Examples and Applications of Floodplain Restoration

Potential for Beaver Related Restoration in Colorado

Juli Scamardo

Stage 0 Restoration

Sarah Hinshaw

Reconnecting the river corridor

Disconnected floodplain

Incised stream

Drier vegetation species

Lower water table

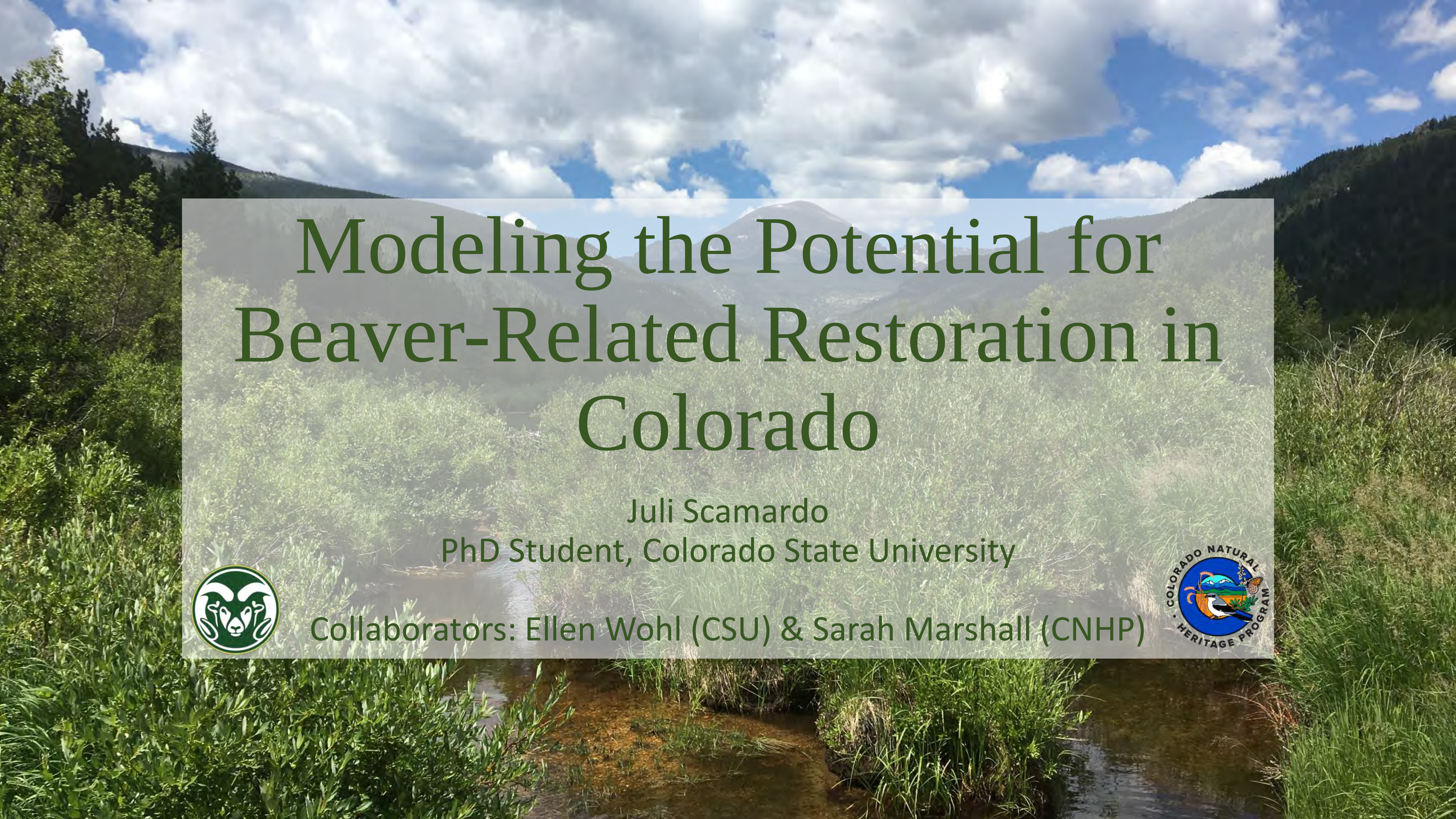
Restoration Action

Connected floodplain

Functions as a sink for water, sediment, and solutes

Benefits for habitat

Resilient



Modeling the Potential for Beaver-Related Restoration in Colorado

Juli Scamardo
PhD Student, Colorado State University

Collaborators: Ellen Wohl (CSU) & Sarah Marshall (CNHP)

Headwater river corridors benefit from beaver dams

- Store sediment, water, and solutes behind dams and on the floodplain (Naiman et al., 1986; Butler and Malanson, 1995; Wegener et al., 2017)
- Increase groundwater infiltration through overbank flooding (Westbrook et al., 2006)
- Support biodiversity (Rosell et al., 2005; Westbrook et al., 2011)
- Beaver meadows store carbon, mitigate floods, and could protect against wildfire (Wohl, 2013)

Where can we use beaver-related restoration in Colorado?

What is the Beaver Restoration Assessment Tool (BRAT)?

Geomorphology 277 (2017) 72–99

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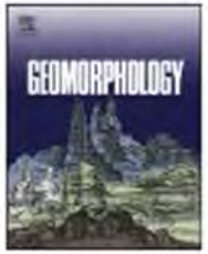

Modeling the capacity of riverscapes to support beaver dams

William W. Macfarlane [a,*], Joseph M. Wheaton [a,b], Nicolaas Bouwes [a,c], Martha L. Jensen [a], Jordan T. Gilbert [a], Nate Hough-Snee [a,b], John A. Shivik [d]

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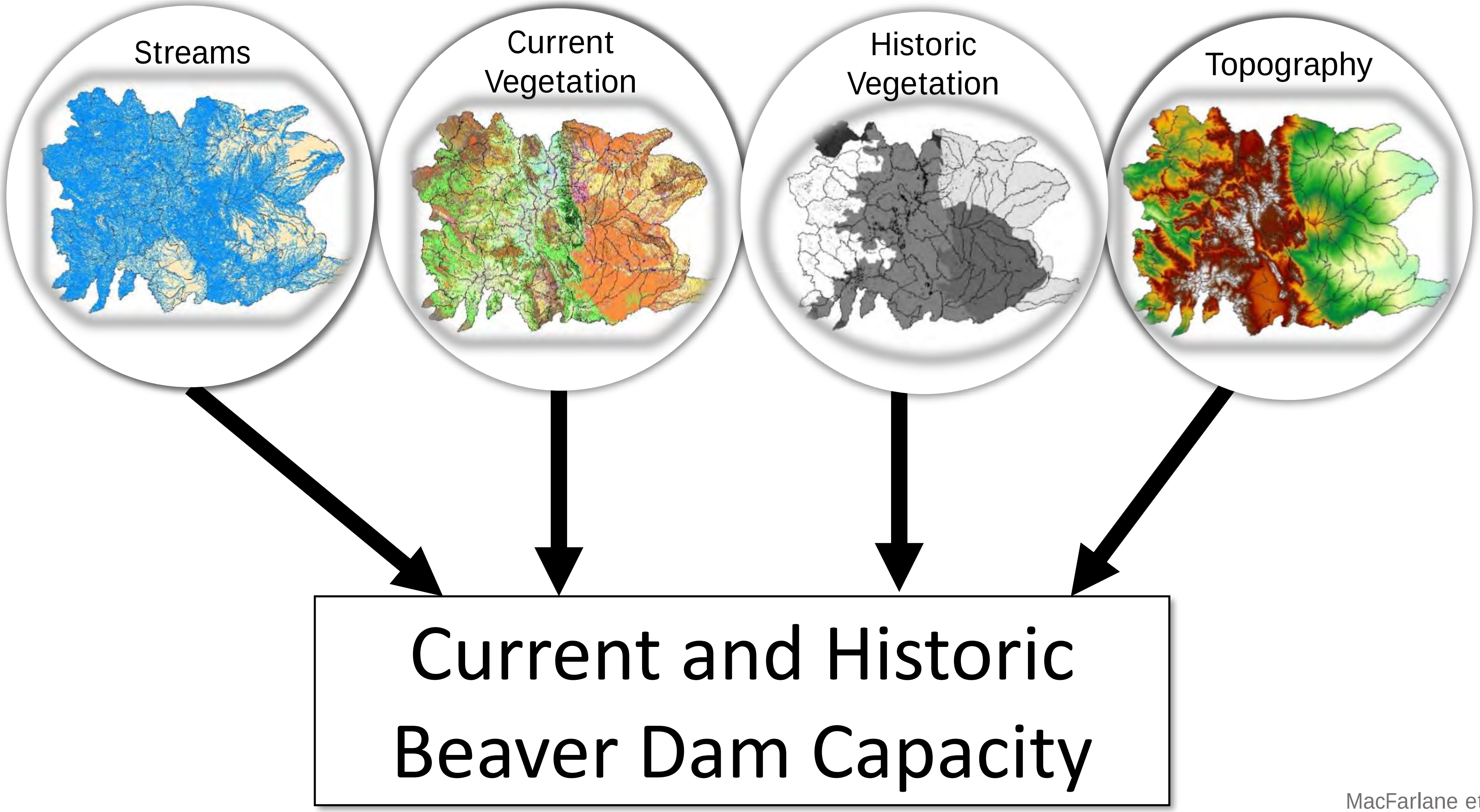
[d] *U.S. Forest Service, Intermountain Region, 324 25th Street Ogden, UT 84401, USA*

MacFarlane et al. (2017)

What is the Beaver Restoration Assessment Tool (BRAT)?

