Application of the Probability-based Maryland Biological Stream Survey to the State's Water Quality Standards Program

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Outline

- Needs of WQS program
- Need to assess all streams
- Need for detailed information
- DNR and MDE partnership
- Evolving MBSS design

Needs of WQS Program

- Clean Water Act presents a daunting task for states
  - – CWA 305b requires comprehensive inventory
  - – CWA 303d requires listing of all impaired waters
  - – TMDLs require identification of stressors for all impaired waters
  - ➢ All streams must be assessed
  - ➢ Assessment must fit the scale of restoration

Traditional Biomonitoring Programs

- Historically states have monitored stream sites that are selected on an “ad hoc” basis, i.e., where
  - Problems are expected
  - Ease of access
  - ➢ Belief that sampling more sites will meet CWA
- Intensive sampling effort is focused at the site level
  - To insure all taxa are captured
  - To increase precision
  - ➢ Belief that more sampling effort at site will meet CWA

Ad Hoc Sampling

- Long history of ad hoc sampling perpetuates the belief that the condition of streams in an area (e.g., watershed or state) can be assessed if enough sites are sampled
- How much stream length can really be assessed directly?
- *Example*: How much of Maryland can be assessed directly?

Ad Hoc Sampling

- Over five years, MBSS can directly sample 1,500 75-m sites or 112 km (70 miles) of streams statewide
- If sampled ad hoc, only 0.76 % of Maryland’s 14,811 stream km (9,203 stream miles) would be assessed

