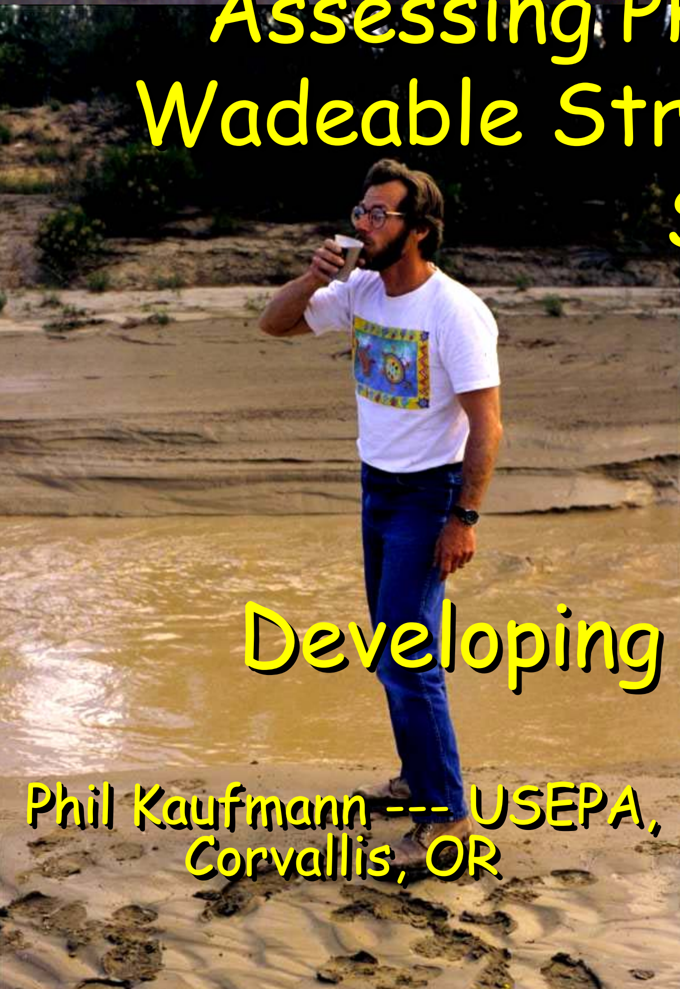
Assessing Physical Habitat Condition in Wadeable Streams and Rivers Using EMAP Style Protocols:

Developing Indices of Habitat Condition



Phil Kaufmann --- USEPA, Corvallis, OR

California Aquatic Bioassessment Workgroup Meeting -- Nov 2006 Davis, California

EMAP PHYSICAL HABITAT PROTOCOL:

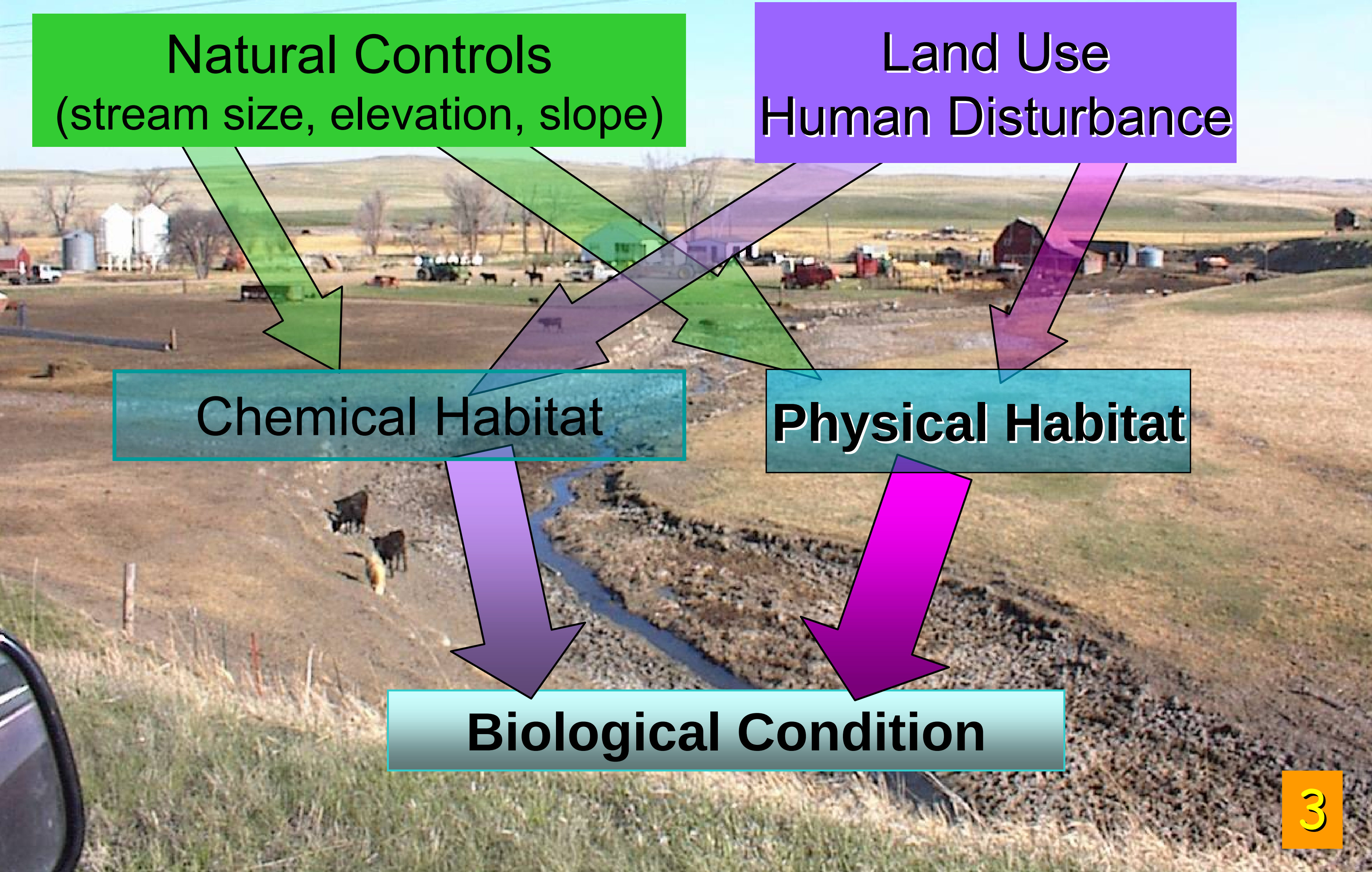
Quantitative Measurements:

- Channel Dimensions
- Slope, Bearing
- Substrate ("Pebble Count")
- Riparian Canopy Density

Visual Estimates/Tallys:

- Fish Concealment Features
- Woody Debris Tally
- Embeddedness
- Riparian Vegetation Cover
- Riparian Veg. Structure
- Human Disturbances

Primary interpretation of condition from biota, but land use and natural controls affect biota indirectly through their effect on habitat.



Habitat Assessments

- Raw Measurements
- Habitat Characterization
- **Habitat "Alteration"**
  - of Particular Habitat Features
  - of *Integrated* Habitat Measures
- **Habitat "Quality"**
  - of Particular Habitat Features
  - of *Integrated* Habitat Measures
- Multi-Dimensional Assessments
- Multi-Scale Assessments

Habitat Indicators Reported in the National Wadeable Streams Assessment

- Streambed Excess Fine Sediments --- scaling based on low end of RBS distribution in Ecoregional Ref Sites.
- Habitat Cover Complexity --- Sum of all types other than algae and trash,etc, (XFC_NAT) scaled by Ecoregional Ref Sites.
- Riparian Vegetation --- Density and Complexity meas'd by summed cover of 3 Layers of Woody Vegetation XCMGW – scaled by Ecoregional Ref Sites.
- Riparian Disturbance --- Proximity-weighted human disturbance index (W1_Hall) -- values of 0.33 and 1.5 for low and high disturbance.

----------Stream Size ----------->

------ Gradient --------->

Relative Bed Stability and Excess Fines

based on mean particle diameter ratio: Observed/Mobile

$LRBS = Log(D_{gm}/D^*_{cbf})$

D_{gm} --- observed geometric mean diameter from field "pebble count".

D^*_{cbf} : max mobile D "Critical D" at bankfull --- by equating bankfull and critical shear stress:

<u>Bankfull Bed Shear Stress ($\rho g R^*_{bf} S$), controlled by</u>:

+ Channel slope (S)

+ Adjusted Bankfull Hydraulic Radius (R^*_{bf})

 + Bankfull Depth,

 - Residual pool depth, - Form roughness,- Large wood volume

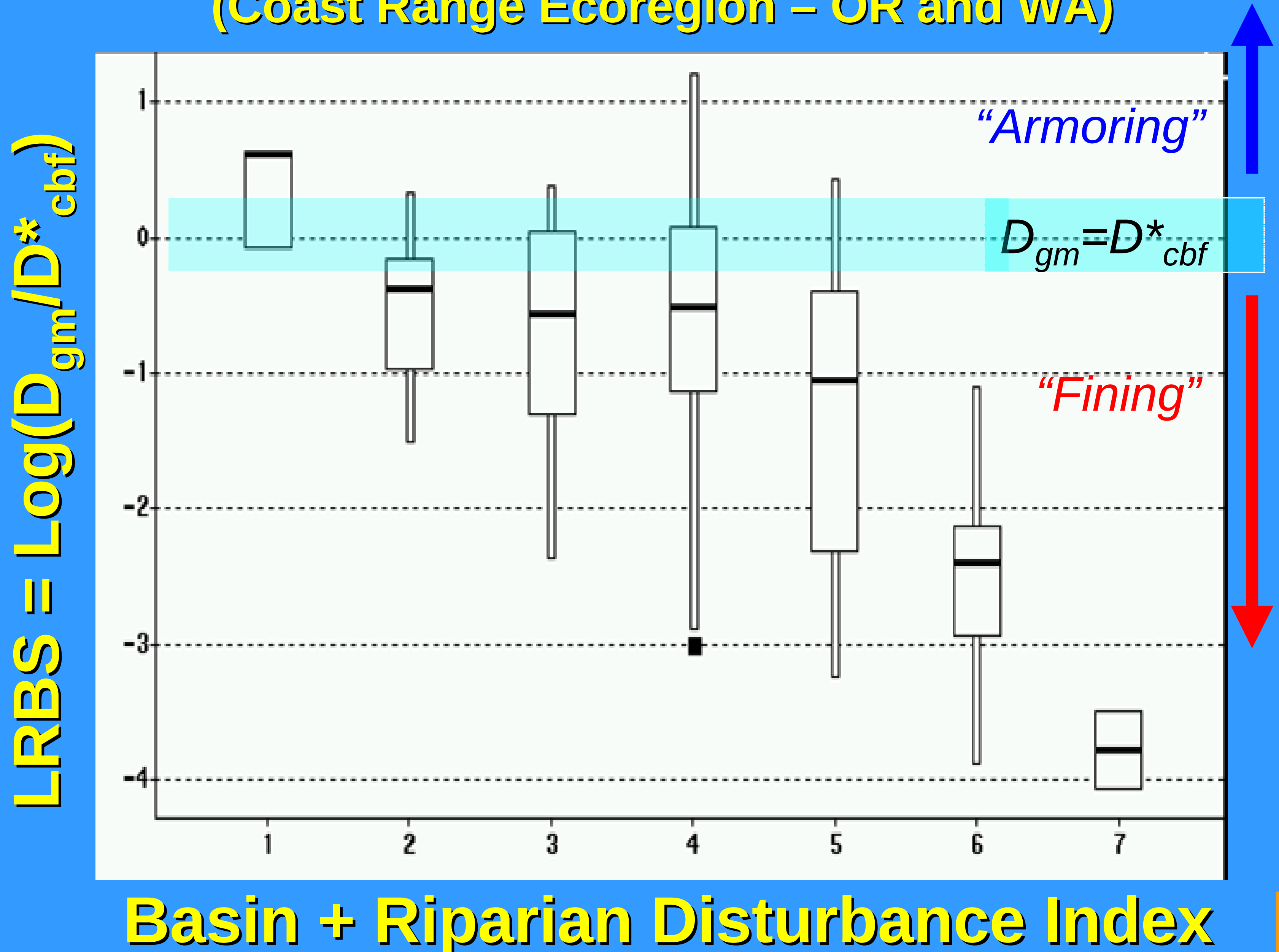
<u>Critical Shear Stress $\theta(\rho_s-\rho)gD$, influenced by</u>:

+ Particle Diameter (D)

+ mass density of particles in water ($\rho_s-\rho$)

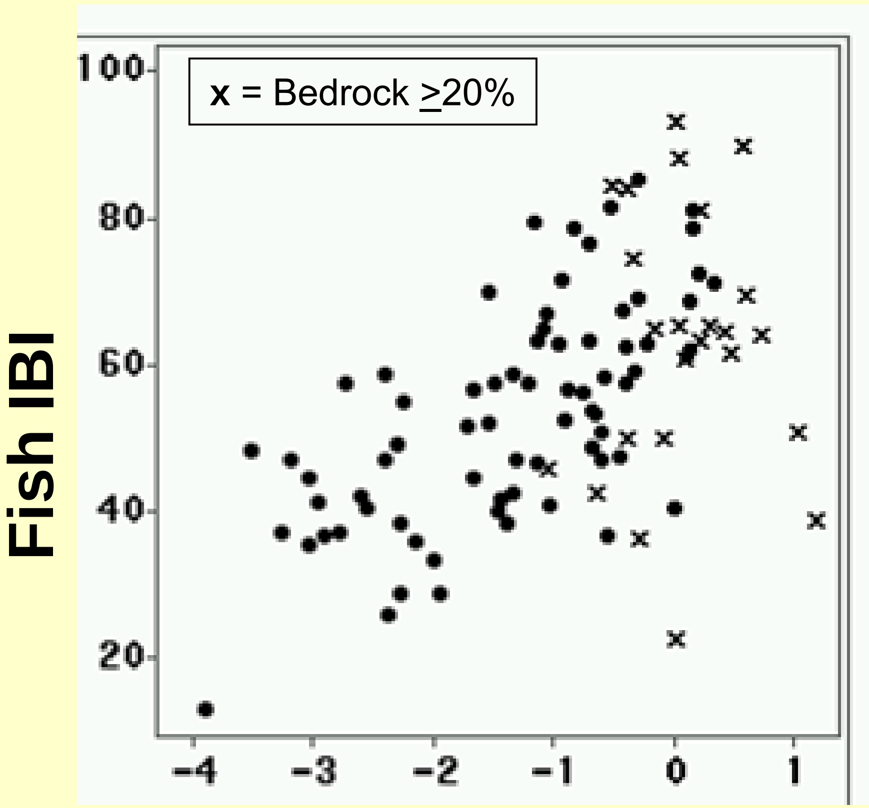
. shape, exposure, size variance, turbulence, relative submergence (θ)

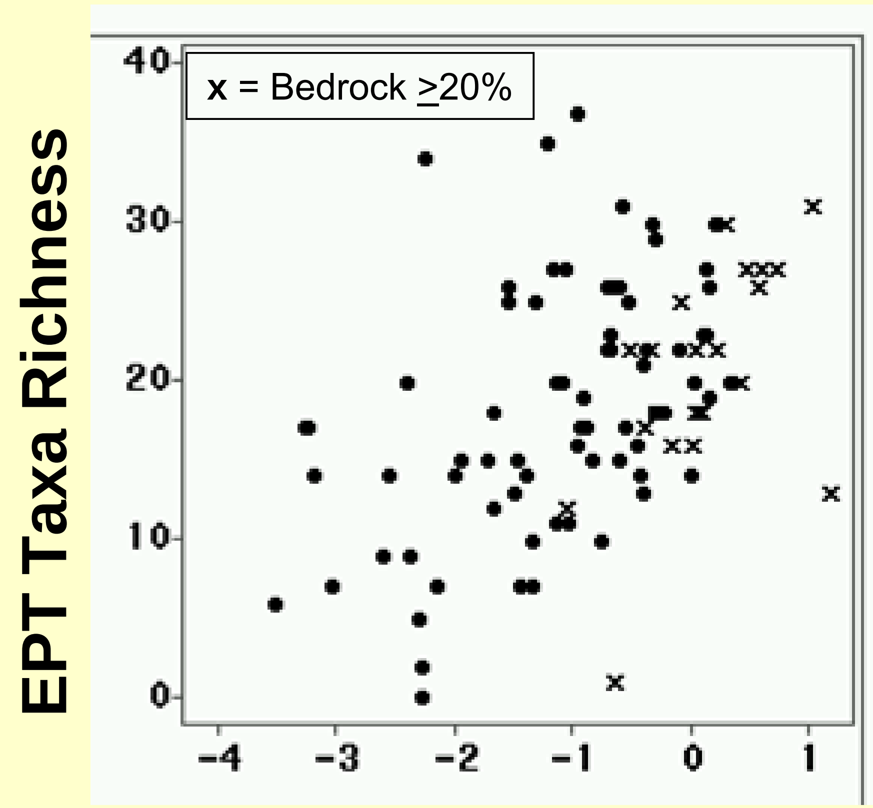
Relative Bed Substrate Stability vs Disturbance (Coast Range Ecoregion – OR and WA)



Is Relative Bed Stability important to fish and bugs ?

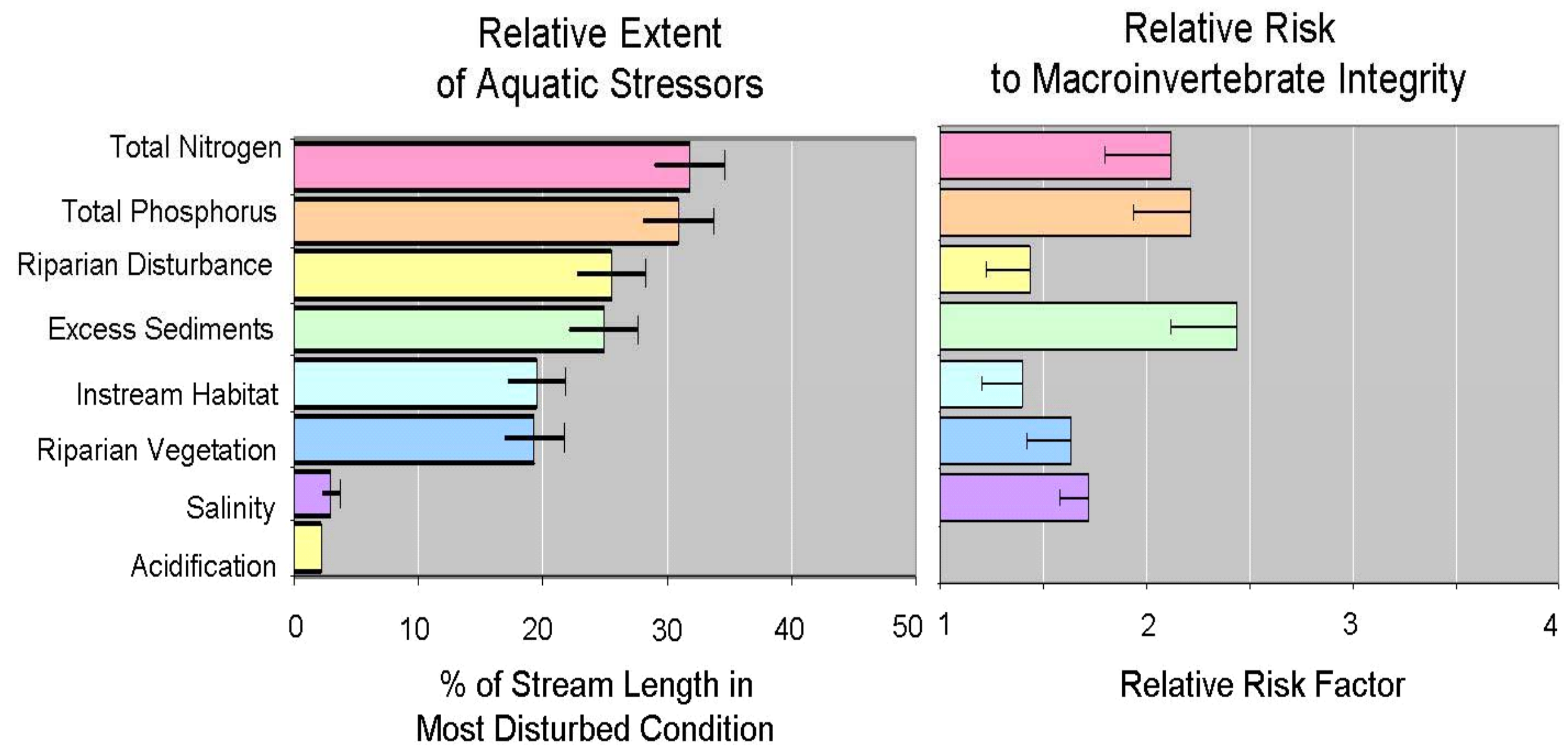
(Data from OR/WA Coast Range REMAP '94-'95)





LRBS: Log(D_{gm}/D^*_{cbf})

National Wadeable Streams Assessment: Extent and Relative Risk of Stressors to Biological Condition



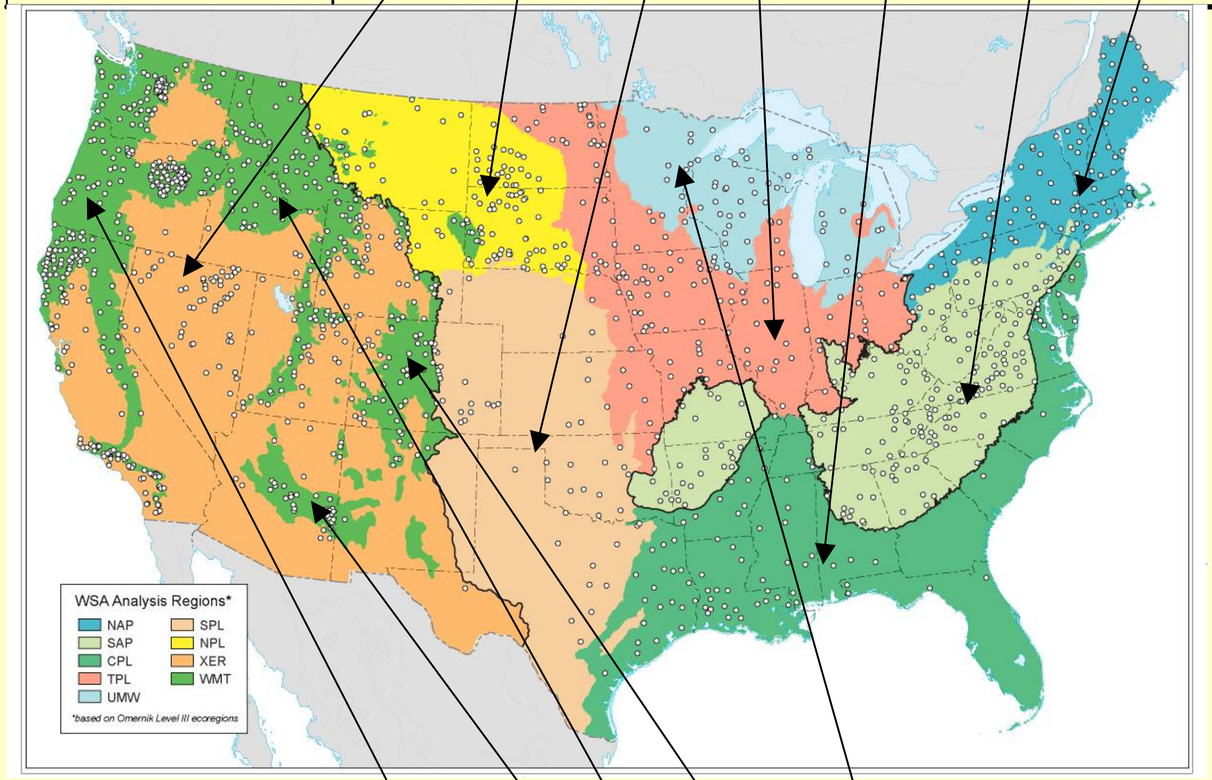
Relative Risk relates stressor condition and biological condition by estimating the increased likelihood of poor biological condition when a given stressor is rated in poor condition. (This calculation treats each stressor independently and does not account for the effects of combinations of stressors.)