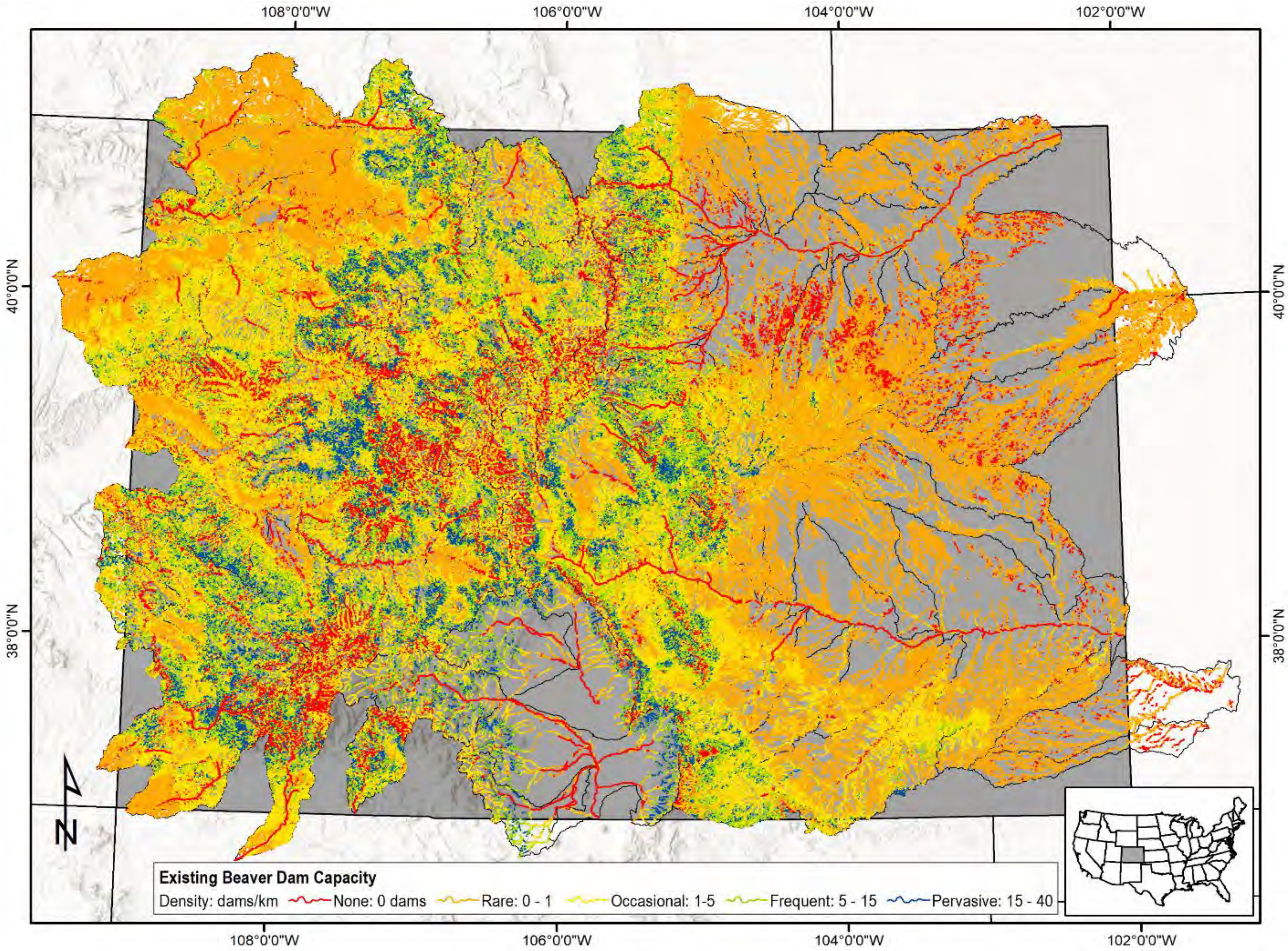


MacFarlane et al. (2017)

MacFarlane et al. (2017)

BRAT in Colorado

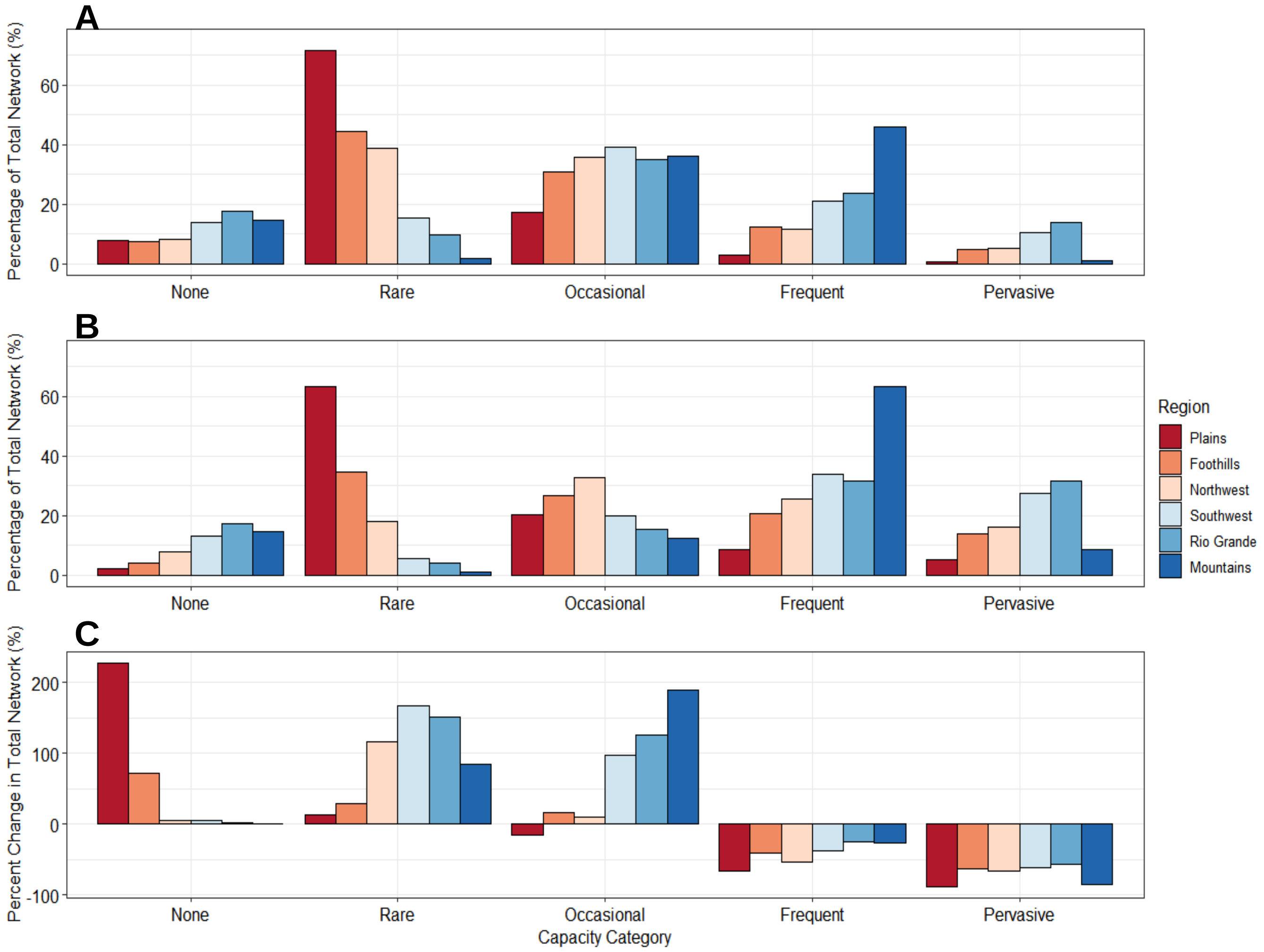
- BRAT run for 62 watersheds
- Available for visualization and download as a part of the CNHP Watershed Planning Toolbox
- https://cnhp.colostate.edu/cwic/tools/toolbox/



Scamardo, Wohl, & Marshall (in prep)

How has beaver capacity changed in Colorado?

