“It is hard to imagine that a transport estimate made in the absence of a sound understanding of watershed history and dynamics would be of much use at all.”
Great diversity in channels and watersheds...

G. Parker. Fly River, Papua New Guinea.

J. Imran. Brahmaputra River, Bangladesh.

A. Alabyan and A. Sidorchuk. Siberia
...emerging from complex interactions
How *much* and what *type* of sediment is being delivered to this channel?

What information do you need to answer those questions?

Is sediment supply a *BIG* number or *SMALL* number?
Interception Storage
Surface Storage
Unsaturated Zone Storage
Saturated Zone Groundwater Storage
Channel Storage

- Transpiration
- Evaporation
- Rain, snow, condensation
- Stemflow, canopy drip
- Infiltration
- Percolation
- Surface runoff
- Sub-surface runoff
- Seepage
- Plant uptake

Hydrology matters...
Land use matters...
Soils, surficial and bedrock geology matter...
Storage matters...

Natural and human-caused ‘legacy effects’

Sediment transport through watersheds is complicated
Grain size matters

Figure 7.1. Categories of transported materials in a stream
Grain size matters...
Coarse and fine load often have different sources/transport paths

Floodplains preserve old channel deposits + overbank

Banks and levees made of suspended load

Bed and lower point bars made of bed material load
Grain size matters...
Coarse and fine load often have different sources/transport paths

All else held constant, aggradation on the bed causes...
Grain size matters...
Coarse and fine load often have different sources/transport paths

All else held constant, aggradation on the floodplain...

So while the sources may be independent, effects on channel morphology and hydraulics are linked

Big implications for habitat: Rachelly et al., 2020
How can we STOP erosion?

This is not always the right question to ask.
The simple, key questions...

How much and what type of sediment is supplied?

How do flow and supply change over time and with distance downstream?

How many distinct ‘reaches’ are there along my stream?

In what ways might each reach adjust to changes in flow or sediment supply?
A few key messages up front…

In many cases, all that is needed/feasible is to know if supply is a big # or small #

Measuring channel behavior, morphology and bed characteristics will inform your understanding of supply and ‘sensitivity’

Sometimes you need numbers, but good numbers don’t come easy
- Spatial and temporal variability over wide range of scales, Interactions of many non-linear processes

- Develop conceptual model of reach types, sources, sinks, connectivity…
  …then measure/model key rates

- Multiple independent and semi-redundant estimates often needed

May need to know locations, mechanisms, and rates of erosion and deposition
- Size matters…boulders, cobbles, gravel, sand, mud play distinct roles
- Models can be useful and/or misleading
- Examine and consider implications of hydrologic non-stationarity
- Many new tools available, none are comprehensive or bullet-proof
Insightful books for watershed analysis and stream restoration
Roadmap

**TOMMORROW**

- Basin-average erosion rates: The cosmo method
  - Millennial-scale landscape rates of erosion.

- Reservoir and pond sedimentation rates
  - Time- and space-integrated measurements that may be useful.

**TODAY**

- Basic Reconnaissance
  - With a tight budget, what do you really need to know?

- Case studies in sediment supply, transport, and morphodynamics

- Hydrologic analysis and non-stationarity
  - Targeted modeling and metrics. Stationarity Assumption?

- Push-button Geomorphology
  - The geek approach. What computer models can and can’t tell you.

**FORGET RATES. WHAT CAN WE LEARN FROM BASIC FORM-PROCESS RELATIONSHIPS?**


**WATERSHED SEDIMENT BUDGET**

- Tools and techniques for robust constraints on sources and sinks.
How would you describe these channels?
Stages of a Watershed Assessment

Stage 1  **Data Compilation (description and mapping)**
- Evaluate watershed context
- Determine landscape units
- Assess river character

Stage 2  **Data Analysis**
- Define and interpret River Styles
- Explain contemporary character/behavior
- Assess river history

Stage 3  **Predict future river structure**

Stage 4  **Prioritize watershed management issues**

Stage 5  **Identify target conditions for river**
River Styles Hierarchy

Watershed
- Watershed area determined by drainage divide. Determines the boundary conditions within which rivers operate.

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- Topographic unit determined on the basis of local relief, valley slope and morphology. Defines the valley-setting.

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Hydraulic Unit
- Uniform patches of flow and substrate material within a geomorphic unit.

