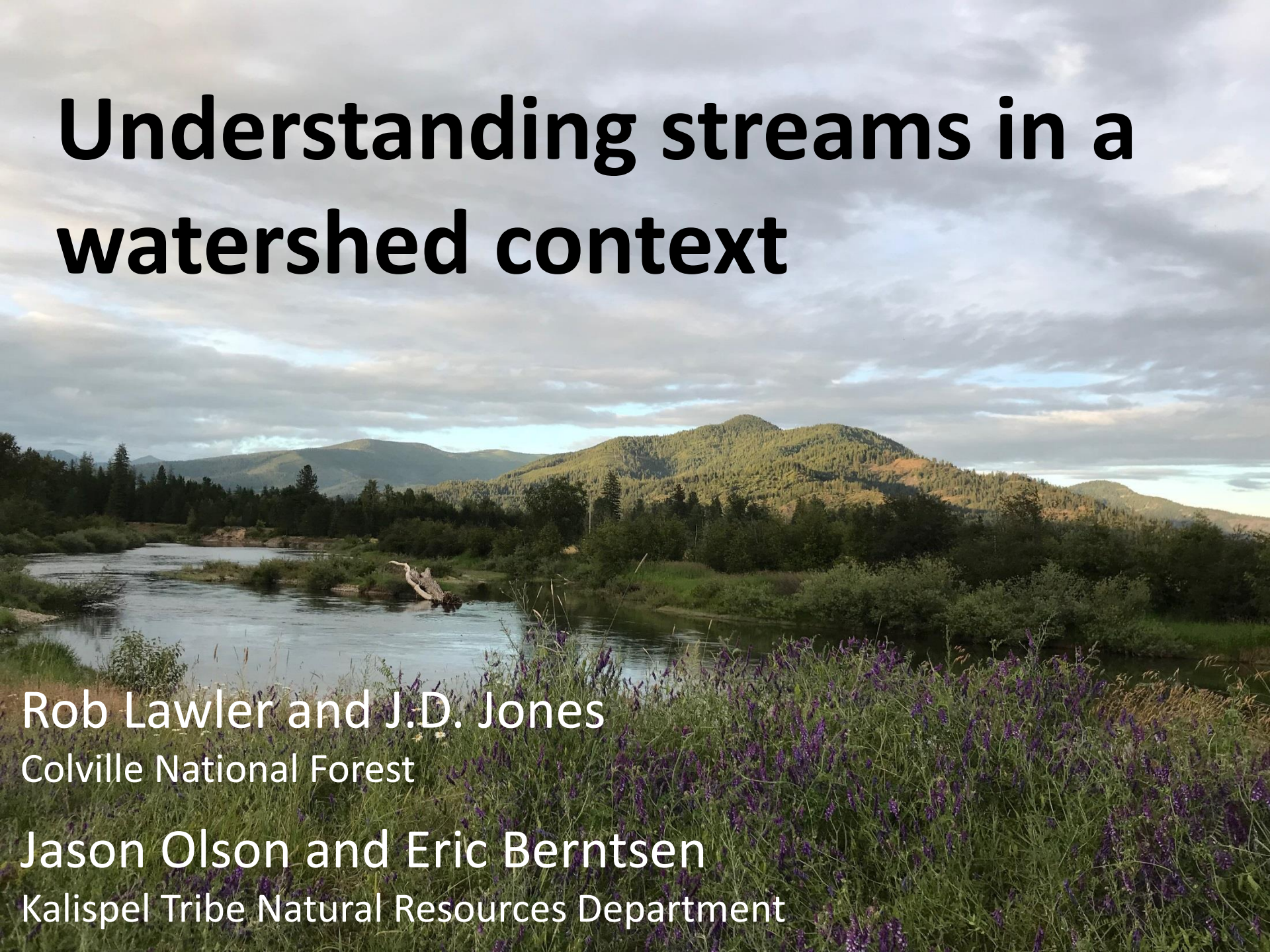
Understanding streams in a watershed context



Rob Lawler and J.D. Jones
Colville National Forest

Jason Olson and Eric Berntsen
Kalispel Tribe Natural Resources Department

A stream vs. a watershed

A **stream** is a small water body with surface water flowing within the bed and banks of the channel. It exists by itself & joins with other streams to form a large river. It can be permanent or seasonal depending on source, climate & geography

vs.

A **watershed** is an area of land that drains all the streams & rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel.

Streams and the watersheds they drain form nested hierarchies

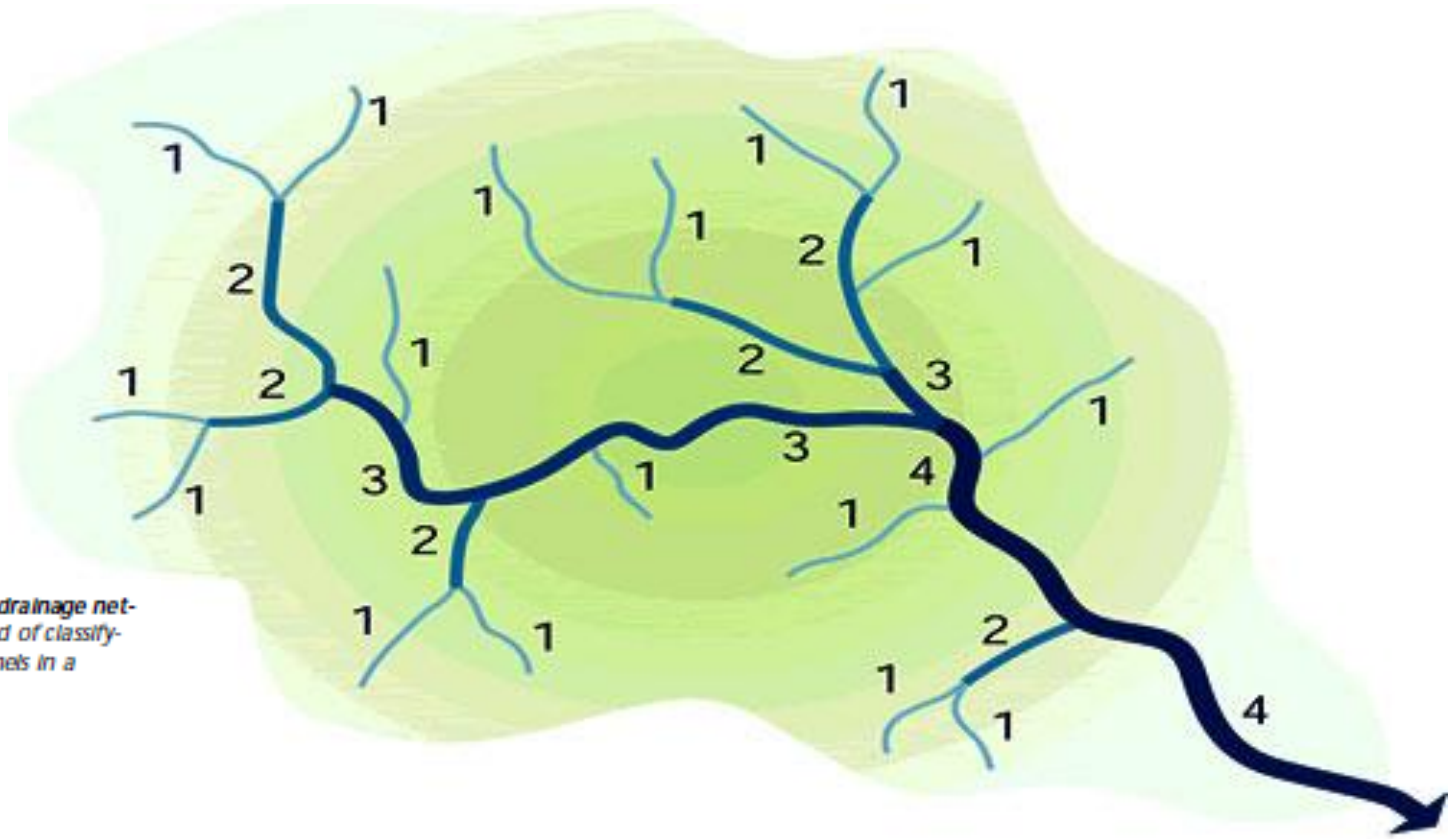
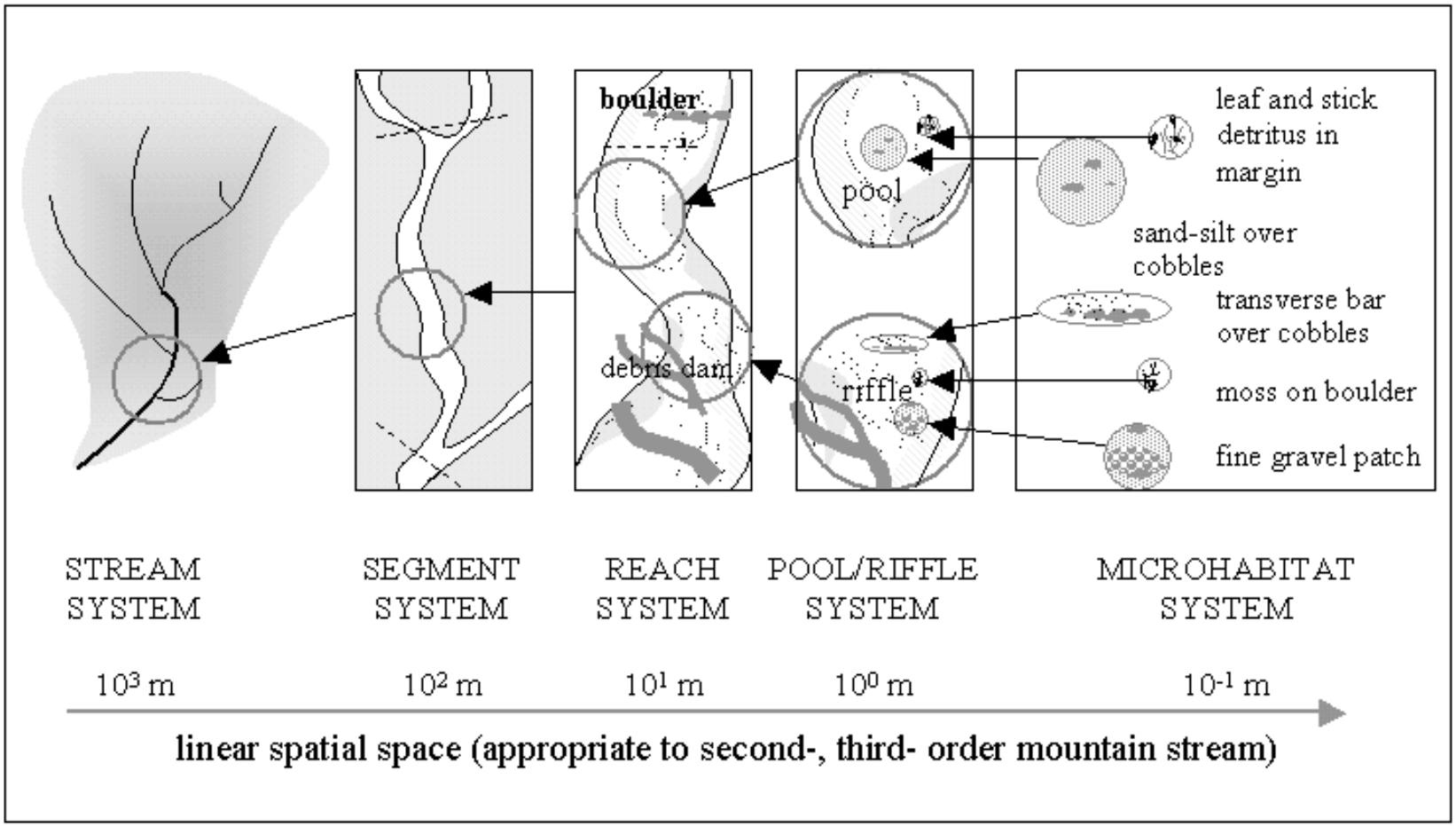


