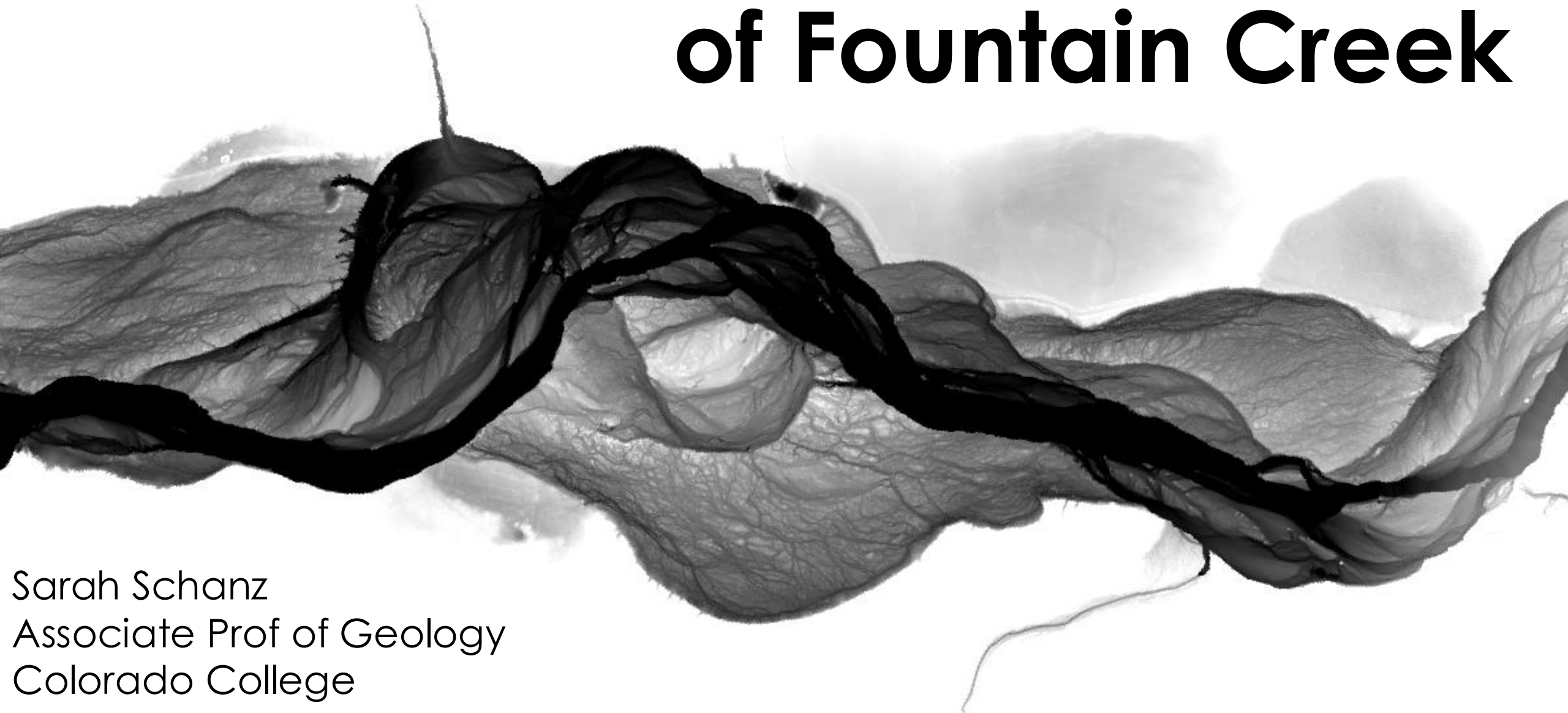
Reading the landscape of Fountain Creek



Sarah Schanz
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Colorado College

Where are we going today?

1. A geomorphologist's toolkit
2. Knowledge frameworks
3. Application to Fountain Creek
    1. You are the scientist!
    2. A sampling of findings from my students

1. A geomorphologist's toolkit

Geomorphology

- "scientific study of the origin and evolution of topographic and bathymetric features generated by physical, chemical or biological processes operating at or near Earth's surface." – Wikipedia

- "why does it look that way?" – me, c 2009

1. A geomorphologist's toolkit

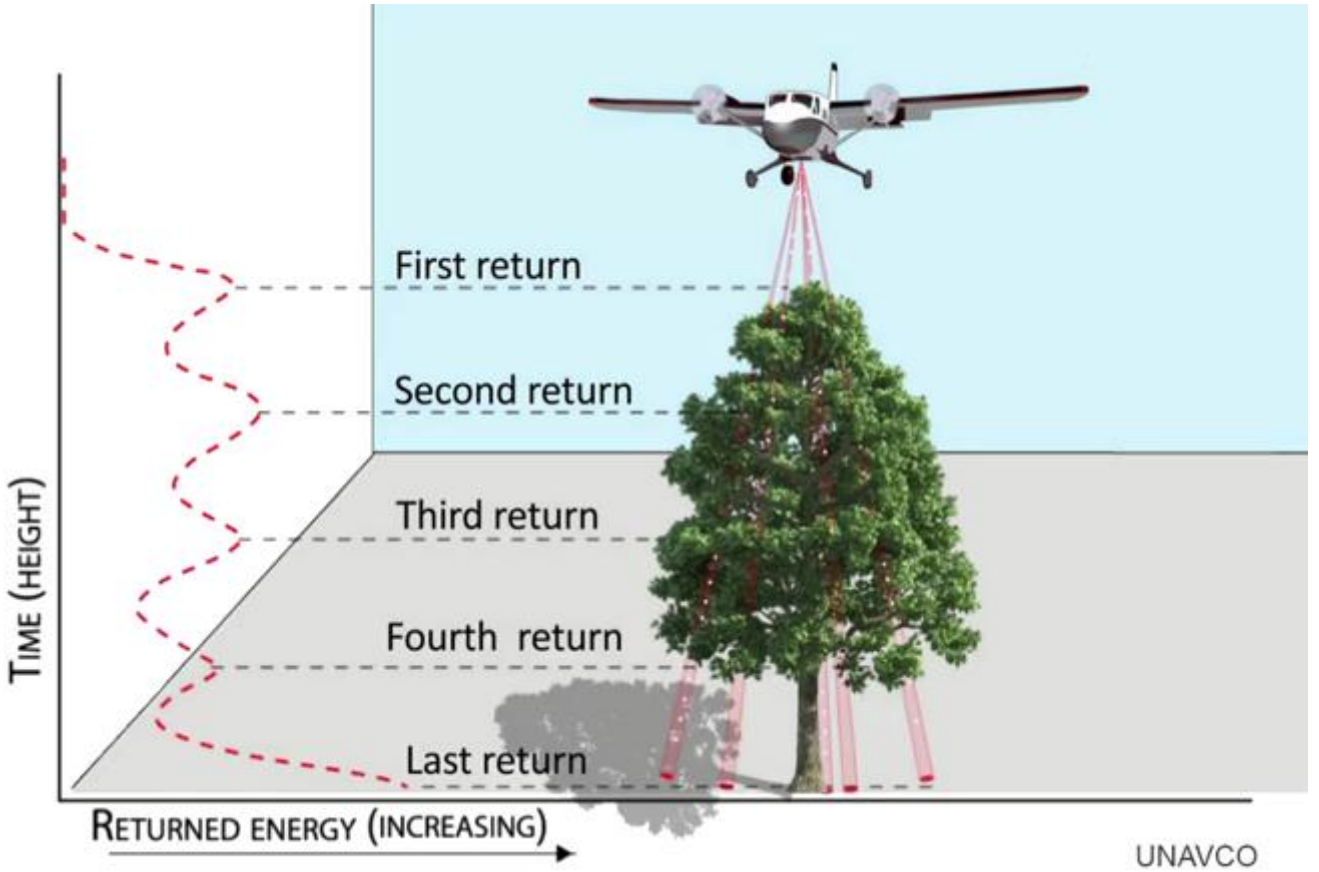
- Historic imagery
  - Aircraft stills
  - Satellite imagery
  - Often back to 1930s

Find images anywhere in the US with EarthExplorer!

earthexplorer.usgs.gov/
(free to use & download!)

1. A geomorphologist's toolkit

- Historic imagery
- Lidar
  - **Li**ght **D**etection **a**nd **R**anging
  - Light is released from an aircraft/drone
  - As light bounces off objects, it returns to the aircraft (or drone)
  - Transform the time the light traveled to a distance



1. A geomorphologist's toolkit

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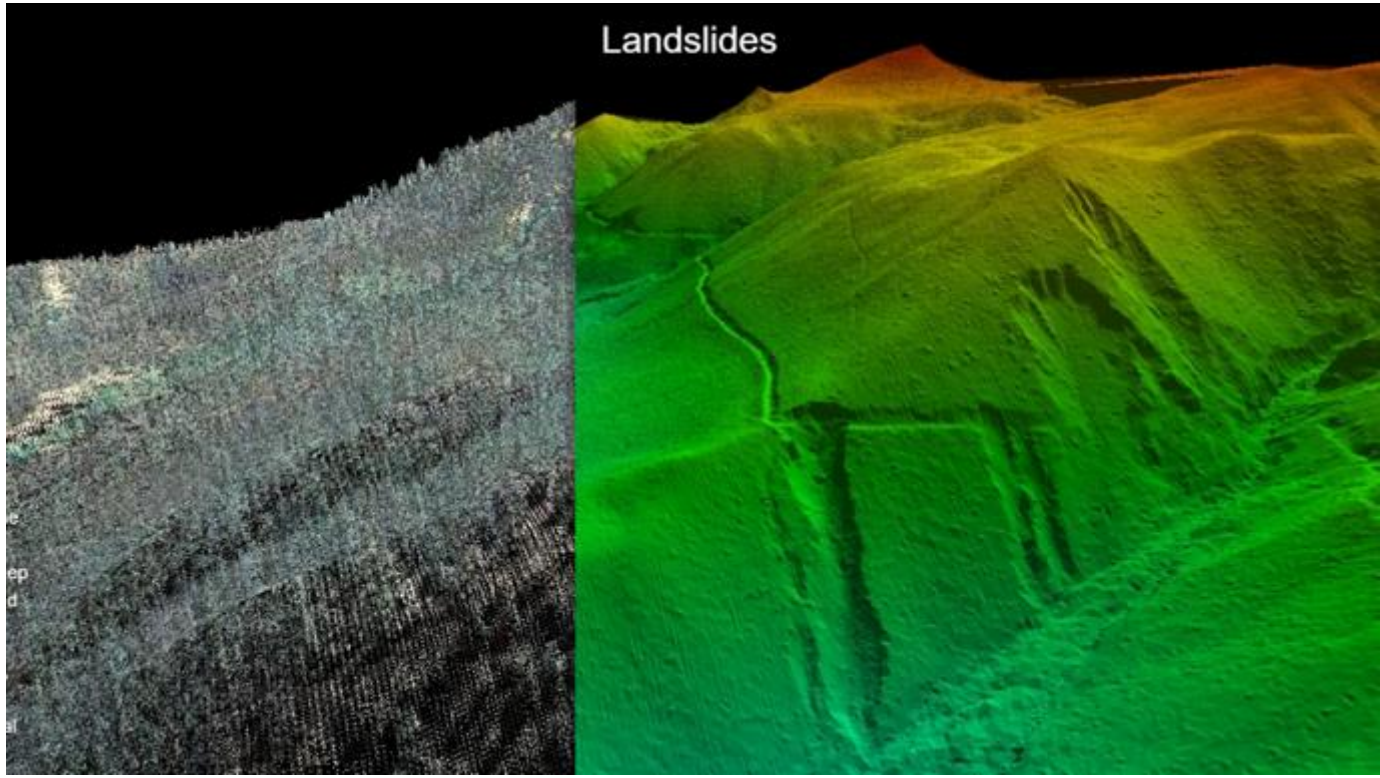

Majority of lidar data is hosted by OpenTopography, an NSF-funded data facility.

