Sediment transport and river management in the Upper Klamath Basin: a summary of issues related to why we sample sediment

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Outline

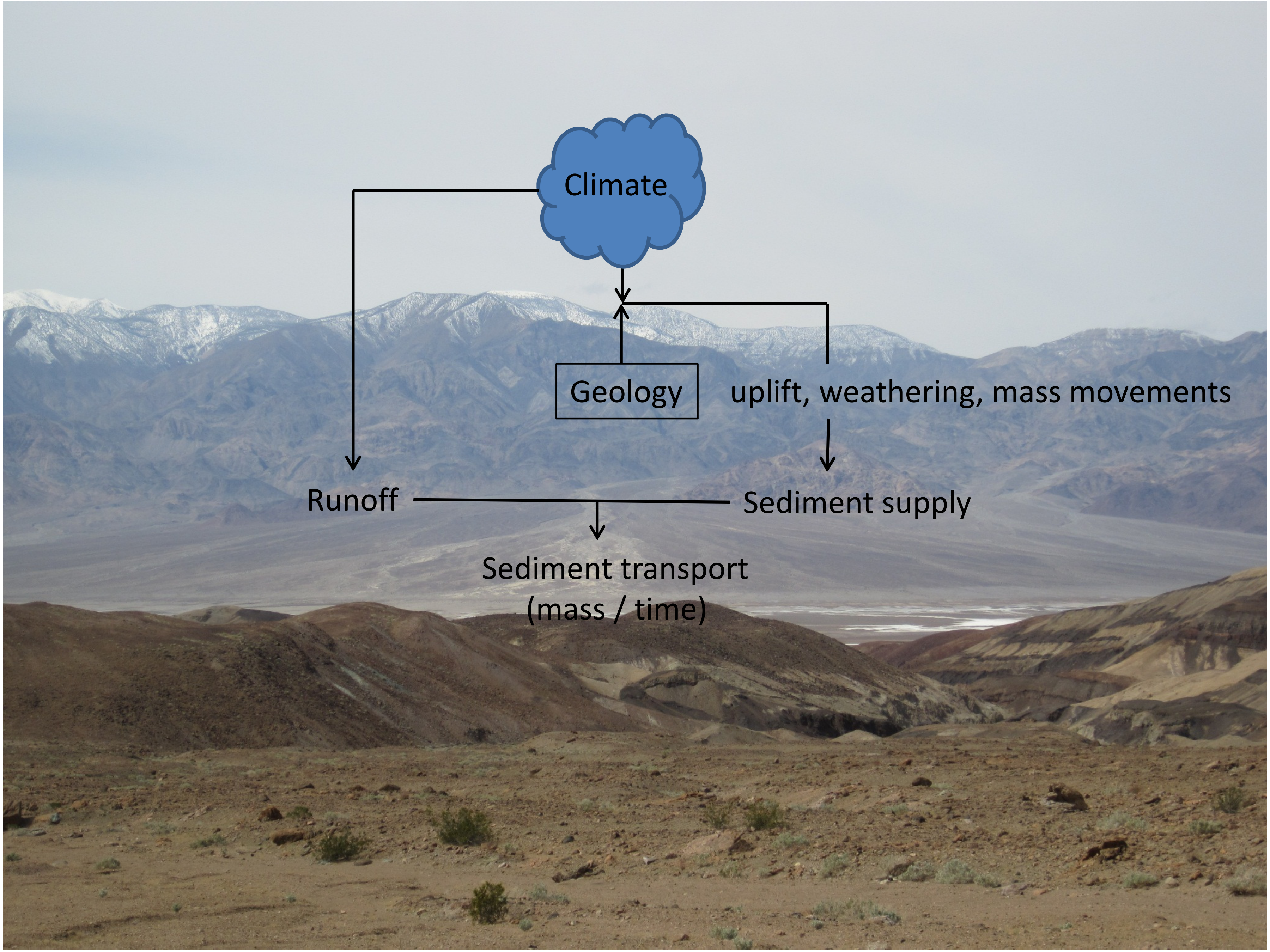
Basic theory of sediment transport and its relation to channel change

Geology and geomorphology of Upper Klamath Basin (UKB)

Overview of active research and management issues

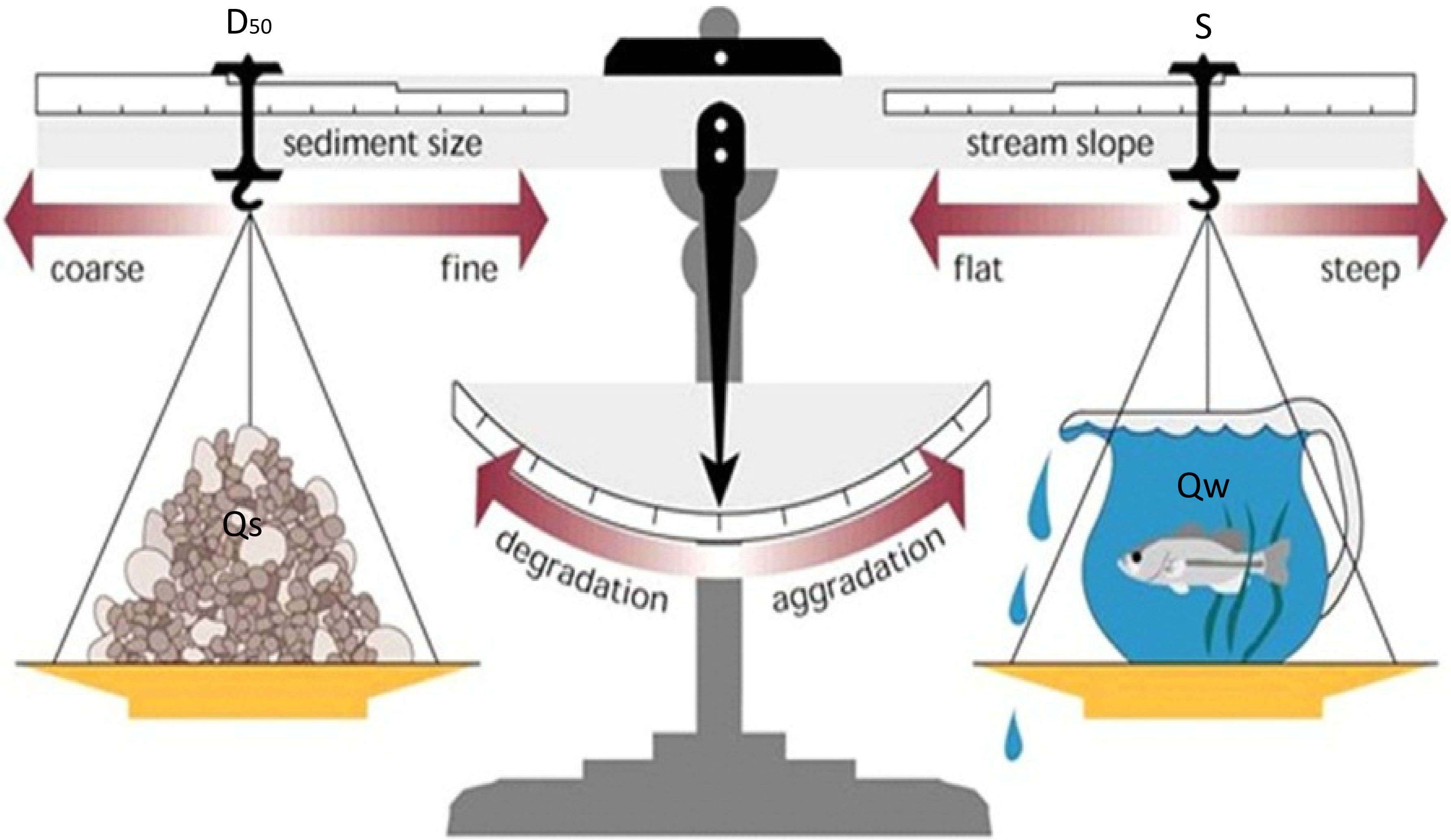
History and status of sediment transport measurement efforts in the UKB

