A Basinwide Index for Biological Assessment of Potomac Nontidal Streams:

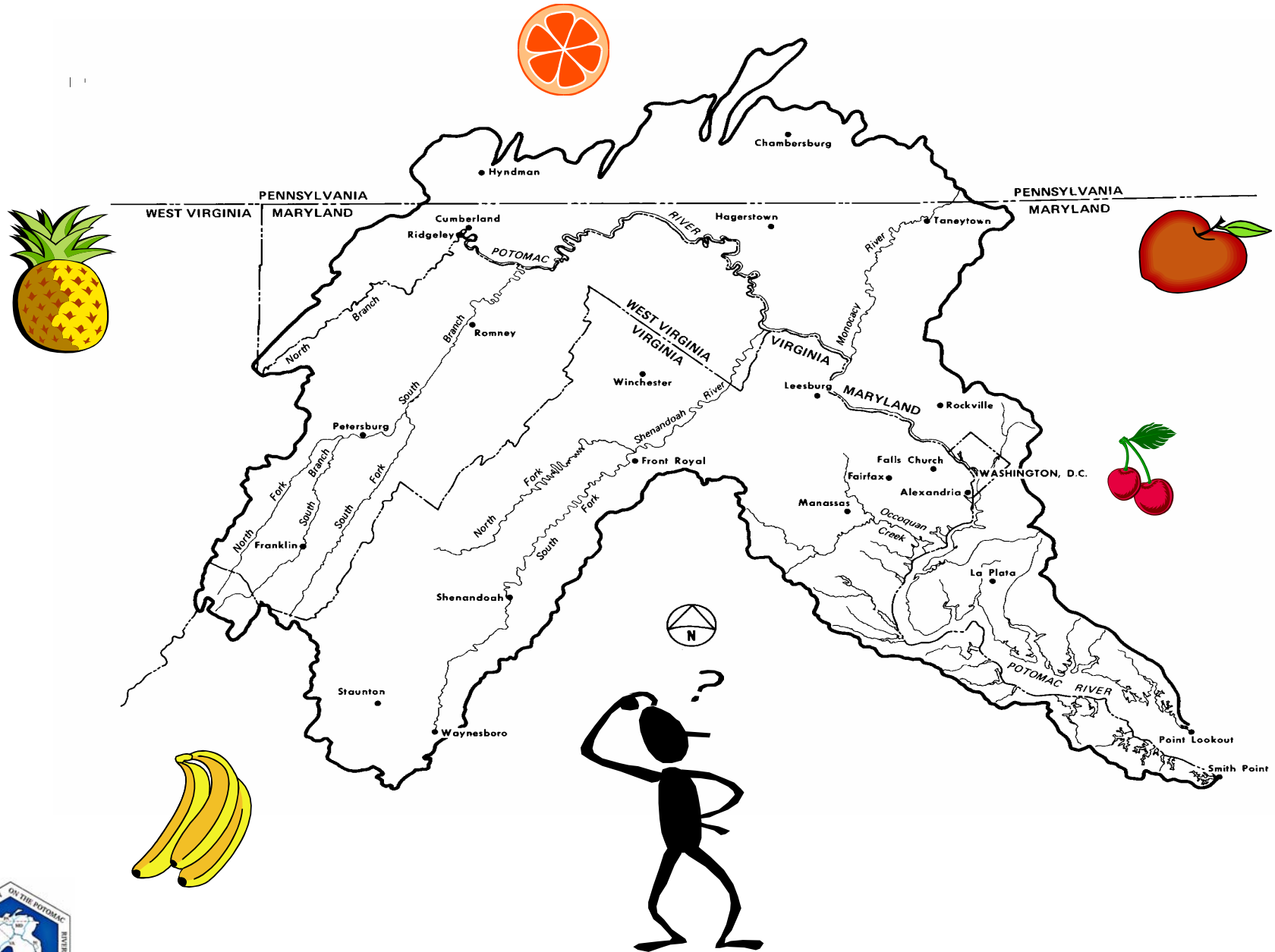
Results from the Potomac River Basinwide Assessments Project

Potomac River Basinwide Assessments

Enhance state water quality monitoring & assessment programs with consistent, watershed-wide assessments of stream health

"The ability to combine datasets is desirable to make judgements on the condition of the water resource." (Barbour et al. 1999)

