Groundwater denitrification[1]

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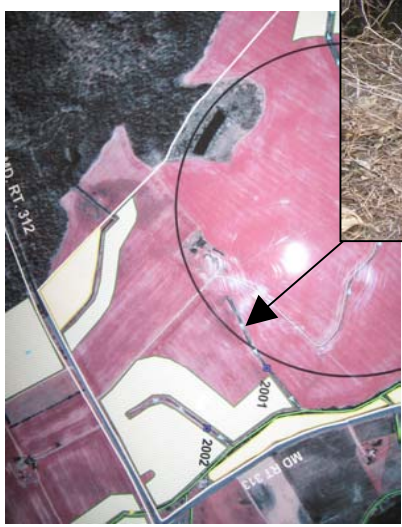
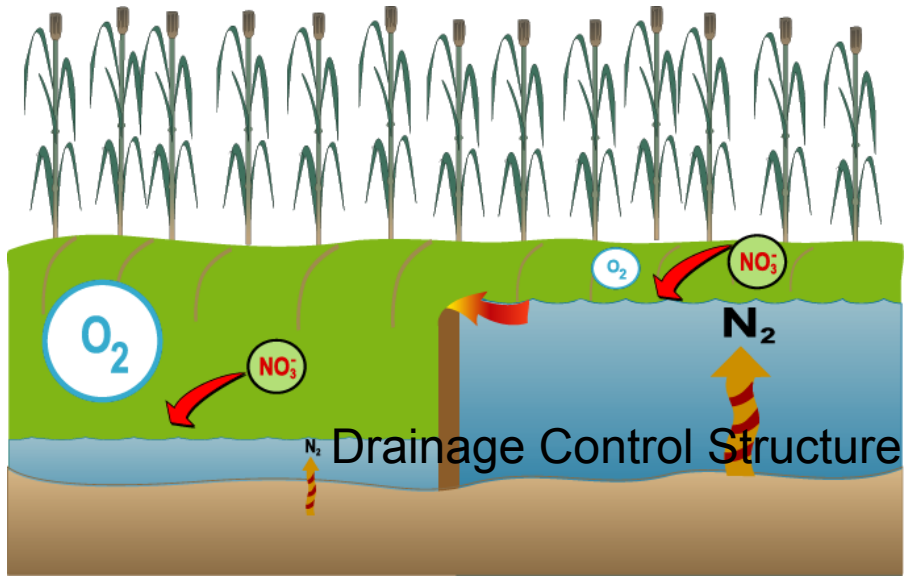
Watershed N imbalances

- Stream export of N from watersheds are routinely 20-30% of net anthropogenic inputs (Jordan and Weller 1996, Howarth et al. 1996, Lee et al. 2001)
- Denitrification and storage of N in watershed pools are routinely invoked to explain this discrepancy.
- If land cover and watershed N pool sizes are stable, can ecosystem denitrification account for as much as 80% of net anthropogenic inputs?
- We are quantifying rates of denitrification in hydric (water-saturated) environments within 16 watersheds in the Choptank basin on the Delmarva Peninsula (mid-Atlantic coastal plain region).

Goundwater wells: location and significance





- Radcliffe Farm: 21 wells
- Mason Farm: 3 wells
- Collier Farm: 11 wells
- Harris Farm: 3 wells

Piezometer Instrumentation

- Grid of instrumented piezometers at three farms
  - Radcliffe Farm
    - Heavy clay soils, mostly hydric, CREP/CRP
  - Collier Farm
    - Mix of soils, drainage control structure
  - Harris Farm
    - Mix of soils, topographically low “wet spots”
  - Mason Farm
    - Light, sandy soils, high NO_3, riparian buffers
- Instrumented with Solinst data loggers
  - 30 min recording of temp, water depth
  - Sampled monthly for gases, nutrients

Testing groundwater for dissolved methane and nitrogen gas

- Wells pumped out 24 h prior to sampling
- Fishing floats reduce exchange with atmosphere
- Bailer minimizes gas exchange during sampling

