



National Lake and Stream Sampling Protocols

Forest Service Air Program

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Products

- Field Sampling Protocol
- Laboratory Protocol
- QA/QC Protocol
- Data Analysis Protocol
- Biological Protocol
- Training Plan
- Transition Plan.

What's Covered in the Protocols:

Field Sampling Protocol

- Study Design (what, where, when, how)
- Analytes
- Field Methods (lake, stream)
- Documentation
- Forms

Laboratory

- Bottles
- Sample Processing
- Chain of Custody
- Chemical Analyses

QA/QC

- Detection and Reporting Limits
- Attributes of Data Quality
- QC/QA Sample Types
- Laboratory Audits and Certification

DAP

- Validation
- Data Preparation (censored data, outliers, missing values, multiple observations, zeros, negative values)
- Exploratory Analyses
- Statistical Analyses

Biological

- Lake Zooplankton
- Stream Benthic Macroinvertebrates

Importance of Careful Sample Collection and Documentation

All activities down the chain depend on collection of a good representative sample:

- laboratory analysis
- QA/QC
- data analysis
- decision making

Considerable personnel and financial resources are expended as one proceeds from field sample collection to decision making. The whole chain is dependent on **YOU** collecting and properly documenting a good sample.

Why do you have to be careful about how and where to collect your sample?

- You can contaminate your sample with disturbed sediment, sweat, sunscreen, your hands, etc.
- You can collect water from a location that is not representative of the overall lake or stream.

Why do you have to be careful about when to sample?

- Surface waters change in their chemistry with rainstorms, snowmelt, season, drought cycles, etc. Your sampling should either strive to compare apples to apples (spatially and/or over time) or strive to reveal and perhaps quantify such variability.

Identification of Management Needs Will Lead to Specific Procedures:

Management needs will lead into a series of questions, which in turn will guide the sampling effort:

- What kinds of sampling are required to support the management needs?
- What are the protocols to meet those sampling requirements?
- What are the Standard Operating Procedures (SOPs) to implement those protocols?

Ten Basic Questions to be Considered in Designing Water Quality Characterization, Monitoring, and Assessment Studies

1. Why is the sampling taking place?
2. Who will use the resulting data, and how will that influence the level of quality assurance that will be required?
3. How will the data be used, and how will the intended use influence data requirements?
4. What parameters or conditions will be measured?
5. How good do the data need to be in terms of accuracy, representativeness, completeness, and intrasite and intersite comparability?
6. What methods should be used?
7. Where are the sampling sites?
8. When will the sampling occur?
9. How will the data be managed and analyzed?
10. How will the program ensure that the data are credible?

Pre-trip Activities

- Develop sampling itineraries
- Instrument calibration, if appropriate
- Equipment checks and repair, as needed
- Supply inventories
- Sample container and label preparation
- Consult appropriate checklists
 - ✓ site documentation
 - ✓ stream sampling
 - ✓ discharge measurement
 - ✓ lake sampling
- Arrange for site access, accommodations, vehicles, as needed

Site Documentation

Establish and document new sampling sites (and update documentation for established sites), providing:

- site description
- travel directions and access information
- site GPS coordinates
- site and access photos

Collection of Water Sample

- Follow stream or lake sampling procedures, as appropriate
- Take great care to avoid contaminating the sample while it is being collected:
 - ✓ Rinse all sample containers 3 times with lake or stream water before filling them with sample
 - ✓ Make sure that none of the water sample contacts your hands before going into the sample bottle or syringe.
 - ✓ Wear powder-free gloves
 - ✓ Make sure that you do not stir up sediment that could be captured in your sample bottle or syringe
- Enter the time of sample collection on the bottle and syringe labels. Make sure all labels are fully and correctly completed. Place plastic tape over each label

Standard Operating Procedures (SOPs):

- Detailed sequential steps in carrying out the water sampling
- Based on the principles outlined in the Protocol
- In modifying SOPs, the guidelines represented in the Protocol should always be carefully considered.

Post Sampling Actions

- Complete the Sample Record Form.
- Transport samples to vehicle
- Double-bag bottle(s) and syringes in cooler at vehicle
- Review labels and data forms
- Clean boat or raft, equipment, and clothing before leaving the site

Processing Site Documentation Data and Information

- File system and database (w/ backup) for site records and files, map images, photos
 - ✓ Retrieve site coordinates (and any tracks) from the GPS unit
 - ✓ Retrieve photos from the camera
 - ✓ Enter or revise the site record
- Create site maps for access and orientation

