Assessment of Long-term Monitoring of Nitrogen, Sulfur, and Mercury Deposition and Environmental Effects in New York State

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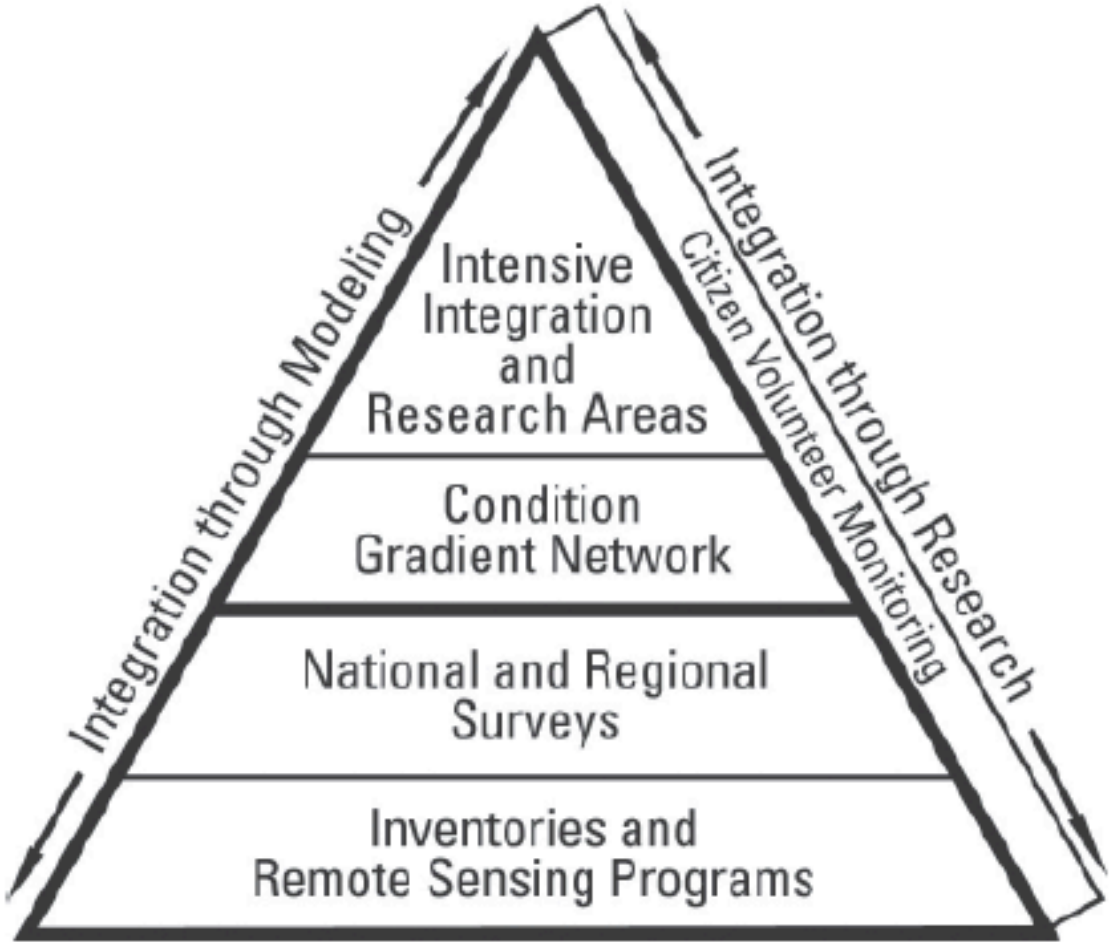
Conceptual framework for achieving the multiple goals of environmental monitoring and research



(Committee on Environment and Natural Resources, 1997)

NYSERDA Assessment Objectives

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- We addressed monitoring efforts in the following topic areas:
    - Atmospheric deposition
    - Lakes
    - Streams
    - Vegetation
    - Soils
    - Fauna

Statistical Approaches

We used certain data analysis methods depending on the available data (pg. 7).

Model Type	Time Series	Multiple Sites
Repeated measures mixed effects model	X	X
Mann Kendall trends test and General Linear Model	X	
Detectable difference analysis		X

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Detectable difference analysis: describes the ability to detect significant changes in a future survey. The input variables include the sample size and standard deviation of the original survey and an alpha and power level.

