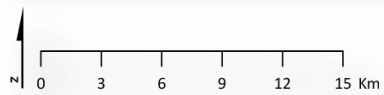
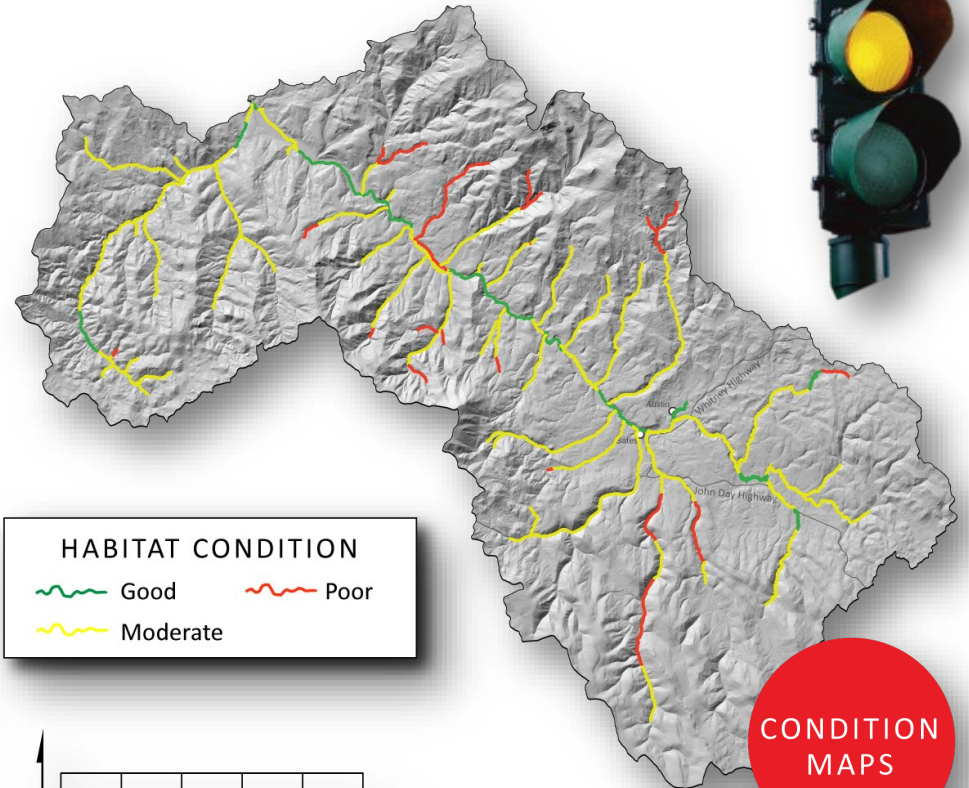
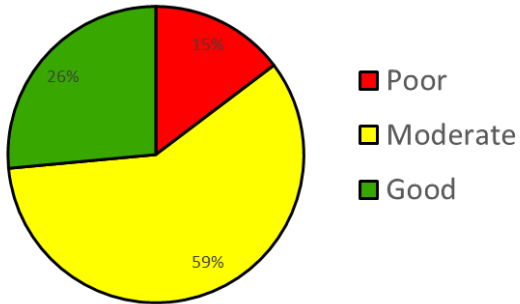




CONDITION & IMPAIRMENT ASSESSMENT



PURPOSE OF TODAY

- Build an understanding of condition & impairment assessment
- Focus on condition assessment as part of conservation planning process for any project
- Think about what condition is used for...



Problem is Simple to State...

- Scope of stream and mesic riparian degradation is massive
- Even with >> \$10 Billion spent annually, barely scratching surface
- We spend disproportionate amount of money on too few miles of streams and rivers
- Leaving millions of miles neglected...

[Agricultural Stream Ecosystem \(PDF\)](#)

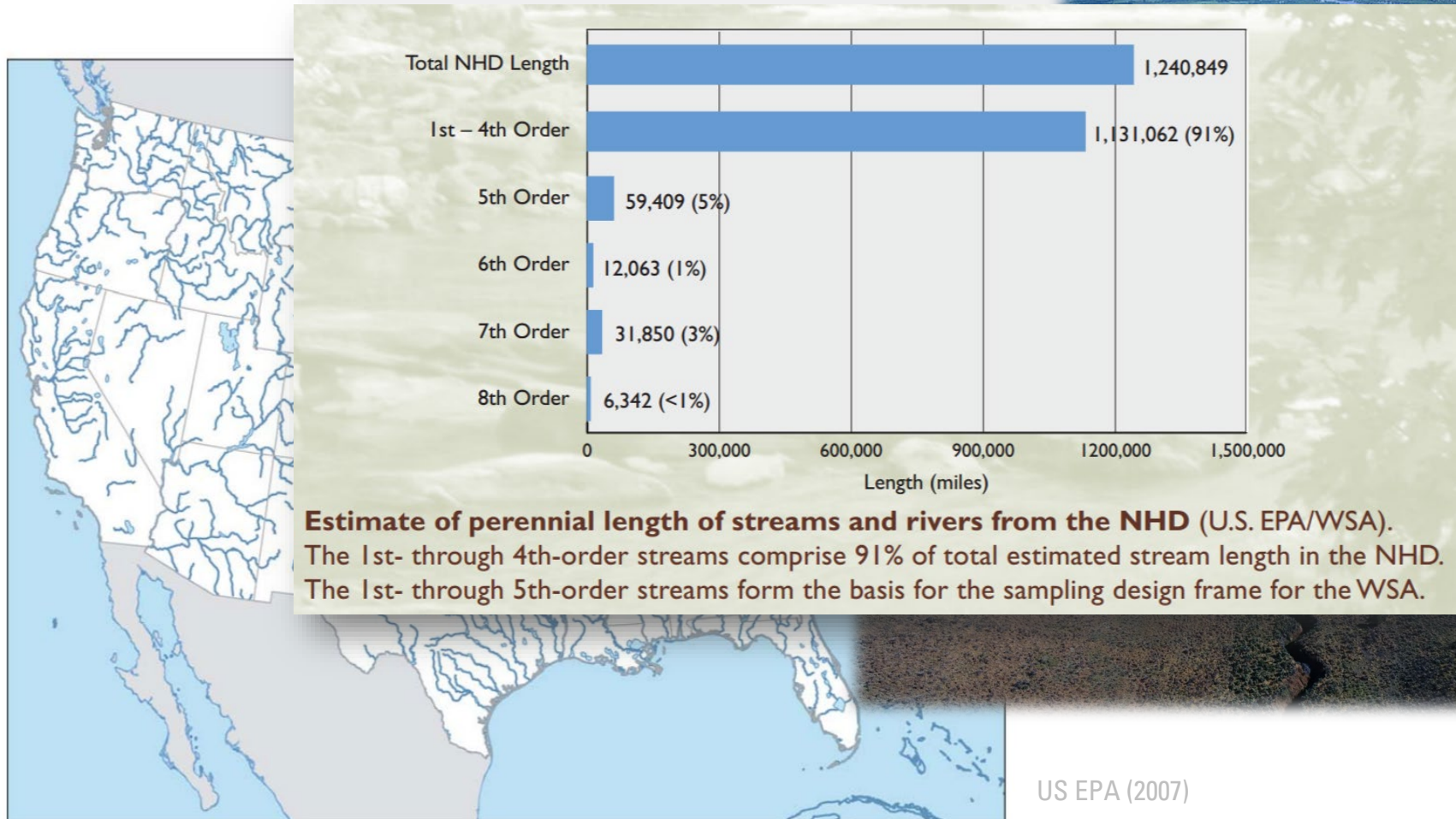


[Urban Stream Ecosystem \(PDF\)](#)



Big Rivers Are Important, But...

- They constitute < 3% of the 3.5 million miles of streams in US...

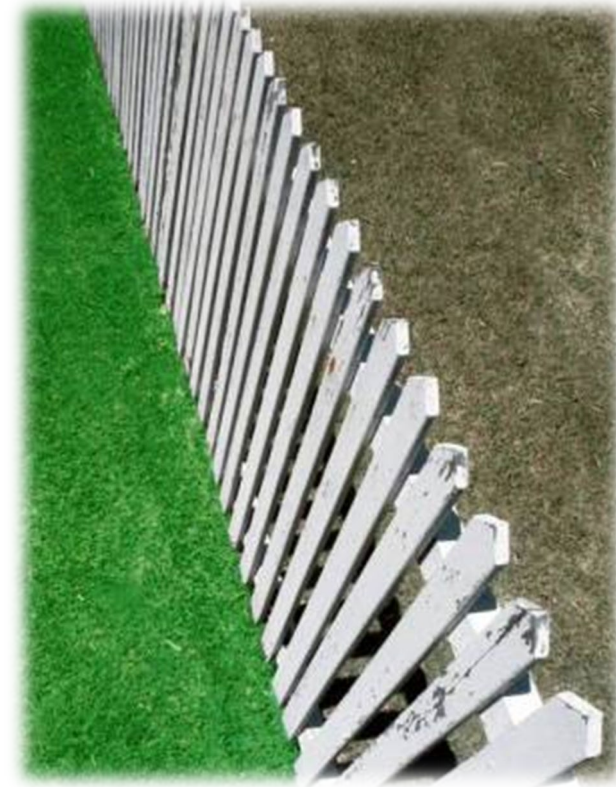


US EPA (2007)

Figure 3. Major rivers and streams of the conterminous United States (NationalAtlas.gov, 2006). Major rivers comprise only 10% of the length of U.S. flowing waters, whereas the nation's wadeable streams and rivers comprise 90% of the length of U.S. flowing waters.

Preamble to Condition...

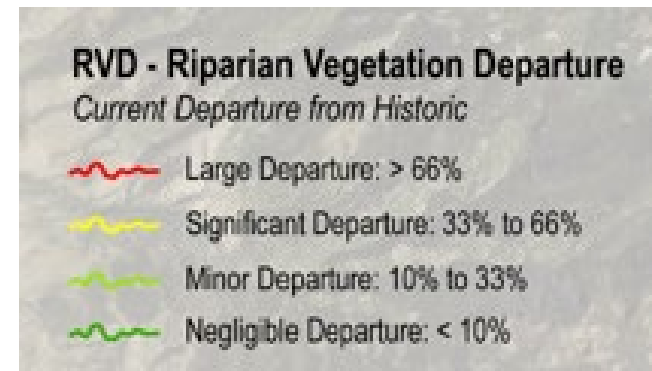
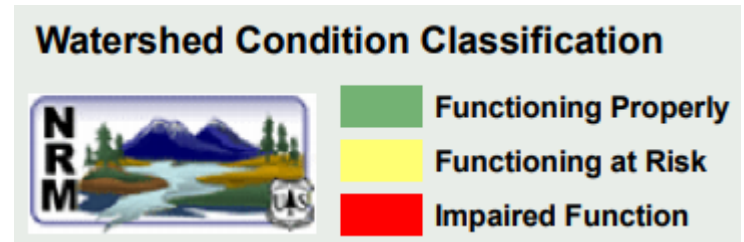
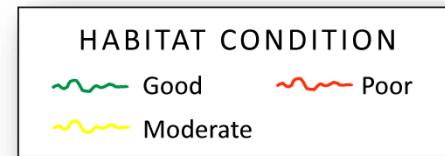
- Many ways to define restoration and the related management actions we take to improve things
- Regardless of definition, implicit in taking such restoration actions is the idea that *current conditions* are worse than either they were previously, or worse than they could be
- Thus, most restoration actions are focused on **improving** *current conditions* towards something better.
- We will discuss developing appropriate targets for condition and analogues when we get into recovery potential



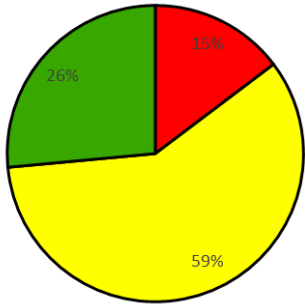
Condition Categories?

Condition can be described with:

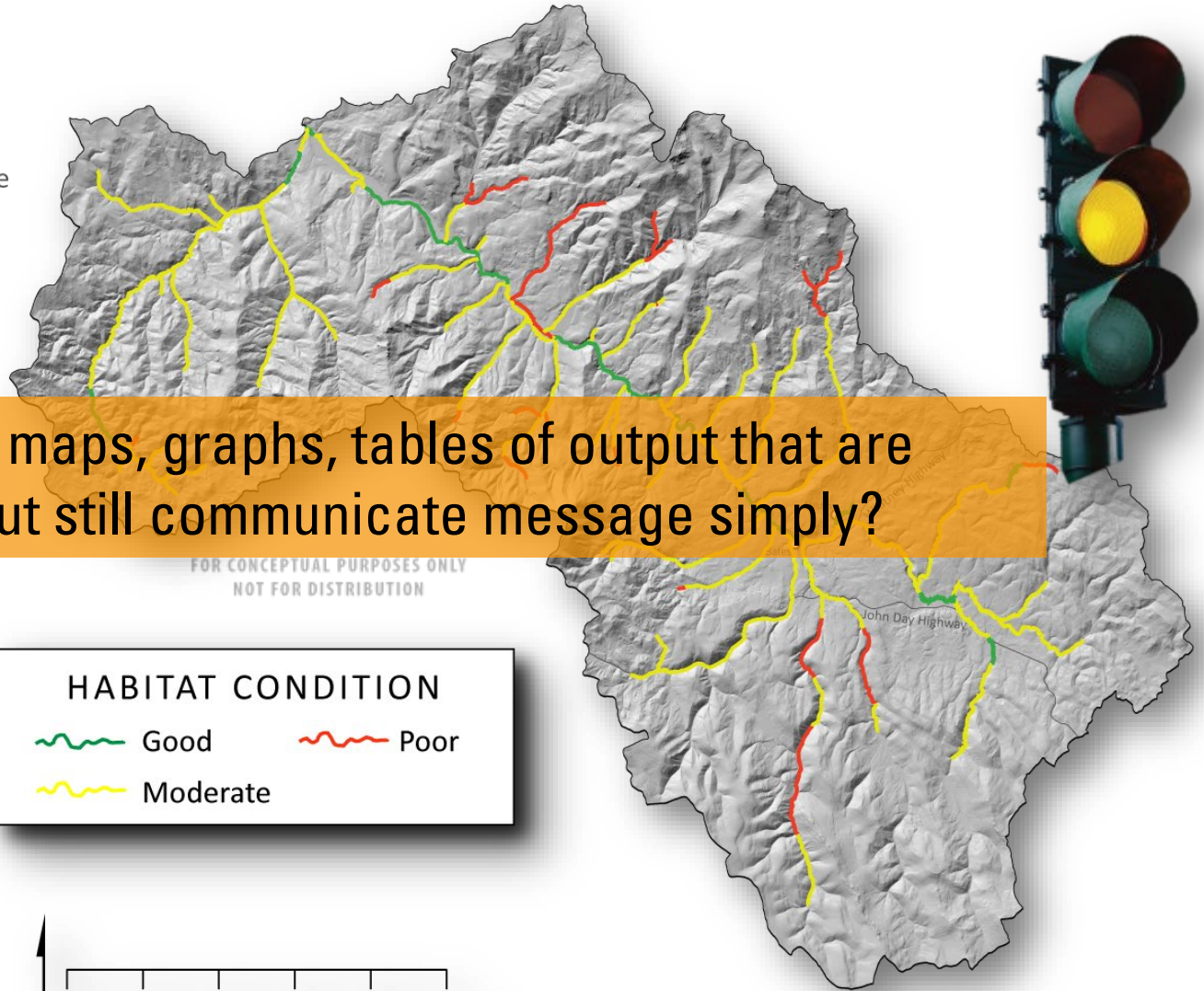
- Simple qualitative categories (e.g. poor, moderate, good intact),
- Descriptive categories (e.g. functioning properly, functioning at risk, impaired function)
- Some sort of continuous score (e.g. 0 to 100% departure from historic).



The Stop-Light Demand Dilemma



- Poor
- Moderate
- Good

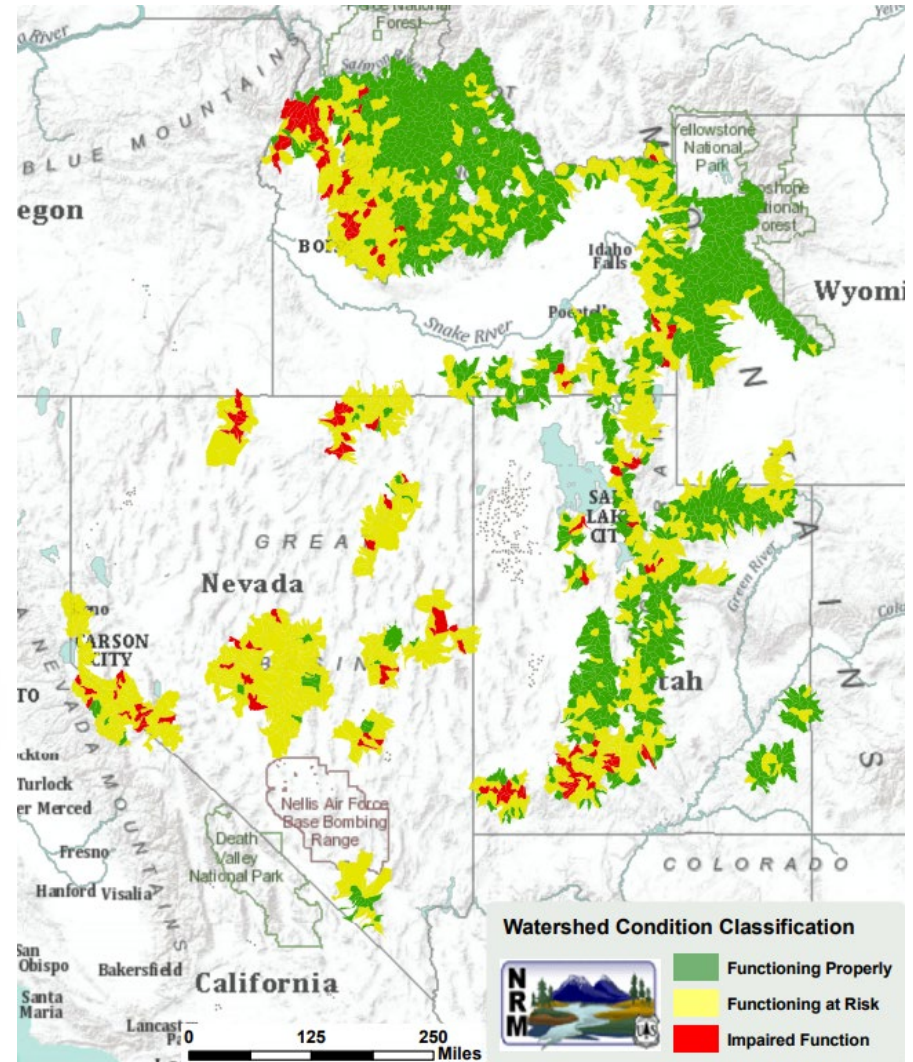
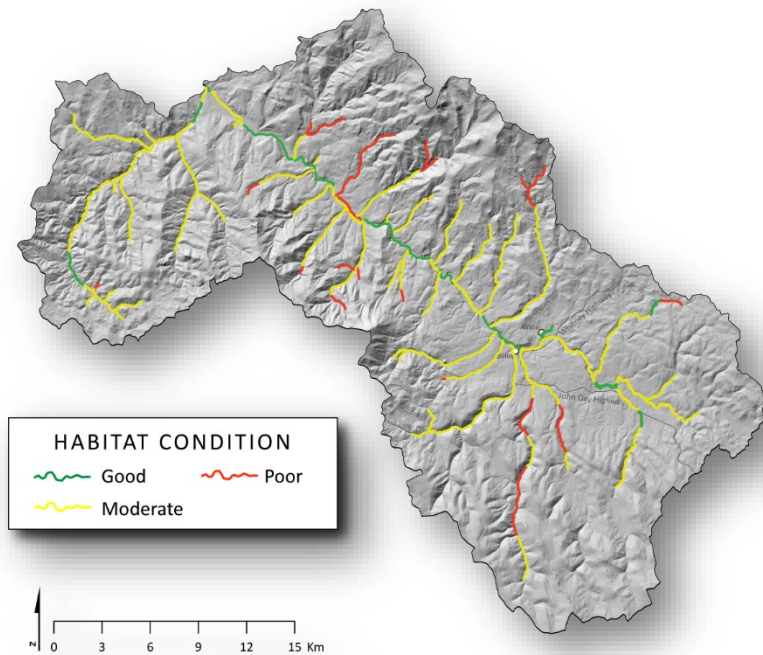


How to make maps, graphs, tables of output that are informative but still communicate message simply?

CONDITION
MAPS

Condition Geography

- Condition of what extent /resolution?



2. Riverscapes: a framework for understanding rivers

2.1. *The riverscape concept*

The concept of the “riverscape” dates to at least the 1960s, when Leopold and Marchand (1968) used the term to describe the large-scale physical, biological, and aesthetic nature of rivers. The most common use of the term today, originating in the early 2000s (Fausch et al., 2002; Poole, 2002; Ward et al., 2002b; Wiens, 2002) represents an ecological perspective that portrays rivers as a combination of broad scale trends in energy, matter, and habitat structure as well as local discontinuous zones and patches. The large and local extent variations affect the movement and dynamics of biological popula-

The term has become explicitly multi-scalar, and explicitly inter-disciplinary...

Making riverscapes real

Patrice Carbonneau ^a, Mark A. Fonstad ^{b,*}, W. Andrew Marcus ^c, St

Landscapes to Riverscapes: Bridging the Gap between Research and Conservation of Stream Fishes

KURT D. FAUSCH, CHRISTIAN E. TORGERSEN, COLDEN V. BAXTER, AND HIRAM W. LI

Rivers and streams, by their very nature long ribbons of aquatic habitat, are inherently difficult to study. Approaching the banks of a flowing-water (lotic) system, one can see only a short fragment of the entire stream, from one bend to another, and can gain little appreciation for important features that lie beyond view. Moreover, materials transported downstream by the flow, and organisms traveling up or down the hydraulic highway, are soon gone from the reach and the opportunity to study them is often lost. Lakes present their own challenges for study, but by contrast to streams, one can usually see large expanses from shore that encompass all major habitats needed for aquatic organisms to complete their life history, such as gravel shoals, beds of aquatic vegetation, and open water habitats. Much of our knowledge of the ecology of rivers and streams is based on observations and experiments on organisms and habitat in the short fragments we can view or quickly traverse on foot, and this limited understanding underpins our efforts at conservation of stream fishes. Here, we argue that this understanding is incomplete, like viewing only disjoint parts of a landscape painting through small holes in a curtain draping it. We propose that a continuous view of rivers is essential for effective research and conservation of their fishes and other aquatic biota—a view not just of disjoint reaches but of the entire spatially heterogeneous scene of the river environment, the riverscape, unfolding through time.

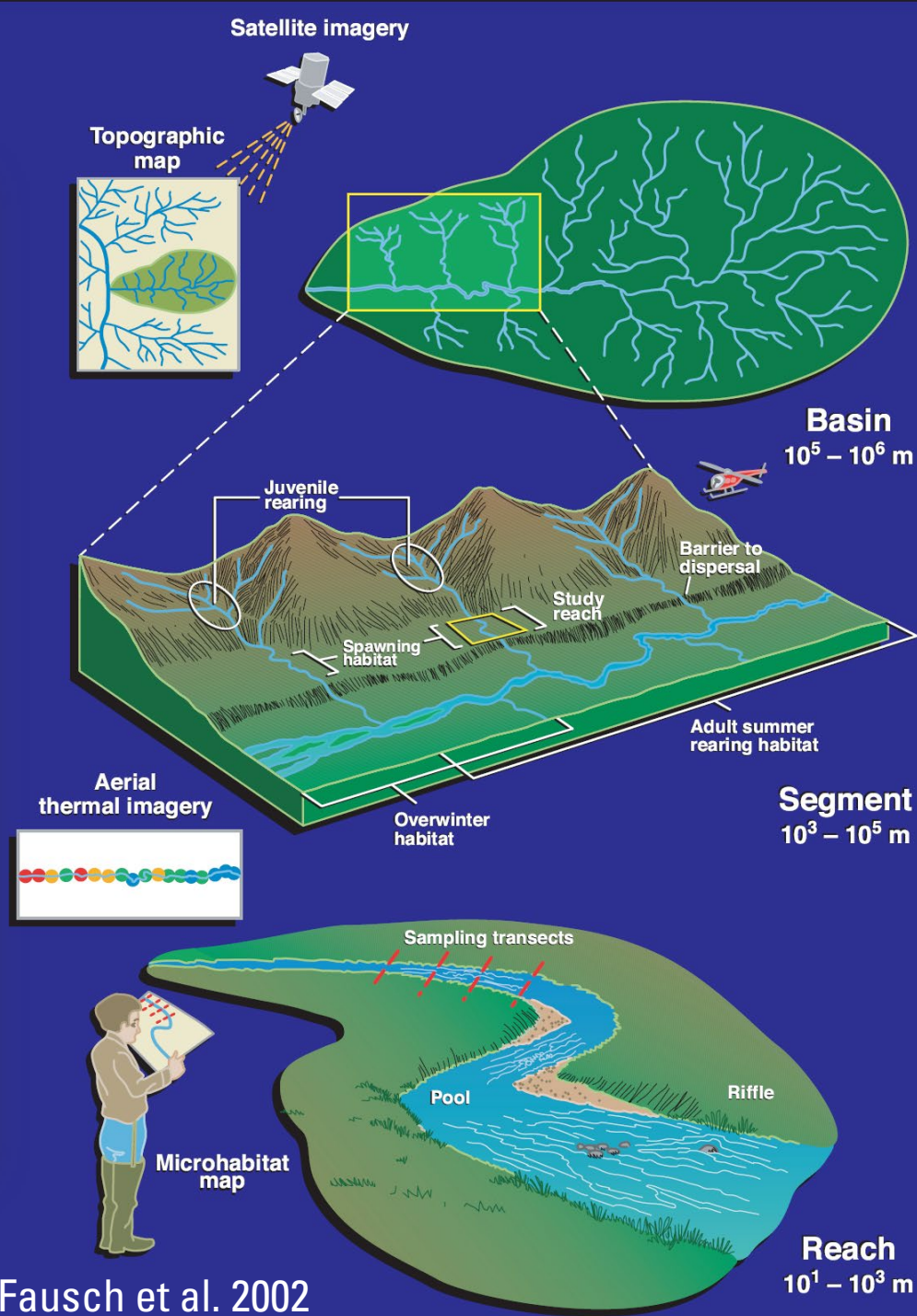
One symptom of our incomplete understanding is the alarming rate of decline over the last 50 years of fishes that inhabit rivers and streams of North America. The public is aware that salmon are disappearing from the Pacific Northwest, with about a quarter of the 214 stocks of anadromous salmon and trout imperiled a decade ago (Nehlsen et al. 1991). Even little-known small fishes native to Great Plains and southwestern desert streams have suffered drastic declines

A CONTINUOUS VIEW OF THE RIVER IS
NEEDED TO UNDERSTAND HOW PROCESSES
INTERACTING AMONG SCALES SET THE
CONTEXT FOR STREAM FISHES AND THEIR
HABITAT

(Minckley and Douglas 1991, Fausch and Bestgen 1997), and many are now either protected by federal or state listing as endangered or threatened species or are being considered for such protection. North America harbored the greatest diversity worldwide of temperate freshwater fishes (Warren and Burr 1994), crayfishes (Taylor et al. 1996), and mussels (Williams et al. 1993), but about 30% to 75% of the taxa in each group are at increased risk of extinction (i.e., categorized as rare, threatened, or endangered species). Fishes are also the most imperiled vertebrates worldwide (Allan and Flecker 1993, Leidy and Moyle 1998) and a large proportion spend at least part of their lives in streams.

Kurt Fausch (e-mail: kurt@concolorstate.edu) is a professor in the Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO 80523. Christian Torgersen and Colden Baxter are graduate students, and Hiram Li is a professor, in the Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331. Li is also assistant unit leader of the Oregon Cooperative Fish and Wildlife Research Unit, Biological Resources Division, US Geological Survey. © 2002 American Institute of Biological Sciences.

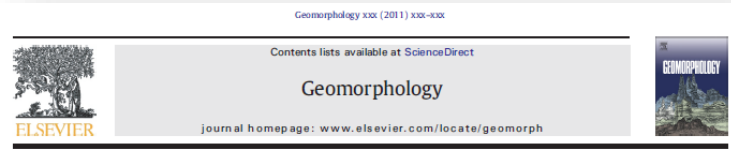
June 2002 / Vol. 52 No. 6 • BioScience 483



Fausch et al. 2002

Landscapes to riverscapes: by conservation of stream fishes understand how ...
 KD Fausch, CE Torgersen, CV Baxter...
 Fisheries ecologists have attempted to populations and assemblages by conduct Typical studies have consisted of obser Cited by 1032 Related articles All 16

ONS...



Making riverscapes real

Patrice Carbonneau ^a, Mark A. Fonstad ^{b,*}, W. Andrew Marcus ^c, Stephen J. Dugdale ^d

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ABSTRACT

The structure and function of rivers have long been characterized either by: (1) qualitative models such as the River Continuum Concept or Serial-Discontinuity Concept which paint broad descriptive portraits of how river habitats and communities vary, or (2) quantitative models, such as downstream hydraulic geometry, which rely on a limited number of measurements spread widely throughout a river basin. In contrast, authors such as Fausch et al. (2002) and Wiens (2002) proposed applying existing quantitative, spatially comprehensive ecology and landscape ecology methods to rivers. This new framework for river sciences which preserves variability and spatial relationships is called a riverine landscape or a 'riverscape'. Application of this riverscape concept requires information on the spatial distribution of organism-scale habitats throughout entire river systems. This article examines the ways in which recent technical and methodological developments can allow us to quantitatively implement and realize the riverscape concept. Using 3-cm true color aerial photos and 5-m resolution elevation data from the River Tromie, Scotland, we apply the newly developed Fluvial Information System which integrates a suite of cutting edge, high resolution, remote sensing methods in a spatially explicit framework. This new integrated approach allows for the extraction of primary fluvial variables such as width, depth, particle size, and elevation. From these first-order variables, we derive second-order geomorphic and hydraulic variables including velocity, stream power, Froude number and shear stress. Channel slope can be approximated from available topographic data. Based on these first and second-order variables, we produce riverscape metrics that begin to explore how geomorphic structures may influence river habitats, including connectivity, patchiness of habitat, and habitat distributions. The results show a complex interplay of geomorphic variable and habitat patchiness that is not predicted by existing fluvial theory. Riverscapes, thus, challenge the existing understanding of how rivers structure themselves and will force development of new paradigms.

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1. Introduction: views of the river

"...we perceive a need to conceptualize rivers not as sampling points, lines, or gradients, but as spatially continuous longitudinal and lateral mosaics. As such, heterogeneity in the river landscape, or riverscape, becomes the focus of study" Fausch et al. (2002) (p. 3)

In this seminal work, Fausch et al. (2002) argue that the temporal and spatial scales of the processes that drive stream ecology often remain unsampled in our basic methodologies. Indeed, for over a century, river morphology and habitat has either been sampled with highly localized, high resolution, point sampling methods (e.g. Heggenes, 1996; Buffin-Bélanger et al., 2006) or broadly spaced surveys yielding average trends

in river response at watershed scales (e.g. Leopold and Maddock, 1953; Allan and Johnson, 1997; Rice and Church, 1998). One consequence of this approach is that the broadly spaced averaging approaches have been the major source of input into theory. This has led to the widely-accepted view that the flow of water, other materials, and energy produces an environment that changes relatively smoothly and predictably through space (Vannote et al., 1980; Leopold, 1994).

The continuous view of river systems and its characteristic gradual, averaged, variation of key parameters like grain size, depth and width has been strongly challenged, however, by a number of authors who argue that discontinuities and variations are key to characterizing river systems (Ward and Stanford, 1983a,b; Fausch et al., 2002; Ward et al., 2002a,b; Wiens, 2002; Thorp et al., 2006, 2008, 2010). This body of literature establishes an important conceptual framework of rivers as holistic systems where process scales range from small microhabitats to entire watersheds. The need to test these concepts with quantitative data, thus, making these conceptual, highly-abstracted riverscapes 'real', has created the impetus to change our approach to

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A Riverscape Analysis Tool Developed to Assist Wild Salmon Conservation Across the North Pacific Rim

FEATURE
Fisheries Conservation and Management

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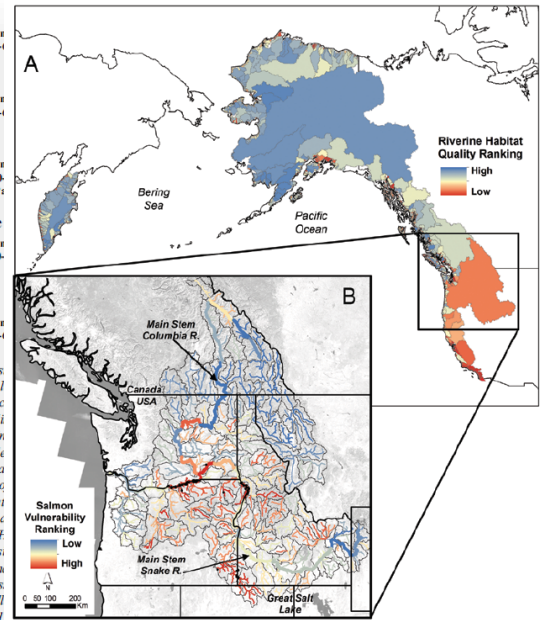
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 CA 69093

Jack A. Stanford

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Una herramienta de análisis fluvial desarrollada para apoyar la conservación del salmón silvestre a lo largo de la cordillera del Pacífico Norte

RESUMEN: Una de las limitantes en el manejo y conservación del salmón silvestre es la enorme extensión

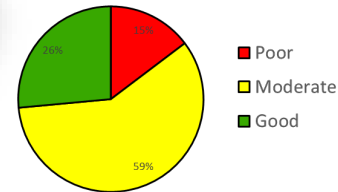
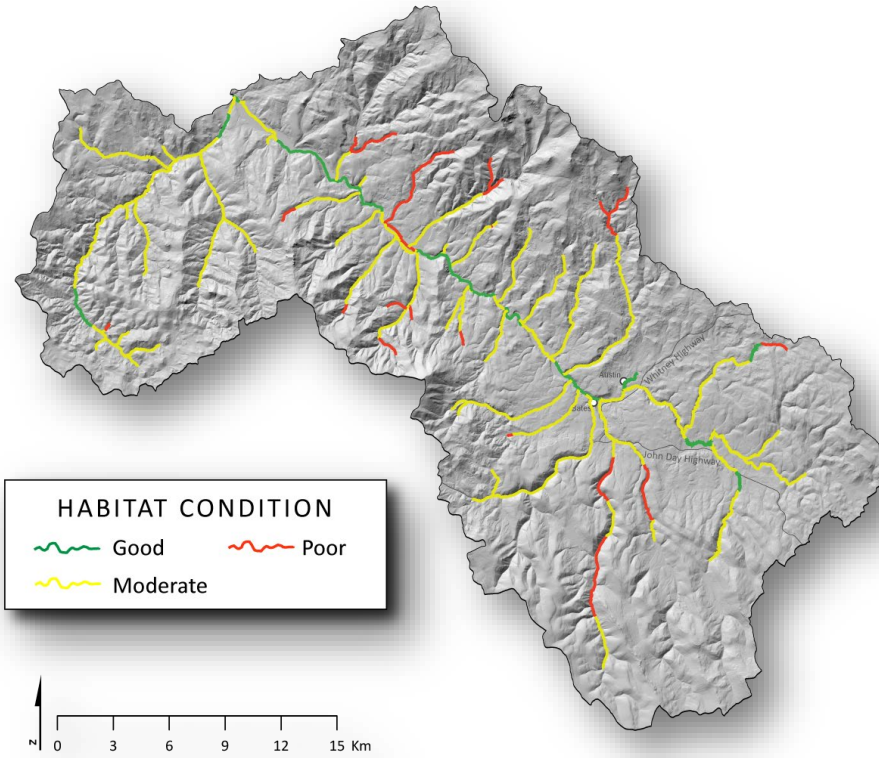


ABSTRACT: A major conservation of wild salmon is the of rivers that provide critical production and sustainability entire river systems, cross-jurisdictional, while and landscape conditions a the Riverscape Analysis Pro and comprehensive geospatial and compare the physical the North Pacific Rim (NPR). E a web-based GIS and decision, salmon conservation around, RAP database is a seamless, multispectral satellite instrument series, mapped digital terrain Digital Evaluation (DEM) information to a consistent global projection; these data produced a set of watershed, river and floodplain physical features and derived riverine freshwater habitat metrics important for salmon. The

(conservation) and are necessary for the production and sustainability of wild salmon populations. Freshwater habitat abundance and distribution are generally poorly defined for the majority of the NPR and are increasingly influenced by hu-

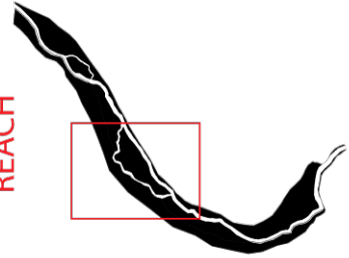
Argument for Network Scale

'A **continuous** view of the river is needed to understand how processes interacting among scales set the context for stream fishes and their habitat' – Fausch et al. (2002)

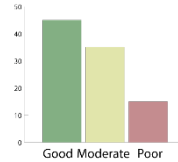
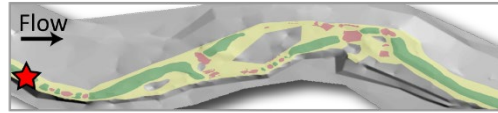


The Scale Crux...

REACH



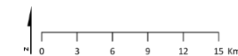
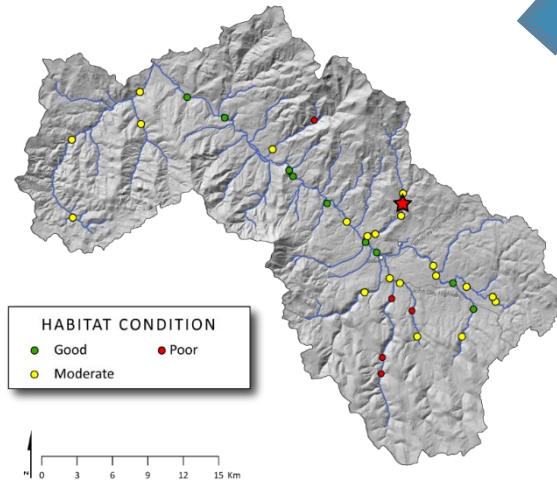
① SITE LEVEL



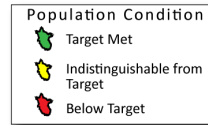
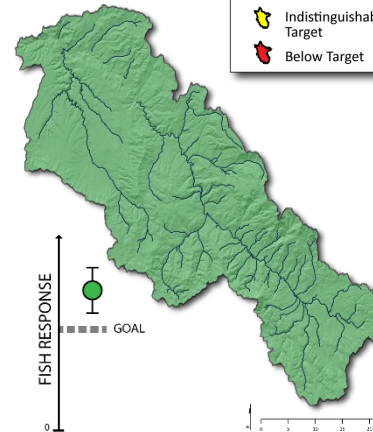
② SITE SUMMARY:

③ SITES ON NETWORK

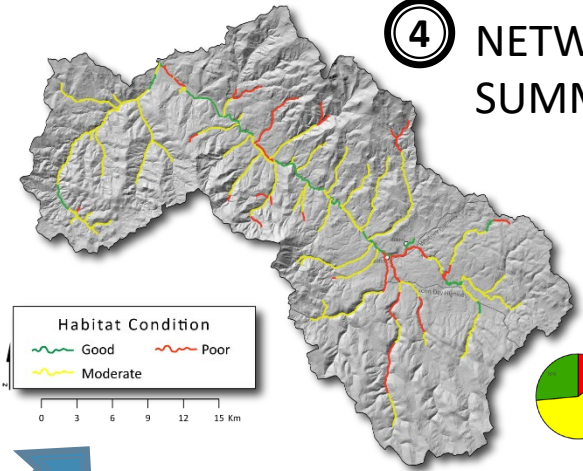
NETWORK



⑤ WATERSHED / POPULATION



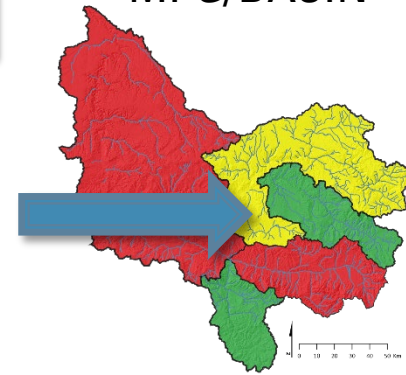
④ NETWORK SUMMARY



BASIN



⑥ MPG/BASIN



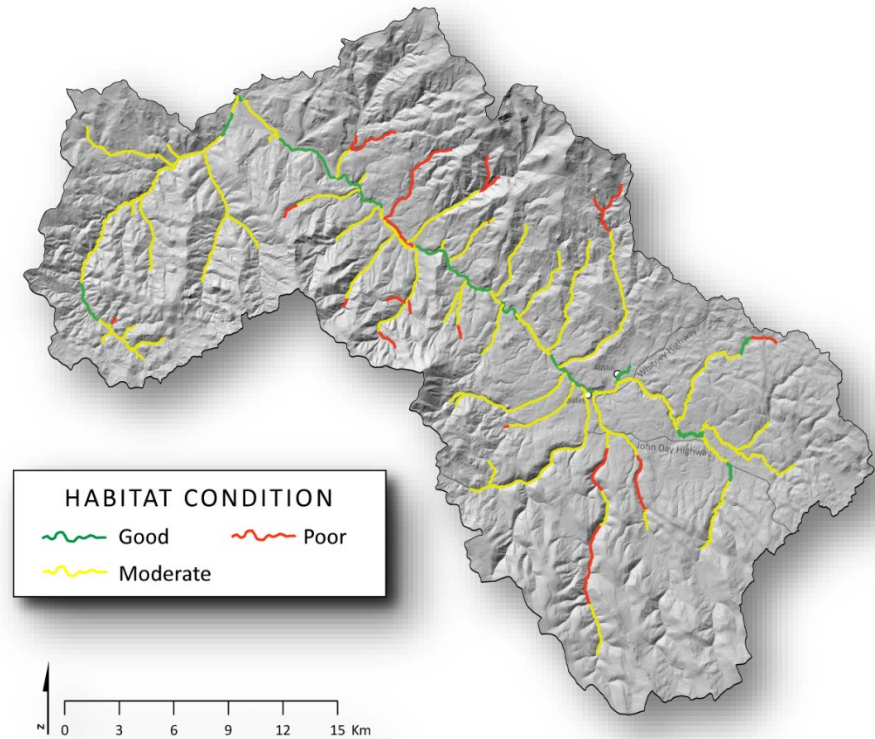
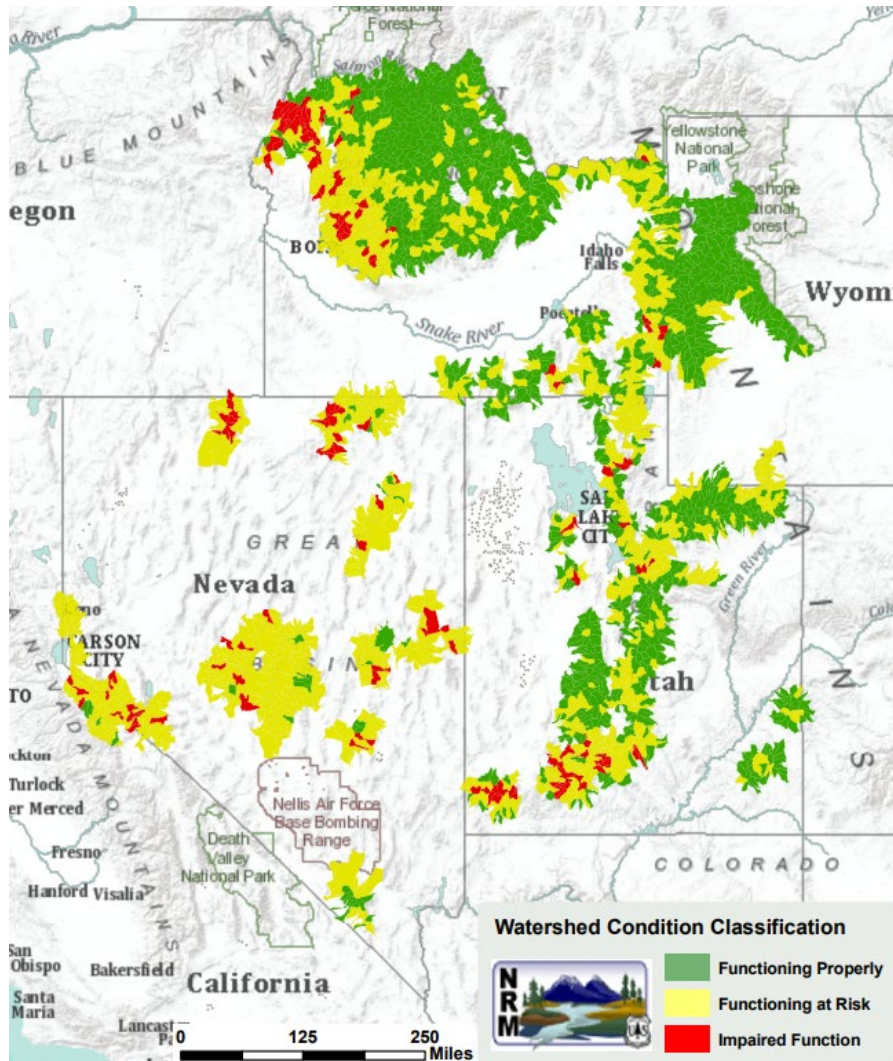
FOR CONCEPTUAL PURPOSES ONLY
NOT FOR DISTRIBUTION

Condition of What?

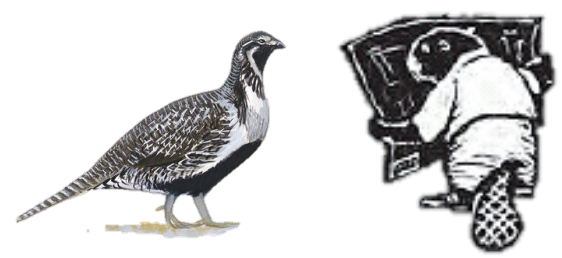
- What **type** of **condition** are we talking about?
 - Is this the **condition** of a **particular population** of species of concern (e.g. fish~ McHugh et al 2017; Wheaton et al. 2017) or that species' **habitat condition** (e.g. beaver habitat - Macfarlane et al 2015)?
 - Is this some integrated measure of **ecosystem condition** or multiple species that are indicative of such condition (e.g. biotic integrity censu Hawkins et al. 2000)?
 - Are we concerned with **riparian conditions** (e.g. Macfarlane et al. 2016) or **wetland conditions** or floodplain **condition**?
 - Is it a **physical condition** (geomorphic, hydrologic)?
- There are many lenses by which we can consider **condition**, and its important to be clear what specific aspect of **condition** we are considering.



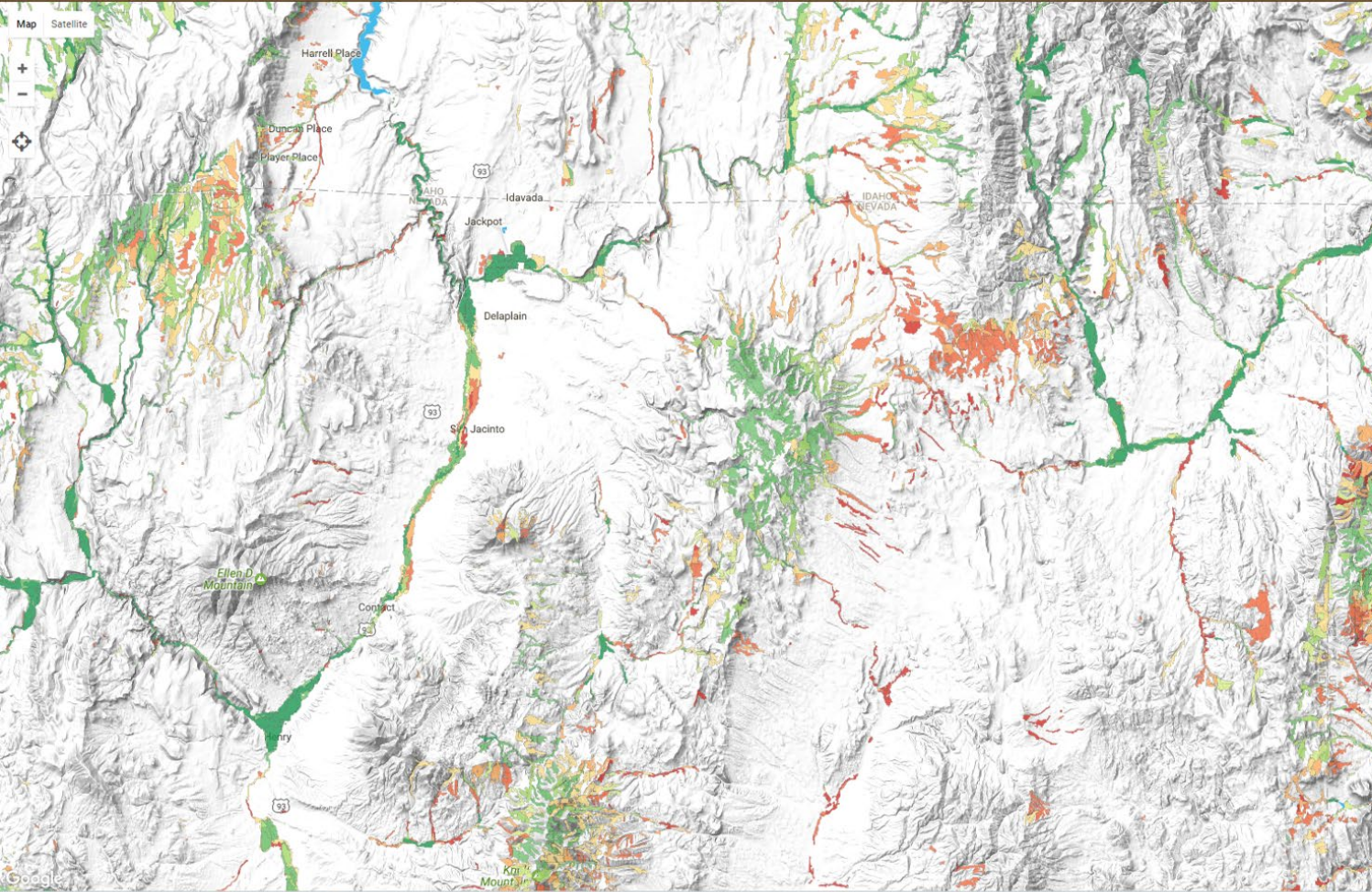
Do Impairments Come Out of Condition Assessment or Limiting Factors Assessment?