- Historically, Colorado streams could sustain up to 2.4 million beaver dam, compared to 1.35 million today (44% decline)
- Decrease in average carrying capacity for every region in Colorado
- Fewer reaches can sustain high densities of beaver
- Potential drivers of decline:
  - Urbanization
  - Agriculture
  - Positive feedback with beaver loss



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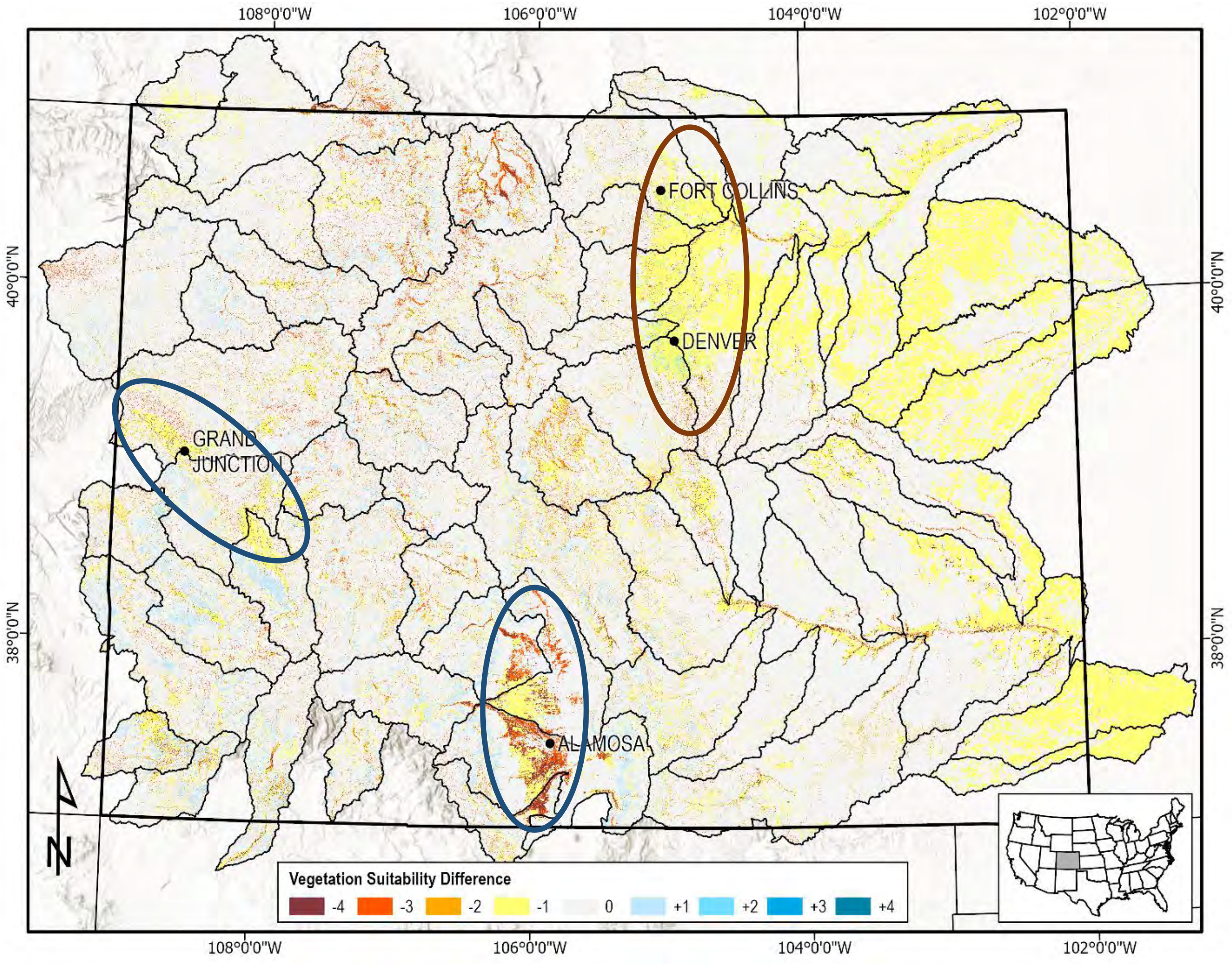


Scamardo, Wohl, & Marshall (in prep)

What are the consequences of beaver decline in Colorado?

- Streams can incise and disconnect with floodplains post-beaver loss (e.g., Polvi and Wohl, 2013)
- Loss of beaver ponds means loss of sediment and water storage
  - Stream incision
  - Riparian Vegetation decline
  - Loss of habitat
- In Colorado, the decline in beaver dam carrying capacity has led to an ~40% decline in surface water and sediment storage (Scamardo, Wohl, & Marshall, in prep)

How can we restore floodplains using beaver?

Beaver reintroductions

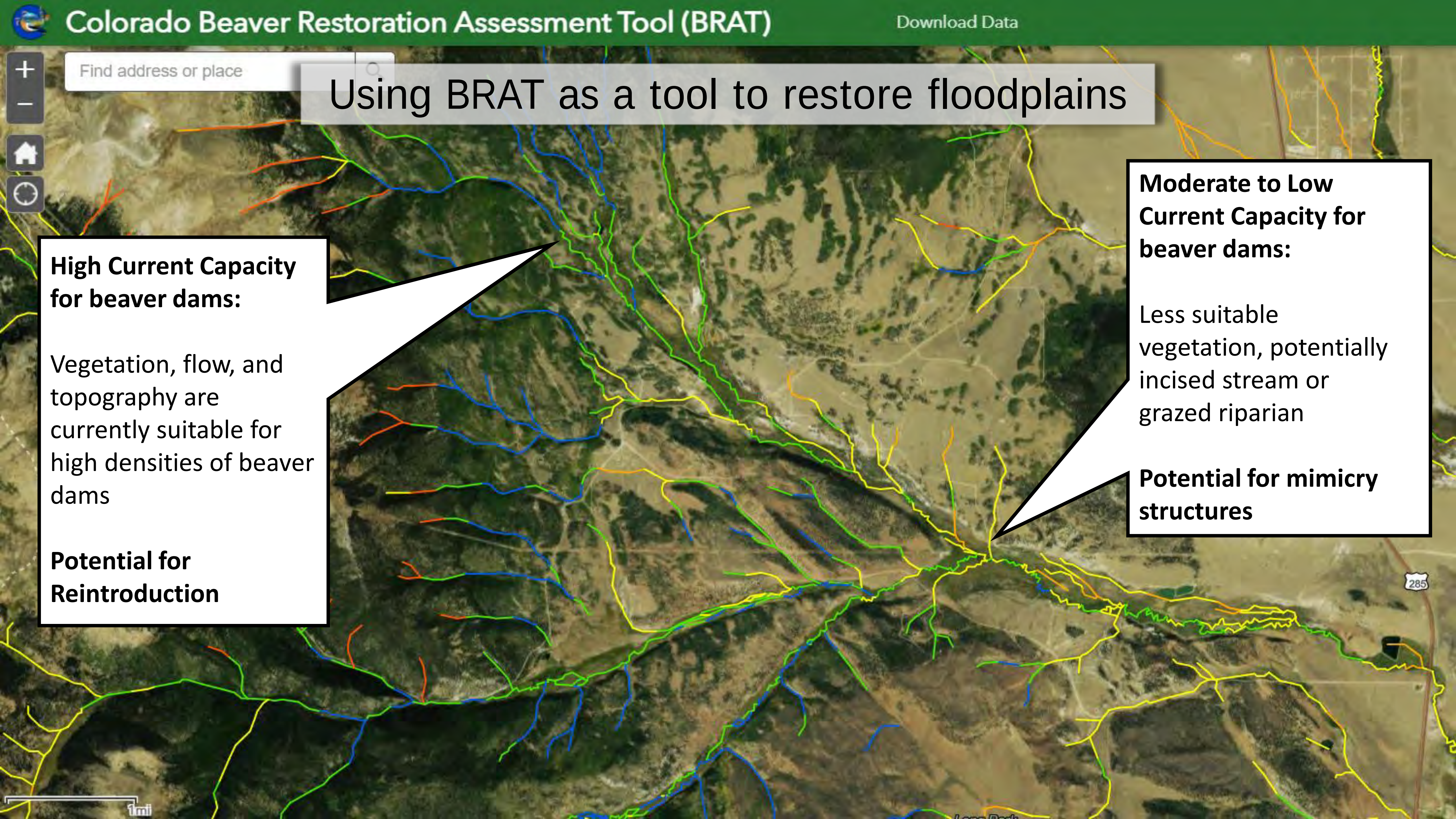
Relocation of beaver to suitable habitats

Beaver dam analogs (BDAs)

Create mimicry structures to restore connectivity

(e.g., Scamardo and Wohl, 2020)

Using BRAT as a tool to restore floodplains



High Current Capacity for beaver dams:

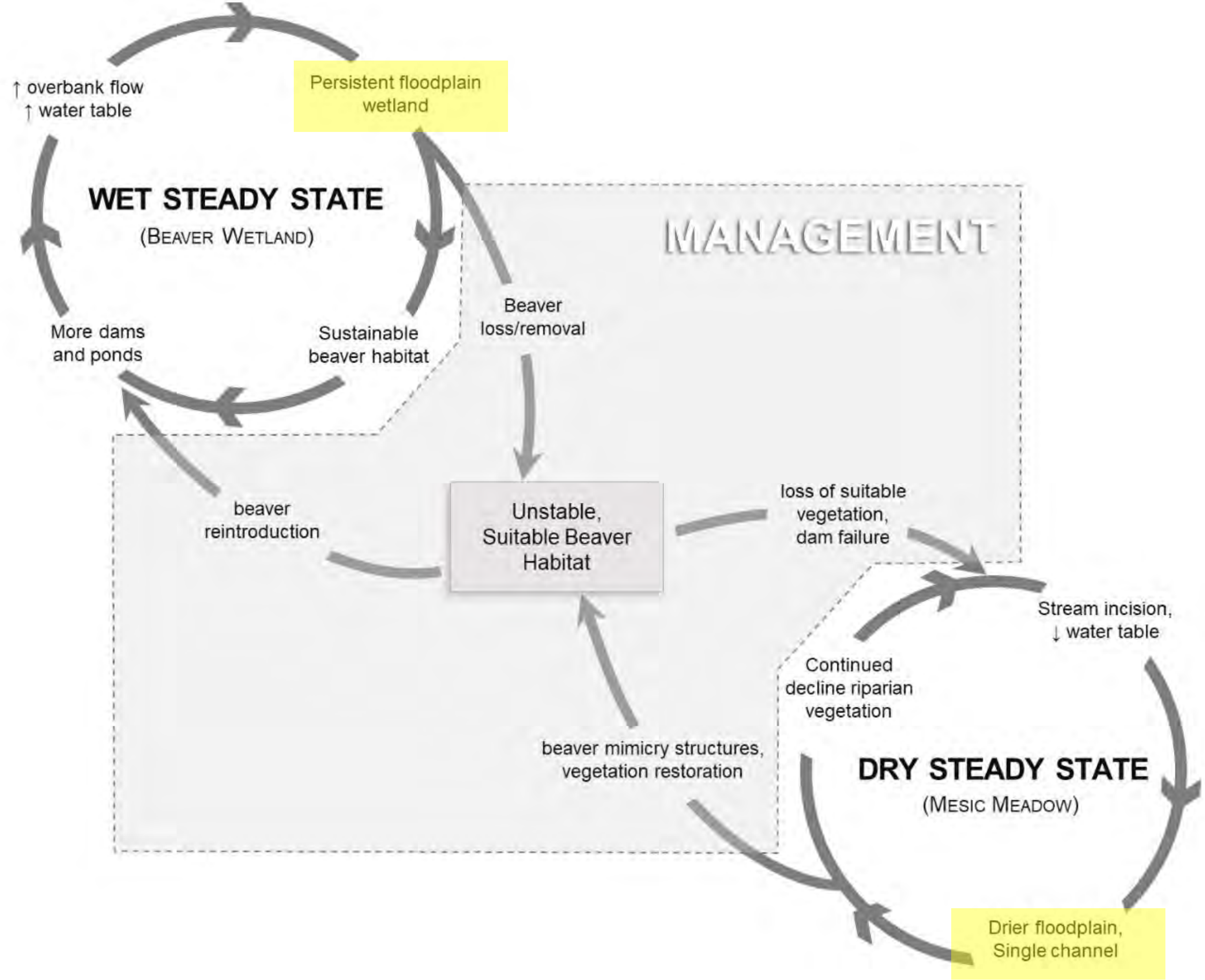
Vegetation, flow, and topography are currently suitable for high densities of beaver dams

Potential for Reintroduction

Moderate to Low Current Capacity for beaver dams:

Less suitable vegetation, potentially incised stream or grazed riparian

Potential for mimicry structures



Scamardo, Wohl, & Marshall (in prep)

Stage 0 Restoration

Sarah Hinshaw, PhD Student

Sustaining Colorado Watersheds Conference

Floodplain Workshop

October 5th, 2021

Contributors: Johan Hogervorst, Forest Hydrologist &

Kate Meyer, Fisheries Biologist, Willamette NF

Middle Fork South Platte River

Stage 0 restoration definition

"Stage 0 restoration" is a valley-scale, **process-based** (hydrologic, geologic, and biological) approach **that aims to** reestablish depositional environments **to maximize** longitudinal, lateral, and vertical connectivity at base flows and facilitate development of dynamic, self-formed and self-sustaining wetland-**stream complexes.**

- Jan 2020 Programmatic Modeling Workshop

Summarized by Bill Brignon, Nov 2020 Stage 0 Workshop

Sheep Creek

Where does the term “Stage 0” come from?

RIVER RESEARCH AND APPLICATIONS

River Res. Applic. **30**: 135–154 (2014)

Published online 10 January 2013 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/rra.2631

A STREAM EVOLUTION MODEL INTEGRATING HABITAT AND ECOSYSTEM BENEFITS

B. CLUER[a*] AND C. THORNE[b]

[a] *Fluvial Geomorphologist, Southwest Region, NOAA’s National Marine Fisheries Service, Santa Rosa, California, USA*
[b] *Chair of Physical Geography, University of Nottingham, Nottingham, UK*

Why do we care?

This model sparked another implementation movement to enhance floodplain heterogeneity and self-forming processes in stream restoration.

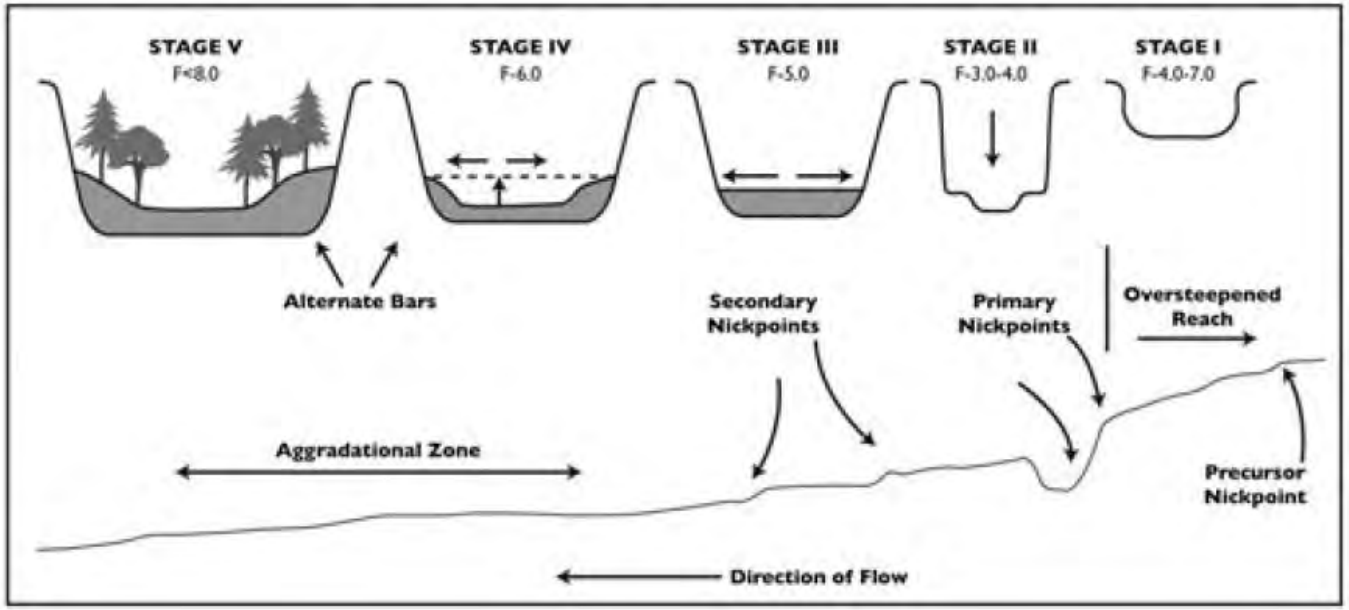
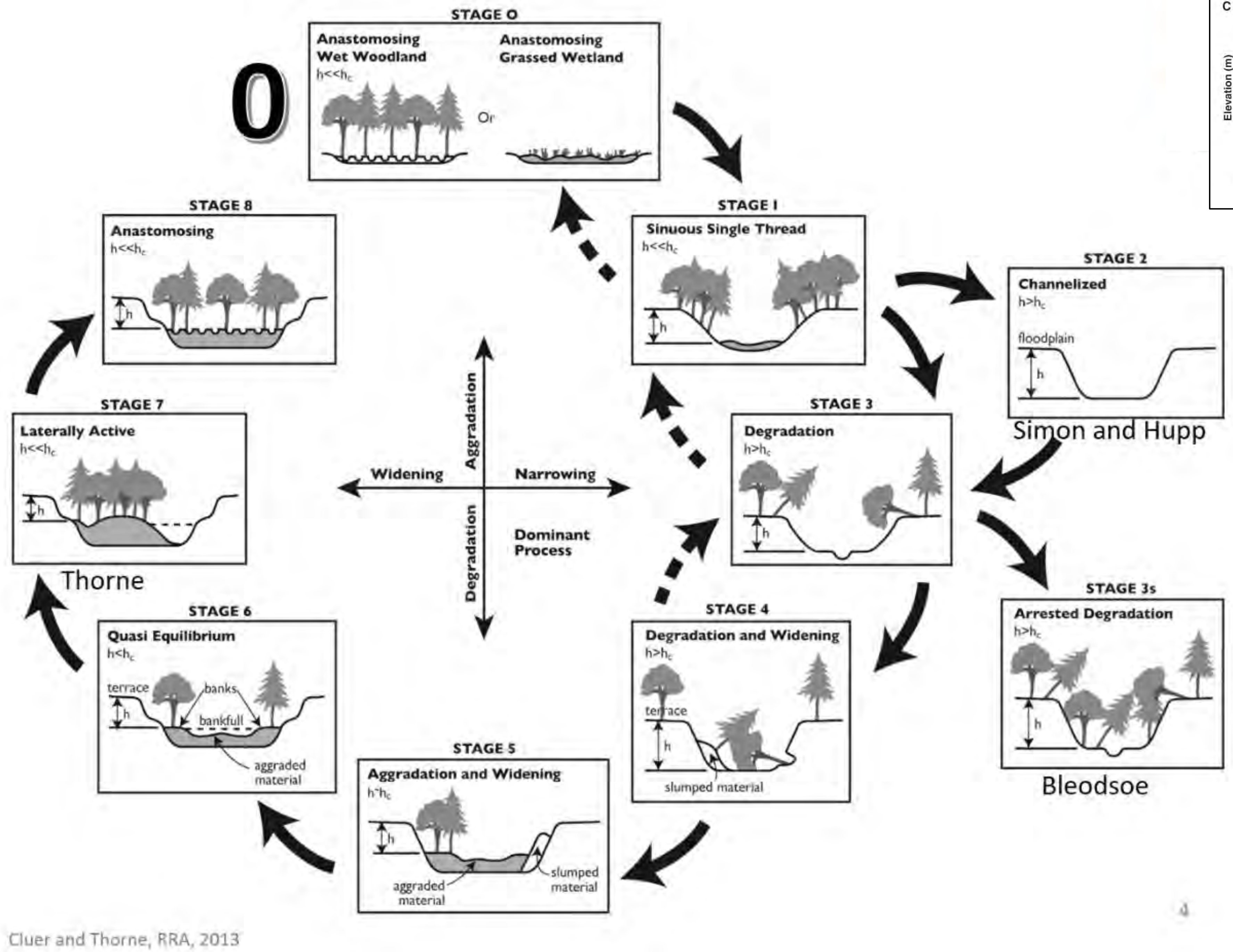
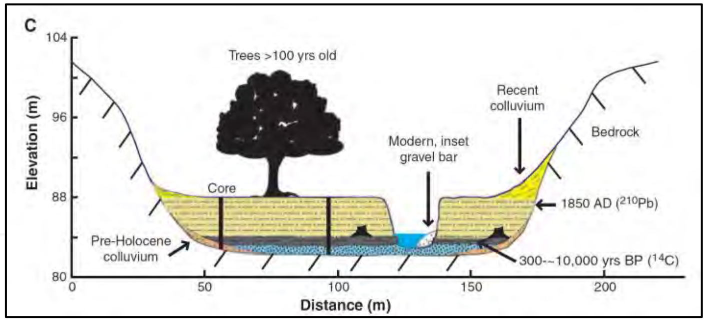