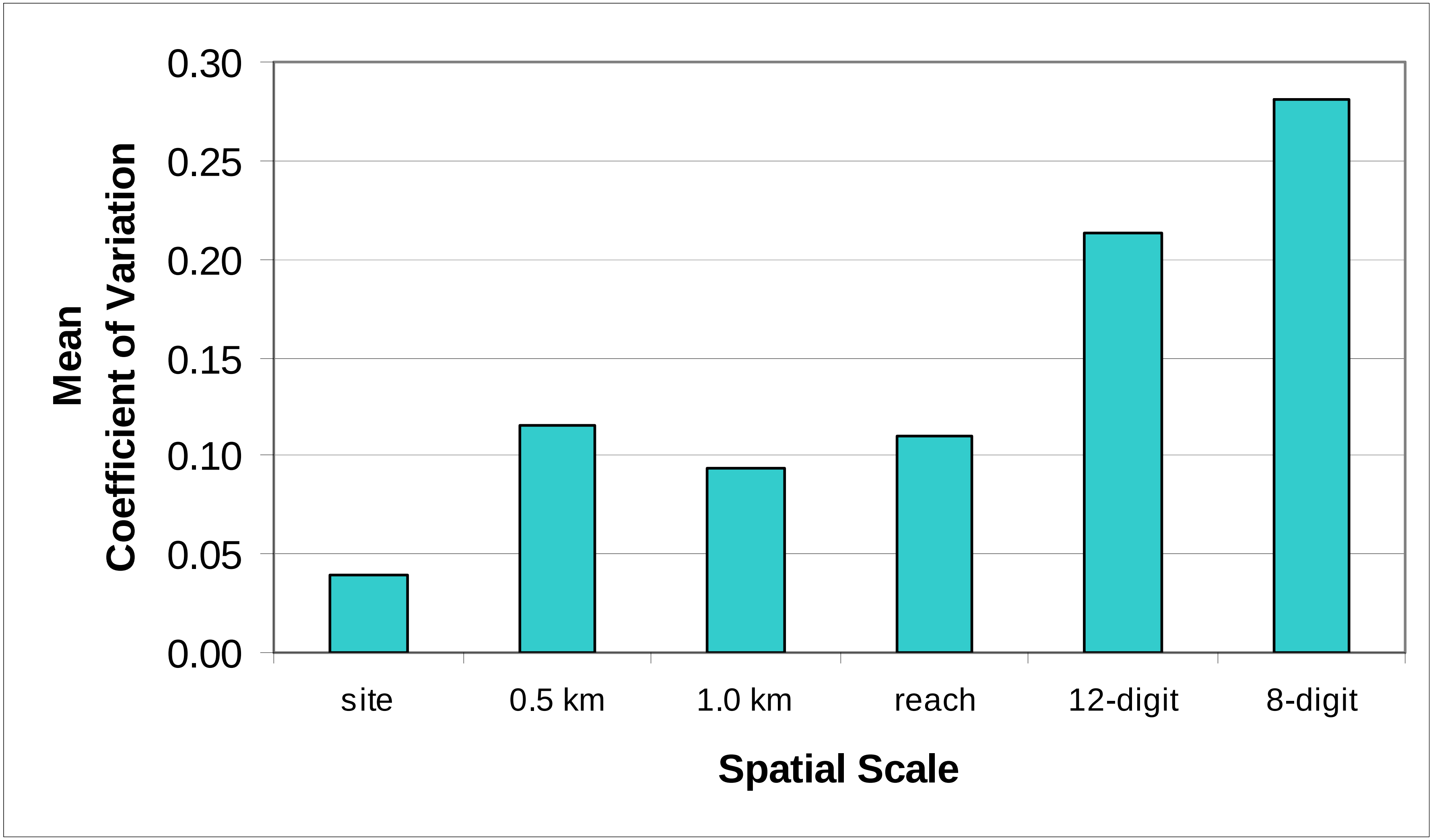
Ad Hoc Sampling

- Can we say anything about the other 99% of streams?
- Can we assume that sampling a 75-m segment is representative of a longer length of stream or even an entire watershed?
- *To answer*: How variable are IBI scores with scale?

