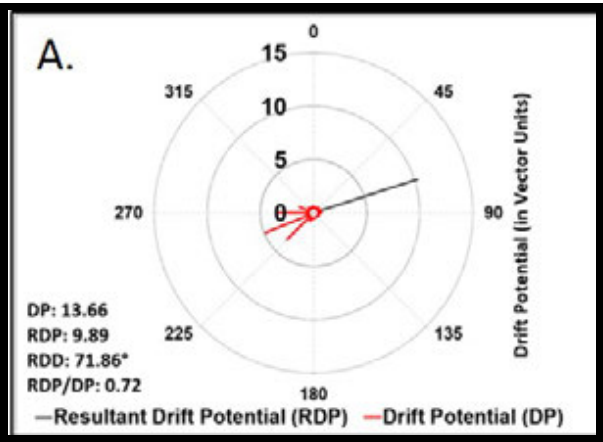


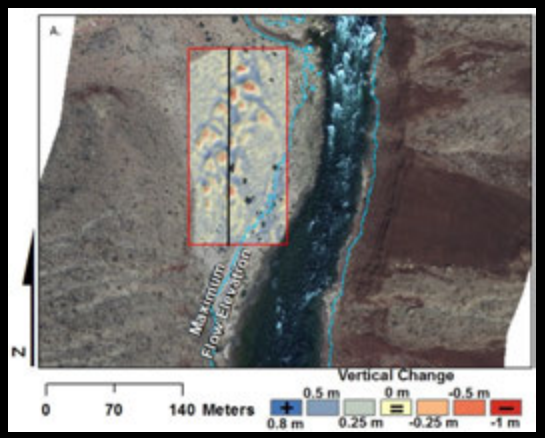
Sankey et al. (2018a) The response of source-bordering aeolian dunefields to sediment-supply changes 1: Effects of wind variability and river-valley morphodynamics. *Aeolian Research*, 32, pp.228-245.

Did the 2012-16 HFEs resupply dunefields with sand by rebuilding upwind sandbars?









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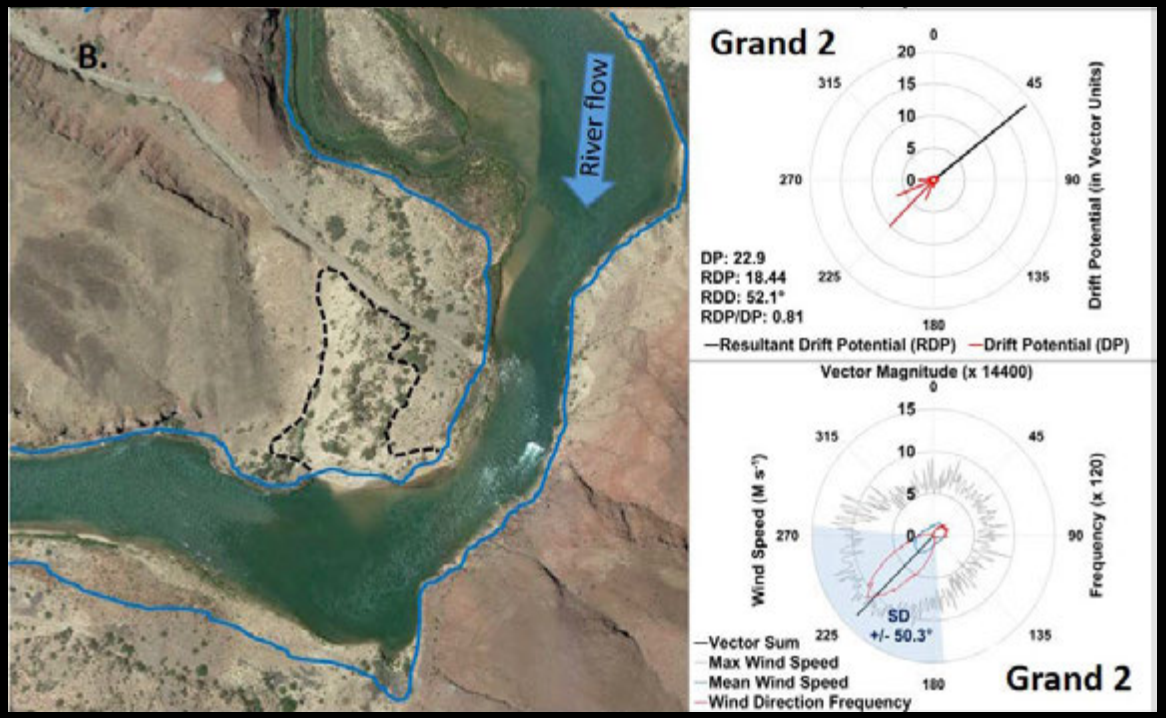
Dunefield response to HFEs