Figure 1. Schumm *et al.* (1984) Channel Evolution Model with typical width–depth ratios (F). The size of each arrow indicates the relative importance and direction of the dominant processes of degradation, aggradation and lateral bank erosion. (Redrawn with permission from Water Resources Publications)



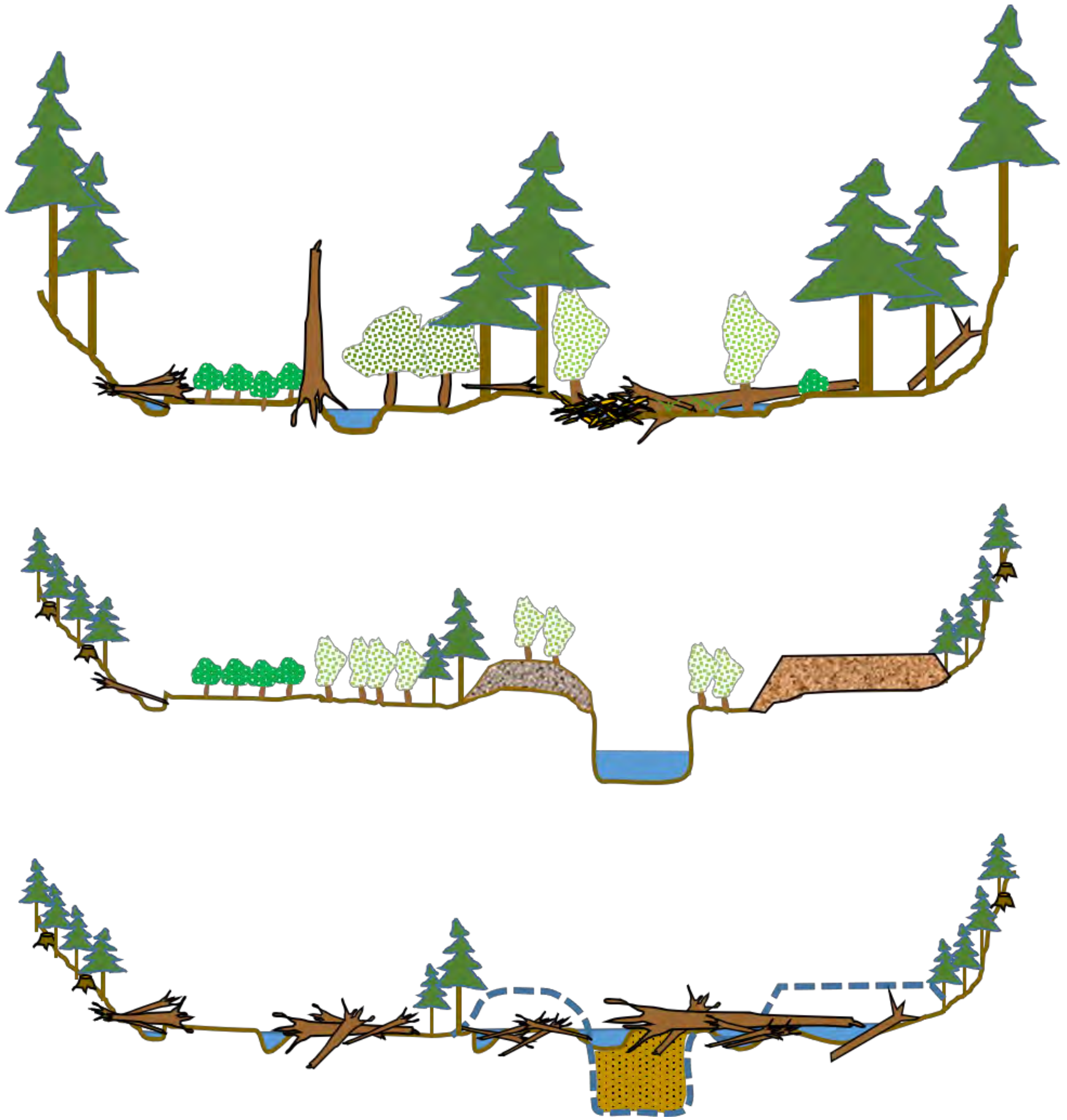


Walter and Merrits 2008

History of Degradation
Roads
Levees
Beaver removal
Timber harvest
Draining
Agriculture
Grazing

Credit: Brian Cluer

Stage 0, process-based restoration



Credit: Johan Hogervorst

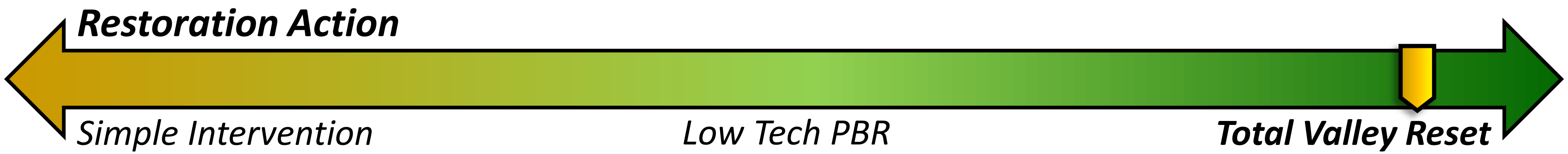
Process Based Restoration

Process Based Principles *(Beechie et al. 2010)*

1. Target the root cause of degradation.
2. Actions must be consistent with site potential.
3. Match the scale of restoration to the scale of the problem.
4. Be explicit about expected outcomes.

Potential Methods

- Geomorphic Grade Line *(Powers et al. 2019)*
- Low-tech PBR *(Wheaton et al. 2019)*
- Legacy sediment removal *(Walter and Merritts 2008)*
- Other BDA installation *(Scamardo and Wohl 2020)*



The PBR Continuum

Action depends on local constraints

Scale of problem
Water rights
Infrastructure
Property owners
Permits
Funds
Staffing