Figure 1.30: Stream ordering in a drainage network. *Stream ordering is a method of classifying the hierarchy of natural channels in a watershed.*

Image from the Prince William Conservation Alliance

The hierarchical organization of a stream system is a framework for analyzing processes at various spatial scales



Frissell et al. 1986

River continuum (longitudinal patterns)

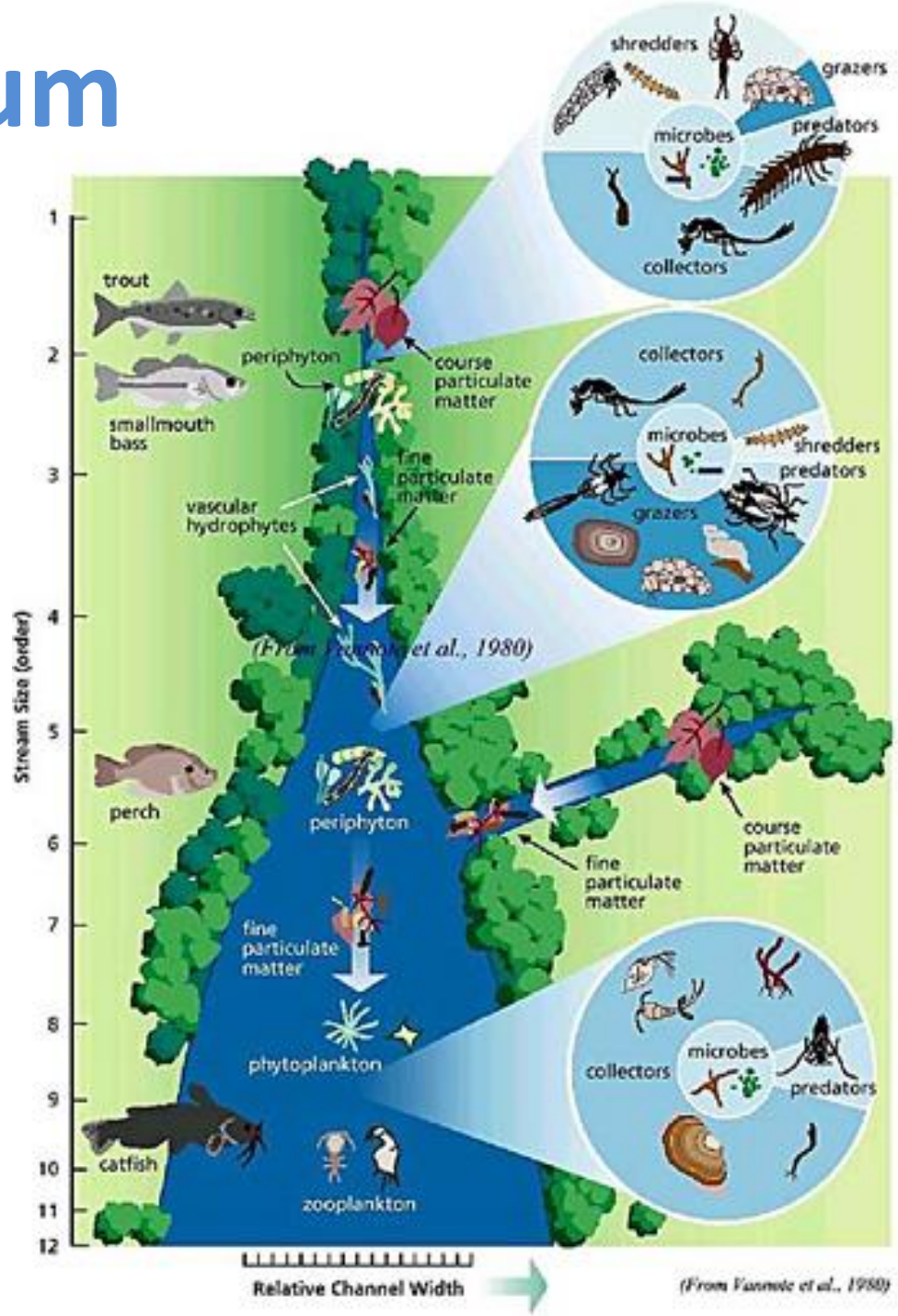
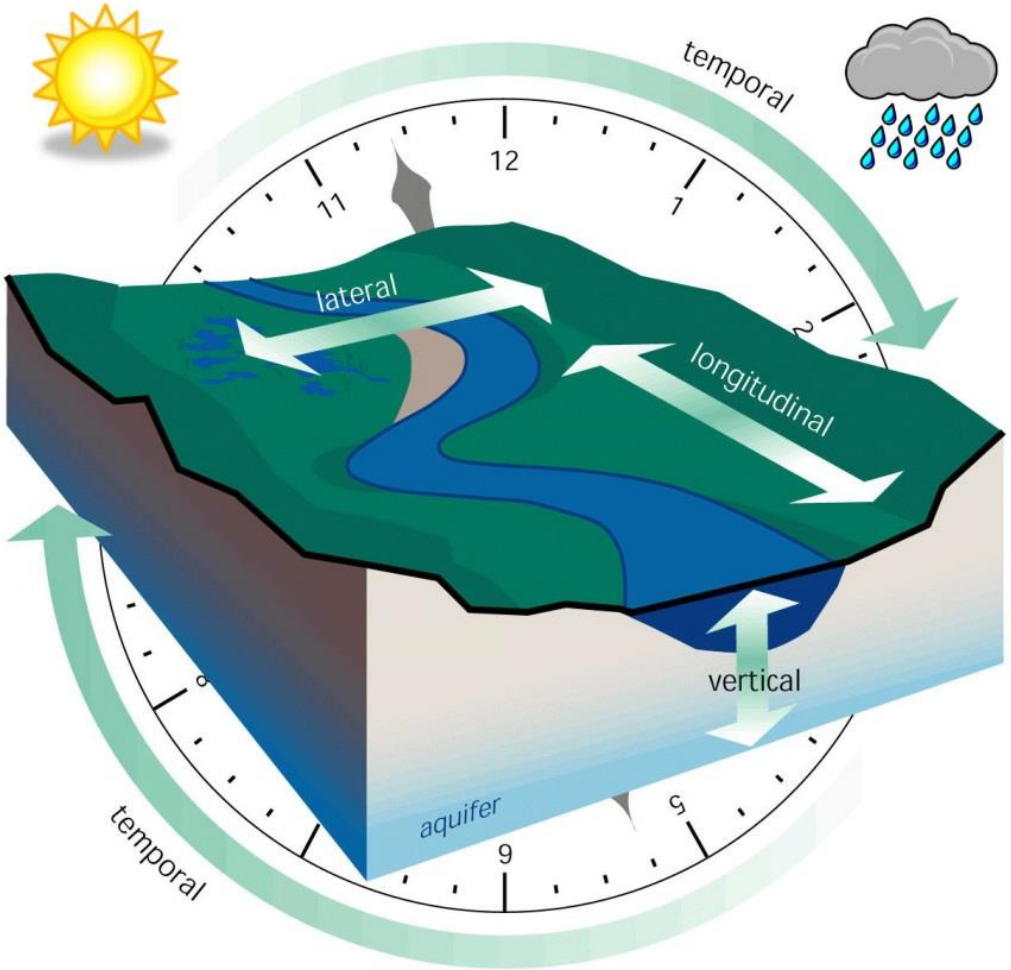


Image from stream Corridor Restoration: Principles, Processes, and Practices.

