Aggrade and Recover: Process-Based Restoration After Monsoon Floods on Dugout Ranch, UT

Wally Macfarlane

Dallin Baker

Jeff Adams

Kristen Redd

terrasophia

Ancestral Lands Conservation Corps

The Nature Conservancy

Walton Family Foundation

National Fish and Wildlife Foundation NFWF

newventurefund

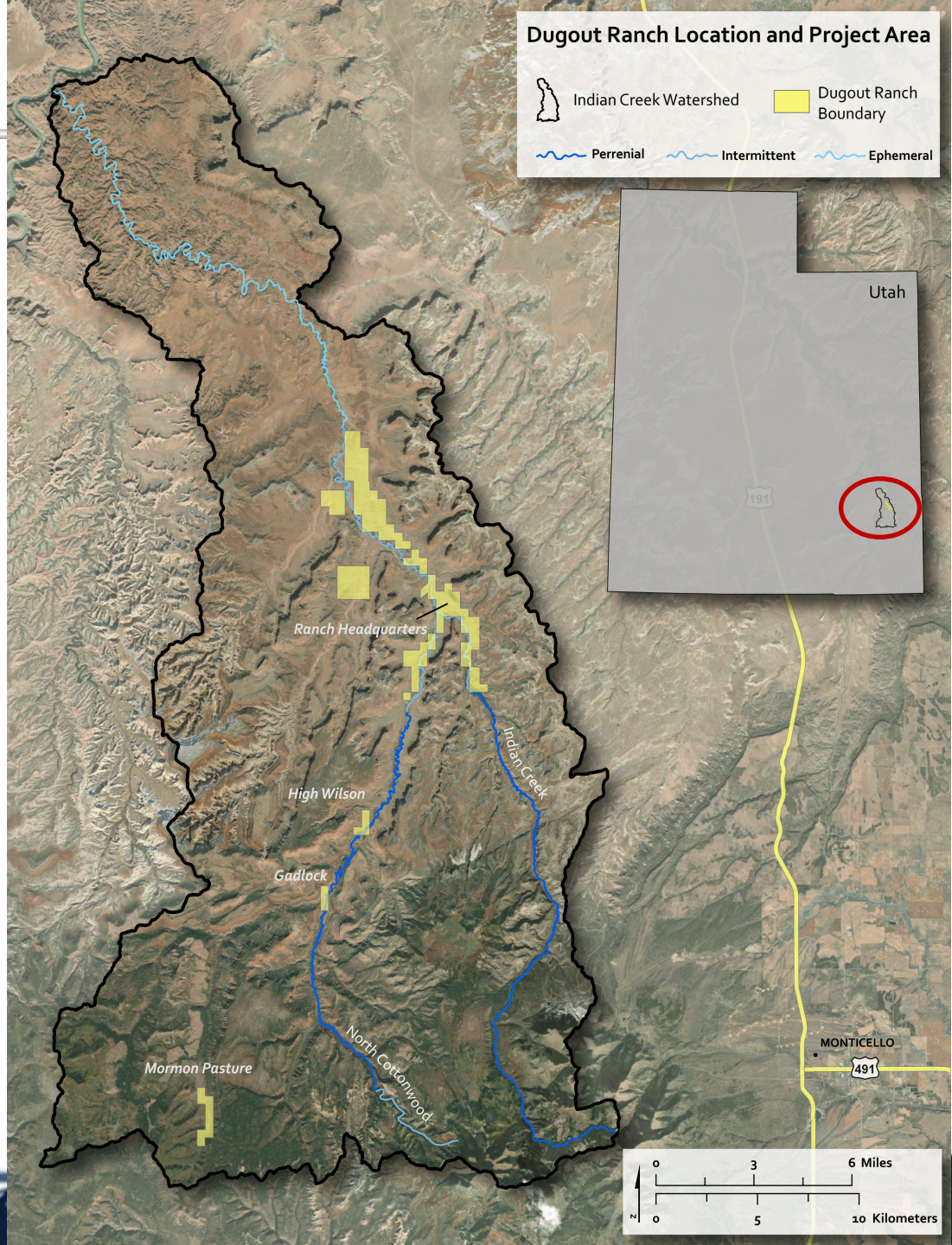
Colorado River Resilience

Utah State University

Riverscapes Assessment & Monitoring Laboratory

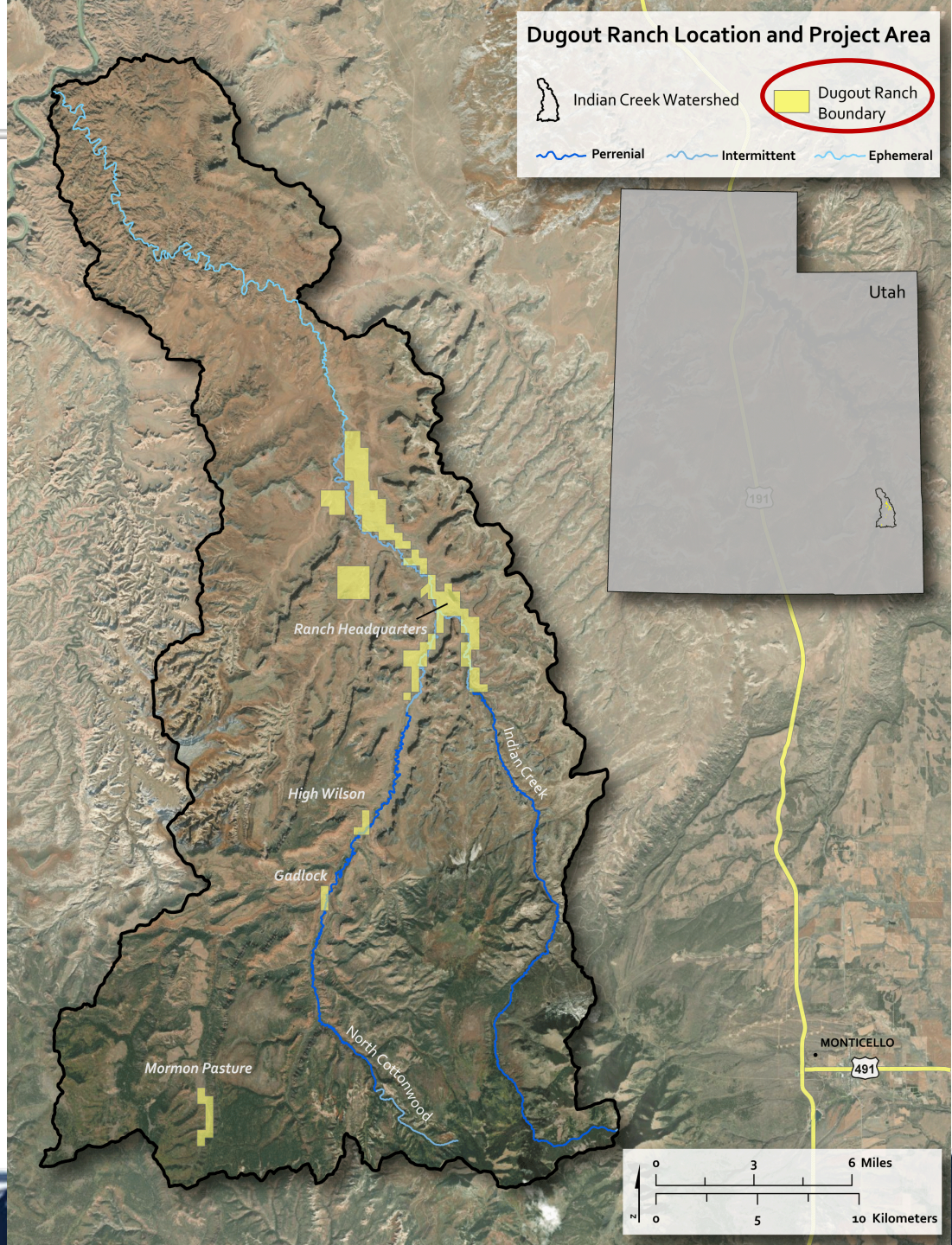
Site Location:

- Indian Creek watershed



Site Location:

- TNC's Dugout Ranch, Bears Ears National Monument



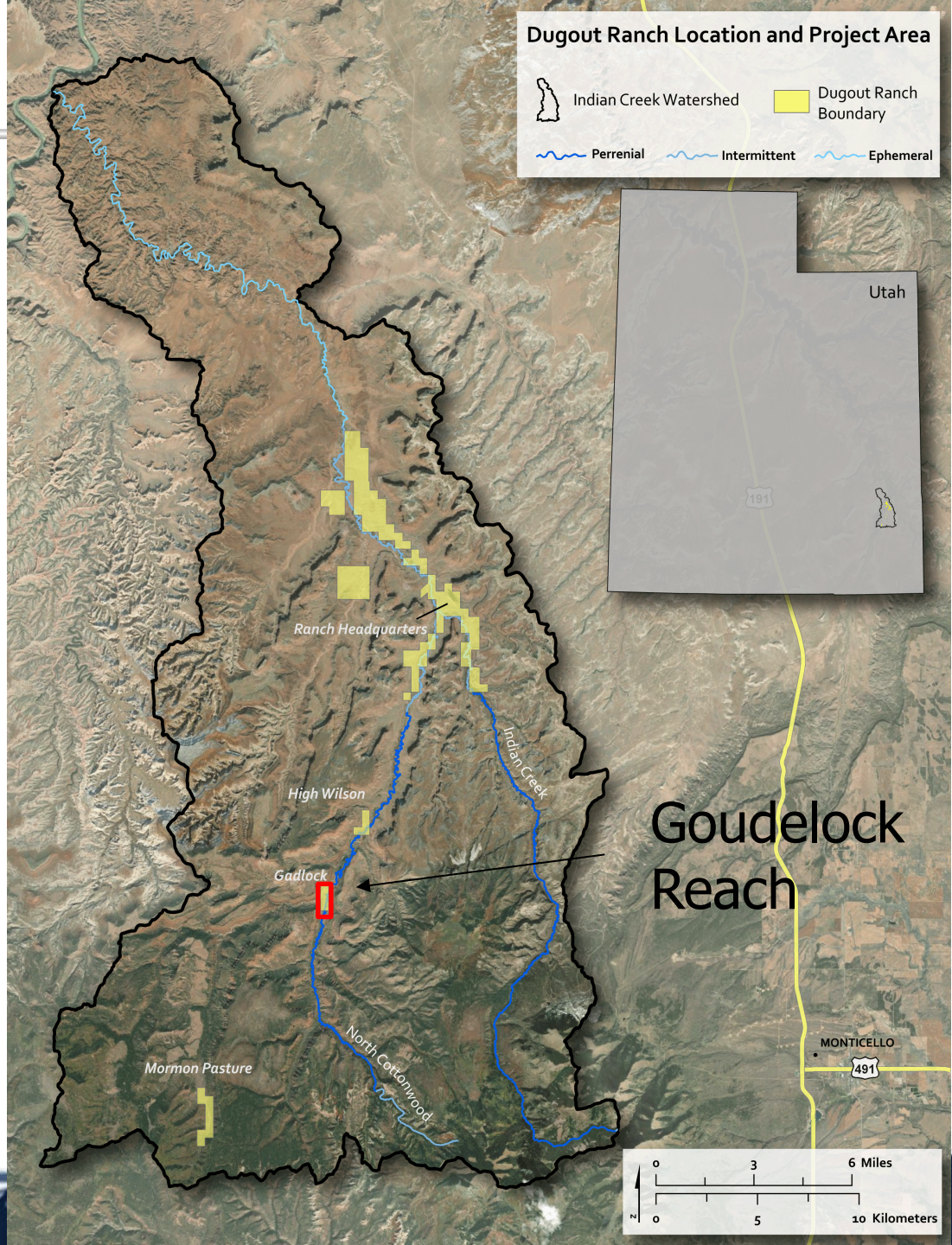
TNC's Dugout Ranch, Utah

© Ted Wood, used with permission, https://www.tedwoodphoto.com/

Dugout Ranch headquarters is in the center of the photo; Indian Creek is located on the left and North Cottonwood Creek is located on the right and the Abajo Mountains are in the upper left of the photo.

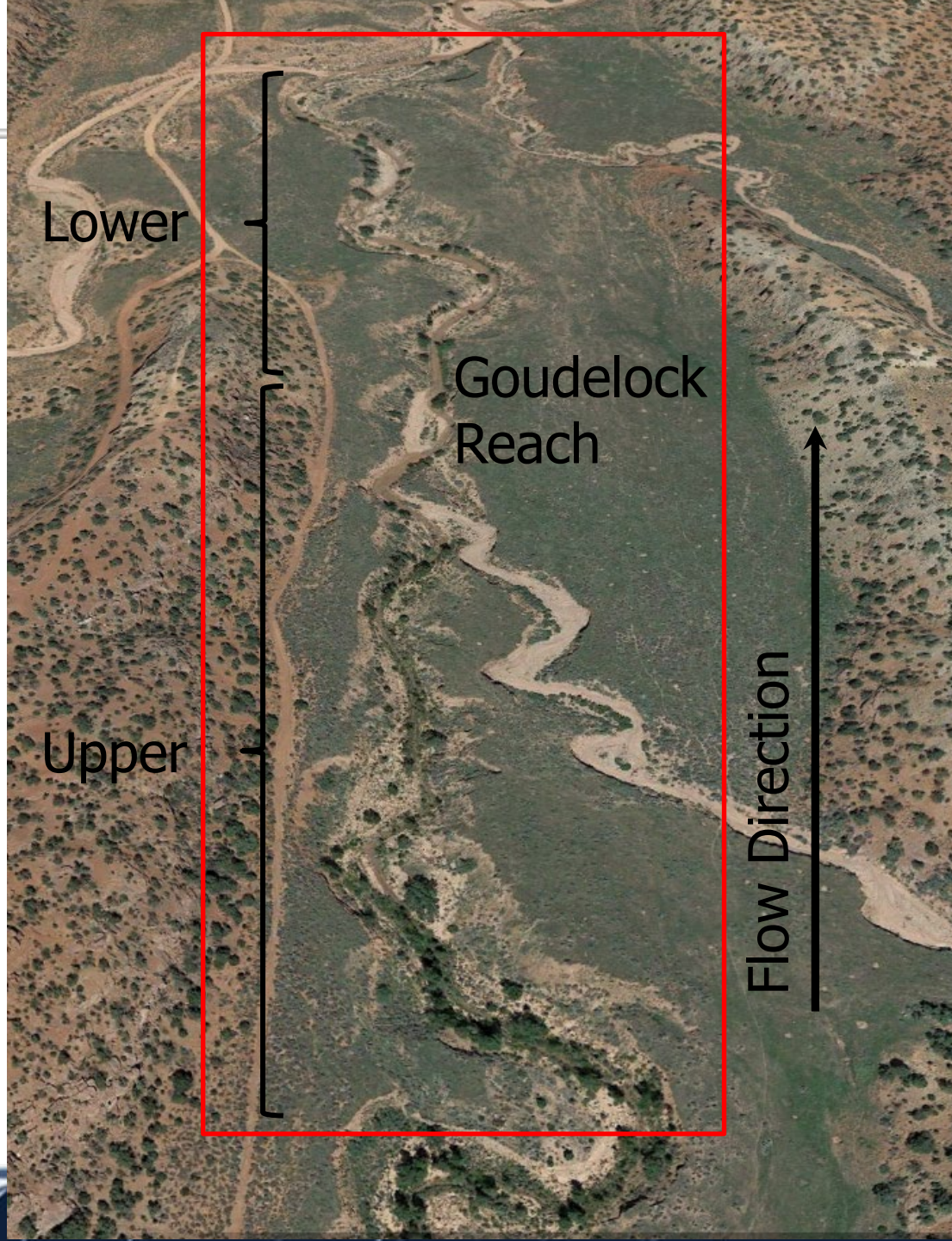
Site Location:

- 1.1 km reach of North Cottonwood Cr
- Small perennial stream: baseflow of 3 to 4 CFS (no current USGS gauge)
- Partly confined valley setting
- Elev: 1829 m (6000 ft)
- Transition reach from high-energy mountain headwaters to low-energy, flat valley
- Low levels of Tamarisk and no Russian olive!



Site Location:

- 1.1 km reach of North Cottonwood Cr
- Lower reach
  - Slope: **2%** (moderate)
  - Active channel width: **6-10 m**
  - Valley bottom width: **15-20 m**
- Upper reach
  - Slope: **3%** (mod/high)
  - Active channel width: **1-3 m**
  - Valley bottom width: **10-15 m**

