Species-level evaluation of riparian vegetation dynamics using remotely sensed imagery from aerial overflights

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Species-level evaluation of riparian vegetation dynamics using remotely sensed imagery from aerial overflights

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- Joel B. Sankey, US Geological Survey, SBSC, GCMRC
- Temuulen Sankey, NAU, School of Informatics, Computing & Cyber Systems
- Brad Butterfield, NAU, Department of Biological Sciences
- Charles Yackulic, US Geological Survey, SBSC, GCMRC,
- Paul Grams, US Geological Survey, SBSC, GCMRC
- Tom Gushue, US Geological Survey, SBSC, GCMRC

REMOTE SENSING AND GEOINFORMATICS LAB
NORTHERN ARIZONA UNIVERSITY

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- Project C.2 Imagery-based riparian vegetation monitoring at the landscape scale
- LTEMP Resource and Goal
  - Riparian Vegetation
  - Maintain native vegetation and wildlife habitat, in various stages of maturity, such that they are diverse, healthy, productive, self-sustaining, and ecologically appropriate.

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

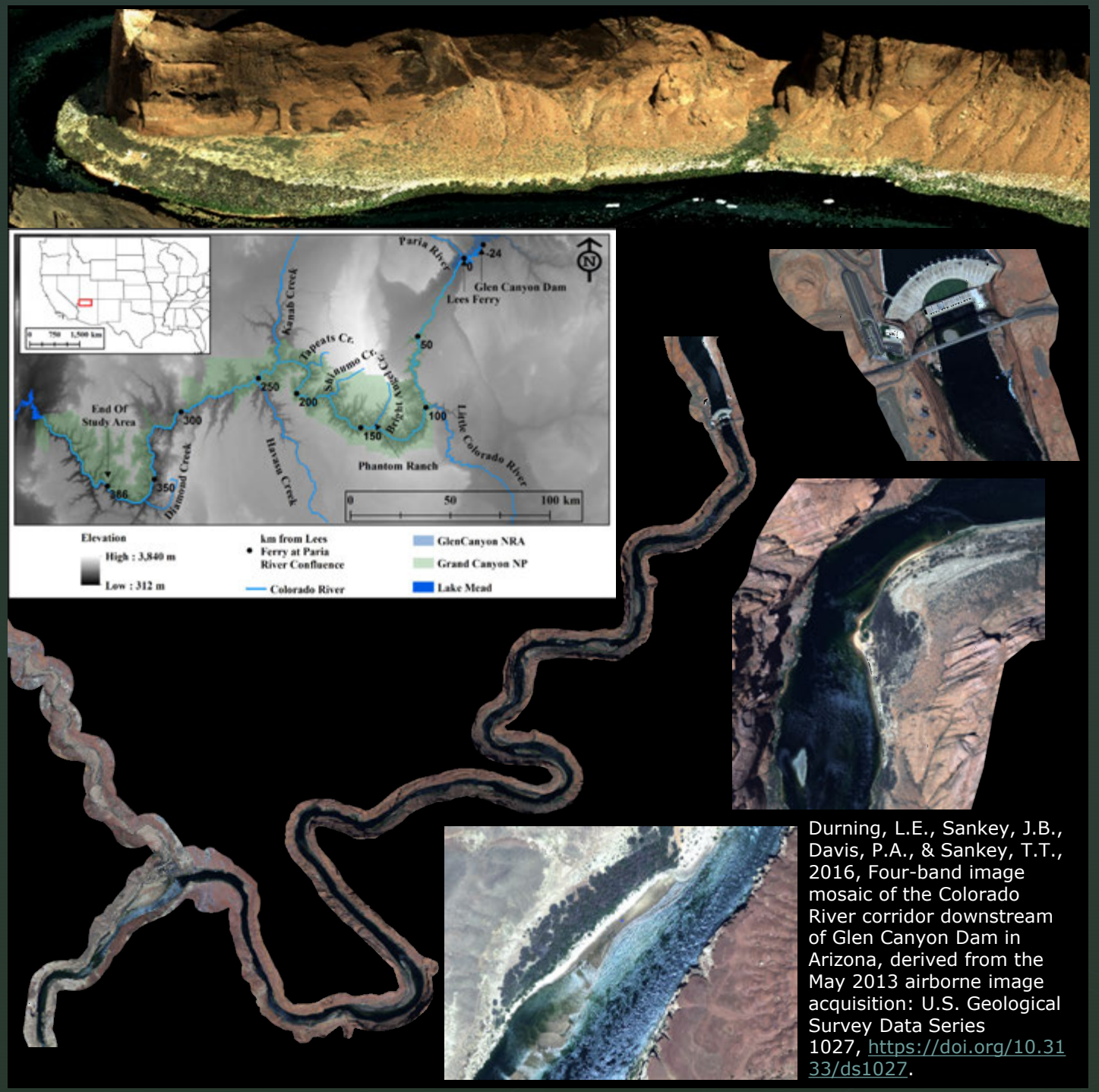
NATIONAL PARK SERVICE

Presentation Outline

- Remote sensing overflights
- Species-level evaluation of riparian vegetation dynamics from remote sensing overflight imagery
- Closing thoughts

Remote Sensing Overflights

- "Historical" overflights
  - Analog air photos since the 1960s (and even earlier)
- "Modern" overflights
  - Multispectral digital image mosaics
    - 2002, 2004, 2005, 2009, 2013, 2021



Durning, L.E., Sankey, J.B., Davis, P.A., & Sankey, T.T., 2016, Four-band image mosaic of the Colorado River corridor downstream of Glen Canyon Dam in Arizona, derived from the May 2013 airborne image acquisition: U.S. Geological Survey Data Series 1027, https://doi.org/10.3133/ds1027.

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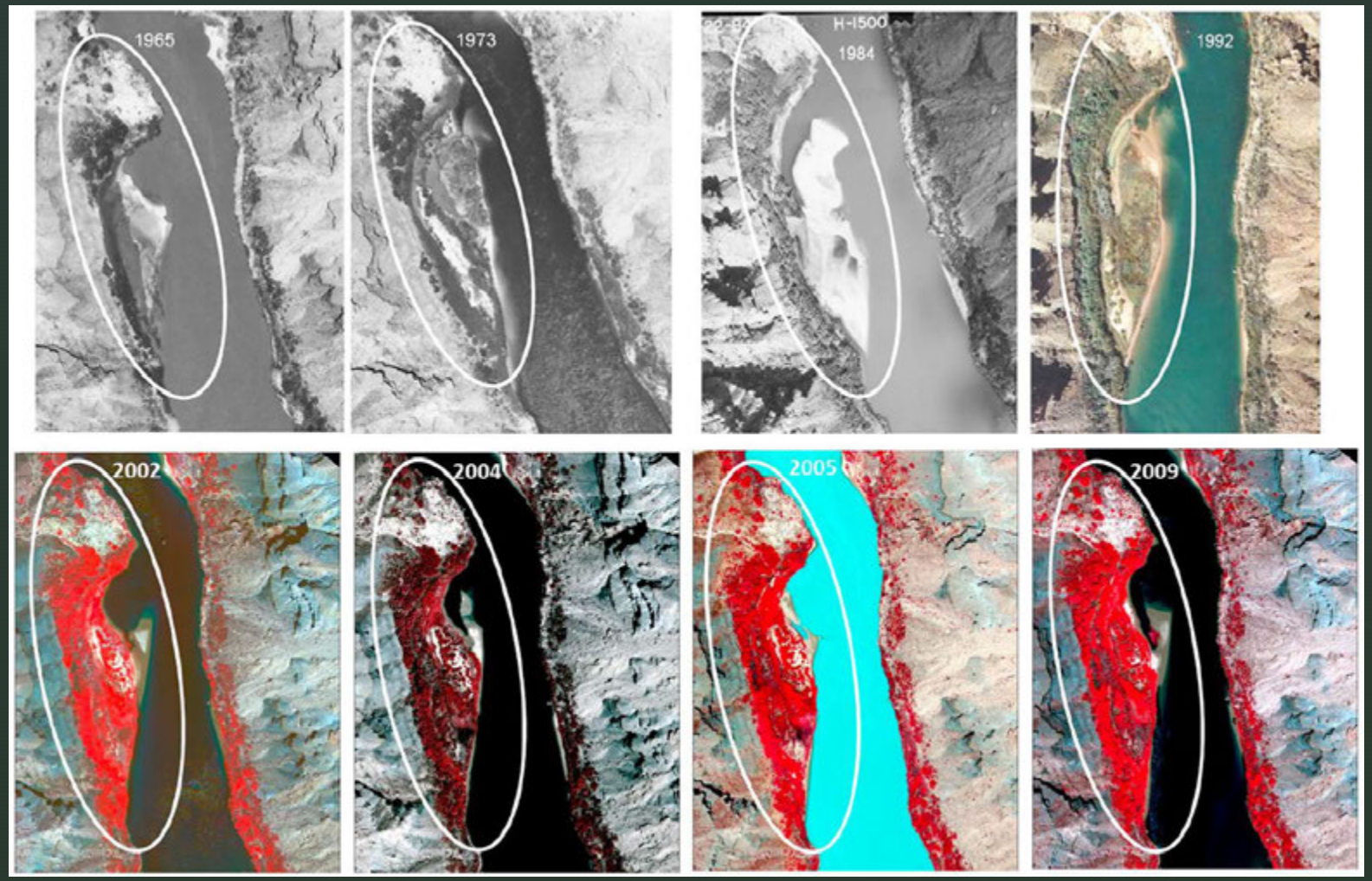
Air Photos and Multispectral Imagery from Overflights of the Colorado River in Grand Canyon



Sankey, J.B., Ralston, B., Grams, P.E., Schmidt, J.C., and Cagney, L.E., 2015, Riparian vegetation, Colorado River, and climate: five decades of spatiotemporal dynamics in the Grand Canyon with river regulation: Journal of Geophysical Research, v. (online), doi: 10.1002/2015JG002991.

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Products from Modern Overflights

Multispectral imagery

Digital topography

Website content and virtual online maps.

Cartographic products

- River map books
- Publication maps

Colorado River Centerline and River Mile System

Flowlines

– Extracted from low-flow water's edge (~8,000 CFS) in overflight imagery

- Modelled from overflight topography and water surface elevation data(Magirl, 2008)

Land cover classification

- water, sand, vegetation

Vegetation species classification

Campsite delineation

– Campsite atlas

Topography data

- Topographic change detection
- Hydrologic flow modeling.

