

## Stable Isotopes as Indicators of Sources and Processes Influencing Nitrate Distributions in Dairy Monitoring Wells and Domestic Supply Wells in the Central Valley, California

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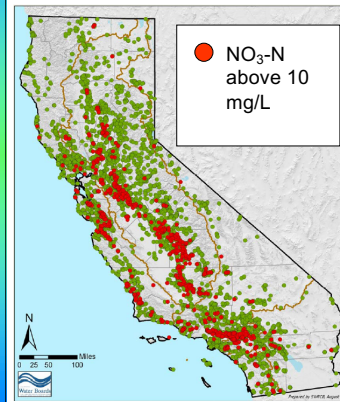
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Lawrence Livermore National Laboratory, CA



## Wide-spread Groundwater Nitrate Contamination

Source: SWQCB, GAMA Program, Groundwater Information Sheet, Nitrate, August 2010



“65% of domestic wells at Central Valley dairies test over the public health limit for nitrates... (yet) none of the dairies was fined for a nitrate problem identified by the state”.

-SFGate.com, May 17, 2010

- Widespread use of inorganic fertilizers and manure, current and historical.
- Other potential sources such as leaking septic systems, waste water disposal.
- Age of contamination?

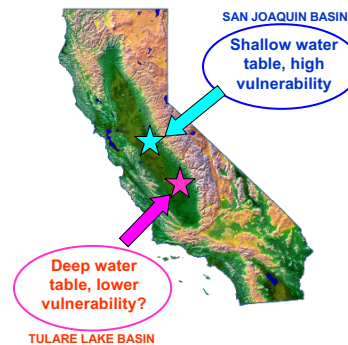
## USGS Isotope Tracers Project Research Questions

- Does ground water impacted by dairy use have a distinct isotopic signature?
- What are the primary drivers of ground water quality variability beneath dairies?
  - ❖ Different land uses within a dairy (lagoons, corrals, fields)
  - ❖ Source inputs versus biological and chemical processes?
  - ❖ Length of time in use as a dairy?
  - ❖ Regional differences/ depth to ground water?
- How do these findings relate to local drinking water quality?



## Study Design: two regions, two well types

Collaborative study led by Thomas Harter (UC Davis), funded by a Prop 50 Clean Drinking Water Grant.



**Dairy Monitoring Wells:** dedicated sampling wells installed at first-encounter ground water. Seven dairies, multiple wells per dairy.

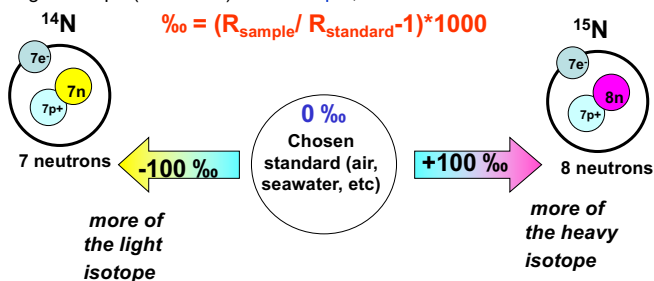
**Domestic Supply Wells:** 200 private domestic wells, sampled with owner permission, wide range of screen and total depths.



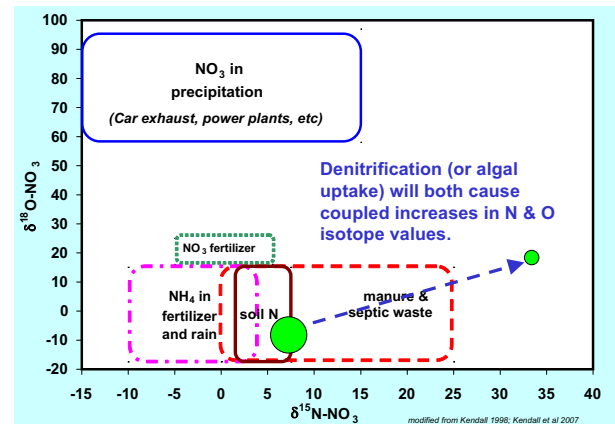
## Isotope Ratios- Relative to a Standard

Isotopes are forms of the same element that have different numbers of neutrons

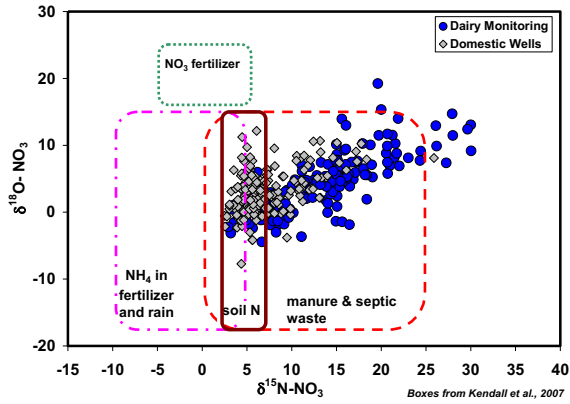
Isotope values are reported as the ratio of the heavy isotope to the light isotope (ie  $^{15}\text{N}/^{14}\text{N}$ ) in the sample, relative to a chosen standard