OUTLINE



- I. Discussion of Trail Creek
- II. Condition & Impairment Definitions
- III. Condition & Impairment Methods**
- IV. Riverscapes Network Examples
 - I. VBET
 - II. RCAT
 - III. BRAT
- V. Decide Homework... 'Condition Assessment / Impairment Reports'



- TREE CANOPY COVER >
- ECOSYSTEM RESILIENCE & RESISTANCE >
- CULTIVATION RISK >
- MESIC RESOURCES >

Mesic Resources ⓘ

Turn on to display average of all years. (1984-2016)

Color represents the percentage of years the mesic resource was productive

0 100
Mesic Legend

Layer Transparency:

View specific years

Custom analysis

Zoom in and click on a polygon to show a time series chart of productivity.

map.sagegrouseinitiative.com



TREE CANOPY COVER >

ECOSYSTEM RESILIENCE & RESISTANCE >

CULTIVATION RISK >

MESIC RESOURCES v

Mesic Resources ⓘ

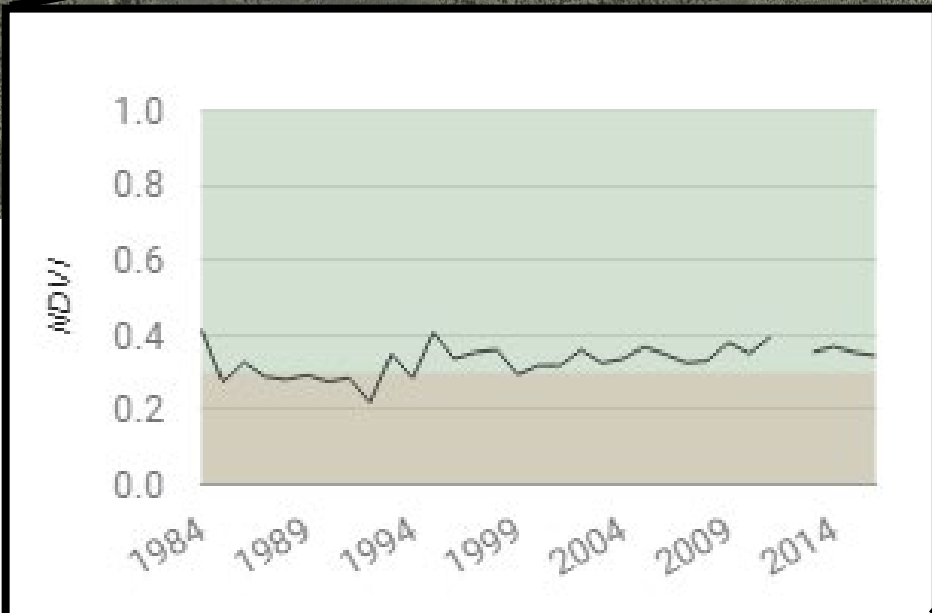
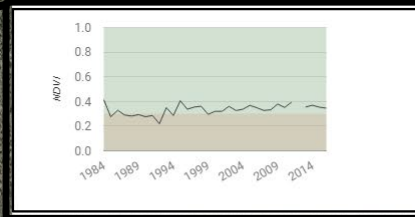
Persistence of mesic resources from 1984 to 2016. Color represents the percentage of years the mesic resource was productive in the late season. Click on a specific resource to view a time series chart of late season productivity.

0 100
Years productive (%)

Layer Transparency:

View specific years

Custom analysis

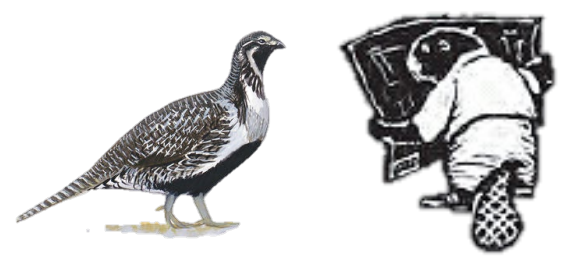


Google Earth Engine

IN YOUR FIRMS... REVIEW & REPORT BACK

- Geomorphic Condition (censu Brierley & Fryirs (2005; chap 10; and Fryirs 2015)
- Watershed Condition (censu [USFS 2011](#))
- Wadeable Streams Assessment (censu [EPA 2004](#))

OUTLINE



- I. Discussion of Trail Creek
- II. Condition & Impairment Definitions
- III. Condition & Impairment Methods
- IV. Riverscapes Network Examples**
 - I. VBET
 - II. RCAT
 - III. BRAT
- V. Decide Homework... 'Condition Assessment / Impairment Reports'

RESTORATION PROCESS



```
graph LR; A[Planning] --> B[Design]; B --> C[Implementation]
```

Planning

Design

Implementation

Add Adaptive Management

Standard NRCS CPP
with Adaptive
Management:
i.e. evaluate &
adjust

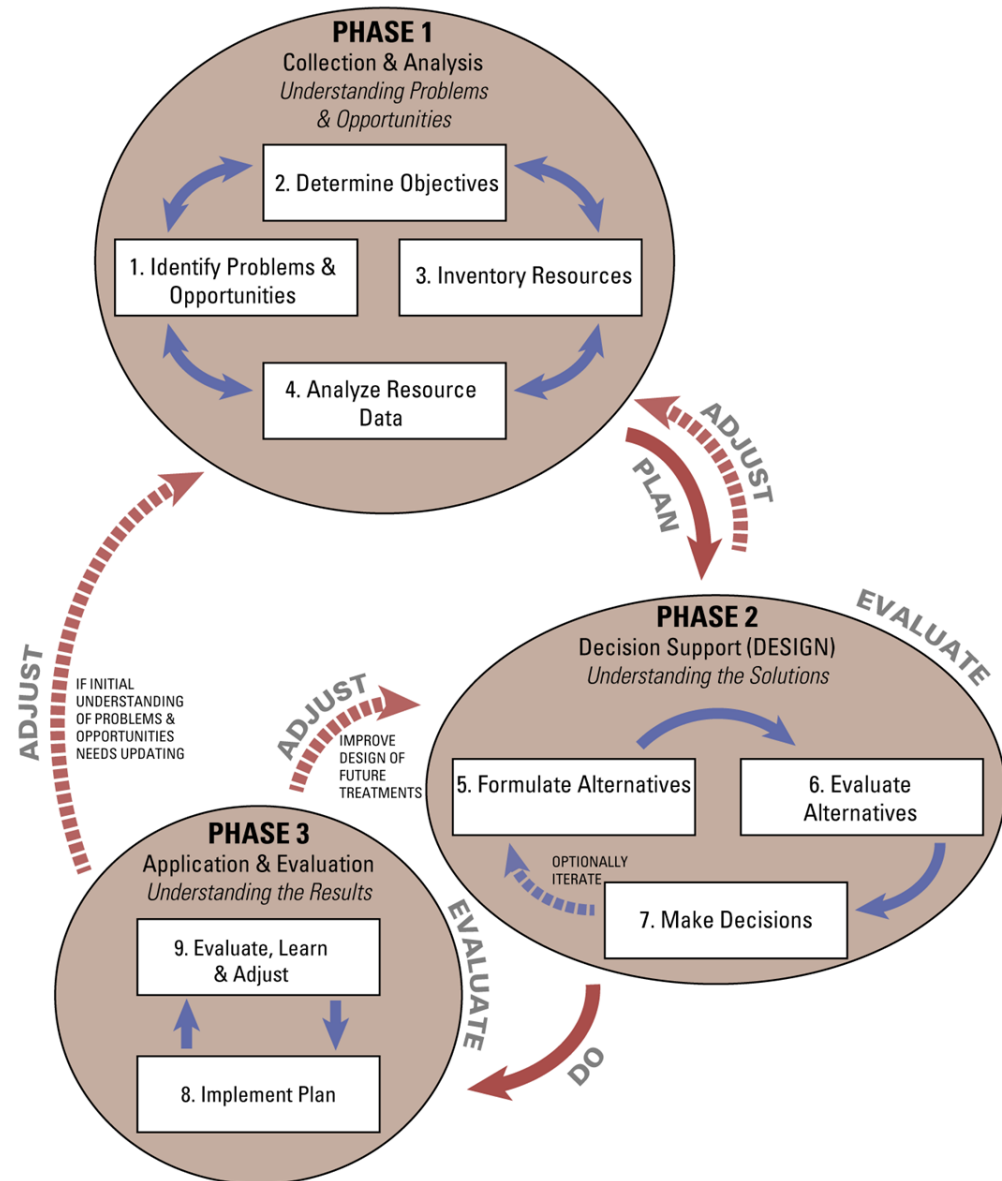
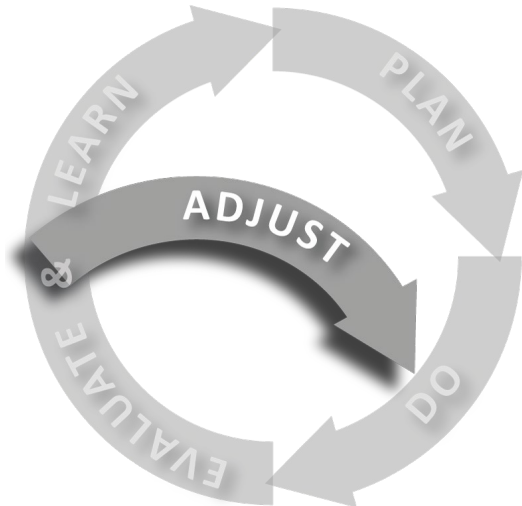


Figure 3.1 (p. 89) from Bennett et al. (2019)

Adapted for Low-Tech PBR

- Condition feeds design
- Design decisions feed implementation
- Number of treatments estimated in design

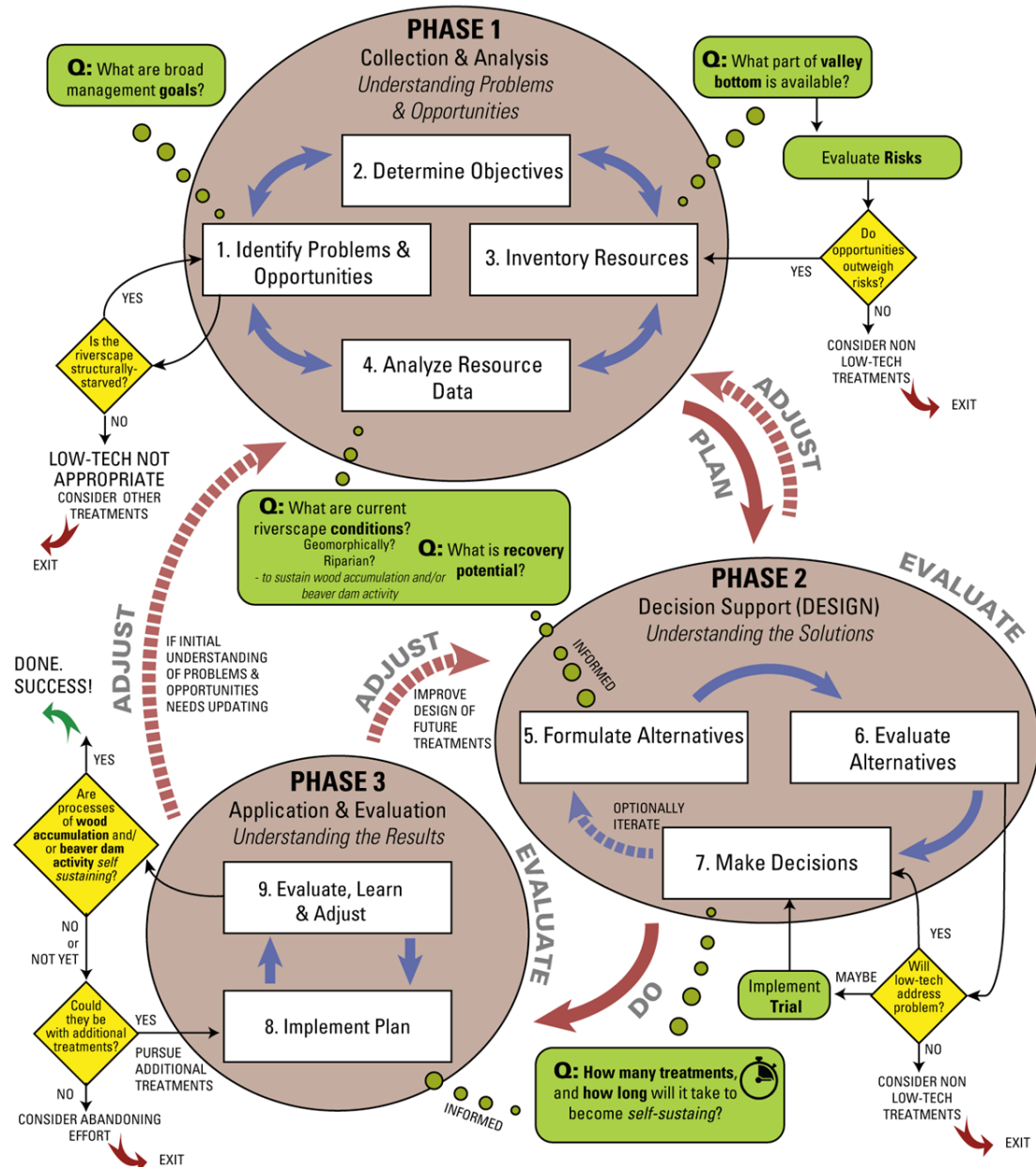


Figure 3.20 from Bennett et al. (2019, p 115)

From Chapter 3 of LTPBR Manual



Bennett et al. (2019) – Chapter 3 LTPBR Manual

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

OUTLINE: Low-Tech Planning



I. Review

II. Conservation Planning Process

I. Phase 1 – **Planning**

II. Phase 2 – Design

III. Phase 3 - Implementation

PHASE 1 with Low-Tech

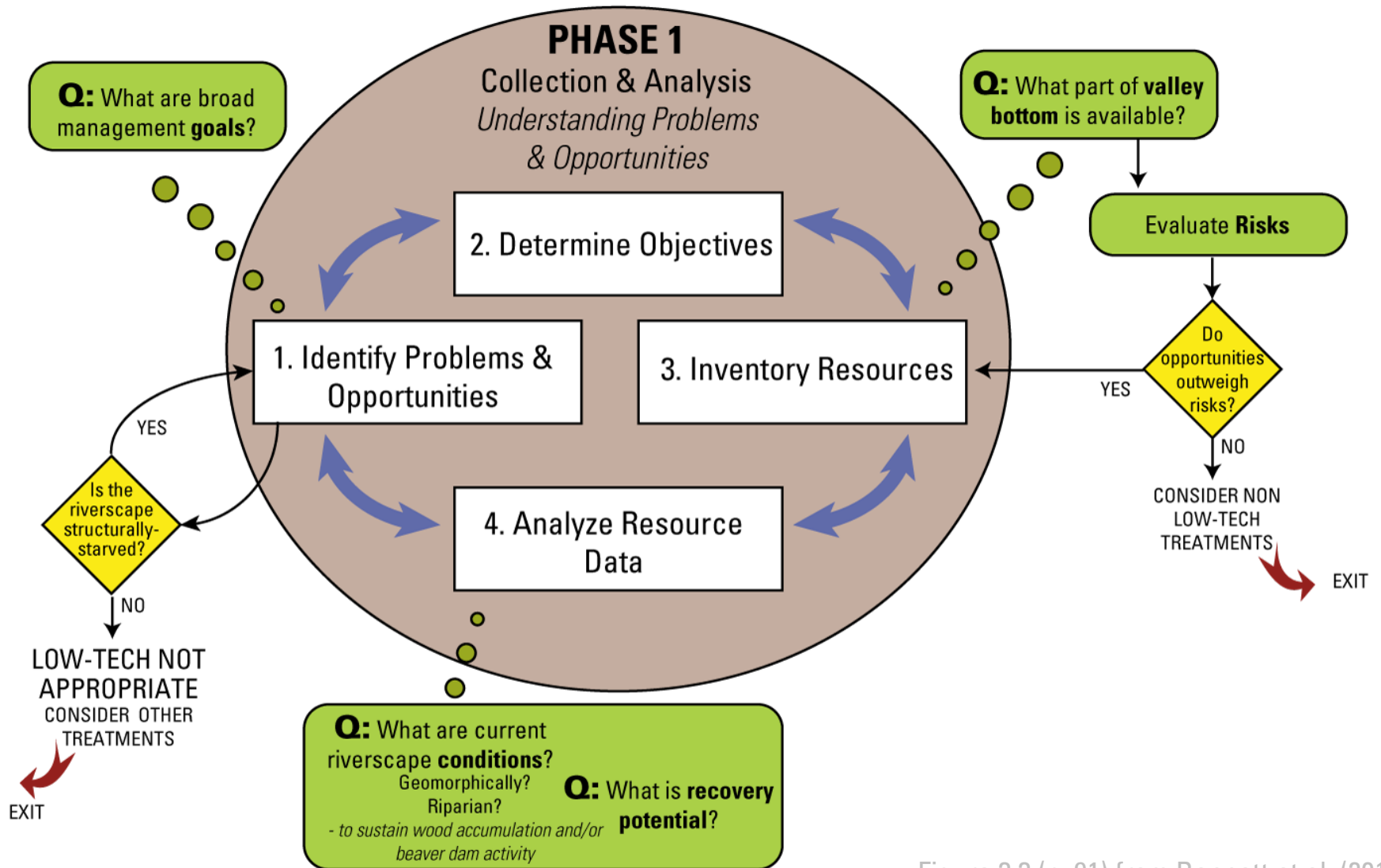


Figure 3.3 (p. 91) from Bennett et al. (2019)

PHASE 1 with Low-Tech

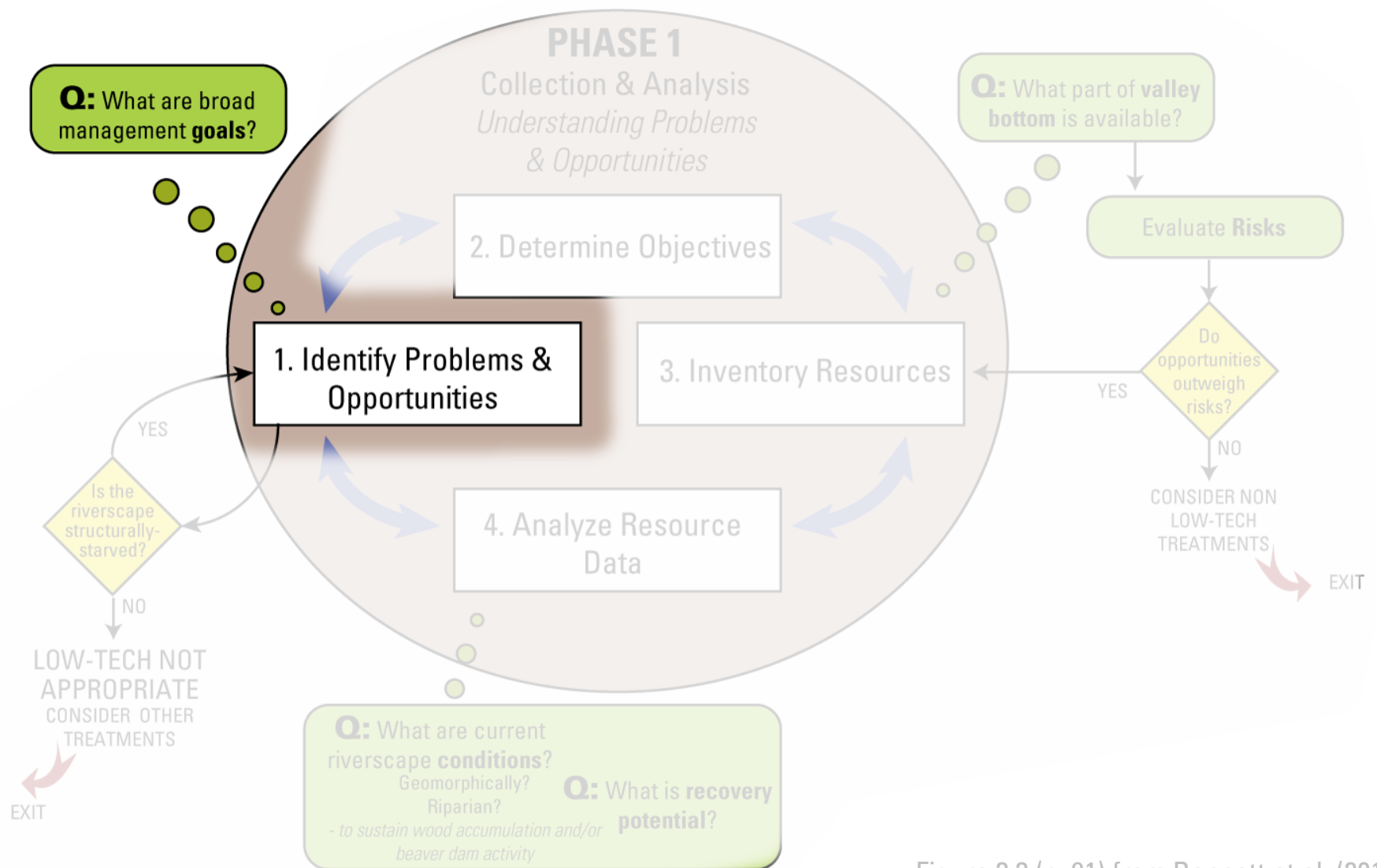
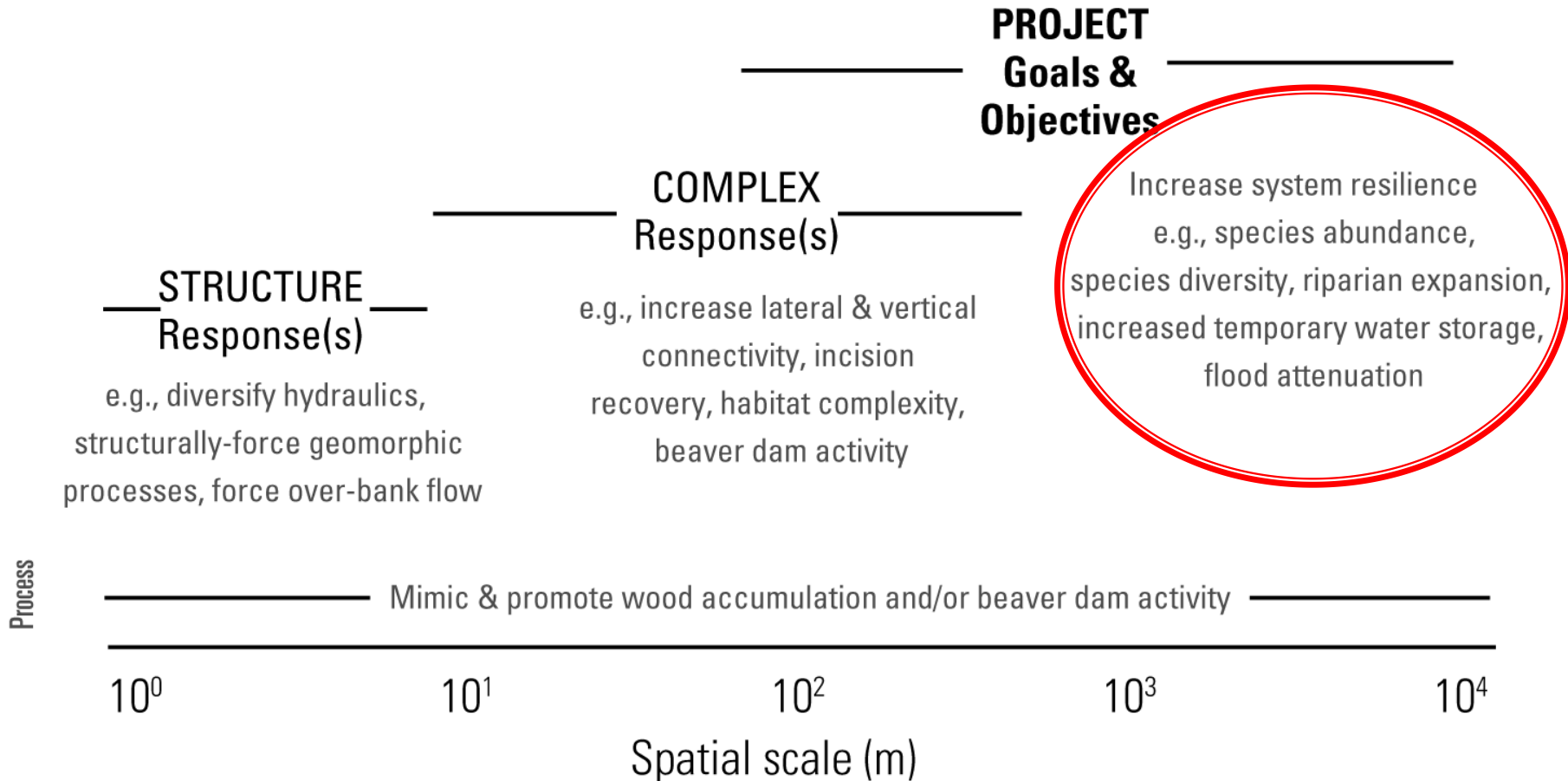


Figure 3.3 (p. 91) from Bennett et al. (2019)

Common Project Level Goals



PHASE 1 with Low-Tech

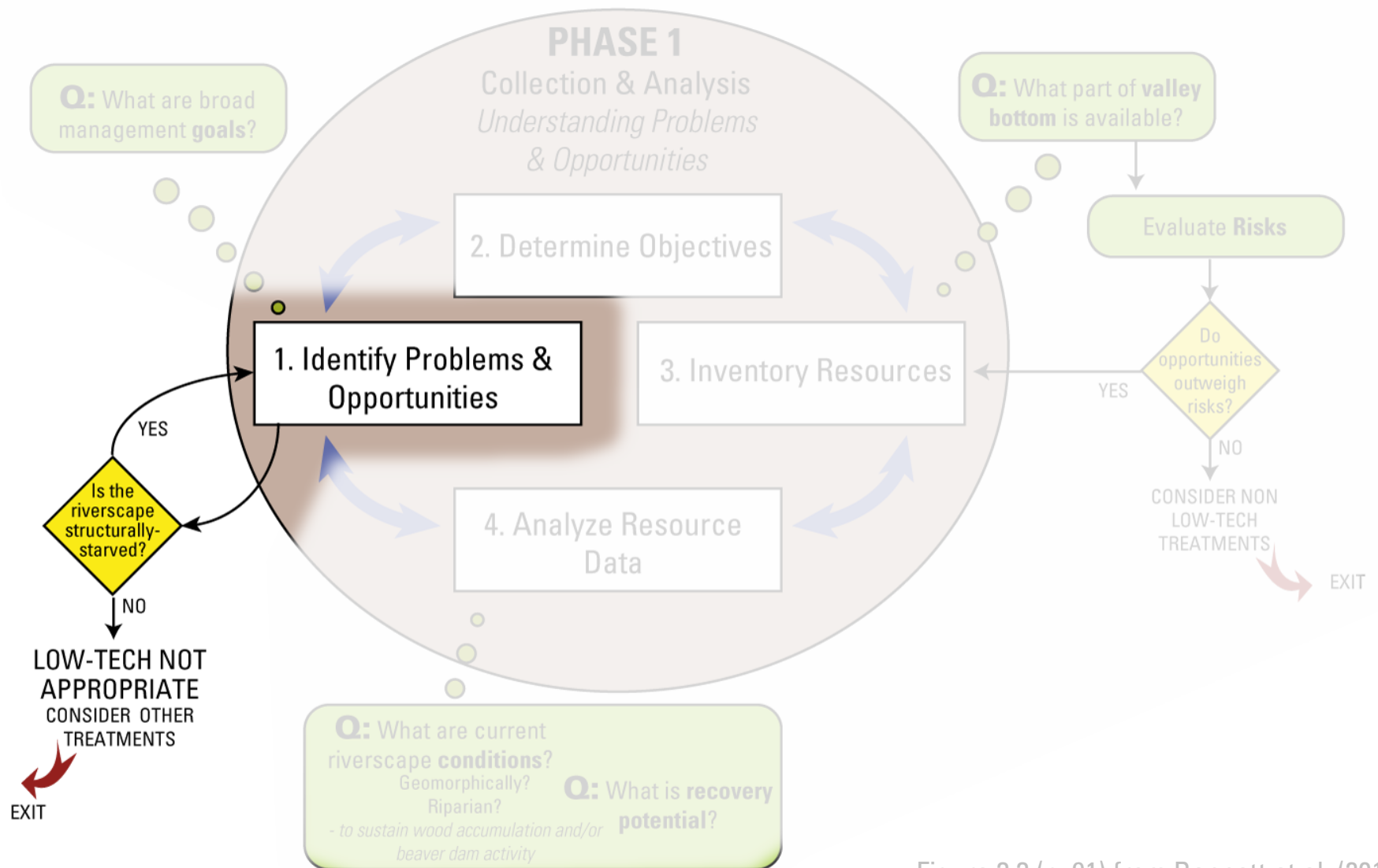
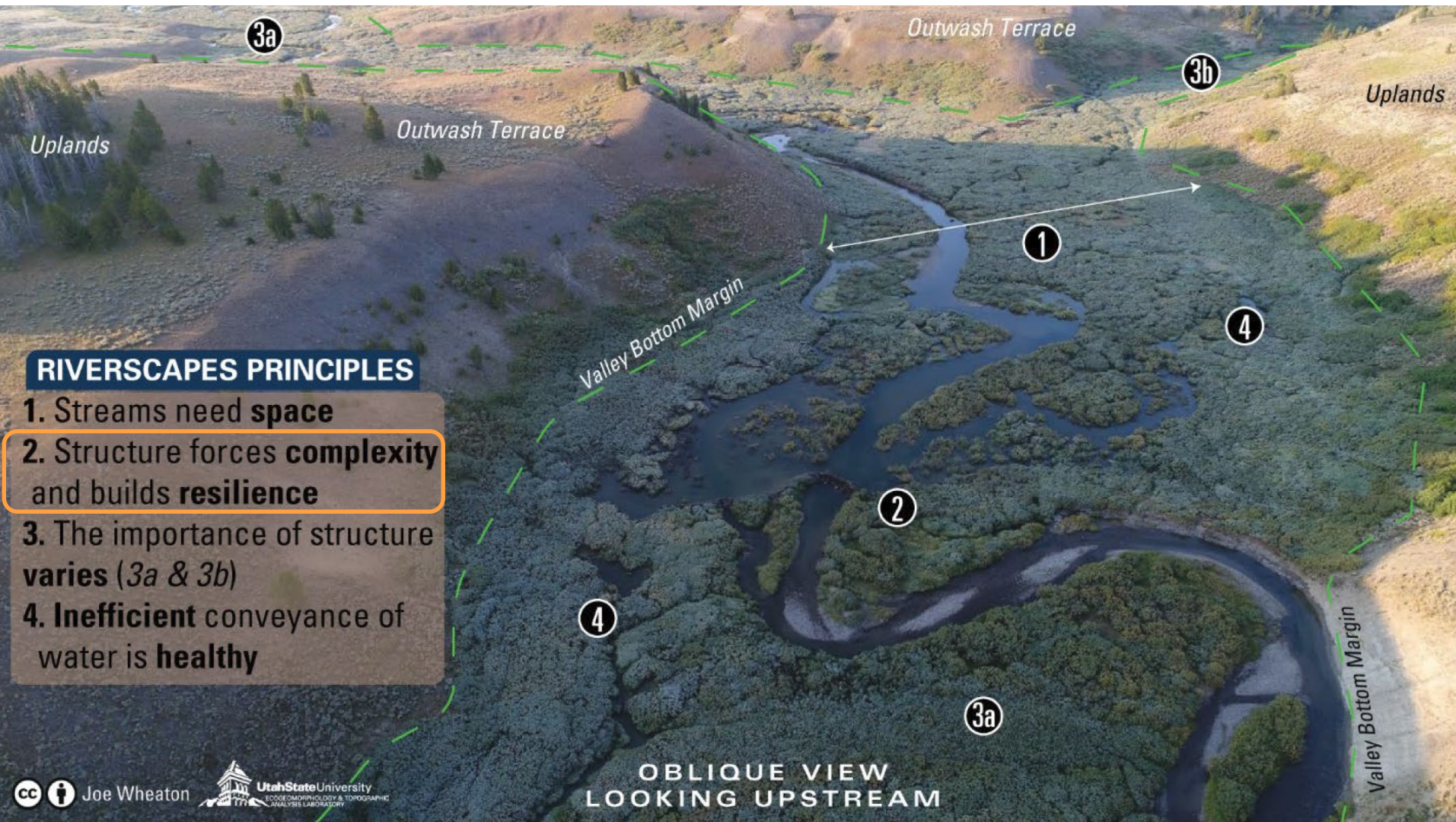


Figure 3.3 (p. 91) from Bennett et al. (2019)

– Chapter 3 LTPBR Manual

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

RECALL, **Structure** drives complexity



From Figure 2.1 (p. 60) Wheaton et al. (2019)
Chapter 2 of LTPBR Manual

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

Broad Goals? & Screening Question

Is the riverscape structurally-starved?

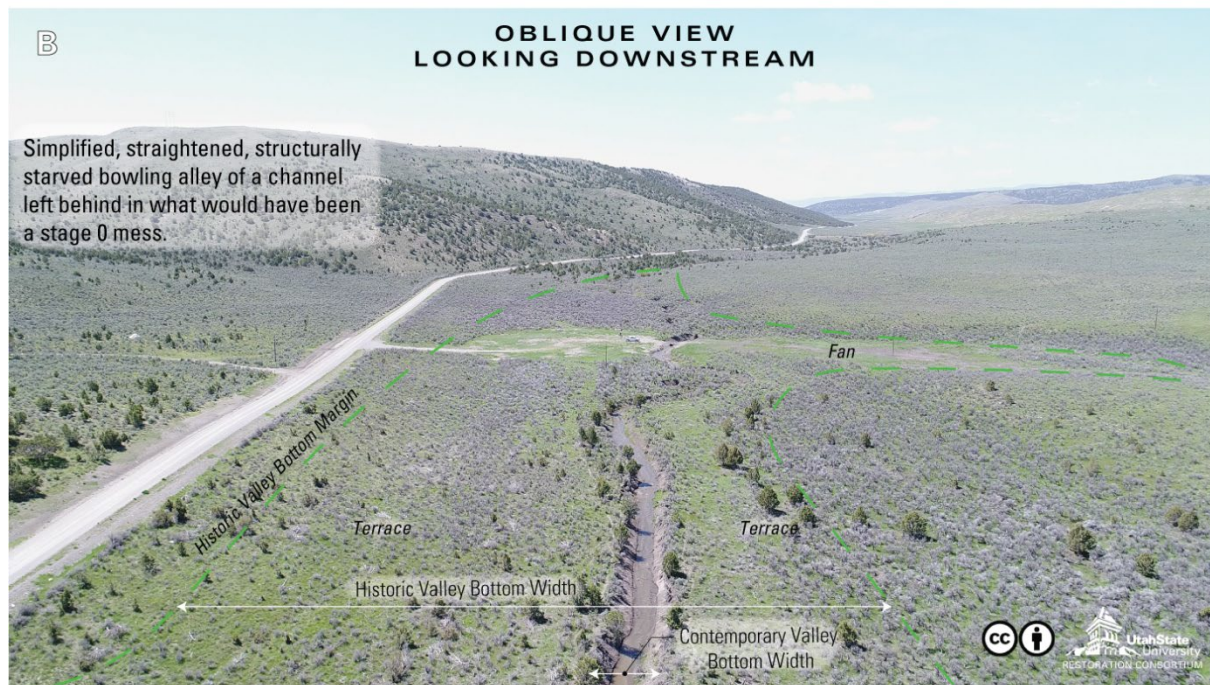
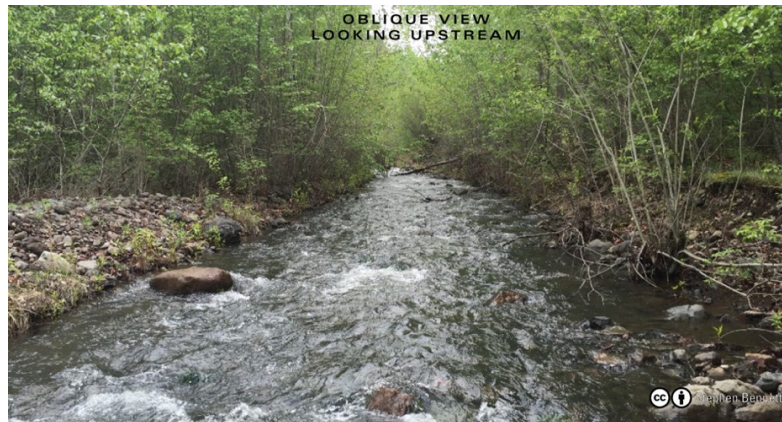
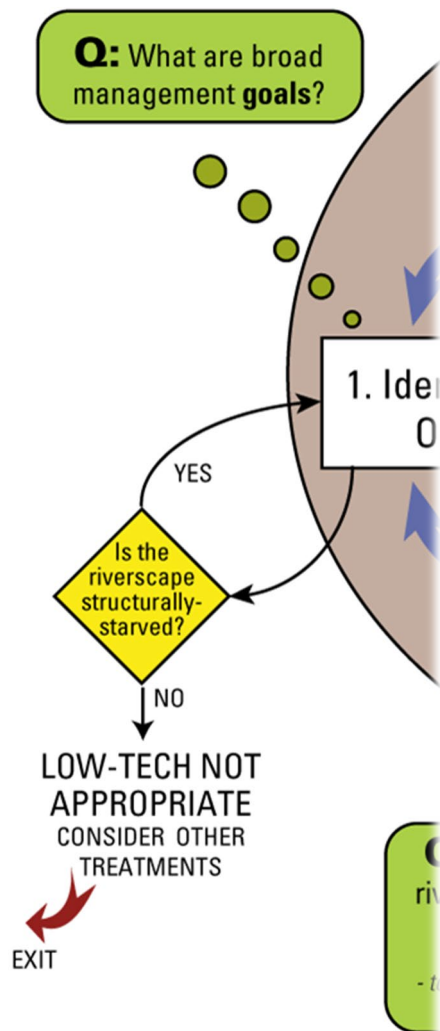


Figure 1.2 & 1.3 (p 31-32) of Shahverdian et al. (2019) - Chapter 1 LTPBR Manual

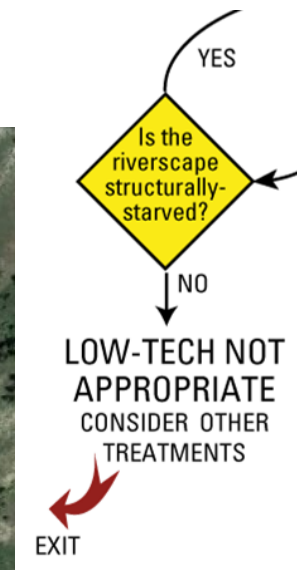
DOI: [10.13140/RG.2.2.14138.03529](https://doi.org/10.13140/RG.2.2.14138.03529)

Is this Riverscape Structurally-Starved?

- Starved of **wood accumulations**?
 - Number of wood accumulations relative to capacity?
- Starved of **beaver dams**?
 - Number of dams relative to capacity?

Look For:

- Evidence that woody veg should be present
- Current conditions limiting woody veg (invasive, grazing,



© 2018 Google

Google Earth

PHASE 1 with Low-Tech

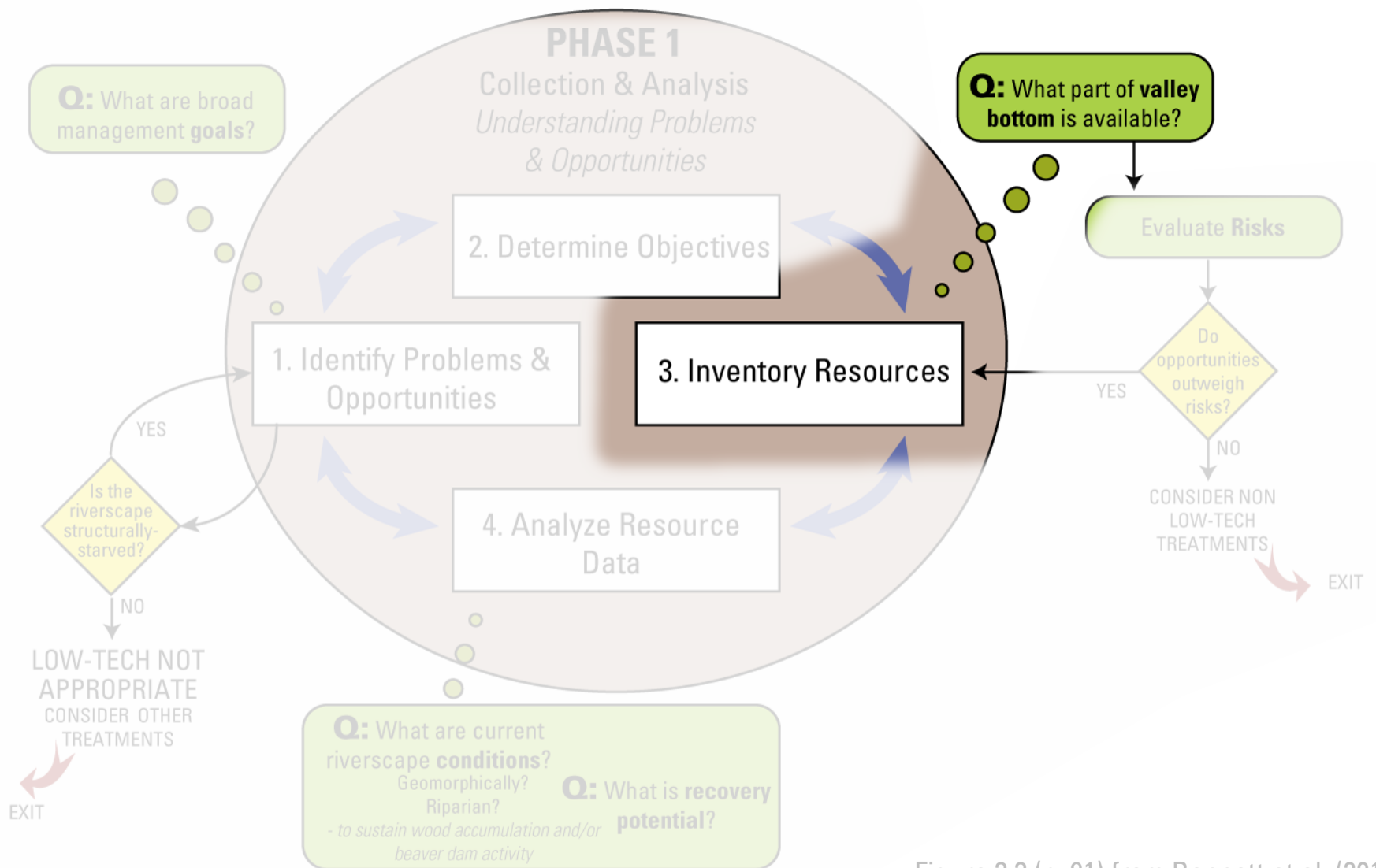
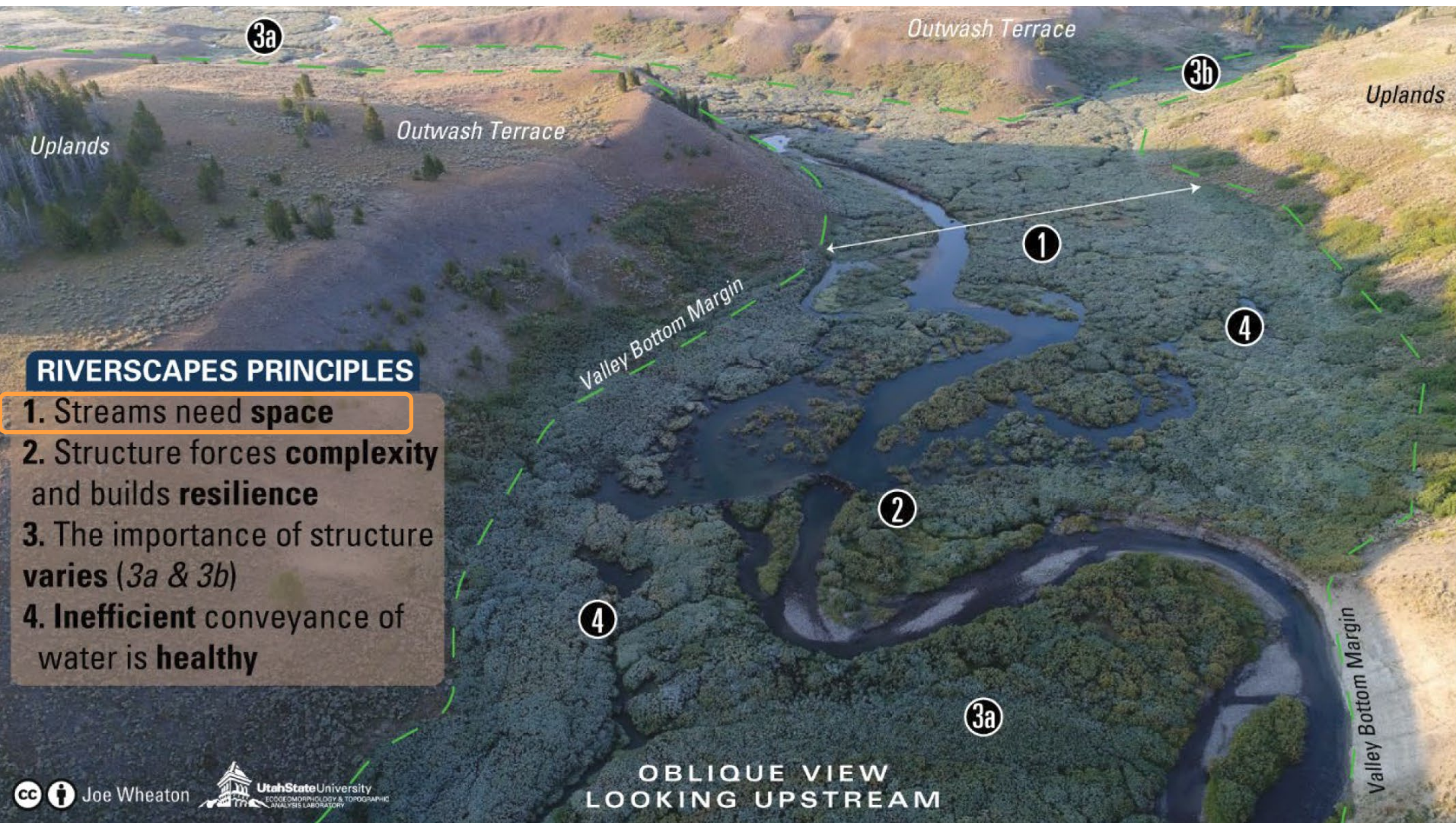


Figure 3.3 (p. 91) from Bennett et al. (2019)

RECALL, Streams need space (i.e. their valley bottoms)

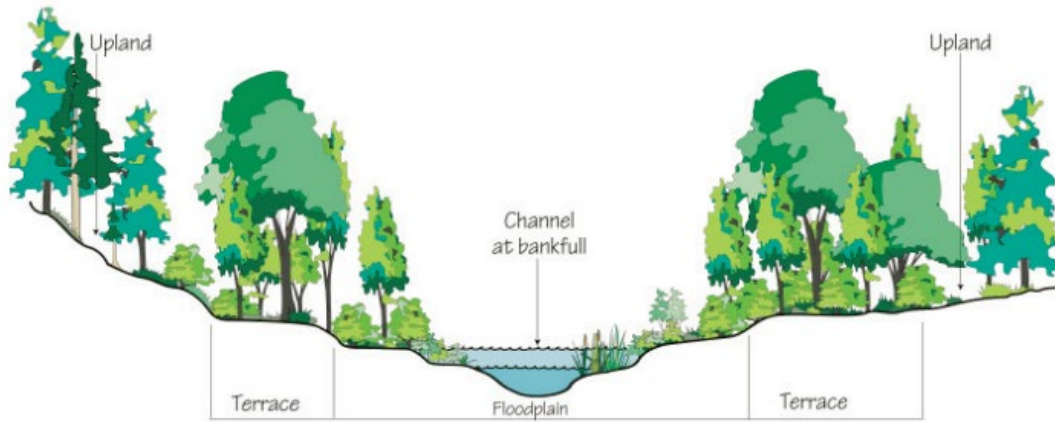


From Figure 2.1 (p. 60) Wheaton et al. (2019)
Chapter 2 of LTPBR Manual

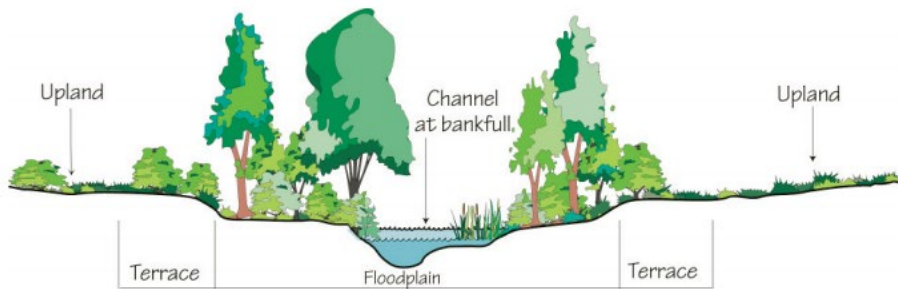
DOI: [10.13140/RG.2.2.19590.63049/1](https://doi.org/10.13140/RG.2.2.19590.63049/1)

We care about Mesic Habitat – i.e. Riparian

Cross Sectional Valley View



Riparian Ecosystem Cross Section
Steep to Gentle Terrain
not to scale



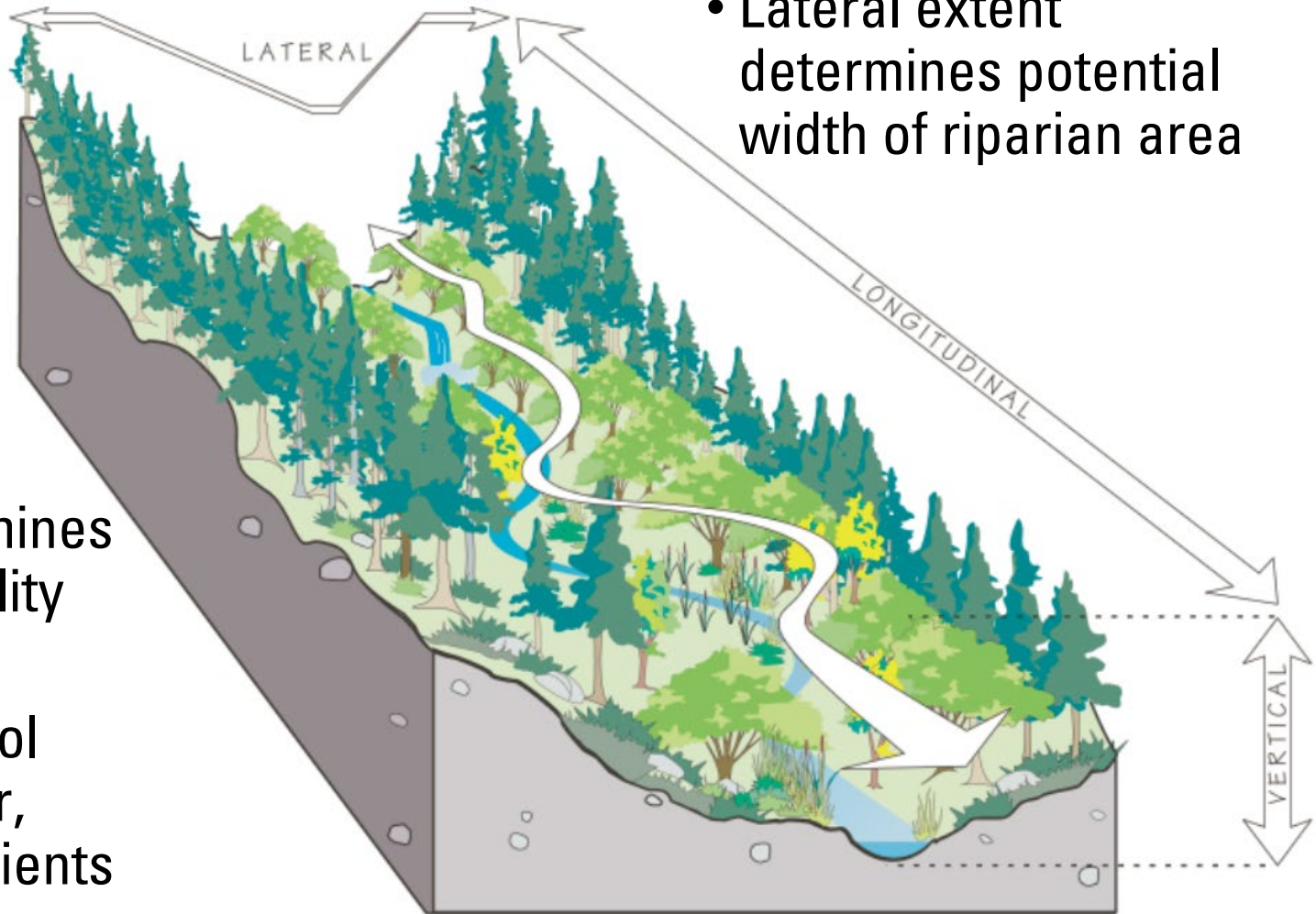
Riparian Ecosystem Cross Section
Gentle to Flat Terrain
not to scale

The lateral and vertical dimensions...