1. A geomorphologist's toolkit

Want to view lidar of anywhere in the US? Check out: https://apps.nationalmap.gov/3depdem/

(google "National Map 3DEP")

- Historic imagery
- Lidar
  - **Li**ght **D**etection **a**nd **R**anging
  - Light is released from an aircraft/drone
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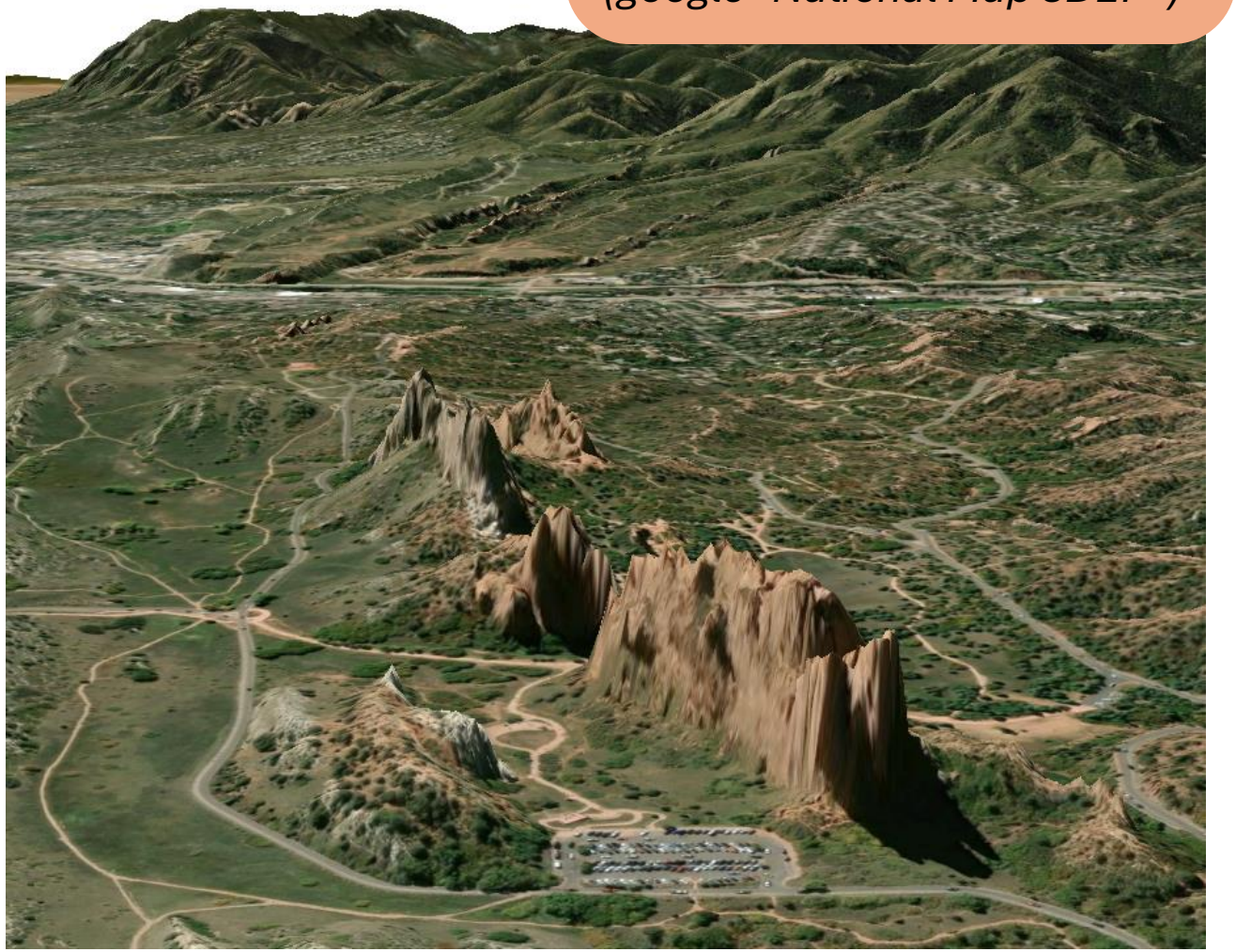
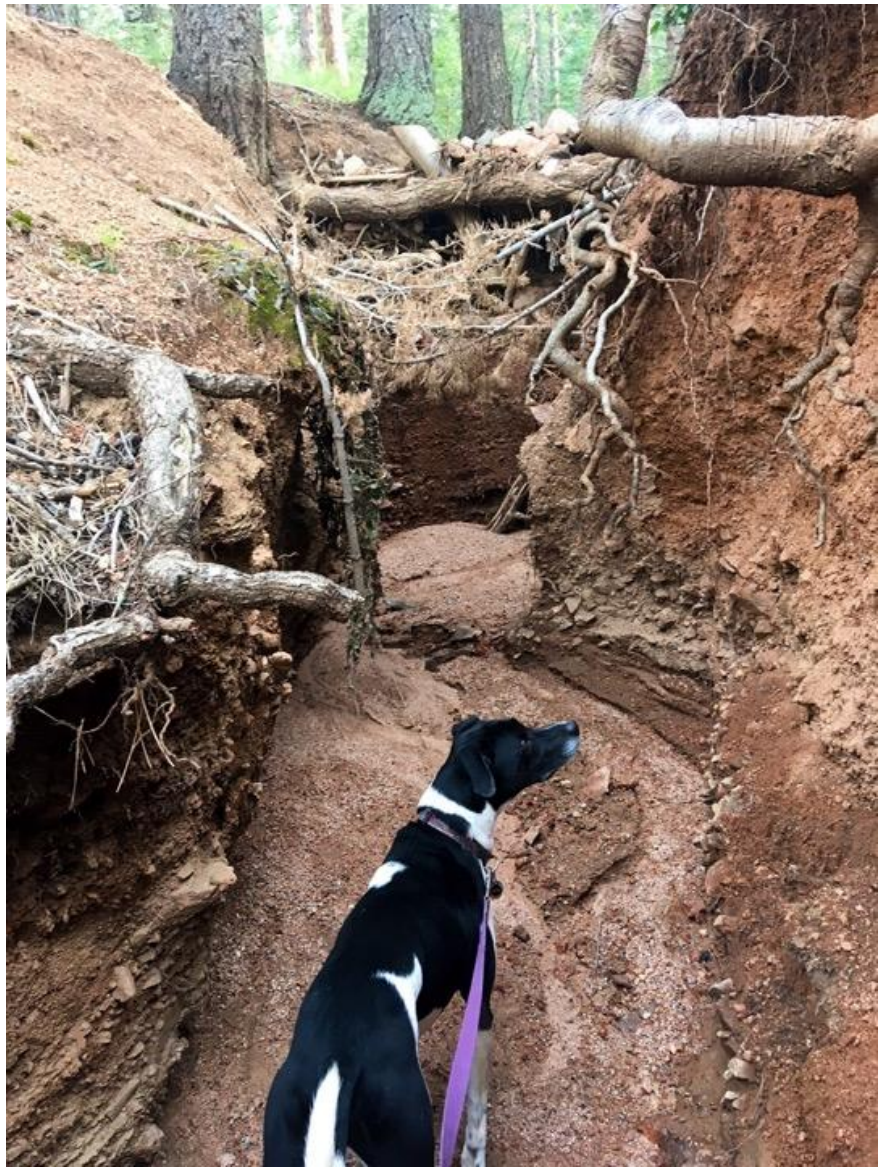


1. A geomorphologist's toolkit

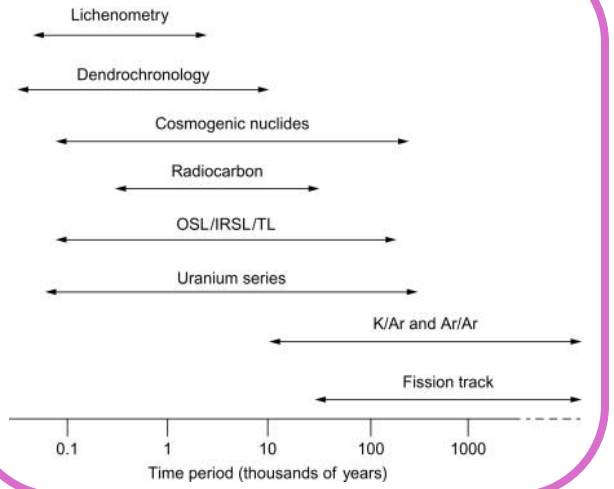
- Historic imagery
- Lidar
- Rocks & stratigraphy
  - "Present is the key to the past"
  - Useful for reading much older landscapes

Check out the ROCKD app or Macrostrat (macrostrat.org) to find out more about the rocks under your feet!

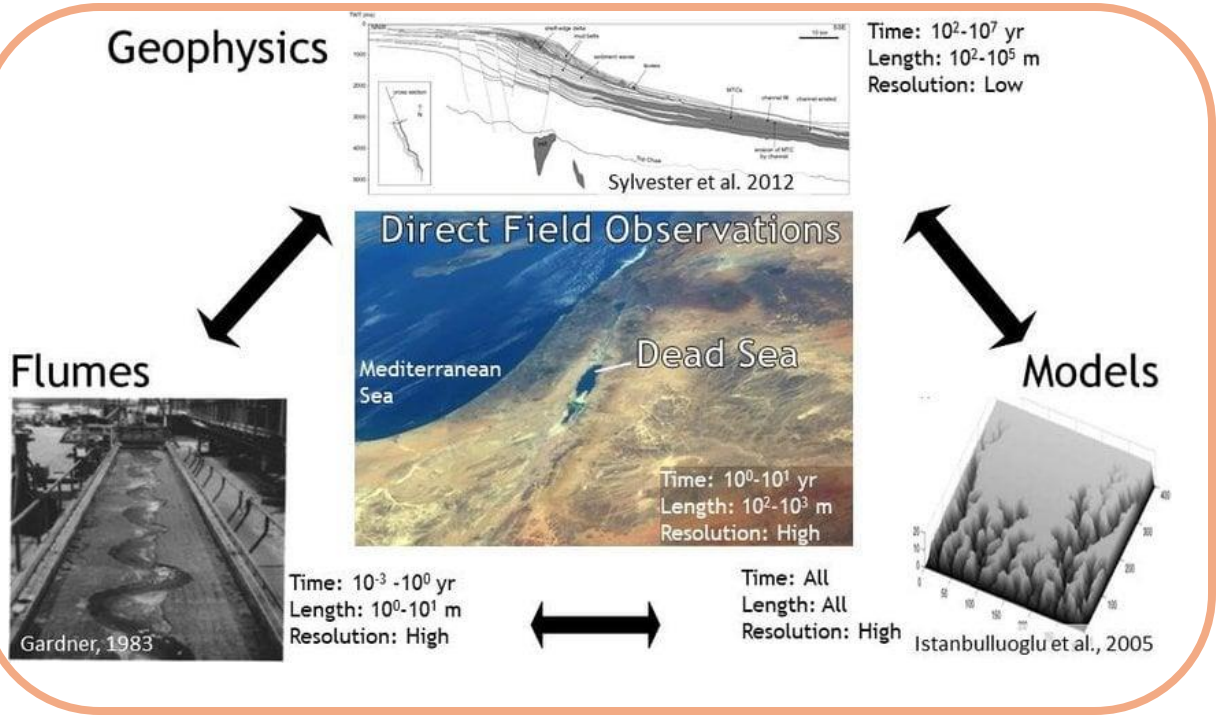


1. A geomorphologist's toolkit

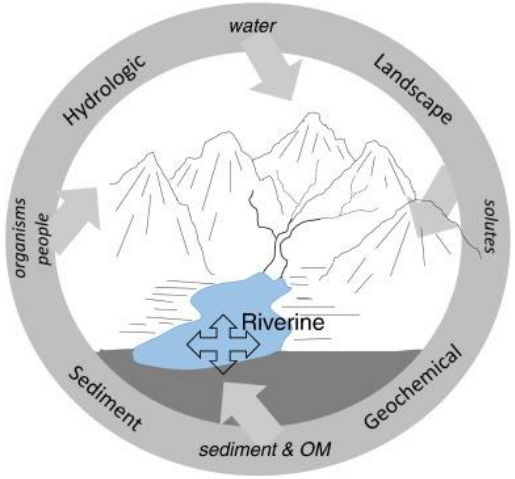
Dating landforms & processes



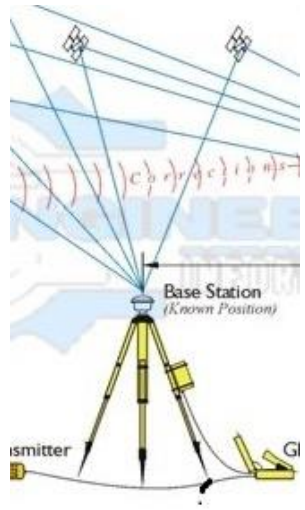
Data connections: field to geophysical to numerical to analog