"Combining information from separate monitoring surveys improves understanding of the biological integrity of riverine systems." (Handcock et al.)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RIVER
Hagerstown
Taneytown
Monocacy
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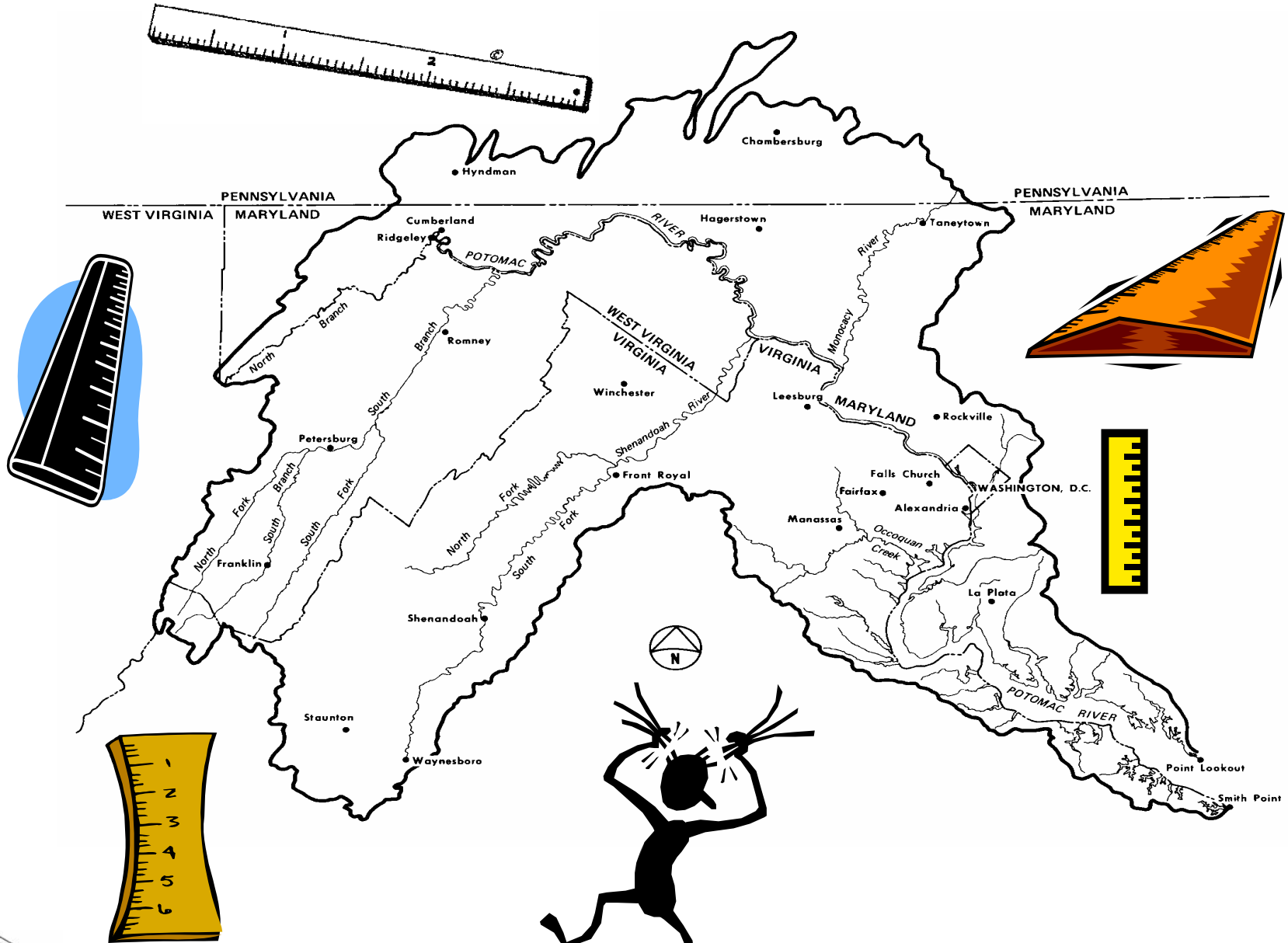
Staunton
Waynesboro
Point Lookout
Smith Point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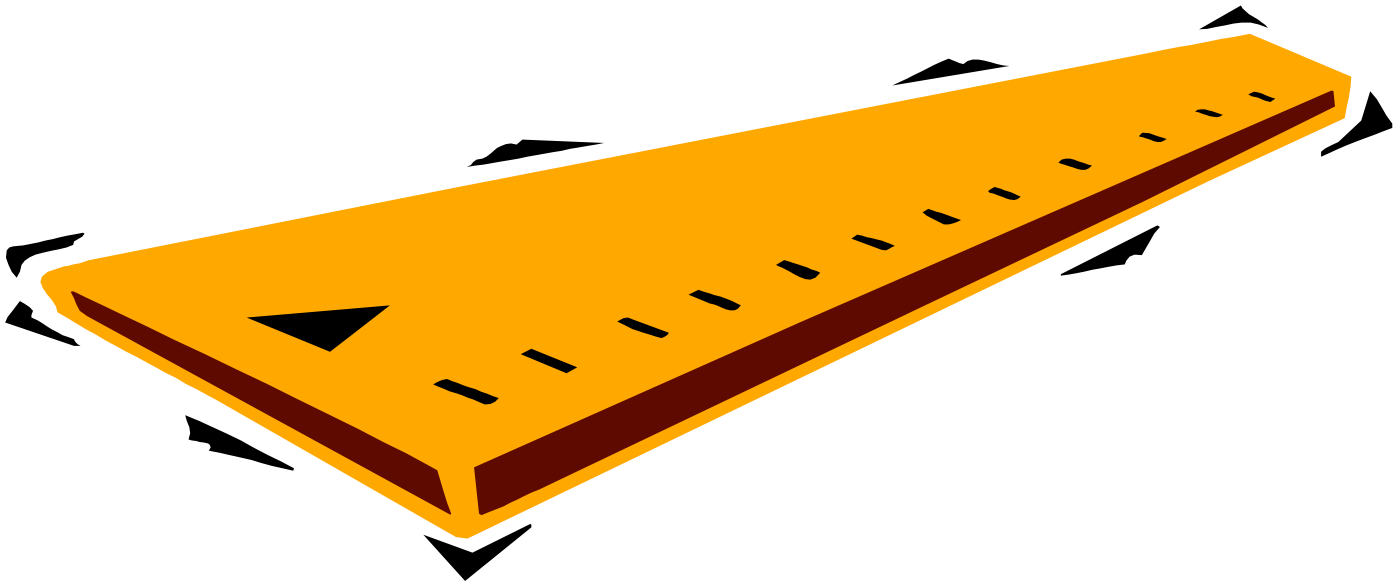
Index Development Steps

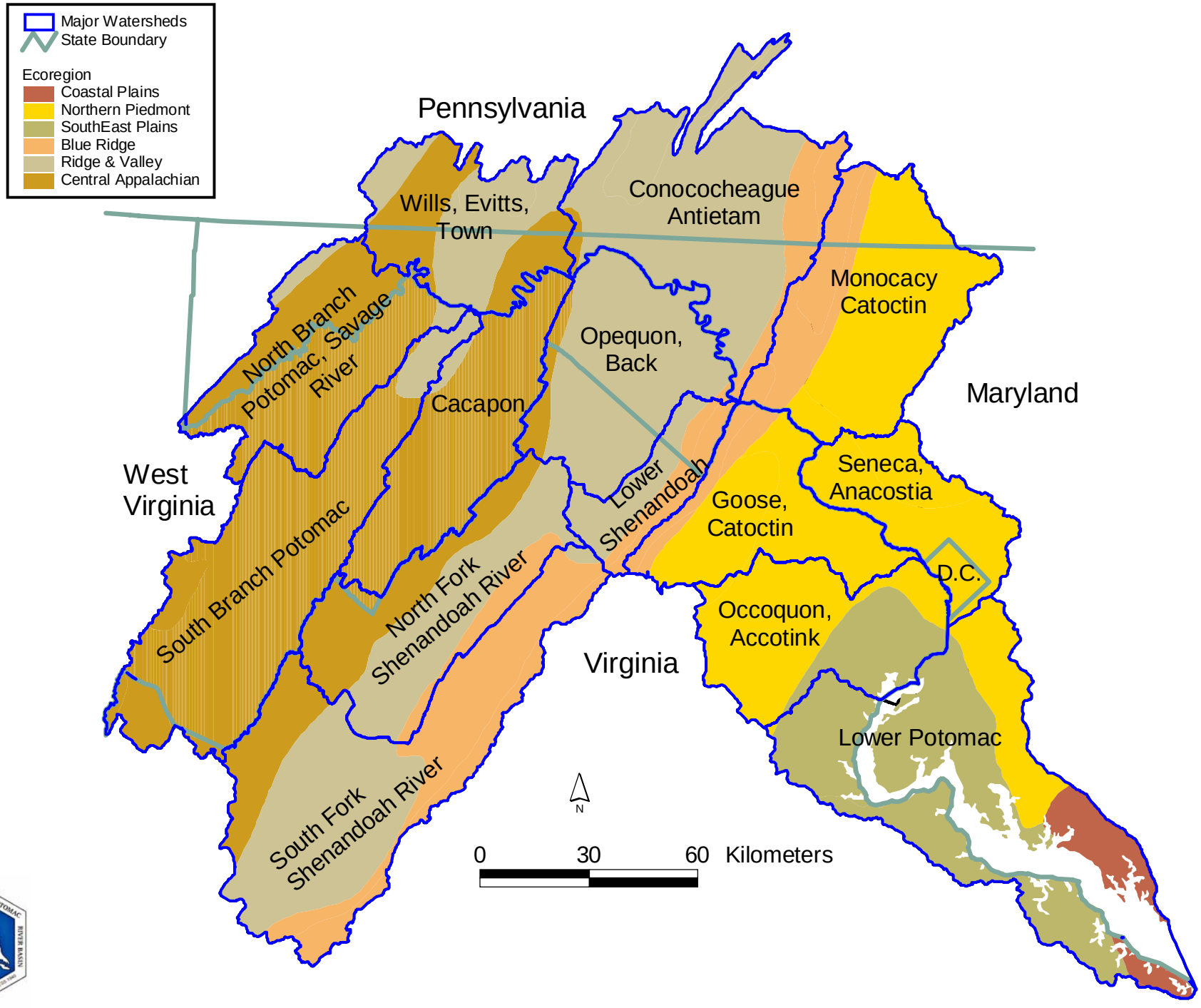
- Combine states' monitoring datasets
- Resolve methods & data comparability issues
- Group stream sites into homogeneous classes
- ID reference & nonreference criteria & sites
- Select robust measures that distinguish between good & poor conditions
- Evaluate the validity of aggregating reference data across site classes
- Aggregate core metrics into an assessment index
- Evaluate index performance

