# Development of a Rapid Geomorphic Assessment Procedure

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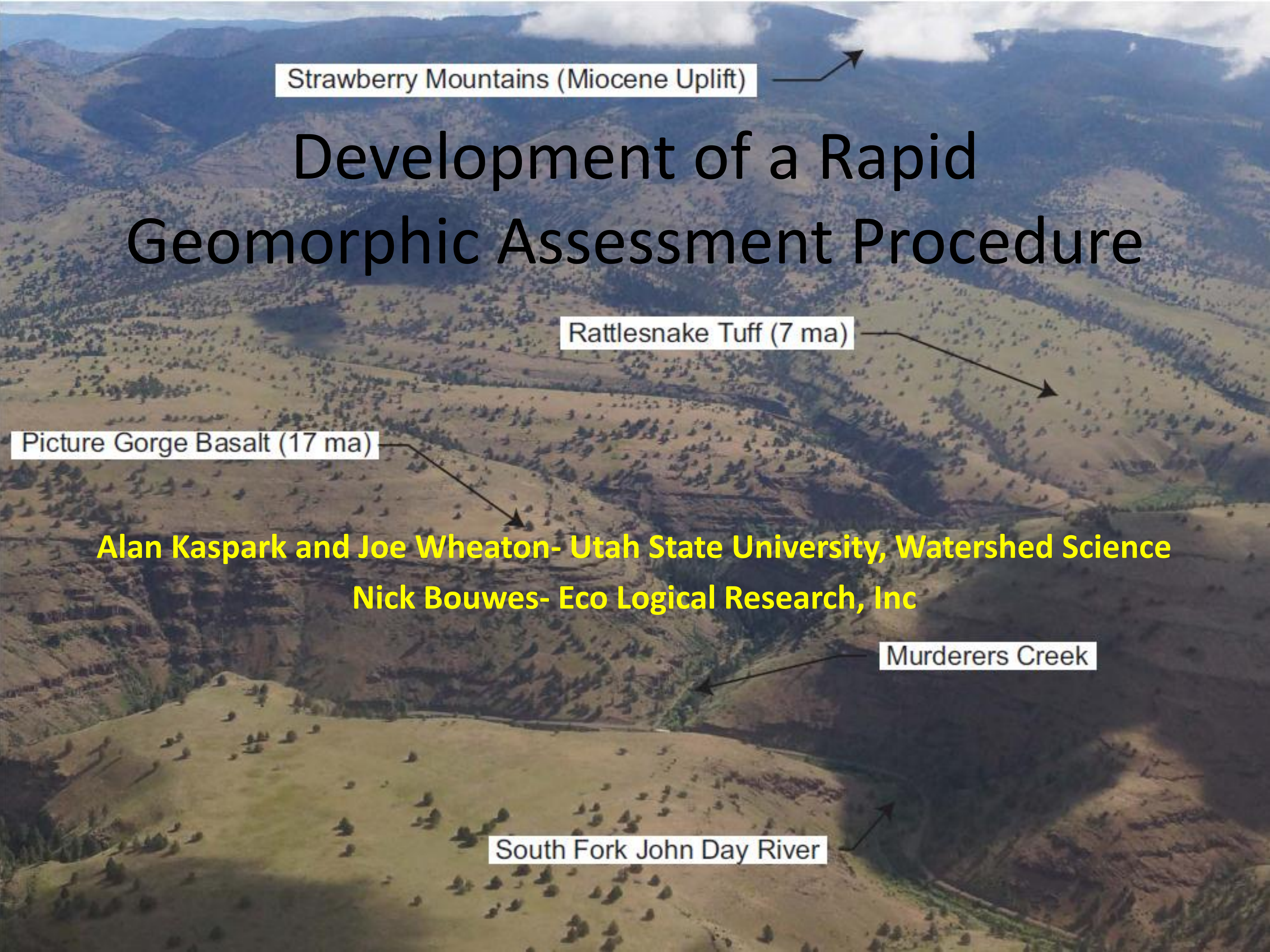
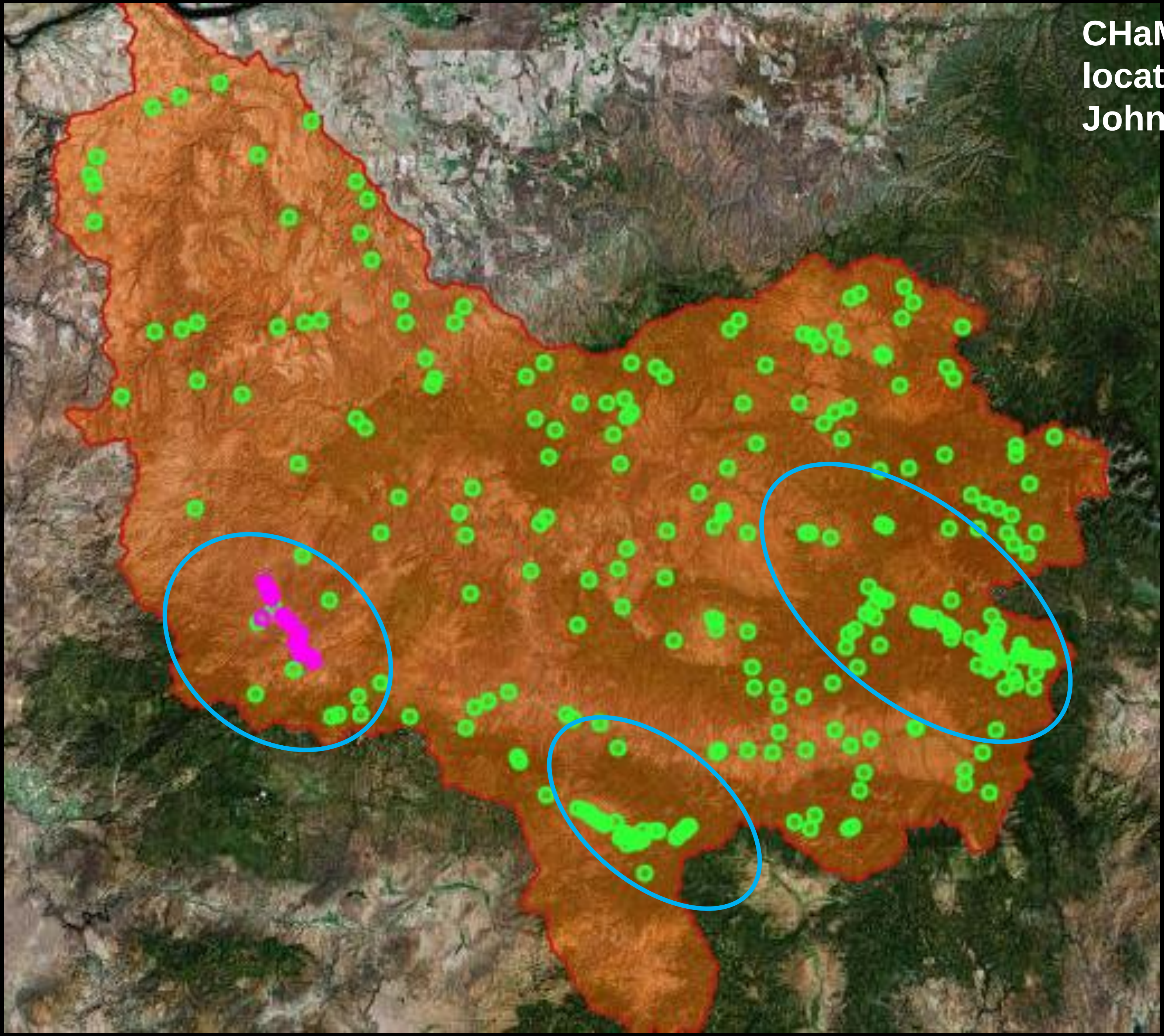


# CHaMP site locations in the John Day Basin



# Why Rapid Geomorphic Assessments

- Context for interpretation of intensive site evaluation (e.g. CHaMP)
- Extrapolation of intensive site evaluations to entire drainage network
- Describe watershed condition
- Identify and prioritize stream restoration and land management strategies
- Survey design- distribute sites in a more informed fashion (use of prior field visits)

# Inherent problems with site based assessments

- Difficulty Capturing the Full Range of Basin Variability- stratification helps but need prior field-based knowledge
- Difficulty in Capturing Within-Channel Variability- the eco-geomorphic conditions found at a location are driven by **upstream** and **local characteristics**
- Difficulty in Untangling Form and Process with Snapshots- must know **process regime** acting to shape particular channel and know current **disturbance regime**

# River Styles Framework (Brierley and Fryis 2005)

**STAGE 1**

Catchment-wide baseline survey of river character and behaviour and classification of River Styles®

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**STAGE 2**

Catchment-framed assessment of geomorphic river condition, analysed in terms of the potential for adjustment and associated geoindicators for each River Style®

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**STAGE 3**

Assessment of the future trajectory of change and geomorphic river recovery potential, framed in terms of evolutionary adjustments of each reach, related to catchment-wide geomorphic changes

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**STAGE 4**

River management applications and implications: catchment-based vision building, identification of target conditions and prioritisation of management efforts

