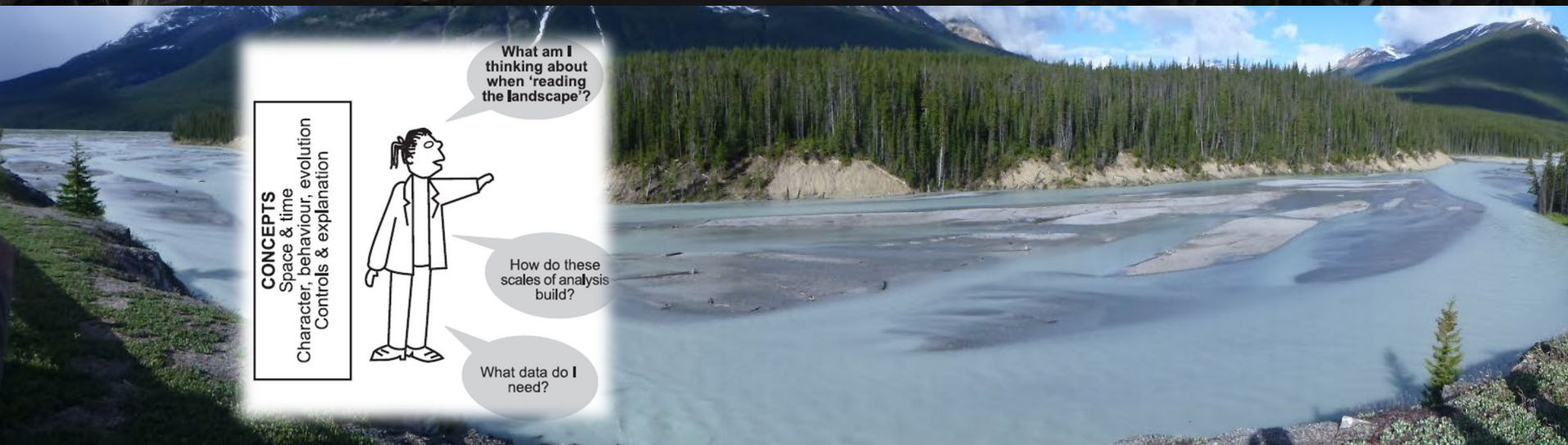


WATS 5150 – Fluvial Geomorphology

Geomorphic Analysis of River Systems



Reading for this Module

- CHAPTER ONE: Geomorphic analysis of river systems: an approach to reading the landscape

CHAPTER ONE

Geomorphic analysis of river systems: an approach to reading the landscape

Introduction

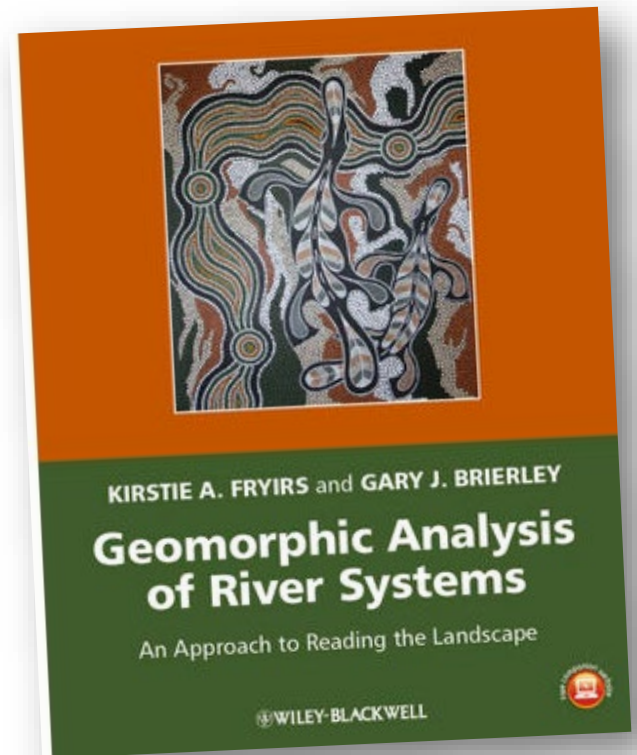
Landscapes have been a source of fascination and inspiration for humans for thousands of years. Sensory responses to landscapes vary markedly from person to person. To many, spiritual associations evoke a sense of belonging, perhaps tinged with nostalgic sentiments. To others, a sense of awe may be accompanied by alienation or innate fear. Artists strive to capture the essence of landscapes through paintings, prose, poetry or other media. Our experiences in life are often fashioned by the landscapes in which we live and play. Relationships and associations vary from place to place and over time. New experiences may generate new understandings, wherein observations are compared with experiences elsewhere. These collective associations not only reflect the bewildering range of landscapes in the natural world, they also reflect the individual consciousness with which we relate to landscapes, and the influences/experience that fashion our way of thinking, whether taught or intuitive. No two landscapes are exactly the same. Each landscape is, in its own way, 'perfect'. Different sets of controls interact in different ways in different settings, bringing about unique outcomes in any particular landscape. Just as importantly, interactions change over time, such that you cannot step in the same river twice (Heraclitus, 535-c. 475 BCE). Sometimes it seems a shame to formalise our understandings of landscapes within the jargonistic language of scientific discourse, but that is what geomorphologists do!

In simple terms, geomorphology is the scientific study of the characteristics, origin and evolution of landscapes. Geomorphic enquiry entails the description and explanation of landscape forms, processes and genesis. Implicitly, therefore, it requires both a generic understanding of the physics and mechanics of process and an appreciation of the dynamic behaviour of landscapes as they evolve through time. The key to effective use of geomorphic knowledge is the capacity to place site-specific insights and relationships in their broader landscape context, framing contemporary

process-form linkages in relation to historical imprints. Theoretical and modelling advances are pivotal in the development and testing of our understanding. However, the ultimate test of geomorphological knowledge lies in field interpretation of real-world examples.

This book outlines general principles with which to interpret river character, behaviour and evolution in any given system. Emphasis is placed upon the development of field-based skills with which to read the landscape. Field-based detective-style investigations appraise the relative influence of a multitude of factors that affect landscape-forming processes, resulting patterns of features and evolutionary adjustments. Interactions among these factors change over time. Inevitably, such investigations are undertaken with incomplete information. Information at hand has variable and uncertain accuracy. Some facets of insight may be contradictory. Individual strands of enquiry must be brought together to convey a coherent story. Significant inference may be required, drawing parallels with records elsewhere. Unravelling the inherent complexities that fashion the diversity of the natural world, the assemblages of features that make up any given landscape and the set of historical events that have shaped that place is the essence of geomorphic enquiry. Just as importantly, it is great fun!

Although this book emphasises process-form relationships on valley floors, it is implicitly understood that rivers must be viewed in their landscape and catchment context. Rivers are largely products of their valleys, which, in turn, are created by a range of geologic and climatic controls. Hillslope and other processes exert a primary control upon what happens on valley floors. Sediment delivery from river systems, in turn, exerts a major influence upon coastal-zone processes. Source-to-sink relationships are a function of catchment-scale controls on sediment supply, transport and delivery. Efforts to read the landscape place site-specific observations, measurements and analyses in an appropriate spatial and temporal context. Understanding of this dynamic landscape template provides a coherent platform for a wide range of management applications.



- Brierley G and Fryirs K. 2005. *Geomorphology and River Management: Applications of the River Styles Framework*. Blackwell Publishing: Victoria, Australia, 398 pp.

Geomorphic Analysis of River Systems

I. Intro

II. How is geomorphology useful?

III. Geomorphic Analysis of Rivers Systems (reading)

- I. Identify and interpret landforms and their process-form relationships
- II. Analyze assemblages of landforms to interpret behavior
- III. Explain controls on process-form interactions @ reach scale
- IV. Integrate understanding of geomorphic relationships @ catchment scale

A few highlights.. By way of introduction

and play. Relationships and associations vary from place to place and over time. New experiences may generate new understandings, wherein observations are compared with experiences elsewhere. These collective associations not only reflect the **bewildering range of landscapes** in the natural world, they also reflect the individual consciousness with which we relate to landscapes, and the influences/experience that fashion our way of thinking, whether taught or intuitive. **No two landscapes are exactly the same.** Each landscape is, in its own way, 'perfect'. **Different sets of controls interact in different ways in different settings, bringing about unique outcomes** in any particular landscape. Just as importantly, interactions change over time, such that **you cannot step in the same river twice** (Heraclitus, 535–c. 475 BCE). Sometimes **it seems a shame to formalise our understandings of landscapes within the jargonistic language of scientific discourse, but that is what geomorphologists do!**

historical events that have shaped that place is the essence of geomorphic enquiry. Just as importantly, it is great fun!

Although this **book emphasises process–form relationships on valley floors**, it is implicitly understood that **rivers must be viewed in their landscape and catchment context.** Rivers are largely products of their valleys, which, in turn, are created by a range of geologic and climatic controls. Hillslope and other processes exert a primary control upon what happens on valley floors. Sediment delivery

field interpretation or real-world examples.

This book outlines general principles with which to interpret river character, behaviour and evolution in any given system. Emphasis is placed upon the development of field-based skills with which **to read the landscape.** Field-based detective-style investigations appraise the relative influence of a multitude of factors that affect landscape-forming processes, resulting patterns of features and evolutionary adjustments. Interactions among these factors change over time. **Inevitably, such investigations are undertaken with incomplete information.** Information at hand has variable and uncertain accuracy. Some facets of insight may be contradictory. Individual strands of enquiry must be brought together to convey a coherent story. Significant

In simple terms, geomorphology is the scientific study of the characteristics, origin and evolution of landscapes. **Geomorphic enquiry entails the description and explanation of landscape forms, processes and genesis.** Implicitly, therefore, it **requires both a generic understanding of the physics and mechanics of process** and an **appreciation of the dynamic behaviour** of landscapes as they evolve through time. The key to effective use of geomorphic knowledge is the capacity to **place site-specific insights and relationships in their broader landscape context**, framing contemporary

