

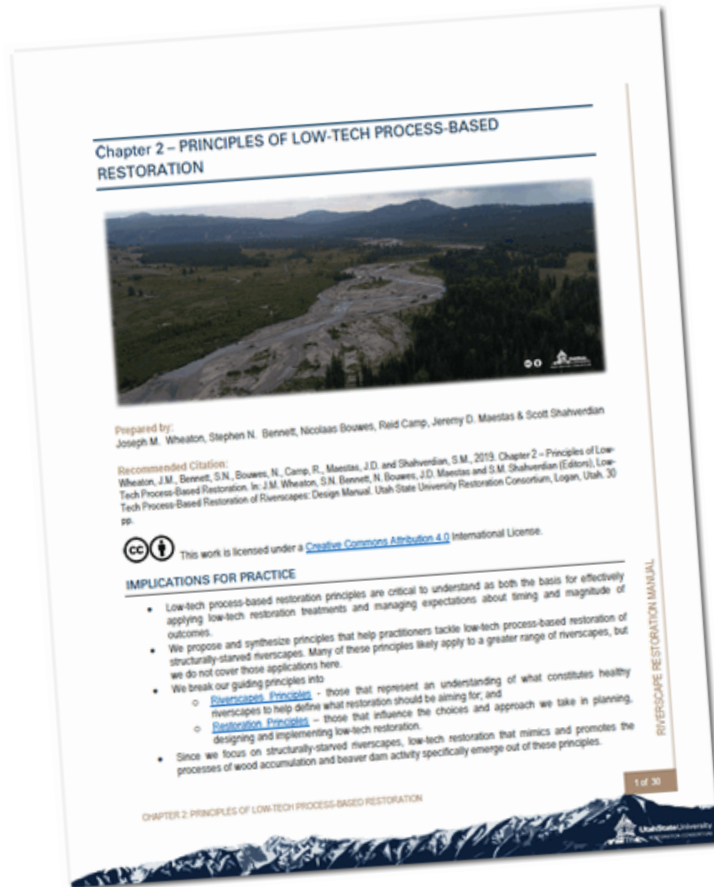
LTPBR WORKSHOP



LOW-TECH PBR PRINCIPLES



Design Manual References – Chapter 2



Chap 2: Wheaton et al. (2019a)
DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

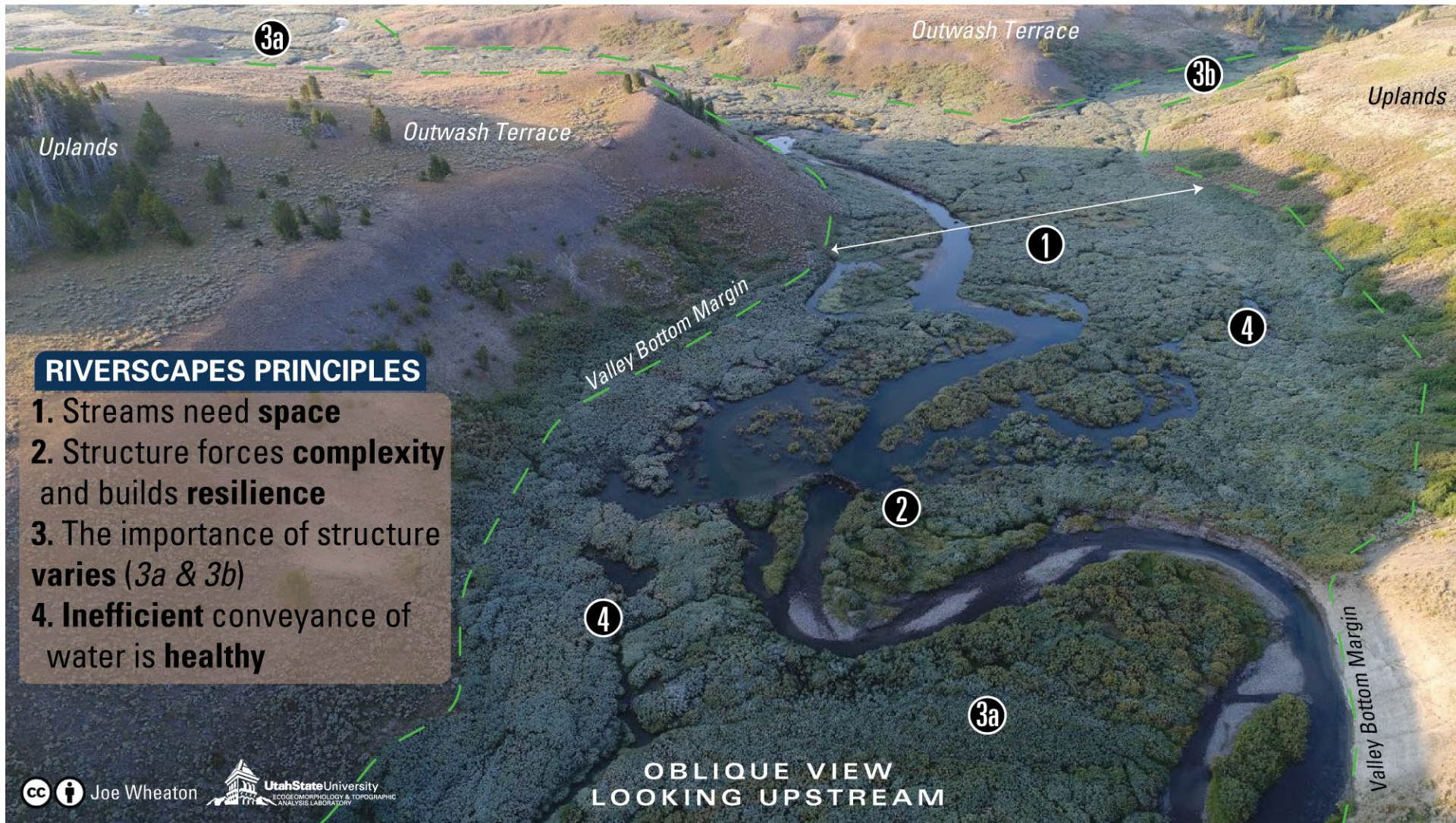
From pages 1-6 of Pocket Guide; Wheaton et al. (2019)
DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

PBR? Just a cute can or some science?



Principle	Description
1. Target root causes of habitat and ecosystem change	Restoration actions are designed to address the human alterations to processes that are degrading habitat conditions
2. Tailor restoration actions to local potential	A given reach in a river network operates within specific constraints based on its location within the watershed and climatic and physiographic setting. Understanding the types and magnitudes of processes within a given reach helps design restoration actions.
3. Match the scale of restoration to the scale of the problem	When disrupted processes causing degradation occur at the reach scale, restoration actions at individual sites can effectively address root causes. When causes of degradation occur at the watershed scale, many individual site-scale actions are required.
4. Be explicit about expected outcomes	Process-based restoration is a long-term endeavor and there are often long lag times between implementation and recovery and biota may not improve dramatically with any single action. Articulating restoration goals and pathways is critical to setting appropriate expectations.

What constitutes a healthy riverscape?



Riverscapes Principles

See Wheaton et al. (2019, p 60): Chapter 2 LTPBR Manual for Principles

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

A topographic map of a mountainous watershed. The terrain is shown in shades of gray, with elevation indicated by contour lines. A network of blue lines represents rivers and streams. Several areas, primarily along the river channels and in the valleys, are highlighted in green, representing floodplains or river corridors. The text is overlaid on the map: a title box in the top left and a definition box in the center.

Reminder: Riverscapes span the network across a watershed

Riverscapes are the part of the landscape that could plausibly flood by their rivers & streams in the natural flow regime.

1. Streams Need Space

Healthy streams are dynamic, regularly shifting position within their valley bottom, re-working and interacting with their floodplain. Allowing streams to adjust within their valley bottom is essential for maintaining functioning riverscapes.

- Give rivers back their floodplains
- Assess what a river needs to *exercise* during floods
- Either reclaim, or conserve space to flood

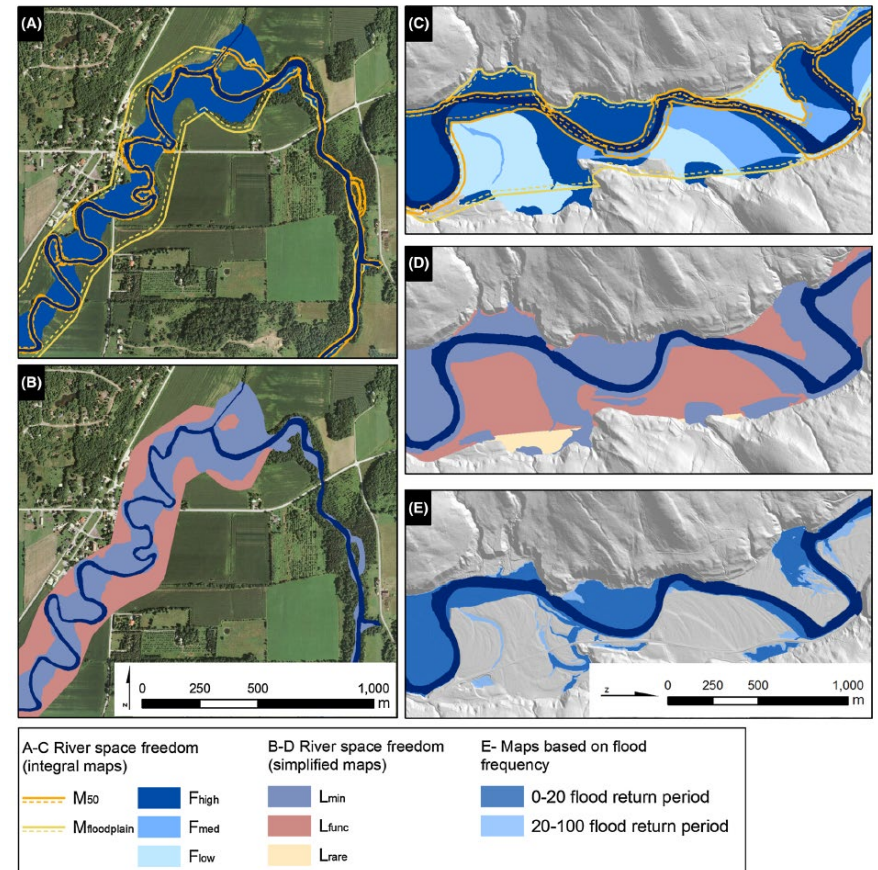
From pages 1-2 of Pocket Guide; Wheaton et al. (2019)

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

See Wheaton et al. (2019, p 61)

Chapter 2 LTPBR Manual for Principles

DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

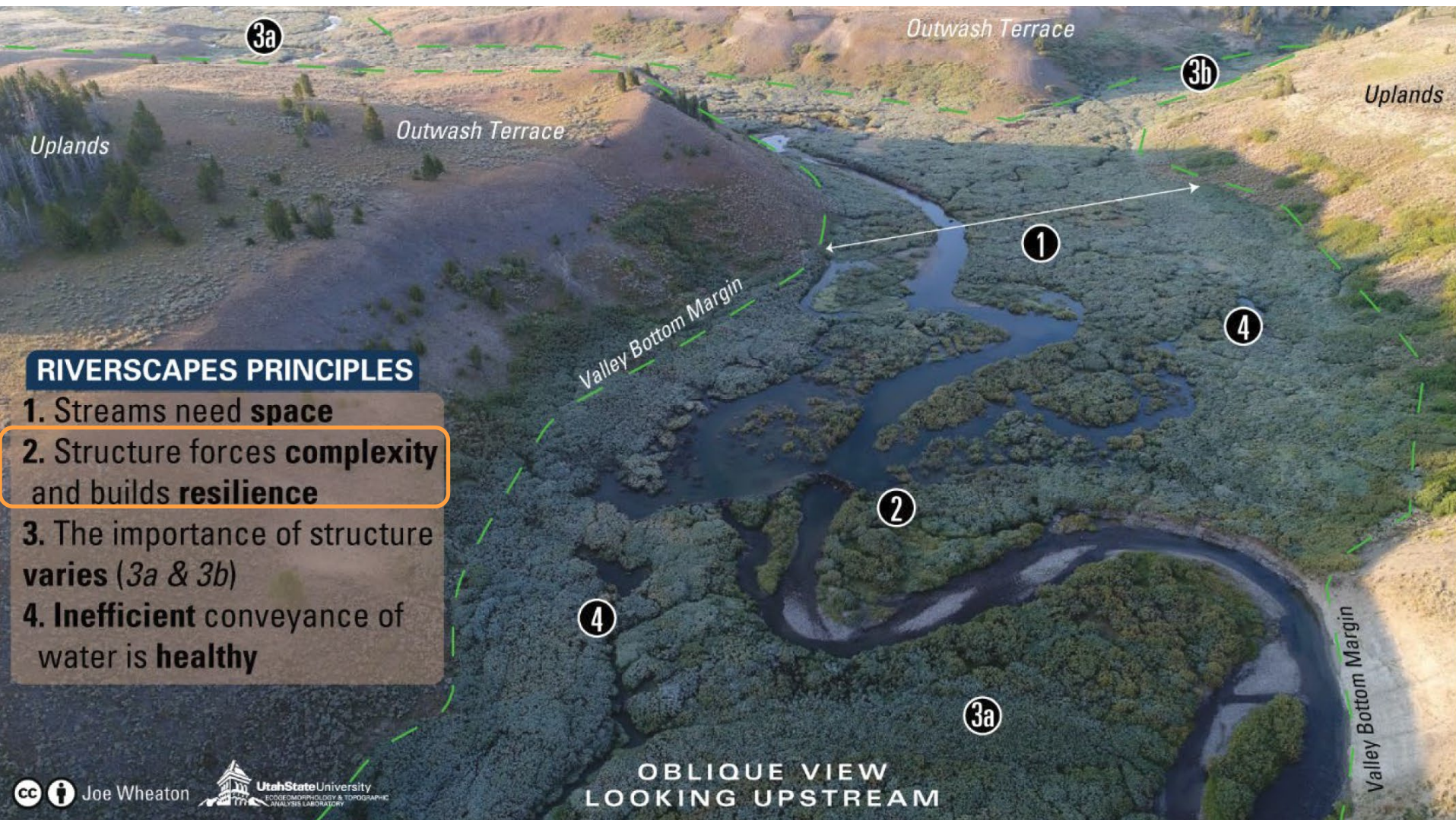


e.g. Biron (2014). Freedom space for rivers: a sustainable management approach to enhance river resilience. DOI: [10.1007/s00267-014-0366-z](https://doi.org/10.1007/s00267-014-0366-z).