Repeated Measures Mixed Effects Model Analysis

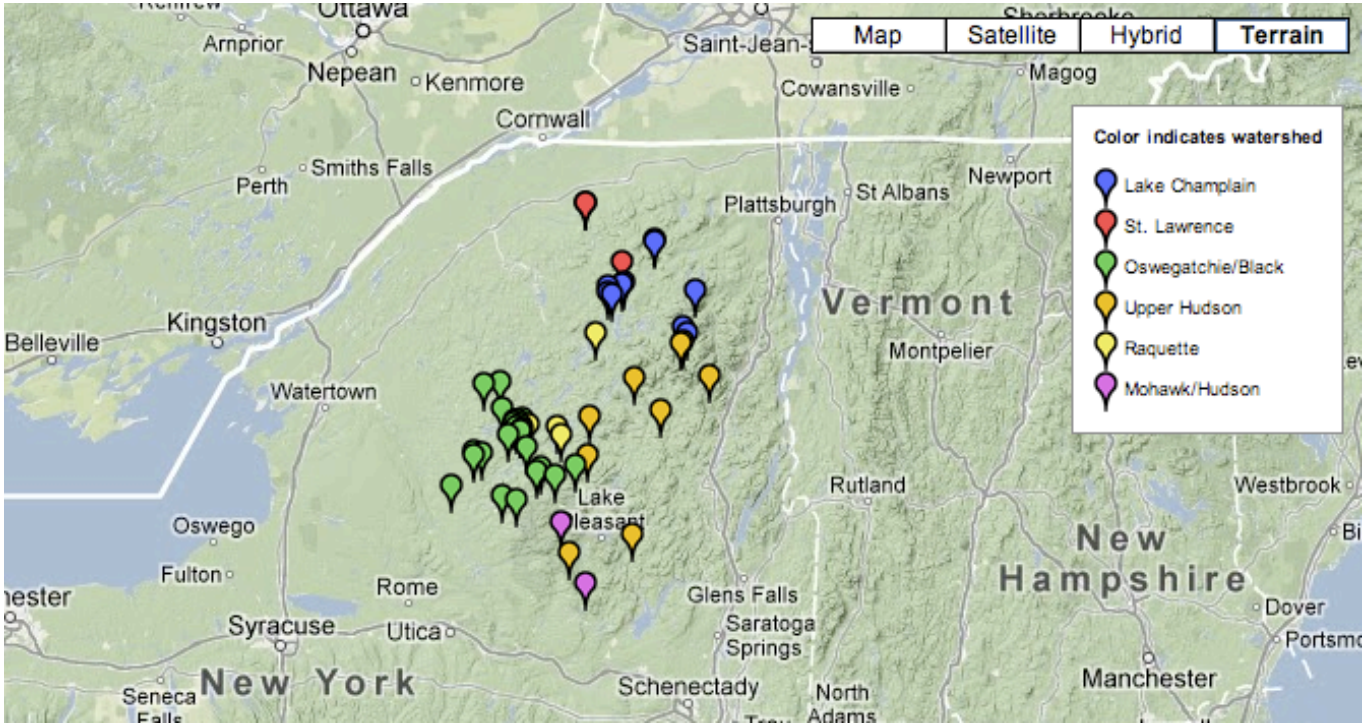
Question:

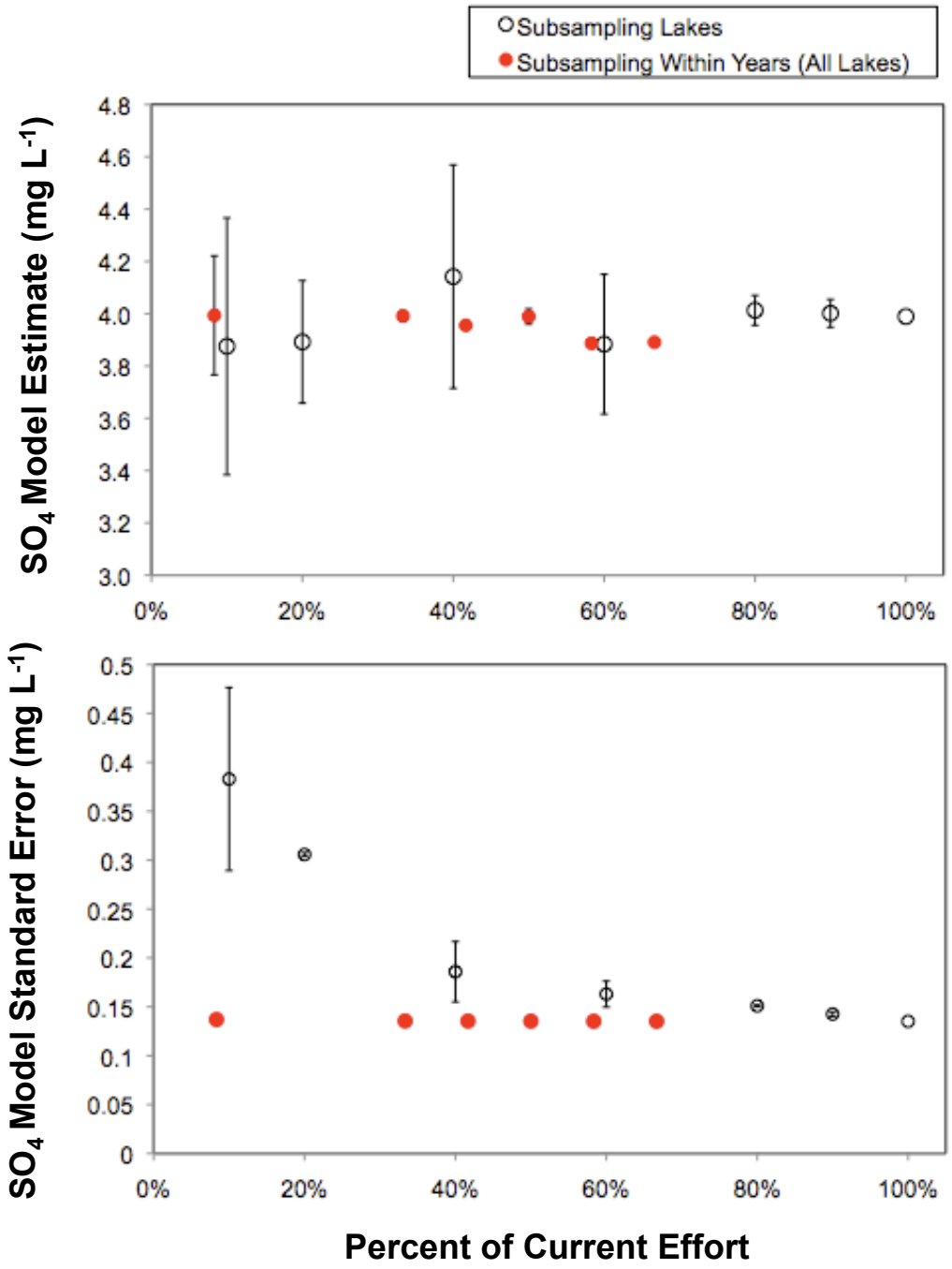
• When monitoring Adirondack lakes, how many lakes should be monitored, and how often?