Geomorphic Analysis of River Systems

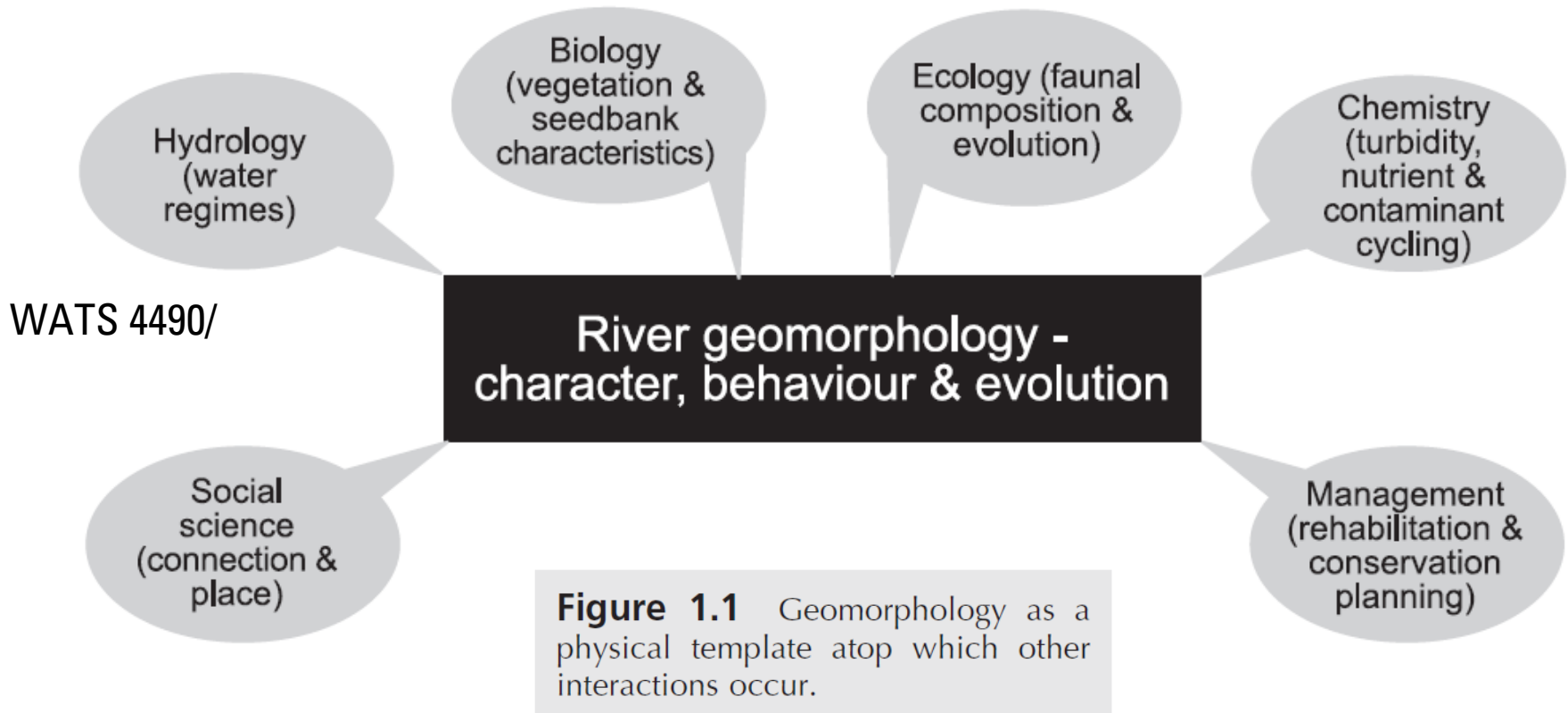
I. Intro

II. How is geomorphology useful?

III. Geomorphic Analysis of Rivers Systems (reading)

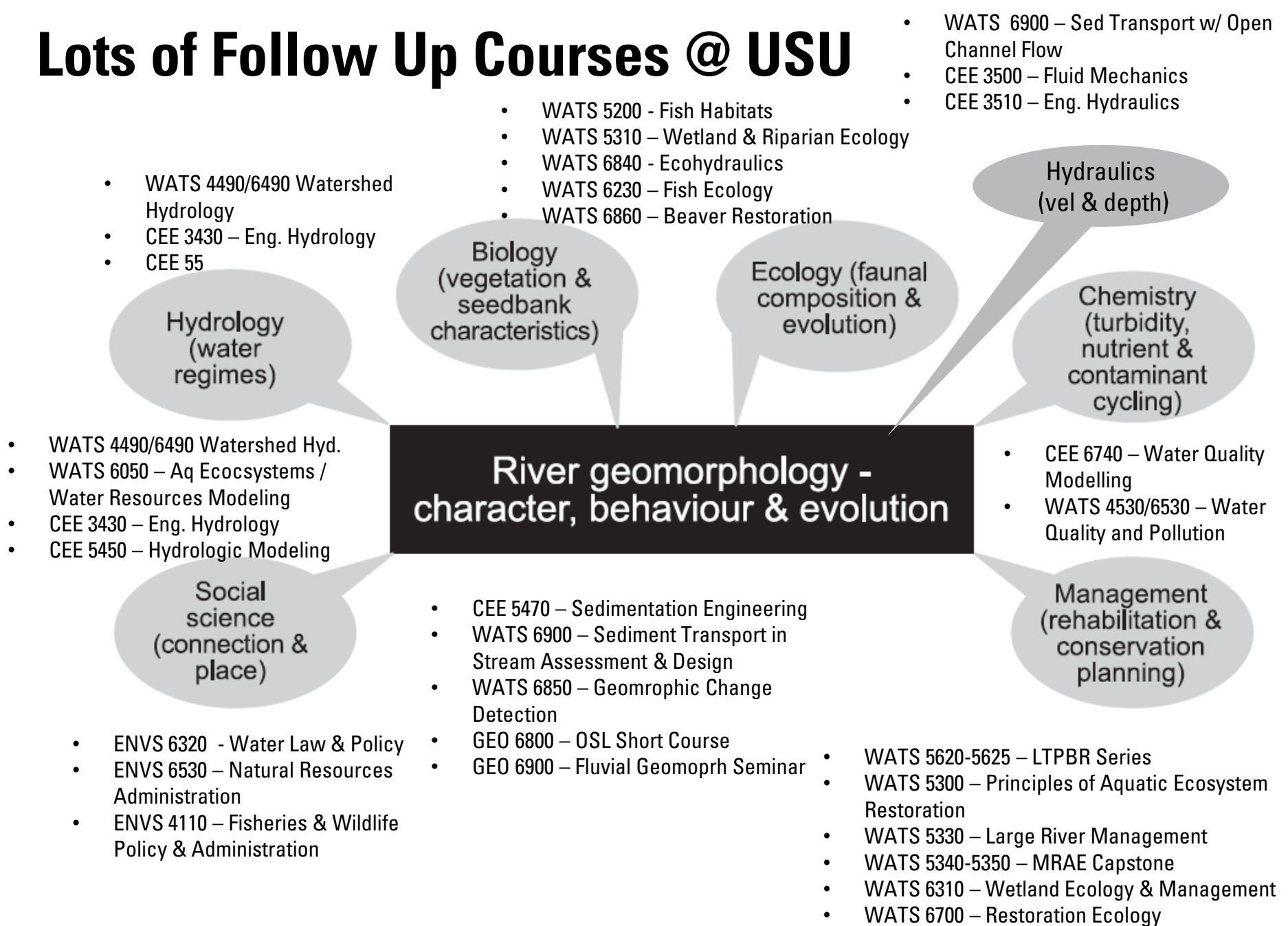
- I. Identify and interpret landforms and their process-form relationships
- II. Analyze assemblages of landforms to interpret behavior
- III. Explain controls on process-form interactions @ reach scale
- IV. Integrate understanding of geomorphic relationships @ catchment scale

Geomorphology as Center of It All..



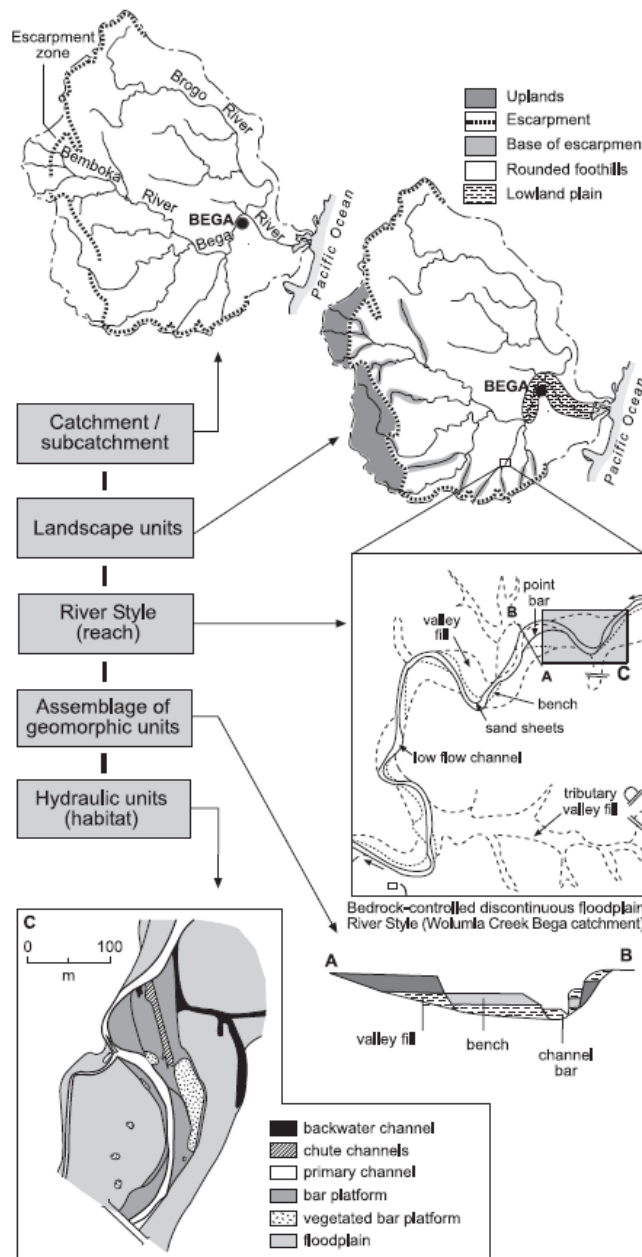
- A wise (-a*s) person once said, “I encourage you all to draw one of these cartoons where your discipline is the center of the universe and all related disciplines fit in”.

Lots of Follow Up Courses @ USU



Nested- Hierarchal Scales

1. 'Reach Types' or 'River Styles' are flavors of riverscapes
2. Flavor based on physiography:
 1. Climate
 2. Geology
 3. Ecology
3. River Style predicts what you will find at finer-scale (i.e. habitat)



SPATIAL SCALE OF RIVERSCAPE ANALYSIS

Increasing
Low Broad



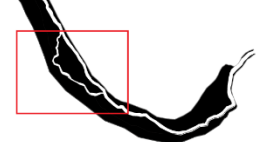
BASIN-SCALE & WATERSHED-SCALE



NETWORK-SCALE



SITE-SCALE



GEOMORPHIC UNIT-SCALE



RESOLUTION EXTENT



Multiple Populations

Individual Population

Multiple Individuals

Geomorphic Units

- Run
- Pool
- Riffle
- Terrace
- Channel Cuts
- Floodplain
- Bar

Network

Segment

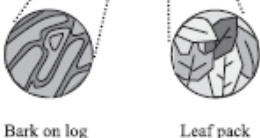
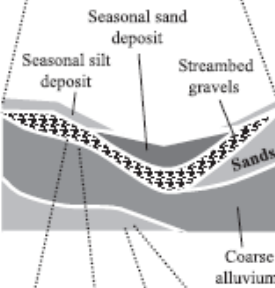
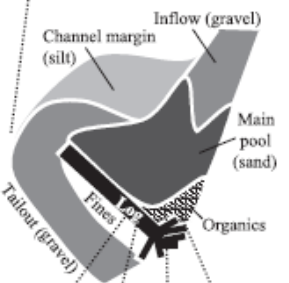
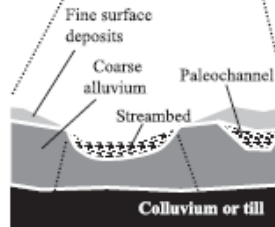
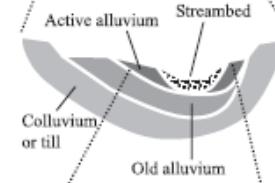
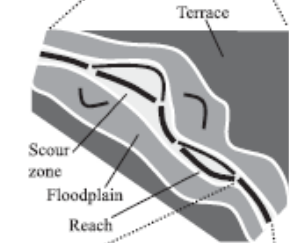
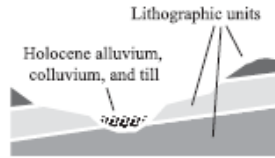
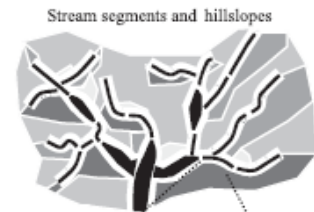
Reach

Habitat

Microhabitat

Plane view

Lateral cross-section



We'll revisit spatial & temporal scales, over and over

- For Spatial think *extent & resolution*
- For Temporal think *duration & frequency*

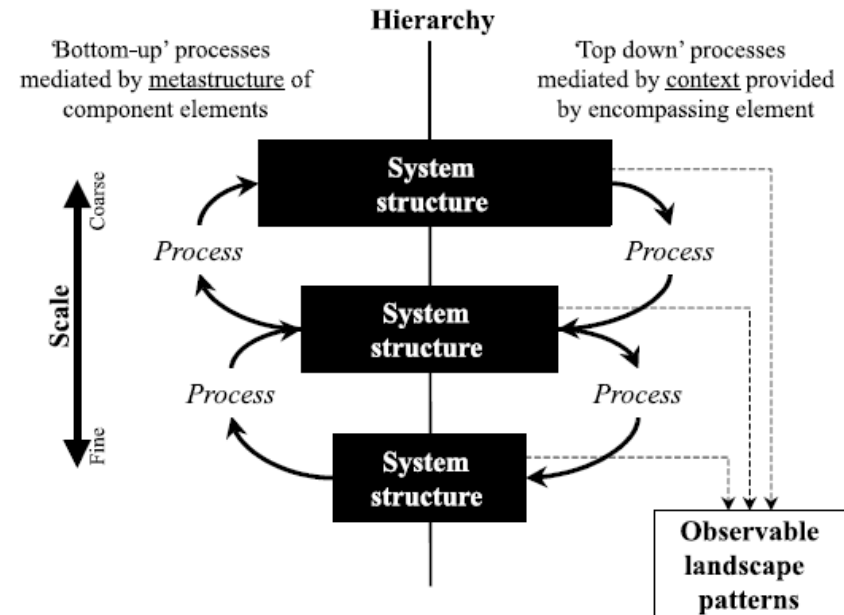
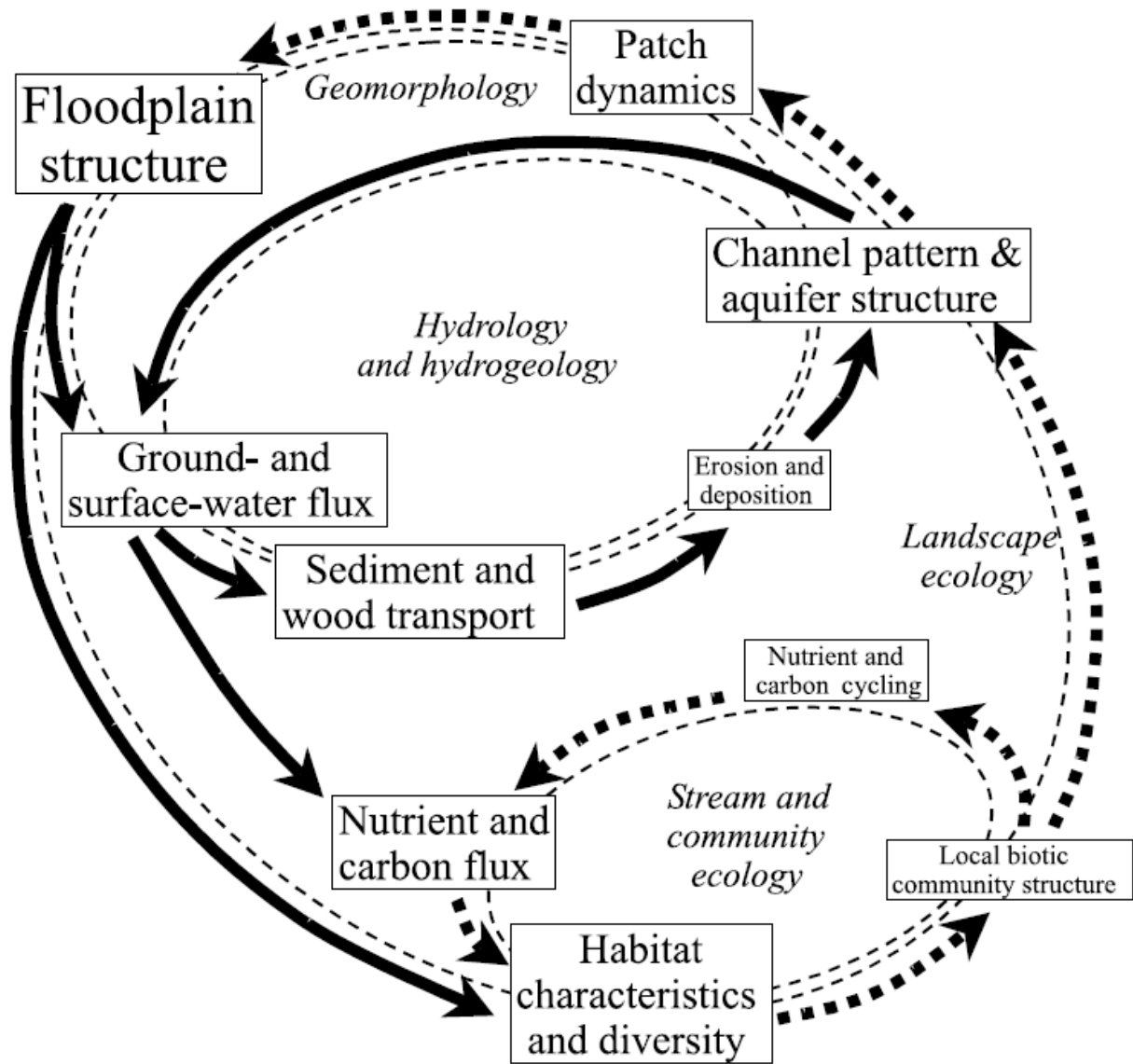


Fig. 3 Top-down and bottom-up relationships between encompassing and component elements as mediated by *trans-scale* processes.

“Landscapes are linked & dynamic systems”

From Poole (2002)

Fig. 4 A conceptualisation of biocomplexity and fluvial landscape dynamics on river floodplains. Text size represents relative spatial and temporal scales; large text represents coarse spatial and long temporal scales, small text connotes fine spatial and short temporal scales. Solid arrows represent linkages driven predominantly by physical processes and dashed arrows represent biogeochemical interactions. Thin dashed ovals represent feedback mechanisms studied primarily by specific academic disciplines shown in italic text within each oval.





Reading the Landscape... Refined

- In geomorphology, we need to read the *entire* landscape
- In fluvial geomorphology, we need to be able to recognize the parts of landscapes that bound rivers (i.e. valleys) , but we focus on reading riverscapes.