- Riparian vegetation associations with different surfaces
- Floodplain = Valley Bottom = MAXIMUM Probable Riparian Extent
- Terraces = Former Floodplains
- Uplands = NON-Riparian

Riparian Dimensions & Connectivity

- Vertical cross section determines water availability
- Longitudinal patterns control fluxes of water, sediment, nutrients and seeds (sources, transfer vs. sinks)



- Lateral extent determines potential width of riparian area

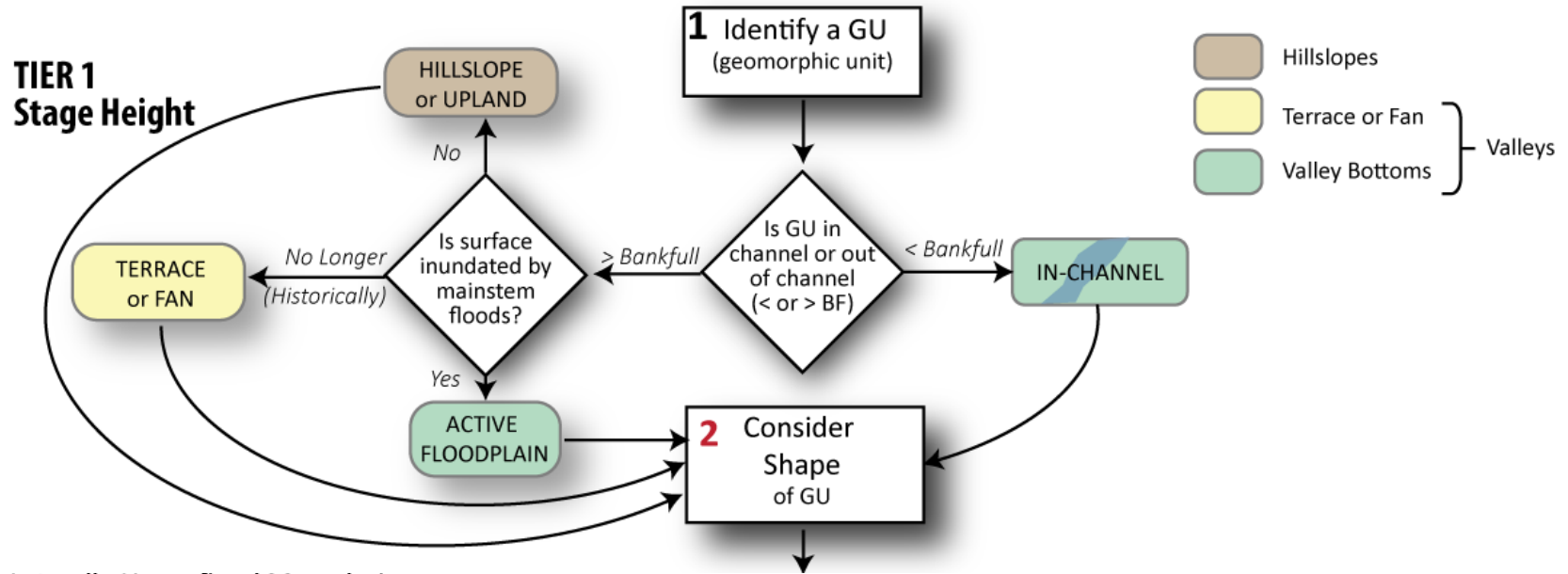
What is a Valley?

Valley

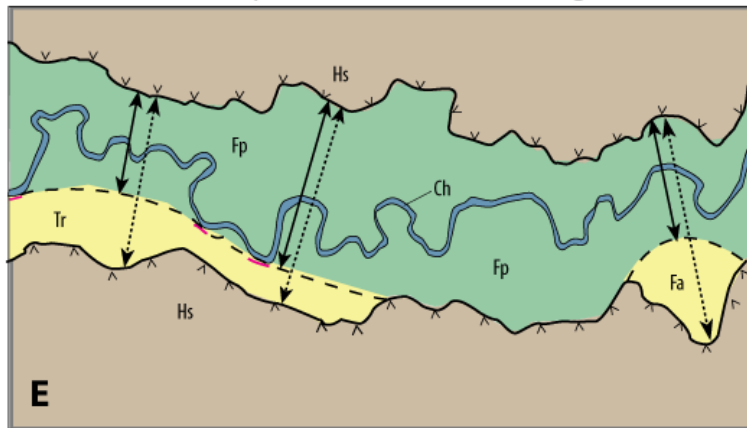
noun

1. Relatively flat, low-lying area between hills or mountains typically containing watercourse. The geomorphic units that comprise valleys can include [channel\(s\)](#), [floodplain\(s\)](#), [terrace\(s\)](#), and [fan\(s\)](#). From: Wheaton et al. (2015b)

Valley Bottom vs. Valley?



Laterally-Unconfined Meandering



GEOMORPHIC UNITS (TIER 1)

- Ch = Channel
- Fp = Floodplain
- Hs = Hillslope
- Tr = Terrace
- Fa = Fan

What are the building blocks of:

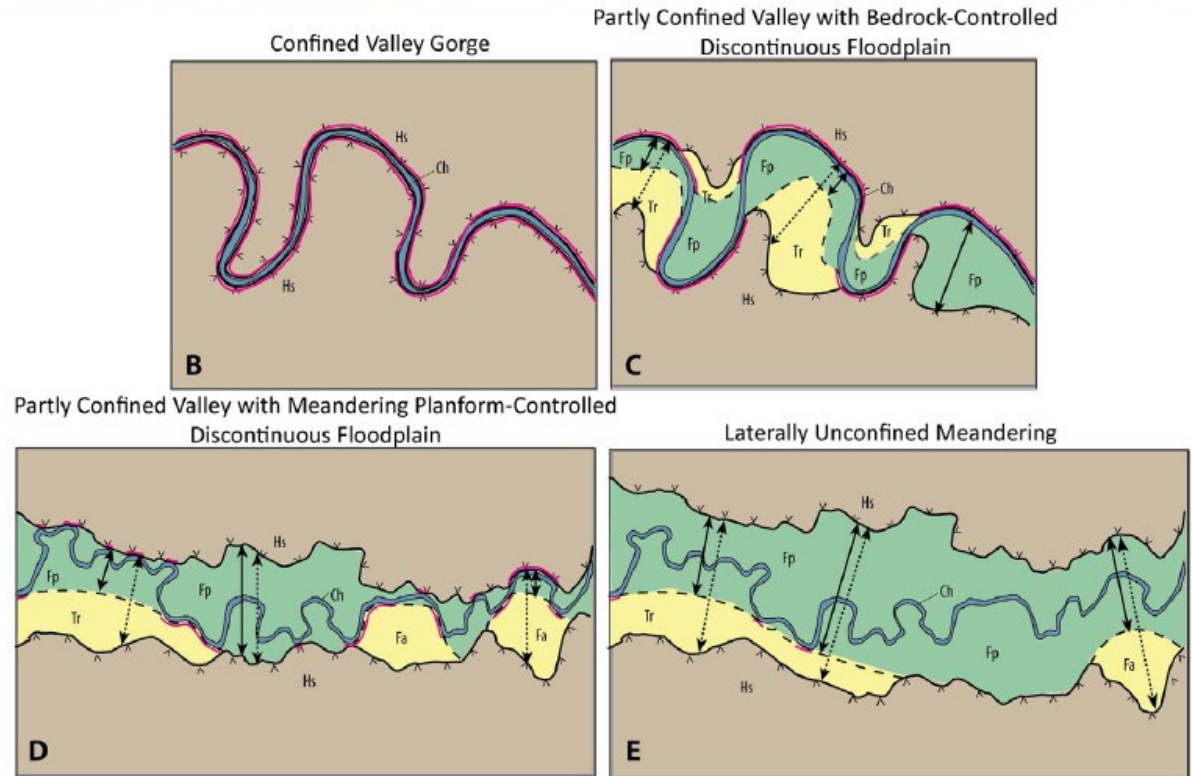
- A Valley?

VS.

- A Valley Bottom?

Valley Margins In Different Settings

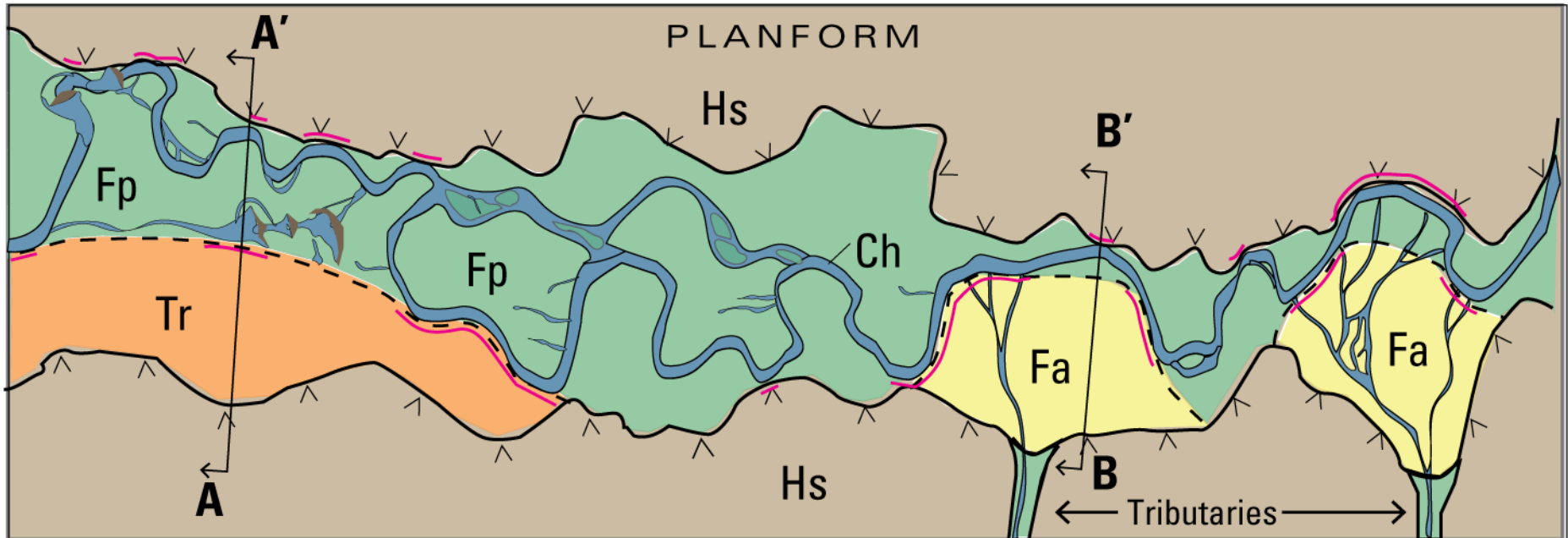
- Interesting thing is identifying where different margins overlap
- Fundamental control on channel's capacity to adjust
- Differentiates reach types
- Sets up planform steering of flows



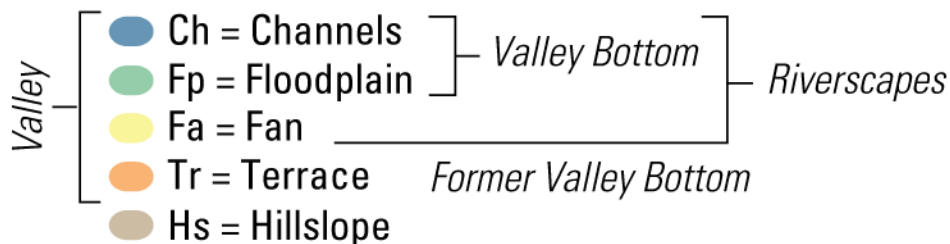
From: Fryirs et al. (2015) – ESPL;
DOI: [10.1002/esp.3893](https://doi.org/10.1002/esp.3893)

From: Wheaton et al. (2015) – Geomorphology;
DOI: [10.1016/j.geomorph.2015.07.010](https://doi.org/10.1016/j.geomorph.2015.07.010)

Reading your riverscape... to look for opportunities



GEOMORPHIC UNIT KEY



The valley bottom is comprised of areas that could plausibly flood in the contemporary flow regime.

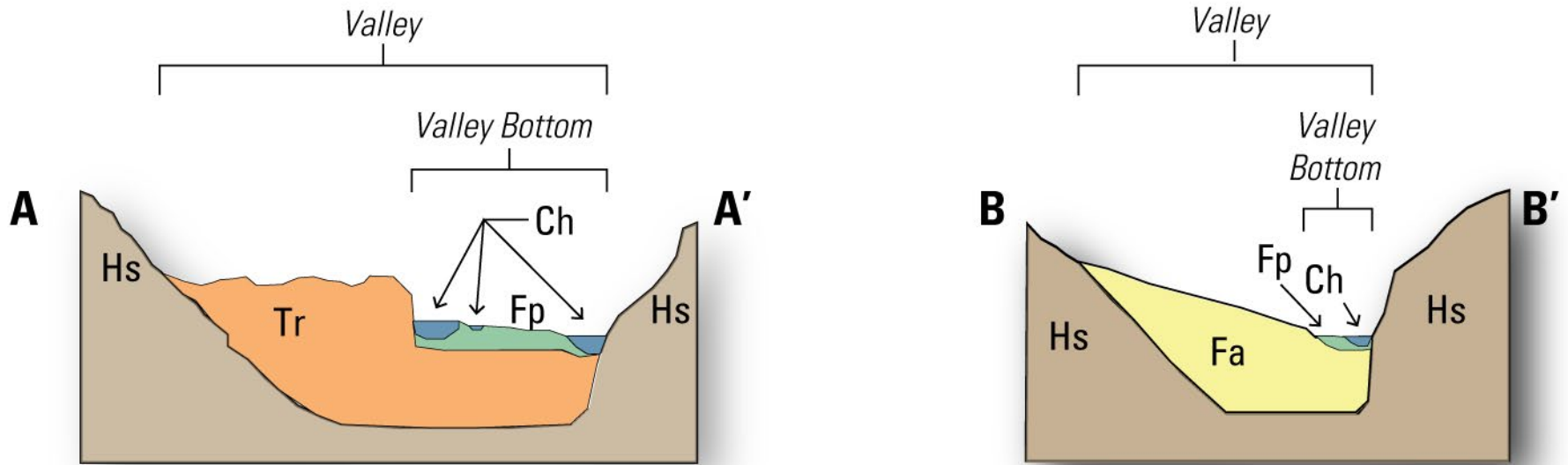
MARGIN TYPES

- ×× Valley Margin
- Valley Bottom Margin
- Active Confining Margin

Where are their mesic/riparian restoration opportunities?

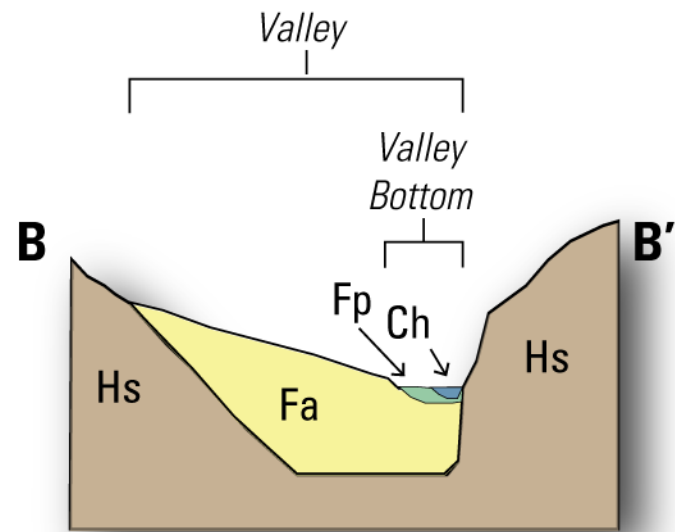
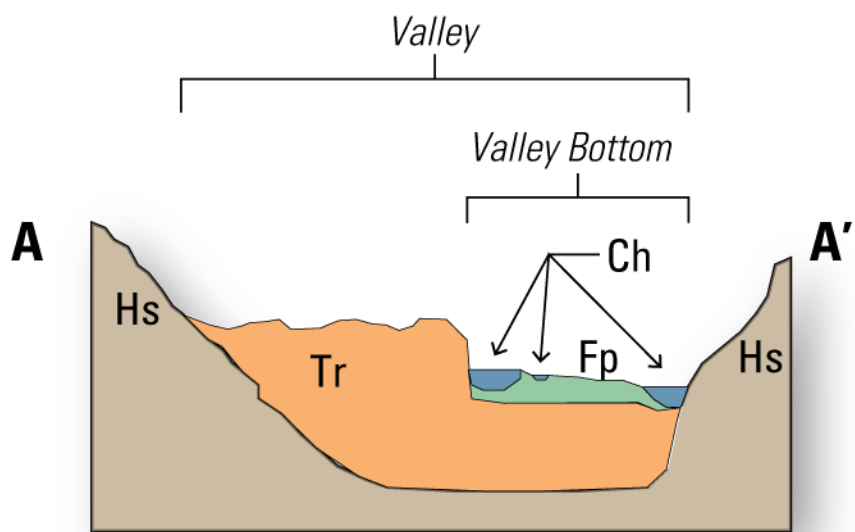
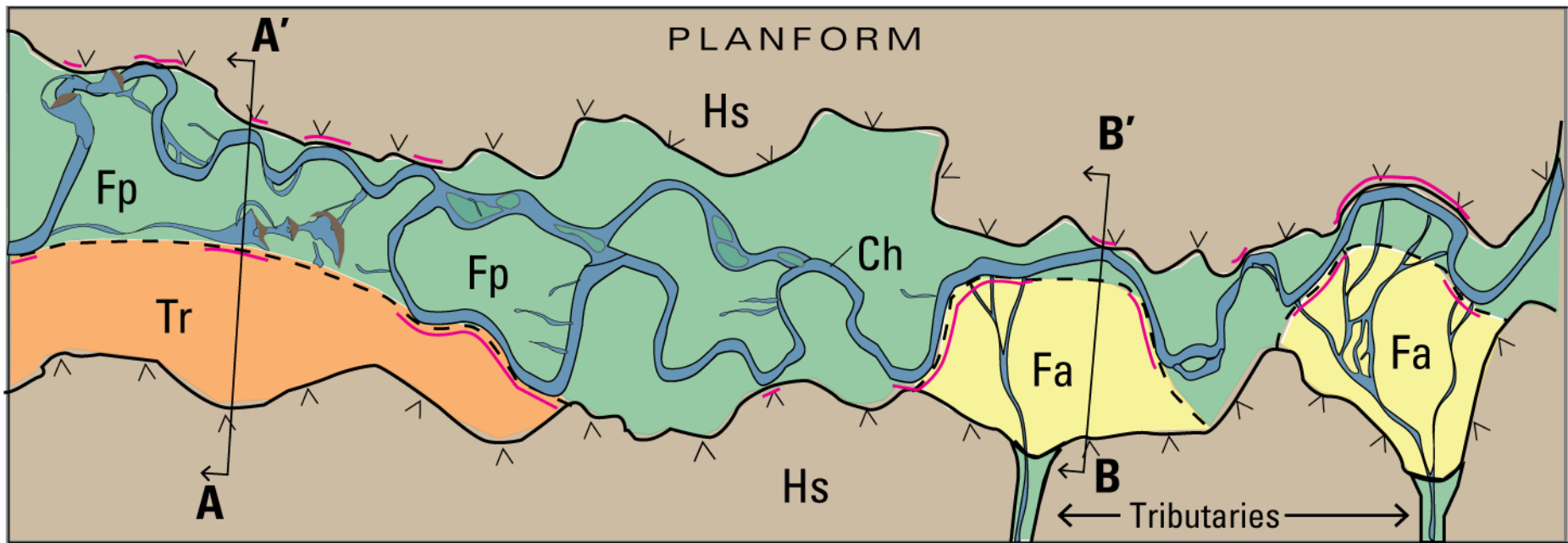
Contrasting Valley Settings Define Reach Breaks

VALLEY CROSS SECTIONS



From page 10 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)



From pages 9-10 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)

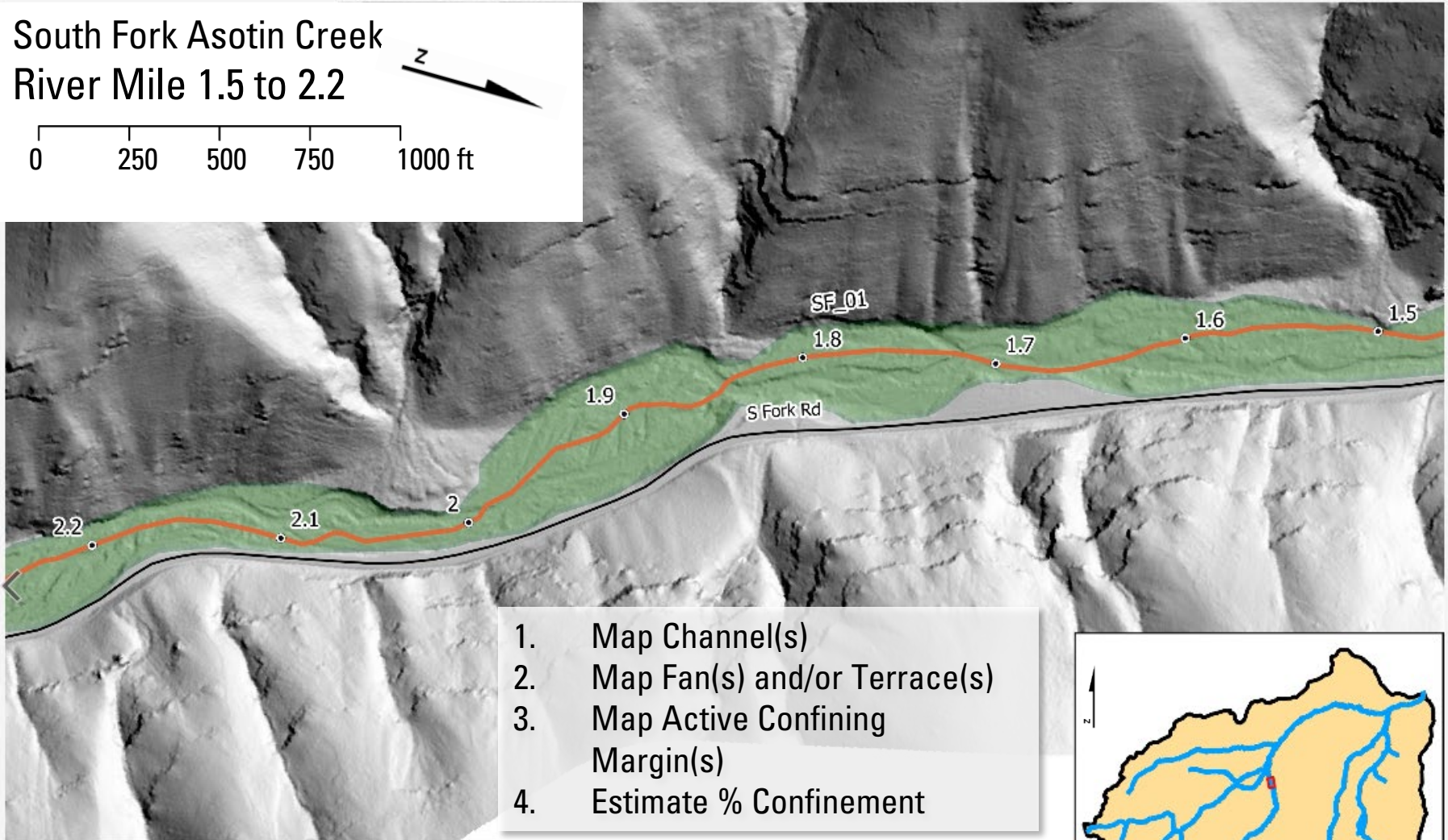
← **Which way is river flowing?** →

Exercise – Reading Valley Setting

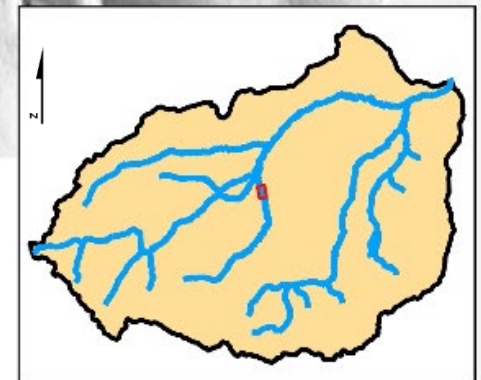
South Fork Asotin Creek
River Mile 1.5 to 2.2



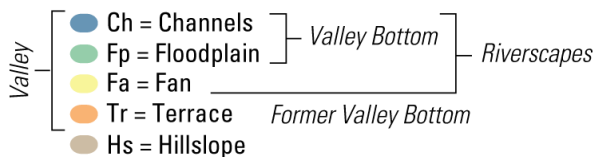
0 250 500 750 1000 ft



1. Map Channel(s)
2. Map Fan(s) and/or Terrace(s)
3. Map Active Confining Margin(s)
4. Estimate % Confinement



GEOMORPHIC UNIT KEY



The valley bottom is comprised of areas that could plausibly flood in the contemporary flow regime.

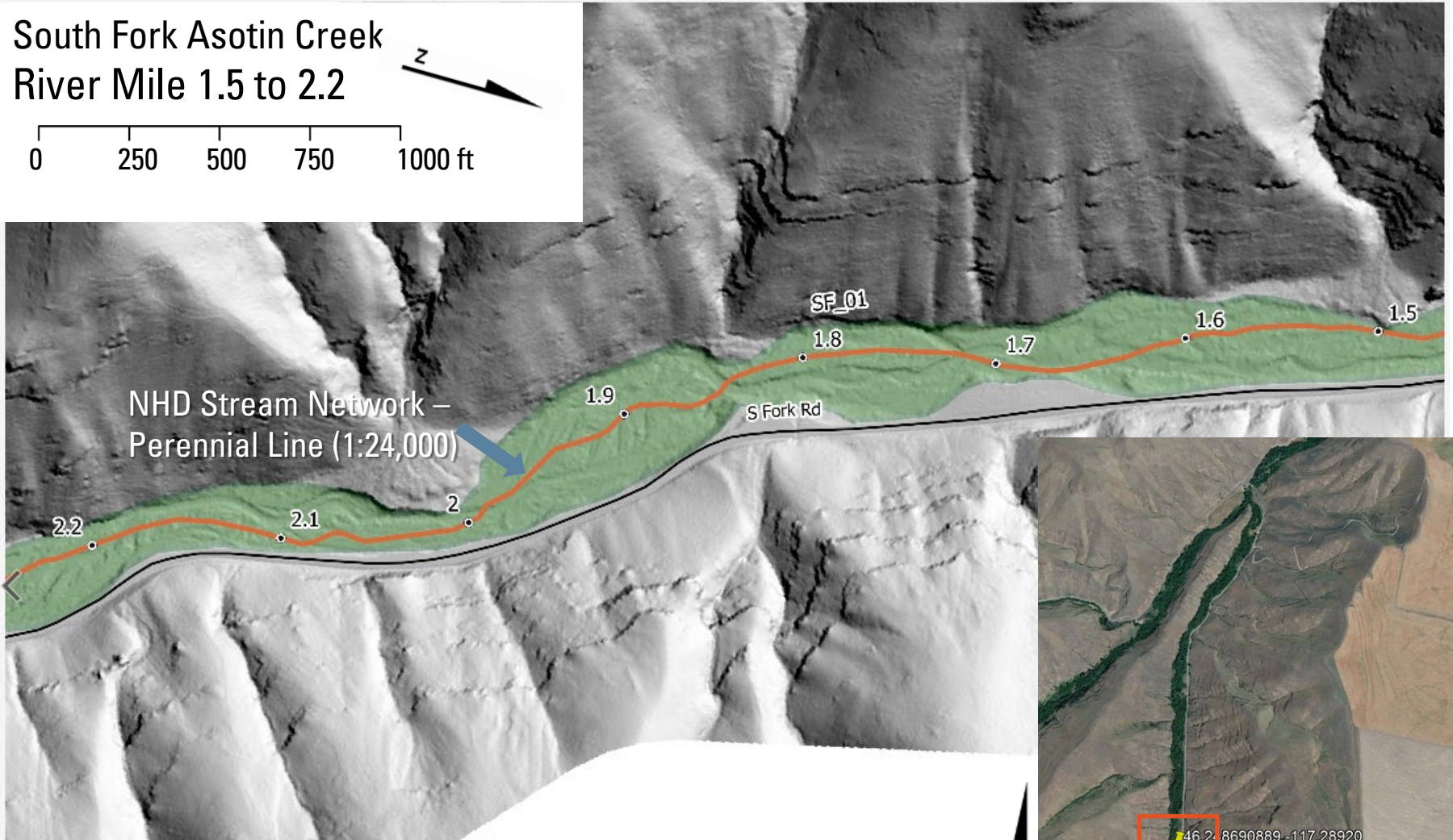
MARGIN TYPES

- Valley Margin
- - Valley Bottom Margin
- Active Confining Margin

Context

South Fork Asotin Creek
River Mile 1.5 to 2.2

0 250 500 750 1000 ft



GEOMORPHIC UNIT KEY

- | | | | | | | |
|--------|---|-------------------|---|---------------|----------------------|-------------|
| Valley | { | ● Ch = Channels | } | Valley Bottom | } | Riverscapes |
| | | ● Fp = Floodplain | | | | |
| | | ● Fa = Fan | | | | |
| | | ● Tr = Terrace | | | | |
| | | ● Hs = Hillslope | | | | |
| | | | | | Former Valley Bottom | |

The valley bottom is comprised of areas that could plausibly flood in the contemporary flow regime.

MARGIN TYPES

- Valley Margin
- - Valley Bottom Margin
- Active Confining Margin



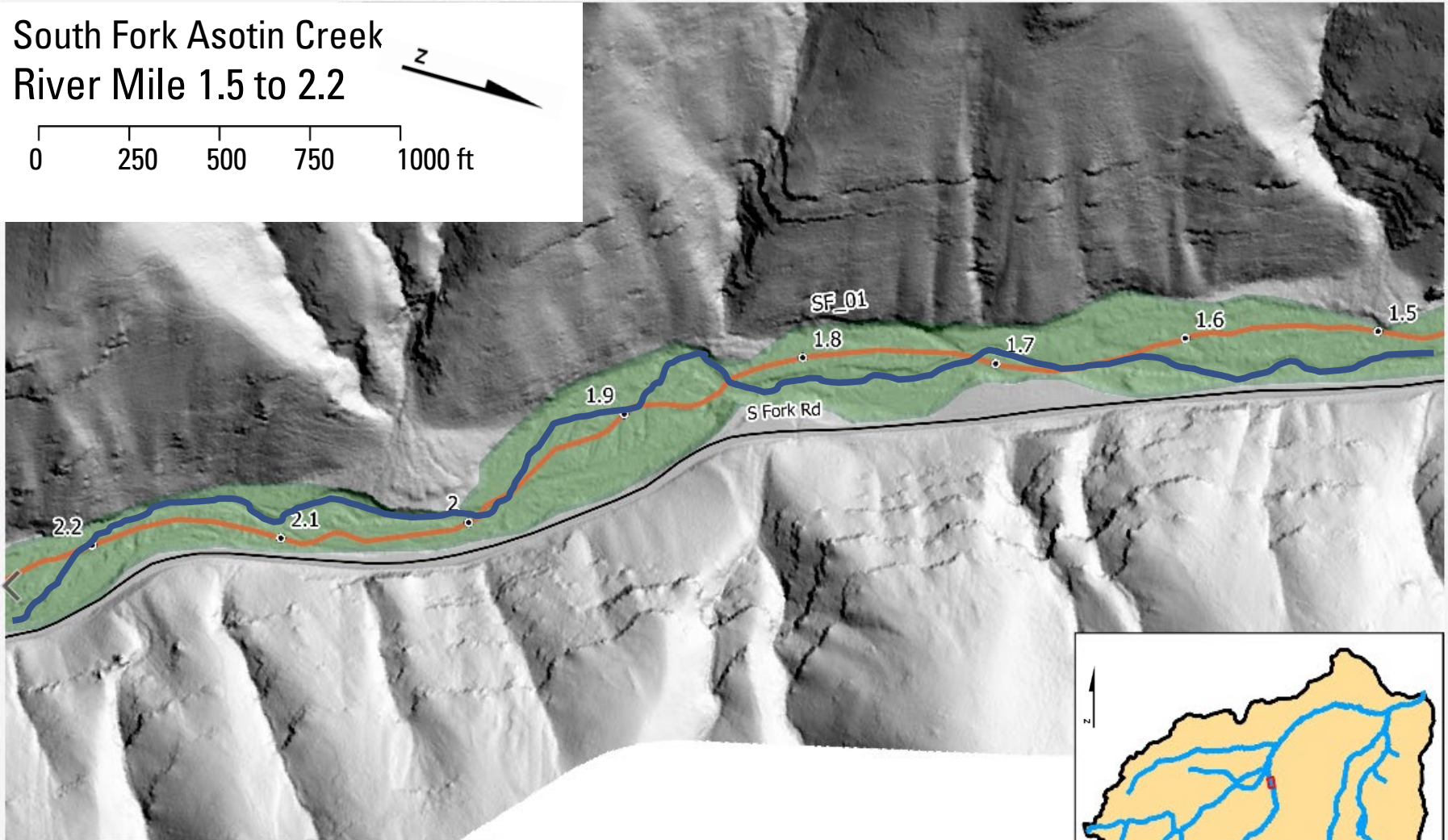
Trace the Actual Channel



South Fork Asotin Creek
River Mile 1.5 to 2.2



0 250 500 750 1000 ft



GEOMORPHIC UNIT KEY

- | | | | | | |
|--------|--|---|----------------------|---|-------------|
| Valley | ● Ch = Channels | } | Valley Bottom | } | Riverscapes |
| | ● Fp = Floodplain | | | | |
| | ● Fa = Fan | } | Former Valley Bottom | | |
| | ● Tr = Terrace | | | | |
| | ● Hs = Hillslope | | | | |

The valley bottom is comprised of areas that could plausibly flood in the contemporary flow regime.

MARGIN TYPES

- x— Valley Margin
- Valley Bottom Margin
- Active Confining Margin

Map the Fans



South Fork Asotin Creek
River Mile 1.5 to 2.2



0 250 500 750 1000 ft

coupled river left fans



Anthropogenically
Disconnected river left Fans

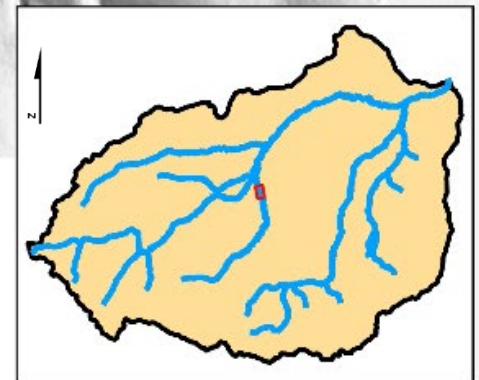
GEOMORPHIC UNIT KEY

Valley	{	● Ch = Channels	}	Valley Bottom	}	Riverscapes
		● Fp = Floodplain				
		● Fa = Fan	}	Former Valley Bottom		
		● Tr = Terrace				
		● Hs = Hillslope				

The valley bottom is comprised of areas that could plausibly flood in the contemporary flow regime.

MARGIN TYPES

- x— Valley Margin
- Valley Bottom Margin
- Active Confining Margin



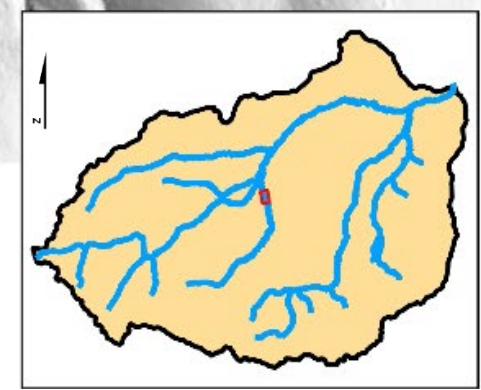
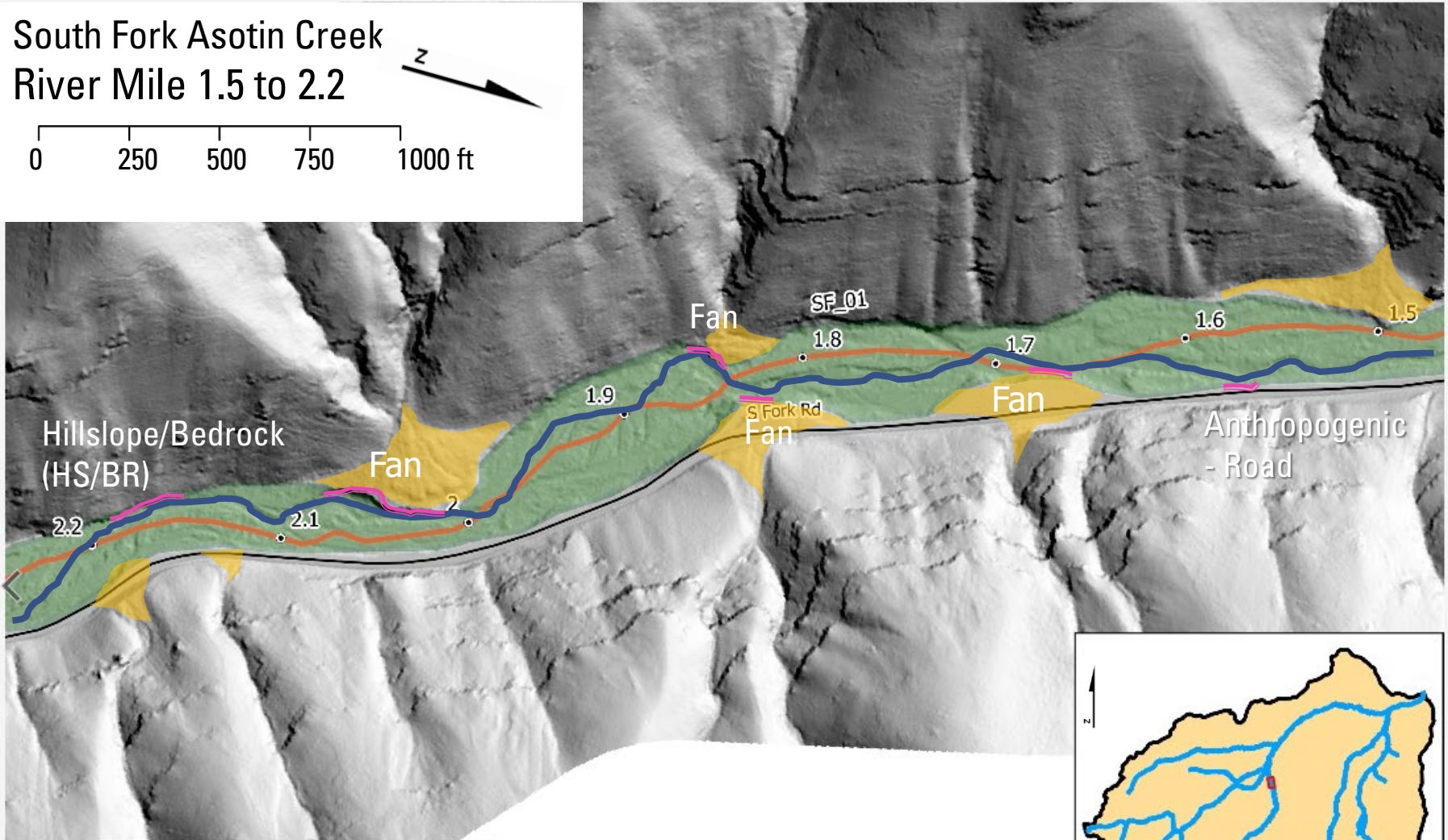
Map the Confining Margins



South Fork Asotin Creek
River Mile 1.5 to 2.2



0 250 500 750 1000 ft



GEOMORPHIC UNIT KEY

Valley	{	● Ch = Channels	}	Valley Bottom	}	Riverscapes
		● Fp = Floodplain				
		● Fa = Fan				
		● Tr = Terrace				
		● Hs = Hillslope				
		Former Valley Bottom				

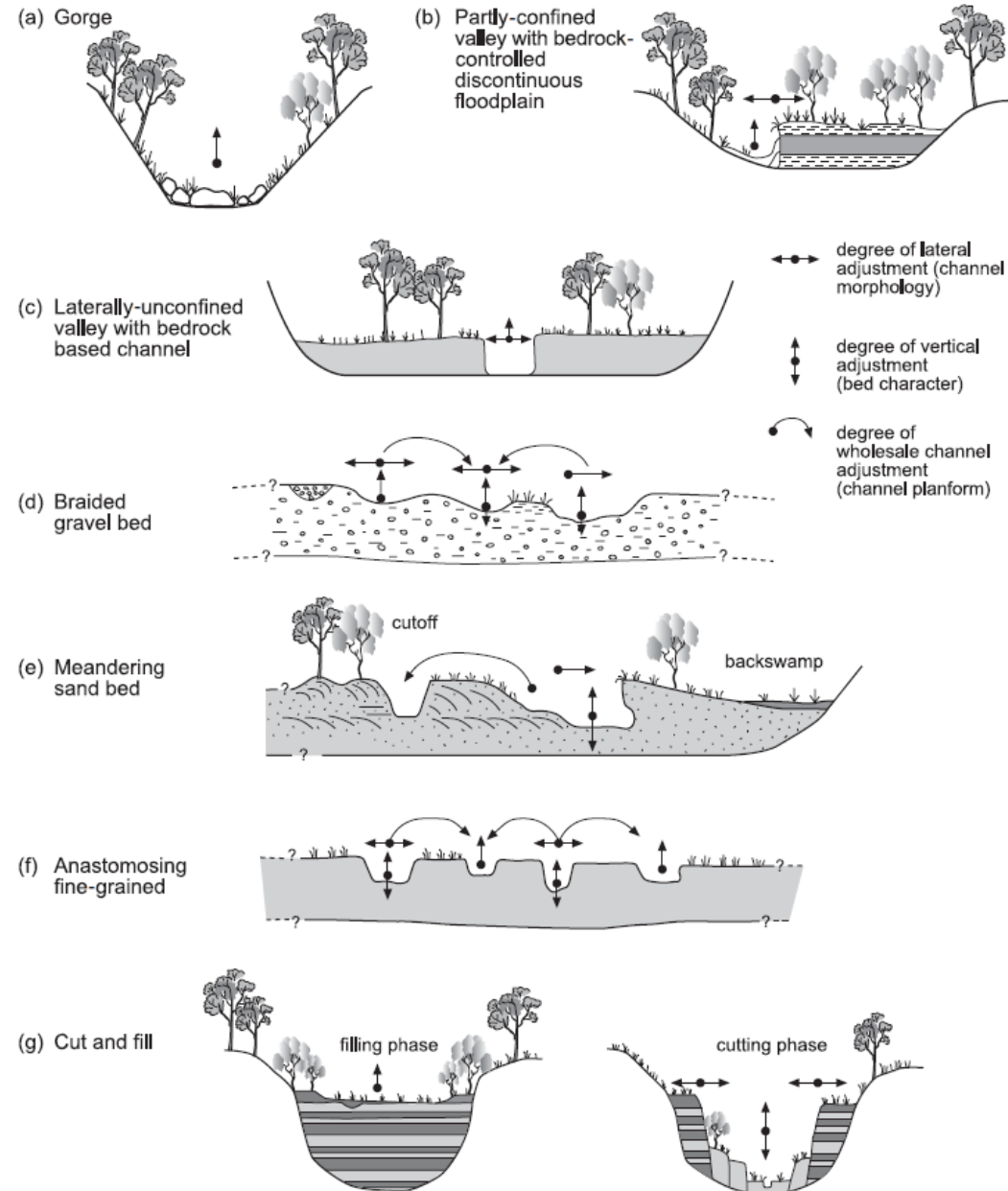
The valley bottom is comprised of areas that could plausibly flood in the contemporary flow regime.