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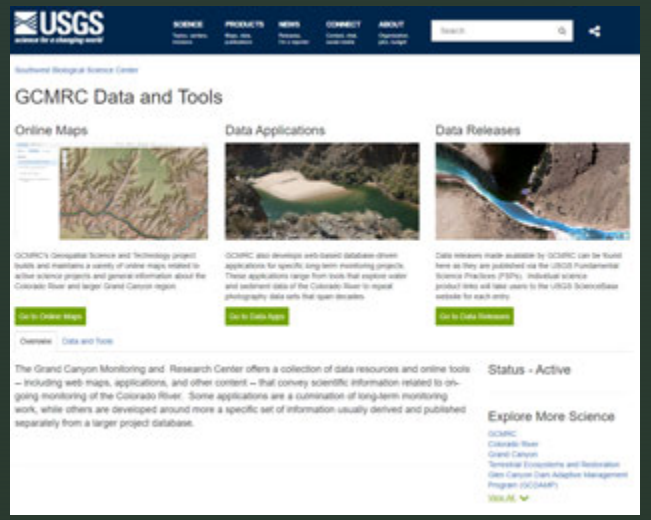
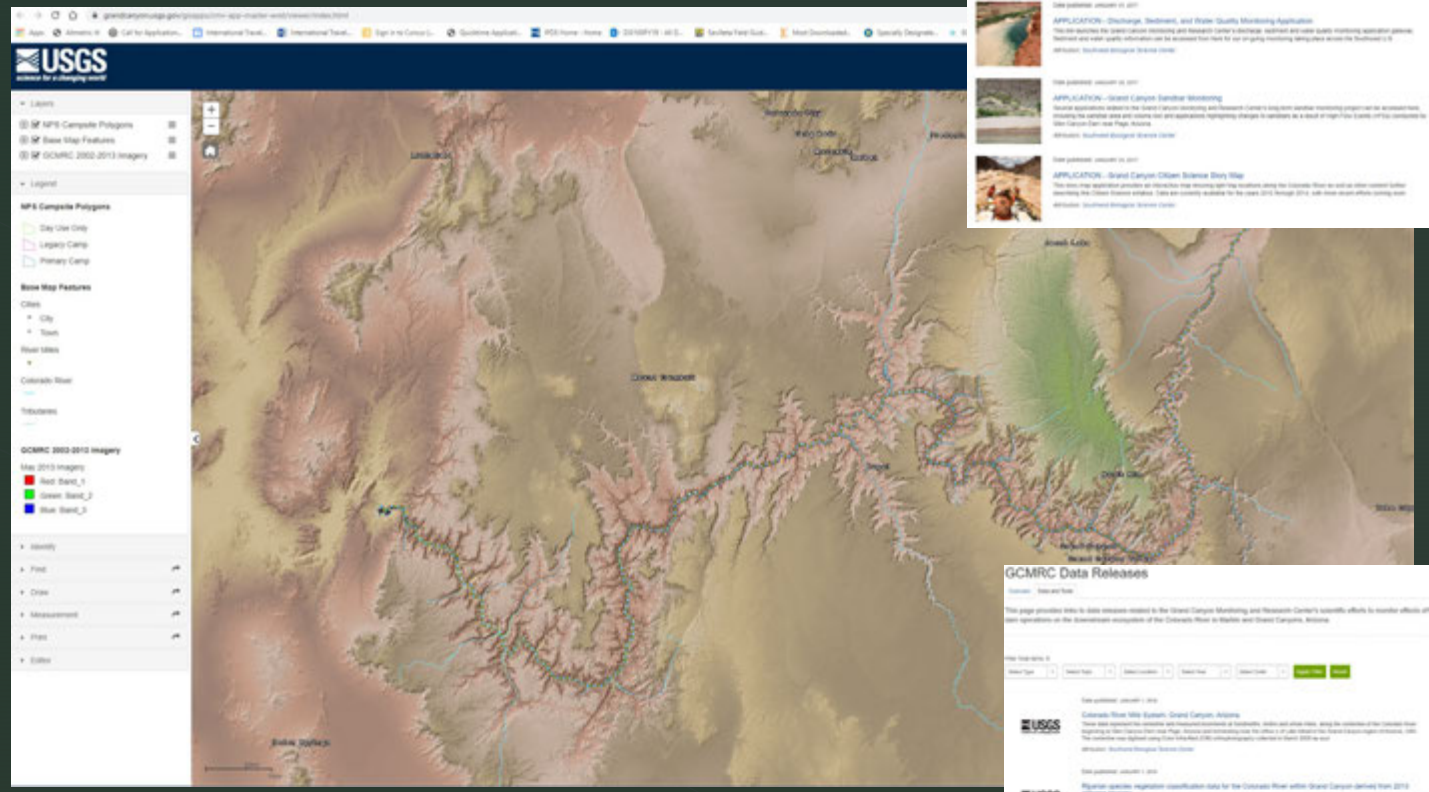
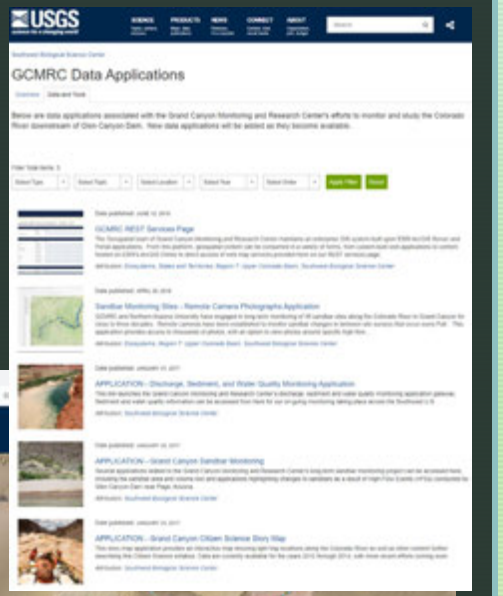
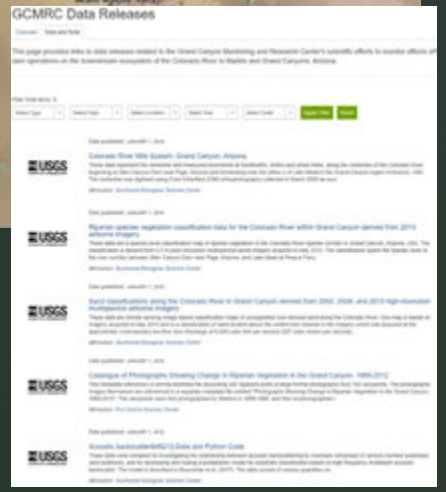
Modern Overflight Products

- Imagery and datasets available through GCMRC website
  - Online maps
  - Data applications
  - Data releases









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Modern Overflight Products

Mapbooks

- All projects use these!
- Critical to field data collection
- River navigation
- Citizen science

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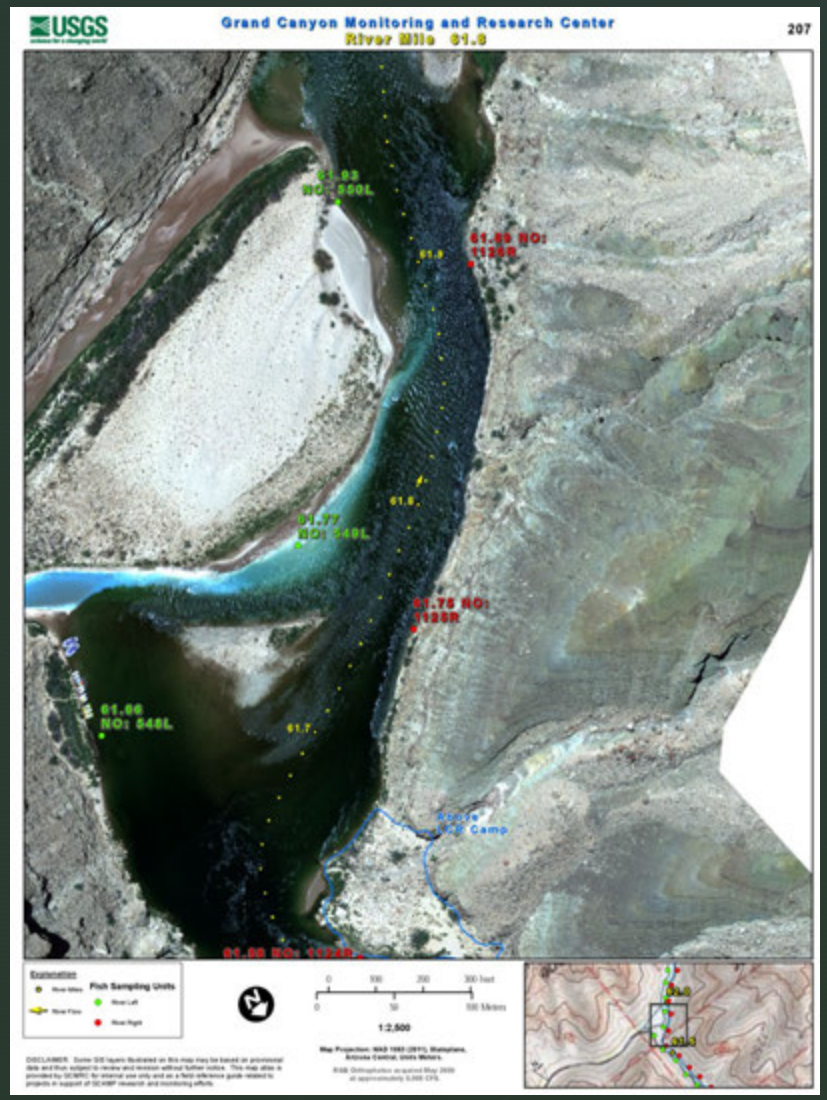
Modern Overflight Products

- Fish sampling unit system
  - Based on shorelines derived from imagery
  - Used for all fish monitoring and research
- LCR humpback monitoring depends on imagery too

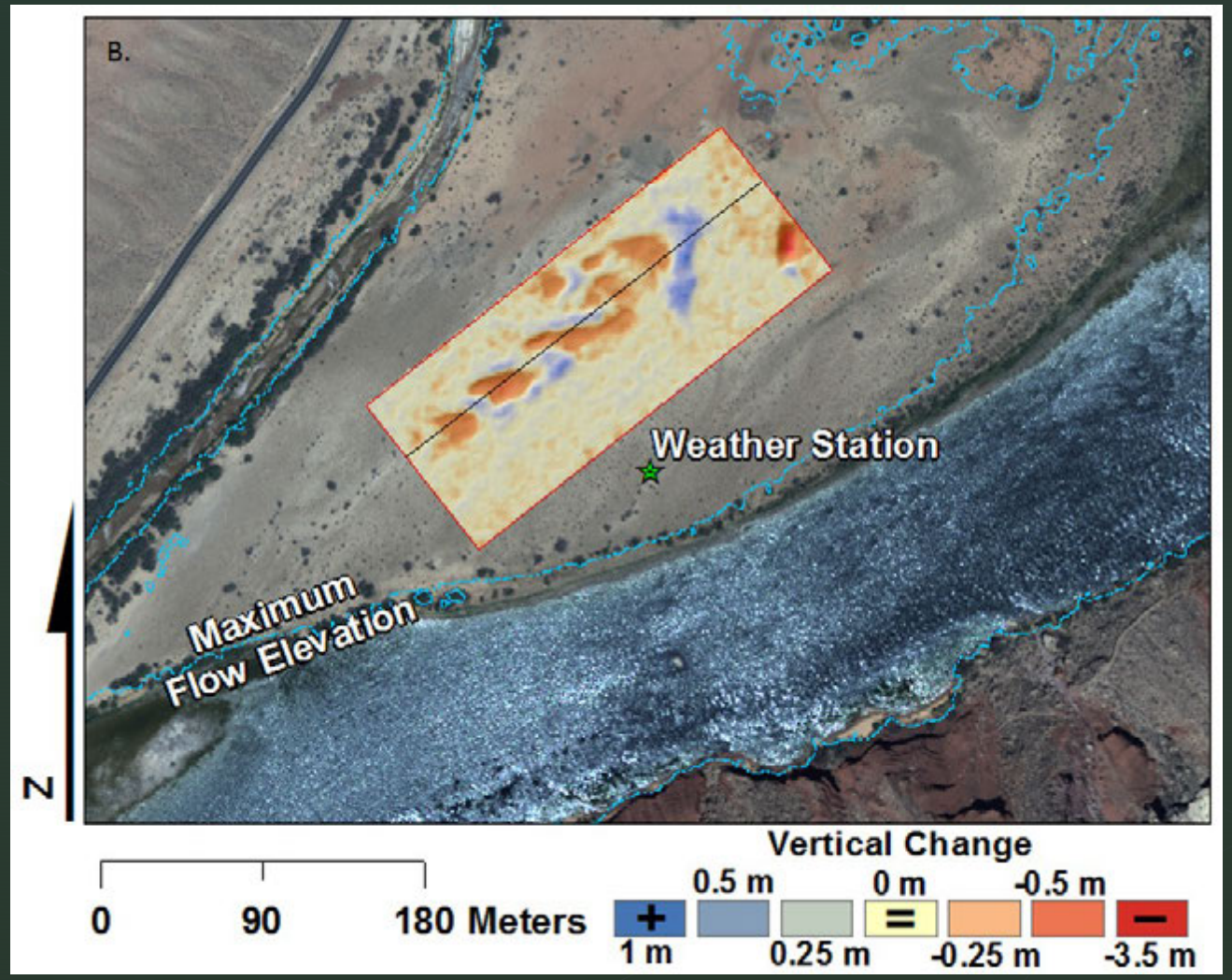


Modern Overflight Products

Digital Surface & Elevation Models (DSM & DEM)

- DEM topographic change detection
- e.g., sand dunes

Remote sensing topographic change detection 2002-2013



Sankey, J.B., Kasprak, A., Caster, J., East, A.E. and Fairley, H.C., 2018. 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.