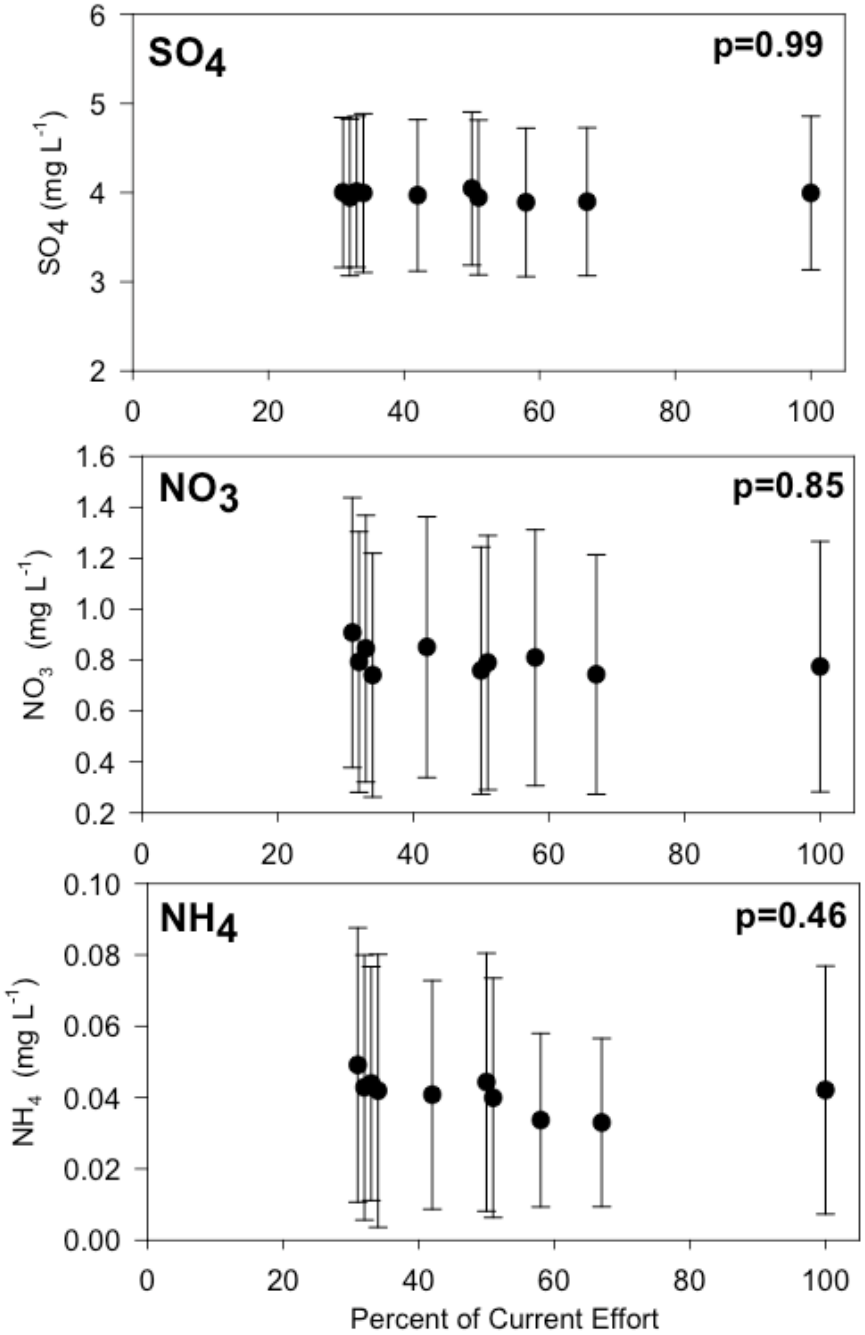
Data sets used in analysis:

• The Adirondack Lake Survey Corporation has been collecting monthly lake water samples for a full suite of chemistry analyses from 52 lakes since 1992

• Monthly data from 48 lakes for the period from 1992-2010 were used in this analysis.