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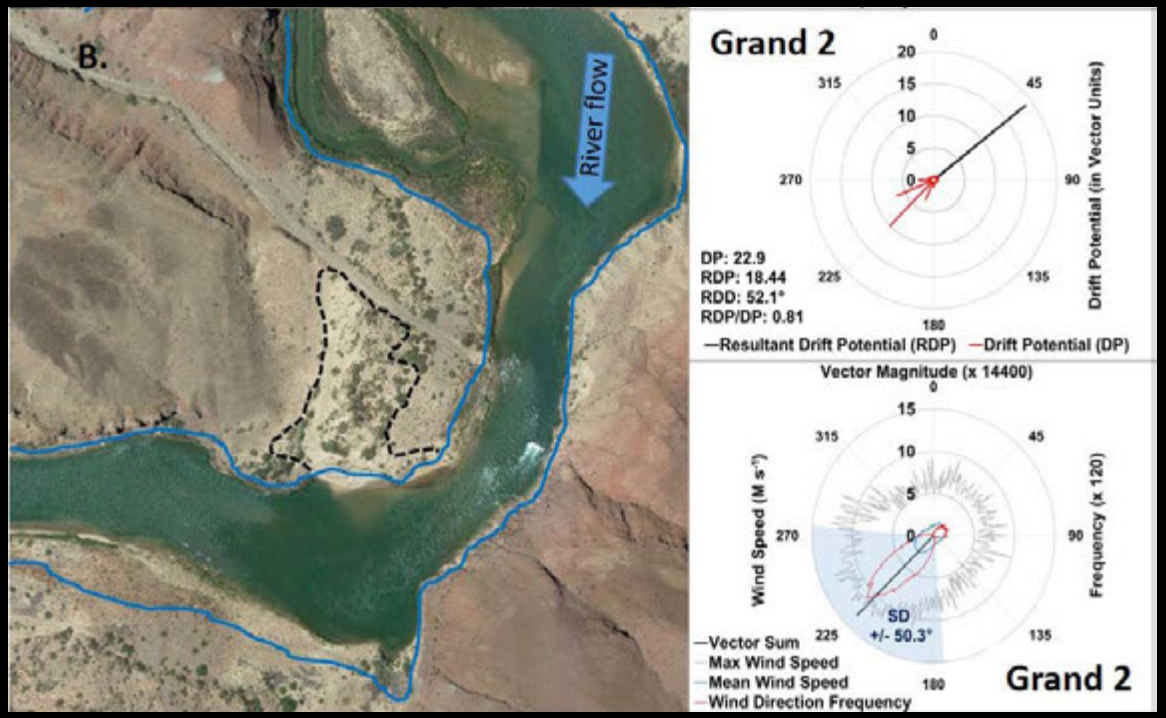