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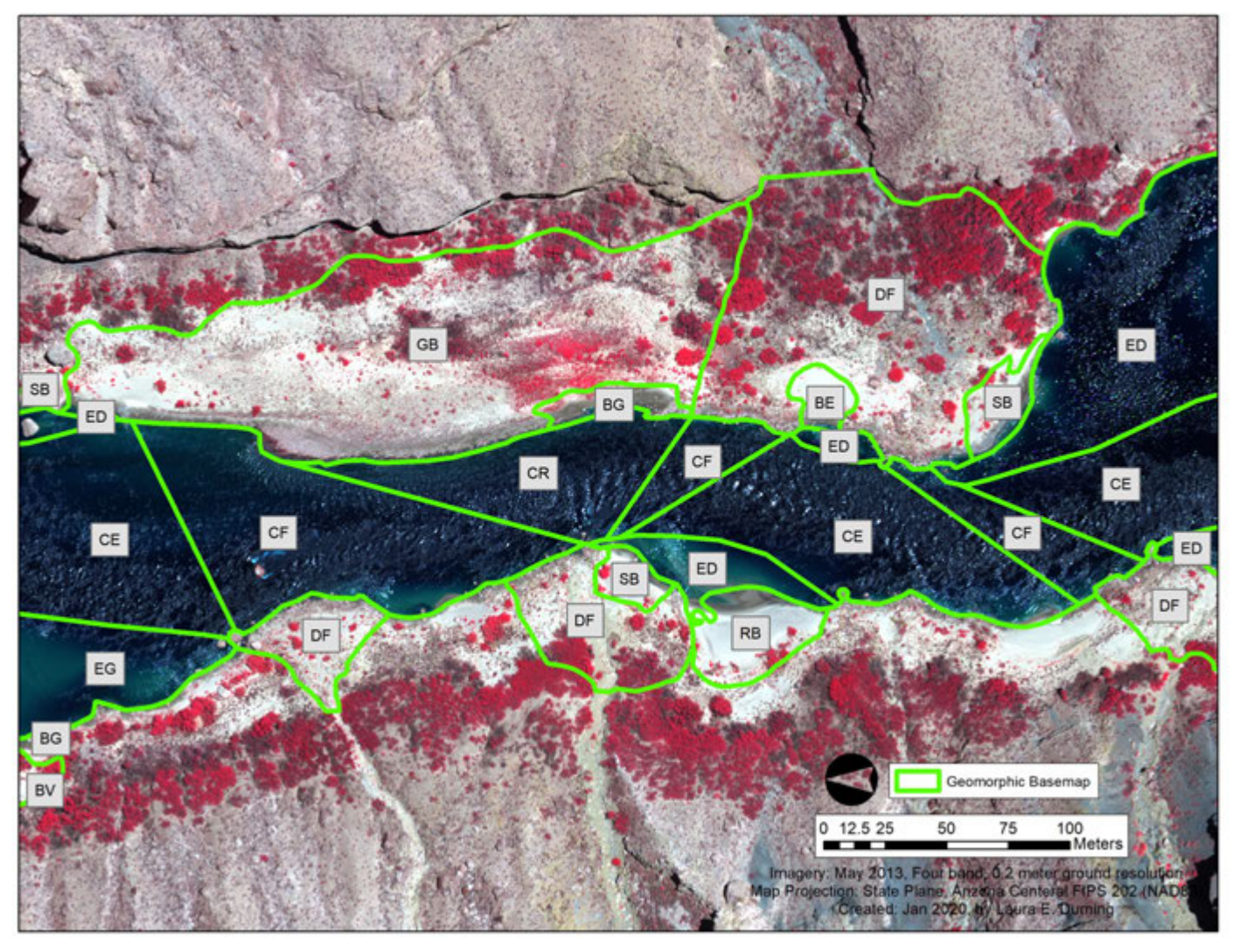
Modern Overflight Products

- Geomorphic basemap



Unpublished data, do not cite

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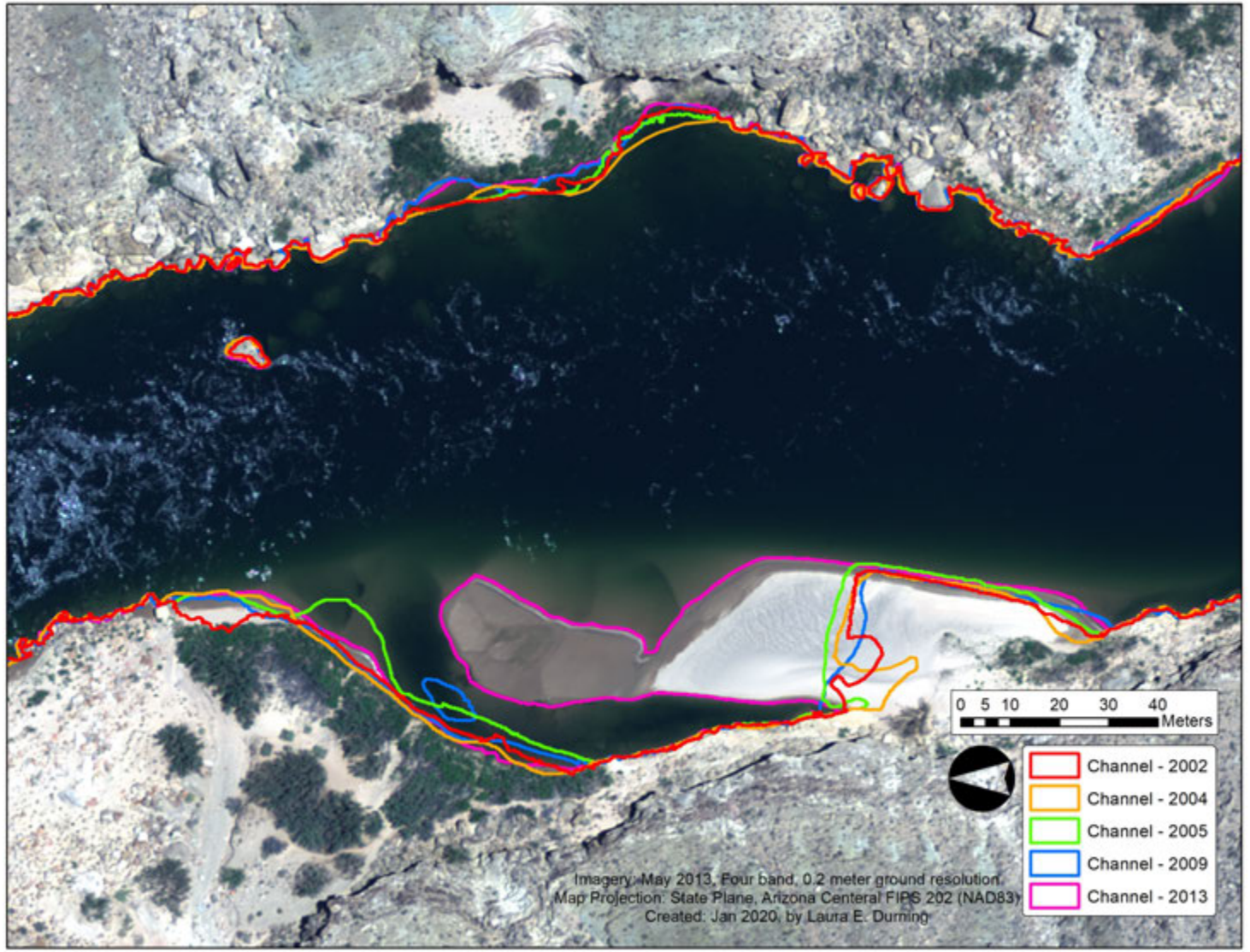
Modern Overflight Products

River channel changes

- Flowlines depicting low-flow water's edge (~8,000 CFS) in overflight imagery
- 2002, 2004, 2005, 2009, & 2013



- Sankey, et al., 2015
- Durning, L.E., Sankey, J.B., Chain, G.R., and Sankey, T.T., 2017, Water classification of the Colorado River Corridor, Grand Canyon, Arizona, 2013—Data: U.S. Geological Survey data release, https://doi.org/10.5066/F7PZ5799.

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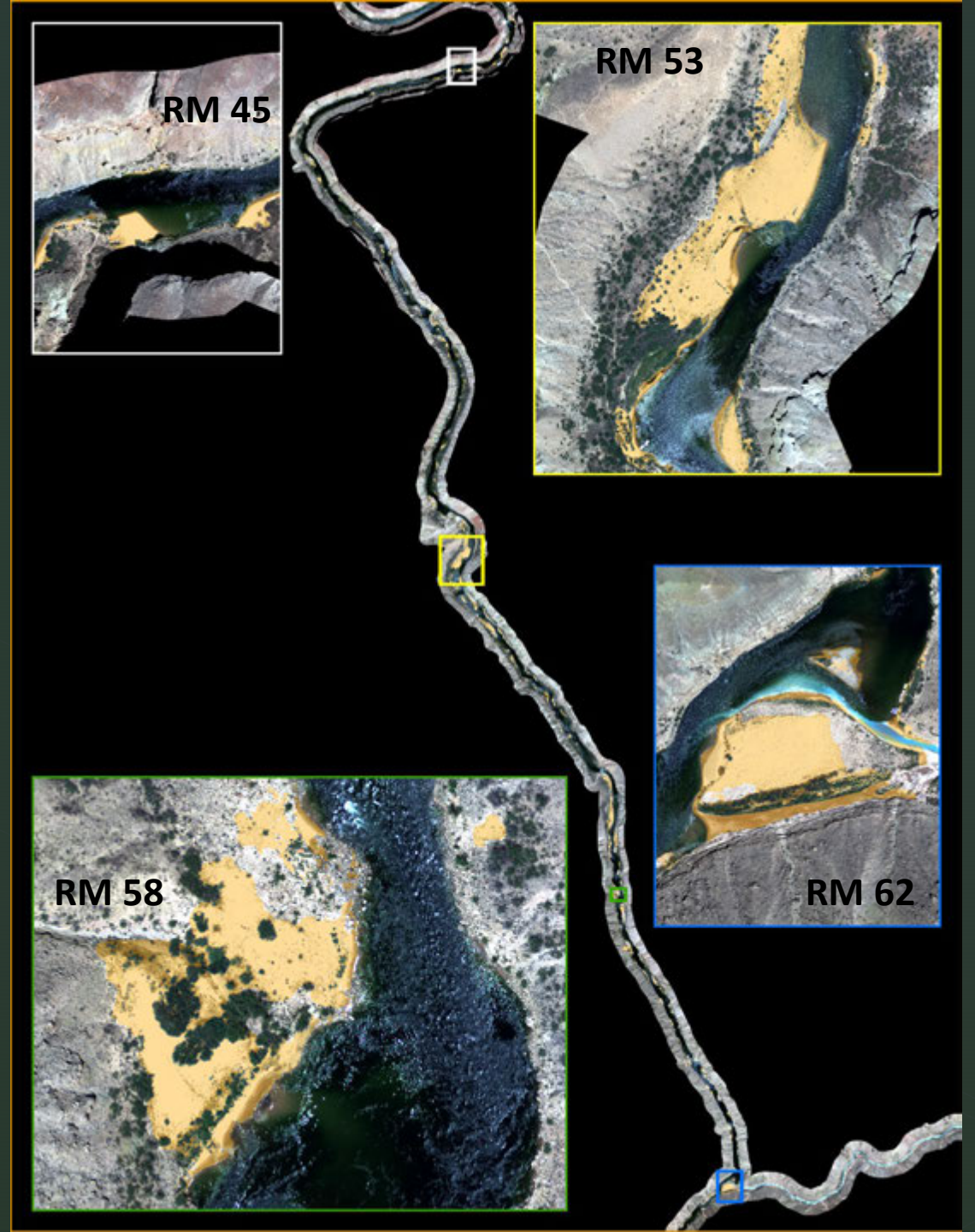
Modern Overflight Products

Landcover changes

- Image classifications of bare unvegetated sand
- 2002, 2009, 2013



Sankey, J.B., Chain, G.R., Solazzo, D., Durning, L.E., Bedford, A., Grams, P.E., and Ross, R.P., 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.

