Project L: Remote Sensing Overflight in Support of Long-Term Monitoring and LTEMP

Annual Reporting Meeting – January 12, 2022

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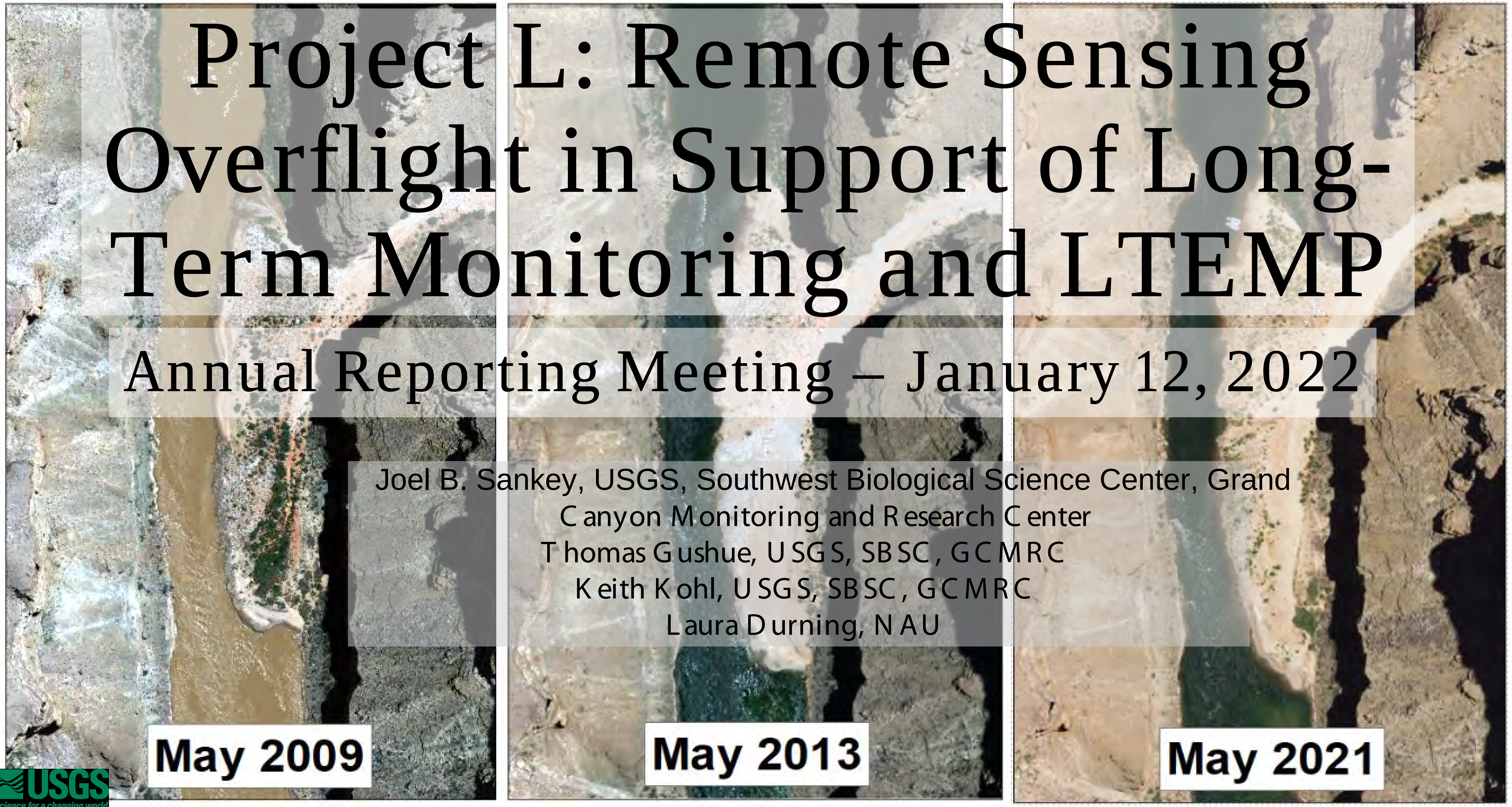

