The Continued Search for BMI Responses to Deposited Sediments in Streams of the Sierra and Central Coast

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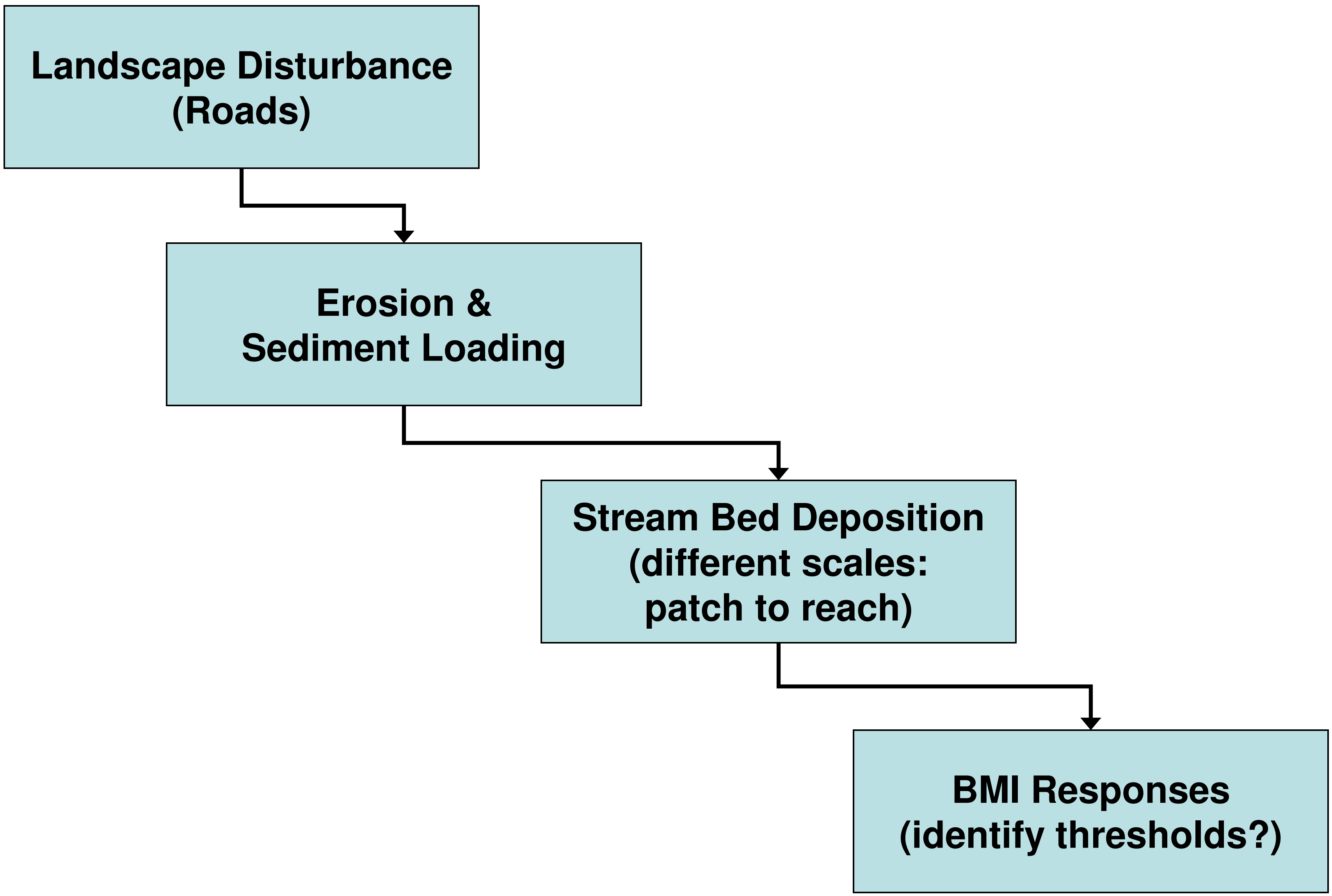
Goal of Study to Define Linkages



Selected Recent Studies of Biological Responses to Fine Sediments

> use varied definitions of particle sizes, and cover vs. bulk volume

> differing methods for measurement of responses

> findings varied and difficult to compare

Reference	Biological Indicator	Sediment Measure	Location & Study Type	Sediment Effect & Limits on Response Indicator
Angradi 1999	BMIs	FS bulk weight <2 mm	WV Experiment	Declines in density / biomass with sediment increase, but otherwise weak metric responses if any. Range 0-30% at 5% increments, n=240 trays in 3 reaches of one stream.
Relyea et al 2000	BMIs	FS cover <2 mm	ID OR WA WY Field	Fine sediment tolerance index developed for list of common western taxa based on max range of occurrence (n=562 possible surveys). Graded responses found for %EPT (n=270 stream surveys).
Mebane 2001	BMIs	FSG cover <6 mm	ID Field	Continuous declines over range for many metrics but esp. pronounced change at >30-40% cover for n=279 streams.
Zweig-Rabeni 2001	BMIs	FS visual cover <2mm and embeddedness	MO Field	Total and EPT richness and density decline with sediment increase. FS cover recorded at 5% intervals visual estimate for 4 streams and n=85 samples.
Suttle et al 2004	Fish & BMIs	FS cover <2 mm	CA Experiment	Juvenile steelhead growth decline over range, with most decrease at >40%FS. BMI burrowers ↑ & clinger-types ↓ Study on one river only, n=24 trays at 20% increments.
Kaller-Hartman 2004	BMIs	F bulk weight <0.25 mm or <0.125 mm	WV Field	Above 0.8-0.9% F by weight showed ↓ in %EPT but not other metrics. Variable results across 2 seasons and 7 streams (inconsistent F size and samples analyzed).
Braccia-Voshell 2006	BMIs	FS bulk weight <2 mm	VA Field	Some but not all group metrics respond in patch-scale samples, and FS taxa index calculated (6 streams n=230).
Cover et al 2008	BMIs	FS cover <4 mm	CA Field	No correlations of sediment with community metrics, and only a few taxa found with predicted negative responses. For 6 streams, n=4 riffle samples/stream. Limited range of sediment (just 4-16% cover).
Bryce et al 2008	Fish	F cover <0.06 mm	West US Field	Fish IBI declines about 5% for each 10% increase in F. 75th percentile of reference =5%F critical level (n=169 mountain ecoregion sites)
Bryce et al. 2010	BMIs & Fish	F cover <0.06 mm FS cover <2 mm	West US Field	Minimum effect level for fish were 5-13% F and FS, and for macroinvertebrates were 3-10% F and FS for the <u>most</u> sediment-sensitive BMIs in mountain streams (n=557 stream surveys)

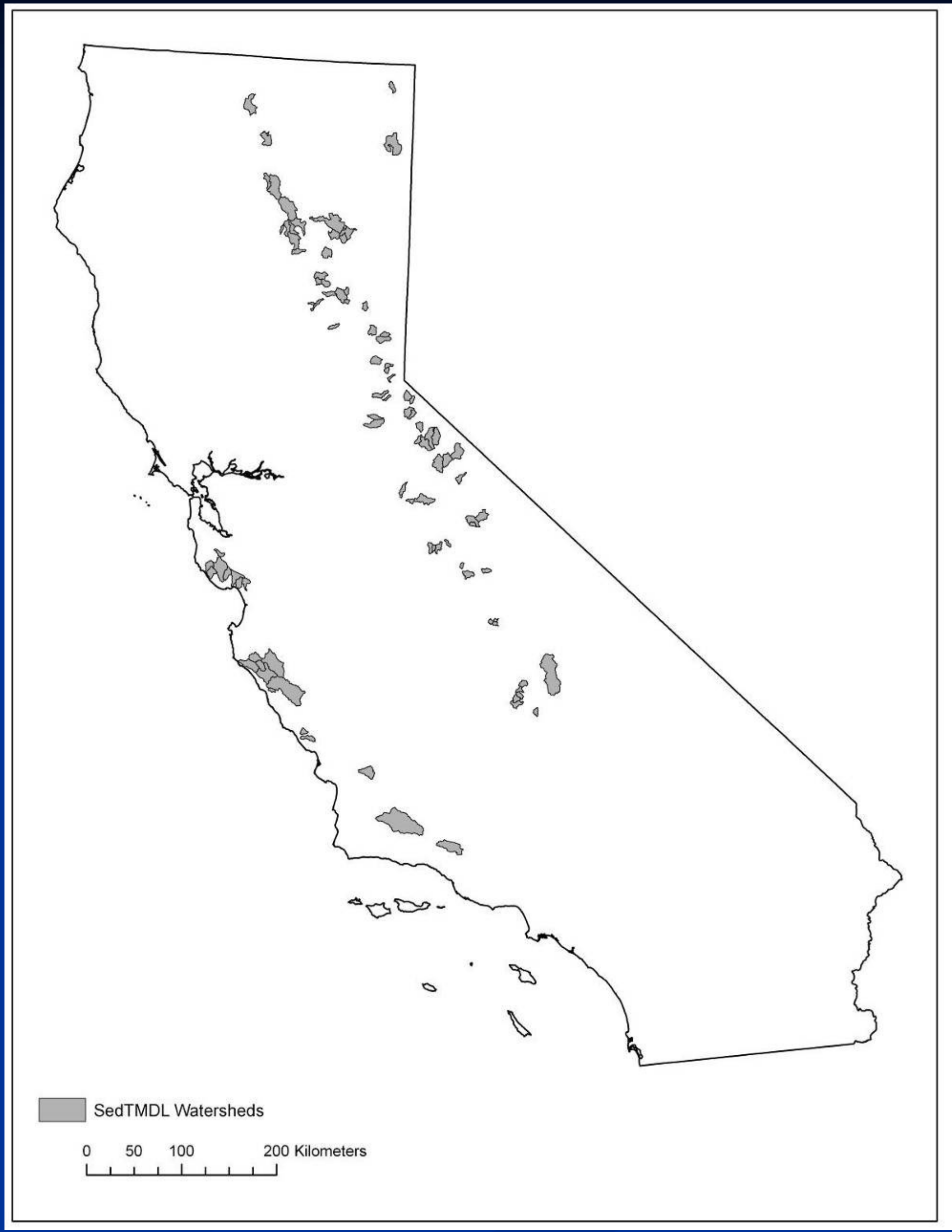
Site Selection Study Design:

Initial screening of >300 sites over range of road densities to obtain potential variation in sediment levels.