Calibration Data

- Provided by member jurisdictions (305b/303d monitoring)
  - Maryland MBSS 1995-1997
  - Pennsylvania Unassessed Waters 1997-2001
  - Virginia WQ Assessment/Surface Water Monitoring 1994-2001
  - West Virginia WAP 1996- Spring 2001
- Combined within a Microsoft Access database

Stream Site Classification

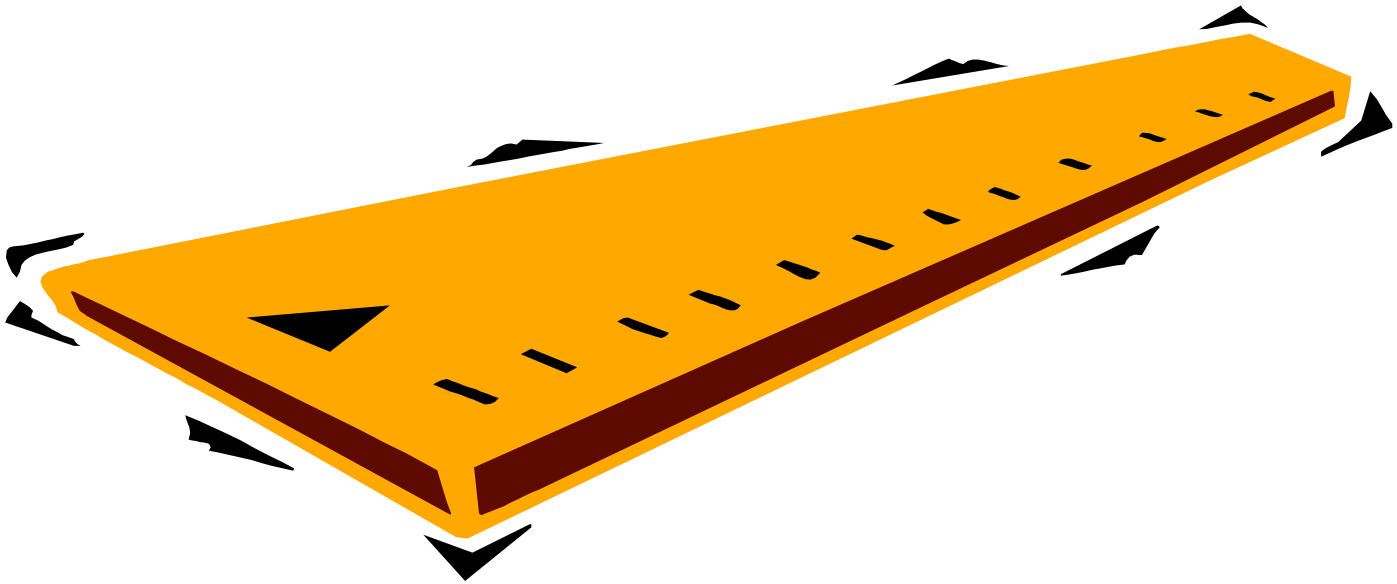



Major Watersheds
State Boundary
Ecoregion
Coastal Plains
Northern Piedmont
SouthEast Plains
Blue Ridge
Ridge & Valley
Central Appalachian
Pennsylvania
Maryland
West Virginia
Virginia
D.C.
Wills, Evitts, Town
Conococheague Antietam
Monocacy Catoctin
North Branch Potomac, Savage River
Opequon, Back
Cacapon
Lower Shenandoah
Seneca, Anacostia
Goose, Catoctin
South Branch Potomac
North Fork Shenandoah River
Occoquon, Accotink
Lower Potomac
South Fork Shenandoah River
N
0
30
60
Kilometers

Test the Classification Scheme

- Confirm site classes with total habitat scores
  - PrimShed highly significant,ecoregions significant, seasons nonsignificant as grouping variables
- Confirm site classes with select biological metrics
  - TR, EPT, FBI all widely used
  - %Hapto (clingers+crawlers) after Smith and Voshell (1997)
  - PrimShed & ecoregion significant; seasons nonsignificant

Establish Reference & Impairment Criteria for Site Classes



Parameter	ParamCode	Which "rapid" habitat assessment parameters?
Instream Condition	INSTR_COND	Epifaunal Substrate+Cover/2 OR EpiSub&Cover Score
Habitat Heterogeneity	HAB_HETERO	Riffle Frequency OR Sinuosity OR Pool/Glide/Eddy Quality
Channel Alteration	**CHAN_ALT**	Channel Alteration
Bank Stability	BANK_STAB	Bank Stability
Substrate Quality	SUB_QUAL	Embeddedness OR Pool Substrate OR %Embeddedness scored to same scale
Riparian Zone	**RIP_ZONE**	Riparian Buffer score OR Riparian width (M) scored to same scale
Anthropogenic Alterations	**ANTHRO_ALT**	Grazing OR Aesthetic+Remoteness/2
Total Score	TOTSCORE	Sum of all parameter scores
pH	pH	
Conductivity	Cond	