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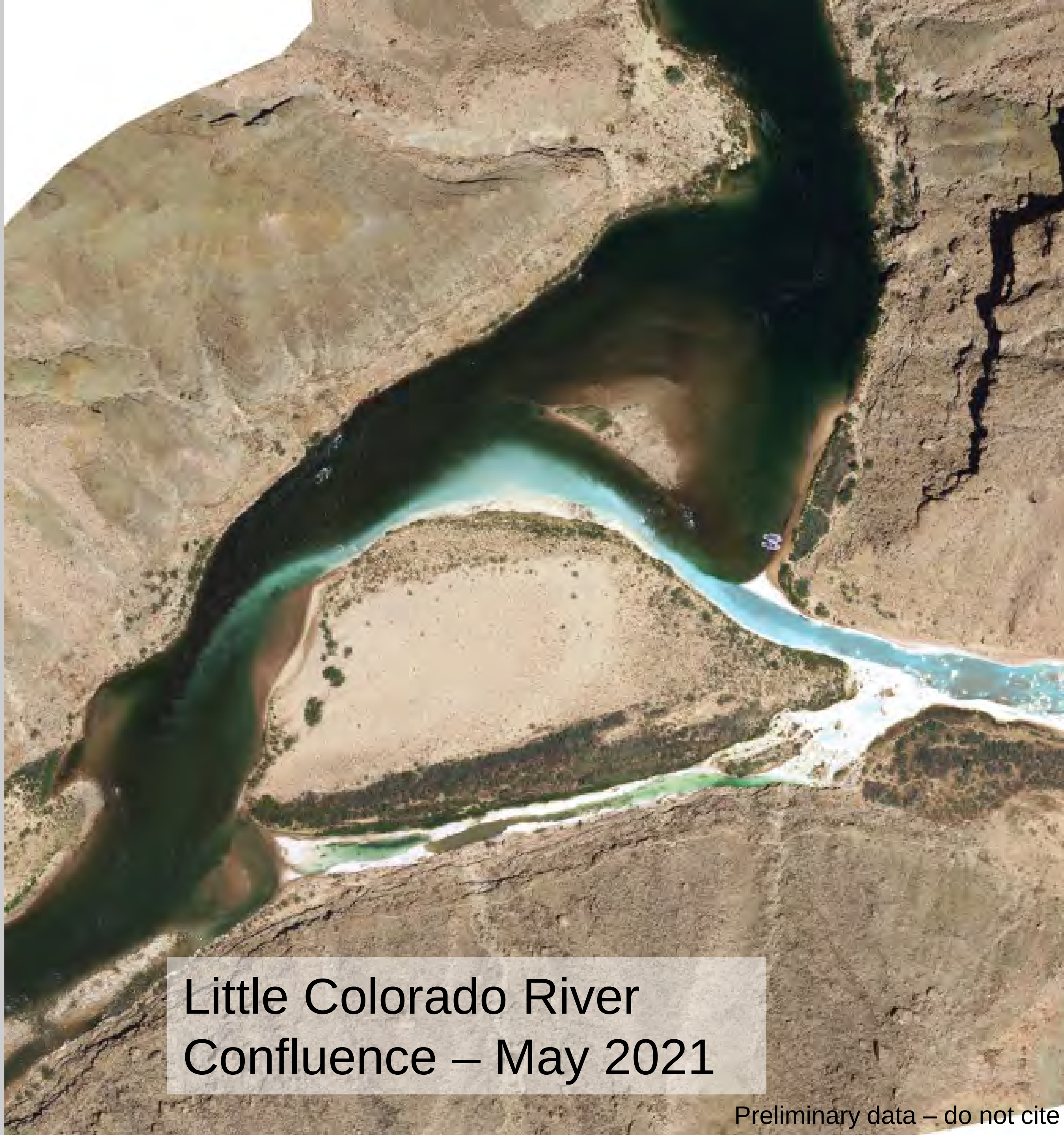
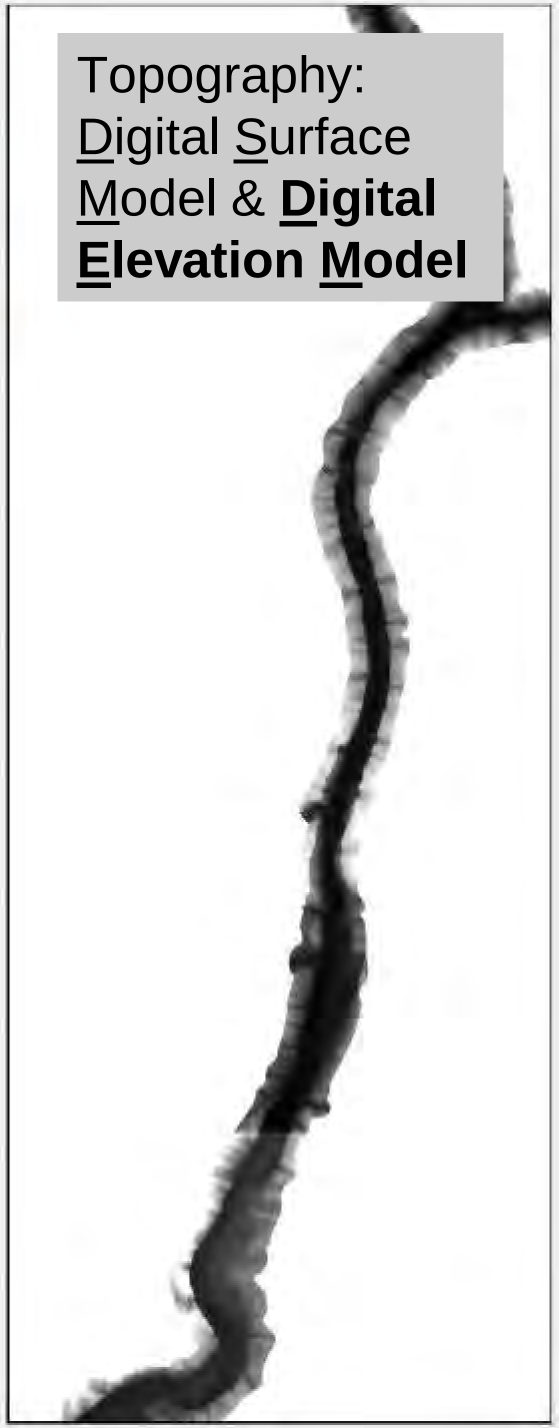
Goals, Objectives, Results

Imagery and derivative data products from overflight remote sensing are used either directly or indirectly by every science project proposed in this TWP to address every resource goal of the LTEMP

Science Questions:

- How has landcover changed in the Colorado River Ecosystem (CRe) in 2021 relative to preceding decades?
- How are observed landcover changes related to dam operations, other land use and management activities, as well as climate and other environmental factors in the ecosystem?





May 2021 Overflight Deliverables

Preliminary data – do not cite

May 2021 Overflight status

Fiscal Year	Quarter(s)	Activities
2021	1st	· Write Task Order and negotiate contract with GPSC (USGS Geospatial Products and Services Contracts) and contractor for overflight mission consisting of imagery and digital topographic data acquisition
	2nd	· Contract awarded to Fugro Earth Data Inc. · Coordinate logistics for the overflight mission with GCDAMP agencies and stakeholders Plan GCMRC logistics, including the rim- and river-level operations to be conducted by GCMRC in coordination with the contractor
	3rd	· Overflight mission · Rim-level GPS base station operations · River-level accuracy assessment and ground-truthing operations
	4th	· Monitor image processing performed by Fugro (contractor)
2022	1st	· Data delivered to GCMRC · QA/QC performed by GCMRC in coordination with vendor
	2nd	· Final modifications to mosaic performed
	3rd & 4th	· Begin publication process for finalized mosaic
2023	All	· Image mosaic published · Landcover classification maps produced by GCMRC remote sensing staff

QA/QC Evaluation Steps

- o Examine orthomosaic pixel values from key feature types (examples: dry sand, shadow, vegetation, etc.)
- o Compare tile overlaps in orthomosaic and topographic elevation models
- o Compare X and Y coordinates to known placed ground truth panels
- o Compare Z values to low flow concurrent ground truth survey data

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May 2021 Overflight Imagery Positional (Horizontal) Accuracy

- 156 black and white ground truth panels were placed between Glen Canyon Dam and Pearce Ferry to assess positional accuracy on the Earth surface.

- Many of the same ground truth locations were also occupied in previous overflights allowing GCMRC to accurately assess positional accuracy between overflights.