Streams and rivers are dynamic systems



google

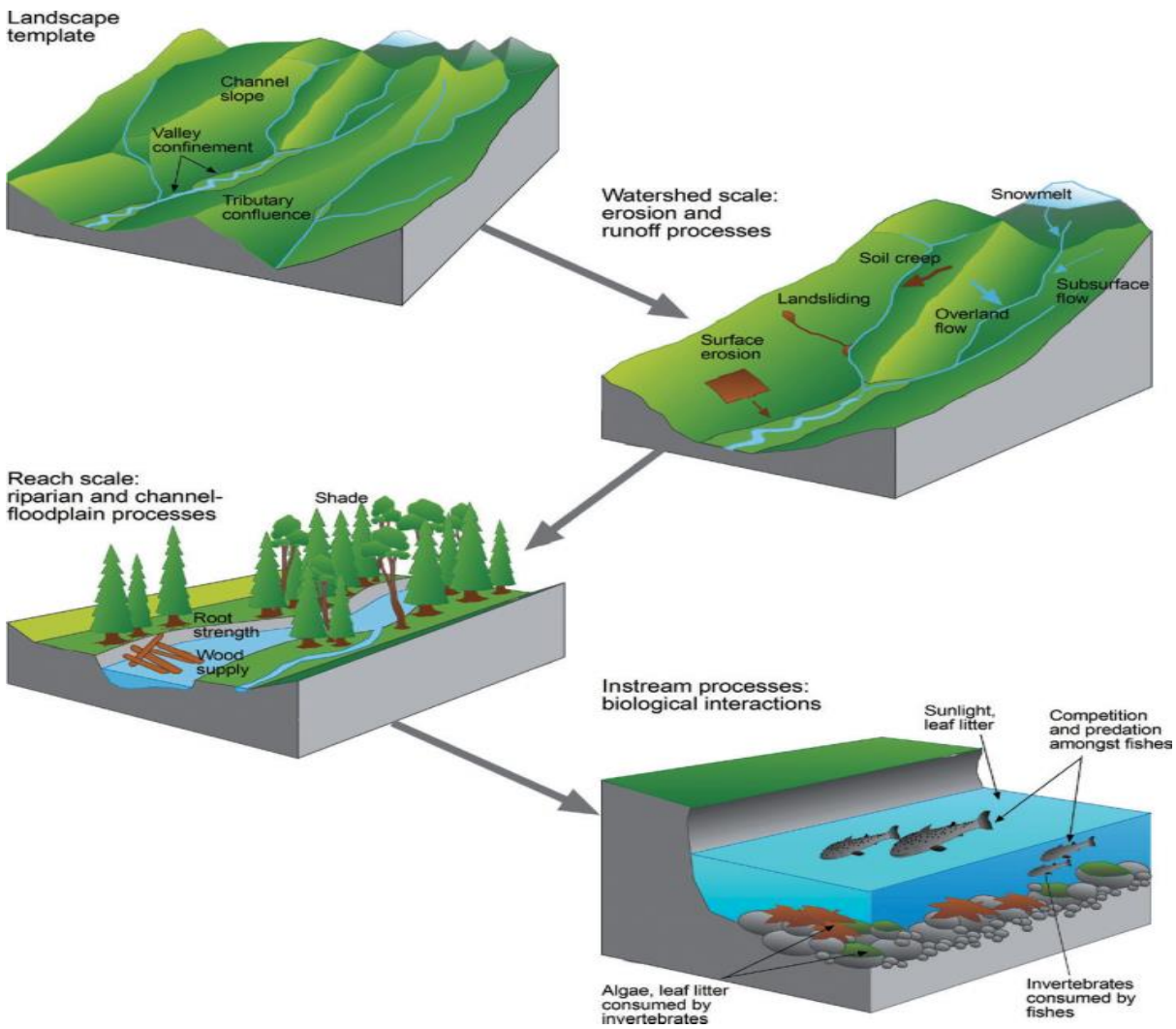
Source: *Stream Corridor Restoration (FISRWG)*

Addressing habitat restoration: restoring at the watershed and reach scale

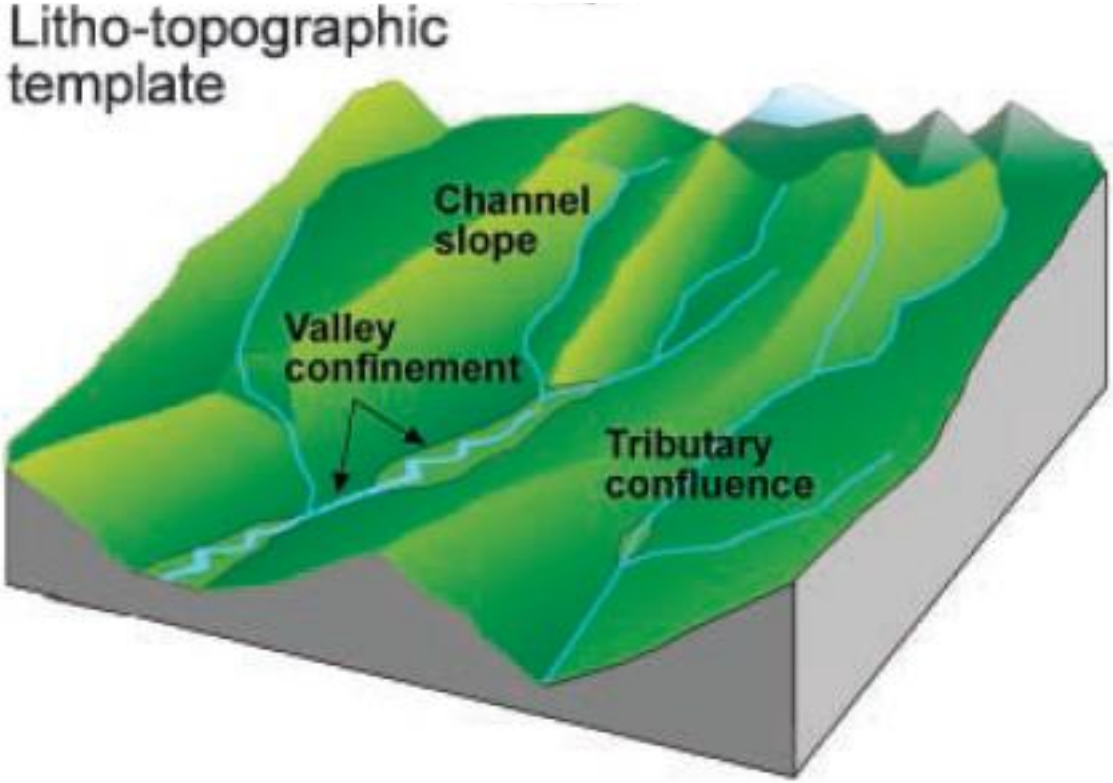
Methow River Salmon Recovery Foundation

USGS Elwha project

Hierarchical nature of watersheds and related watershed processes *(from Roni and Beechie 2013)*



Litho-topographic template



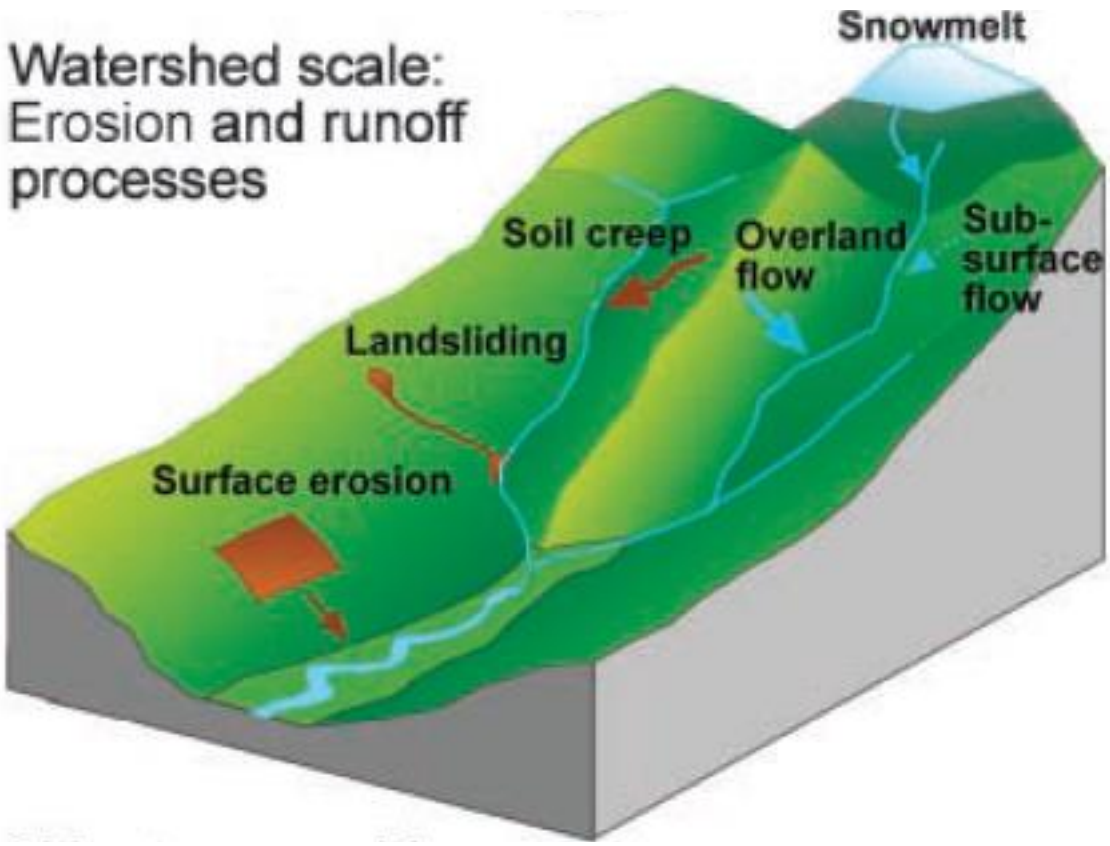
Driving variables controlled by the litho-topographic template:
- channel slope
- valley confinement