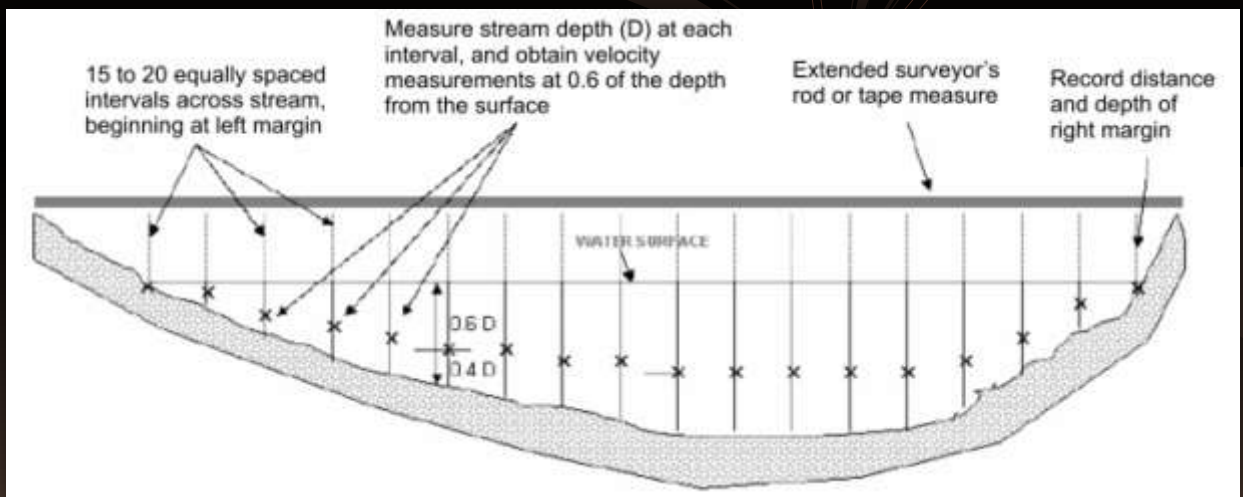
Measuring Stream Discharge

Q = velocity x vertical cross sectional area of flowing water. It reflects the volume of water per unit time (i.e., L/s) that passes a particular location:

- velocity-area method
- calibrated bucket timing method

Velocity-area Procedure

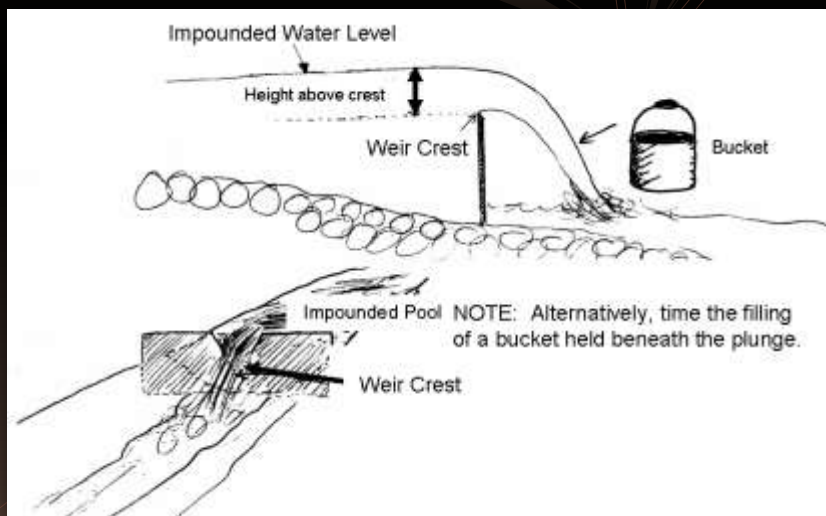
- Discharge measurements are made *at only one carefully chosen channel cross section within the sample reach.*
- You may remove rocks and other obstructions to improve the cross-section **before** any measurements are made.
- Measure the mean velocity and flow cross-sectional area of many increments across a channel.
- The whole is calculated as the sum of these parts.
- Velocity measurements are generally made at 60% of the stream depth at each location.



Layout of a channel cross-section for obtaining discharge data by the velocity-area procedure.

Steps in the Timed Filling Procedure

- Measure the time it takes to fill a container of known volume.
- Requires one or more natural or constructed spillway(s) of free-falling water. A temporary spillway can be constructed, if necessary.
- Place bucket under the spillway; make sure that the entire flow of the spillway is going into the bucket.
- Repeat the procedure 5 times: discharge will be calculated as an average of these five measurements.
- If the cross-section contains multiple spillways, you will need to do separate determinations for each spillway, and add them together.



Use of a portable weir in conjunction with a calibrated bucket to obtain an estimate of stream discharge.