Geochemical & tracer studies



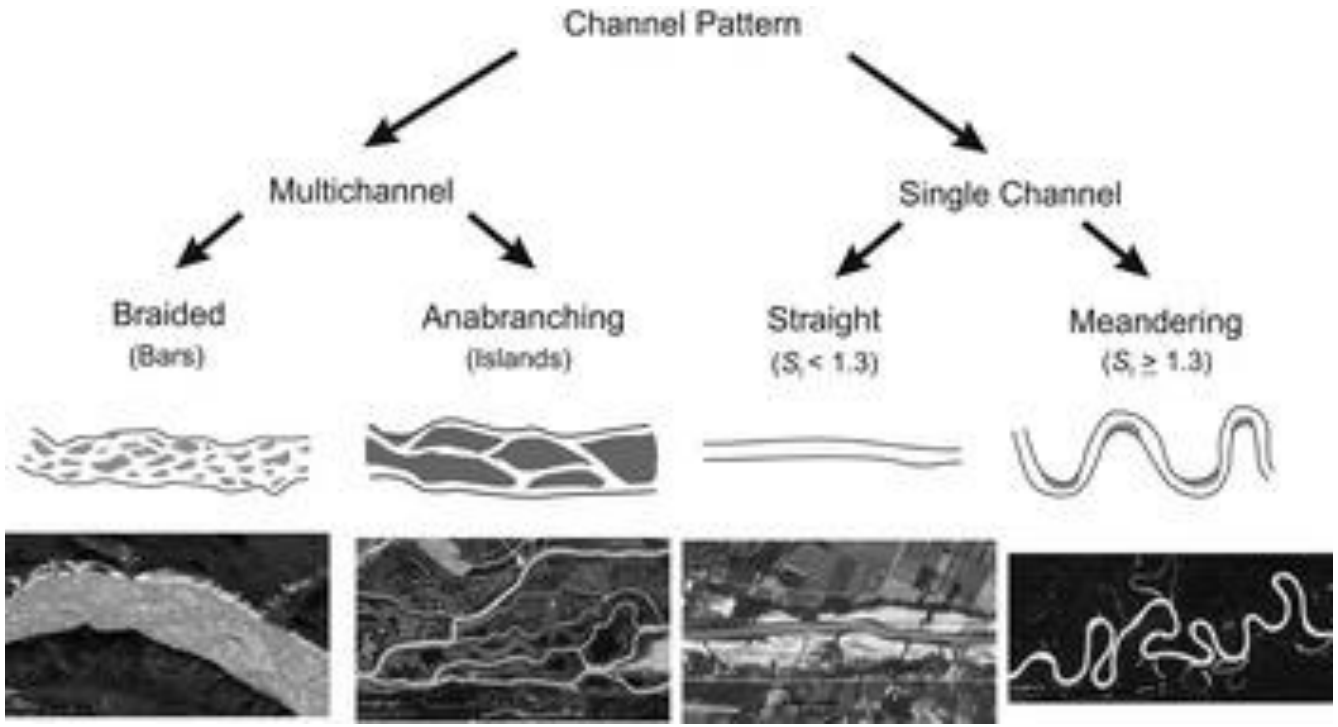
Surveys!

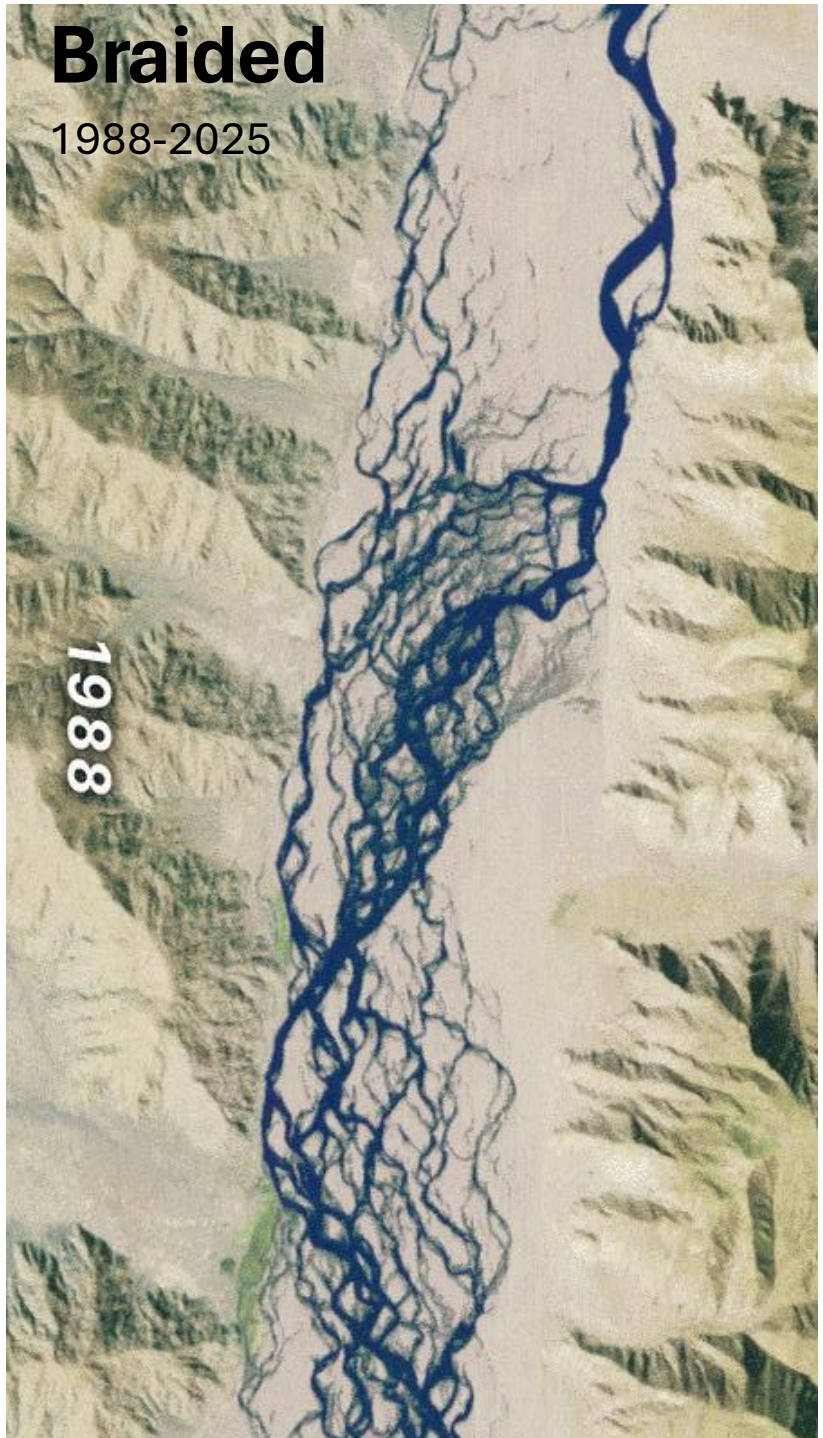


And many more methods that I forgot and that are actively developing!!

2. Knowledge frameworks

Using those tools, we develop frameworks to understand landscapes, their evolution, and emergent hazards/risks.





1. **What** is the rate (slow, fast) of change?

2. **When/where** does channel change occur?

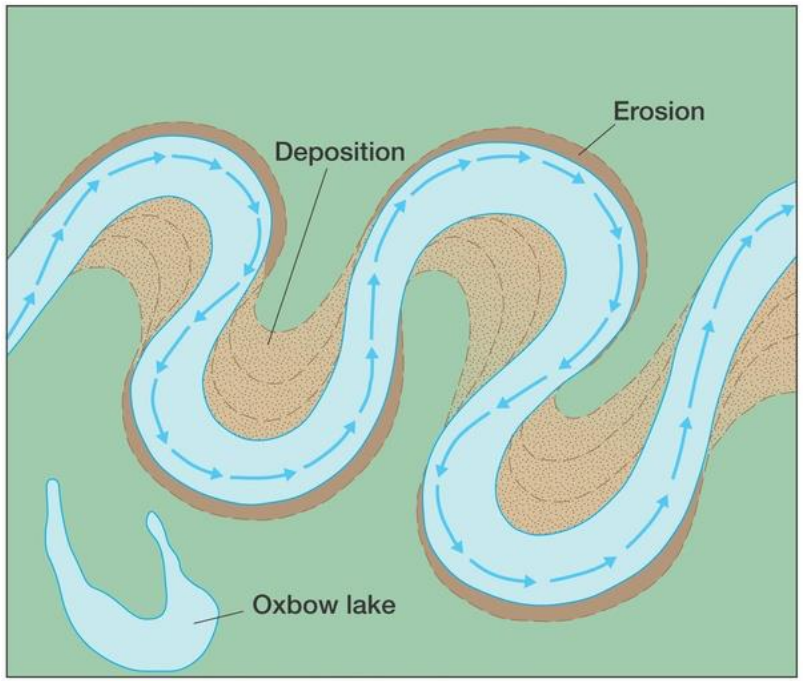
3. **Why** does change occur (can you hypothesize a reason?)?

4. Is there a predictable **pattern**?

Now we have predictable patterns and categories:

Meandering

- Slower rates of change
- Change driven by curvature



Braided

- Highly dynamic
- Works within a straight corridor

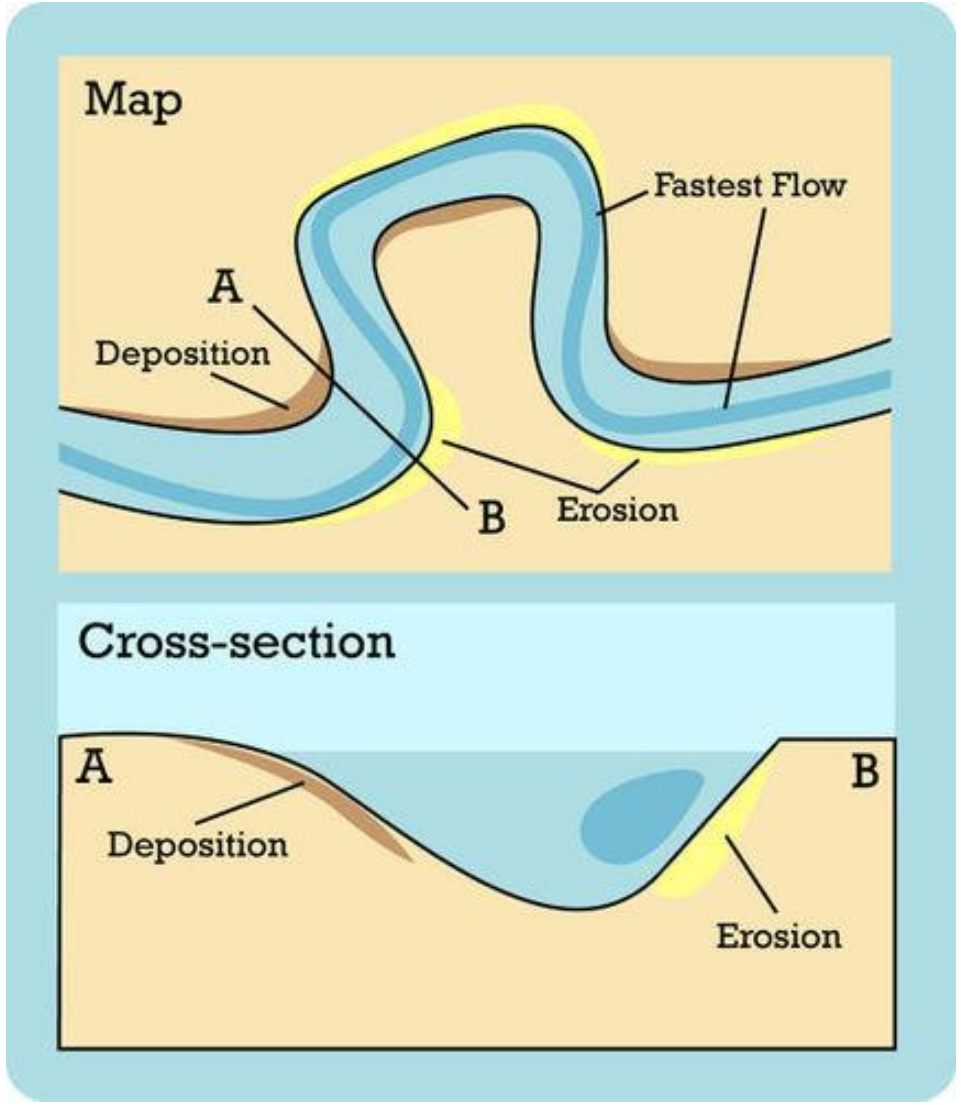
Predictable patterns = geometry-based equations!