Subsampling Lakes
Subsampling Within Years (All Lakes)
SO4 Model Estimate (mg L-1)
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
0%
20%
40%
60%
80%
100%
SO4 Model Standard Error (mg L-1)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0%
20%
40%
60%
80%
100%
Percent of Current Effort



ANOVA of average concentrations for selected subsampling schemes (pg. 51)

Subsampling Scenarios	%Effort	Number of scenarios tested
12 months (Jan-Dec)	100%	1
8 months (Mar-Oct)	67%	1
7 months (Mar-Sept)	58%	1
6 months	50%	2: even months, odd months
5 months (Mar, Apr, Jun, Sept, Oct)	42%	1
4 months	33%	4: Feb, May, Aug, Nov; Jan, Apr, Jul, Oct; Mar, Jun, Sept, Dec; Mar, Apr, Sept, Oct

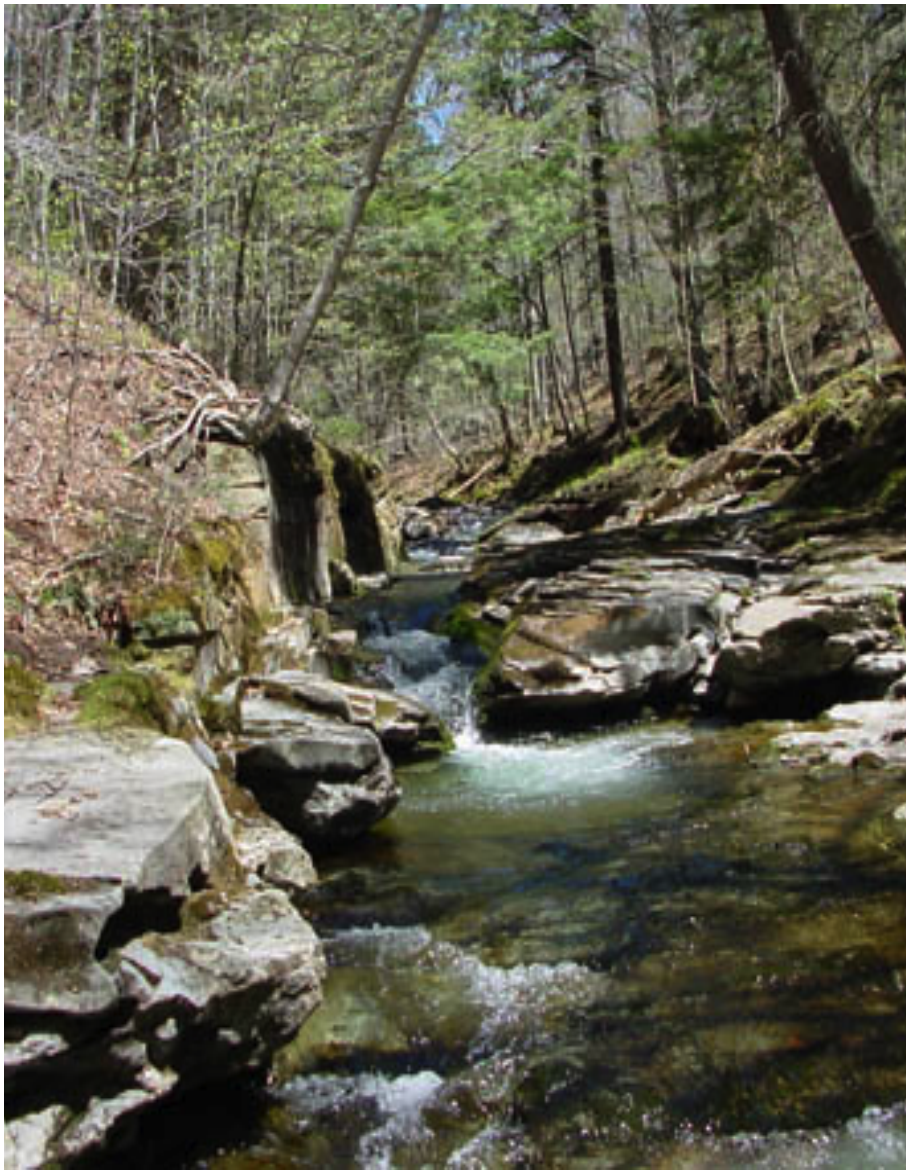
Linear Regression Analysis

Question:

• How often should stream chemistry samples be collected in order to detect long-term chemistry trends?