Lake Sampling Site:

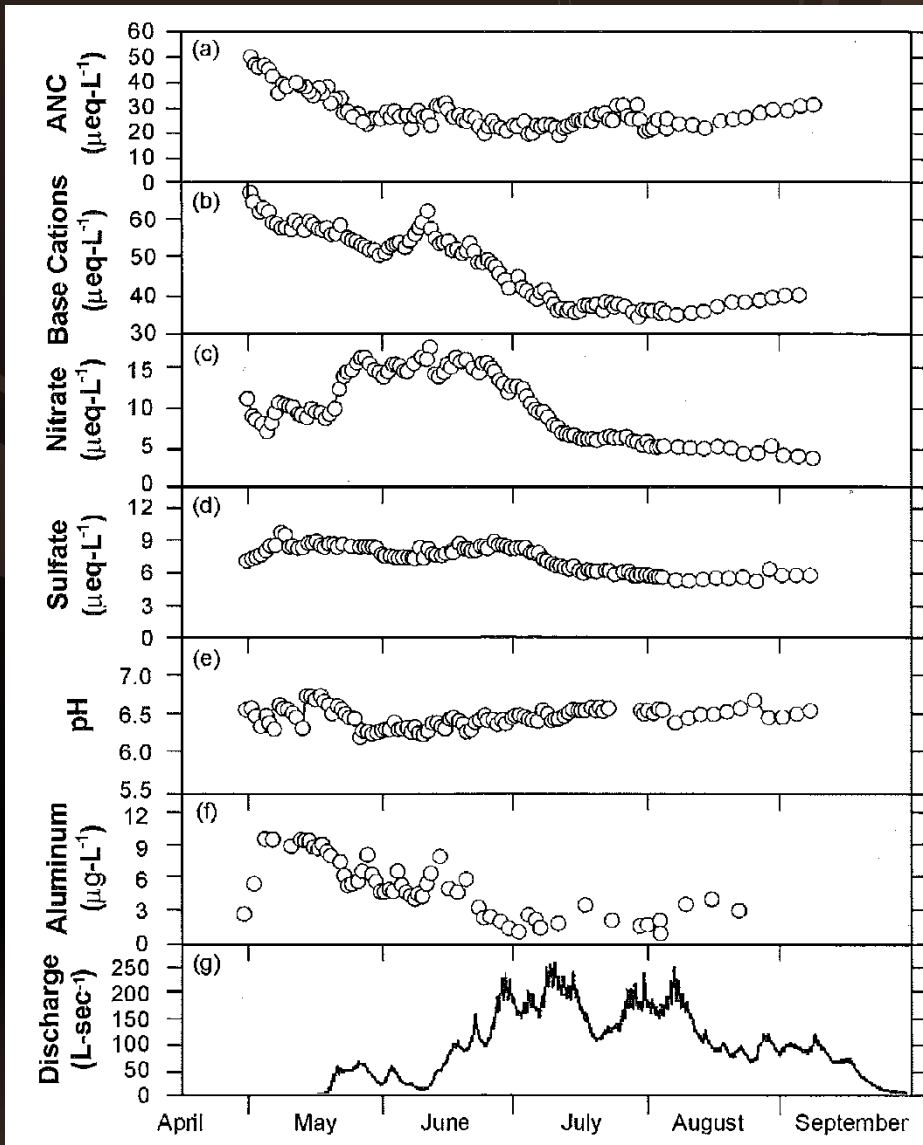
- Index Site
- Outlet
- Shoreline

Two Videos are Available for Viewing

- Stream sampling video
- Stream discharge measurement video

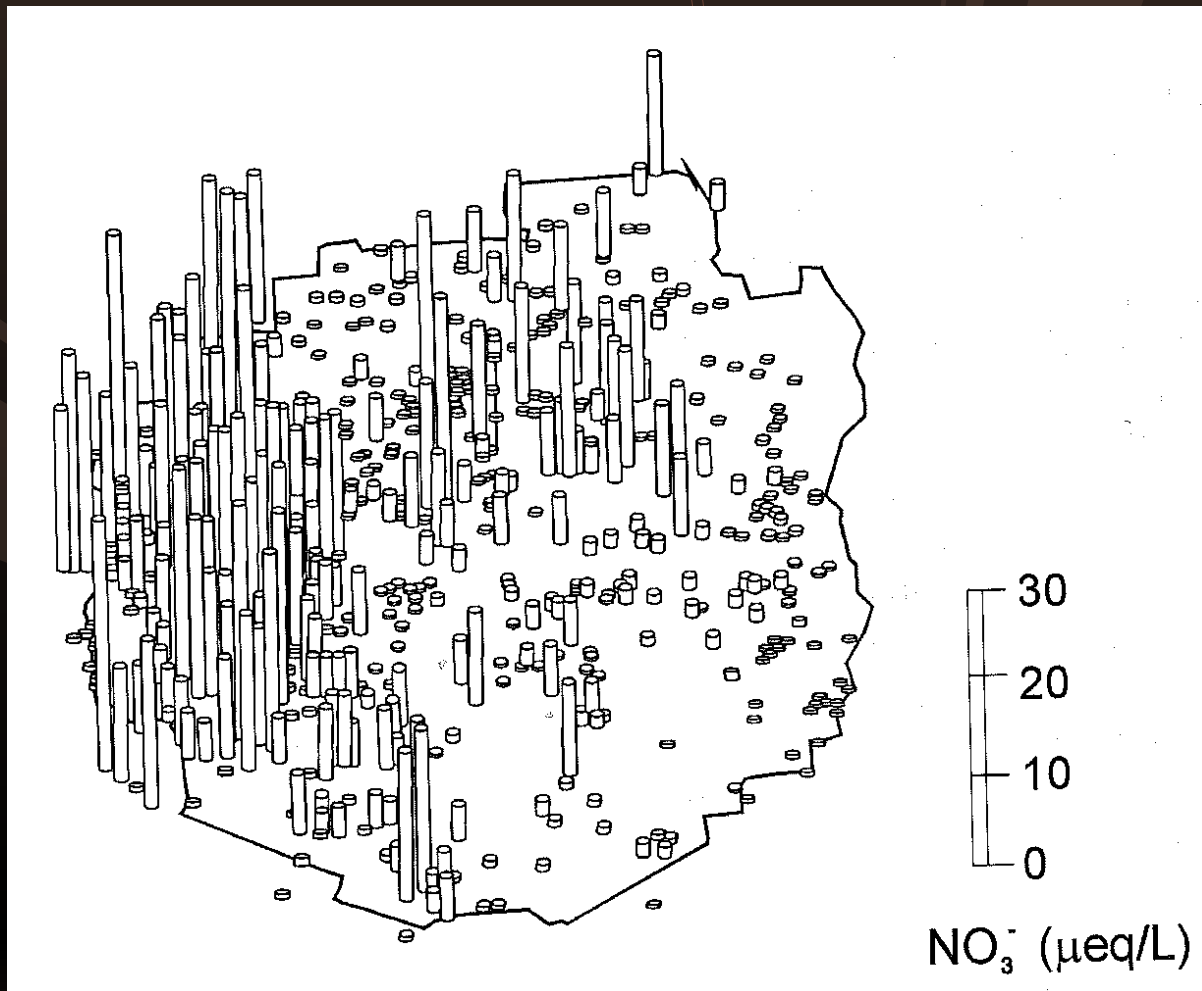
Some Example Data Analysis Approaches

Time Series of Major Ions and Discharge