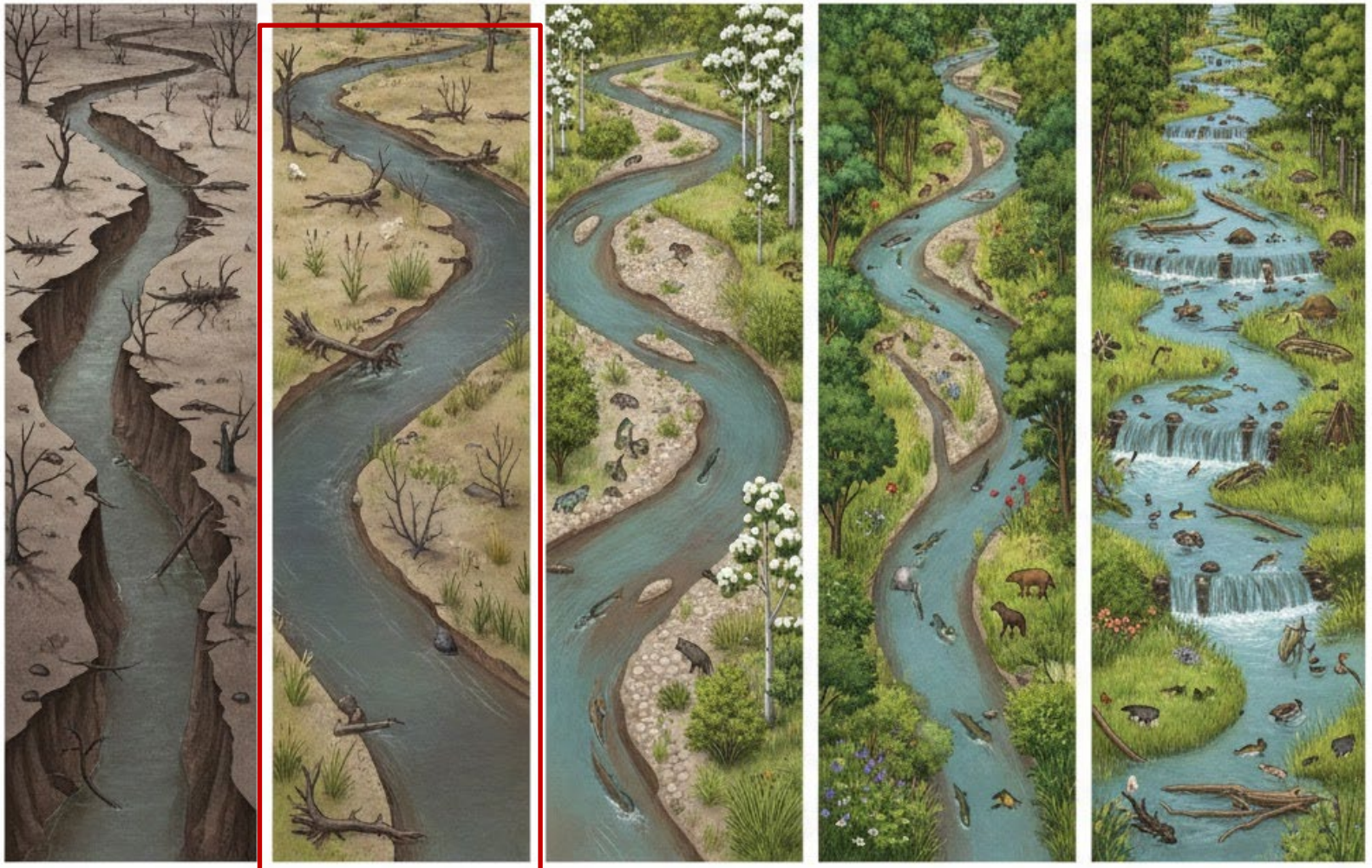


Pre-Restoration Condition

- Prior to restoration the **Goudelock reach** was an incised reach, that has widened. It is structurally starved, with minimal riparian veg & extensive upland veg encroachment.

Riverscape Restoration Continuum

Increasing Ecological Complexity & Resilience



DEGRADED
Incised Channel,
Poor Habitat,
Low Biodiversity

Trench Widening
Early Revegtation,
Bank Instability

Aggradation
Bed Aggradation
Riparian Growth

HEALTHY
Braided Channels,
Rich Habitat,
High Biodiversity

BEAVER DAM COMPLEX
Beaver Engineered,
Wetland Creation,
Ecosystem Resilience

Restoration Goals

- Increase the amount of water and its residence time on the landscape
- Capture sediment to aggrade channel
- Reconnect floodplain
- Reconnect side channels
- Create overbank flow to promote riparian vegetation expansion

Restoration Actions

- **31 machine-built** structures (postless BDAs, PALS, and large wood additions)
- **21 hand-built** structures (postless BDAs, PALS, one rock dams, rock run downs, hinge-felled trees)

A hand-built, postless BDA.

Restoration Actions

- In the lower 0.6 km heavy machinery was used.
- The upper 0.5 km was inaccessible to heavy machinery, so structures were hand built.
- Control reaches provided a baseline to verify if post-restoration gains were associate with changes taking place system-wide.

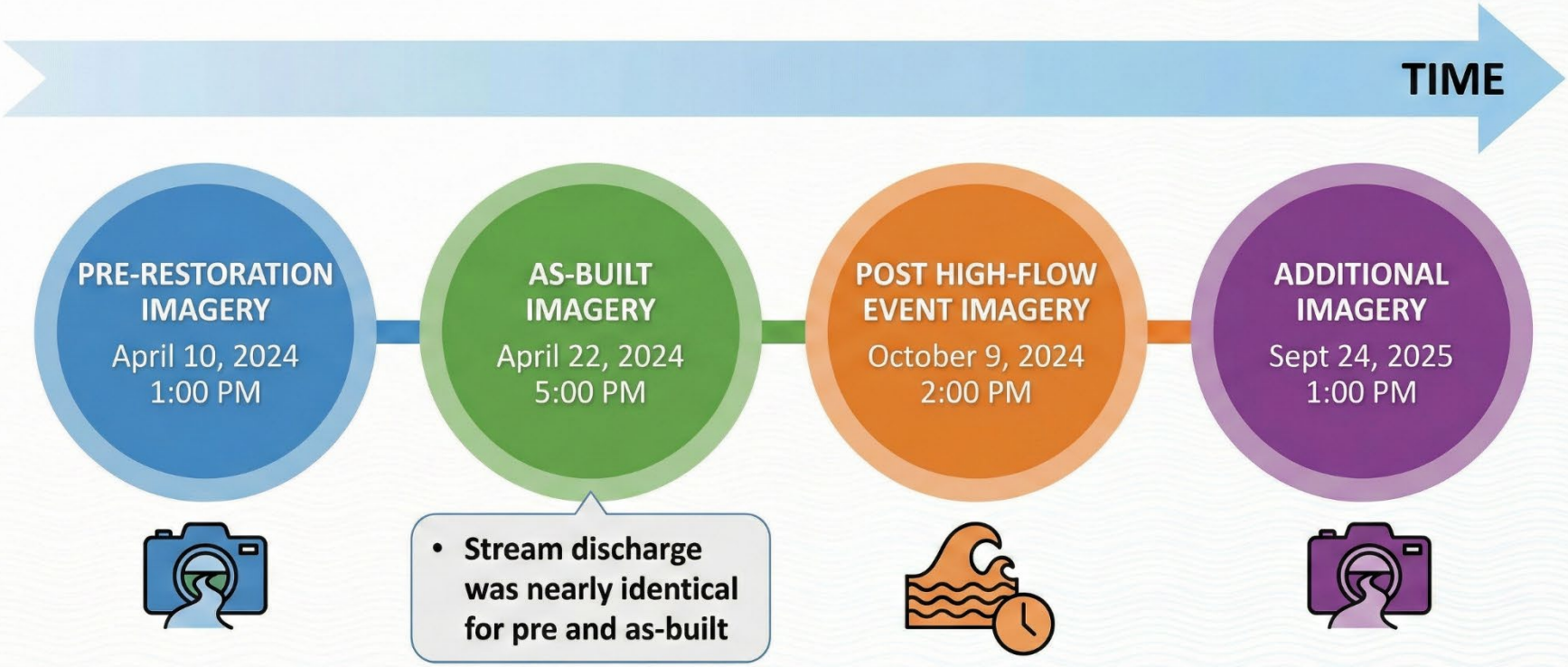
BDAs were designed to…

mimic beaver dams found in flashy, high-sediment systems, where dams commonly reach 2.5 m in height and span the entire inset floodplain.

Mechanical BDA Construction

- https://youtu.be/htpAAUh1if8 (Building a BDA)
- Each structure was mechanically "scratched in" using multiple layers of pinyon/juniper limbs oriented parallel to flow, with butt-ends facing upstream covered with a mixture of bed and bank sediment (cobble to mud).
- Each structure was hand-finished to plug gaps missed by machinery.
- 100 pinyon/juniper trees were harvested adjacent to the channel, either manually felled or excavator-pulled.
- Cottonwood carcasses and hinge-felled cottonwoods were used to build wood jams.

Monitoring: High resolution imagery collection using Unmanned Aerial Vehicle (UAV)



- **Imagery type**
  - True color RGB
  - Orthoimage with a resolution of 4 pixels per inch
  - Georectified using Esri satellite imagery

Mapping Methods

- Manual aerial photo interpretation in QGIS
- Scale of 1:100
- Create a layer file for each component

Mapping Components

- Mapped **inundation** extent & type (free-flowing, ponded, overbank)
- Classified **land cover**: water, riparian and non-riparian
- Classified **stream channels** as primary or secondary

Monitoring: Using Ground Surveys

The following info was recorded:

- **Presence/absence** of structures relative to as-built conditions;
- **Structure condition** (intact, breached, blown out, moved, or buried; burial defined as >75% crest height infilled);
- **Geomorphic response** (erosion, deposition, pool formation, cut banks);
- **Natural dam and wood accumulation**, including beaver take-over or new wood loading;
- **Total structure count** through time, incorporating both natural and restoration features.