Streams need space (i.e. their valley *bottoms*)



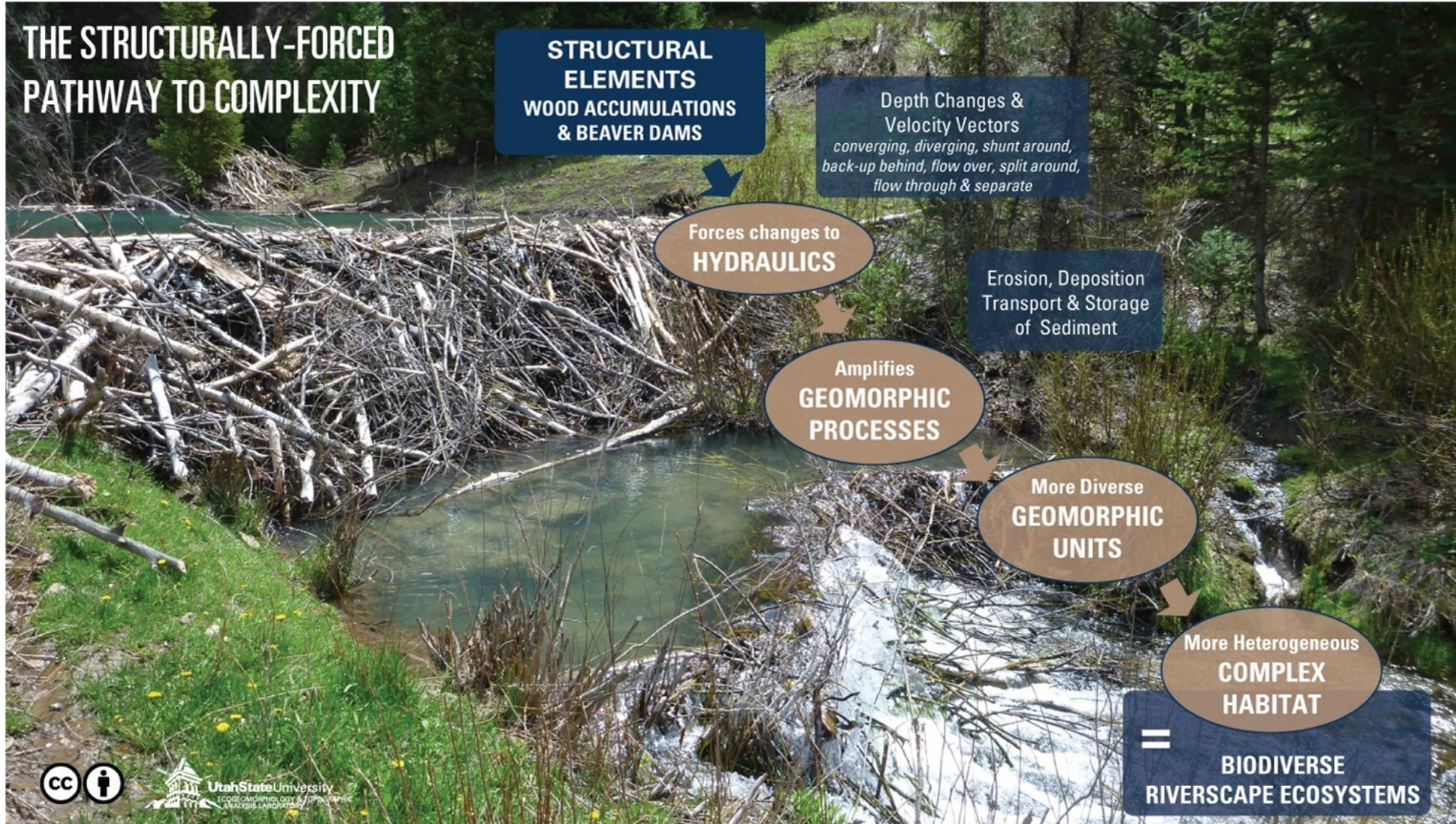
2. Structure forces Complexity & Builds Resilience



From Wheaton et al. (2019) – LTPBR Manual

DOI: [10.13140/RG.2.2.19590.63049/1](https://doi.org/10.13140/RG.2.2.19590.63049/1)

Key Processes are Structurally-Forced



From Wheaton et al. (2019) – LTPBR Manual

DOI: [10.13140/RG.2.2.19590.63049/1](https://doi.org/10.13140/RG.2.2.19590.63049/1).

What are some component **processes**?

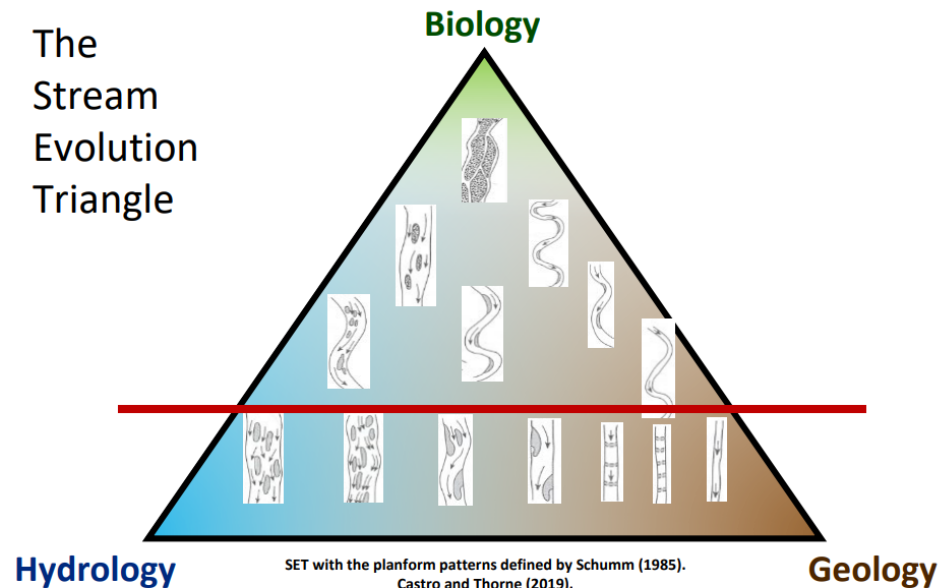
Verbs vs. Nouns vs. Adjectives...

- **Hydrologic** → flood floodplain, attenuate flood flows, augment baseflow
- **Hydraulic** → slow, deepen, speed up, shunt, split, back up
- **Geomorphic** → build up, cut down, store topography/sediment
- **Biologic** → grow, survive, reproduce, die (production)

So are these the **P** in PBR?



The
Stream
Evolution
Triangle



Castro, J.M. and Thorne, C.R. 2019. The Stream Evolution Triangle: linking Geology, Hydrology and Biology, *River Research and Applications*. <https://doi.org/10.1002/rra.3421>

Key Processes to **DESIGN** & **SOLVE** for!!!



From Shahveridan et al. (2019)

Chap 4 LTPBR Manual

DOI: [10.13140/RG.2.2.22526.64324](https://doi.org/10.13140/RG.2.2.22526.64324)

Need A Simple Before & After?

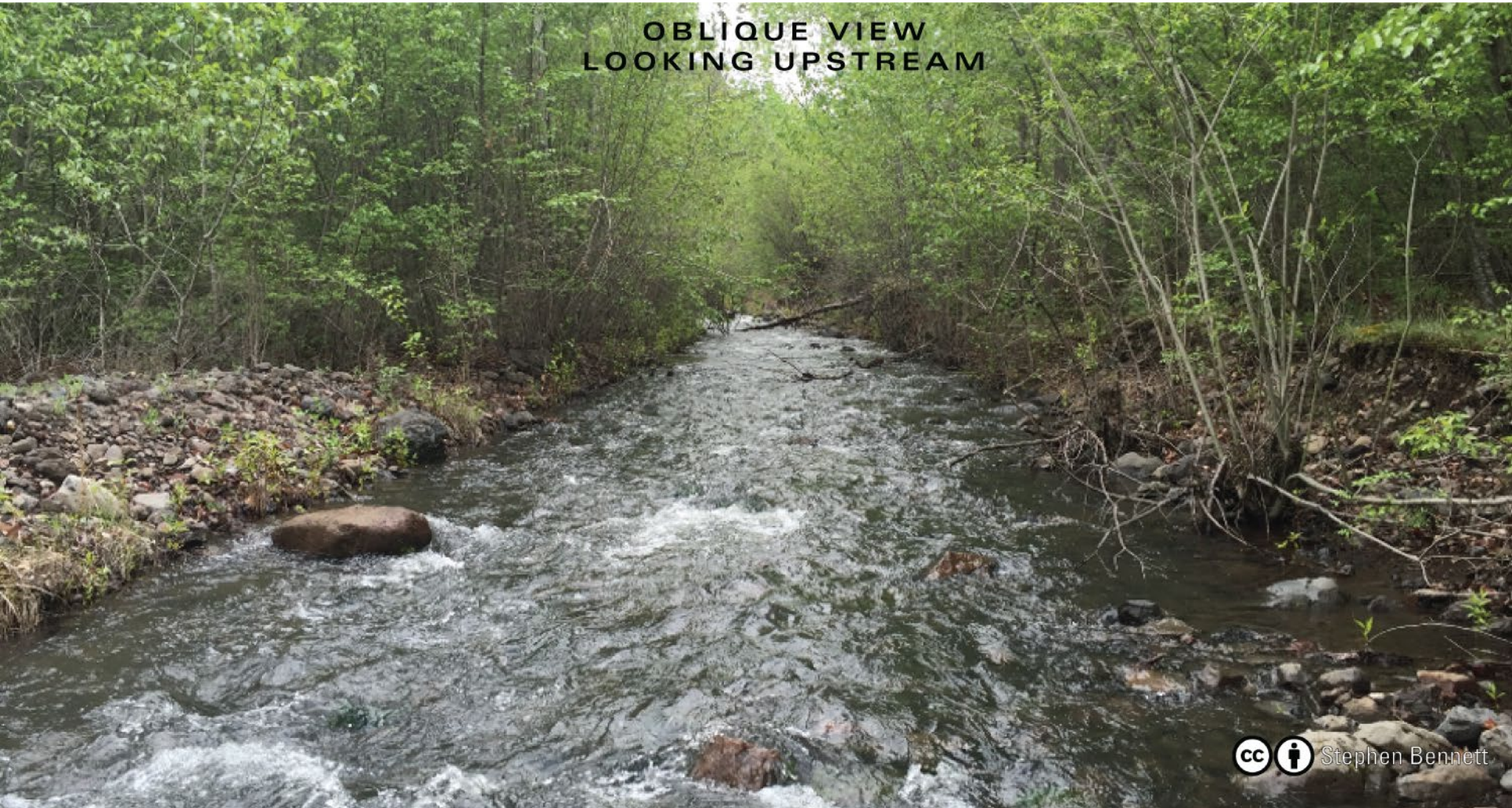
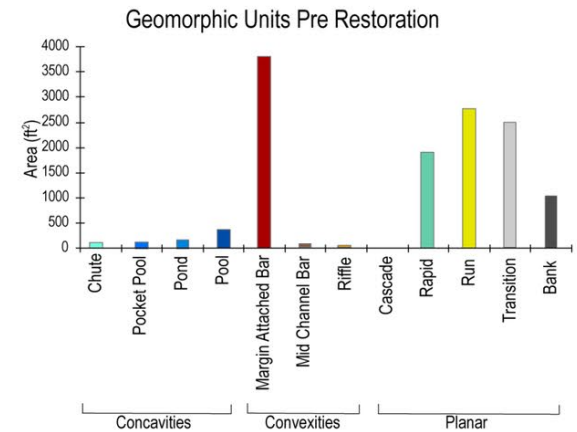
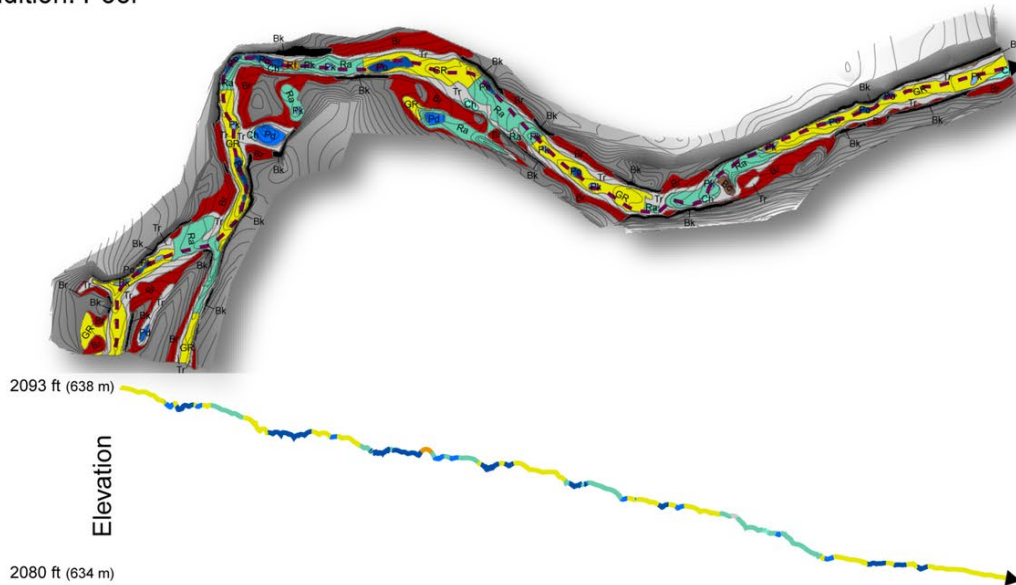