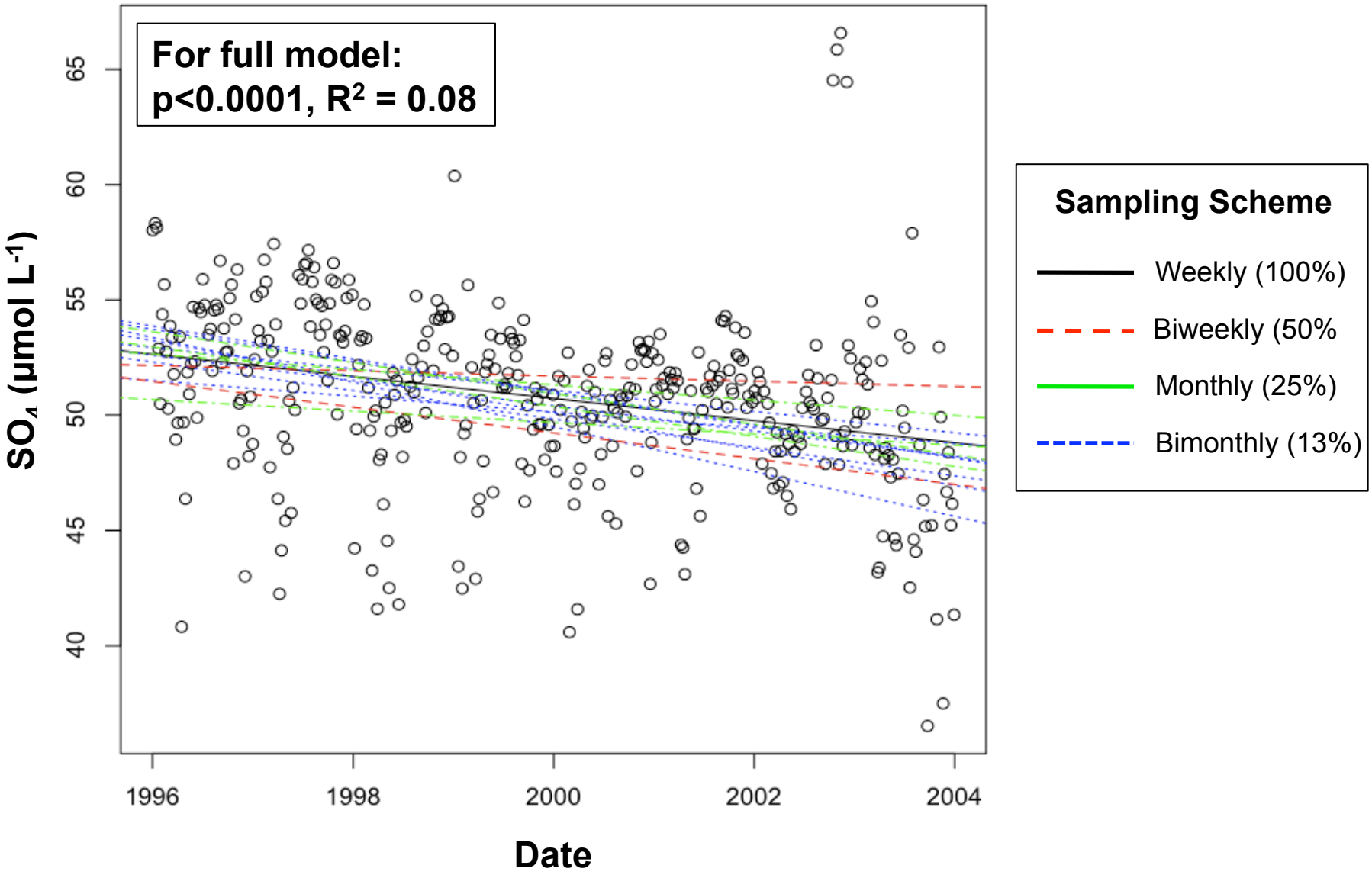
Data sets used in analysis:

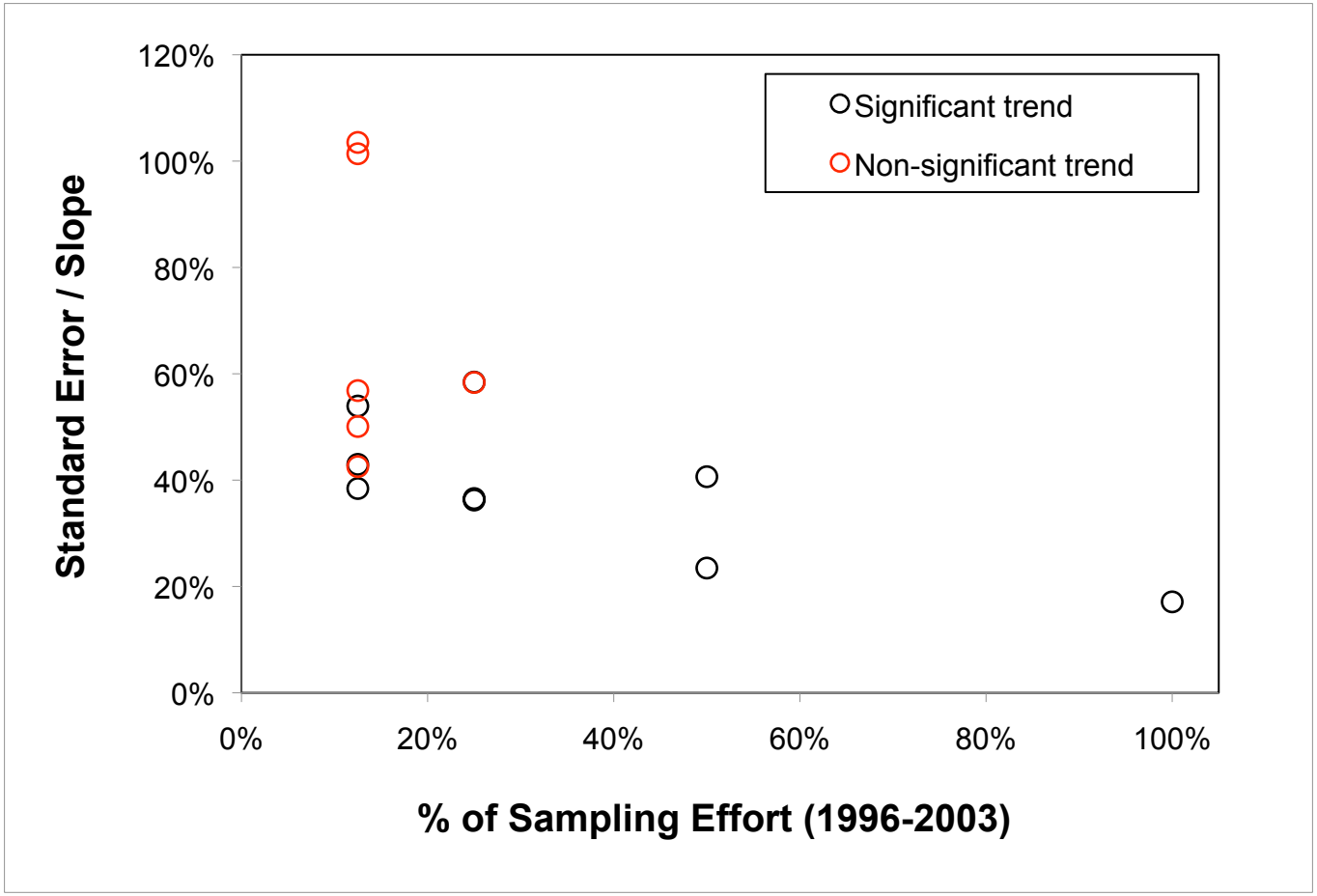
• Biscuit Brook weekly stream chemistry (1991-2003).