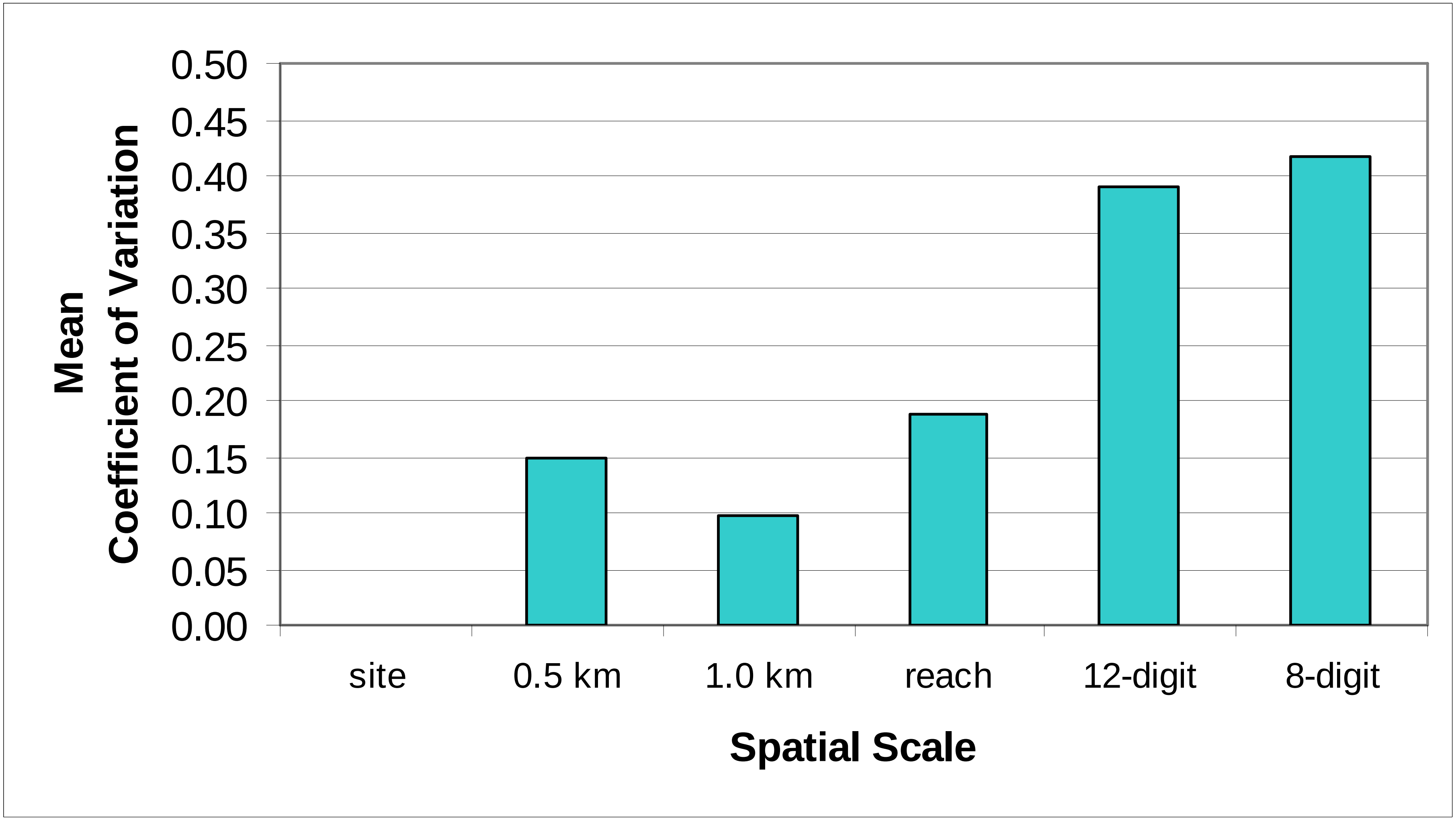
Scale Variability

- Evaluated variability of MBSS IBIs at scales ranging from
  - same site on same day
  - within 0.5 km within same index period
  - within 1.0 km
  - within same reach (average of 2.2 km)
  - same 12-digit watershed (average of 14 km)
  - same 8-digit watershed (average of 111 km)

Benthic IBI Variability with Scale



Fish IBI Variability with Scale



IBI Variability with Scale

B-IBI

	Mean CV	N
Site	0.039	66
0.5 km	0.115	51
1.0 km	0.094	80
Reach	0.110	118
12-digit	0.213	526
8-digit	0.282	133

F-IBI

	Mean CV	N
Site	No data	0
0.5 km	0.149	45
1.0 km	0.097	72
Reach	0.188	109
12-digit	0.390	486
8-digit	0.417	128

Ad Hoc Sampling

- Assume that 75-m sites are representative of 2.2 km reaches (based on CV =10%)
- 1,500 MBSS sites can assess 3,300 km (2,050 miles) of streams statewide
  - i.e., 22% of Maryland's 14,811 stream km (9,203 stream miles)
    - ➢ Ad hoc sampling will still leave 78% of stream km unassessed

Ad Hoc Sampling

- Maryland is small state with a robust program, but using ad hoc sampling
  - Only 1 to 22% of a state's stream lengths can be assessed
- Condition of all streams in an area (e.g., watershed or state) <u>cannot</u> be assessed simply by sampling more ad hoc sites
  - This is Lesson #1
  - ➢ Need to implement a probability-based survey for to infer condition (e.g., means and confidence intervals) at "reaches" not sampled