2021 accuracy to Survey Control (meters)			
	Total	Northing (y)	Easting (x)
RMSE	0.521	0.436	0.284
95% Confidence	1.274	0.855	0.557

Results subject to change following Fugro's revision of deliverables in response to USGS QA/QC (Preliminary data – do not cite)

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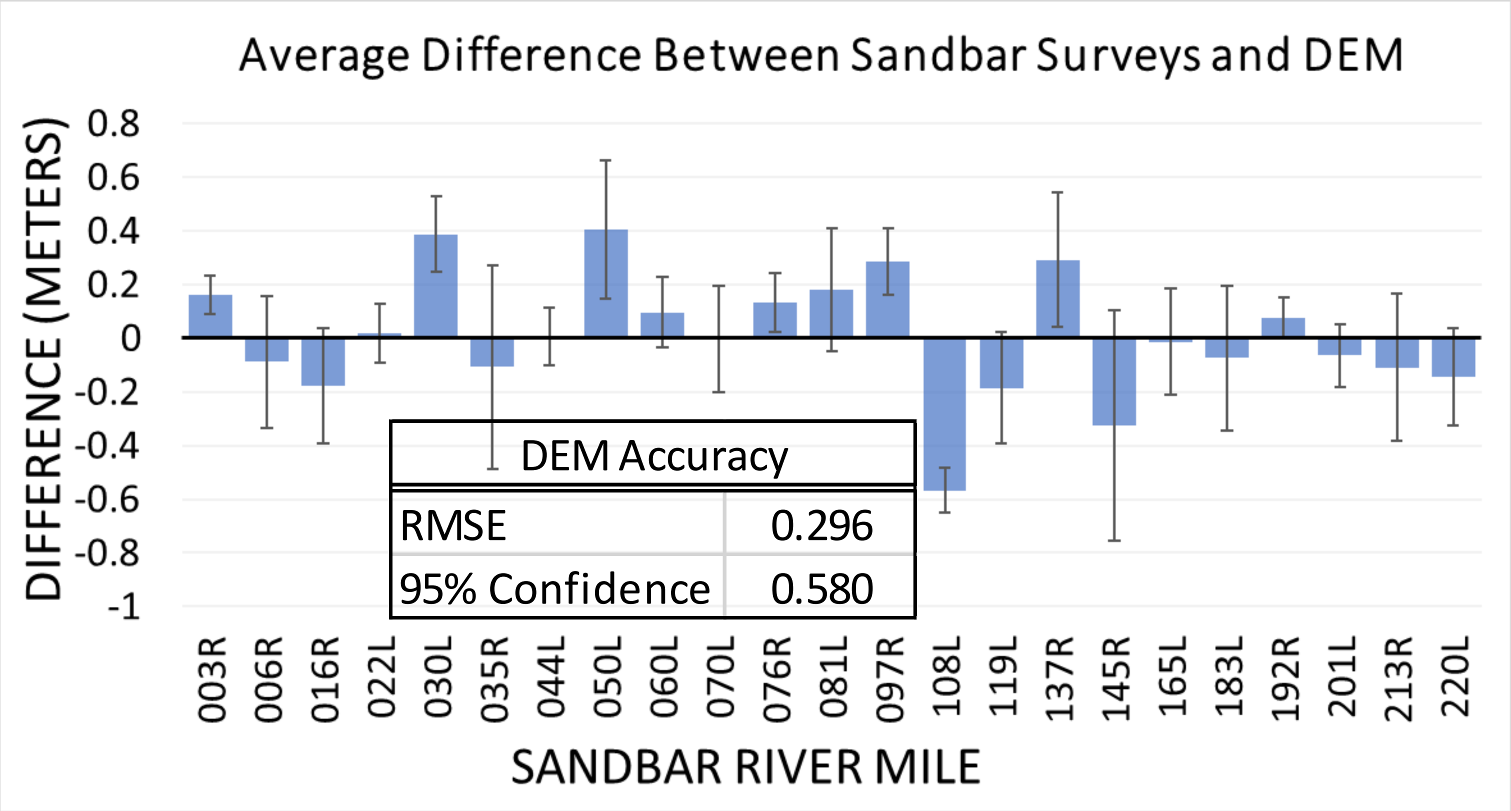
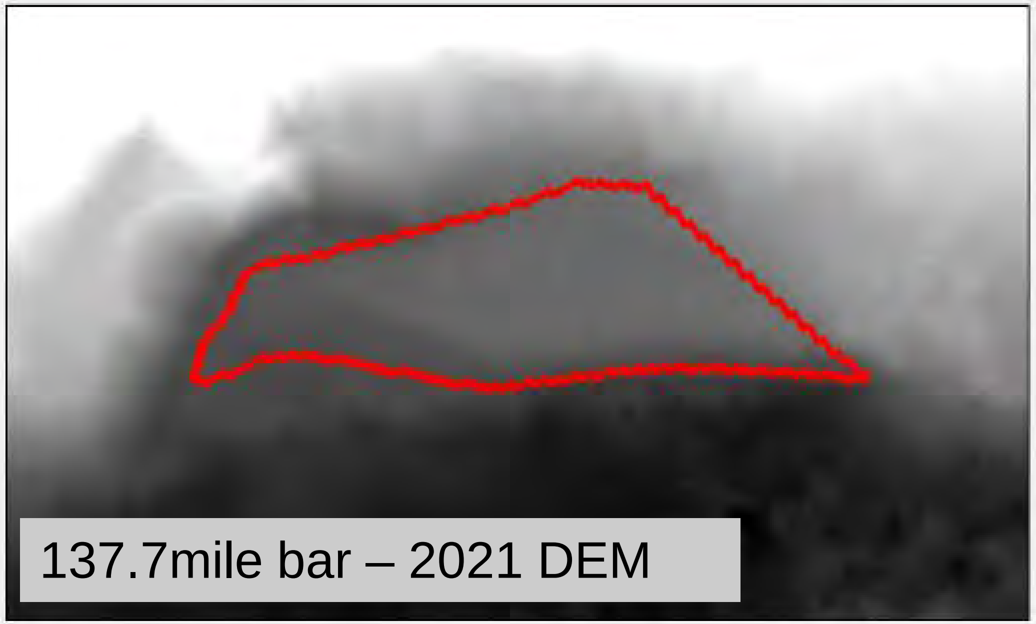
May 2021 Overflight Topography Positional (Vertical) Accuracy

- 23 sandbars were topographically surveyed during the overflight steady low flows.
- We used the interpolated survey surfaces for these bars to evaluate the accuracy of the DEM & DSM datasets.