Microhabitat
- Individual elements (e.g., logs, rocks, gravel patches) within a stream.
Many other classification schemes out there

<table>
<thead>
<tr>
<th>Spatial Scale</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment</td>
<td>Land cover/land use (LCLU)</td>
</tr>
<tr>
<td></td>
<td>Land topography</td>
</tr>
<tr>
<td>Landscape unit</td>
<td>LCLU and sediment production</td>
</tr>
<tr>
<td></td>
<td>Land topography and sediment production</td>
</tr>
<tr>
<td></td>
<td>Rainfall and groundwater</td>
</tr>
<tr>
<td>Segment</td>
<td>Valley setting</td>
</tr>
<tr>
<td></td>
<td>Channel gradient</td>
</tr>
<tr>
<td></td>
<td>River flows and levels</td>
</tr>
<tr>
<td></td>
<td>Sediment delivery</td>
</tr>
<tr>
<td></td>
<td>Riparian corridor and wood production</td>
</tr>
<tr>
<td>Reach</td>
<td>Channel planform, migration, and features</td>
</tr>
<tr>
<td></td>
<td>Channel geometry</td>
</tr>
<tr>
<td></td>
<td>Sediment transport</td>
</tr>
<tr>
<td></td>
<td>Riparian vegetation, aquatic vegetation, wood</td>
</tr>
</tbody>
</table>

Grabowski et al. 2014
Many other classification schemes out there

Montgomery and Buffington, 1997

Why are we going to spend the next 30 min + most of the afternoon talking about this?

This is the first step in:

- Understanding why different parts of your river behave differently
- Designing a rapid assessment protocol
- Determining what to pursue for contextual analysis
- Deciding what/where to measure for a sediment budget
River Styles Hierarchy

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Uniform patches of flow and substrate material within a geomorphic unit.

Microhabitat

Individual elements (e.g., logs, rocks, gravel patches) within a stream.
What are the different parts of the watershed?

Which detachment, transport, deposition processes are occurring where?
How well connected is the system?
Where are complete or partial barriers?
How has/might connectivity change?

see Fryirs et al., 2007
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Microhabitat
- Individual elements (e.g., logs, rocks, gravel patches) within a stream.
What are the different parts of the river network?

River Styles™ tree developed for NSW, Australia

YOU decide how to divide up the river network!

Brierley et al., 2002
Visual representation
of NSW River Styles

Which river styles are you working on?

These are each different ‘process domains’

Different ecological functions
hydro-geomorphic processes
sensitivities to change
potential for recovery
What's in a name?

<table>
<thead>
<tr>
<th>River Styles procedural tree</th>
<th>Naming convention - verbose</th>
<th>Naming convention - abbreviated</th>
<th>Resultant verbose and abbreviated names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Party-confined valley setting</td>
<td>Partly confined</td>
<td>PC</td>
<td>Partly confined</td>
</tr>
<tr>
<td>(10-85% of channel abuts valley bottom margin)</td>
<td>Partly confined</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td>degree of lateral confinement</td>
<td>planform-controlled, 10-50% confined</td>
<td>PC</td>
<td>PC_Pc</td>
</tr>
<tr>
<td>river planform</td>
<td>planform descriptor</td>
<td>planform descriptor</td>
<td>PC_Pc_LSin_TrCS</td>
</tr>
<tr>
<td>(# channels, sinuosity, lateral constraint)</td>
<td>descriptor constrained</td>
<td>descriptor constrained</td>
<td>PC_Pc_LSin_TrCS_DcFp</td>
</tr>
<tr>
<td>geomorphic units (instream and floodplain)</td>
<td>geomorphic units descriptor</td>
<td>geomorphic units descriptor</td>
<td>PC_Pc_LSin_TrCS_DcFp_Gbed</td>
</tr>
<tr>
<td>bed material texture</td>
<td>bed descriptor</td>
<td>bed descriptor</td>
<td>not compulsory - use if splitting or more detail needed</td>
</tr>
</tbody>
</table>

Key:
- descriptor: add existing or new term
- compulsory: must have
- not compulsory: use if splitting or more detail needed
A common taxonomy for describing rivers