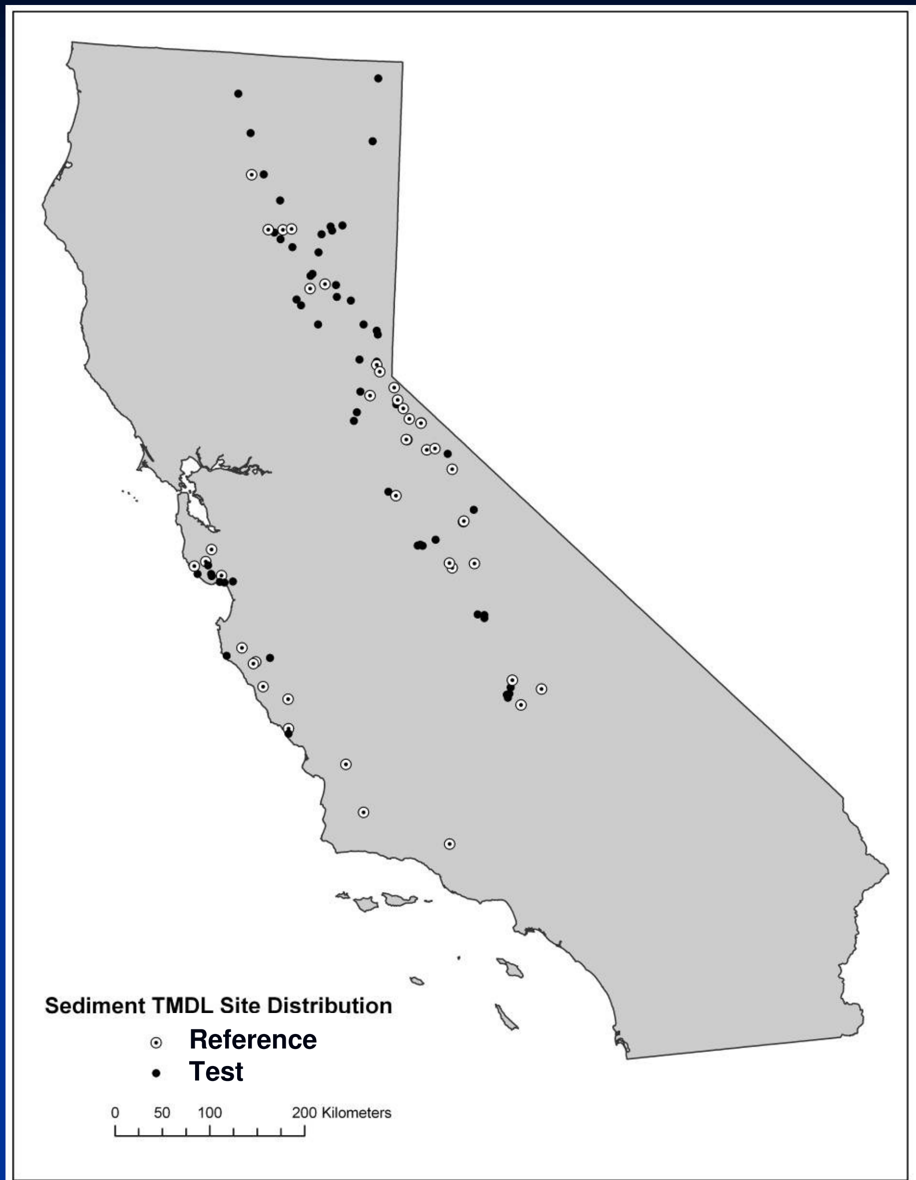
Sites conformed to these criteria:

- 2 ° - 4 ° Perennial
- <2 % Slope
- Riffle/Pool Geomorphology
- Alluvial (flows on and in transported sediments)
- Depositional bar formations
- No upstream dams/reservoirs

Sierra: 3000-8000 feet
Coast: above tidal influence up to 3300 feet



Reference / Test Designation



Sierra

- Riparian Road Density <1.0 km/km^2
- <0.4 Road Crossings/stream km

  = 29 Reference; 45 Test (74 total)

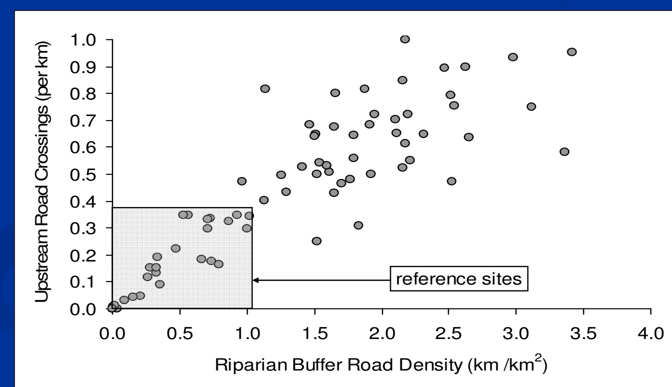
Coast

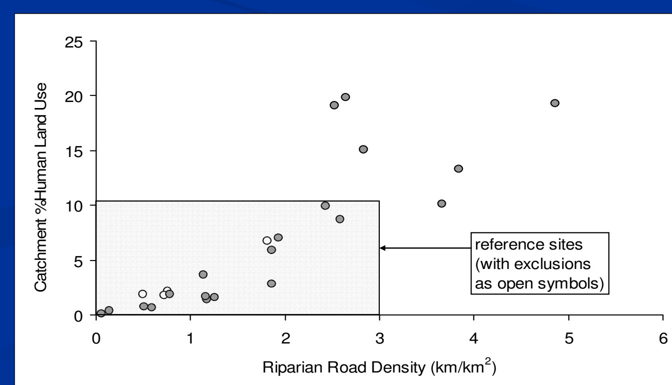
- Riparian Road Density <3.0 km/km^2
- <10% human land use within catchment

(some exceptions for local disturbances)

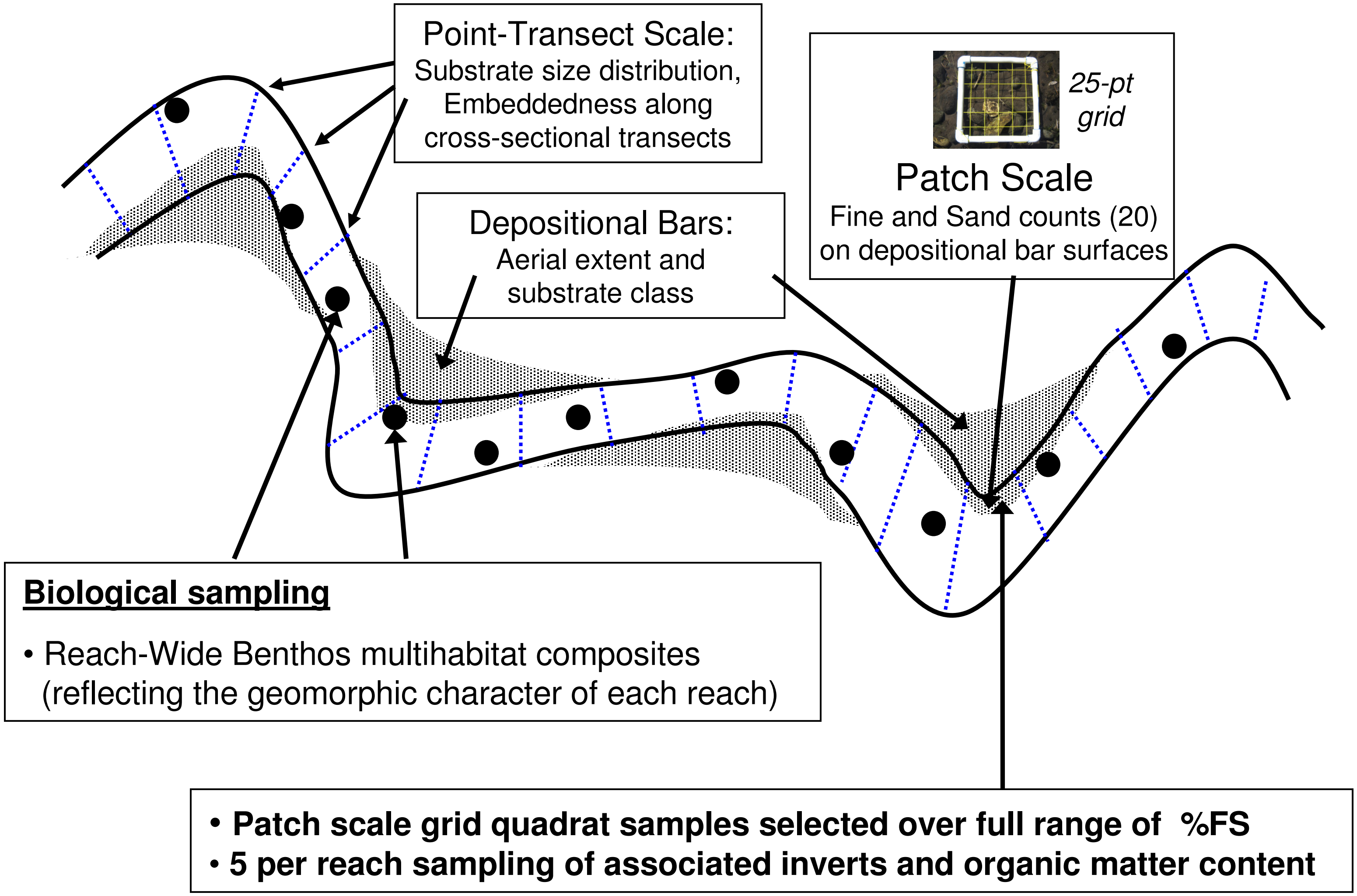
  = 14 Reference; 10 Test

Plus 25 Reference; 35 Test added from San Lorenzo River region (84 total)

