Quantifying uncertainty in filling data gaps: atmospheric deposition at the Sevilleta National Wildlife Refuge.

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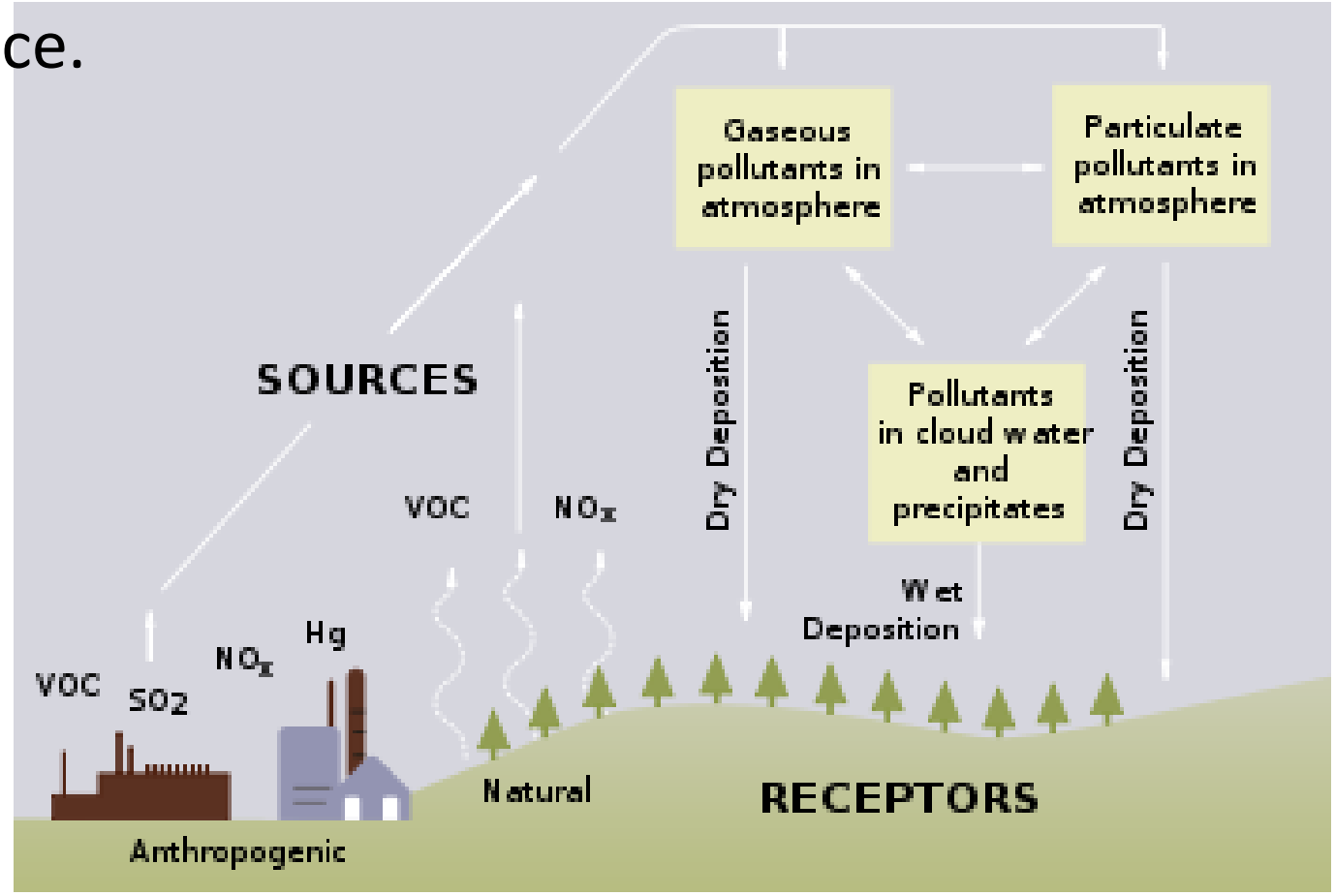
Atmospheric Deposition

The process by which chemical substances, are transferred from the atmosphere to the earth's surface.



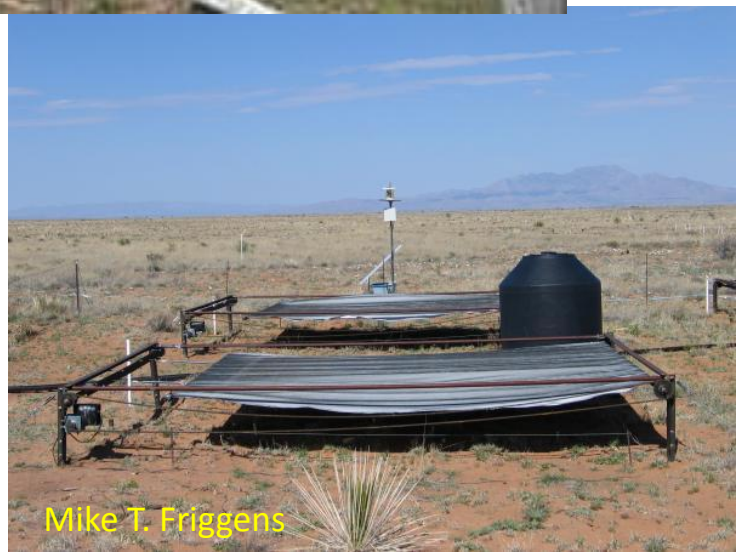
Source: wikipedia.org

Why Care?