MARGIN TYPES

- x— Valley Margin
- - Valley Bottom Margin
- Active Confining Margin

Natural Capacity For Adjustment

- Plausible limits on what adjustments are possible
- Geomorphic context matters
 - Confinement
 - Sediment Supply
 - Flow Regime
 - Vegetation
 - Land use
 - History



Next, we do condition assessment in valley bottom

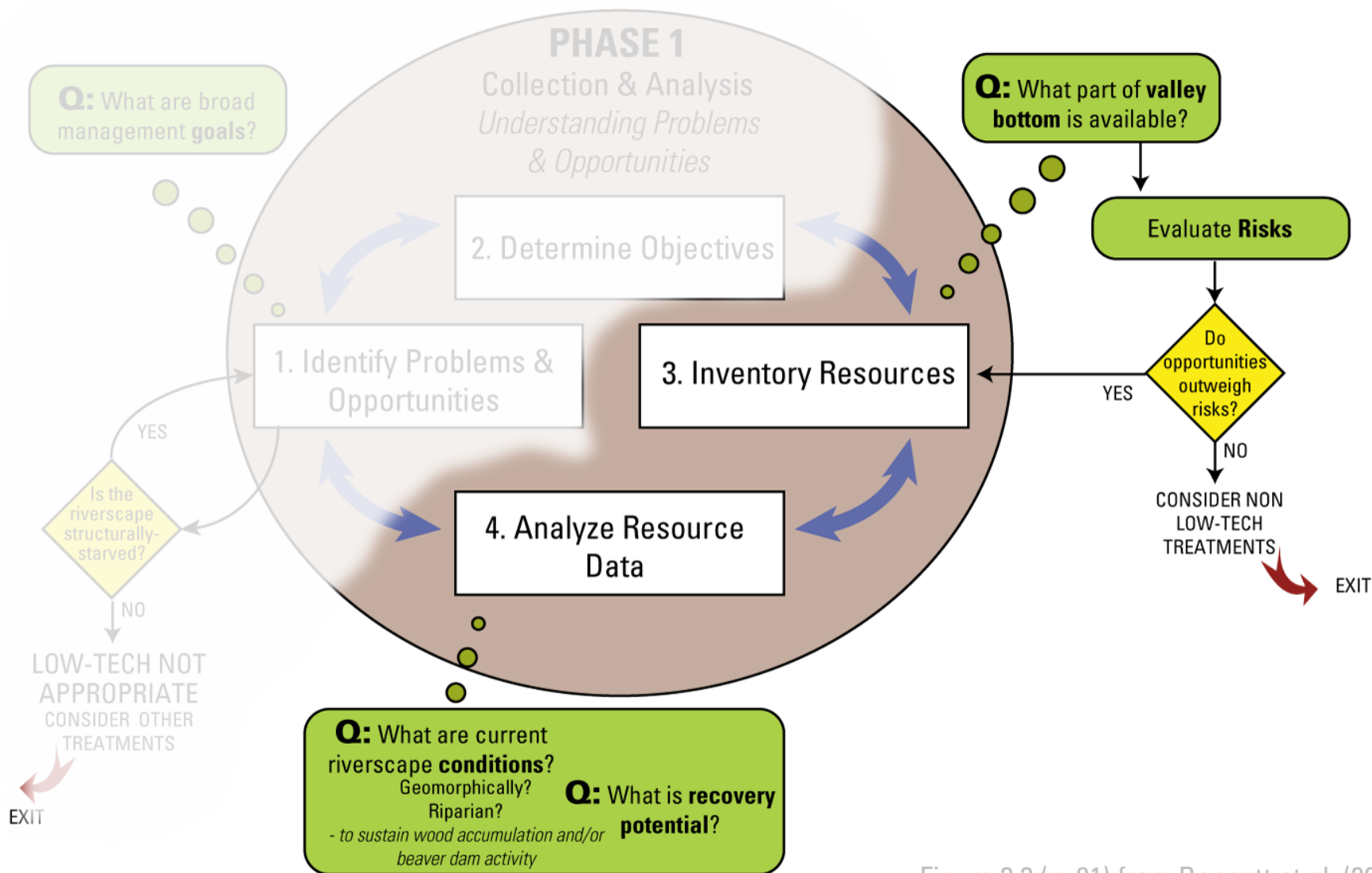


Figure 3.3 (p. 91) from Bennett et al. (2019)

OUTLINE: Low-Tech Planning



I. Review

II. Conservation Planning Process

I. Phase 1 – **Planning**

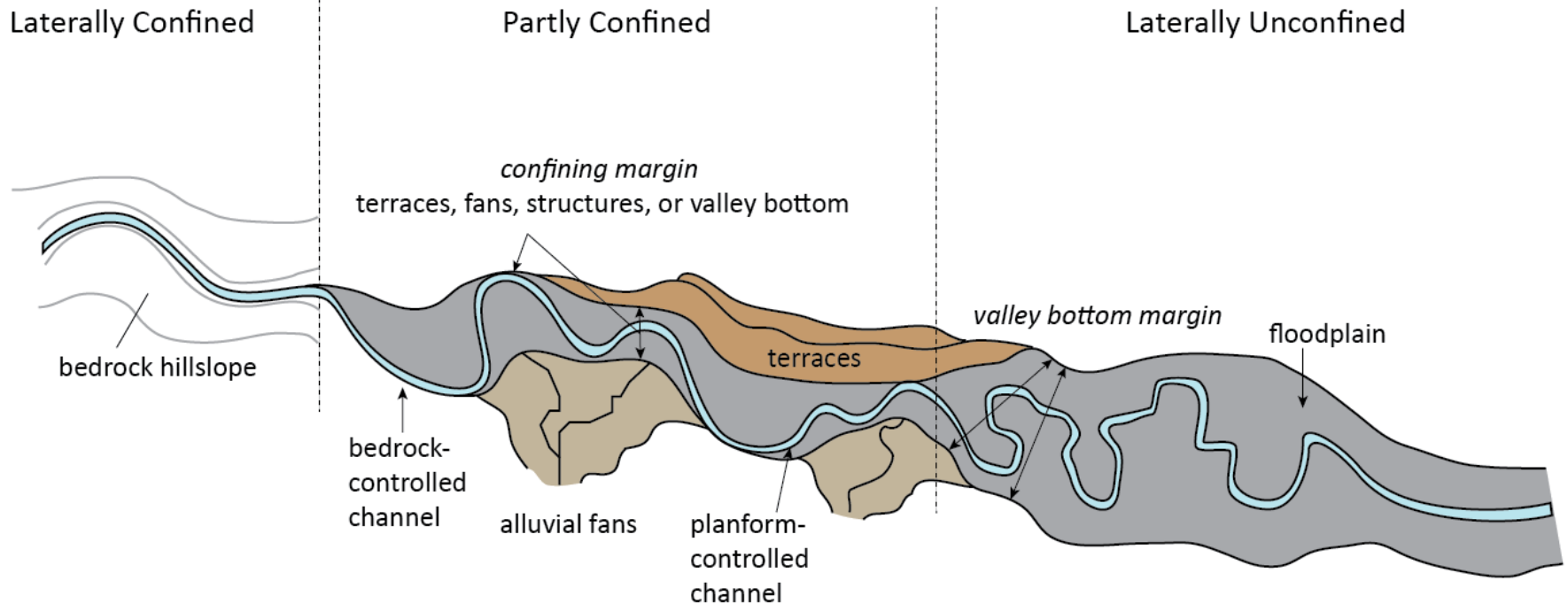
II. Phase 2 – Design

III. Phase 3 - Implementation

Where are we talking about?

Q: What part of **valley bottom** is available?

What part of valley bottom is available for low-tech restoration?



Remember This Place?



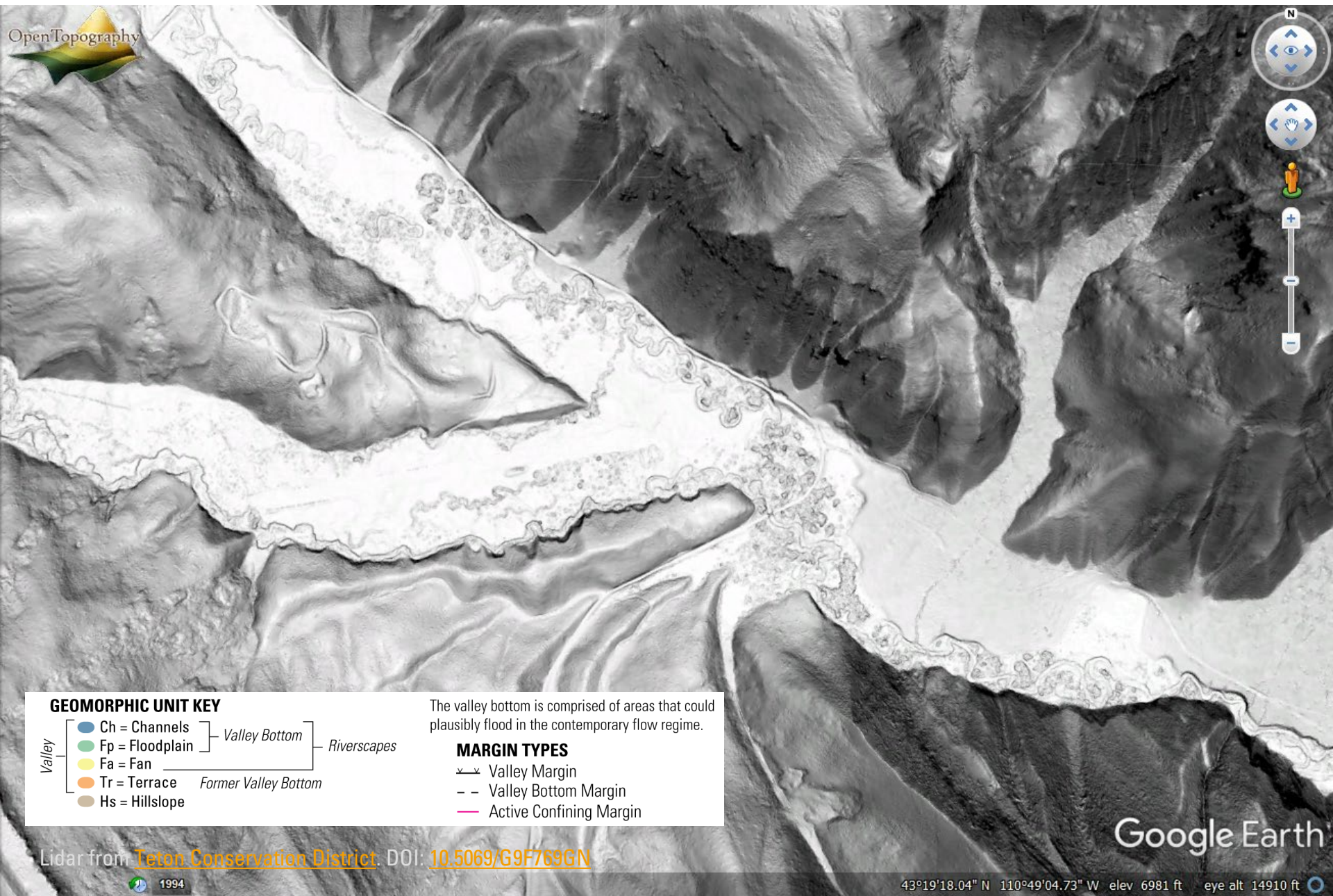
© 2018 Google

Google Earth

1994

Imagery Date: 6/21/2017 43°19'45.60" N 110°48'03.63" W elev 6283 ft eye alt 14910 ft

Map Your Perennial Valley Bottom & Channel(s)



OpenTopography

GEOMORPHIC UNIT KEY

- | | | | |
|--------|--|------------------------|---------------|
| Valley | ● Ch = Channels | } Valley Bottom | } Riverscapes |
| | ● Fp = Floodplain | | |
| | ● Fa = Fan | | |
| | ● Tr = Terrace | } Former Valley Bottom | |
| | ● Hs = Hillslope | | |

The valley bottom is comprised of areas that could plausibly flood in the contemporary flow regime.

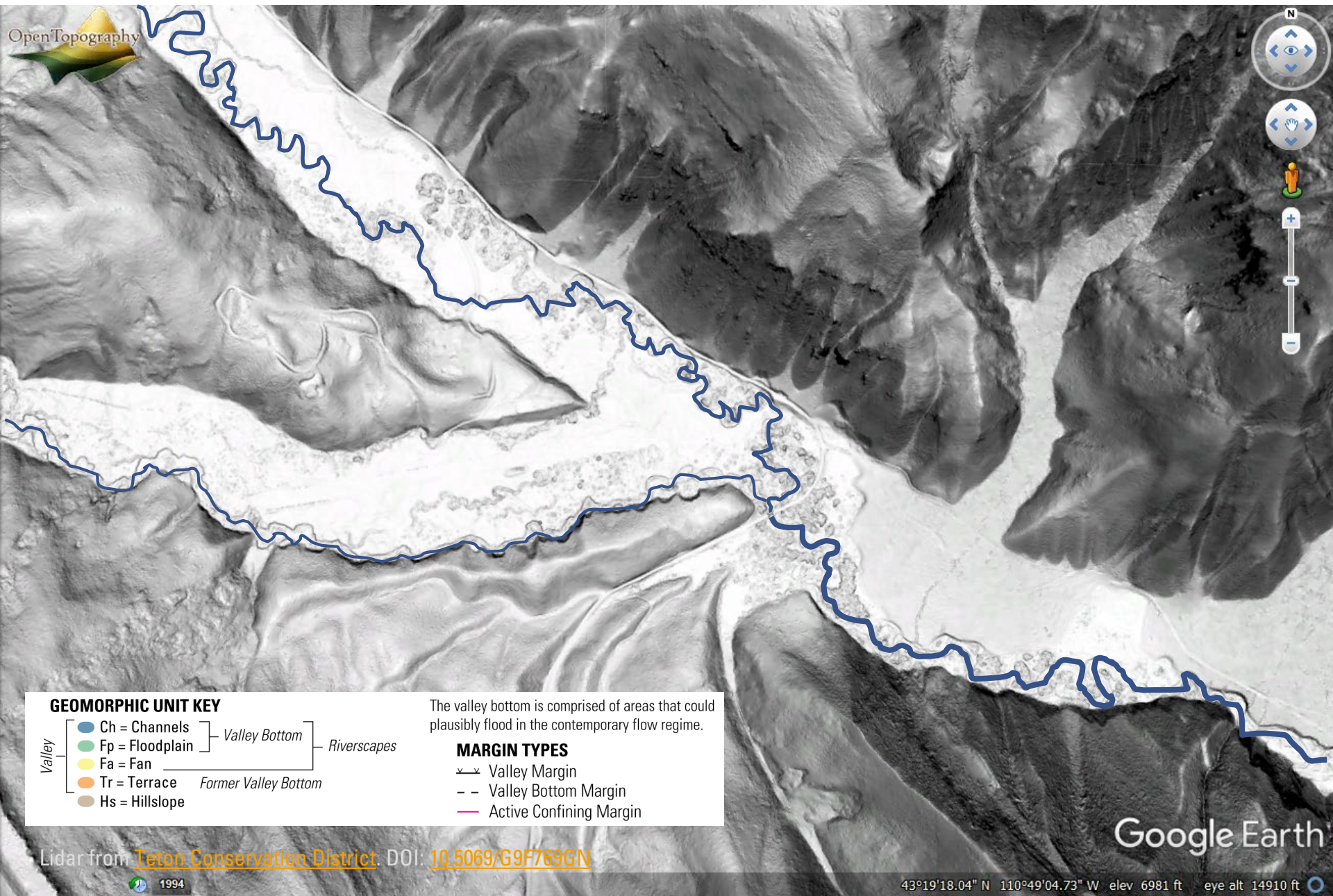
MARGIN TYPES

- x Valley Margin
- - Valley Bottom Margin
- Active Confining Margin

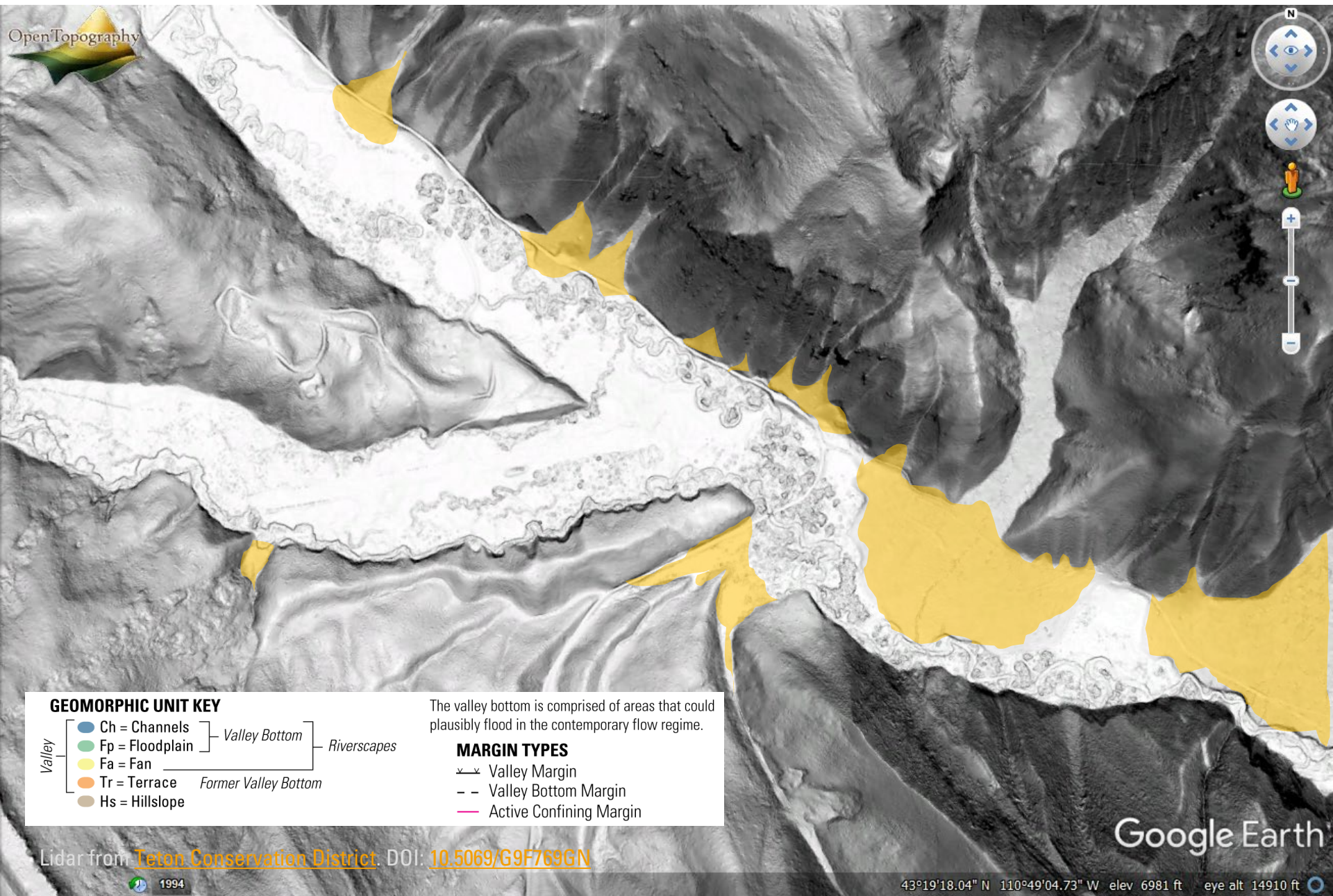
Lidar from [Teton Conservation District](#). DOI: [10.5069/G9F769GN](#)

Google Earth

Start with those channels first!



Next, map the fans (i.e. non valley bottom)



OpenTopography

GEOMORPHIC UNIT KEY

- | | | | |
|----------------|----------------------|-----------------|---------------|
| Valley | Ch = Channels | } Valley Bottom | } Riverscapes |
| | Fp = Floodplain | | |
| | Fa = Fan | | |
| Tr = Terrace | Former Valley Bottom | | |
| Hs = Hillslope | | | |

The valley bottom is comprised of areas that could plausibly flood in the contemporary flow regime.

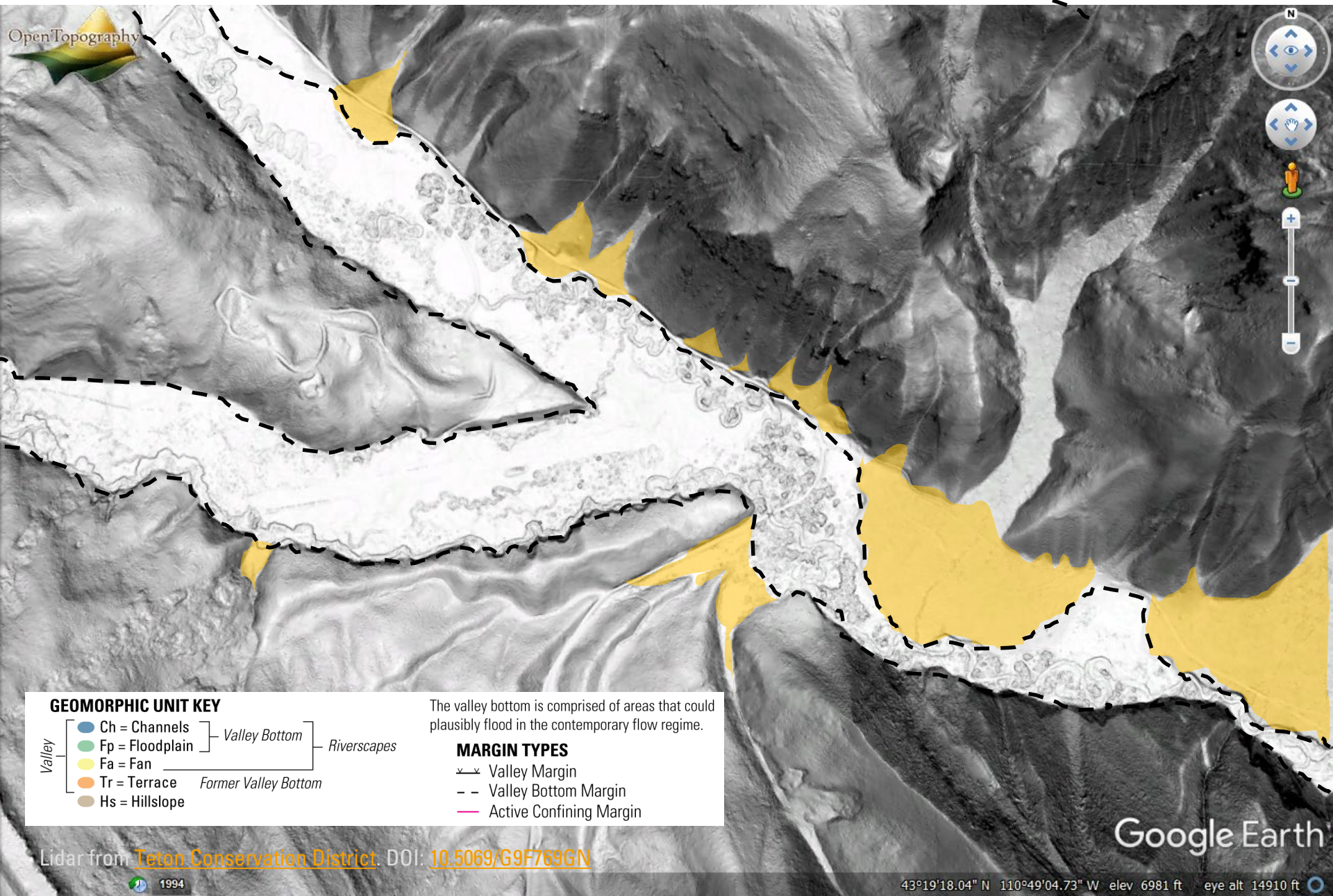
MARGIN TYPES

- Valley Margin
- Valley Bottom Margin
- Active Confining Margin

Lidar from [Teton Conservation District](#). DOI: [10.5069/G9F769GN](#)

Google Earth

Next, trace the valley bottom margin



Open Topography

GEOMORPHIC UNIT KEY

- | | | | |
|--------|-----------------|----------------------|---------------|
| Valley | Ch = Channels | } Valley Bottom | } Riverscapes |
| | Fp = Floodplain | | |
| | Fa = Fan | | |
| | Tr = Terrace | Former Valley Bottom | |
| | Hs = Hillslope | | |

The valley bottom is comprised of areas that could plausibly flood in the contemporary flow regime.

MARGIN TYPES

- Valley Margin
- Valley Bottom Margin
- Active Confining Margin

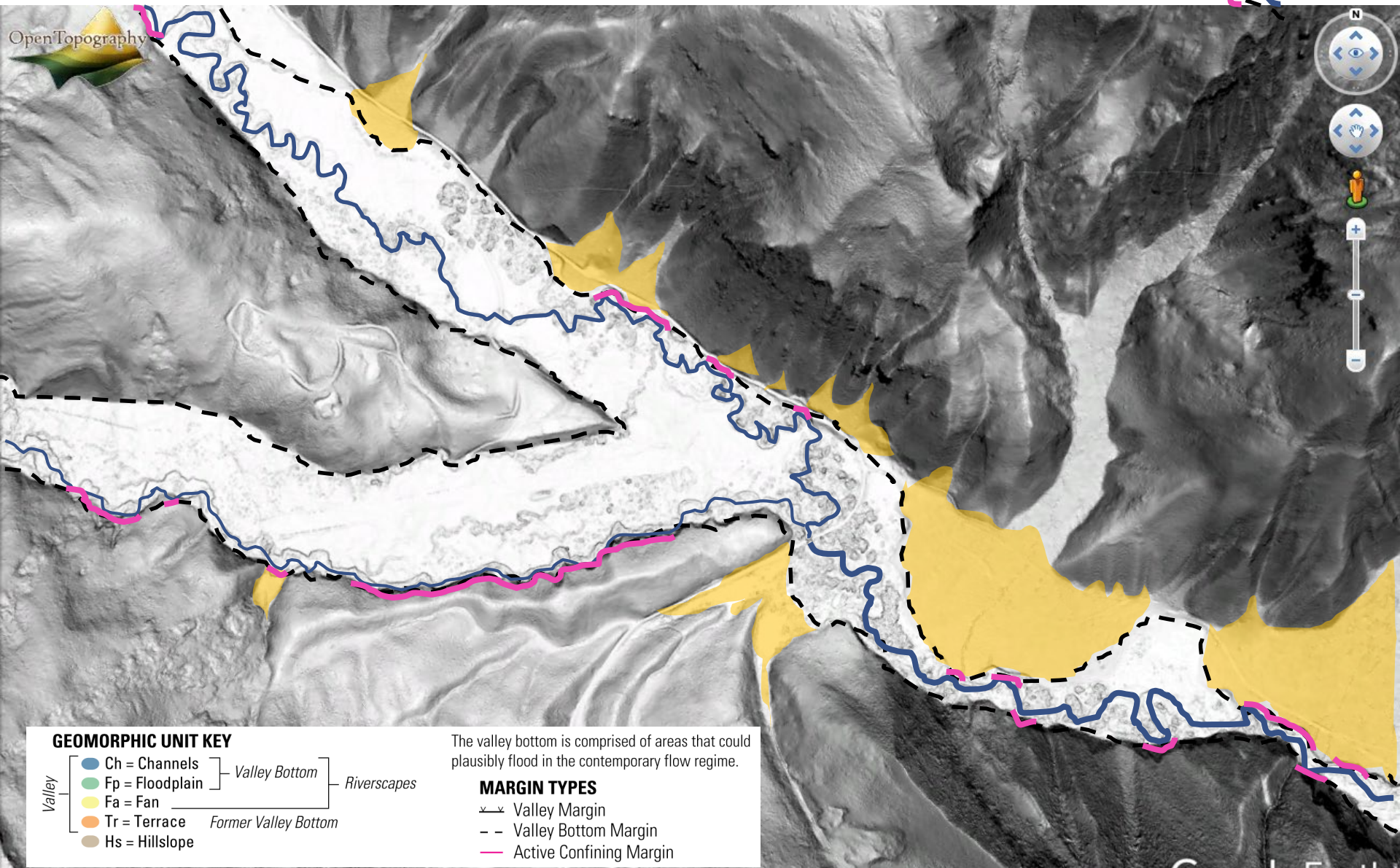
Lidar from [Teton Conservation District](#). DOI: [10.5069/G9F769GN](#)

1994

43°19'18.04" N 110°49'04.73" W elev 6981 ft eye alt 14910 ft

Google Earth

Finally, Identify Active Confining Margins



Lidar from [Teton Conservation District](#). DOI: [10.5069/G9F769GN](#)

You Don't Need to be a GIS Whiz!

Visit USGS National Map: <https://viewer.nationalmap.gov/advanced-viewer/>

The screenshot displays the USGS National Map viewer interface. At the top left, the USGS logo is accompanied by the tagline "science for a changing world" and "The National Map". A green navigation bar contains links for "Help", "Data Download", and "Services", along with a series of icons for map navigation and tools. On the right side of this bar is a search input field with the placeholder text "Find address or place" and a search icon. The main map area shows a topographic view of a region with yellow contour lines, blue water features, and green vegetation. Labels on the map include "BIG MOUNTAIN", "MUNGER MOUNTAIN", "COBURN CREEK", "MULE FOOT DR", and "Fair Creek". A scale bar in the bottom left corner indicates a scale of 1:16,050 and a distance of 0.2 miles. The bottom center of the map shows the coordinates "-110.793 43.343 Degrees". In the bottom right corner, there is a copyright notice: "USGS The National Map: Orthoimagery and US Topo. Data refreshed April, 2018." and the Esri logo.

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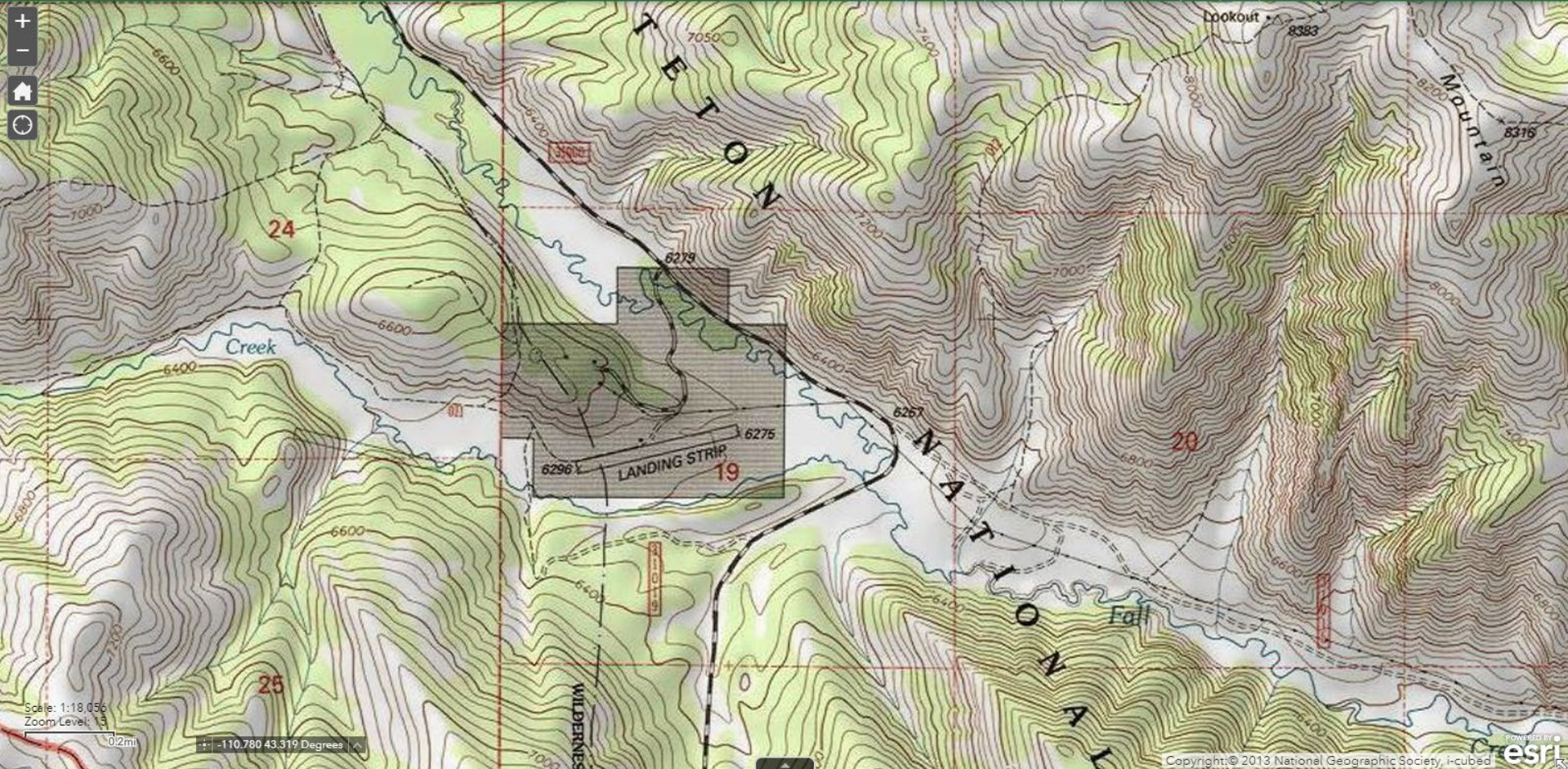
You can change Basemap to USGS 7.5 Quad!

Use USA Topo Maps @ Zoom Level ≥ 14



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Help Data Download Services



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Make Basic Measurements

e.g. Valley Bottom Width



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Search USGS

Help Data Download Services



Find address or place



Measurement

Feet (US)

Measurement Result

883.1 Feet (US)

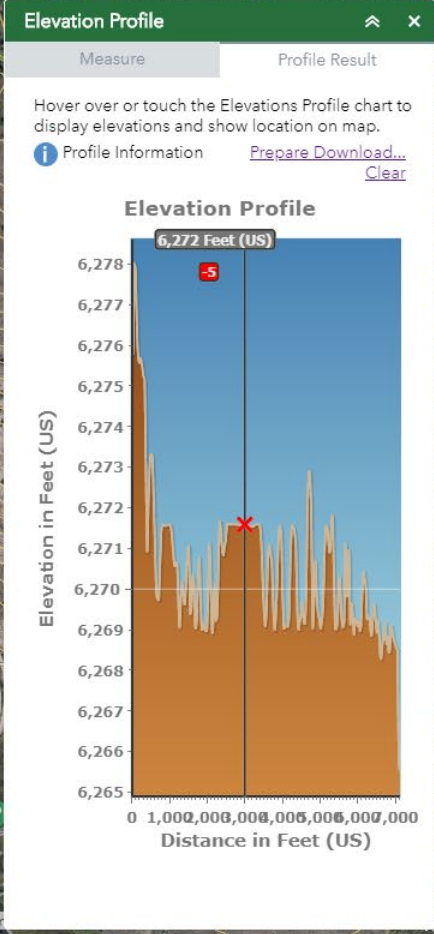
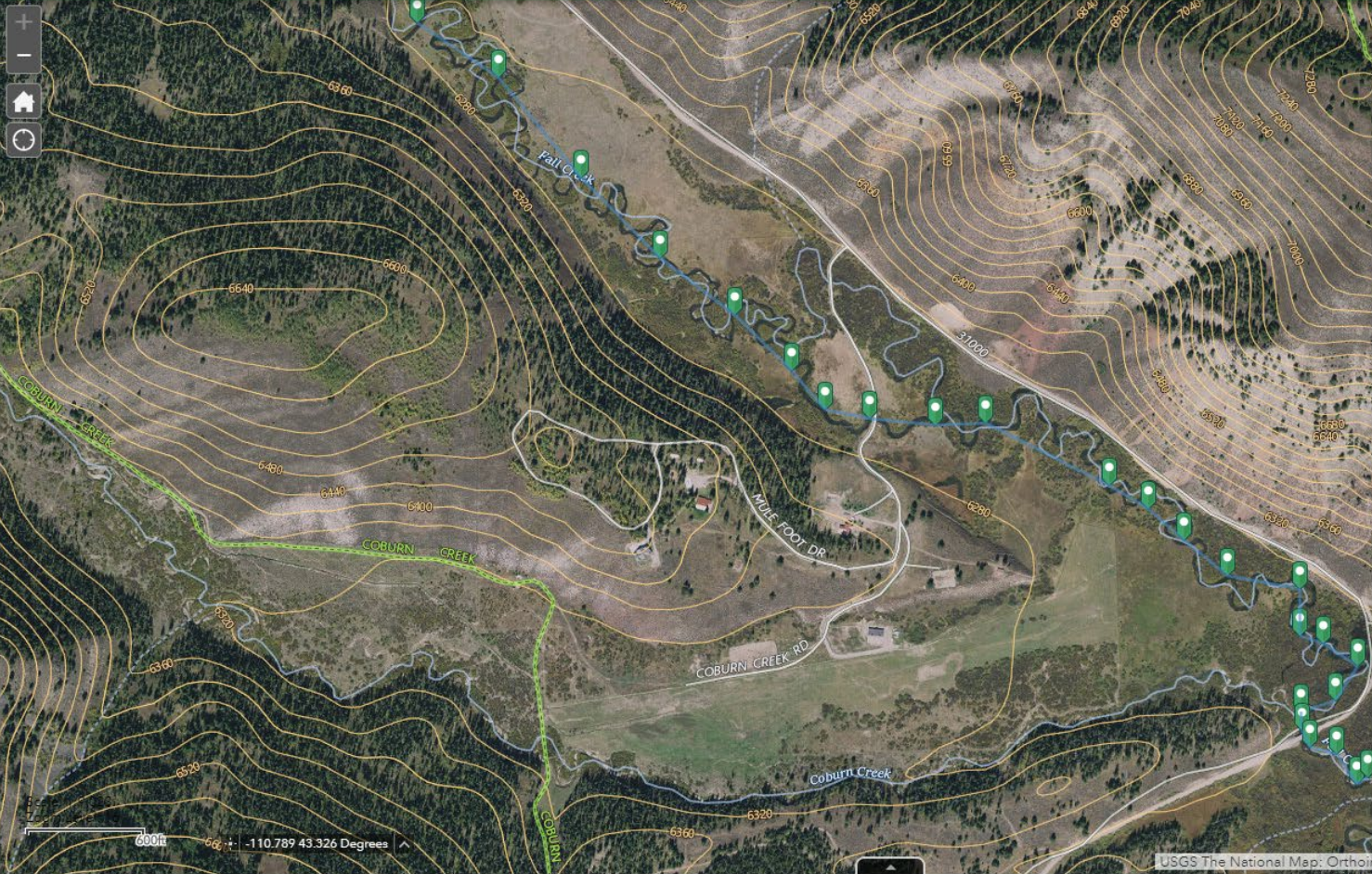
Clear

USGS The National Map: Orthoimagery Press CTRL to enable snapping

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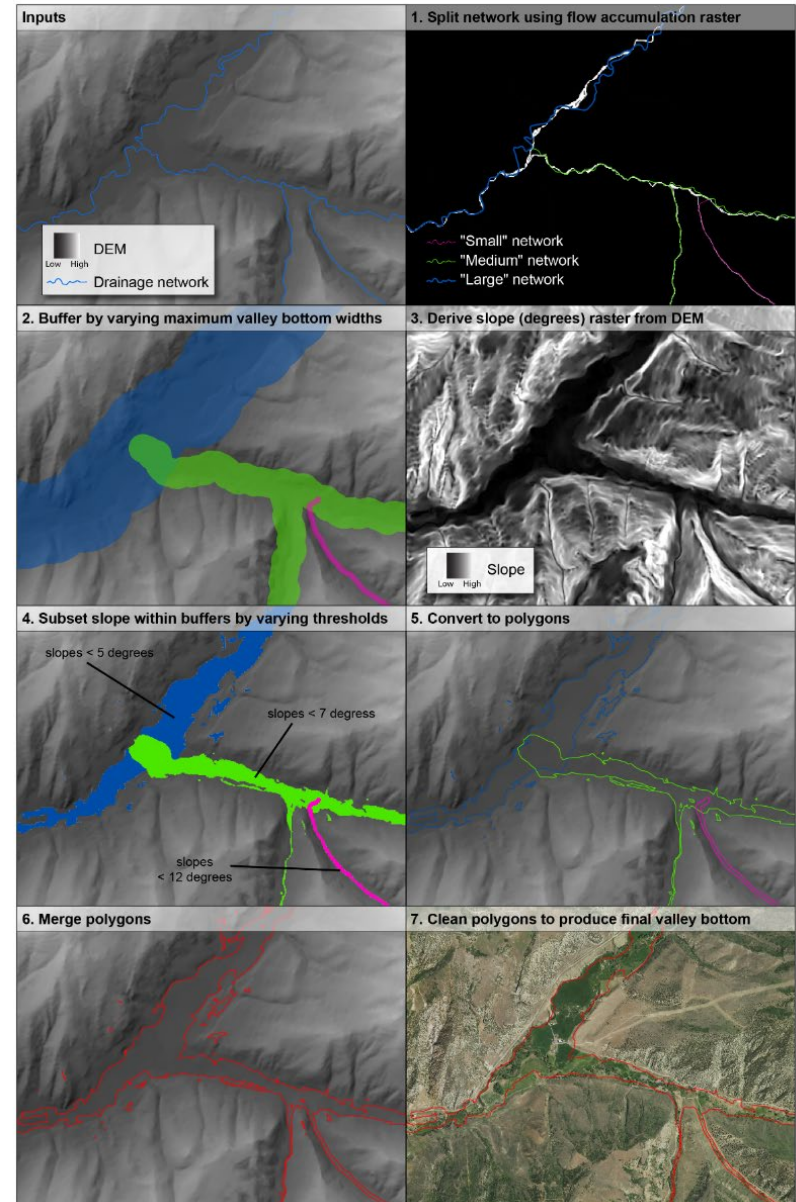
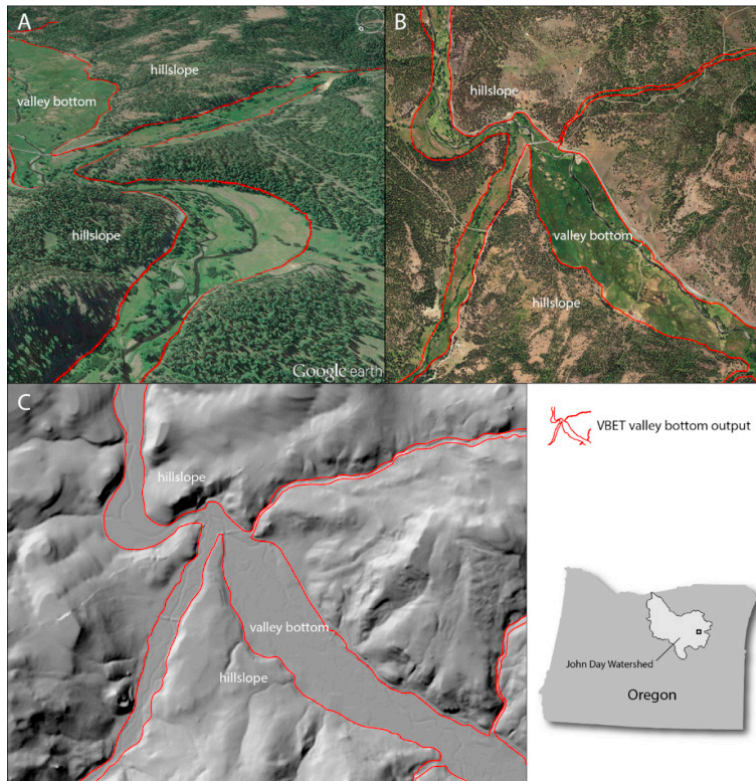


Pull Rough Sections or Profiles i.e. From 10 m NED DEM



V-BET: VALLEY BOTTOM EXTRACTION TOOL

- From topography (e.g. USGS 10 m NED or LiDAR) & V-BET

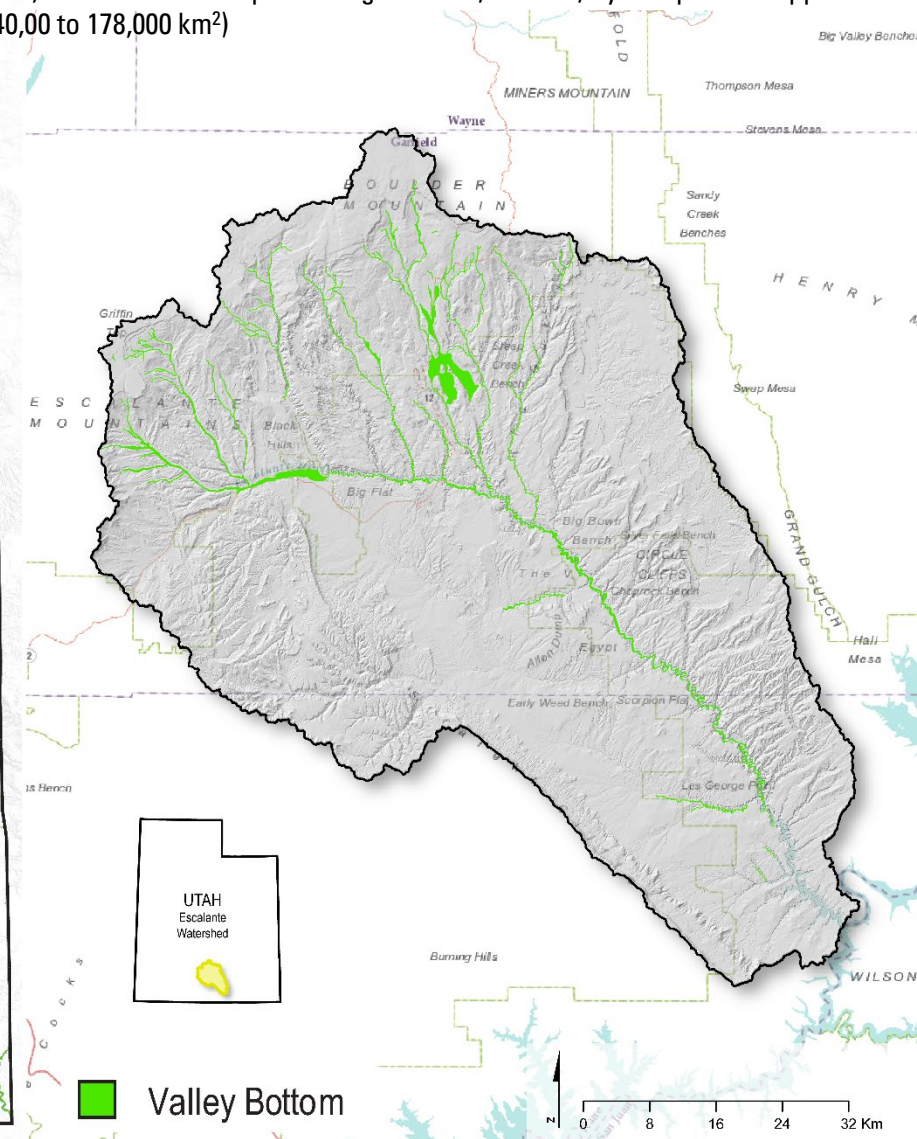
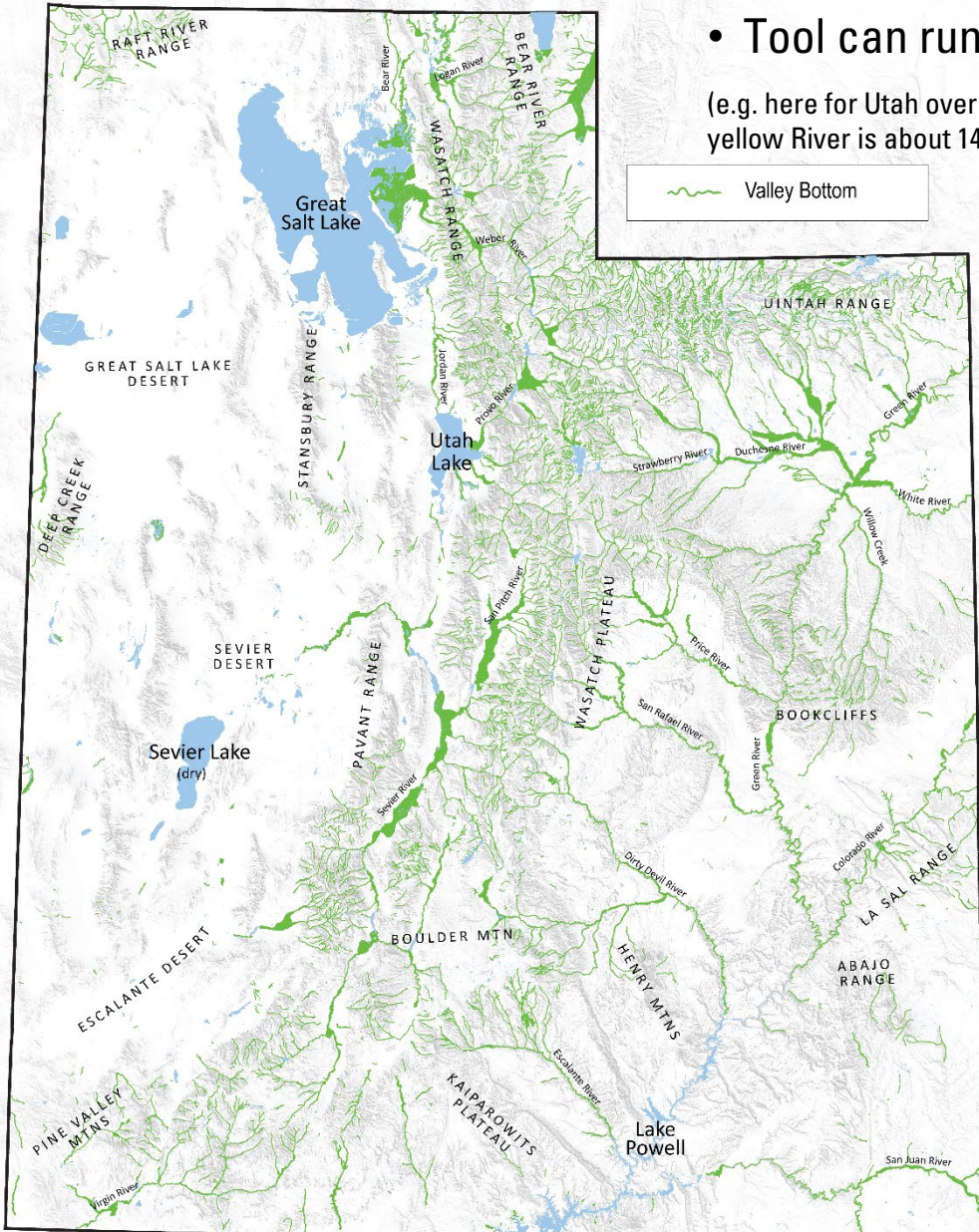
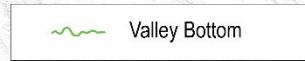