NYSDEC: http://ny.cf.er.usgs.gov/nyc/site_page.cfm?ID=01434025

Subsampling the data set affects the slope and intercept of the regression of long-term data.





- **There is a trade-off between sampling effort and the standard error of the regression.**

- **This relationship can be used to determine an optimal sampling scheme that fits research and policy goals as well as monitoring budgets.**

Effect of reduced sampling schemes on detectability of long-term trends in stream chemistry at Biscuit Brook (1996-2003)

	# of significant regressions / Total # of possible regressions			
	Weekly	**Biweekly**	**Monthly**	**Bimonthly**
SO_4^{2-}	1/1	2/2	3/4	3/8
NO_3^-	1/1	2/2	3/4	4/8
H^+	1/1	1/2	2/4	2/8
Total monomeric Al	1/1	2/2	4/4	7/8

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Integrated Monitoring Approaches

- We recommend the establishment of integrated research sites distributed throughout the state.
- Sites can be developed at a range of scales: research plots, watersheds, or basins including several watersheds.
- Trends in co-located deposition collectors, streams, lakes, vegetation, soils, and fauna can be integrated in statistical analyses and projection models to better quantify overall ecosystem response to changes in acid and mercury deposition rates.
- Integrated sites would include:
    - *Routine monitoring*: deposition, gauged streams, lakes where applicable
    - *Periodic survey activities*: vegetation, soils, fauna
- Common methods across sites would allow for comparisons in different regions throughout the state
- Many sites already have several monitoring activities and could be considered for expansion into integrated monitoring sites
    - One important consideration: change methods at existing sites to match, or continue to monitor sites differently?

Catskill Mountains, NY (http://japgar.smugmug.com/Other/2008/overlookmtnpano01/589452741_Tt8jD-M.jpg)

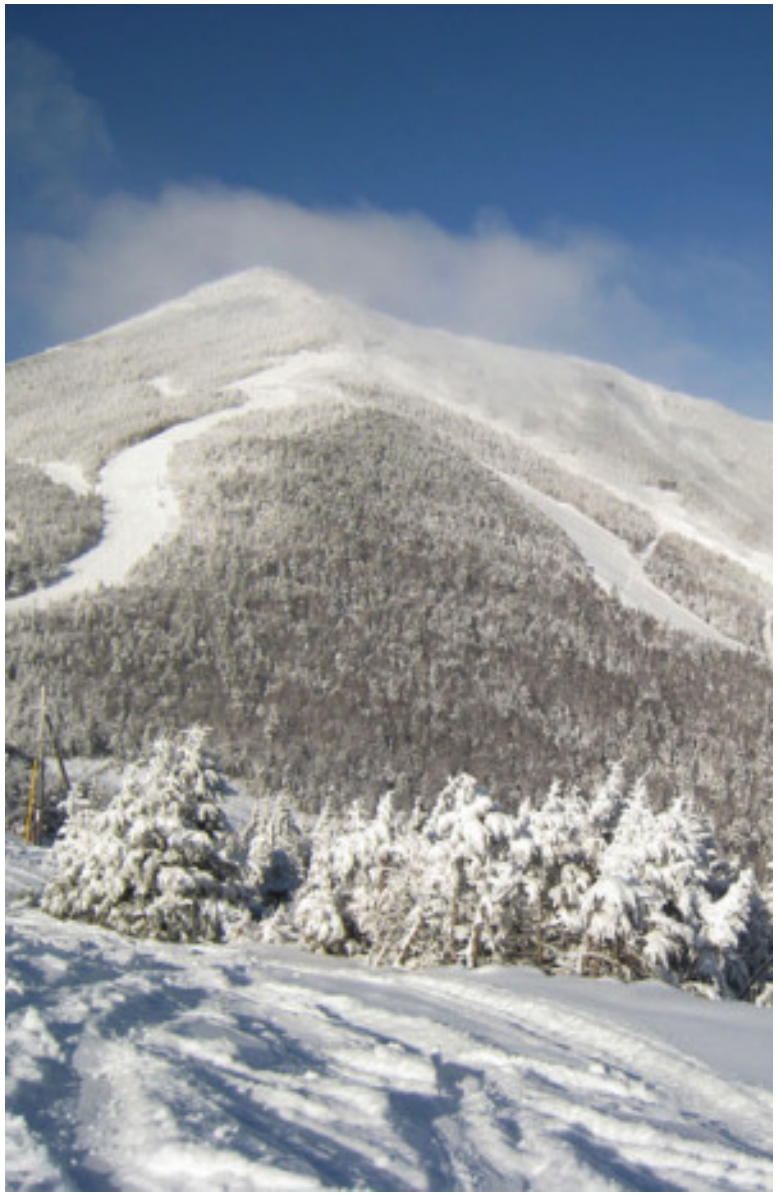
General Monitoring Recommendations

- Prioritize sensitive areas for monitoring:
  - High elevation areas
  - Areas characterized by soils with low buffering capacity
- Support studies that examine already-collected data
  - Many underutilized monitoring data sets exist
- Support broad-scale surveys and resampling for baseline data of understudied topic areas (vegetation, soils, biota)
- Encourage identical methods across studies for making direct comparisons between studies