One Approach for Setting RBS Criteria for Excess Fine Sediments

(Used in National Wadeable Streams Assessment for defining "good" and "poor" condition)

**No sediment or instream biota info used to define reference sites

(percentiles of ecoregional reference site distribution of RBS)	
25th/10th	XER, NPL, SPL,TPL, CPL, SAP, NAP



Ref sites disturbed

Higher quality ref sites

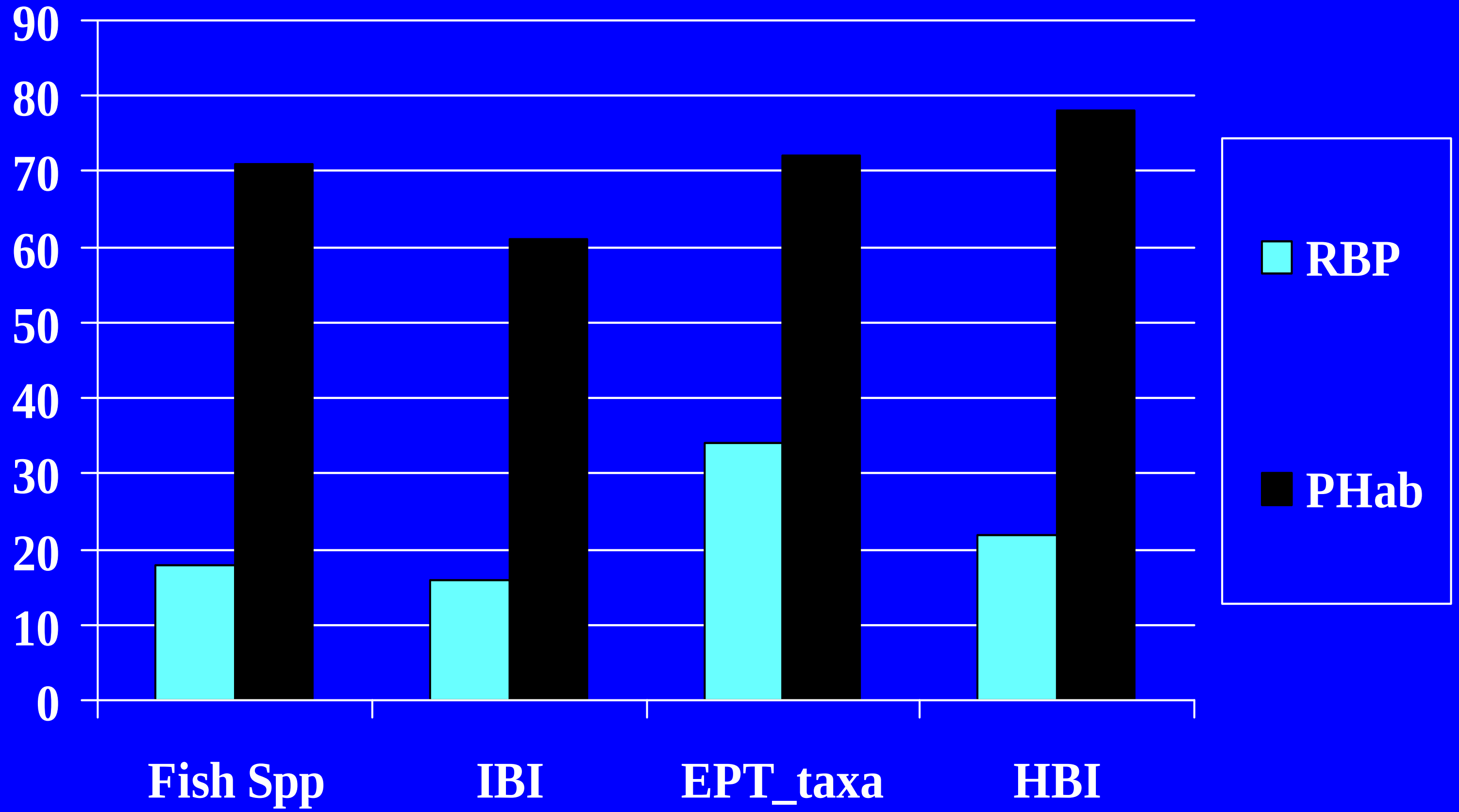
25th/5th	WMT (PNW, SW NR,SR), UMW

Relative Bed Stability -- Excess Fines (low end of RBS)

Region	"Good"	"Poor"
Coastal Plain	> -2.4	> -3.1
Northern Plains	> -2.0	> -2.6
Southern Plains	> -2.0	> -2.6
Temperate Plains	> -2.0	> -2.6
Upper Midwest	> -1.3	> -1.5
S. Appalachians	> -0.6	> -1.2
N. Appalachians	> -0.9	> -1.4
N.Rockies	> -1.1	> -1.8
Pac Northwest	> -0.7	> -1.3
Southwest Mts	> -0.9	> -1.6
S. Rockies	> -0.6	> -1.3
Xeric Regions	> -0.9	> -1.7

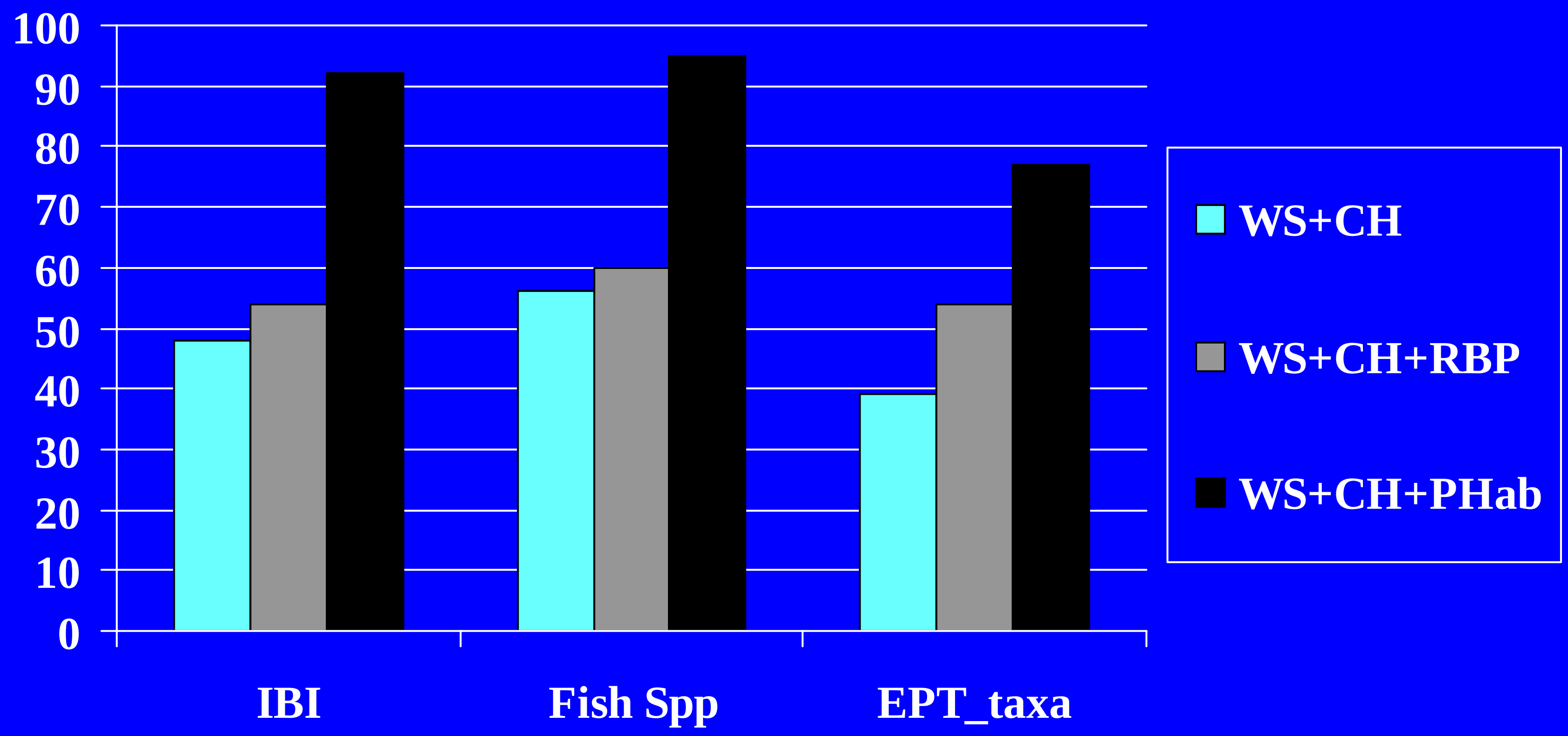
Field Protocol Component	RelBedStab	Resid Pool	HabComplex	RipVeg Struct	Rip Disturb
Thalweg Profile	X	X	X		
Slope	X	X			
Channel/Bank X-Sects	X				
Substrate Pebble-Count	X				
Wood Tally	X				
Fish Cover Ests			X		
Riparian Veg Cvr & Struct				X	
Human Disturbance Tally					X