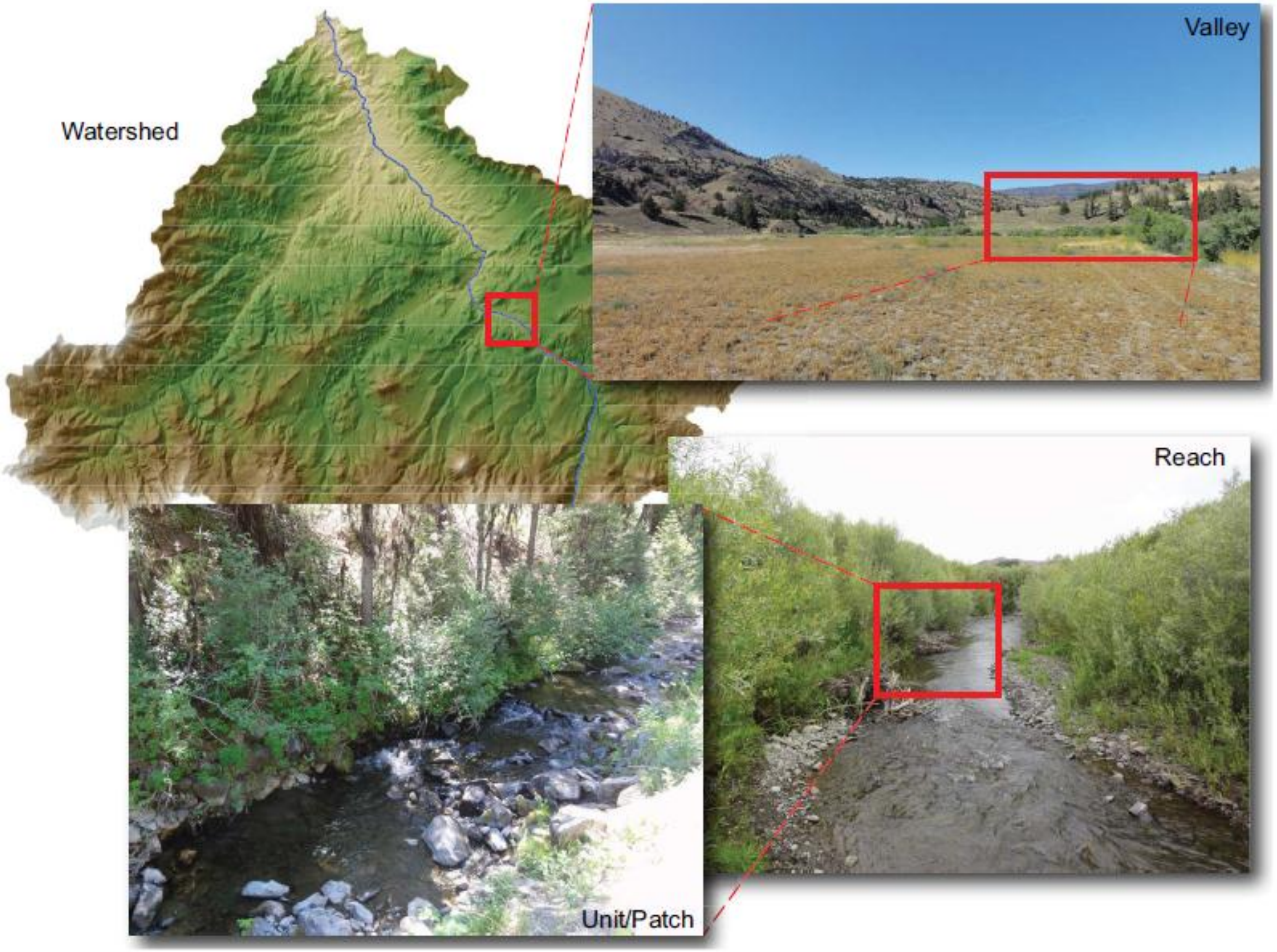
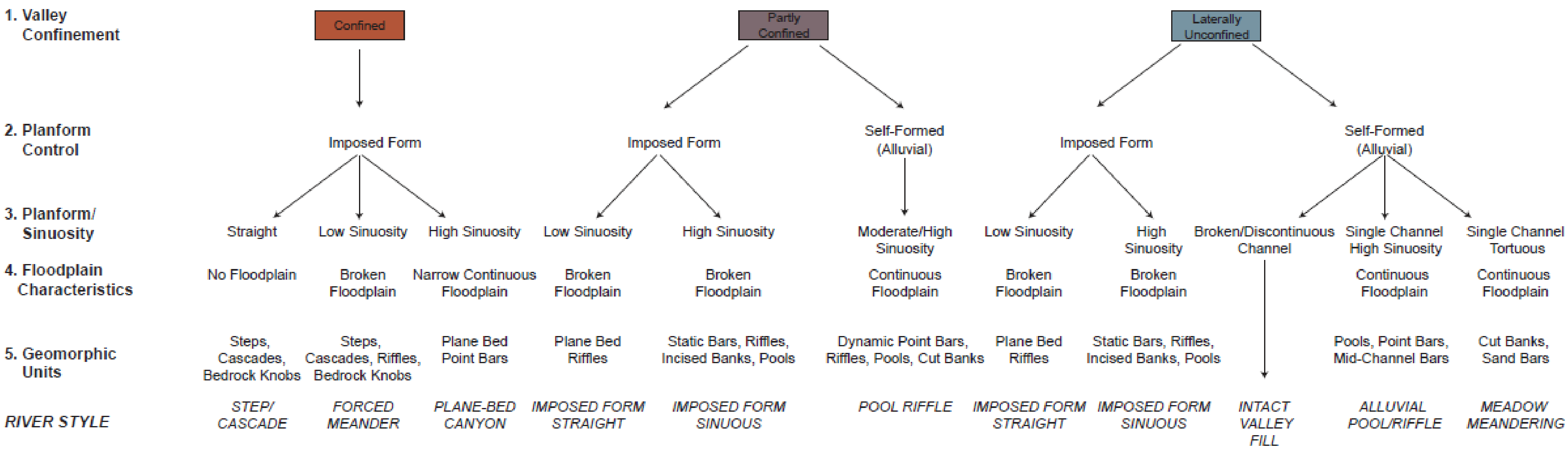


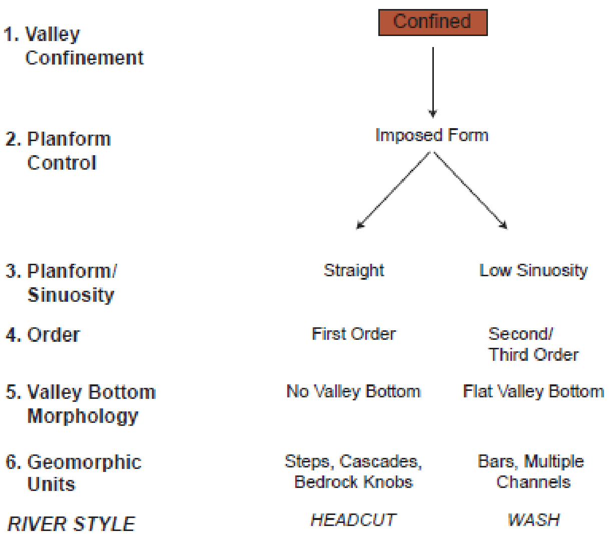

Figure 2: Scales of information relevant to understanding reach-scale habitat availability. Note that CHaMP collects information at the reach and unit scale and is designed to be upscaled to valley and watershed scales (but does not sample at these scales).