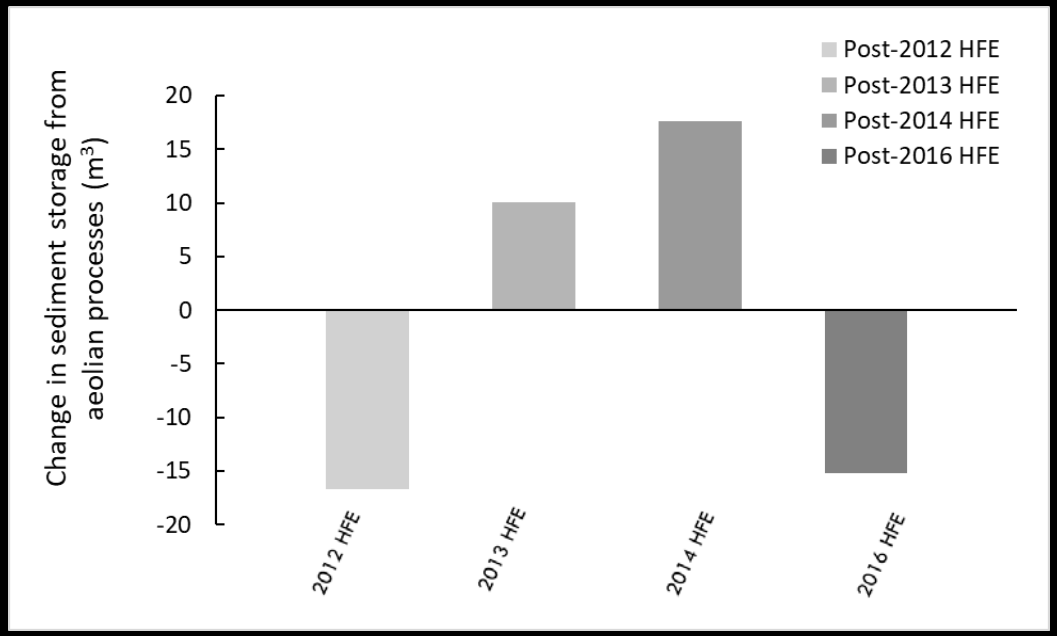

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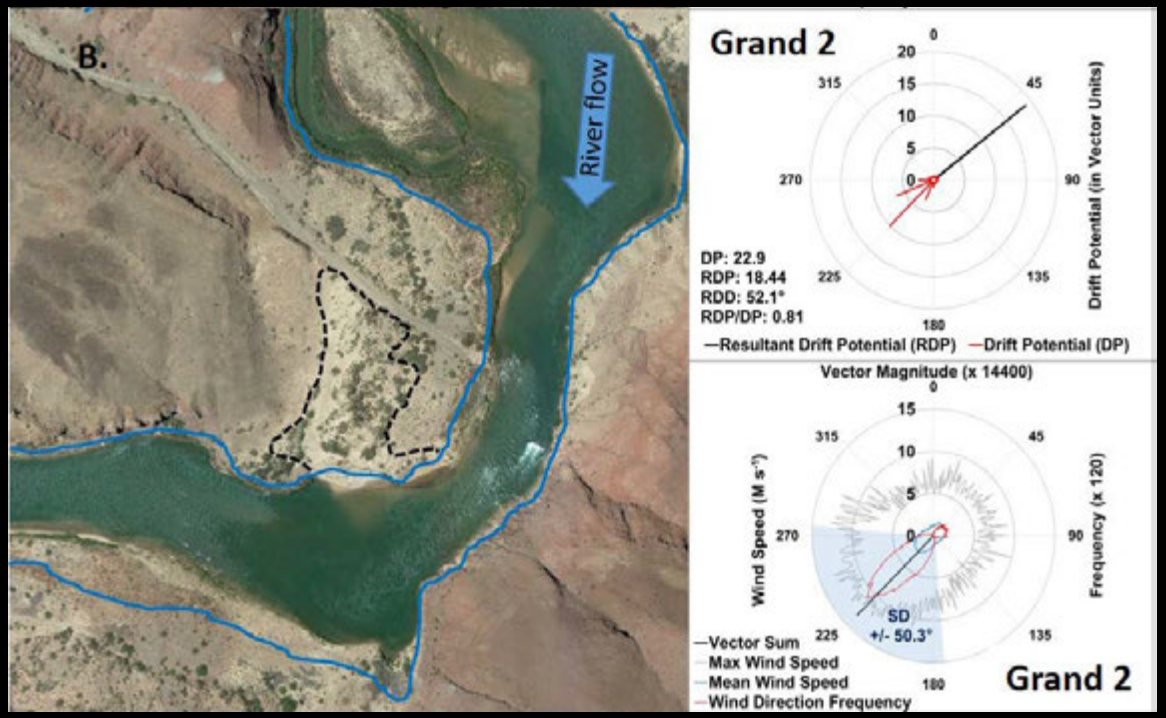