## Nitrate isotopes reflect sources & processes

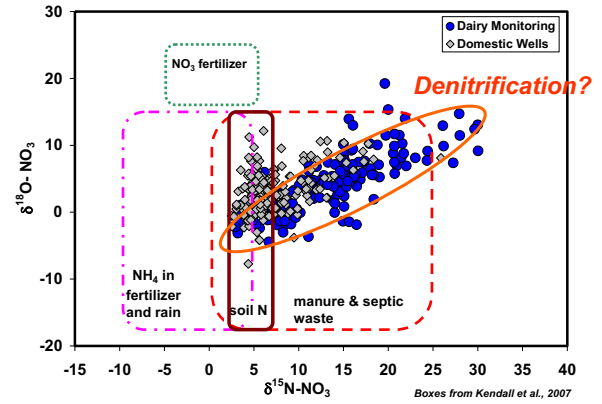


### Dairy monitoring wells show extreme variability



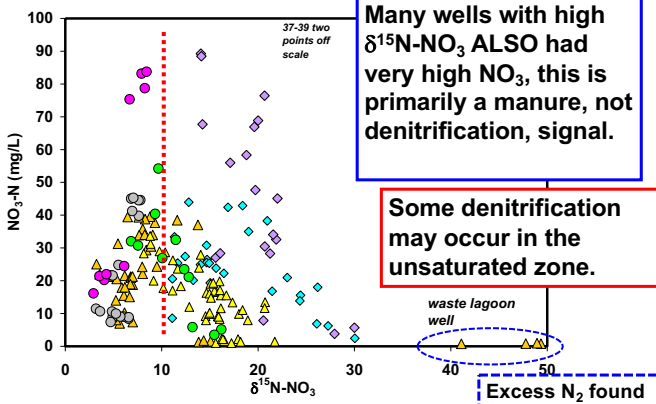
USGS

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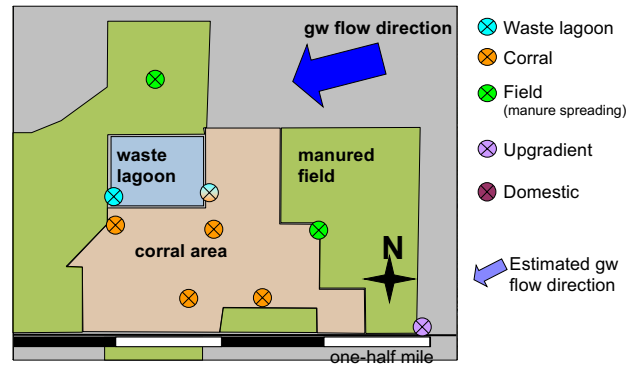
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### No strong denitrification trends- maybe partial?



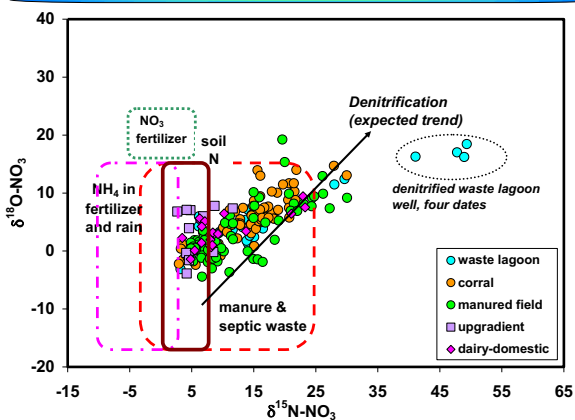
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### Different Land Uses Within a Dairy



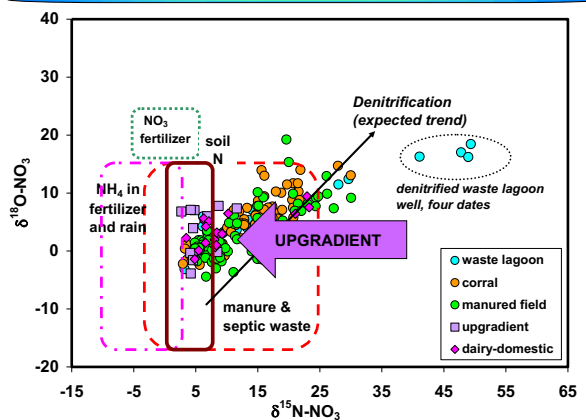
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### All dairy-related land uses showed full range of isotope values