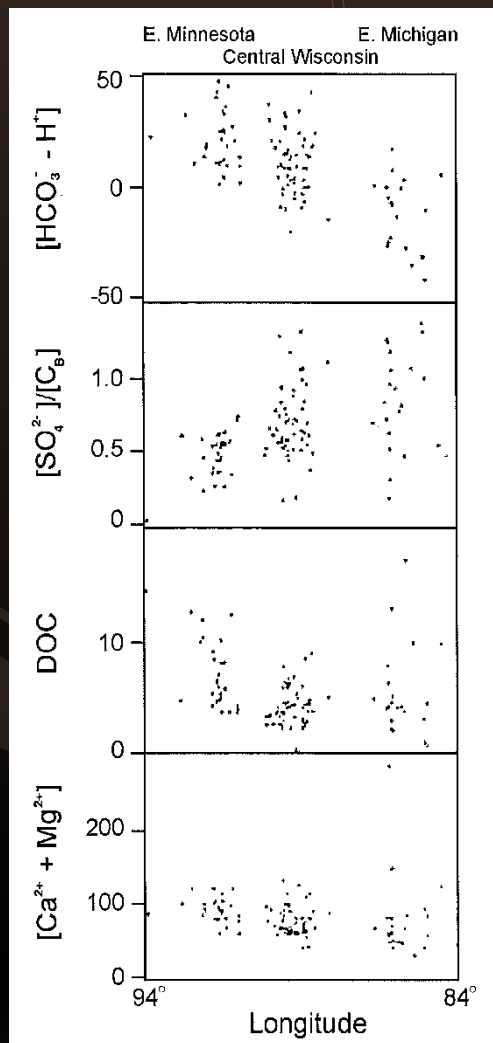
Time series of major ions and discharge in Treasure Lake in the Sierra Nevada during snowmelt in 1993 (source: Stoddard 1995). Seasonal and episodic changes in surface water chemistry can be examined using these simple time series plots.