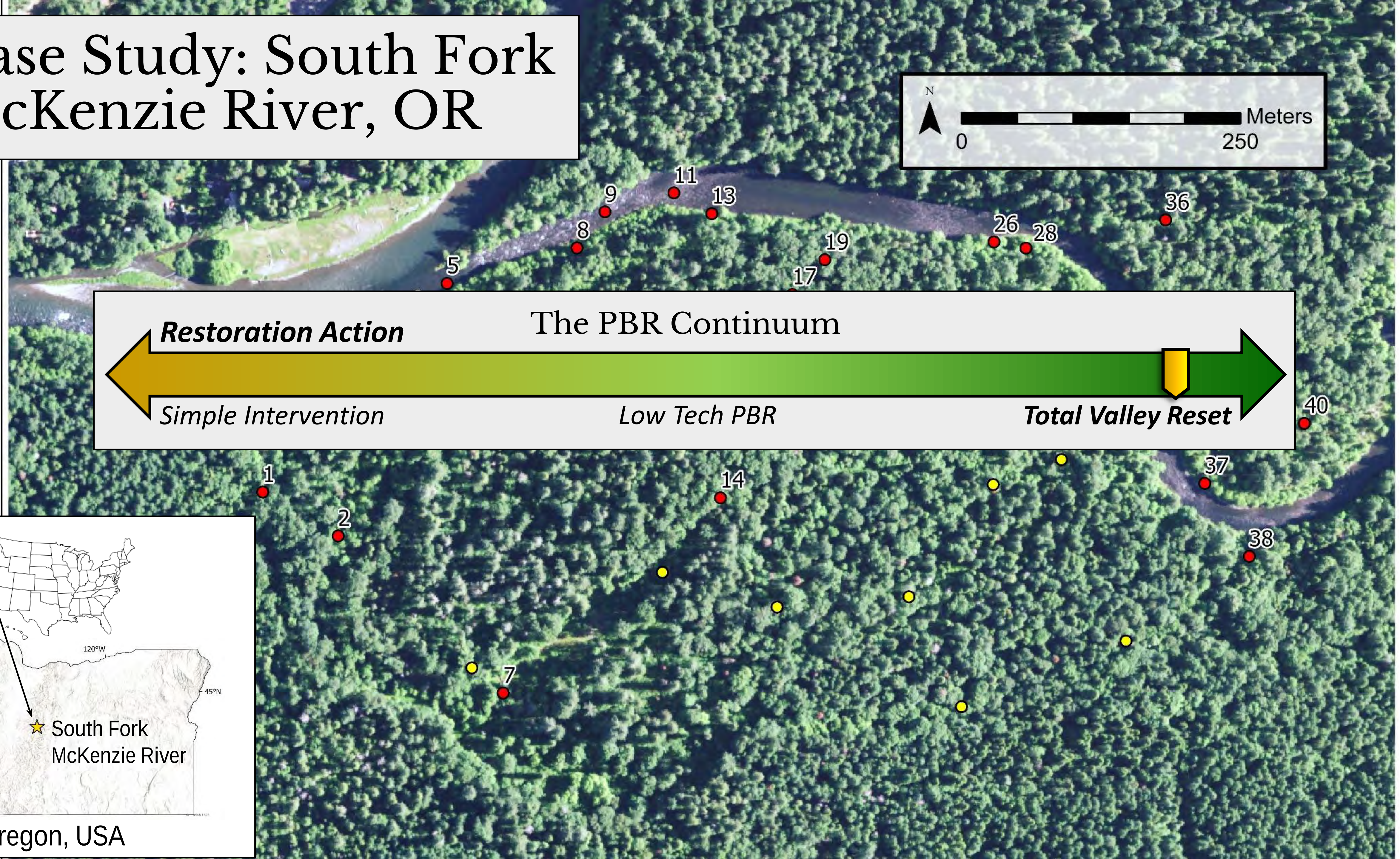
Lost Creek

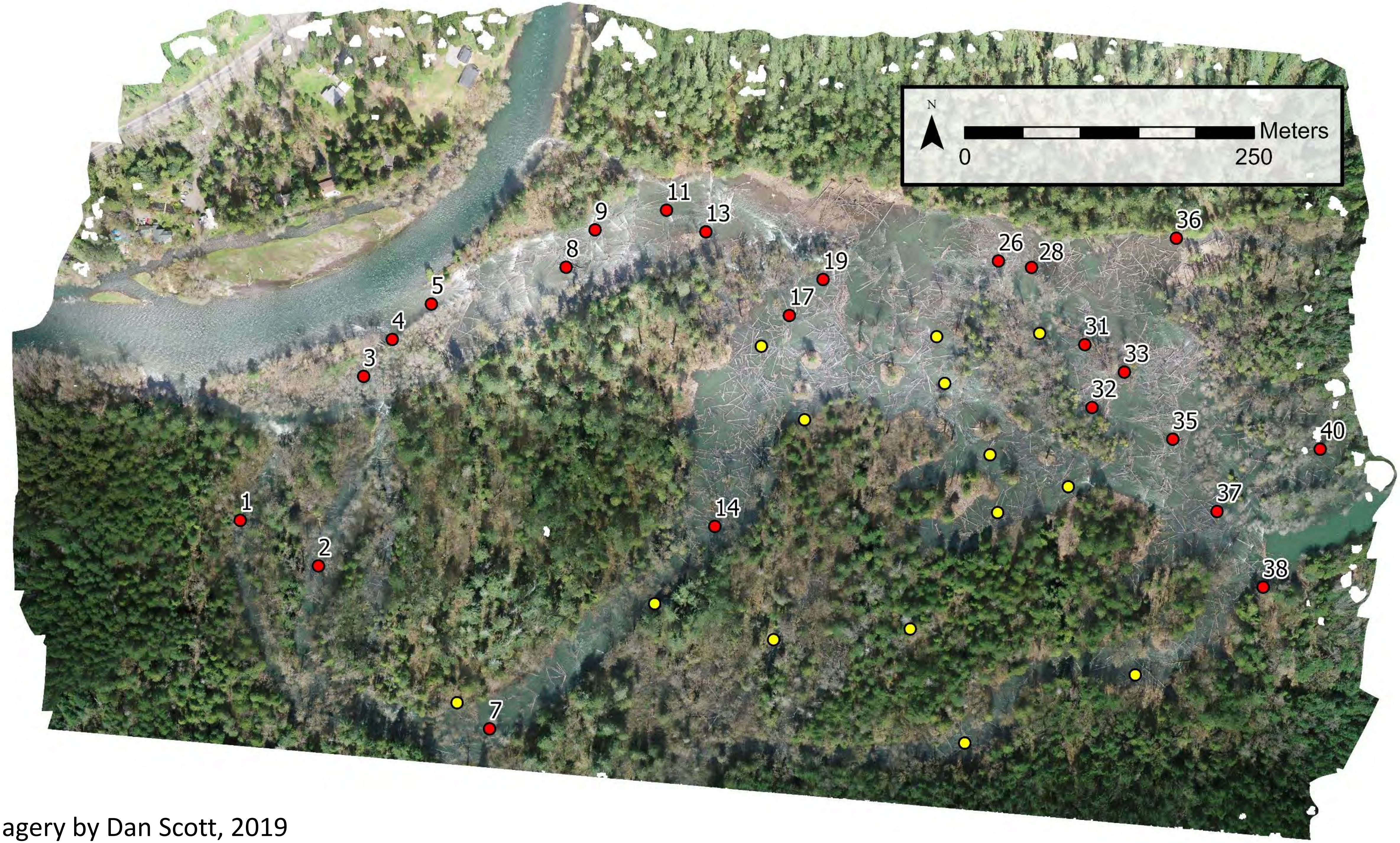
Stage 0 is a condition, not a technique

Where is this applicable in Colorado?

Wide floodplains with little infrastructure, either historically wood dominated (higher slope) or beaver dominated (low slope)

Case Study: South Fork McKenzie River, OR

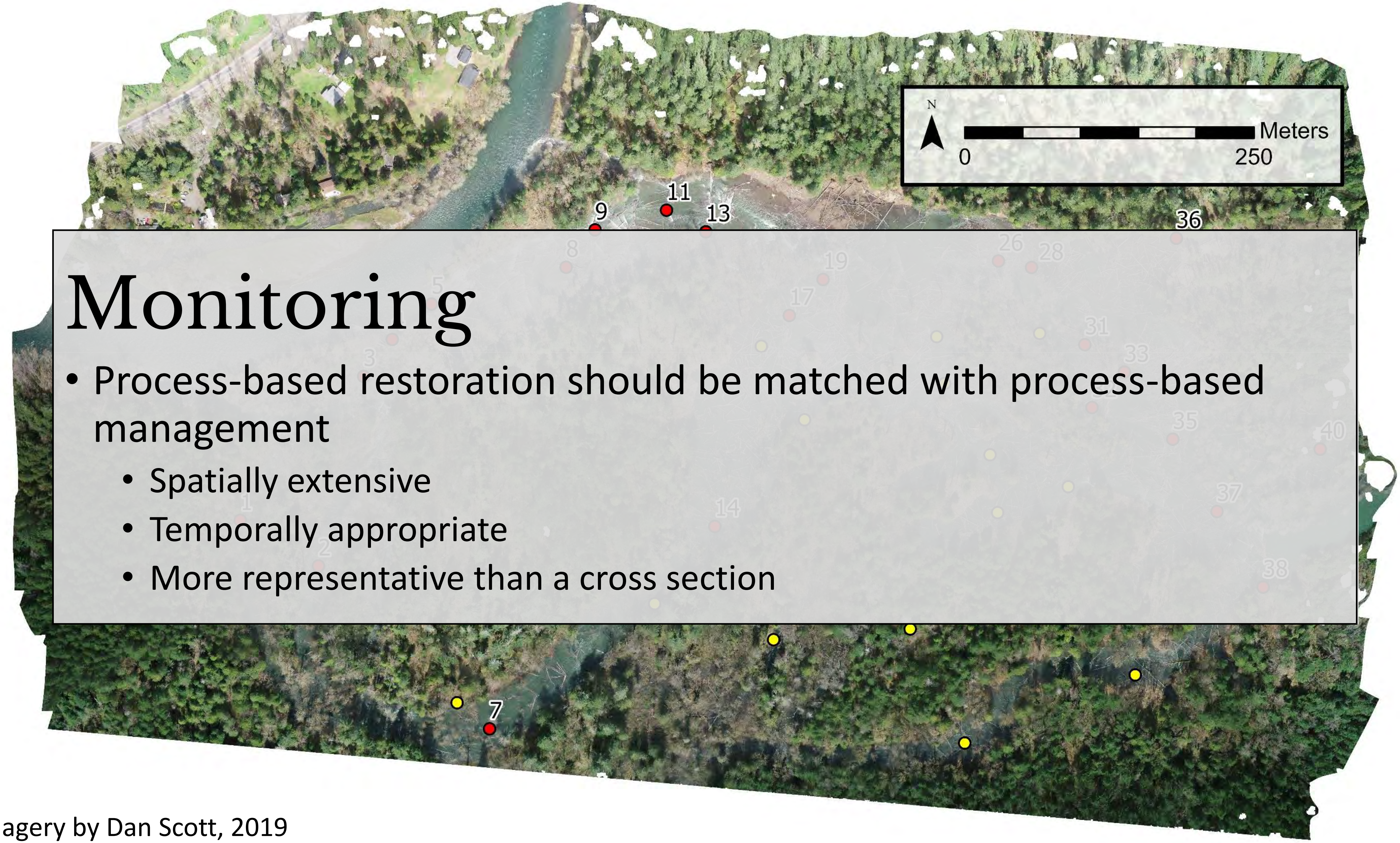




Imagery by Dan Scott, 2019

Post-Holiday Farm Fire drone image showing Stage 0 riparian-related tree and shrub survival at lower South Fork McKenzie River Floodplain Enhancement Project (credit Kate Meyer). Resiliency of vegetation, soils, macroinvertatbrates and bird presence are being studied by a group of scientists from the US and UK in 2021.