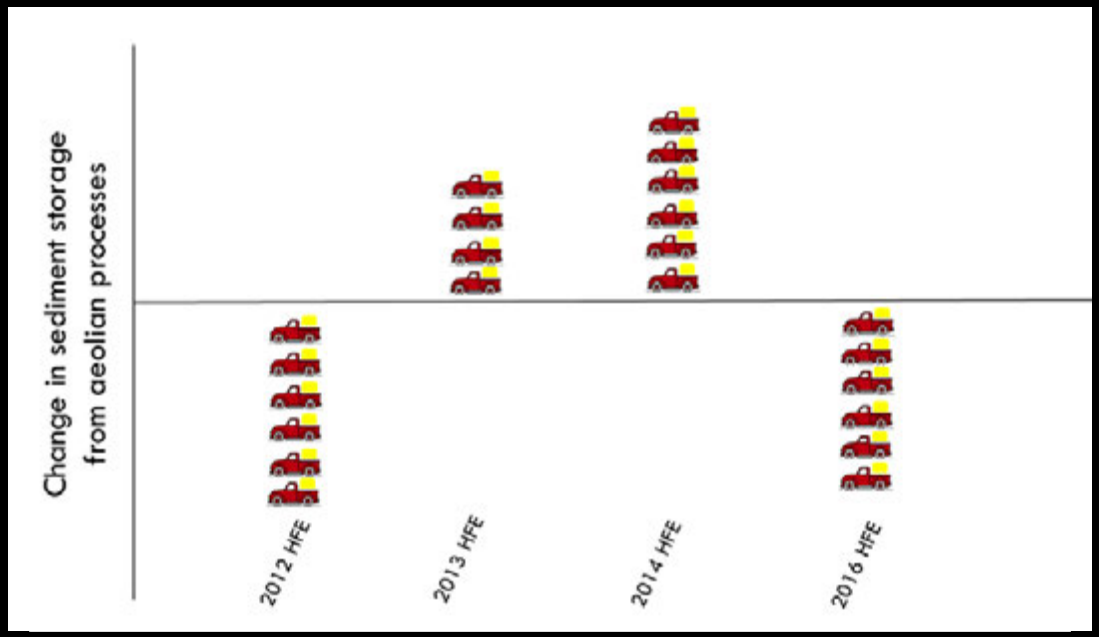

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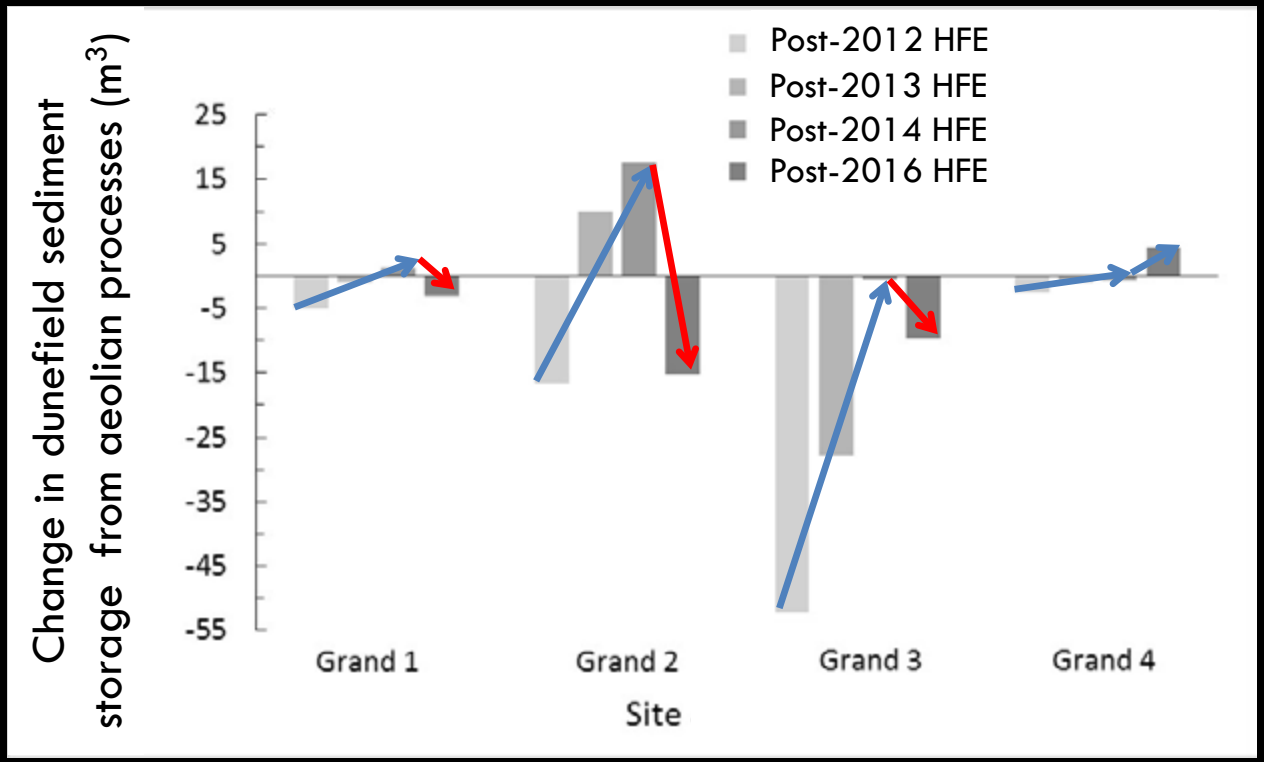
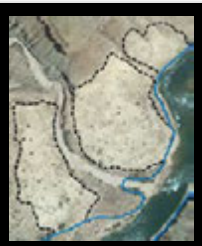
Dunefield response to HFEs