Figure 1.3 (p 32) of Shahverdian et al. (2019) – Chapter 1 LTPBR
Manual DOI: [10.13140/RG.2.2.14138.03529](https://doi.org/10.13140/RG.2.2.14138.03529)

Condition: Poor



- Plane bed dominated (rapids & runs)
- Starved of wood..
- Limited interaction with floodplain



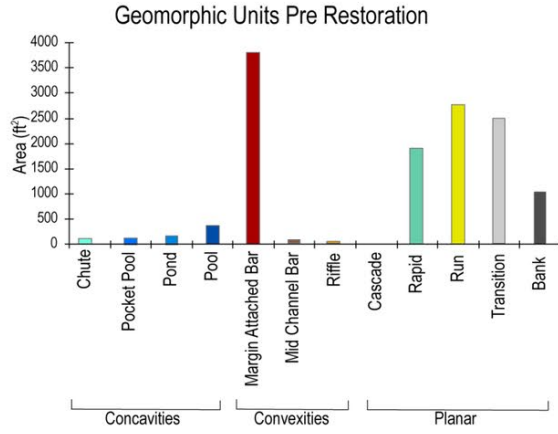
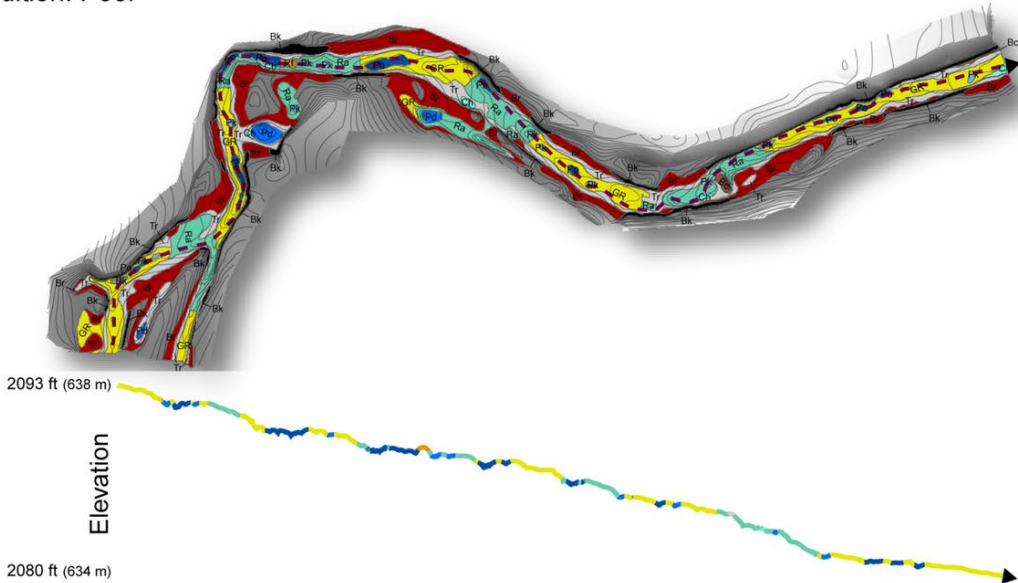
Adding P.A.L.S. (Wood)

HDLOWD

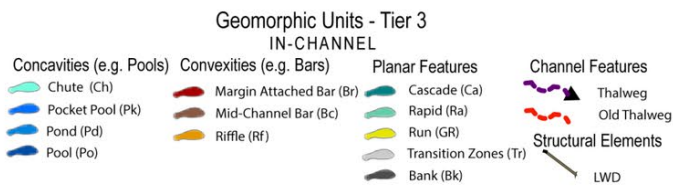
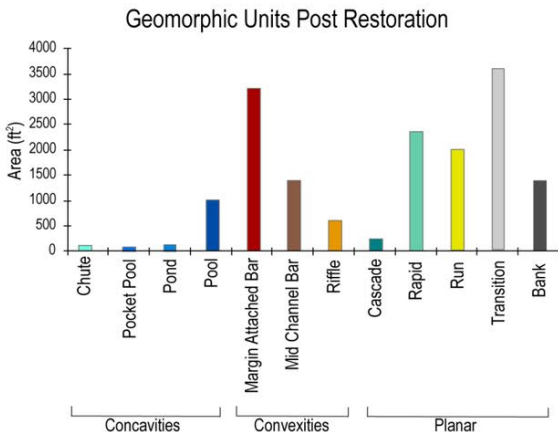
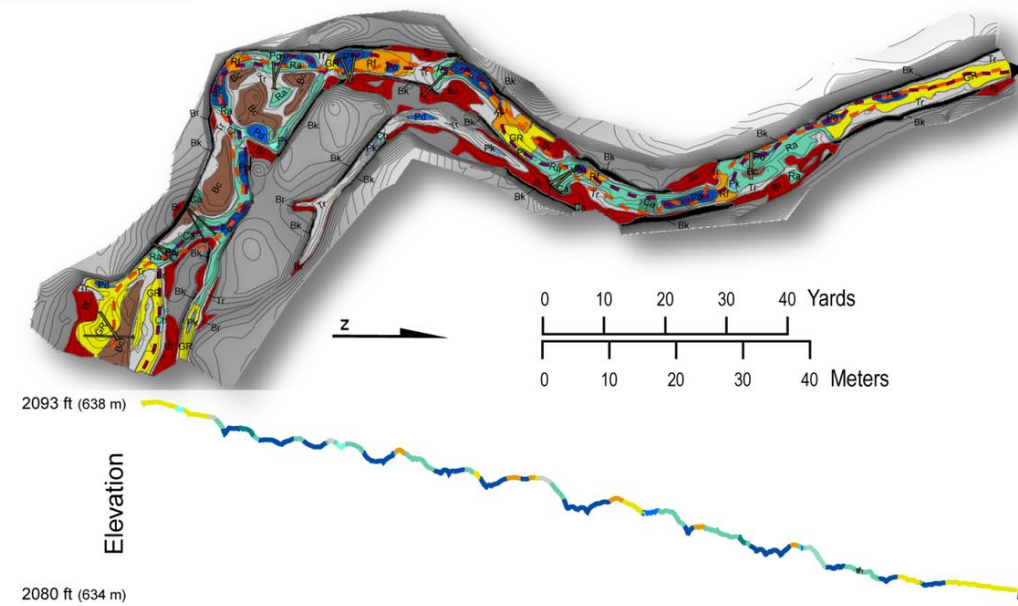


STRUCTURE FORCES COMPLEXITY & BUILDS RESILIENCE
RIVERSCAPES PRINCIPLE 2.

Condition: Poor



Condition: Moderate



Managing Riverscapes for **Resilience** of _____, water, wildlife, working lands?

What is resilience?

"The capacity to recover quickly from difficulties, toughness."

The lack of sensitivity to disturbance

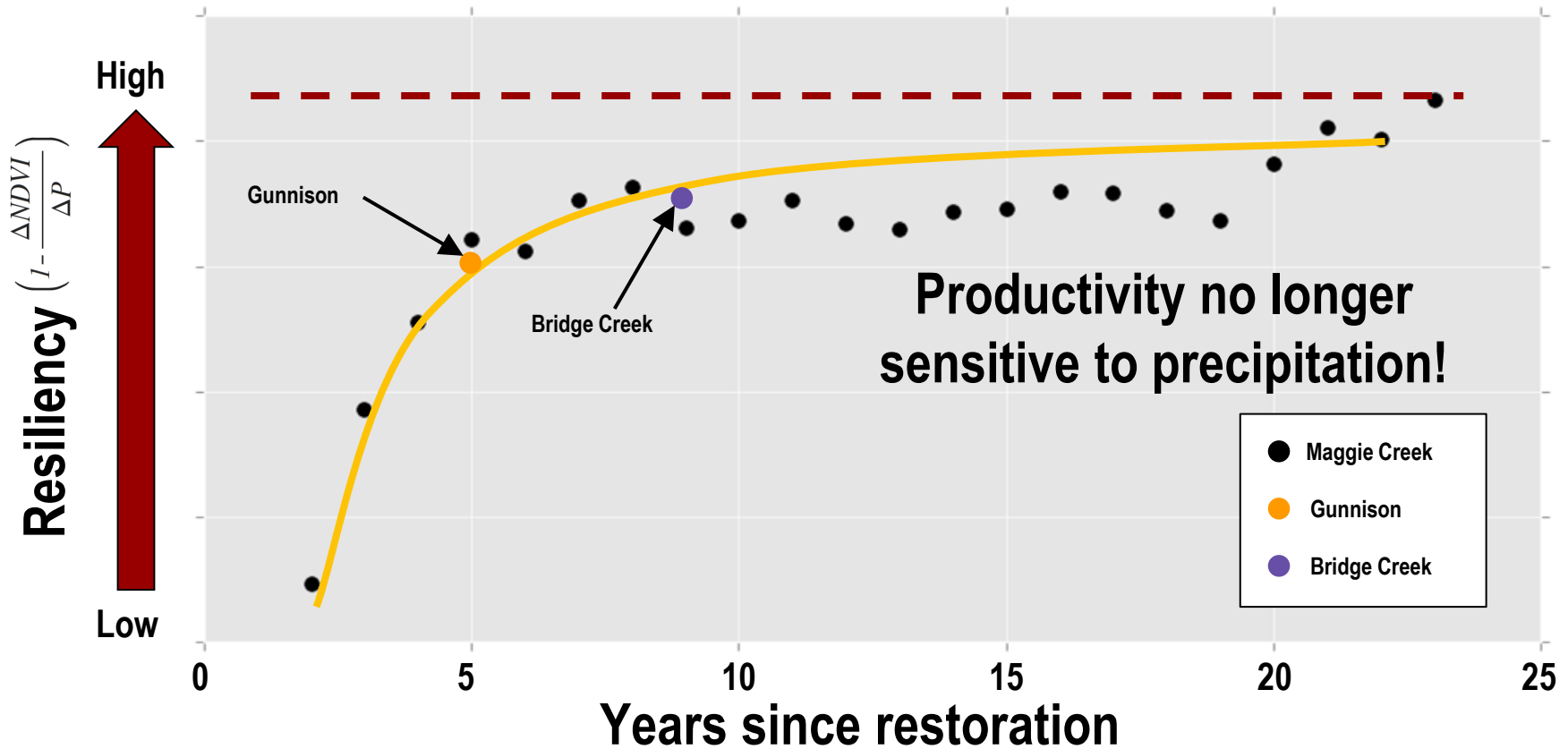


Structurally-Forced Resilience to Drought

Silverman et al. (2018)

DOI: <https://doi.org/10.1111/rec.12869>

Page 15 of LTPBR Pocket Guide



Zeedyk Structures

(Short-term: 2-5 yrs)



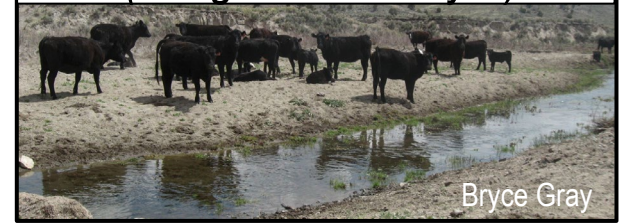
Beaver Dam Analogs

(Mid-term: 9 yrs)



Grazing Management

(Long-term: 20+ yrs)



Another example of Structurally-Forced Resilience

Riparian areas burnt to ground across entire valley bottom in most the watershed

EXCEPT, where beaver dam complexes kept the valley bottoms wet, the riparian areas did not burn!