Implications for future work

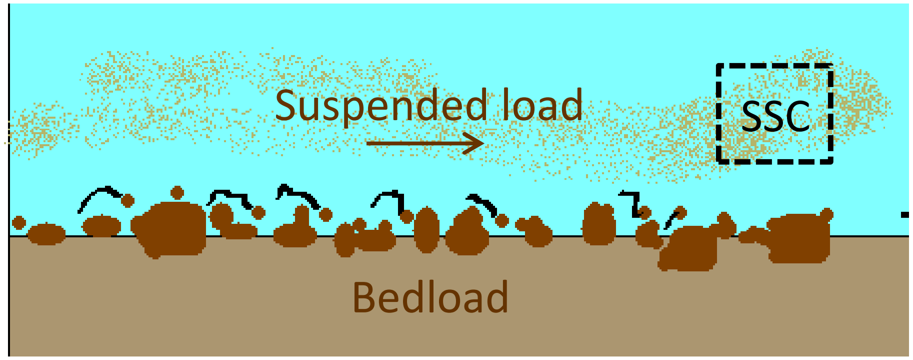

Climate
Geology
uplift, weathering, mass movements
Runoff
Sediment supply
Sediment transport
(mass / time)

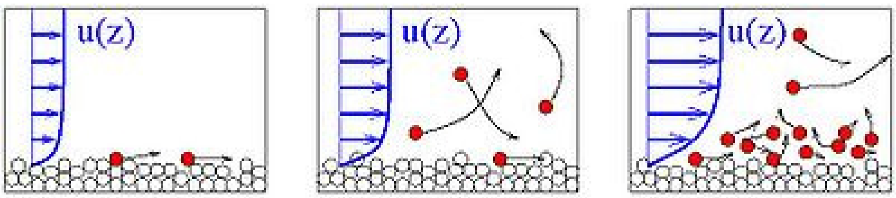
Relationship of variables affected channel erosion and deposition

(modified from, and based on, concepts presented by Lane, 1955)



$$Q_s \cdot D_{50} \propto Q_w \cdot S$$





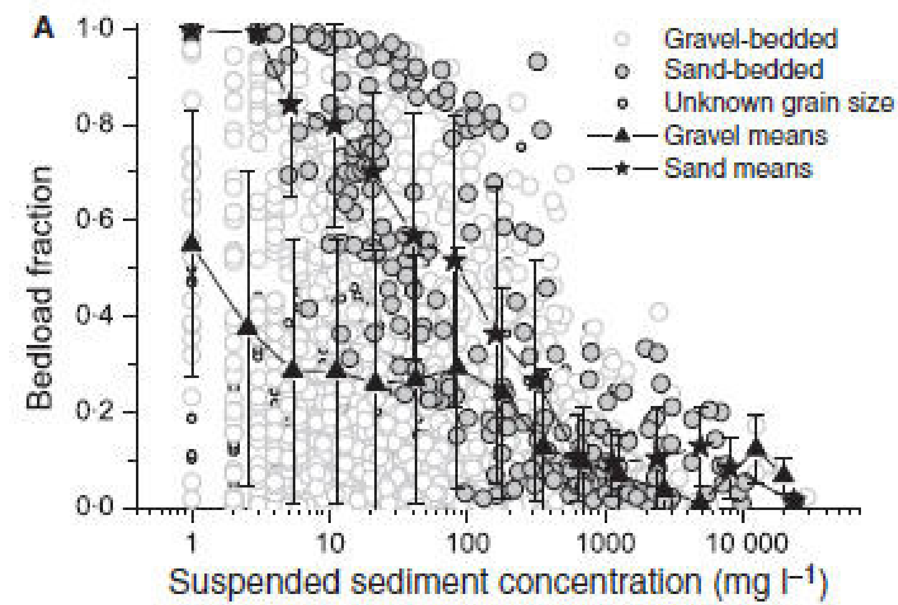
As velocity increases:

More bed friction

Overall sediment transport increases (although relations can be complex)

Proportion of bedload in total sed trans decreases

Turowski et al., 2010



"SSC"

Upper Klamath Basin Geomorphology:

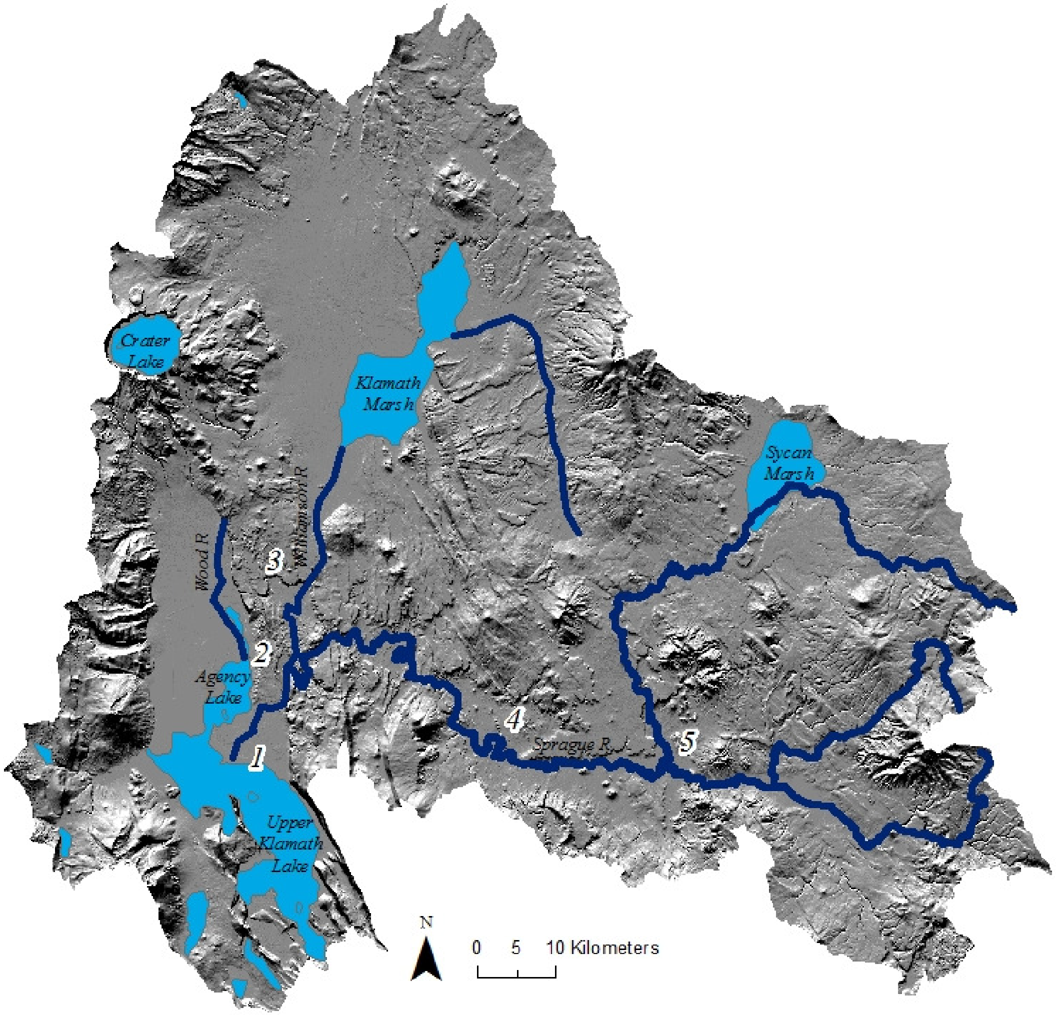
Nestled between Eastern Cascade Foothill (east) and Basin-and-Range (west) Provinces

Western edge is being tectoncially uplifted while the eastern edge is being pulled apart

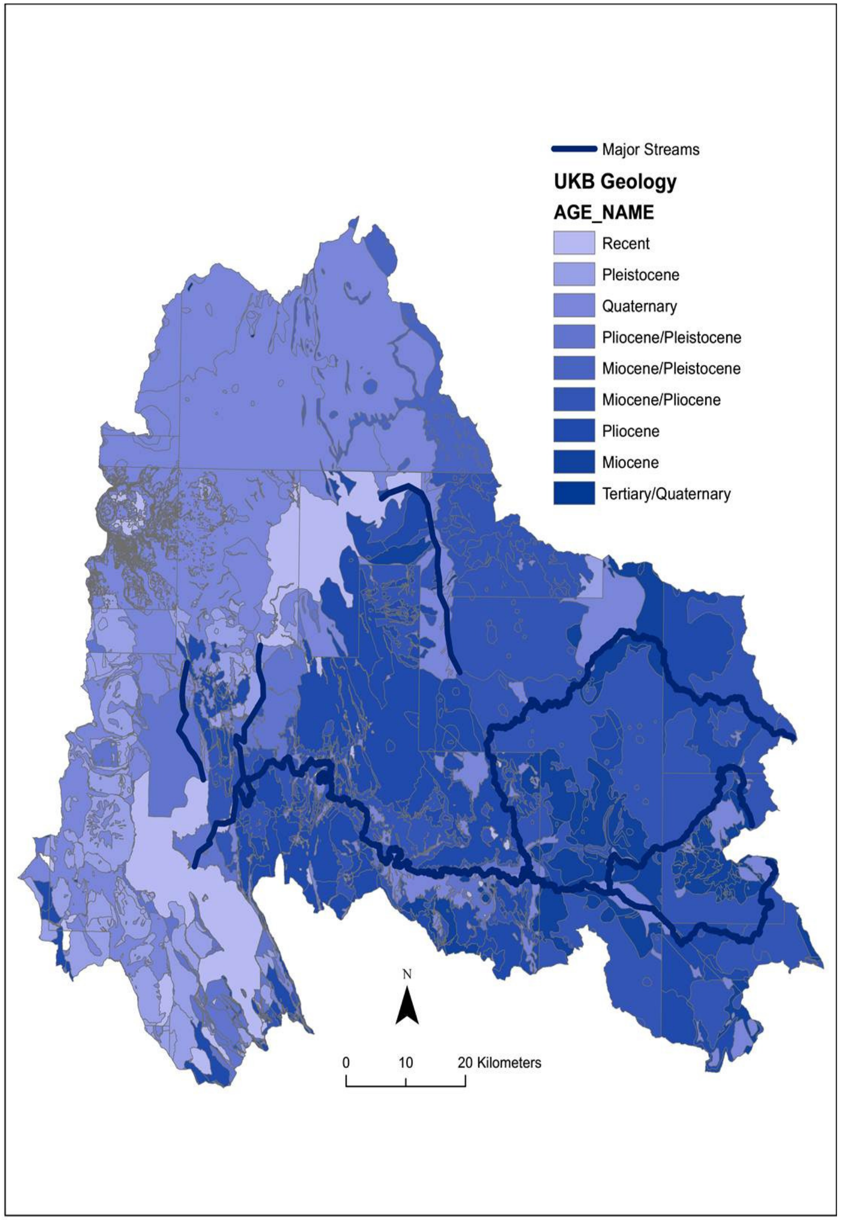
~5000 ft relief (Mt. Scott to UKL)