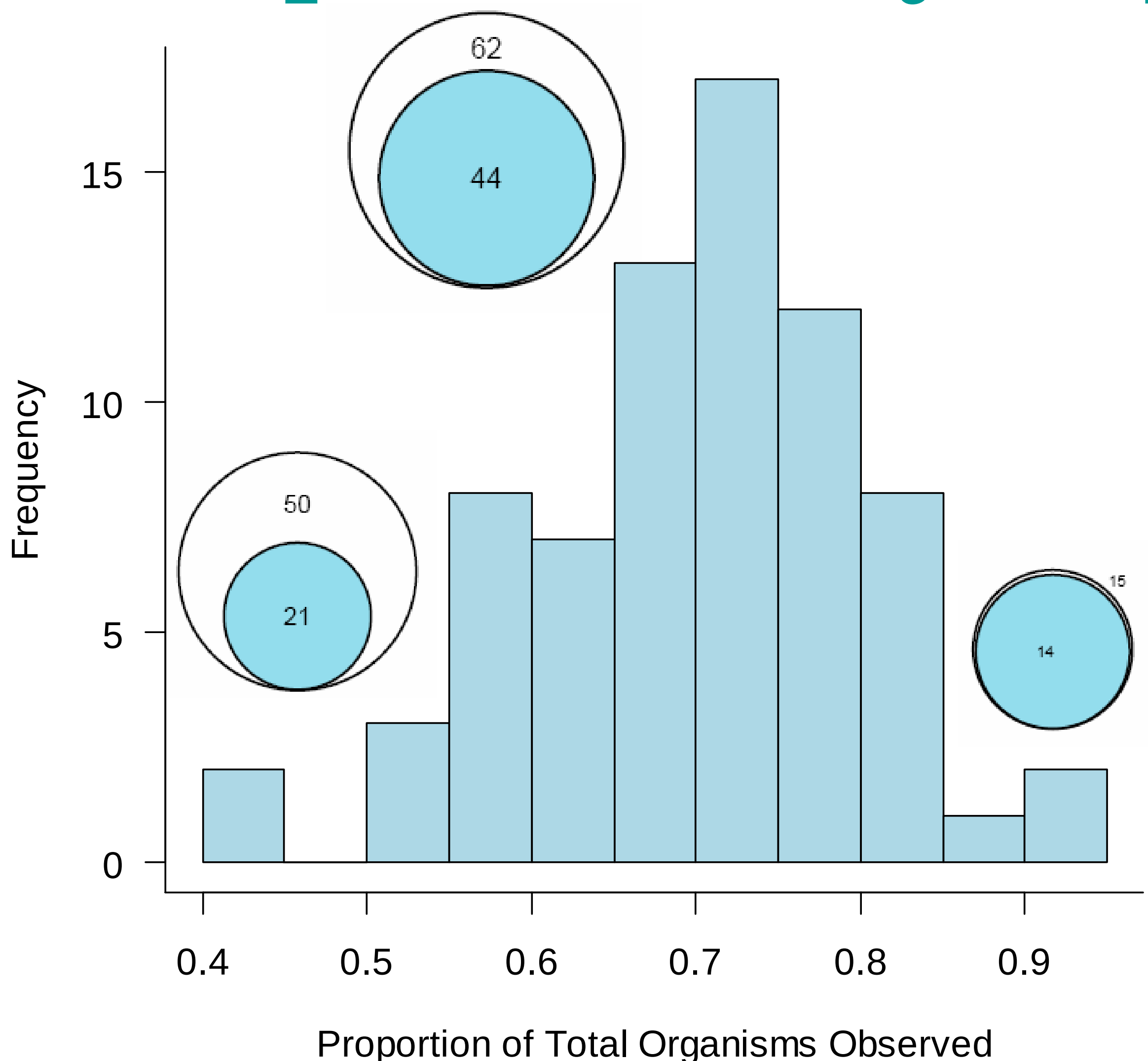
Intensive Site Sampling

- Recent research has focused on improving assessment of streams at the site level
  - Replicate samples at each site
  - Fixed-count sampling, minimum subsample sizes, and levels of taxonomic identification
- Will increased effort at individual sites provide better assessments of all streams?

Sampling Effort

- We evaluated 73 MBSS sites where two benthic samples of 100 organisms were collected as replicates to provide a surrogate 200-organism subsample
  - How many additional taxa were collected in the second sample?
  - What increase in precision of IBI was obtained with a replicate sample?