Migration rate is the product of **bank erosivity**, **channel width**, and **curvature**:

$$R_o = k_l W C$$

Modified by the upstream curvature via a weighting function (aka, taking into account the inertia of water towards the banks)

$$R_1(s) = \Omega R_0(s) + \left(\Gamma \int_0^\infty R_0(s-\xi)G(\xi)d\xi\right)\left(\int_0^\infty G(\xi)d\xi\right)^{-1}$$



Meandering predictions of the Jurua River show that equations match reality pretty well!

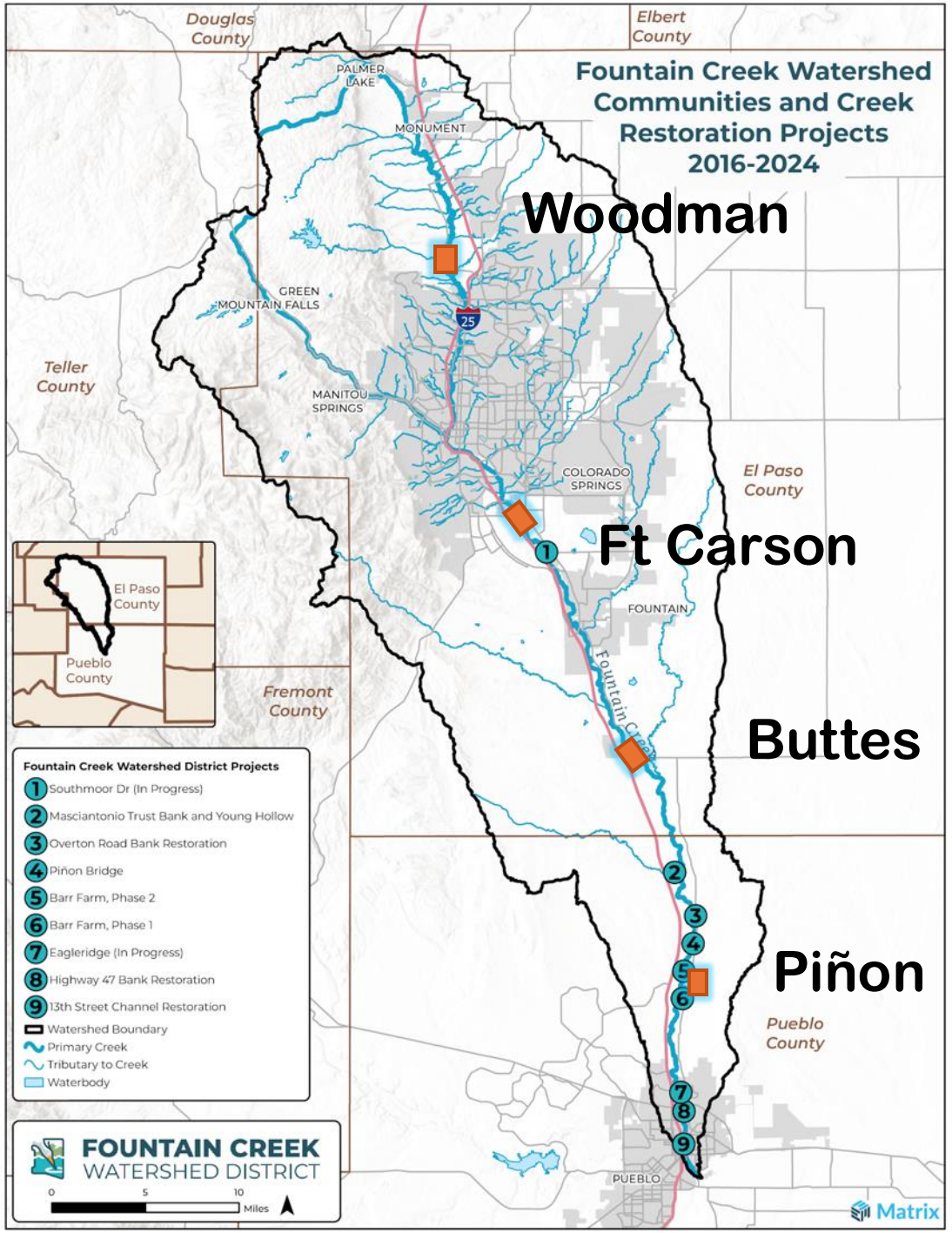
Z Sylvester: https://zsylvester.github.io/post/curvature_migration_rate/

Part 3. Applications to Fountain Creek

It's your turn to be the scientist!

We'll look at historic imagery of these four places:

- Woodman
- Ft Carson
- Buttes
- Piñon



Part 3. Applications to Fountain Creek

Each of you will get a photoset and some markers! Feel free to mark up the photos.

1. Describe: What changes do you see? Purely narrative!
2. Quantify: Measure the amount of widening/narrowing, vegetation loss/gain. Using the photo years, can you convert to an annual rate? Is the rate the same between photosets?
3. Frameworks: Is the creek meandering or braided?

Friendly reminder: dry-erase markers on the whiteboards, wet-erase on the photo prints!

Woodman

Describe:
Quantify:
Frameworks:

Woodman

Channel sinuosity is high and doesn't change much from 1937-2009.
Active channel narrows
Vegetation near the channel increases in height and density

Ft Carson

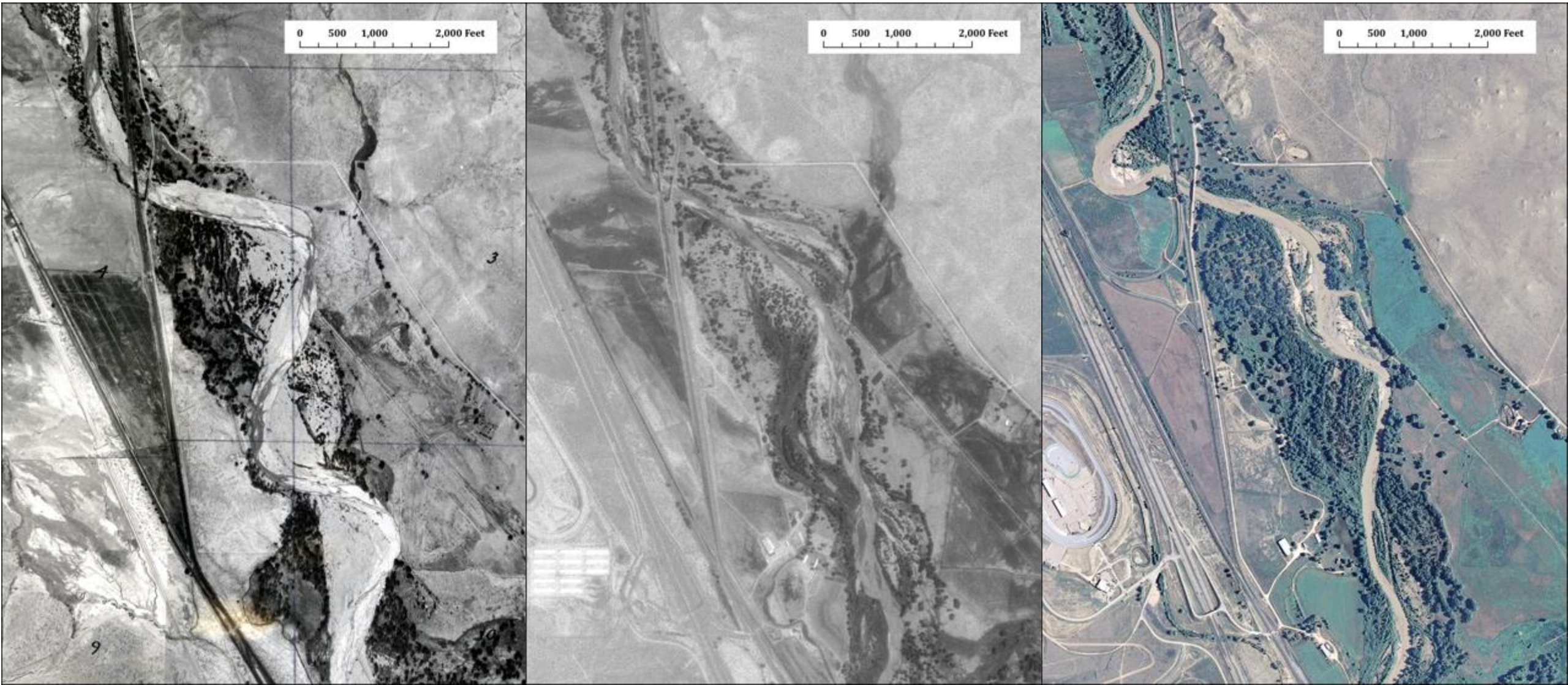
Describe:
Quantify:
Frameworks:

Ft Carson

Channel starts straight, becomes more sinuous, then straightens again
Active channel narrows by a lot! (5-10x)
Vegetation near the channel increases in height and density
Structures and levees on parts of the channel active in 1937