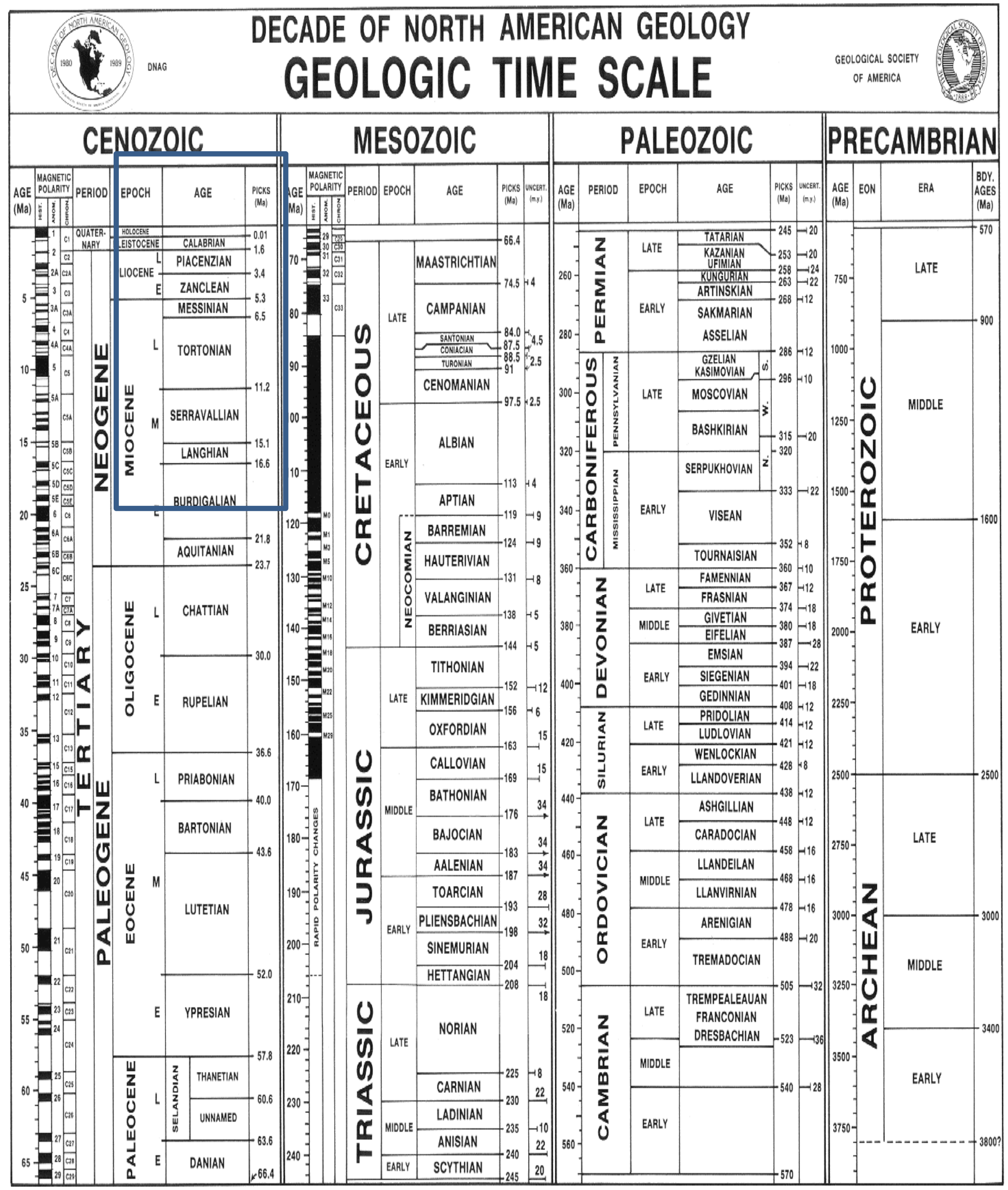
Extensive basins undergoing active sedimentation

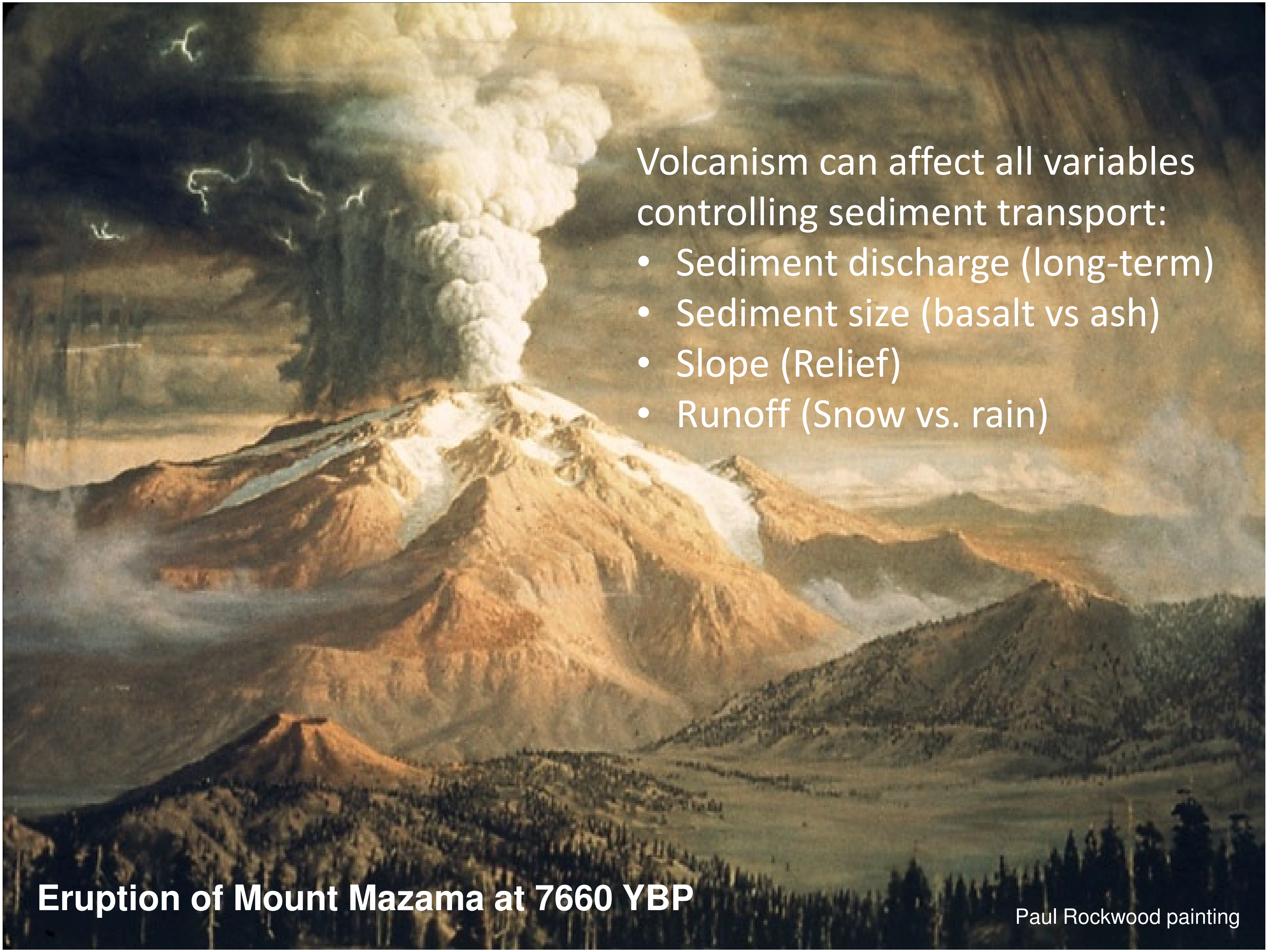
Lakes were once more extensive, valleys now dominated by extensive wet meadows and low-gradient channel systems