Testing groundwater for dissolved methane and nitrogen gas

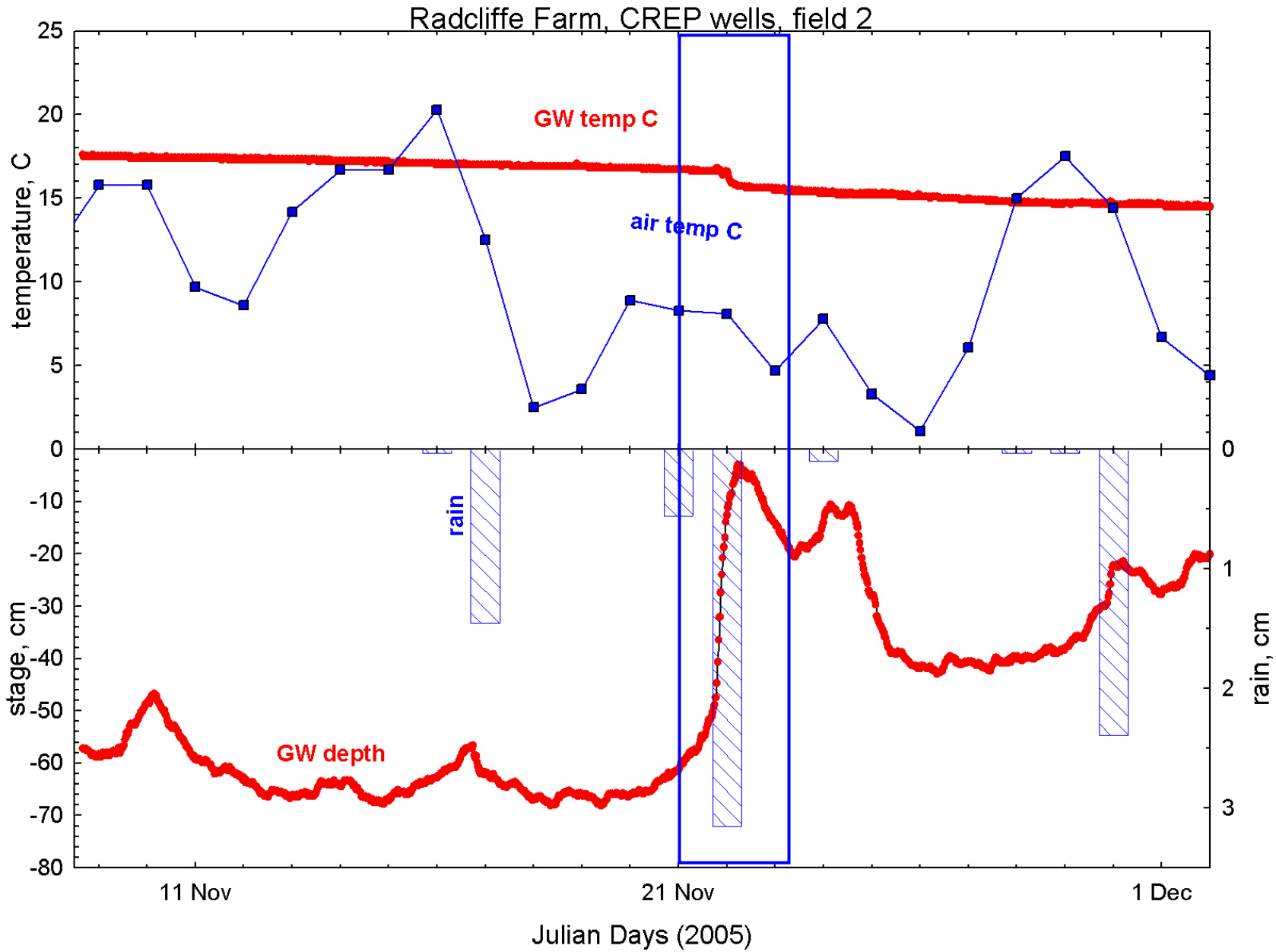
- Stopcock is attached
- Ground glass tube filled from bottom
- Allowed to overflow
- Capped and kept under ice water until analyzed

Testing groundwater for dissolved methane

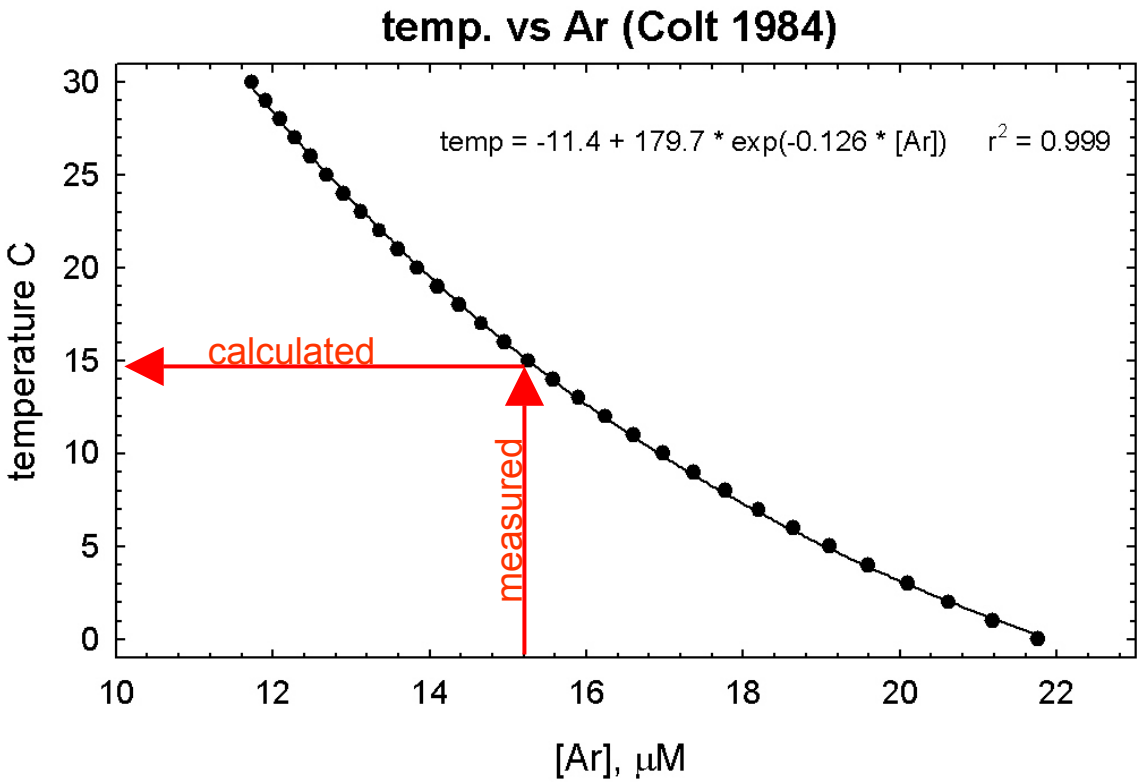
- Methane Analysis
  - Septa capped vials were purged with nitrogen
  - 5ml of sample injected
  - Shaken for 1.5min
  - GC-FID (Shimadzu)

Testing groundwater for dissolved N_2

- Dissolved Gas Analyzer (DGA)
- Measures dissolved N_2, Ar, and O_2
- Ar used to compute groundwater recharge temperature
- N_2 and recharge temperature are used to compute excess N_2-N in groundwater from denitrification



Groundwater depth varies considerably with groundwater recharge, whereas groundwater temperature is very conservative. Note event on Nov 21-22.

