Adapting Physical Habitat Protocols for Diagnosing Aquatic Life Impairment Related to Sediment

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Issues for detecting sediment supply effects on stream habitat and benthos

- sediment transport is a natural process of streams, characterized by high temporal and spatial variability
- anthropogenic influence is often diffuse (non-point), and complex to characterize and link to stream responses
- stream hydrology is coupled to sediment dynamics, and land use changes are likely to influence both
- sediment supplies and responses may be acute and/or chronic and vary in duration, frequency, seasonality, and severity
- effects of sediment transport vs. deposition vary as a function of stream gradient, delivery source, and timing of flux/re-suspension
- other effects from landscape disturbance may be difficult to separate from sedimentation (nutrients, riparian…..)

Questions and Study Objectives

- What is the relationship of the macroinvertebrate community and metrics to both reach-scale and local-scale variation in sediment deposition?

- What is the natural background sediment contribution relative to excess due to human disturbance, and how is biological integrity degraded over this range?

- What is the dose-response relation of added sediment and deposition to changes in the structure of benthic communities?

- Can we use this information to develop general guidance on biological targets for sediment TMDLs?

Reach survey: Samples are taken from randomized locations (within riffles OR at multi-habitats along a typical 150 m reach length) and then combined as a composite collection representing <u>the reach</u>

riffle zone

◆ Riffle Samples   ● Multi-Habitat Samples | Habitat Transect
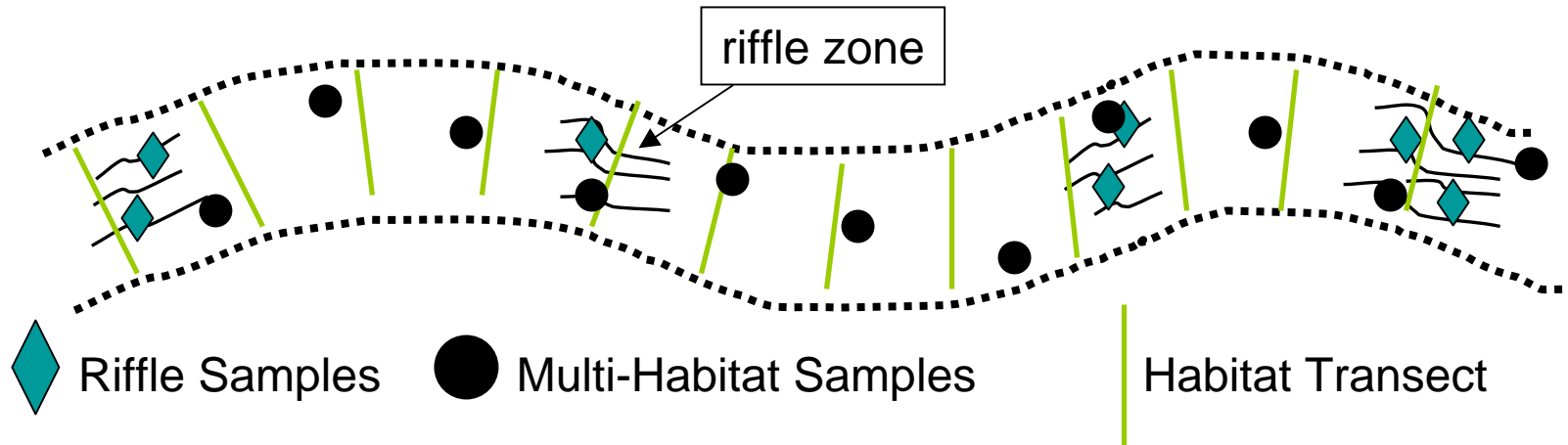
- Physical habitat surveys are conducted at repeated transects along the reach such that measures of substrate particle size distribution or percent fines-sand-gravel are <u>reach-wide average values</u>
- >> Associating the biological collections with the physical measures are therefore "fuzzy" – they are limited by the lack of exact correspondence between the habitats from which bugs are collected, and where habitat is measured

