Channel Morphologic Changes Associated with Invasive Vegetation Removal

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USGS

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RiversEdge West
RESTORE + CONNECT + INNOVATE

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[4]United States Geological Survey
[5]Water Resources Division, NPS

Canyon de Chelly, AZ, Nov. 2019

A Removal Database

As part of my research, I intend to compile site-specific data on vegetation removal projects.

Please email me if you would like to contribute to the database:

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Outline

How will the river respond?

- Post-removal monitoring usually overlooked

Invasive vegetation control methods

Rio Puerco, photo: J. Friedman

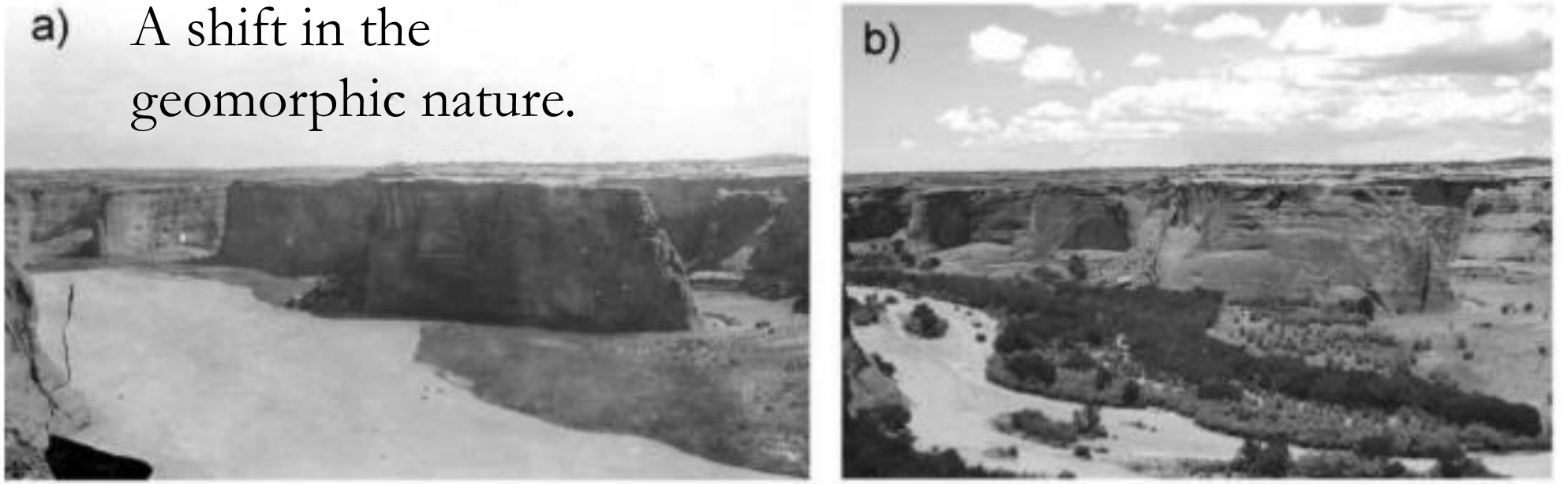
My research

i) A literature review of post-removal channel morphologic changes

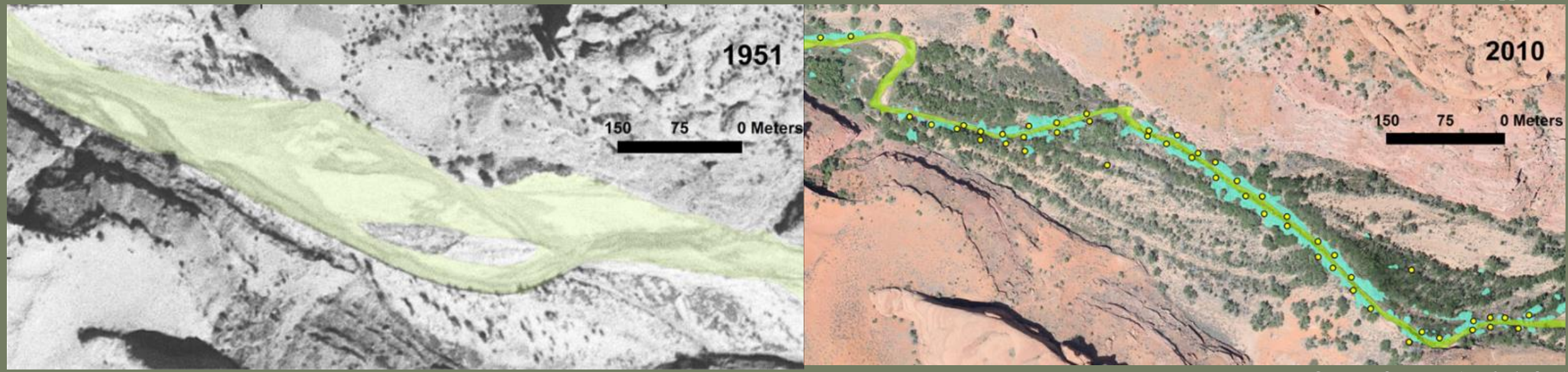
ii) Ongoing reach- to segment-scale field monitoring – CACH

iii) Geomorphic-vegetation interactions through sediment dynamics – BIBE (In development)

A shift in the geomorphic nature.