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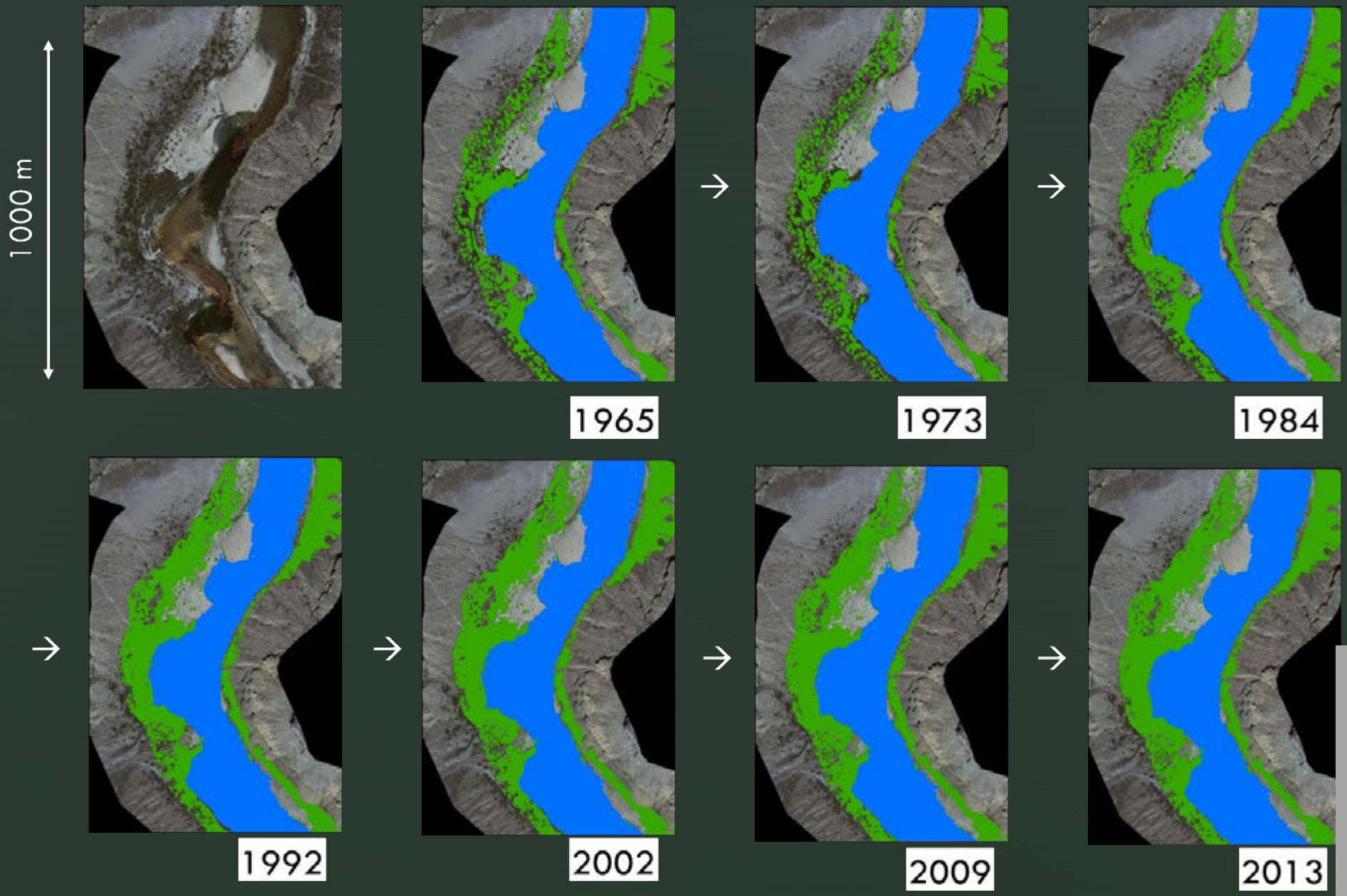
Modern Overflight Products

Landcover changes – Total Vegetation



Kasprak, A., Sankey, J.B., Buscombe, D., Caster, J., East, A.E. and Grams, P.E., 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: Earth and Environment, 42(6), pp.739-764.

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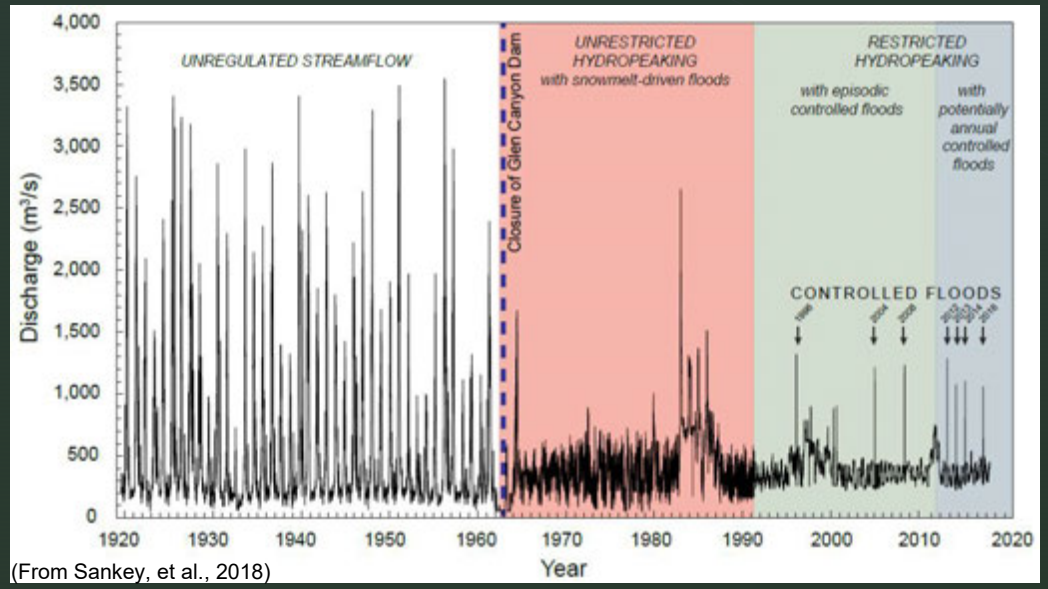
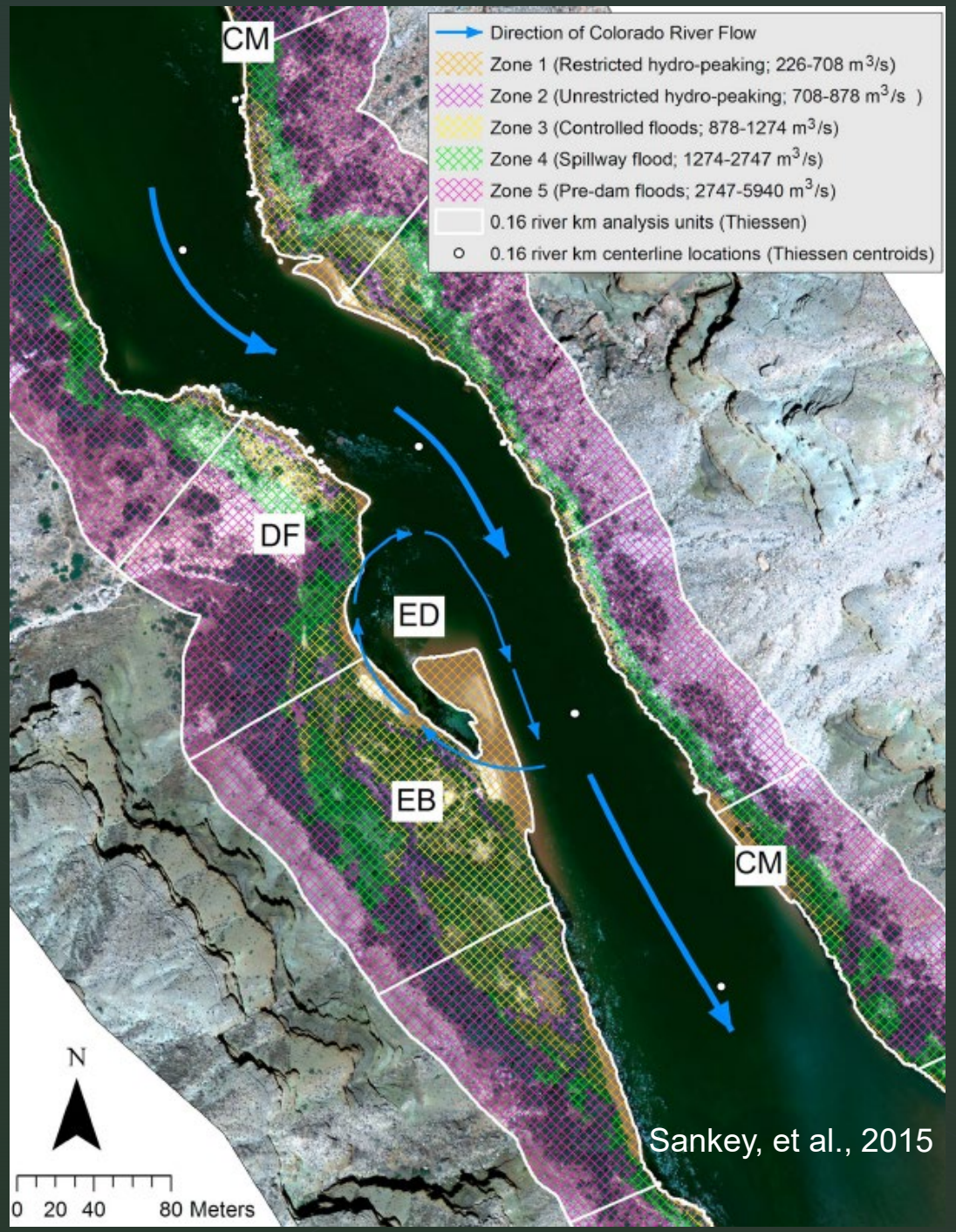
Modern Overflight Products

- Landcover changes and Glen Canyon Dam and Colorado River hydrology
  - Modelled Shorelines
  - Geomorphic basemap
  - River center-line and river-mile system
  - Landcover changes



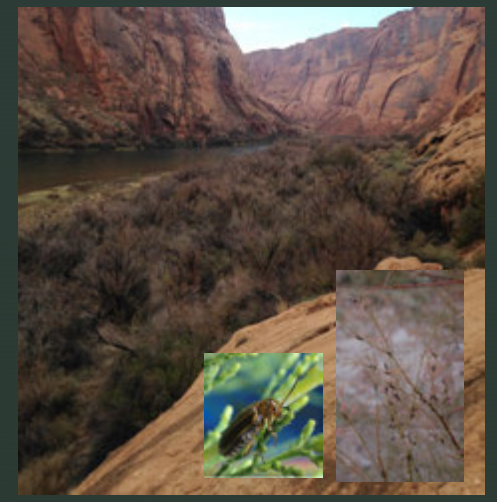
(From Sankey, et al., 2018)