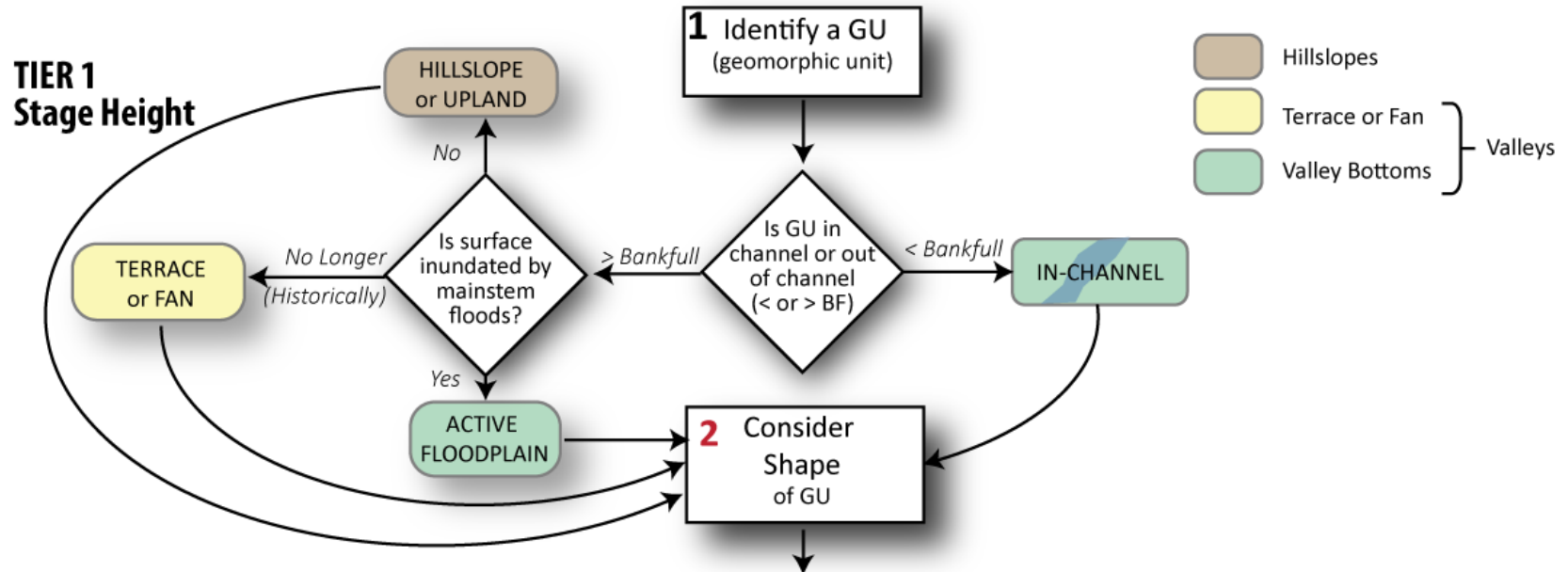
What is a Valley?

Valley

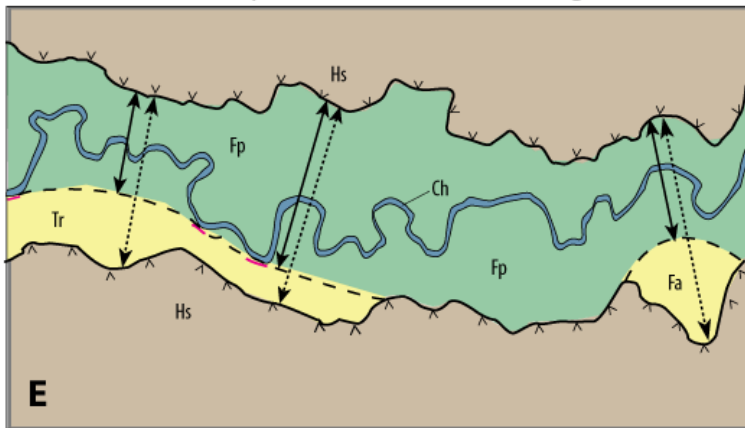
noun

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?

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

KURT D. FAUSCH, CHRISTIAN E. TORGENSEN, 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

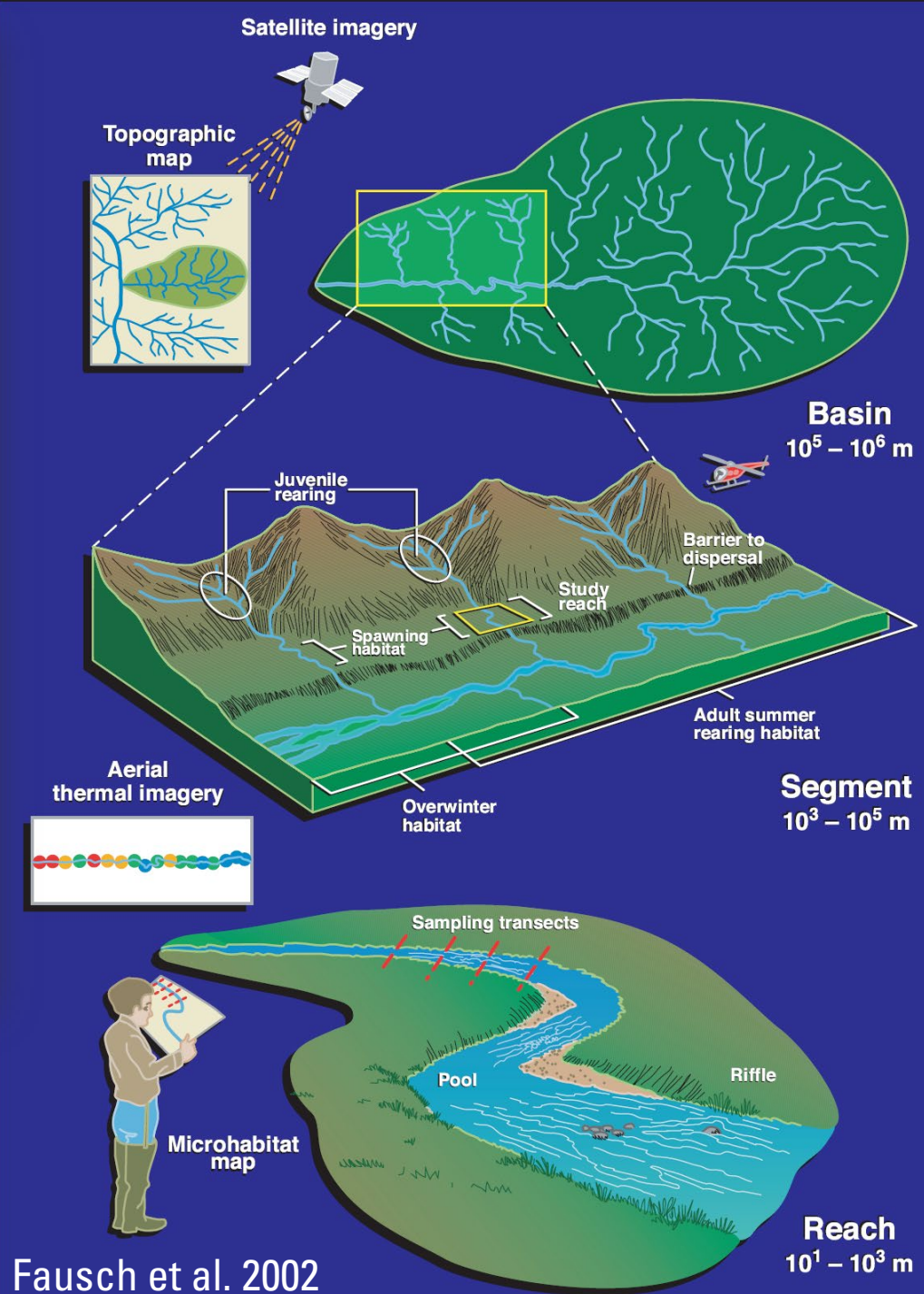
(Minkley and Douglas 1991, Fausch and Bestgen 1997), and many are now either protected by federal or state listing as endangered or threatened species or are being considered for such protection. North America harbored the greatest diversity worldwide of temperate freshwater fishes (Warren and Burr 1994), 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: kurtf@colorado.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

Landscapes to riverscapes: by conservation of stream fishes we 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



A grayscale topographic map of a mountainous region. The terrain is characterized by numerous ridges and valleys. A river is visible, winding through a valley in the lower-left portion of the image. The map uses shading to represent elevation, with darker areas indicating higher altitudes.

Lets start with some basics

(i.e. some awkward rhetorical questions on a webinar)

Is this a riverscape?

A grayscale topographic map of a mountainous region, overlaid with a network of blue lines representing rivers and streams. The lines follow the valleys and ridges of the terrain.

Is this a **Riverscape** ?

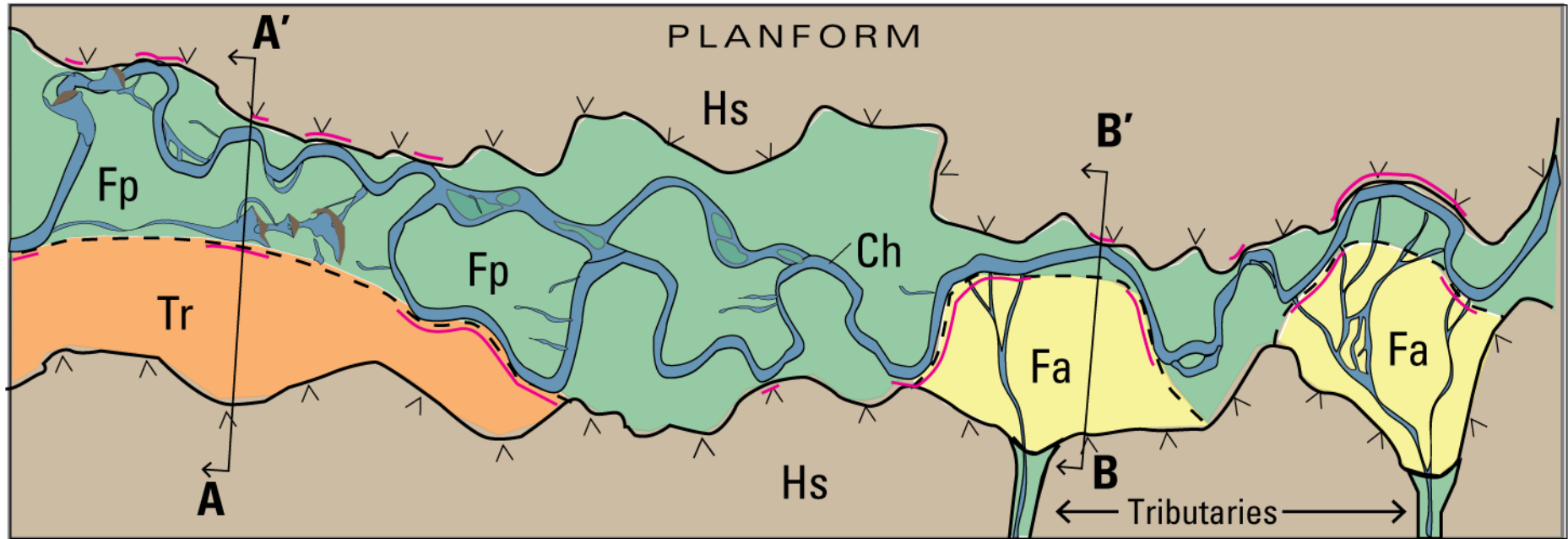
We know that our rivers and streams are critically important to our fresh-water ecosystems

A topographic map of a watershed, showing a network of rivers and streams in blue. The floodplains, or riverscapes, are highlighted in green. The terrain is rugged with many mountains and valleys. The text is overlaid on a semi-transparent grey box in the upper left.

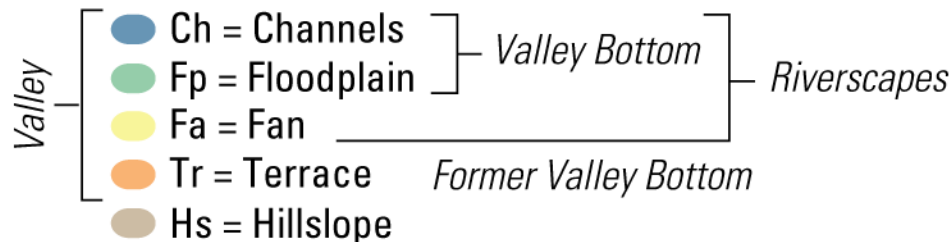
Riverscapes span the network across a watershed

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

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.

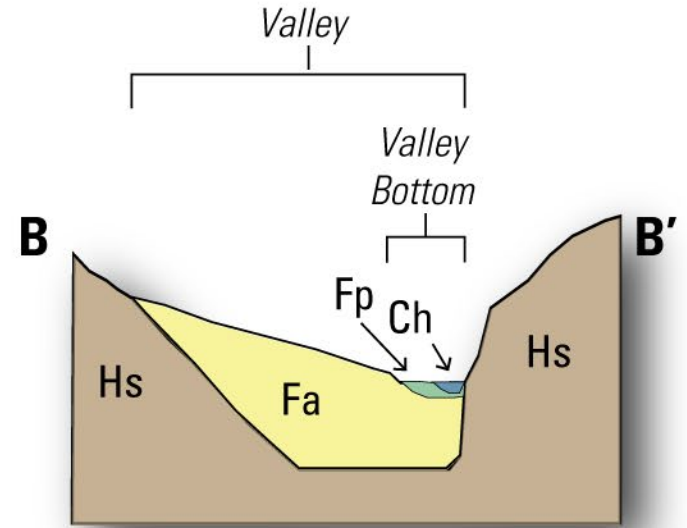
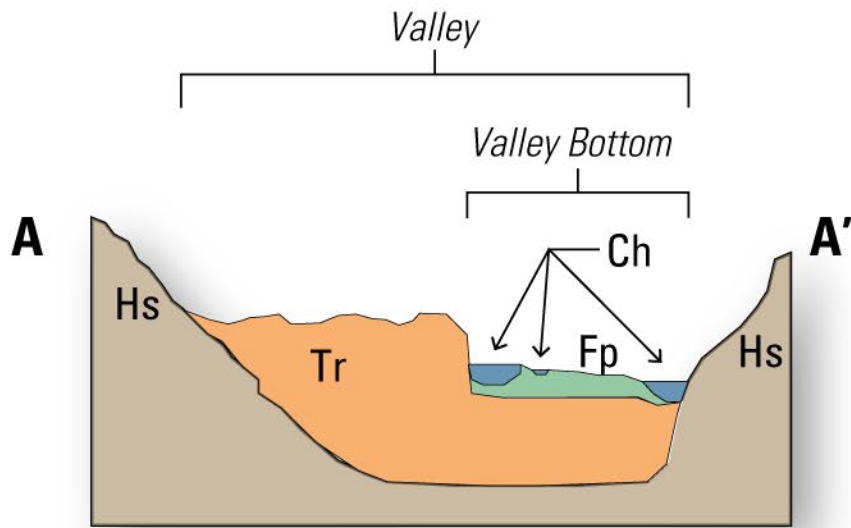
MARGIN TYPES

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

Where are their mesic/riparian restoration opportunities?