Summer NO_3^- Concentrations



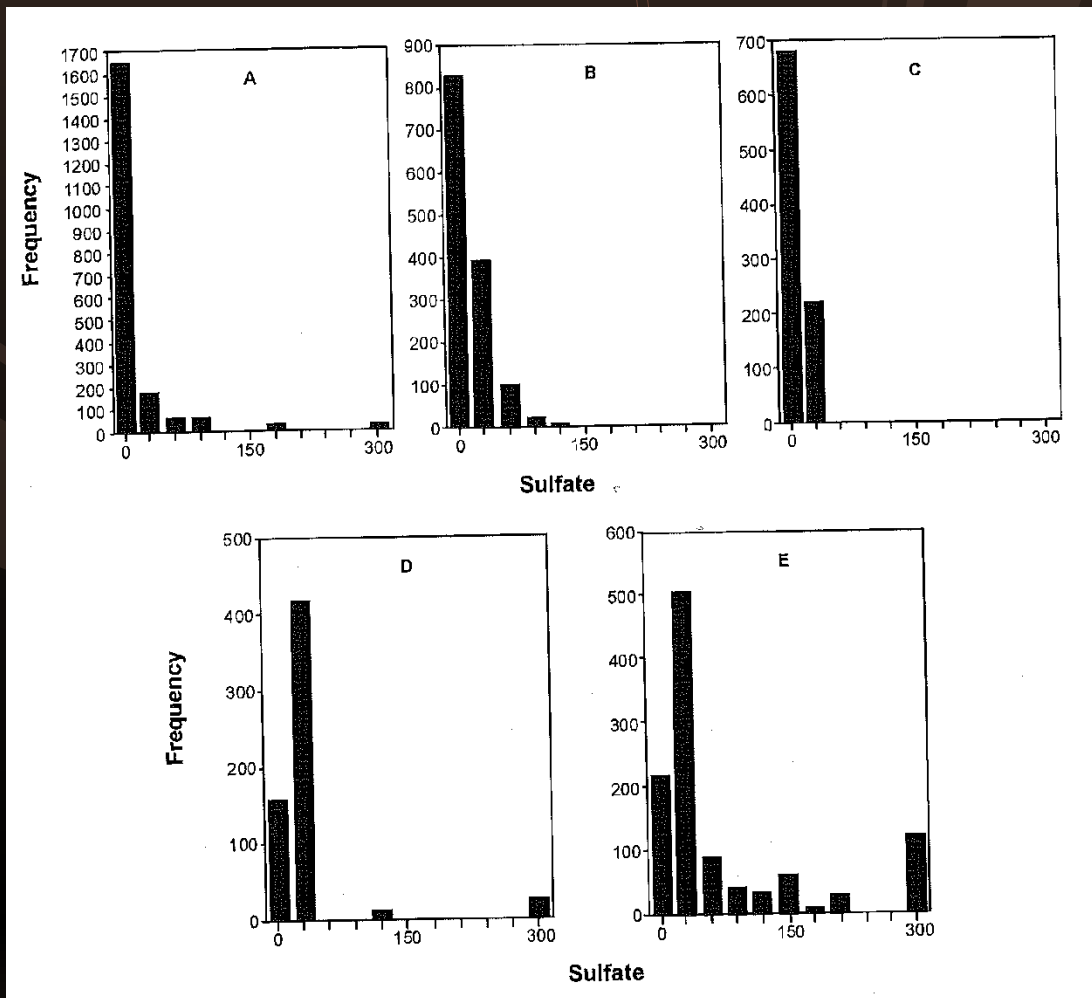
Map of summer NO_3^- concentrations in drainage lakes sampled by the Adirondack Lakes Survey Corporation in the Adirondack region of New York (source: Sullivan et al. 1997). Maps such as this can reveal spatial patterns in the concentration of any surface water variable across a study area.