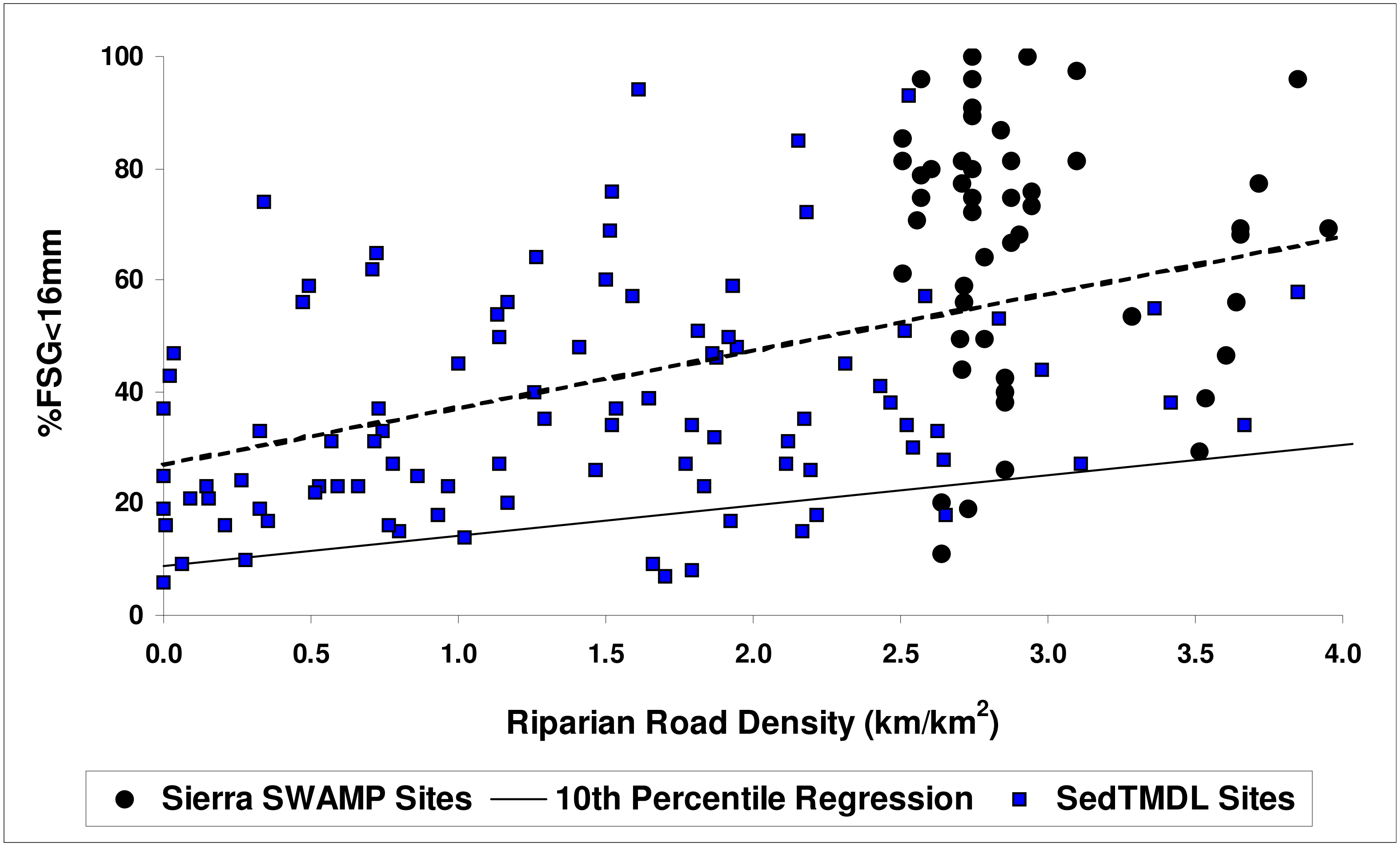




Field Measures of Sediment Deposition and Geomorphology



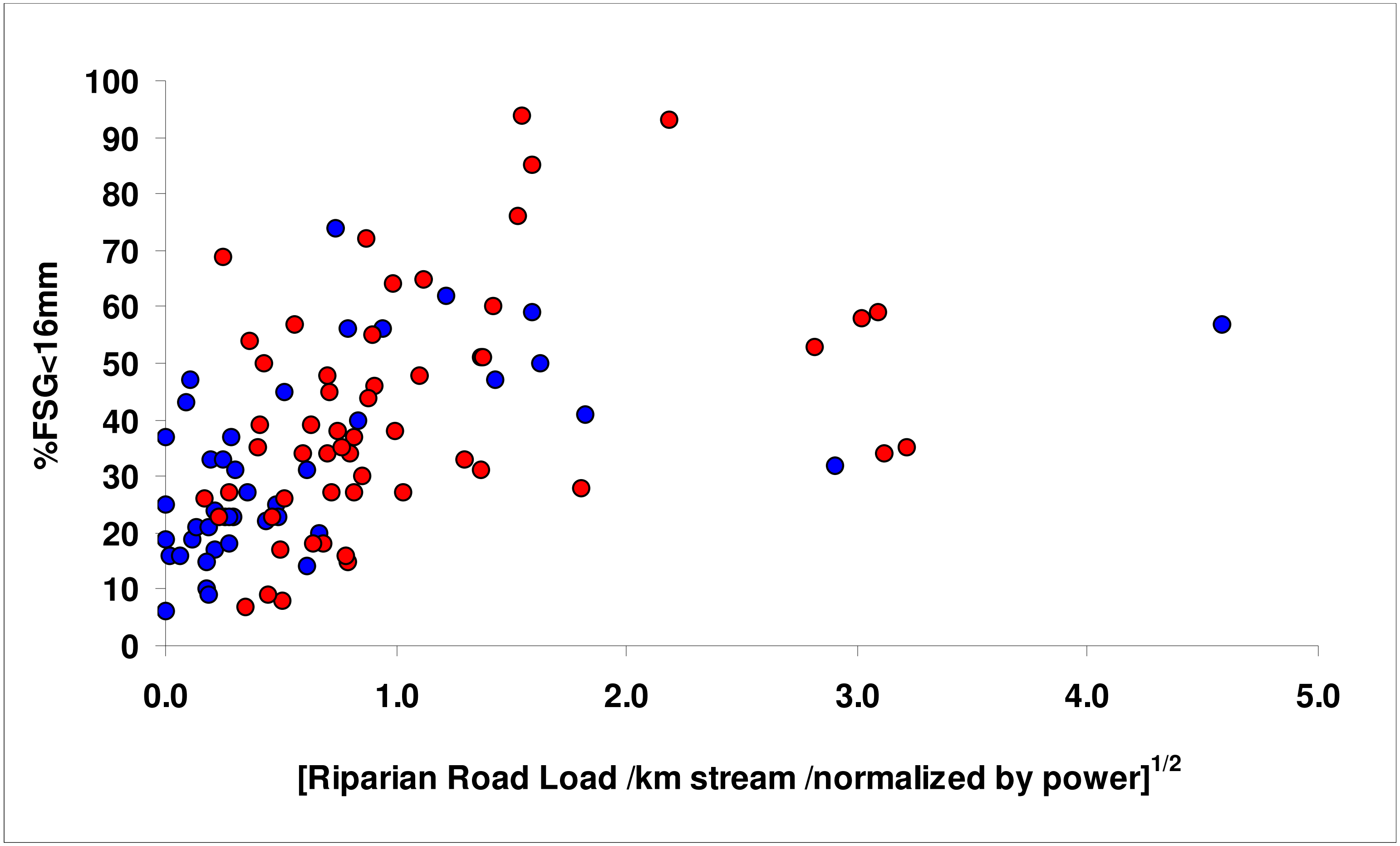
Roads and sediment deposition



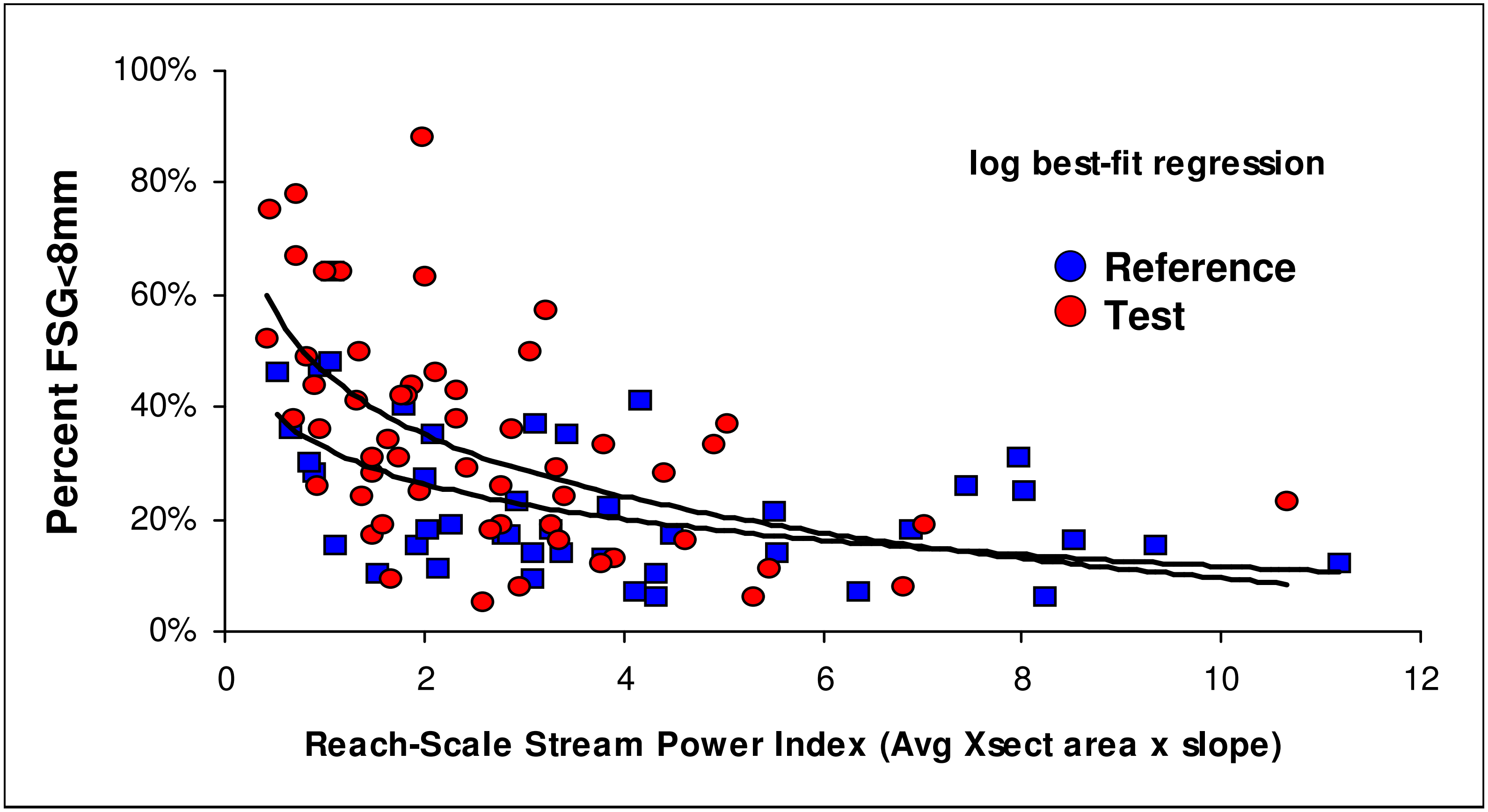
Quantile regression shows a <u>minimum</u> of 5% increase in fines, sand and gravel for every km/km^2 increase in road density