But samples from reach-level surveys can still show clear relationships between particle size distributions and biological signal:
Lahontan Riffle-based samples and %FSG
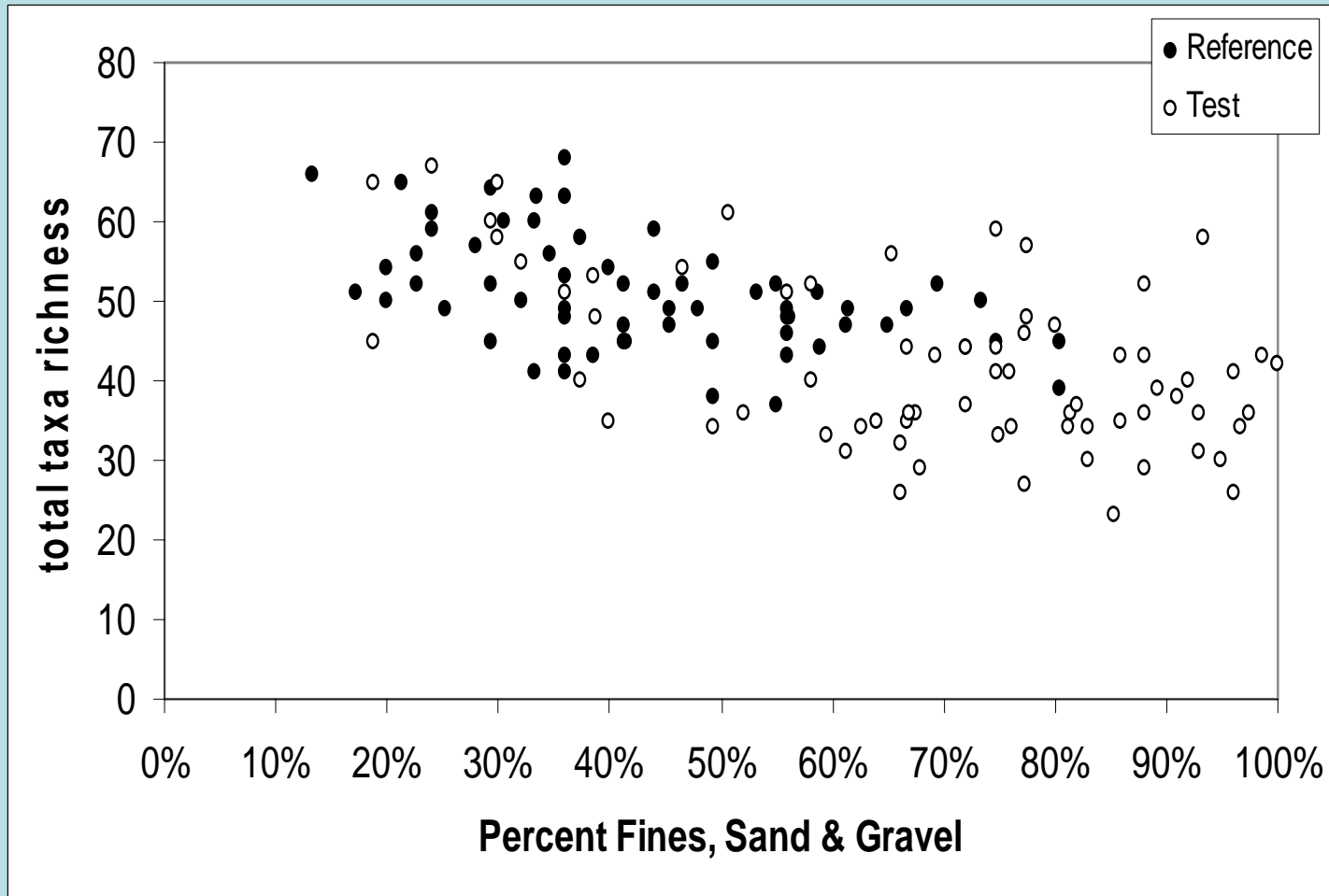
LOCAL-SCALE SEDIMENT