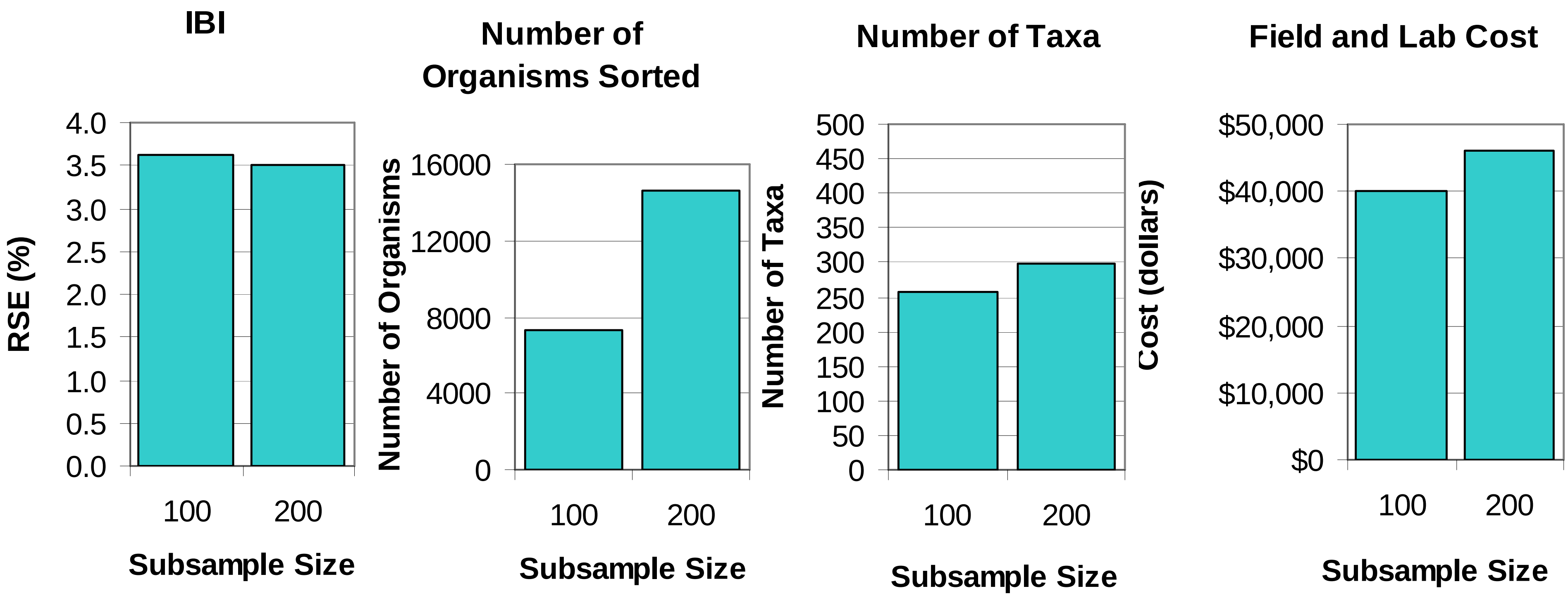
Overlap of Taxa By Replicate



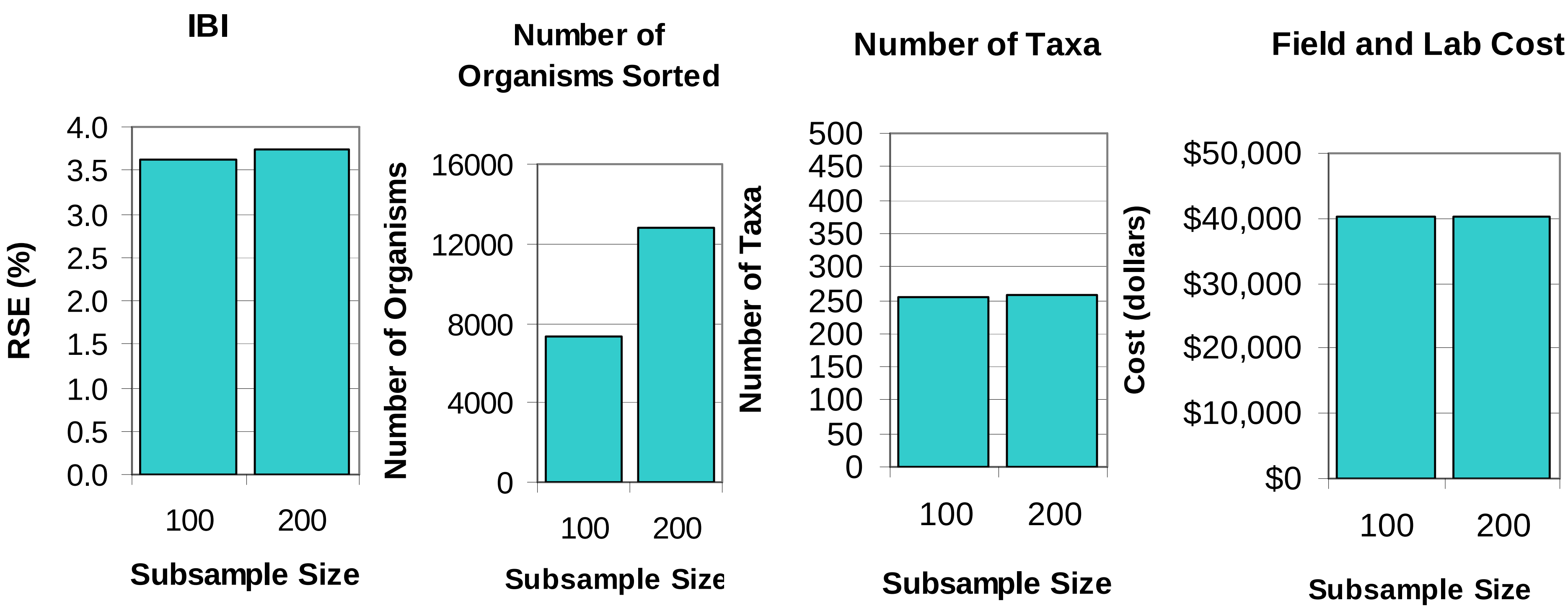
Subsample Effort

- What are the gains from 200-organism subsample at all sites
  - in IBI precision
  - proportion of taxa captured?
- Assuming 25% greater laboratory effort for 200- vs. 100-organism subsample, what is the cost benefit?

Subsample Effort for Fixed Number of Sites (73)



Subsample Effort at Fixed Cost



Subsample Effort

- For fixed number of sites, using 200 organisms rather than 100 results in
  - 3% increase in IBI precision
  - 16% more taxa
- For fixed field and lab cost, using 200 organisms requires that 15% fewer sites be sampled, resulting in
  - 3% <u>decrease</u> in IBI precision
  - 1% more taxa

Subsample Effort

- Additional sampling effort at individual sites provides
  - No improvement in IBI precision
  - Some more taxa (but not per cost)
- Increased effort at individual sites does not provide better assessments of all streams
  - This is Lesson #2
  - ➢ Sampling effort should be allocated to meet assessment objectives at desired scale

Lessons

- Ad hoc sampling cannot assess all streams
  - "The Elephant in the Room"
  - ➢ Probability-based sampling is needed to infer condition
- Intensive site sampling does not increase the assessment of all streams
  - "Gilding the Lilly"
  - ➢ Sampling effort should be allocated according to desired scale