# River Styles: Delineate streams both top-down and bottom-up hierarchical approach

*MIDDLE FORK JOHN DAY RIVER, MURDERERS/BRIDGE CREEKS - PERENNIAL RIVER STYLES PROCEDURAL TREE*




*MIDDLE FORK JOHN DAY RIVER, MURDERERS/BRIDGE CREEKS - EPHEMERAL RIVER STYLES PROCEDURAL TREE*

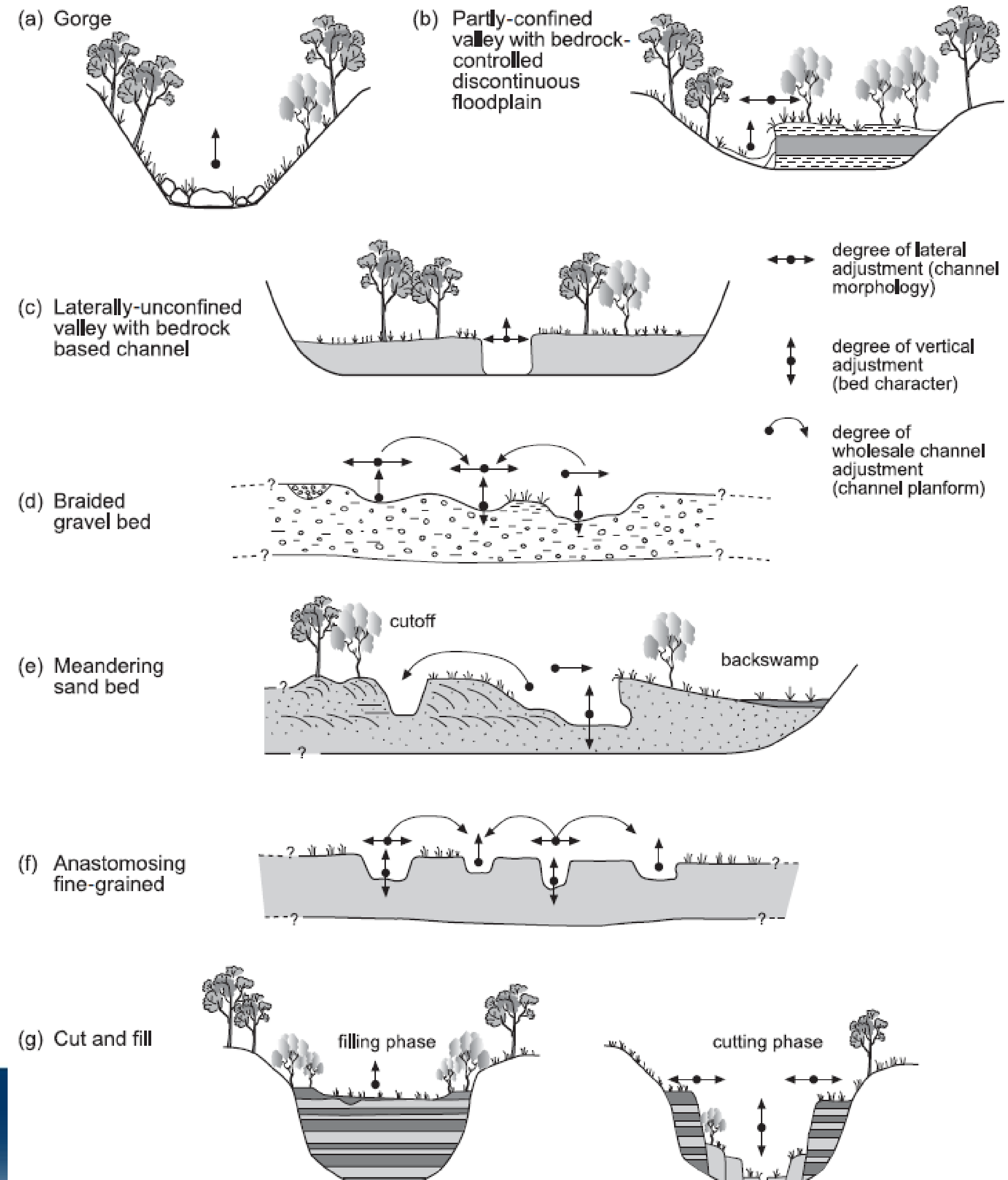


*MIDDLE FORK JOHN DAY RIVER, MURDERERS/BRIDGE CREEKS - PERENNIAL RIVER STYLES PROCEDURAL TREE*

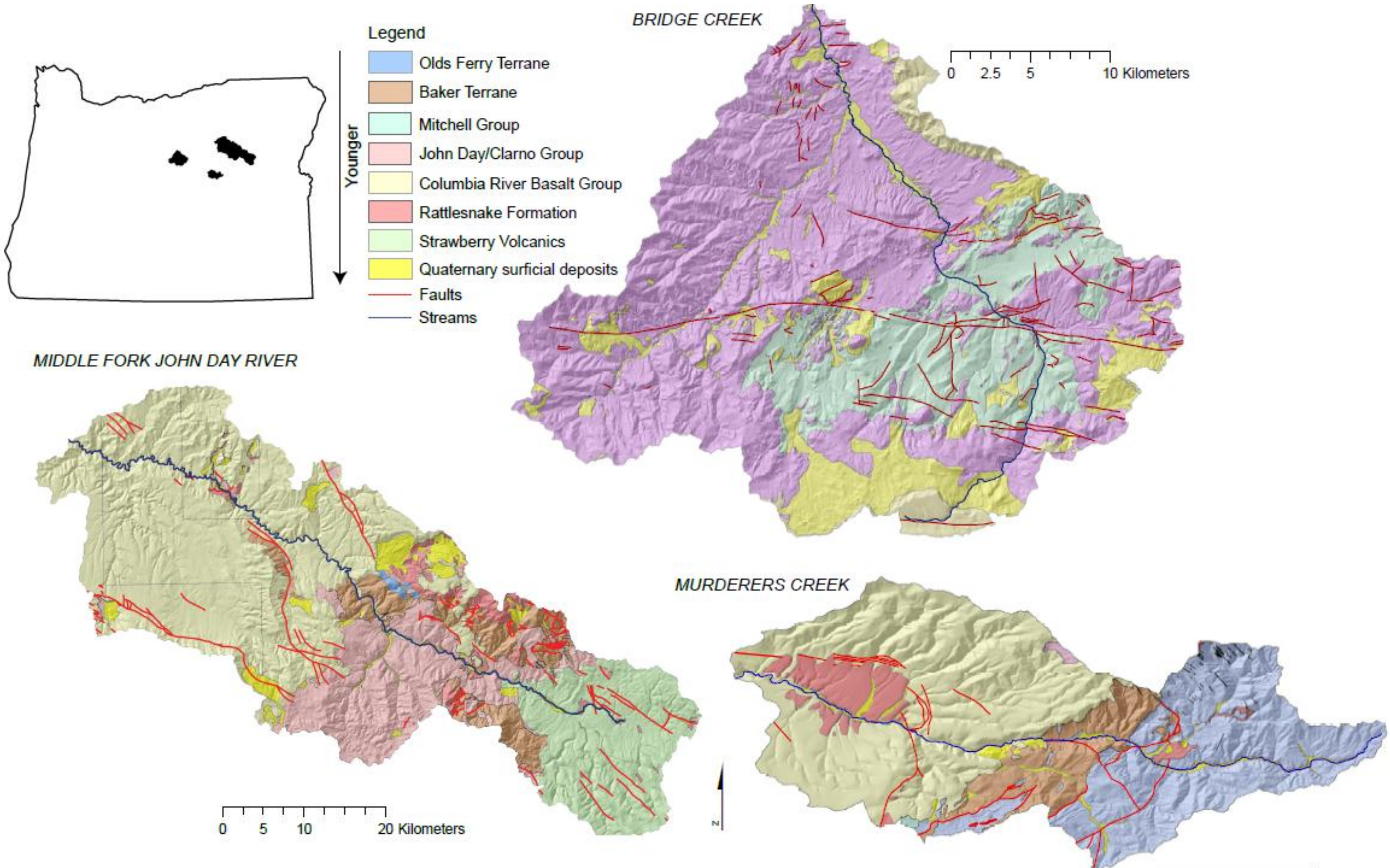
| | | | | | | |
|---|---|---|---|---|---|---|
| **1. Valley Confinement** | Confined | | | Partly Confined | | |
| **2. Planform Control** | Imposed Form | | | Imposed Form | | Self-Formed (Alluvial) |
| **3. Planform/ Sinuosity** | Straight | Low Sinuosity | High Sinuosity | Low Sinuosity | High Sinuosity | Moderate/High Sinuosity |
| **4. Floodplain Characteristics** | No Floodplain | Broken Floodplain | Narrow Continuous Floodplain | Broken Floodplain | Broken Floodplain | Continuous Floodplain |
| **5. Geomorphic Units** | Steps, Cascades, Bedrock Knobs | Steps, Cascades, Riffles, Bedrock Knobs | Plane Bed Point Bars | Plane Bed Riffles | Static Bars, Riffles, Incised Banks, Pools | Dynamic Point Bars, Riffles, Pools, Cut Banks |
| ***RIVER STYLE*** | *STEP/ CASCADE* | *FORCED MEANDER* | *PLANE-BED CANYON* | *IMPOSED FORM STRAIGHT* | *IMPOSED FORM SINUOUS* | *POOL RIFFLE* *IM* |

# NATURAL CAPACITY FOR ADJUSTMENT

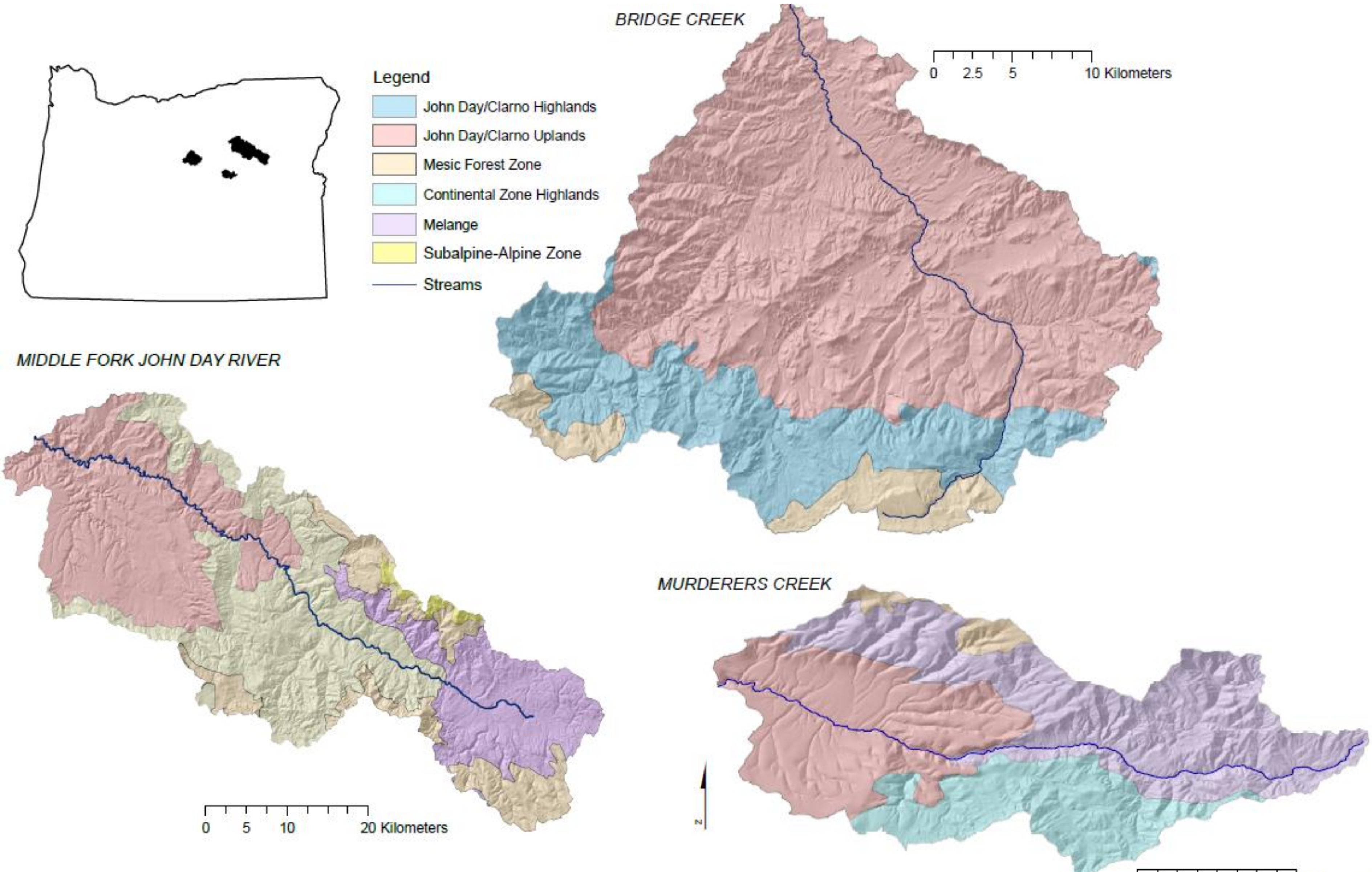
- Plausible limits on what adjustments are possible
- Framed within context of



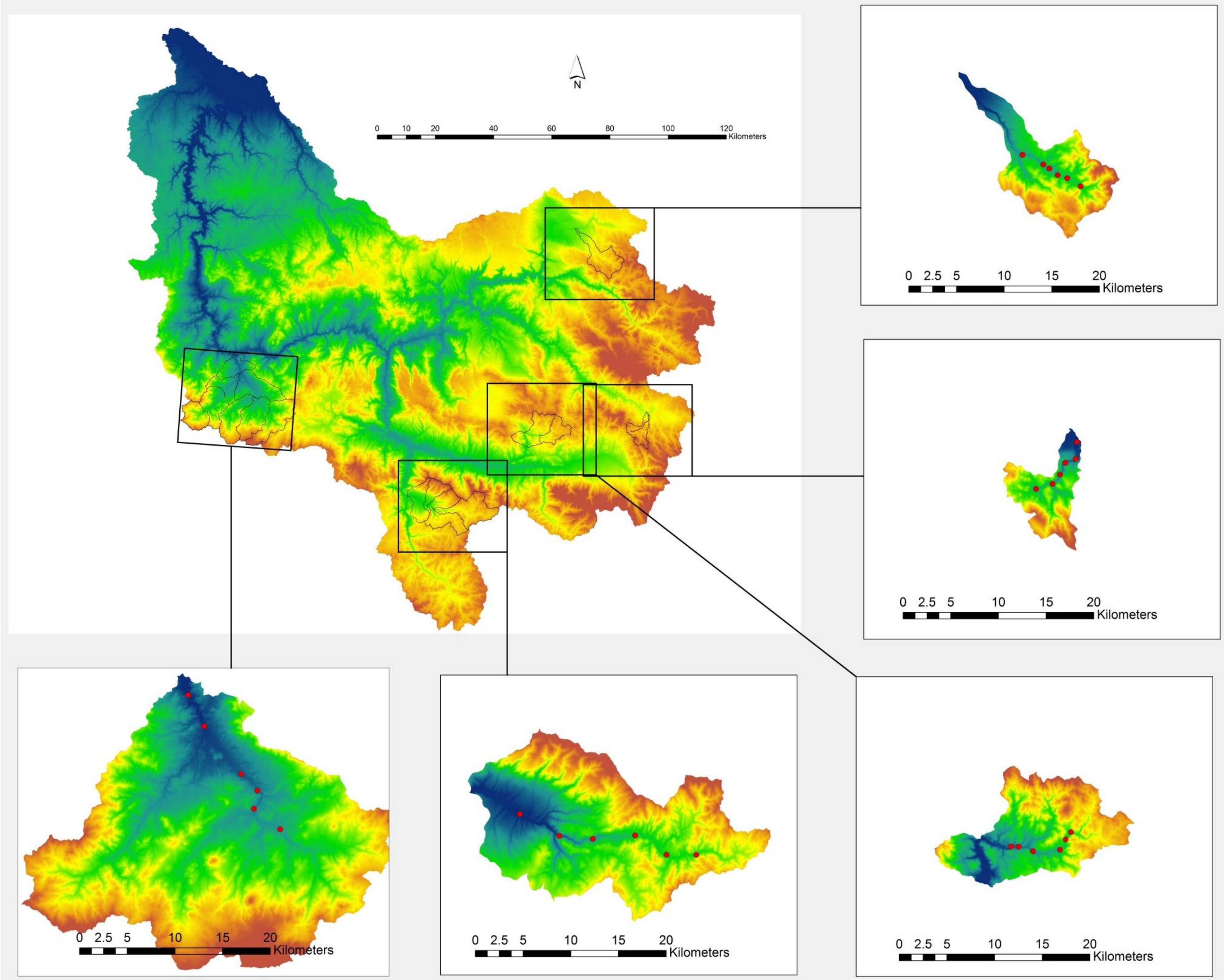

From Brierley & Fryirs (2005)