PUMP-CORE SAMPLER:
core-pipe isolates sample area along shallow depositional margins, fine fraction and benthic fauna removed with bilge pump and fine net (constant volume pumped)
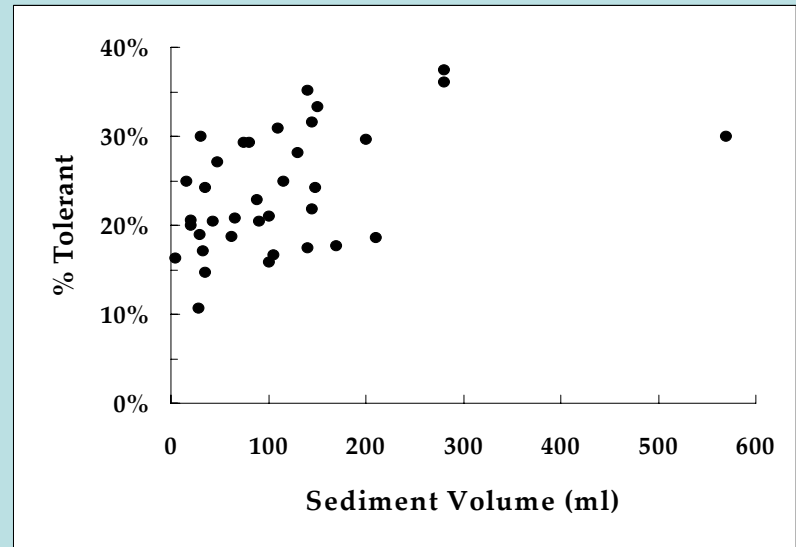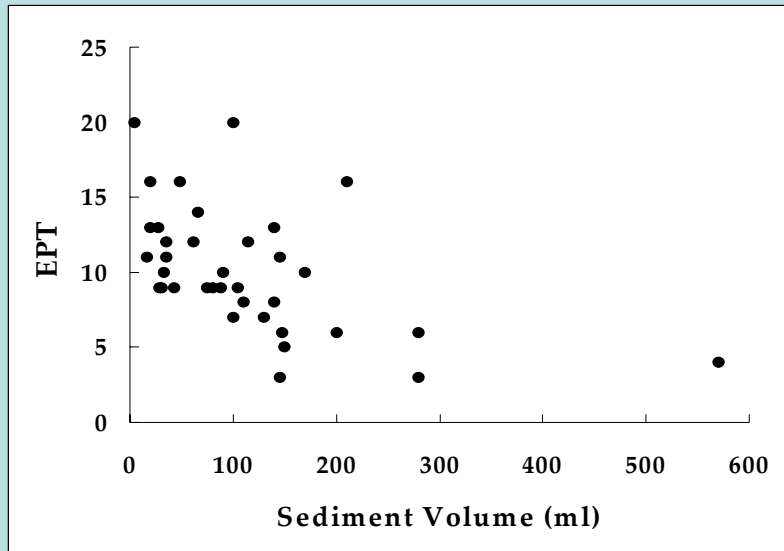