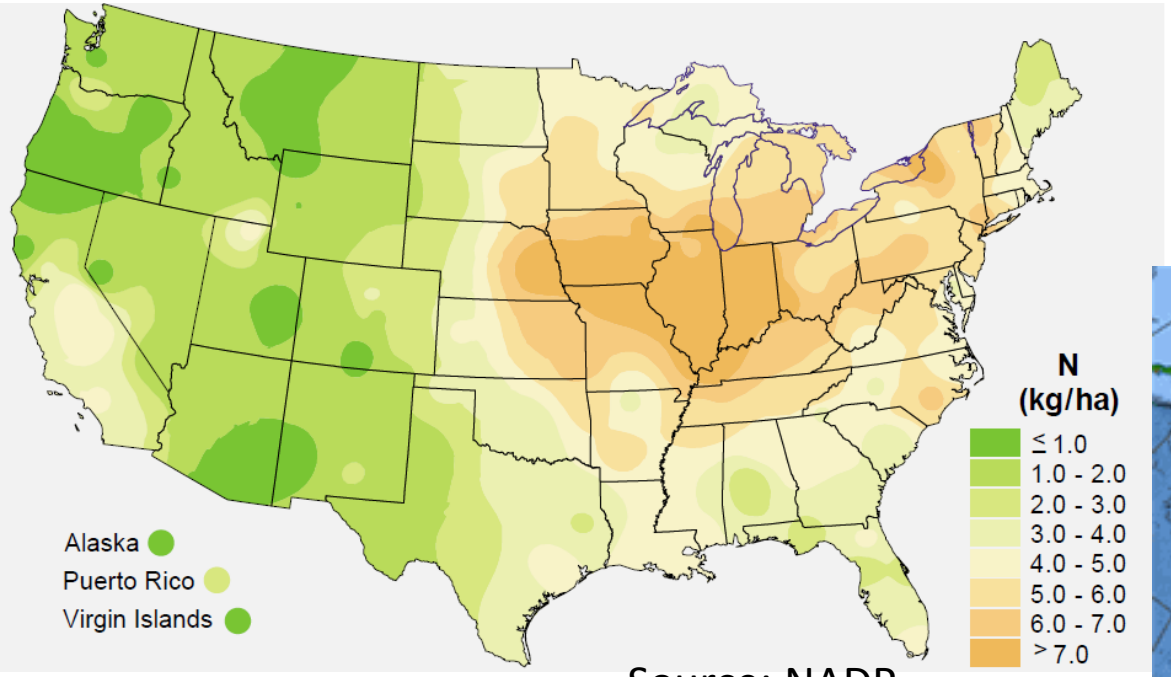

Fisheries and Oceans Canada


US Forest Service


University of Minnesota

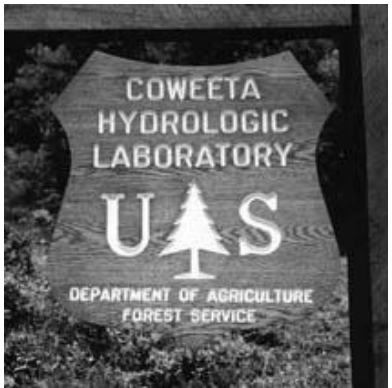

Mike T. Friggens

Deposition can be measured at different scales across space and time

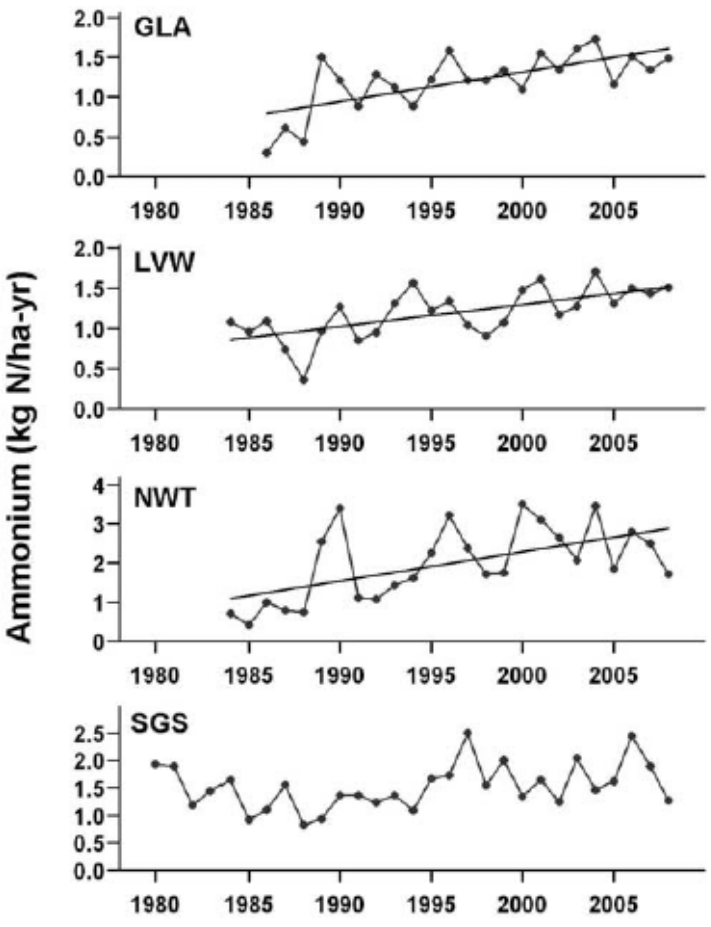


Source: NADP

- NADP
- AIRmon
- LTER

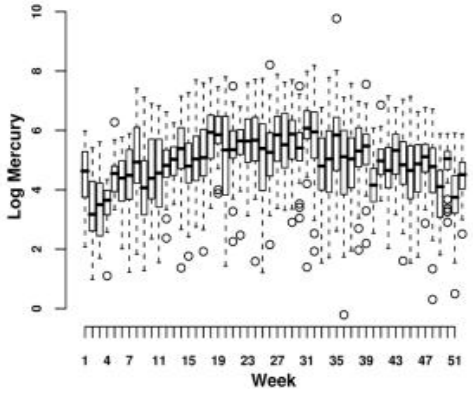


Calculating total deposition

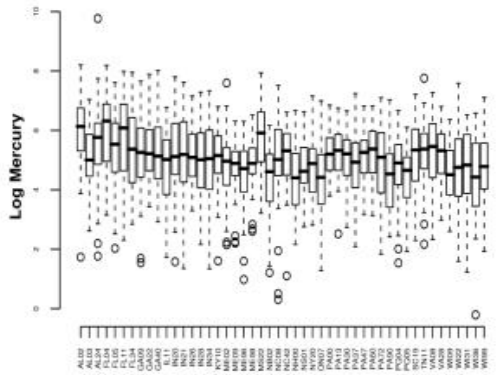


Driscoll et al. 2012

- Volume X solute concentration of precipitation event
- Products are summed for period of interest
- Must include ALL precipitation events for period



(a)



(b)

Rappold et al. 2009