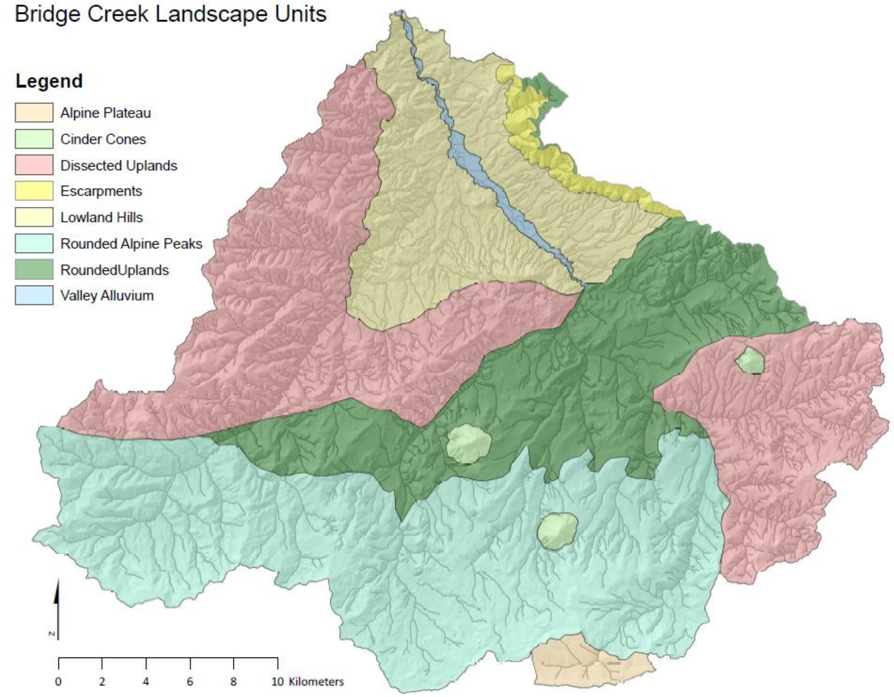


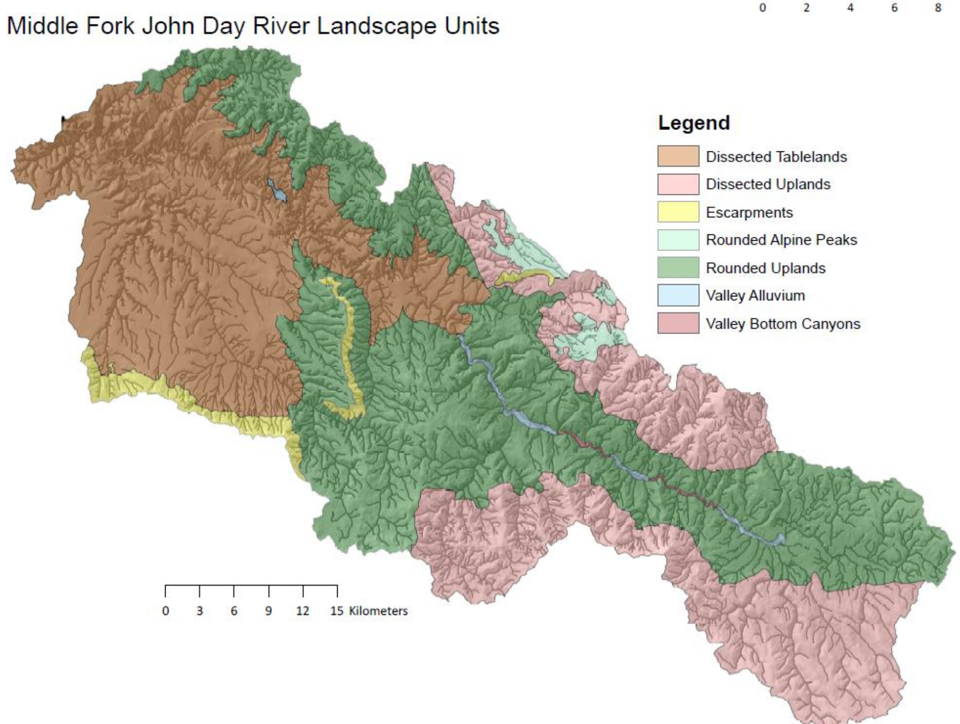
BRIDGE CREEK
Legend
Olds Ferry Terrane
Baker Terrane
Mitchell Group
John Day/Clarno Group
Columbia River Basalt Group
Rattlesnake Formation
Strawberry Volcanics
Quaternary surficial deposits
Faults
Streams
Younger
0 2.5 5 10 Kilometers
MIDDLE FORK JOHN DAY RIVER
0 5 10 20 Kilometers
MURDERERS CREEK
N
0 2.5 5 10 Kilometers

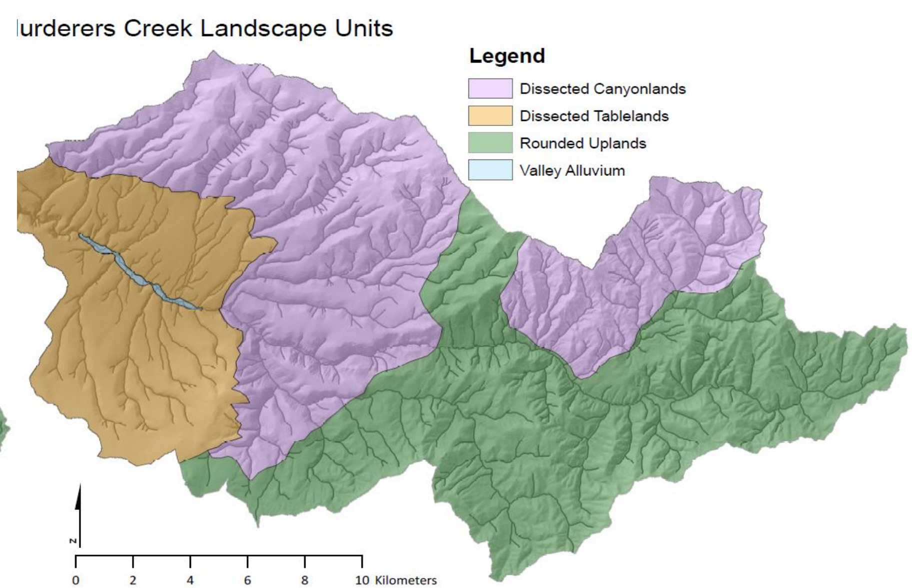


BRIDGE CREEK
Legend
John Day/Clarno Highlands
John Day/Clarno Uplands
Mesic Forest Zone
Continental Zone Highlands
Melange
Subalpine-Alpine Zone
Streams
0 2.5 5 10 Kilometers
MIDDLE FORK JOHN DAY RIVER
0 5 10 20 Kilometers
MURDERERS CREEK
N
0 2.5 5 10 Kilometers


N
0 10 20 40 60 80 100 120 Kilometers
0 2.5 5 10 15 20 Kilometers
0 2.5 5 10 15 20 Kilometers
0 2.5 5 10 15 20 Kilometers
0 2.5 5 10 15 20 Kilometers
0 2.5 5 10 15 20 Kilometers


Bridge Creek Landscape Units
Legend
Alpine Plateau
Cinder Cones
Dissected Uplands
Escarpments
Lowland Hills
Rounded Alpine Peaks
RoundedUplands
Valley Alluvium
N
0 2 4 6 8 10 Kilometers

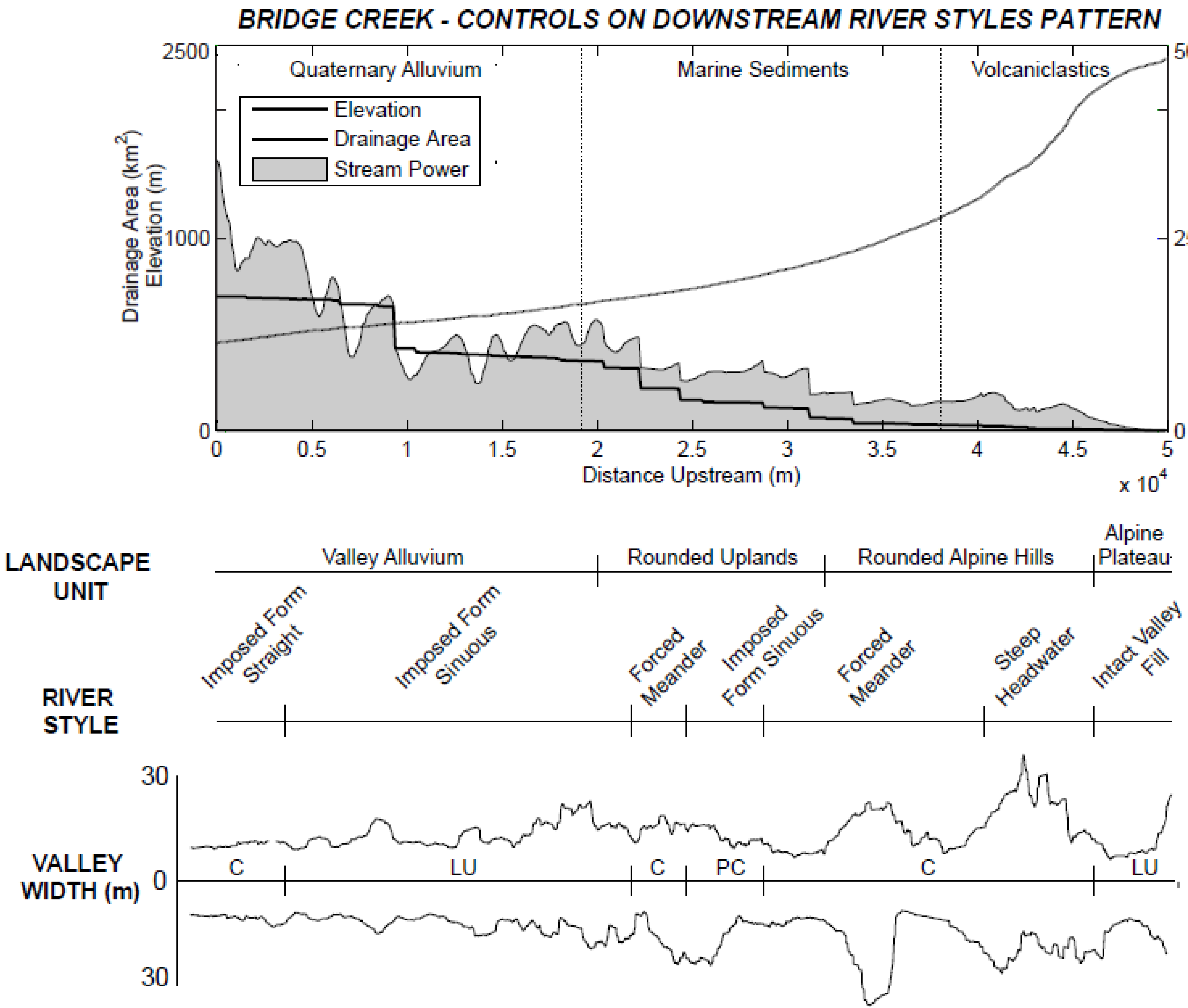

Middle Fork John Day River Landscape Units
Legend
Dissected Tablelands
Dissected Uplands
Escarpments
Rounded Alpine Peaks
Rounded Uplands
Valley Alluvium
Valley Bottom Canyons
0 3 6 9 12 15 Kilometers


lurderers Creek Landscape Units
Legend
Dissected Canyonlands
Dissected Tablelands
Rounded Uplands
Valley Alluvium
N
0 2 4 6 8 10 Kilometers

# River Styles on 3 watersheds in John Day Basin

| Parameter | Middle Fork John Day River | Bridge Creek | Murderers Creek |
|---|---|---|---|
| Drainage Area ($km^2$) | 2051 | 697 | 344 |
| Mean Elevation (m) | 1378 | 1134 | 1439 |
| Max Elevation (m) | 2478 | 2075 | 2204 |
| Min Elevation (m) | 664 | 451 | 896 |
| Relief (m) | 1814 | 1625 | 1308 |
| Mean Slope (degrees) | 11.7 | 14.3 | 13.8 |
| Max Slope (degrees) | 52.3 | 56.8 | 53.1 |
| Min Slope (degrees) | 0 | 0 | 0 |
| Total Stream Length (km) | 1605 | 501 | 280 |
| Drainage Density ($km/km^2$) | 0.78 | 0.72 | 0.81 |
| Mean Precipitation (cm/year) | 52.8 | 42.4 | 41.9 |
| 2-Year 24-Hour Peak Precipitation (cm) | 2.5 | 2.95 | 2.34 |
| Percent Forest | 65.2 | 45.1 | 69.1 |
| Percent Impervious Surfaces | 0.16 | 0.25 | 0.07 |
| Average Soil Permeability (cm/hour) | 2.21 | 1.37 | 2.24 |