Collect fraction <1 mm through sieve

Settle in Imhoff cone and measure volume

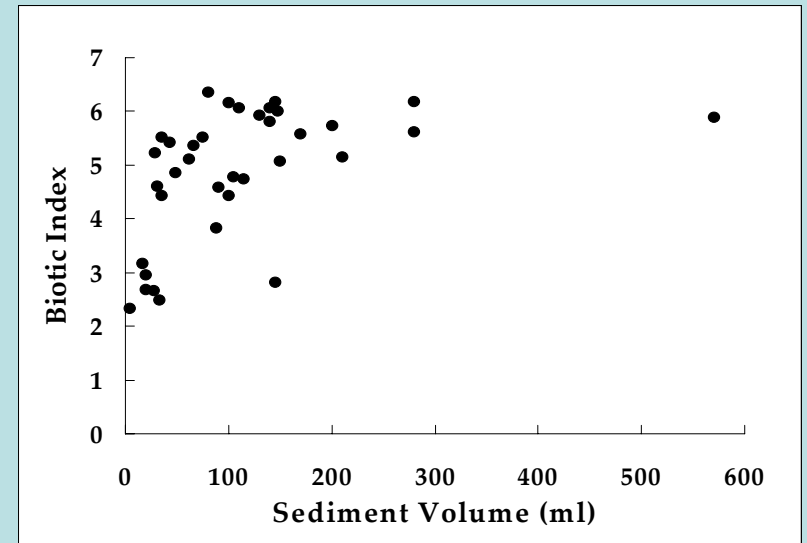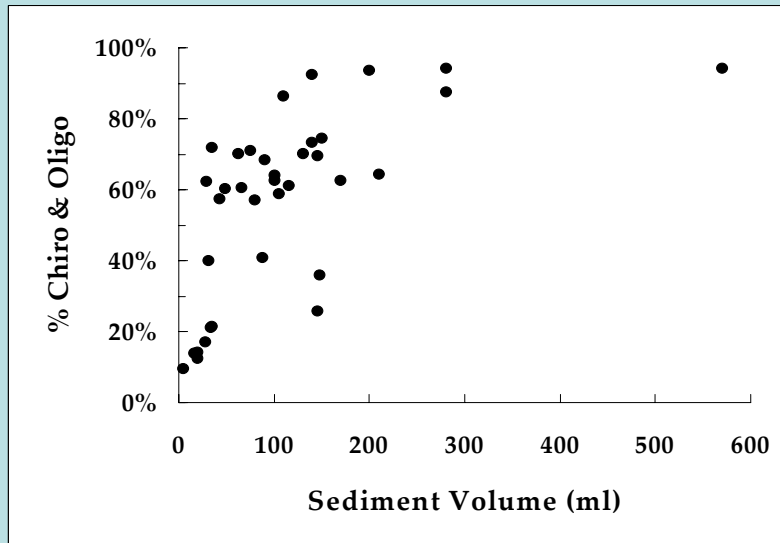Remove all associated invertebrates from sieved and settled fractions for IDs

Local-scale relation of fine deposition to benthic fauna

still scatter

fill data gaps

Sediment TMDL study program: 2006-2009

- **Three phases on a continuum of spatial scale, temporal scale, representation, integration, and applicability:**

Large Scale	Snapshot Single Surveys	Natural Variation	Integrated/ Community Responses	Applicable to TMDL Criteria & Modeling

Field phase
Systematic surveys to control for extraneous variability through reference approach: used to predict test site communities

Stream mesocosm phase
Dose-response experiments using natural community under controlled, simulated sedimentation events of varied frequency, duration and intensity

Laboratory microcosm phase
Dose-response experiments to examine individual responses of relevant taxa

Small Scale	Sequential Data	Controlled Experiments	Population/ Individual Responses	Mechanisms & Criteria Refinement

<u>Site Selection and Watershed Analysis:</u>

- **GIS analysis of watershed disturbance related to erosion potential from both natural and human sources**
- **Survey ~100 sites to represent broad region and adequately model variability – Sierra Nevada and Central Coast Range**
- **Site selection criteria to optimize between-site comparability and potential for detection of sediment supply effects, and to limit confounding influences**
  - **3rd - 4th order streams or similar watershed size**
  - **3,000-8,000 ft elevation (lower in Coast Range)**
  - **<2% slope, with riffle-pool MB-type geomorphology**
  - **unconfined sinuous channel, potential for bar formation**
  - **no dams and few lakes upstream**
  - **exclude or minimize other stressor sources**
- **Half of sites in least-disturbed basins (reference sites)**
- **Half of sites in basins with variable degrees of disturbance (roads, logging, development, etc.)**
- **Physical habitat measures of sediment deposition features>**