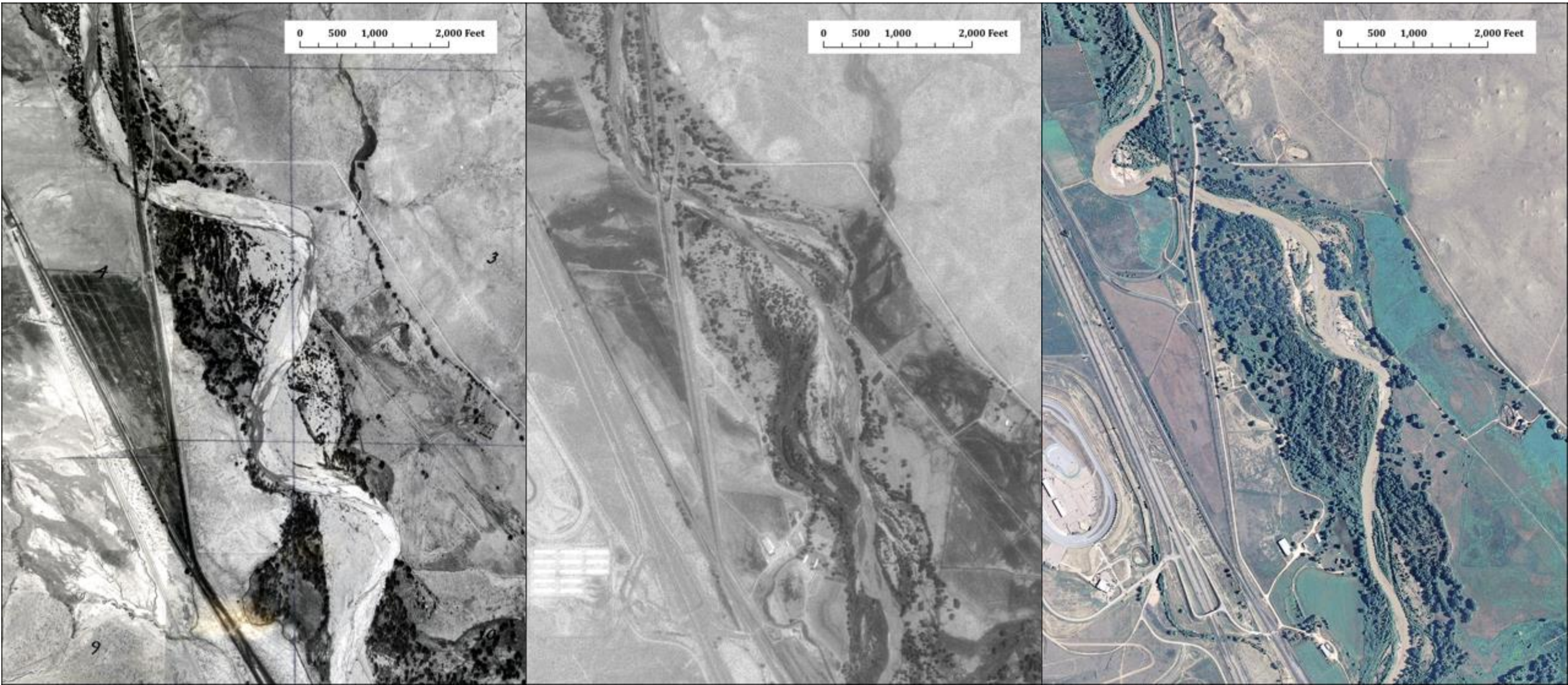
Buttes

Describe:
Quantify:
Frameworks:



Buttes

Channel sinuosity is high and doesn't change much from 1937-2009.
Active channel narrows
Vegetation near the channel increases in height and density
Increased erosion and sinuosity upstream of the bridges



Piñon

Describe:
Quantify:
Frameworks:

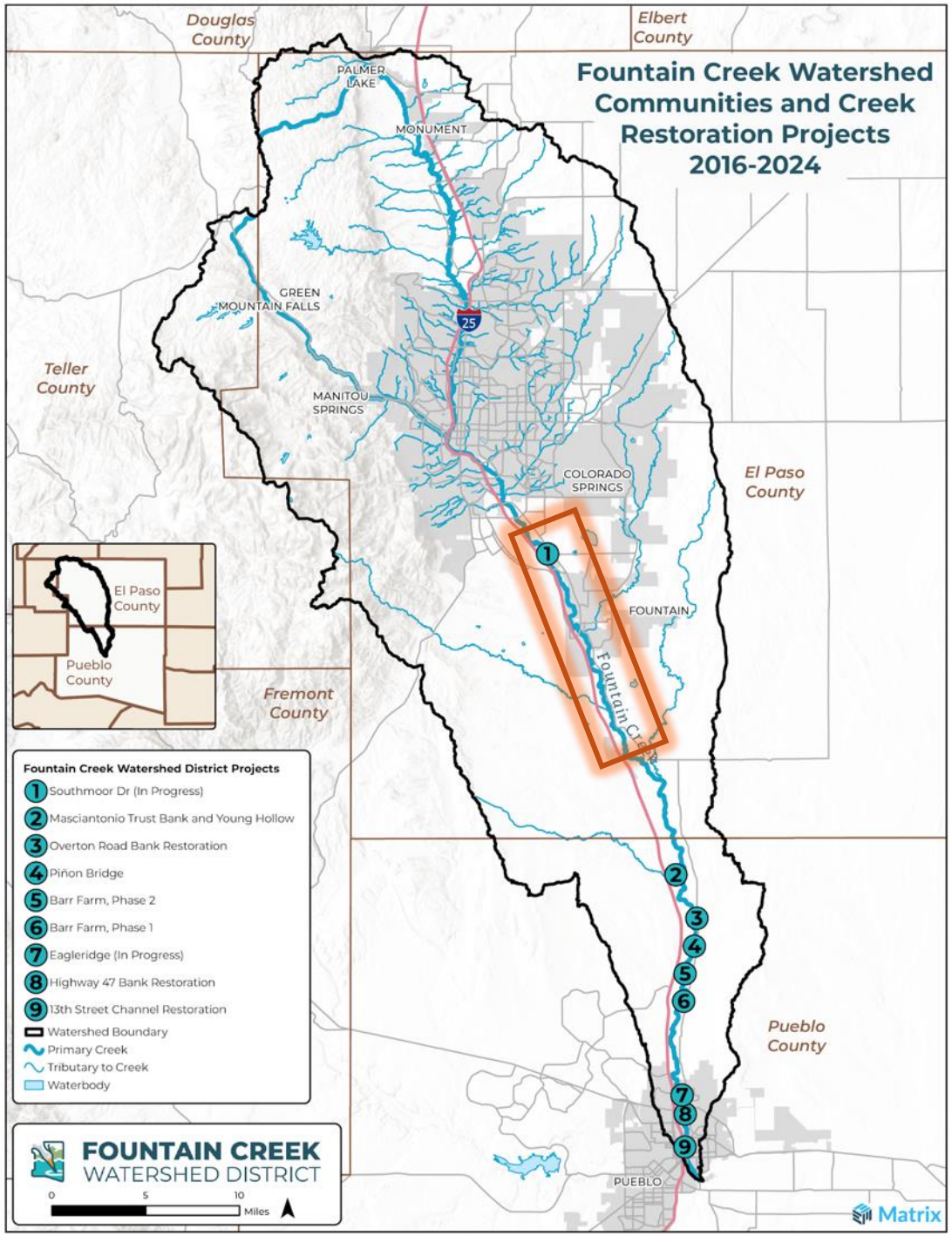
Piñon

Channel sinuosity is high and doesn't change much from 1937-2009
Re-occupation of meander bends from 1937 and 2009.
Active channel narrows by 10x
Vegetation near the channel increases in height and density

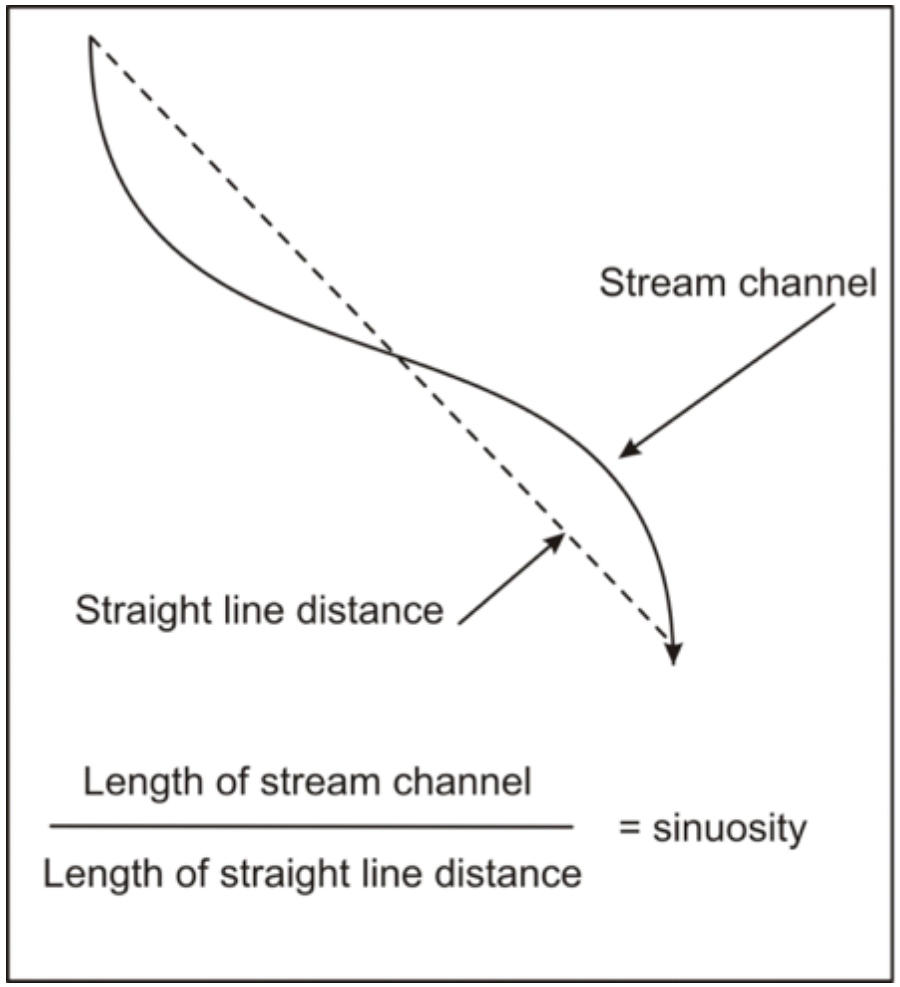
Part 3, cont'd. A sampling of findings from my students

Changes in sinuosity over 80 years

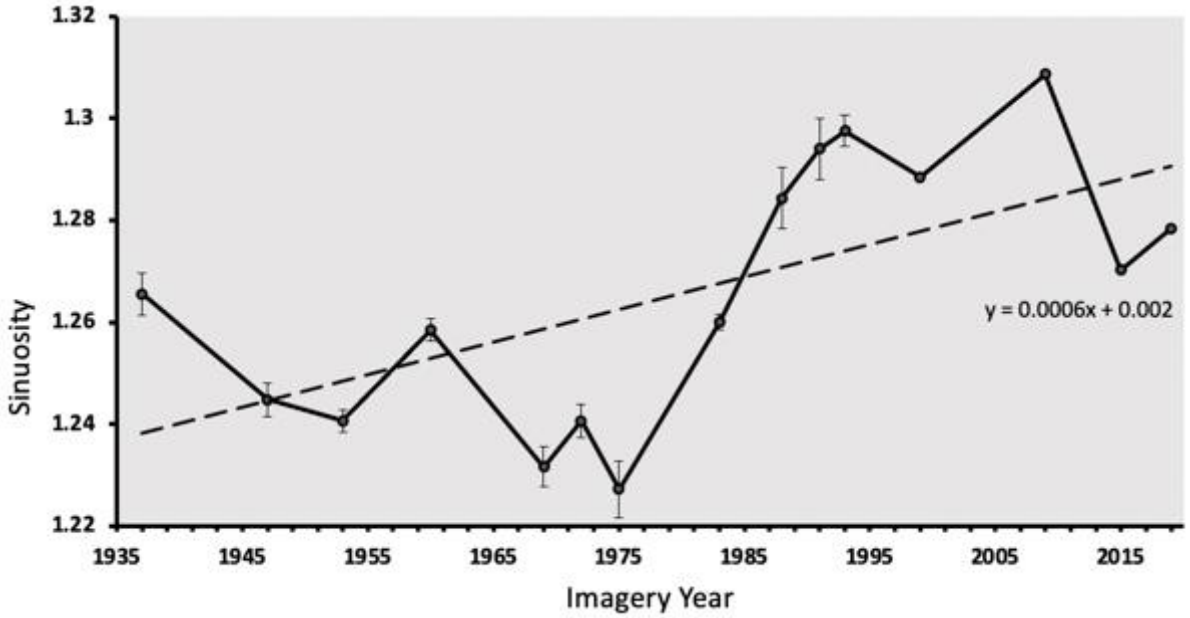
- 1937 to 2019 aerial photo analysis from South Academy to Old Pueblo bridge