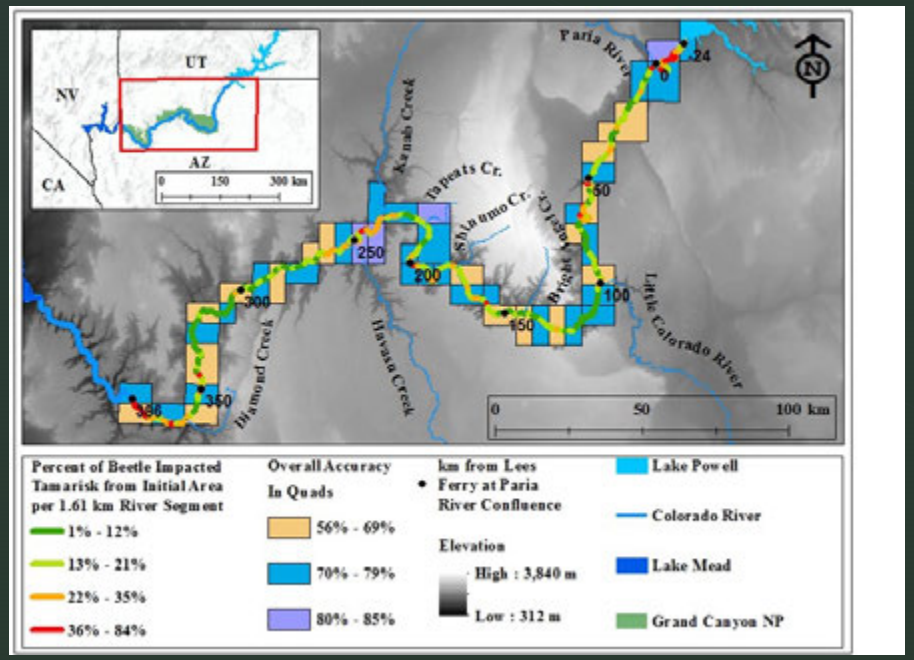


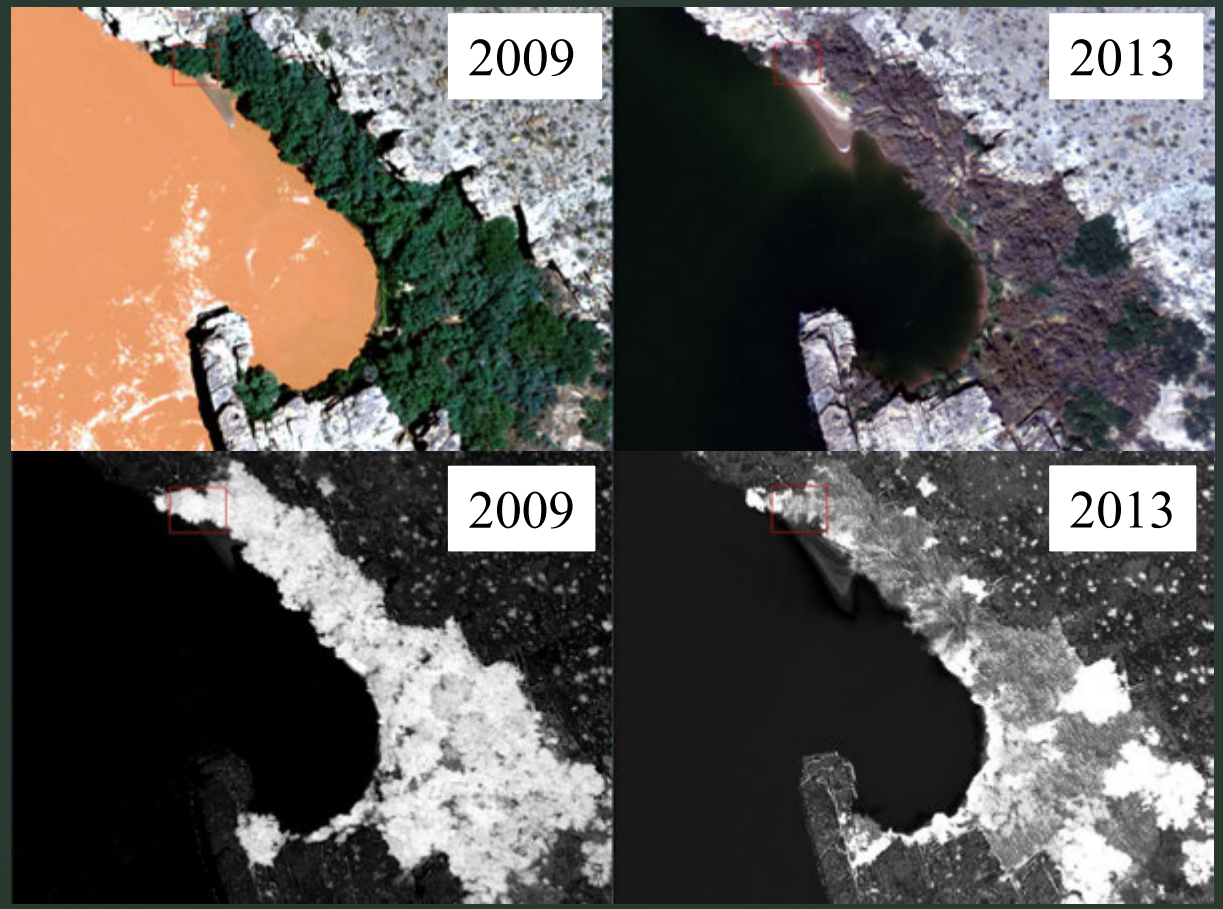
Sankey, et al., 2015

Modern Overflight Products

Tamarisk and Tamarisk Beetle Impacts







Bedford, A., Sankey, T.T., Sankey, J.B., Durning, L.E., and Ralston, B.E., 2018, Remote sensing of tamarisk beetle (Diorhabda carinulata) impacts along 412 km of the Colorado River in the Grand Canyon, Arizona, USA: Ecological Indicators, v. 89, p. 365-375, https://doi.org/10.1016/j.ecolind.2018.02.026.

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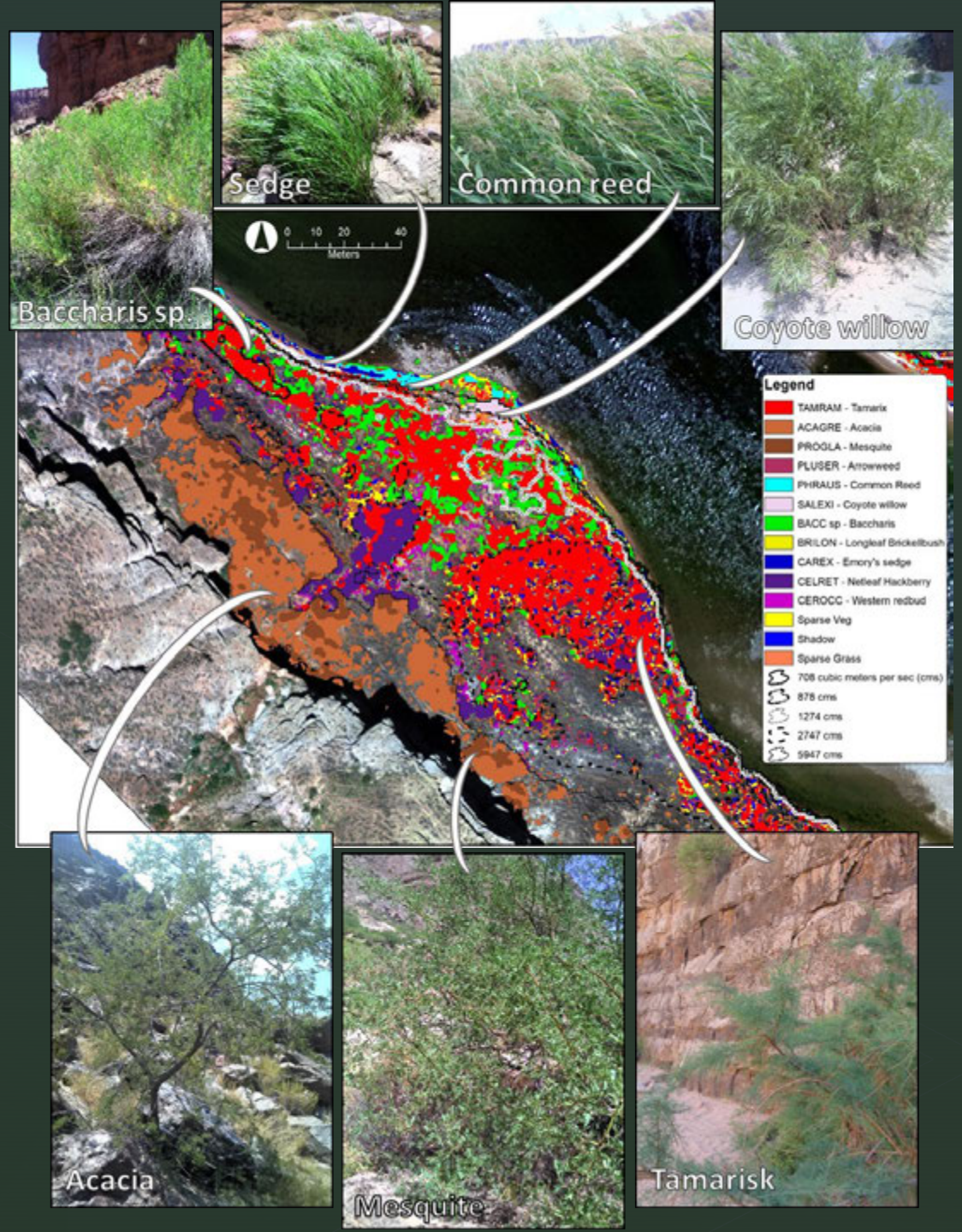
Modern Overflight Products

Vegetation Species Classification

- Map covers from Glen Canyon Dam to Pearce Ferry
- 26 species and 7 additional generalized vegetation classes
- Overall accuracy 71%



Durning, L.E., Sankey, J.B., Bedford, A., and Sankey, T.T., 2018, Riparian species vegetation classification data for the Colorado River within Grand Canyon derived from 2013 airborne imagery: U.S. Geological Survey data release, https://doi.org/10.5066/P9OUB1RS.

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Overflight – 2021

- General timeframe
  - 2021-2024 Work plan
    - 2021 - 1 year for managing contract and acquiring data
      - Mission scheduled for May 2021
    - 2022 - 1 year for building image mosaic & serving it online
    - 2023 - Image analysis and product generation begin
- Approximately $0.6 million to contract the acquisition
- GCMRC staff support and funding required
  - to plan and manage the acquisition
  - to process, serve, and analyze the data

Species-level evaluation of riparian vegetation dynamics: analysis of overflight imagery from 2002, 2009, and 2013