Table 1: Hydrologic parameters for the three study basins (generated using USGS StreamStats)


BRIDGE CREEK - CONTROLS ON DOWNSTREAM RIVER STYLES PATTERN
Quaternary Alluvium
Marine Sediments
Volcaniclastics
Elevation
Drainage Area
Stream Power
Drainage Area (km2)
Elevation (m)
Stream Power (W)
Distance Upstream (m)
x 10^4
LANDSCAPE UNIT
Valley Alluvium
Rounded Uplands
Rounded Alpine Hills
Alpine Plateau
RIVER STYLE
Imposed Form Straight
Imposed Form Sinuous
Forced Meander
Imposed Form Sinuous
Forced Meander
Steep Headwater
Intact Valley Fill
VALLEY WIDTH (m)
C
LU
C
PC
C
LU


Overflight
Picture Gorge Basalts (17 ma)
Big Basin Tuff (40 ma)

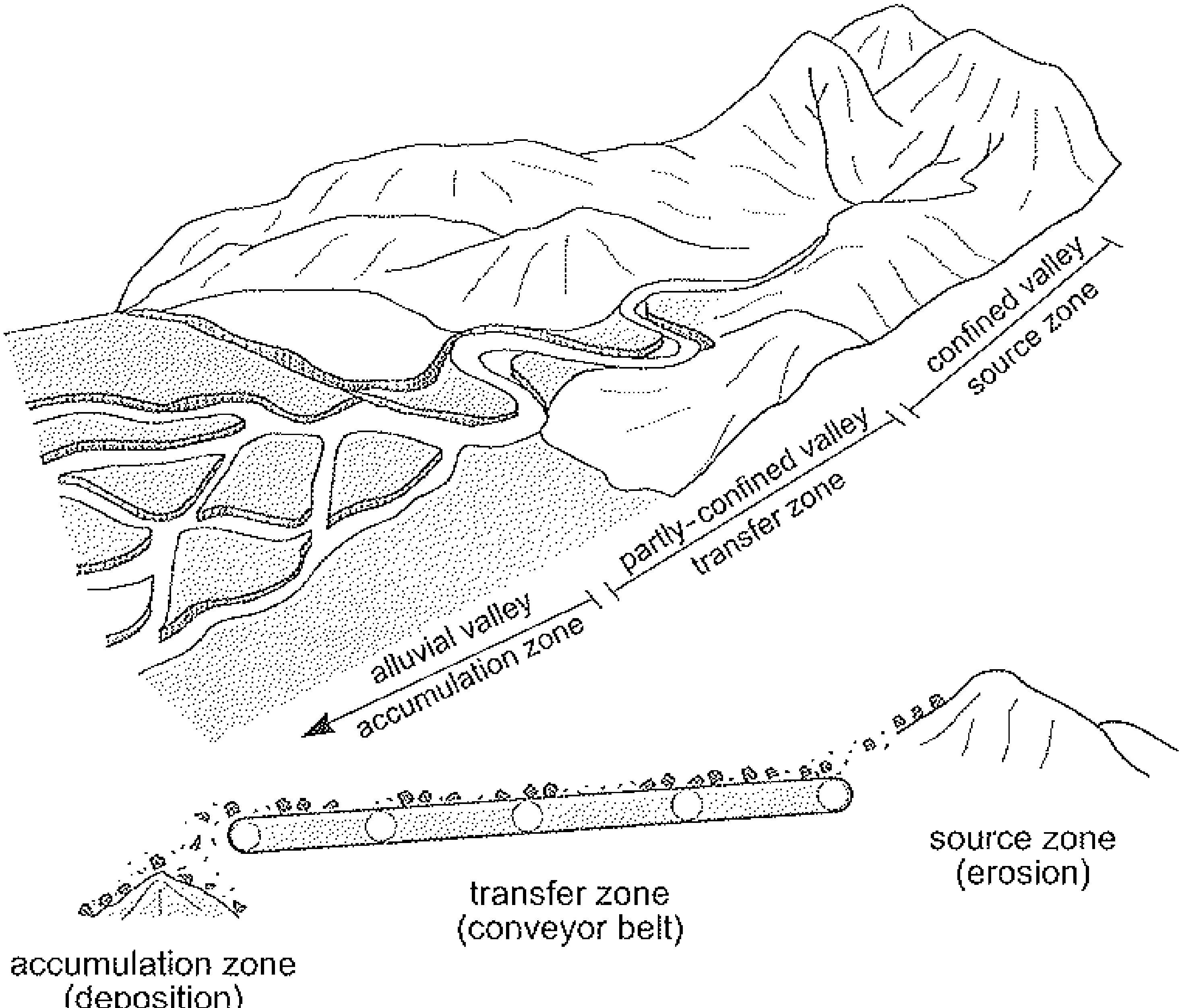
# Fluvial Audits
# (on-the-ground rapid assessments)

- Gradient
- Substrate
- Pool Density
- LWD Density
- Montgomery & Buffington Reach Type
- Sediment source and sink areas (bank failures, landslide scarps, braided reaches etc)
- Valley Confinement

Coarse

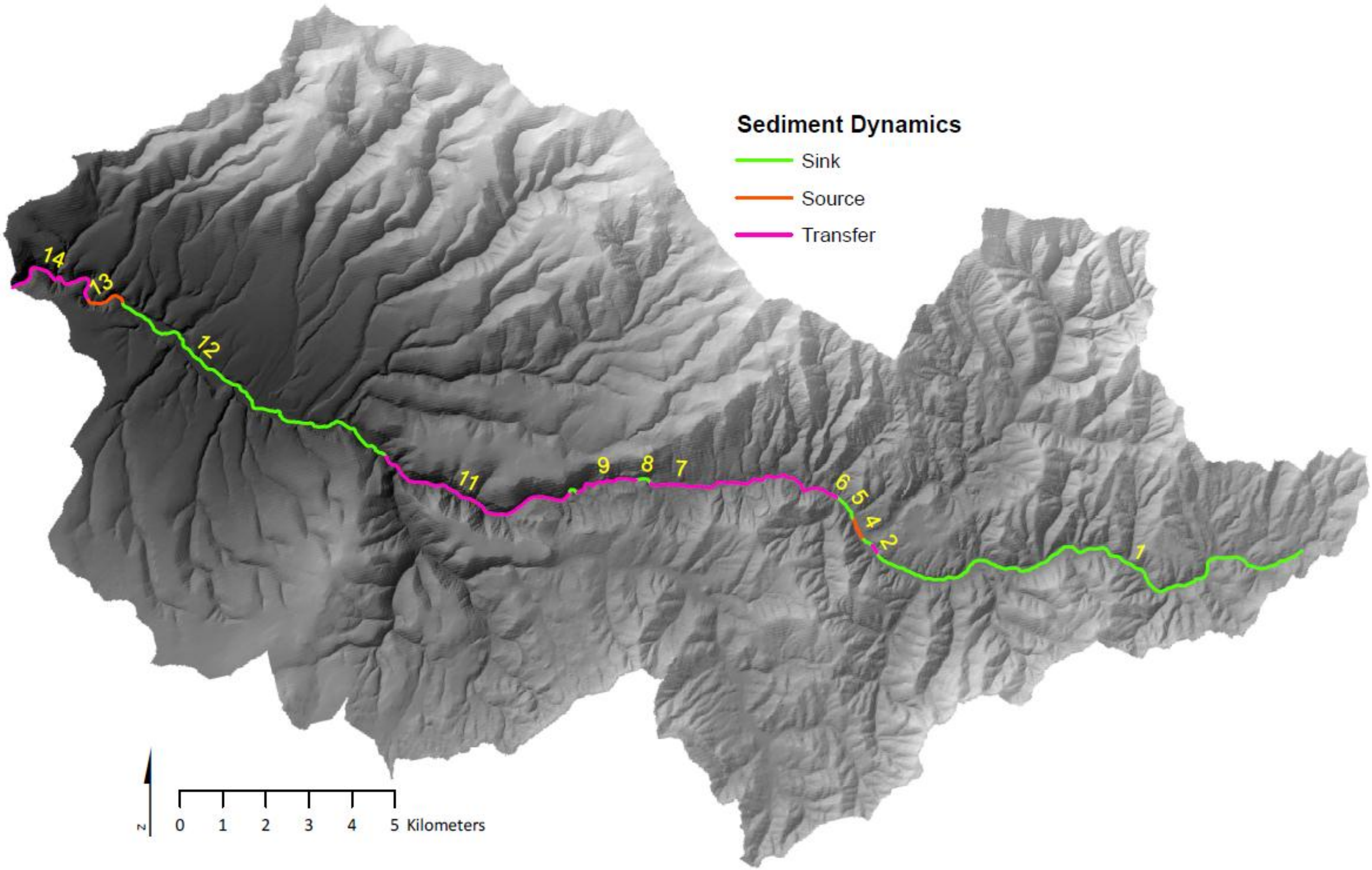
| *Scale* | *Method* | *Processes* | *Forms* |
|---|---|---|---|
| Basin/Sub-Basin ($10^3$ $m^2$)  | Aerial Overflights | - Hillslope Dynamics<br>- Differential Erosion Zones<br>- Vegetation Dynamics | - Hillslope Dissection<br>- Drainage Density<br>- Soil Development |
| Valley Segment ($10^3$ m)  | Fluvial Audit (Reach Delineation) | - Tributary Inputs<br>- Channel/Hillslope Coupling | - Alluvial Fan/Debris Flow Presence<br>- Floodplain/Terrace Dynamics |
| Channel Reach ($10^2$ m)  | River Styles (Desktop) | - Bank Erosion<br>- Vegetation Dynamics<br>- Eco-Geomorphic Feedbacks<br>- Sediment Budget Dynamics | - Incised Channels<br>- Large Woody Debris Jams<br>- Beaver Dams<br>- Bars/Floodplain Stratigraphy |
| Channel Unit (10 m)  | Fluvial Audit (Individual Reach Description) | - Patch-Scale Erosion/Deposition<br>- Vegetation Dynamics | - Channel Substrate<br>- Bar Forms<br>- Pool/LWD Density |
| Hydraulic Unit (1 m)  | River Styles (Field Proforma Validation) | - Flow Field, Bed/Bank Stress | - Individual Pools/Bars<br>- Logjams<br>- Undercut Banks |