Consistent Habitat/WQ Attributes

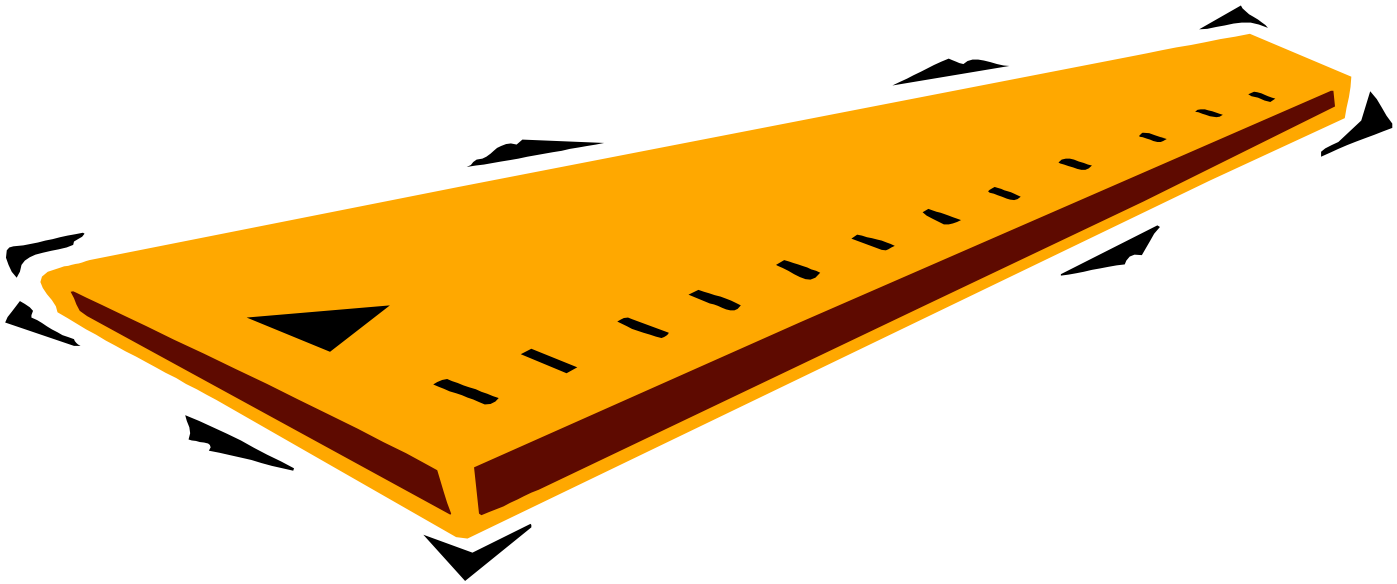
Establish "Relative Status" (Best & Worst)

- Select consistent criteria to ID candidate ref sites
- Group sites by strata
- Pool habitat/WQ variables within strata (*don't* average repeat visits)
- Find the range of each habitat/WQ parameter's values within strata
- ID a ranking scheme (e.g. quartiles, 33%ile)
- ID & pool "good" sites for each stratum (candidate ref sites)
- ID ref (& stressed) conditions for each stratum

Reference Criteria (ALL of the following):				
Param	64	66	67	69
ANTHRO_ALT	≥70%	≥70%	≥70%	≥70%
BANK_STAB	≥70%	≥50%	≥70%	≥50%
CHAN_ALT	≥70%	≥50%	≥50%	≥50%
HAB_HETERO	>10%	>10%	>10%	>10%
INSTR_COND	>30%	>10%	>10%	>10%
SUB_QUAL	≥70%	≥70%	≥70%	≥70%
RIP_ZONE	≥50%	≥70%	≥70%	≥70%
	AND: (Both)			
pH	Between 6 and 9			
CON	<500			

Impairment Criteria (3 or more of the following):				
Param	64	66	67	69
ANTHRO_ALT	≤10%	<10%	<10%	<10%
BANK_STAB	≤10%	≤10%	≤10%	≤10%
CHAN_ALT	≤10%	≤10%	≤10%	≤10%
HAB_HETERO	<10%	<10%	<10%	<10%
INSTR_COND	<10%	<10%	<10%	<10%
SUB_QUAL	≤10%	≤10%	≤10%	≤10%
RIP_ZONE	≤10%	≤10%	≤10%	≤10%
	OR: (Either)			
pH	≤4.5			
CON	>1000			

Characterize Biological Communities at Reference & Nonreference Sites



Metric Selection & Screening

- Select potential metrics from the literature (60)
- Equalize level of taxonomic resolution (Family)
- Screen out ref & stressed sites w/<u>both</u> TaxRich & TotAbun > or < 2 SD's from mean
- Range Test (can calculate for ≥90% of ref sites)
- Variability Test (C.V. ≤0.50 in ref sites)
- Discrimination Test - ID metrics that distinguish ref from stressed sites in each ecoregion
- Redundancy Test (Pearson Correlation coeff <0.75)

2 approaches to test metrics' ability to distinguish good sites from bad:

- Statistically compare metric values of reference sites to those of stressed sites. Which test is the "right" test?
  - IF the ref & imp populations are both Normally distributed (N) and their variances are equal : Parametric t assuming = var's
  - IF ref pop is N, stress pop is not, BUT variances are equal: Parametric t assuming = vars
  - IF both pops are N but variances are unequal: Parametric t assuming unequal vars
  - IF neither pop is N but variances are equal: Parametric t assuming equal vars
  - BUT IF neither pop is N and the variances are unqequal: Nonparametric test
- Calculate discrimination efficiency (DE) of each metric:

$$DE=100*(a/b)$$

…where a= number of stressed sites <25%ile of the reference distribution (for metrics where ExpResponse=Decrease; >75%ile for metrics where ExpResponse=Increase)