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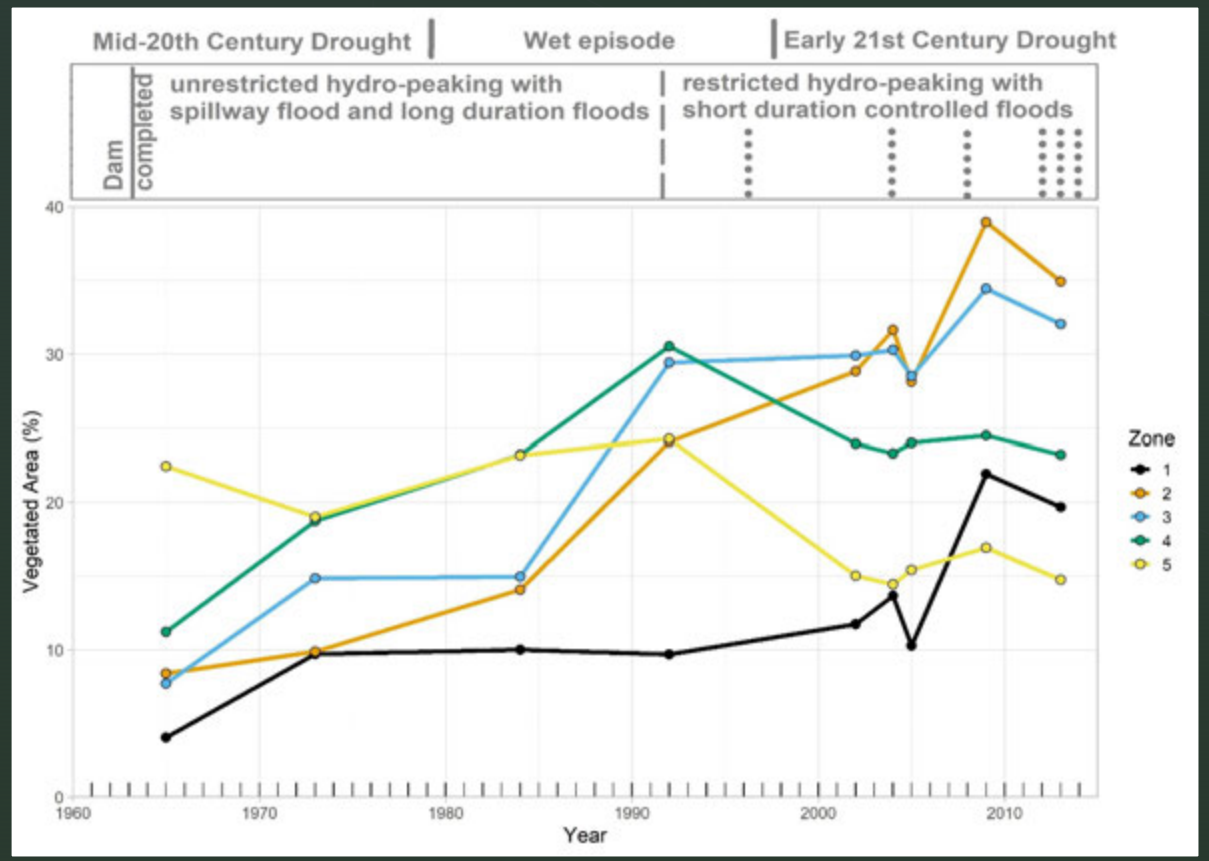
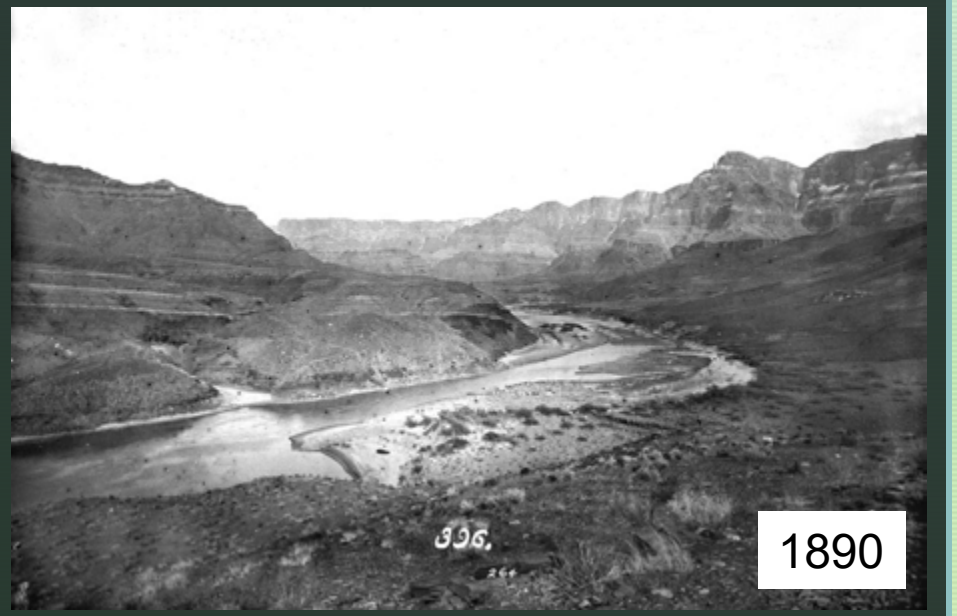
Long-term changes in riparian vegetation quantified with historic and modern overflight imagery (1965 - 2013)





Sankey et al., 2015

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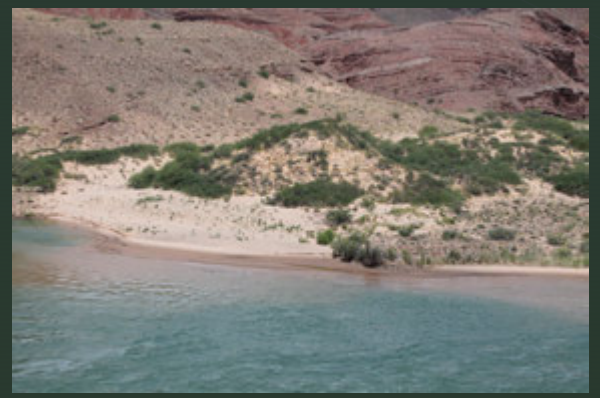
Changes in riparian vegetation and vegetation-sand dynamics quantified with modern overflight imagery (2002-2009-2013)

- Types of riparian vegetation encroachment onto sand
  - "Sustained" – sand in 2002 and vegetated in 2009 & 2013
  - "Recent" – sand in 2002 & 2009 but vegetated in 2013
  - "Burial and emergence" – vegetated in 2002 & 2013, but sand present in 2009.



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Unpublished results, do not cite

Changes in riparian vegetation and vegetation-sand dynamics quantified with modern overflight imagery (2002-2009-2013)

Research Questions:

How do the spatial distributions of vegetation species vary by inundation frequency and geomorphic surface?

How does vegetation encroachment onto bare sand vary by species, inundation frequency and geomorphic surface?

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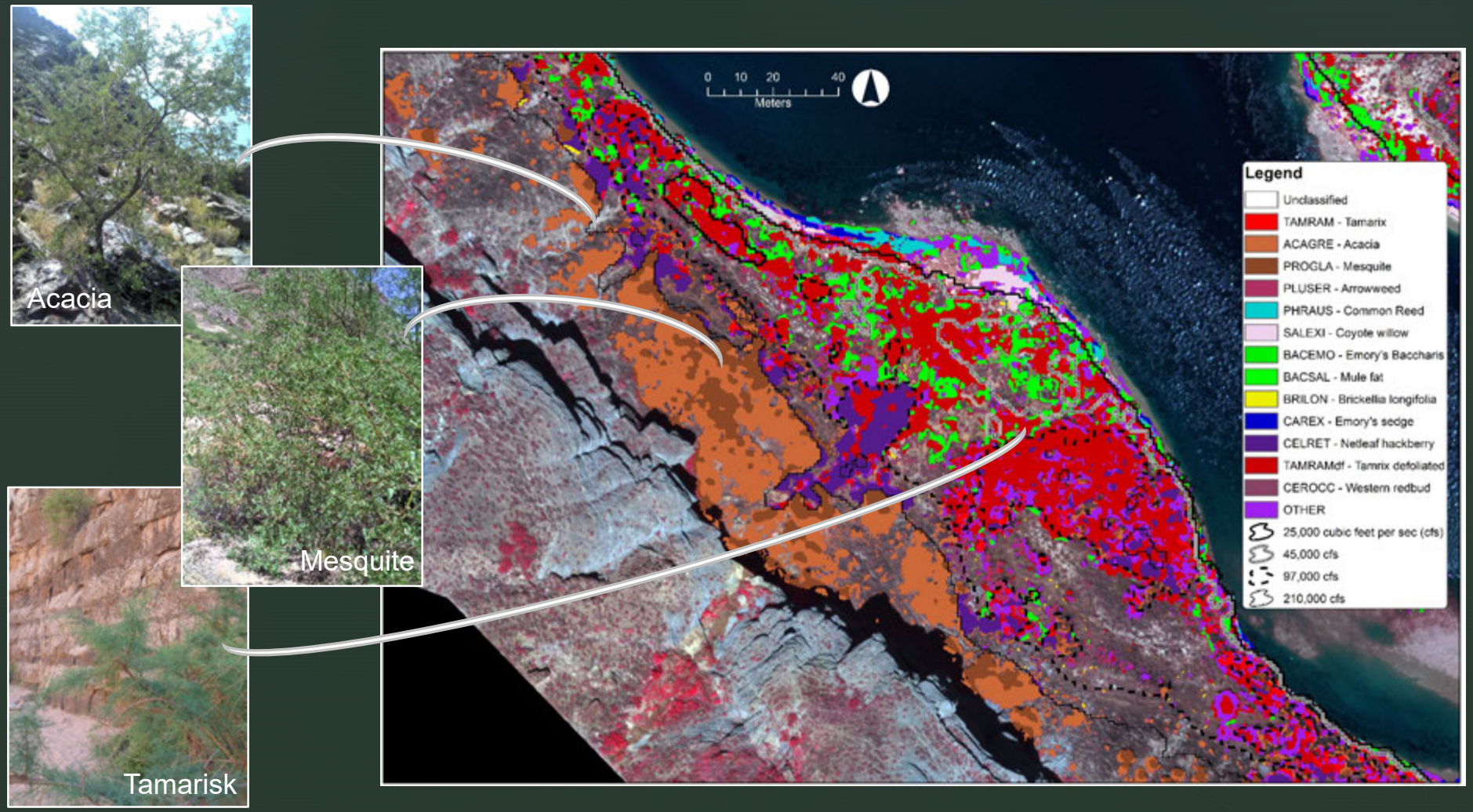
Methods – Species-level Classification of Riparian Vegetation



Durning et al., 2018.

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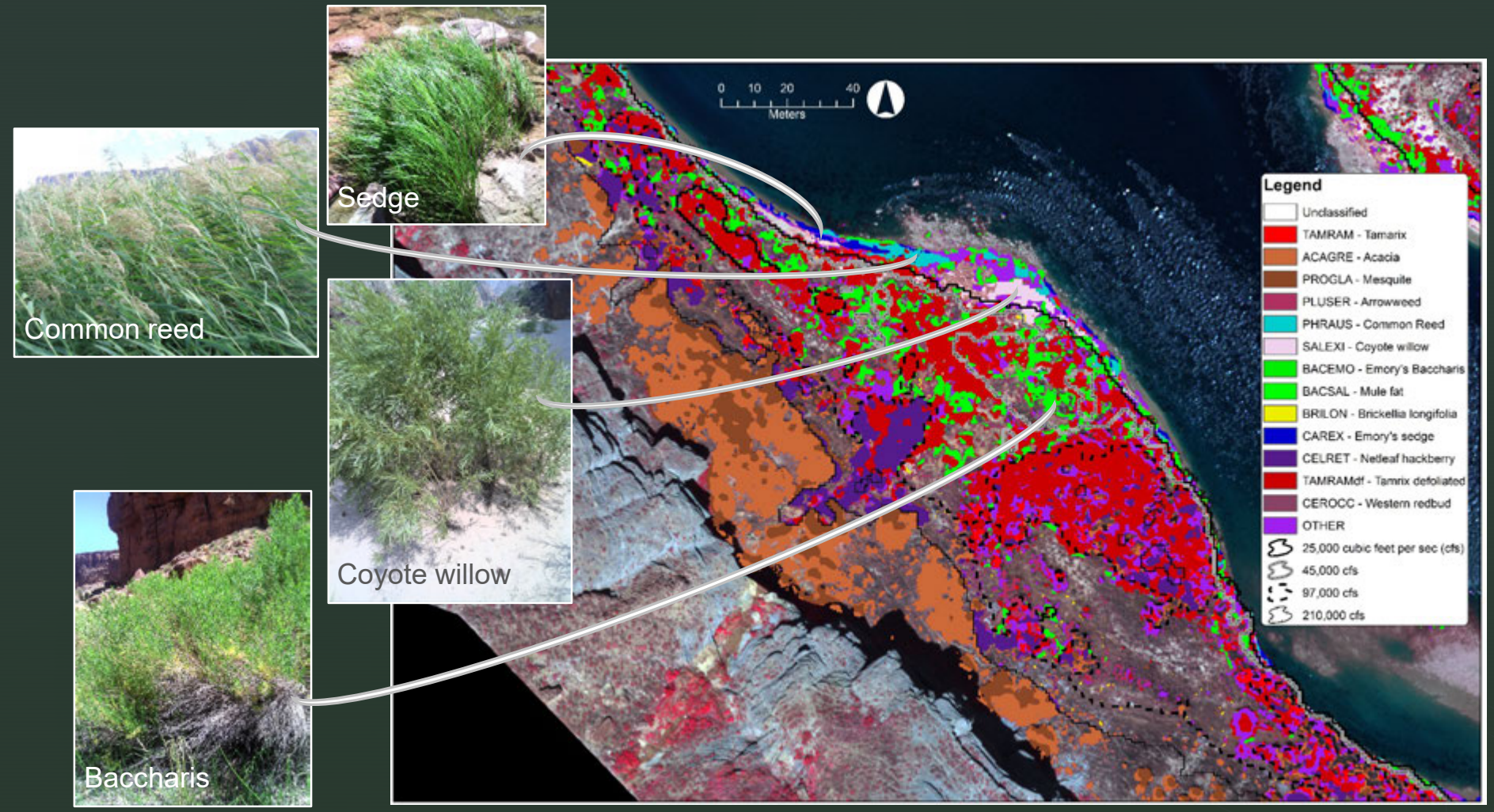

Durning et al., 2018.