<table>
<thead>
<tr>
<th>TYPES OF MARGIN CONTROL OR CONSTRAINTS</th>
<th>PLANFORM TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrock</td>
<td>Br  Headwater</td>
</tr>
<tr>
<td>Terrace</td>
<td>Tr  Gorge</td>
</tr>
<tr>
<td>Fan</td>
<td>Fn  Canyon</td>
</tr>
<tr>
<td>Dune</td>
<td>Dn  Braided</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TYPES OF ANTHROPOGENIC MARGIN</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stopbank</td>
<td>SBk  Wandering</td>
</tr>
<tr>
<td>Constructed levee</td>
<td>Colv  Low sinuosity</td>
</tr>
<tr>
<td>Embankment</td>
<td>EBk  Anastomosing</td>
</tr>
<tr>
<td>Bank revetment</td>
<td>BKRe  Anabranching</td>
</tr>
<tr>
<td>Railroad</td>
<td>RaRd  Chain of ponds</td>
</tr>
<tr>
<td>Flood</td>
<td>RF  Valley fill</td>
</tr>
<tr>
<td>Pipe</td>
<td>Pip  Swamp</td>
</tr>
<tr>
<td>Concrete</td>
<td>Crt  Floodout</td>
</tr>
<tr>
<td>Earth</td>
<td>Ea  Canal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UNSTREAM GEOMORPHIC UNITS</th>
<th>Mid-channel geomorphic units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sculted, erosional geomorphic units</td>
<td></td>
</tr>
<tr>
<td>Bedrock step (waterfall)</td>
<td>BrSt  Alluvial riffle</td>
</tr>
<tr>
<td>Step-pool</td>
<td>SPo  Alluvial pool</td>
</tr>
<tr>
<td>Cascade</td>
<td>Cc  Longitudinal bar (medial bar)</td>
</tr>
<tr>
<td>Rapid</td>
<td>Rp  Transverse bar (linguoid bar)</td>
</tr>
<tr>
<td>Run (glide, plane-bed)</td>
<td>Ru  Diagonal (diamond bar)</td>
</tr>
<tr>
<td>Forced riffle</td>
<td>FoRi  Expansion bar</td>
</tr>
<tr>
<td>Forced pool</td>
<td>FoPo  Island</td>
</tr>
<tr>
<td>Plunge pool</td>
<td>PPs  Boulder mound</td>
</tr>
<tr>
<td>Pot hole</td>
<td>PHo  Bedrock core bar</td>
</tr>
<tr>
<td>Bank-attached geomorphic units</td>
<td></td>
</tr>
<tr>
<td>Lateral bar (alternate or side bar)</td>
<td>LaBa  Gravel sheet</td>
</tr>
<tr>
<td>Scroll bar</td>
<td>ScBa  Forced mid-channel bar (pandent bar, wake bar, lee bar)</td>
</tr>
<tr>
<td>Point bar</td>
<td>PIBa  Compound mid-channel bar</td>
</tr>
<tr>
<td>Tributary confluence bar (channel junction bar, eddy bar)</td>
<td>TaBa  Alluvial riffle</td>
</tr>
<tr>
<td>Ridge</td>
<td>Ri  Alluvial pool</td>
</tr>
<tr>
<td>Chute channel</td>
<td>CCCh  Longitudinal bar (medial bar)</td>
</tr>
<tr>
<td>Ramp (chute channel fill)</td>
<td>Rp  Fine-grained sculted geomorphic units</td>
</tr>
<tr>
<td>Bench</td>
<td>Be  Sculpted lateral bar</td>
</tr>
<tr>
<td>Point bench</td>
<td>PIBe  Sculpted longitudinal bar</td>
</tr>
<tr>
<td>Ledge</td>
<td>Le  Sculpted point bar</td>
</tr>
<tr>
<td>Point ledge</td>
<td>PLe  Sculpted run</td>
</tr>
<tr>
<td>Boulder berm</td>
<td>BBrm  Sculpted pool</td>
</tr>
<tr>
<td>Concrave bank bench</td>
<td>CCCBe</td>
</tr>
<tr>
<td>Compound bank-attached bar</td>
<td>CBABA</td>
</tr>
<tr>
<td>Forced bank-attached bar</td>
<td>FBABA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FLOODPLAIN GEOMORPHIC UNITS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Occasional floodplain</td>
<td>OccFp  Palaeochannel (prior channel, abandoned, ancestral channel)</td>
</tr>
<tr>
<td>Discontinuous floodplain</td>
<td>DcFp  Ridge</td>
</tr>
<tr>
<td>Floodplain (alluvial flat)</td>
<td>Fp  Swale</td>
</tr>
<tr>
<td>Leyer</td>
<td>Lv  Valley fill (swamp, swampy meadow)</td>
</tr>
<tr>
<td>Crevasse splay</td>
<td>Csp  Meander cutoff (neck cutoff, billabong)</td>
</tr>
<tr>
<td>Floodchannel (back channel)</td>
<td>FCh  Ox bow</td>
</tr>
<tr>
<td>Flood runner</td>
<td>FFr  Chute cut-off</td>
</tr>
<tr>
<td>Backswamp (distal floodplain, floodplain wetland, floodplain lake)</td>
<td>Bsw  Floodplain channel anabranch (secondary or flood channel)</td>
</tr>
<tr>
<td>Floodplain sand short</td>
<td>FpsS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BED MATERIAL TEXTURE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrock</td>
<td>Br  Gravel</td>
</tr>
<tr>
<td>Boulder</td>
<td>B  Sand</td>
</tr>
<tr>
<td>Cobble</td>
<td>C  Fine grained</td>
</tr>
</tbody>
</table>