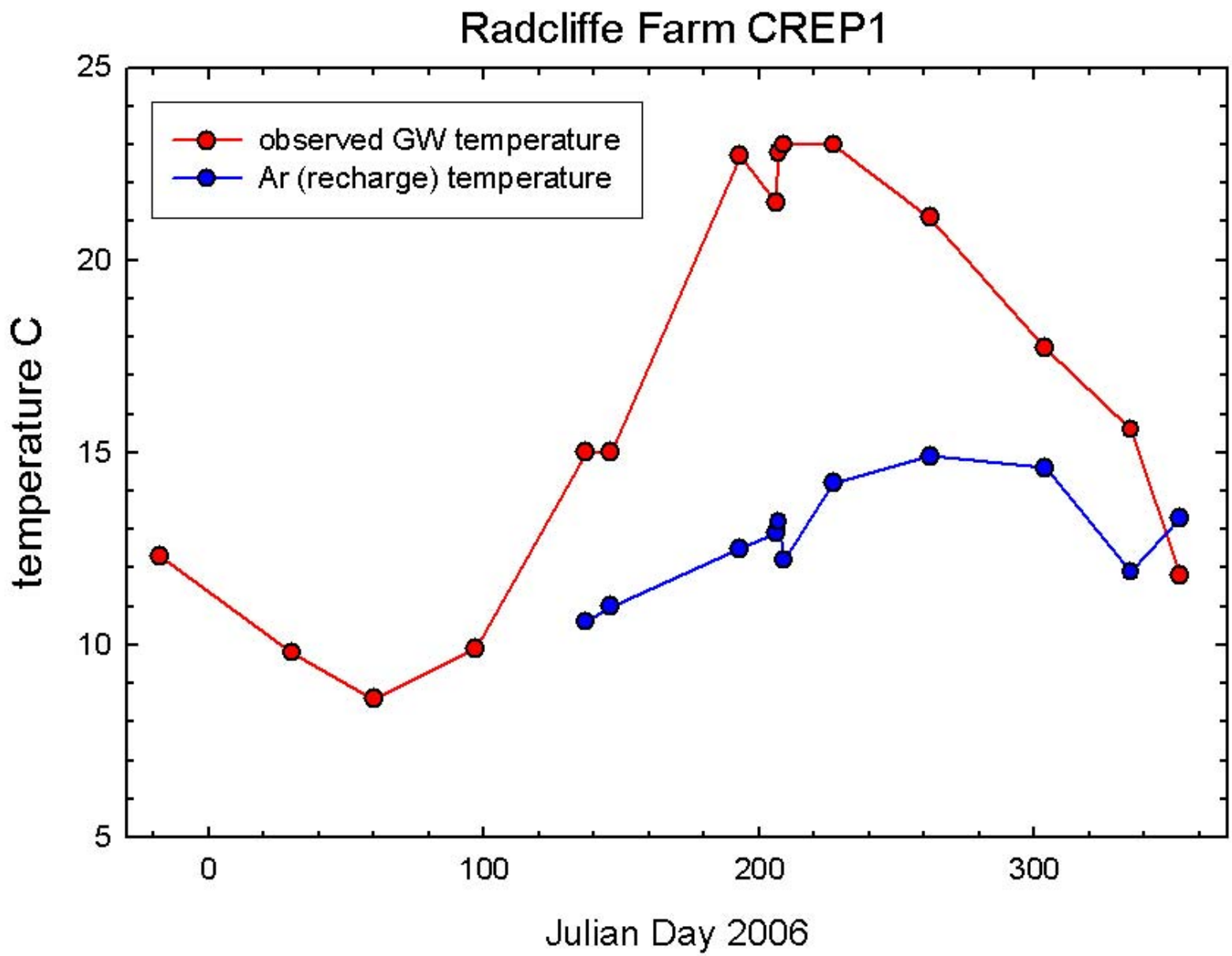


The Argon Thermometer for GW recharge:

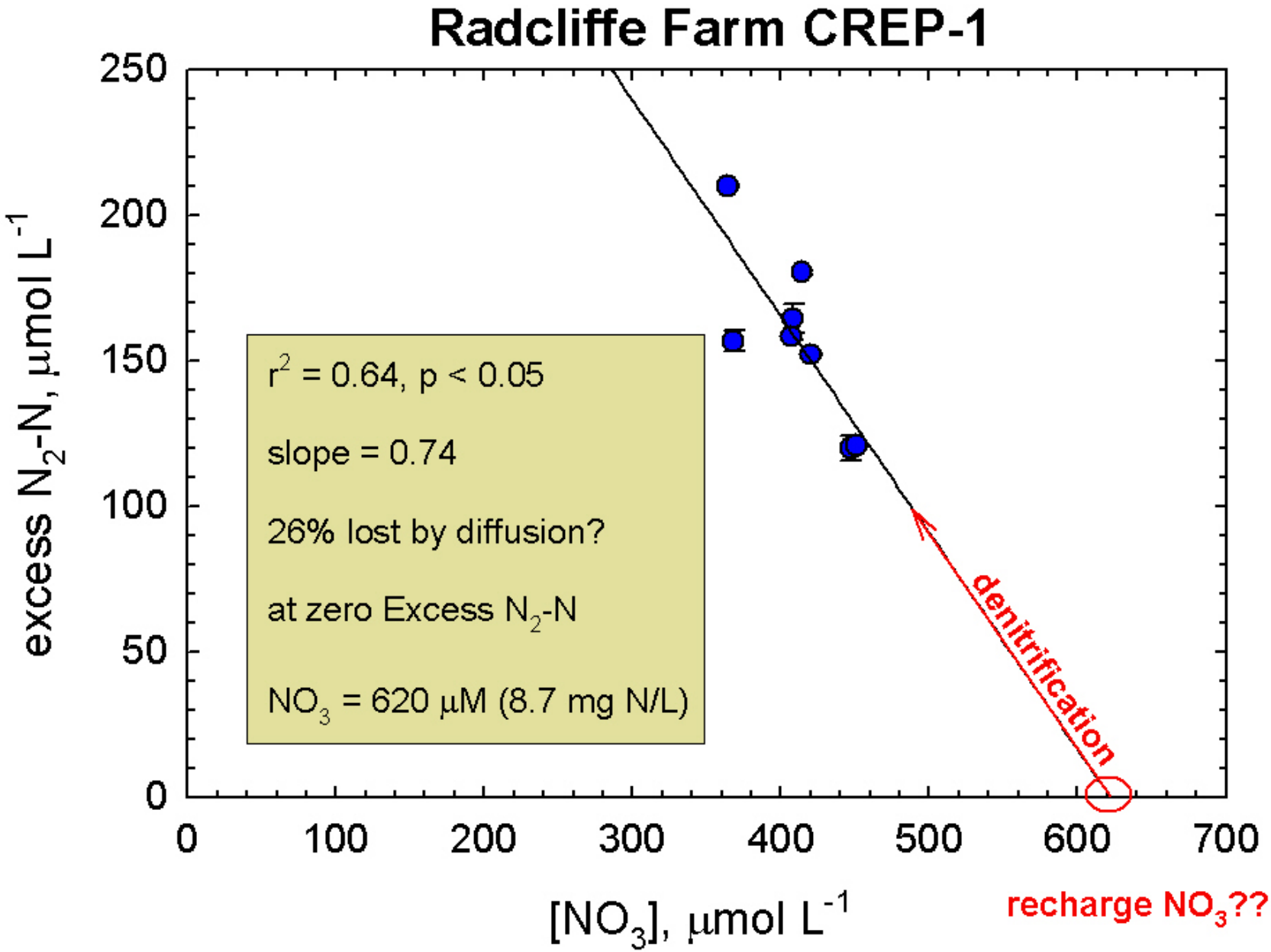
An inverted temperature vs Ar plot fitted as a simple exponential function. The observed Ar concentration is used to estimate the recharge temperature, which is then used to compute the expected background N_2 concentration at the recharge temperature. Excess dissolved N_2 is estimated as:

$$\text{excess } N_2 = \text{observed } N_2 - \text{background } N_2$$

Equivalent to use of N_2/Ar, but we explicitly calculate the recharge temperature assuming no degassing.