Cadol et al., 2011 (River Res. Applic.)



Scott et al., 2017 (Ecohydrology)

$\tau_o > \tau_c$

Erosion

$\downarrow \tau_o$

Introduce Vegetation

Increased bank stability

Channel Narrowing

$\uparrow \tau_o$

Remove Vegetation

Potential Response to Invasive Vegetation

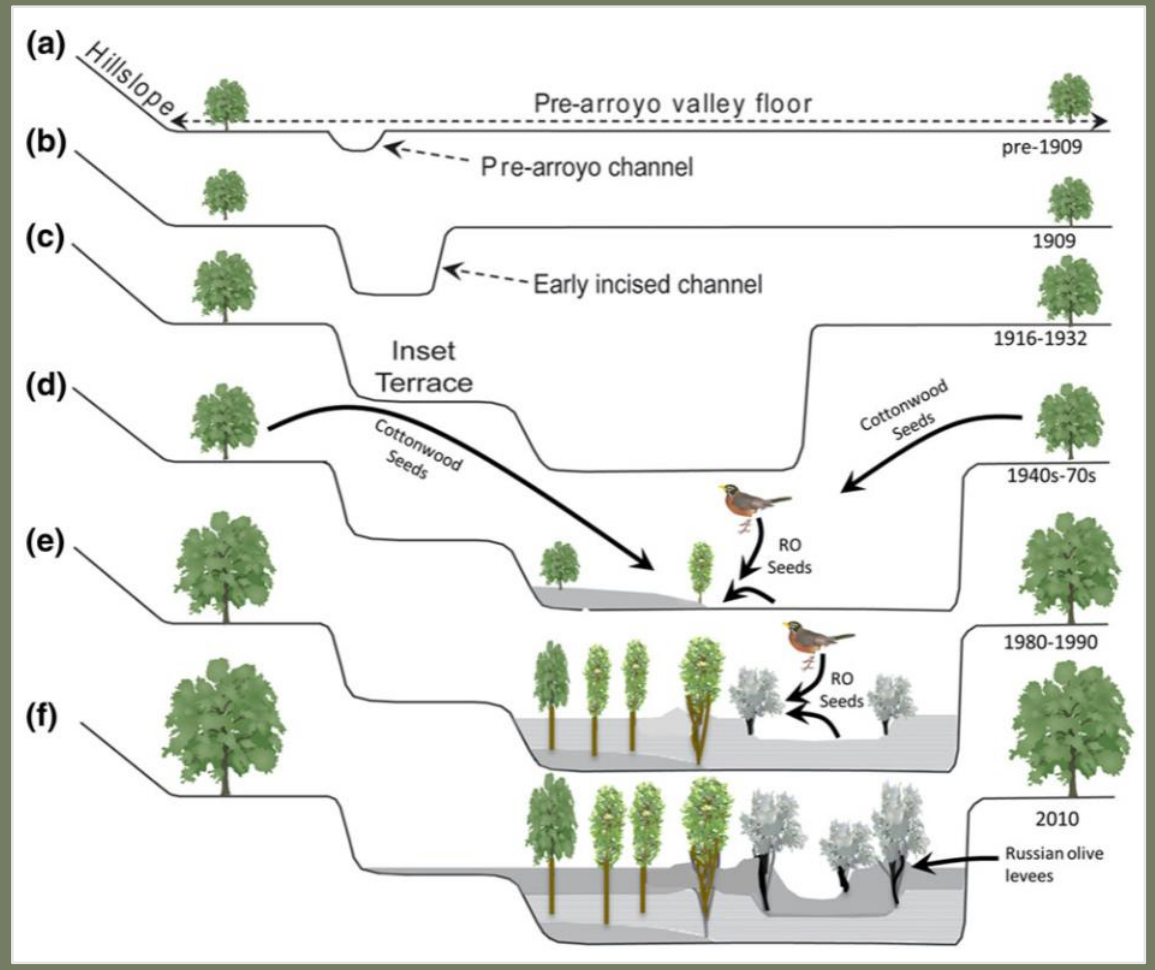
Morphologic changes

Channel narrowing

- Graf, 1978 (*GSA Bulletin*)
- Friedman et al., 1996b (*Geomorphology*)
- Cadol et al., 2011 (*River Res Applic.*)
- Dean and Schmidt, 2011 (*Geomorphology*)
- Scott et al., 2018 (*Ecohydrology*)

Channel incision

- Simon and Rinaldi, 2006 (*Geomorphology*)
- Jaeger and Wohl, 2011 (*Water Resour. Res.*)



Scott et al., 2018 (Ecohydrology)

Control methods

Mechanical (Whole Plant), Cut-Stump, Chemical, Biological, Grazing, Fire, Flooding.