Experimental sediment-dosing studies will utilize stream mesocosm channels at SNARL

but the studies outlined here today relate to field surveys of physical habitat for sediment deposition…

Physical Habitat Surveys

- Particle size distribution and D-50
- Embeddedness
- Residual pool depths
- Extent and mapping of depositional bar formations (area and clast class distributions, photographs for automated particle size analysis)
- Thalweg profile (2-m intervals over 150-200 m reach lengths)
- Lateral bankfull profiles (20 equal-space points at 10 transects)
- Excess sediment calculation (relative bed stability of EMAP)
- Fines and sand composition on depositional bars using 20 x 20 cm quadrat frames of 25-point grid at 20 random locations (500 points per reach) at fixed depth

Biological sampling

- Multi-Habitat reachwide composite (reflects geomorphic character of reach)
- Quadrat samples selected over full range of %FS – 5/reach (500 total) and associated inverts and organic matter content
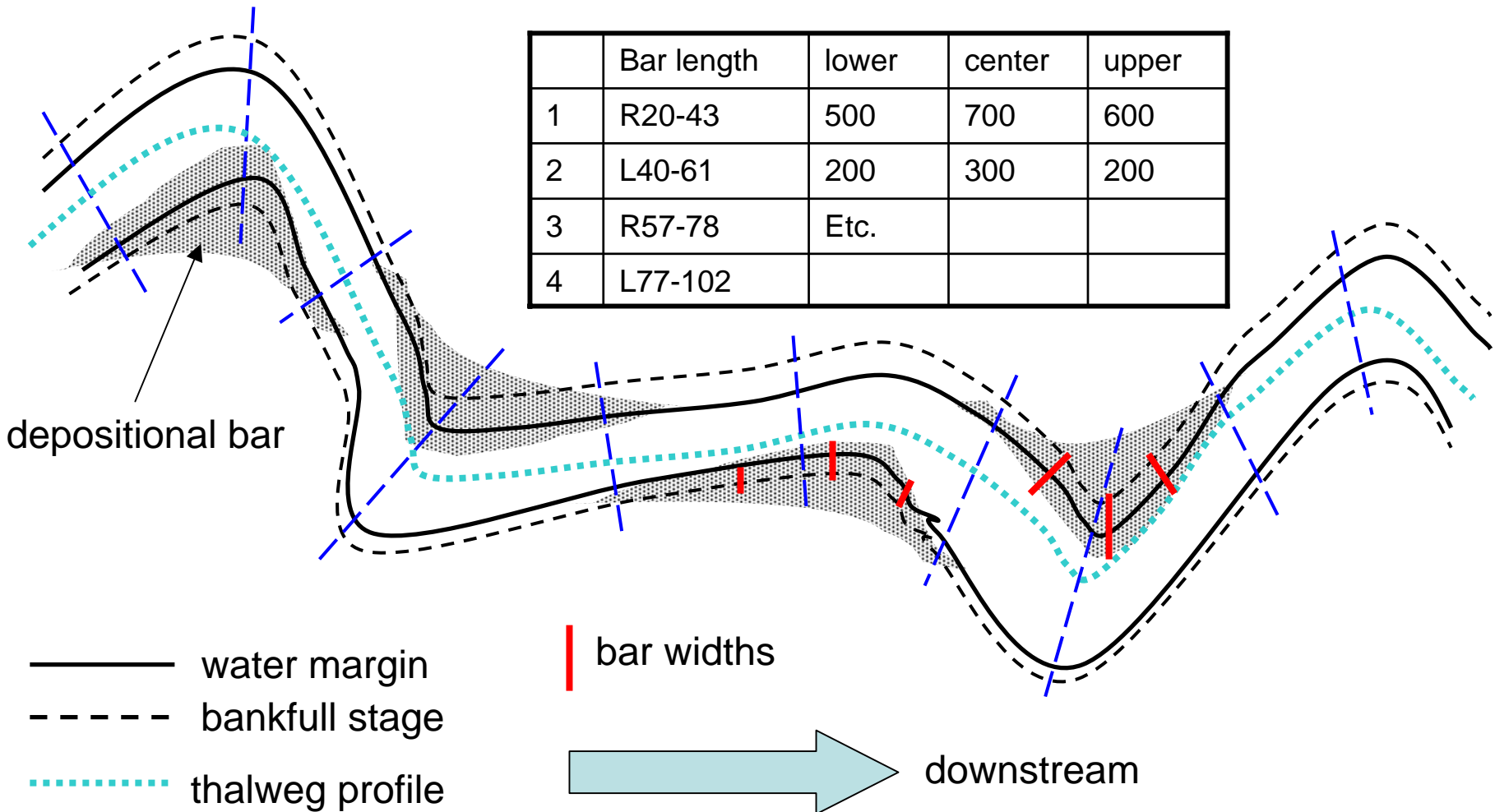
**Idealized cross-section profile of transport and deposition:
surveys of depositional margin zones under moderate to base flow conditions**
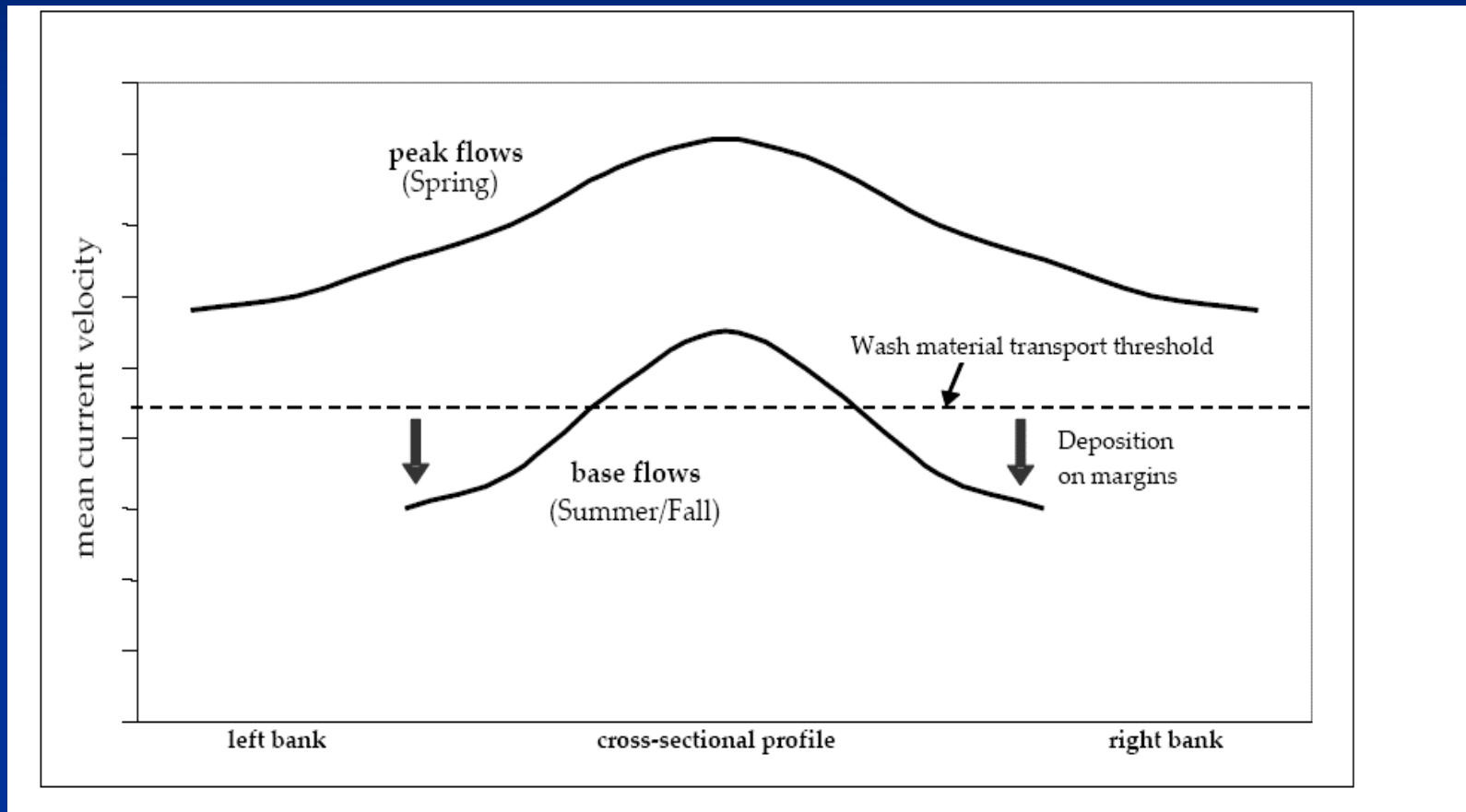
**In reality, flows swing side-to-side, and forms drop-zones
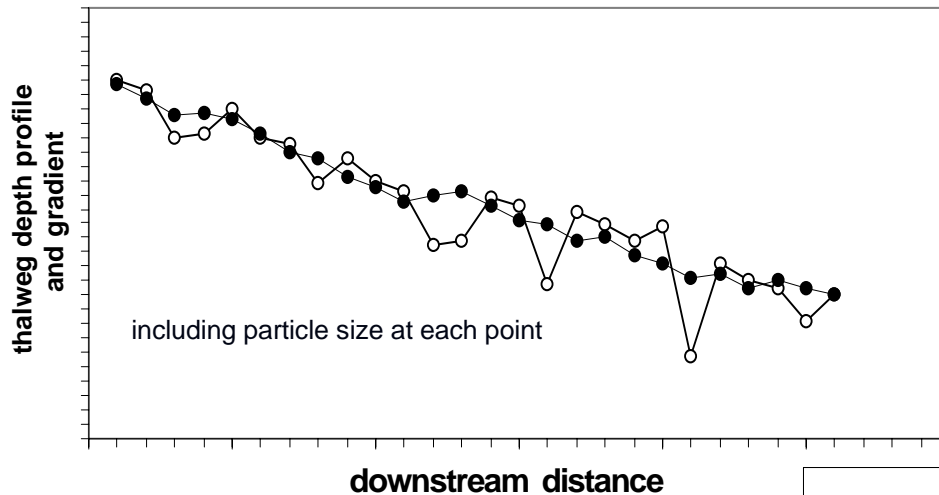where the gradient falls from steeper to flat, or riffles into pools**