Results: As-built Condition

- Our UAV analyses showed an initial **93% increase** in inundated area immediately following construction

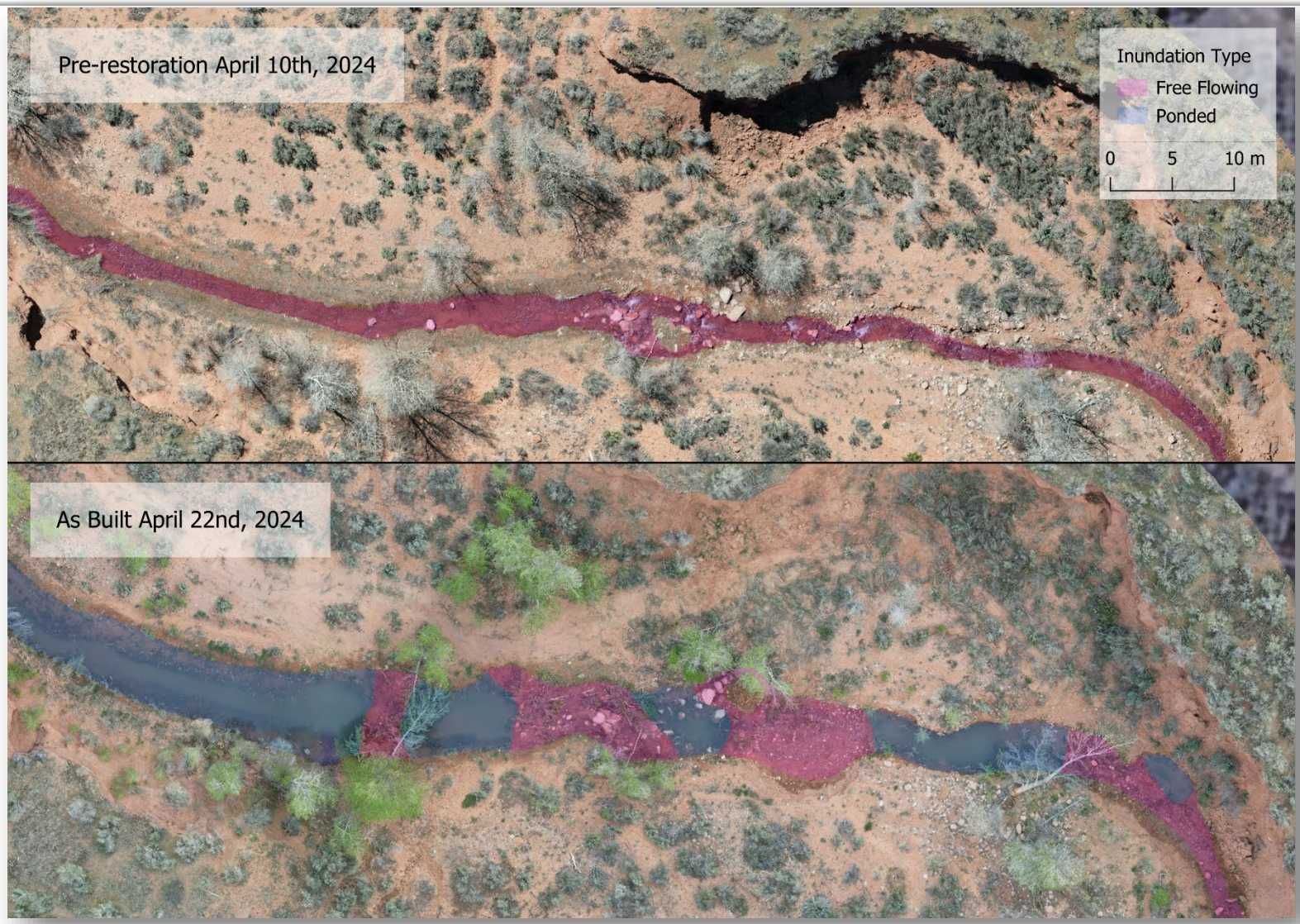
This increase was in the form of **ponded area** created by the in-stream structures