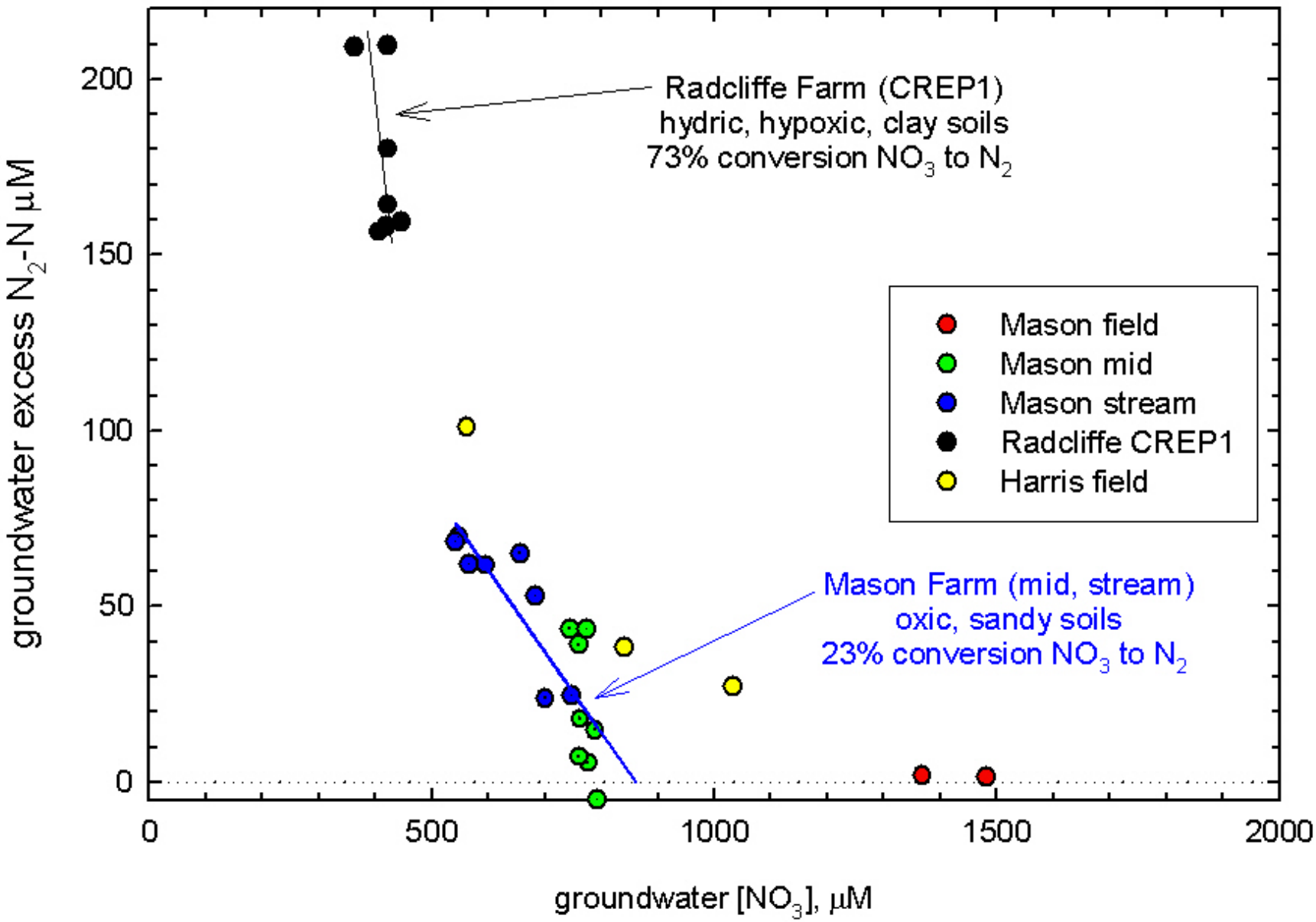


Observed groundwater temperature has a truncated annual cycle compared to air, and the Ar recharge temperature is cooler and converges with groundwater temperature in fall and winter when most recharge occurs.

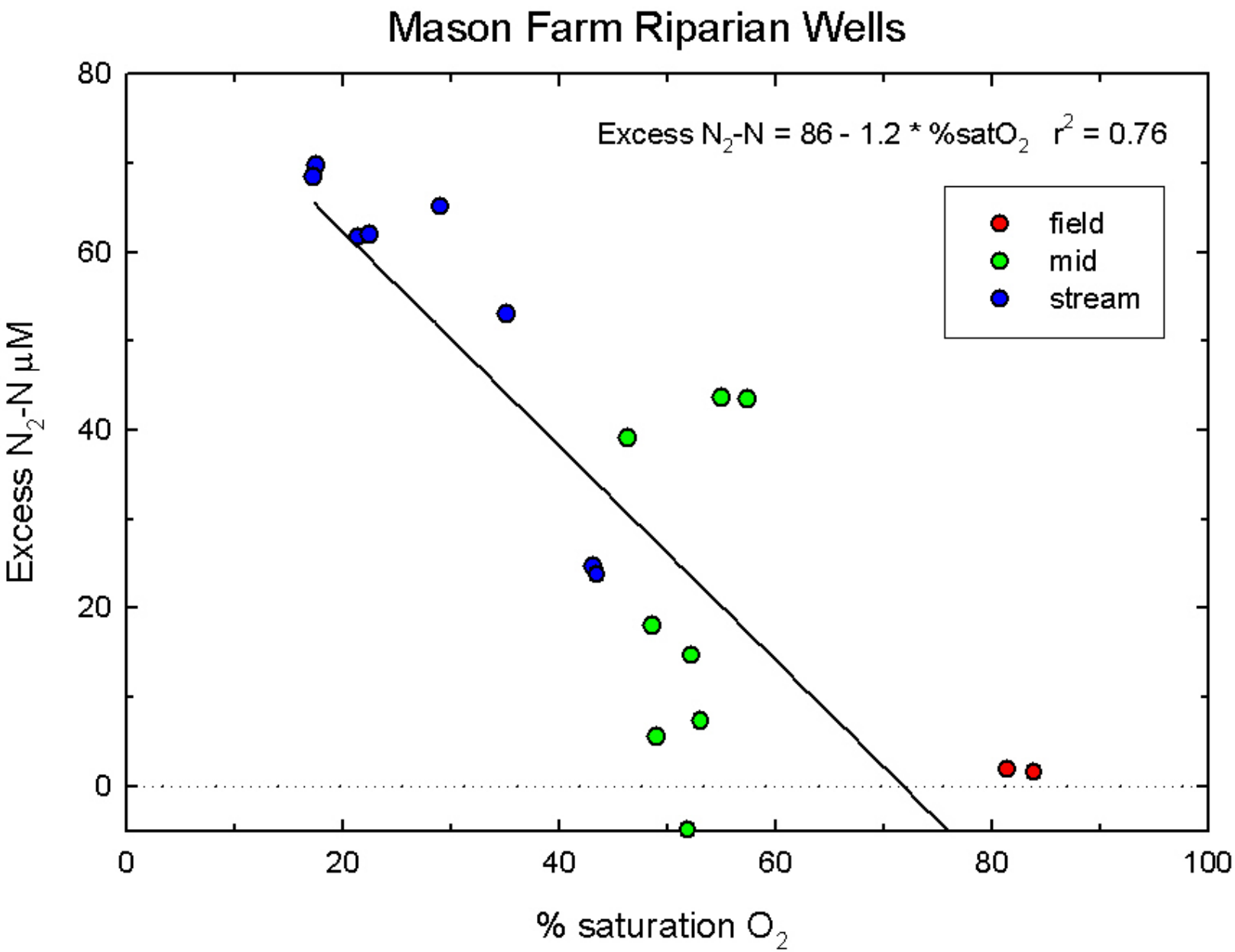


Inverse covariance of NO_3 and excess N_2-N at one well over time suggests variations in denitrification driven by groundwater flow, O_2, temp., NO_3, etc.