And <u>on average</u>, 10% FSG increase for each km/km^2 roads

Explicit modeling of road-derived loading normalized by stream length and reach-scale power: relation to sediment deposition



Reference (Natural) Vs. Test (Disturbed) Sites



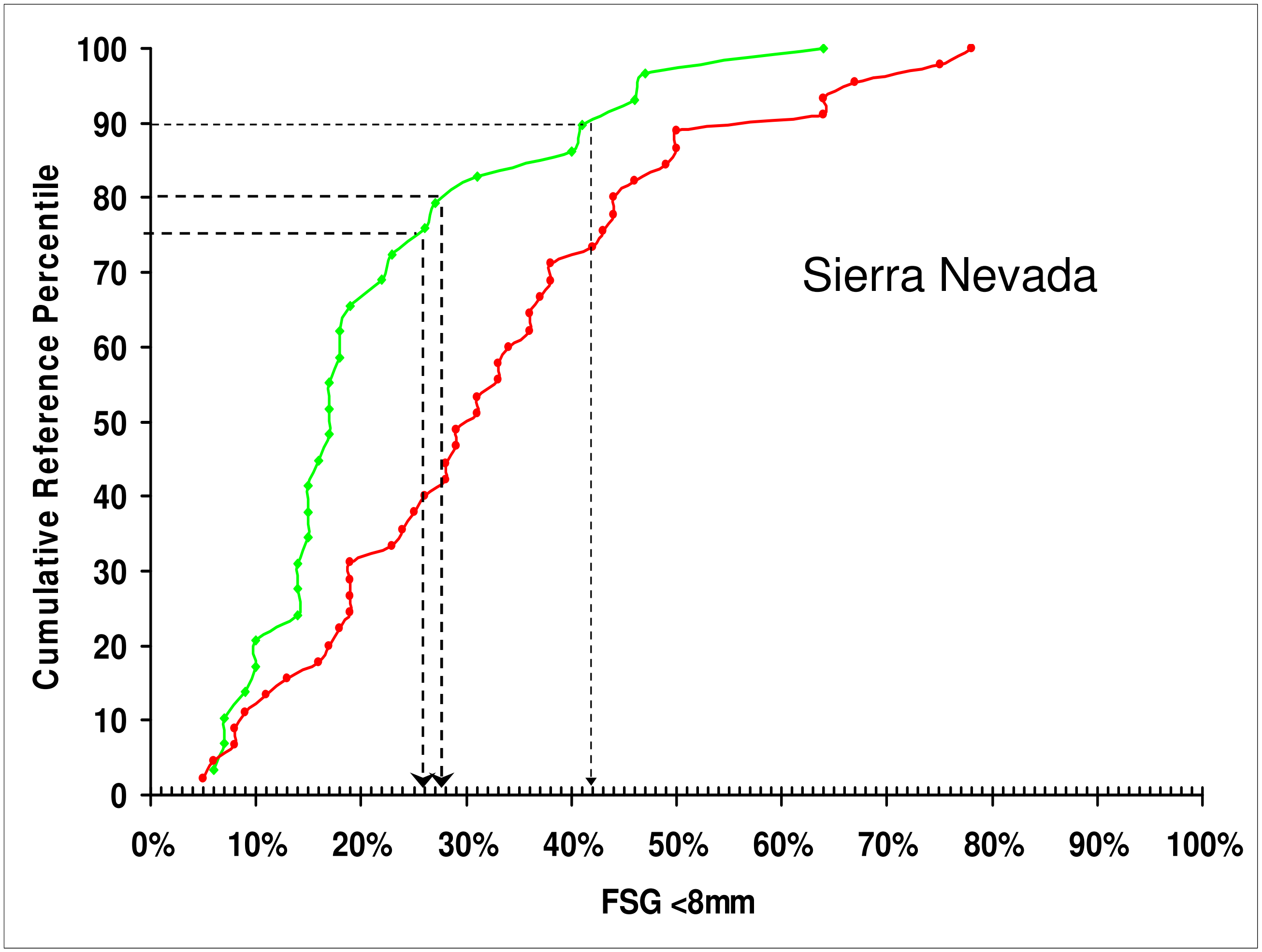
- **Streams of low power (lower gradients, smaller size) are more susceptible to accumulation of sediment deposition**
- **Test sites with low to moderate stream power have 5-20% more fine, sand, and gravel-sized sediment on average compared to Reference streams of similar power**

Using percentiles of sediment in references to set the criterion thresholds: Western EMAP used 75th

But, depends on the inflection in the distribution

Sierra Nevada data set here shows 75th= 26% FS, 90th= 42%

Central Coast 75th = 35% FS



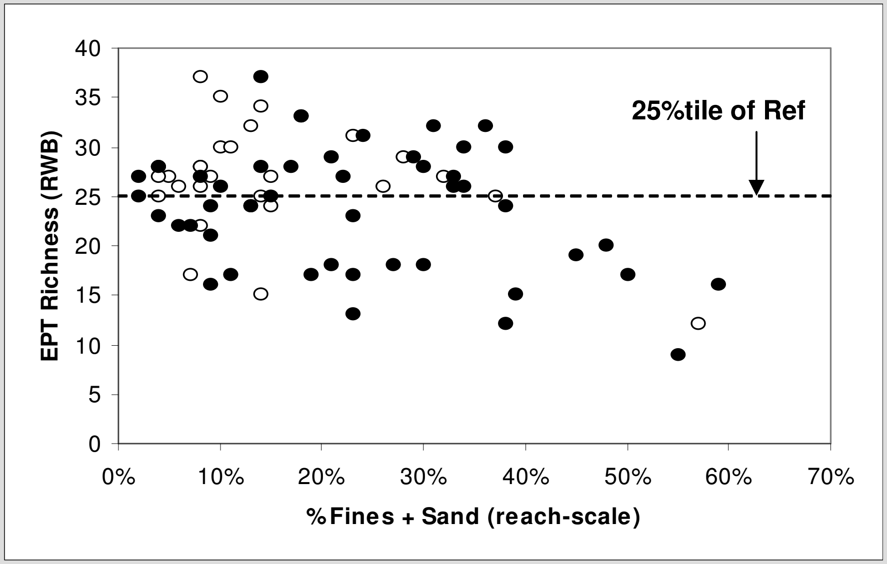
Too high >
Type II errors

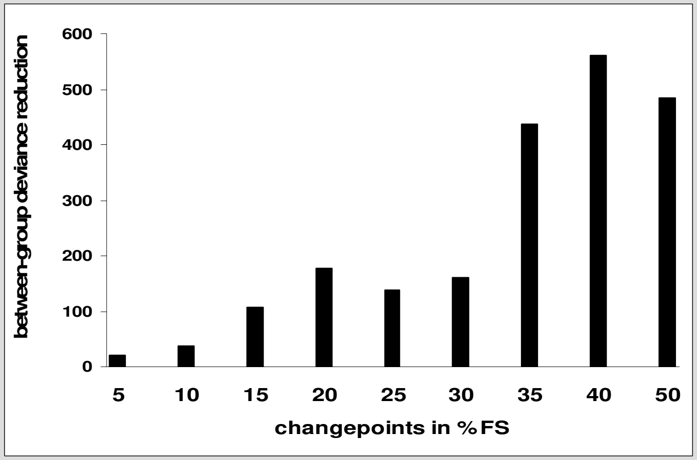
under-protective (failure to detect)

Too low >
Type I errors

impairment misjudged at both test & reference sites (false detections)

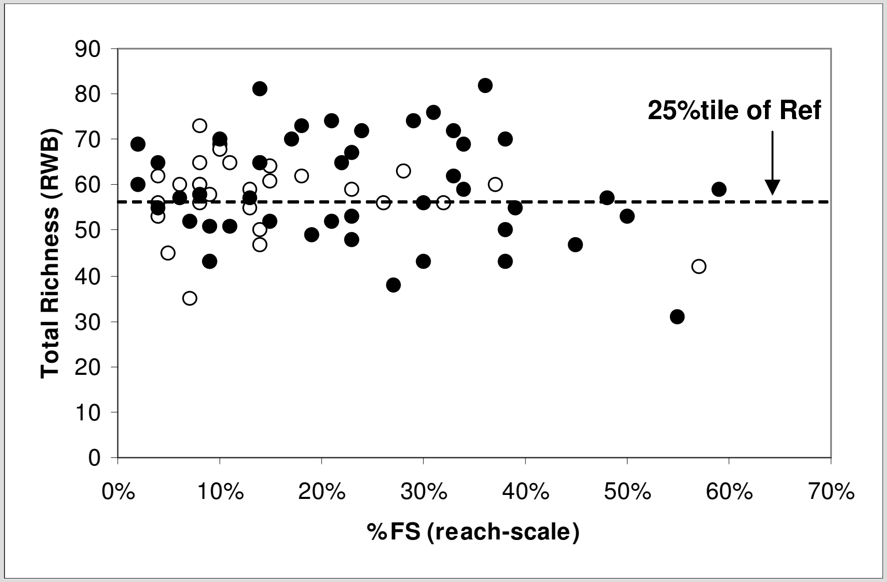
Environmental thresholds for stressor effects can be detected using deviance reduction method (Qian et al. 2003). Max change at 35-40% FS.