Pre-restoration vs. As-built

Pre-restoration April 10, 2024

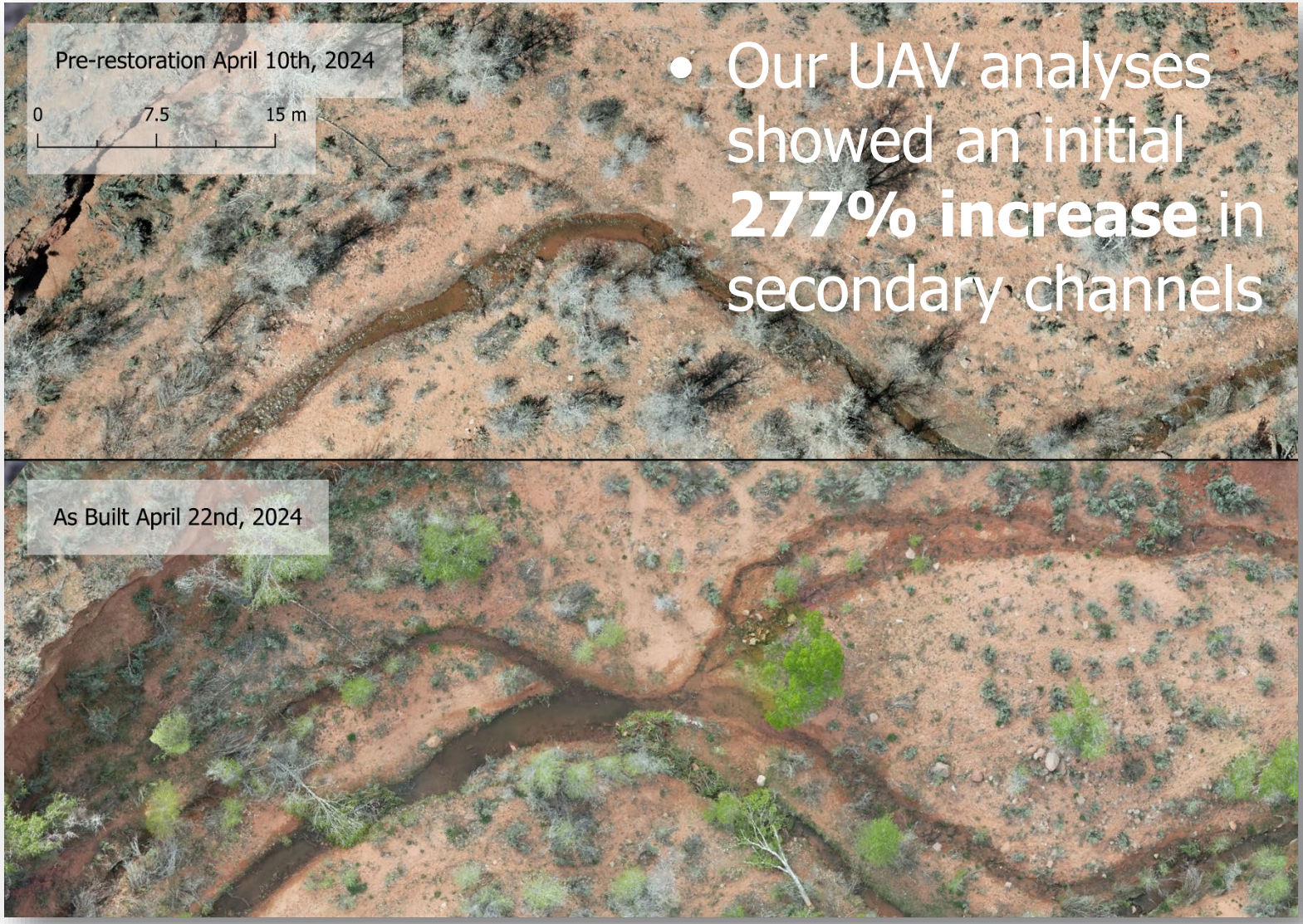
As-built April 22, 2024

Inundation: Pre-restoration vs. As-built



RIVERSCAPES ASSESSMENT & MONITORING LABORATORY

Channels: Pre-restoration vs. As-built



- Our UAV analyses showed an initial **277% increase** in secondary channels

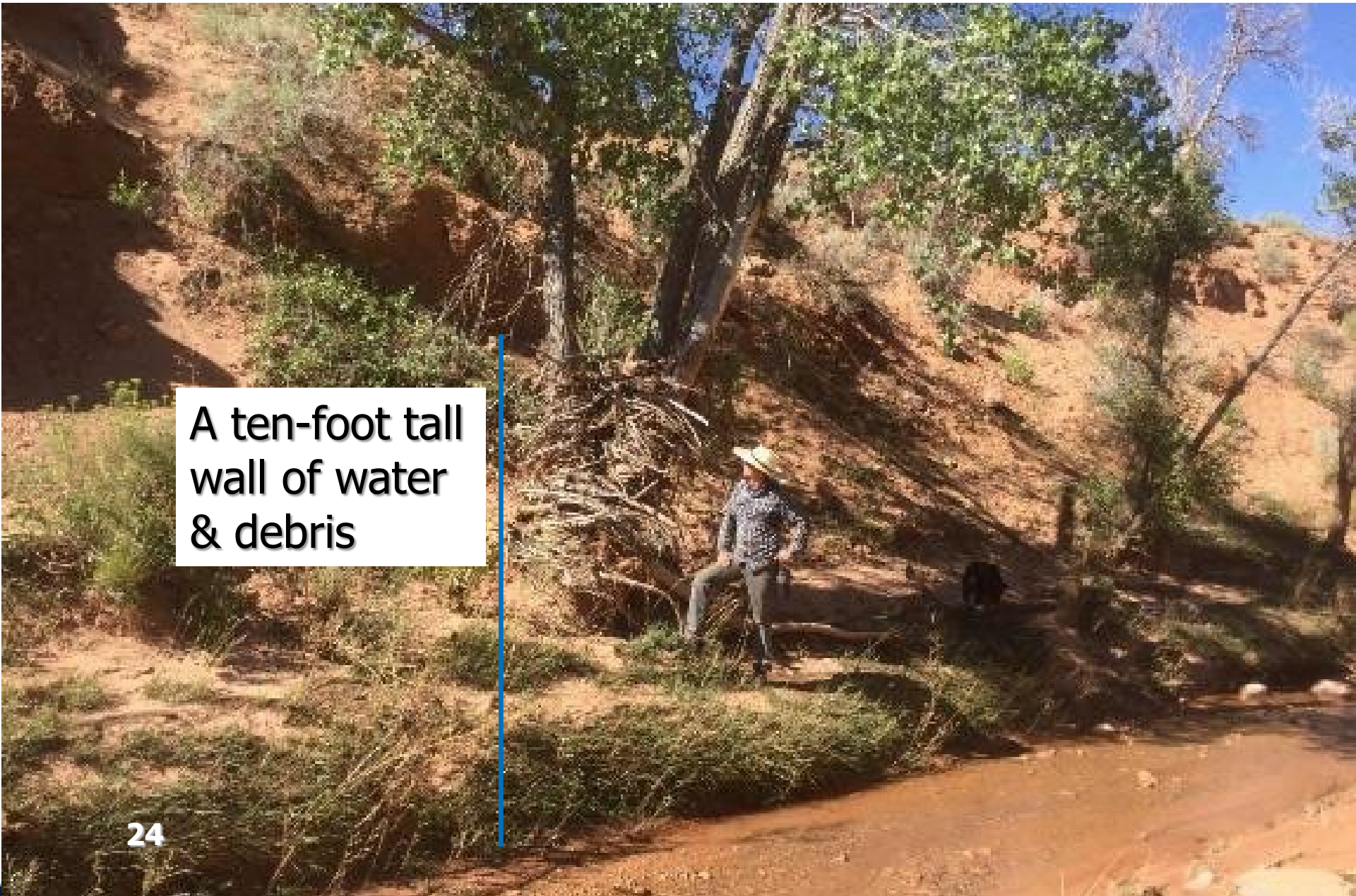
RIVERSCAPES ASSESSMENT & MONITORING LABORATORY

2024 Flash Floods

2024 Flash Floods

2024 Flash Floods

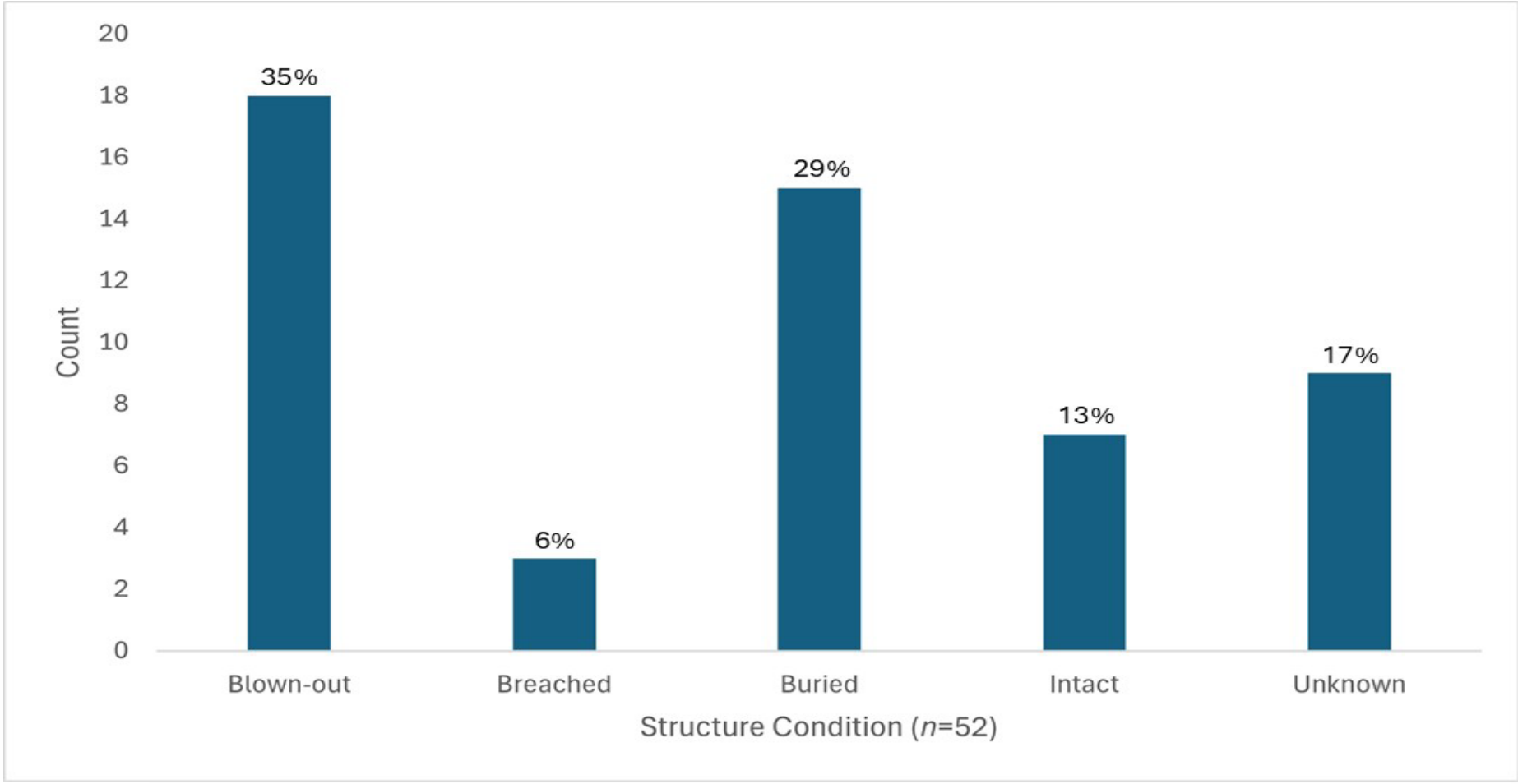
2024 Flash Floods



Post-Floods (May 29, Aug 13, Aug 17, 2024) Results

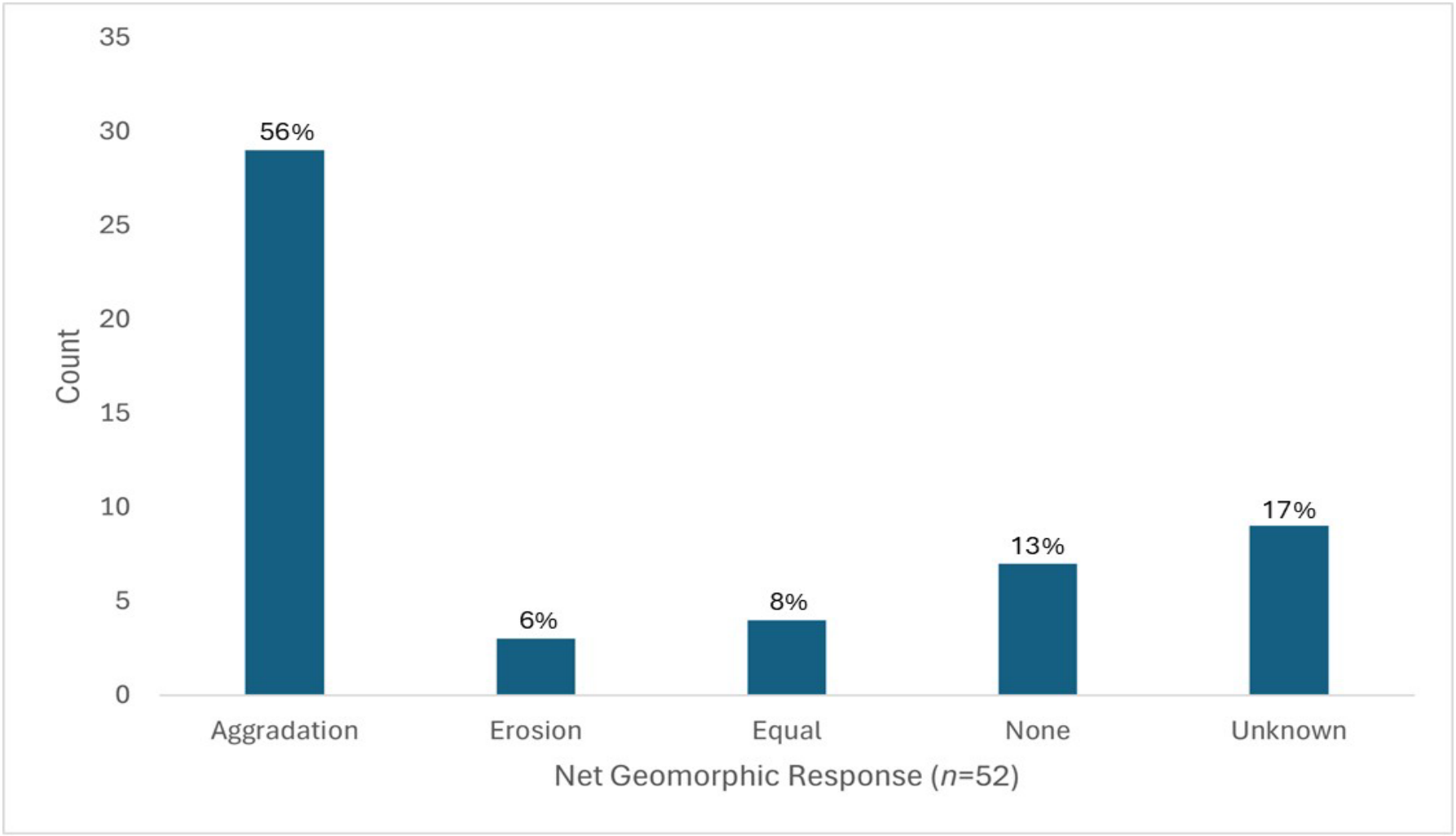
- Many BDA ponds filled in with sediment resulting in a substantial reduction in ponded extent.
- The infilling of BDA ponds indicates accelerated channel aggradation
  - an indicator of incision recovery, increased lateral connectivity and it is expected to facilitate future colonization by woody riparian vegetation.