Fine

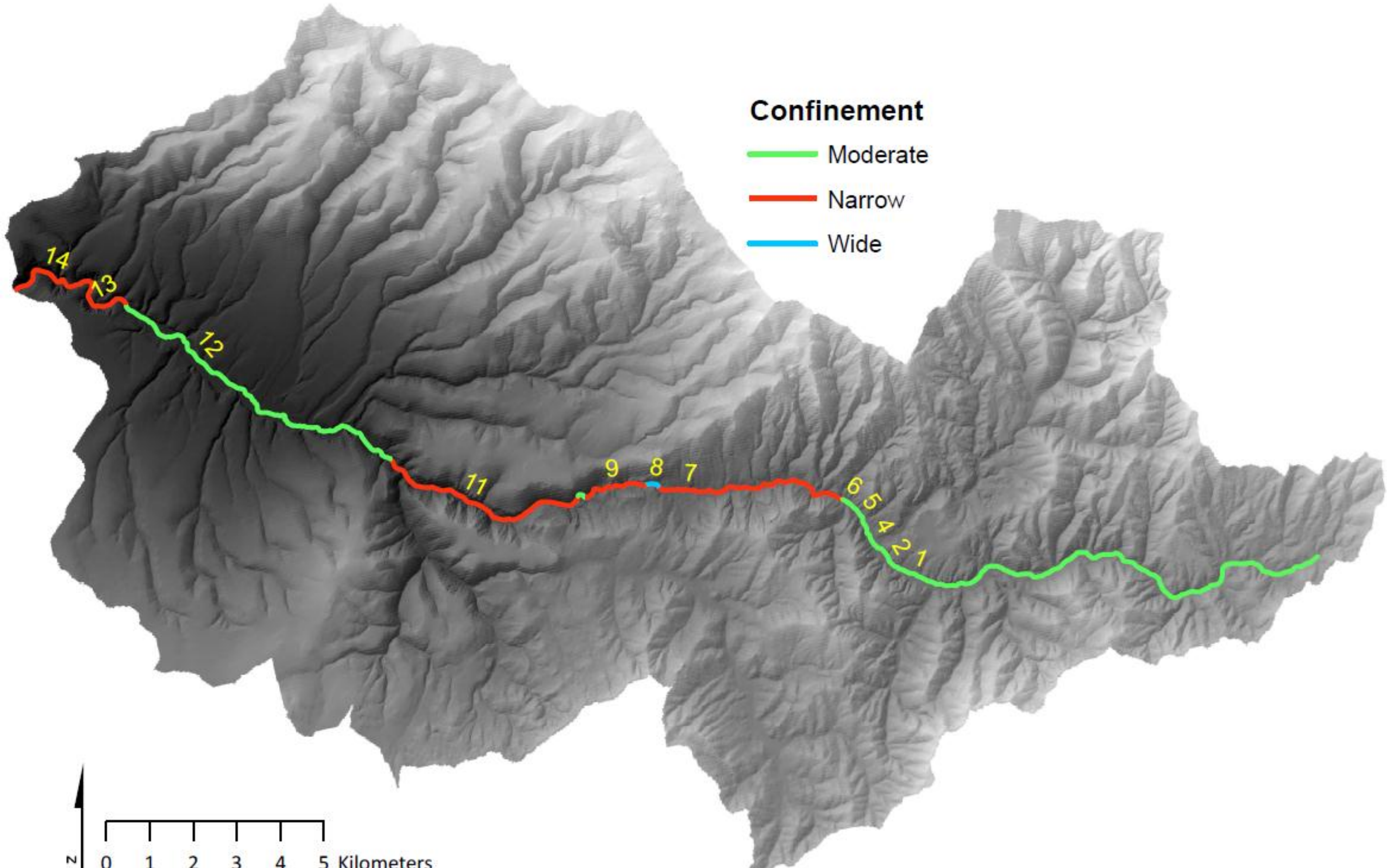


confined valley
source zone
partly-confined valley
transfer zone
alluvial valley
accumulation zone
source zone
(erosion)
transfer zone
(conveyor belt)
accumulation zone
(deposition)