Page 16 of LTPBR Pocket Guide
From Wheaton et al. (2019) – LTPBR Manual

DOI: [10.13140/RG.2.2.19590.63049/1](https://doi.org/10.13140/RG.2.2.19590.63049/1)

3. The Importance of Structure Varies

The relative importance and abundance of structural elements varies based on reach type, valley setting, flow regime and watershed context. Recognizing what type of stream you are dealing with (i.e., what other streams it is similar to) helps develop realistic expectations about what that stream should or could look (form) and behave (process) like.

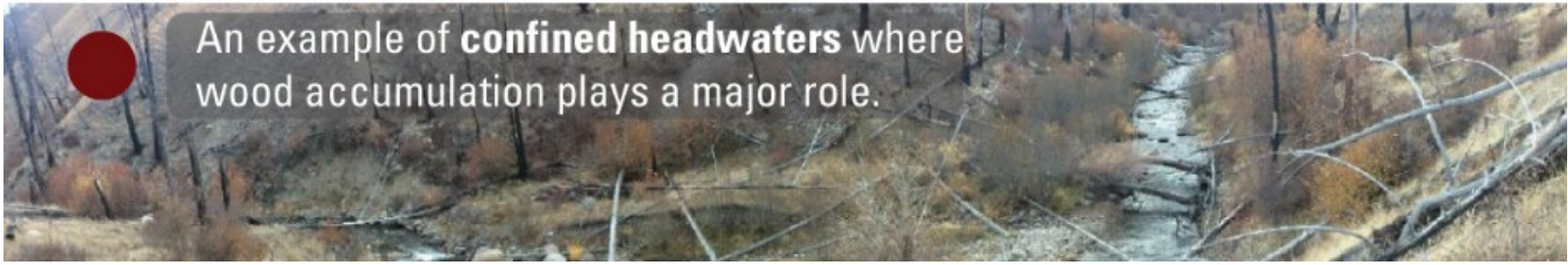
Pocket Guide; Wheaton et al. (2019, p. 8)

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)


Figure 2.7 from Wheaton et al. (2019, p 64)

Chapter 2 LTPBR Manual for Principles


DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)



An example of **confined headwaters** where wood accumulation plays a major role.

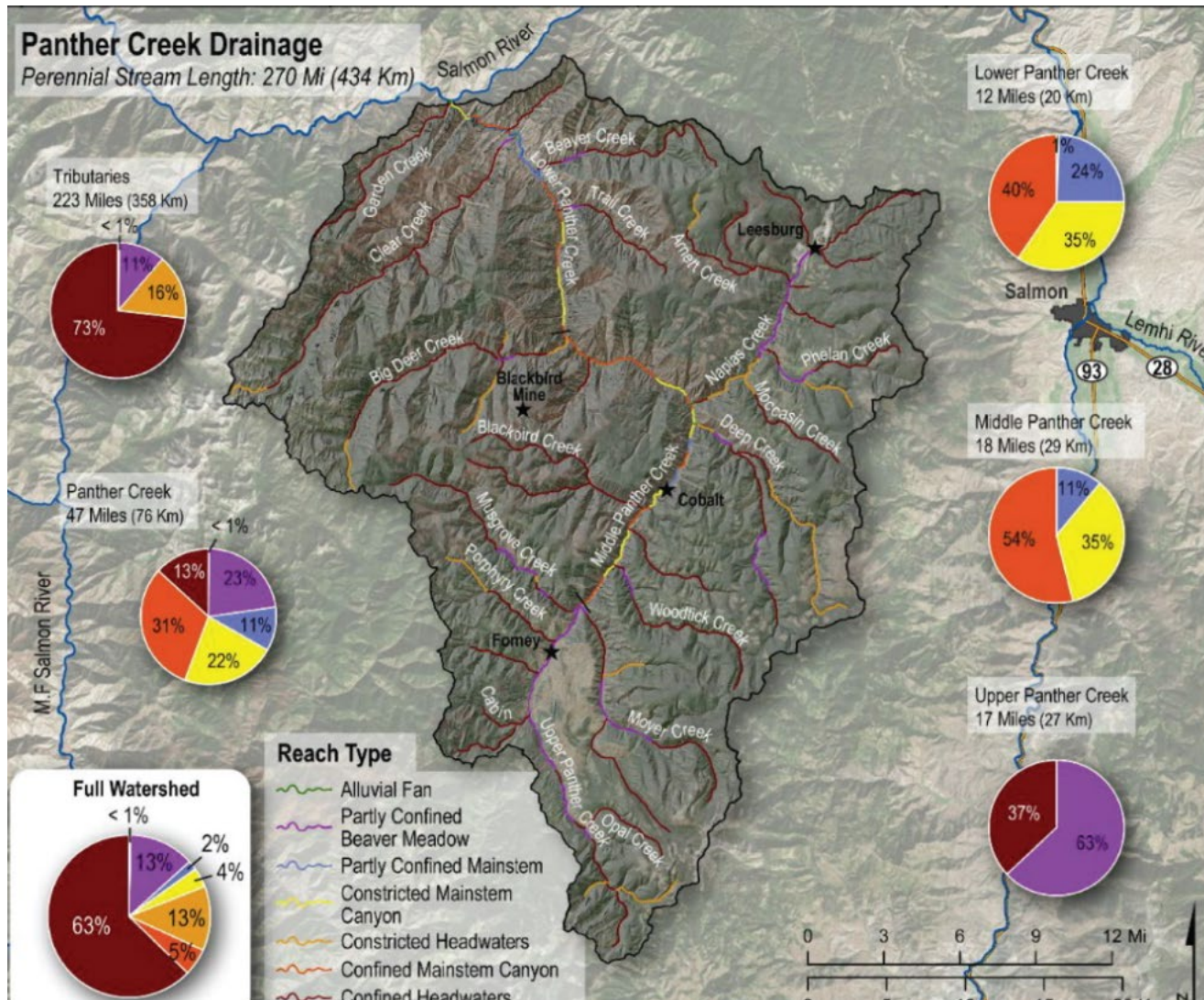


Partly-confined beaver meadow reach where beaver dam activity plays a major role.



Partly-confined mainstem reach where the flow regime plays a larger role than structure.

And we can map geomorphology matters



Pocket Guide; Wheaton et al. (2019, p. 8)

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

Figure 2.7 from Wheaton et al. (2019, p 64)

Chapter 2 LTPBR Manual for Principles

DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

4. Inefficiency is healthy

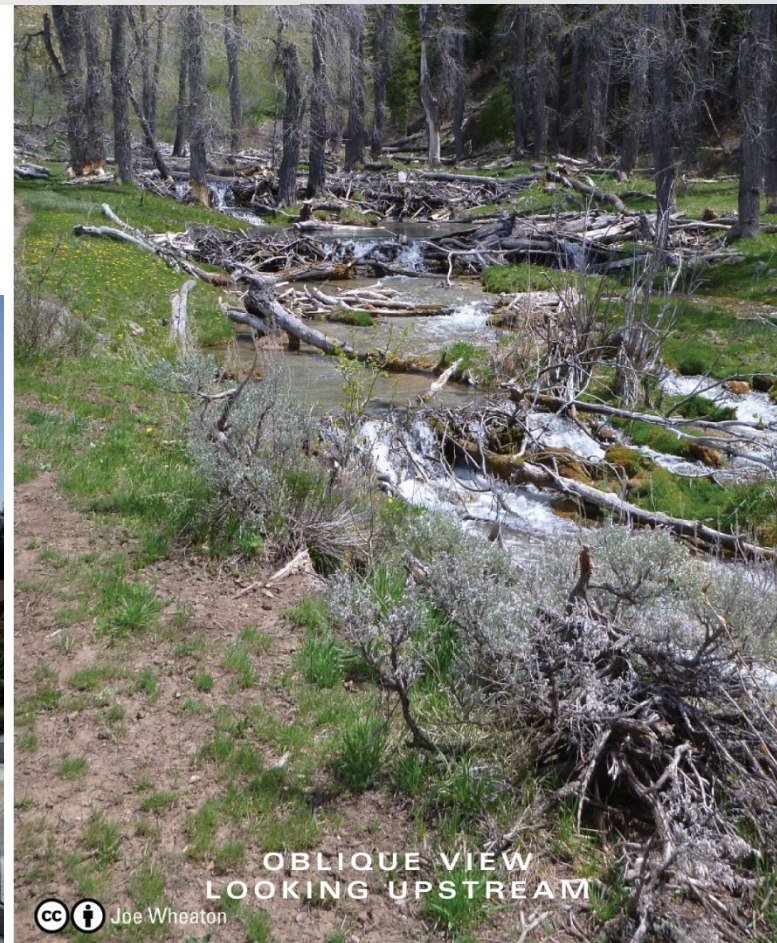
Hydrologic inefficiency is the hallmark of a healthy system. More diverse residence times for water can attenuate potentially damaging floods, fill up valley bottom sponges, and slowly release that water later elevating baseflow and producing critical ecosystem services.

Adapted from figure 2.3 from
Wheaton et al. (2019, p 62)

Chapter 2 LTPBR Manual for Principles

DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

Which one wins race? Efficient or Inefficient?



OBLIQUE VIEW
LOOKING UPSTREAM

cc i Joe Wheaton

How Does Flow Change With Dams?

Flow In



- i.e. – What about slowing the water down? Could that help?

Flow Direction

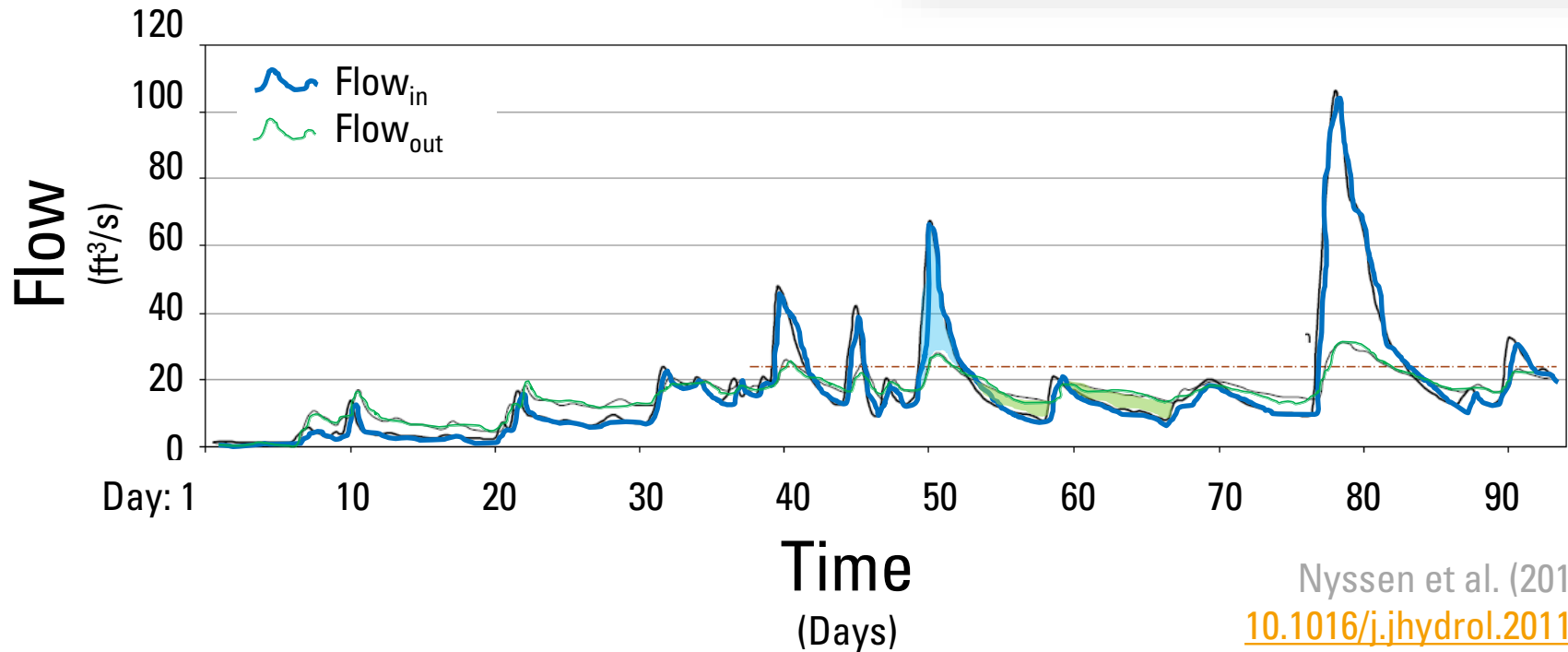
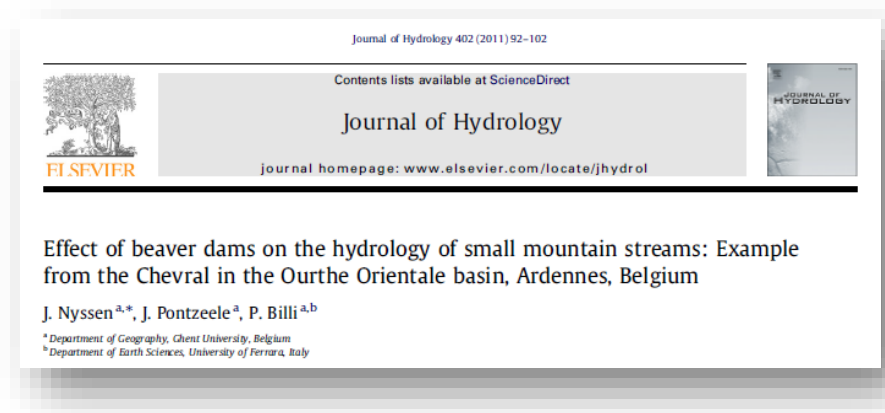
Flow Out