DEM Accuracy	
RMSE	0.296
95% Confidence	0.580



Results subject to change following Fugro's revision of deliverables in response to USGS QA/QC (Preliminary data – do not cite)

Measurement of water-surface profile during 2021 overflight

- Continuous profile collected by boat from Lees Ferry to Pearce Ferry
- 187 surveyed water surface elevations at (1 every ~1.2 miles)
- 23 topographic surveys for validating the overflight digital elevation model

- All water-surface and topographic surveys have been processed
- Preliminary comparison between 10 surveyed water-surface elevations and boat-based measurements indicate improved accuracy (maximum difference of 0.11 m with mean difference of 0.02 m)

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Measurement of water-surface profile during 2021 overflight

- The water-surface profile at a constant discharge (8,000 cfs) is used to delineate the river shoreline and is used to calibrate models for predicting the water surface at other discharges
- The best profile currently available is based on lidar data collected in 2000
  - Accuracy of water-surface elevations estimated to be ± 0.5 m, based on limited ground-truth data
  - 0.5 m vertical error can equal 25 m or more horizontal error in shoreline location
- Purpose of 2021 effort:
  - Measure continuous profile from at least two sources
    - Overflight digital surface model (lowest ground surface elevation adjacent to water)
    - Moving boat with high-accuracy GNSS receivers
  - Verify accuracy with surveyed check-points throughout river corridor

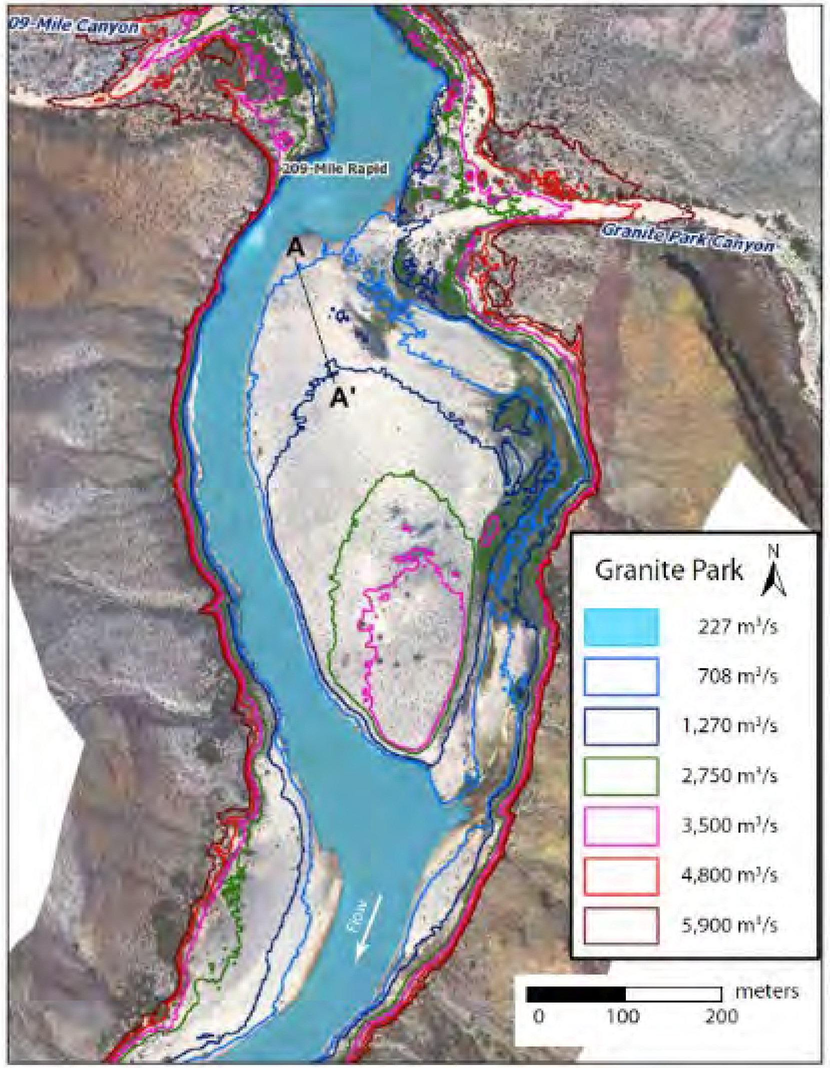

Figure 21. Virtual shorelines at Granite Park (river mile 209) as predicted by the hydraulic model. The line A-A' extends between the 708 and 1,274 m^3/s shorelines and rises 1.9 meters across a distance of 100 meters.

From Magirl et al. (2008)

Continued Analysis of 2013 and Earlier Overflight Imagery

- 2 papers published in 2021
  - Durning et al., 2021
  - Bransky et al., 2021

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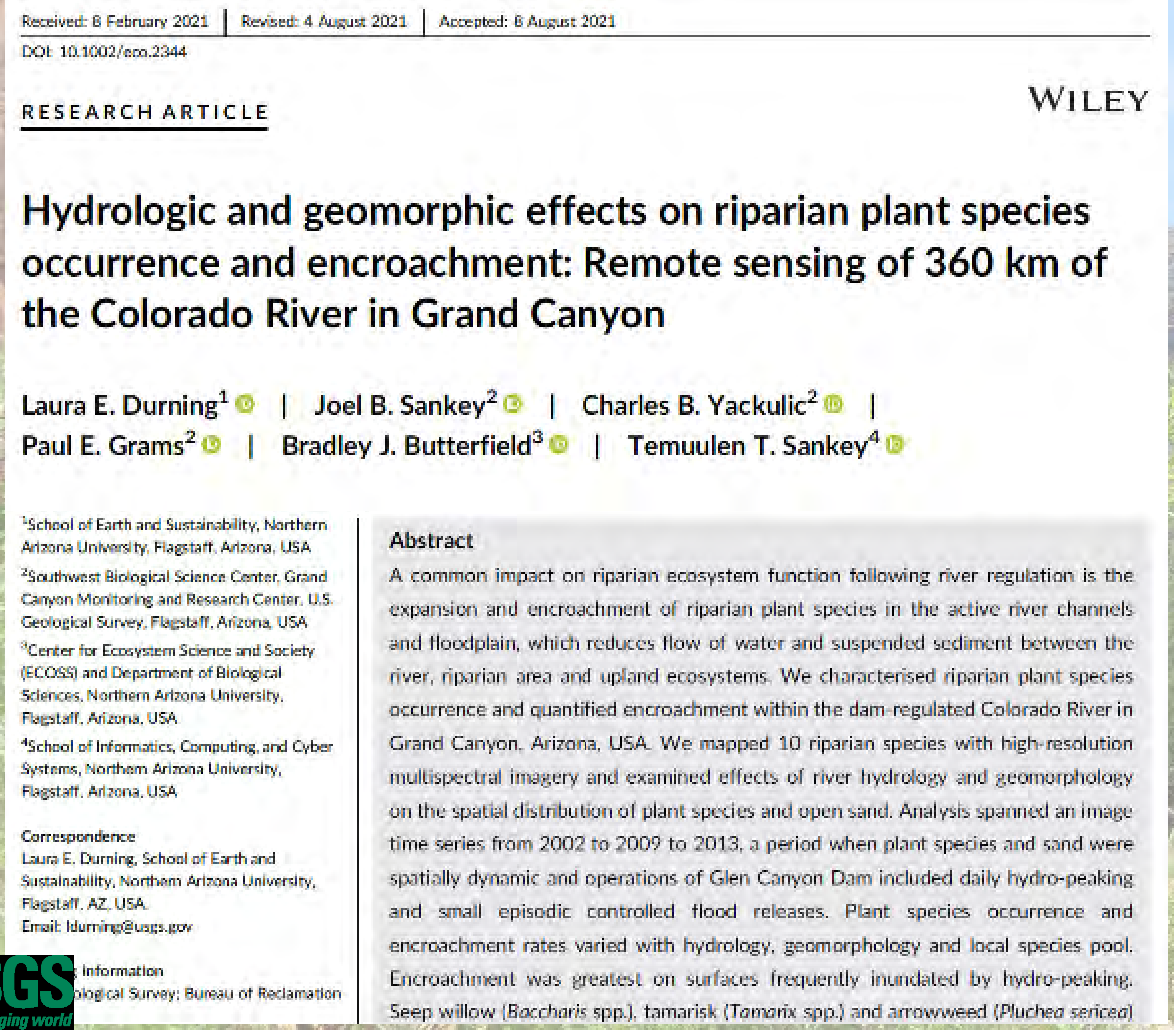
Hydrologic and geomorphic effects on riparian plant species occurrence and encroachment: remote sensing of 360 km of the Colorado River in Grand Canyon