But rain gauges can overflow, or spill

And samples can get contaminated...

Gap filling (imputation) methods

- Use of historical averages
- Bayesian Bootstrapping
- Expectation-maximization algorithm
- Use neighboring gauge values
  - Direct substitution
  - Regression

All gap filling methods introduce new error into the final total!

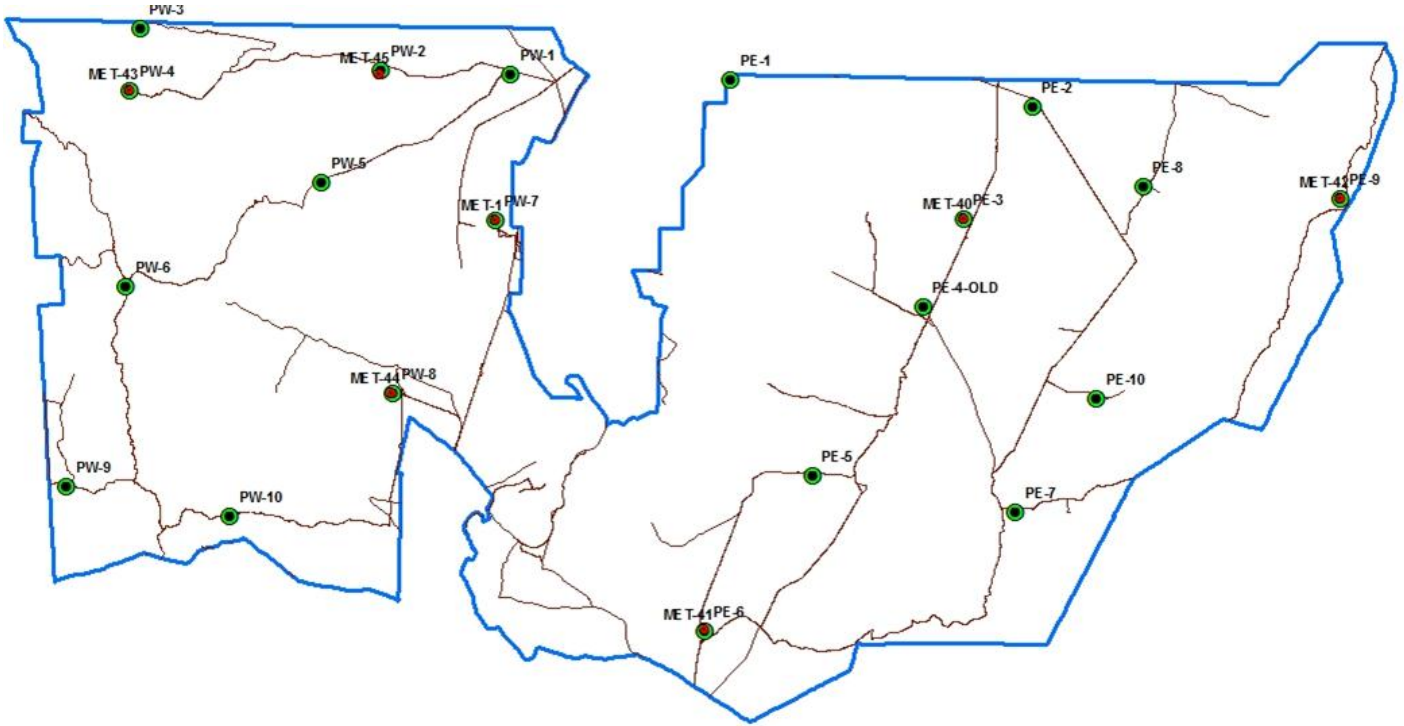
Sevilleta National Wildlife Refuge

- Long term network of gauges collecting precipitation volume and solute chemistry
- South of ABQ, concerned about NO3 pollution

Objective: Calculate annual wet deposition of nitrate for the rain gauges at Sevilletta, including error from regression based gap filling.