Post-Floods Structure Condition



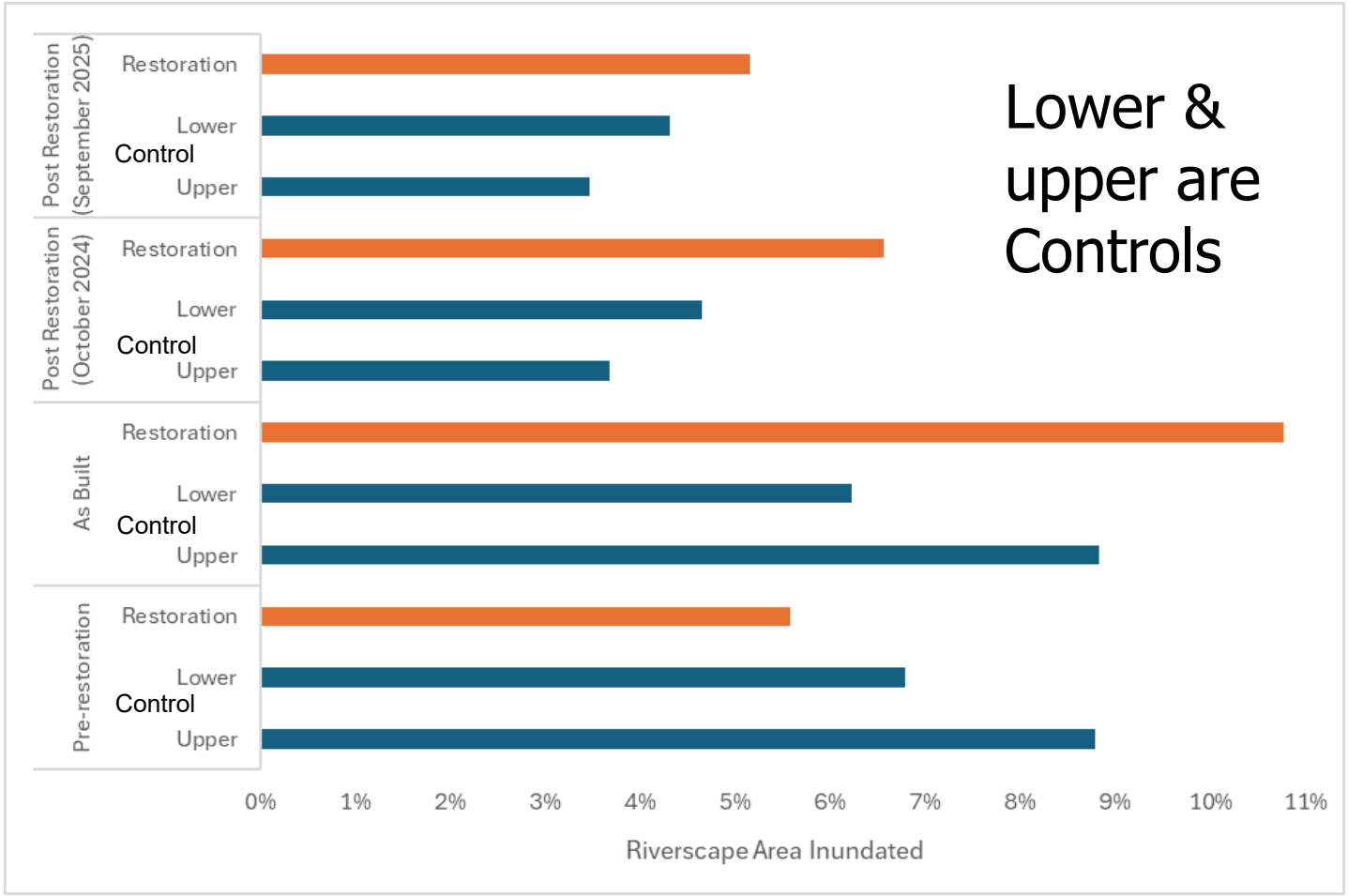
The count of each structure by the structure condition post-restoration in October 2024 for the Goudelock Reach. Nine structures were not surveyed due to unknown location or condition.

Post-Floods Geomorphic Response



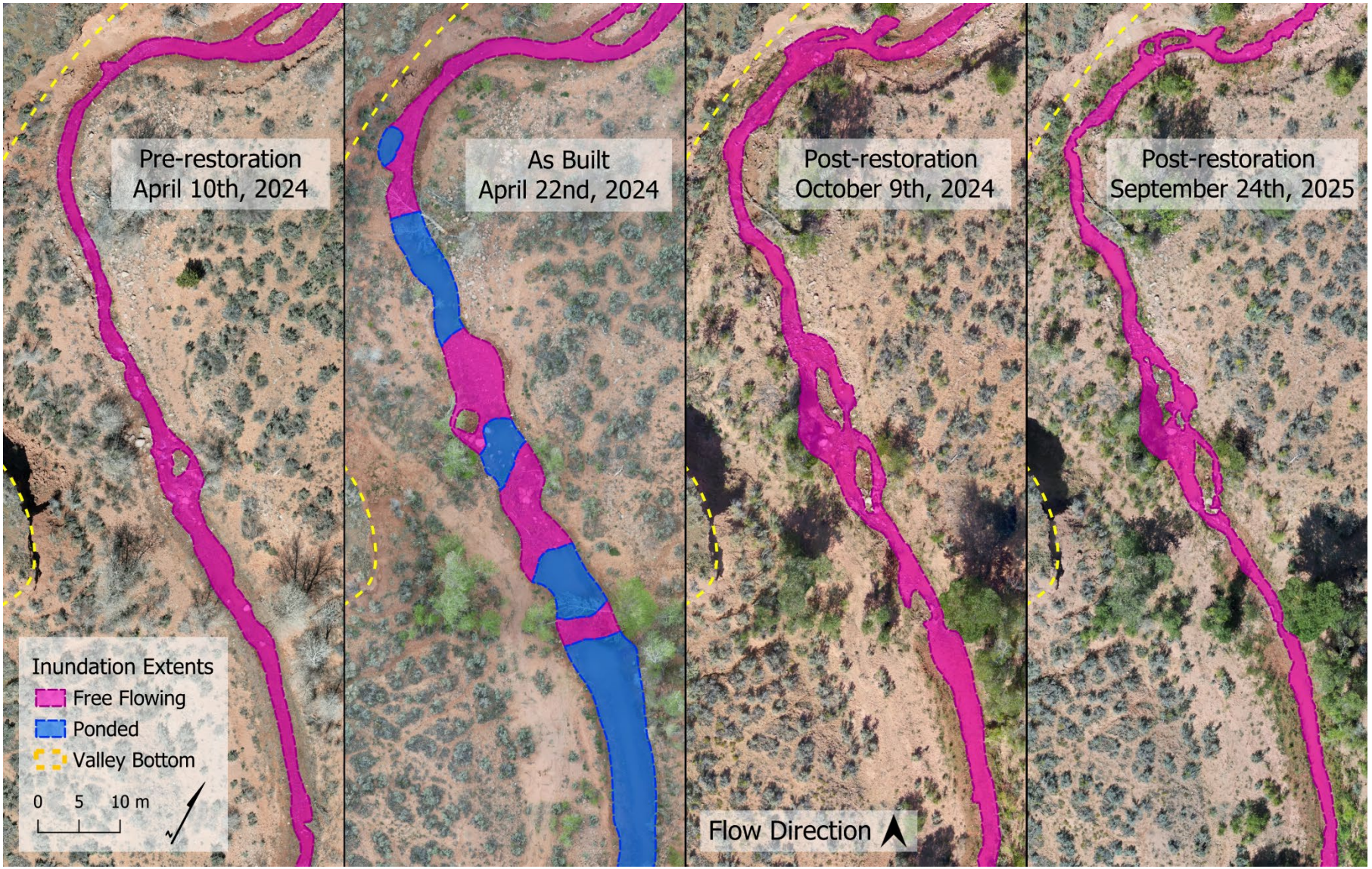
The count of net geomorphic responses for each surveyed structure post-restoration in October 2024 for the Goudelock Reach. Nine structures were not surveyed due to unknown location or condition.