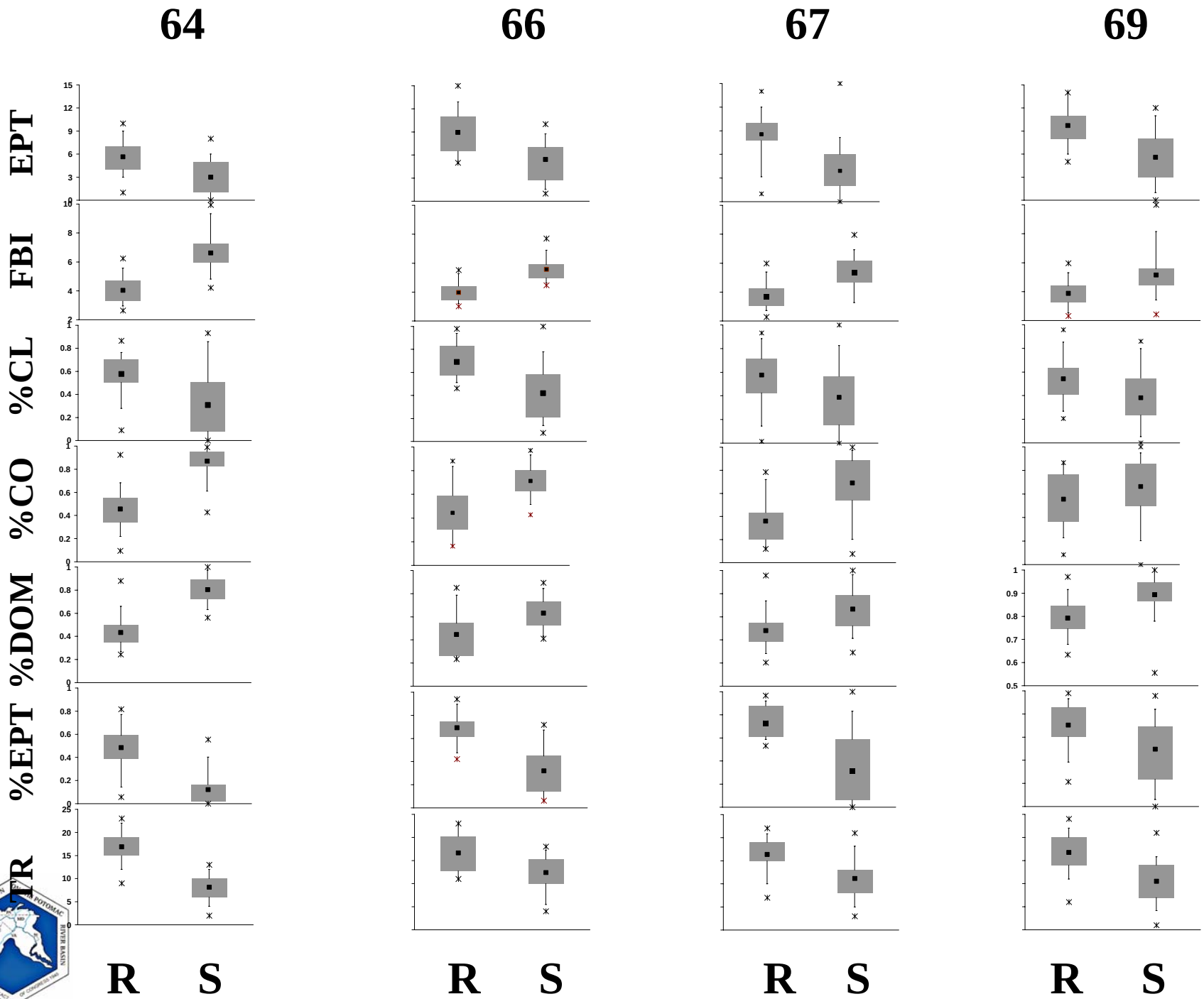
and b=total number of impaired sites

Results of t-tests between metric values of reference and impaired sites for Ecoregions 64, 66, 67, 69. ** indicates highly significant result (p<0.01); * indicates significant result (p<0.10); NS indicates nonsignificant result.

MetricName	64	66	67	69	Selected
CFTaxa	**	*	**	**	
ClingTaxa	**	**	**	**	
DipteraTaxa	**	NS	NS	*	
EphemTaxa	**	NS	**	**	
EPT_Taxa	**	**	**	**	x
EPTTax_NoHydro	**	**	**	**	
HaptoTaxa	**	*	**	**	
IndexFBI	**	**	**	**	x
IndexMargalef	**	**	**	**	
IndexShanWein	**	**	**	**	
IndexSimpDiversity	**	**	*	*	
NumTrichop	**	*	**	**	
PercentCling	**	**	**	*	x
PercentColl	**	**	**	NS (marg)	x (<>69)
PercentDom1	**	*	**	**	
PercentDom2	**	**	**	**	x (<>69)
PercentDom5	**	*	**	**	x(69)
PercentEPT	**	**	**	**	x
PercentEPTTaxa	NS	*	**	*	
PercentFilter	NS	NS	NS	NS	
PercentHapto	**	**	**	NS	
SensitiveTaxa	**	**	**	**	
TaxRich	**	*	**	**	x

Percent of stressed sites correctly assigned as stressed (<25th percentile of the reference site distribution) for Ecoregions 64, 66, 67, 69. Metrics selected for the index are specified.

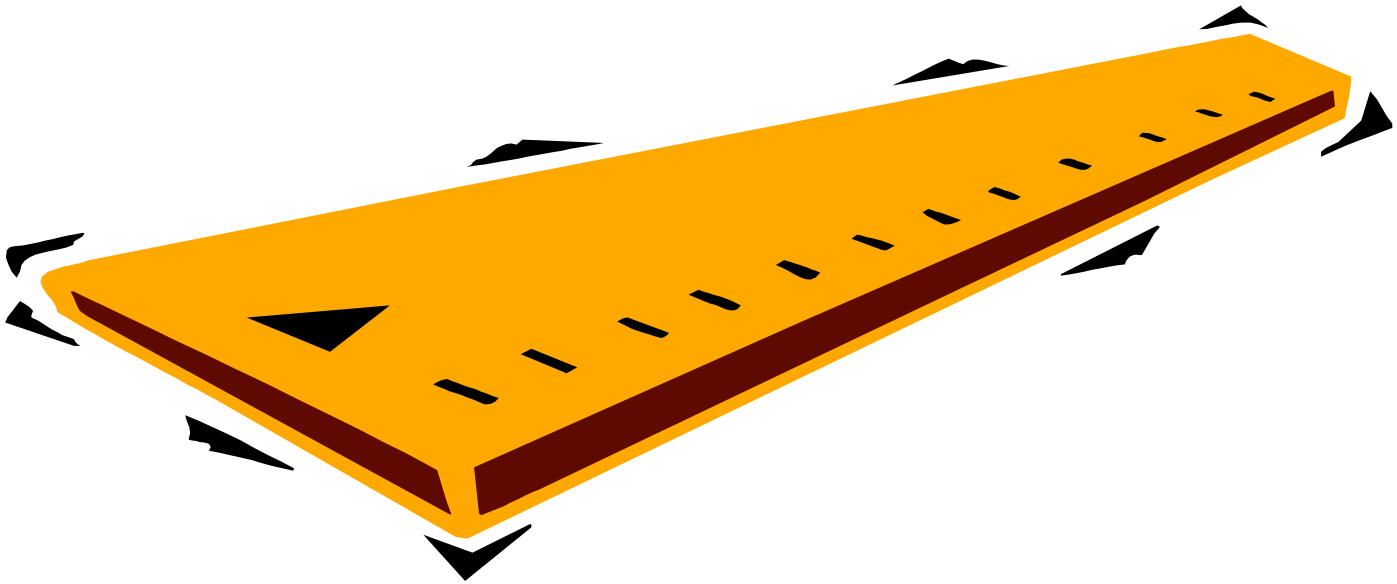
		Discrimination Efficiencies (DEs)					
MetricName	Category	64	66	67	69	Overall	Selected
CFTaxa	F	N/A	23	14	2	8	
ClingTaxa	H	97	62	84	77	83	
DipteraTaxa	T	N/A	N/A	17	57	24	
EphemTaxa	R	90	38	66	59	66	
EPT_Taxa	R	77	62	91	68	79	x
EPTTax_NoHydro	R	74	62	90	68	77	
HaptoTaxa	H	97	62	91	80	86	
IndexFBI	T	100	92	91	77	89	x
IndexMargalef	R	97	85	69	75	78	
IndexShanWein	R	97	92	64	75	77	
IndexSimpDiversity	R	97	92	67	57	72	
NumTrichop	R	39	62	57	57	53	
PercentCling	H	77	77	67	57	67	x
PercentColl	F	94	69	86	52	76	x (<>69)
PercentDom1	T	97	62	90	50	77	
PercentDom2	T	100	77	81	64	79	x (<>69)
PercentDom5	T	100	54	83	77	82	x (69)
PercentEPT	C	97	100	79	50	76	x
PercentEPTTaxa	C	42	69	81	48	62	
PercentFilter	F	26	23	31	25	27	
PercentHapto	H	65	69	74	43	62	
SensitiveTaxa	T	97	62	91	70	84	
TaxRich	R	100	54	88	73	83	x