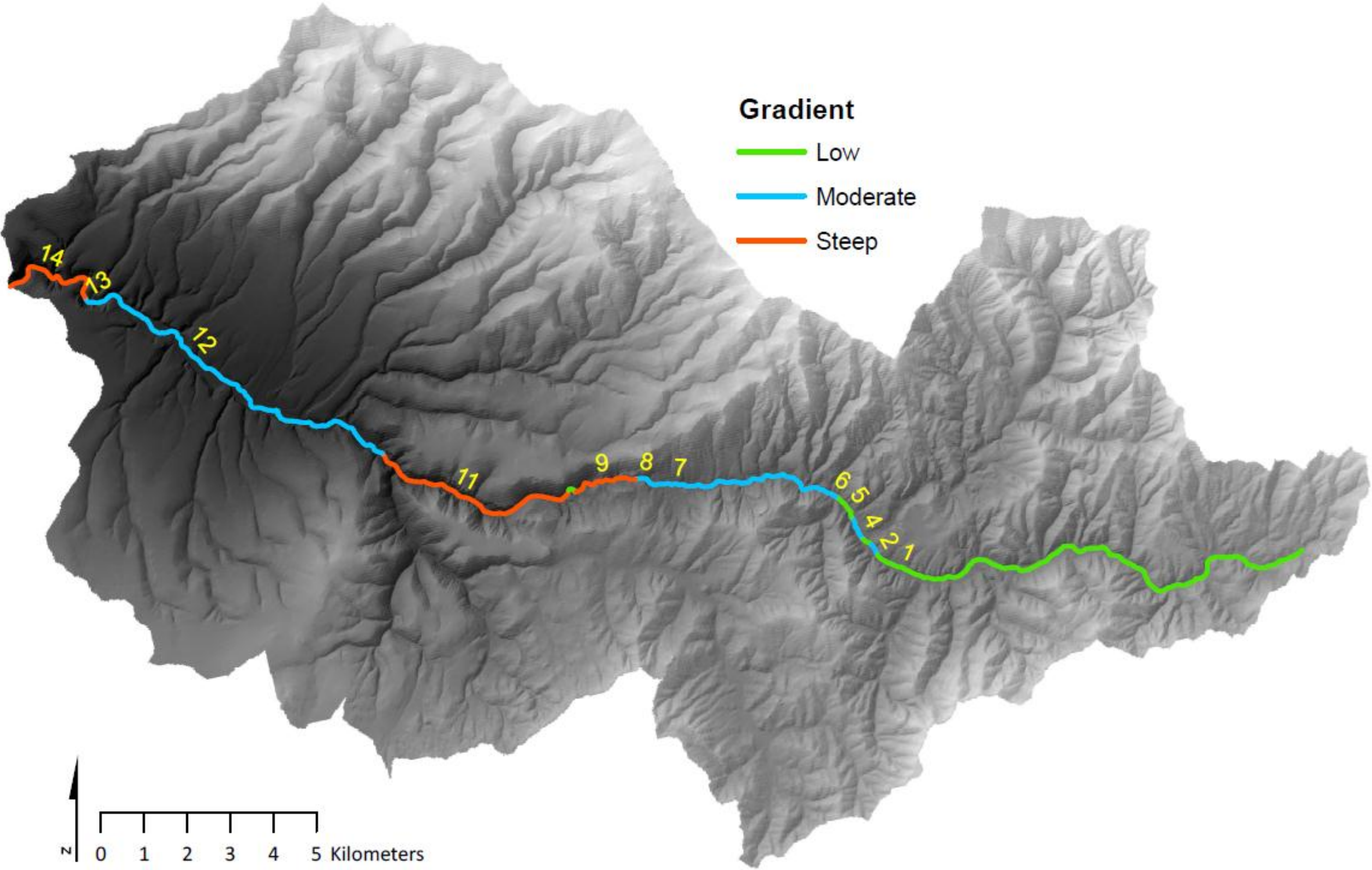
# Murderers Creek- Process zones



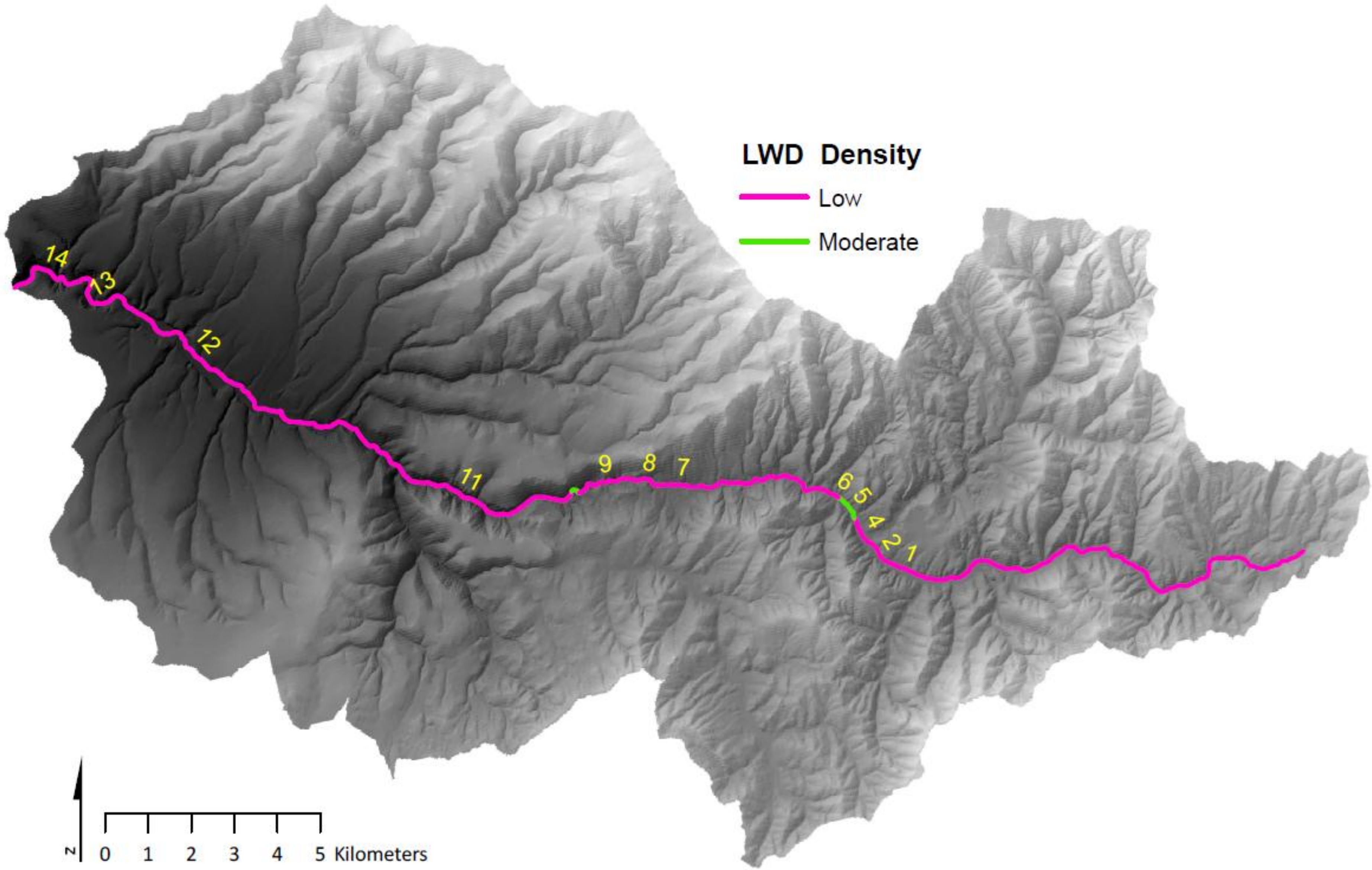
# Murderers Creek- Confinement



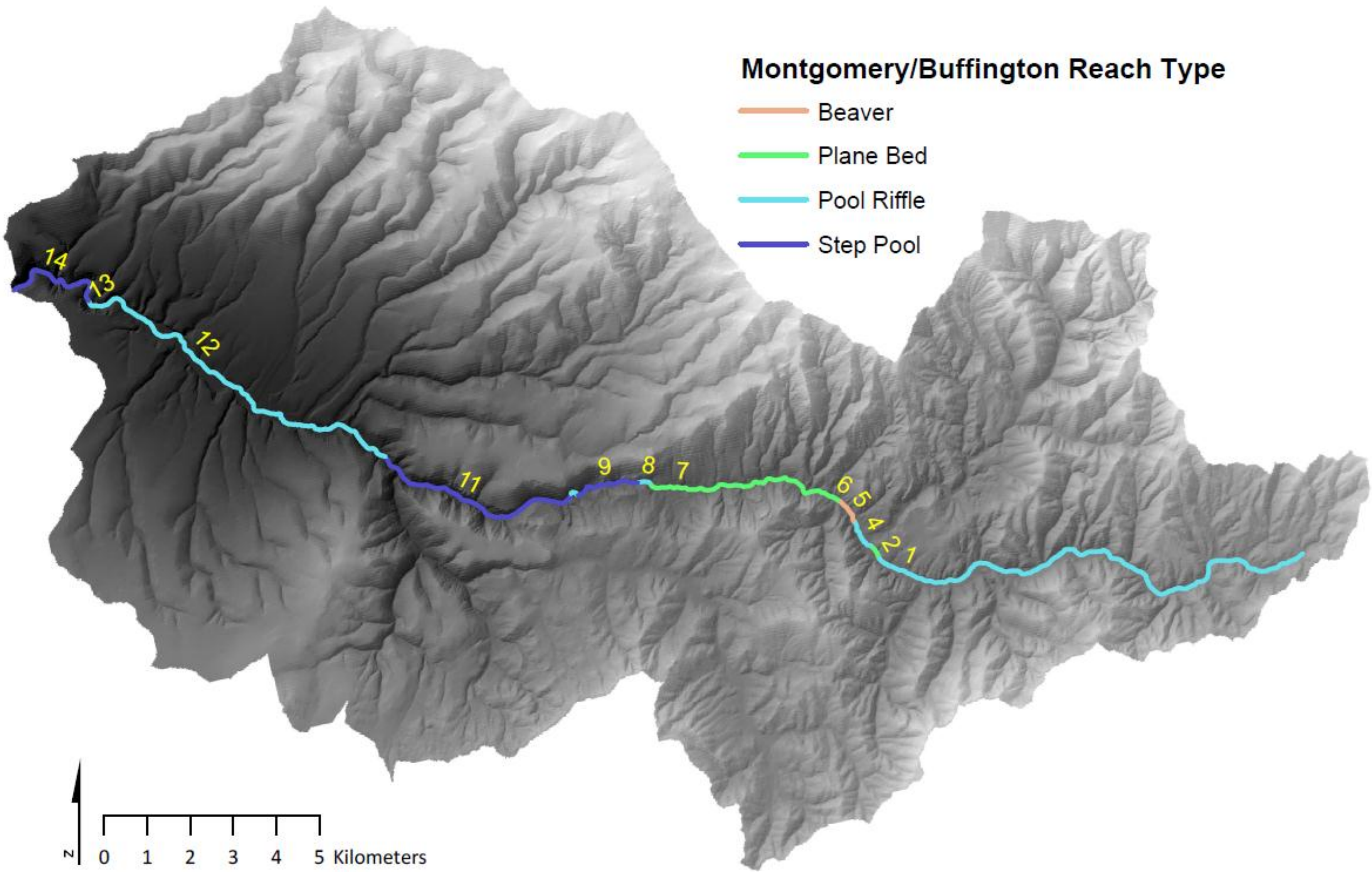
# Murderers Creek- Gradient



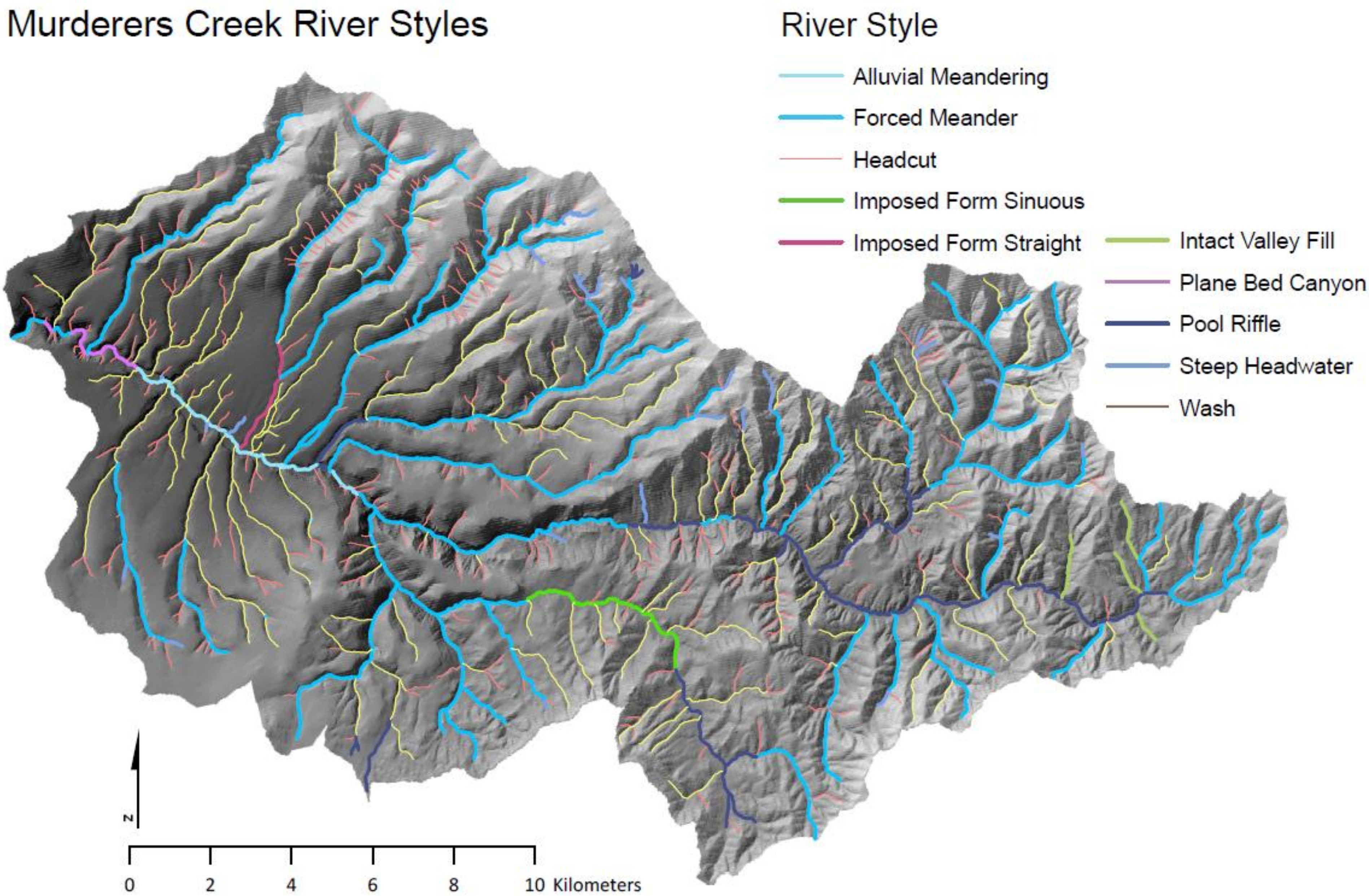
# Murderers Creek - LWD

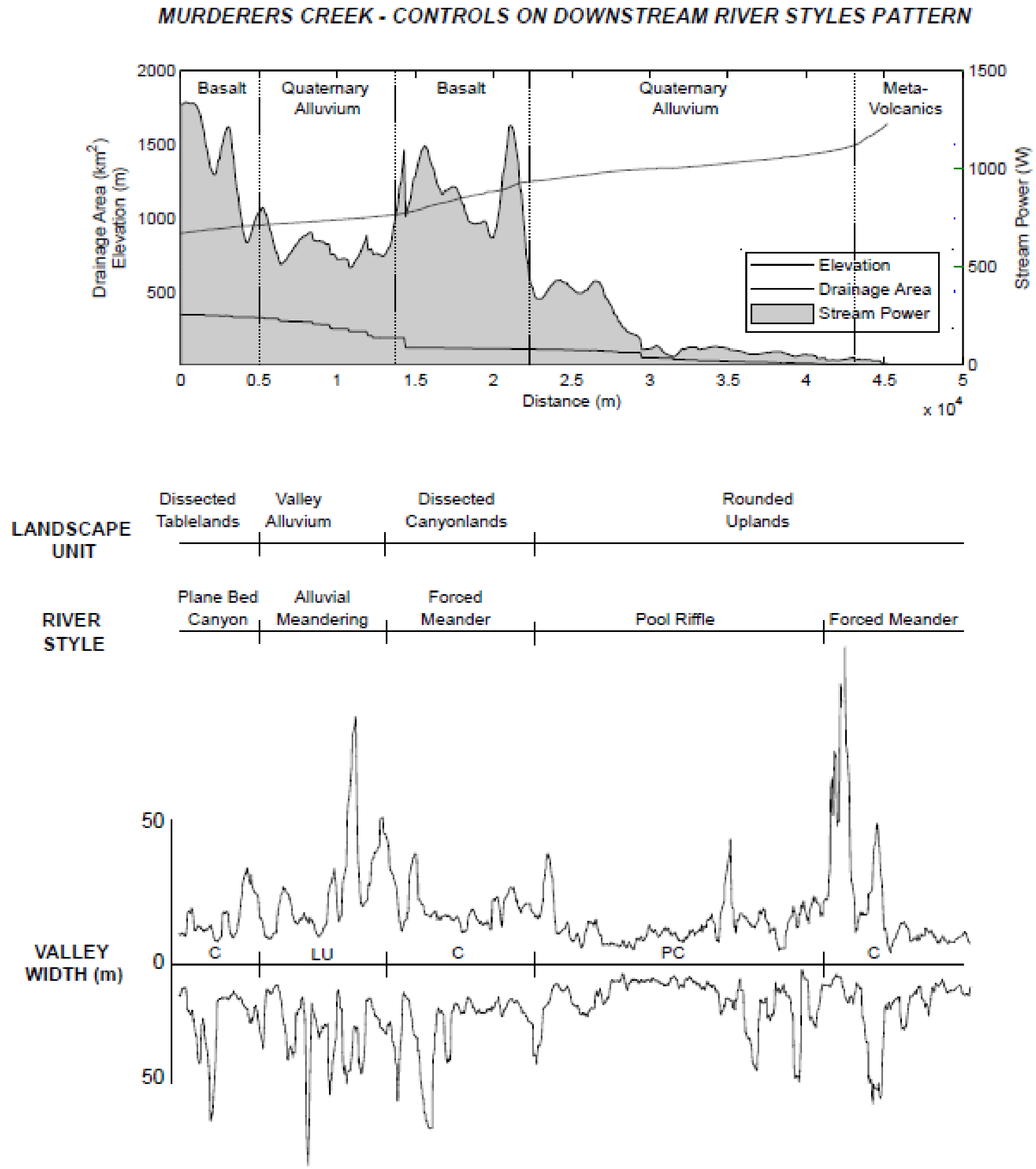


# Stream Types (Montgomery/Buffington)



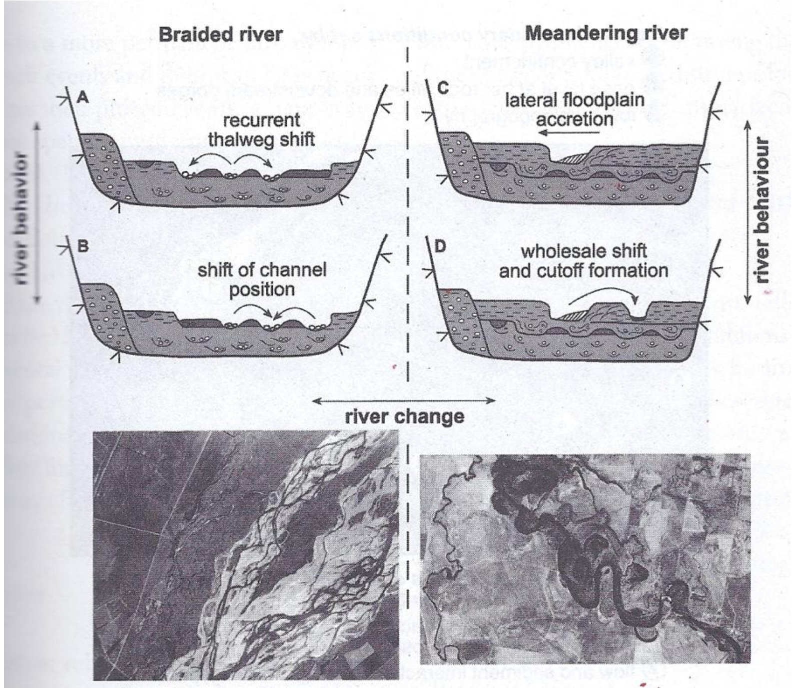
# Murderers Creek – River Styles





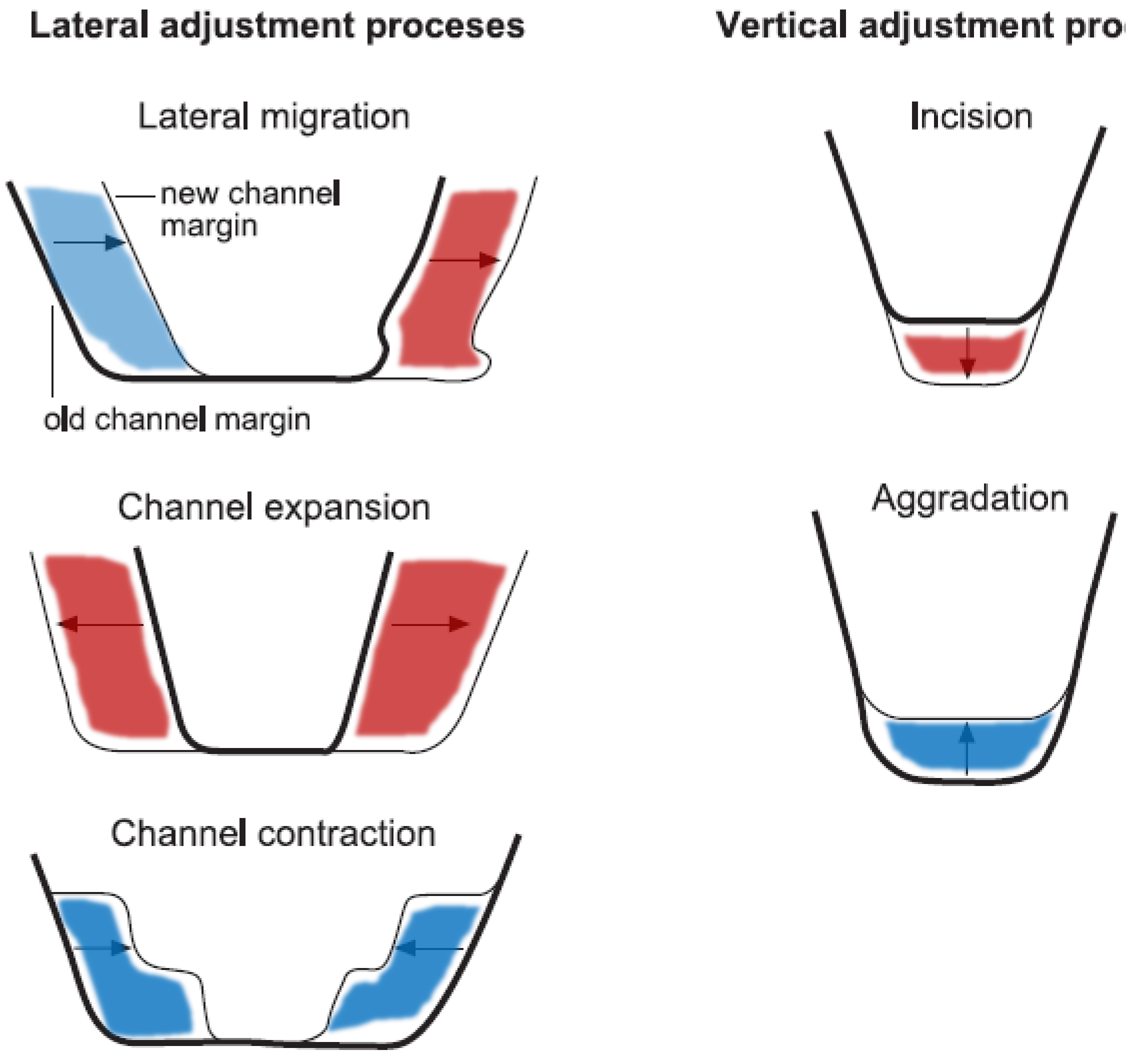
MURDERERS CREEK - CONTROLS ON DOWNSTREAM RIVER STYLES PATTERN
Basalt
Quaternary Alluvium
Basalt
Quaternary Alluvium
Meta-Volcanics
Drainage Area (km2) Elevation (m)
Stream Power (W)
Elevation
Drainage Area
Stream Power
Distance (m)
x 10^4
2000
1500
1000
500
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
LANDSCAPE UNIT
Dissected Tablelands
Valley Alluvium
Dissected Canyonlands
Rounded Uplands
RIVER STYLE
Plane Bed Canyon
Alluvial Meandering
Forced Meander
Pool Riffle
Forced Meander
VALLEY WIDTH (m)
50
0
50
C
LU
C
PC
C

# WAYS A RIVER CAN ADJUST LOCALLY




- Adjustments (Erosion/Deposition)
  - Channel morphology
    - Channel Size
    - Channel Shape
  - Bed Character
  - Planform
  - Arrangement of geomorphic units
- An adjustment is not a *change* in river type!
- "River *behavior* equates to adjustments around a characteristic assemblage of geomorphic units"

# FORMS OF ADJUSTMENT TO CHANNEL SHAPE




- Geomorphologists have lots of special names for things…
- Basically, all expressions or special cases of erosion or deposition

From Brierley & Fryirs (2005)

**Table 5.2** The natural capacity for adjustment of rivers in different valley settings.

| Valley setting | Bed character | Channel morphology | Channel planform | Natural capacity for adjustment (bandwidth) and river sensitivity |
|---|---|---|---|---|
| Confined | Grain size, sorting, and hydraulic diversity are constrained by bedrock, restricting adjustments to local reworking of transient bedload fluxes. | Channel size, shape, and bank morphology are imposed by bedrock or ancient materials. Bank erosion is negligible. Local slope and forcing elements such as woody debris induce the pattern of geomorphic units, such as the spacing of step–pool sequences. | No potential to adjust the number of channels, sinuosity, or lateral stability. Geomorphic units are largely imposed forms. Riparian vegetation is not a significant control on geomorphic structure. | Limited (narrow band) Resilient |
| Partly-confined | Bed often constrained by bedrock. Gravel-bed rivers have well-segregated point bars, riffles, etc. that induce significant hydraulic diversity. Surface–subsurface textural variability may be significant. Bed adjustments are dependent on material availability and the history of bedload transporting events. | Channel width and shape are adjustable where floodplain pockets occur; otherwise they are constrained by bedrock or ancient materials along the valley margins. Bank erosion is restricted to areas where floodplain pockets occur. Instream geomorphic units adjust locally where space permits. | Local potential for lateral or downstream translation of bends, but largely constrained by bedrock. Floodplain pockets may be prone to scour, stripping, and reformation. Adjustments are restricted to areas where floodplain pockets occur. | Localized (relatively narrow band) Moderately resilient |
| Laterally-unconfined, high-energy with continuous channel(s) | Grain size, sorting, and hydraulic diversity may be constrained by coarse sediments that armor the bed. Transient bedload fluxes induce significant local | Channel size and shape can adjust laterally and vertically over the valley floor. Moderate potential for bank erosion. Largely bedload dominated geomorphic units. | Significant potential for adjustment to the number, sinuosity, and lateral stability of channels. May be considerable variability in floodplain geomorphic units, with significant potential for floodplain reworking. | Moderately significant (moderately wide band) Moderately sensitive |