% Variance Explained Using Different Habitat Assessment Approaches in MLR



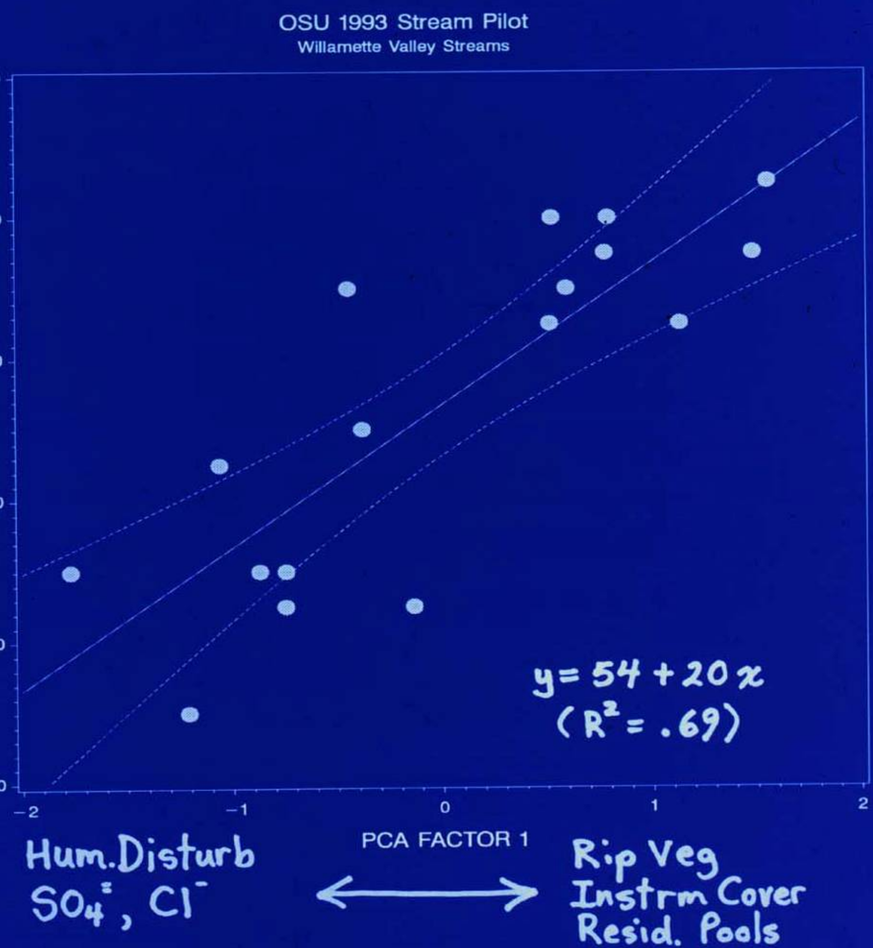
Mid-Atlantic Region Streams (7/97)

% Variance Explained Using Different Habitat Assessment Approaches in MLR



Mid-Atlantic Lowland Streams

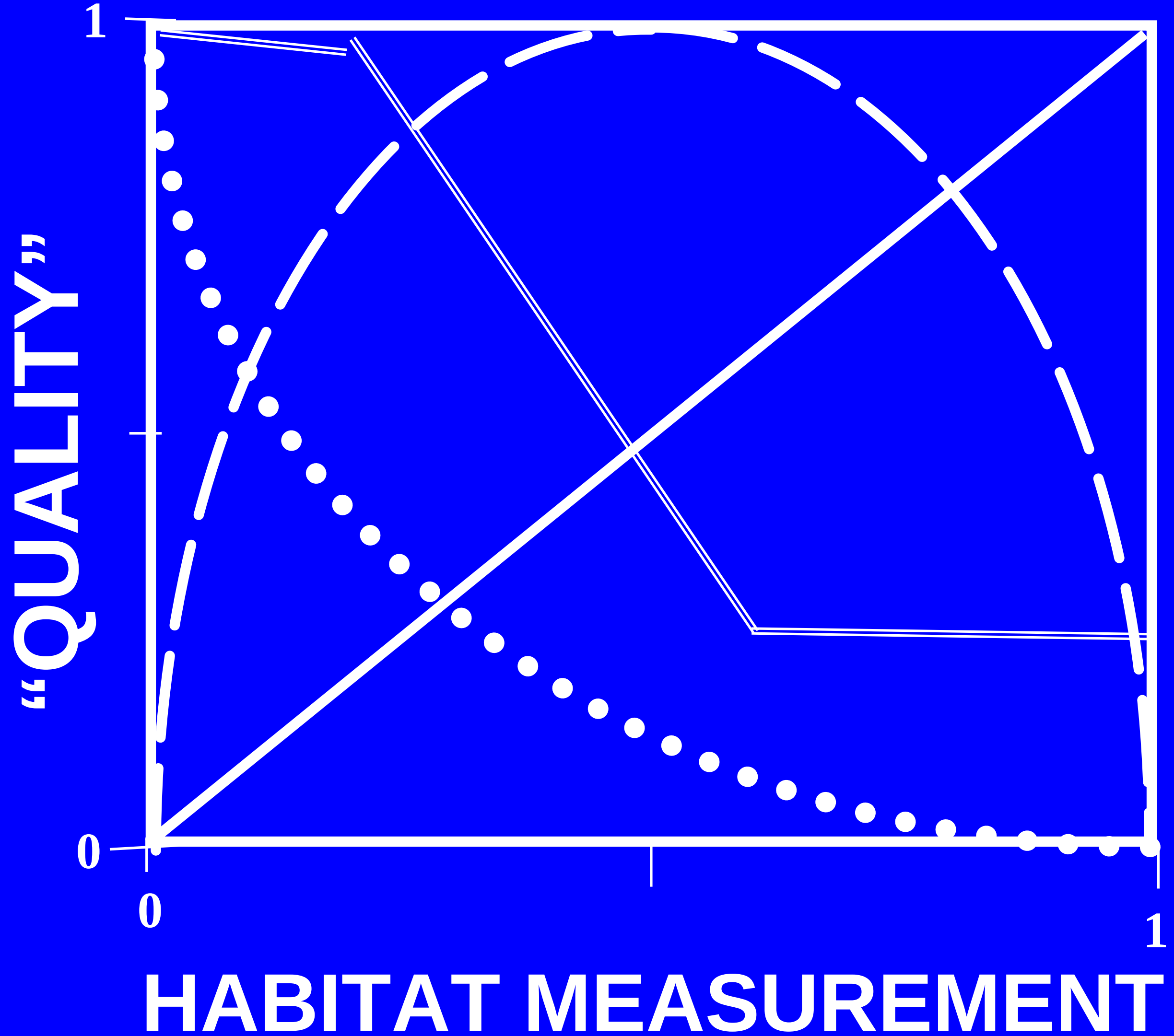
Multivariate Index of Habitat Quality



Index of Biotic Integrity

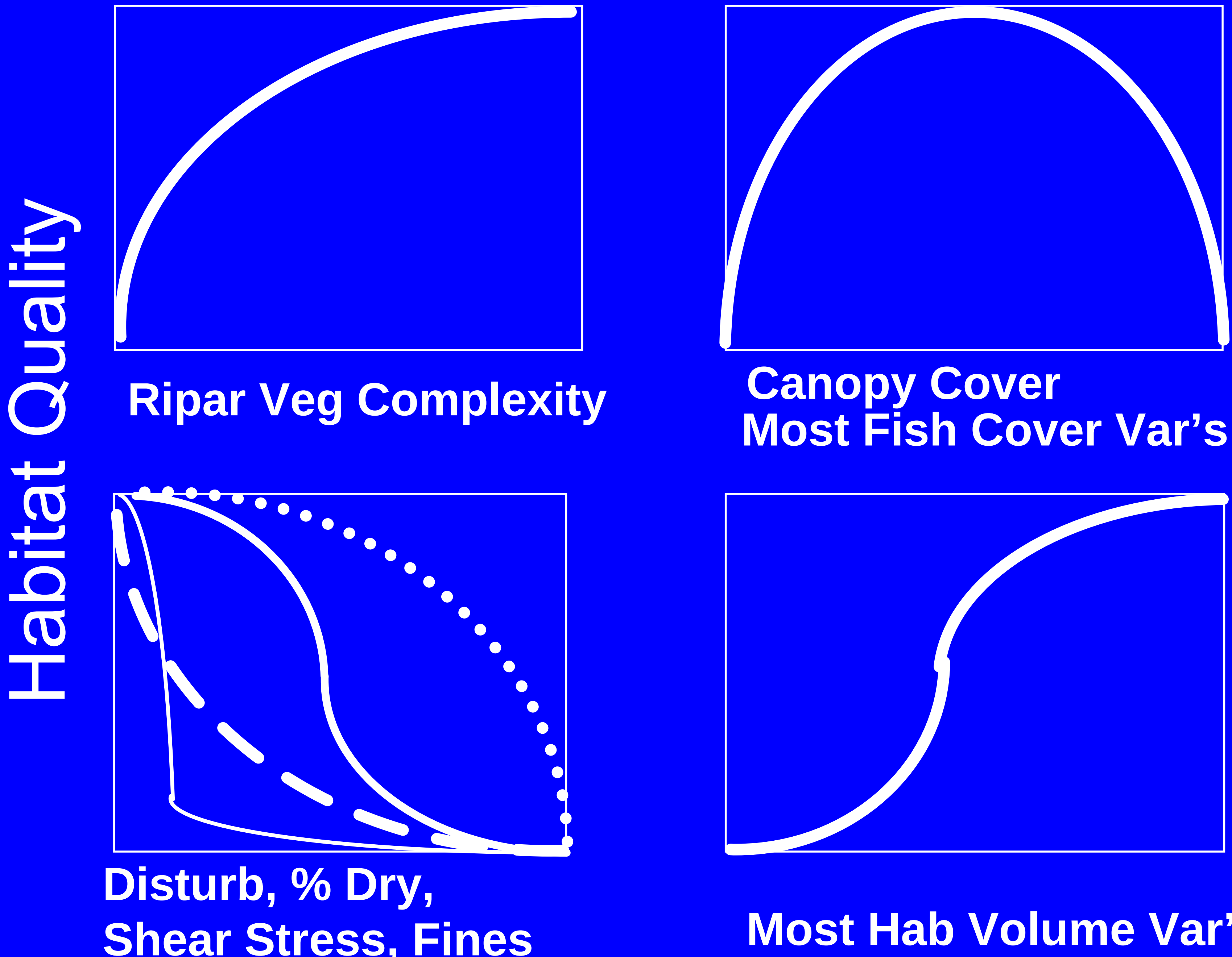
Habitat Quality

Multimetric Habitat Quality Index, built from Habitat "Response Curves"



MODELLED RESPONSES :

* Monotonic Increase
* Monotonic Decrease
* Threshold Response
  -- Hi, Low, Both
* Hyperbolic


Habitat Quality
Ripar Veg Complexity
Canopy Cover
Most Fish Cover Var's
Disturb, % Dry,
Shear Stress, Fines
Most Hab Volume Var's

Multimetric Habitat Quality Index Sub-Components

1) **Rip. Veg. -----** Complexity, Cover

2) **Rip. Disturb--** Proximity-Weighted Tally

3) **Substrate ---** Fines, Embeddedness, Bedrock, Macrophytes Algae

4) **Channel Alts--** Pipes, Revetment, Rel. Bed Stability,
Deviation in Resid. Pool Vol

5) **Volume ------** Width, X-Sect. Area, Resid. Pool, %Dry

6) **Complexity ---** CV Depth, Sinuosity

7) **Cover ---------** Separate and Sum of 6 Cover Types

8) **Velocity -----** Slope, Shear Stress

Multimetric Habitat Quality Index

Calculation

Component 1 = Mean of Subcomponents

Component 2 = Mean of Subcomponents

--- etc for 8 Components

Quality Index = $(1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8)^{(1/8)}$