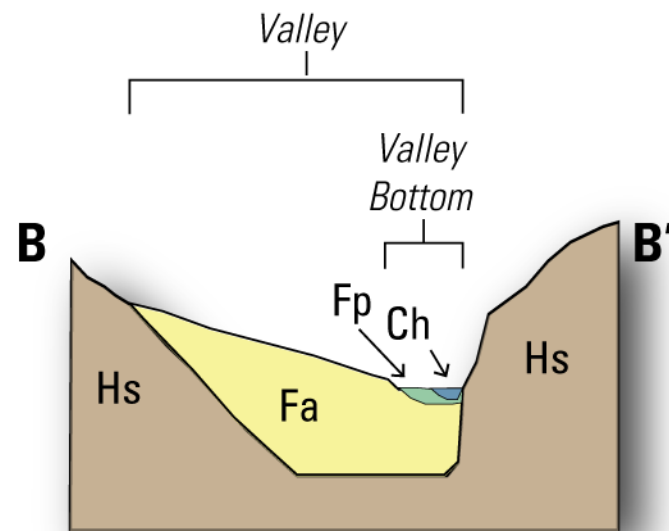
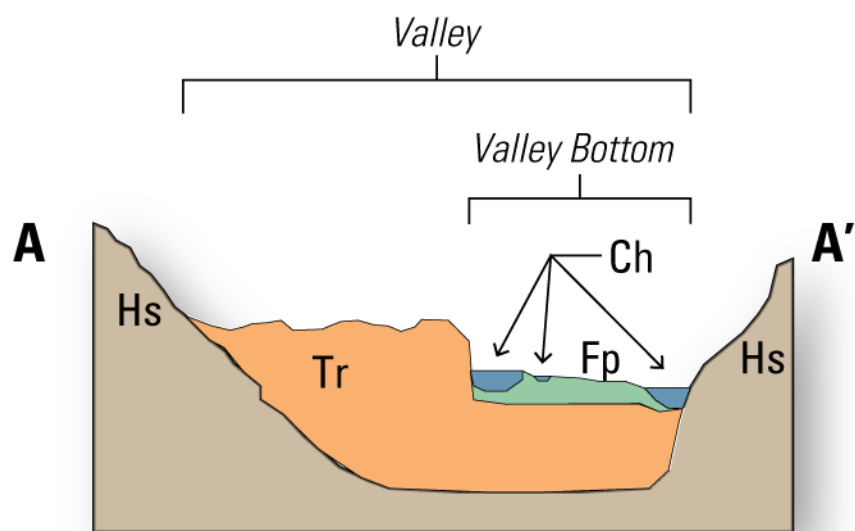
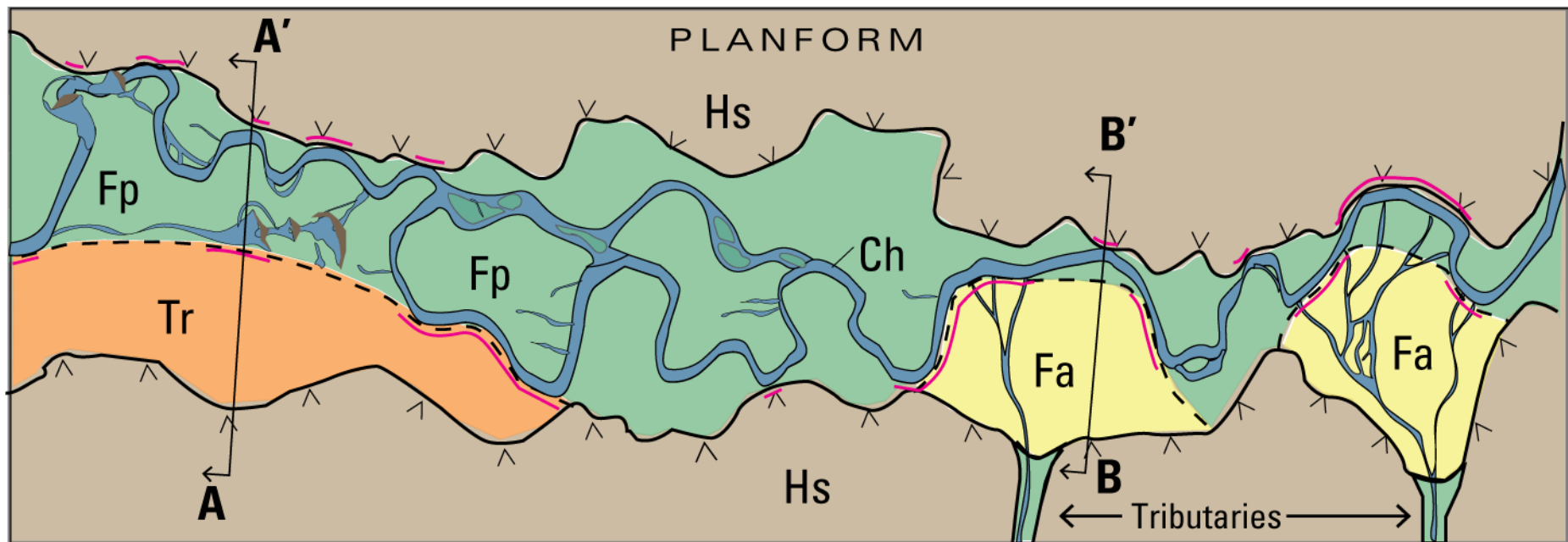
Contrasting Valley Settings Define Reach Breaks

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? →

Geomorphic Analysis of River Systems

I. Intro

II. How is geomorphology useful?

III. Geomorphic Analysis of Rivers Systems (reading)

- I. Identify and interpret landforms and their process-form relationships
- II. Analyze assemblages of landforms to interpret behavior
- III. Explain controls on process-form interactions @ reach scale
- IV. Integrate understanding of geomorphic relationships @ catchment scale

If I Took You To An Overlook...



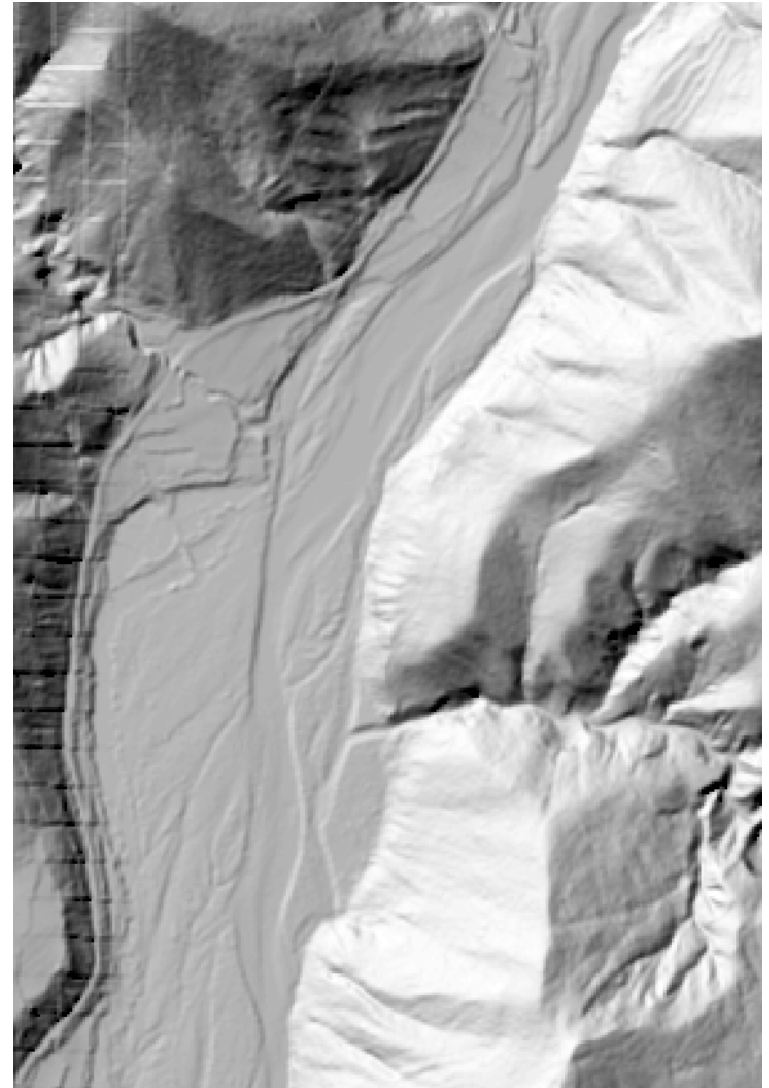
- And I asked you to draw a map... (i.e. the documentation of “reading” the landscape)
- **What would you draw?**



For Real, What Would You Draw?



- If I gave you an aerial photo?



- Would you draw something different from a DEM?

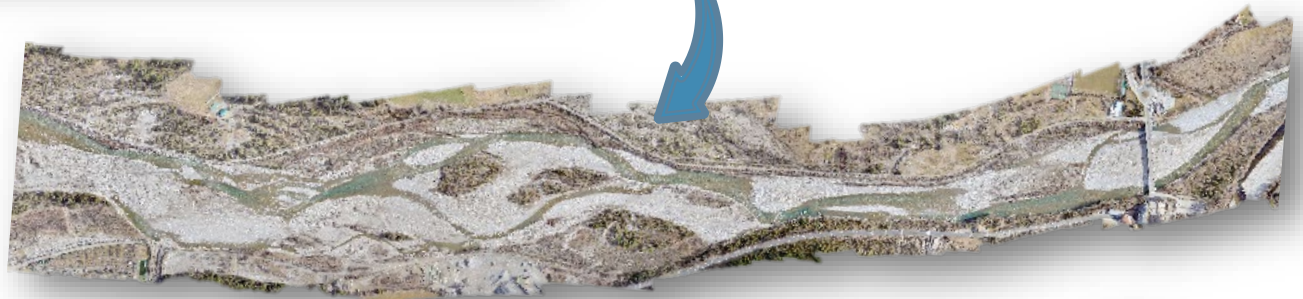
Technology buys us beautiful, HR, digital maps...

From point clouds

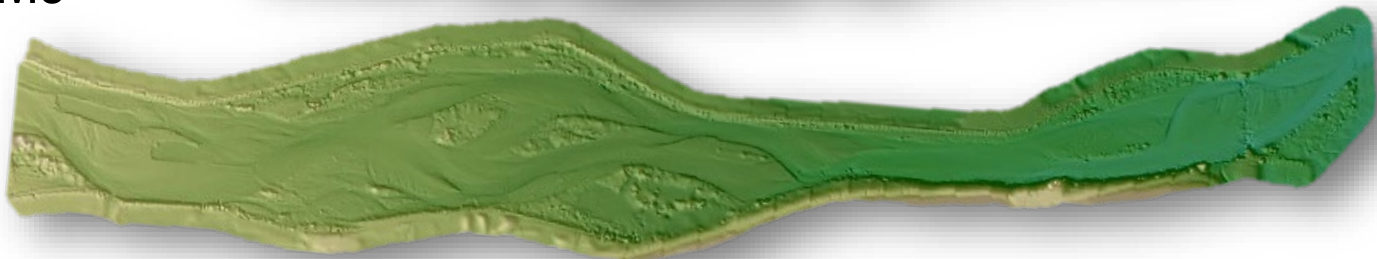


- But then what?
- What can you do with these base maps?

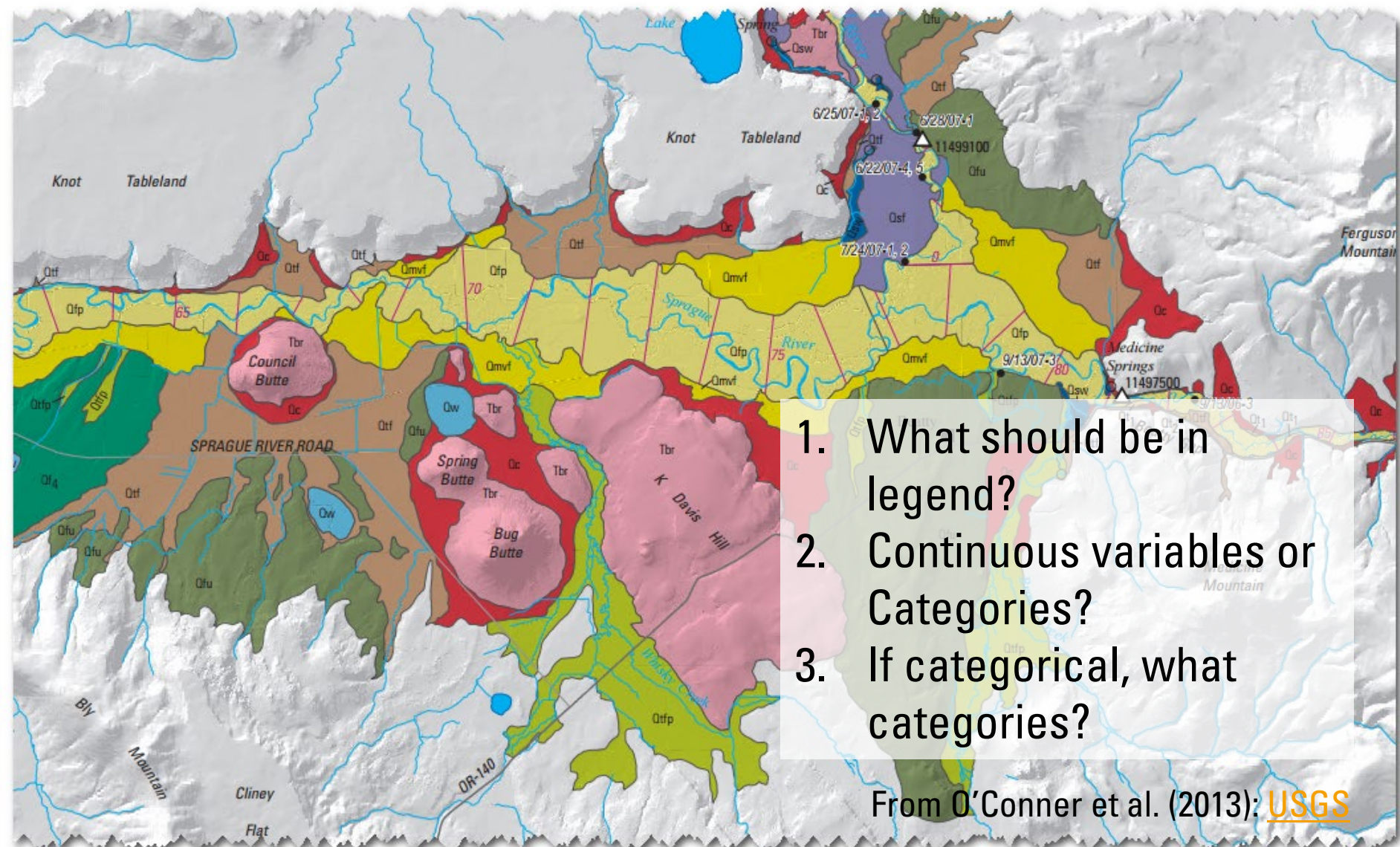
To Aerial Images



& DEMs



What are the components of a geomorphic map?