Increase in sediment storage with consecutive annual HFEs





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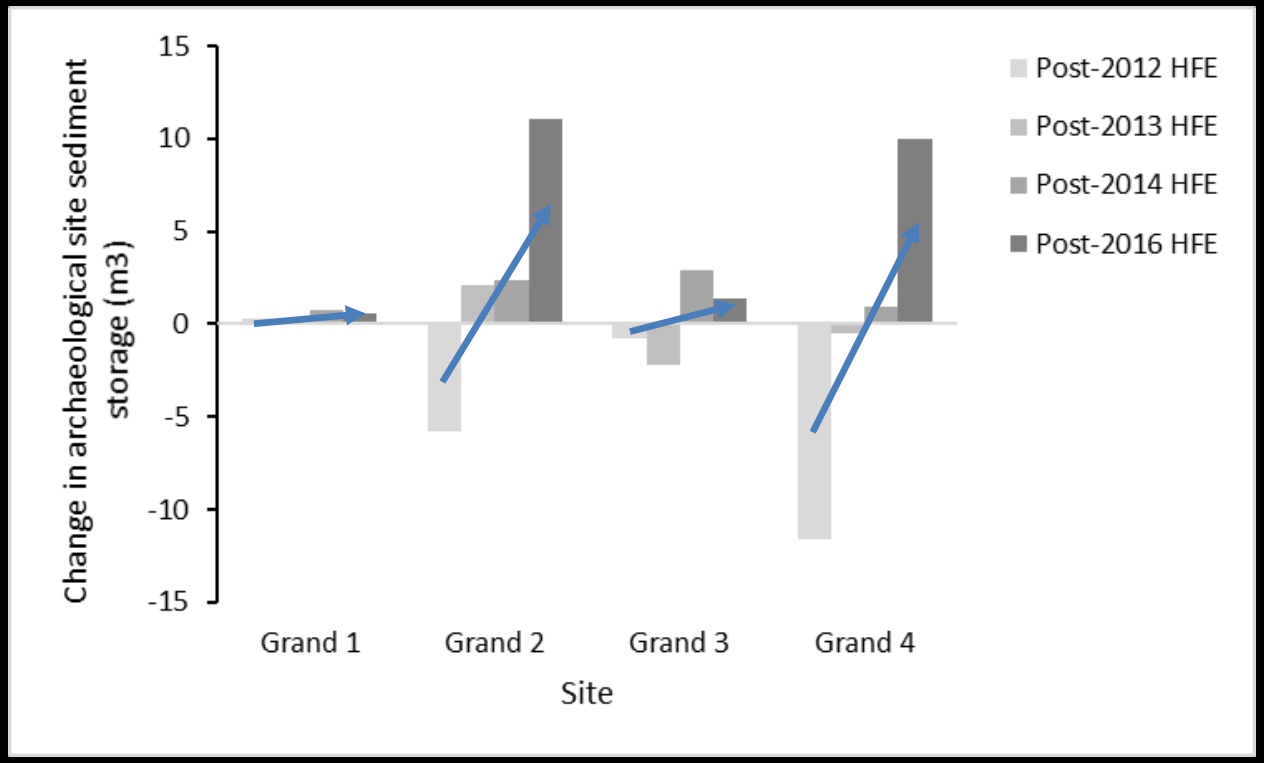
Dunefield archaeological site response to HFEs