Tupper Lake, NY (http://blog.mrfishk.com/wp-content/uploads/2010/01/TupperLakePanoramaAtSunset1280.jpg)

Considerations for Designing and Redesigning Monitoring Approaches

- The longer a record is maintained, the more power we have to detect changes with fewer samples.
  - If sampling is reduced in the future, the older record still provides strong statistical power.
- Sampling strategies can be combined in a variety of ways.
  - For example, streams with regular and event sampling, labeled as such for different analyses, or some lakes sampled monthly while a subset are sampled seasonally.
- Remember that there are other applications for data.
  - We may not want to omit winter sampling of lakes, even if not necessary from a deposition monitoring perspective, if winter chemistry is important for climate change research.
- Consistent methods and colocation of monitoring activities should be prioritized.



Whiteface Mountain, NY (http://www.onthesnow.com/ots/community/img_reviews/7299_1_lg.jpg)

Acknowledgments

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- Thanks to the Project Advisory Committee: Doug Burns (US Geological Survey), Kevin Civerolo (NYS Department of Environmental Conservation), Alan Domaracki (NYS Department of Public Service), Gary Lovett (Cary Institute of Ecosystem Studies), and Jason Lynch (US Environmental Protection Agency).

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- Thanks to the various entities and researchers who contributed data to allow us to complete the analyses.

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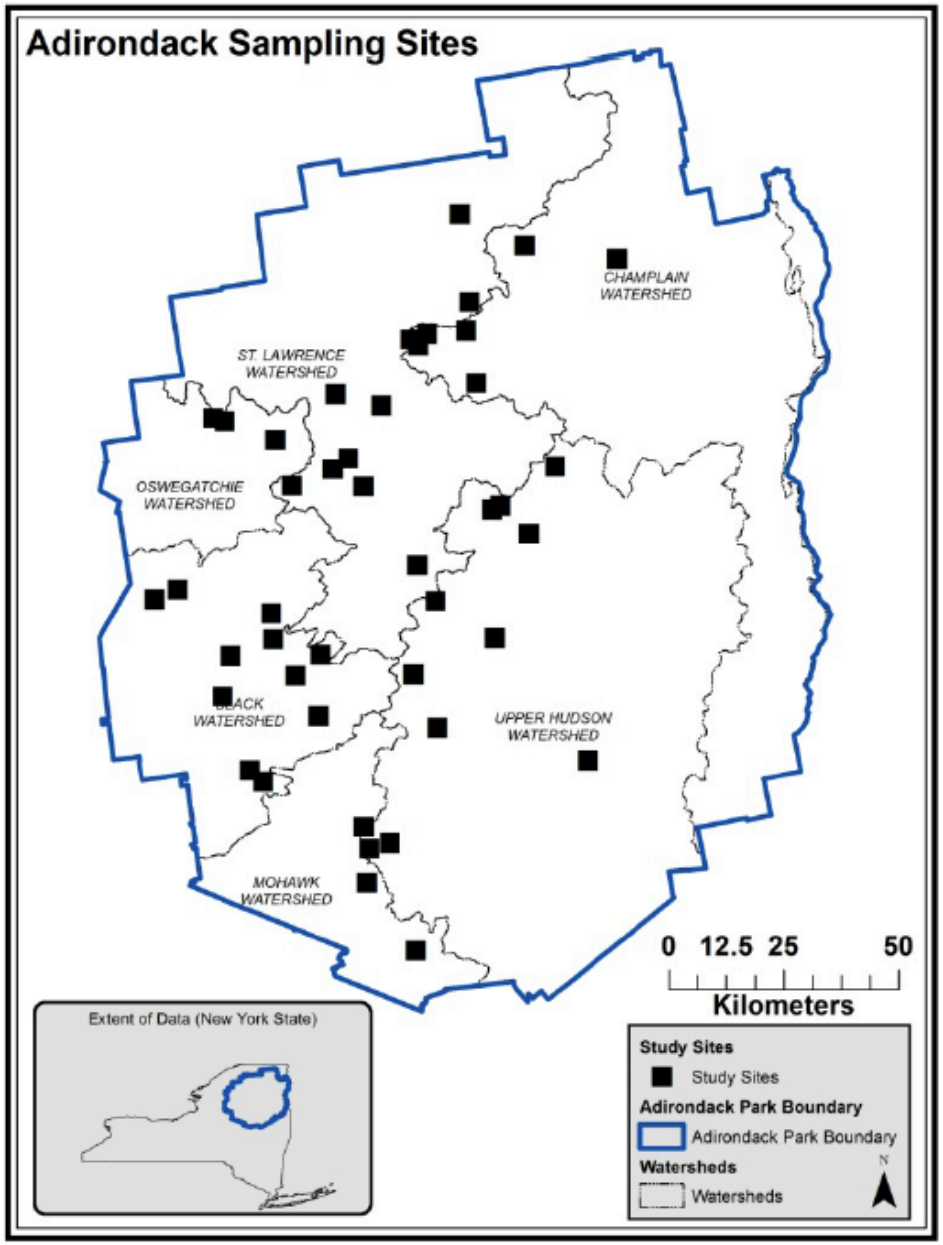
Detectable Difference Analysis