From: Gilbert et al. (2016) – Computers & Geosciences ;
DOI: [10.1016/j.cageo.2016.07.014](https://doi.org/10.1016/j.cageo.2016.07.014)
<http://rcat.riverscapes.xyz>

Province-wide or Watershed Wide: VALLEY BOTTOMS

- Tool can run @ broad spatial scales from DEM

(e.g. here for Utah over 25,000 km of riverscape in a region ~ 220,000 km²; by comparison Upper yellow River is about 140,00 to 178,000 km²)



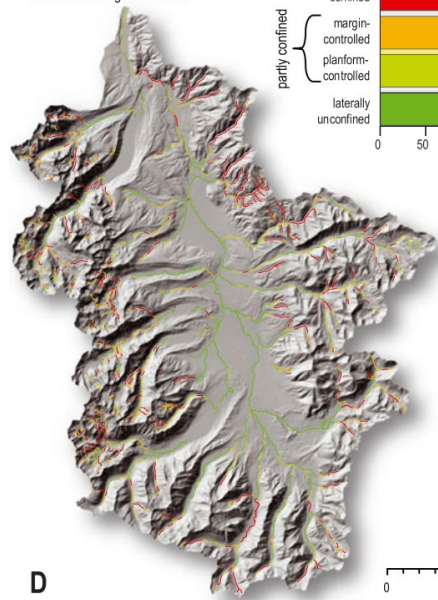
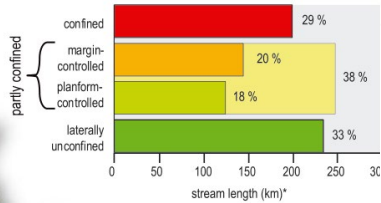
Map Confinement – Understand Valley Setting



Inputs: VB +
Channel(s) Position



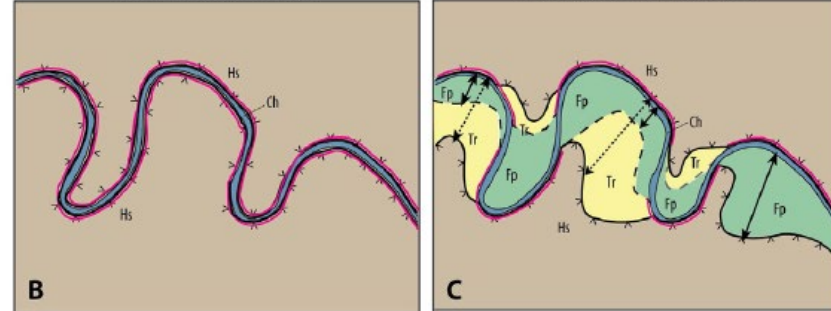
Upper Salmon
*total stream length = 729 km



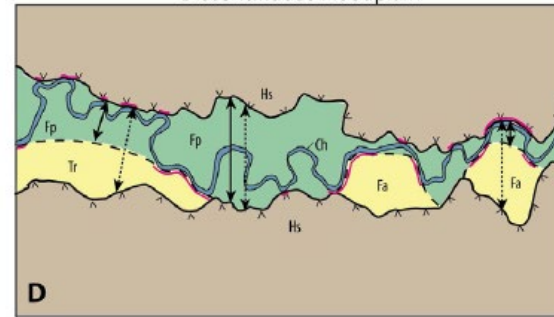
D
0 5 10 kilometers

From: O'Brien et al. (2019) – ESPL;
DOI: [10.1002/esp.4615](https://doi.org/10.1002/esp.4615)

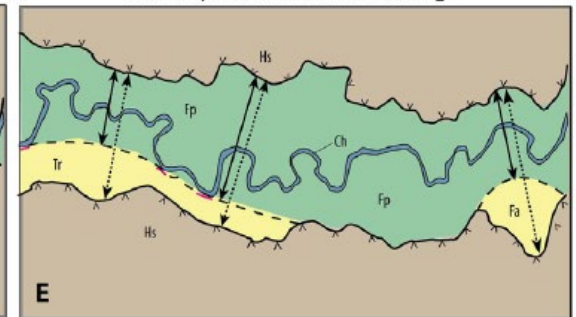
Partly Confined Valley with Bedrock-Controlled Discontinuous Floodplain



Partly Confined Valley with Meandering Planform-Controlled Discontinuous Floodplain



Laterally Unconfined Meandering



WIDTHS
 <---> Valleys
 <---> Valley Bottoms

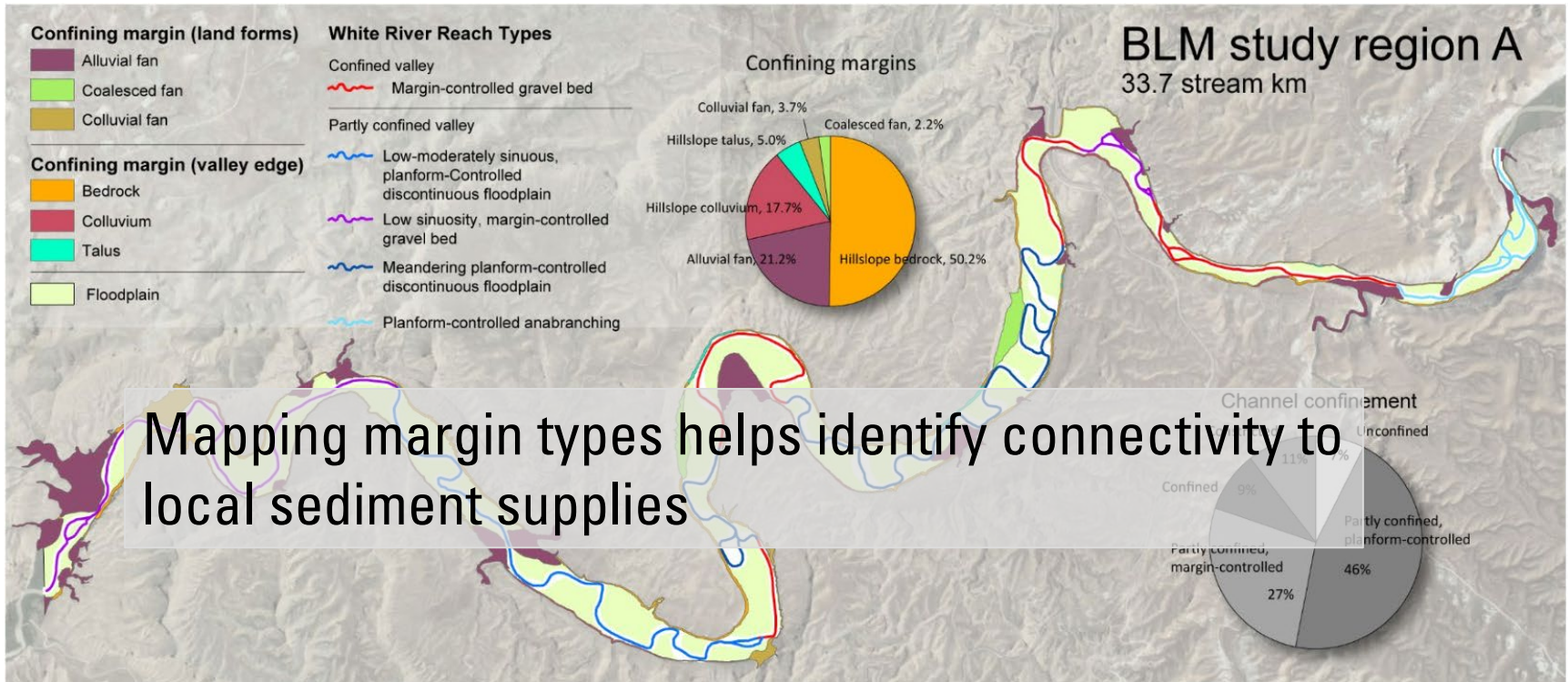
MARGIN TYPES
 --- Confining Margin
 -x-x Valley Margin
 - - - Valley Bottom Margin

GEOMORPHIC UNITS (TIER 1)
 Ch = Channel
 Fp = Floodplain
 Tr = Terrace
 Fa = Fan
 Hs = Hillslope

Check out: Confinement Tool in GNAT:
<http://gnat.riverscapes.xyz/>



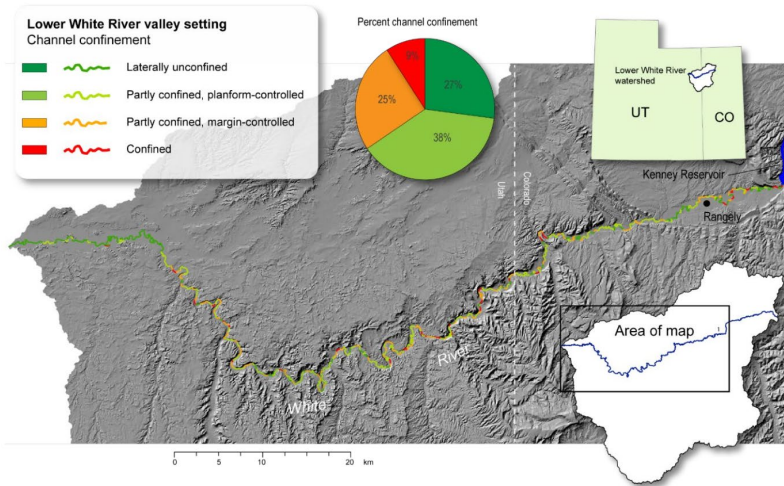
From: Fryirs et al. (2015) – ESPL;
 DOI: [10.1002/esp.3893](https://doi.org/10.1002/esp.3893)



Partly confined valley, low sinuosity, margin-controlled gravel bed	Partly confined valley, low-moderately sinuous, planform-controlled, discontinuous floodplain	Partly confined valley, meandering planform discontinuous floodplain	Confined valley, margin-controlled gravel bed	Partly confined valley, planform-controlled anabranching
<p>Total stream km: 7.5 km</p> <p>Sinuosity: 1.2</p> <p>Planform: low sinuosity</p> <p>Confinement: 50%</p> <p>Constriction: 0.02%</p> <p style="text-align: center;">Total confinement (3.4 km)</p>	<p>Total stream km: 5.8 km</p> <p>Sinuosity: 1.4</p> <p>Planform: sinuous</p> <p>Confinement: 30%</p> <p>Constriction: 0.02%</p> <p style="text-align: center;">Total confinement (1.9 km)</p>	<p>Total stream km: 9.7 km</p> <p>Sinuosity: 1.7</p> <p>Planform: meandering</p> <p>Confinement: 40%</p> <p>Constriction: 0</p> <p style="text-align: center;">Total confinement (4.2 km)</p>	<p>Total stream km: 7.3 km</p> <p>Sinuosity: 1.1</p> <p>Planform: low sinuosity</p> <p>Confinement (average): 75%</p> <p>Constriction: 10%</p> <p style="text-align: center;">Total confinement (5.2 km)</p>	<p>Total stream km: 3.67 km</p> <p>Sinuosity: 1.2</p> <p>Planform: low sinuosity</p> <p>Confinement (average): 50%</p> <p>Constriction: 10%</p> <p style="text-align: center;">Total confinement (2.2 km)</p>

Stacked Profile Plots

Network models of Geomorphic Attributes



Give us reach types (River Styles) and condition

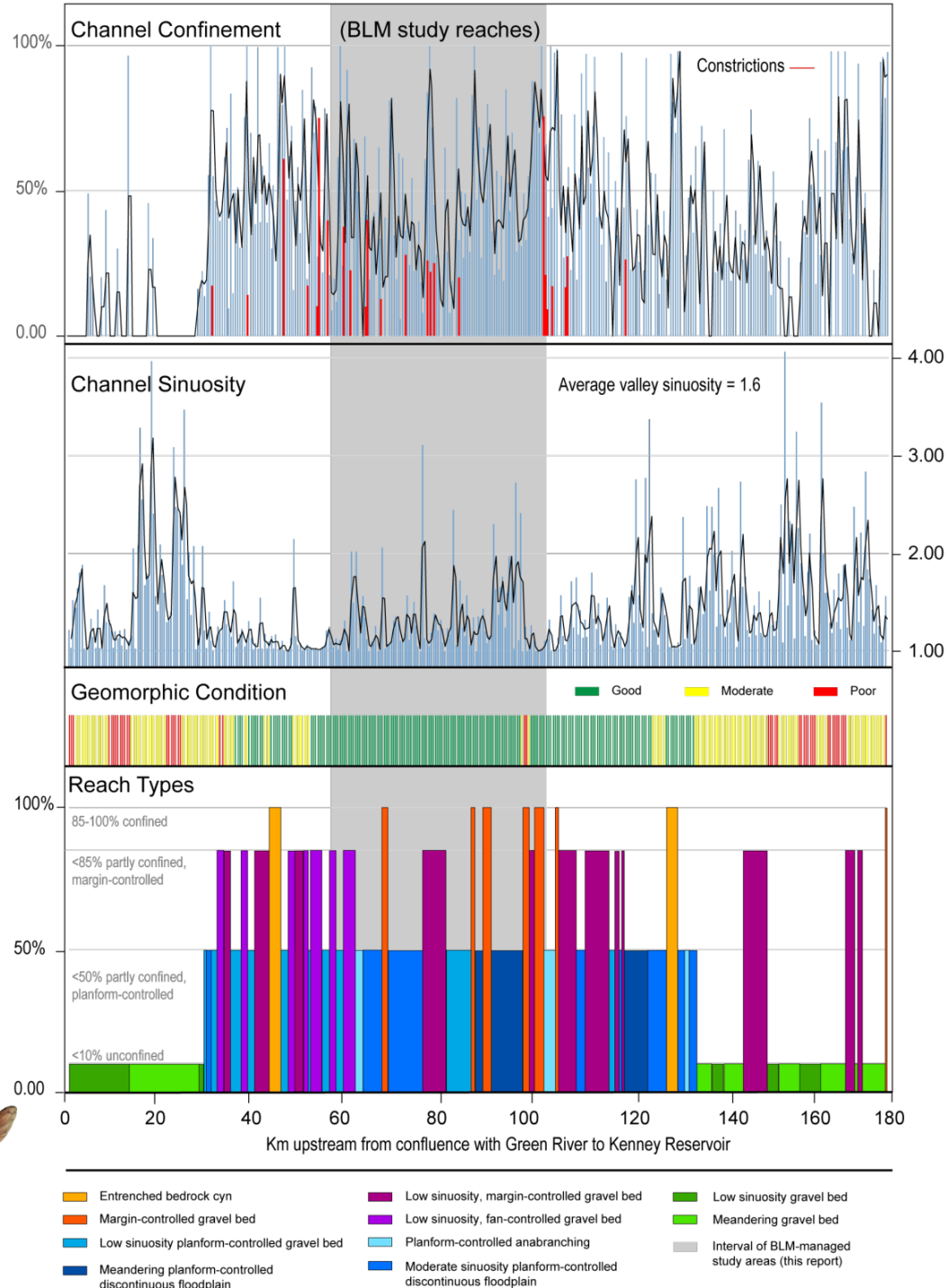
From: O'Brien et al. (2019) : DOI: [10.13140/RG.2.2.28838.57924/1](https://doi.org/10.13140/RG.2.2.28838.57924/1)

Check out: Confinement Tool in GNAT:

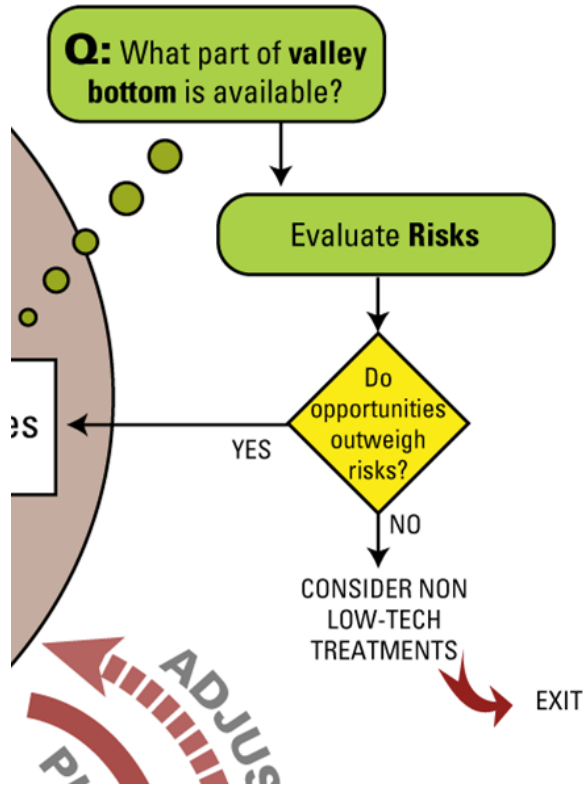
<http://gnat.riverscapes.xyz/> &

Network Profiler Tool:

<https://riverscapes.github.io/NetworkProfiler/>



Evaluate Risks



Risk Considerations Checklist for Low-Tech Stream and Meadow Restoration

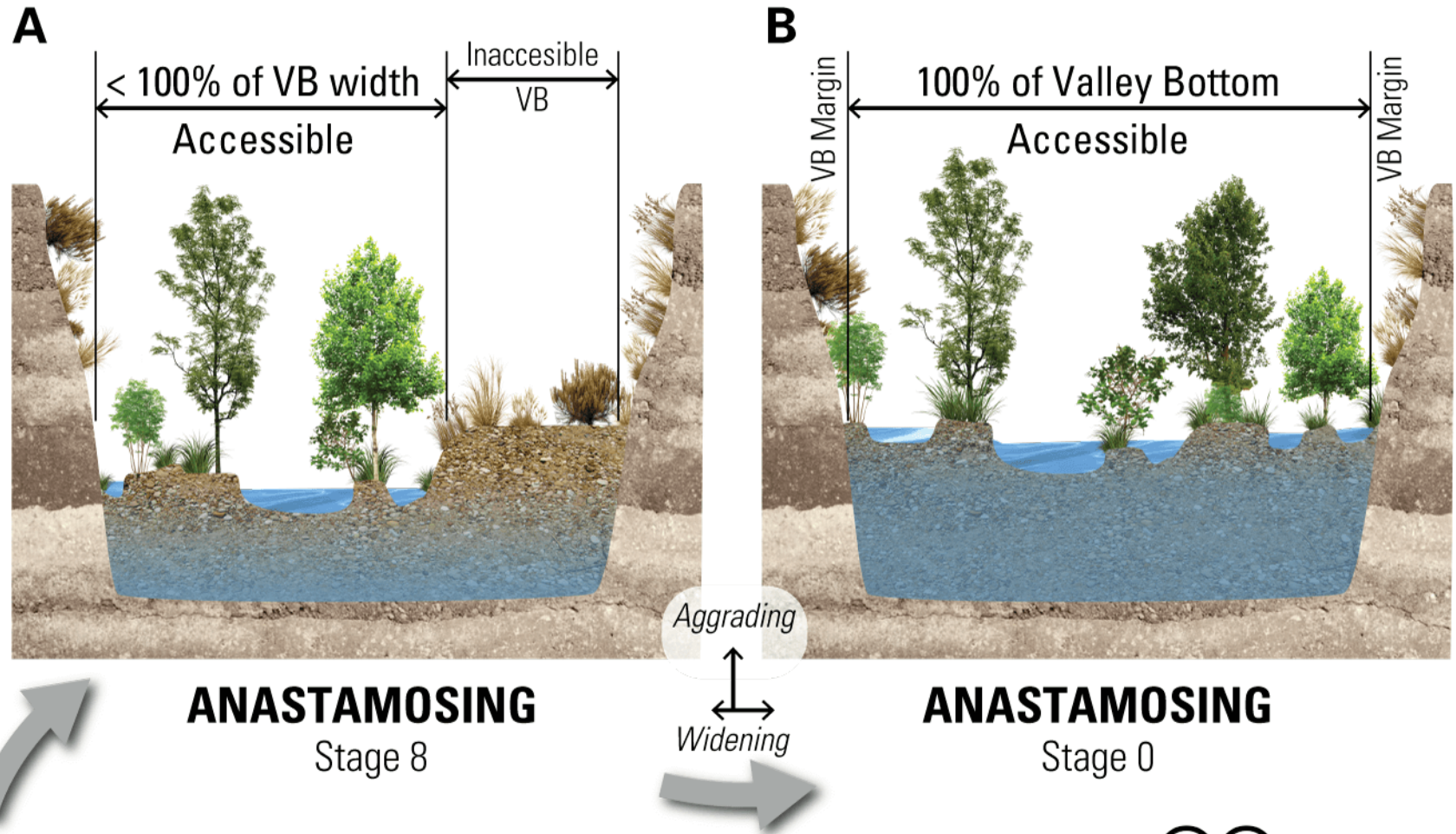
Instructions

For each factor, select the characteristic that best describes the project site. If answers vary within project area, consider breaking site into multiple reaches and assessing each separately. This is not a comprehensive list, but rather, represents some basic considerations related to assessing potential risks to property, infrastructure, and public safety to discuss with the landowner/manager and stakeholders (green = lower risk, yellow = moderate risk, red = higher risk). For factors rating yellow or red, project planners may need to engage other technical specialists for additional review and analysis. Alternatives to mitigate or lower risks to acceptable levels should be evaluated in the planning process. In the notes, describe the situation and how risks are being reduced. In some cases, low-tech restoration approaches may not be appropriate based on constraints and risks.

+

Areas Adjacent to Riverscape Land Use		
Areas adjacent are in an undeveloped range or forest land setting		Green
Areas adjacent are in a crop, pasture, or hay land setting		Yellow
Areas adjacent are in a developed setting		Red
Valley Bottom Land Use (e.g., roads, bridges, culverts, buildings, diversions)		
Valley bottom and adjacent area (up and downstream) does not contain infrastructure of concern		Green
Valley bottom or adjacent area (up and downstream) contains some infrastructure, but would not be negatively impacted by processes of wood accumulation or beaver dam activity, or consequences of impact would be low		Yellow
Valley bottom or adjacent area (up and downstream) contains infrastructure that may be negatively impacted by low-tech structure failure and consequences would be unacceptable		Red
Stream Order & Wadeability		
1st through 3rd order wadeable stream		Green
3rd – 5th order wadeable stream		Yellow
5th order non-wadeable stream or greater		Red
Channel Change and Floodplain Reconnection		
Landowner/manager willing/able to give the stream space to adjust in the valley bottom and understands this may include lateral erosion, deposition, change of stream channel position, and inundation		Green
Landowner/manager willing/able to give the stream space to adjust in some portions of the valley bottom but not all of it		Yellow
Landowner/manager unwilling/unable to give the stream space to adjust in the valley bottom		Red
Willingness to allow processes of wood accumulation and/or beaver dam activity		
Landowner/manager willing/able to allow dynamic processes & no concerns with nearby landowner/managers.		Green
Landowner/manager willing/able to allow some processes (but maybe not all) and/or concerns of or with nearby landowner/managers		Yellow
Landowner/manager unwilling/unable to allow processes of wood accumulation and/or beaver dam activity		Red
Adaptive Management		
Landowner/manager understands multiple treatments through time may be needed and is committed to follow-up monitoring, maintenance, and adaptive management		Green
Landowner/manager understands multiple treatments through time may be needed but resources to do follow-up may limit the ability to adjust or correct problems		Yellow
Landowner/manager wants a single intervention; no monitoring, maintenance, or adaptive management will occur		Red
Notes:		

How Much of Valley Bottom?



From Stage 5-7

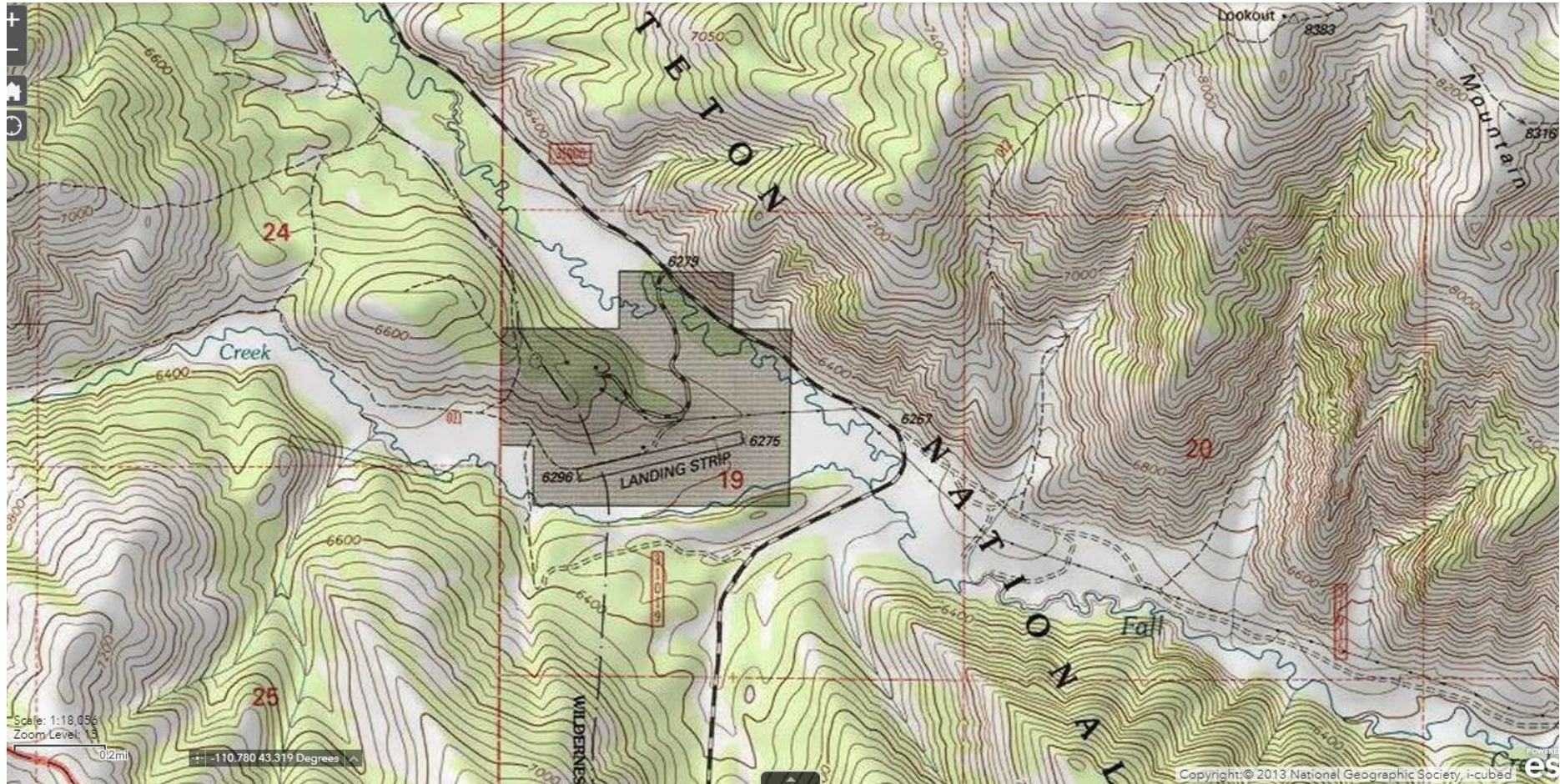
 Nick Weber

From 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)

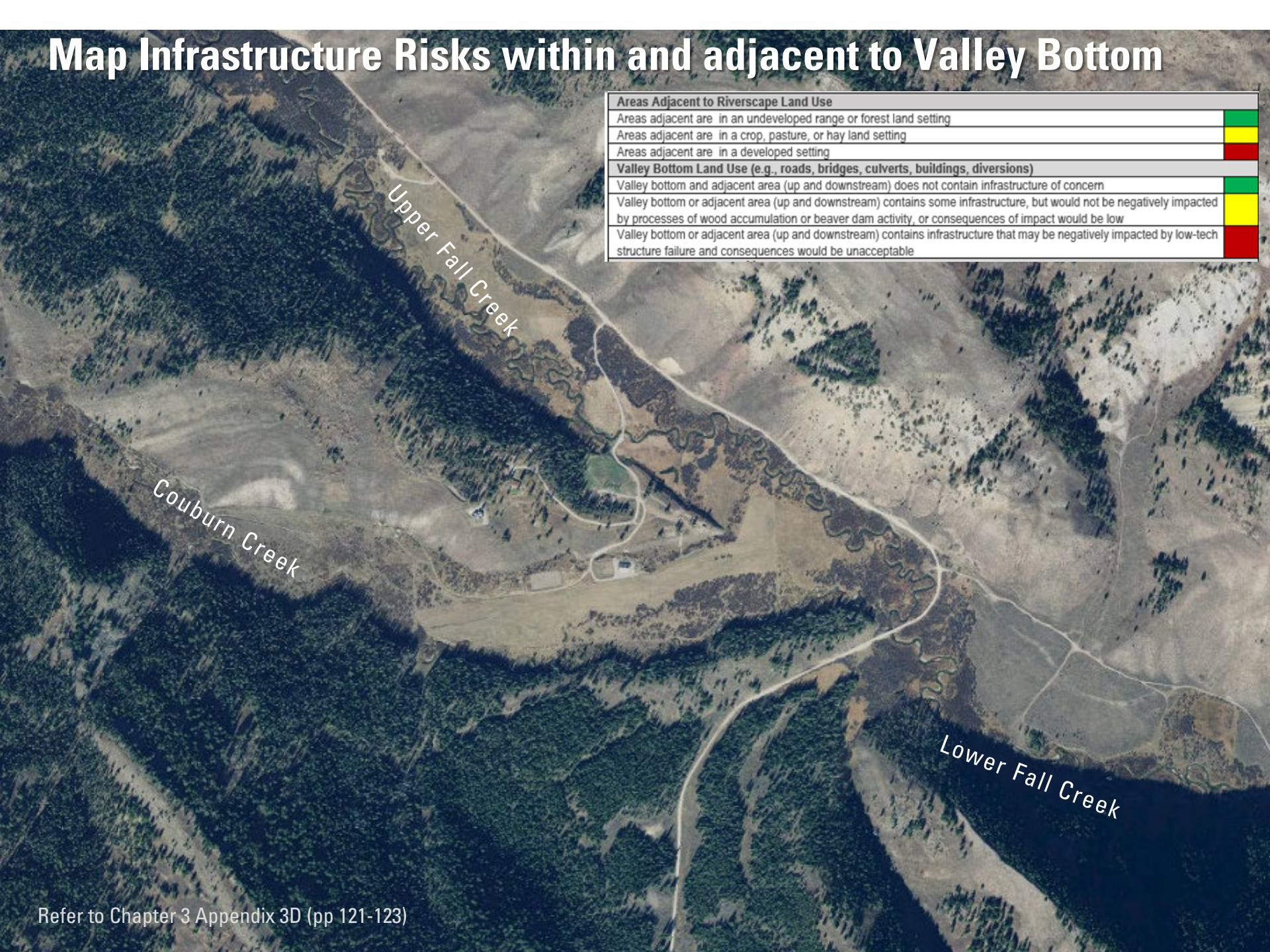
Next we will map anthropogenic Constraints...

With some limited photographic & map-based evidence



Map Infrastructure Risks within and adjacent to Valley Bottom

Areas Adjacent to Riverscape Land Use	
Areas adjacent are in an undeveloped range or forest land setting	Green
Areas adjacent are in a crop, pasture, or hay land setting	Yellow
Areas adjacent are in a developed setting	Red
Valley Bottom Land Use (e.g., roads, bridges, culverts, buildings, diversions)	
Valley bottom and adjacent area (up and downstream) does not contain infrastructure of concern	Green
Valley bottom or adjacent area (up and downstream) contains some infrastructure, but would not be negatively impacted by processes of wood accumulation or beaver dam activity, or consequences of impact would be low	Yellow
Valley bottom or adjacent area (up and downstream) contains infrastructure that may be negatively impacted by low-tech structure failure and consequences would be unacceptable	Red



Just as a reminder...



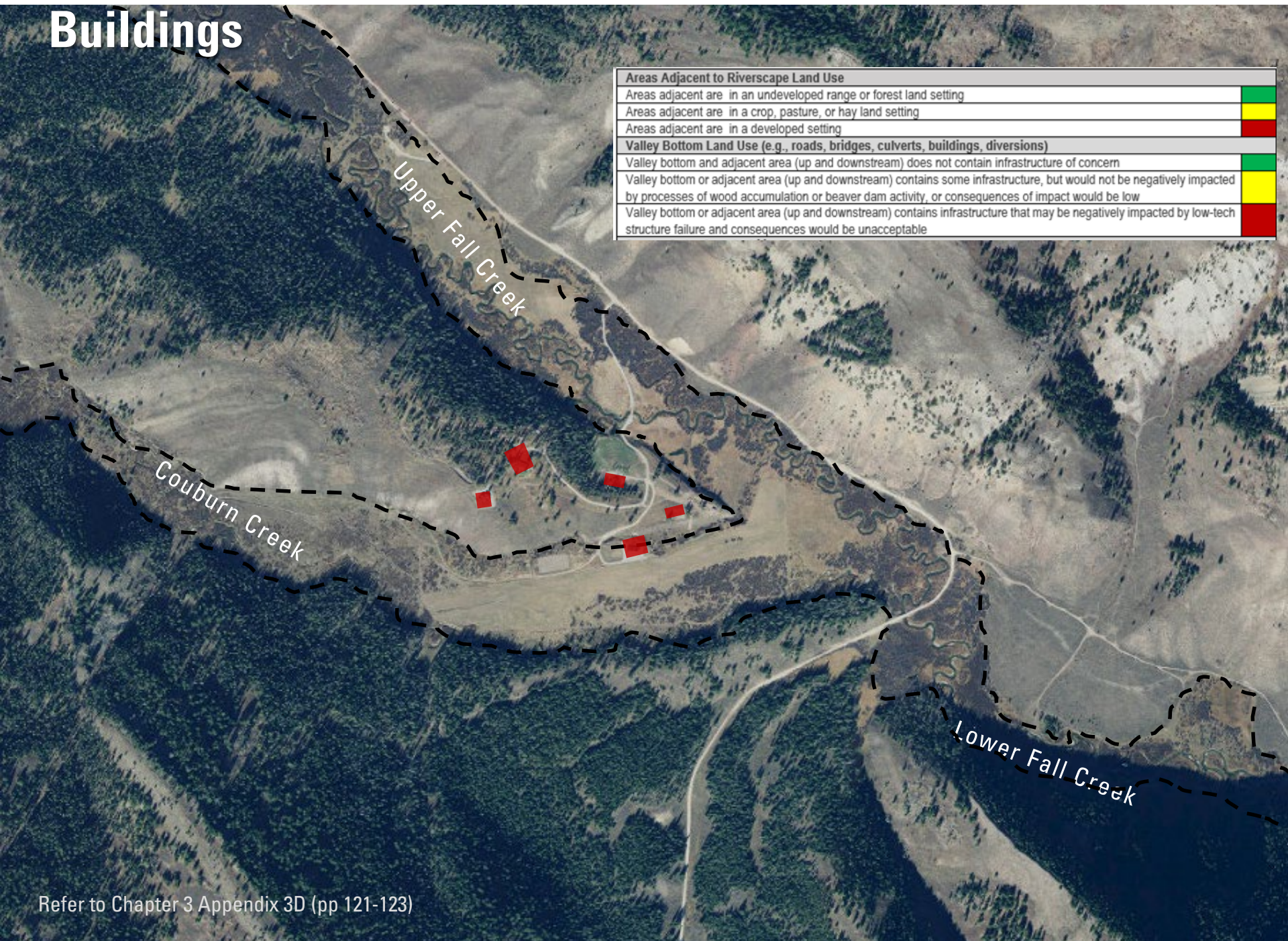
© 2018 Google

Google Earth

1994

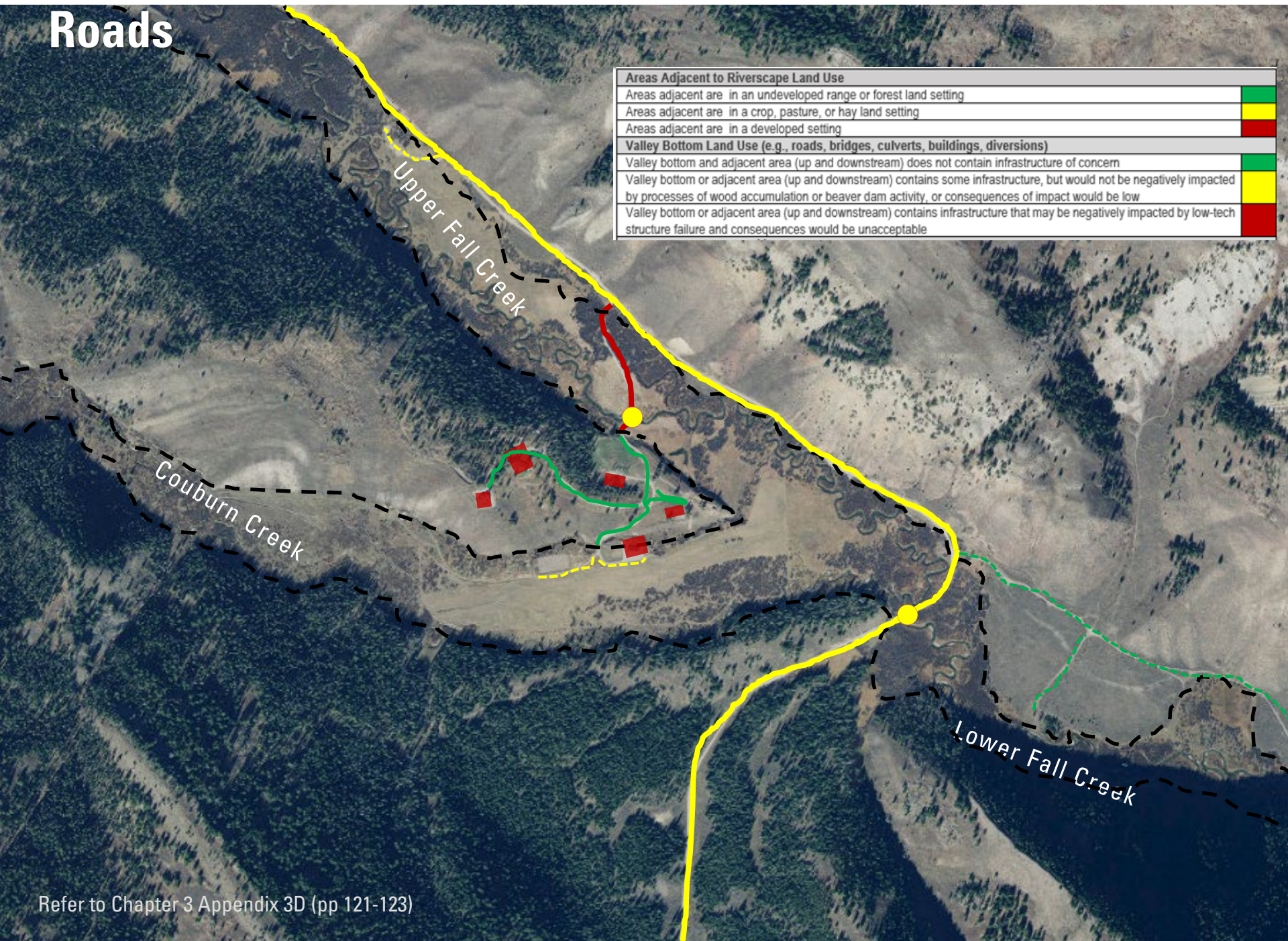
Imagery Date: 6/21/2017 43°19'45.60" N 110°48'03.63" W elev 6283 ft eye alt 14910 ft

Buildings



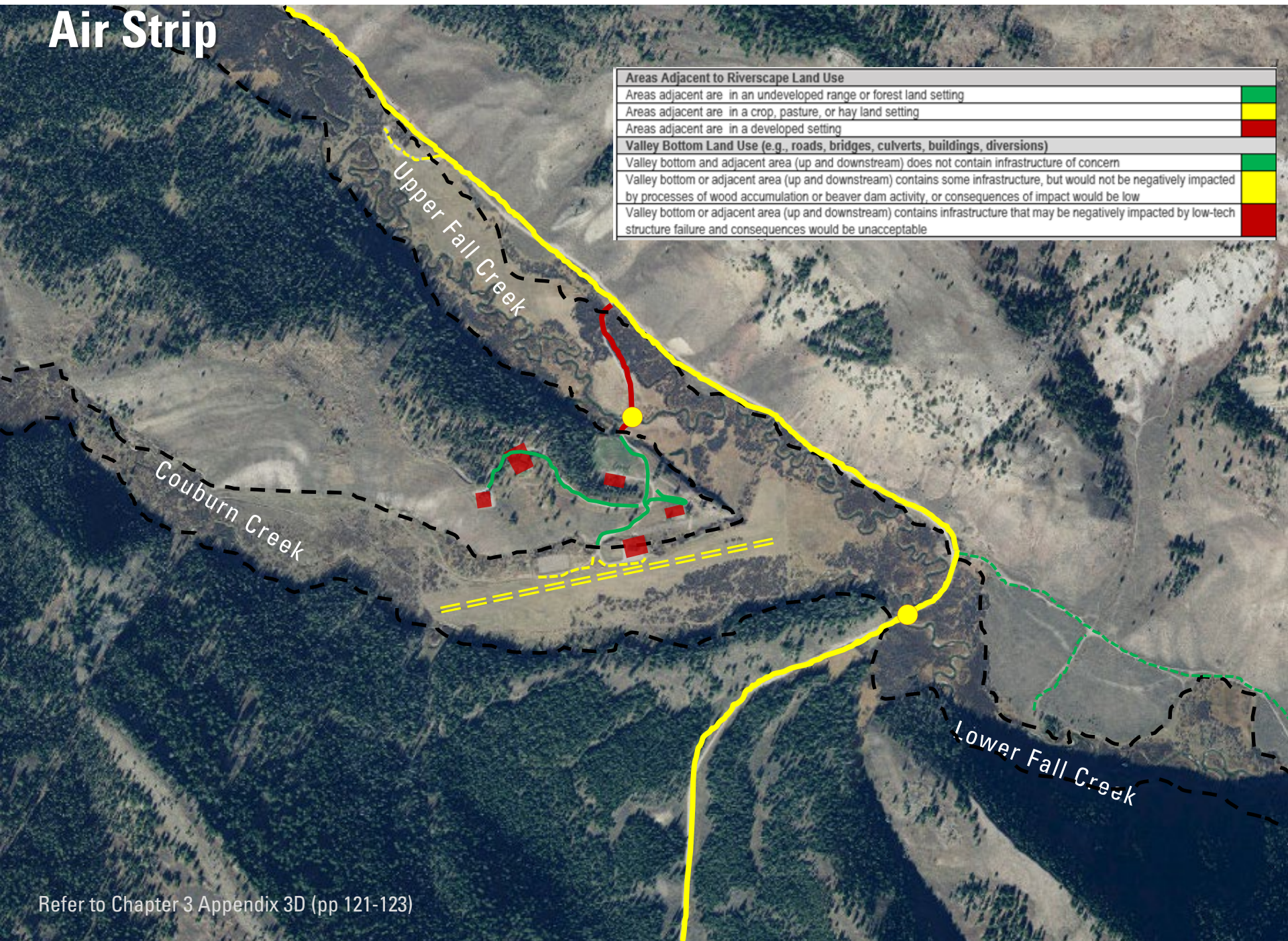
Roads

Areas Adjacent to Riverscape Land Use	
Areas adjacent are in an undeveloped range or forest land setting	Green
Areas adjacent are in a crop, pasture, or hay land setting	Yellow
Areas adjacent are in a developed setting	Red
Valley Bottom Land Use (e.g., roads, bridges, culverts, buildings, diversions)	
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Valley bottom or adjacent area (up and downstream) contains infrastructure that may be negatively impacted by low-tech structure failure and consequences would be unacceptable	Red

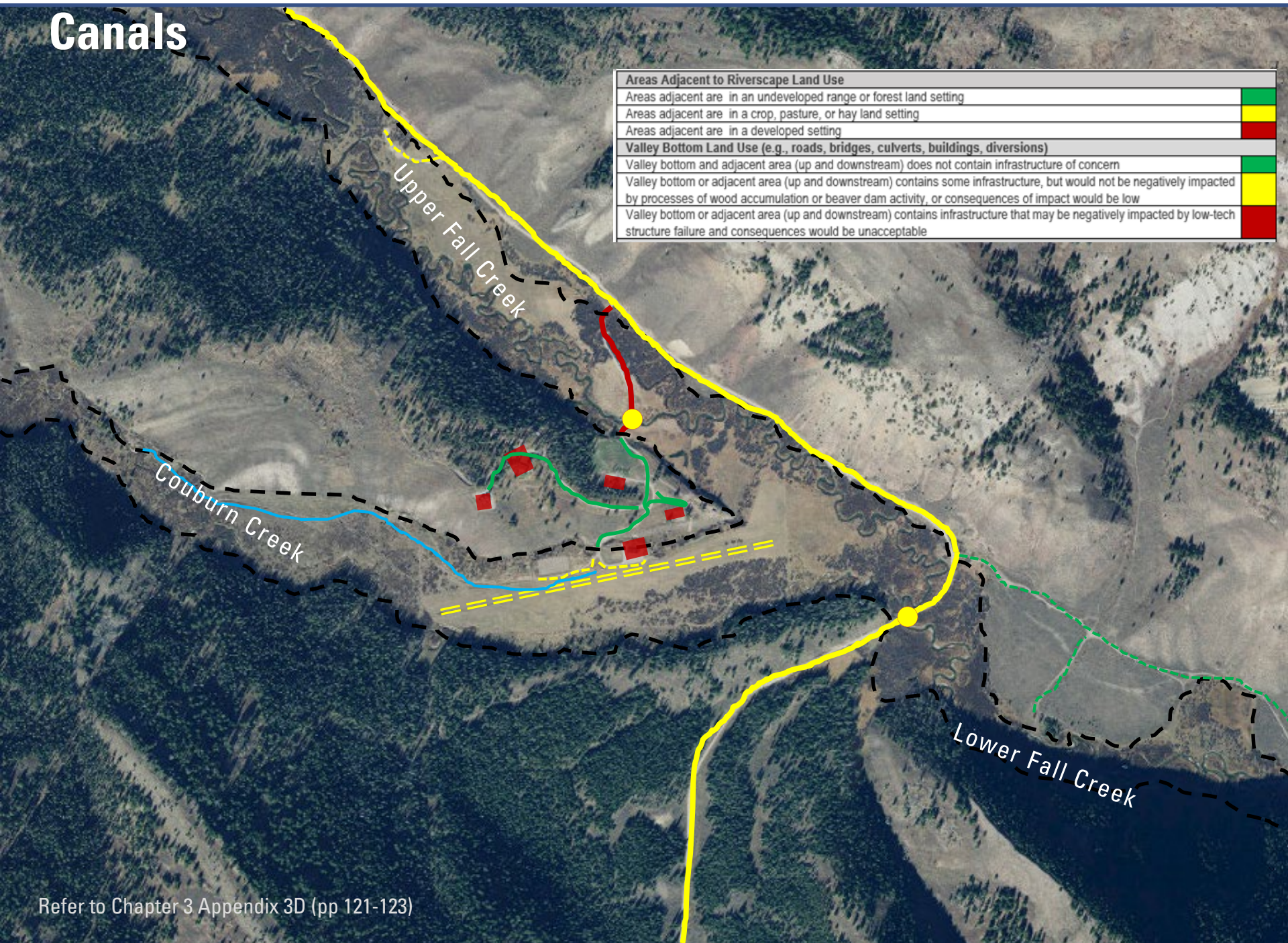


Air Strip

Areas Adjacent to Riverscape Land Use	
Areas adjacent are in an undeveloped range or forest land setting	Green
Areas adjacent are in a crop, pasture, or hay land setting	Yellow
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Valley bottom or adjacent area (up and downstream) contains infrastructure that may be negatively impacted by low-tech structure failure and consequences would be unacceptable	Red



Canals

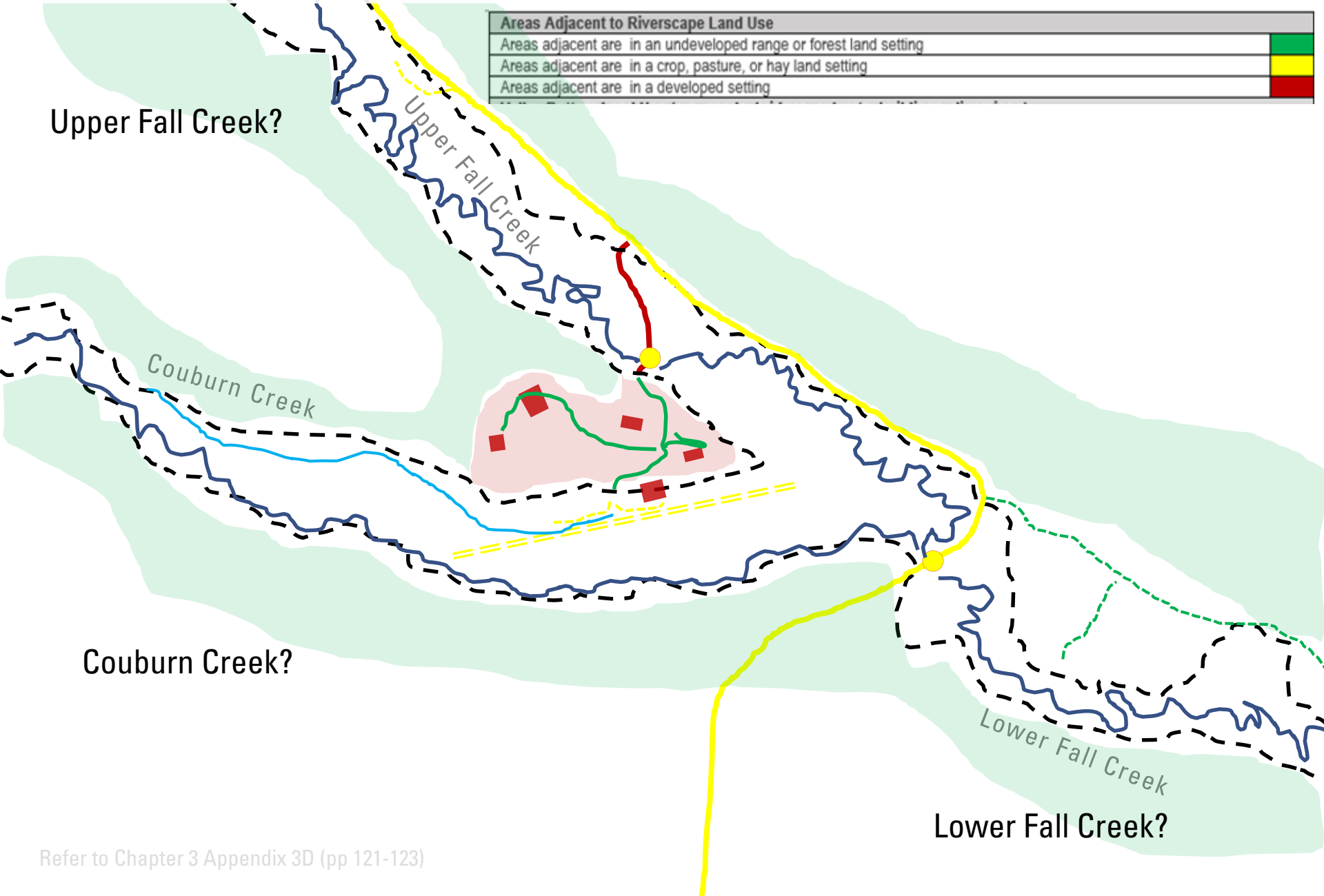


Areas Adjacent to Riverscape Land Use	
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Valley bottom or adjacent area (up and downstream) contains infrastructure that may be negatively impacted by low-tech structure failure and consequences would be unacceptable	Red

Areas Adjacent to Riverscape Land Use?