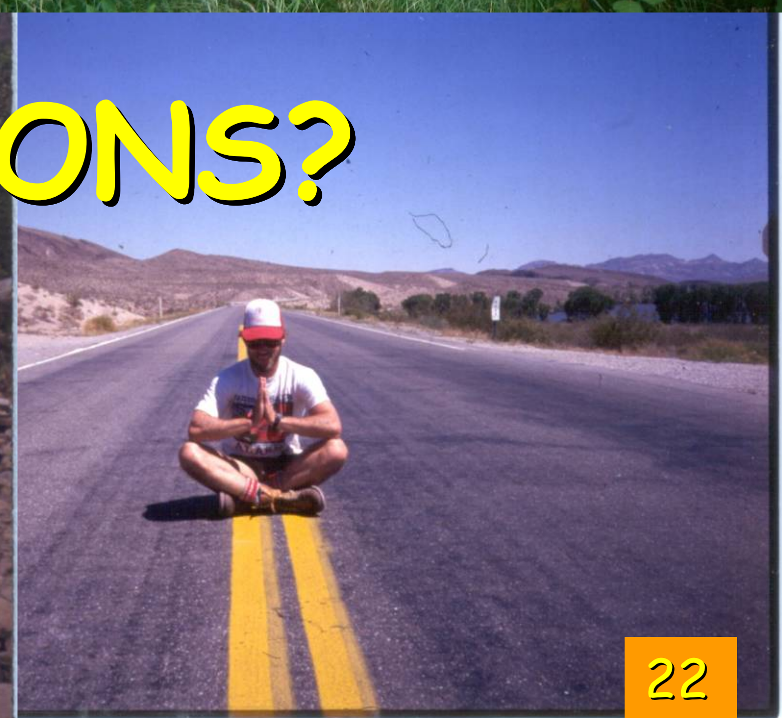
= Geometric Mean of Subcomponents

IBI vs Phab Correlations R7 Streams (Signif p<.05) *Spearman r * >.10, ** >.20, *** >.30 etc.)*

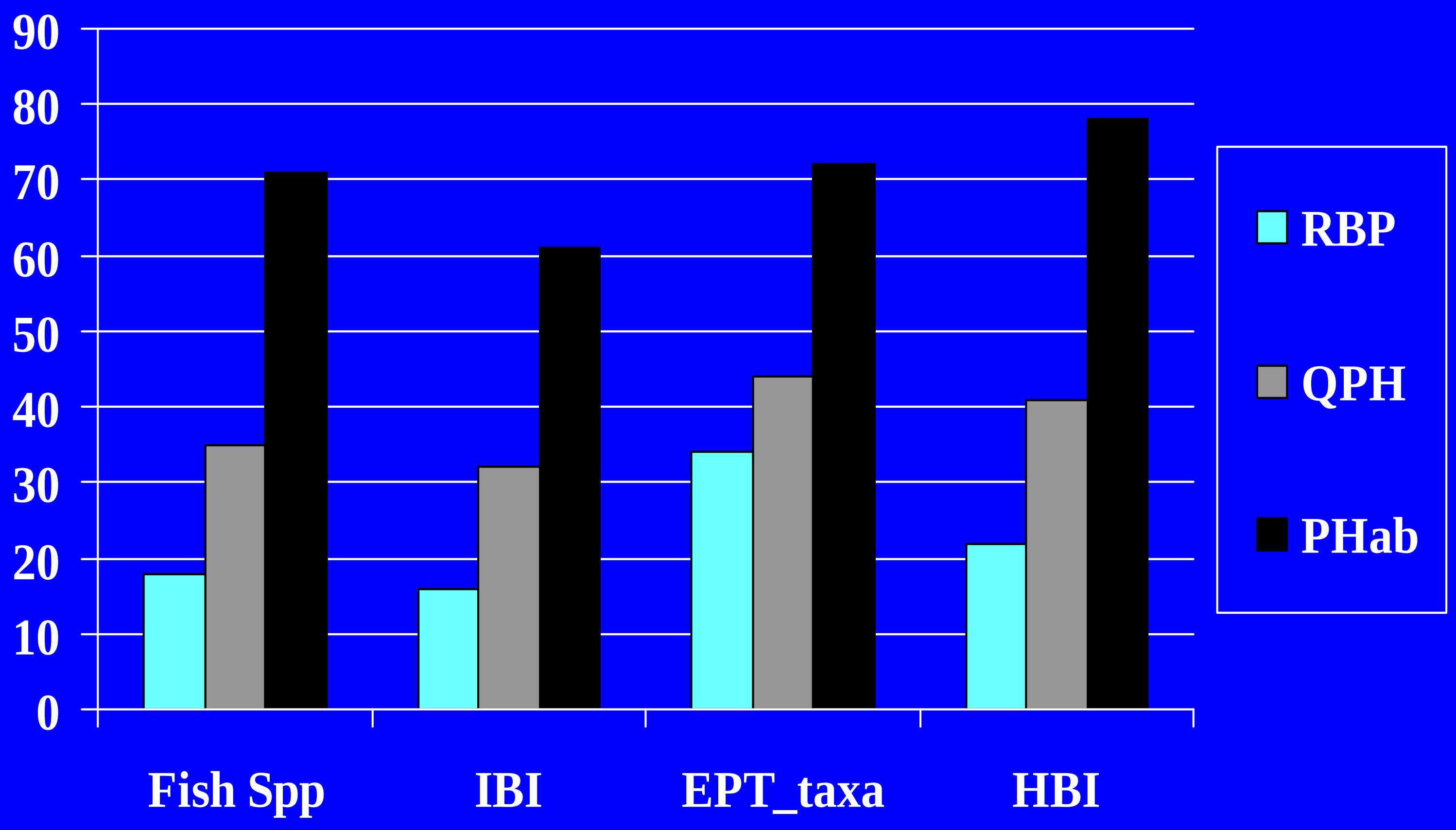
	Rveg	Rdist	Sub	ChAlt	Vol	Comp	Cov	Velo	QTPH1
Whole Reg	.	*	***	***	.	*	*	*	****
E. Lowland	*	.	***	****	.	**	.	**	****
Uplands	.	.	.	.	.	**	.	****	**
W. Plains	.	.	***	***	.	.	.	.	****
Width <5m	.	.	***	**	.	.	.	.	***
Width 5-32	.	*	****	*****	.	****	*	***	*****
Width >32	(**)	****	(**)	(***)	(**)	(**)	(**)	.	(**)

QUESTIONS?


Wadeable Streams and Rivers Using
EMAP Style Protocols:
Precision and Reach Length Issues
Phil Kaufmann -- USEPA- Corvallis, OR.
Cal. Aquatic Bioassessment
Workgroup Meeting
-- Nov 2006 Davis, California



% Variance Explained Using Different Habitat Assessment Approaches in MLR



Mid-Atlantic Region Streams (7/97)

Algebra for Deriving D^*_{cbf}

- Bankfull Shear = $\rho g R_{bf} S$
- Critical Shear = $\theta(\rho_s - \rho) g D$
- Equate $\rho g R_{bf} S = \theta(\rho_s - \rho) g D$
- Rearrange:

$$D^*_{cbf} = (\rho g R_{bf} S) / [\theta(\rho_s - \rho) g]$$

- Substitute values:

$$D^*_{cbf} = (0.604 / \theta)\, R_{bf} S$$

if $\theta = 0.044 \rightarrow D^*_{cbf} = 13.7\, R_{bf} S$

Expected Streambed Particle Size

Over time, streams adjust transport to match sediment supply.

Where transport limited by competence, Bed substrate D_{gm} in minimally disturbed streams should tend towards D^*_{cbf}, the size the stream is capable of moving as bedload at bankfull (RBS = D_{gm}/D^*_{cbf} not far from 1 in reference sites ($Log_{10}RBS=0$)

Where transport limited by capacity, D_{gm} in minimally disturbed streams should tend towards values lower than D^*_{cbf}, with reference RBS values considerably lower than 1 ($Log_{10}RBS<0$), but higher than in streams of similar type, but having large anthopogenic sediment sources.

Challenges for Future Assessments:

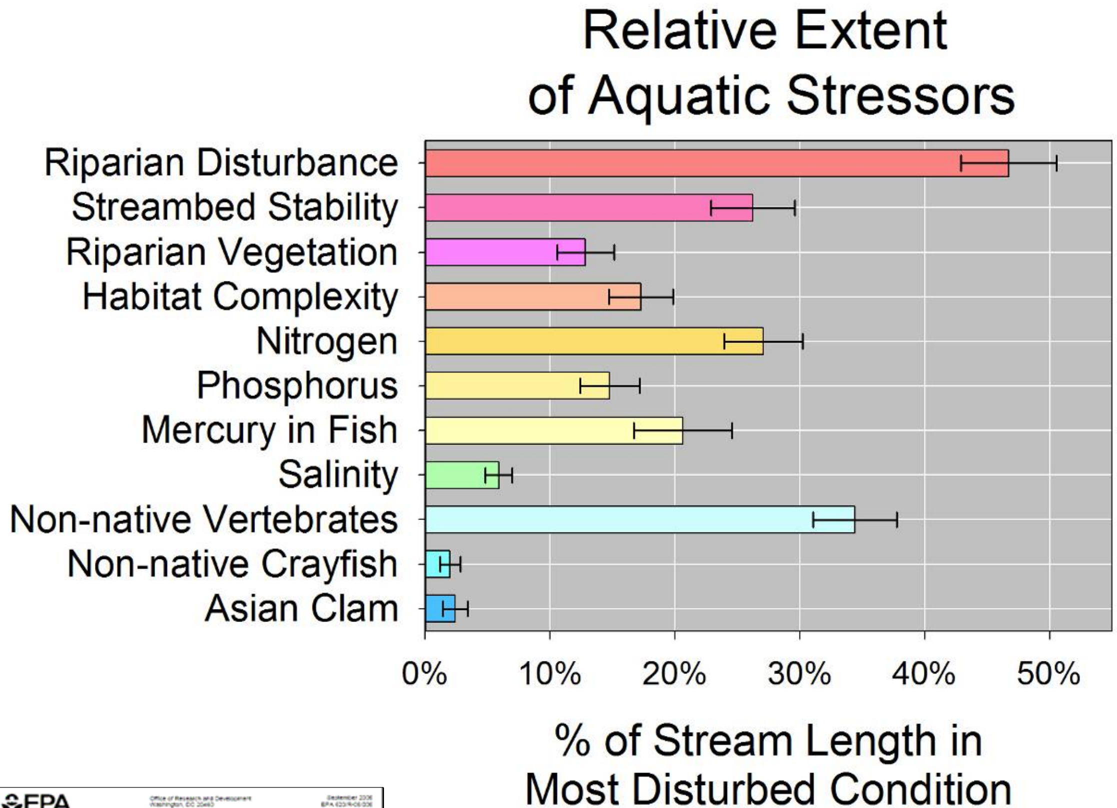
Hydrologic Alteration, which can result from:

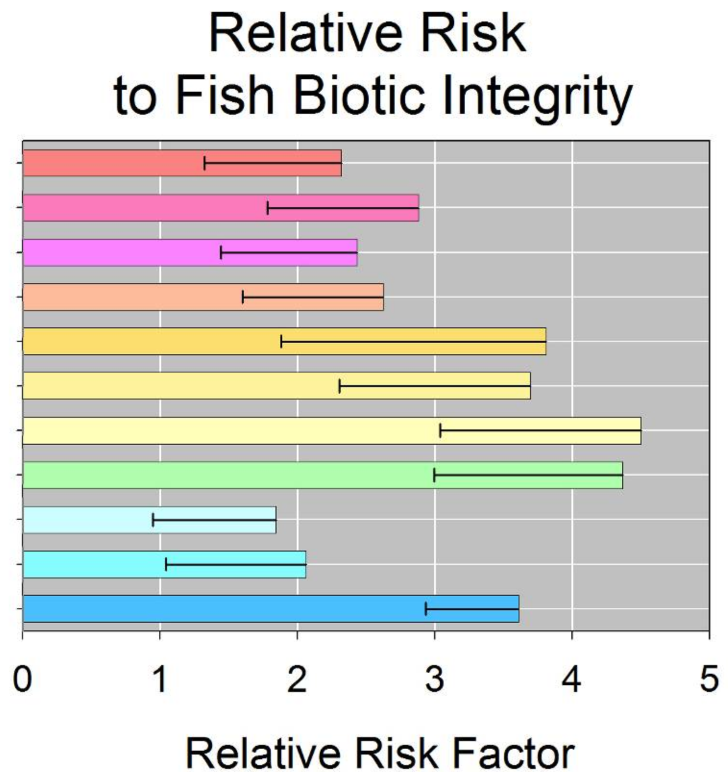
- Change in precipitation or runoff
- Water withdrawal or augmentation