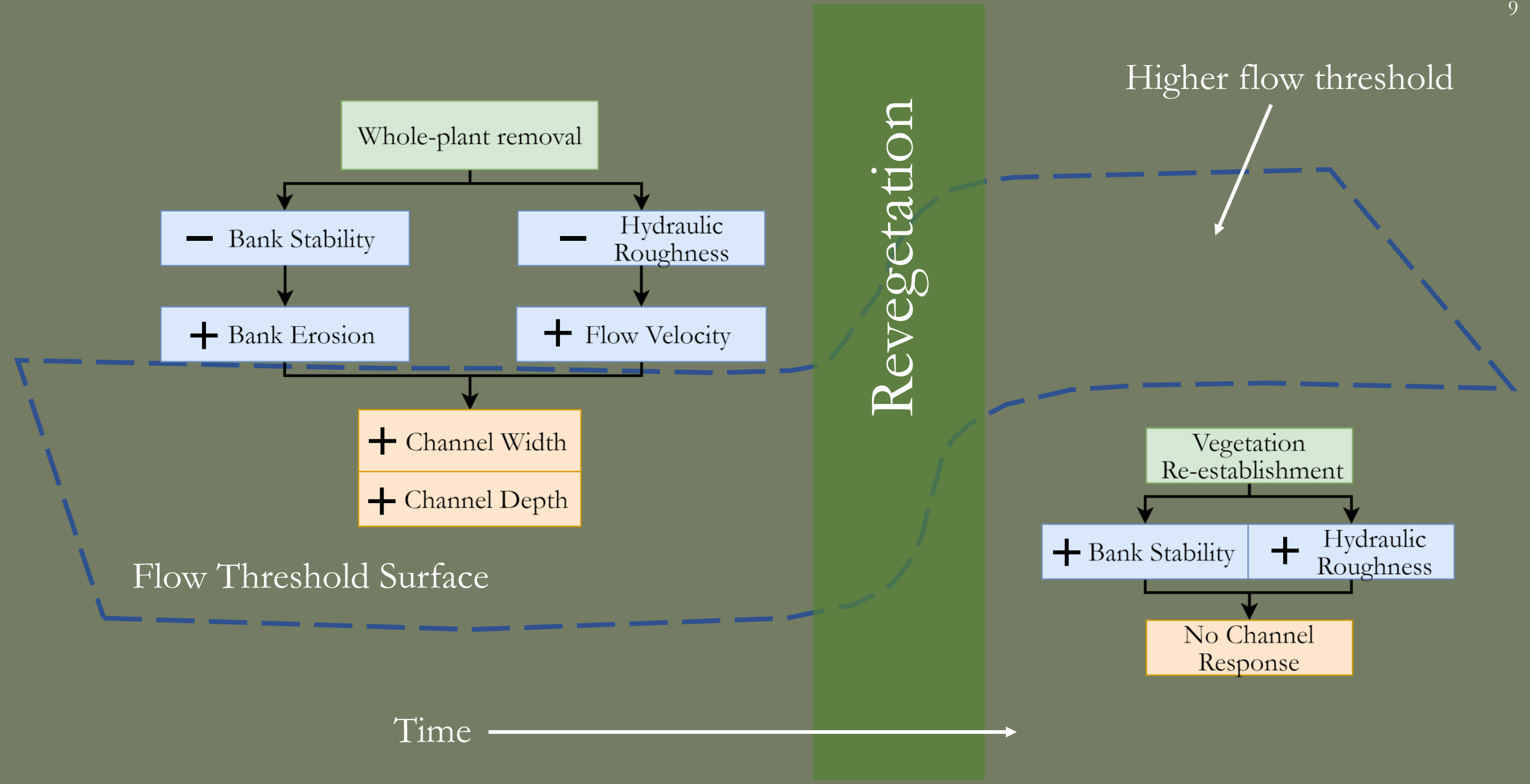
MC, CSC, CC, BC, GC, FC, FlC

USGS Russian Olive and Saltcedar Assessment
https://www.nps.gov/glca/learn/nature/tamarisk-leaf-beetle.htm

Removal of invasive vegetation: What happens next?