Areas Adjacent to Riverscape Land Use	
Areas adjacent are in an undeveloped range or forest land setting	Green
Areas adjacent are in a crop, pasture, or hay land setting	Yellow
Areas adjacent are in a developed setting	Red

Upper Fall Creek?



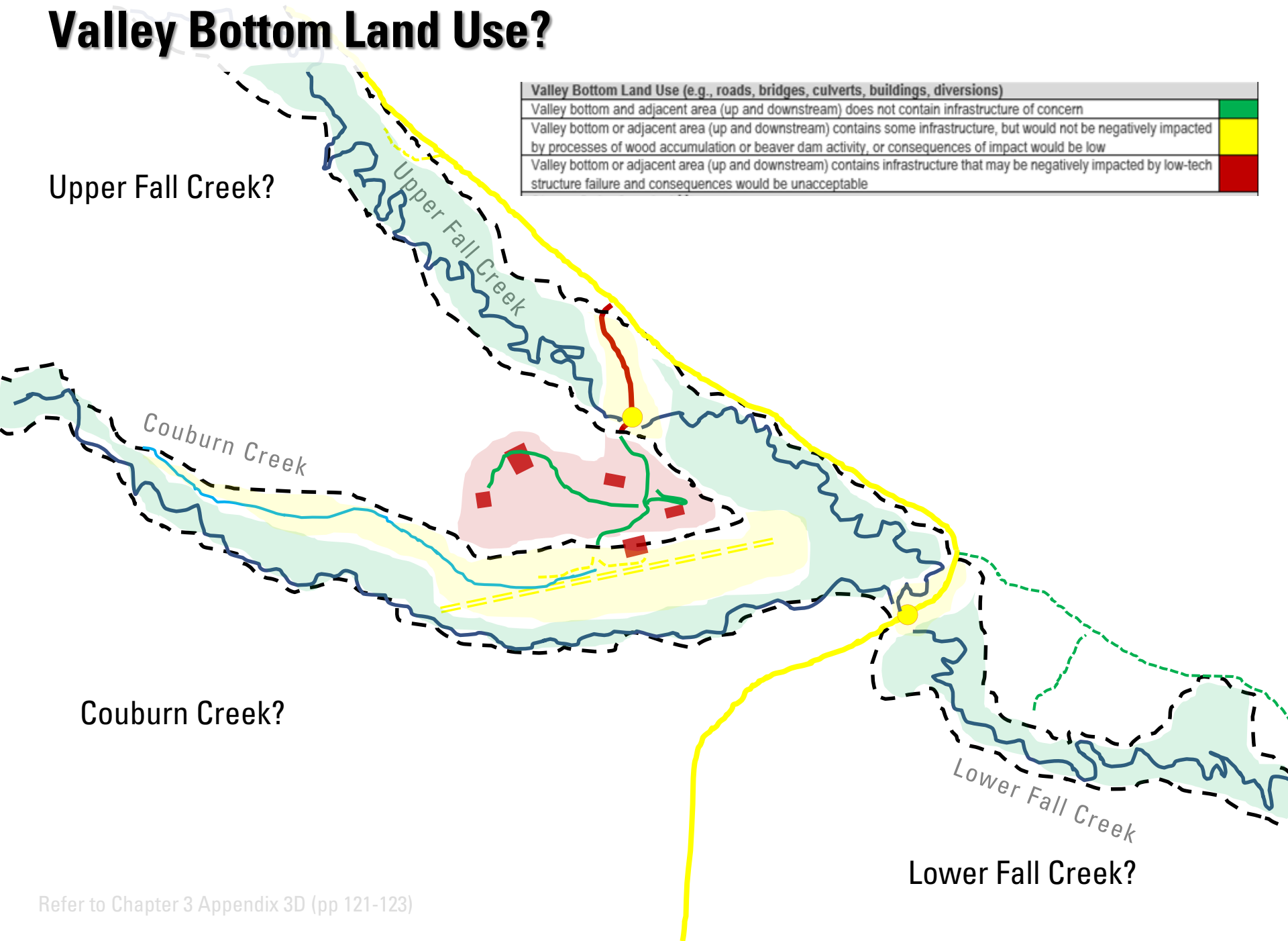
Couburn Creek?

Lower Fall Creek?

Valley Bottom Land Use?

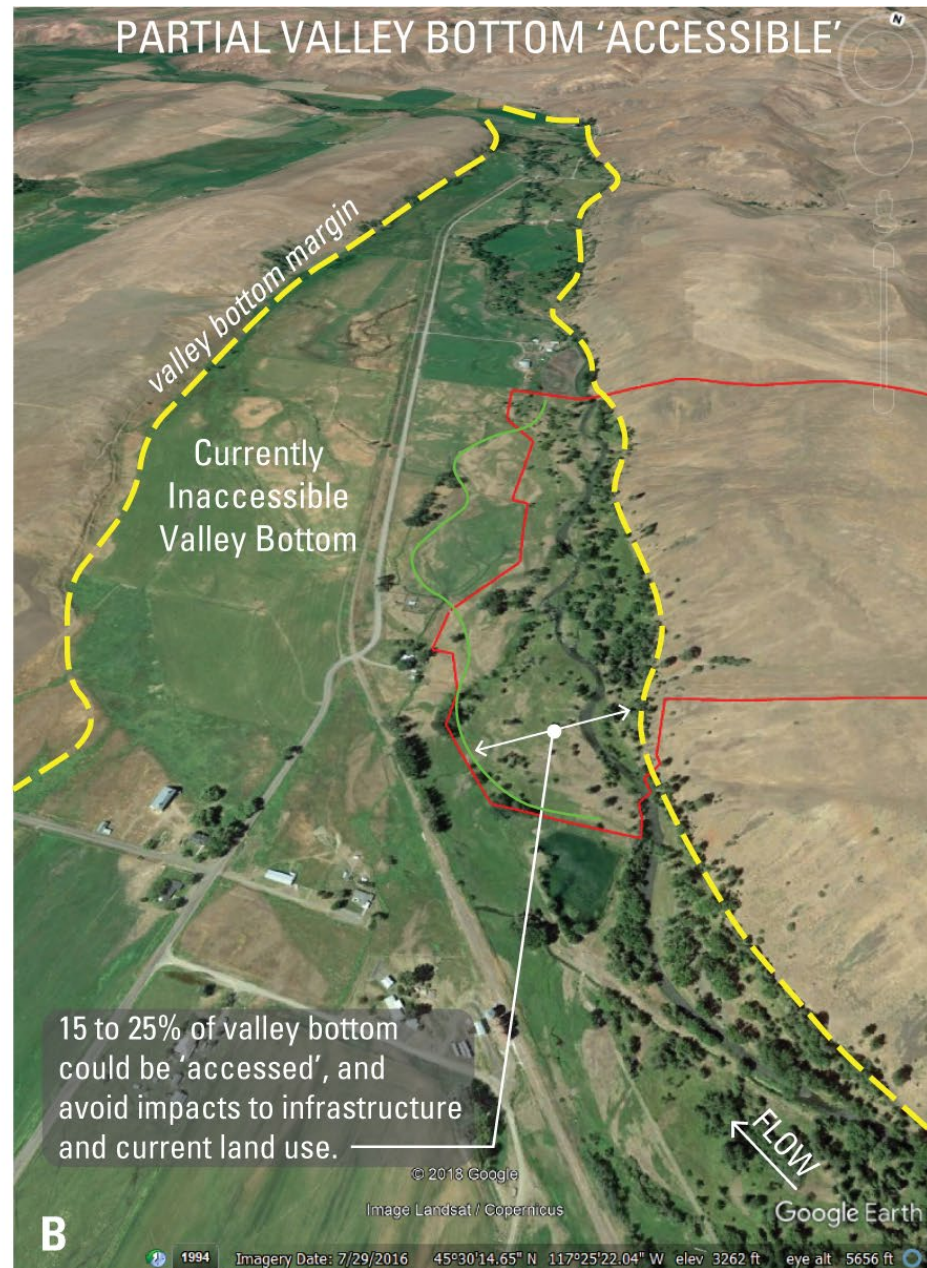
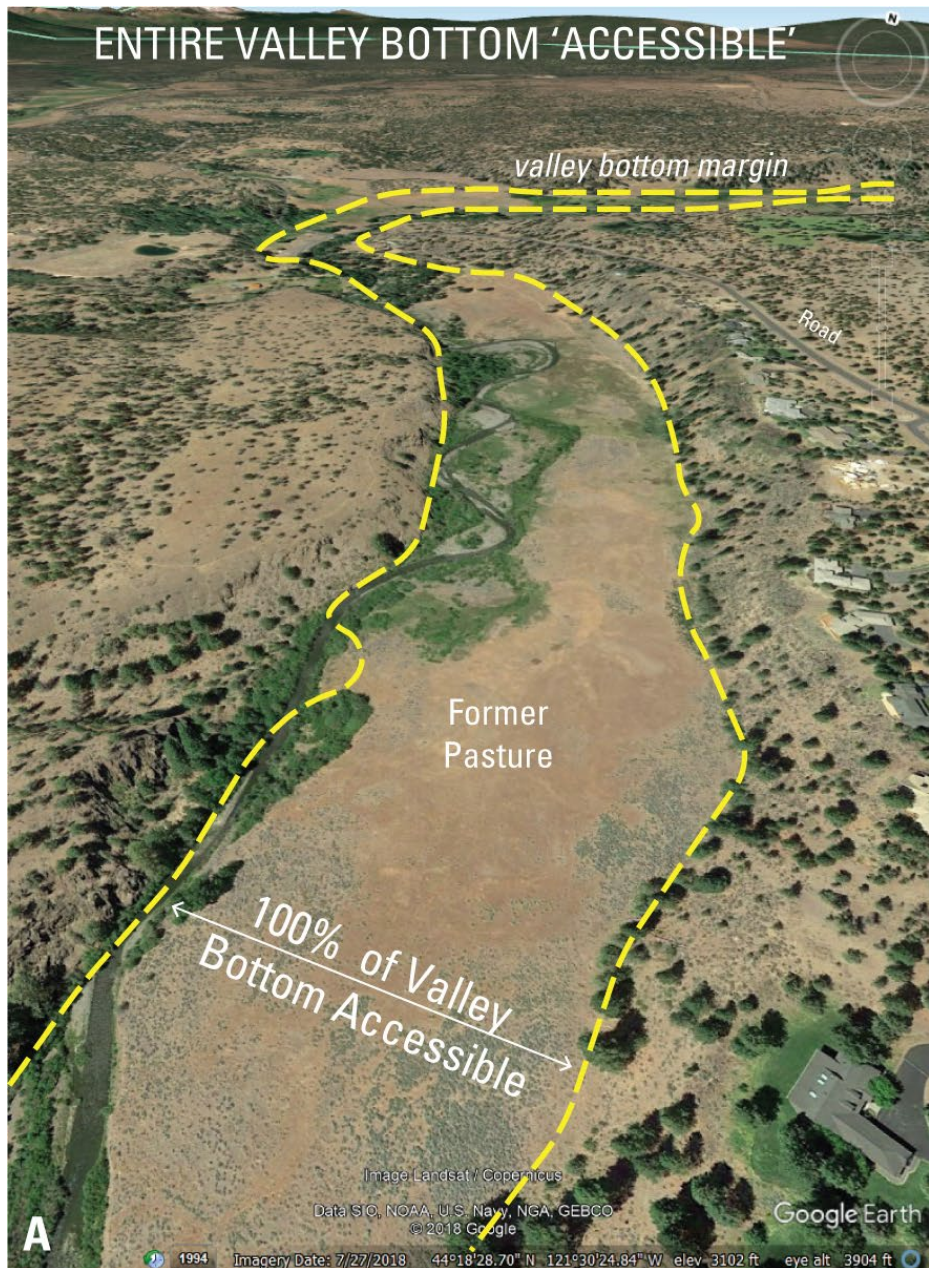
Valley Bottom Land Use (e.g., roads, bridges, culverts, buildings, diversions)	
Valley bottom and adjacent area (up and downstream) does not contain infrastructure of concern	
Valley bottom or adjacent area (up and downstream) contains some infrastructure, but would not be negatively impacted by processes of wood accumulation or beaver dam activity, or consequences of impact would be low	
Valley bottom or adjacent area (up and downstream) contains infrastructure that may be negatively impacted by low-tech structure failure and consequences would be unacceptable	

Upper Fall Creek?



Couburn Creek?

Lower Fall Creek?



From page 14 of Pocket Guide; Wheaton et al. (2019)

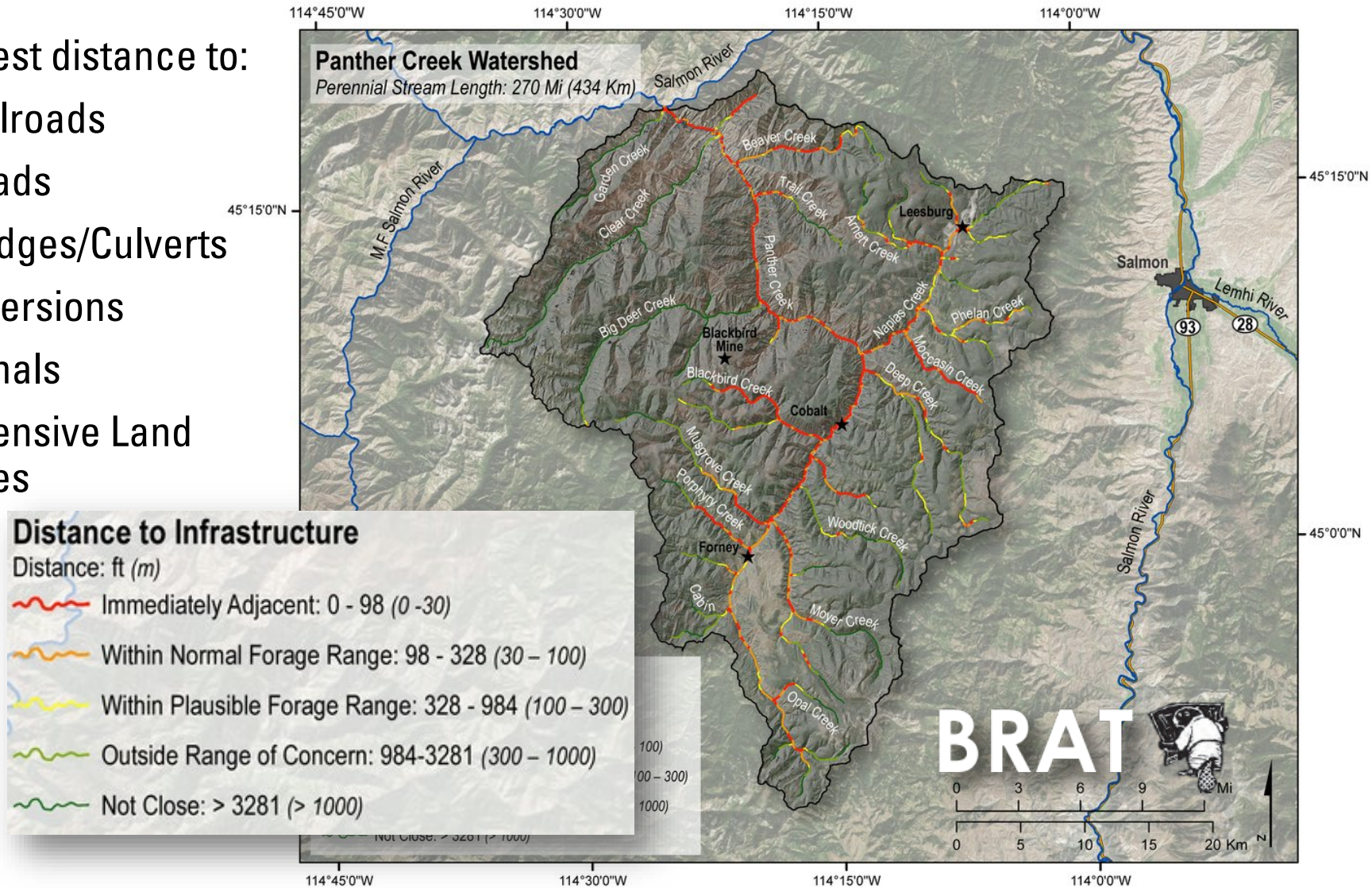
DOI: [10.13140/RG.2.2.28222.13123/1](https://doi.org/10.13140/RG.2.2.28222.13123/1)

How much is in play for restoration?

Approximations from Freely Available Data

Closest distance to:

- Railroads
- Roads
- Bridges/Culverts
- Diversions
- Canals
- Intensive Land Uses



See Appendix 3D of Bennett et al. (2019, p 121-123) Chapter 3 LTPBR Manual

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

See: <http://brat.riverscapes.xyz>

Contextualizing Risk (e.g. with Beaver)

Closet distance to:

- Railroads
- Roads
- Bridges/Culverts
- Diversions
- Canals
- Intensive Land Uses

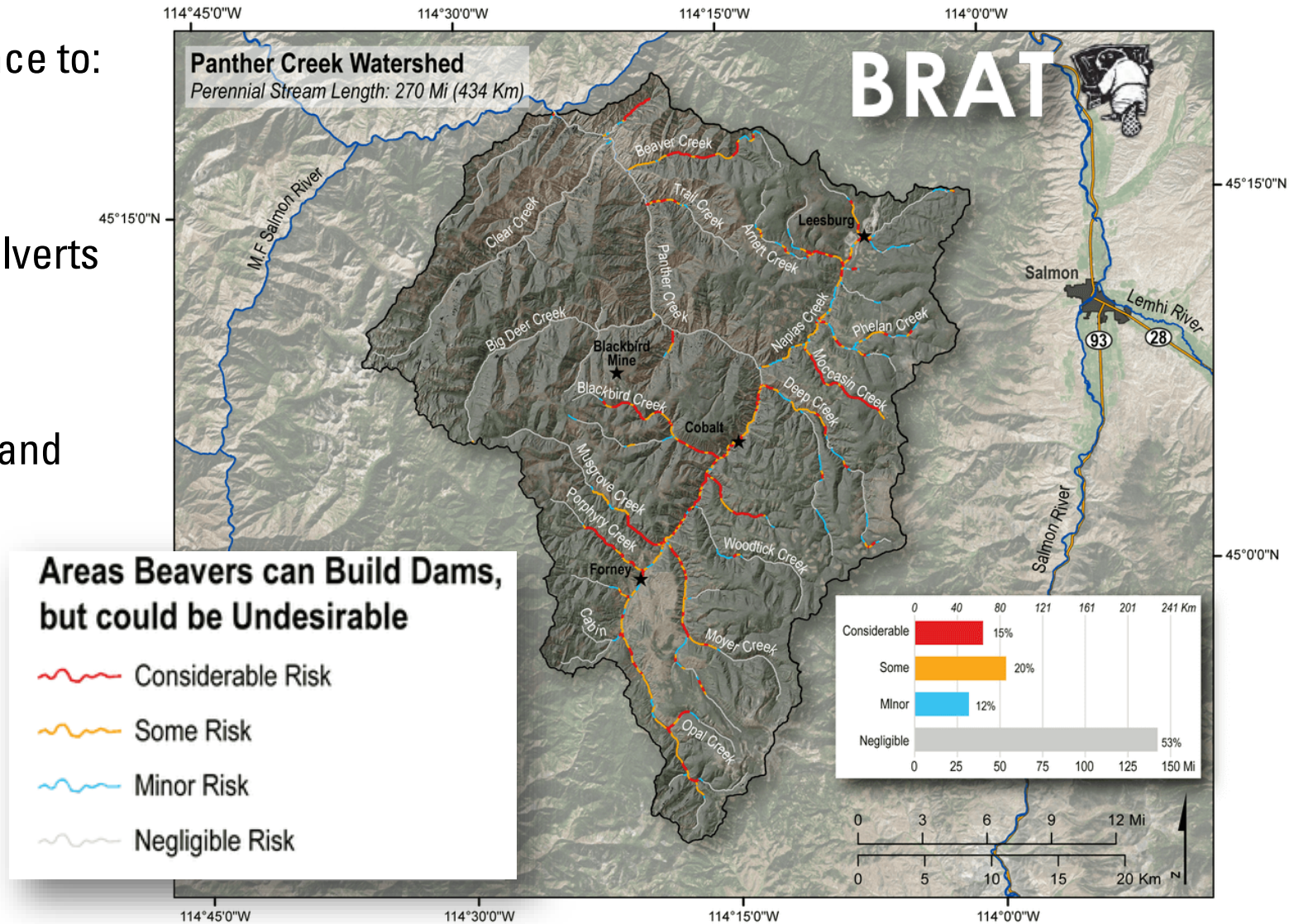


Figure 3.24 from Bennett et al. (2019, p. 123) Chapter 3 LTPBR Manual

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

See: <http://brat.riverscapes.xyz>

Analyze Resource Data – Consider Conditions!

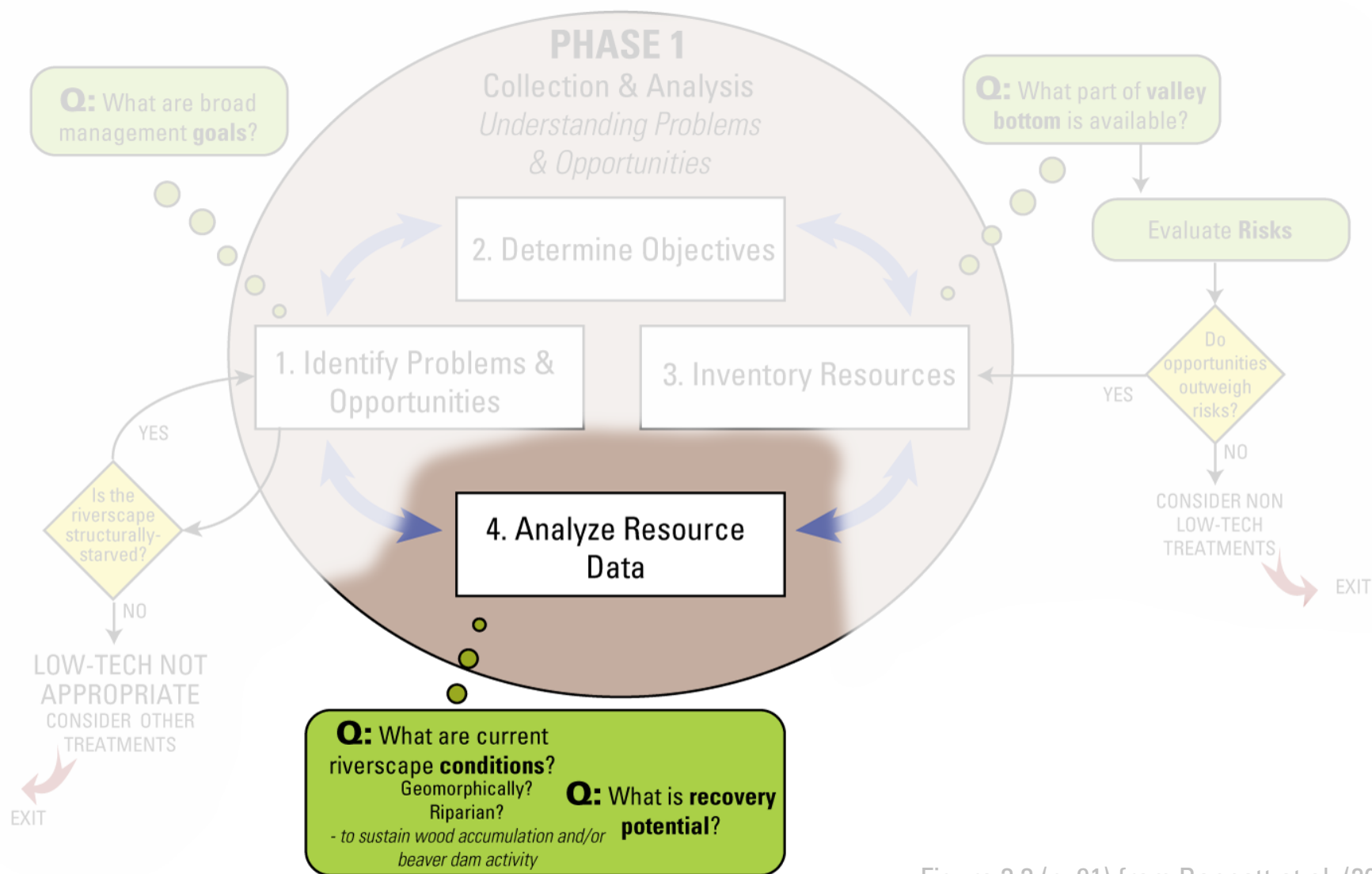
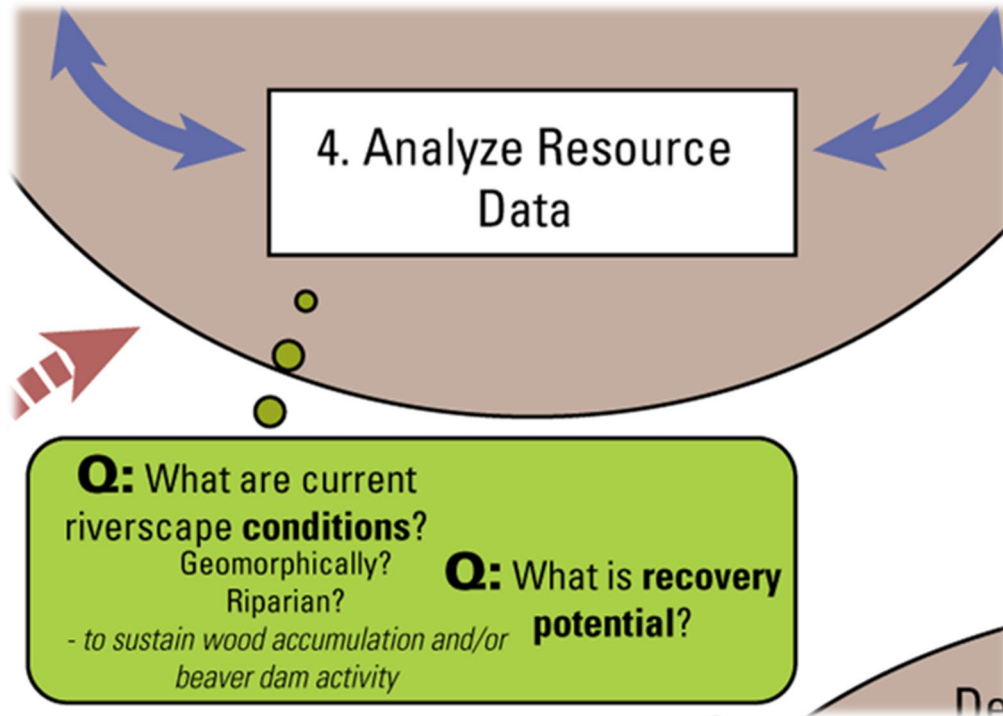


Figure 3.3 (p. 91) from Bennett et al. (2019)

– Chapter 3 LTPBR Manual

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

Current & Potential Conditions



Therein, we focus on processes that can sustain wood accumulation and/or beaver dam activity

Key LTPBR Questions – Step 4

Q: What are current riverscape **conditions**?

Geomorphically?
Riparian?

Q: What is **recovery potential**?

- to sustain wood accumulation and/or beaver dam activity

Key Low-Tech Questions and Considerations

There are two key questions, with regards to analysis of resources, for low-tech restoration we consider from two perspectives (Figure 3). Those key questions are:

- What are the current riverscape conditions?
- What is the recovery potential of the riverscape?

Now

& What could be...

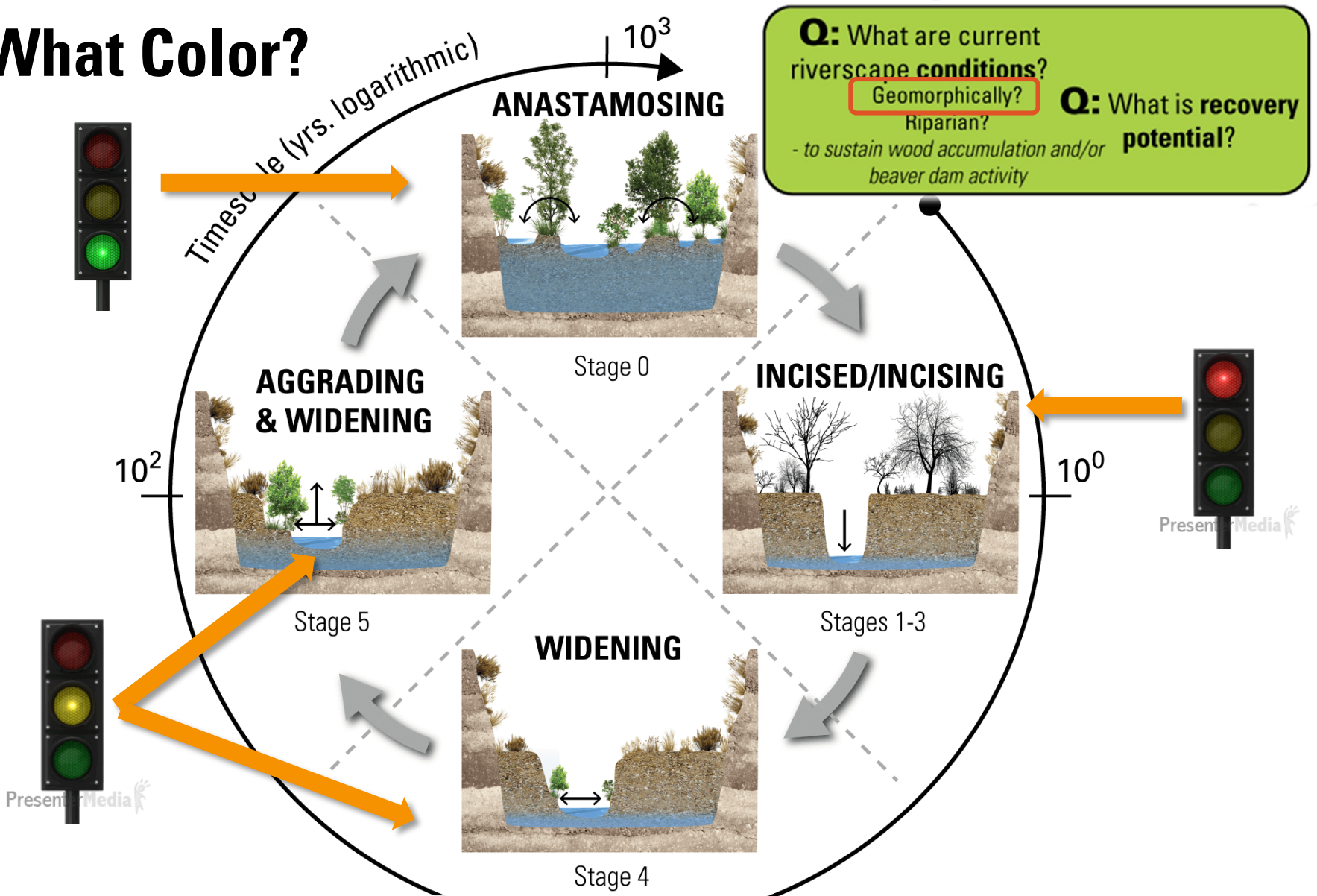
Since the primary strategy with low-tech process-based restoration of riverscapes is mimicking, promoting and eventually sustaining processes of wood accumulation and/or beaver dam activity, we must consider the above questions about current and potential conditions from the perspective of geomorphic conditions and riparian conditions. Therefore, we can cast these key questions from both a geomorphic and riparian perspective as:

1. Are my channel(s) and floodplain well-connected (geomorphology/hydrology)?
2. Is it likely that a self-sustaining source of woody structure can be restored (riparian and beaver ecology)?

1. Are my channel(s) and floodplain well-connected (geomorphology/hydrology)?

2. Is it likely that a self-sustaining source of woody structure can be restored (riparian & beaver ecology)?

What Color?



1. Are my channel(s) and floodplain **well-connected**?

Current Geomorphic Conditions

Q: What are current riverscape conditions?
Geomorphically?

Riparian?

- to sustain wood accumulation and/or beaver dam activity

Q: What is recovery potential?



CONDITION
MAPS

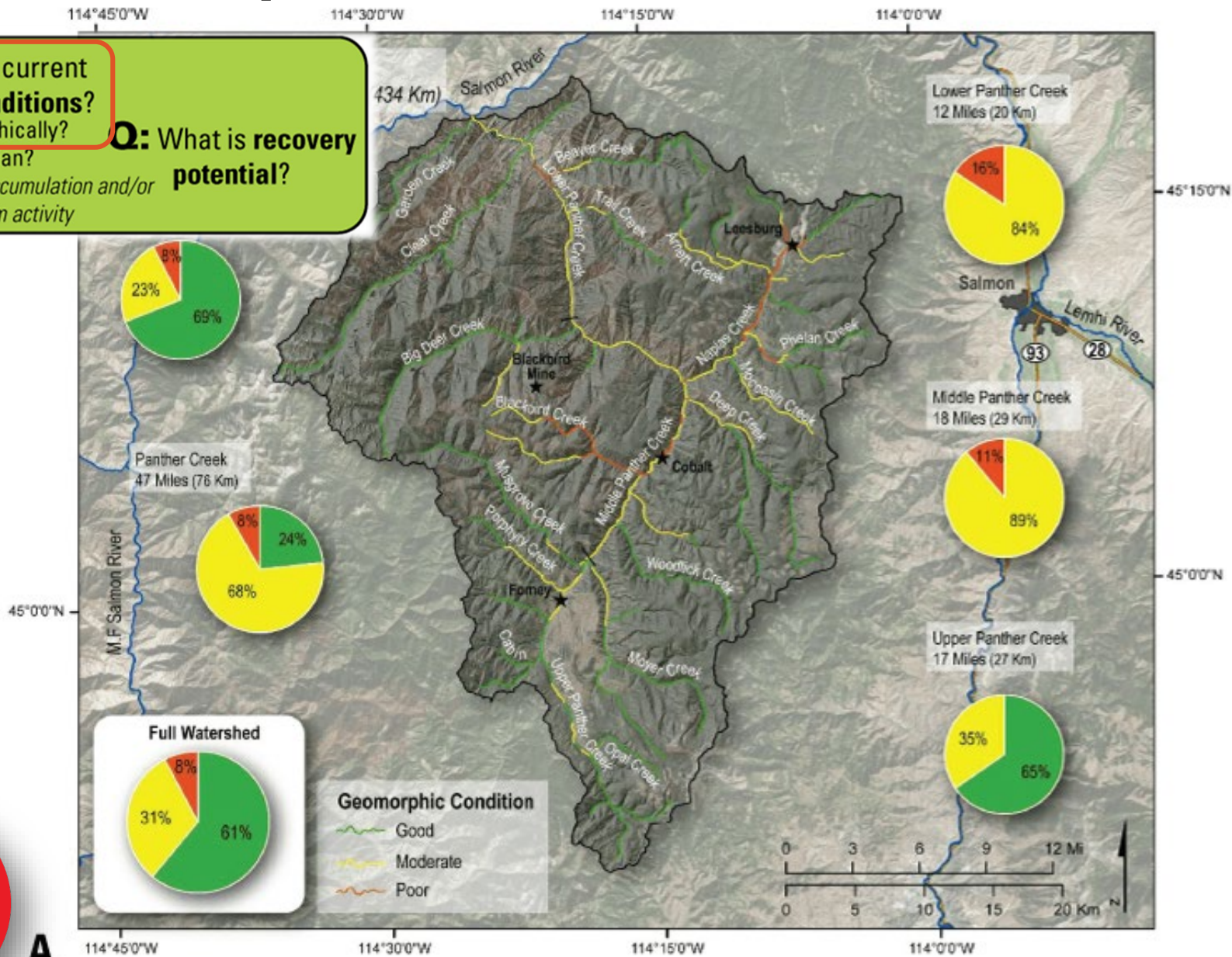


Figure 3.10A (p. 102) from Bennett et al. (2019), Chapter 3 LTPBR Manual

Potential Geomorphic Conditions (i.e. recovery potential)

Q: What are current riverscape conditions?

Geomorphically?
Riparian?

- to sustain wood accumulation and/or beaver dam activity

Q: What is recovery potential?



RECOVERY
POTENTIAL
MAPS

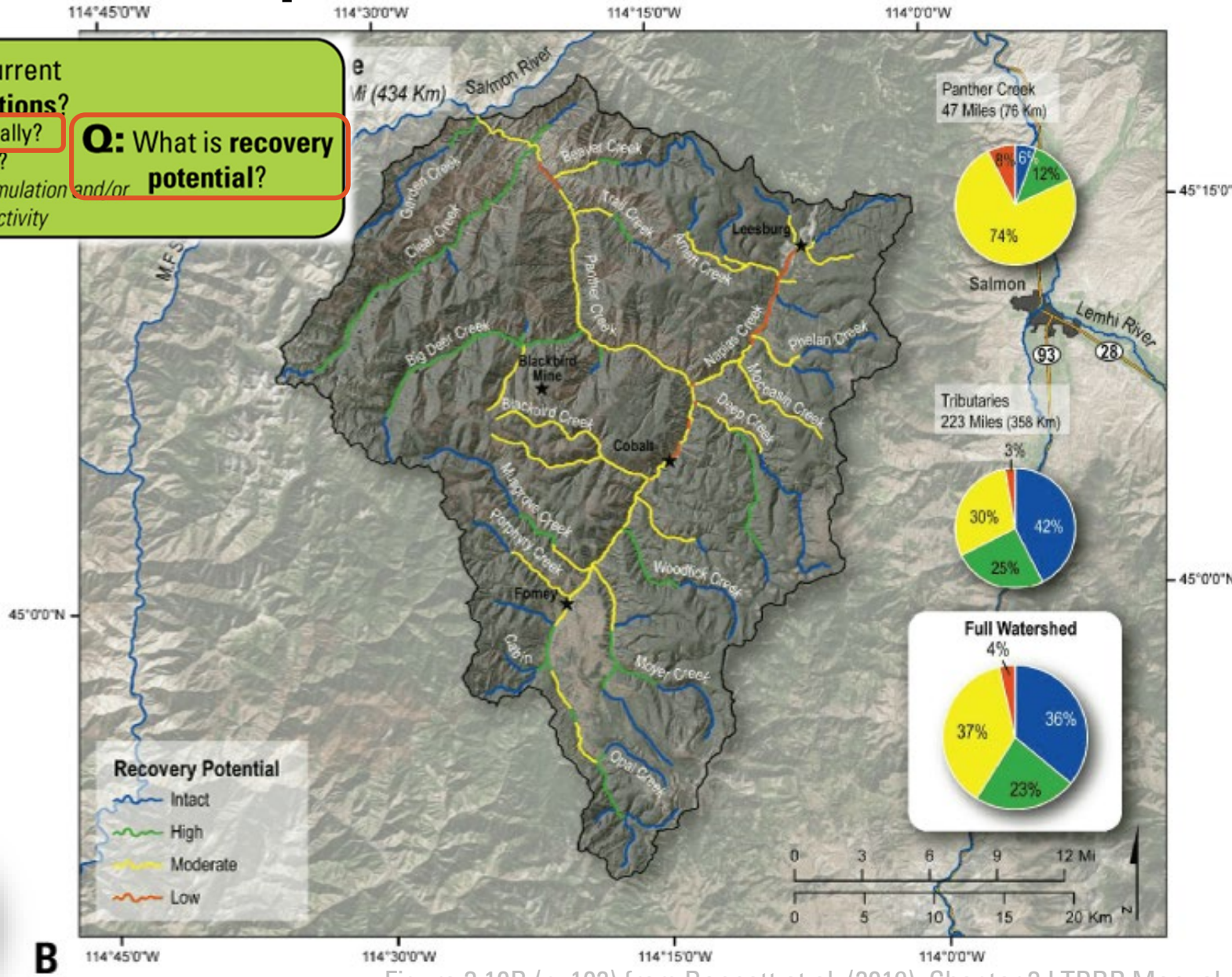


Figure 3.10B (p. 102) from Bennett et al. (2019), Chapter 3 LTPBR Manual

Is flow regime present to “Do the Work”?

SELECT A STATE / REGION >

Step 2: You have zoomed in sufficiently to select a state or regional study area. Your selection will dictate the data used to perform basin delineation and flow statistics calculation.

Click to select a State or Regional Study Area

Wyoming

Search for a place

Help

IDENTIFY A STUDY AREA

SELECT SCENARIOS

BUILD A REPORT

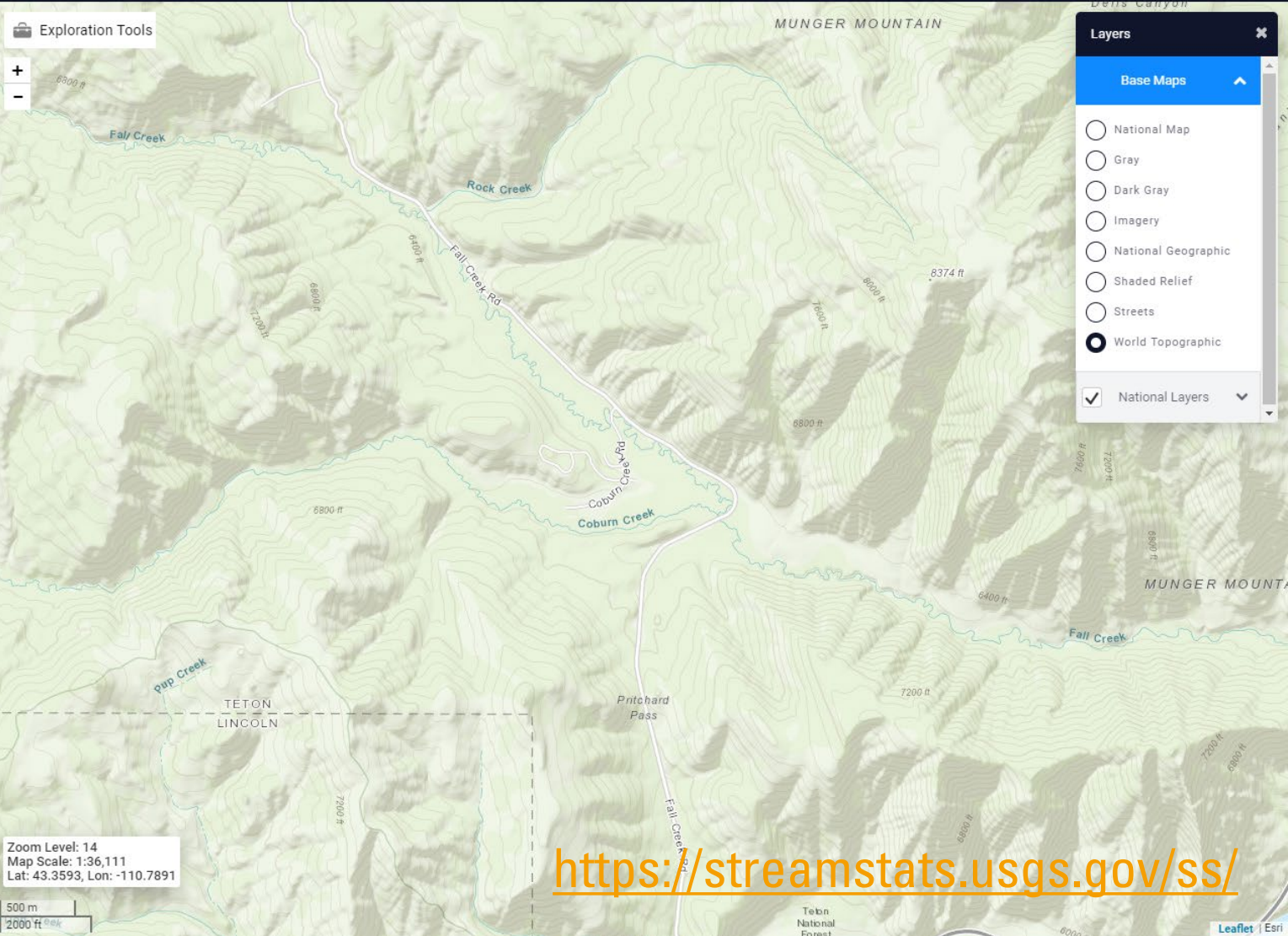
POWERED BY WIM

USGS Home Contact USGS Search USGS
Accessibility FOIA Privacy Policy & Notices

Exploration Tools

+

-



Zoom Level: 14
Map Scale: 1:36,111
Lat: 43.3593, Lon: -110.7891

500 m
2000 ft

Layers

Base Maps

- National Map
- Gray
- Dark Gray
- Imagery
- National Geographic
- Shaded Relief
- Streets
- World Topographic

National Layers

<https://streamstats.usgs.gov/ss/>

Where StreamStats is present...