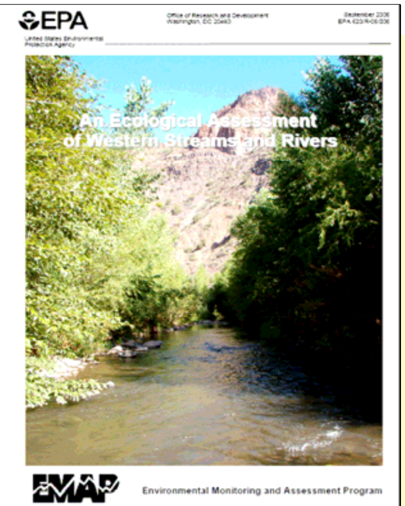
Channel Incision – a result of increase in sediment transport relative to sediment supply:

- Increase in storm flows?
- Decrease in bed and bank stability?
- Decrease in sediment supply or size ?
- Change in channel slope/sinuosity/roughness ?

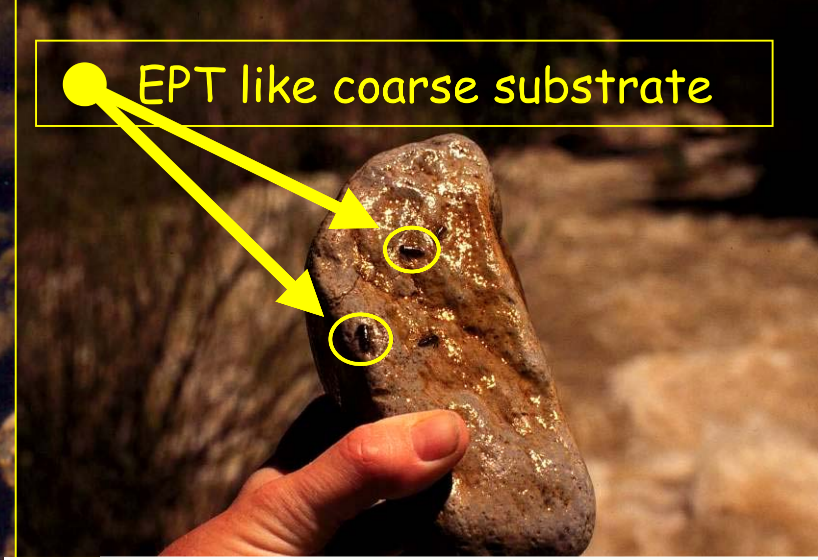
How has PHab been used to evaluate condition of streams?

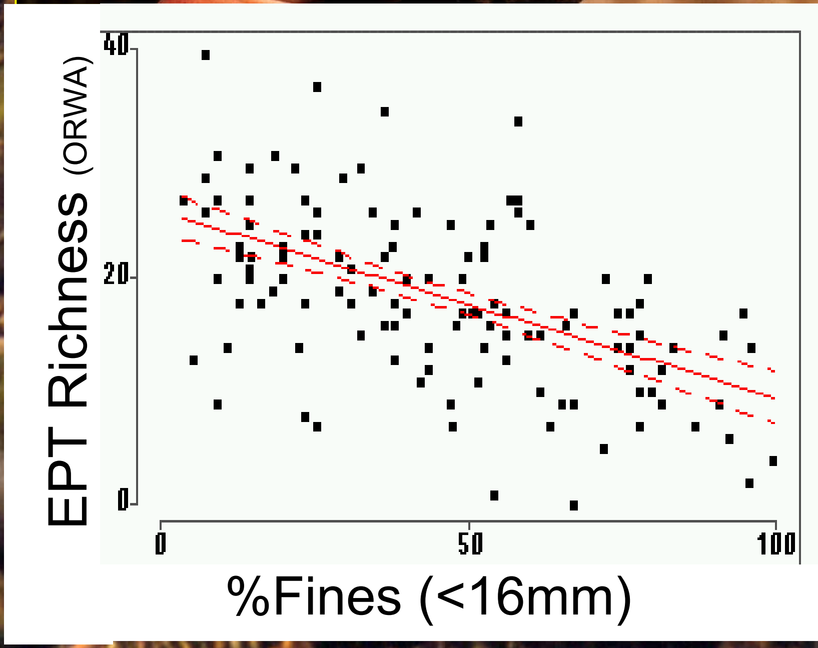






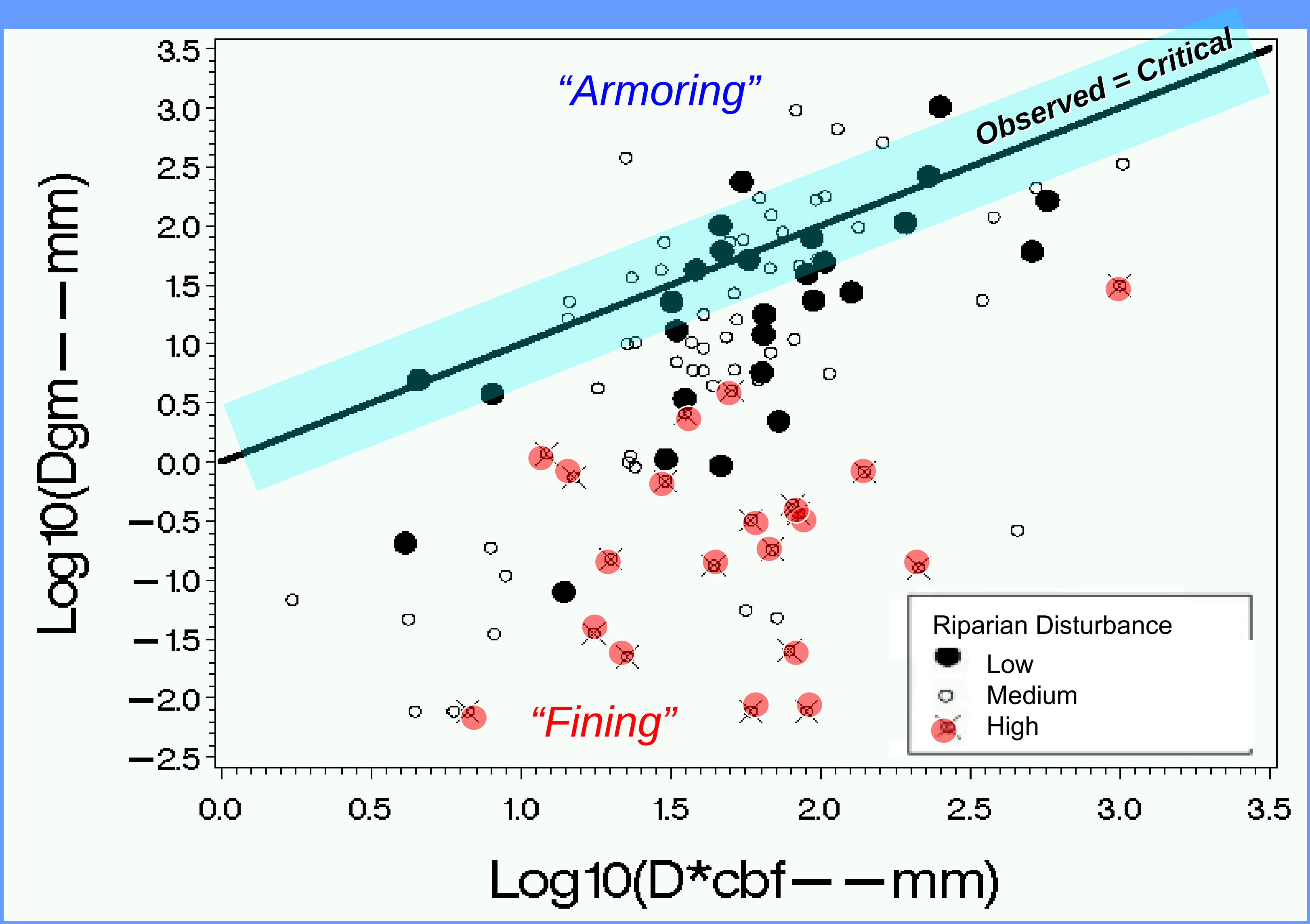
EMAP-West Assessment:
Regional Population Estimates of the relative extent of major stressors on stream condition and the relative risk of having poor fish biotic integrity, given stressor level at "most disturbed" condition (with 90% confidence intervals). Criterion for poor condition based on percentiles of ecoregionally-specific reference sites.



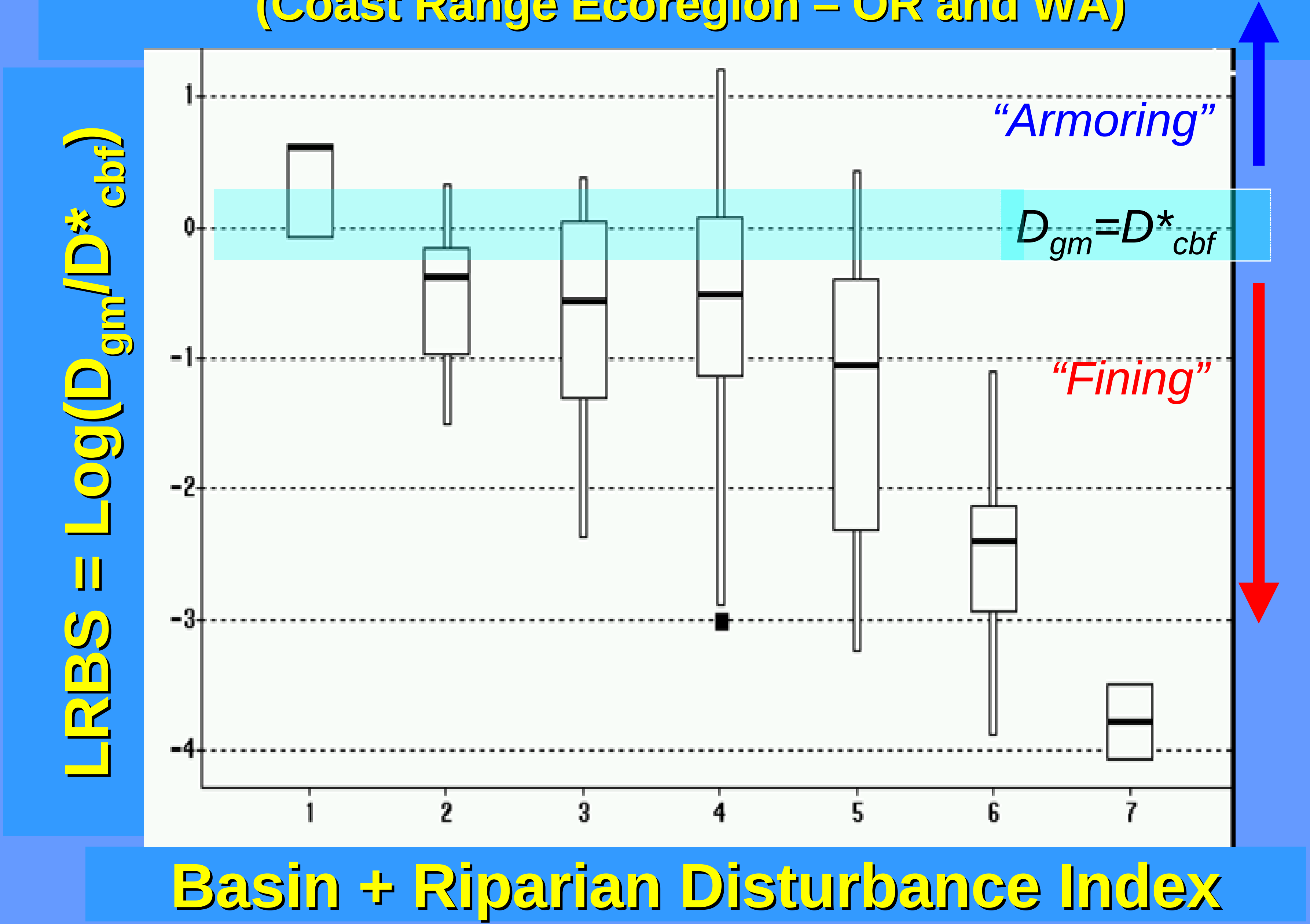


Fine particles fill spaces between larger particles, reducing water circulation, habitat space and diversity for invertebrates, benthic fishes, and spawning habitat for other fishes.