Space-for-time Substitution



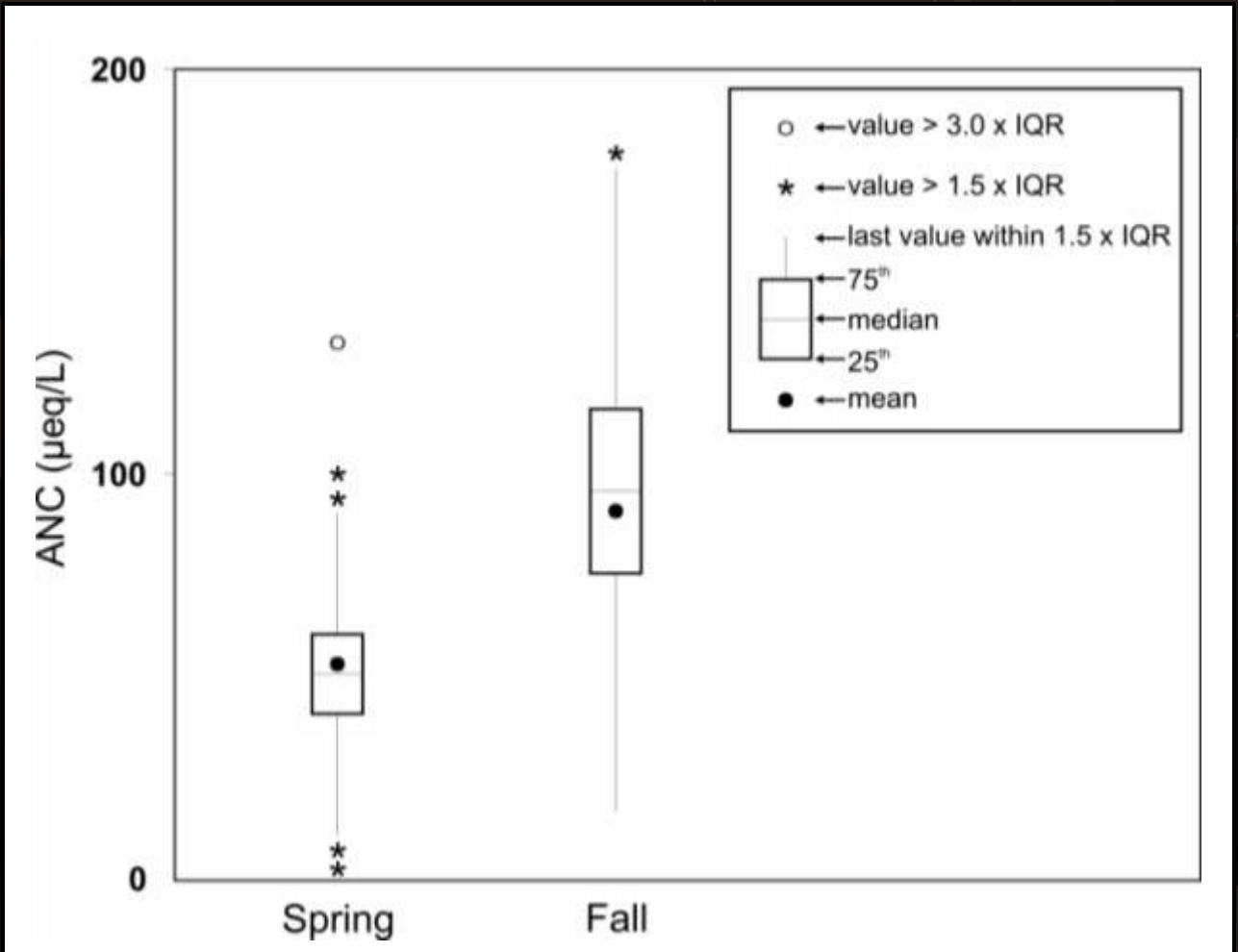
Example space-for-time substitution analysis for four variables across a gradient of expected response. This example is based on subsetting the available data, across a gradient of acidic deposition in the Midwest, to include only seepage lakes having low silica concentration. Data were further subset to delete lakes having high Cl^- concentration (to remove road salt influence) and those having ANC above $50 \mu\text{eq/L}$. Note that the variable $[\text{HCO}_3^- - \text{H}^+]$ is one representation of ANC. (Source: Sullivan 1990)

Histograms



The concentrations of sulfate ($\mu\text{eq/L}$) in lakes in (A) Sierra Nevada, (B) Cascade Mountains, (C) Idaho Batholith, (D) NW Wyoming, and (E) Colorado Rockies are examined. (Data from Western Lake Survey) If a given study area receives relatively homogenous levels of atmospheric S deposition, then it can be assumed that the observed outlier high concentrations in lake water represent largely non-atmospheric input. (Source: Sullivan 2000)