"Long-term monitoring and follow-up treatment are necessary"

– *USGS Saltcedar and Russian Olive Control Demonstration Act Science Assessment*


Whole-plant removal
− Bank Stability
− Hydraulic Roughness
+ Bank Erosion
+ Flow Velocity
+ Channel Width
+ Channel Depth
Revegetation
Higher flow threshold
Vegetation Re-establishment
+ Bank Stability
+ Hydraulic Roughness
No Channel Response
Flow Threshold Surface
Time

Drivers of post-removal channel change

Is there a flood?

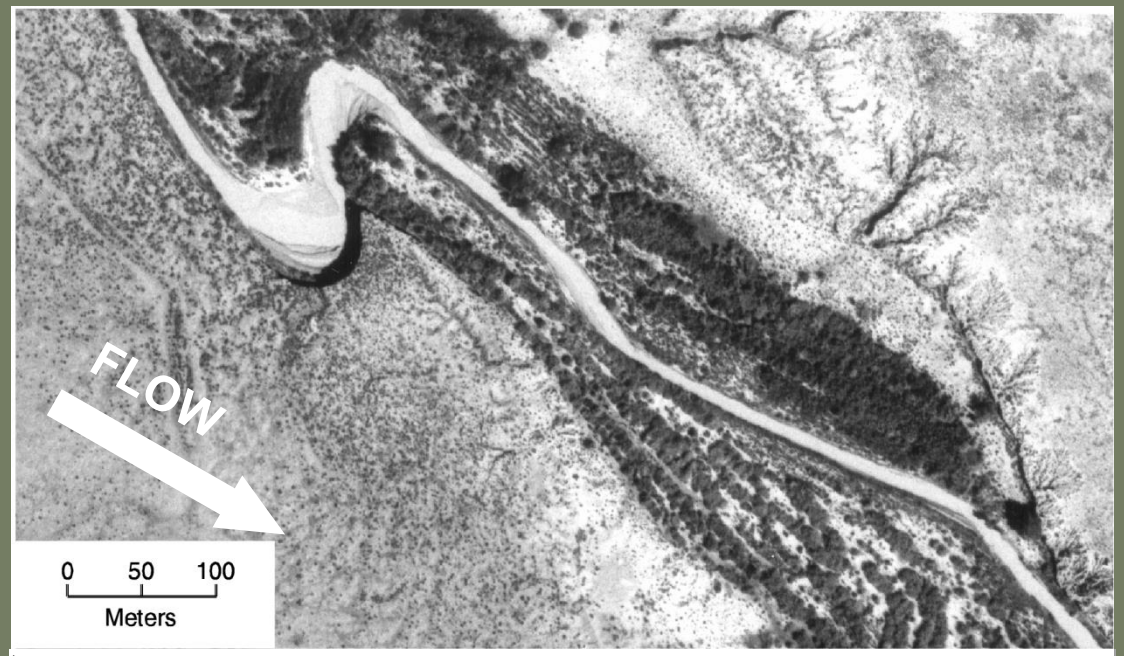
How large was the flood?

How long after?

Rio Puerco, photo: J. Friedman

Aerial images of channel widening within the sprayed reach at Rio Puerco

Average channel width = 15.7 m



October 1996 NAPP photograph

Average channel width = 35.7 m

Nov. 2006 satellite image (DigitalGlobe)

content: J. Friedman

Removal of riparian vegetation: What happens next?

What we are seeing at Canyon de Chelly NM…

i) Literature Review

Site Name	Contributing Drainage Area (km^2)	Primary Invasive Vegetation Type	Removal Control Method	Amount of Vegetation Controlled	Control Method Timing	Post-removal Channel Response
Canyon de Chelly	1,500	RO, tamarisk	MC, CSC	Four 1.1-km reaches	2005	I, W
Rio Puerco	4,000	Tamarisk	CC	12-km reach	2003	W
Escalante	5,200	RO	CSC	50-km reach	2000-2018	?
Rio Grande	471,400	Tamarisk, Giant cane, RO (NM)	BC,FC, CC	150-km reach (NM)	?	?
Dolores	11,800	Tamarisk	BC,CSC	280-km	2009	?
Gila	150,700	Tamarisk	FC,BC	25 acres	2015?	?
Verde	17,100	Tamarisk, RO, Giant cane, Tree of heaven	?	?	2012	?
Colorado	637,100	Tamarisk, RO	CSC,CC, BC	?	?	?

*W=widening, N=narrowing, I=incising

ii) Ongoing monitoring

What are the fundamental controls that govern the suite of probable channel responses following invasive vegetation removal?

How do different removal methods compare in terms of resulting stream morphologic changes?

Does mechanically removing the whole plant lead to the greatest channel morphologic response?

CACH XS and UAS Survey Sites

Whole plant removal, cut-stump, and control areas at each site.