Fryirs and Brierley, 2018
Begin to classify channel network with these primary gradients...

Valley confinement

River longitudinal profile

Flow accumulation
Valley confinement

Confined
>90% interacting with confining margins

Partly Confined
90-50%: margin controlled
10-40%: planform controlled

Unconfined
<10% interacting with cm
Confinement tells you more than any other metric about channel constraints and adjustment capacity.
Confinement tells you more than any other metric about channel constraints and adjustment capacity.

All have the same channel/valley ratio!
Confinement tells you more than any other metric about channel constraints and adjustment capacity.

O'Brien et al., 2019
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Second tier characteristics for classification
Indicators of channel behavior

Assemblage of geomorphic units that make up a reach

Channel planform

Bed material texture
Metrics of channel planform

(a) Number of channels
- single
- up to 3 (wandering)
- > 3 (braided)
  > 3 (anastomosing / anabranching)
- discontinuous or absent

(b) Sinuosity
- Degrees of sinuosity (modified from Schumm, 1985)
  - 1–1.05 (straight)
  - 1.06–1.30 (low sinuosity)
  - 1.31–3.0 (sinuous / meandering)

Types of sinuosity (from Church, 1992)
- sinuous
- irregular meanders (passive)
- regular meanders
- tortuous meanders
- confined pattern

(c) Lateral stability
- Meander growth and shift
  - extension / increasing amplitude
  - translation / downstream progression
  - rotation
  - neck cutoffs

Degree of braiding (from Schumm, 1985)
- < 5%
- 5–34%
- 35–65%
- > 65%

Character of braiding
- mostly bars
- bars and islands
- mostly islands, diverse shape
- mostly islands, long and narrow

Avulsive behavior
- 1st order avulsion
- wholesale shift
- 2nd order avulsion
- reoccupation
- 3rd order avulsion
- thalweg shift
Interpretations from channel planform

Kleinhans, 2010
Modes of adjustment vary considerably for different river types

<table>
<thead>
<tr>
<th>Channel type</th>
<th>Grain size</th>
<th>Width &amp; depth</th>
<th>Bedforms</th>
<th>Stream gradient (sinuosity/elevation) $^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colluvial</td>
<td>p</td>
<td>p</td>
<td>-</td>
<td>$-/-p^c$</td>
</tr>
<tr>
<td>Bedrock</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$-/-$</td>
</tr>
<tr>
<td>Cascade</td>
<td>p</td>
<td>-</td>
<td>-</td>
<td>$-/-$</td>
</tr>
<tr>
<td>Step-pool</td>
<td>p</td>
<td>$-/-p^d$</td>
<td>p</td>
<td>$-/-p$</td>
</tr>
<tr>
<td>Plane-bed</td>
<td>+</td>
<td>$p/+p$</td>
<td>-</td>
<td>$-/-p$</td>
</tr>
<tr>
<td>Braided</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>$++/+p$</td>
</tr>
<tr>
<td>Pool-riffle</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>$++/+p$</td>
</tr>
<tr>
<td>Dune-ripple</td>
<td>p</td>
<td>+</td>
<td>+</td>
<td>$++/+p$</td>
</tr>
</tbody>
</table>

$^a$ Modified from Montgomery and Buffington (1997). Response potential for each channel type is discussed elsewhere (Montgomery and Buffington, 1997; 1998; Buffington et al., 2003).

$^b$ Changes in stream gradient may occur via altered sinuosity or incision/aggradation that alter the absolute elevation change across a reach. Slashes in the table distinguish these two responses.

$^c$ Fluvial incision/deposition is possible, depending on the degree of colluvial fill.