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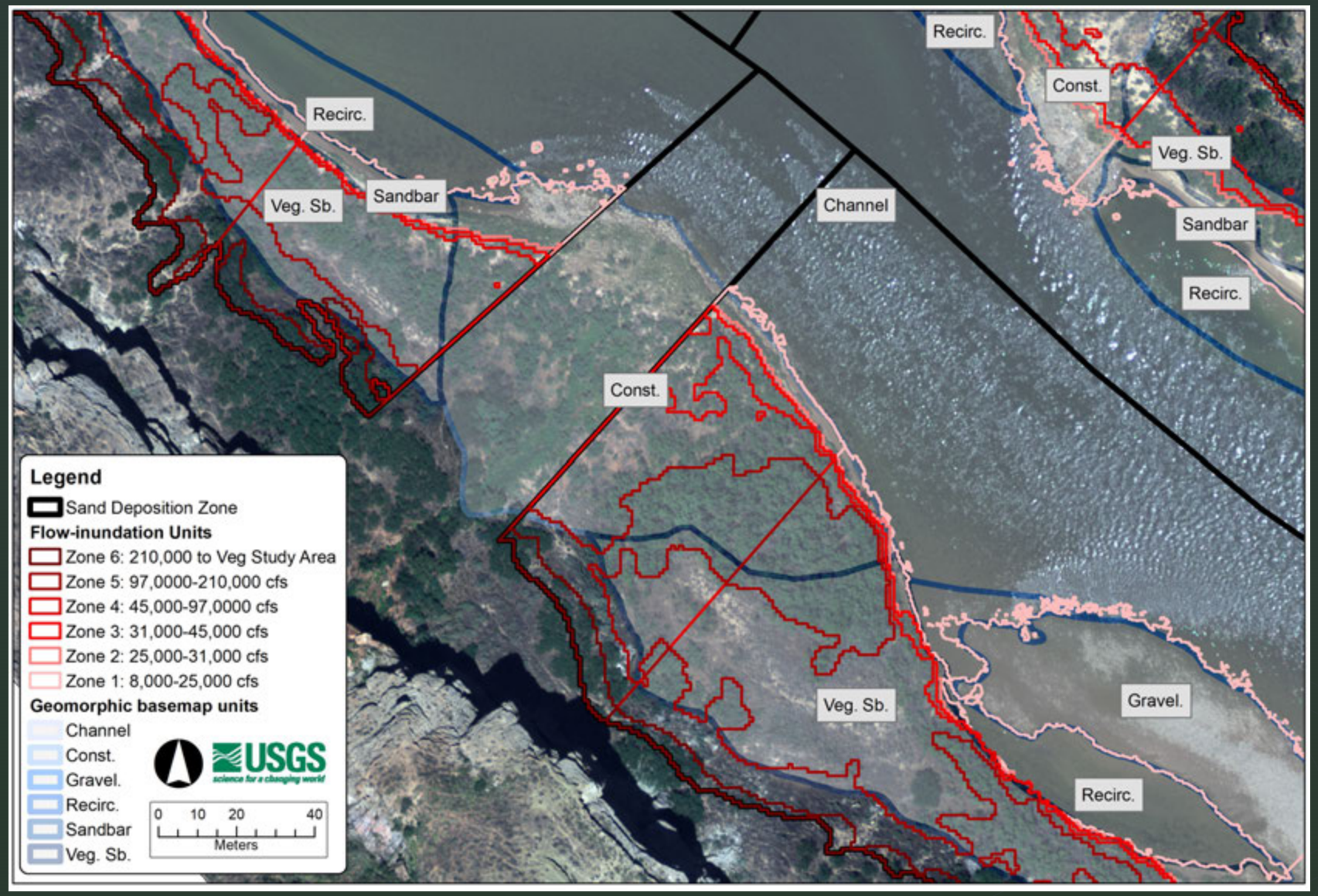
Methods – Geomorphic basemap and inundation zones



Unpublished results, do not cite

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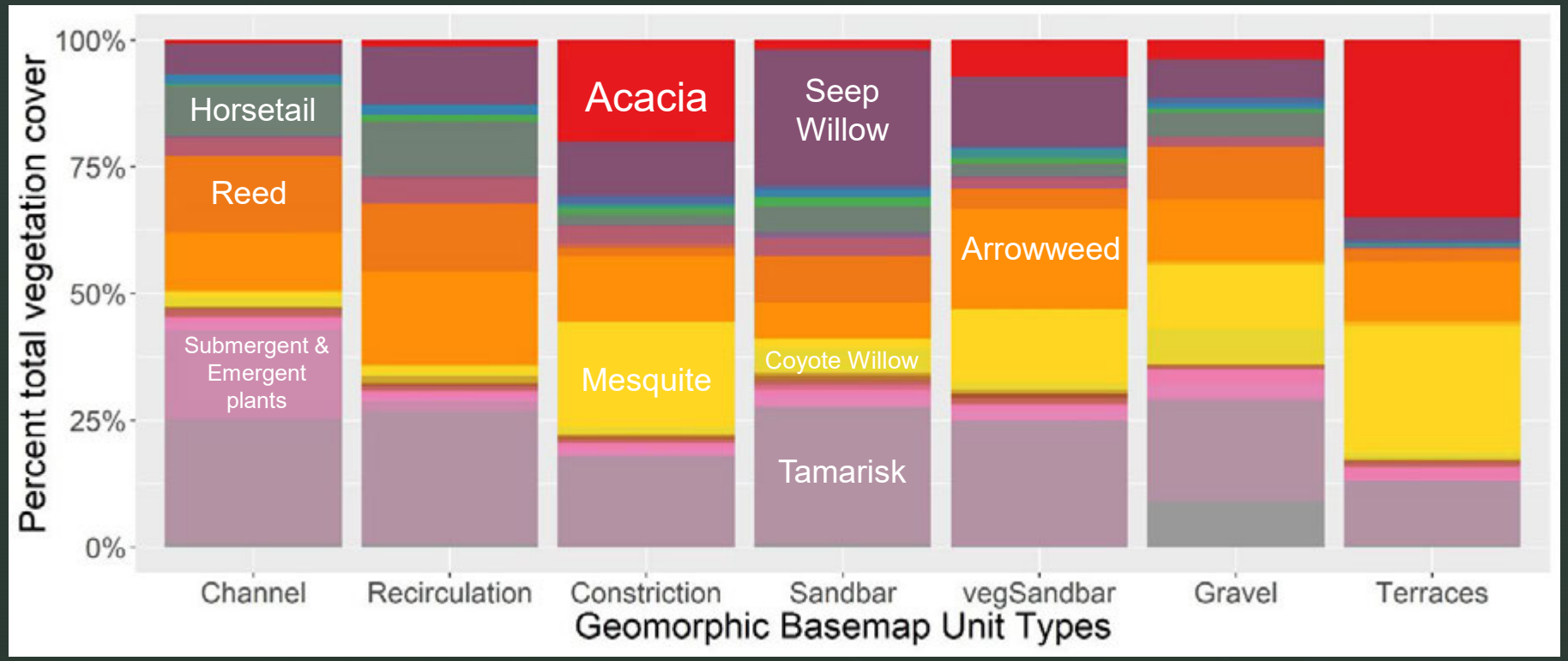
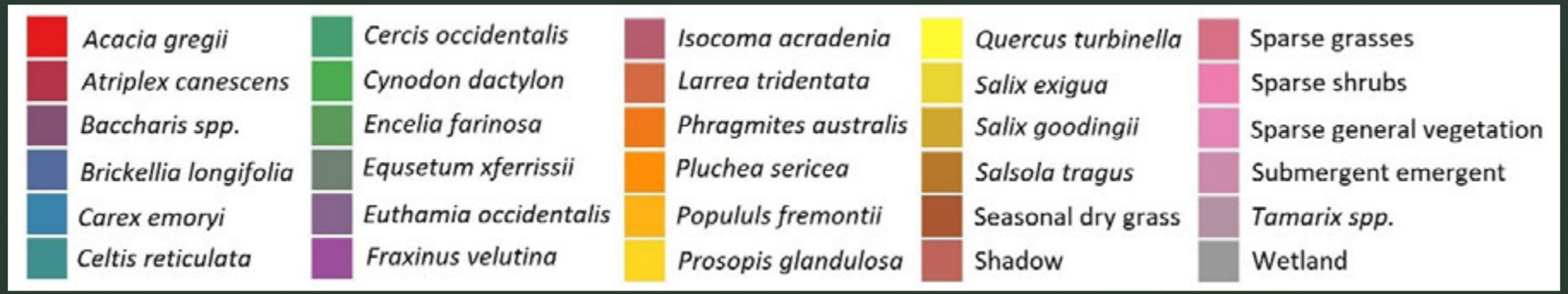
Results - Species cover on geomorphic landforms





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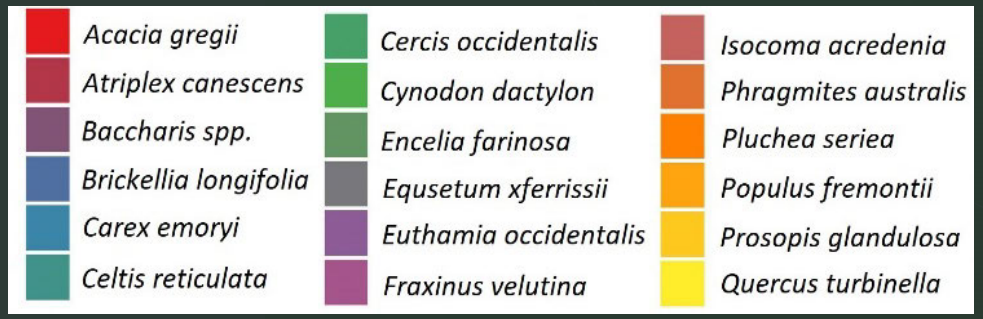
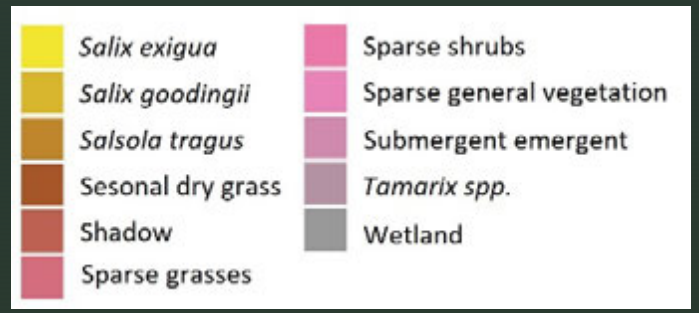
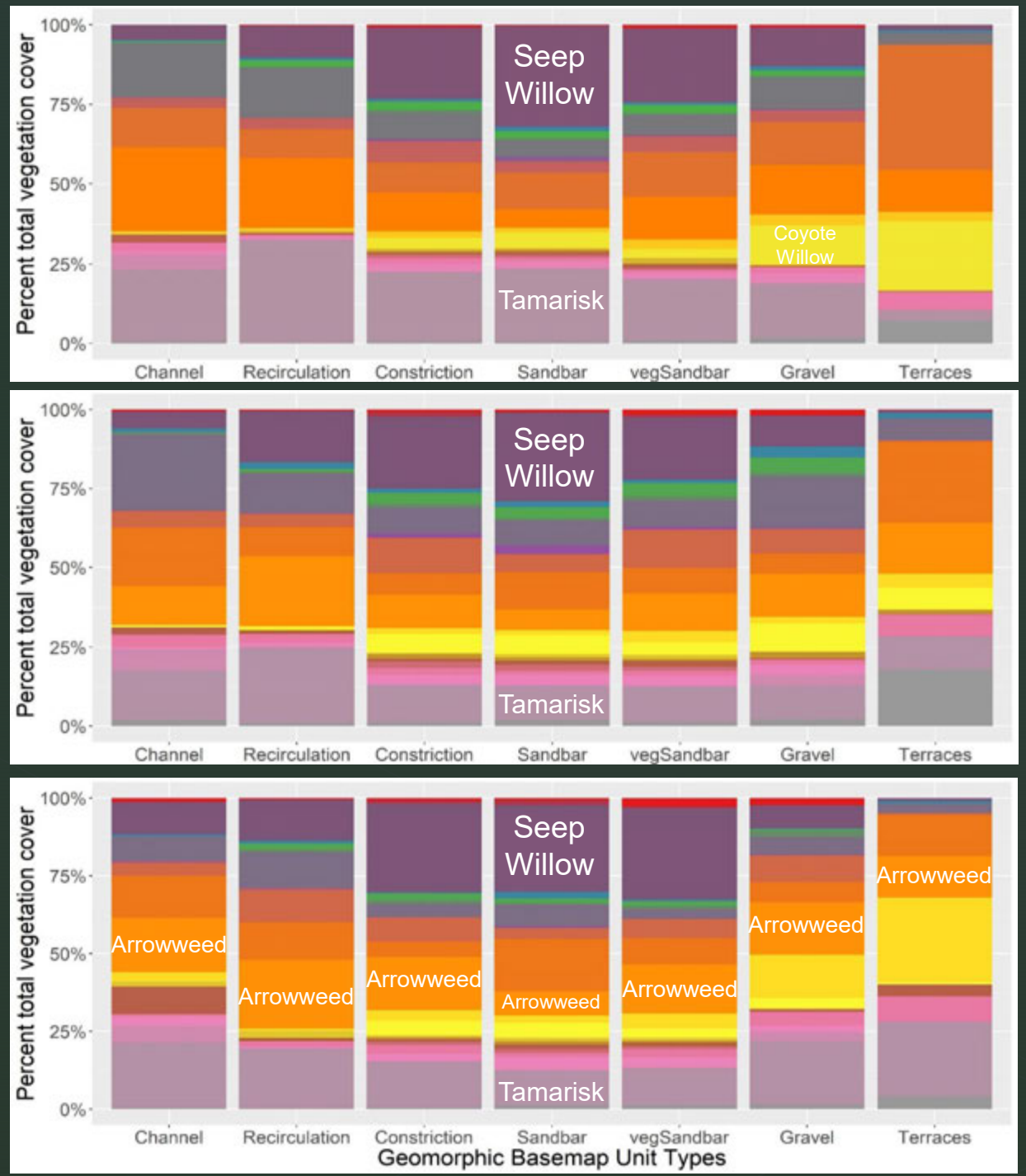
Results - Encroachment on geomorphic landforms