1. What should be in legend?
2. Continuous variables or Categories?
3. If categorical, what categories?

From O'Conner et al. (2013): [USGS](https://www.usgs.gov/)

Fryirs & Brierley (2013, p 3) argue

Analysis of geomorphic systems cannot be meaningfully formalised using a prescriptive check-list, tick-box set of procedures. Such rigidity belies the inherent diversity of landscapes, and the overwhelming range of factors, process-relationships and controls that combine to generate the pattern of features formed (and reworked) at any given place. This is not to say that all landscapes are necessarily complex; indeed, some may be extremely simple or even near featureless! An open-minded approach to enquiry recognises implicitly the potential for unique outcomes (manifest as assemblages of features and their interactions) in any given setting.

Flexibility is key... unfortunately you need to think

The Reading the Landscape Approach

Analysis of geomorphic systems cannot be meaningfully formalised using a prescriptive check-list, tick-box set of procedures. Such rigidity belies the inherent diversity of landscapes, and the overwhelming range of factors, process-relationships and controls that combine to generate the

Reading the landscape is an approach by which practitioners use their knowledge and experience to **identify** the assemblage of landforms or features that make up rivers, **develop hypotheses to interpret** the processes responsible for those landforms, **determine** how those features have/will adjust and change over time and, finally, place this understanding in its **spatial and temporal context**. Successful interpretations draw on existing theory, questioning and testing its relevance to the system under investigation.

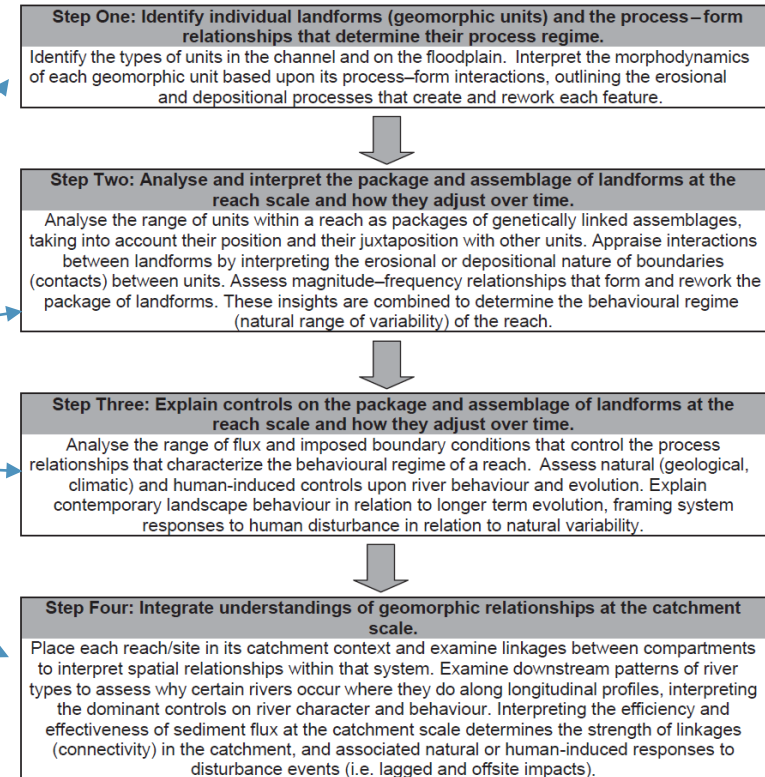
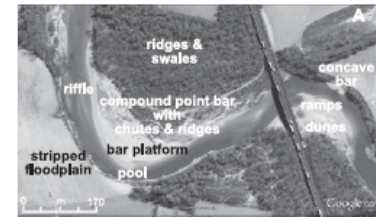


Figure 1.3 An approach to reading the landscape.

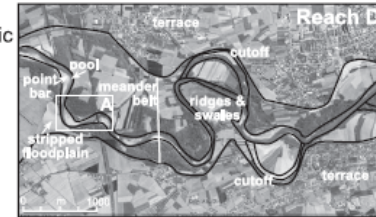
Reading Riverscapes

Step 1: Identify individual instream and floodplain geomorphic units and determine their process-form relationships.



Example of interpretation
**ridges & swales* formed by helicoidal flow forming scroll bars, concave bank erosion and channel migration
**compound point bar* formed by deposition of gravel on the inside of a meander bend, flow realignment over the bar at bankfull stage and scour of chute channels. Sediment is deposited around vegetation to form ridges.

Step 2: Analyse and interpret the assemblage of geomorphic units at the reach scale and how they adjust over time.



Example of interpretation
**low flow stage* - flow aligned around bars and over riffles. Undercutting of concave bank occurs.
**bankfull stage* - point bars are short-circuited, pools are scoured, riffles are deposited, concave bank erosion and deposition on convex bank leads to channel migration.
**overbank stage* - flow aligned over the neck of meander bends, forming cutoffs

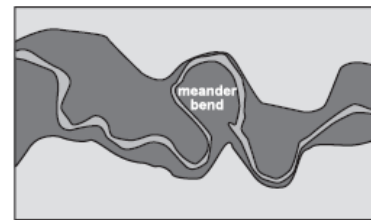
Step One: Identify individual landforms (geomorphic units) and the process-form relationships that determine their process regime.
 Identify the types of units in the channel and on the floodplain. Interpret the morphodynamics of each geomorphic unit based upon its process-form interactions, outlining the erosional and depositional processes that create and rework each feature.

Step Two: Analyse and interpret the package and assemblage of landforms at the reach scale and how they adjust over time.
 Analyse the range of units within a reach as packages of genetically linked assemblages, taking into account their position and their juxtaposition with other units. Appraise interactions between landforms by interpreting the erosional or depositional nature of boundaries (contacts) between units. Assess magnitude-frequency relationships that form and rework the package of landforms. These insights are combined to determine the behavioural regime (natural range of variability) of the reach.

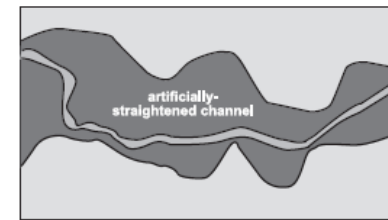
Step Three: Explain controls on the package and assemblage of landforms at the reach scale and how they adjust over time.
 Analyse the range of flux and imposed boundary conditions that control the process relationships that characterize the behavioural regime of a reach. Assess natural (geological, climatic) and human-induced controls upon river behaviour and evolution. Explain contemporary landscape behaviour in relation to longer term evolution, framing system responses to human disturbance in relation to natural variability.

Step Four: Integrate understandings of geomorphic relationships at the catchment scale.
 Place each reach/site in its catchment context and examine linkages between compartments to interpret spatial relationships within that system. Examine downstream patterns of river types to assess why certain rivers occur where they do along longitudinal profiles, interpreting the dominant controls on river character and behaviour. Interpreting the efficiency and effectiveness of sediment flux at the catchment scale determines the strength of linkages (connectivity) in the catchment, and associated natural or human-induced responses to disturbance events (i.e. lagged and offsite impacts).

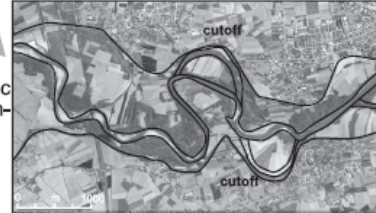
Past



Future



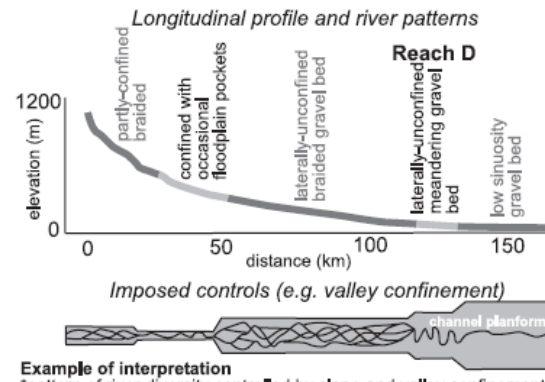
Present



Step 3: Explain controls on the assemblage of geomorphic units, and 'natural' and human-induced impacts.

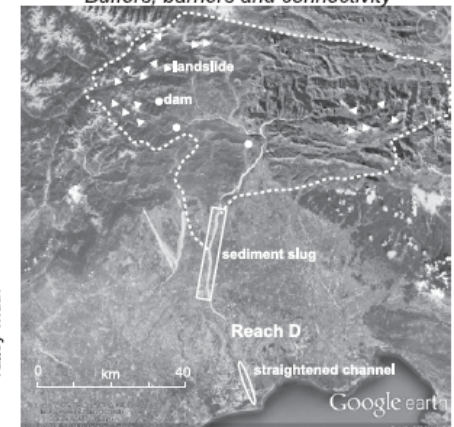
Example of interpretation
**flux controls* - transport-limited river with high sediment supply, Flashy flow regime.
**imposed controls* - tectonic activity resets base level.
**human impacts* - devegetation, cutoff formation and artificial straightening of channel.

Step 4: Integrate understandings of geomorphic relationships at the catchment scale.



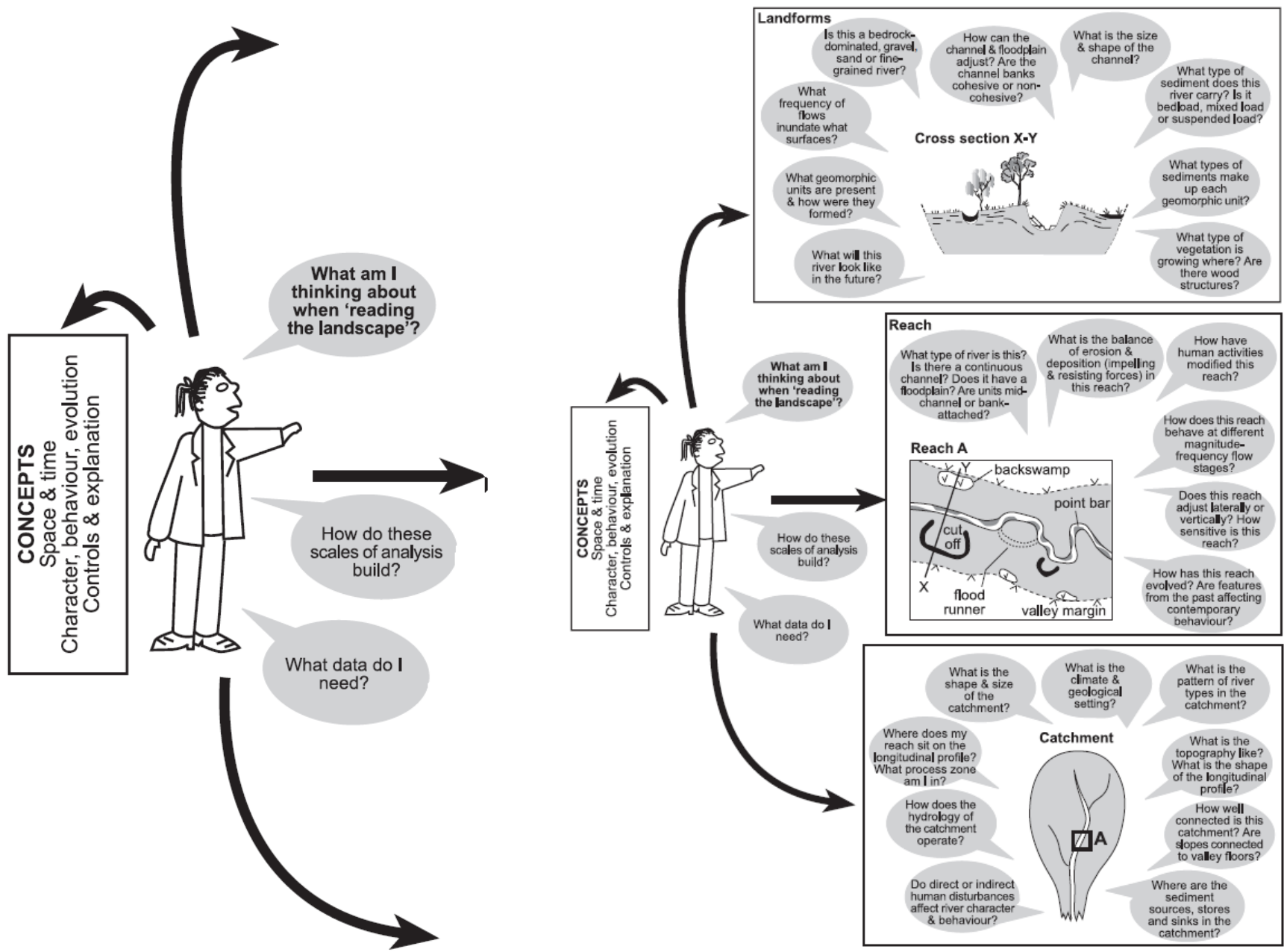
Example of interpretation
**pattern* of river diversity controlled by slope and valley confinement
**sediment supply* is high due to landslide connectivity in headwaters
**role* of disconnected tributaries varies over time (e.g. dams)
**channelised* reaches convey sediment more efficiently