Multi-farm Summary

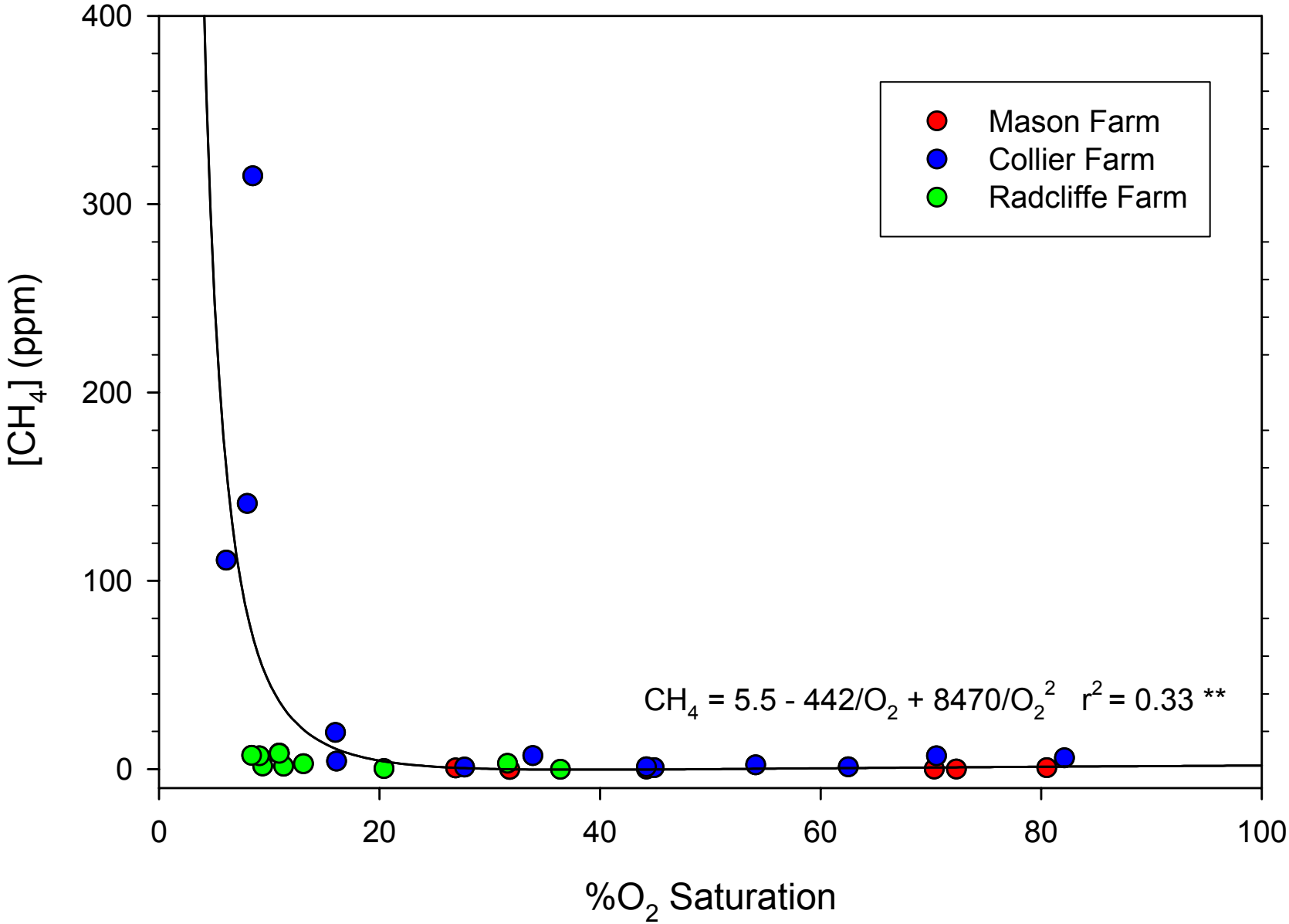


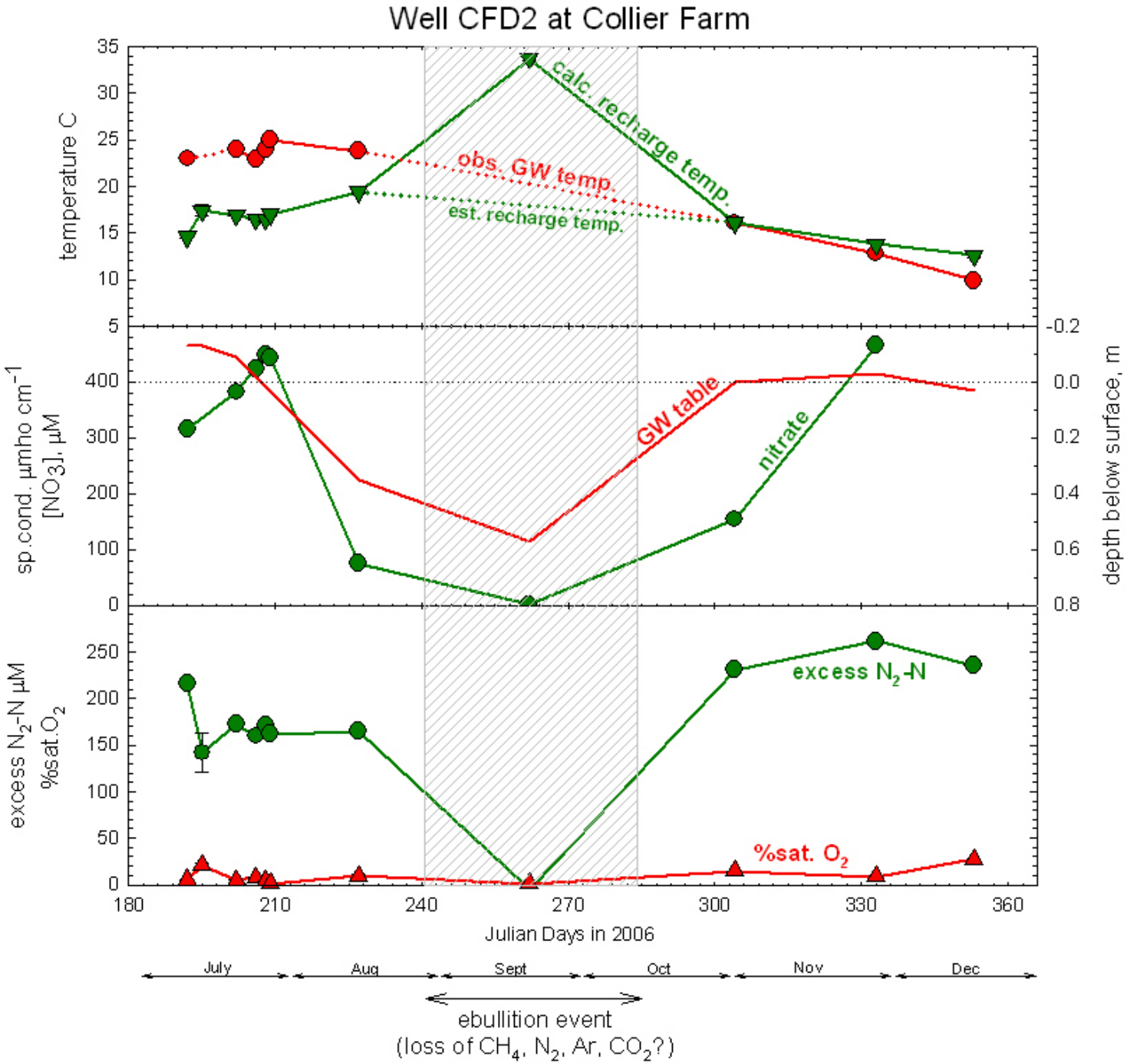
Groundwater in coarse-textured soils appears to lose more excess N_2-N via diffusive losses to the vadose zone than fine-textured soils.



Groundwater O_2 poises the redox and controls the amount of denitrification.