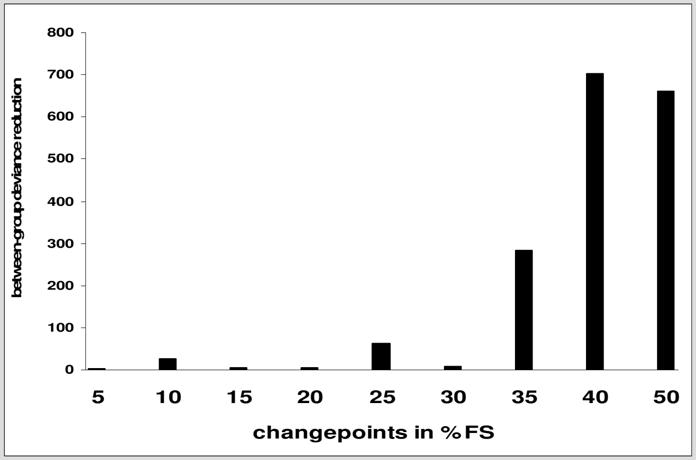




Sierra Data Set

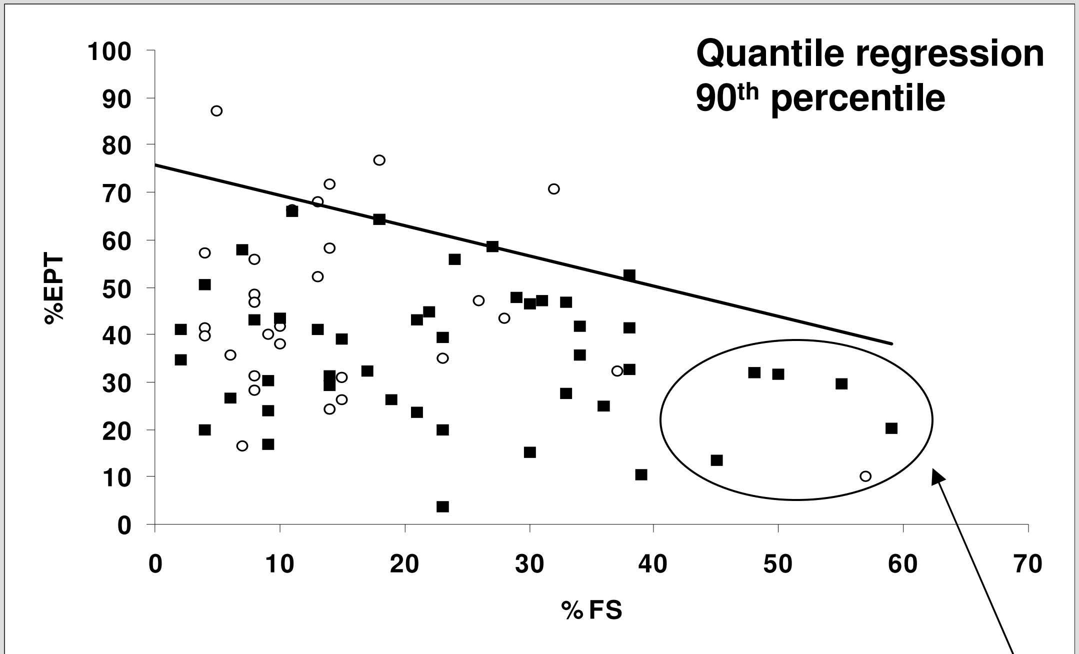
More gradual for EPT Rich

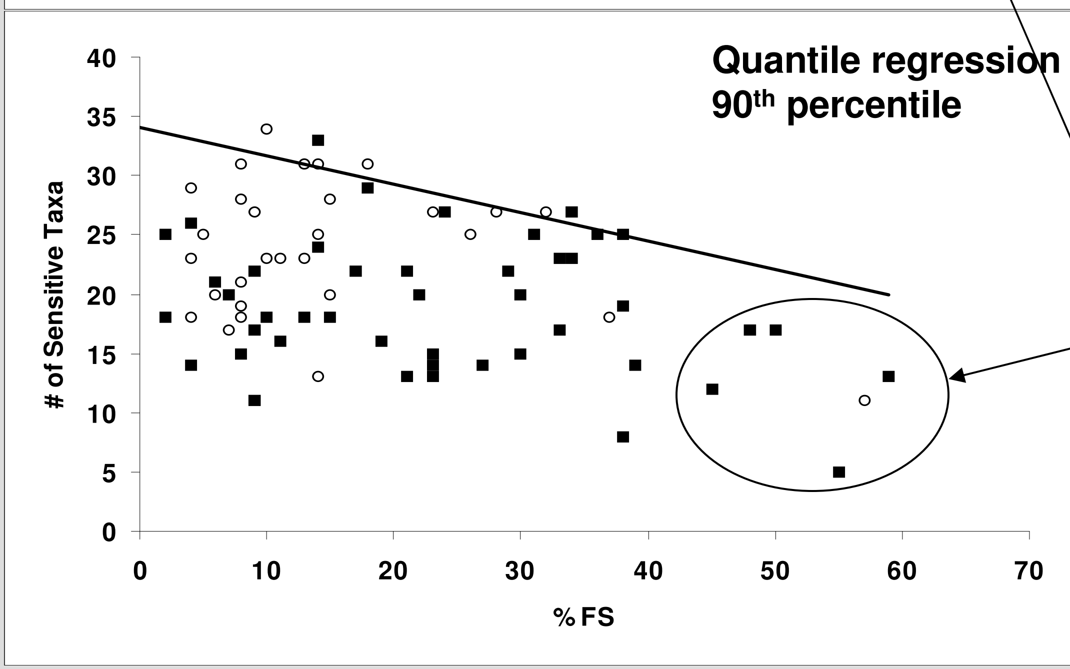




More abrupt for Total Rich

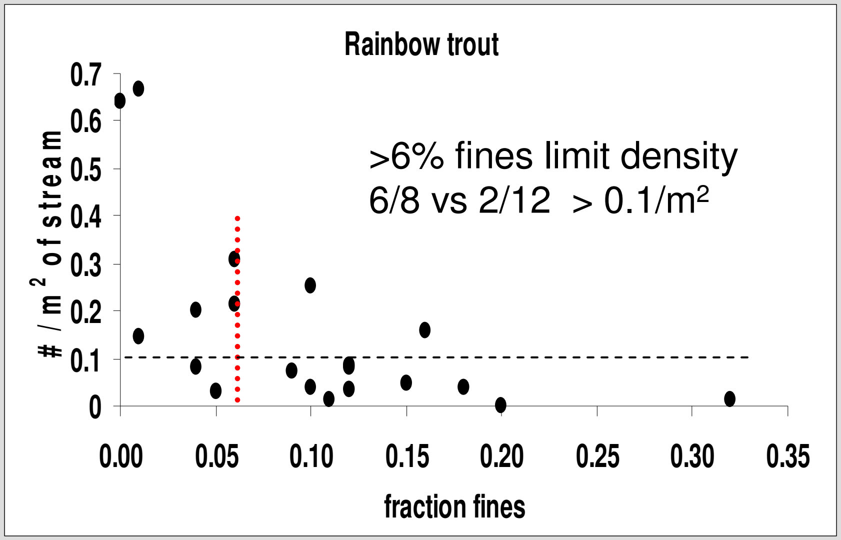
Sierra data set

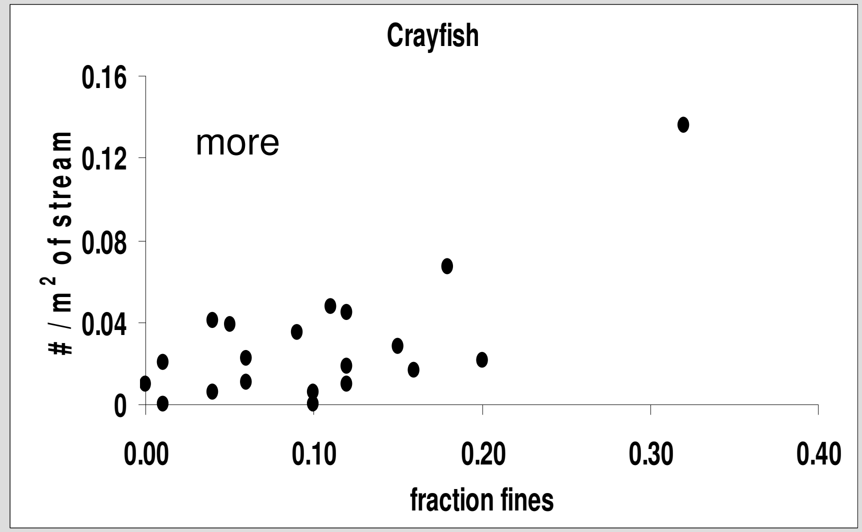


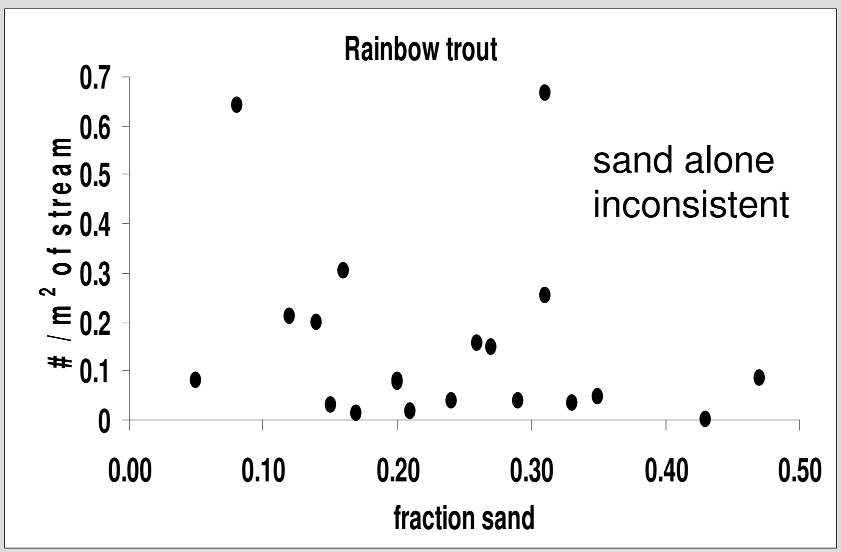


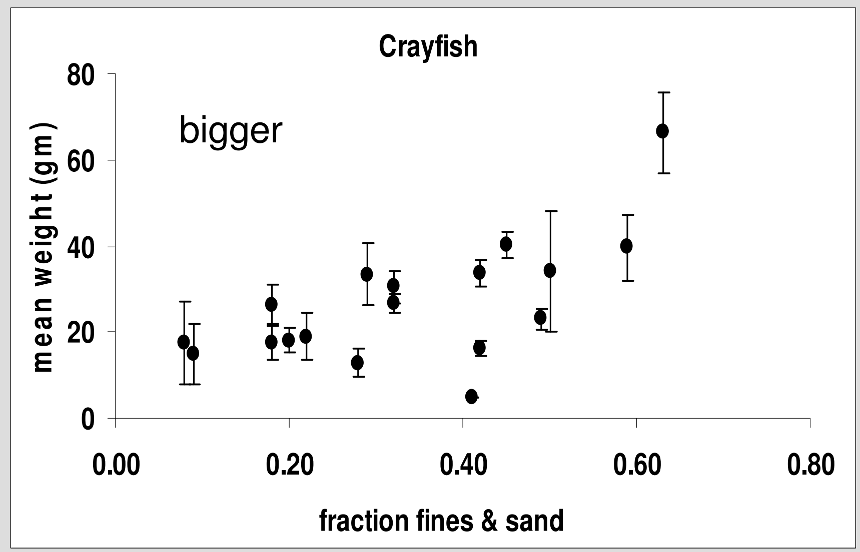
- Max %EPT reduced by 5-10% for every 10% increase in FS
- Max number of sensitive taxa (TV 0-2) reduced by about 2 for each 10% FS increase