The UKB is geologically young






Volcanism can affect all variables controlling sediment transport:
• Sediment discharge (long-term)
• Sediment size (basalt vs ash)
• Slope (Relief)
• Runoff (Snow vs. rain)
Eruption of Mount Mazama at 7660 YBP
Paul Rockwood painting

Sycan Outburst Flood Case Study

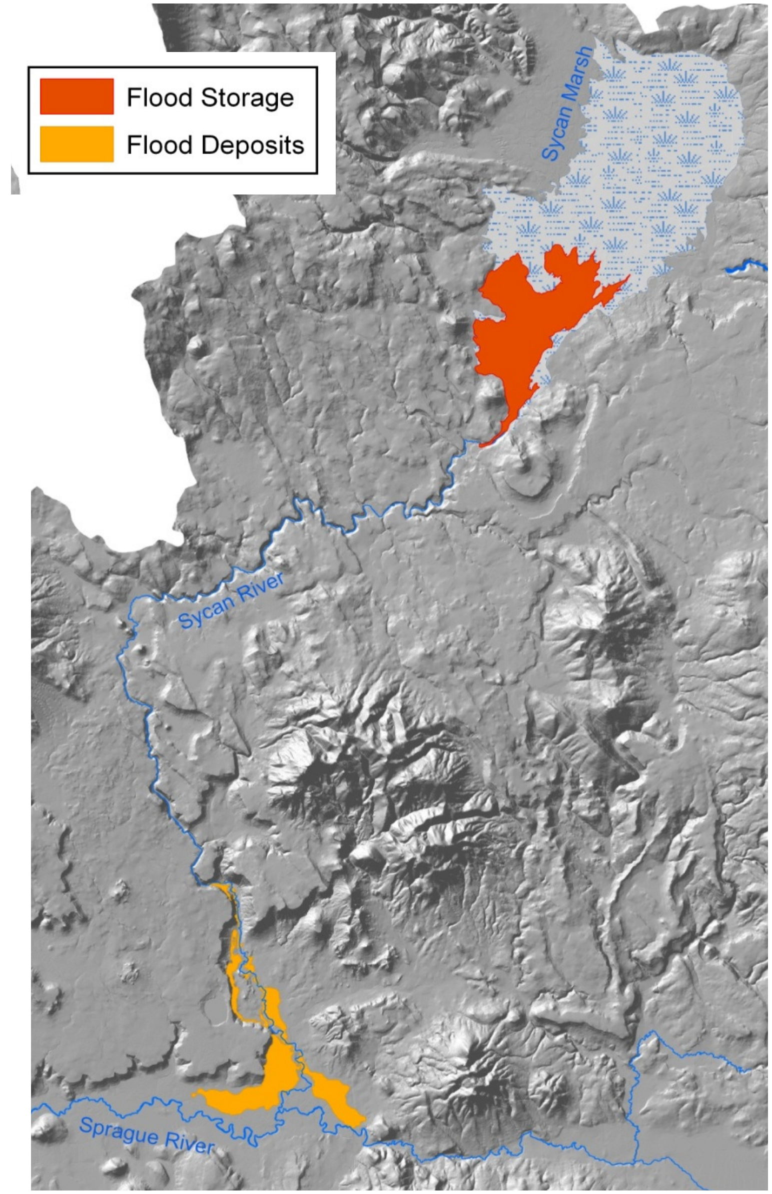
Post-Mazama blockage of Sycan Marsh drainage

Q ~ 5,775 m^3/s (25 x flood of record)