Delineates Watershed

SELECT A STATE / REGION
Idaho

Exploration Tools

IDENTIFY A STUDY AREA
Basin Delineated

Step 5: Your delineation is complete. You can now clear, edit, or download your basin, or choose a state or regional study specific function (if available). Click **continue** when you are ready.

Clear Basin

Edit Basin

Download Basin

or

Continue

SELECT SCENARIOS

BUILD A REPORT

POWERED BY WIM

USGS Home Contact USGS Search USGS
Accessibility FOIA Privacy Policy & Notices

Zoom Level: 15
Map Scale: 1:18,055
Lat: 43.1991, Lon: -111.2008

300 m
1000 ft

Layers

Base Maps

Application Layers

ID Map Layers

National Layers

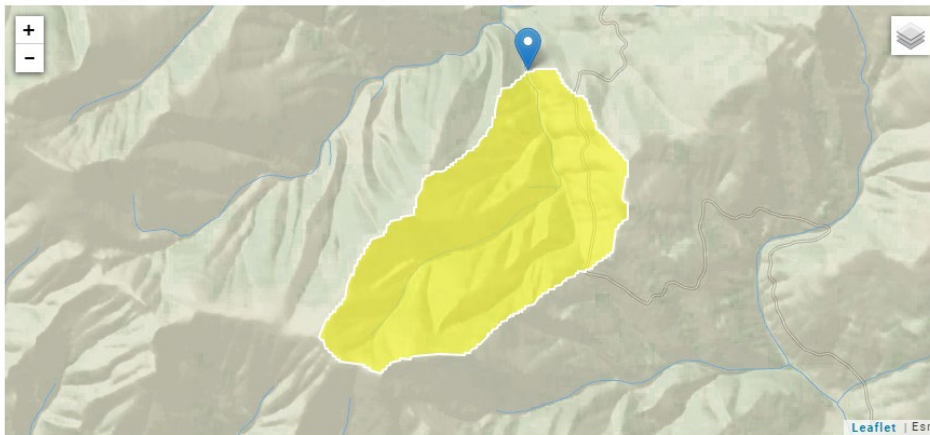
<https://streamstats.usgs.gov/ss/>

Where StreamStats is present...

Provides flow statistics based on regional curves

StreamStats Report

Region ID: ID
 Workspace ID: ID20190729050512812000
 Clicked Point (Latitude, Longitude): 43.22144, -111.21683
 Time: 2019-07-28 23:06:04 -0600



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.79	square miles
PRECPRIS10	Basin average mean annual precipitation for 1981 to 2010 from PRISM	29.7	inches
BSLDEM30M	Mean basin slope computed from 30 m DEM	49.8	percent

Peak-Flow Statistics Parameter Report (Peak Flow Region 6 and 8 2016 5083)

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.79	square miles	2.77	3740
PRECPRIS10	Mean Annual Precip PRISM 1981 2010	29.7	inches	18.9	54.6

Peak-Flow Statistics Disclaimers (Peak Flow Region 6 and 8 2016 5083)

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Peak-Flow Statistics Flow Report (Peak Flow Region 6 and 8 2016 5083)

Statistic	Value	Unit
1.25 Year Peak Flood	7.39	ft ³ /s
1.5 Year Peak Flood	9.77	ft ³ /s
2 Year Peak Flood	13	ft ³ /s
2.33 Year Peak Flood	14.8	ft ³ /s
5 Year Peak Flood	22	ft ³ /s
10 Year Peak Flood	29.3	ft ³ /s
25 Year Peak Flood	39.1	ft ³ /s
50 Year Peak Flood	46.9	ft ³ /s
100 Year Peak Flood	56.8	ft ³ /s
200 Year Peak Flood	65.5	ft ³ /s
500 Year Peak Flood	80.6	ft ³ /s

Peak-Flow Statistics Citations

Wood, M.S., Fosness, R.L., Skinner, K.D., and Veilleux, A.G., 2016. Estimating peak-flow frequency statistics for selected gaged and ungaged sites in naturally flowing streams and rivers in Idaho: U.S. Geological Survey Scientific Investigations Report 2016-5083, 56 p.

Low-Flow Statistics Parameters (Low Flow Region 8 2006 5053)

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
		0.79			

<https://streamstats.usgs.gov/ss/>

Flow Regime to “Do the Work”?

- Stream power is an expression of flow strength and the erosive capacity of streams. calculated as:

$$\Omega = \rho g Q S$$

- Where Ω is the stream power (in Watts), ρ is the density of water (1000 kg/m³), g is acceleration due to gravity (9.8 m/s²), Q is discharge (m³/s), and S is the channel slope.

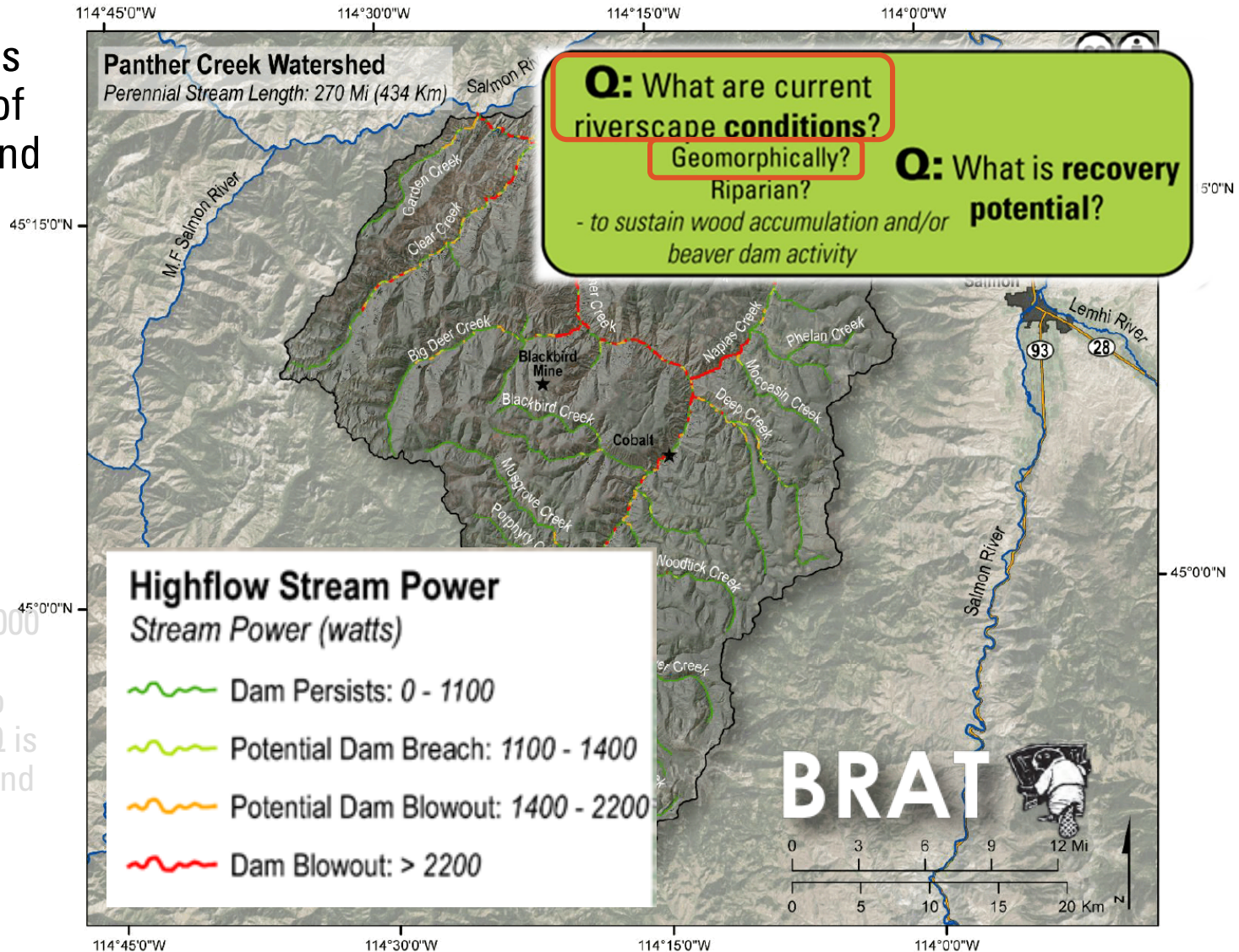


Figure 3.9 (p. 101) from Bennett et al. (2019) Chapter 3 LTPBR Manual

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

See: <http://brat.riverscapes.xyz>

Take a Moment to Consider...

Q: What are current
riverscape **conditions?**

Geomorphically?

Riparian?

- to sustain wood accumulation and/or
beaver dam activity

Q: What is **recovery**
potential?

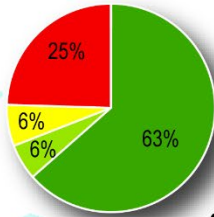
1. Are the woody or vegetative resources present to support process of **wood accumulation**?

Riparian Vegetation Departure (RVD)

Popo Agie

Stream Length: 3618 Km

What % of riparian vegetation has been lost in valley bottom?



EXAMPLE OF MODEL INSIGHT

Q: What are current riverscape conditions?

Geomorphologically?





Riparian?

- to sustain wood accumulation and/or beaver dam activity

Q: What is recovery potential?

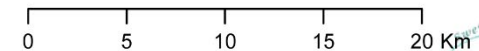
RVD - Riparian Vegetation Departure

Current Departure from Historic

-  Large Departure: > 66%
-  Significant Departure: 33% to 66%
-  Minor Departure: 10% to 33%
-  Negligible Departure: < 10%

From <http://rcat.riverscapes.xyz>

RCAT



Existing

Q: What are current riverscape **conditions?**

Geomorphically?

Riparian?

- to sustain wood accumulation and/or beaver dam activity

Q: What is **recovery potential?**

-
- Valley Bottom
 - Stream
 - Non-Riparian
 - Riparian

Historic Estimate

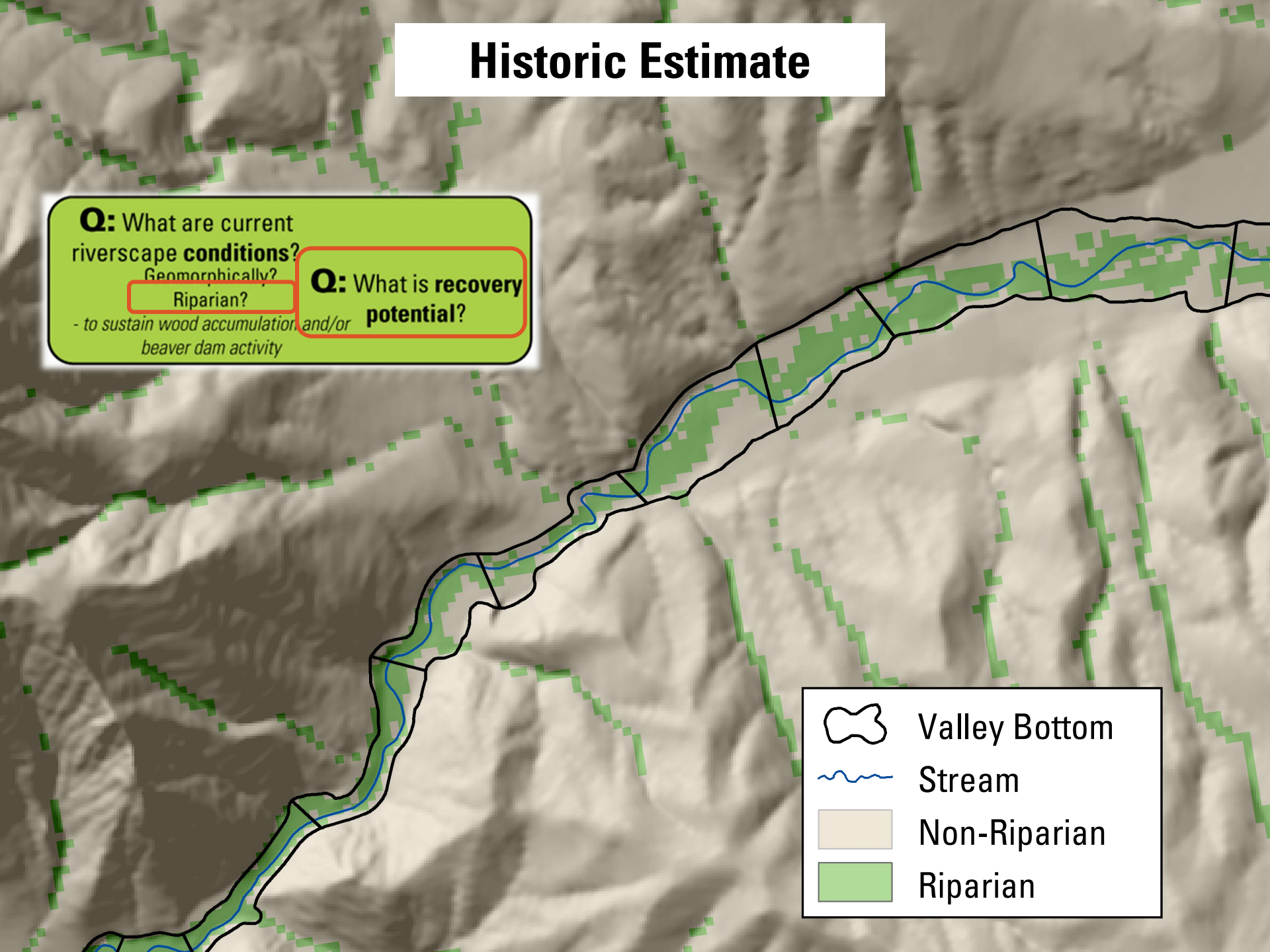
Q: What are current
riverscape **conditions**?

Geomorphically?

Riparian?

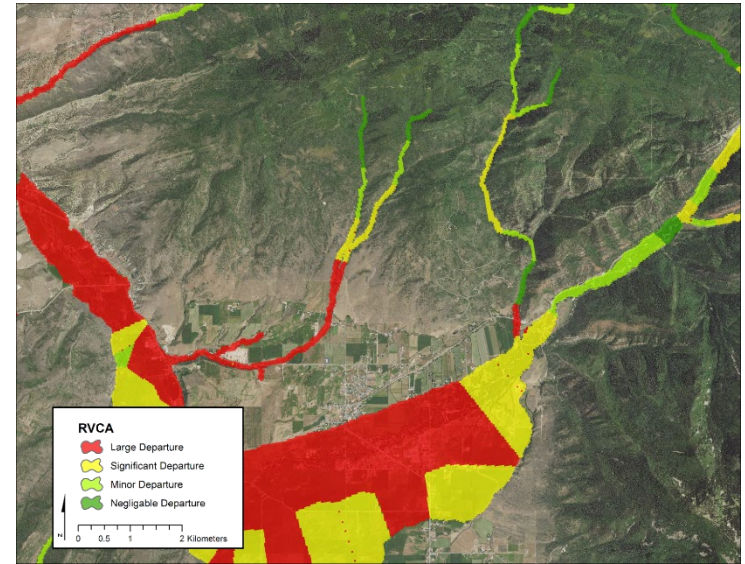
- to sustain wood accumulation
and/or
beaver dam activity

Q: What is **recovery**
potential?

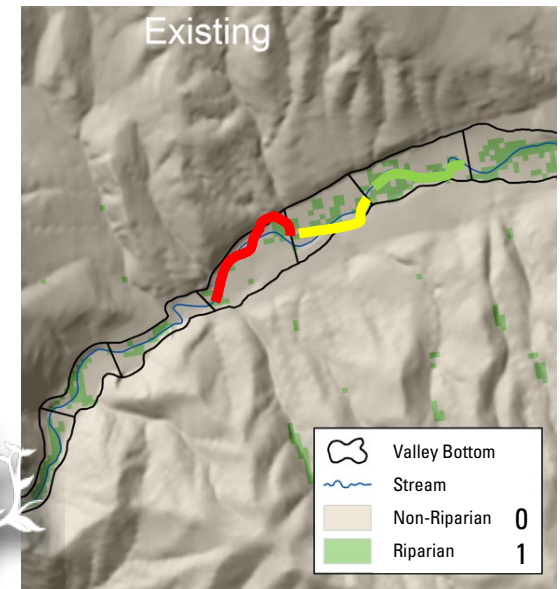
- 
- The map displays a topographic view of a river valley. A blue stream flows through the center, flanked by a black line representing the valley bottom. The area between the stream and the valley bottom is shaded green, indicating riparian zones. The surrounding areas are shaded tan, indicating non-riparian zones. A legend in the bottom right corner defines these symbols and colors.
- Valley Bottom
 - Stream
 - Non-Riparian
 - Riparian

The 'local' reach by reach example...

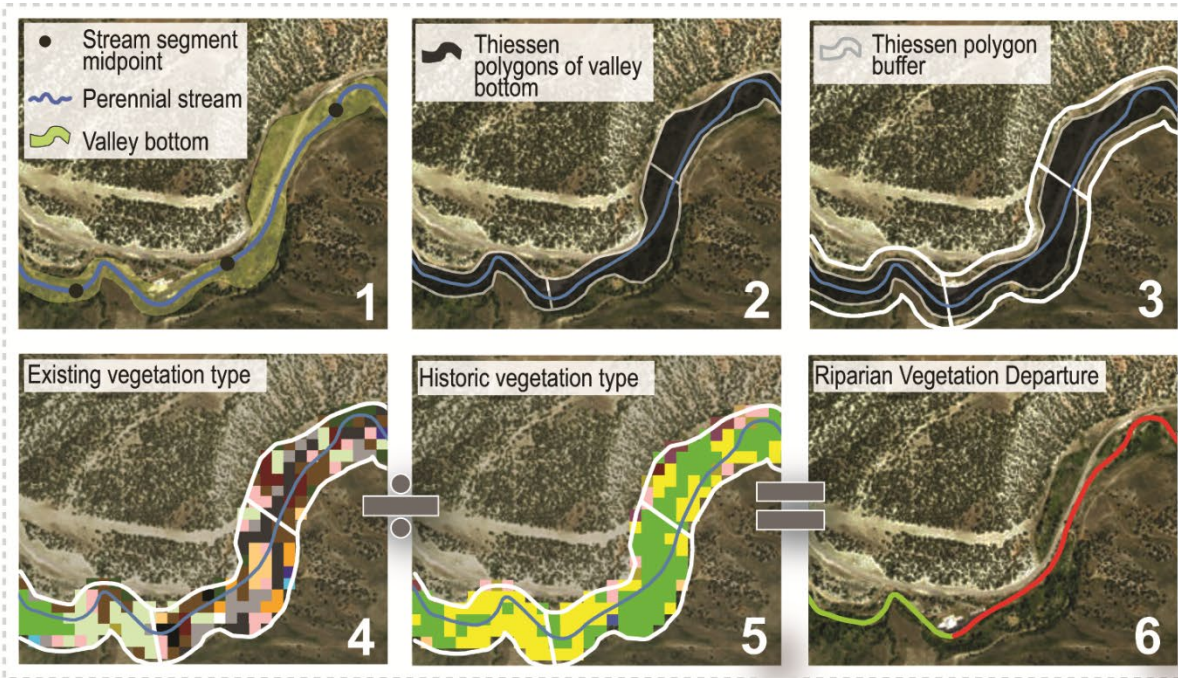
- Riparian vegetation departure calculated for every 30 m pixel within valley bottom
- Then.. summed up by reaches... for display at broader scales...



- Large Departure: > 66%
- Significant Departure: 33% to 66%
- Minor Departure: 10% to 33%
- Negligible Departure: < 10%



Riparian Vegetation Departure (RVD)



Existing vegetation

Riparian

- Open Water
- Cottonwood-Willow
- Bigtooth Maple
- Introduced Upland Vegetation
- Tall Forb
- Sparsely Vegetated
- Developed

- Curlleaf Mountain-Mahogany
- Mountain Big Sagebrush
- Wyoming Big Sagebrush
- Juniper-Pinyon Pine Woodland
- Gambel oak
- Saltbush-Greasewood
- Chokecherry-Serviceberry Rose
- No Dominant Lifeform

Historic vegetation

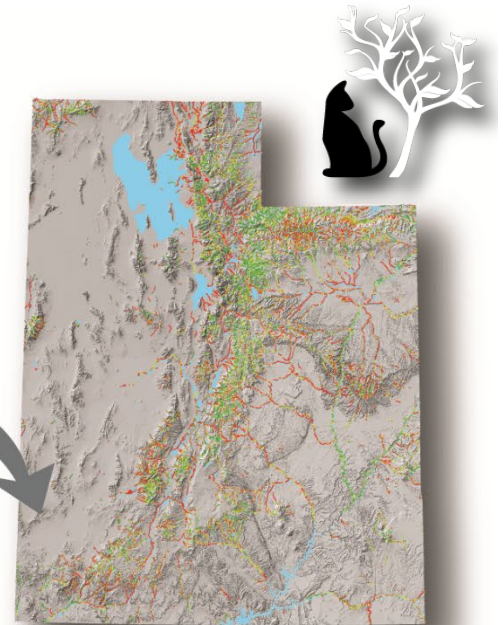
Riparian

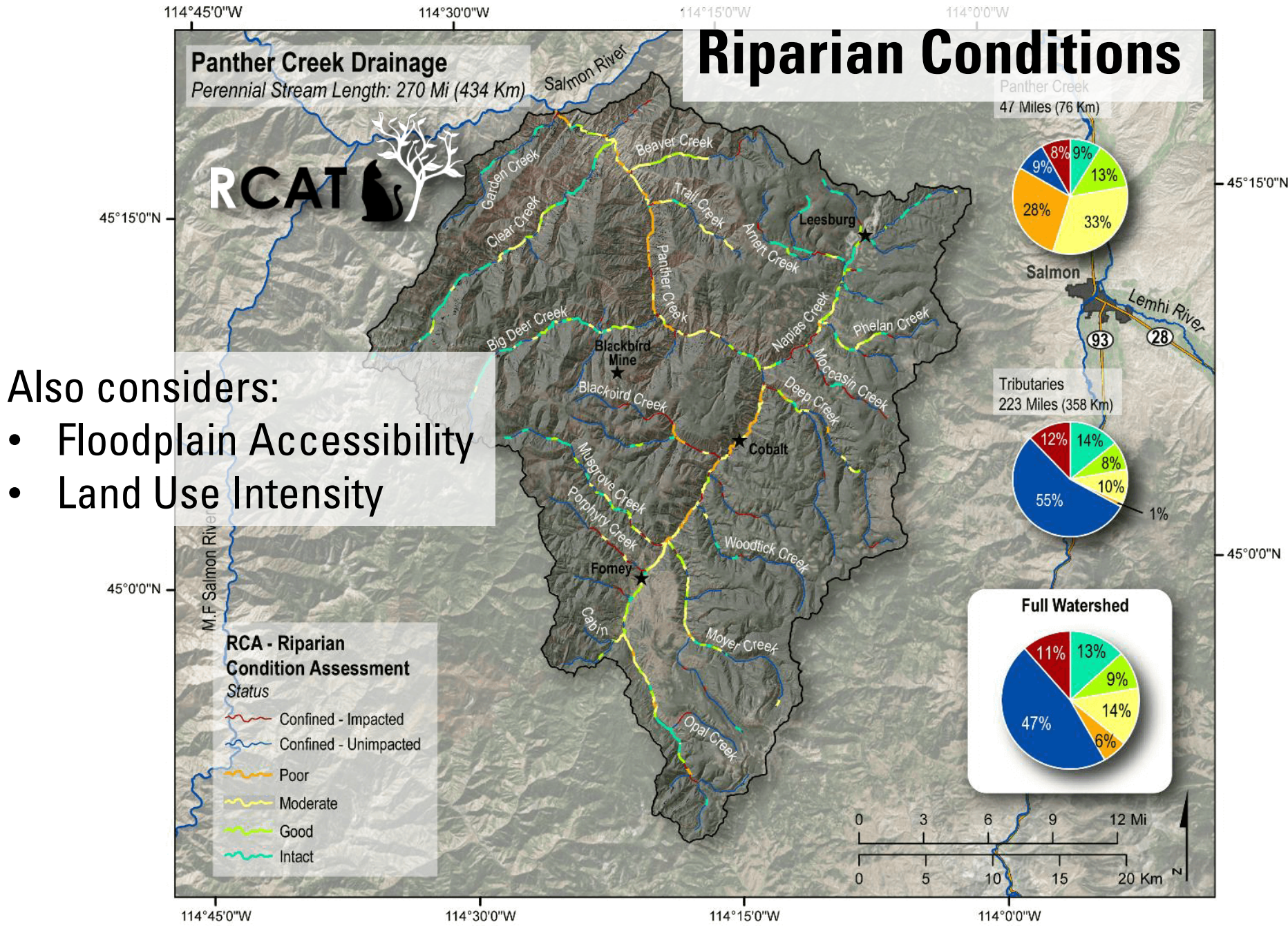
- Open Water
- Black Cottonwood-Narrowleaf Willow
- Gambel Oak-Serviceberry
- Wyoming Big Sage-Wheatgrass
- Wyoming Big Sage-Rubber Rabbitbrush
- Mountain Sagebrush-Bluebunch Wheatgrass - Idaho Fescue
- Greasewood-Shadscale

RVD - Riparian Vegetation Departure

Current Departure from Historic

- ~ Large: > 66%
- ~ Significant: 33% - 66%
- ~ Minor: 10% - 33%
- ~ Negligible: < 10%





Also considers:

- Floodplain Accessibility
- Land Use Intensity

Figure 3.9 (p. 101) from Bennett et al. (2019) Chapter 3 LTPBR Manual

Take a Moment to Consider...

Q: What are current
riverscape **conditions?**

Geomorphically?

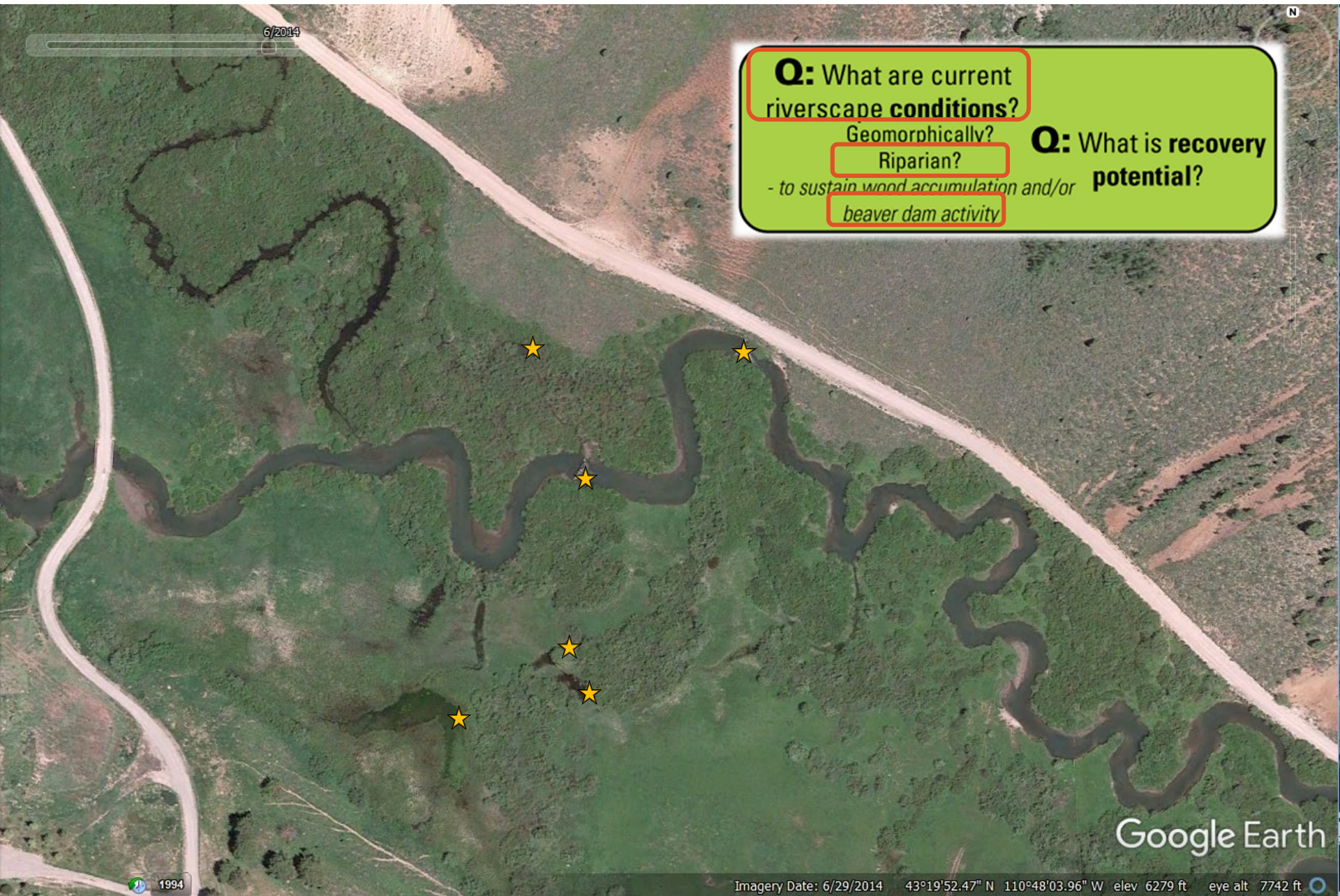
Riparian?

- to sustain wood accumulation and/or
beaver dam activity

Q: What is **recovery
potential?**

1. Are the woody or vegetative resources present to support process of **wood accumulation**?
2. Could **beaver dam activity** be supported?

Could **beaver dam activity** be supported?



6/2014

Q: What are current riverscape **conditions**?

Geomorphically?

Riparian?

- to sustain wood accumulation and/or

beaver dam activity

Q: What is **recovery potential**?

Google Earth

1994

Imagery Date: 6/29/2014 43°19'52.47" N 110°48'03.96" W elev 6279 ft eye alt 7742 ft

Could **beaver dam activity** be supported?

6/2014

See Appendix 3F (p 127) in Bennett et al. (2019)

Chapter 3 LTPBR Manual

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

BRAT 

See: <http://brat.riverscapes.xyz>

Q: What are current
riverscape **conditions**?

Geomorphically?
Riparian?

Q: What is **recovery
potential**?

- to sustain wood accumulation and/or
beaver dam activity

Google Earth

1994

Imagery Date: 6/30/2014 43°19'40.13" N 110°47'48.18" W elev 6271 ft eye alt 7603 ft

Massive Enthusiasm... But

- How do we temper that enthusiasm constructively?
- How do we provide more realistic expectation management?

The Beaver Restoration Guidebook

Working with Beaver to Restore Streams, Wetlands, and Floodplains

Version 1.02, July 14, 2015



Photo credit: Worth A Dam Foundation (martinczbeavers.org)

Prepared by

US Fish and Wildlife Service
National Oceanic and Atmospheric Administration
Portland State University
US Forest Service

Janine Castro
Michael Pollock and Chris Jordan
Gregory Lewallen
Kent Woodruff

Funded by

North Pacific Landscape Conservation Cooperative



Version 1.02. Get the latest version at: <http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp>

BioScience Advance Access published March 26, 2014

Overview Articles

Using Beaver Dams to Restore Incised Stream Ecosystems

MICHAEL M. POLLOCK, TIMOTHY J. BEECHIE, JOSEPH M. WHEATON, CHRIS E. JORDAN, NICK BOUWES, NICHOLAS WEBER, AND CAROL VOLK

Biogenic features such as beaver dams, large wood, and live vegetation are essential to the maintenance of complex stream ecosystems, but these features are largely absent from models of how streams change over time. Many streams have incised because of changing climate or land-use practices. Because incised streams provide limited benefits to biota, they are a common focus of restoration efforts. Contemporary models of long-term change in streams are focused primarily on physical characteristics, and most restoration efforts are also focused on manipulating physical rather than ecological processes. We present an alternative view, that stream restoration is an ecosystem process, and suggest that the recovery of incised streams is largely dependent on the interaction of biogenic structures with physical fluvial processes. In particular, we propose that live vegetation and beaver dams or beaver dam analogues can substantially accelerate the recovery of incised streams and can help create and maintain complex fluvial ecosystems.

Keywords: ecosystem restoration, stream restoration, conservation, beaver, *Castor canadensis*

Throughout many regions of the world, channel incision is a widespread environmental problem that has caused extensive ecosystem degradation (Wang et al. 1997, Montgomery 2007). The defining characteristics of an incised alluvial stream are a lowered streambed and disconnection from the floodplain (Darby and Simon 1999). The resulting changes in physical habitat degrade stream ecosystems (Shields et al. 1994, 2010). Ample evidence in the geological record indicates that channel incision occurs naturally and may be related to changes in climate (Bryan 1925, Elliot et al. 1999). However, a great many instances of channel incision have been shown to be caused by or to be correlated with changes in land use (Cooke and Reeves 1976, Montgomery 2007). Many of these changes are also contemporary with the widespread extirpation of beaver (*Castor canadensis*) in the nineteenth century (Naiman et al. 1988).

In addition to lowered streambed elevation and disconnection from the floodplain, common physical effects of alluvial incision include lowered groundwater tables, the loss of wetlands, lower summer base flows, warmer water temperatures, and the loss of habitat diversity. Biological effects include a substantial loss of riparian plant biomass and diversity and population declines in fish and other aquatic organisms (for a review, see Cluer and Thorne 2014).

Understanding how the ecology of an incised stream changes over time is essential for assessing recovery potential. However most incision-aggradation models describe only those geomorphological changes on the basis of

relationships between sediment transport and hydrology. The role of living organisms is generally minimized, especially for beaver, live vegetation, and dead wood (Schumm et al. 1984, Simon and Hupp 1986, Elliot et al. 1999). The absence of beaver in such models is particularly notable, given their widely recognized role in shaping stream ecosystems (Naiman et al. 1988, Gurnell 1998, Pollock et al. 2003, Burchsted et al. 2010). More recently, incision-aggradation models have included floodplain complexes as an additional and ecologically desirable hydrogeomorphic stage that occurs in some fluvial ecosystems (see Cluer and Thorne 2014). Restoration of complex floodplains is important because such habitat is essential for the maintenance of biological diversity, including commercially important species, and for providing other important ecosystem services, such as flood control, groundwater recharge, and carbon storage (Groszholz and Gallo 2006, Westbrook et al. 2006, Jeffers et al. 2008, Wohl 2011, Bellmore et al. 2012, Cluer and Thorne 2014, Polvi and Wohl 2013).

In this article, we propose an alternative and more comprehensive view of stream evolution as an ecological—more precisely, *ecosystem*—process (*sensu* Wheaton et al. 2011). We provide a conceptual model for incised stream evolution that describes stream succession as a process dependent on the interaction of living organisms with hydrologic and sediment dynamics. We believe that such a model is consistent with recent findings concerning the role of biogenic features, such as wood and beaver dams, in

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Pollock et al. (2014) Bioscience
DOI: [10.1016/j.geomorph.2015.11.019](https://doi.org/10.1016/j.geomorph.2015.11.019)

Expectation Management... A Beaver Dam Capacity Model

- Resolves where and at what level (within a drainage network) beaver dams can be built and sustained.
- BRAT (Beaver Restoration Assessment Tool) is all about *how many* of these:



- Not how many of these:



<http://brat.riverscapes.xyz>

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Geomorphology xxx (2015) xxx–xxx

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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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ABSTRACT

The construction of beaver dams facilitates a suite of hydrologic, hydraulic, geomorphic, and ecological feedbacks that increase stream complexity and channel–floodplain connectivity that benefits aquatic and terrestrial biota. Depending on where beaver build dams within a drainage network, they impact lateral and longitudinal connectivity by introducing roughness elements that fundamentally change the timing, delivery, and storage of water, sediment, nutrients, and organic matter. While the local effects of beaver dams on streams are well understood, broader coverage network models that predict where beaver dams can be built and highlight their impacts on connectivity across diverse drainage networks are lacking. Here we present a capacity model to assess the limits of riverscapes to support dam-building activities by beaver across physiographically diverse landscapes. We estimated dam capacity with freely and nationally-available inputs to evaluate seven lines of evidence: (1) reliable water source, (2) riparian vegetation conducive to foraging and dam building, (3) vegetation within 100 m of edge of stream to support expansion of dam complexes and maintain large colonies, (4) likelihood that channel-spanning dams could be built during low flows, (5) the likelihood that a beaver dam is likely to withstand typical floods, (6) a suitable stream gradient that is neither too low to limit dam density nor too high to preclude the building or persistence of dams, and (7) a suitable river that is not too large to restrict dam building or persistence. Fuzzy inference systems were used to combine these controlling factors in a framework that explicitly also accounts for model uncertainty. The model was run for 40,561 km of streams in Utah, USA, and portions of surrounding states, predicting an overall network capacity of 356,294 dams at an average capacity of 8.8 dams/km. We validated model performance using 2,852 observed dams across 1947 km of streams. The model showed excellent agreement with observed dam densities where beaver dams were present. Model performance was spatially coherent and logical, with electricity indices that effectively segregated capacity categories. That is, beaver dams were not found where the model predicted no dams could be supported, beaver avoided segments that were predicted to support rare or occasional densities, and beaver preferentially occupied and built dams in areas predicted to have pervasive dam densities. The resulting spatially explicit reach-scale (250 m long reaches) data identifies where dam-building activity is sustainable, and at what densities dams can occur across a landscape. As such, model outputs can be used to determine where channel–floodplain and wetland connectivity are likely to persist or expand by promoting increases in beaver dam densities.

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1. Introduction

Due to the suite of hydrologic, hydraulic, geomorphic, and ecological feedbacks associated with the dam-building activities of beaver, both *Castor canadensis* in North America and *Castor fiber* in Europe and Asia, are widely recognized as ecosystem engineers (Burchsted et al., 2010; Garnett, 1988; Naiman et al., 1988; Rosell et al., 2005; Warren, 1927). As such, beaver dam building activities affect the lateral, longitudinal, and temporal connectivity of stream channels, floodplains, and adjacent uplands. Beaver dams increase lateral connectivity by linking stream channels, floodplains, and adjacent uplands subsequently by increasing longitudinal discontinuities downstream (Burchsted et al., 2010). Beaver dams can enhance vertical connectivity by increasing exchanges between surface and ground water (Majurova et al., 2015). Longitudinally, beaver dams disrupt the delivery of water, sediment, wood and nutrients (Wohl, 2013b), potentially dramatically altering the connectivity of up-estuary sediment sources to downstream sinks and providing greater variation in the residence time in sinks for sediment storage associated with beaver dams. Whereas dam breadth,

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Macfarlane et al. (2016) DOI:
[10.1016/j.geomorph.2015.11.019](http://dx.doi.org/10.1016/j.geomorph.2015.11.019)

The Primary Questions We Ask

1. Is their *enough* water present to maintain a pond?
2. Are *enough* and the *right* type of woody resources present to support dam building?
3. Can they build a dam at *base flows*?
4. Are dams likely to withstand *typical floods*?

Some nationally-available lines of evidence to address questions:

- NHD – perennial streams (1:24K)
- LANDFIRE - vegetation type (EVT)
- USGS Regional Curves for
 - *Baseflow statistics*
 - Q_2
- USGS NED 10 m DEM – derive reach slope and estimate stream power

Macfarlane et al. (2016) DOI:

[10.1016/j.geomorph.2015.11.019](https://doi.org/10.1016/j.geomorph.2015.11.019)

Capacity Model in a Nutshell



- Beaver need water and wood...
- Type and extent of wood/vegetation matters most
- Flow regime act to potentially limit capacity

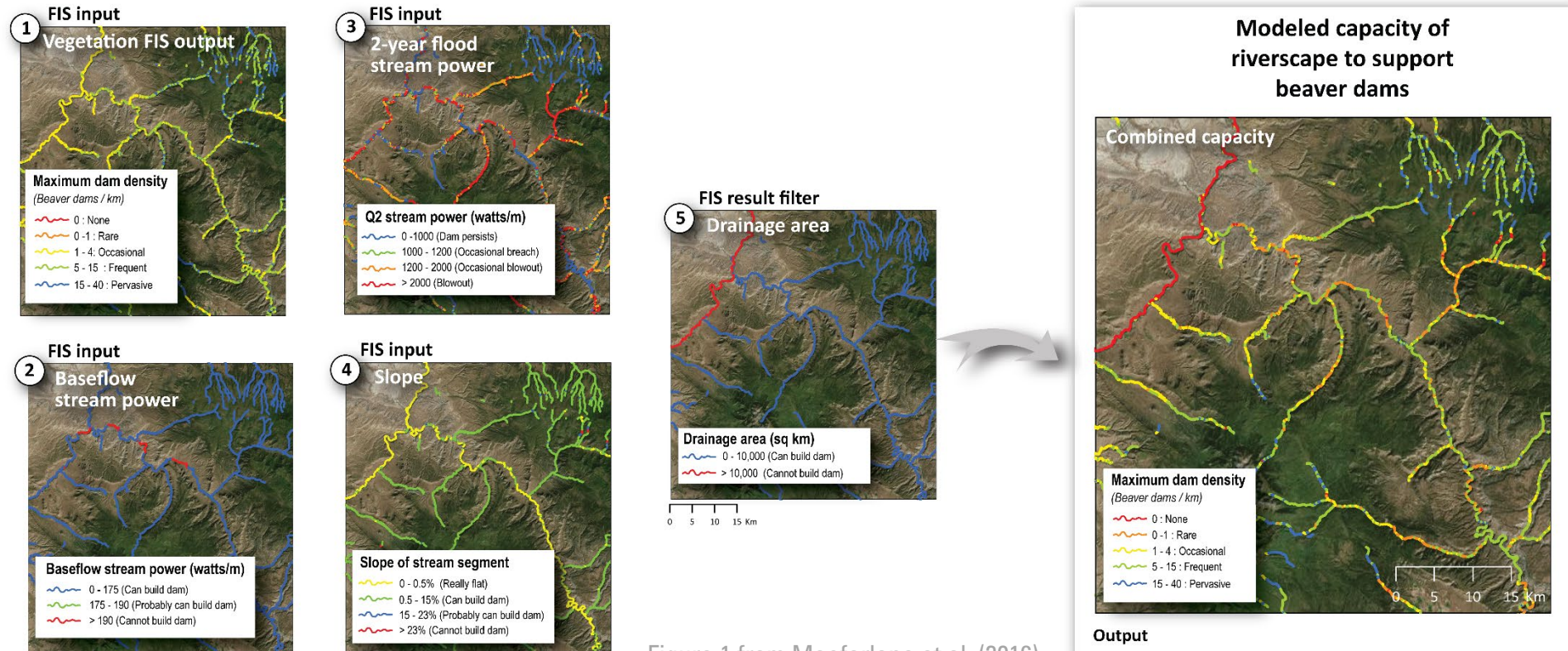


Figure 1 from Macfarlane et al. (2016)
DOI: [10.1016/j.geomorph.2015.11.019](https://doi.org/10.1016/j.geomorph.2015.11.019)

How Many & Where?

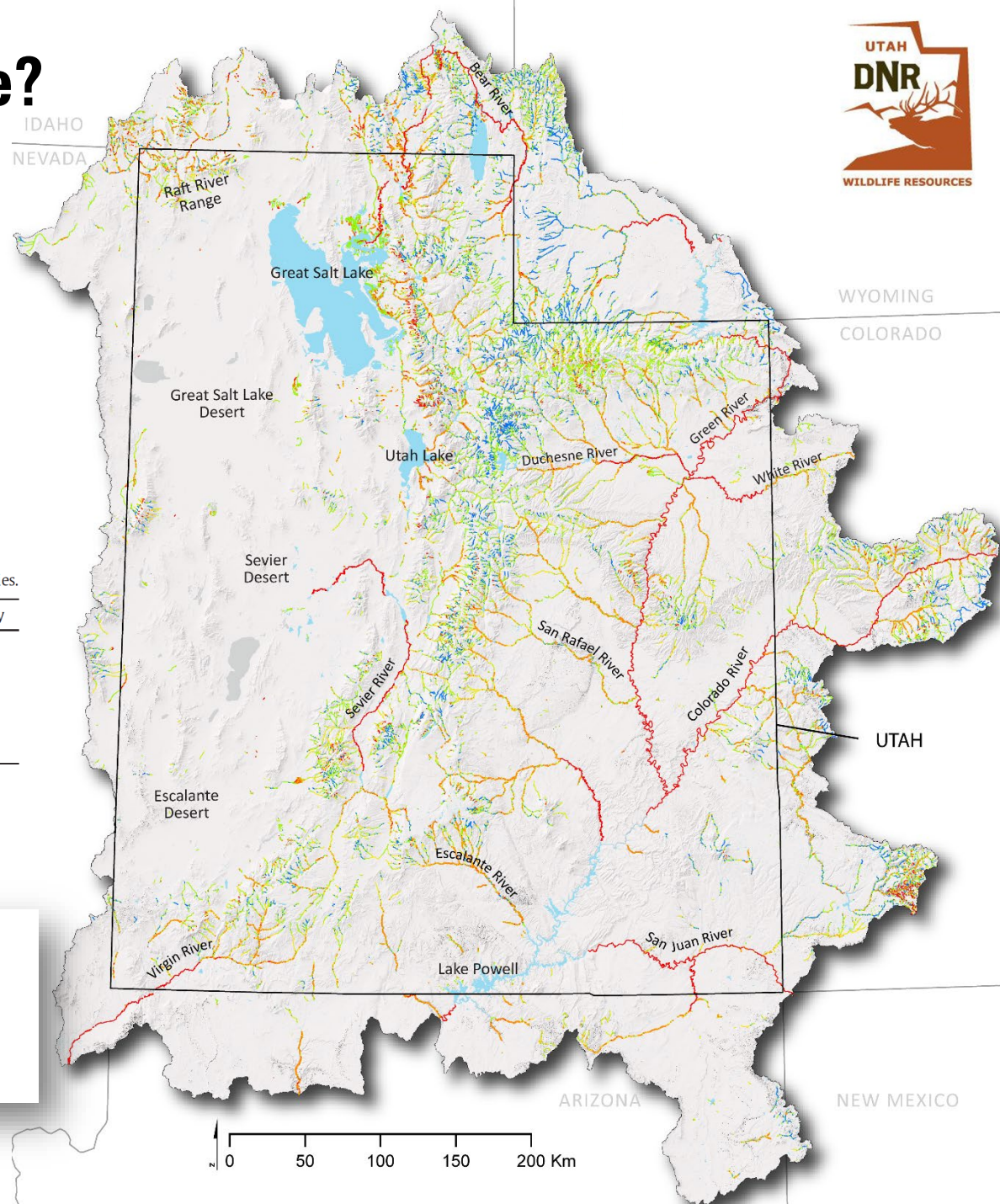
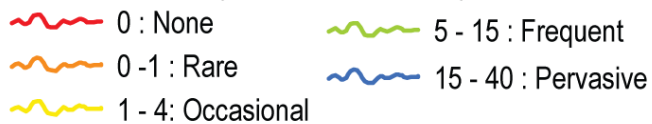
- Existing capacity: 356,294 dams
- 8.3 dams/km



Table 4
Summary of existing beaver dam gross modeled capacity estimates by capacity categories.

Category	Stream length (km)	% of stream network	Estimated dam capacity
Pervasive	6219	15%	147,644
Frequent	18,162	45%	186,184
Occasional	8234	20%	21,544
Rare	3307	8%	922
None	4639	12%	-
Total	40,561		356,294

Maximum Dam Density (Beaver Dams / km)



Capacity... Max Number of Dams

- By answering the basic questions on this form & using the inference system tables we can estimate beaver dam capacity.