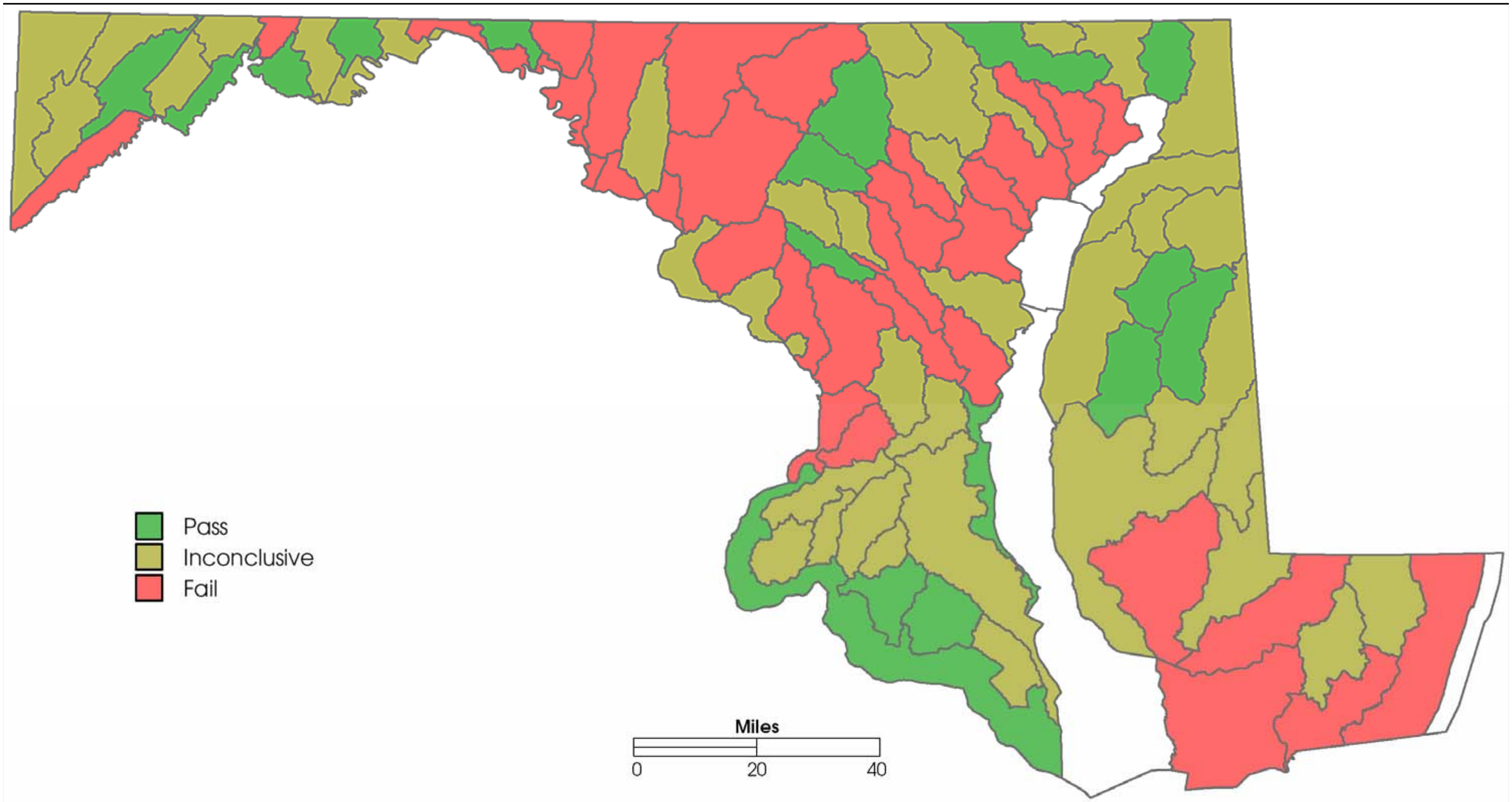
DNR and MDE Partnership

- Used MBSS data to develop biocriteria to support WQS
- Applied the lessons of probability-based sampling to assess all waters for 305b and 303d
- Used MBSS data to develop a method for identifying watersheds impaired by
  - Flow or sediment
  - Energy sources
  - Inorganic pollutants
- Augmenting core MBSS with sampling to get more detail for TALUs and TMDLs