Landscape-scale processes:
- tectonics
- erosion

Spatial scale of processes:
$> 10^1$ km^2

Temporal scale of processes:
$> 10^3$ years

Watershed scale processes

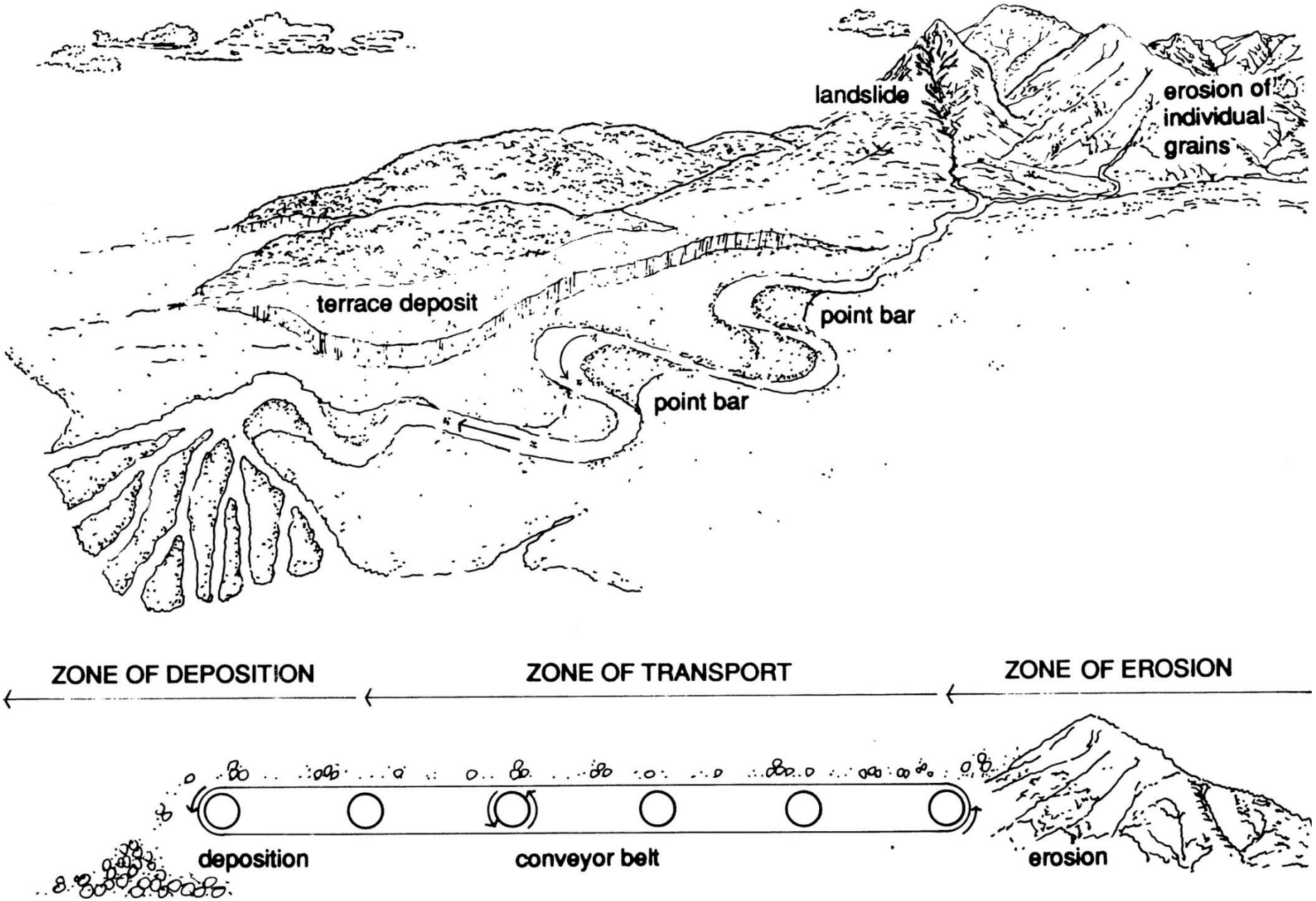


Driving variables controlled by watershed-scale processes:
- sediment supply
- discharge

Watershed-scale processes:
- runoff processes
- erosion

Spatial scale of processes:
10^{-1} – 10^{4} km^2

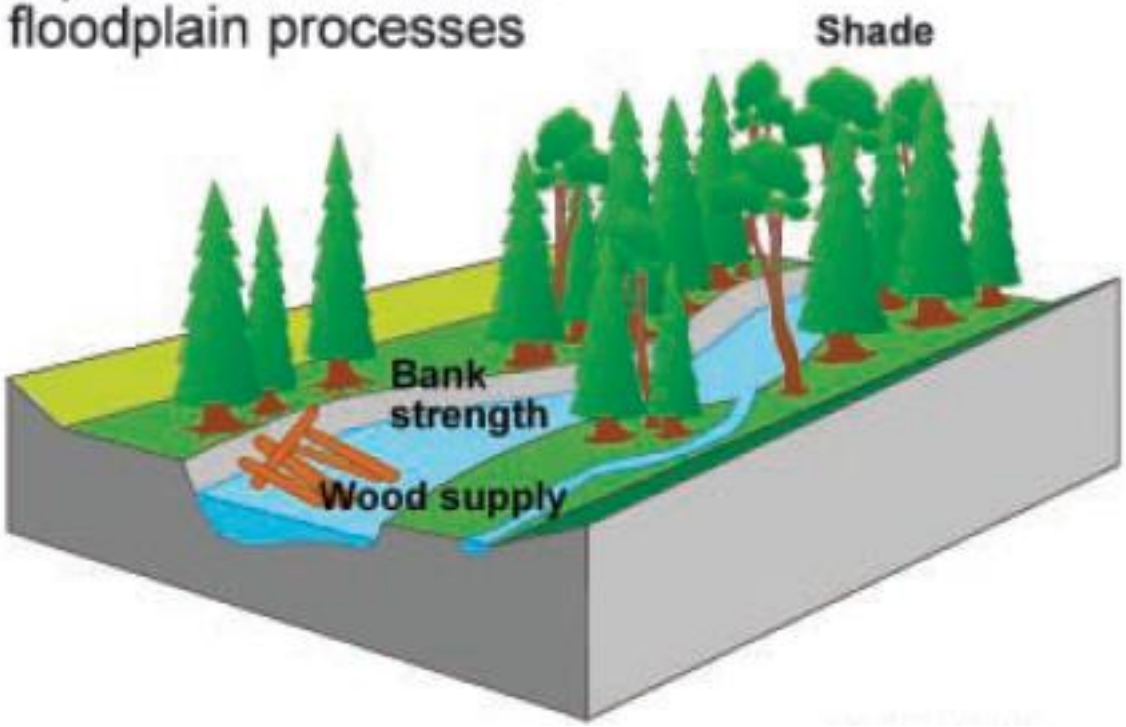
Temporal scale of processes:
10^{-1} – 10^{2} years



(*Kondolf 1997*)

Reach scale processes

Reach scale:
Riparian and channel-floodplain processes



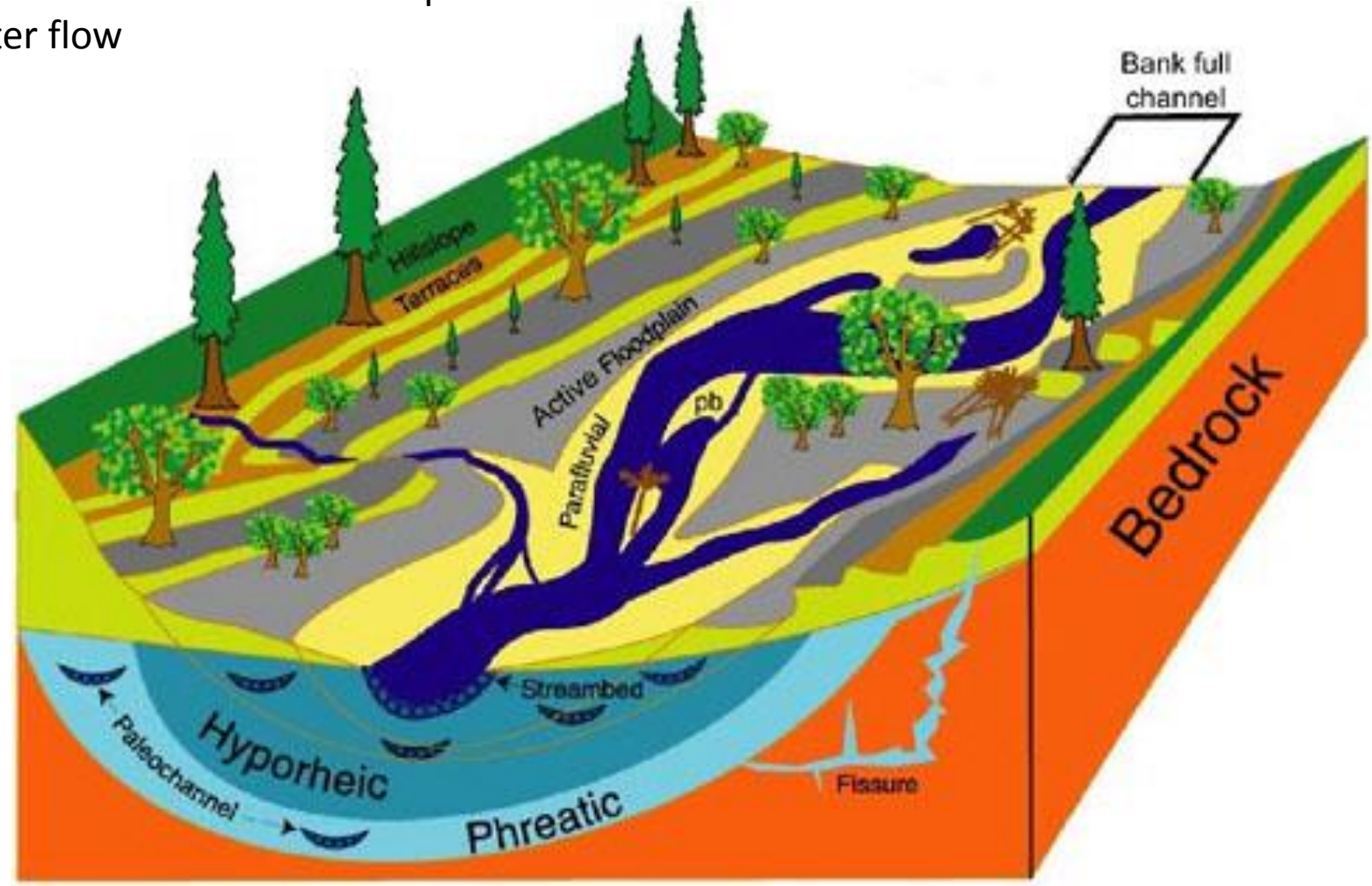
Driving variables controlled by reach-scale processes:
- root reinforcement
- wood supply