$^d$ Changes in channel depth can occur via pool fill/scour.
Armoring allows gravel bed rivers to adjust transport rates to changes in sediment supply. Trends converge (armoring is eliminated) at high sediment concentrations.
Armoring tends to increase under low sediment supply conditions.
## Tools for geomorphic assessments

Fryirs, et al., 2019

https://riverscapes.xyz/

| Tool | Website or download page | Key related papers/
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Confinement and valley setting</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valley-bottom extraction tool (V-BET)</td>
<td><a href="http://rcat.riverscapes.xyz/Documentation/Version_1.0/VBET.html">http://rcat.riverscapes.xyz/Documentation/Version_1.0/VBET.html</a></td>
<td>Gilbert, Macfarlane, and Wheaton (2016)</td>
</tr>
<tr>
<td>TerEx toolbox (terrace and floodplain mapping)</td>
<td><a href="https://gcnr.usu.edu/labs/belmont_lab/resources">https://gcnr.usu.edu/labs/belmont_lab/resources</a></td>
<td>Cubb et al. (2017), Stout and Belmont (2014)</td>
</tr>
<tr>
<td><strong>River planform</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beaver restoration assessment tool (BRAT)</td>
<td><a href="http://brat.riverscapes.xyz/">http://brat.riverscapes.xyz/</a></td>
<td></td>
</tr>
<tr>
<td><strong>Geomorphic units</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geomorphic unit tool (GUT)</td>
<td><a href="http://gut.riverscapes.xyz/">http://gut.riverscapes.xyz/</a></td>
<td>Bangen, Wheaton, Bouwes, Bouwes, and Jordan (2014)</td>
</tr>
<tr>
<td>Geomorphic unit survey (GUS)</td>
<td></td>
<td>Wheaton et al. (2015)</td>
</tr>
<tr>
<td><strong>Bed material texture</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topographic analysis tools (TAT), including ToPCAT</td>
<td><a href="http://tat.riverscapes.xyz/">http://tat.riverscapes.xyz/</a></td>
<td>Brasington, Vericat, and Rychkov (2012)</td>
</tr>
<tr>
<td><strong>River behavior</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morphological change—Geomorphic change detection (GCD)</td>
<td><a href="http://gcd.riverscapes.xyz/">http://gcd.riverscapes.xyz/</a></td>
<td>Wheaton, Brasington, Darby, and Sear (2010), Wheaton et al. (2013)</td>
</tr>
</tbody>
</table>
## Tools for geomorphic assessments

<table>
<thead>
<tr>
<th>Tool</th>
<th>Website or download page</th>
<th>Key related paper/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planform statistics</td>
<td><a href="https://repository.nceo.umn.edu/browser.php?current=author&amp;author=37&amp;dataset_id=15">https://repository.nceo.umn.edu/browser.php?current=author&amp;author=37&amp;dataset_id=15</a></td>
<td>--</td>
</tr>
<tr>
<td>Measures of channel width and centreline</td>
<td>RivWidth: <a href="http://unglobalhydrology.org/rivwidth/">http://unglobalhydrology.org/rivwidth/</a></td>
<td>Pavelsky and Smith (2008)</td>
</tr>
<tr>
<td></td>
<td>RivMap: <a href="https://www.mathworks.com/matlabcentral/fileexchange/58264-rivmap-river-">https://www.mathworks.com/matlabcentral/fileexchange/58264-rivmap-river-</a></td>
<td>Schwenk, Khandelwal, Fratkin, Kumar, and</td>
</tr>
<tr>
<td></td>
<td>PyRIS: <a href="https://github.com/fmonegaglia/pyris">https://github.com/fmonegaglia/pyris</a></td>
<td>Monegaglia, Zolezzi, Gineralp, Henshaw, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tubino (2018)</td>
</tr>
<tr>
<td>SCREAM</td>
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<td>Rowland et al. (2016)</td>
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</tbody>
</table>

### Downstream patterns of rivers and controls

<table>
<thead>
<tr>
<th>Tool</th>
<th>Website or download page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal profile—ArcMap stacked profile</td>
<td><a href="http://www.aregis.com/index.html">http://www.aregis.com/index.html</a></td>
</tr>
<tr>
<td>Network Profiler Tool</td>
<td><a href="https://riverscapes.github.io/NetworkProfiler/">https://riverscapes.github.io/NetworkProfiler/</a></td>
</tr>
<tr>
<td>Geospatial modeling environment</td>
<td><a href="http://www.spatialEcology.com/gme/">http://www.spatialEcology.com/gme/</a></td>
</tr>
<tr>
<td>Catchment area—ArcMap flow accumulation</td>
<td><a href="http://www.aregis.com/index.html">http://www.aregis.com/index.html</a></td>
</tr>
<tr>
<td>Gross stream power</td>
<td><a href="http://brat.riverscapes.xyz/">http://brat.riverscapes.xyz/</a></td>
</tr>
</tbody>
</table>

**Note:** This is not intended to be an exhaustive list of all available tools, rather a guide to direct the reader to the tools identified in Figures 2b and 3, and mentioned in the text. All websites were accessed June 17, 2019.