MBSS Design

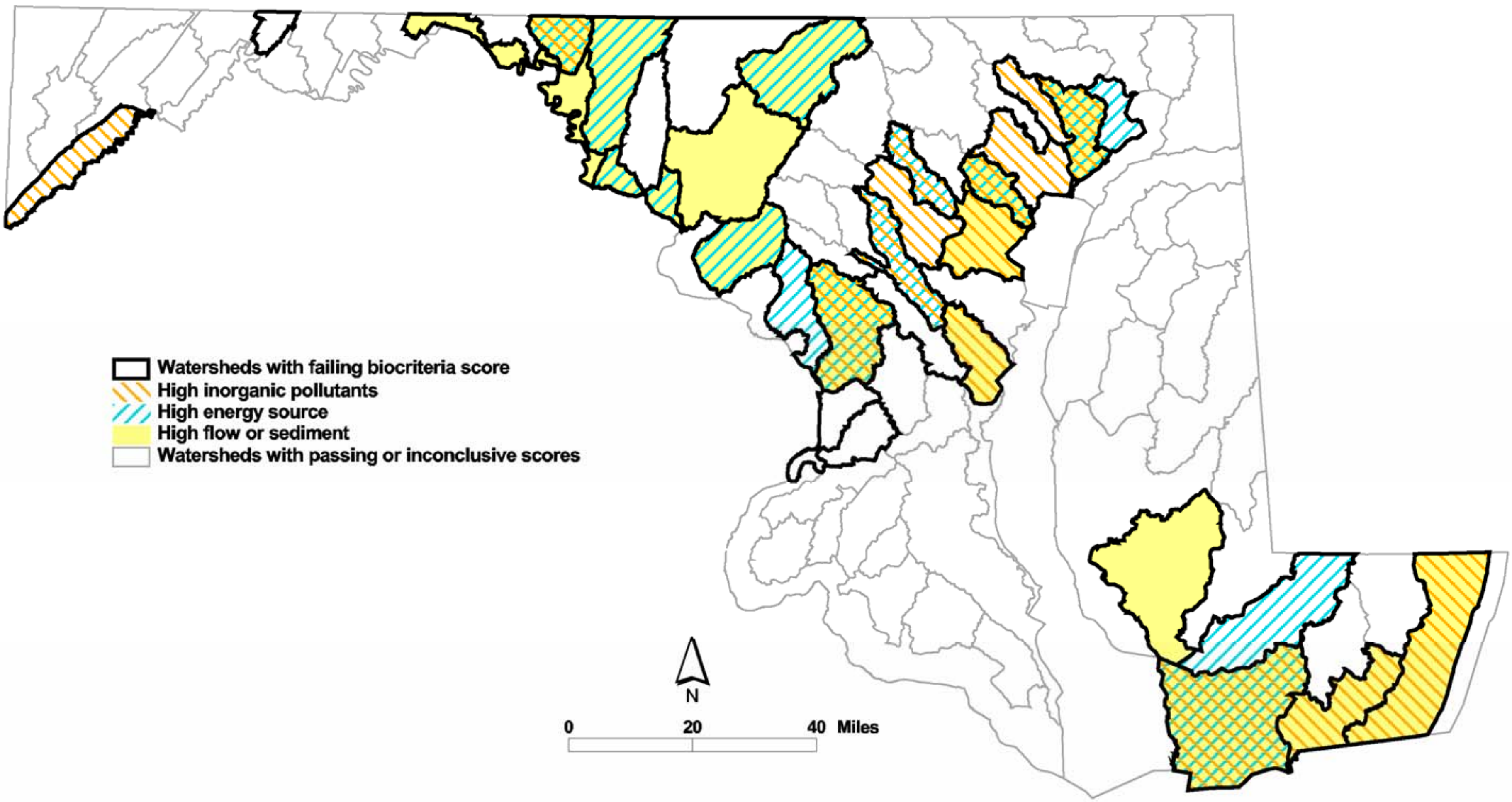
- Maryland can sample about 200 core monitoring sites per year
- Random sampling can give robust estimate with 10 sites in a watershed
- MD 8-digit watersheds (with smaller watersheds combined) equals 84 PSUs
- 84 PSUs x 10+ sites = about 1,000 sites
- Maryland can sample statewide at 8-digit scale (average of 111 km) every 5 years

Biocriteria Status by Watershed



DNR and MDE

Likely Stressors in Failing Watersheds



DNR and MDE

MBSS Design

- MBSS will conduct "biocriteria" round every 10 years, i.e., 2000-2004 and then 2010-2014
- All streams will be included in probability design with some partial replacement to improve trends detection
- Intervening MBSS rounds will address WQS needs for
  - 303d listings on finer scale
  - TALU designations for high-quality waters (Tier II)
  - Additional identification of stressors

MBSS Design

- In 2007, MBSS is sampling
  - Additional random sites in watersheds with less than 10 sites or indeterminate condition
  - Sites in adjacent reaches to known high-quality waters using adaptive approach
- As needed, MDE will sample watersheds to identify stressors not found with method employing MBSS data

Conclusion

- DNR and MDE partnership is using probability-based MBSS as an effective tool to meet the needs of Maryland water quality standards program