UtahStateUniversity
ECOGEOGRAPHY & TOPOGRAPHIC
ANALYSIS LABORATORY

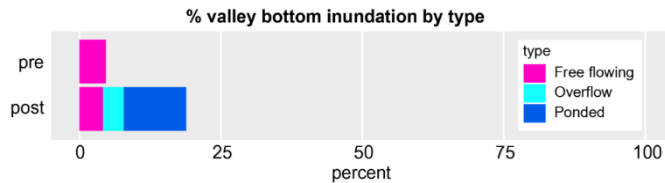
Typical Impact on Flows

- Lower peaks @ flood
- Elevated baseflow following



Nyssen et al. (2011) DOI:
[10.1016/j.jhydrol.2011.03.008](https://doi.org/10.1016/j.jhydrol.2011.03.008)

The Water Magic Trick



- Inundation types great proxy for residence time...

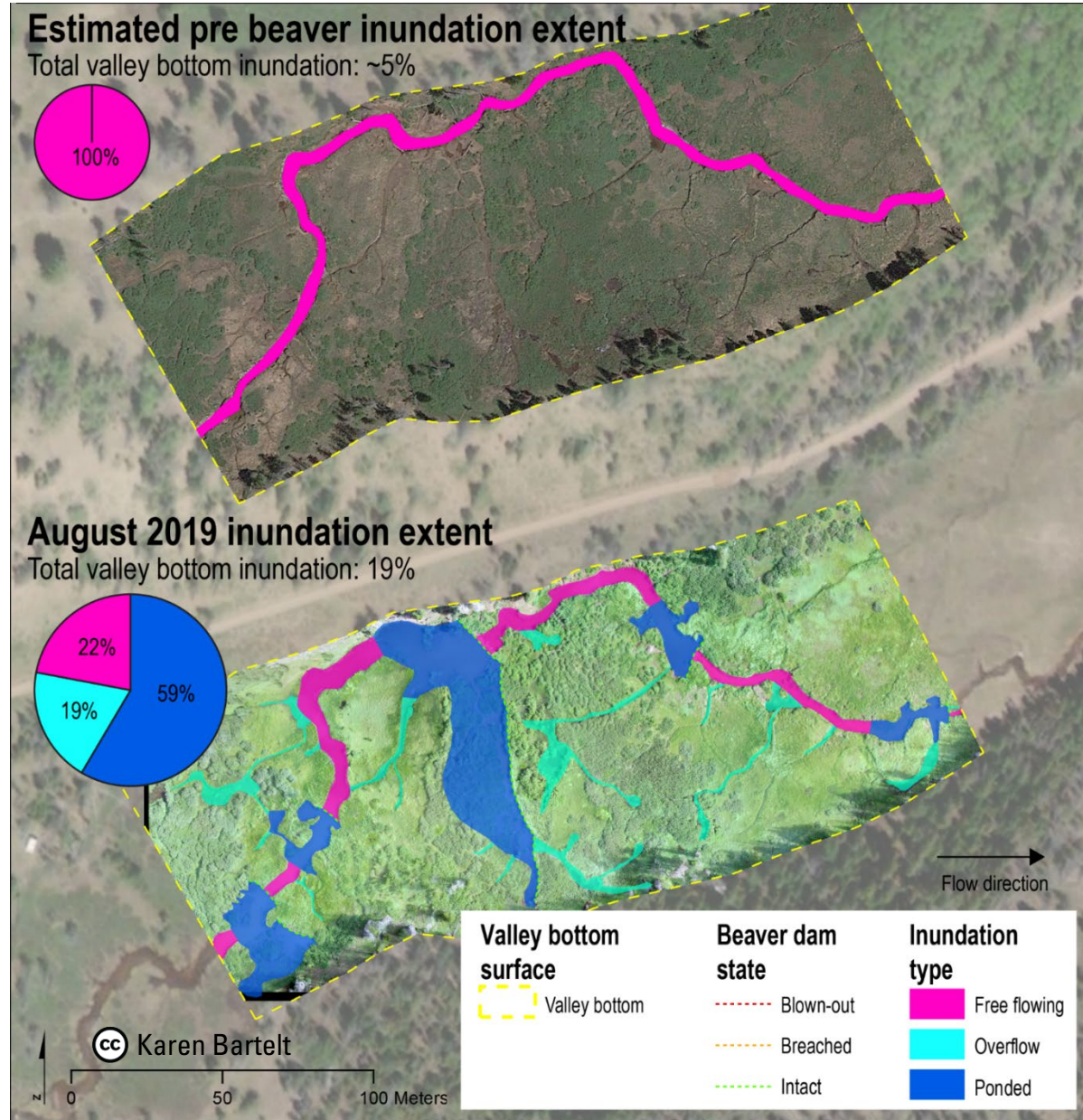
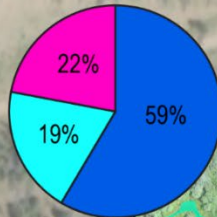
Estimated pre beaver inundation extent

Total valley bottom inundation: ~5%



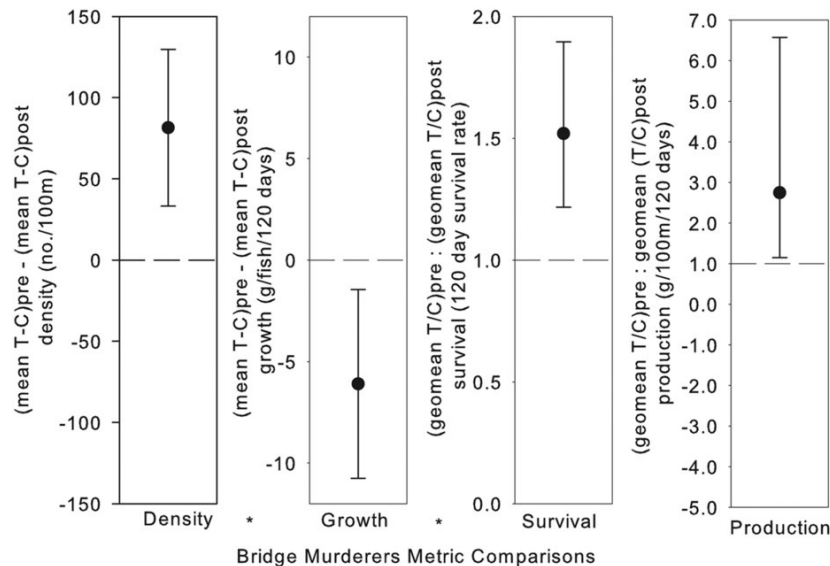
August 2019 inundation extent

Total valley bottom inundation: 19%



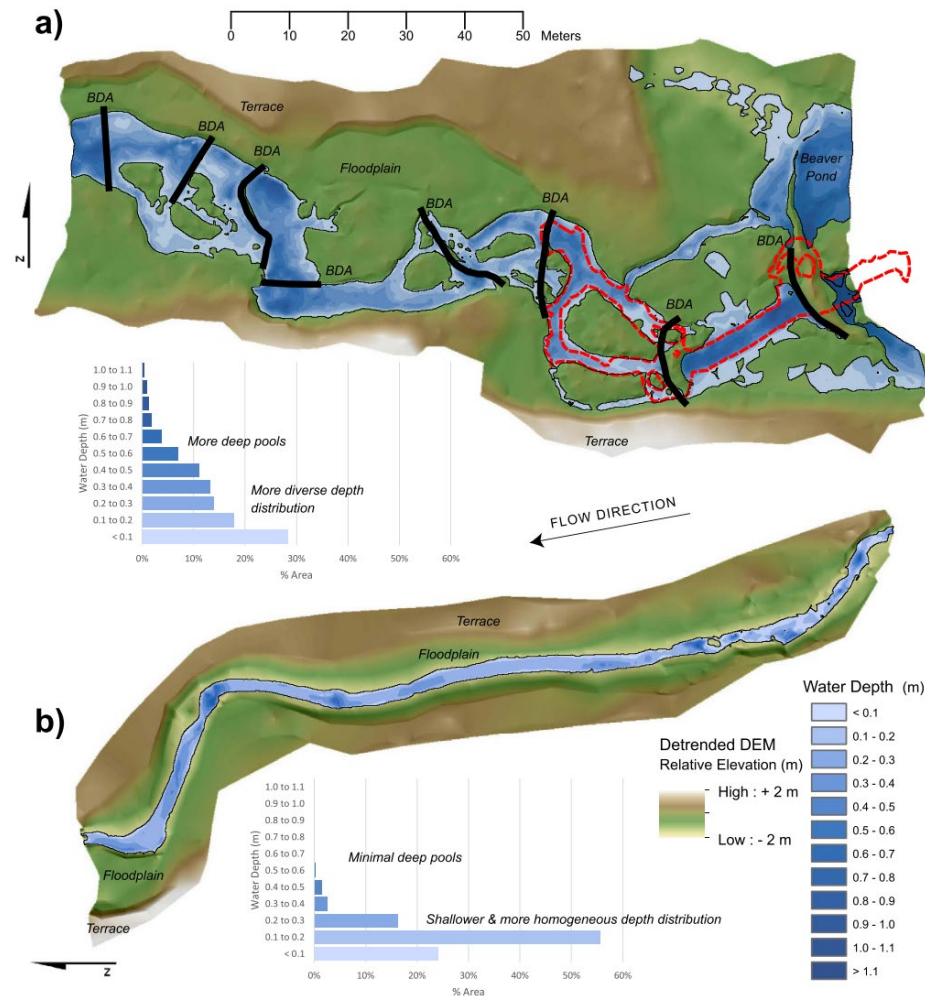
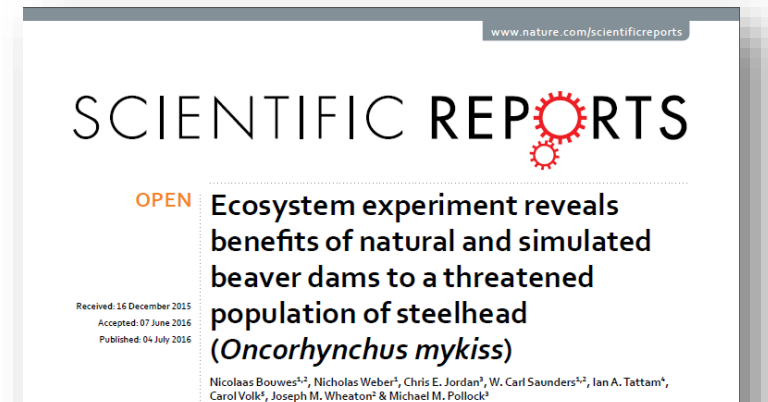
Habitat quality matters, but quantity matters more to fish & The Water Magic Trick

- Restoration using BDAs & beaver as restoration agent produced a population level increase in density, survival and production of ESA listed salmon