Fryirs, et al., 2019
Rapid Assessment vs Contextual Analysis

Rapid Assessments:
- Aim to be repeatable, quantitative, and representative
- Limited ability to discern cause of problems in complex systems
- Often require frequent sampling, large number of sites

Contextual Analysis:
- Aim to attain comprehensive, holistic understanding of the system
- Often difficult to quantify components
- Can guide assessments, monitoring, measurements for sediment budget
Roadmap

**TODAY**

Forget rates. What can we learn from basic form-process relationships?

Basic Reconnaissance
- With a tight budget, what do you really need to know?
- Case studies in sediment supply, transport, and morphodynamics

Hydrologic analysis and non-stationarity
- Targeted modeling and metrics. Stationarity Assumption?

**TOMORROW**

Push-button Geomorphology
- The geek approach. What computer models can and can’t tell you.

Basin-average erosion rates: The cosmo method
- Millennial-scale landscape rates of erosion.

Reservoir and pond sedimentation rates
- Time- and space-integrated measurements that may be useful.

Watershed Sediment Budget
- Tools and techniques for robust constraints on sources and sinks.
Reach 1

Laterally unconfined, low gradient channel

Steep hillslopes deliver sediment to low-gradient valley floor

Weak tuff and rhyolite bedrock, recent severe burn

Example: North Fork Cable Creek, Oregon
Partly confined, planform controlled with strong veg influence
Channel incised into a narrow, high-gradient valley
Channel gradient steeper, bed material coarser, less heterogeneity
Reach 3
Laterally unconfined, occasional confining terraces
Valley widens, well developed (and connected) floodplain
Much gravel deposition and heterogeneity in bedforms
Partly confined, margin controlled.

Channel crosses fault and enters onto hard Columbia River Basalt.

Reach 4: Sediment Transport

Step-pool to pool-riffle morphology.
Some history on the landscape we’ll be examining this afternoon.
Long profiles of EF, SF Little Bear and other drainages of the Bear River Range

Longitudinal profiles extracted with Stream Profiler Tool: geomorphtools.org
Your assignment for this afternoon:

Work in groups of 3-4

The Logan River Watershed is being targeted for a major watershed restoration project with the goal of restoring cutthroat and brown trout habitat.

Utah DNR has requested a map illustrating the **different reach types that occur** along the river. This info will be used to determine which sites to prioritize for further monitoring and restoration.
Your assignment for this afternoon:

1. Obtain paper maps, GIS and/or Google Earth data

2. Peruse the data for 30 min. Identify points/areas of interest along the channel and throughout the watershed.

3. Spend ~30 min delineating distinct reaches of the mainstem Logan River along our tour route. Delineate distinct River Styles and describe each reach wrt:
   1. valley confinement
   2. number of channels, sinuosity
   3. slope and/or discontinuities in the long profile
   4. notable sediment sources and sinks
   5. other relevant attributes (e.g., D50, slope)

Turn in by 5pm:

1. Paper map showing reach breaks
2. Answers to questions at each stop and brief descriptions of each River Style
Questions we’ll discuss at each stop

(1) Which erosional processes do you see evidence for? What is conveying sediment to the channel? Amount and type of sediment supplied?

(2) Is there a clearly defined bankfull channel? How deep is it?

(3) What geomorphic units do you see?

(4) Is the bed armored? Does bed material move at channel filling flow?

(5) Is there evidence of coarse suspended load (little in the bed, but deposits of fine gravel or sand in sheltered locations or within bars)?

(6) How sensitive is this reach to changes in flow and/or sediment supply?
What is a bankfull channel?
So what is bankfull?

The elevation at which water spills out of the channel and onto the floodplain (so it only occurs where you have well defined banks and a floodplain)

Elevation of the top of bank
If banks are at different elevations, it is the top of the lower bank

It is typically identified at a visible break in slope between the channel and floodplain
Often it is the transition from unvegetated to (woody) vegetated surface

Not all channels have banks…not all channels have a bankfull elevation!
Flood flows, bankfull, and effective discharge