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RESEARCH ARTICLE

WILEY

Hydrologic and geomorphic effects on riparian plant species occurrence and encroachment: Remote sensing of 360 km of the Colorado River in Grand Canyon

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...information
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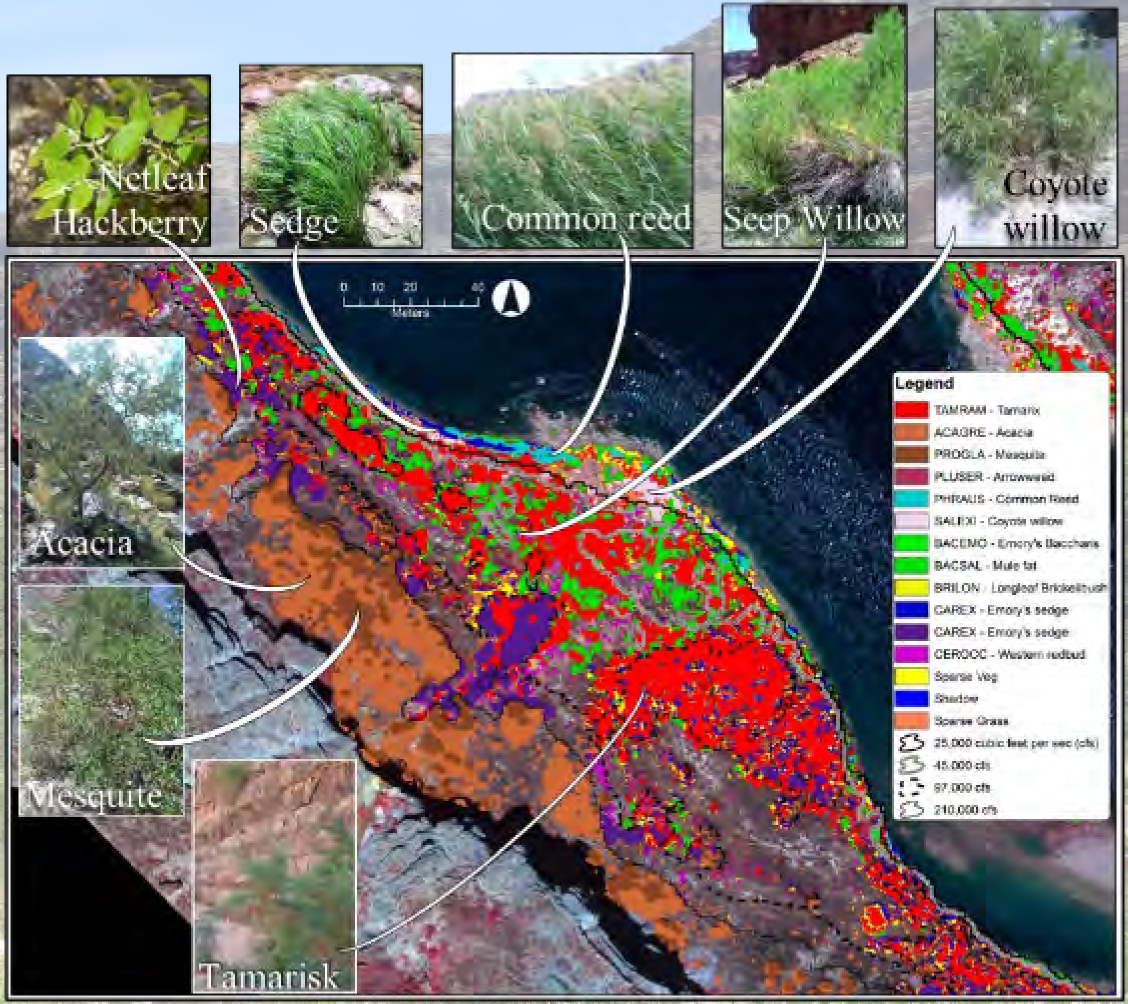
Abstract

A common impact on riparian ecosystem function following river regulation is the expansion and encroachment of riparian plant species in the active river channels and floodplain, which reduces flow of water and suspended sediment between the river, riparian area and upland ecosystems. We characterised riparian plant species occurrence and quantified encroachment within the dam-regulated Colorado River in Grand Canyon, Arizona, USA. We mapped 10 riparian species with high-resolution multispectral imagery and examined effects of river hydrology and geomorphology on the spatial distribution of plant species and open sand. Analysis spanned an image time series from 2002 to 2009 to 2013, a period when plant species and sand were spatially dynamic and operations of Glen Canyon Dam included daily hydro-peaking and small episodic controlled flood releases. Plant species occurrence and encroachment rates varied with hydrology, geomorphology and local species pool. Encroachment was greatest on surfaces frequently inundated by hydro-peaking. Seep willow (*Baccharis* spp.), tamarisk (*Tamarix* spp.) and arrowweed (*Pluchea sericea*)