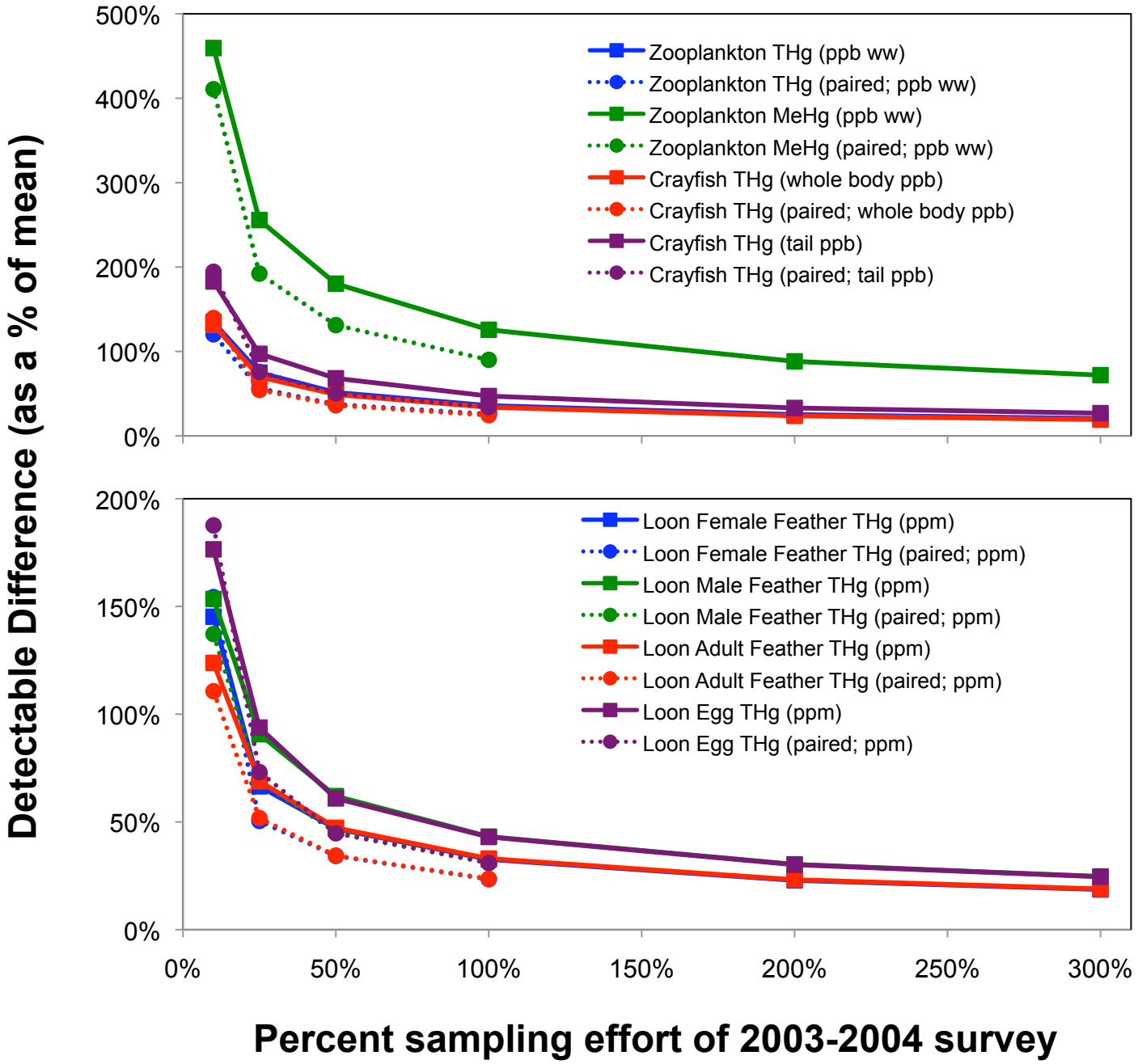
Question:

• When resurveying loon and loon prey tissue mercury concentrations, what is our power to detect a significant change in concentrations? How many samples are needed to detect change at a specific level?

Data sets used in analysis:

• The Biodiversity Research Institute (BRI) conducted a survey in 2003-2004 of loons in 44 lakes to assess mercury concentrations in loons, loon prey species, and loon habitat.




Detectable Difference (as a % of mean)
500%
400%
300%
200%
100%
0%
Zooplankton THg (ppb ww)
Zooplankton THg (paired; ppb ww)
Zooplankton MeHg (ppb ww)
Zooplankton MeHg (paired; ppb ww)
Crayfish THg (whole body ppb)
Crayfish THg (paired; whole body ppb)
Crayfish THg (tail ppb)
Crayfish THg (paired; tail ppb)
200%
150%
100%
50%
0%
Loon Female Feather THg (ppm)
Loon Female Feather THg (paired; ppm)
Loon Male Feather THg (ppm)
Loon Male Feather THg (paired; ppm)
Loon Adult Feather THg (ppm)
Loon Adult Feather THg (paired; ppm)
Loon Egg THg (ppm)
Loon Egg THg (paired; ppm)
0%
50%
100%
150%
200%
250%
300%
Percent sampling effort of 2003-2004 survey