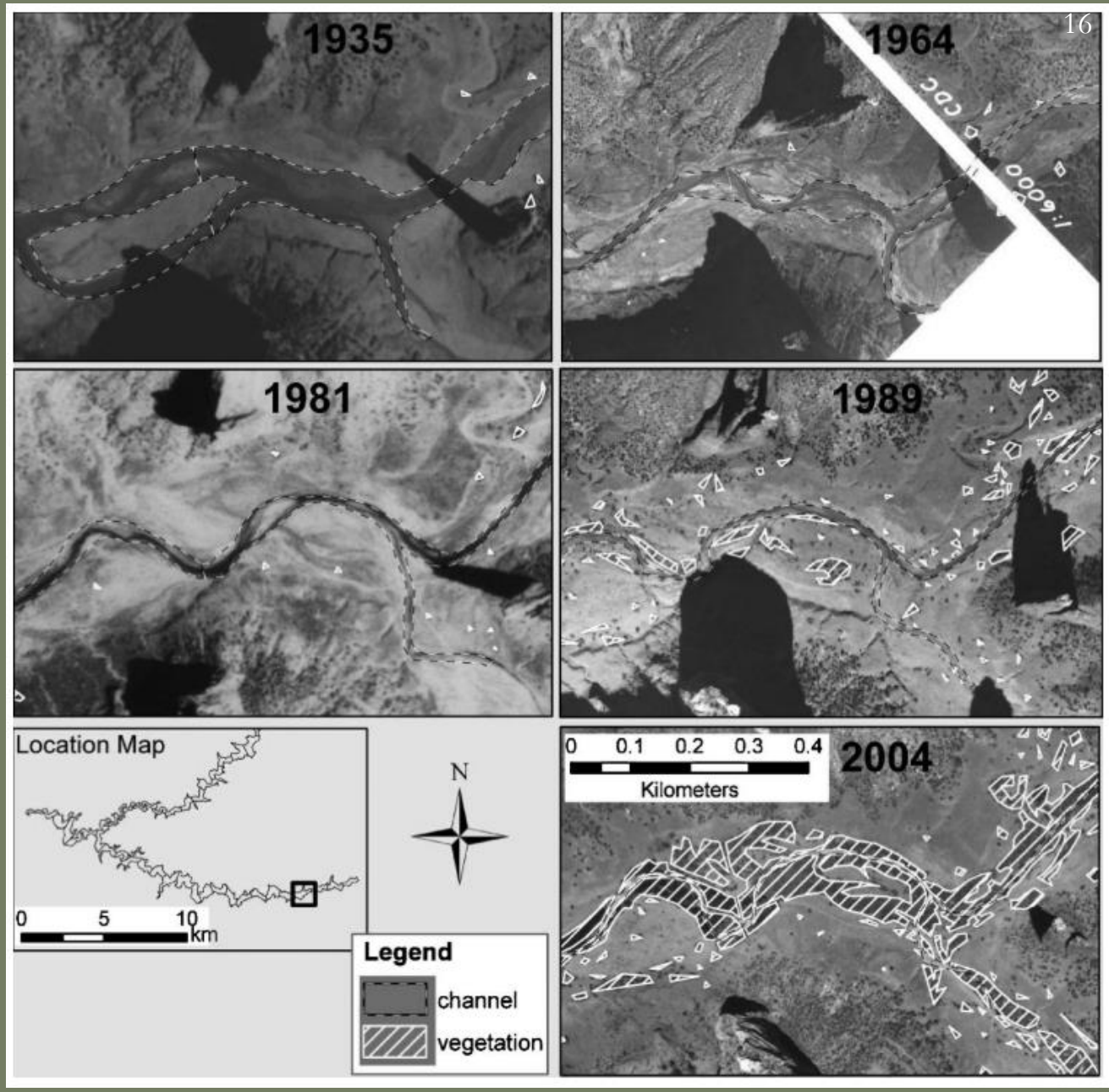
CACH Aerial Imagery

Follow-up to Cadol et al., 2011

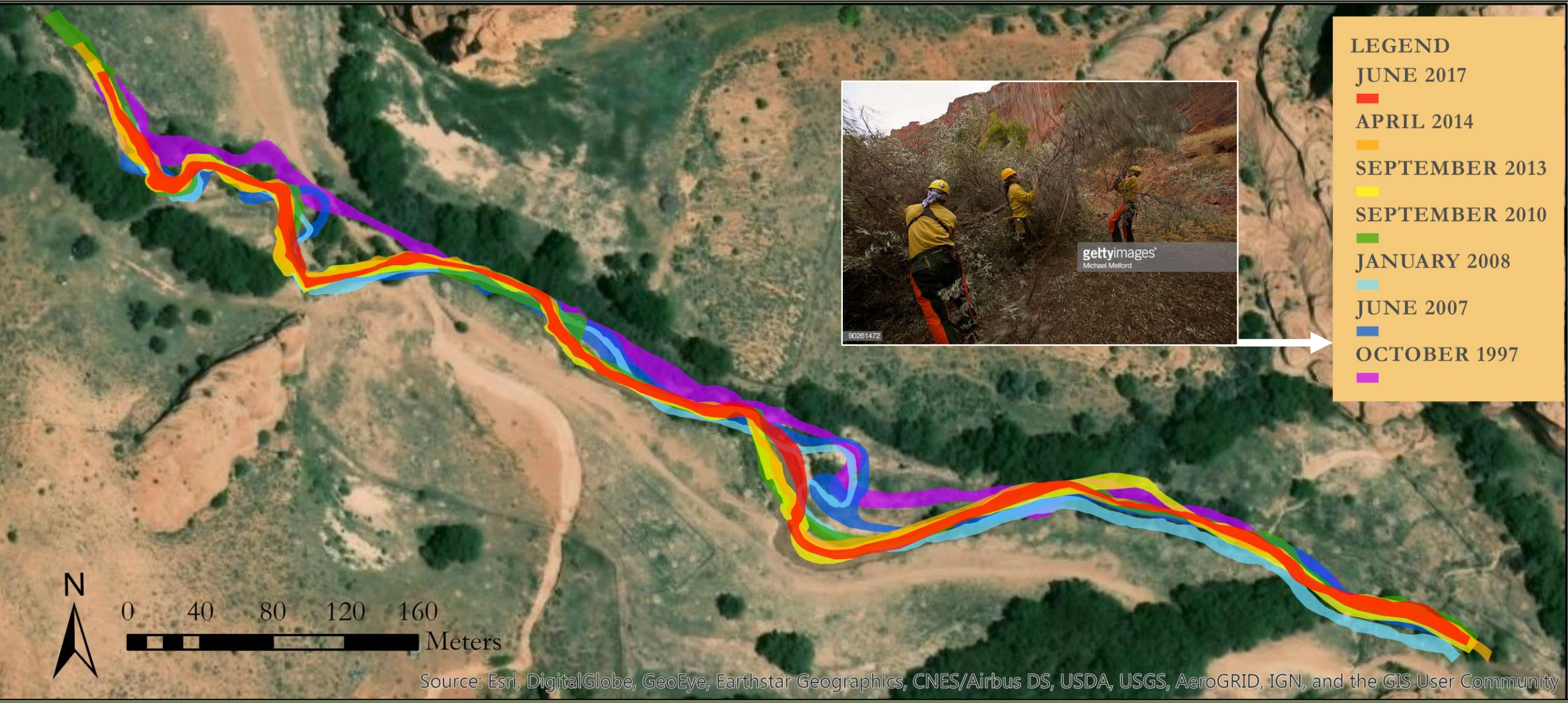
(River Res. Applic.)

Sources of imagery:

Google Earth, NAIP, NPS



LWH Whole Plant – Channel Planform Delineations



CACH – LWH XS – July 2019

Relative Elevation (m)