- While quantile regression can specify limits on responses, it does not show where thresholds may occur

Native steelhead & non-native crayfish in the San Lorenzo R: fines (not sand) limit trout & are favorable to crayfish







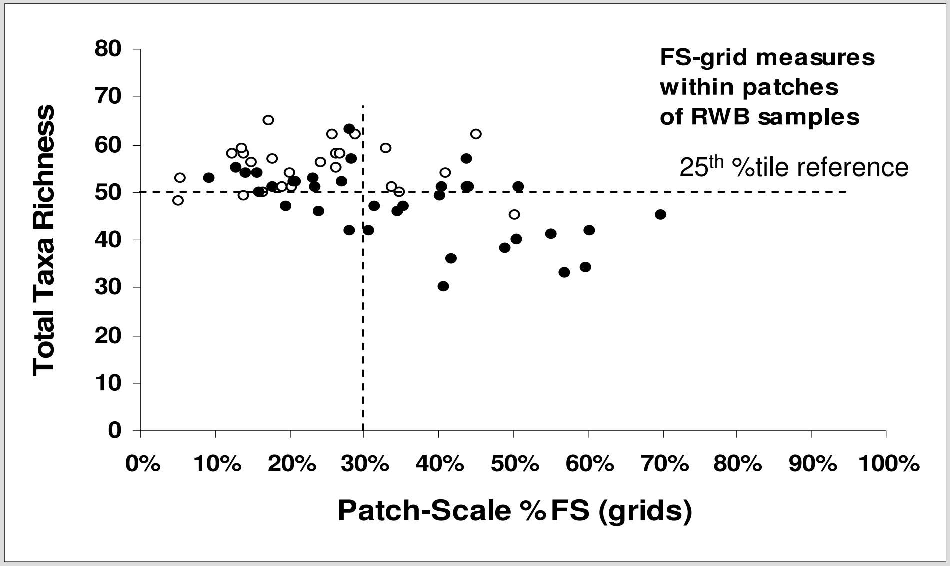


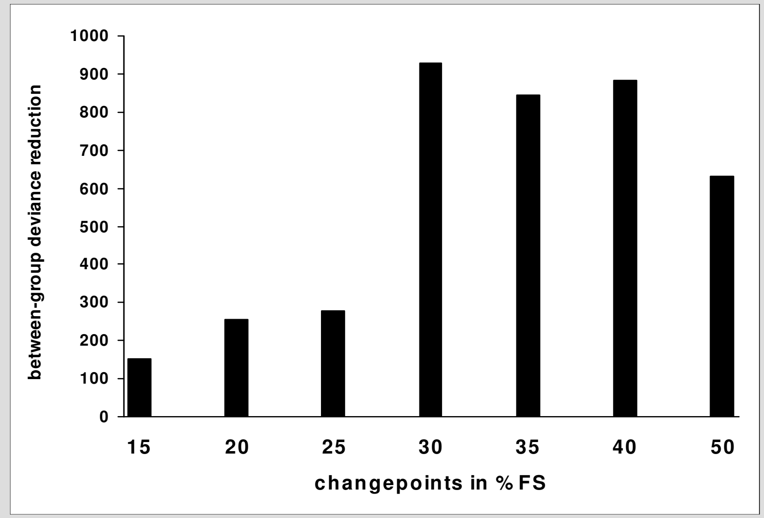
Scale of sediment-BMI sampling makes a difference

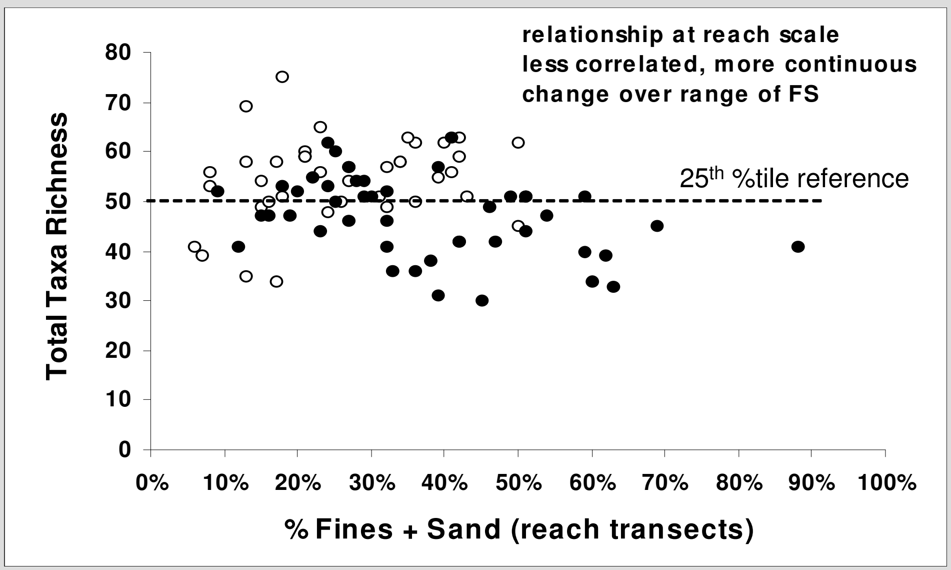
○ Reference ● Test

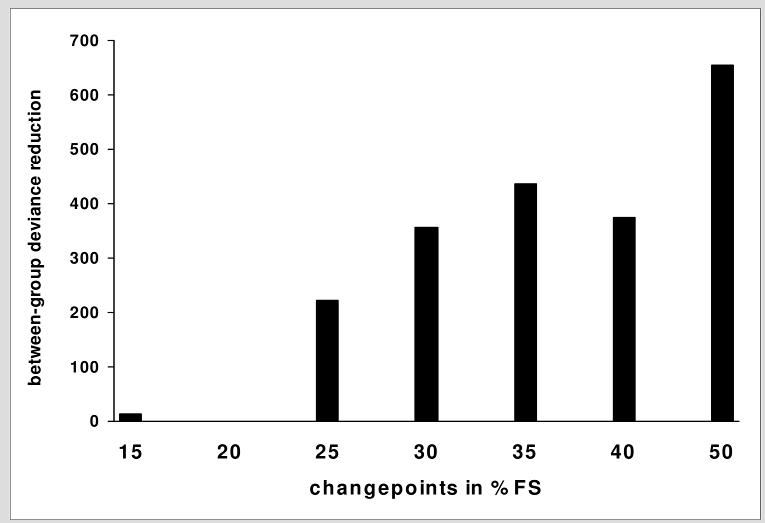
Central Coast Streams

Deviance reduction:



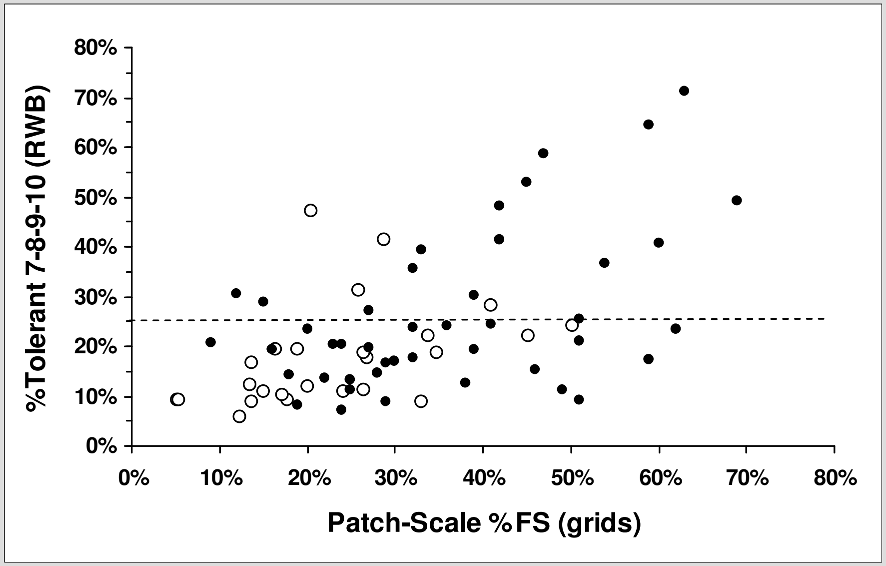


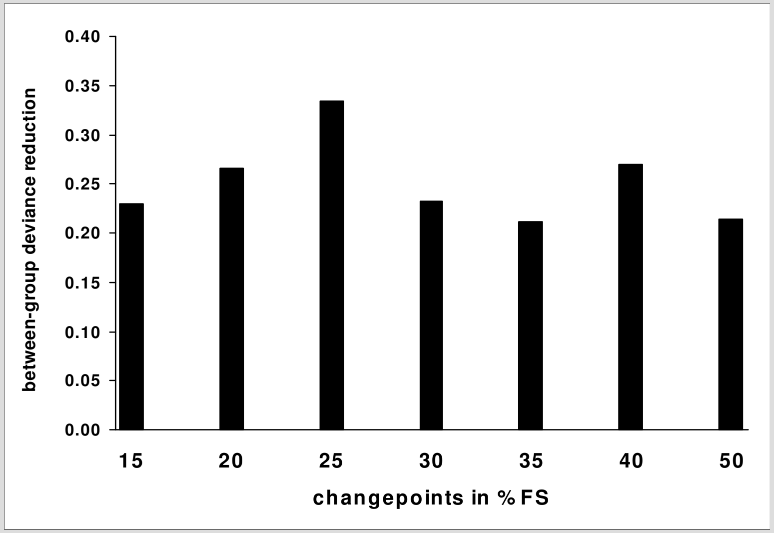


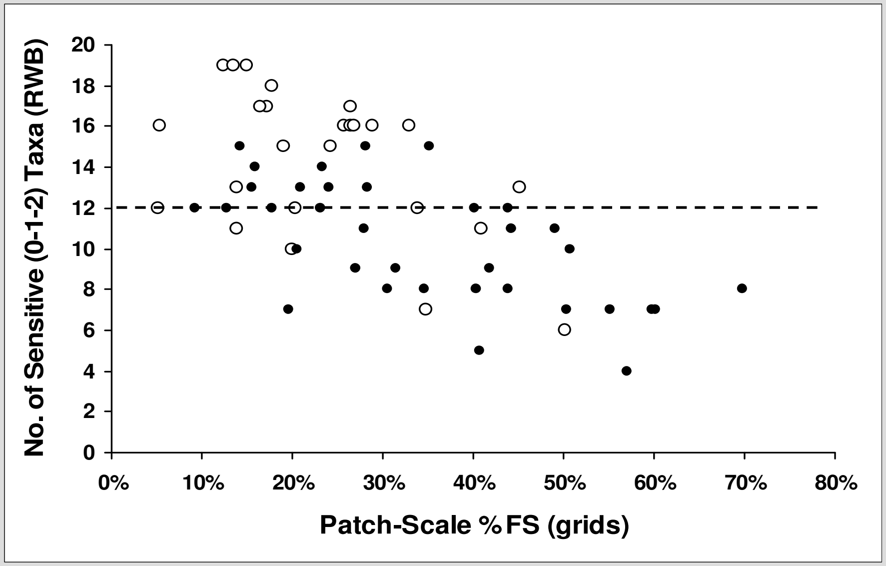


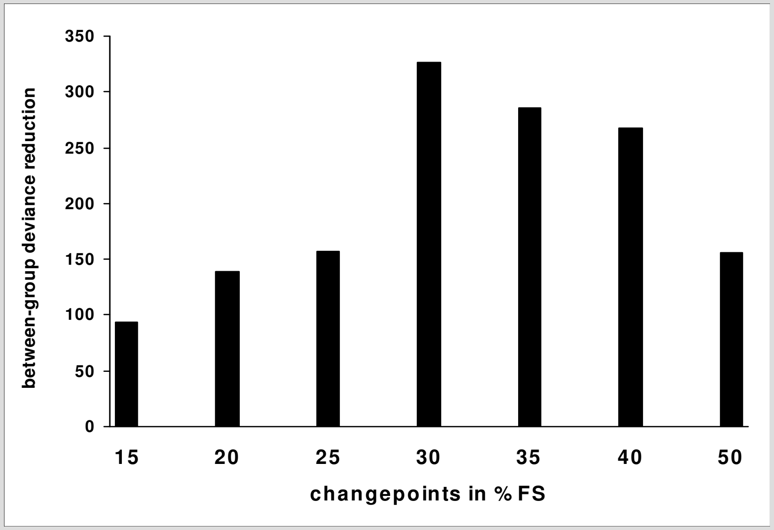
- Central Coast data set

Some changes more continuous, others show thresholds

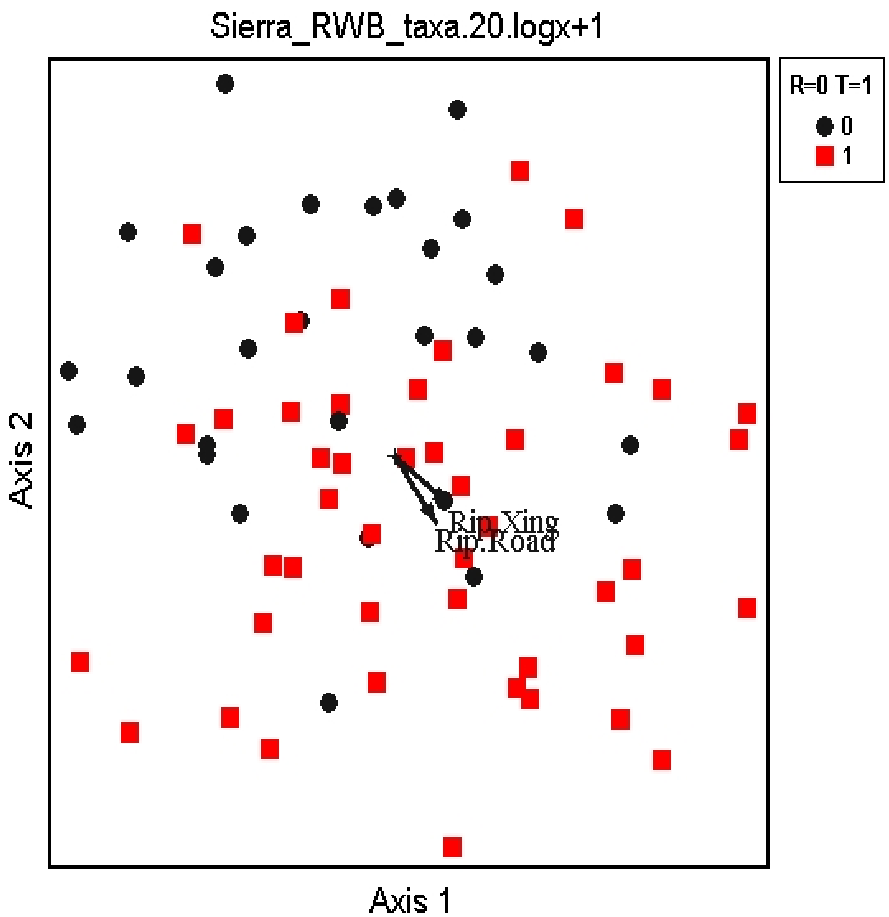


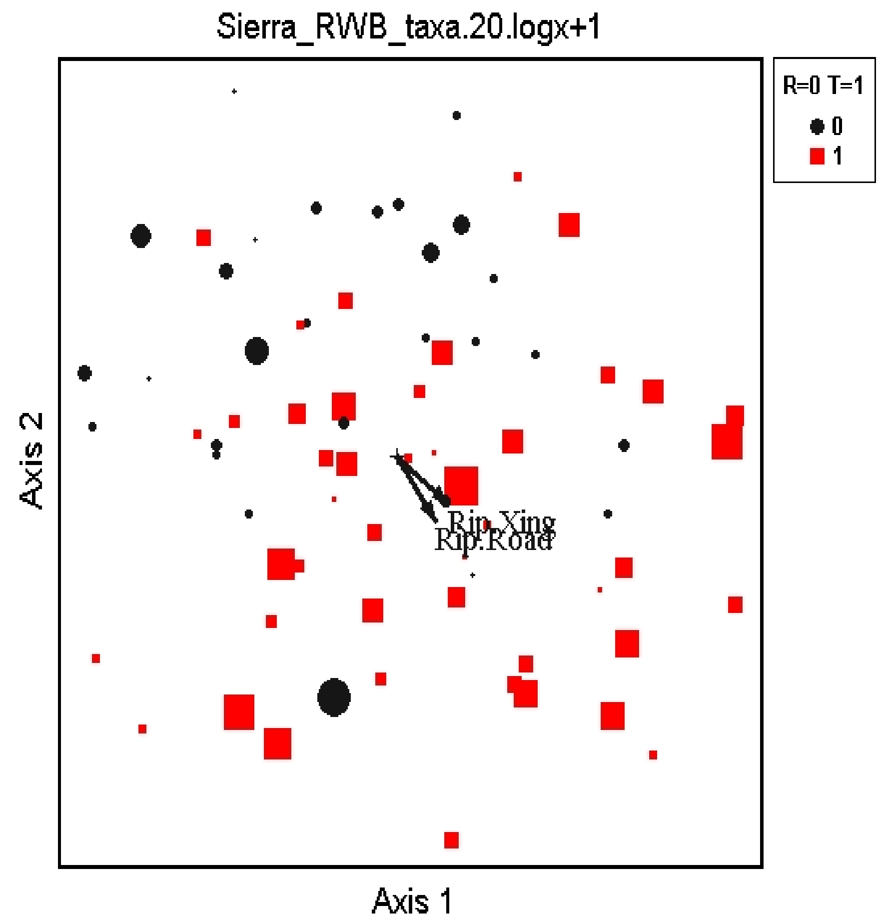






- Sierra Nevada streams also showed R-T separation along gradients of riparian road density and FS deposition