Increase in sediment storage owing to resupply from 2012-2016 HFE sand

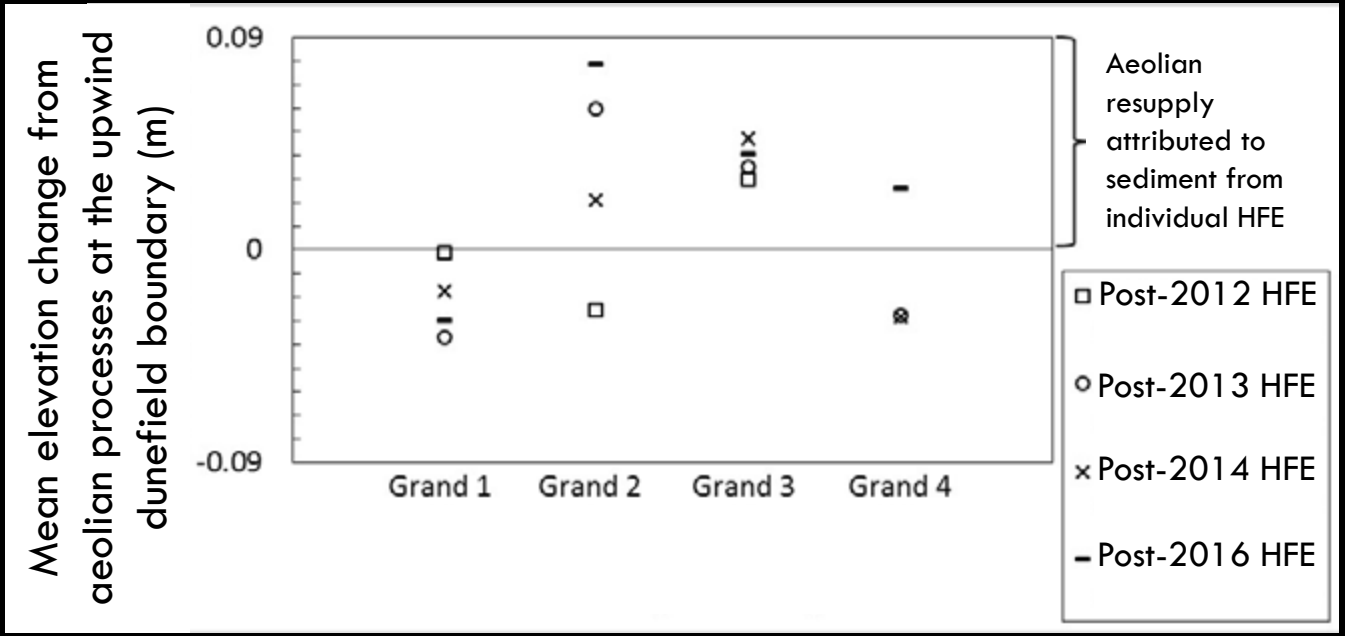


Unpublished results, do not cite

Dunefield response to HFEs

Resupply occurred for 50 % (8 of 16) of flood-dunefield instances

Analogous to resupply of sandbars by HFEs;
e.g., ~ ½ of monitored sandbars increased in size following the 2012, 2013, 2014 HFEs (Grams et al., 2015)