Reach-scale processes:
- riparian processes
- channel-floodplain interactions

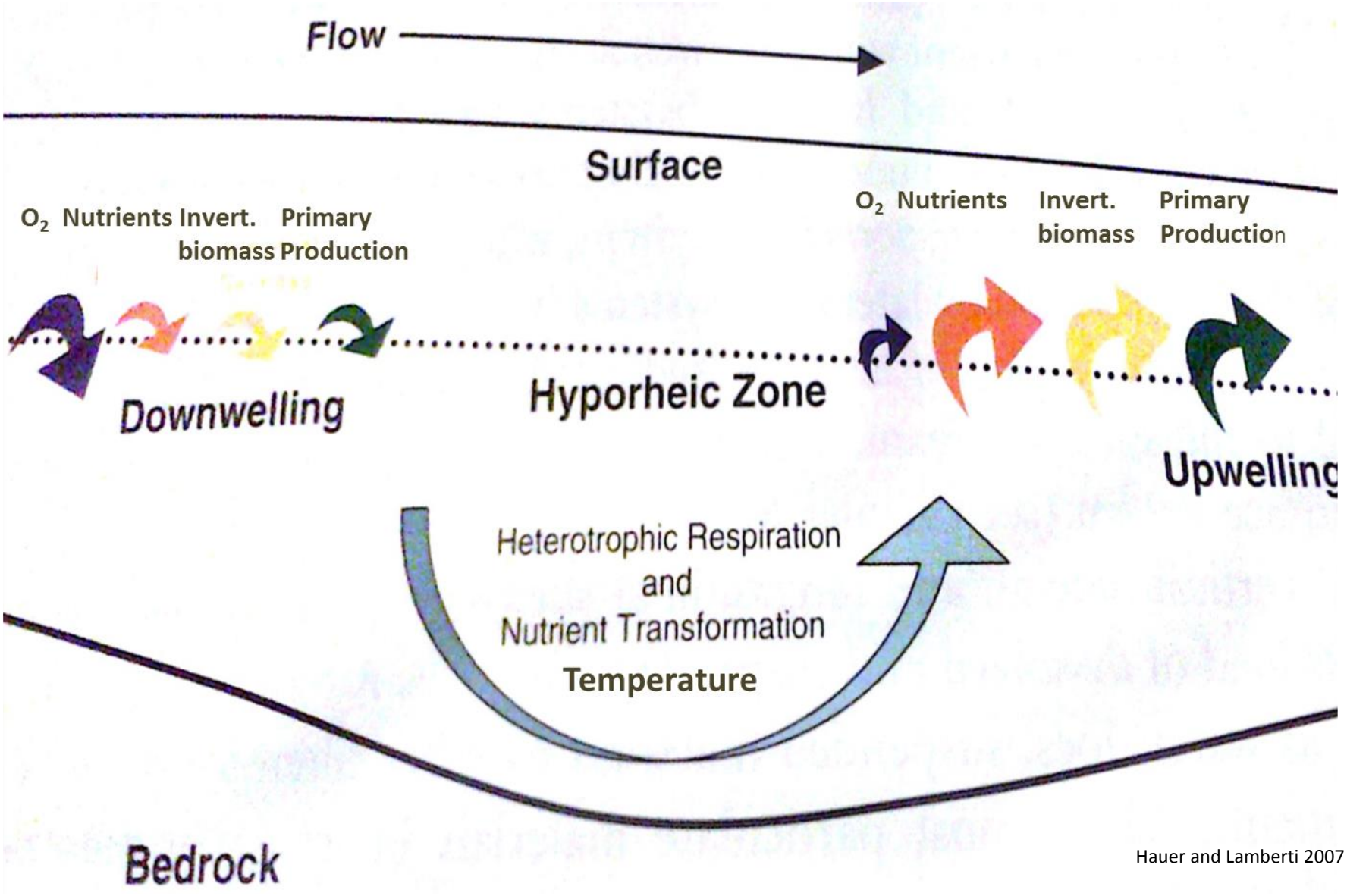
Spatial scale of processes:
10^{-1} – 10^{1} km^2

Temporal scale of processes:
10^{-1} – 10^{1} years

The hyporheic zone is defined by the penetration of river water into the alluvium and may mix with ground water from hillslope or other aquifers not directly recharged by the river. Alluvial aquifers usually have complex bed sediments with interstitial zones of preferential groundwater flow