Bed Surface Particle D_{gm} vs Adjusted D^*_{cbf}
(104 Oregon and Washington Coast Range Streams)

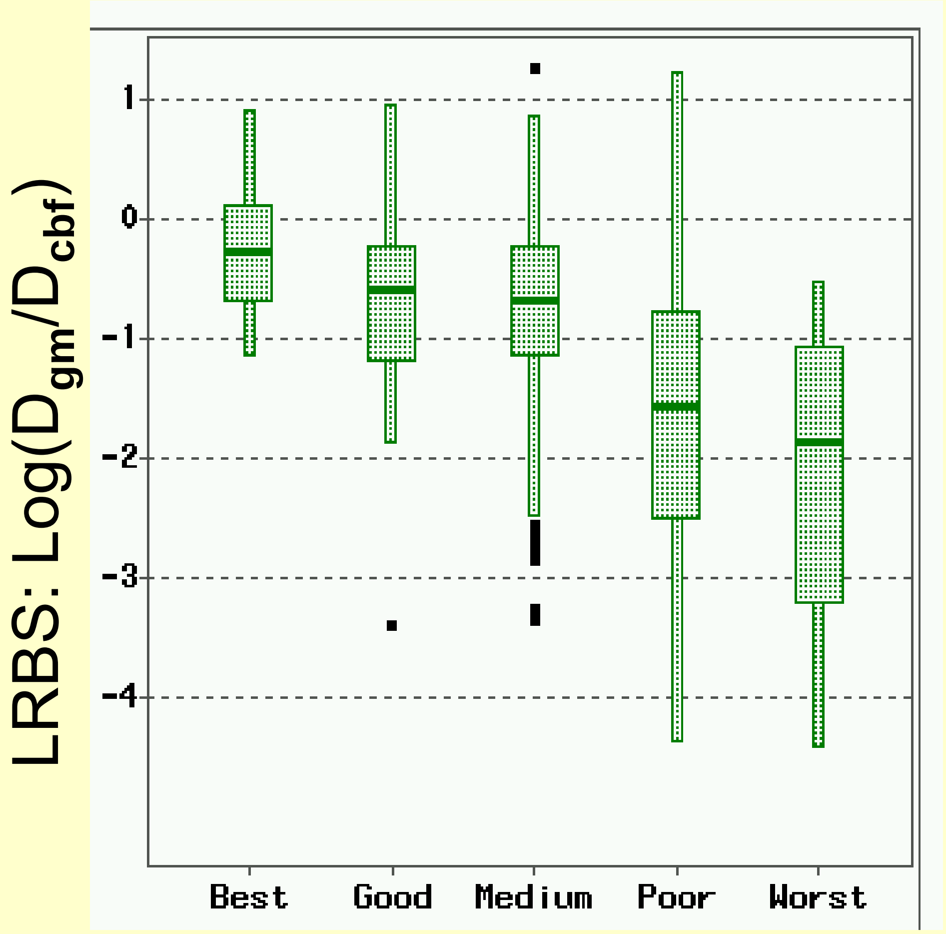


Relative Bed Substrate Stability vs Disturbance (Coast Range Ecoregion – OR and WA)



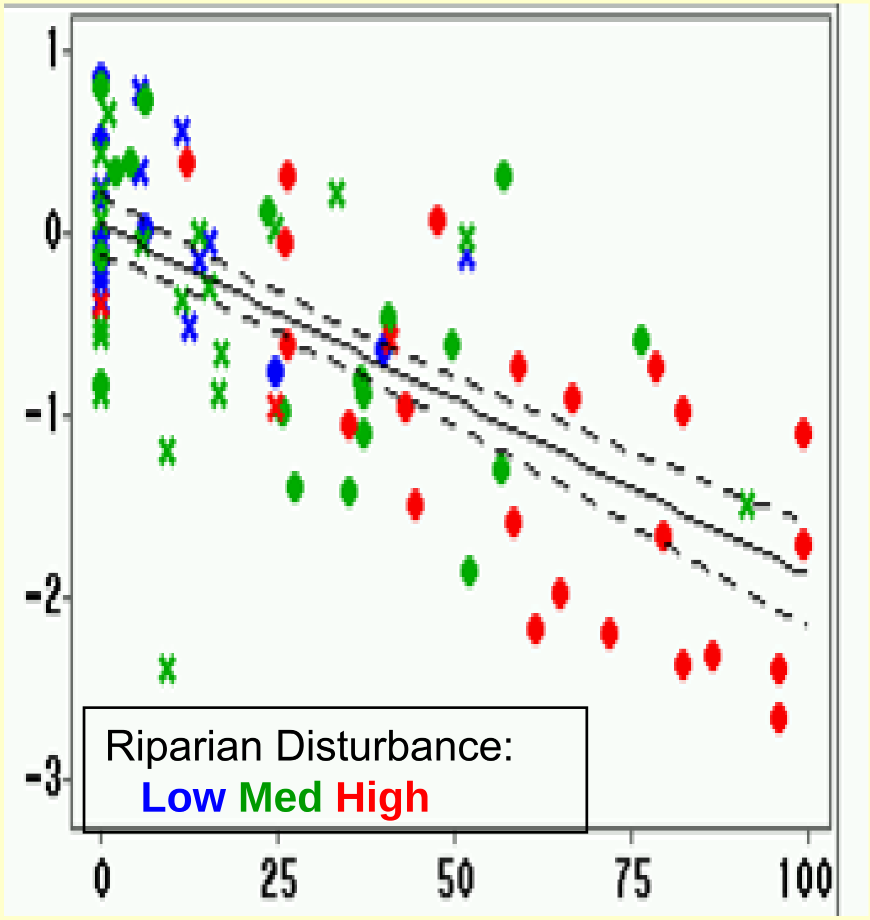
Relative Bed Substrate Stability (RBS) responsive in many regions

EMAP-West (n=900, 12 States)



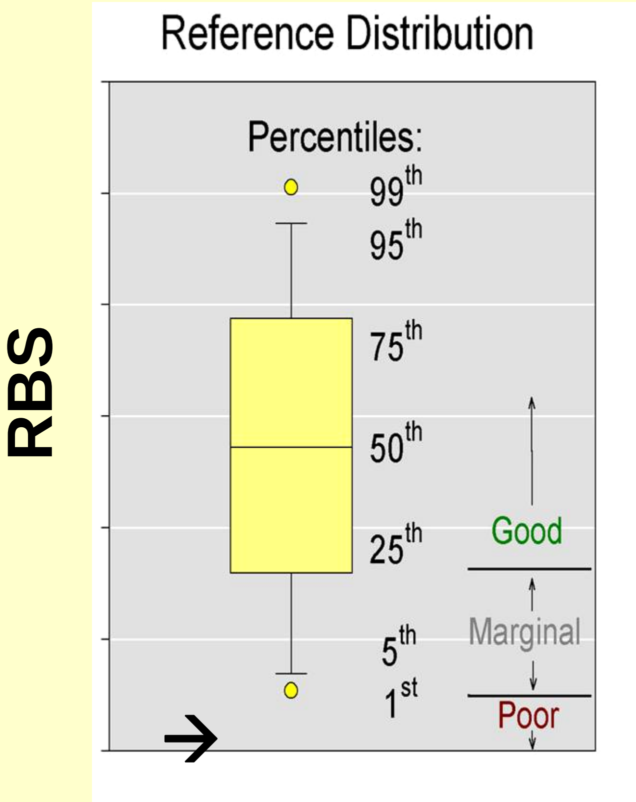
Riparian Condition Class

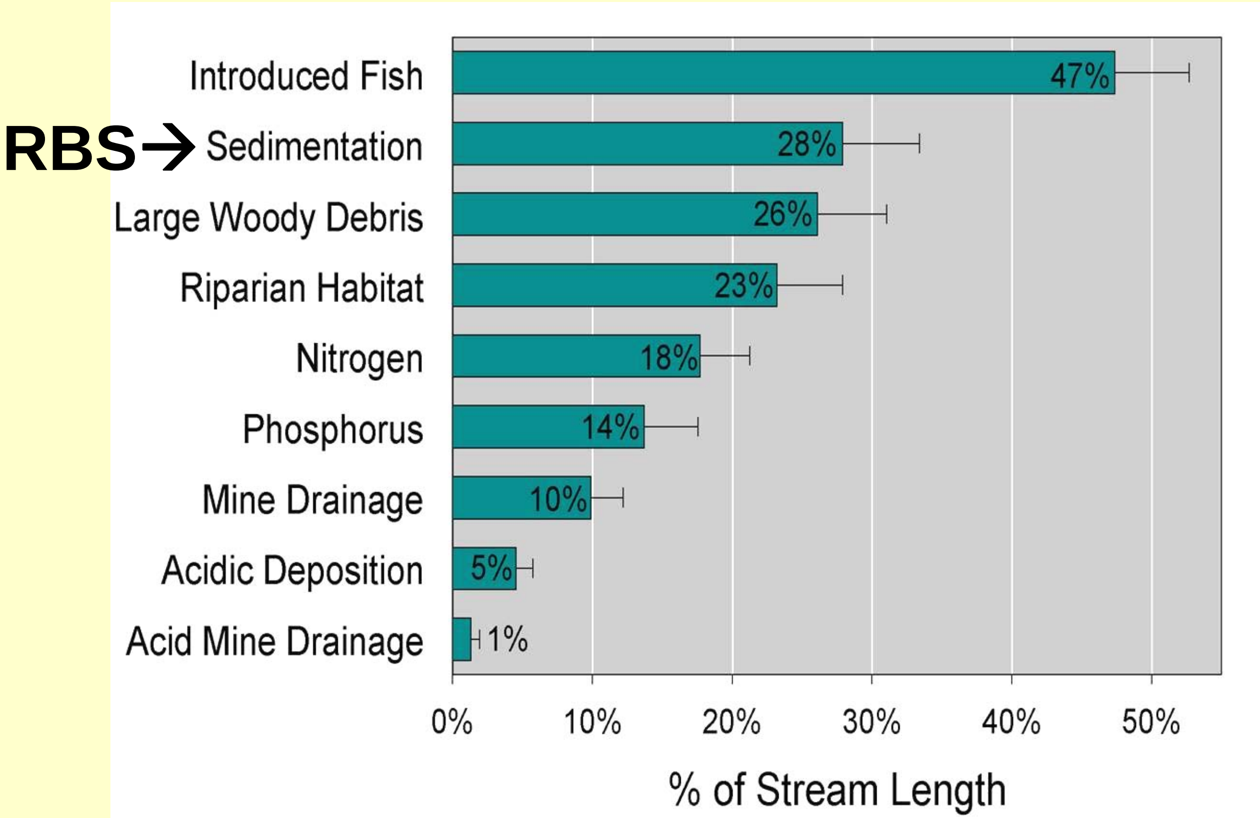
Mid Atlantic Ridge (X) Valley (.)(n=84)