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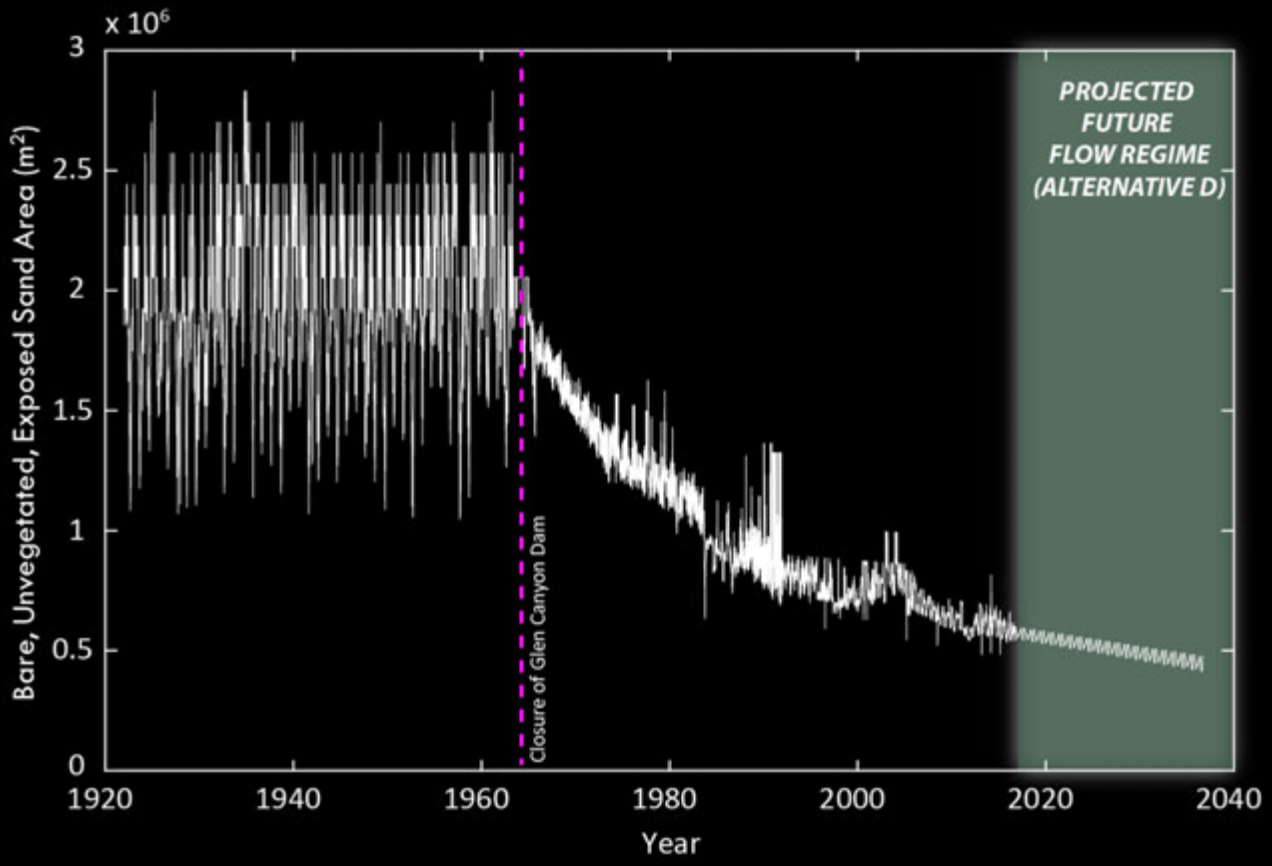
Summary - The response of source-bordering aeolian dunefields to the 2012-2016 High Flow Experiments of the Colorado River in Grand Canyon

- In Grand Canyon, approximately ½ of the area of bare, unvegetated sand derived from the Colorado River is located in 117 large dunefields
- HFEs do not directly inundate most of these dunefields, however, HFEs resupply the dunefields with sand by rebuilding upwind sandbars
- Aeolian dunefields were resupplied with windblown sand from HFE deposits in half of the instances monitored after the 2012, 2013, 2014, and 2016 HFEs
- Frequency of dunefield resupply by HFEs is analogous to resupply of sandbars by HFEs
- Dunefield sediment storage increases cumulatively when HFEs are conducted consistently on an annual basis. Sediment storage decreased with 1-year hiatus from HFE in 2015.
- Sediment storage increased at dunefield archaeological sites owing to resupply from 2012-2016 HFE sand