Reach-Scale: Deposition within active bankfull channel

- Measure dimensions of point bars, lateral bars and islands below bankfull
- Map particle clast facies over each bar (sand-fine, gravel, cobble, mixed)
- Photograph random facies for auto-analysis of particle size distribution

	Bar length	lower	center	upper
1	R20-43	500	700	600
2	L40-61	200	300	200
3	R57-78	Etc.		
4	L77-102			

depositional bar

| bar widths

——————— water margin

– – – – – bankfull stage

············· thalweg profile

downstream

Thalweg and Cross-Section Profiles

variance of thalweg depth

thalweg depth profile and gradient

including particle size at each point

downstream distance

- **How would we expect these features to change with increase in sediment deposition?
 > decreased variance measures
  (as in filled symbols)**

Bartley and Rutherford 2005
Riv. Res. Appl. 21:39-59
demonstrate utility in measuring reach-scale geomorphic and habitat diversity as affected by sediment

variance of cross-sectional profile

Depth from Bankfull

Bank Left   Cross-Sectional Profile   Bank Right
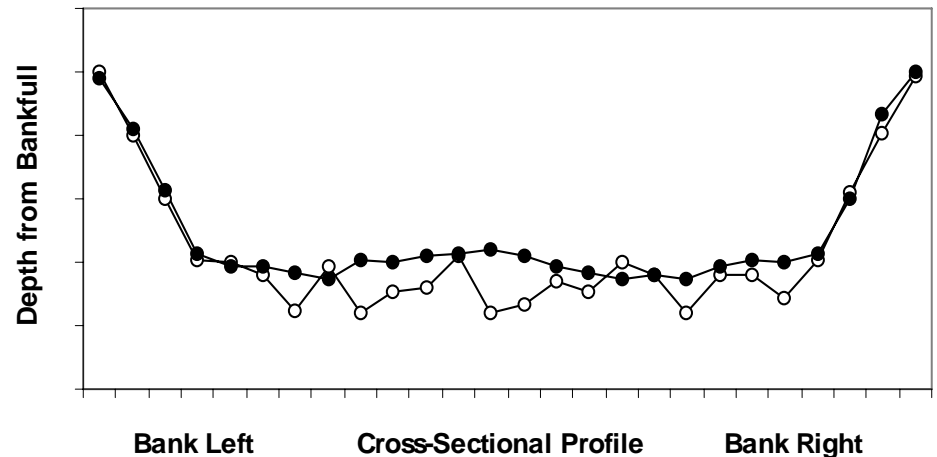
Depositional bar data set:

- Extent and area of active channel occupied by depositional features
- Particle size distribution on bar formations (from drawn maps and auto-analysis of digital photos of facies represented)
- 20 randomly placed quadrat frames along bar forms, 25-point grids each (20x20 cm at fixed depth of 5-10 cm on bar margins) to determine percent fines & sand at local patch-scale
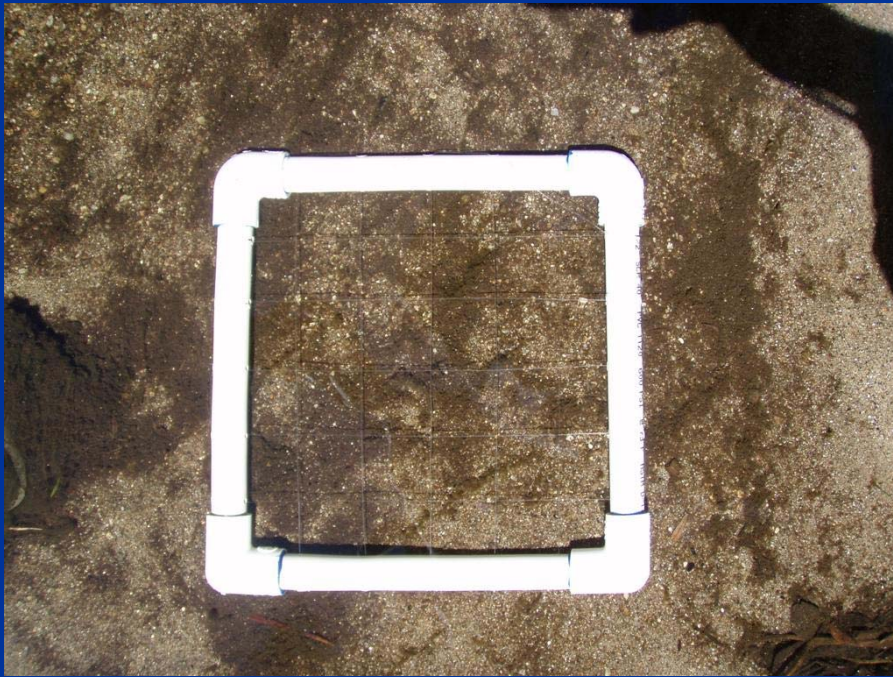
Macroinvertebrate sampling at 5 quadrats each site:
Selected to cover low to high range of F&S local-scale deposition

%FS & organic matter content
vs. invertebrates present
>> 500 data points

stay tuned…….