BRAT-clS – BEAVER DAM CAPACITY ASSESSMENT FORM - BASIC

CC BY-NC-SA Utah State University
 BEAVER DAM CAPACITY ASSESSMENT FORM

OBSERVATION INFO

Observer Name: _____ Observation Date: _____
 Reach ID: _____ Stream Name: _____

LOCATION OF ASSESSMENT REACH _____
 GPS UTM Easting: _____
 GPS UTM Northing: _____

LENGTH OF REACH _____
 Length _____ meters OR _____ x bankfull widths

VEGETATION CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

<p>SUITABILITY OF STREAMSIDE VEGETATION</p> <p><input type="radio"/> Unsuitable <input type="radio"/> Barely Suitable <input type="radio"/> Moderately Suitable <input type="radio"/> Suitable <input type="radio"/> Preferred</p> <p><i>Vegetation within 30 m of water's edge</i></p> <p>What vegetation types are abundant? <input type="checkbox"/> Desirable woody (e.g. Aspen, Willow, Cottonwood) <input type="checkbox"/> Other woody (e.g. conifers, sagebrush) <input type="checkbox"/> Grasses <input type="checkbox"/> Crops <input type="checkbox"/> Ornamentals <input type="checkbox"/> Developed</p>	<p>SUITABILITY OF RIPARIAN/UPLAND VEGETATION</p> <p><input type="radio"/> Unsuitable <input type="radio"/> Barely Suitable <input type="radio"/> Moderately Suitable <input type="radio"/> Suitable <input type="radio"/> Preferred</p> <p><i>Vegetation within 100 m of water's edge</i></p> <p>What vegetation types are abundant? <input type="checkbox"/> Desirable woody (e.g. Aspen, Willow, Cottonwood) <input type="checkbox"/> Other woody (e.g. conifers, sagebrush) <input type="checkbox"/> Grasses <input type="checkbox"/> Crops <input type="checkbox"/> Ornamentals <input type="checkbox"/> Developed</p>
--	--

DAM DENSITY CAPACITY ASSESSMENT BASED ON SUITABILITY OF VEGETATION ONLY (USE TABLE 1)

None (no dams)
 Rare (0-1 dams/km)
 Occasional (1-4 dams/km)
 Frequent (5-15 dams/km)
 Pervasive (15-40 dams/km)

COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

CAN BEAVER BUILD A DAM AT BASEFLOWS?

Probably can build dam
 Can build dam
 Can build dam (saw evidence of recent dams)
 Could build dam at one time (saw evidence of relic dams)
 Cannot build dam (streampower really high)

HOW DOES THE REACH SLOPE IMPACT THEIR ABILITY OR NEED TO BUILD DAMS?

So steep they cannot build a dam (e.g. > 20% slope)
 Probably can build dam
 Can build dam (inferred)
 Can build dam (evidence or current or past dams)
 Really flat (can build dam, but might not need as many as one dam might back up water > 0.5 km)

IF BEAVERS BUILD A DAM, CONSIDER WHAT HAPPENS TO THE DAM(S) IN A TYPICAL FLOOD (E.G. MEAN ANNUAL FLOOD)?

Blowout Occasional Blowout
 Occasional Breach Dam Persists

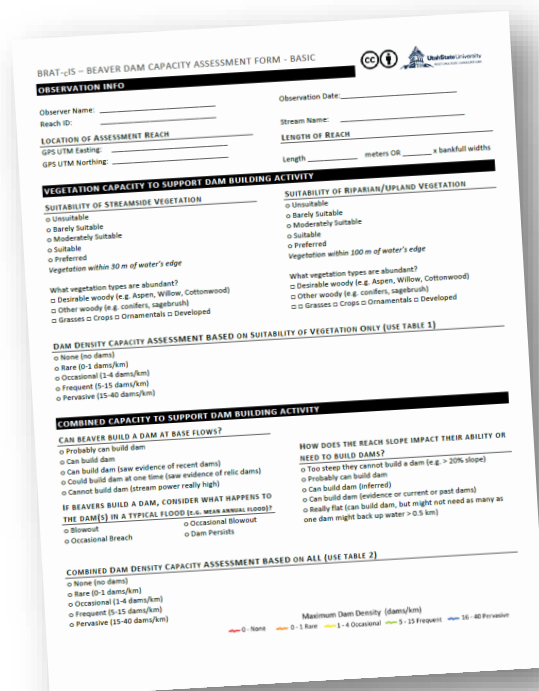
COMBINED DAM DENSITY CAPACITY ASSESSMENT BASED ON ALL (USE TABLE 2)

None (no dams)
 Rare (0-1 dams/km)
 Occasional (1-4 dams/km)
 Frequent (5-15 dams/km)
 Pervasive (15-40 dams/km)

Maximum Dam Density (dams/km)
 0 - None 0 - 1 Rare 1 - 4 Occasional 5 - 15 Frequent 16 - 40 Pervasive

BRAT - cIS

Who?
Where?
When?



BRAT-cIS – BEAVER DAM CAPACITY ASSESSMENT FORM - BASIC



OBSERVATION INFO

Observer Name: _____

Observation Date: _____

Reach ID: _____

Stream Name: _____

LOCATION OF ASSESSMENT REACH

GPS UTM Easting: _____

LENGTH OF REACH

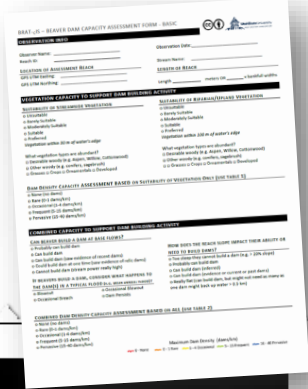
GPS UTM Northing: _____

Length _____ meters OR _____ x bankfull widths



BRAT - cIS

The veg questions... - dam building materials



VEGETATION CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

SUITABILITY OF STREAMSIDE VEGETATION

- Unsuitable
- Barely Suitable
- Moderately Suitable
- Suitable
- Preferred

Vegetation within 30 m of water's edge

What vegetation types are abundant?

- Desirable woody (e.g. Aspen, Willow, Cottonwood)
- Other woody (e.g. conifers, sagebrush)
- Grasses
- Crops
- Ornamentals
- Developed

SUITABILITY OF RIPARIAN/UPLAND VEGETATION

- Unsuitable
- Barely Suitable
- Moderately Suitable
- Suitable
- Preferred

Vegetation within 100 m of water's edge

What vegetation types are abundant?

- Desirable woody (e.g. Aspen, Willow, Cottonwood)
- Other woody (e.g. conifers, sagebrush)
- Grasses
- Crops
- Ornamentals
- Developed

DAM DENSITY CAPACITY ASSESSMENT BASED ON SUITABILITY OF VEGETATION ONLY (USE TABLE 1)

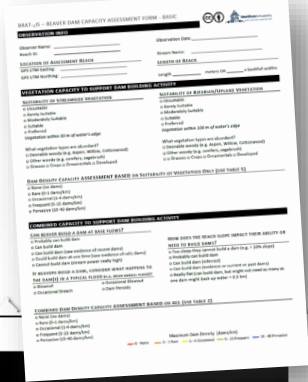
- None (no dams)
- Rare (0-1 dams/km)
- Occasional (1-4 dams/km)
- Frequent (5-15 dams/km)
- Pervasive (15-40 dams/km)

COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

CAN BEAVER BUILD A DAM AT BASE FLOWS?

BRAT - cIS

The inference system... look up table on back!



VEGETATION CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

SUITABILITY OF STREAMSIDE VEGETATION

- Unsuitable
- Barely Suitable
- Moderately Suitable
- Suitable
- Preferred

Vegetation within 30 m of water's edge

- What vegetation types are abundant?
- Desirable woody (e.g. Aspen, Willow, Cottonwood)
 - Other woody (e.g. conifers, sagebrush)
 - Grasses Crops Ornamentals Developed

SUITABILITY OF RIPARIAN/UPLAND VEGETATION

- Unsuitable

INFERENCE SYSTEM OF CAPACITY BASED ON VEGETATION ONLY:

Table 1. Rule table for two input inference system that models the capacity of the reach to support dam building activity (in dam density) using the suitability of streamside vegetation and suitability of riparian/upland vegetation as inputs.

Rules	Inputs	Output
	Suitability of streamside vegetation & Suitability of riparian/upland vegetation	Dam density capacity
1	If Unsuitable & Unsuitable	, then None
2	If Unsuitable & Barely suitable	, then Rare
3	If Unsuitable & Moderately suitable	, then Rare
4	If Unsuitable & Suitable	, then Occasional
5	If Unsuitable & Preferred	, then Occasional
6	If Barely suitable & Unsuitable	, then Rare
7	If Barely suitable & Barely suitable	, then Rare
8	If Barely suitable & Moderately suitable	, then Occasional
9	If Barely suitable & Suitable	, then Occasional
10	If Barely suitable & Preferred	, then Rare
11	If Moderately suitable & Unsuitable	, then Occasional
12	If Moderately suitable & Barely suitable	, then Occasional
13	If Moderately suitable & Moderately suitable	, then Frequent
14	If Moderately suitable & Suitable	, then Frequent
15	If Moderately suitable & Preferred	, then Occasional
16	If Suitable & Unsuitable	, then Occasional
17	If Suitable & Barely suitable	, then Frequent
18	If Suitable & Moderately suitable	, then Frequent
19	If Suitable & Suitable	, then Pervasive
20	If Suitable & Preferred	, then Occasional
21	If Preferred & Unsuitable	, then Frequent
22	If Preferred & Barely suitable	, then Pervasive
23	If Preferred & Moderately suitable	, then Pervasive
24	If Preferred & Suitable	, then Pervasive
25	If Preferred & Preferred	, then Pervasive

DAM DENSITY CAPACITY ASSESSMENT BASE

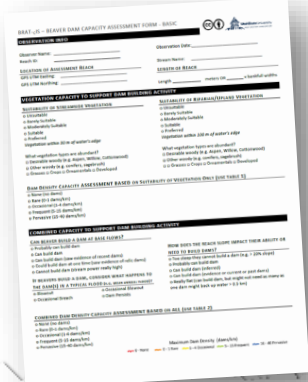
- None (no dams)
- Rare (0-1 dams/km)
- Occasional (1-4 dams/km)
- Frequent (5-15 dams/km)
- Pervasive (15-40 dams/km)

COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

CAN BEAVER BUILD A DAM AT BASE FLOWS?

BRAT - cIS

Does hydrology (manifested as local hydraulics) limit this capacity?



COMBINED CAPACITY TO SUPPORT DAM BUILDING ACTIVITY

CAN BEAVER BUILD A DAM AT BASE FLOWS?

- Probably can build dam
- Can build dam
- Can build dam (saw evidence of recent dams)
- Could build dam at one time (saw evidence of relic dams)
- Cannot build dam (stream power really high)

IF BEAVERS BUILD A DAM, CONSIDER WHAT HAPPENS TO THE DAM(S) IN A TYPICAL FLOOD (E.G. MEAN ANNUAL FLOOD)?

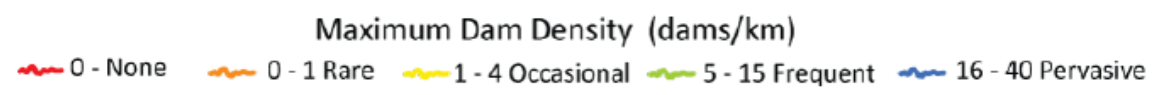
- | | |
|---------------------|----------------------|
| ○ Blowout | ○ Occasional Blowout |
| ○ Occasional Breach | ○ Dam Persists |

HOW DOES THE REACH SLOPE IMPACT THEIR ABILITY OR NEED TO BUILD DAMS?

- Too steep they cannot build a dam (e.g. > 20% slope)
- Probably can build dam
- Can build dam (inferred)
- Can build dam (evidence or current or past dams)
- Really flat (can build dam, but might not need as many as one dam might back up water > 0.5 km)

COMBINED DAM DENSITY CAPACITY ASSESSMENT BASED ON ALL (USE TABLE 2)

- None (no dams)
- Rare (0-1 dams/km)
- Occasional (1-4 dams/km)
- Frequent (5-15 dams/km)
- Pervasive (15-40 dams/km)



COMBINED INFERENCE SYSTEM:

Table 2. Rule table for four input inference system that models the capacity of the reach to support dam building activity (in dam density) using the vegetation dam density capacity (output of Table 1 model), the two-year flood stream power, baseflow stream power and reach slope.

Rules	Inputs	Output
	Vegetation dam density capacity & 2-year flood stream power & Baseflow stream power & Reach slope	Dam density capacity
1	If None & - & - & -	, then None
2	If - & - & Cannot build dam & -	, then None
3	If - & - & - & Cannot build dam	, then None
4	If Rare & Dam persists & Can build dam & NOT Cannot build dam	, then Rare
5	If Rare & Dam persists & Probably can build dam & NOT Cannot build dam	, then Rare
6	If Rare & Occasional breach & Can build dam & NOT Cannot build dam	, then Rare
7	If Rare & Occasional breach & Probably can build dam & NOT Cannot build dam	, then Rare
8	If Rare & Occasional blowout & Can build dam & NOT Cannot build dam	, then Rare
9	If Rare & Occasional blowout & Probably can build dam & NOT Cannot build dam	, then Rare
10	If Rare & Blowout & Can build dam & NOT Cannot build dam	, then None
11	If Rare & Blowout & Probably can build dam & NOT Cannot build dam	, then None
12	If Occasional & Dam persists & Can build dam & NOT Cannot build dam	, then Occasional
13	If Occasional & Dam persists & Probably can build dam & NOT Cannot build dam	, then Occasional
14	If Occasional & Occasional breach & Can build dam & NOT Cannot build dam	, then Occasional
15	If Occasional & Occasional breach & Probably can build dam & NOT Cannot build dam	, then Occasional
16	If Occasional & Occasional blowout & Can build dam & NOT Cannot build dam	, then Occasional
17	If Occasional & Occasional blowout & Probably can build dam & NOT Cannot build dam	, then Occasional
18	If Occasional & Blowout & Can build dam & NOT Cannot build dam	, then Occasional
19	If Occasional & Blowout & Probably can build dam & NOT Cannot build dam	, then Occasional
20	If Frequent & - & - & -	, then None
21	If Frequent & - & - & -	, then None
22	If Frequent & - & - & -	, then None
23	If Frequent & - & - & -	, then None
24	If Frequent & - & - & -	, then None
25	If Frequent & - & - & -	, then None
26	If Frequent & - & - & -	, then None
27	If Frequent & - & - & -	, then None
28	If Frequent & - & - & -	, then None
29	If Frequent & - & - & -	, then None
30	If Frequent & - & - & -	, then None
31	If Frequent & - & - & -	, then None
32	If Frequent & - & - & -	, then None
33	If Frequent & - & - & -	, then None
34	If Frequent & - & - & -	, then None
35	If Frequent & - & - & -	, then None
36	If Frequent & - & - & -	, then None
37	If Frequent & - & - & -	, then None
38	If Frequent & Blowout & Can build dam & Really flat	, then Rare
39	If Frequent & Blowout & Can build dam & Can build dam	, then Rare
40	If Frequent & Blowout & Can build dam & Probably can build dam	, then Rare
41	If Frequent & Blowout & Probably can build dam & Really flat	, then Rare
42	If Frequent & Blowout & Probably can build dam & Can build dam	, then Rare
43	If Frequent & Blowout & Probably can build dam & Probably can build dam	, then Rare
44	If Pervasive & Dam persists & Can build dam & Really flat	, then Frequent
45	If Pervasive & Dam persists & Can build dam & Can build dam	, then Pervasive
46	If Pervasive & Dam persists & Can build dam & Probably can build dam	, then Frequent
47	If Pervasive & Dam persists & Probably can build dam & Really flat	, then Frequent
48	If Pervasive & Dam persists & Probably can build dam & Can build dam	, then Pervasive
49	If Pervasive & Dam persists & Probably can build dam & Probably can build dam	, then Frequent
50	If Pervasive & Occasional breach & Can build dam & Really flat	, then Frequent
51	If Pervasive & Occasional breach & Can build dam & Can build dam	, then Pervasive
52	If Pervasive & Occasional breach & Can build dam & Probably can build dam	, then Frequent
53	If Pervasive & Occasional breach & Probably can build dam & Really flat	, then Frequent
54	If Pervasive & Occasional breach & Probably can build dam & Can build dam	, then Pervasive
55	If Pervasive & Occasional breach & Probably can build dam & Probably can build dam	, then Frequent
56	If Pervasive & Occasional blowout & Can build dam & Really flat	, then Frequent
57	If Pervasive & Occasional blowout & Can build dam & Can build dam	, then Pervasive
58	If Pervasive & Occasional blowout & Can build dam & Probably can build dam	, then Frequent
59	If Pervasive & Occasional blowout & Probably can build dam & Really flat	, then Occasional
60	If Pervasive & Occasional blowout & Probably can build dam & Can build dam	, then Frequent
61	If Pervasive & Occasional blowout & Probably can build dam & Probably can build dam	, then Occasional
62	If Pervasive & Blowout & Can build dam & Really flat	, then Occasional
63	If Pervasive & Blowout & Can build dam & Can build dam	, then Occasional
64	If Pervasive & Blowout & Can build dam & Probably can build dam	, then Rare
65	If Pervasive & Blowout & Probably can build dam & Really flat	, then Occasional
66	If Pervasive & Blowout & Probably can build dam & Can build dam	, then Occasional
67	If Pervasive & Blowout & Probably can build dam & Probably can build dam	, then Rare

Uglier table... but simple to apply

Rules	Inputs	Output
	Vegetation dam density capacity & 2-year flood stream power & Baseflow stream power & Reach slope	Dam density capacity
1	If None & - & - & -	, then None
2	If - & - & Cannot build dam & -	, then None
3	If - & - & - & Cannot build dam	, then None
4	If Rare & Dam persists & Can build dam & NOT Cannot build dam	, then Rare
5	If Rare & Dam persists & Probably can build dam & NOT Cannot build dam	, then Rare

Maximum Dam Density (dams/km)



Could **beaver dam activity** be supported?

6/2014

See Appendix 3F (p 127) in Bennett et al. (2019)

Chapter 3 LTPBR Manual

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

BRAT 

See: <http://brat.riverscapes.xyz>

Q: What are current
riverscape **conditions**?

Geomorphically?
Riparian?

Q: What is **recovery
potential**?

- to sustain wood accumulation and/or
beaver dam activity

Google Earth

Could **beaver dam activity** be supported? – **Census it!**

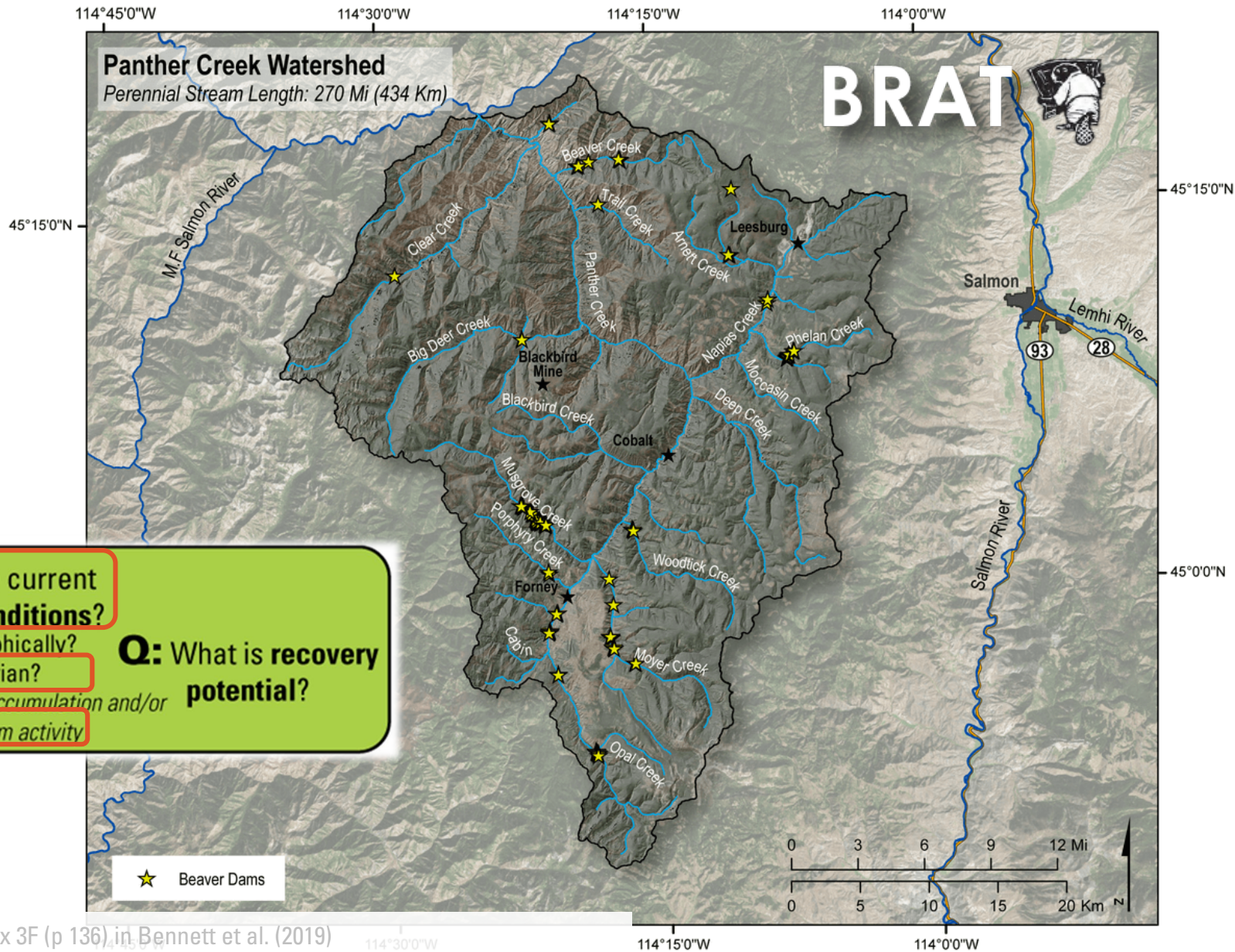


Figure 3.37 of Appendix 3F (p 136) in Bennett et al. (2019)

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

Should beaver dam activity be supported? – Census it!

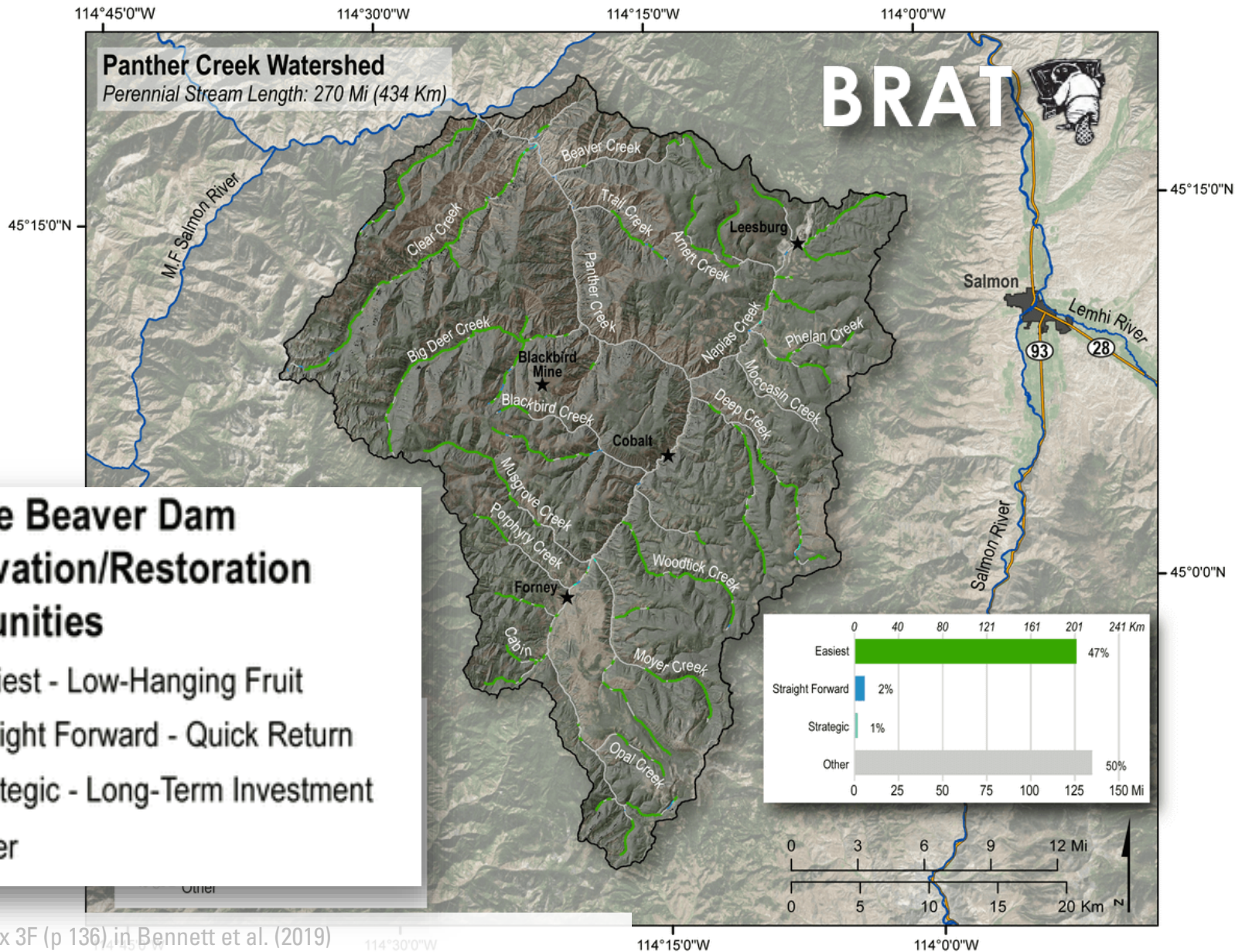


Figure 3.37 of Appendix 3F (p 136) in Bennett et al. (2019)

DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

OUTLINE: Low-Tech Planning



I. Review

II. Conservation Planning Process

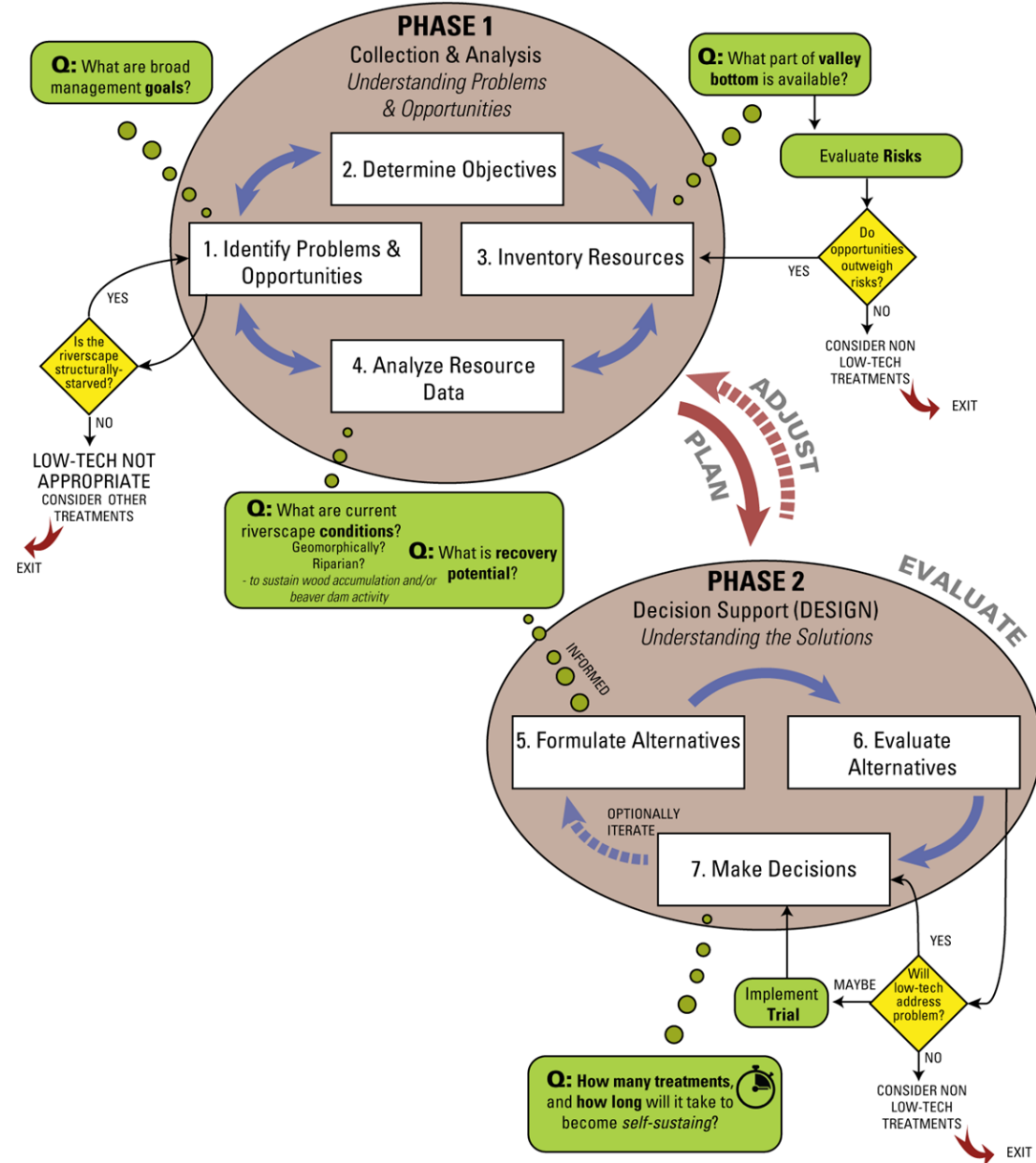
I. Phase 1 – Planning

II. Phase 2 – **Design**

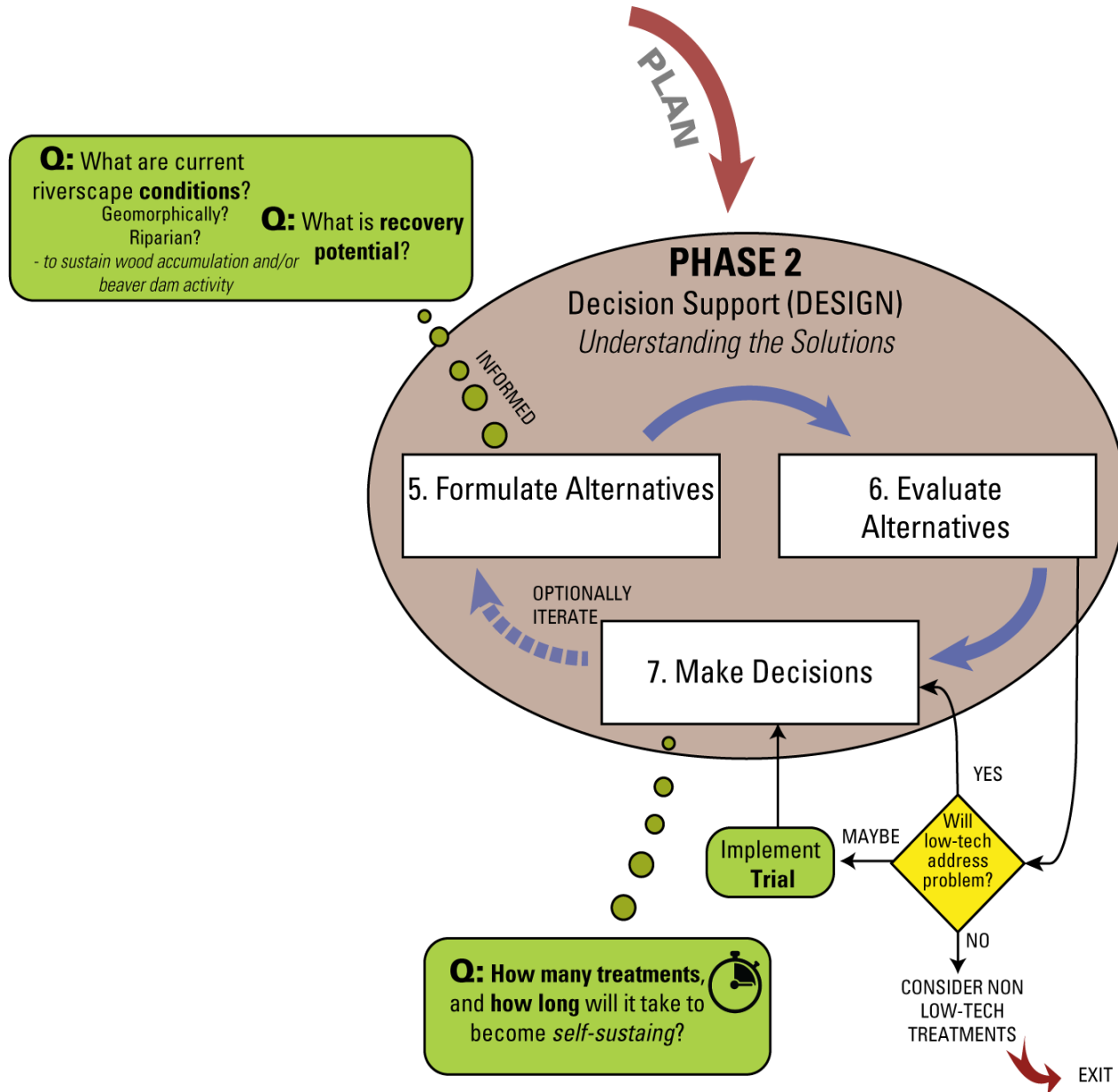
III. Phase 3 - Implementation

Phase 2 - Design

4. Formulate *design* alternatives
5. Evaluate *design* alternatives
6. Make decisions



Summary of Phase 2 with Low-Tech



- Potential **exit point**, based on likelihood of low-tech treatments to address problems.
- Consideration of **how many treatments** and **how long** it may take to achieve a self-sustaining state

Figure 3.13 from Bennett et al. (2019, p. 106)

OUTLINE: Low-Tech Planning



I. Review

II. Conservation Planning Process

I. Phase 1 – Planning

II. Phase 2 – Design

III. Phase 3 - **Implementation**

On to Phase 3

- Fed from Design
- Number of treatments estimated in design

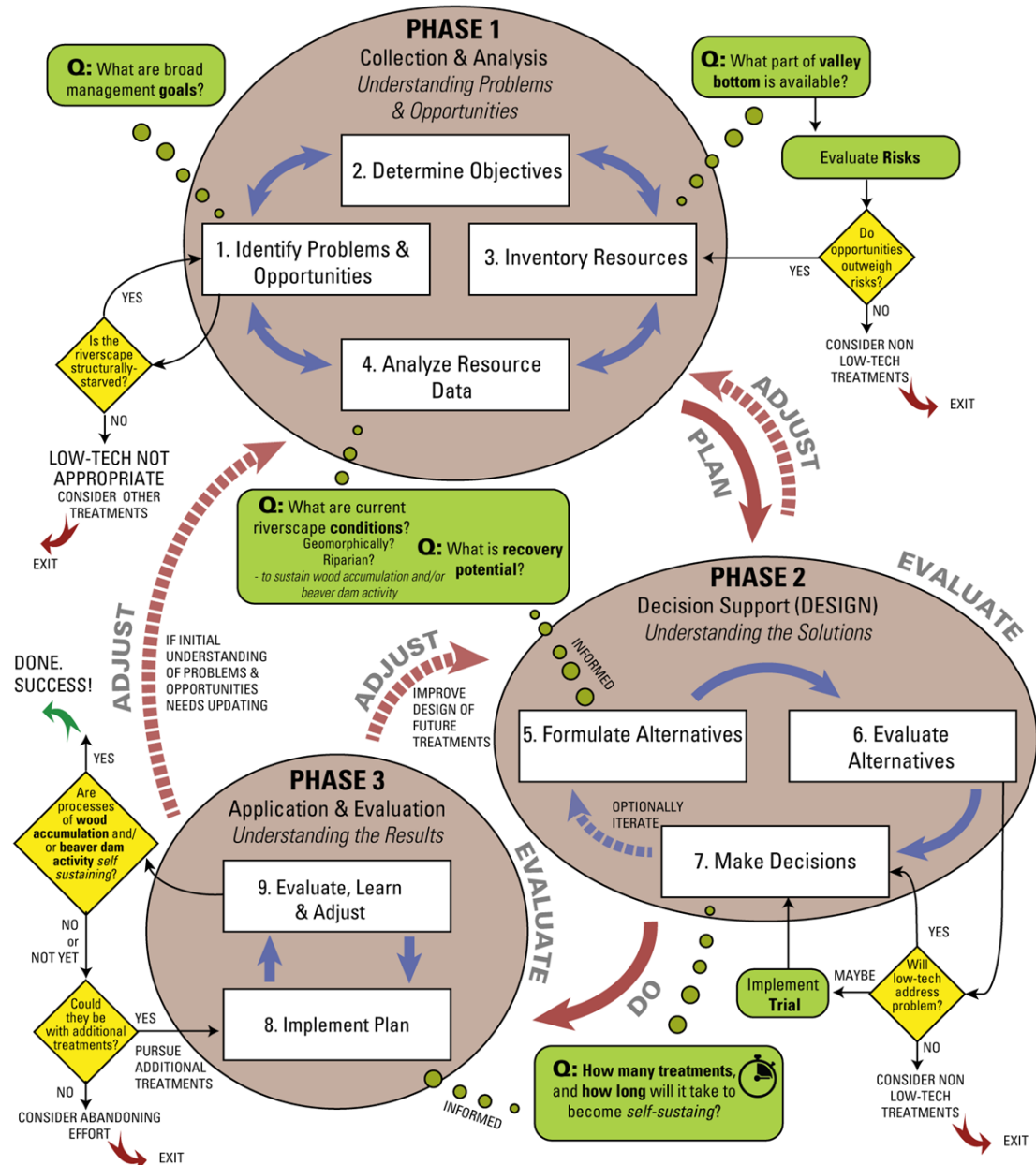
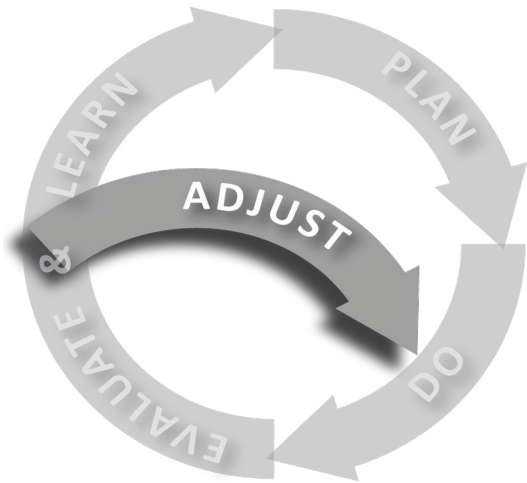
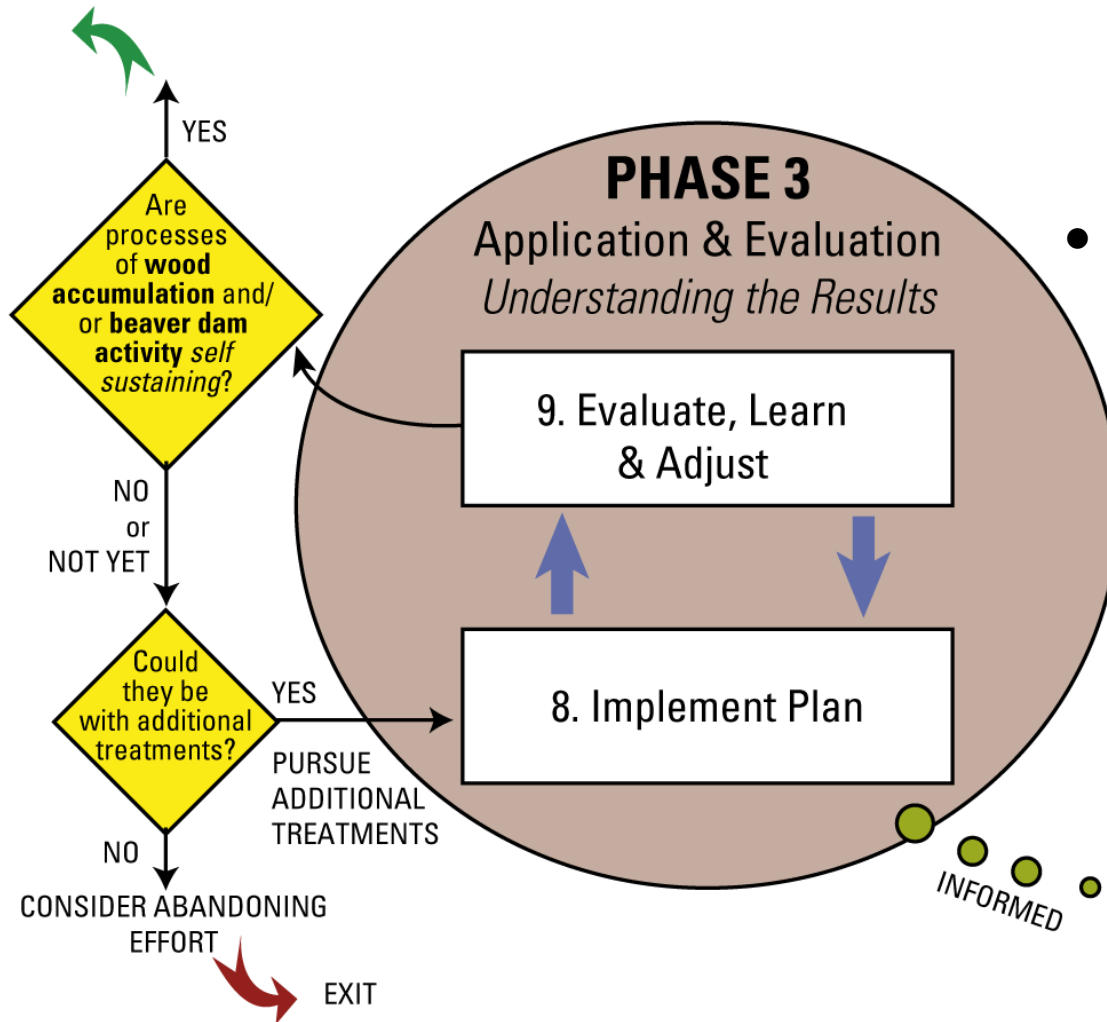


Figure 3.20 from Bennett et al. (2019, p 115)
 Chapter 3 LTPBR Manual
 DOI: [10.13140/RG.2.2.15815.75680](https://doi.org/10.13140/RG.2.2.15815.75680)

Phase 3 – Application & Evaluation

DONE.
SUCCESS!



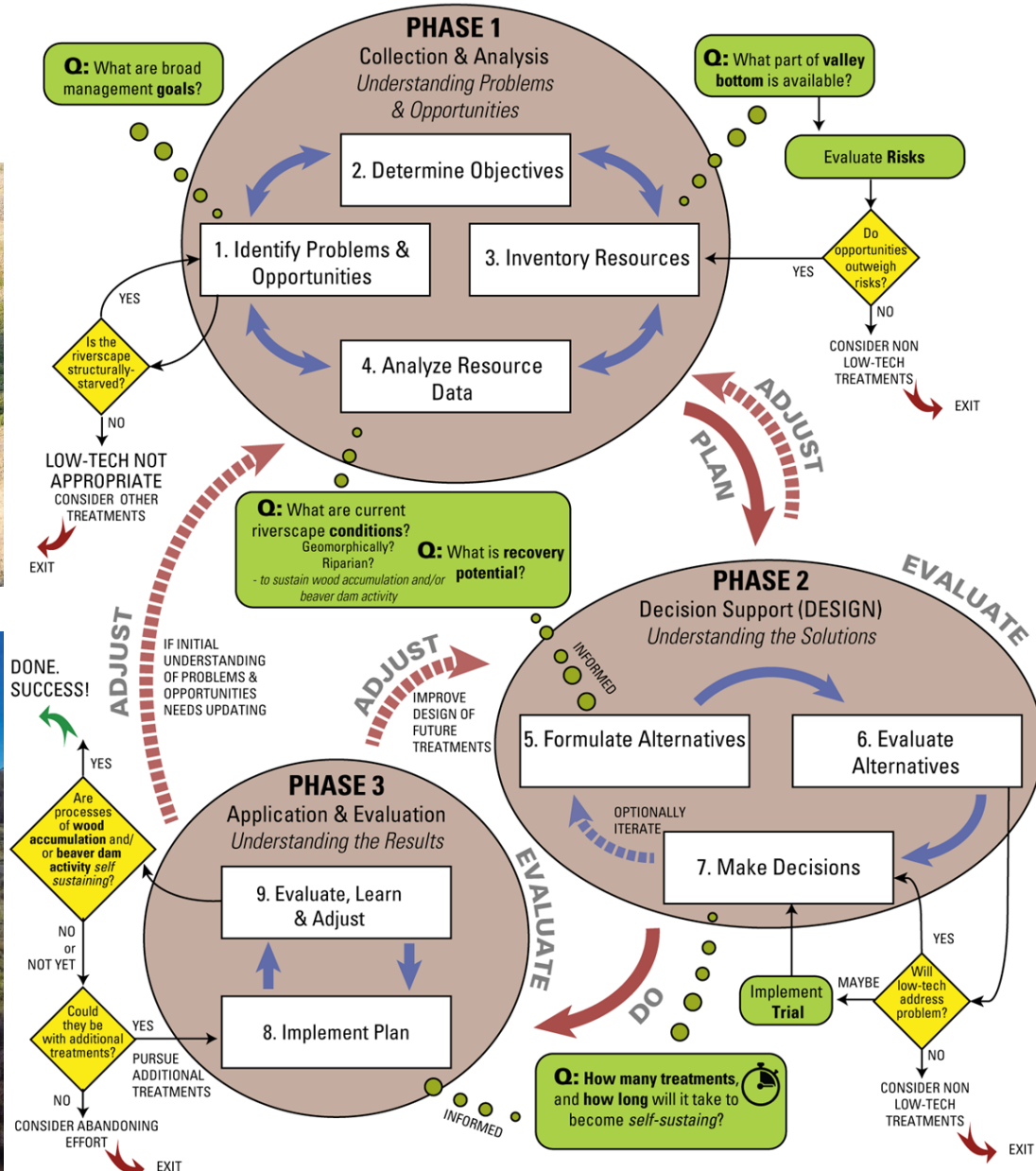
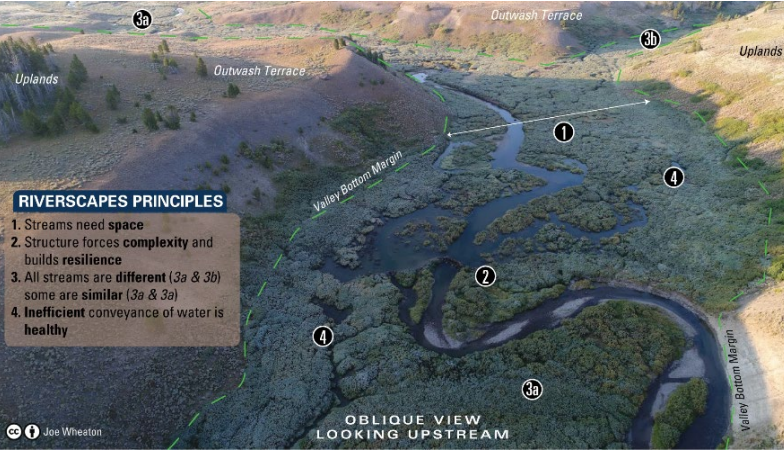
- Treatments are iterated through until processes of wood accumulation and/or beaver dam activity are self-sustaining (informed by Design stage estimates)
- Exit strategy (via successfully self-sustaining) or realizing that was an unrealistic goal



Q: How many treatments, and how long will it take to become self-sustaining?

Figure 3.14 from Bennett et al. (2019, p. 109)

How does modified CPP integrate principles?



Conclusions

- How can you objectively inventory condition and impairments efficiently?
 - Models that can use nationally available datasets, but can be implemented logically in the field or at the desktop with higher-resolution inputs are powerful
 - If you know better.... You CAN & should over ride the outputs. Update the map!
-
- The outputs help build realistic expectations about what beaver may achieve locally, but also helps scale up those expectations regionally and consistently
 - These models can be used as an initial restoration & conservation planning and decision support tool, and can support initial conceptual design and siting of specific restoration actions.



Your Homework

Condition Assessment Report



In this individual assignment, you will prepare a condition assessment report for the Upper Reach (as defined by [Logan River CAP](#) and inclusive of Crockett Reach). As we did in class ([condition assessment](#)), you will use the framework of the [Conservation Planning Process](#) we discussed in [Week 2](#). In your report, you should walk through the same steps we did in class and present evidence (e.g. maps, analysis, rationale, etc.) for answers to all these questions:

1. What part of the valley bottom is available for restoration? (i.e. you need to map valley bottom)
 1. Evaluate and map risks within and adjacent to riverscape.
 2. Assess risks and address whether opportunities outweigh risks?
2. What are current riverscape conditions?
 1. What are the geomorphic conditions (e.g. stage in Cluer & Thorne model; or geomorphic assessment)?
 2. What are the riparian conditions?
 1. Are the riparian conditions conducive to support and/or sustain beaver dam activity?
 2. Are the riparian conditions conducive to support and/or sustain wood accumulations?

You may find [Chapter 3](#) of the LTPBR Manual helpful as a reference. Your report should address the above questions but follow the outline below. Next week, we will modify the report to include consideration of recovery potential.

1. Executive Summary
2. Introduction & Purpose
3. Watershed Description
4. Methods of Riverscape Condition Assessment
5. Results & Interpretation
 1. Valley Bottom Delineation
 2. Riparian Vegetation Departure
 3. Land Use Intensity
 4. Floodplain Accessibility
 5. Riparian Condition Assessment
 6. Present capacity to Support Dam Building Activity
6. Discussion
 1. Management Implications
 2. Management Recommendations
7. Conclusions



Figure 1. Logan River Restoration Conservation Action Plan (CAP) study area.