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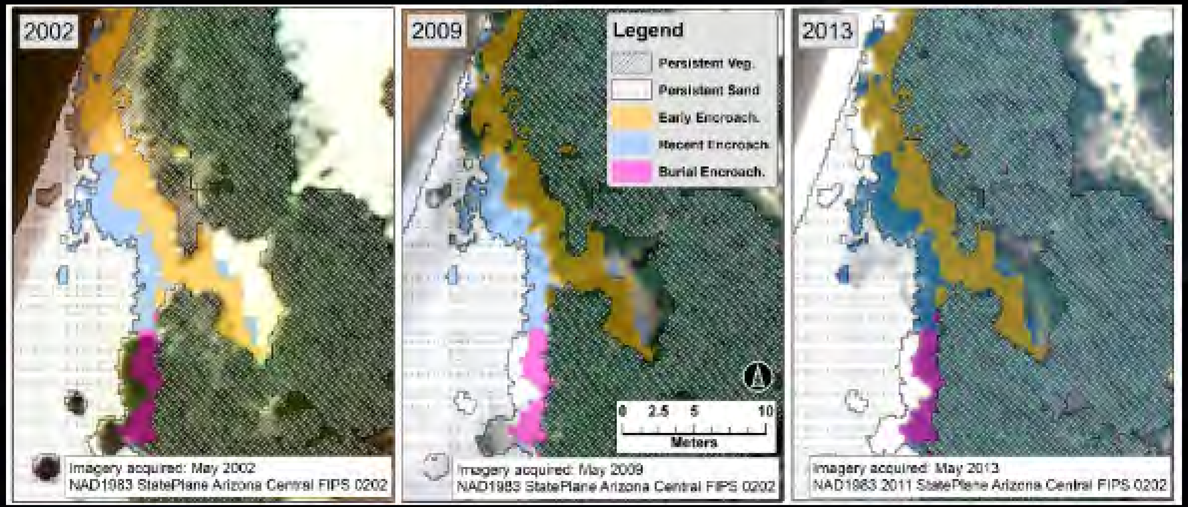
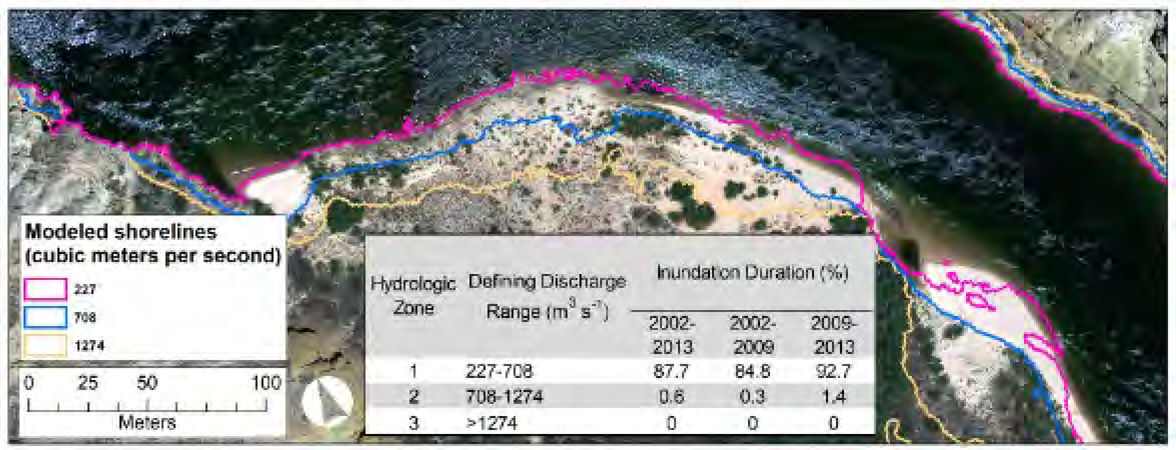
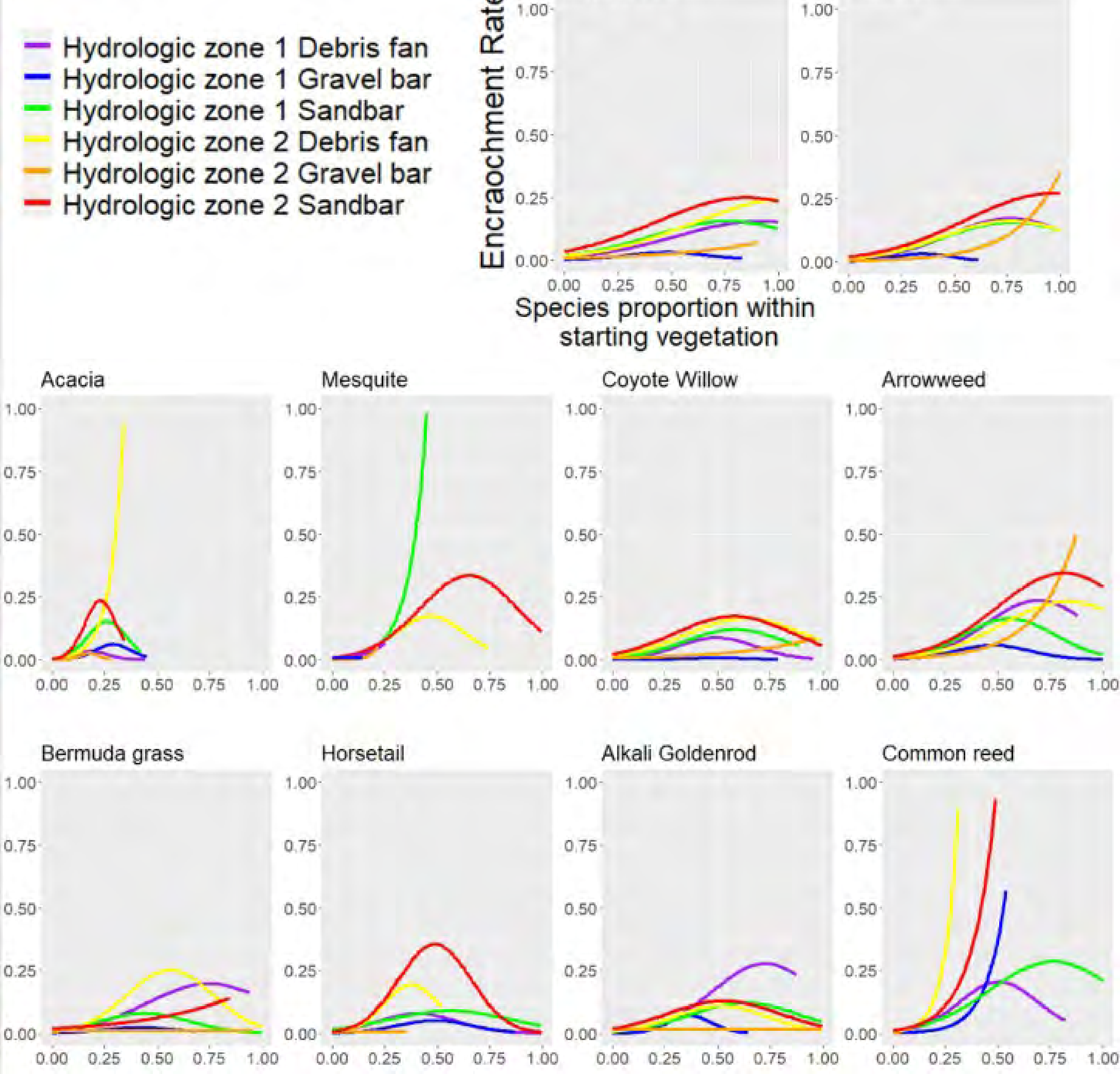
Durning et al, 2021