0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5

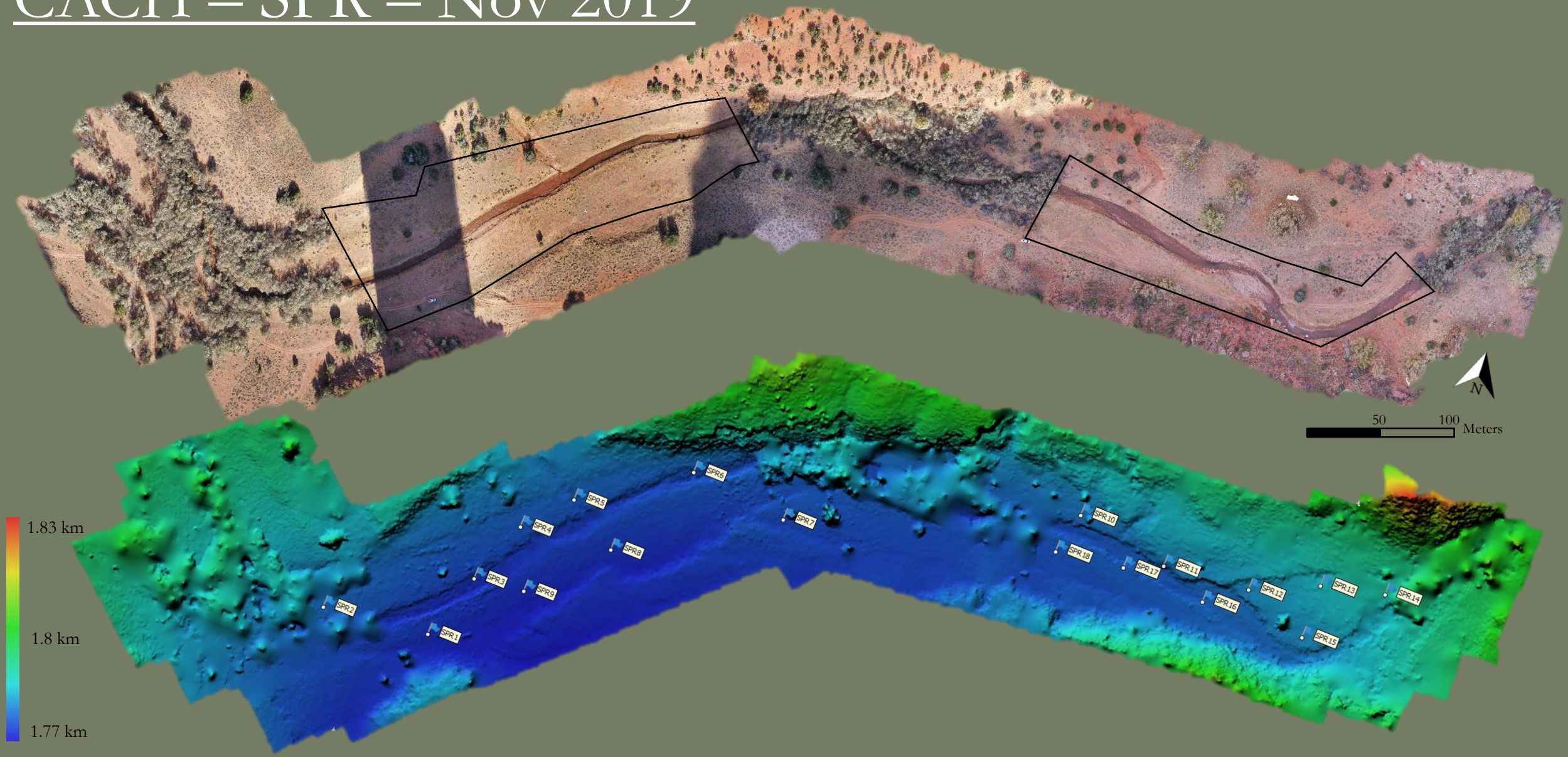
Control
Cut Stump
Whole Plant

WP Previous active channel

0 10 20 30 40 50 60 70 80 90 100

Station (m)