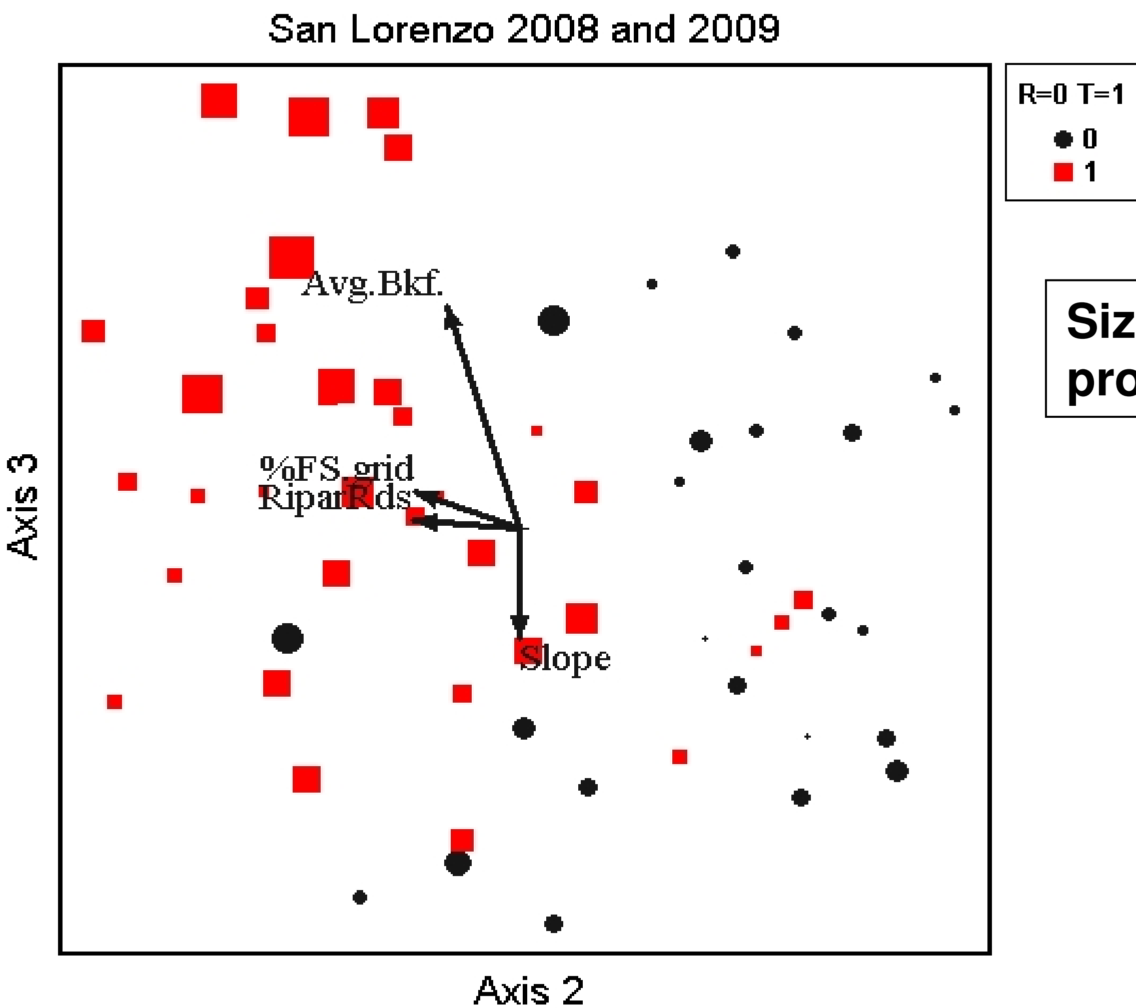




Environmental vectors of road crossings and density in riparian zone

Size of symbol in proportion to %FS

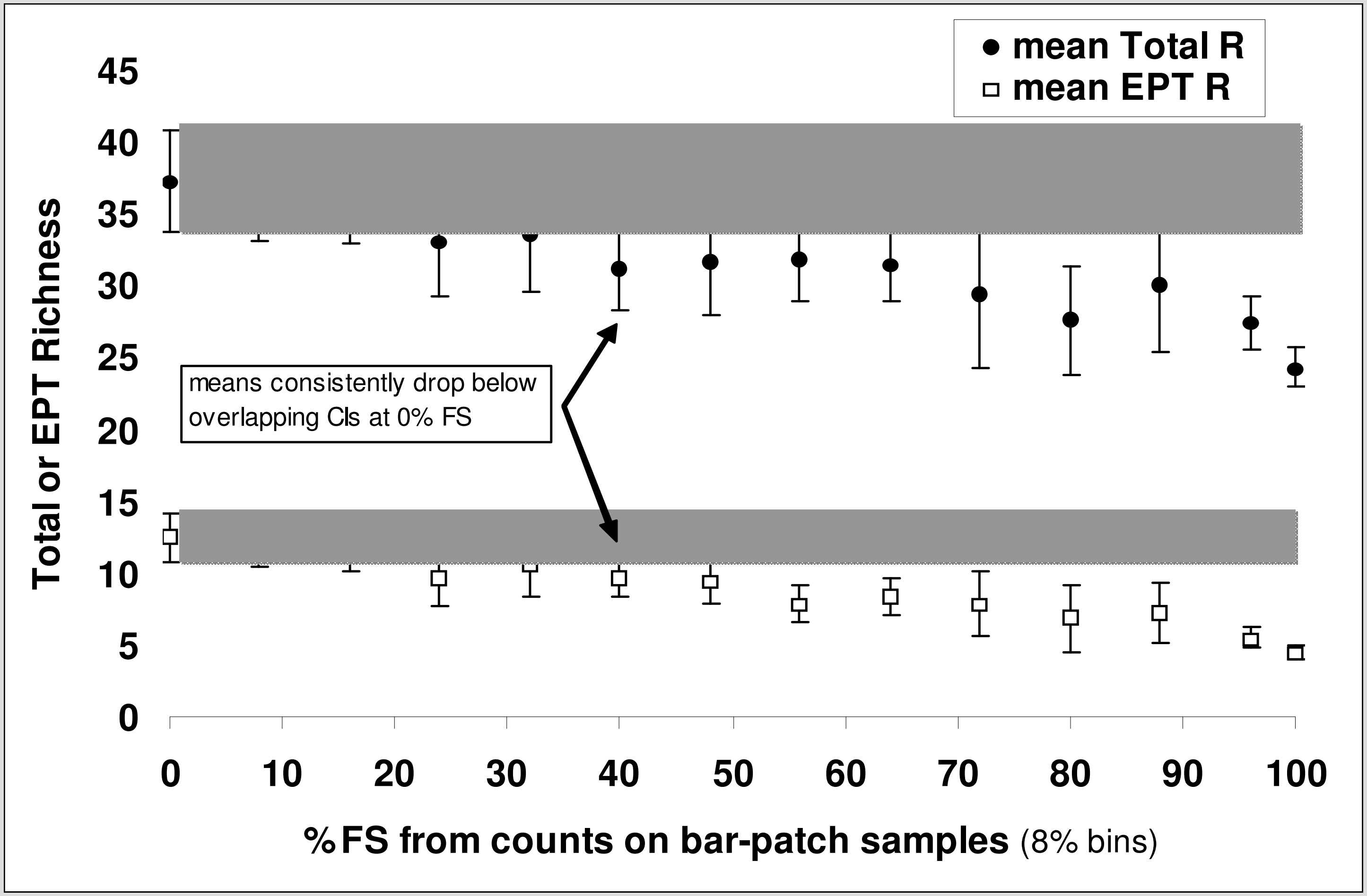
- **NMDS ordination from the San Lorenzo River and adjacent watersheds showed R-T community separation along gradients of riparian zone roadedness and fine-sand deposition levels which were often greater at lower gradient downstream reaches**



Size of symbol in proportion to %FS

San Lorenzo River and region surveys (n=60)

At the patch-scale, from samples taken on depositional bars, the threshold again appears to be at and above 40% FS (Sierra & Coast combined)



Sediment Tolerance and Sediment Aversion:
Abundance of <u>common</u> taxa across a range of %FS measured at different scales (patch-to-reach) used to calculate weighted averages to give a list of indicators

Data set from central coast streams (present in at least 20% of streams and 2 of 3 data sets)

Sediment Indicator Groups for Common Central Coast Taxa (wieghted average Fines and Sand)				
Tolerant	**Moderately Tolerant**	**Intermediate**	**Moderately Sensitive**	**Sensitive**
Parakiefferiella	Phaenopsectra	Thiennemannimyia*	Serratella*	Turbellaria-flat worms
Hygrobates	Polypedilum_scalaenum	Parametriocnemus	Cricotopus_Orthocladius	Physa
Cladotanytarsus	Tanytarsus	Lepidostoma	Microtendipes_rydalensis	Micrasema
Oligochaeta	Tricorythodes	Atractides	Torrenticola	Diphetor_hageni
Heterotrissocladius_marcidus	Lebertia	Sperchon*	Paraleptophlebia	Ceratopsyche
Brillia	Hydra	Baetis*	Bezzia_Palpomyia	Polypedilum_aviceps
Antocha	Corynoneura	Ephemerella_maculata	Rheocricotopus	Epeorus
Neoplasta	Centroptilum	Mucronothrus	Rheotanytarsus	Cinygmula
Paracladopelma	Ostracoda	Thienemanniella_xena*	Synorthocladius	Zapada
Limnesia	Microtendipes_pedellus*	Hemerodromia*	Agapetus	Calineuria_californica
Sphaeromias	Stempellinella	Simulium*	Eubrianax_edwardsii	
Siphlonurus	Micropsectra	Hydroptila	Tvetenia_bavarica	
	Optioservus_quadrimaculatus	Testudacarus	Rhyacophila_betteni	
	Polypedilum_tritum	Gumaga	Suwallia	
	Zavrelimyia	Paratanytarsus	Drunella_flavilinea	
	Hydropsyche			
	Sialis			
These taxa derived from quartile rankings of weighted average scores from three central coast data sets of %FS at different scales.				
*denotes those taxa for which rankings were in both the highest and lowest quartiles and so are uncertain (mostly intermediate); possible multi-species respones				

Experimental sediment-dosing studies utilized stream mesocosm channels at SNARL to study pulse and press of sediment (FS) applications

<u>We found</u>…..

- •Drift export of CPOM increased with FS load (sand mobilized OM)
- •Effects on BMIs were habitat-specific, pools lost more than riffles
- •Recovery occurred after single-application pulse, but sustained depression of density seen under repeated press
- •Legacy (1-yr) of severe pulse was depressed abundance & richness

Summary

- Increased roadedness is associated with elevated levels of sediment deposition in streams
- Sediment load models predict sediment deposition levels
- Reach-scale power explains deposition for local conditions, but for equal power, streams in disturbed landscapes accumulate more sediment
- While some biological indicators show monotonic responses to sediment, most show thresholds at both reach and patch-scales of 30-40% FS
- Community ordinations of reference and test sites separate along gradients of road density & FS sediment
- Experiments suggest effects are more pronounced in depositional habitats, can involve depletion of OM resources, depend on duration of exposure, and may leave a legacy of poor habitat quality & lower BMI density