Hydrologic Zone	Defining Discharge Range ($m^3 s^{-1}$)	Inundation Duration (%)		
		2002-2013	2002-2009	2009-2013
1	227-708	87.7	84.8	92.7
2	708-1274	0.6	0.3	1.4
3	>1274	0	0	0



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Summary (Durning et al. 2021)

- Riparian vegetation expanded from 2002 to 2013.
    - Three quarters of the expansion occurred between 2002 & 2009.
- Seep willow, tamarisk and arrowweed were the primary encroaching woody species.
- Common reed and horsetail were the primary encroaching herbaceous species.
- Encroachment composition from 2002 to 2009 was similar to the entire riparian landscape, whereas encroachment from 2009 to 2013 primarily consisted of seep willow and early colonizing herbaceous species.
- Emergence of seep willow and arrowweed after burial by sand deposited by controlled floods indicated that those species were resilient to this form of disturbance.
- Describing patterns of species encroachment is an important step towards designing flow regimes that favor riparian species and ecosystem functions valued by stakeholders

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Monitoring *Tamarix* Changes Using WorldView-2 Satellite Imagery in Grand Canyon National Park, Arizona

remote sensing

MDPI

Article

Monitoring *Tamarix* Changes Using WorldView-2 Satellite Imagery in Grand Canyon National Park, Arizona