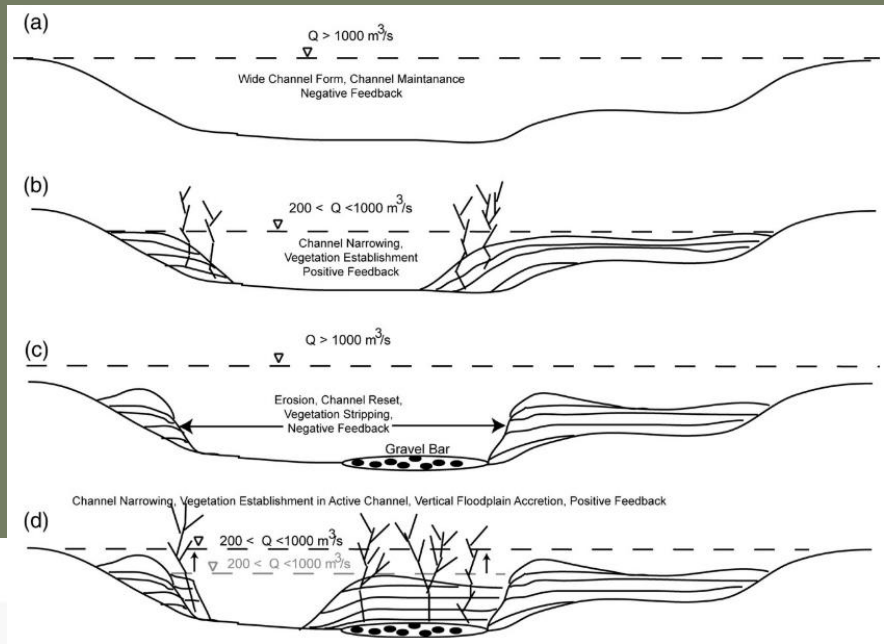
CACH – SPR – Nov 2019



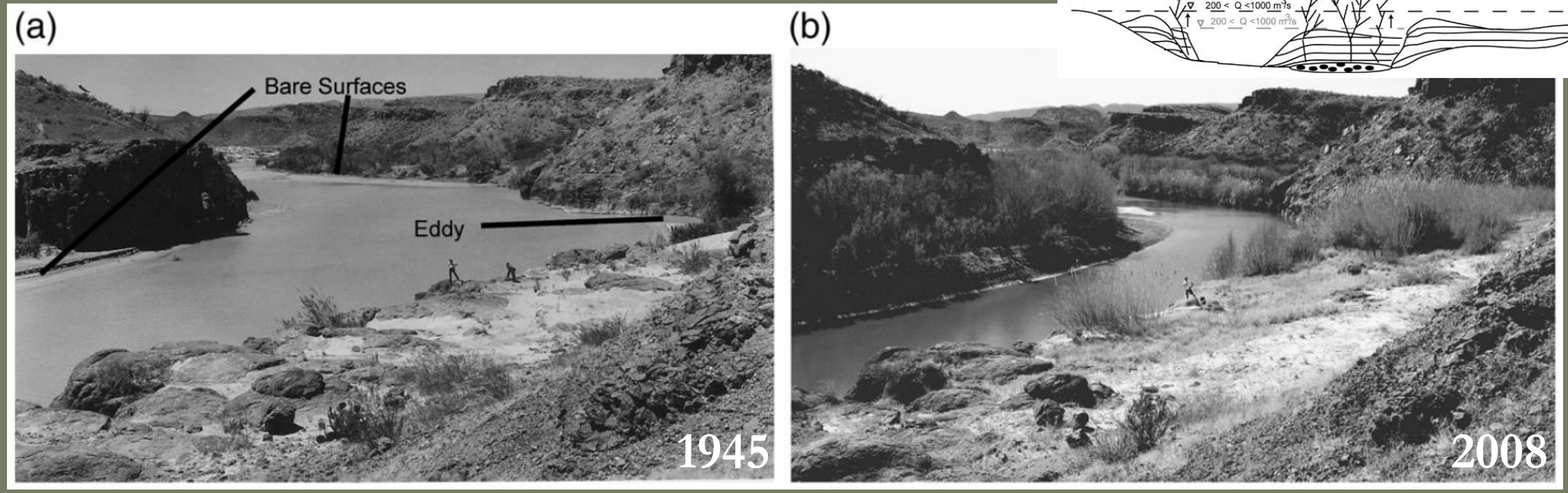
iii) Geomorphic-Vegetation Interactions

Building on Dave Dean's research

- Dean and Schmidt, 2011
- Dean et al, 2011
- Dean and Schmidt, 2013

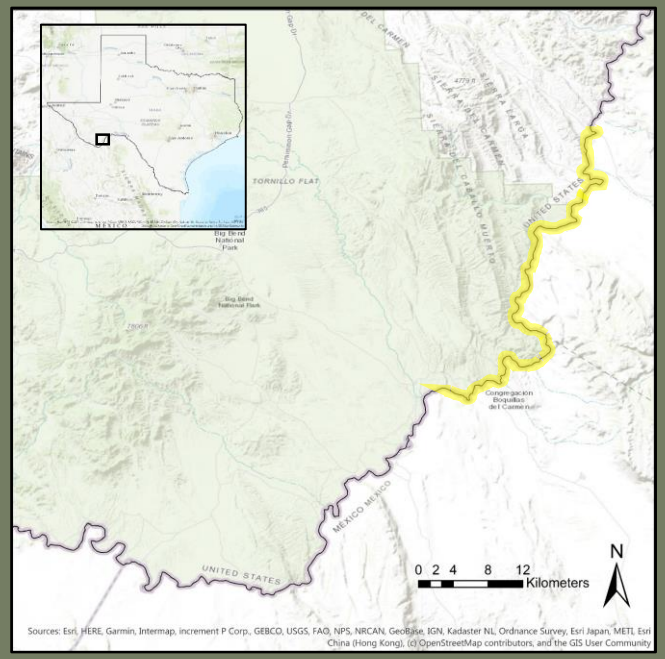


Dean and Schmidt, 2011 (*Geomorphology*)



Big Bend National Park (BIBE)

Which type of vegetation imparts the greatest fluid drag, promoting deposition and channel narrowing?



Inform future vegetation management to:

Increase sediment conveyance

Limit channel narrowing

Giant cane (*Arundo Donax*)

"Seepwillow" (*Baccharis salicifolia*)

Common Reed (*Phragmites australis*)

Desert Willow
(*Chilopsis linearis*)

Summary

Understanding post-removal channel morphologic response is valuable to future river restoration.

A database of removal projects will be created to help interpret future channel response associated with invasive species removal.
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Future work in CACH will link flow characteristics to channel response, analyzing differences in control methods used on Elaeagnus angustifolia L. (Russian olive).

Future work in BIBE to investigate vegetation characteristics to flow and sediment transport dynamics among abundant plant types in Boquillas Canyon.

- Also, how has giant cane removal efforts affected channel morphology?

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