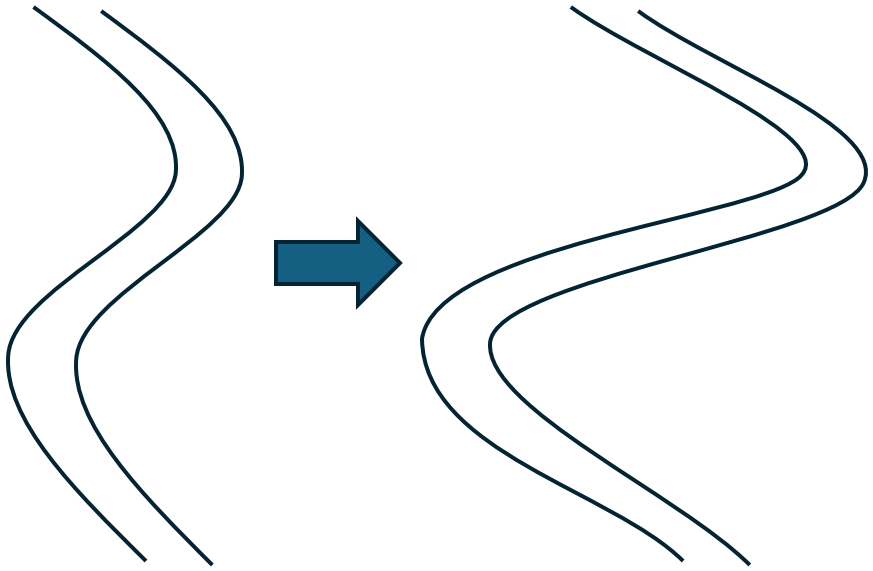
1975-1985 - increase in sinuosity

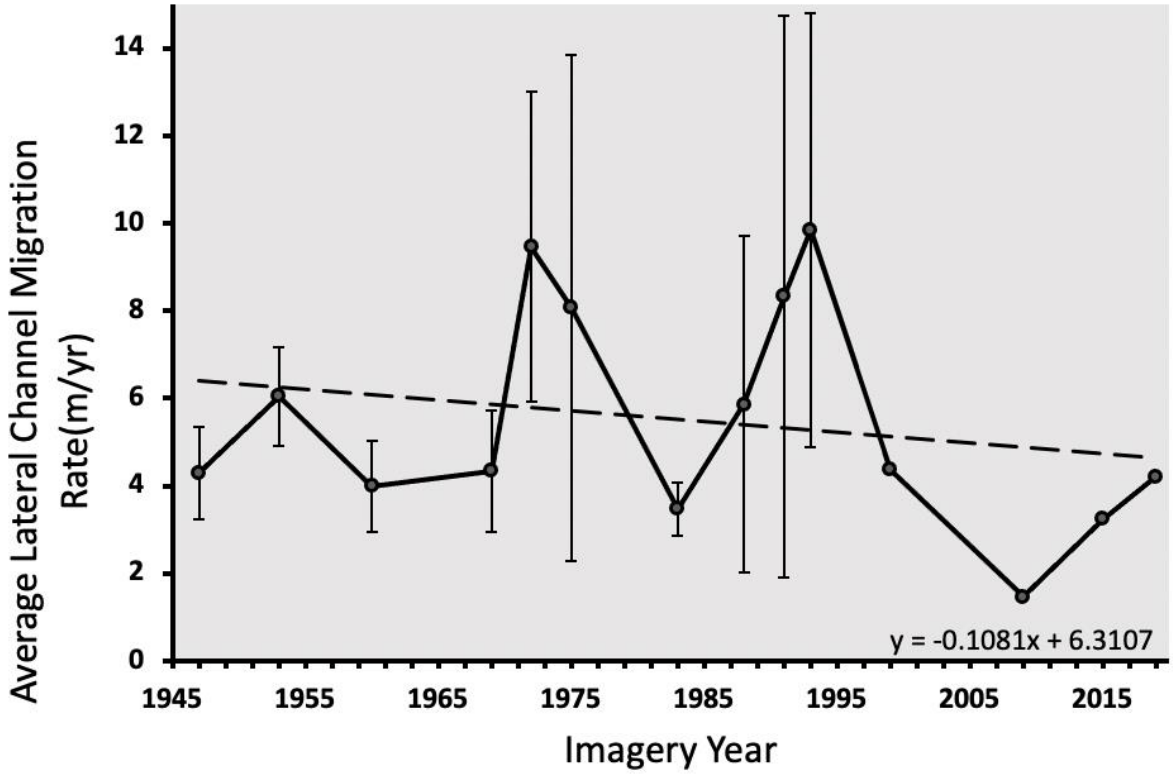


- Sinuosity increases over time
- Why?
  - Hyp 1) Channel lateral motion
  - Hyp 2) Channel narrowing



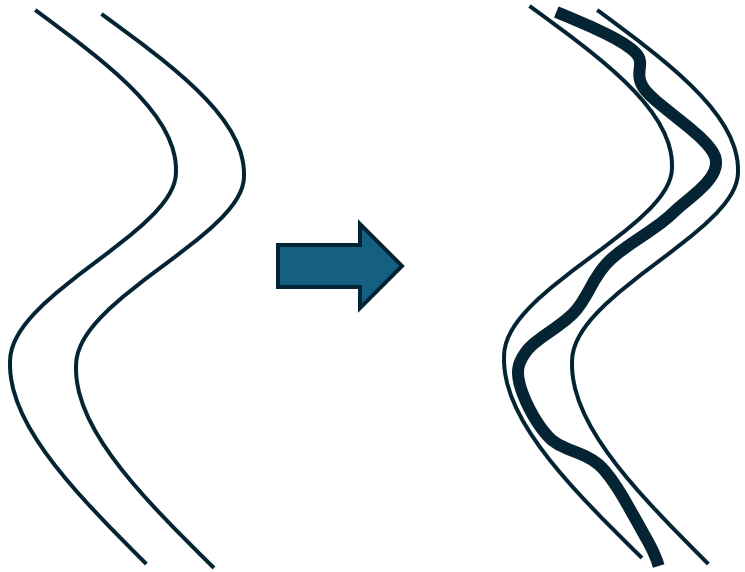
Hypothesis 1: Increased lateral erosion

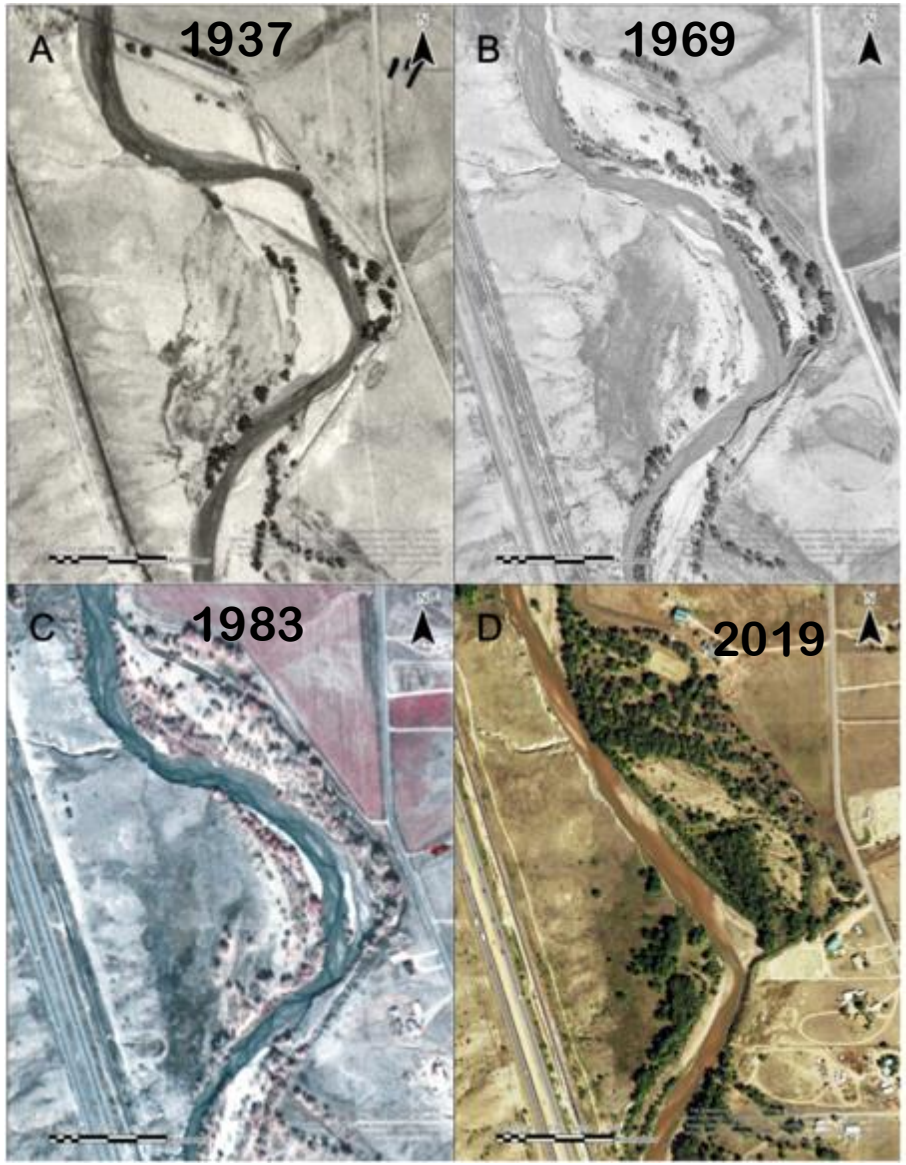




- But: lateral erosion rates decrease over time, and the two increases don't match up with the sinuosity increase.

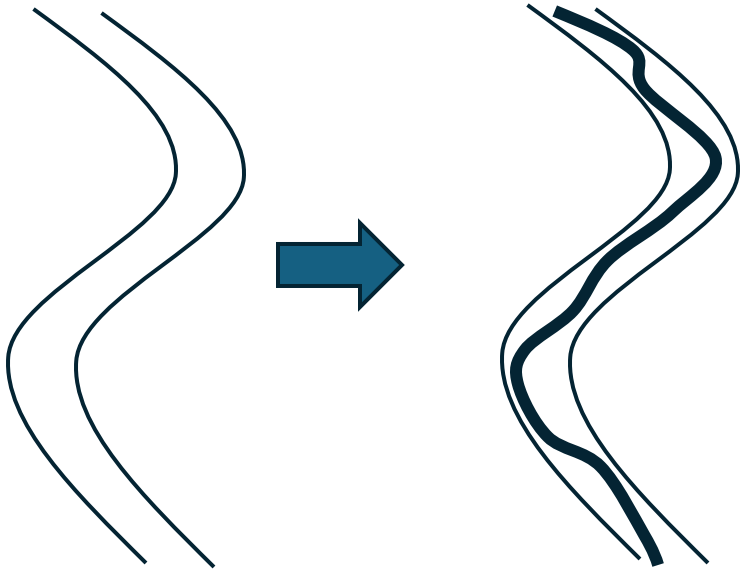
Hypothesis 2: Channel narrowing



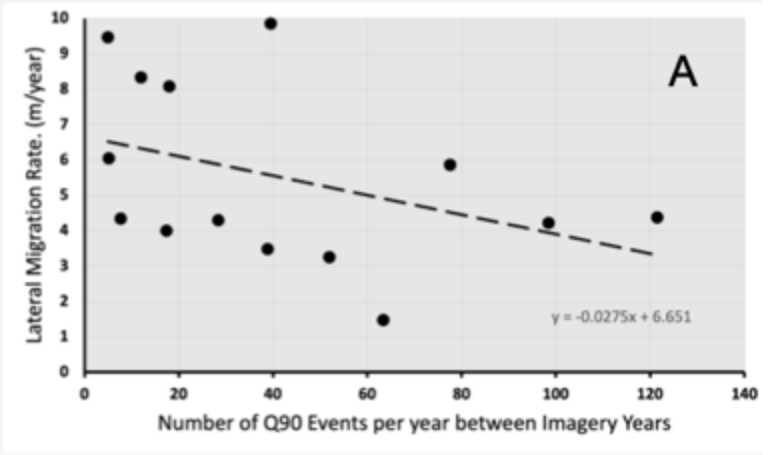


- Repeat aerial images show increasing vegetation through time. Vegetation establishing along point bars, banks, and floodplains helps to stabilize the channel and causes narrowing.