Thickness:
45 - 350 cm

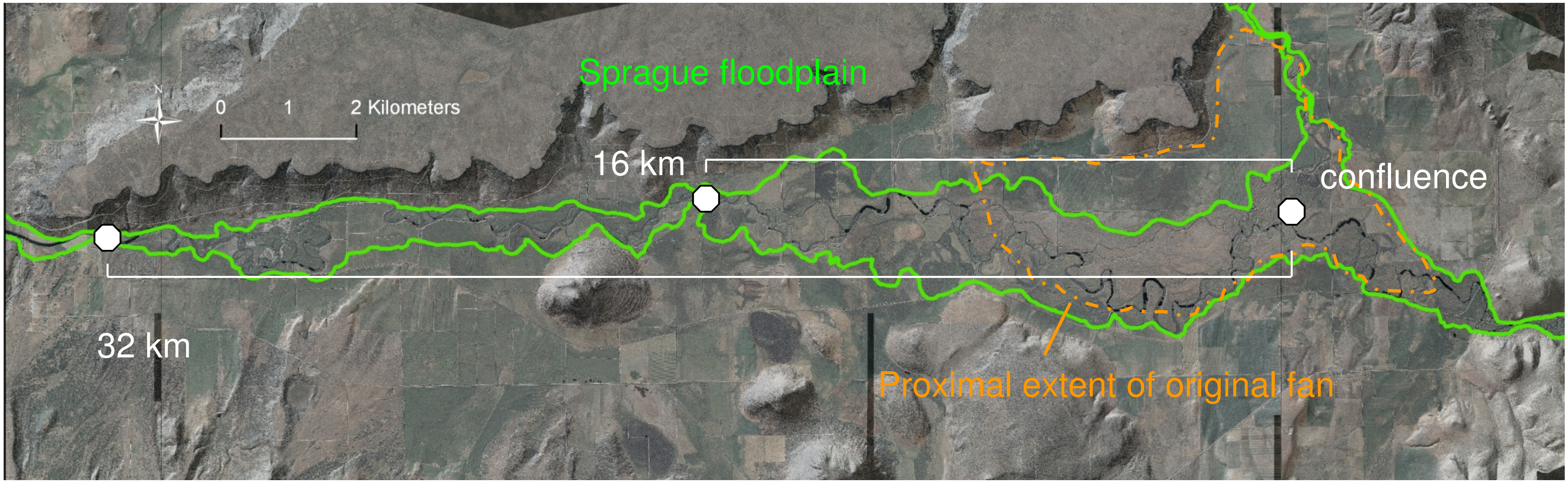
Volume:
~ 13.6 x 10^6 m^3

Map: Pollyanna Lind, MS Thesis, Univ of Oregon

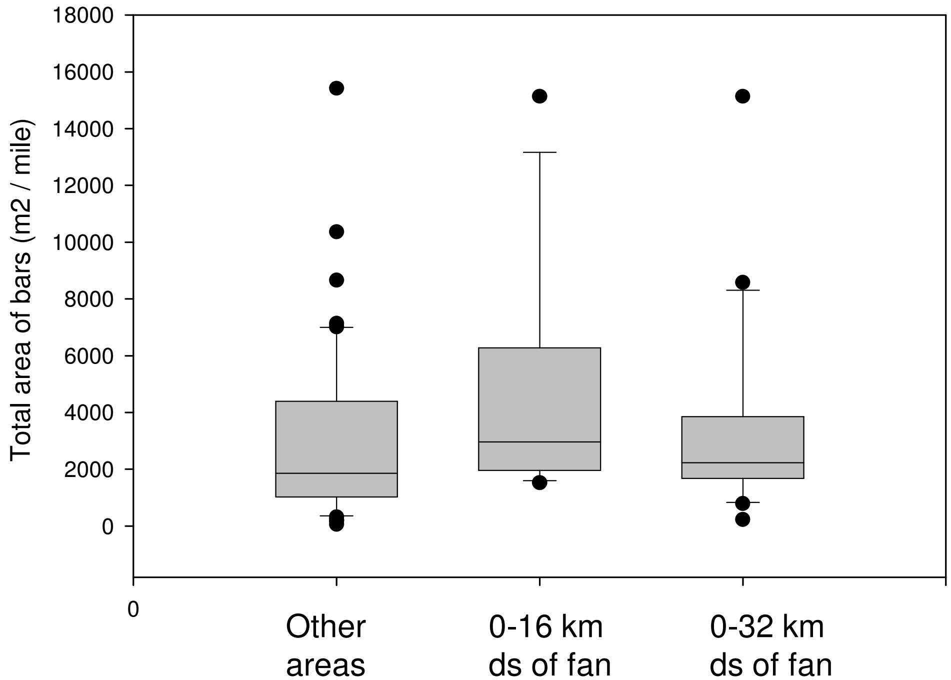


	Water Discharge (CFS)	Suspended Sediment Discharge (t/d)	Bedload (t/d)
Sycan	250	8.5	3.3
	400	30	5
	850	90	7
	1500	--	9
Sprague	850	85	1
	1560	180	2

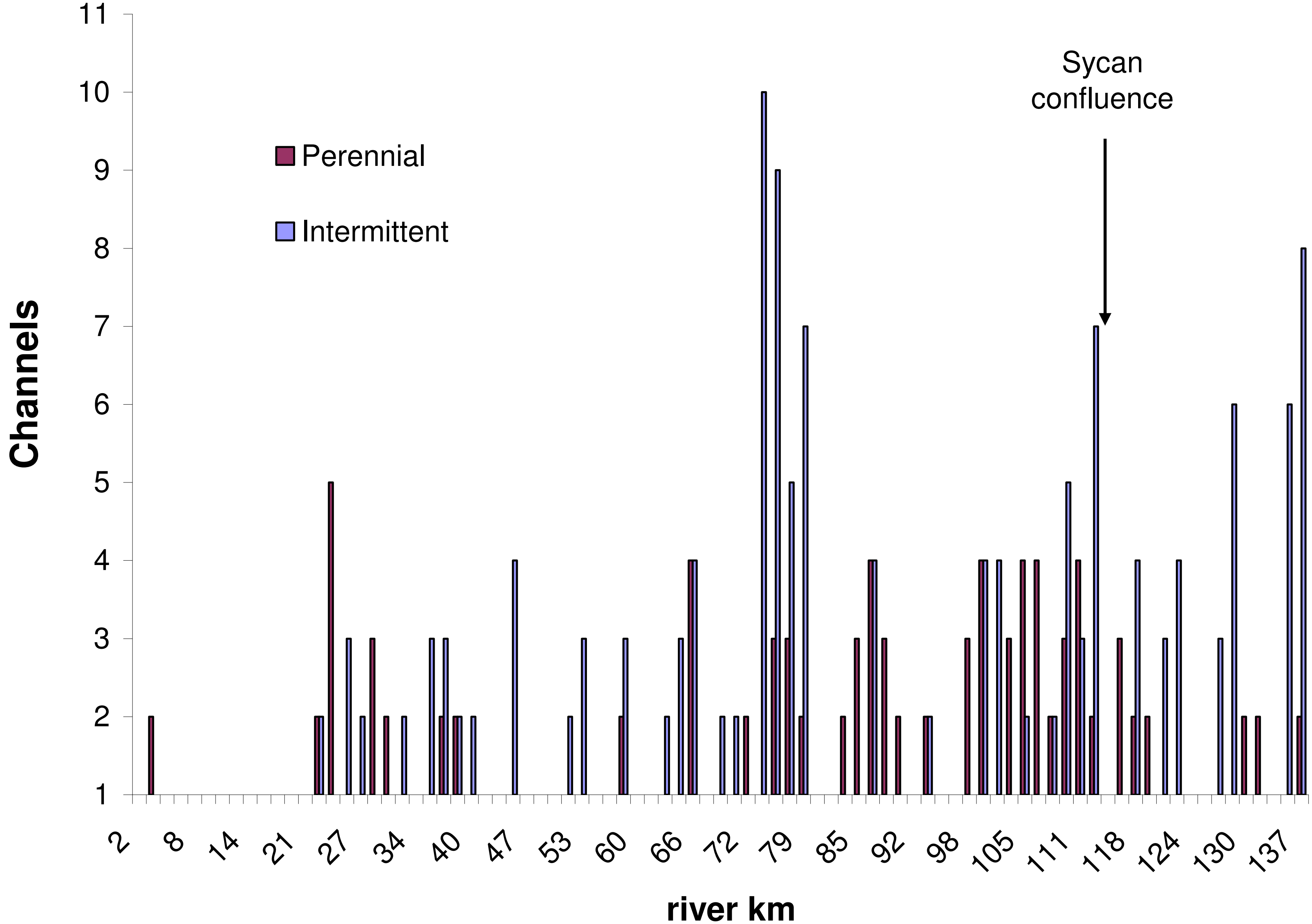
Data collected 2004-2006



Increased sediment loading appears to increase floodplain width and bar accretion