June 2021 photo of island development and wetland vegetation recovery at phase 1 (2018) of Lower South Fork McKenzie River Floodplain Enhancement Project (credit Kate Meyer)

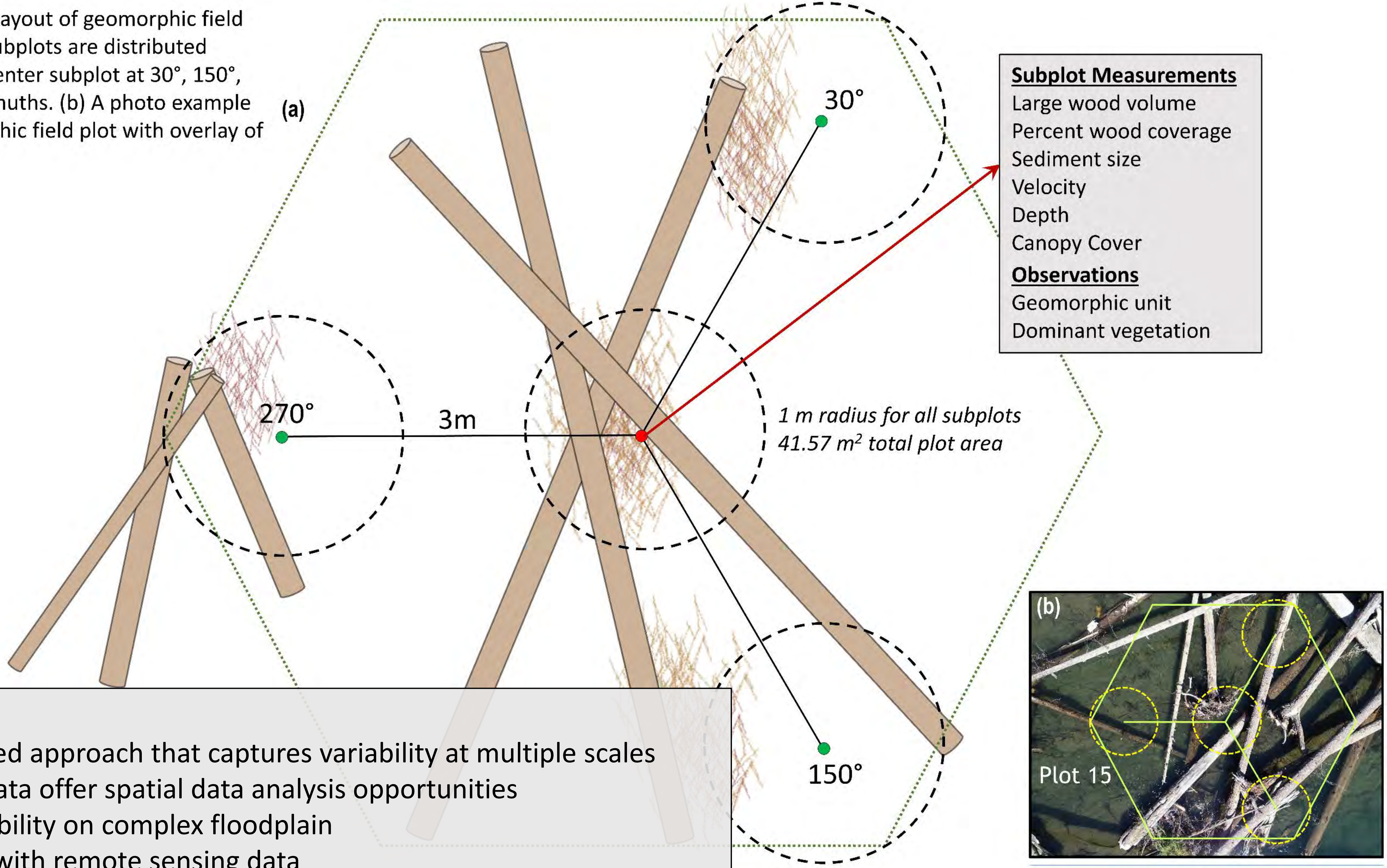


Monitoring

- Process-based restoration should be matched with process-based management
  - Spatially extensive
  - Temporally appropriate
  - More representative than a cross section

Imagery by Dan Scott, 2019

Figure 3. (a) Layout of geomorphic field plot. Outer subplots are distributed around the center subplot at 30°, 150°, and 270° azimuths. (b) A photo example of a geomorphic field plot with overlay of plot design.



Why?

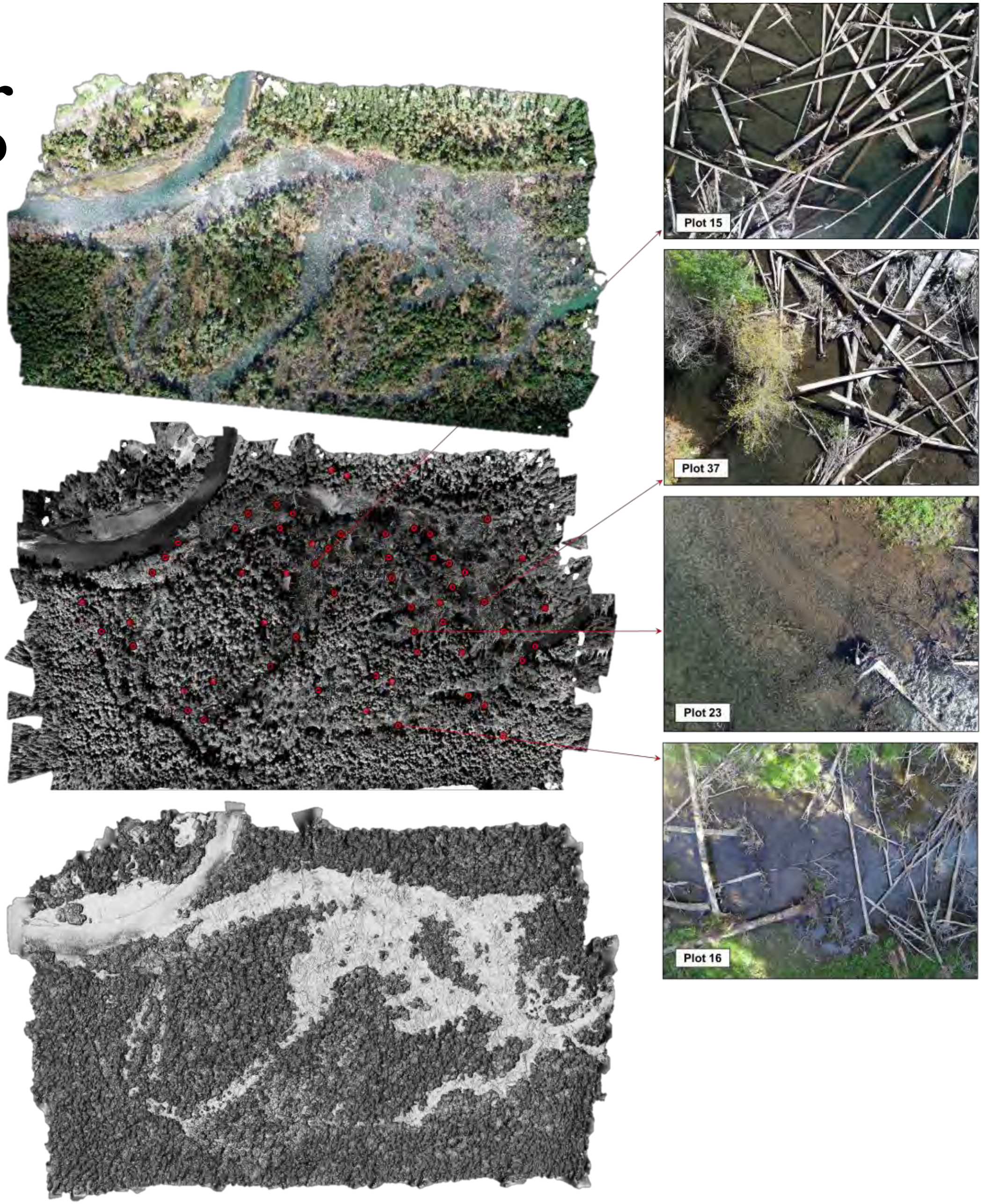
- Unbiased approach that captures variability at multiple scales
- Point data offer spatial data analysis opportunities
- Accessibility on complex floodplain
- Paired with remote sensing data

Remote Sensing

DJI Matrice

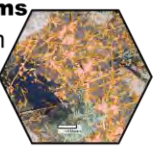
Mica Sense Altum camera

6 band multispectral imagery
(r,g,b, 2 near-infrared, thermal)



Wood

High flows → log jams
Changes in color from imagery can identify wood and track jam formation.



Sediment

More gravel→ spawning habitat
High resolution photo plots can identify sediment patches.