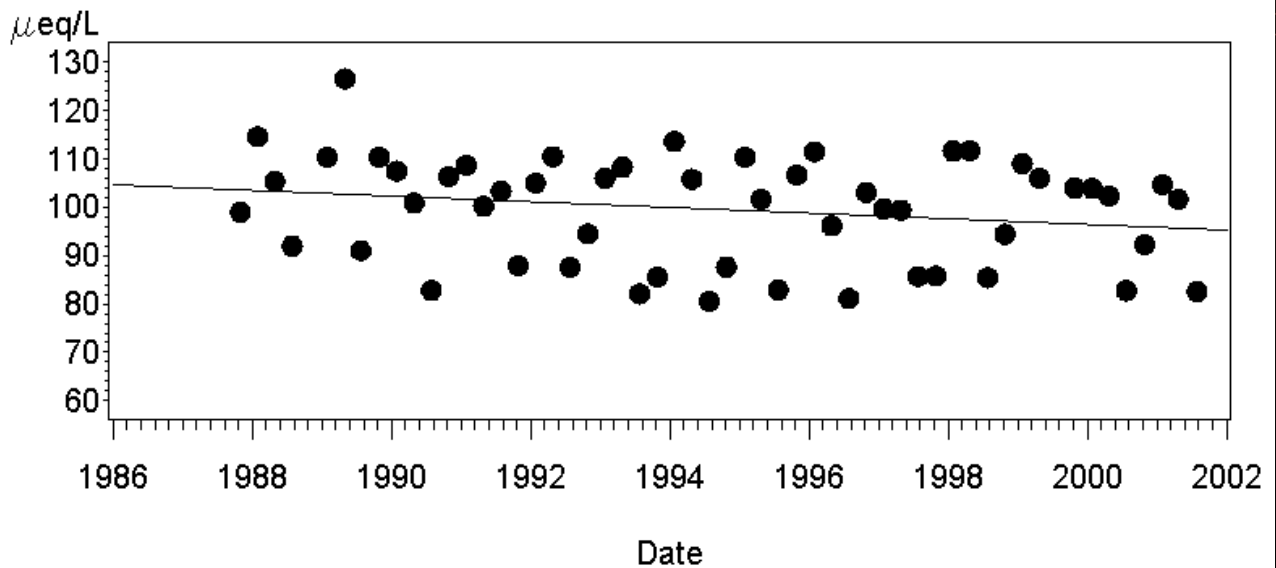
Box Plots



Example box plots to compare hypothetical lake ANC values measured in samples collected during the spring versus the fall season. IQR indicates the interquartile range, or the difference between the 25th and 75th percentile values.

Trends

Sulfate
Site=DR01

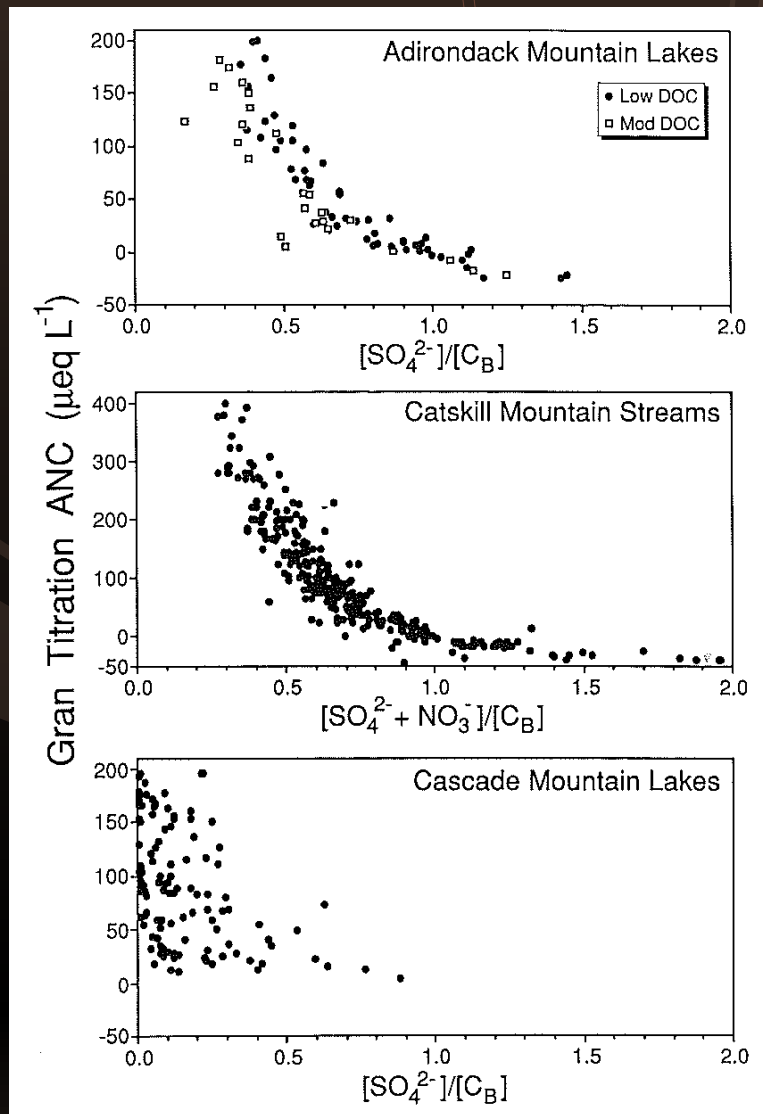


Regression Equation:

$$SO_4 = 1244.275 - 0.573908 * \text{Date}$$

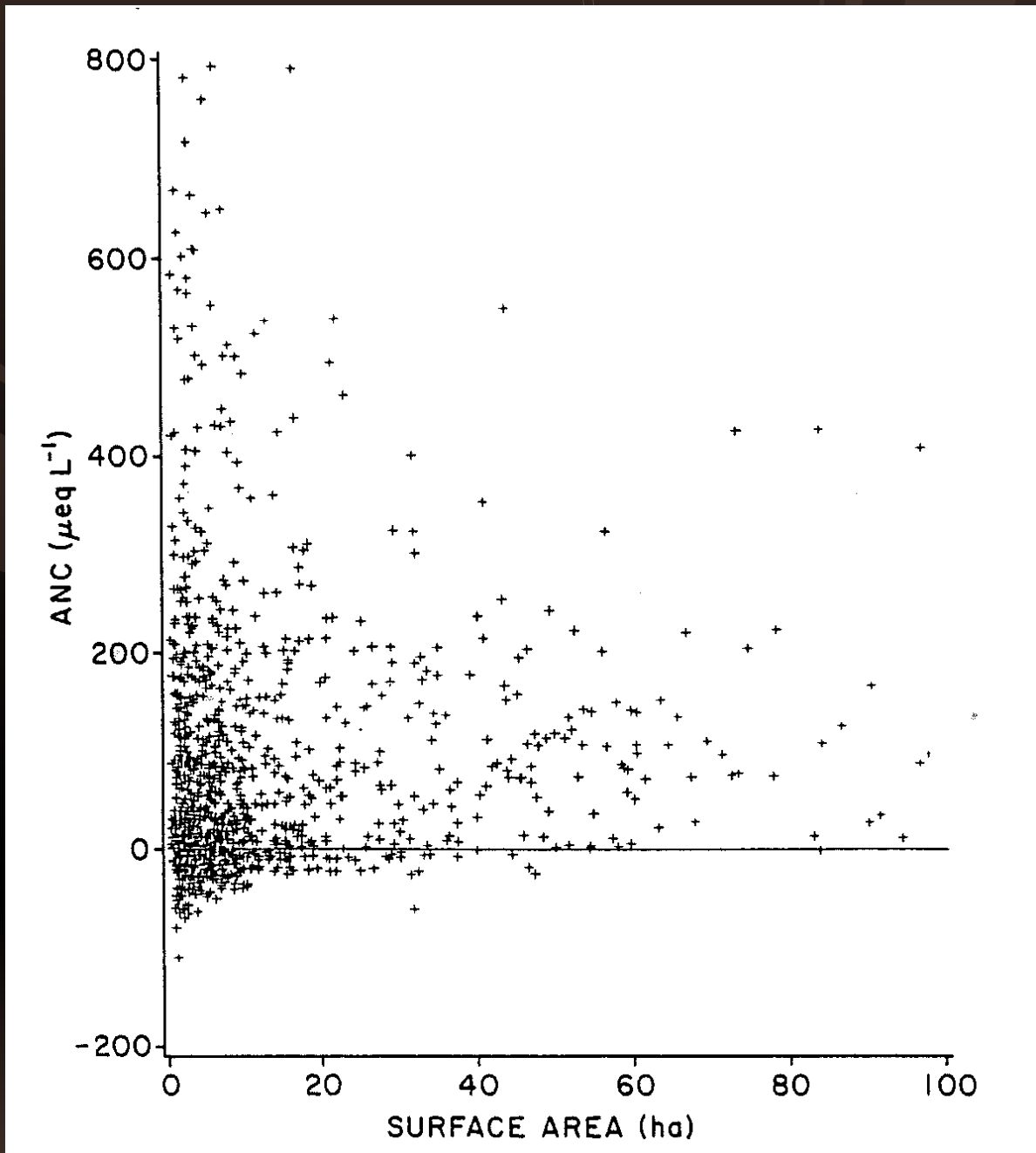
Plot, with regression line, of SO_4^{2-} concentration in Deep Run, Shenandoah National Park, over the period of monitoring record. (Source: Sullivan et al. 2003)

Ion Ratios



Plot of ANC versus the ion ratio of sulfate concentration divided by the sum of base cation concentrations (termed C_B) for low ANC (≤ 200 $\mu\text{eq/L}$) surface waters in (a) Adirondacks, (b) Catskill Mountains, and (c) Cascade Mountains. The base cation sum includes $\text{Ca}^{2+} + \text{Mg}^{2+} + \text{Na}^+ + \text{K}^+$. This plot reveals that surface water ANC is strongly related to the ratio SO_4/C_B in the Adirondack region, and the ratio $(\text{SO}_4 + \text{NO}_3)/\text{C}_B$ in the Catskill region, but weakly related to the ratio SO_4/C_B in the Cascade Mountain region. Such an analysis sheds light on factors controlling surface water ANC. (Source: Sullivan 1990)

Lake Size/Lake ANC Relationship



Relationship between lake size and lake ANC in the Adirondack Mountains. (Source: Sullivan et al. 1990)