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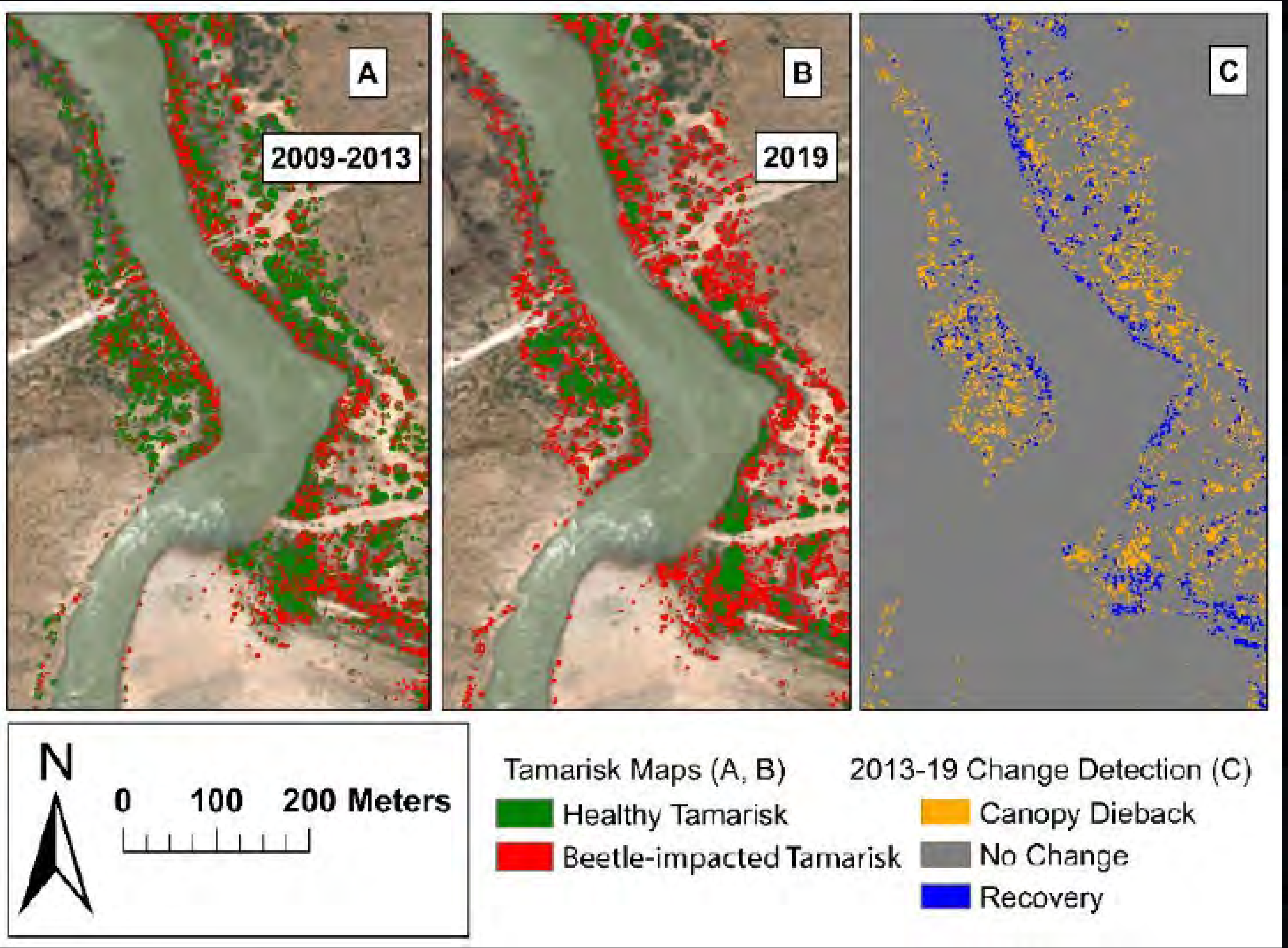
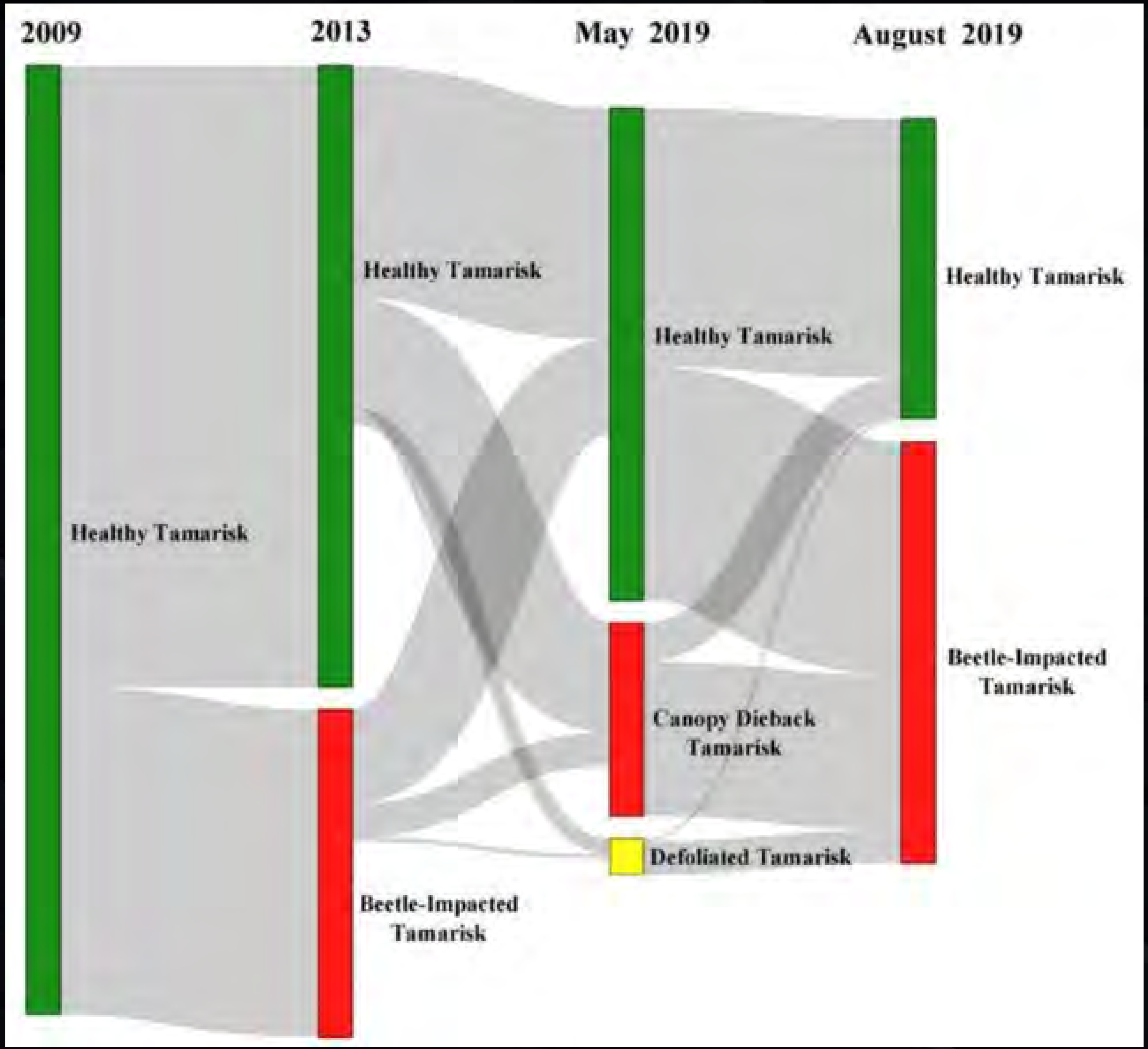
Abstract: Remote sensing methods are commonly used to monitor the invasive riparian shrub tamarisk (*Tamarix spp.*) and its response to the northern tamarisk beetle (*D. carinulata*), a specialized herbivore introduced as a biocontrol agent to control tamarisk in the Southwest USA in 2001. We use a Spectral Angle Mapper (SAM) supervised classification method with WorldView-2 (2 m spatial resolution) multispectral images from May and August of 2019 to map healthy tamarisk, canopy dieback, and defoliated tamarisk over a 48 km segment of the Colorado River in the topographically complex Grand Canyon National Park, where coarse-resolution satellite images are of limited use. The classifications in May and August produced overall accuracies of 80.0% and 83.1%, respectively. Seasonal change detection between May and August 2019 indicated that 47.5% of the healthy tamarisk detected in May 2019 had been defoliated by August 2019 within the WorldView-2 image extent. When compared to a previously published tamarisk map from 2009, derived from multispectral aerial imagery, we found that 29.5% of healthy tamarisk canopy declined between 2009 and 2019. This implies that tamarisk beetle impacts are continuing to accumulate even though land managers have noted the presence of the beetles in this reach of the river for 7 years since 2012.

Citation: Bransky, N.; Sankey, T.; Sankey, J.B.; Johnson, M.; Jamison, L. Monitoring *Tamarix* Changes Using WorldView-2 Satellite Imagery in Grand Canyon National Park,





Summary (Bransky et al. 2021)

- We used highly accurate classifications derived from overflights and satellites to map changes in tamarisk cover
- During the growing season of 2019 we documented a 47.5% decline in tamarisk
- At the decadal scale, we observed a 29.5% decline in healthy tamarisk canopy between 2009 and 2019
- (note 2021 overflight imagery will provide system-wide update on beetle impacts to tamarisk)
- These maps provide detailed information that can allow managers to target mechanical and other invasive species management efforts

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Thank you for listening!

Durning et al. (2021). Hydrologic and geomorphic effects on riparian plant species occurrence and encroachment: Remote sensing of 360 km of the Colorado River in Grand Canyon. Ecohydrology, e2344. https://doi.org/10.1002/eco.2344

Branskyet al. (2021). Monitoring Tamarix Changes Using WorldView-2 Satellite Imagery in Grand Canyon National Park, Arizona, Remote Sensing, https://doi.org/10.3390/rs13050958

Airborne remote sensing webpage
USGS Grand Canyon Monitoring and Research Center