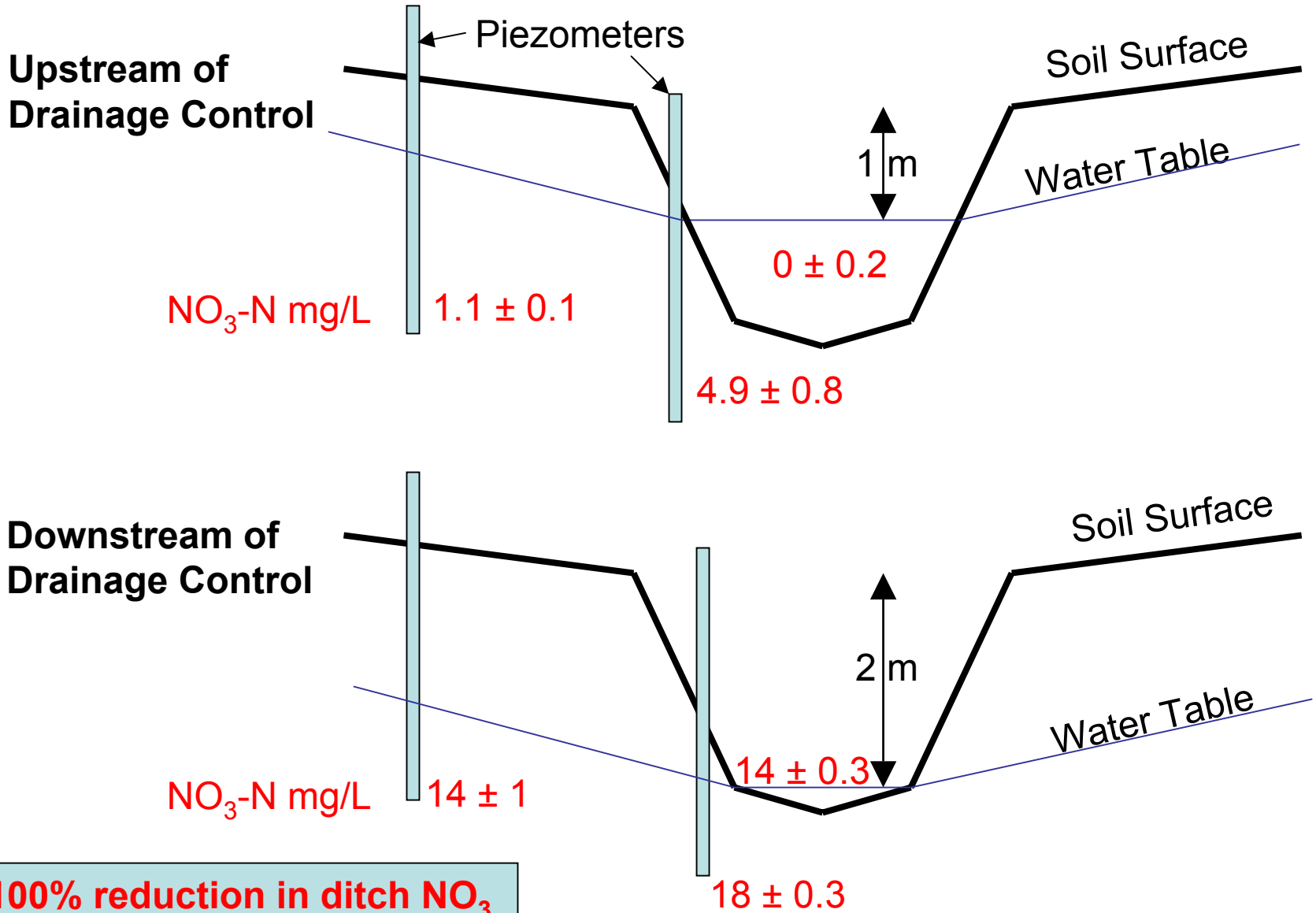
Effect of Oxygen on Methane Production





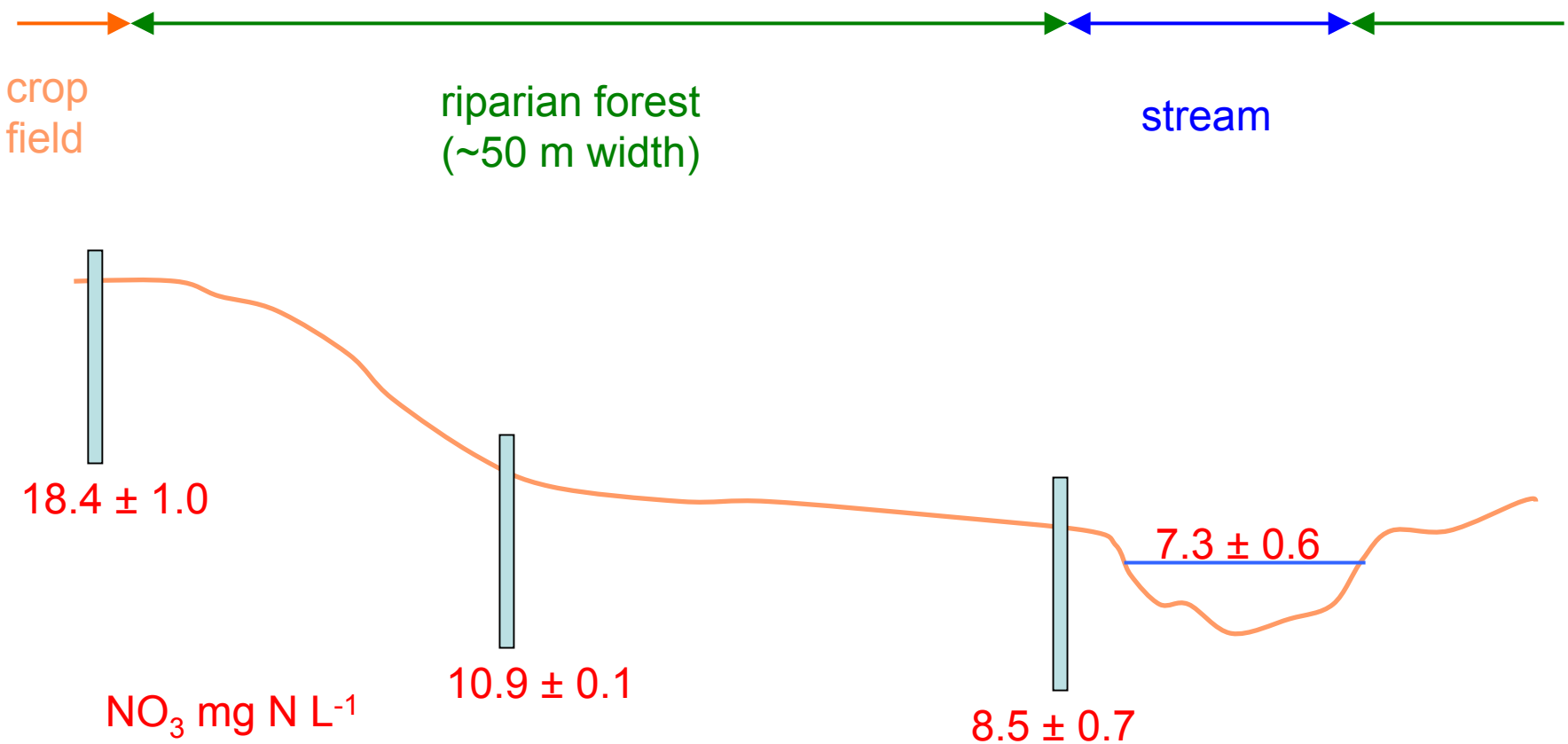
Sometime between Aug and Sept there was a large degassing of N_2 and Ar, probably due to exhaustion of NO_3, accumulation of CH_4, and lowered GW head. However, we didn't sample frequently enough to resolve when or how long this occurred. Large gas fluxes must have occurred into the vadose zone and probably into the atmosphere at this time.

Collier Farm Drainage Control Structure



~100% reduction in ditch NO_3 (June – Sept 2006)

Mason Farm Riparian Forest



60% reduction in GW nitrate (June – Sept 2006)