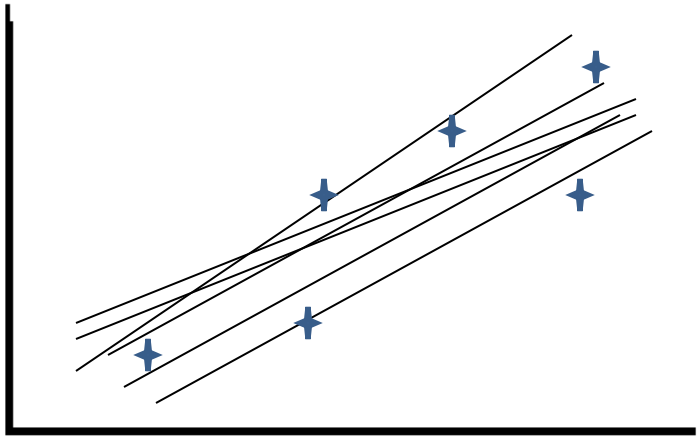
METHODS

- Volume and chemistry measurements taken from 20 collectors across SEV from 1989-1995.
- Solutes: NO3, NH4, SO4, Cl, Na, K, Ca, Mg, and PO4.
- Collections monthly or after heavy rains

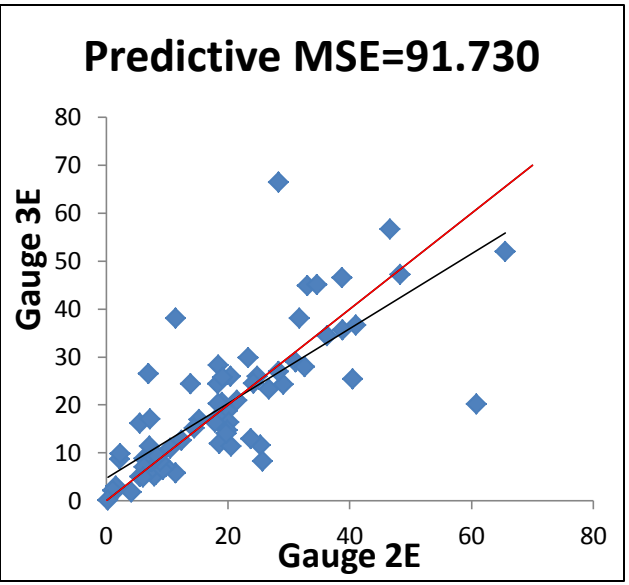


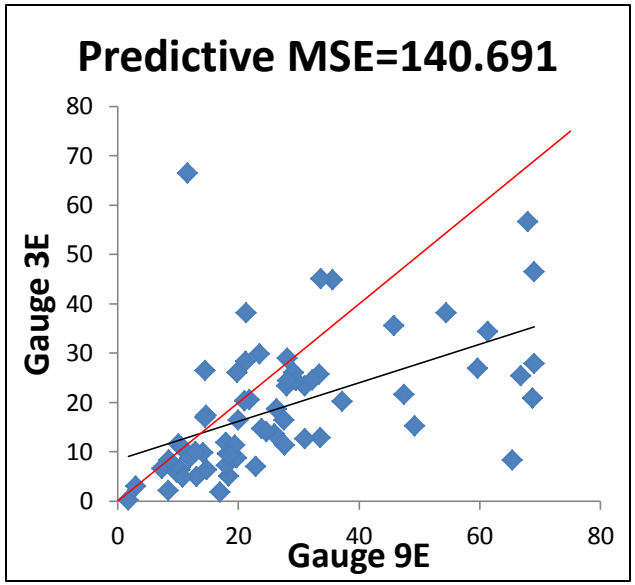
Statistics

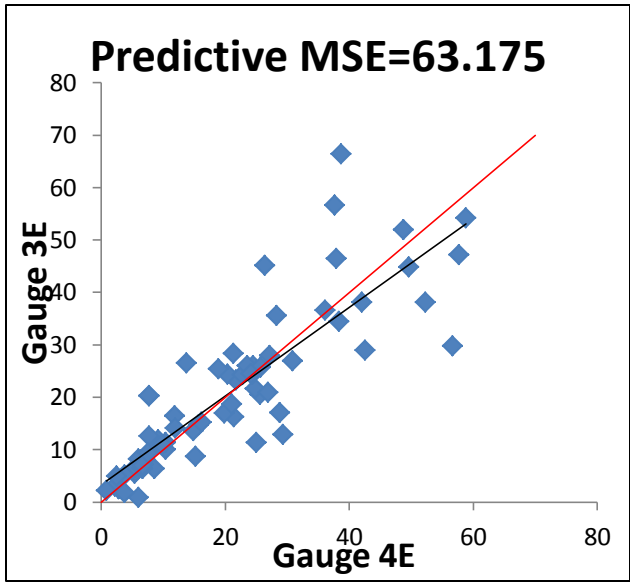
- Created regressions using combinations of up to 4 gauges as predictor variables
- PRESS → PRMSE $\dfrac{\sum_{i=1}^{n}(y_i - \hat{y}_{(i)})^2}{N}$
- 68.2% PI → $\hat{y}_h \pm t_{(\alpha/2,n-2)} \times \sqrt{MSE\left(1+\frac{1}{n}+\frac{(x_h-\bar{x})^2}{\sum(x_i-\bar{x})^2}\right)}$
- Relative errors add