Basin Land Use Disturbance (%)

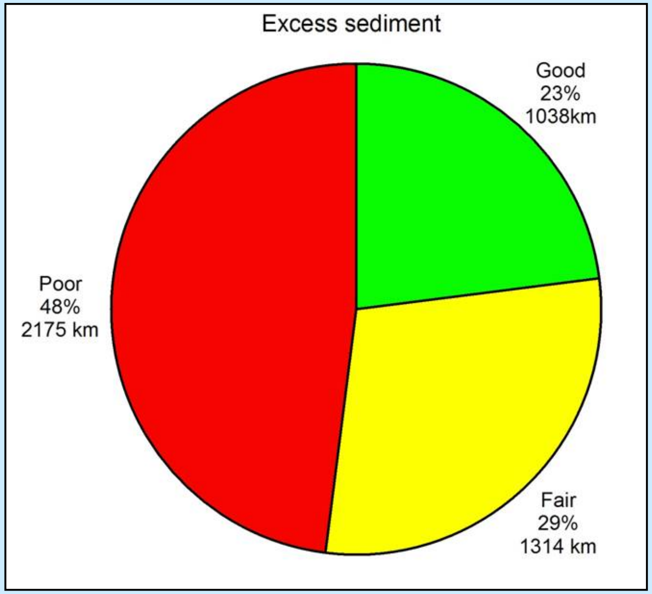
How has RBS been used to evaluate condition of streams?



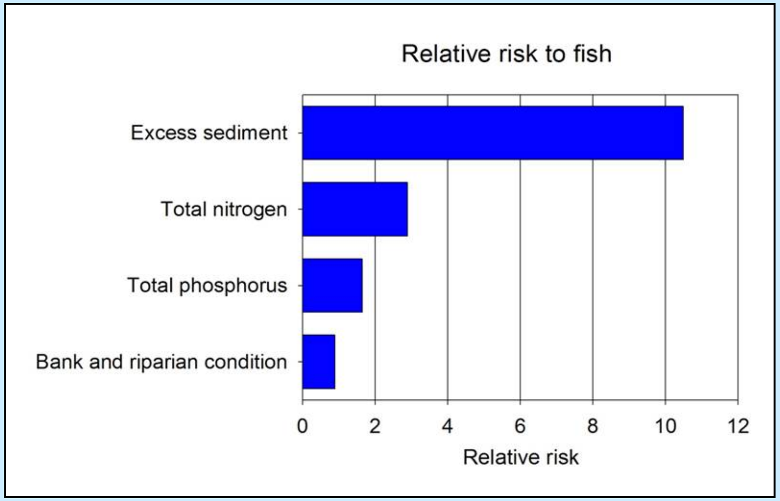


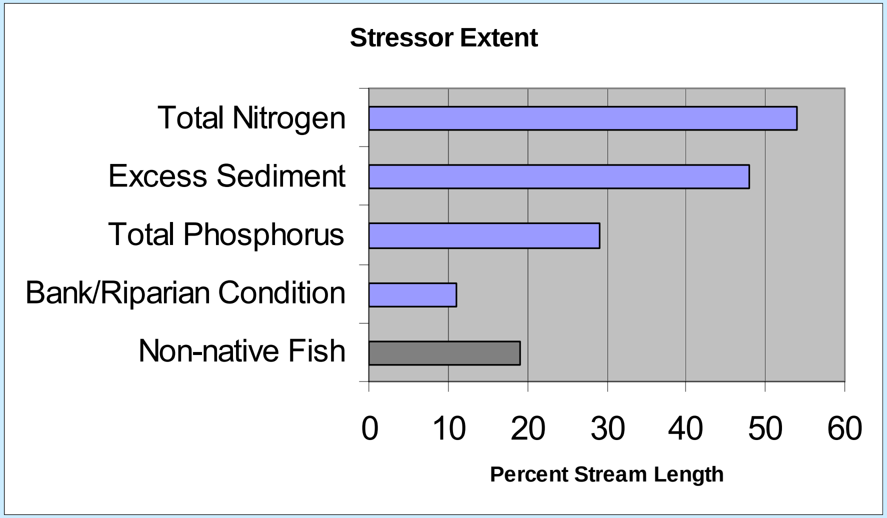
<u>Mid-Atlantic Highlands Assessment and draft Mid Atlantic Integrated Assessment</u>: Regional Population Estimates of the relative extent of major stressors on stream condition. Each bar represents the proportion of stream length in poor condition for that stressor, with 90% confidence intervals around each estimate. Criterion for poor condition: RBS < 1st percentile of ecoregionally-specific reference sites.
(in Piedmont/Coastal Plain: -2.0; in remainder of Region, -0.9)

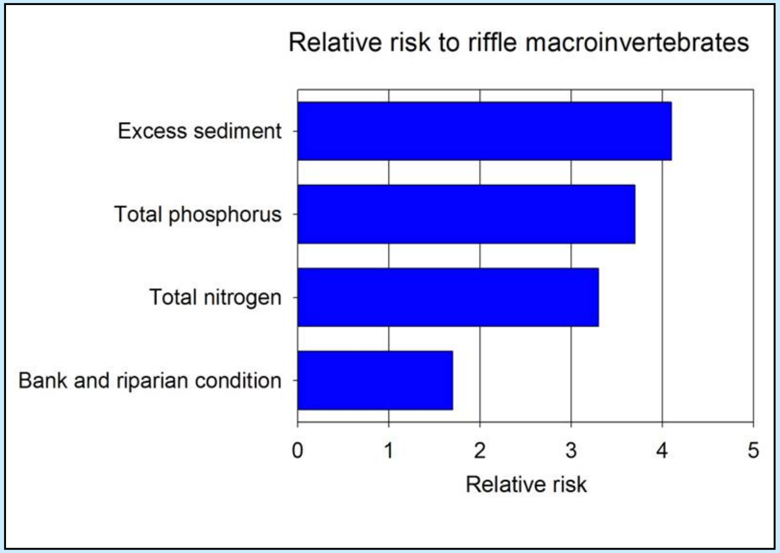
REMAP Results: "Condition of Warm-Water, Perennial Streams in the Eastern Plains of Montana" T. Johnson et al. (2005 DRAFT)



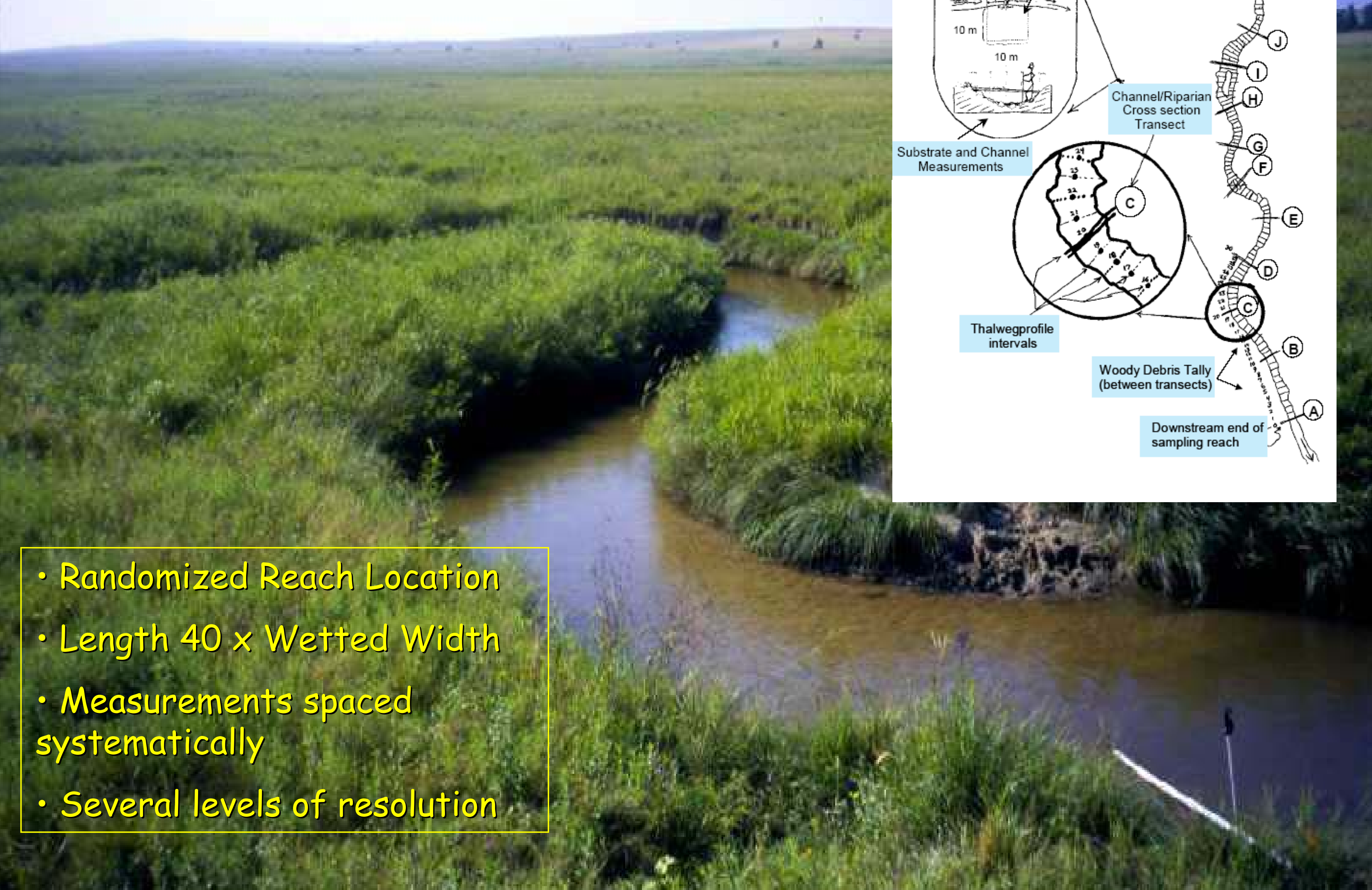
LRBS Values:
≥ -2.2 "good"
-2.7 to -2.1 "fair"
≤ -2.8 "poor"







EMAP/WSA Physical Habitat Protocol for Wadeable Streams



- Randomized Reach Location
- Length 40 x Wetted Width
- Measurements spaced systematically
- Several levels of resolution

Reg7 IBI vs Habitat Quality Index

(Red=Uplands, Blue=E.Lowlands, Green=W.Plains)