Inundation: Restoration Vs Control



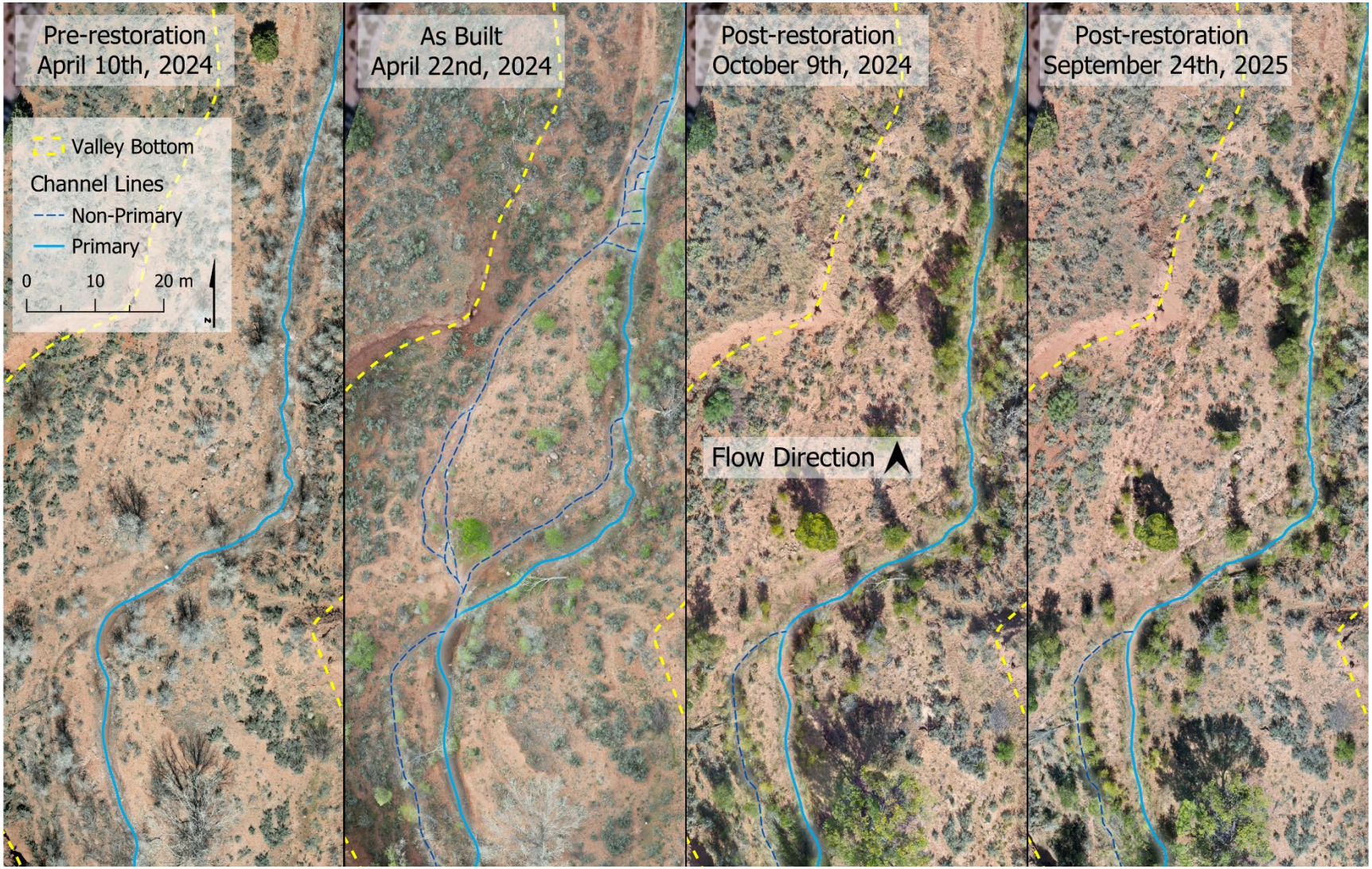
Proportion of inundated valley bottom between restoration reach & control reaches.

Post-Floods Inundation Results (mechanical):



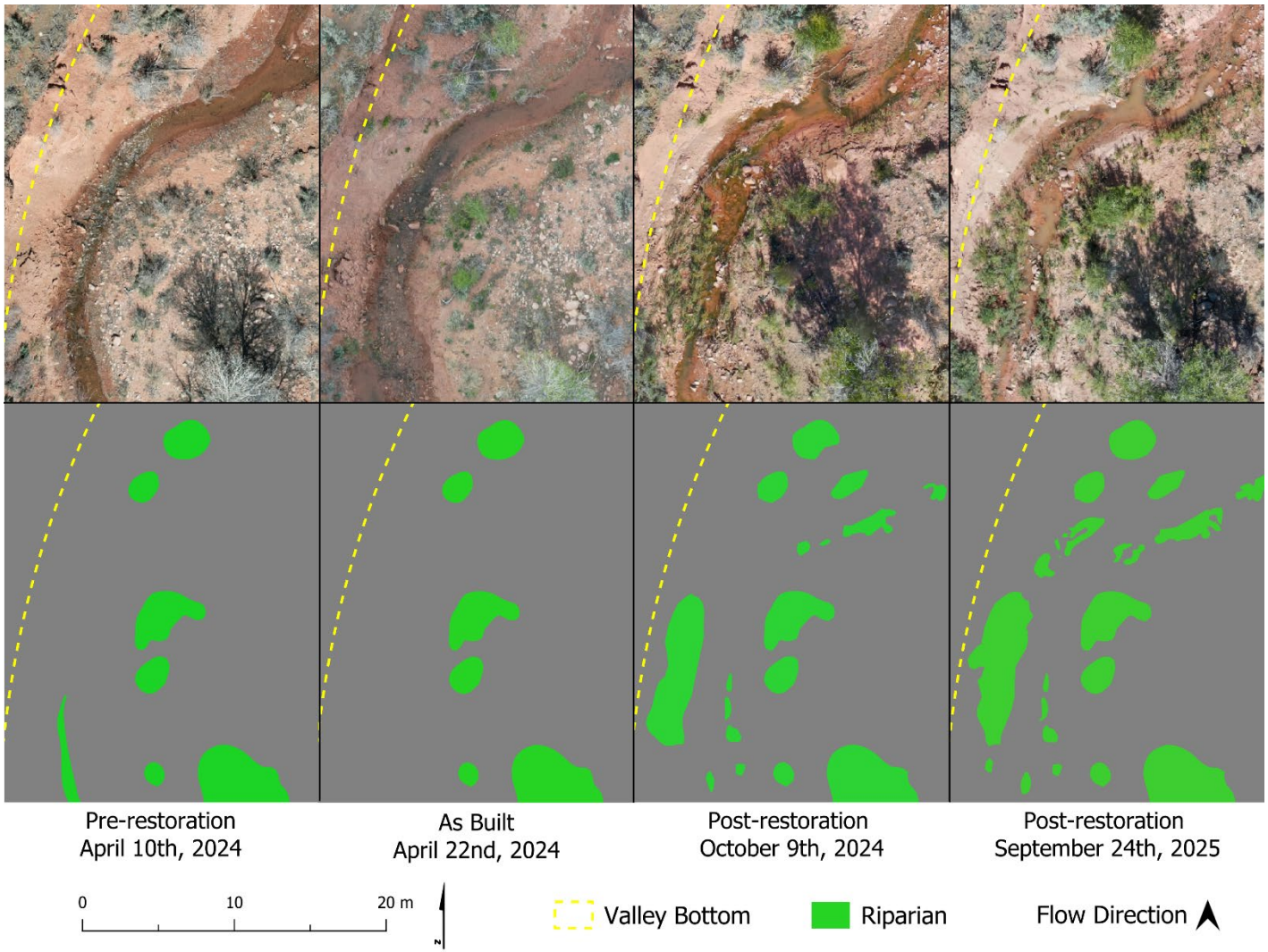
RIVERSCAPES ASSESSMENT & MONITORING LABORATORY