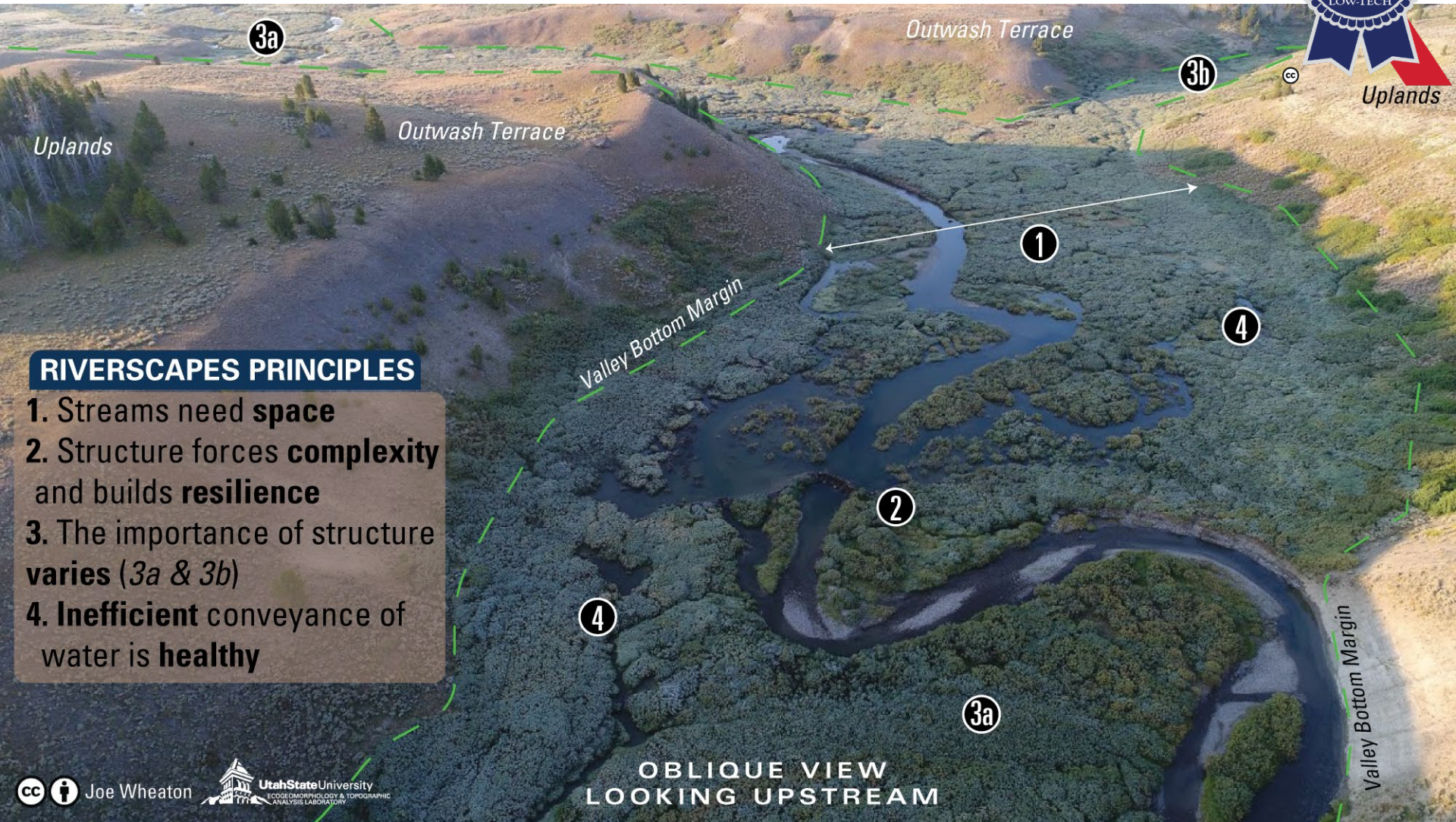


From Bouwes et al. (2016)

DOI: [10.1038/srep28581](https://doi.org/10.1038/srep28581)



Review: Riverscapes Principles



RIVERSCAPES PRINCIPLES

1. Streams need **space**
2. Structure forces **complexity** and builds **resilience**
3. The importance of structure **varies** (3a & 3b)
4. **Inefficient** conveyance of water is **healthy**

From pages 3-4 of Pocket Guide; Wheaton et al. (2019)

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

See Wheaton et al. (2019, p 60): Chapter 2 LTPBR Manual for Principles

DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

RESTORATION PRINCIPLES

- 5. It's okay to be **messy**
- 6. There is strength in **numbers**
- 7. Use **natural** building materials
- 8. Let the system **do the work**
- 9. **Defer decision making** to the system
- 10. **Self-sustaining** systems are the solution

Low-Tech Restoration Principles



From pages 3-4 of Pocket Guide; Wheaton et al. (2019)

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

See Wheaton et al. (2019, p 72)

Chapter 2 LTPBR Manual for Principles

DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

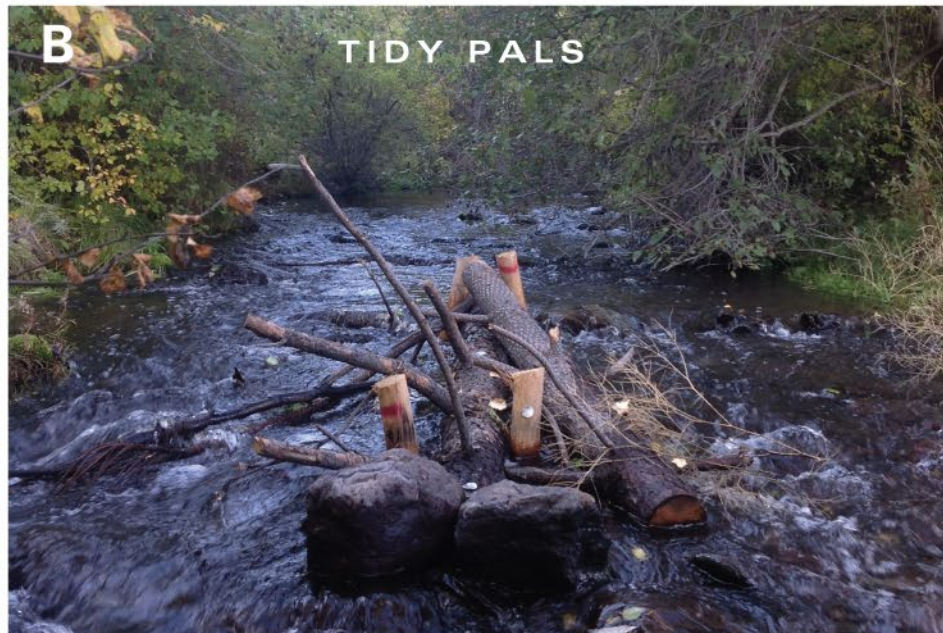
A

MESSY PALS



B

TIDY PALS



CC BY Reid Camp

5. It's okay to be messy



IT'S OKAY TO BE MESSY
RESTORATION PRINCIPLE 5.

Beaver Like to Make Messes... **So can you**



- And it is precisely that messiness, that is so critical to ecosystem health
- So why not take a cue from the rodent?



Helping us articulate messy!



Follow

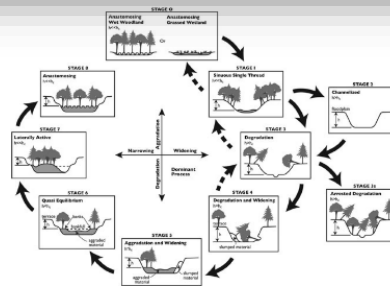
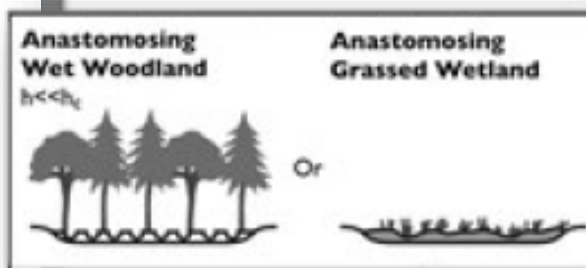


© Mark Beardsley



EcoMetrics

Stream and Riparian Monitoring, Assessment and Restoration



RIVER RESEARCH AND APPLICATIONS
River Res. Applic. (2013)
 Published online in Wiley Online Library
 (wileyonlinelibrary.com) DOI: 10.1002/rre.2651

B. CLIVER¹* and C. THORNE²
¹ NOAA's National Marine Fisheries Service, Santa Rosa, California, US
² Marine Biological Association, Plymouth, Devon, UK

ABSTRACT

[illegible]

Received 1 November 2012; Accepted 13 November 2012

INTRODUCTION

It is now generally accepted that river engineering is a management that works with rather than against natural processes. It is more likely to attain and sustain a range of multiple goals (e.g. land drainage, flood risk management, fisheries conservation, biodiversity, and recreation) demanded by local stakeholders and society more widely (Wohl *et al.*, 2005; Thorne *et al.*, 2010). This, coupled with growing recognition that the range and variety of ecosystem services provided by rivers increase with the degree to which they are allowed to function naturally, fuels the drive for restoration of fluvial systems degraded by past management and engineering actions that have proven, in the long term, to be unsustainable (Wohl *et al.*, 2005).

However, complete restoration of a river to its original condition is seldom possible, nor always desirable (Dow and Gregory, 2004), and deciding whether partial restoration, rehabilitation or environmental enhancement is

*Correspondence to: B. Chert, Fluvial Geomorphologist, South Region, NOAA's National Marine Fisheries Service, 777 Sonoma State 325, Santa Rosa, California 95404, USA.
E-mail: bchert@noaa.gov

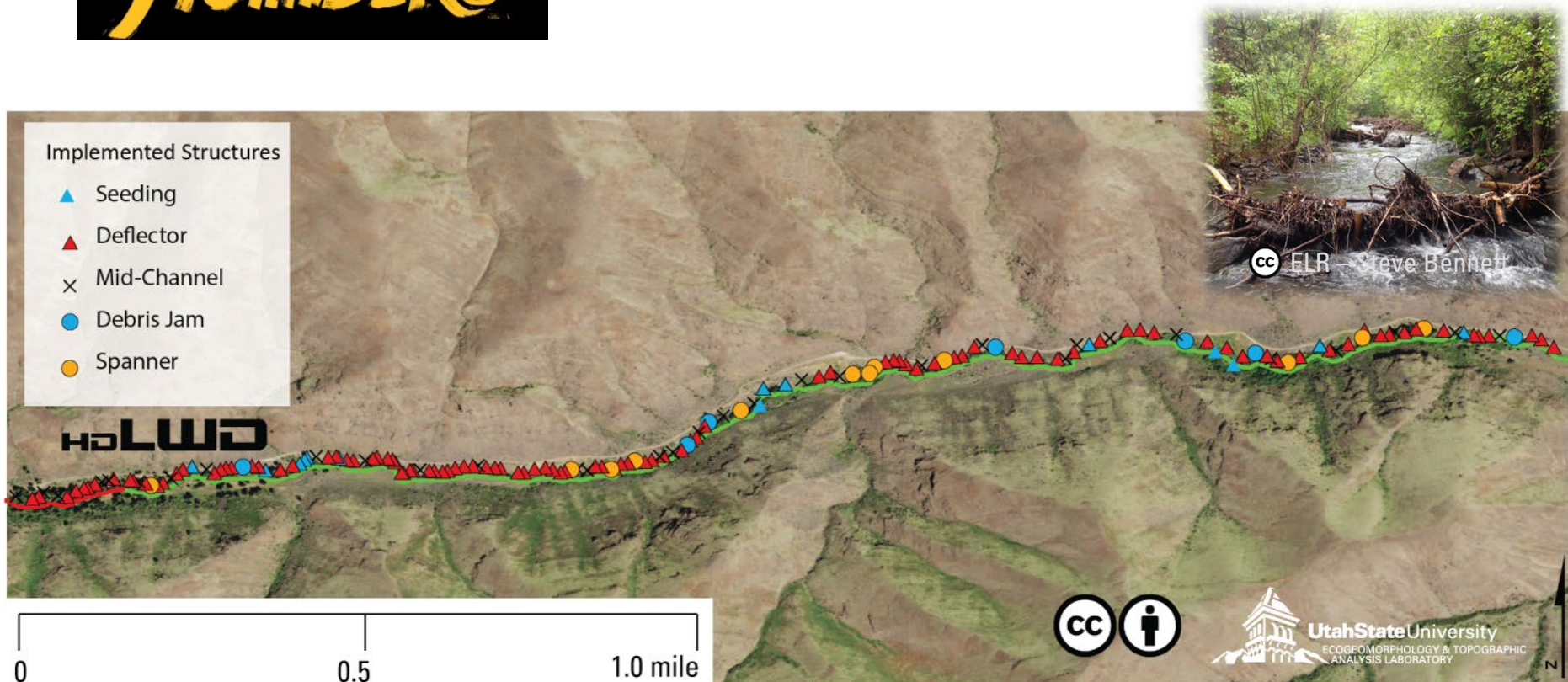
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Photo credit: © Brian Cluer

6. There is strength in numbers



Adapted from Figure 2.10 of Wheaton et al. (2019, p 74-75) –
Chapter 2 LTPBR Manual. DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