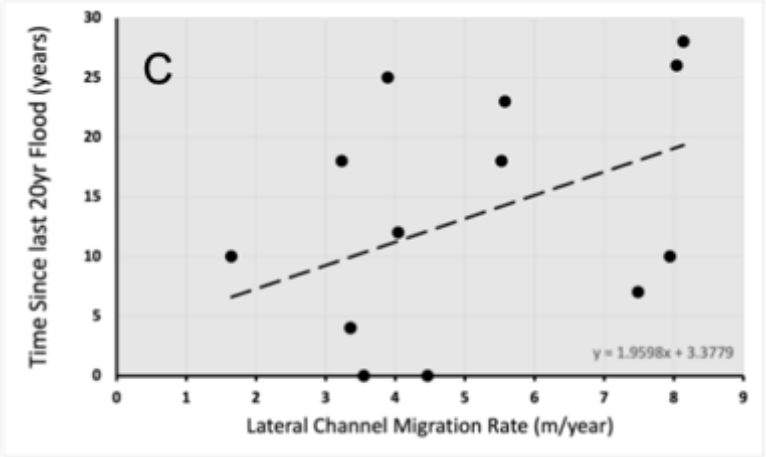
Hypothesis 2: Channel narrowing



90% percentile of flows vs channel movement: less migration with more high flow events??



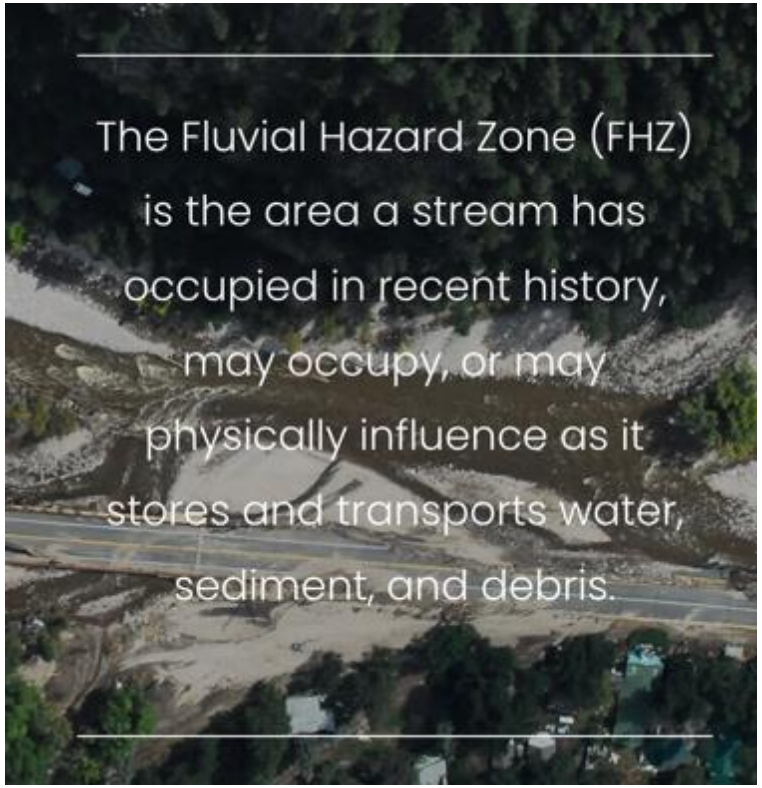
Time since 20-year flood vs channel movement: less migration close to high flow events??



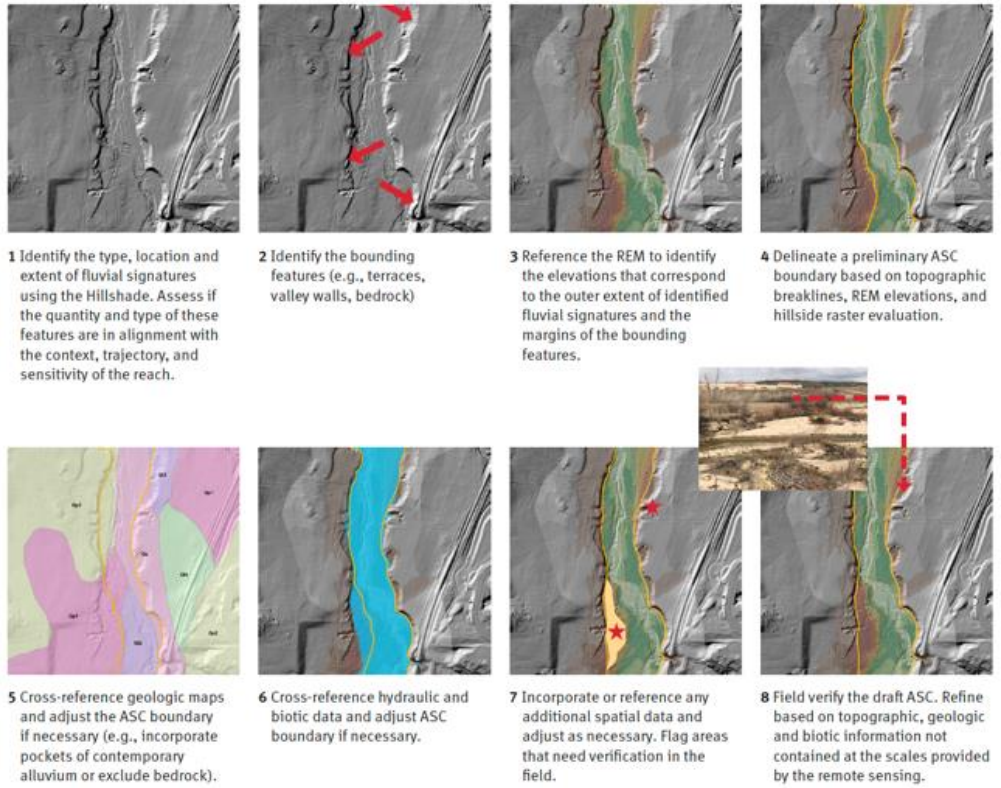
- Supported by lack of expected relationship between large flows and lateral migration rates: vegetation is stabilizing banks!

What's next for Fountain Creek?

- Colorado fluvial hazard zone mapping
- Fall 2024 geomorphology class

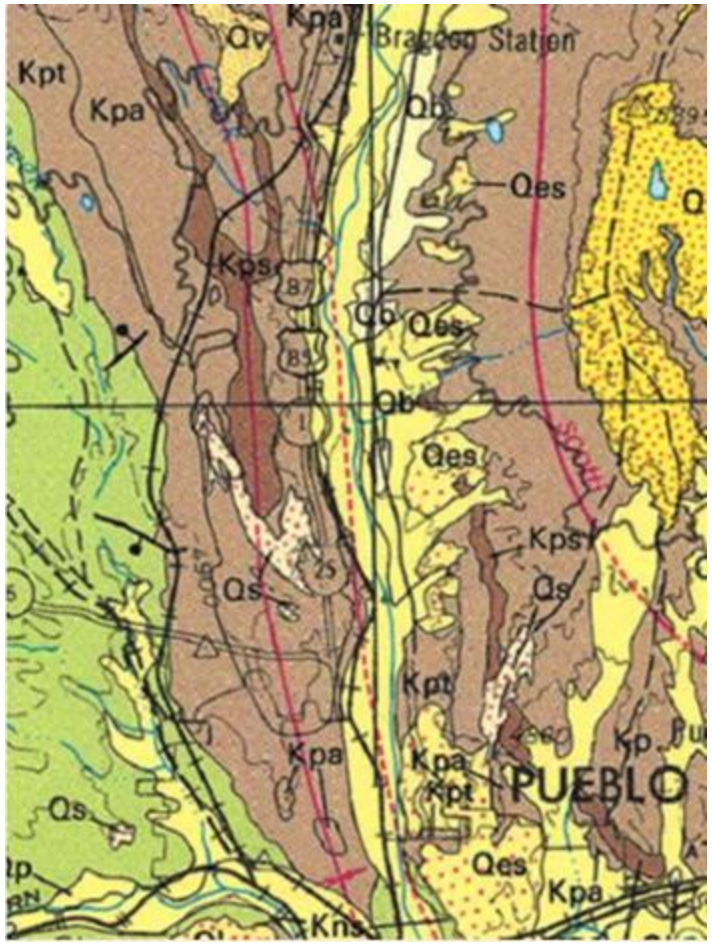


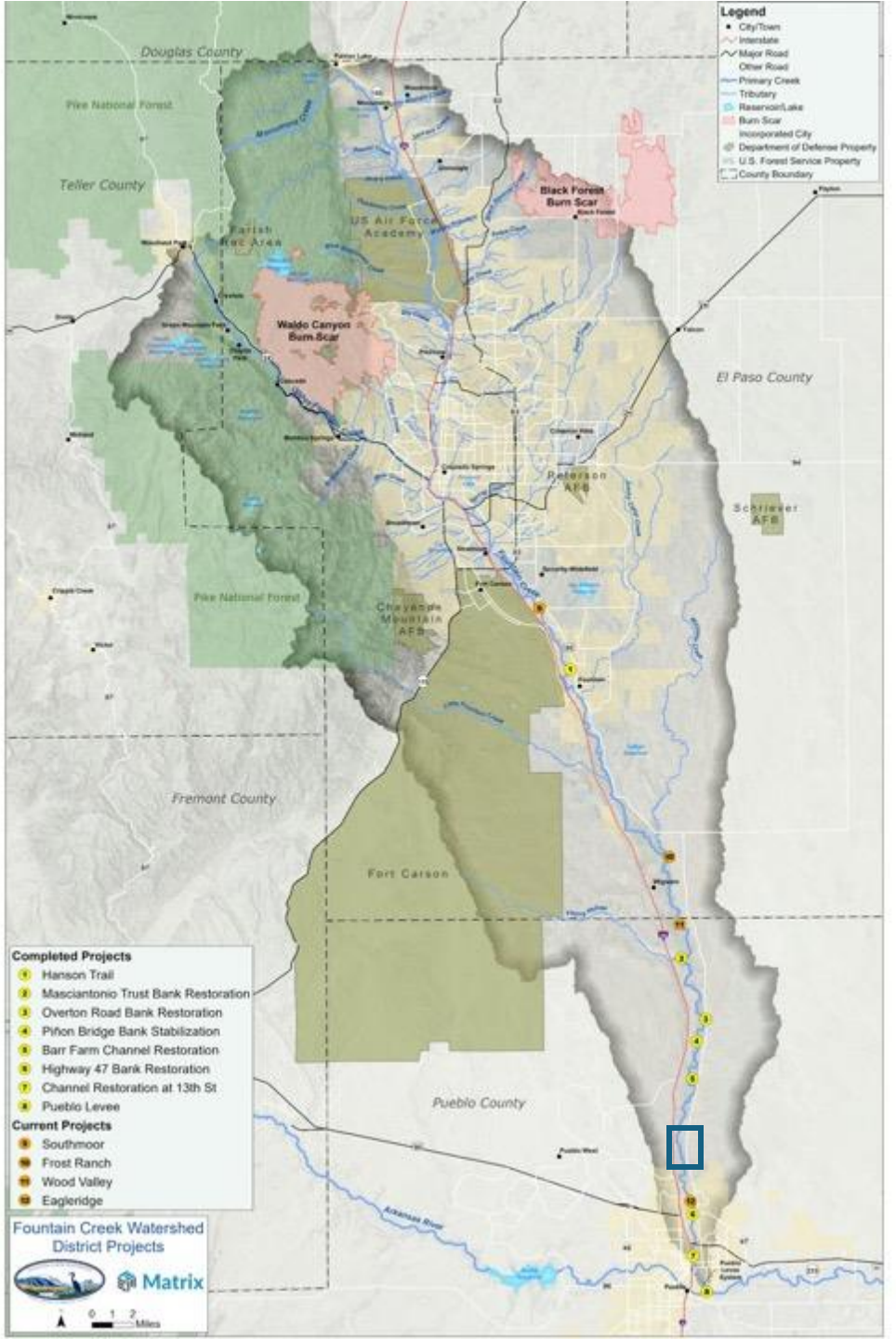
https://www.coloradofhz.com/



Fluvial hazards at Sandoval

- Local geology is the Pierre Shale and alluvium
- These units are easily erodible

