

Optimizing Sampling Frequency to Determine Pollutant Loads

PIs: V. Lyubchich, L. Harris, D. Liang, and J. Testa
Chesapeake Biological Laboratory, UMCES

29 June 2018

Project motivation

- Watershed restoration in Chesapeake Bay has focused on best management practices (BMPs) intended to reduce nutrients and sediments
- Need to effectively measure whether these BMPs work
- Storms and baseflow contribute to pollutant loads
- Natural variability (dry years, wet years) can mask BMP effects
- Monitoring streams to measure loads is expensive
- Need to optimize resources and decide how many weeks per year to monitor within one site

Project goal

- Use existing datasets and statistical analysis / modeling to recommend needed stream sampling frequency to confidently estimate loads at a site

Using the SERC dataset, we:

1. Estimated variability
2. Defined acceptable margin of error at 15% of total annual load
3. Defined acceptable confidence at 90% level
4. Used (1)-(3) to calculate the recommended sample size

Summary of recommended sample sizes across all the watersheds

Percentage of watersheds	Min	25%	50% (half)	75%	Max
Recommended sample size	23	37	43	47	53

- For all watersheds, at least 23 weeks or sampling per year is required (half year)
- For half the watersheds, at least 43 weeks of sampling is required

Conclusions

- Even with high-coverage data, as produced at SERC, there is a chance of missing important storm events responsible for large loads
- As a remedy against that, the calculations suggest large sample sizes to obtain estimates of the total loads with acceptable confidence and margin of error

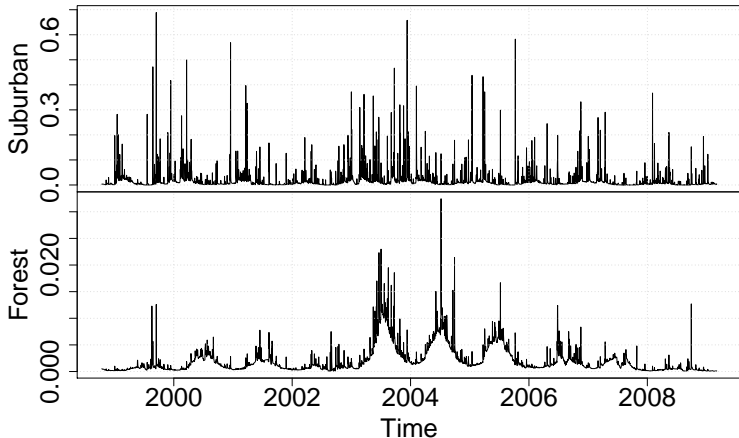
- Hypothesis: Before After Control Impact (BACI) allows detection of load reduction given unpredictable discharge

OBJECTIVE

- To detect change in loads before and after restoration,
- To optimize resources and decide how many days and sites to monitor.

Urban streams are flashy and forested streams are seasonal

TN Yield = Load/Area (daily mean, kg/day/ha)

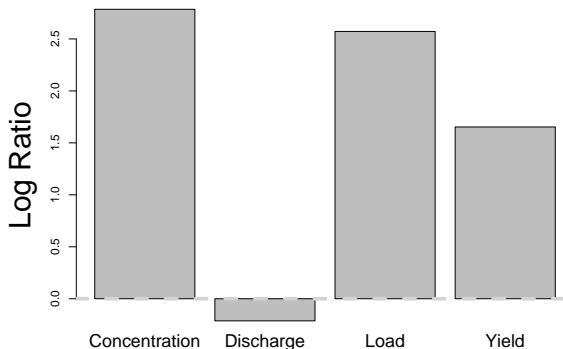


A simulation approach to sample size calculation is more flexible than classical statistical approach.

- Parameter to test best management practice effectiveness
 - ① total Nitrogen
- Study designs tested in suburban and forested watersheds studied
 - ① Before/After
 - ② Before/After, Control Impact - One Control
 - ③ Before/After, Control Impact - Two Controls

If we restore the entire suburban watershed to forest, what average difference in yields or loads can we see?

Modeling Results (Suburban vs Forest)



- Drainage area
 - Suburban 81 ha
 - Forest 32.3 ha

Lesson Learned: Spatial Scales and Statistical Power

- Water-shed scale cumulative impact
 - Moderate reduction in concentration is *un-detectable*
 - Control at watershed scale is *challenging*
- Restoration scale local impact
 - Moderate reduction in concentration is *detectable*
 - Control at local scale is *effective*
 - Sampling baseflow versus stormflow helps

Acknowledgements

Thanks for the support from:

- Smithsonian Environmental Research Center (D. Weller, T. E. Jordan)
- Modeling group at the Chesapeake Bay Program (G. Shenk)
- St. Mary's and Calvert Counties (D. C. Brownlee, D. Conrow)
- Baltimore Ecosystem Studies (P. Groffman)
- Funding: Chesapeake Bay Trust

UMCES

Translation Slides

Optimal (Required?) Monitoring Methodology to

- a) quantify pollutant load of a system, and
- b) quantify change in load due to restoration

What does it mean for me?

- How much/how often you sample depends on
 - Your sampling strategy (how many control sites do you have? None? 1? 3?)
 - How big your system is
 - How much natural variability is in your system
- Before I start sampling, I should try to figure it out to see if it would even be possible to detect my hypothesized load or difference.

Optimal (Required?) Monitoring Methodology to

- a) quantify pollutant load of a system, and
- b) quantify change in load due to restoration

What does it mean for me?

- **For example:**
 - To figure out load in an average watershed, need at least 23 weeks of sampling, and often need as many as 43 weeks.
 - For big watersheds, even if my reductions due to restoration are 50%, I would need 3 years of data to see it if I have no control sites, but only 9 months of data if I have 3 control sites. I can't detect reductions as low as 20%, even if I had 10 years of data.
 - For smaller watersheds, if my reductions due to restoration are 50%, I would only need 15 days of sampling if I have 3 control sites, and I can detect smaller reductions (20%)

What might I do with this info if I am a:

Practitioner:

- Figure out what absolute load/change in load is reasonable to detect.
- You may have to invest time and \$ in a power analysis. It can be money well spent.
- Decide if you have the budget to do the monitoring right

Regulator:

- Assess what you will really be able to tell with any prescribed monitoring regime for a specific restoration project.
- If you are looking to a permittee to demonstrate “success,” decide whether it’s possible if you are not requiring control sites in the monitoring regime.
- How much will the monitoring cost compared to the restoration project?