64
66
67
69
EPT
FBI
%CL
%CO
%DOM
%EPT
LR
R
S
R
S
R
S
R
S

Summary of IQR plots

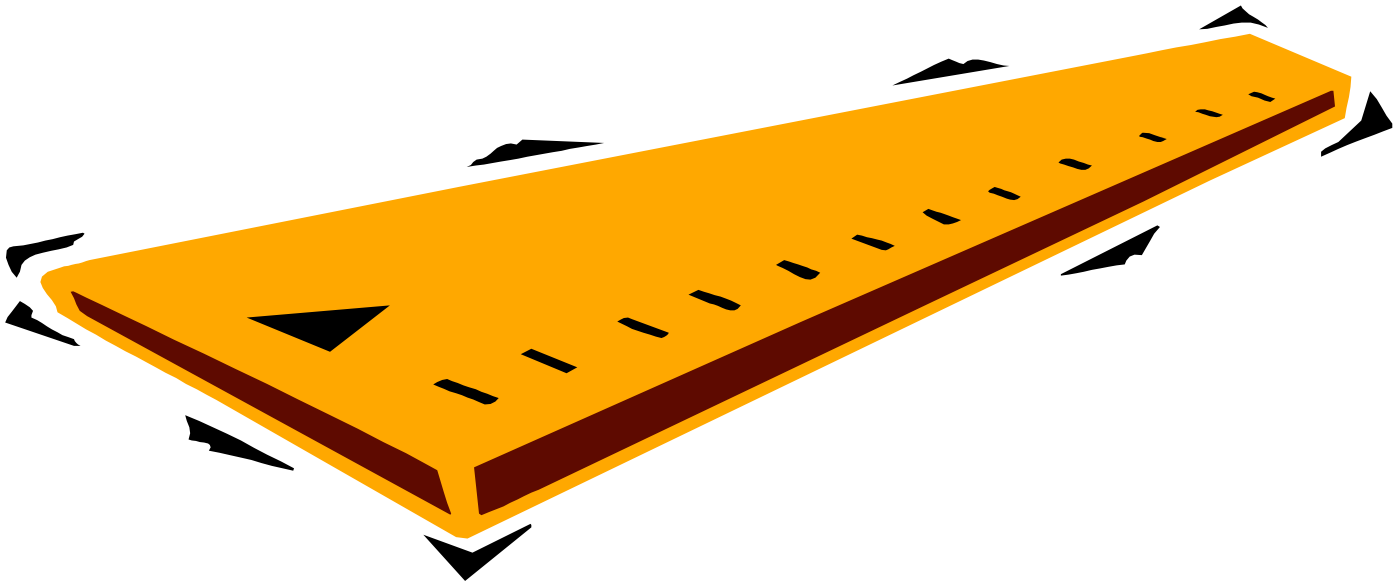
- Eco 64 (N. Piedmont) - ALL metrics clearly separated 25th & 75th percentiles
- Eco 66 (Blue Ridge) - clear separation for all except EPT, %D2, TR (means outside boxes for EPT & %D2)
- Eco 67 (R&V) - clear separation for all except %Cling (means outside boxes)
- Eco 69 (C. Appalachians) - all except %Cling,%EPT (& %Coll)