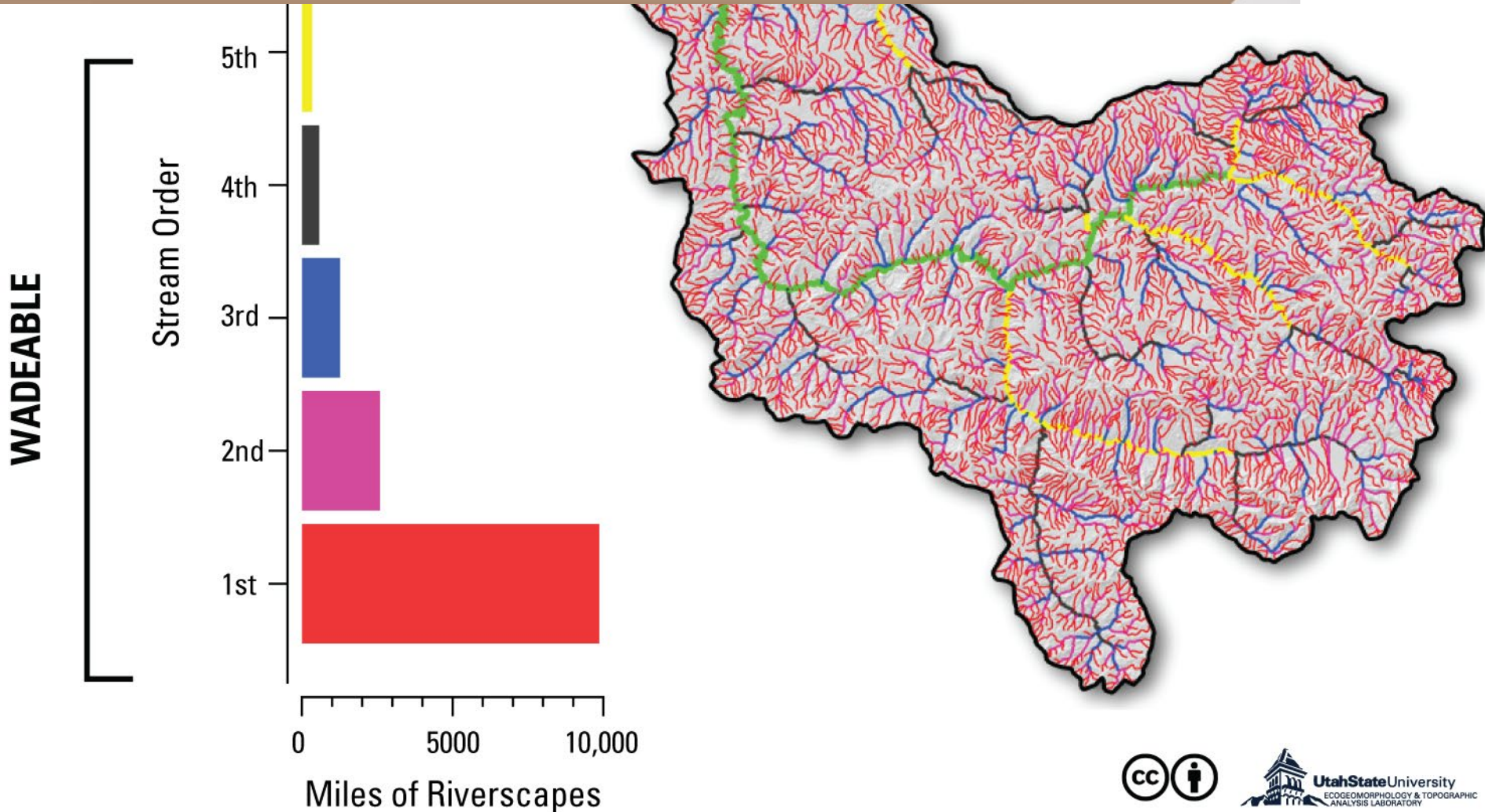
From pages 3-4 of Pocket Guide; Wheaton et al. (2019)

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

Solution Can Scale Up to Scope of Problem!



THERE IS STRENGTH IN NUMBERS
RESTORATION PRINCIPLE 6.



This is what density looks like!

Someone who took this same workshop a few years ago



Courtesy of: Daniel Bertram, Idaho Office of Species Conservation
Location: BLM Salmon Field Office

Build the workforce!



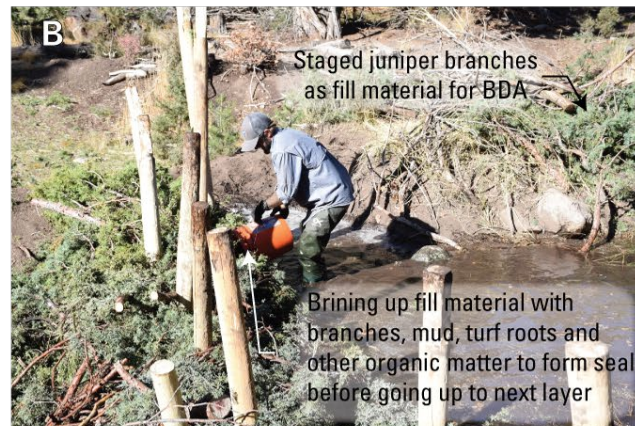
CC Jeremy Maestas

See Wheaton et al. (2019, p. 283)

Chapter 7 of LTPBR Manual

DOI: [10.13140/RG.2.2.18332.33922](https://doi.org/10.13140/RG.2.2.18332.33922).

7. Use Natural Building Materials



Pocket Guide; Wheaton et al. (2019, p. 3-4)

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

See Wheaton et al. (2019, p 76)

Chapter 2 LTPBR Manual for Principles

DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

A

PINYON PINE & JUNIPER REMOVAL

Older PJ removal treatment with subsequent sage brush & rabbit brush moving back in

More recent PJ removal treatments

Untreated areas with high PJ densities from fire suppression

What about fuels reduction to fuel structure back to streams?

USE NATURAL BUILDING MATERIALS
RESTORATION PRINCIPLE 7.

B

PJ removal treatment

And put in the structurally-starved riverscape

Riparian area with LT-PBR Treatment

PJ removal treatment

C

Take harvested woody material where its not needed

Juniper piles following lop & scatter treatment

From Wheaton et al. (2019) – LTPBR Manual

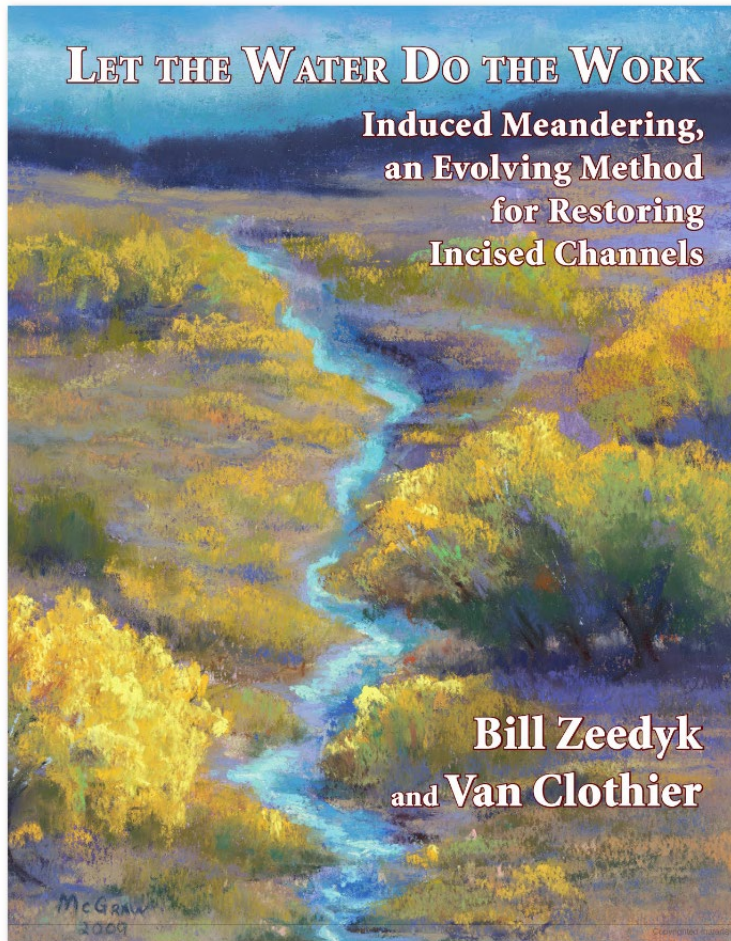
DOI: [10.13140/RG.2.2.19590.63049/1](https://doi.org/10.13140/RG.2.2.19590.63049/1)



ANABRANCH
SOLUTIONS

8. Let the system do the work

Geomorphic work like erosion & deposition instead of grading!



"What if restoration was about stream power doing the work, not diesel power?"

— Jared McKee (USFWS)

See Wheaton et al. (2019, p 77)
Chapter 2 LTPBR Manual for Principles
DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

9. Defer Decision Making to System



Transfer decision making
& liability to the
ecosystem engineer



Joe Wheaton

Pocket Guide; Wheaton et al. (2019, p. 3-4)
DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

See Wheaton et al. (2019, p 77)
Chapter 2 LTPBR Manual for Principles
DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

DEFER DECISION MAKING TO THE SYSTEM RESTORATION PRINCIPLE 9.

Wherever possible, let the system make critical design decisions for us by simply providing the tools and space it needs to adjust. Deferring decision making to the system downplays the significance of uncertainty due to limited knowledge. For example, choosing a floodplain elevation to grade to based on limited hydrology information can be a complex and uncertain endeavor, but deferring to the hydrology of that system to build its own floodplain grade reduces the importance of uncertainty due to limited knowledge.

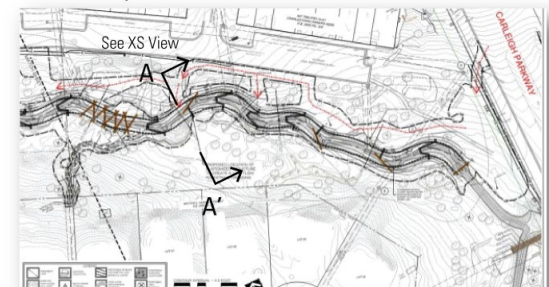
What decisions do we make in traditional restoration design?

- How far to erode bank?
- Channel width
- Slope
- Planform
- Elevation to set floodplain
- Capacity of channel

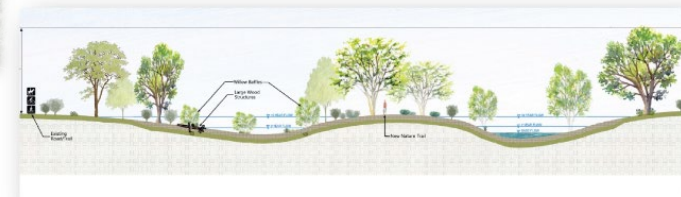


STANDARD ENGINEERING PRACTICE

Engineering Plan Indicates where Specific Features to be Installed



Specific Topographic Design Cross Sections (e.g. A-A')



10. Self-Sustaining Systems are the Solution

From Goldfarb (2018) Science:

<http://science.sciencemag.org/content/360/6393/1058>



Adding dams

Beaver trapping and overgrazing have caused countless creeks to cut deep trenches and water tables to drop, drying floodplains. Installing BDAs can help.

Widening the trench

BDAs divert flows, causing streams to cut into banks, widening the incised channel, and creating a supply of sediment that helps raise the stream bed.

Beavers return

As BDAs trap sediment, the stream bed rebuilds and forces water onto the floodplain, recharging groundwater. Slower flows allow beavers to recolonize.

A complex haven

Re-established beavers raise water tables, irrigate new stands of willow and alder, and create a maze of pools and side channels for fish and wildlife.

NEWS

FEATURES



BEAVERS, REBOOTED

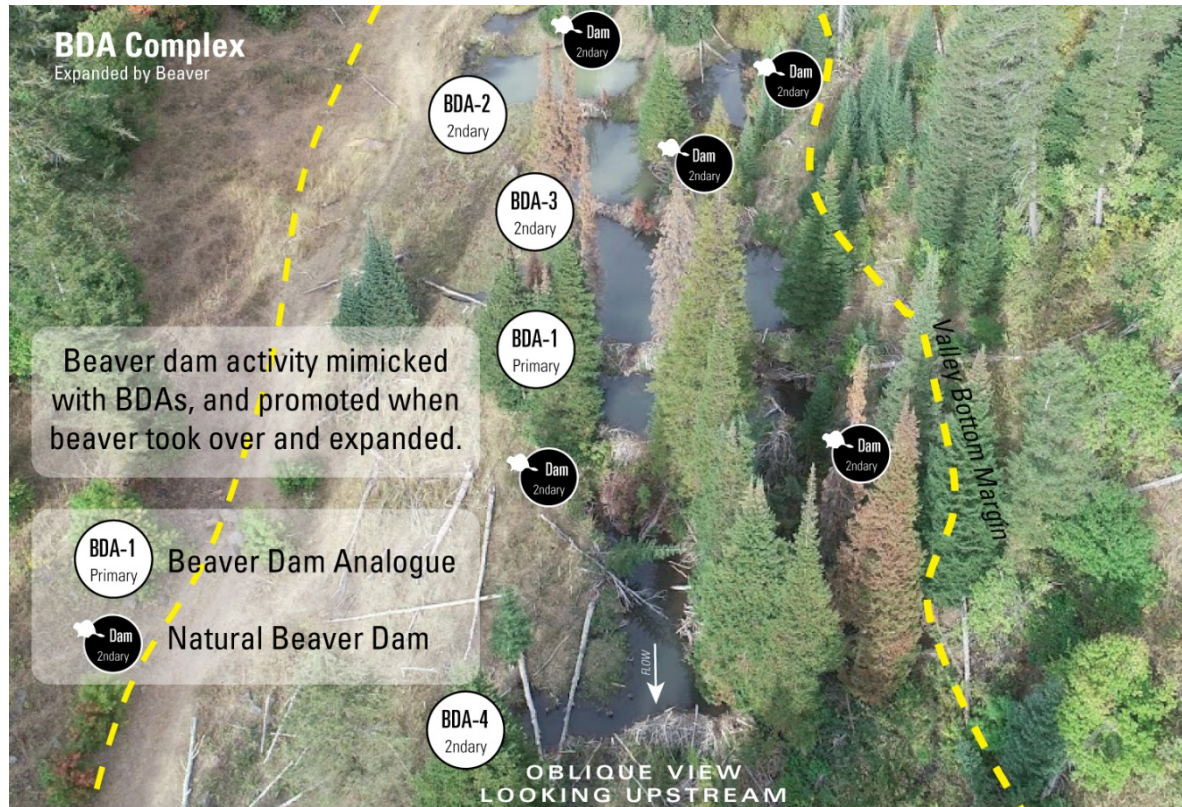
Artificial beaver dams are a hot restoration strategy, but the projects aren't always welcome

By Ben Goldfarb, in the Scott Valley, California

What's your exit strategy?