Buffers, barriers and connectivity

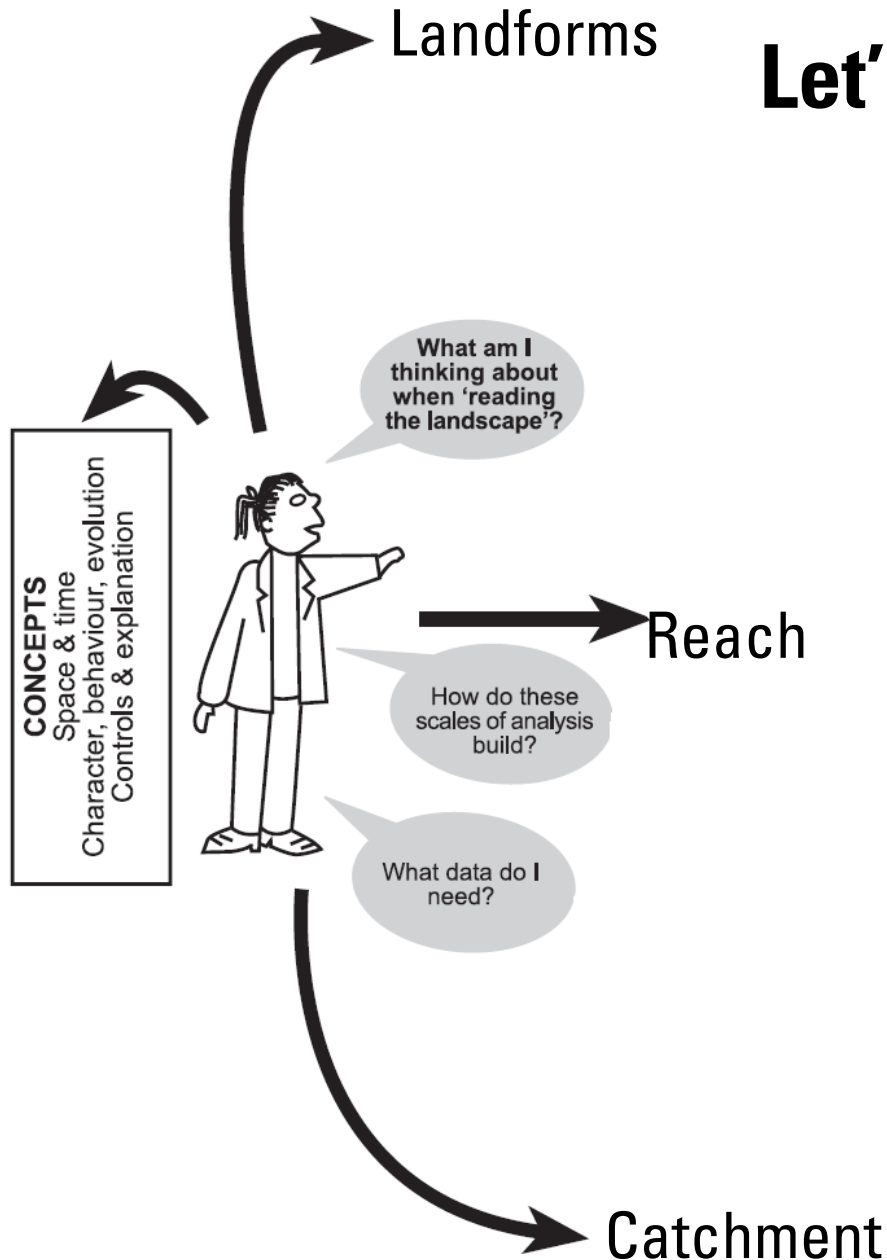


• It's a lot... that's why we'll take all semester learning it...

Figure 1.2 Questions you should ask when reading the landscape at the landform, reach and catchment scales.



Let's Start a Little Simpler



- Landforms roughly correspond to stages 1 & 2
- Reach roughly corresponds to stage 3
- Catchment roughly corresponds to stage 4
- This is considered a constructivist, "building block" approach

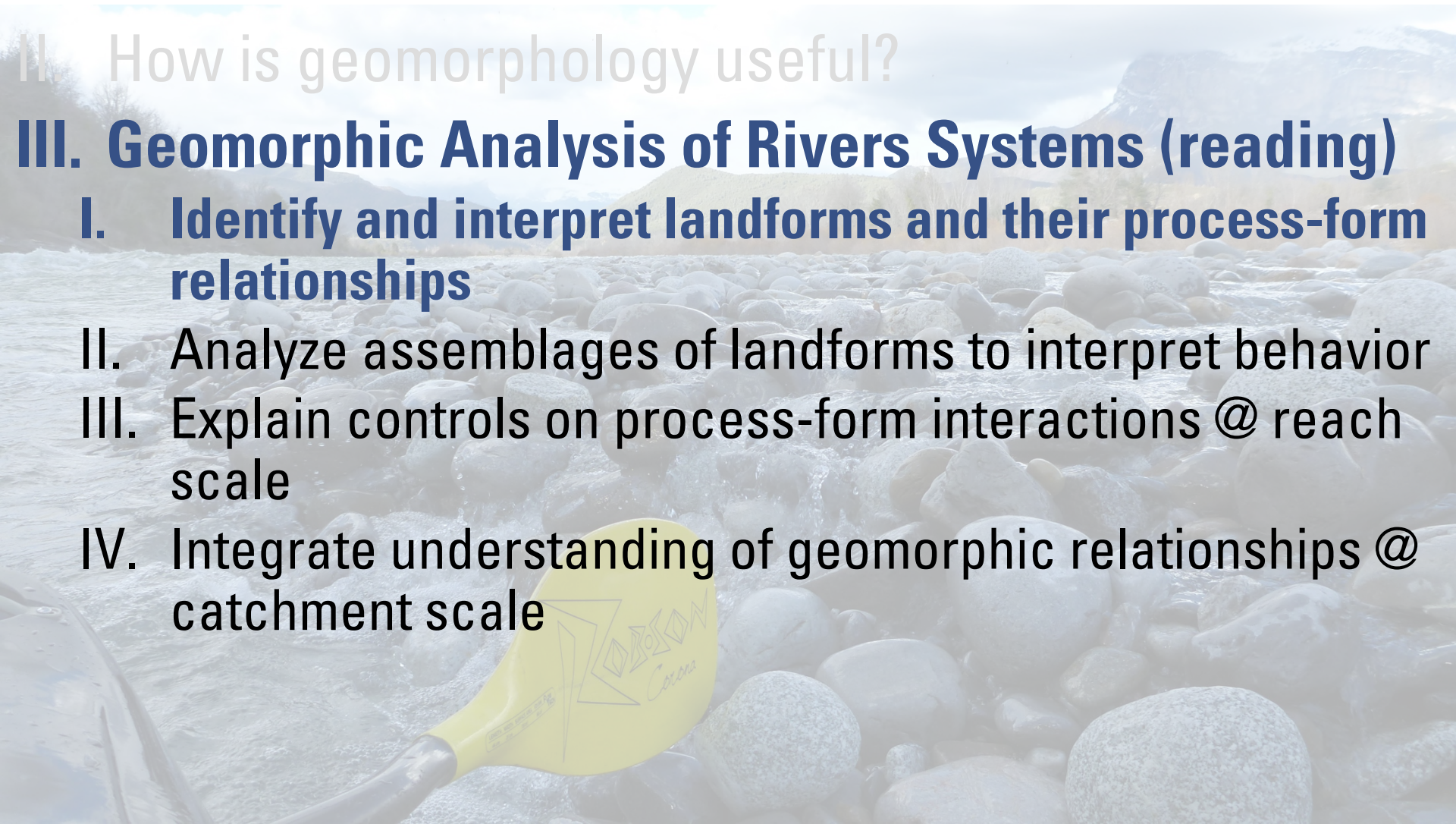
Geomorphic Analysis of River Systems

I. Intro

II. How is geomorphology useful?

III. Geomorphic Analysis of Rivers Systems (reading)

- I. Identify and interpret landforms and their process-form relationships
- II. Analyze assemblages of landforms to interpret behavior
- III. Explain controls on process-form interactions @ reach scale
- IV. Integrate understanding of geomorphic relationships @ catchment scale



Step 1 – Mapping Geomorphic Units

Step 1: Identify individual instream and floodplain geomorphic units and determine their process-form relationships.



Example of interpretation

**ridges & swales* formed by helicoidal flow forming scroll bars, concave bank erosion and channel migration

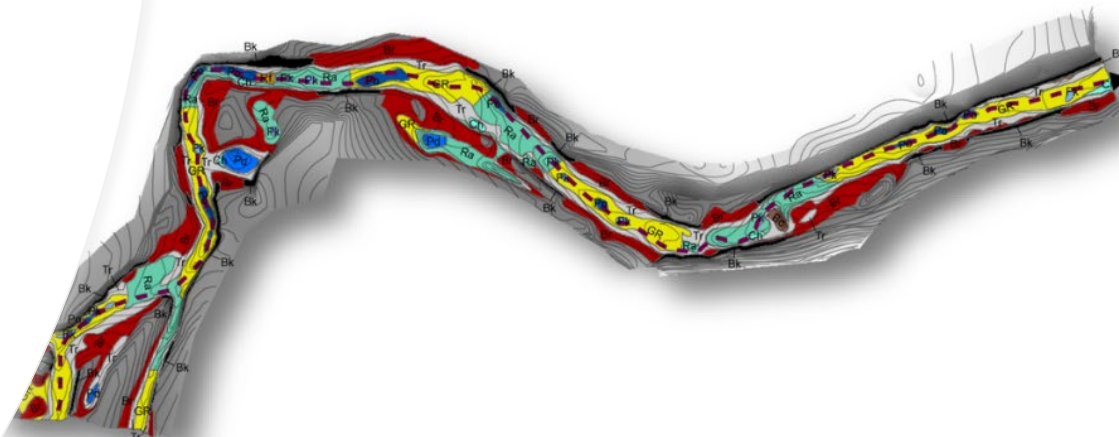
**compound point bar* formed by deposition of gravel on the inside of a meander bend, flow realignment over the bar at bankfull stage and scour of chute channels. Sediment is deposited around vegetation to form ridges.

Figure 1.4 An example of how to apply the reading the landscape approach to a real river system (See Colour Plate 1). The example used here is the Tagliamento River in Italy. The approach begins by interpreting process-form relationships for individual, then assemblages of geomorphic units along different reaches of river type. River behaviour is interpreted for a range of flow stages. The role of natural and human induced disturbance on river adjustments over time is considered when analysing river evolution. Finally, each reach is placed in its catchment context, analysing flux and imposed controls on river diversity along longitudinal profiles and how reaches to fit together in a catchment. Interpreting the efficiency of sediment flux at the catchment scale determines the (dis)connectivity of the catchment and associated off-site responses to disturbance. Maps constructed using Google Earth © 2012 images. Based on information in Bertoldi et al. 2009, Gurnell et al. 2000, Surian et al. 2009 and Tockner et al. 2003. The interpretation of river types, river evolution and connectivity are our own.

Geomorphic Units are building blocks of the landscape

Geomorphic Units are building blocks of the landscape

- You'll learn more about this in Chapters 5 & 6
- GUs can be mapped in field, or off of aerial photos
- GU can be defined and derived from topography



Geomorphic Analysis of River Systems

I. Intro

II. How is geomorphology useful?

III. Geomorphic Analysis of Rivers Systems (reading)

I. Identify and interpret landforms and their process-form relationships

II. Analyze assemblages of landforms to interpret behavior

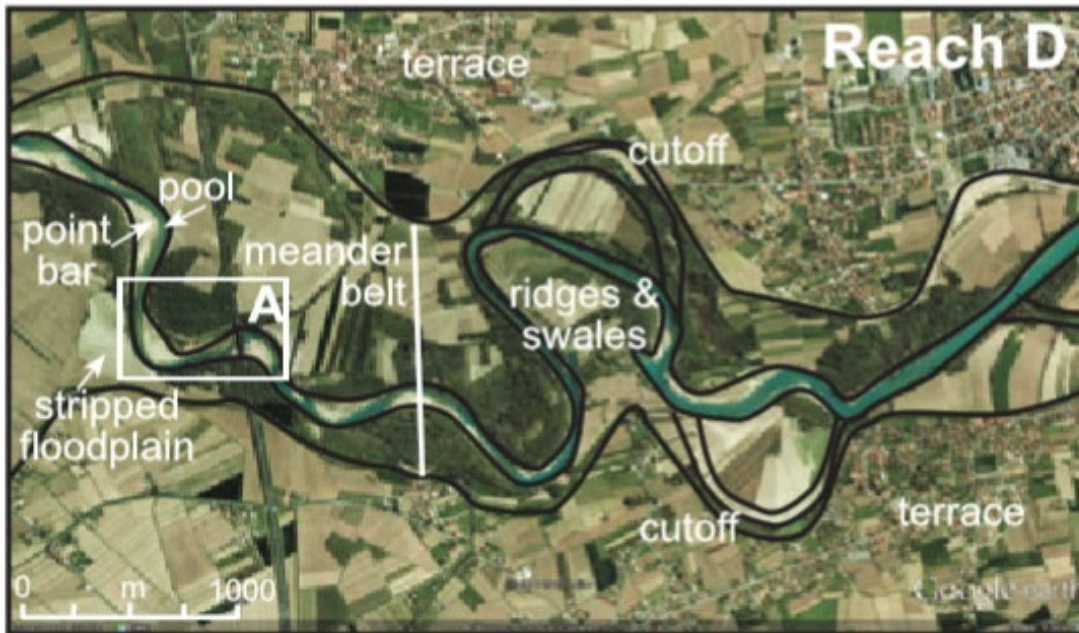
III. Explain controls on process-form interactions @ reach scale

IV. Integrate understanding of geomorphic relationships @ catchment scale

Step 2 – Interpret form process linkages

- We'll learn these in Chapters 5 & 6

Step 2: Analyse and interpret the assemblage of geomorphic units at the reach scale and how they adjust over time.



Example of interpretation

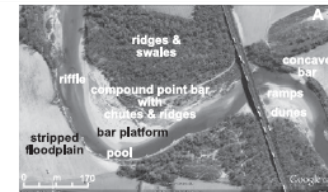
**low flow stage* - flow aligned around bars and over riffles. Undercutting of concave bank occurs.

**bankfull stage* - point bars are short-circuited, pools are scoured, riffles are deposited, concave bank erosion and deposition on convex bank leads to channel migration.

**overbank stage* - flow aligned over the neck of meander bends, forming cutoffs

Stage 1 & 2 - Questions

Step 1: Identify individual instream and floodplain geomorphic units and determine their process-form relationships.



Example of interpretation
**ridges & swales* formed by helicoidal flow forming scroll bars, concave bank erosion and channel migration
**compound point bar* formed by deposition of gravel on the inside of a meander bend, flow realignment over the bar at bankfull stage and scour of chute channels. Sediment is deposited around vegetation to form ridges.

Step 2: Analyse and interpret the assemblage of geomorphic units at the reach scale and how they adjust over time.



Example of interpretation
**low flow stage* - flow aligned around bars and over riffles. Undercutting of concave bank occurs.
**bankfull stage* - point bars are short-circuited, pools are scoured, riffles are deposited, concave bank erosion and deposition on convex bank leads to channel migration.
**overbank stage* - flow aligned over the neck of meander bends, forming cutoffs

Landforms

Is this a bedrock-dominated, gravel, sand or fine-grained river?

What frequency of flows inundate what surfaces?

How can the channel & floodplain adjust? Are the channel banks cohesive or non-cohesive?

What is the size & shape of the channel?

What type of sediment does this river carry? Is it bedload, mixed load or suspended load?

What geomorphic units are present & how were they formed?

What will this river look like in the future?

Cross section X-Y



What types of sediments make up each geomorphic unit?

What type of vegetation is growing where? Are there wood structures?