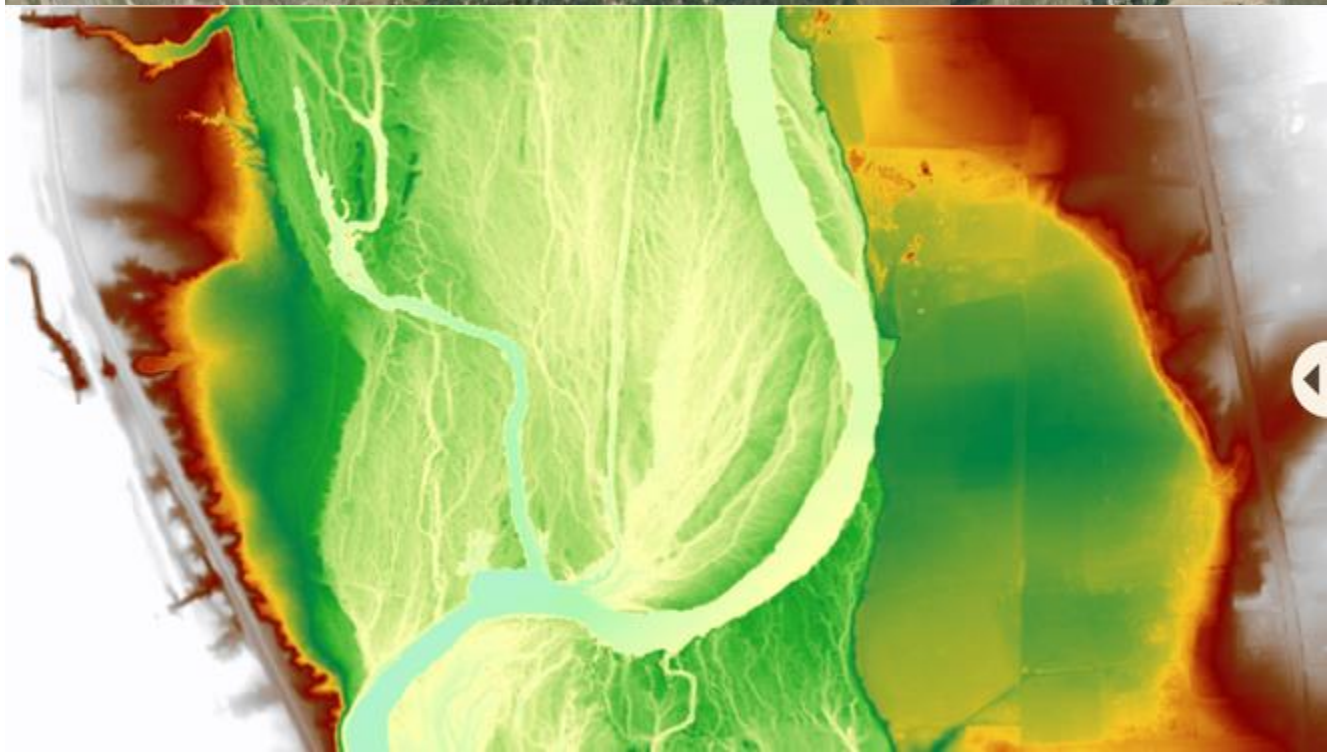




Fluvial hazards at Sandoval

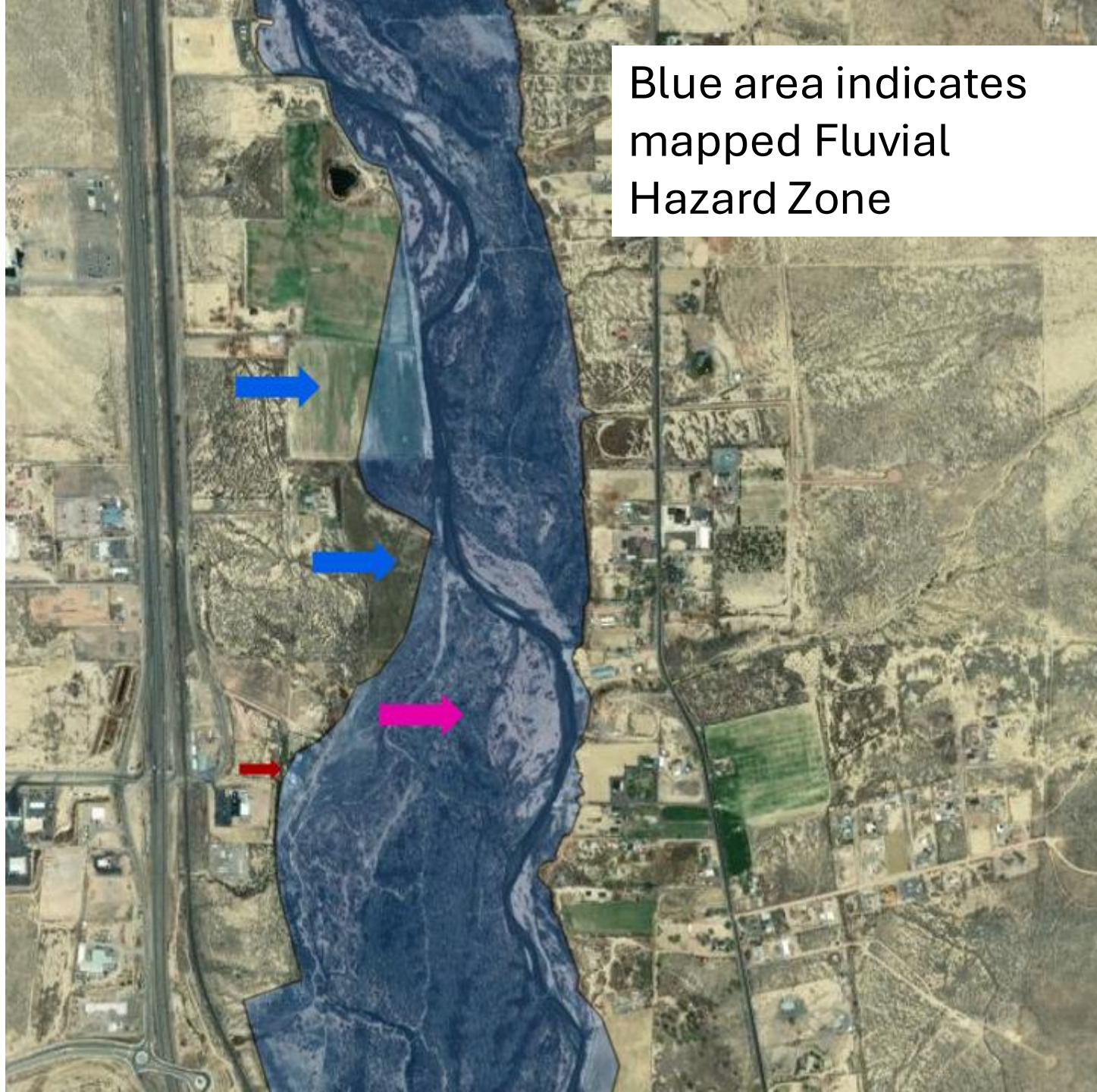
- Despite established trees, lidar shows network of high-flow channels

- Active zone is 10x wider than the modern channel



Fluvial hazards at Sandoval

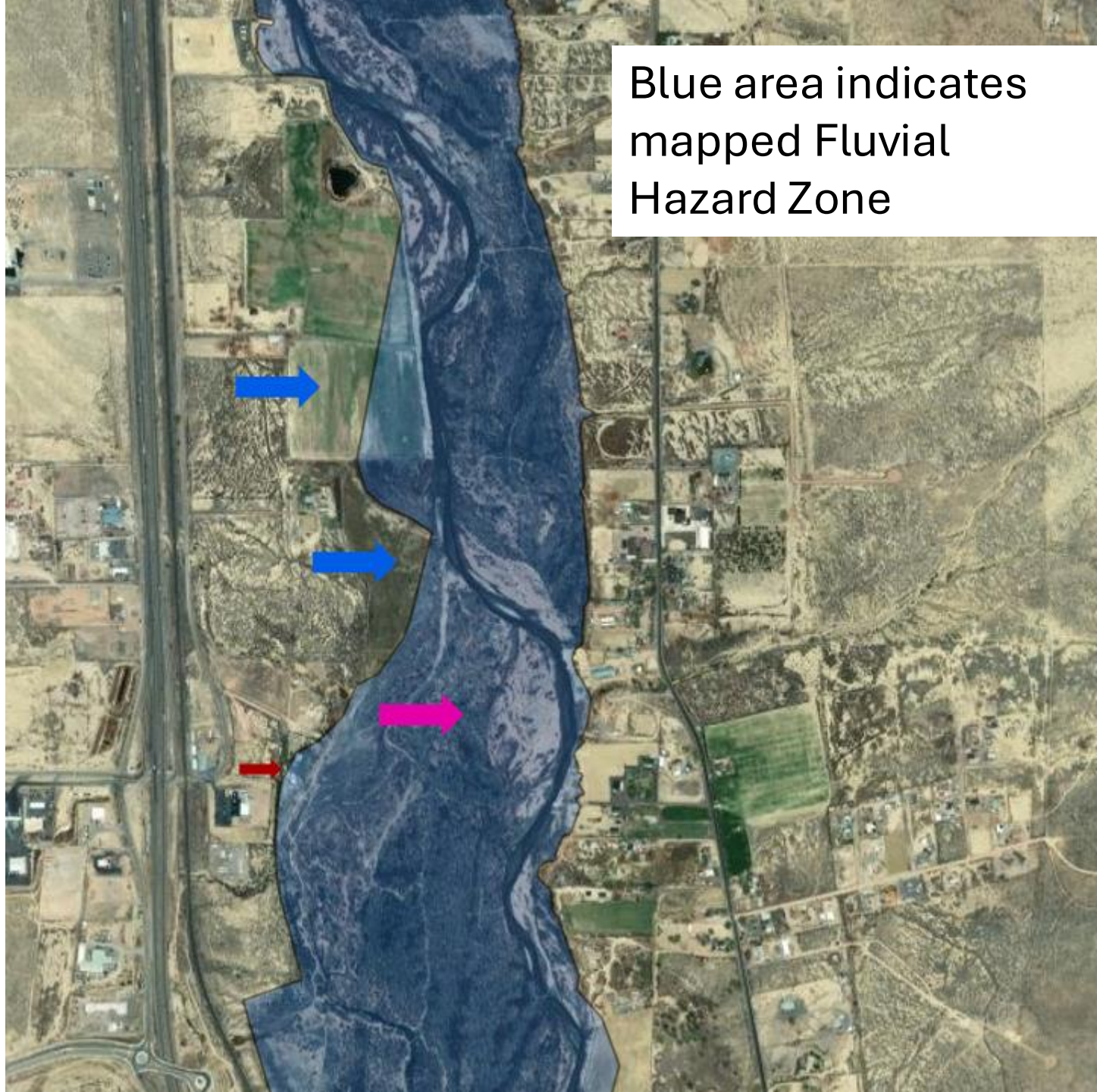
- Blue = active stream corridor from fluvial hazard mapping
- Extends on to some plowed fields and abuts infrastructure



Fluvial hazards at Sandoval

Mapping helps guide/confirm land use decisions:

- Blue arrows are locations where floodplain-channel reconnections are proposed
- Pink is a proposed wetland site



In summary:

- Fountain Creek is dynamic!!!
- Although it may present now as a meandering, vegetated stream, in the past 100 years, it has been more dynamic.
- Recent channel changes seem driven by vegetation stabilization
  - Likely due to flow regulation & increase in base flows (less seasonal flashiness)

Fluvial hazards + project stability

You can read more about my students' 2024 class projects on the FCWD website:

- https://www.fountain-crk.org/2024-colorado-college-student-projects