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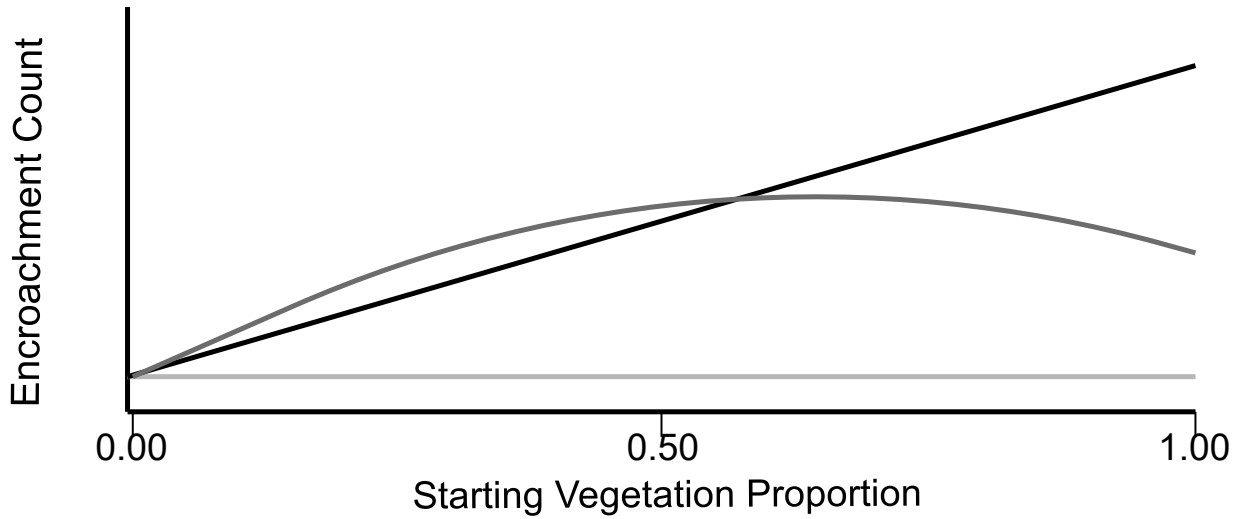
Unpublished results, do not cite

Methods - Modeling encroachment behavior

- Focused on the 7 most common encroachment species encroachment: Tamarisk, seep willow, arrowweed, coyote willow, alkali goldenbush, phragmites, & horsetail.
- Evaluated encroachment rates relative to species cover using 210 generalized linear models



Alternative Models

- rates of encroachment increase linearly with species cover
- encroachment rates "slow" at higher cover
- encroachment rates don't change as cover increases

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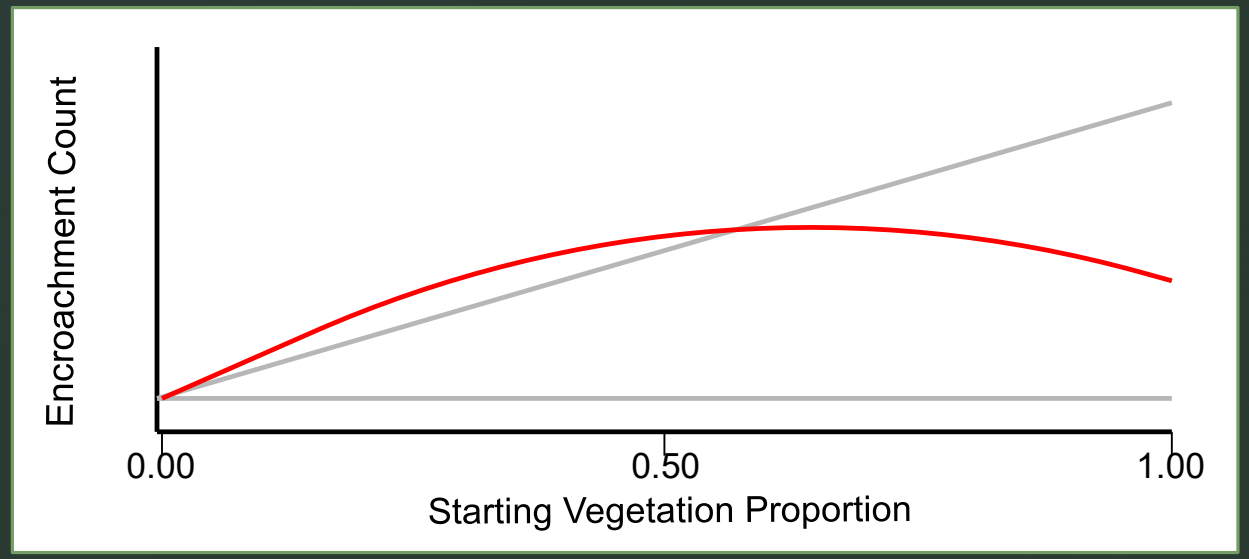
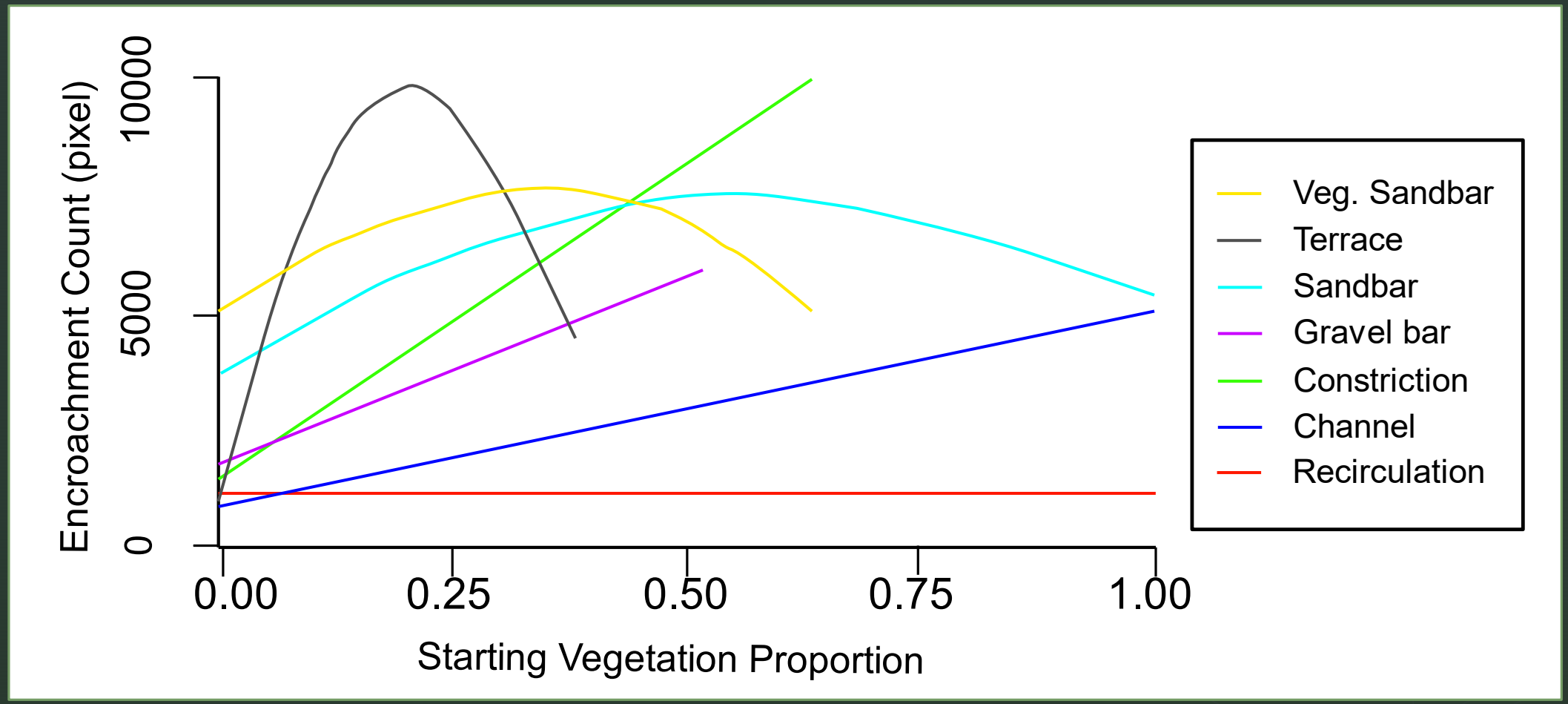
Results - Modeling encroachment behavior



- All species in all inundation zones showed a quadratic trend.
  - Implies that encroachment rates slow down as vegetation cover increases to high amounts;
  - for example, plants might run out of available space for encroachment at high cover,
  - or, might reflect successional changes among species as encroachment and cover increase

Unpublished results, do not cite

Results - Modeling encroachment behavior



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Results - Modeling encroachment behavior

Geomorphic Landforms	Intercept	Linear	Quadratic	no selection
Sandbar		1	6	
Veg. Sandbar		1	6	
Constriction		2	5	
Terrace	1	1	4	1
Gravelbar	1	3	3	
Recirculation	1	3	2	1
Channel		6	1	

- When evaluating encroachment within geomorphic landforms see that species behave differently on the different landforms
- For example:
  - Sandbars: quadratic relationships for nearly all species
  - Channel: linear relationships for nearly all species

Unpublished results, do not cite

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Key Points - Changes in riparian vegetation and vegetation-sand dynamics quantified with modern overflight imagery (2002-2009-2013)

- The occurrence and expansion of riparian vegetation from 2002 to 2013 varied by species for different hydrologic zones and geomorphic landforms.
- On all geomorphic landforms and within all hydrologic zones common drivers of encroachment were seep willow, tamarisk, and arrowweed.
- Sandbars inundated and resupplied from HFE(s) indicate that several of the most common riparian species, most notably seep willow, are resilient to burial by sand.

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Unpublished results, do not cite

Closing Thoughts

- Remote sensing provides a powerful way to evaluate environmental changes synoptically throughout the entire river corridor
- Overflight data are used universally in the GCDAMP
  - all projects, scientists, managers, and stakeholders
- Overflight 2021!!!

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