Mimic → Promote → Sustain

From Mimicking to Promoting to Sustaining **Processes**



How do your restoration actions:

- Immediately **mimic** a process?
- Quickly (relatively) **promote** a process?
- Eventually **sustain** a process?



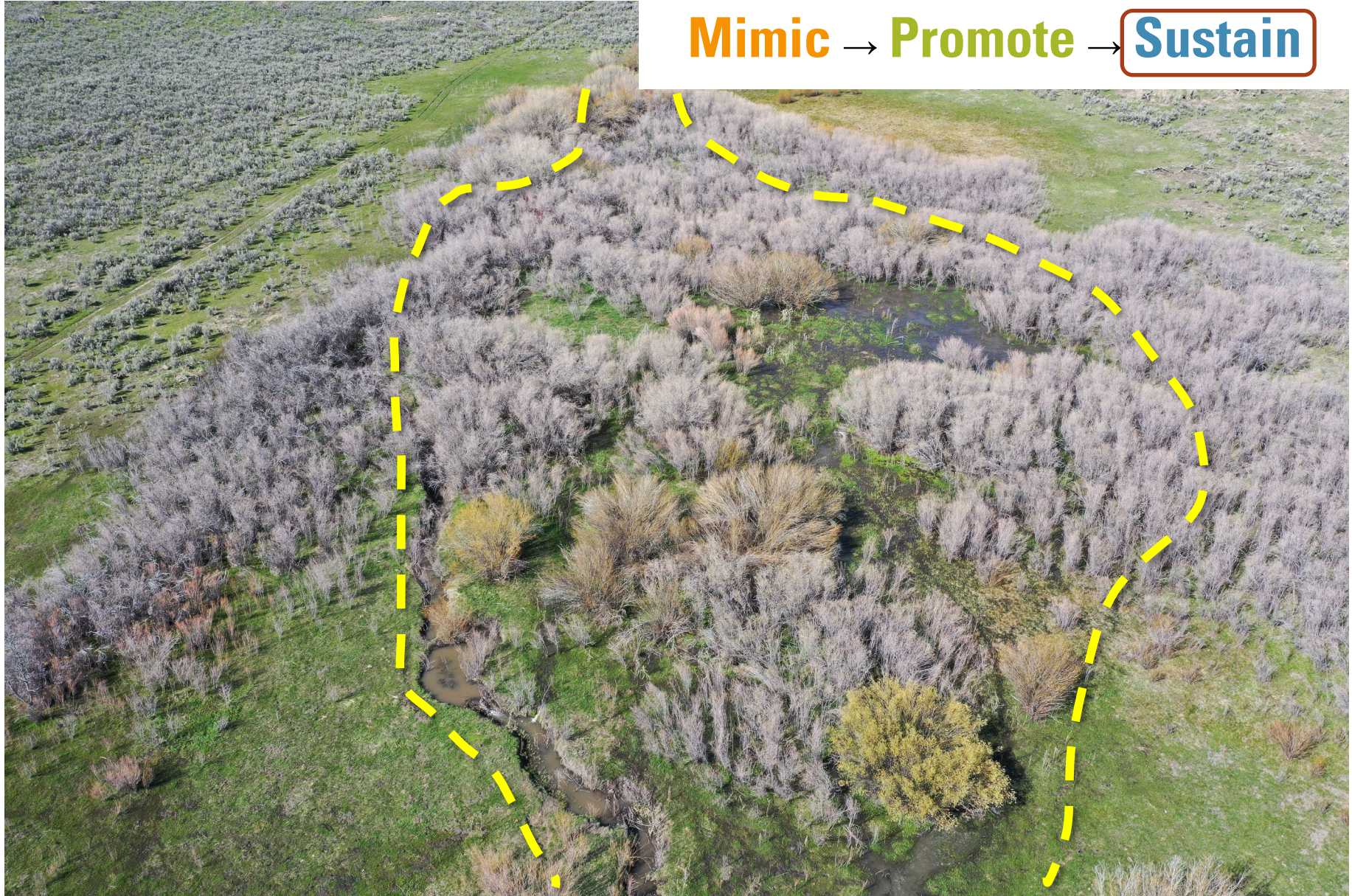
Mimic → **Promote** → **Sustain**

SELF-SUSTAINING SYSTEMS ARE THE SOLUTION
RESTORATION PRINCIPLE 10.

Adapted from Wheaton et al. (2019)

DOI: [10.13140/RG.2.2.19590.63049/1](https://doi.org/10.13140/RG.2.2.19590.63049/1).

Zone of Influence – Beaver Translocation



RESTORATION PRINCIPLES

5. It's okay to be **messy**
6. There is strength in **numbers**
7. Use **natural** building materials
8. Let the system **do the work**
9. **Defer decision making** to the system
10. **Self-sustaining** systems are the solution

Review: Restoration Principles



Ultimate goal is **Self-Sustaining systems**



Nick Weber



OBLIQUE VIEW
LOOKING UPSTREAM

From Wheaton et al. (2019) – LTPBR Manual

DOI: [10.13140/RG.2.2.19590.63049/1](https://doi.org/10.13140/RG.2.2.19590.63049/1)

What principle(s) does this represent?



What principle(s) does this represent?







What principle(s) does this represent?



What principle(s) does this represent?



Joe Wheaton

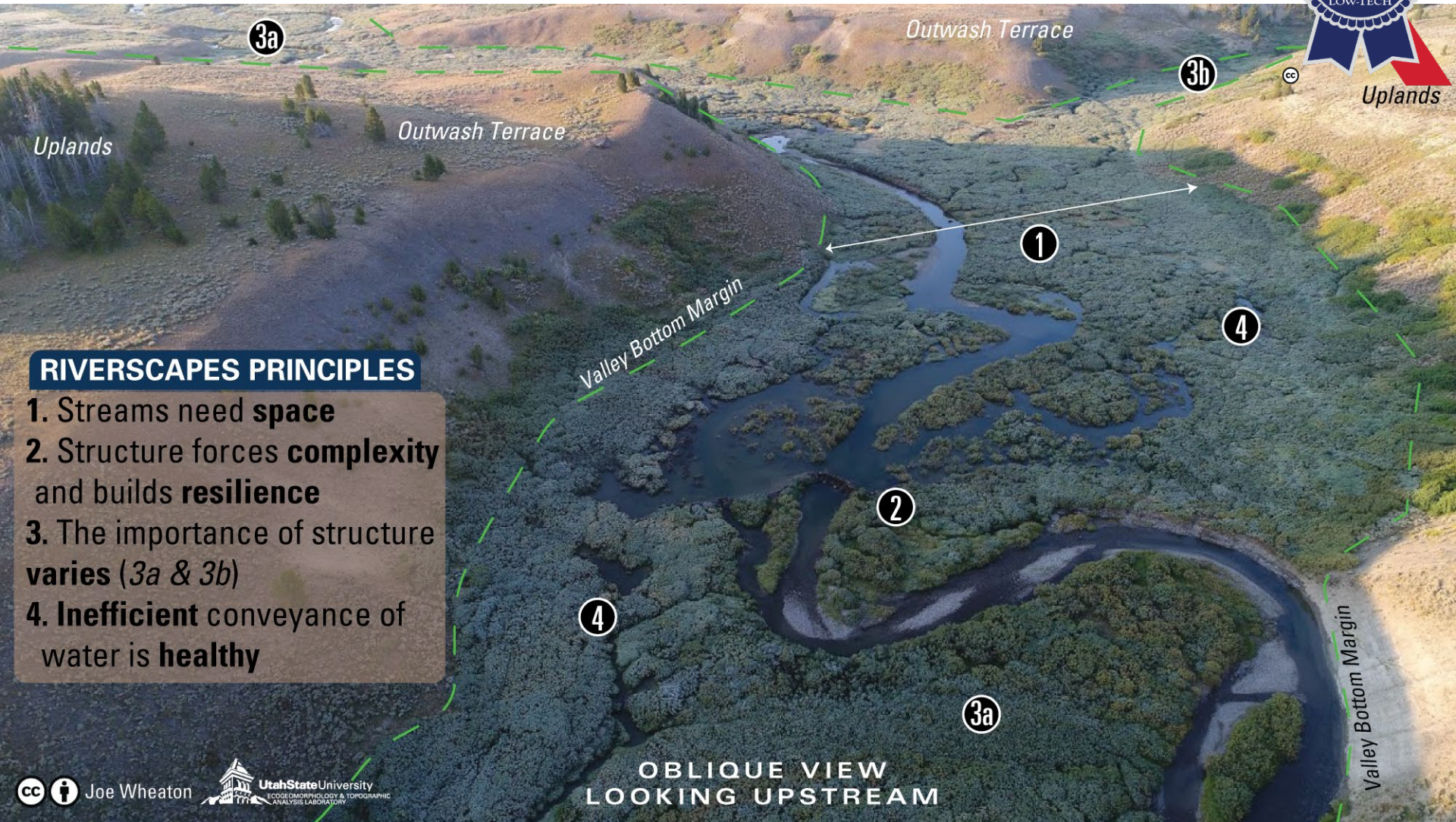
What principle(s) does this represent?



What principle(s) does this represent?



Riverscapes Principles



RIVERSCAPES PRINCIPLES

1. Streams need **space**
2. Structure forces **complexity** and builds **resilience**
3. The importance of structure **varies** (3a & 3b)
4. **Inefficient** conveyance of water is **healthy**

From pages 3-4 of Pocket Guide; Wheaton et al. (2019)

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

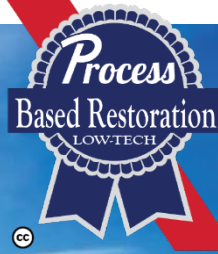
See Wheaton et al. (2019, p 60): Chapter 2 LTPBR Manual for Principles

DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

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Restoration Principles



From pages 3-4 of Pocket Guide; Wheaton et al. (2019)

DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

See Wheaton et al. (2019, p 72)

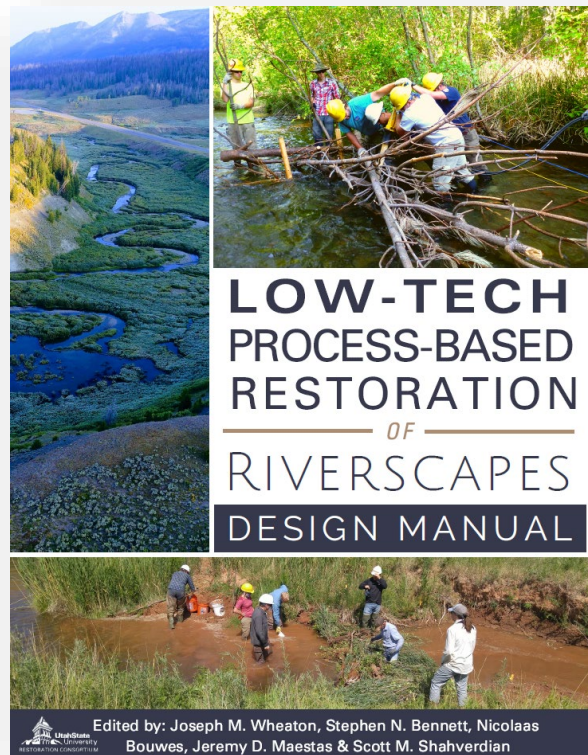
Chapter 2 LTPBR Manual for Principles

DOI: [10.13140/RG.2.2.34270.69447](https://doi.org/10.13140/RG.2.2.34270.69447)

Low-tech process-based restoration

noun

1. A practice of using simple, low unit-cost, structural additions (e.g., wood and beaver dams) to [riverscapes](#) to mimic functions and promote specific processes. Hallmarks of this approach include an explicit focus on the promoting geomorphic and [fluvial](#) processes, a conscious effort to use cost-effective, low-tech treatments (e.g., hand-built, natural materials, non-engineered, short-term design life-spans) because of the need to efficiently scale-up application, and 'Letting the [system](#) do the work', which defers critical decision making to riverscapes and beaver.



From Wheaton et al. (2019, p. 16)

DOI: [10.13140/RG.2.2.19590.63049/2](https://doi.org/10.13140/RG.2.2.19590.63049/2).