Metric Scoring



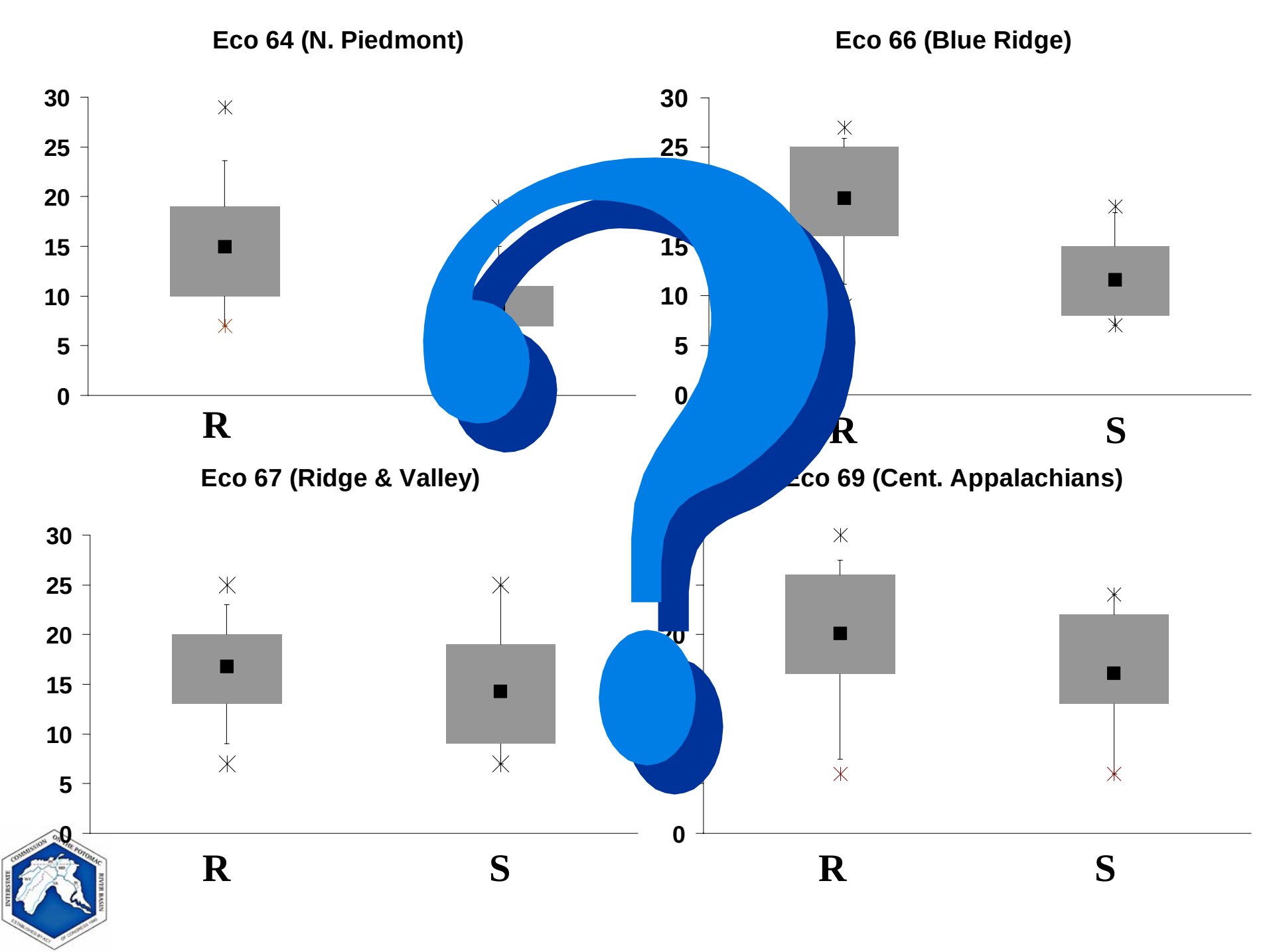
% Imp Sites Correctly Assigned			
Ecoregion	95&Quad	5010	25&Bi
64	90%	100%	100%
66	67%	100%	83%
67	67%	95%	91%
69	59%	70%	70%

Index Validation



Validation Data

- **Maryland MBSS 2000 - 2001**
- **Montgomery County (MD) CSPS 1999 - 2002**
- **Fairfax County (VA) SPS 1999-2001**
- **US EPA EMAP data (MAIA/MAHA) 1993 -1998**
- **Virginia WQ Assessment/Surface Water Monitoring 2001 - 2002**
- **West Virginia WAP Fall 2001 - 2002**

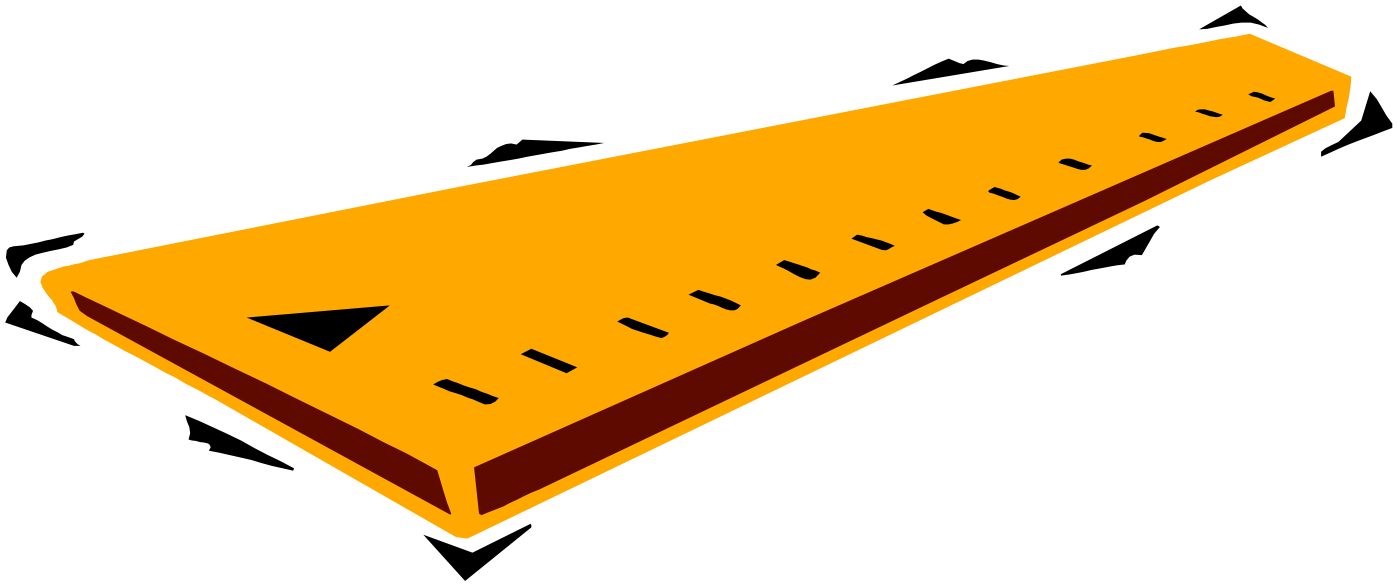

Eco 64 (N. Piedmont)
Eco 66 (Blue Ridge)
Eco 67 (Ridge & Valley)
Eco 69 (Cent. Appalachians)
30
25
20
15
10
5
0
R
S

What Happened?

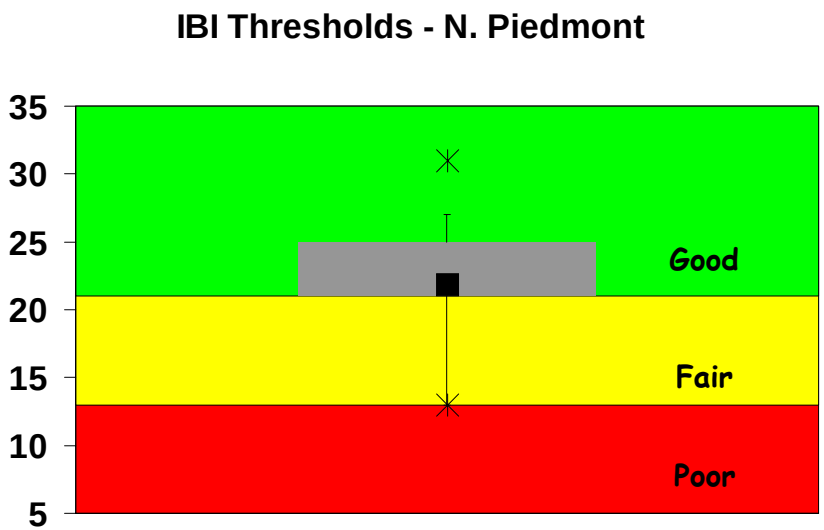
- ANTHRO parameter inconsistent among (& even within) validation datasets
- Remaining parameters insufficient to capture least-disturbed (& most-disturbed) conditions using orig. thresholds
- Jackknife procedure will be used to validate index