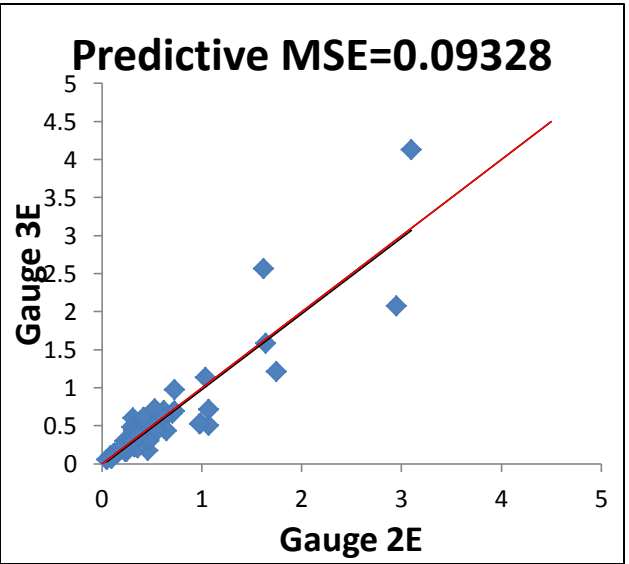
Rainfall Volume Measurements

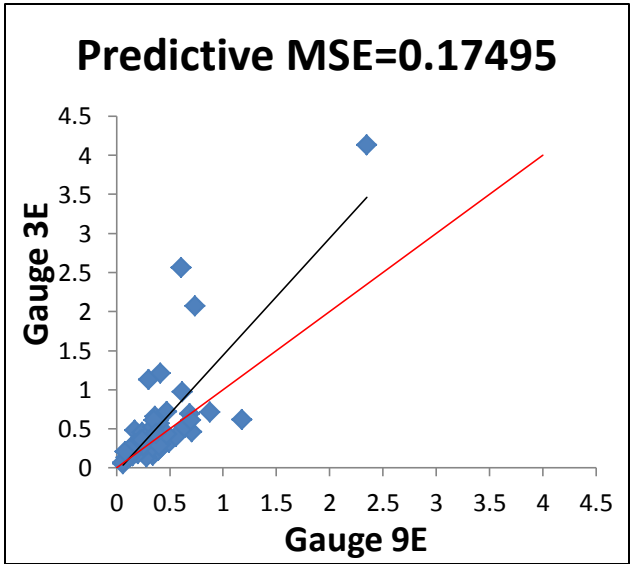


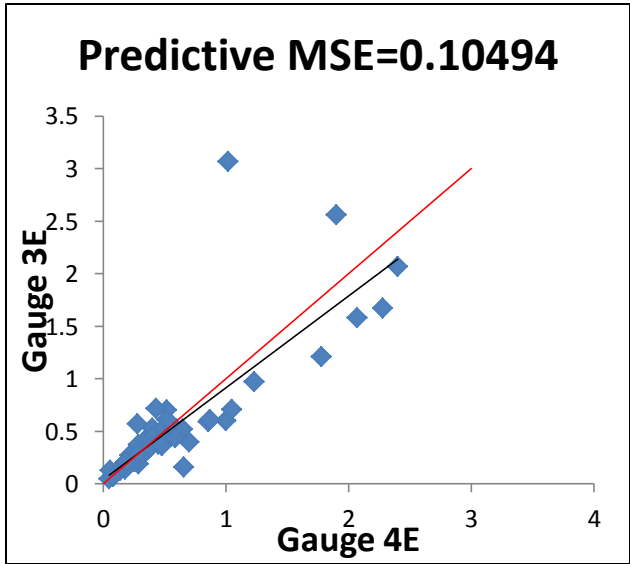




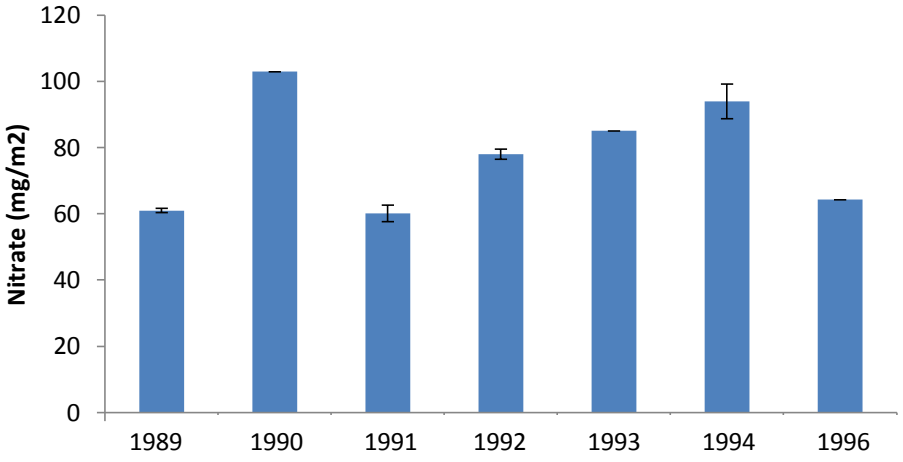
Rainfall Nitrate Concentrations



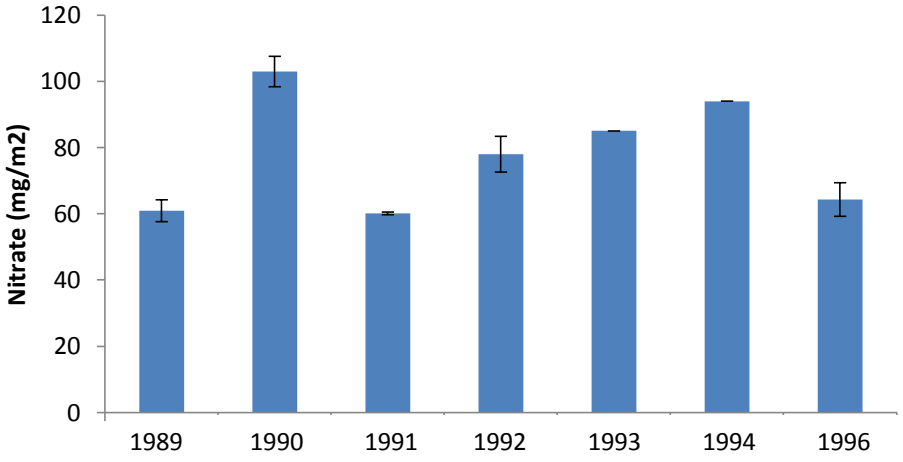




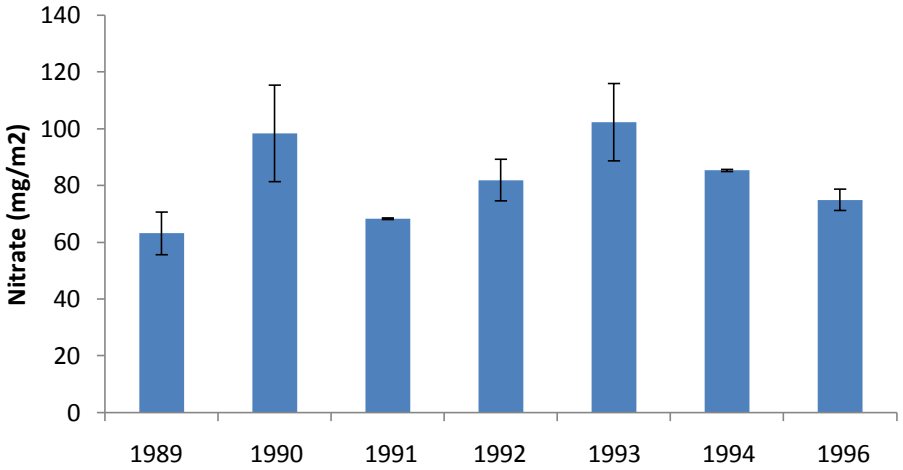