Implications and Future Work



- Bare sand area has decreased by 49% since 1965 owing to a combination of vegetation expansion, increase in baseflow, and erosion (Kasprak et al., 2018).
- Bare sand area is projected to decrease by an additional 12% by 2037 due to future riparian vegetation expansion (Kasprak et al., 2018)
- The past, present, and likely future expansion of riparian vegetation onto sandbars reduces the supply of HFE sand for dunefields

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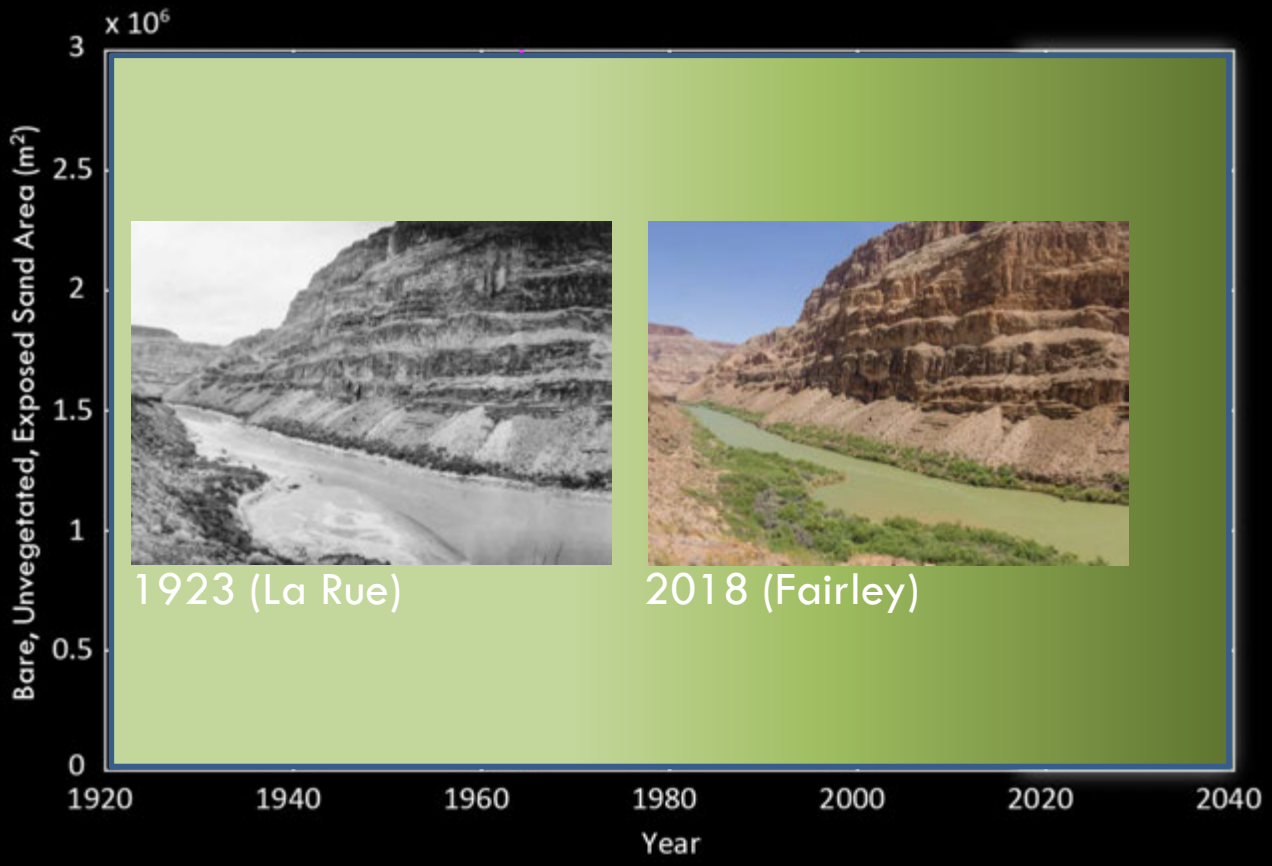

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Implications and Future Work

- In April, 2019 the NPS will implement experimental vegetation removal treatments in Grand Canyon to increase aeolian sediment supply to several dunefields that host archaeological sites
- GCMRC will monitor the outcome of the treatments relative to future HFEs