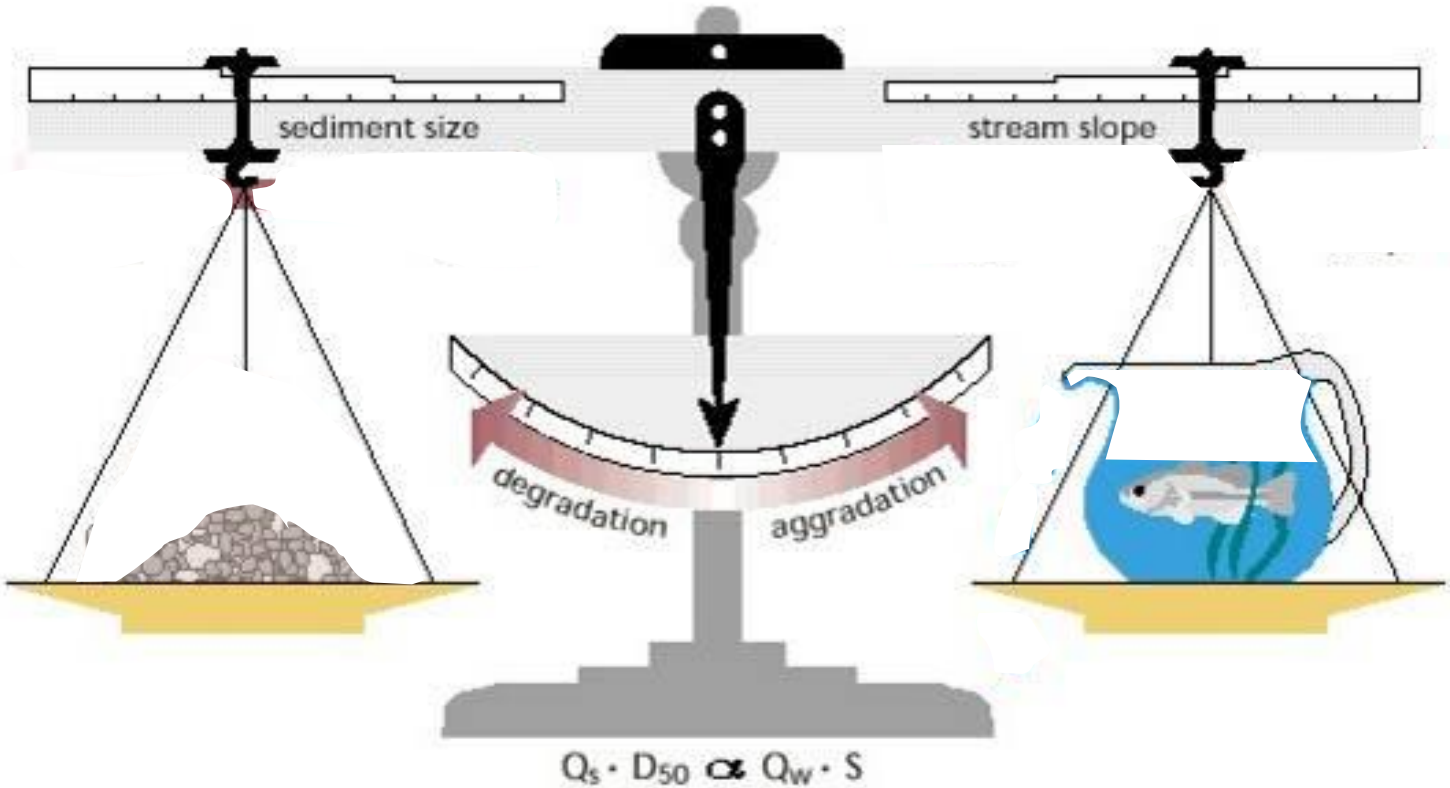


Groundwater-surface water exchange



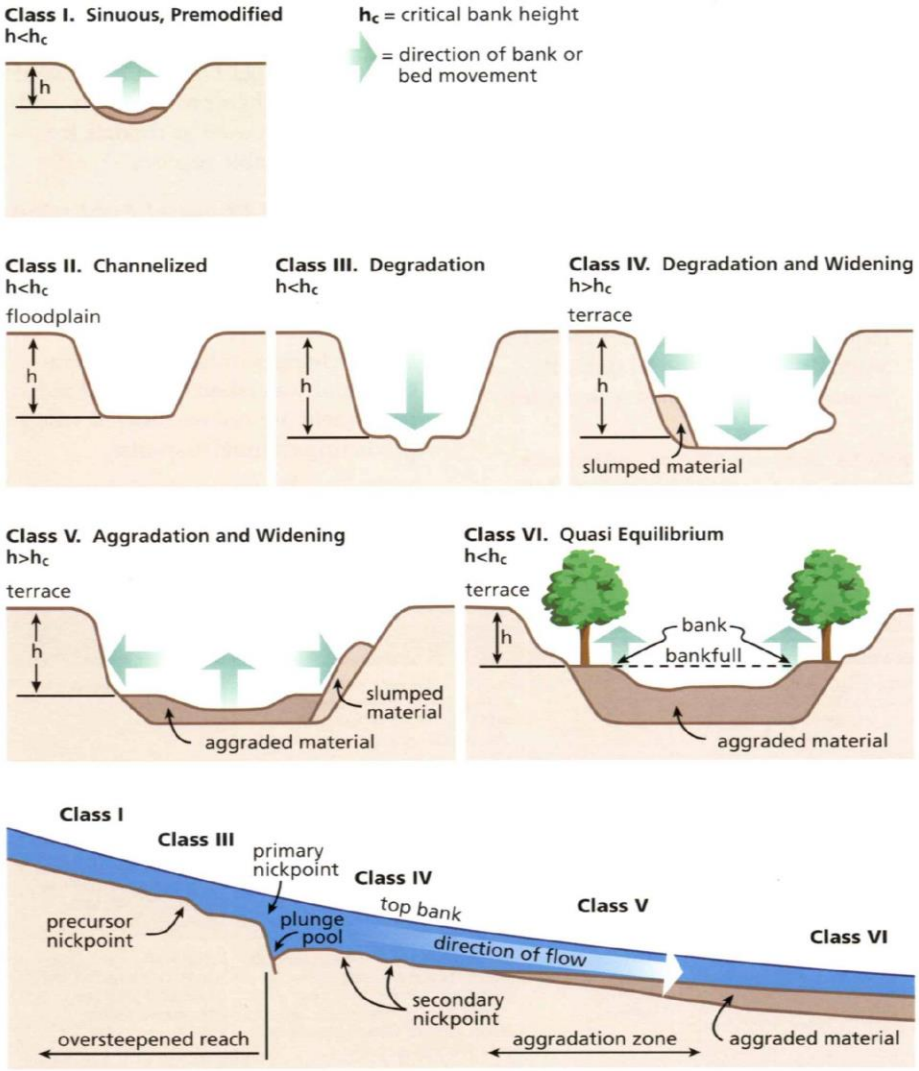
Hauer and Lamberti 2007

Lane's diagram by Rosgen (1996)



Over time channel geometry (width, depth, gradient) adjusts to be in equilibrium with flow and sediment regime.

Channel evolution model

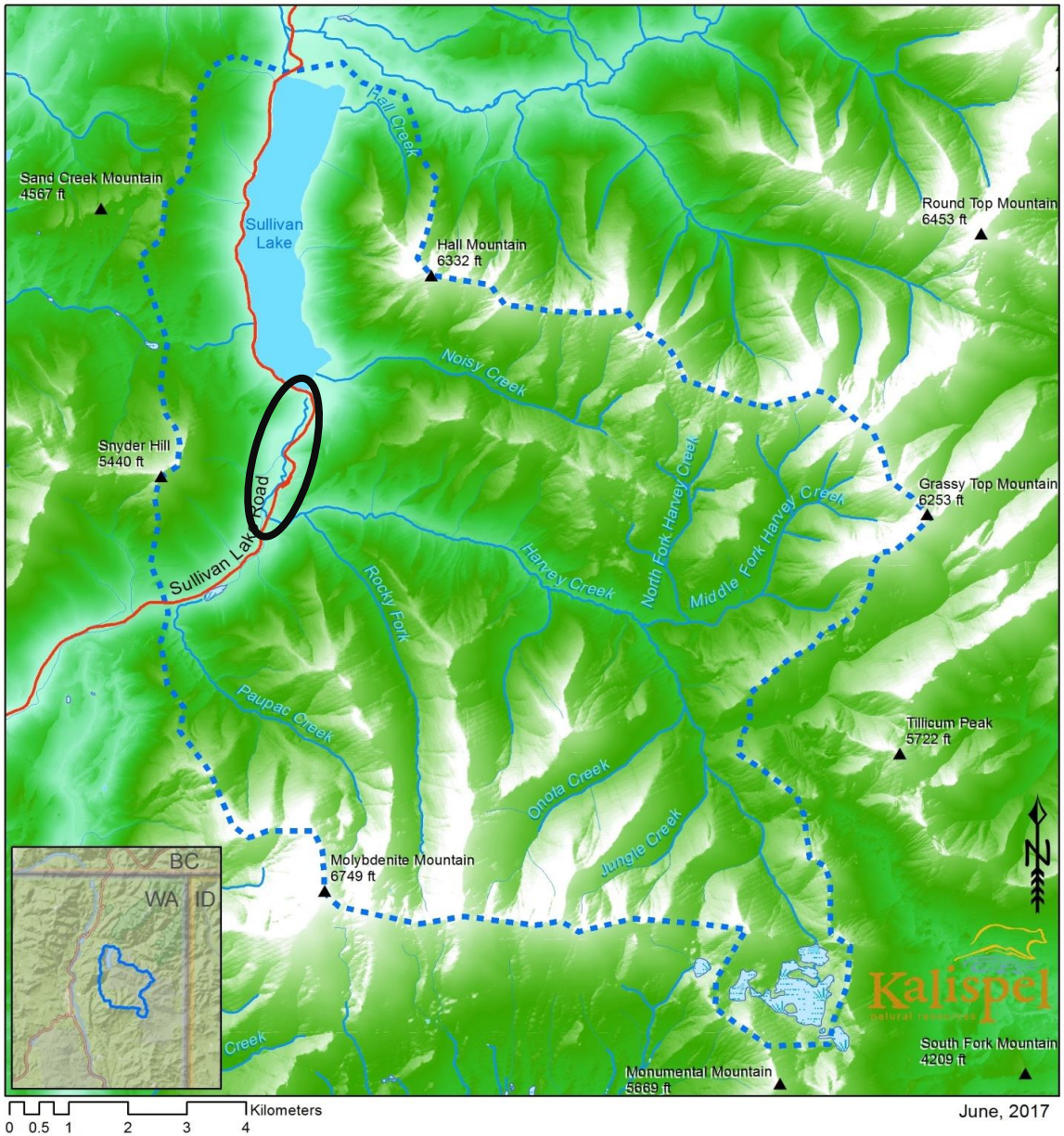


Linking actions to ecosystem response (*from Bohn and Kershner 2002*)