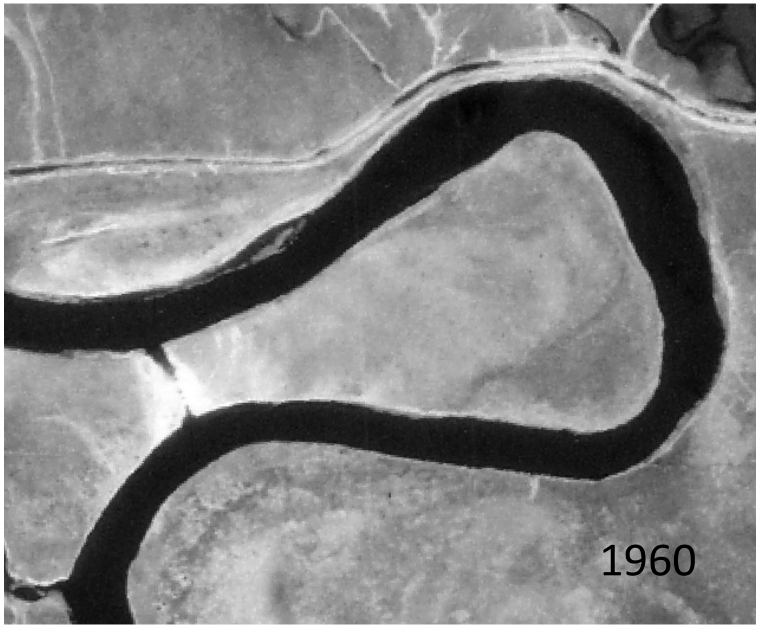


Increased sediment loading also increases the number of channels on the floodplain



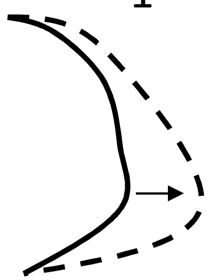
Meander cutoffs are one way of generating a multiple channel pattern

How do they affect, and how are they affected by, sediment transport?



Meander Cutoff Model

1

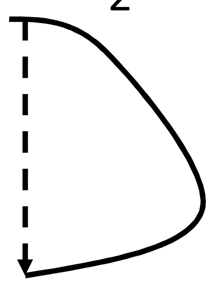


1: Meander extension
(bank erosion, bar deposition)

↓

Meander development stalls, and/or
Flow backs up due to obstruction, loss of
sediment transport capacity/continuity

2



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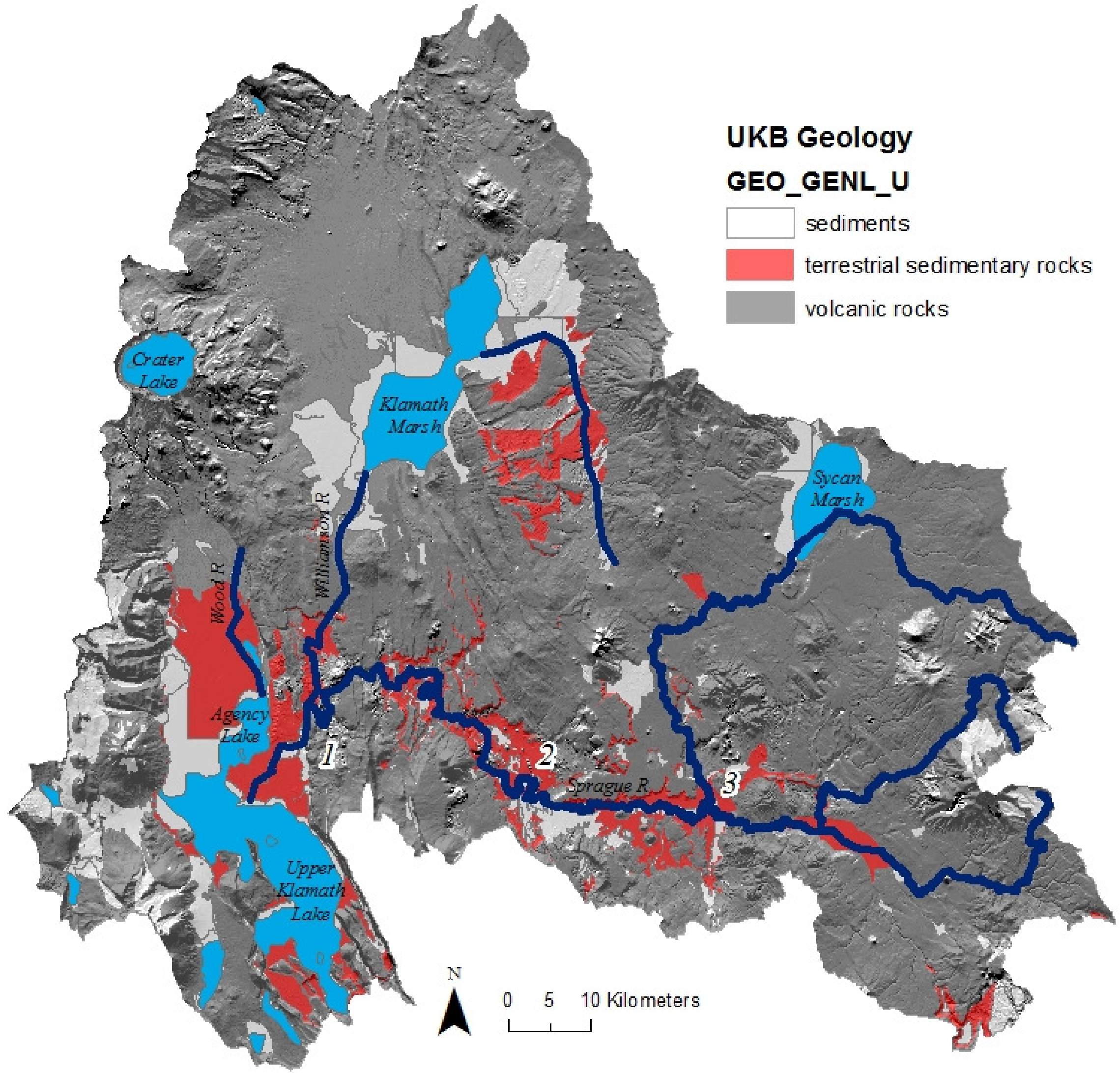
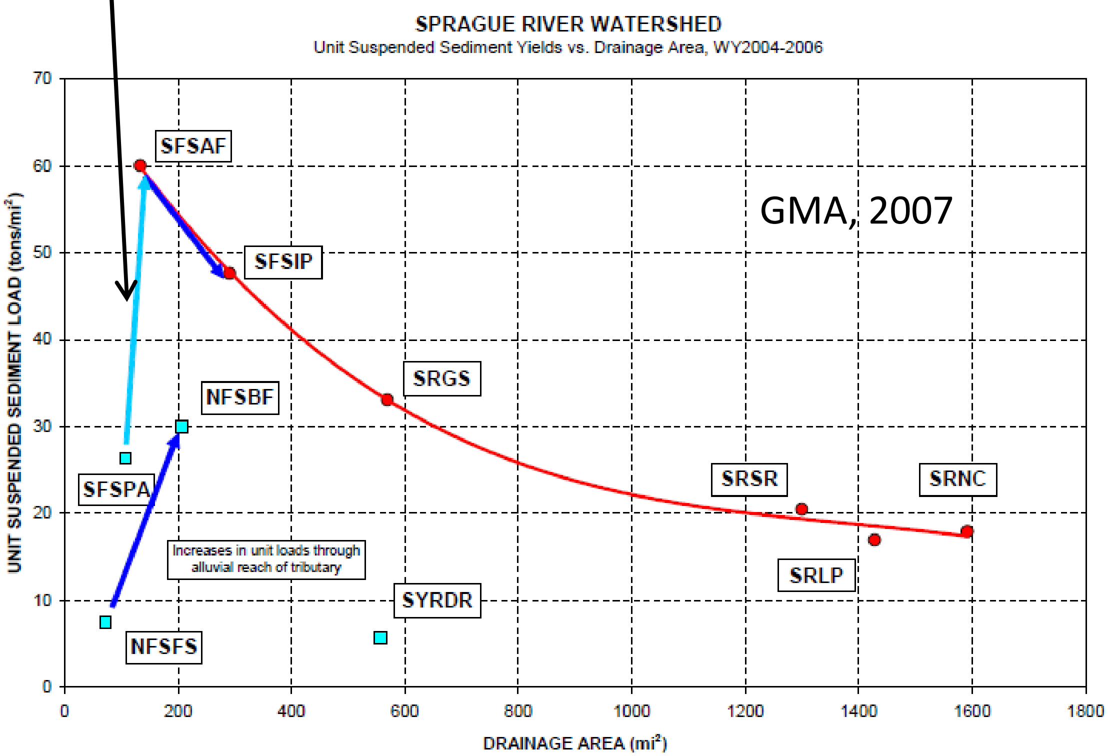
2: Meander cutoff