Gauge 3E Annual Nitrate Deposition



Gauge 2E Annual Nitrate Deposition

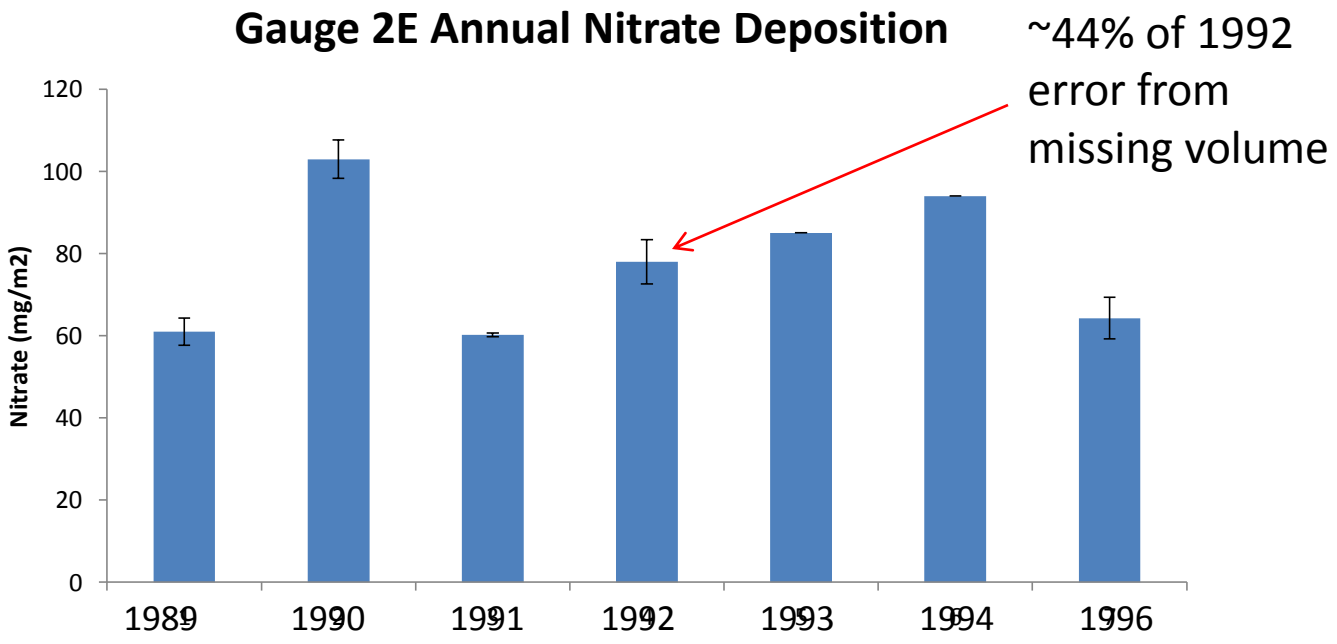


Gauge 8E Annual Nitrate Deposition

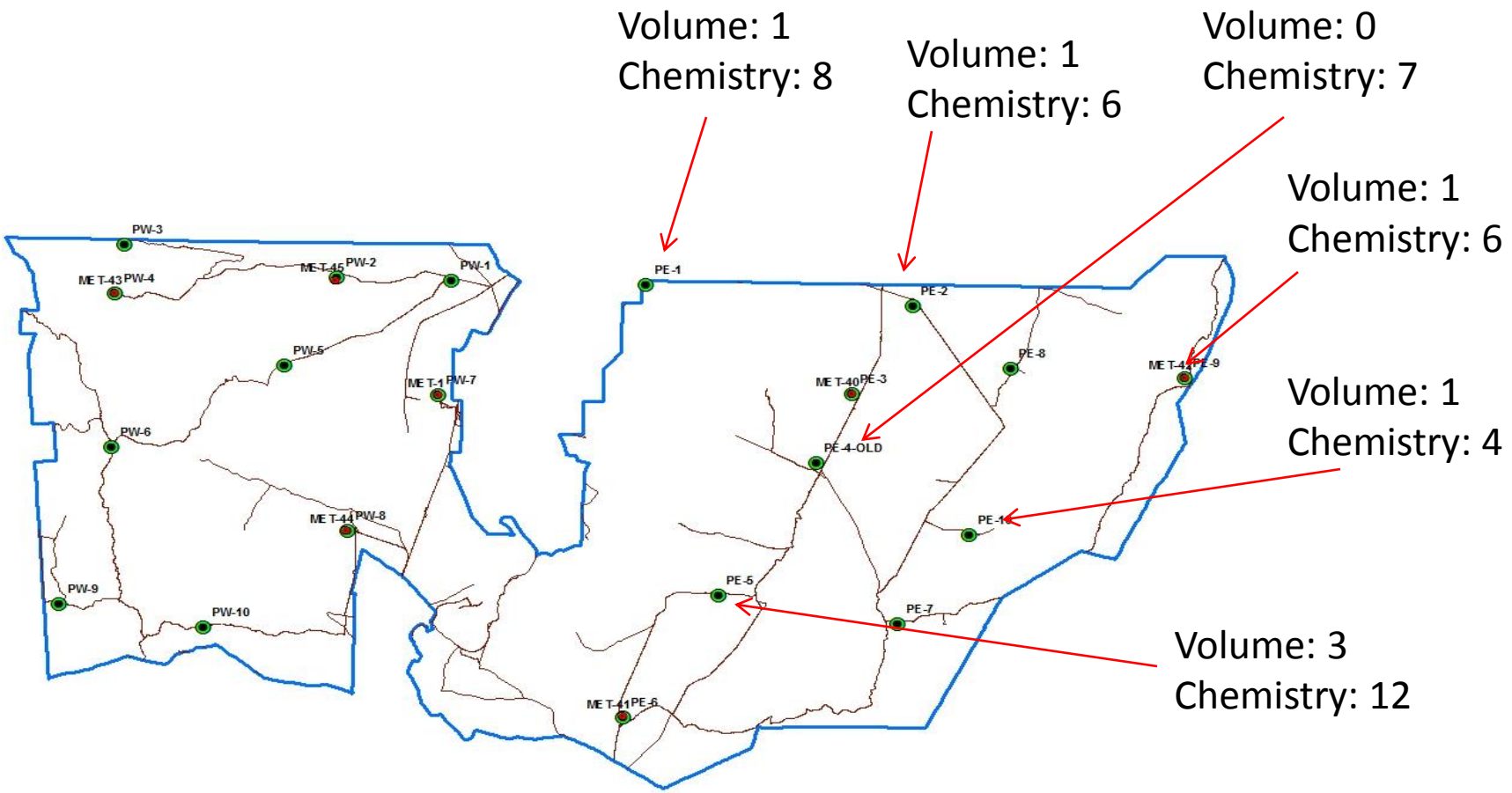


Error contribution

- Volume gaps can have large effect
- Chemistry gaps much more common