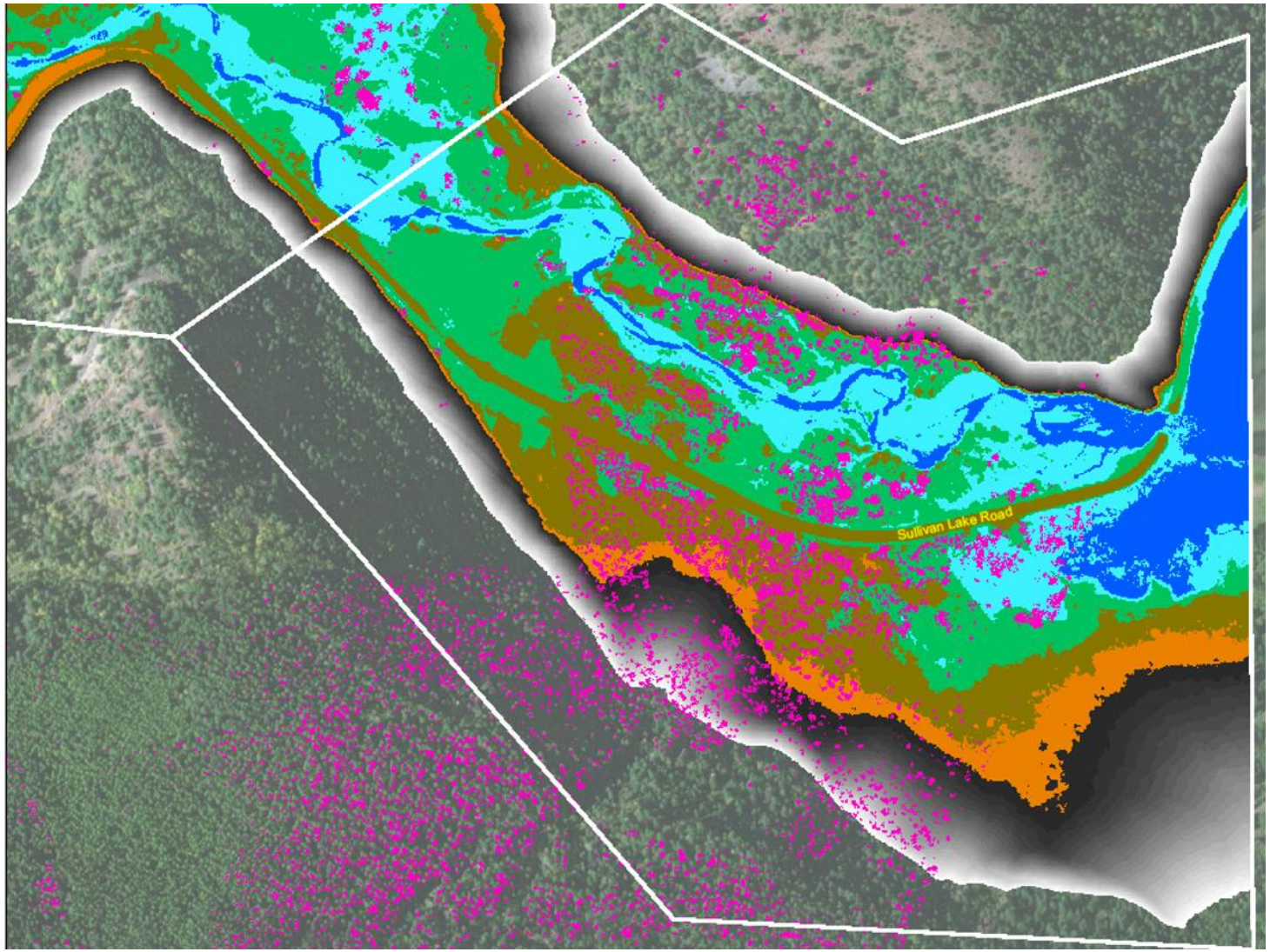
If restoration or change in management leads to this...	And this occurs...	Then the expected ecosystem response would be...
Increased size and amount of wood available from the riparian zones	The material is incorporated into the active channel	Increased fish cover Increased pool frequency and quality Increased gravel storage Increased bed and bank stability
Decrease the amount of chronic sediment being delivered from landslides and hillslope erosion	The amount of large woody debris is increased in the channel	Increased pool frequency Retain and sort spawning gravels Reduce the amount of local channel filling with fine sediment
Remove man-caused fish passage barriers in the main channel and tributaries	Reduce the width-depth ratios via active restoration and enhanced riparian conditions	Fish access to all critical habitats within the watershed.
Decommission roads located on unstable geology and within the rain-on-snow zone	Disconnect hydraulic connections between the road and stream networks	Reduce the concentration of peakflows during storm events Reduce the amount of bank erosion and sedimentation to downstream reaches
Identify stream reaches on private property that are not functioning at their geomorphic potential	Landowners are organized into a watershed group that can effectively work together to accomplish restoration goals	Reduce the overall sediment delivery Improve aquatic habitats in critical lower reaches Improve riparian habitats on private property

Harvey Creek Watershed

Pend Oreille County, Washington



Restoration example–floodplain reconnection

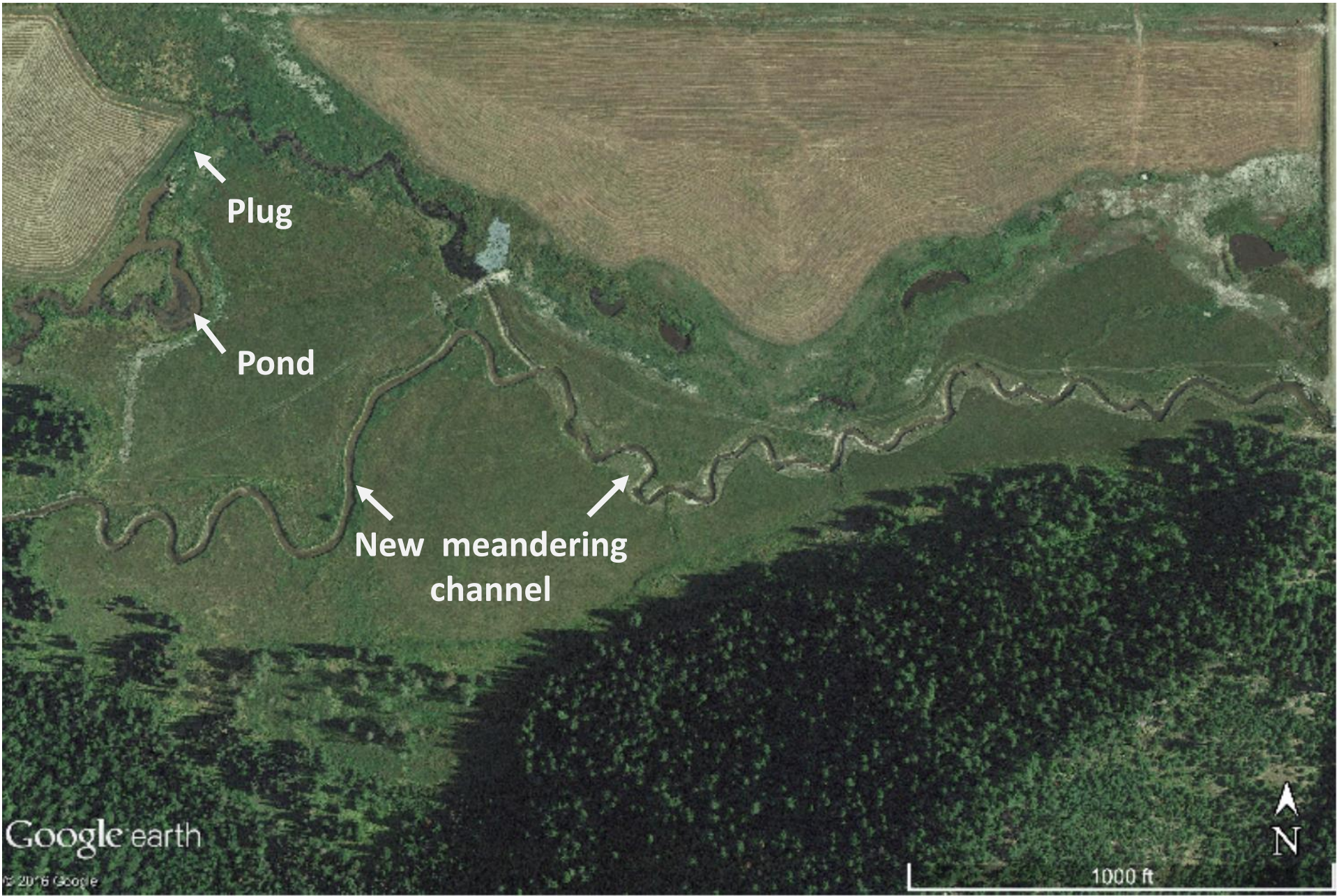


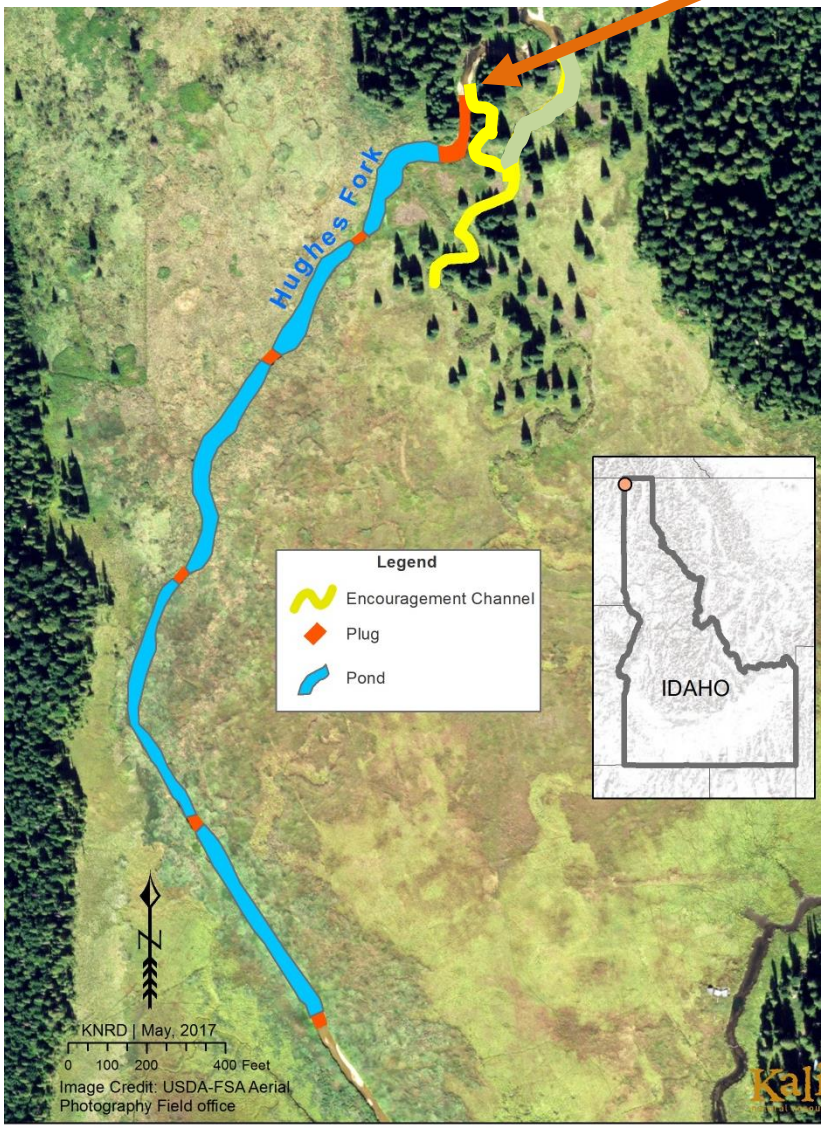
30m+ tree height
Section
Relative elevation (in meters)
<
0
+1
+2
+3
+4
+5
+6
+7
+8
+9
+10
+11
+12
+13
+14
+15
+16
+17
+18
+19
+20
+21
+22
+23
+24
+25
+26
+27
+28
+29