Geomorphic Analysis of River Systems

I. Intro

II. How is geomorphology useful?

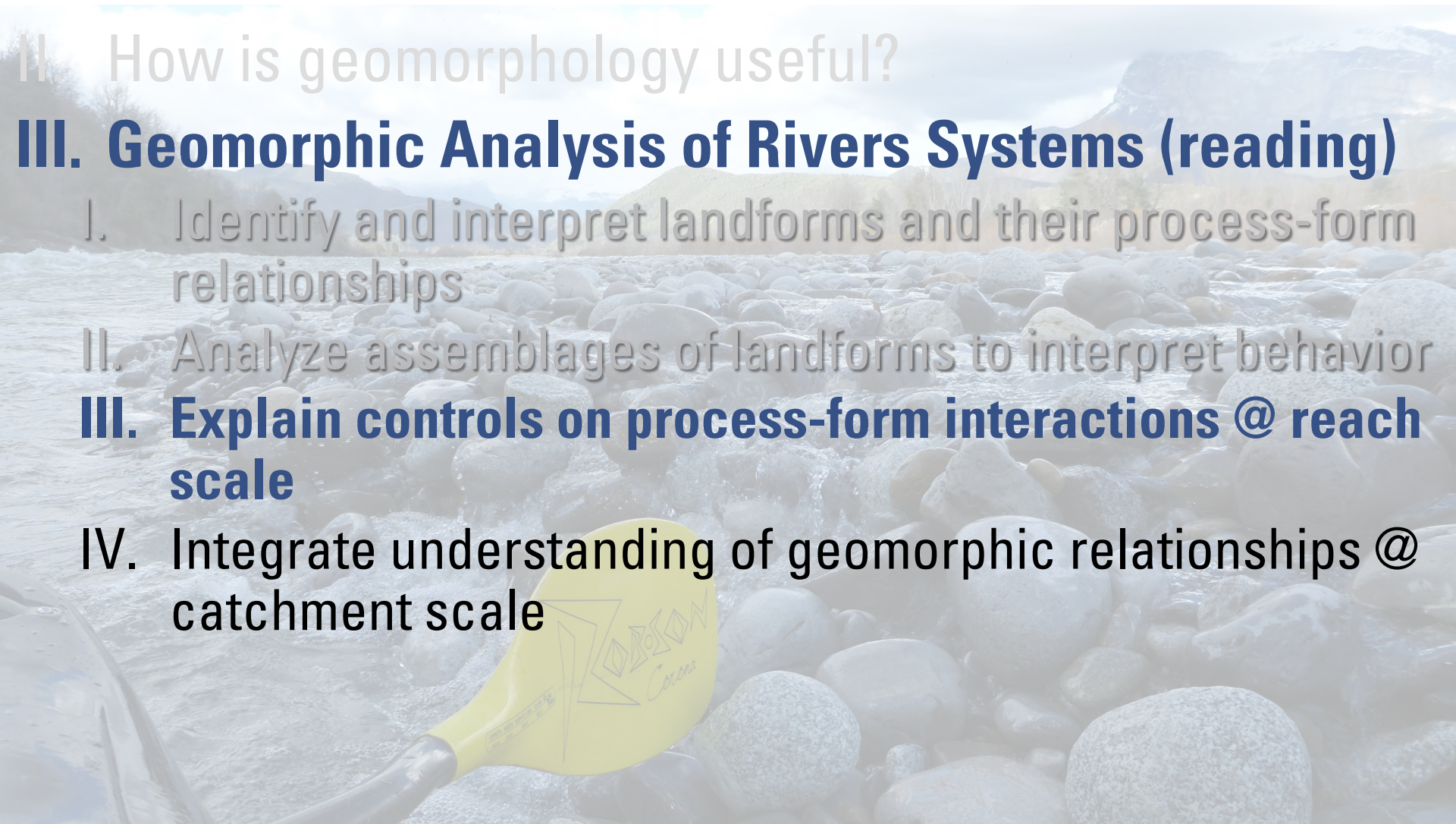
III. Geomorphic Analysis of Rivers Systems (reading)

I. Identify and interpret landforms and their process-form relationships

II. Analyze assemblages of landforms to interpret behavior

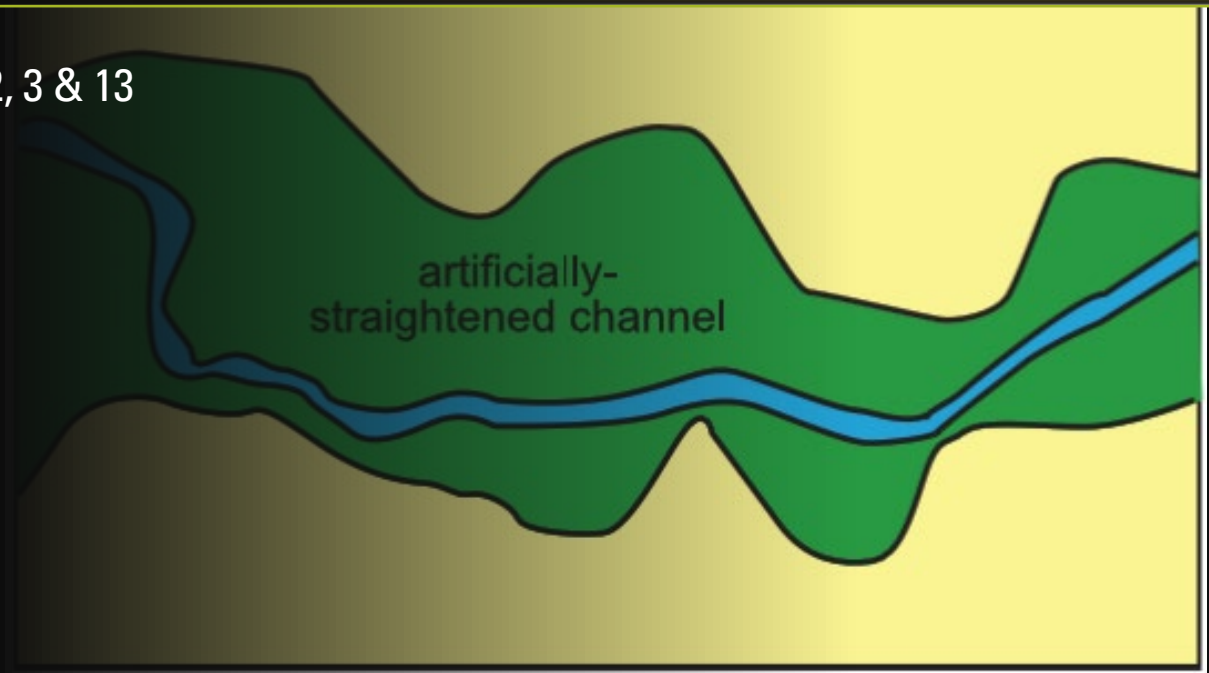
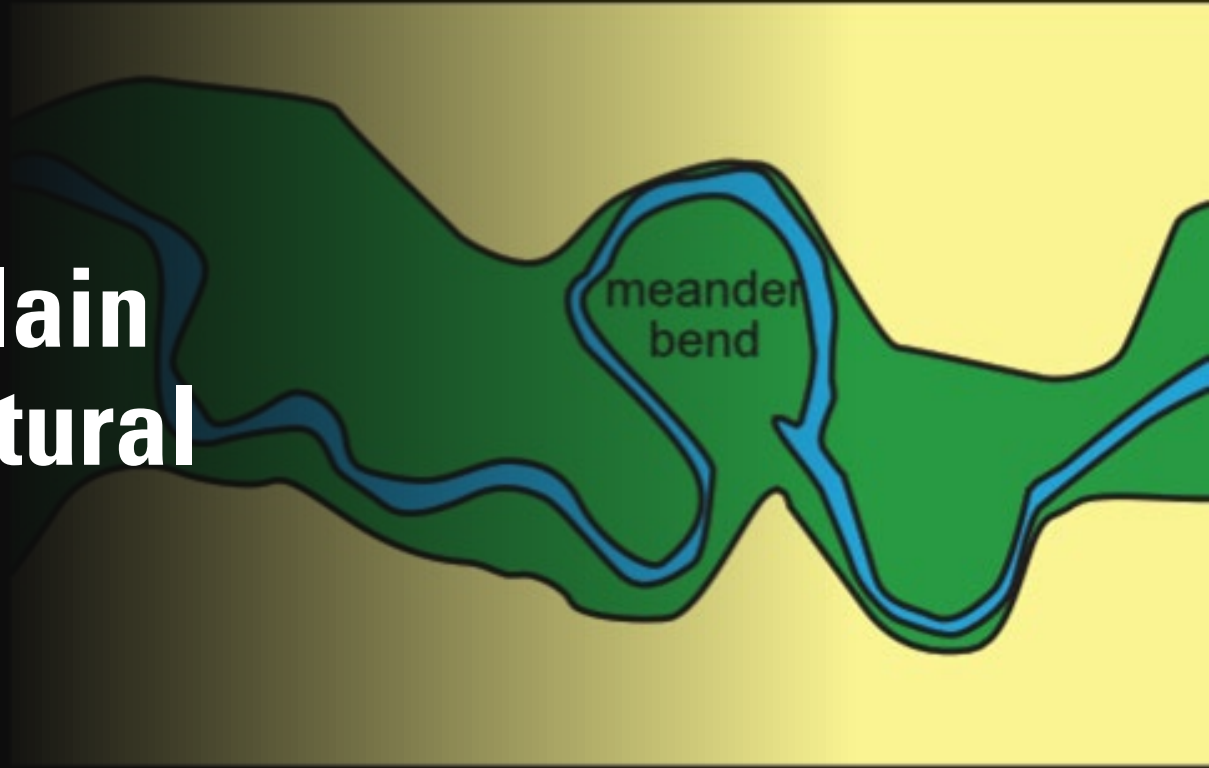
III. Explain controls on process-form interactions @ reach scale

IV. Integrate understanding of geomorphic relationships @ catchment scale

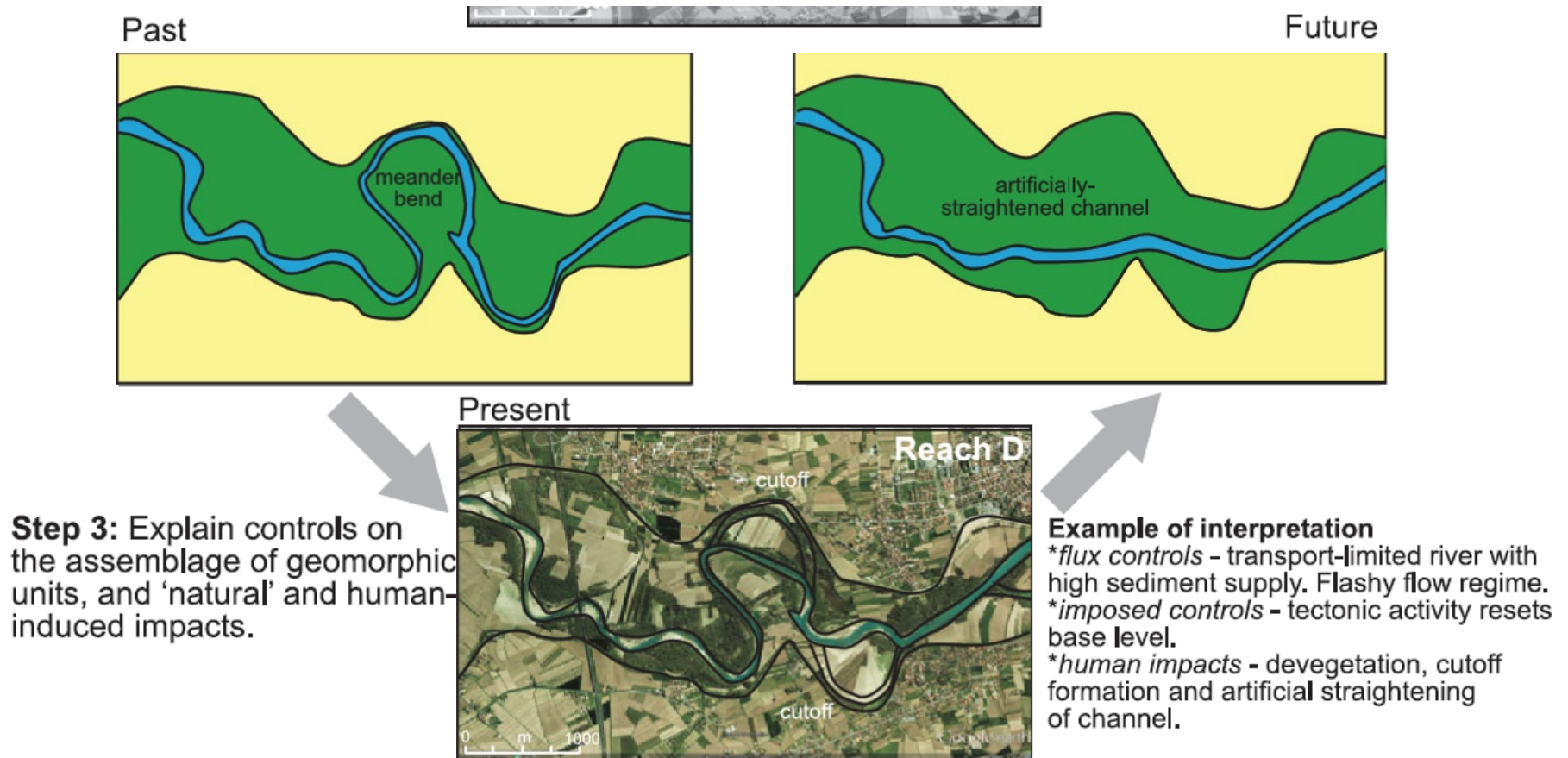


Step 3 – Explain Controls (Natural vs. Human-Induced)

We'll learn these in Chapters 2, 3 & 13

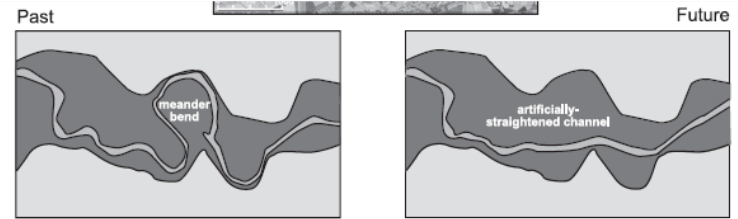


Step 3 – Explain Controls

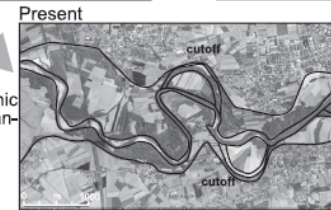


- Untangle the natural boundary conditions from human impacts

Stage 3 - Questions



Step 3: Explain controls on the assemblage of geomorphic units, and 'natural' and human-induced impacts.