1: Q_{water} / $Q_{sediment}$ = high, then erosion dominates

2: Q_{water} / $Q_{sediment}$ = low, then deposition dominates

Clay-rich layers along the bed and banks of the Sprague River inhibit vertical erosion (incision), promote lateral channel movement and wide, shallow x-sections…is this a problem?





<u>Basin-wide pattern</u>

Large increases in sediment loading correspond to area where irrigation channels pick up suspended sediment and deliver it to the South Fork Sprague River

Often, the weather is still wet and irrigation is not needed

Raises questions about the relative importance of different sources of sediment and what can be done to reduce excessive sedimentation and associated nutrient flux to river channel

More sampling is needed to demonstrate and quantify this impact

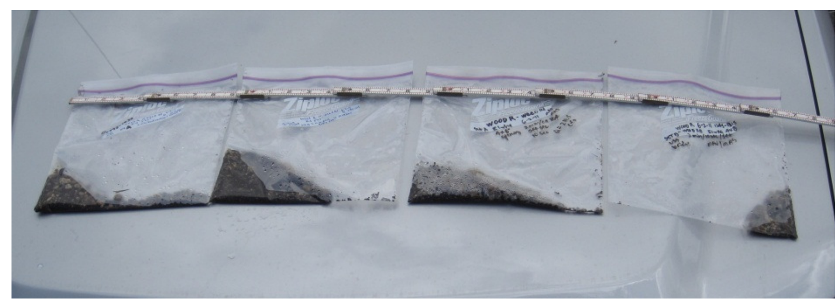
Sediment transport studies in the UKB:

US Forest Service, ~35 locations in the Freemont-Winema Forest, 1993-1996, bridge and wading measurements, relatively complete suspended and bedload measurements

Klamath Tribes Research Station (via contractor), 2004-2006, ~14 locations in the Sprague River Basin, mostly suspended sediment sampling, very limited bedload

Klamath Tribes / USGS, 2008-2010, 3 locations, emphasis on suspended sediment response to Chiloquin Dam removal, limited bedload measurements (not directly associated with dam removal study)

Klamath Tribes/BLM/Hughes, 2011, limited experimental bedload measurements (several combined with SSC) on Wood, Sycan, and Sprague Rivers, continuation planned into 2012



What we are finding out about sediment transport in the UKB:

Highly variable over space and time, reasons not always known

Relationships between flow and sediment transport are not simple – a single discharge value can have multiple sediment concentrations associated with it

SSC is generally low in the UKB in comparison to similar sized rivers in other areas (low slope/energy, low sediment availability)

Bedload is also generally low, can be highly localized and limited to active bars and specific 'slots' along the channel x-section

The Wood River has fairly consistent bedload because of high sediment supply, low density sediment, and steady flow regime – very different than other rivers (Sprague, Sycan, or Williamson) – good for demo of methods

Despite low sediment loads, nutrient flux in conjunction with sediment (as particulate organic material) can be high and is significant in overall nutrient budgets

Prospects for progress in measuring sediment transport:

Measurements are expensive and could be better focused on specific hypotheses about sediment/channel behavior at multiple scales (meander, reach, whole basin)

Meander cutoffs, irrigation diversion and discharge points, and tributary junctions, and pre- and post-restoration sites are good candidate locations for further study

Need to rely less on bridges as sampling locations, especially for bedload measurements; will require boat, tagline, and/or bank-operated apparatus, more funding

Need to further investigate the relationship of flow and sediment transport, especially using ADCP technology and hydraulic data; could help with restoration design and expectations