- Limited adjustment potential (resilient)
- Localized adjustment potential (moderately resilient)
- Significant adjustment potential (sensitive)

# Disturbance Regime

| River Style | Disturbance | Disturbance Frequency | Disturbance Magnitude |
|---|---|---|---|
| Step/Cascade | Fire | Low | High |
| | Landslide | Low | High |
| Forced Meander | Fire | Low | High |
| | Landslide | Low | High |
| | Road | Regular | Moderate |
| Plane Bed Canyon | Landslide | Low | High |
| | Fire | Low | High |
| Imposed Form Straight | Grazing | Regular | High |
| Imposed Form Sinuous | Grazing | Regular | High |
| Pool Riffle | Grazing | Regular | Moderate |
| Intact Valley Fill | Fire | Low | High |
| Alluvial Pool Riffle | Grazing | Regular | Moderate |
| | Grazing | Regular | Moderate |
| | Roads | Regular | Moderate |
| | Mining | Low | High |
| Meadow Meandering | Flood | High | Low |
| | Grazing | Regular | Moderate |

Table 11: Observed disturbances to each River Style across the study basins. Note that floods are a common disturbance to each River Style, and (based on their individual recurrence interval) occur with regularity or rarity and act to shape stream channels.

# River Styles Framework

**STAGE 1**

Catchment-wide baseline survey of river character and behaviour and classification of River Styles®

⇓

**STAGE 2**

Catchment-framed assessment of geomorphic river condition, analysed in terms of the potential for adjustment and associated geoindicators for each River Style®

⇓

**STAGE 3**

Assessment of the future trajectory of change and geomorphic river recovery potential, framed in terms of evolutionary adjustments of each reach, related to catchment-wide geomorphic changes

⇓

**STAGE 4**

River management applications and implications: catchment-based vision building, identification of target conditions and prioritisation of management efforts

# Priority Reaches

| River Style | Adj. Potential | Current Cond. | Primary Disturbances | Priority |
|---|---|---|---|---|
| Step/Cascade | Low | Good | Timber Harvest | Low |
| Forced Meander | Low | Good | Timber Harvest | Low |
| Plane Bed Canyon | Low | Good | Roads | Low |
| Imposed Form Straight | High | Poor | Grazing, Agriculture, Sediment | High |
| Imposed Form Sinuous | High | Poor | Grazing, Agriculture, Sediment | High |
| Pool-Riffle | High | Moderate | Grazing | Moderate |
| Intact Valley Fill | Low | Good | Grazing | Low |
| Alluvial Pool-Riffle | Moderate | Moderate | Mining, Grazing, Roads | Moderate |
| Meadow Meandering | Moderate | Moderate | Grazing | Moderate |

Table 12: Suggested restoration/management priority for River Styles across the study basins, based on the adjustment potential of each style and its current geomorphic condition.

# Displaying Habitat Indicators

- Multi-scale and multi-indicator display
- Watersheds, sub-basins, and basin-scales
- Support for resource managers, expert panel members, and regional decision makers
- High-level graphic and map-based displays
- Ability to drill into the finer resolution of indicators, metrics, and measurements

* Presentation is based on limited requirements analysis. Further discussion is needed to refine requirements and scope.

# Develop as a Multi-phase Approach

Phase 1 - Import habitat indicators generated by statistician and display indicators in interactive graphs and maps

Phase 2 - Automate habitat indicator calculation and importing procedures

Phase 3 - Generate fish production estimates using fish-habitat model

Phase 4 - Automate pulling fish metrics from external sources to parameterize fish-habitat models

* Presentation is based on limited requirements analysis. Further discussion is needed to refine requirements and scope.