Velocity

Variable velocity → fish habitat
10-second videos capture velocity at each plot and are calibrated with field measurements.

Elevation

High flows→ island formation
Drone-based Structure from Motion tracks channel evolution.

Temperature

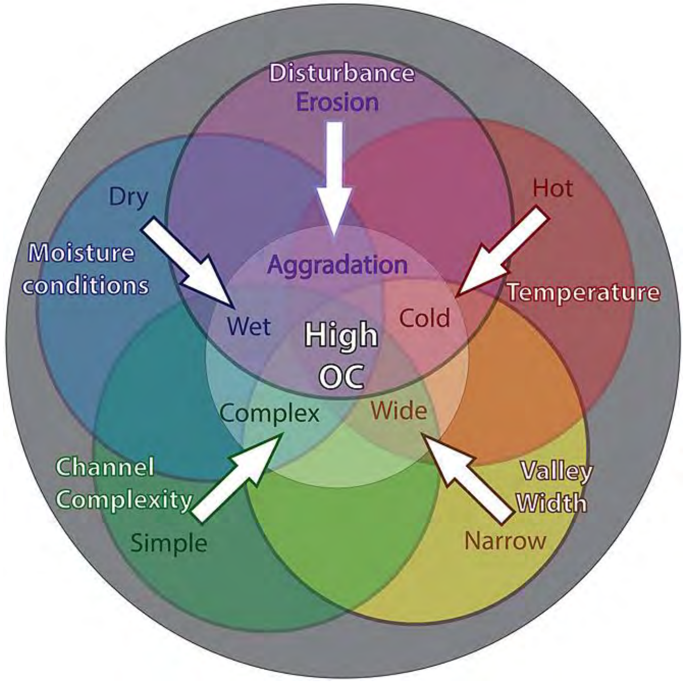
Temperature refugia→ habitat
HOBO temperature sensors paired with thermal images track temperature changes.

Forest cover

Water table rise → forest change
As the water table rises, certain species are expected to die.

Carbon Sequestration

Optimal conditions for C storage



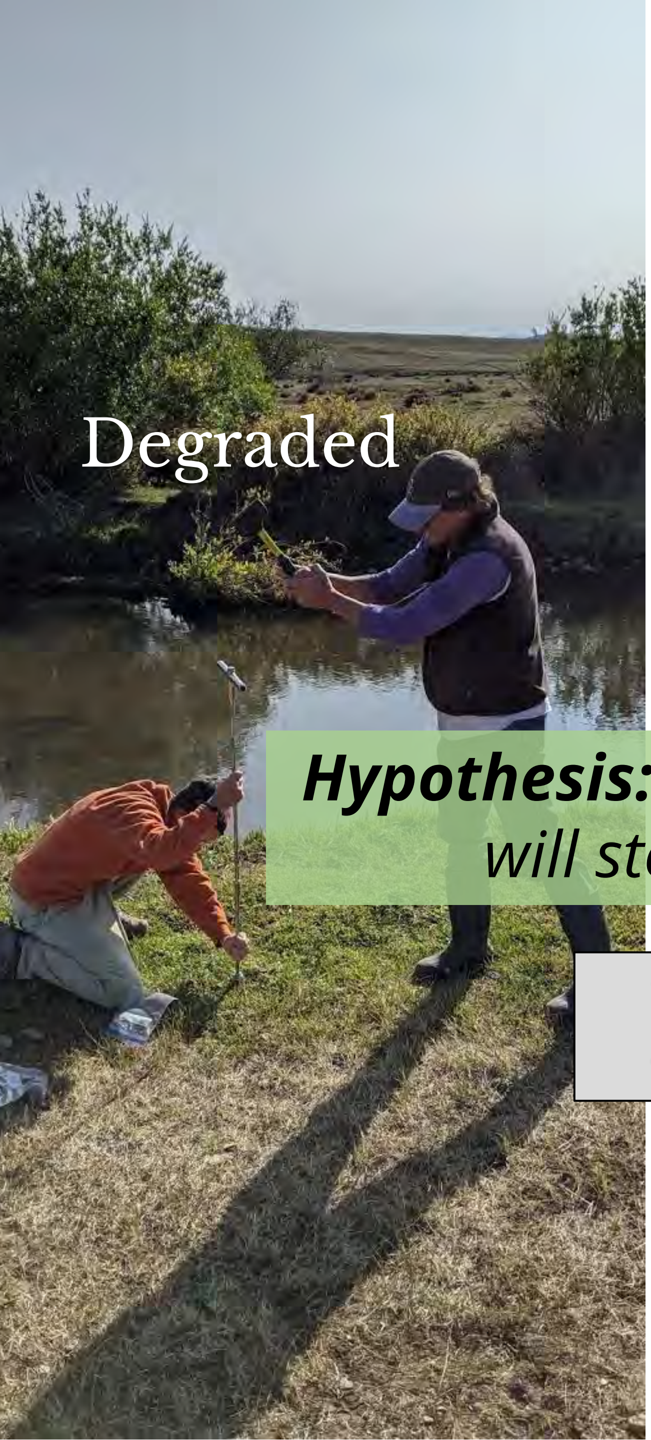
(Sutfin et al. 2016)

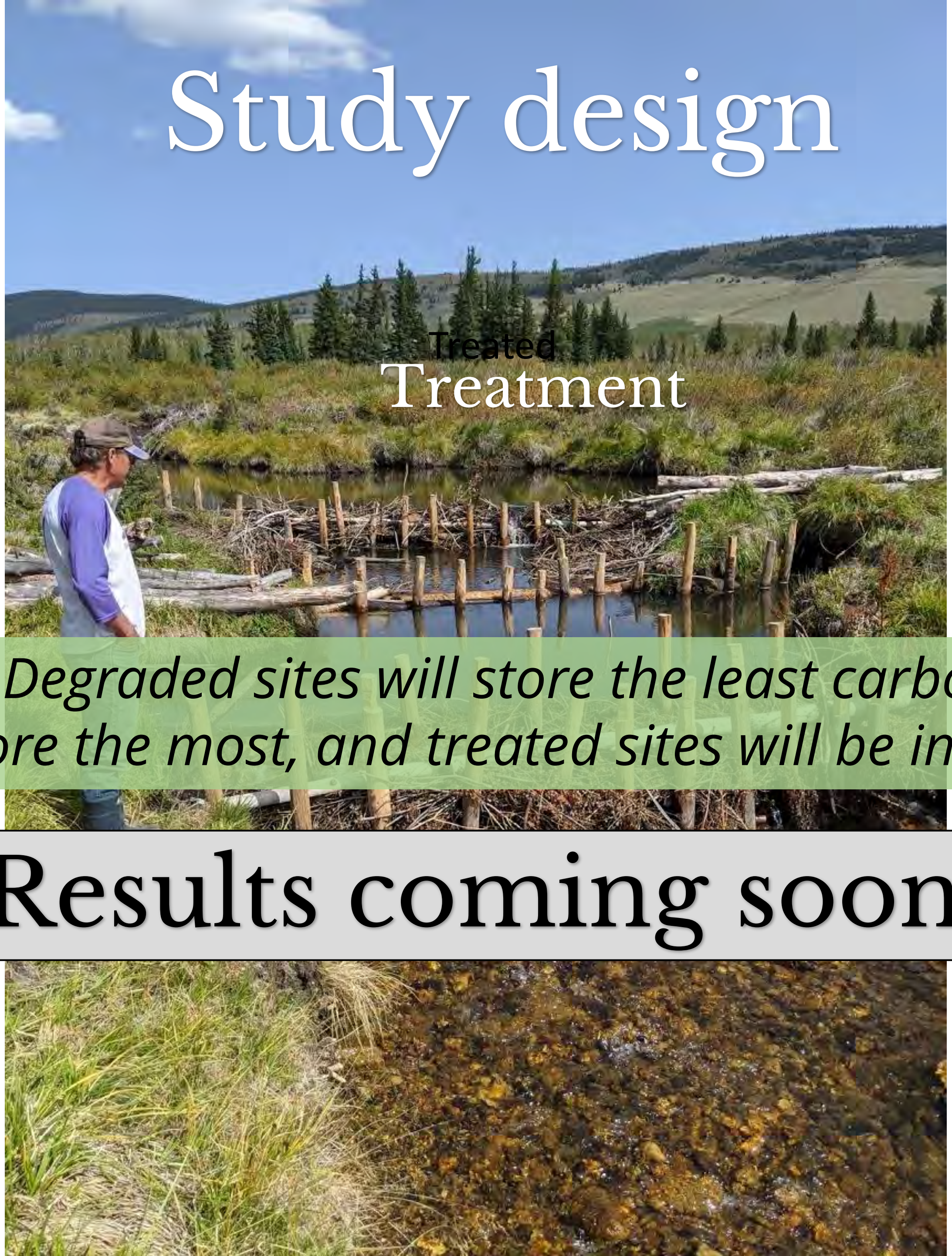
Restoration can also sequester carbon.

- Rewetting the valley bottom
  - Wet soil slows decomposition of organic matter
- Enhancing riparian vegetation

What are optimal restoration techniques for carbon storage?

Study design





Hypothesis: *Degraded sites will store the least carbon, reference sites will store the most, and treated sites will be intermediate*

Results coming soon!

Reconnecting the river corridor

Disconnected floodplain

- Incised stream
- Drier vegetation species
- Lower water table

Treatment →

Connected floodplain

- Functions as a sink for water, sediment, and solutes
- Benefits for habitat
- Resilient


Thank you