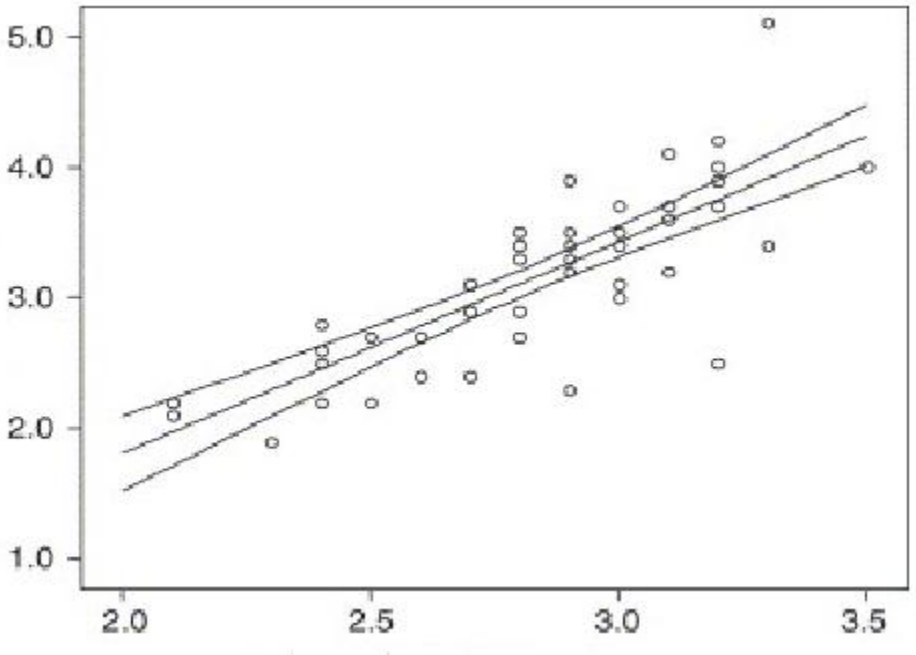


Total number of data gaps by Gauge from 1989-1995



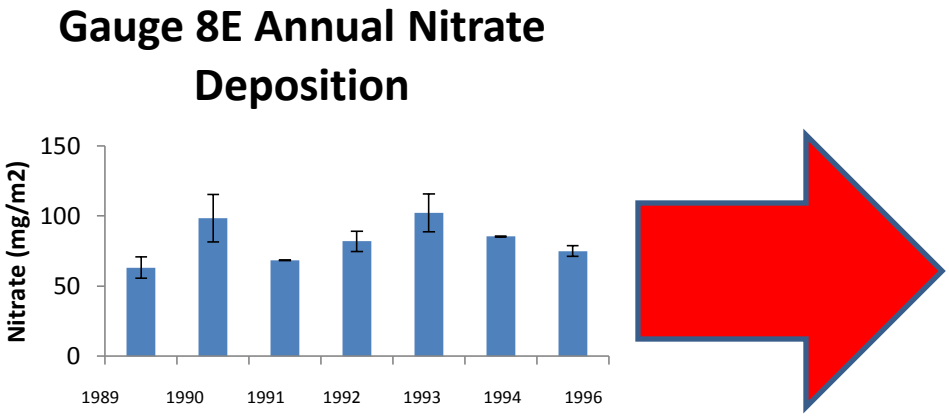
- Volume of event has a large effect on the cumulative error (more rain=greater effect)

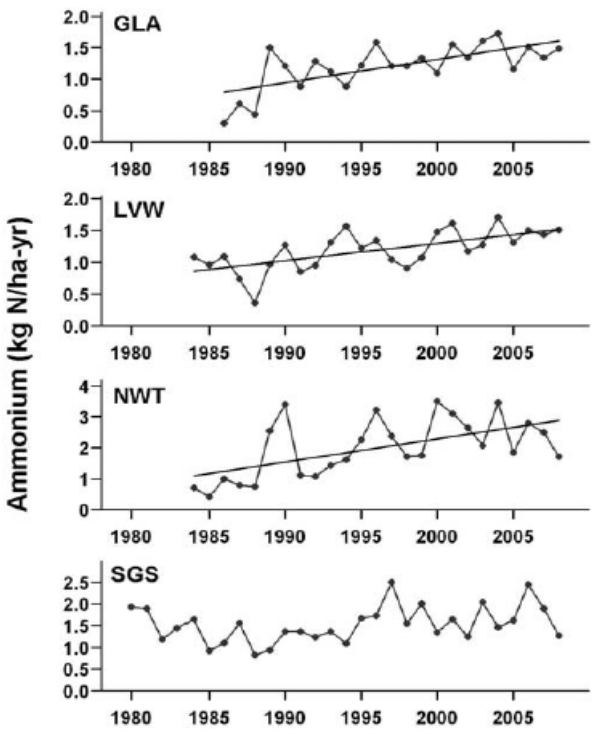
- Sample Contamination occurs randomly
- Missing volume associated with high winds or overflows.



Conclusion

- Calculating error in gaps is relatively easy using regression
- Important first step in putting error bars on ecosystem level loads.





Driscoll et al. 2012

References

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