Example of interpretation
**flux controls* - transport-limited river with high sediment supply, Flashy flow regime.
**imposed controls* - tectonic activity resets base level.
**human impacts* - revegetation, cutoff formation and artificial straightening of channel.



**channel evolution* - meander loop formation and cutoff formation
**human impacts* - revegetation, cutoff formation and artificial straightening of channel

Reach

What type of river is this?
 Is there a continuous channel? Does it have a floodplain? Are units mid-channel or bank-attached?

What is the balance of erosion & deposition (impelling & resisting forces) in this reach?

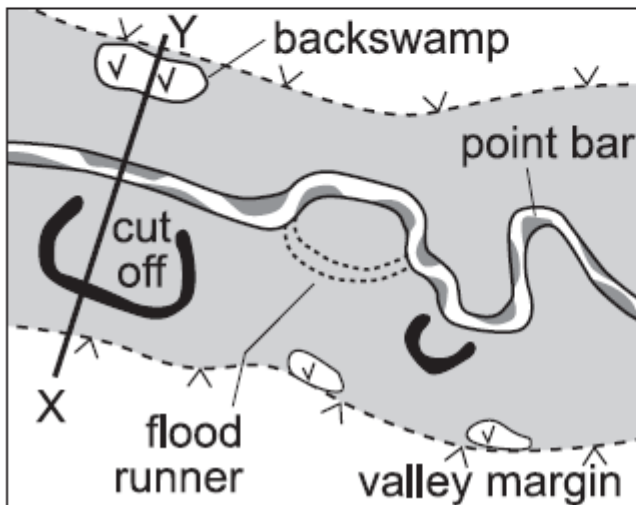
How have human activities modified this reach?

How does this reach behave at different magnitude-frequency flow stages?

Does this reach adjust laterally or vertically? How sensitive is this reach?

How has this reach evolved? Are features from the past affecting contemporary behaviour?

Reach A



Geomorphic Analysis of River Systems

I. Intro

II. How is geomorphology useful?

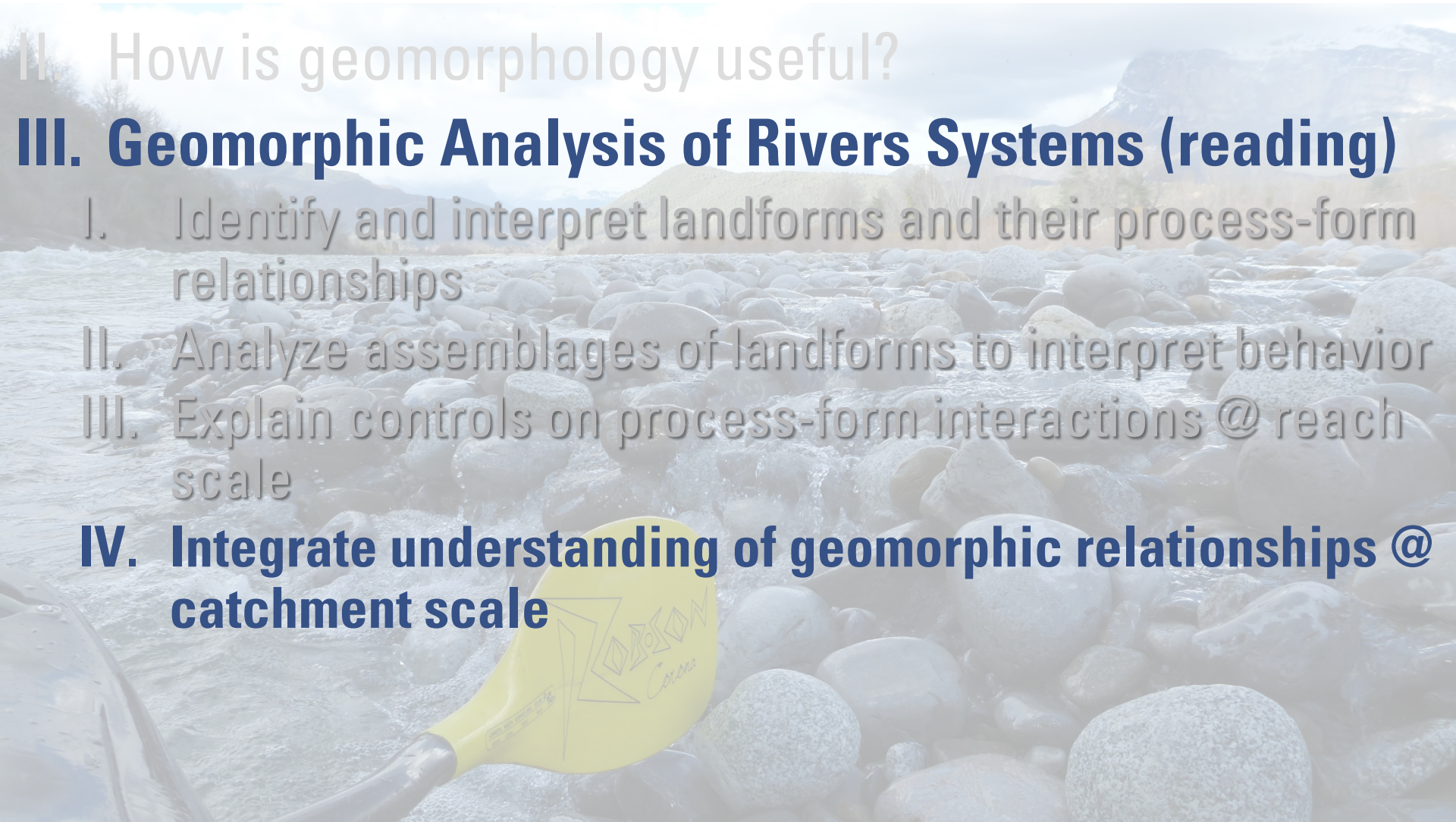
III. Geomorphic Analysis of Rivers Systems (reading)

I. Identify and interpret landforms and their process-form relationships

II. Analyze assemblages of landforms to interpret behavior

III. Explain controls on process-form interactions @ reach scale

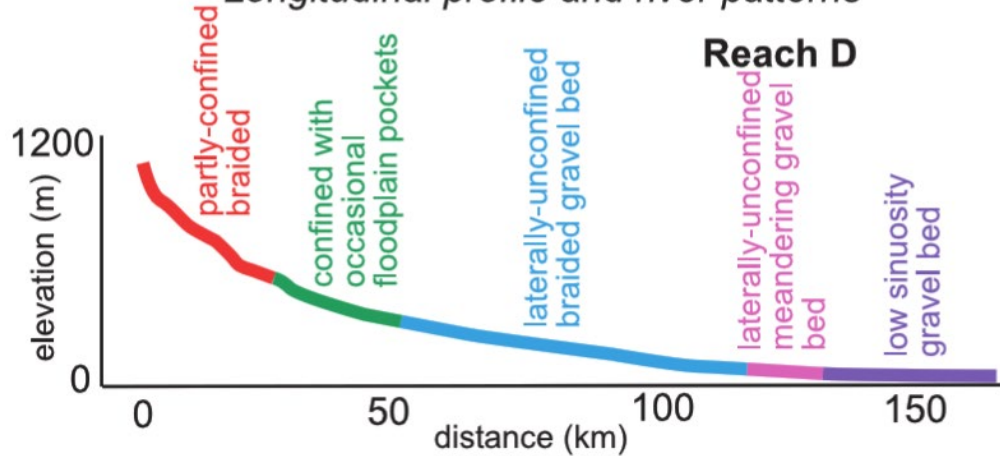
IV. Integrate understanding of geomorphic relationships @ catchment scale



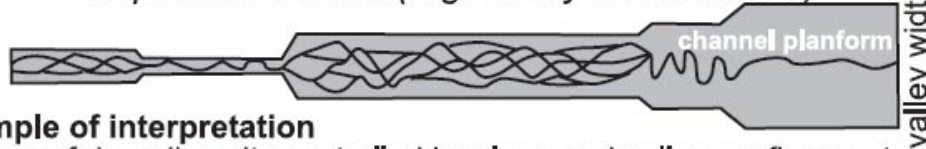
Step 4 – Place Riverscape in Catchment Context

Step 4: Integrate understandings of geomorphic relationships at the catchment scale.

Longitudinal profile and river patterns



Imposed controls (e.g. valley confinement)



Example of interpretation

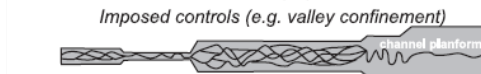
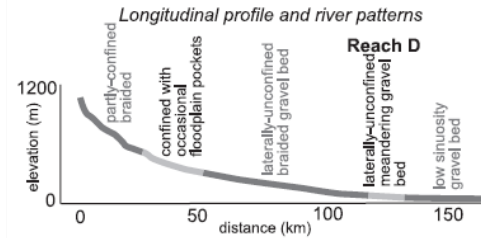
- *pattern of river diversity controlled by slope and valley confinement
- *sediment supply is high due to landslide connectivity in headwaters
- *role of disconnected tributaries varies over time (e.g. dams)
- *channelised reaches convey sediment more efficiently

Buffers, barriers and connectivity



Stage 4 - Questions

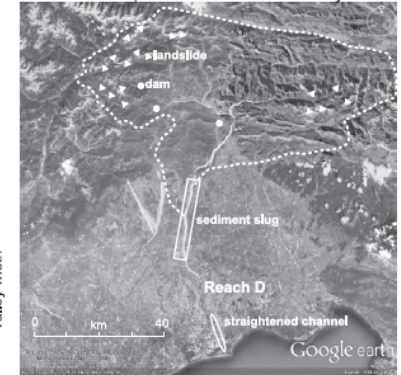
Step 4: Integrate understandings of geomorphic relationships at the catchment scale.



Example of interpretation

- *pattern of river diversity controlled by slope and valley confinement
- *sediment supply is high due to landslide connectivity in headwaters
- *role of disconnected tributaries varies over time (e.g. dams)
- *channelised reaches convey sediment more efficiently

Buffers, barriers and connectivity

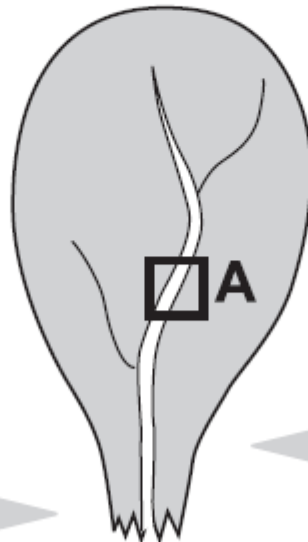


What is the shape & size of the catchment?

What is the climate & geological setting?

What is the pattern of river types in the catchment?

Catchment



Where does my reach sit on the longitudinal profile?
What process zone am I in?

How does the hydrology of the catchment operate?

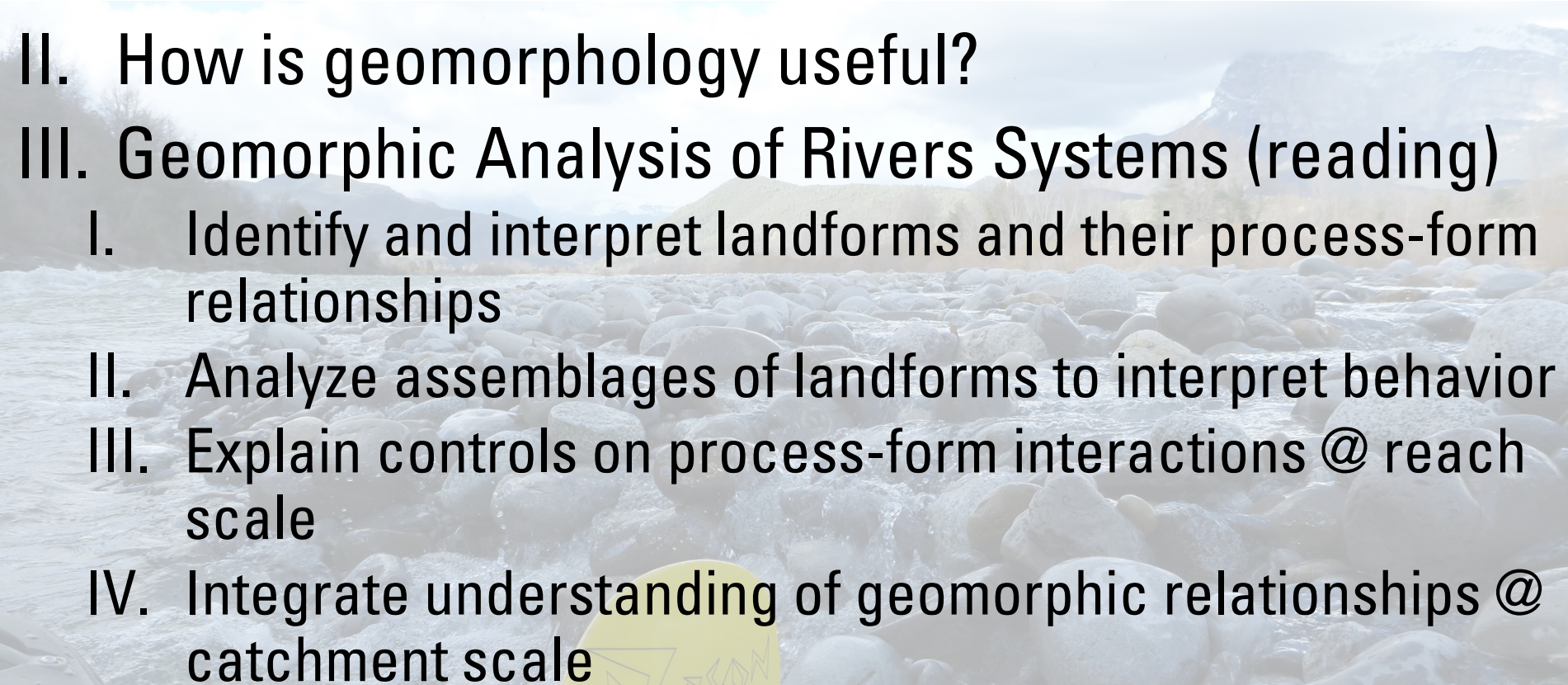
Do direct or indirect human disturbances affect river character & behaviour?

What is the topography like?
What is the shape of the longitudinal profile?

How well connected is this catchment? Are slopes connected to valley floors?

Where are the sediment sources, stores and sinks in the catchment?

Geomorphic Analysis of River Systems

- I. Intro
 - II. How is geomorphology useful?
 - III. Geomorphic Analysis of Rivers Systems (reading)
 - I. Identify and interpret landforms and their process-form relationships
 - II. Analyze assemblages of landforms to interpret behavior
 - III. Explain controls on process-form interactions @ reach scale
 - IV. Integrate understanding of geomorphic relationships @ catchment scale
- 



CC  JOE WHEATON

Next Time

In Chapter Two, we'll explore "Key Concepts in River Geomorphology"