Post-Floods Channel Segments Results



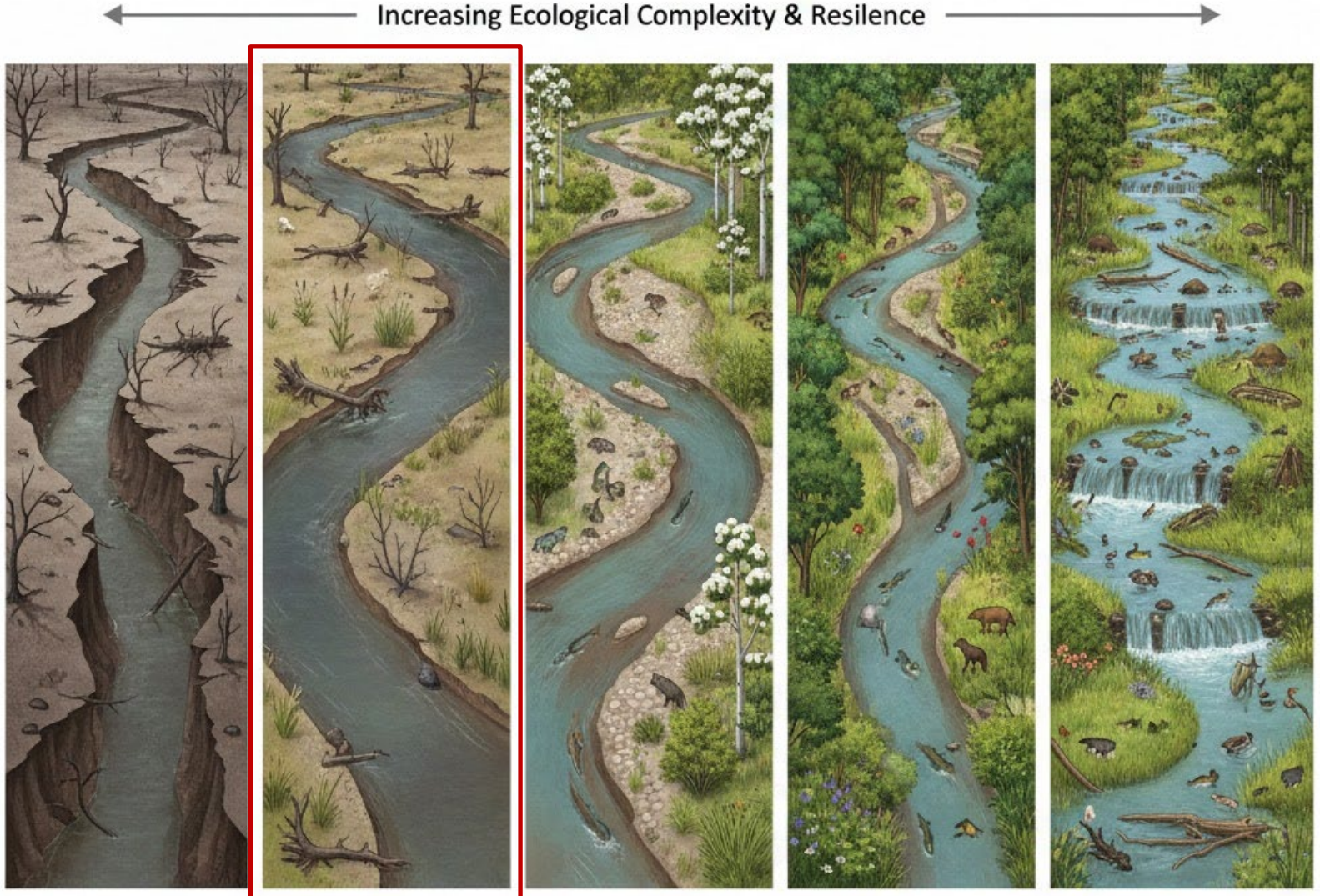
RIVERSCAPES ASSESSMENT & MONITORING LABORATORY

Post-Floods Landcover Results:



RIVERSCAPES ASSESSMENT & MONITORING LABORATORY

Riverscape Restoration Continuum



Riverscape Restoration Continuum

Increasing Ecological Complexity & Resilence

DEGRADED
Incised Channel,
Poor Habitat,
Low Biodiversity

Trench Widening
Early Revegtation,
Bank Instability

Aggradation
Bed Aggradation
Riparian Growth

HEALTHY
Braided Channels,
Rich Habitat,
High Biodiversity

BEAVER DAM COMPLEX
Beaver Engineered,
Wetland Creation,
Ecosystem Resilience

Restoration Goals

- Increase the amount of water and its residence time on the landscape
- Capture sediment to aggrade channel
- Reconnect floodplain
- Reconnect side channels
- Create overbank flow to promote riparian vegetation expansion

Restoration Goals

- ~~Increase the amount of water and its residence time on the landscape~~
- Capture sediment to aggrade channel
- Reconnect floodplain
- Reconnect side channels
- Create overbank flow to promote riparian vegetation expansion

Lessons Learned (from flashy/high sediment systems)

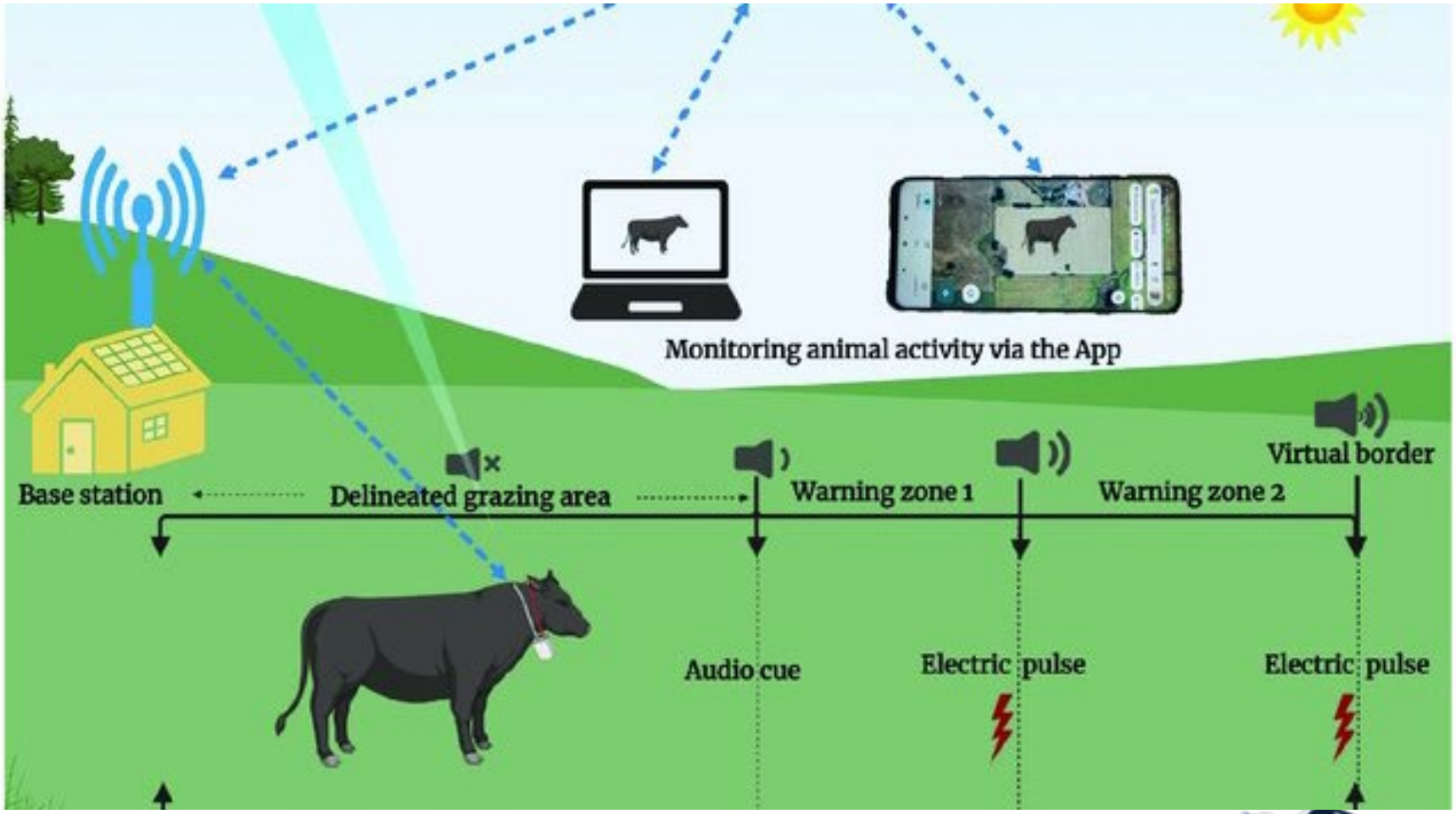
- Do NOT expect prolonged surface-water storage without active beaver dam building.
- Flash floods are simultaneously a **challenge** and an **opportunity**.
  - Expect and embrace buried structures in dryland streams; **buried** structures **drive bed aggradation and floodplain reconnection.**

Lessons Learned (from flashy high sediment systems)

- The feasibility of LT-PBR is constrained by the local availability of woody material—a limiting factor in many dryland settings.
- Rely on local woody material to increase feasibility and minimize costs.
- True restoration requires an iterative, multi-phase, multi-year, adaptive effort with ongoing maintenance (just like beaver do) guided by UAV-based monitoring.
- High-resolution imagery and DEMs provide rapid, cost-effective information on inundation, sediment & channel dynamics, and vegetation response that helps gauge project uplift.

Cows in the restoration reach

Virtual Fencing to the Rescue?



RIVERSCAPES ASSESSMENT & MONITORING LABORATORY

Acknowledgements

- Matt Redd, Sue Bellagamba, & Alix Pfennigwerth of TNC for amazing project support

The Nature Conservancy

WALTON FAMILY FOUNDATION

NFWF

newventurefund

COLORADO RIVER RESILIENCE

Questions?