N

0 25 50 100 150 200 250 300 Meters

Restoration example – ”Pond & Plug”

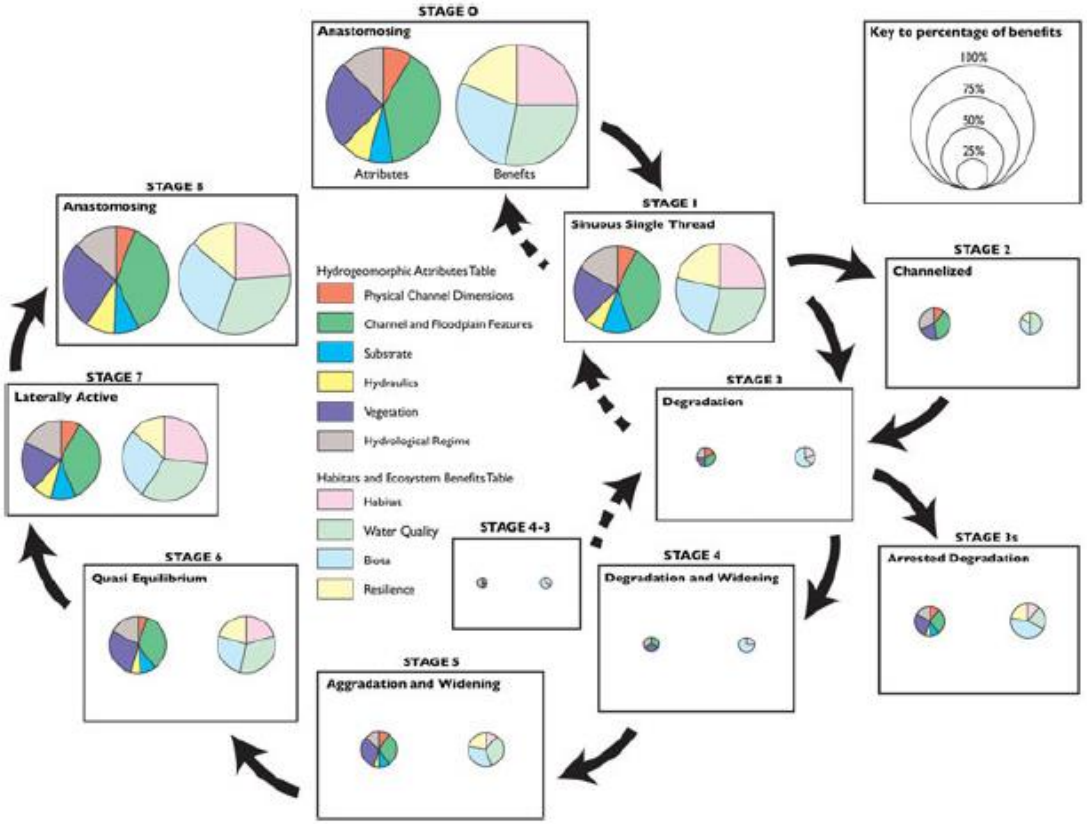




Restoration example – ”Pond & Plug”

Maximizing habitat and ecosystem benefit – Revised channel evolution model

(*from Cluer and Thorne 2014*)



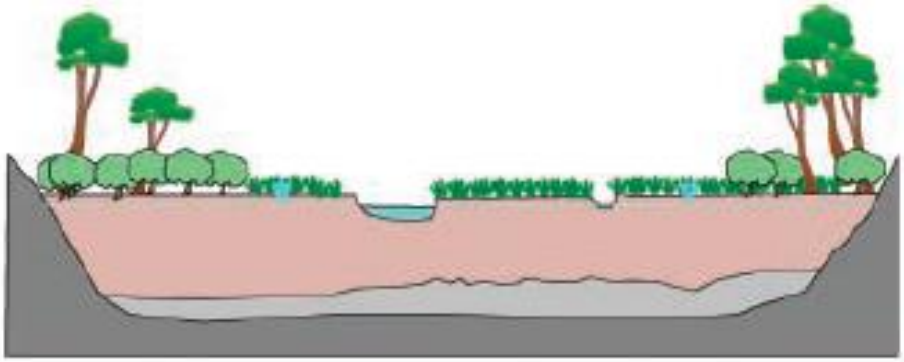
Fixing erosive roads

Photo credit: Lee Benda

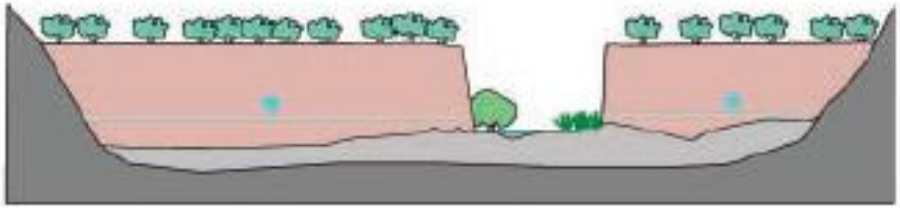
Restoration example– culvert removal

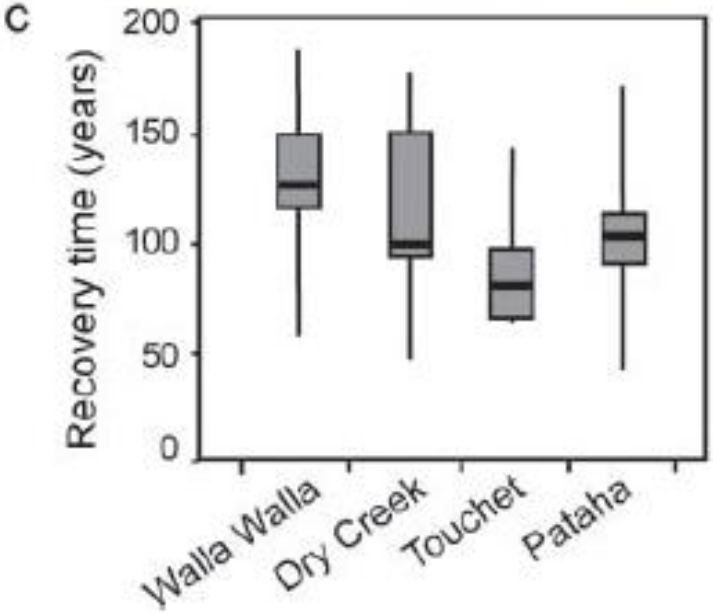
Restoration example – beaver dam analogs

Wet floodplain system:
- sedge meadows
- deep accumulation of sediments
- elevated water table



Incised channel:
- conversion to xeric vegetation
- lowered water table
- intermittent streamflow





Beaver dam analog in Goose Creek, Idaho

Things to consider…

- The litho-topographic template determines valley confinement and channel slope, which defines channel types, erosion and sediment supply, and runoff

- Streams and rivers are nested, hierachical, and dynamic systems and must be viewed and analyzed at various scales

- Restoration must be matched to the scale of the problem – if it ain’t broke, don’t fix it

Trails project aquatics analysis framework

- Watershed-scale analyses conducted at HUC-12 level – Project area located within six HUC-12 watersheds

- Each scale has key aquatic features and associated key questions, datalayers, and analysis tools

- Any proposed restoration actions must be matched to the scale of the problem and clear linkages to ecosystem response need to be made

Key Aquatic Ecosystem Feature	Key Questions	Datalayers	Analyses Tools
Watershed scale Runoff	How is development influencing the drainage network? How will vegetation management influence snow accumulation, retention, and runoff?	Roads, streams, DEM, vegetation cover, snow, soils	NRCS SNOTEL, runoff estimation for gaged and ungaged sites, watershed characterization, current-historic-future condition
Watershed scale Erosion and Sediment Supply	Which roads are contributing fine sediment to streams? Which roads interrupt wood and coarse sediment delivery to streams? What is the road sediment contribution relative to the overall sediment budget?	Roads, streams, DEM, soils, vegetation cover, surficial geology	Sediment yield methods, GRAIP-LITE
Reach scale Riparian conditions and wood supply	What is the current condition of riparian habitats to provide shade, wood, filter sediment, etc.?	Stream type, vegetation, grazing, large trees	Riparian mapping, LiDAR, current-historic-future condition
Reach scale Channel, Floodplain, and Habitat Dynamics (lateral and vertical connectivity)	How have human activities impacted the amount and function of floodplains?	Floodplains, DEM, roads, other human developments	Channel migration zone mapping, stream channel classification, LiDAR, in-channel surveys, active channel area
Reach scale Habitat Connectivity (longitudinal connectivity)	How have human developments affected aquatic organism passage? Do barriers prevent access to current and future cold water? Do barriers prevent invasive species range expansion?	Road-stream crossings, barrier inventory, current and potential fish habitat, cold water	Barrier data, field evaluations, intrinsic habitat potential
Reach scale Habitat for Listed Fish Species	What is the current distribution of listed fish? Are there key spawning and rearing habitats? Do invasive species limit listed fish habitats?	Current fish distribution, potential habitat, stream surveys, invasive species distributions	Fish distribution surveys, intrinsic habitat potential