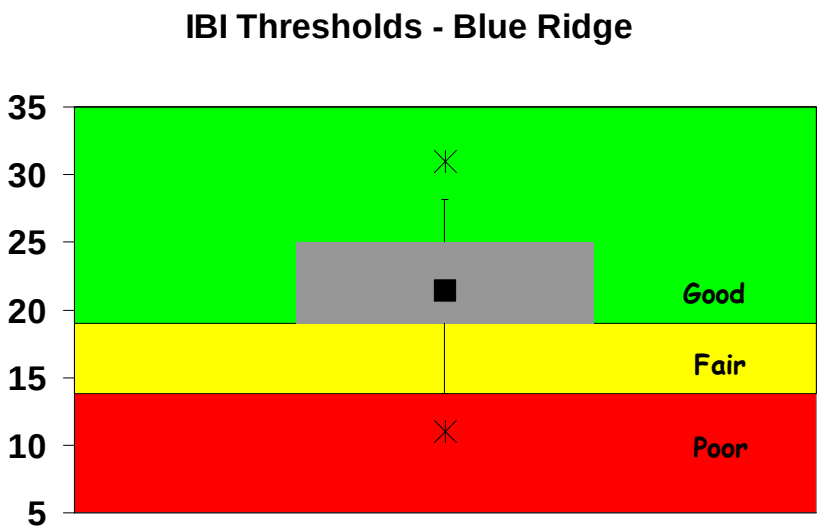
ANTHRO	Status	Eco	EPT	FBI	% CL	% CO	% D2	% D5	% EPT	TR
15	R	64	3	1	5	1	3	3	1	3
16	R	64	1	1	3	5	1	1	1	3
16	R	64	3	1	1	3	3	3	1	3
20	R	66	3	1	1	1	1	1	1	5
20	R	66	3	1	1	1	1	1	3	3
19	R	69	5	3	5	3	5	3	5	5
20	R	69	1	1	1	1	1	1	1	1
16	R	69	3	1	3	1	1	1	1	5
17	R	69	5	3	5	3	3	3	5	5
19	R	69	5	3	1	3	3	3	3	5
17	R	69	5	1	3	3	1	1	3	3
19.5	R	69	5	3	5	3	3	5	5	5
16	R	69	3	1	3	1	3	3	3	5
19	R	69	3	1	1	1	3	1	3	3
18	R	69	5	3	5	1	3	3	5	5
8	S	67	1	1	1	1	1	1	1	1
8	S	67	1	1	1	1	1	1	1	3
6	S	67	3	1	1	1	1	1	1	5
8	S	67	1	1	1	1	1	1	1	5
6	S	67	1	1	1	1	1	1	1	3
18	S	67	1	1	1	1	1	1	1	1
0	S	69	1	1	1	1	1	1	1	1
7.5	S	69	3	1	5	1	1	1	3	3
3	S	69	1	1	1	1	1	1	1	5
16	S	69	1	5	3	5	1	1	5	1

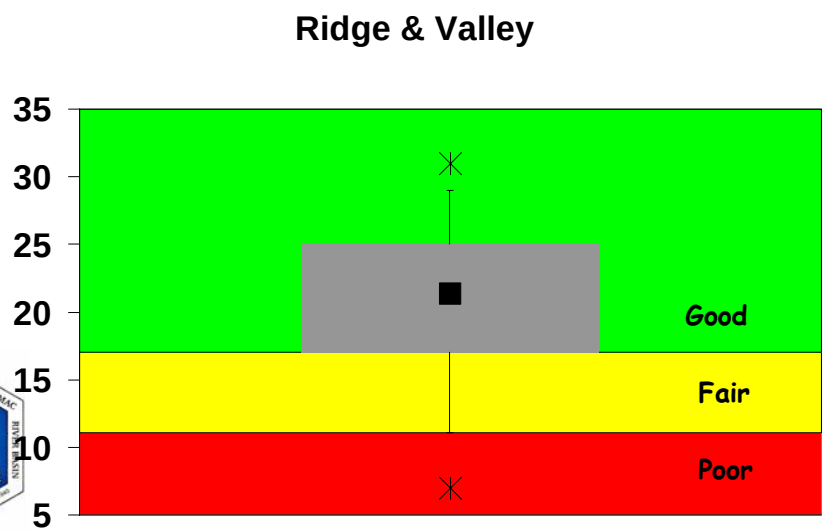
Set Thresholds for IBI Assessment

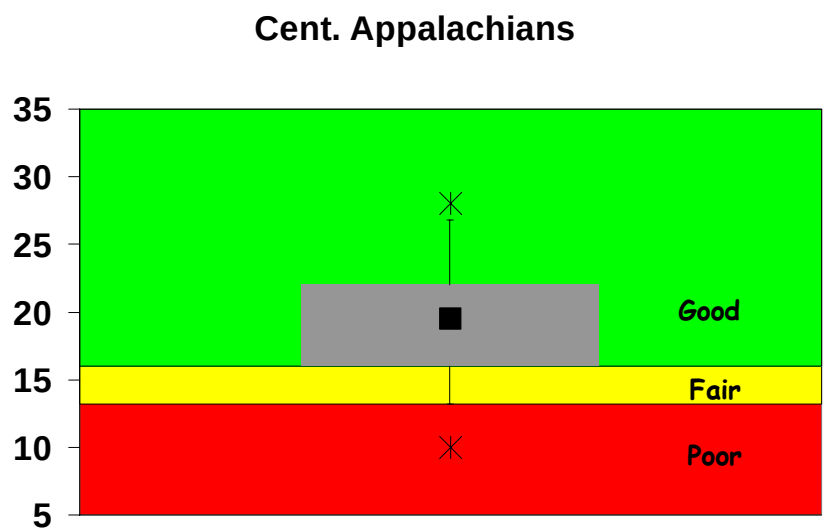


Use Distribution of IBI Scores in Calibration Ref Sites to Set Thresholds









What We Know (Results)

- Data collected using a combination of designs may be integrated into a biological index *if the synthesis is done with care*
- Level III Ecoregions represent “real” ecological subunits of the Potomac basin
- Habitat assessments of Potomac streams should include characterizations of anthropogenic disturbance
- **We have a practical, ecoregionally calibrated tool for characterizing nontidal stream health on a watershed level**

Acknowledgements

- Data contributors
  - MD DNR and MDE
  - PA DEP, VA DEQ
  - WV DEP
  - Montgomery County DEP
  - Fairfax County DPW&ES
  - US EPA
- ICPRB staff