USGS

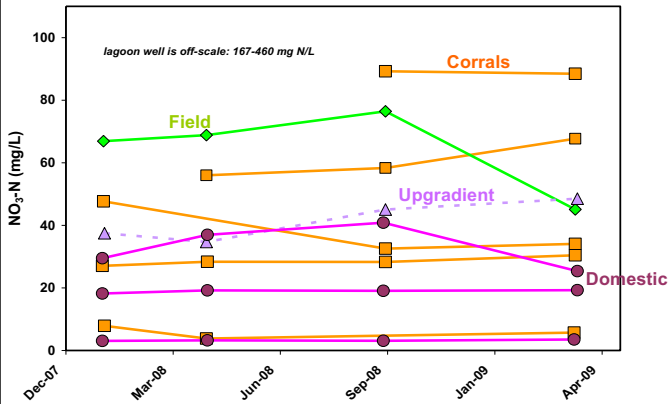
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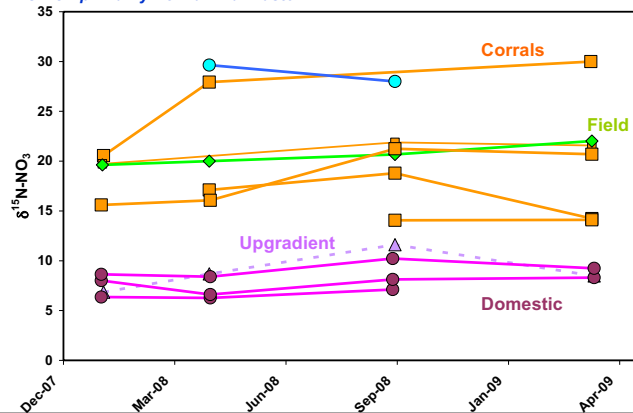
## Nitrate in wells within a single dairy

Stanislaus C.- very shallow gw

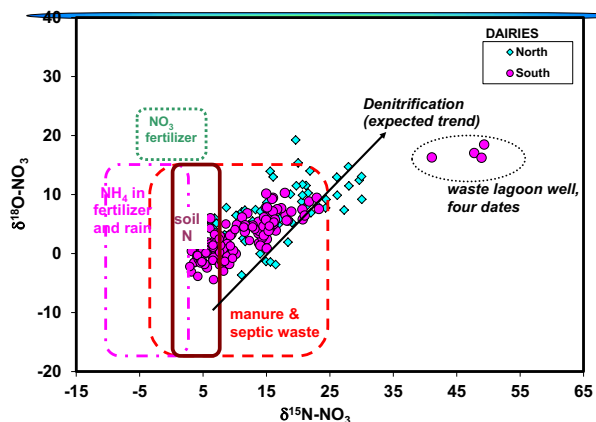


## $\delta^{15}\text{N-NO}_3$ composition within a single dairy

The  $\delta^{15}\text{N-NO}_3$  values suggest that the nitrate in the domestic wells on this dairy IS NOT primarily from animal waste.

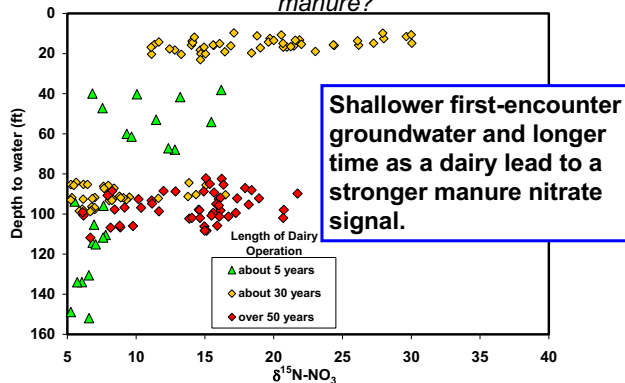


## Regional Differences

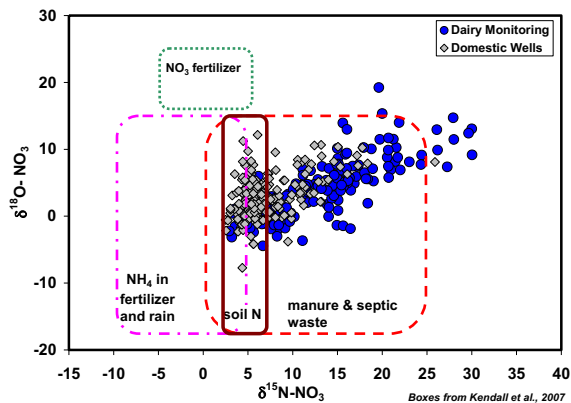


## Transport Effects: Depth & Time

Why don't all the dairy monitoring wells look like typical manure?



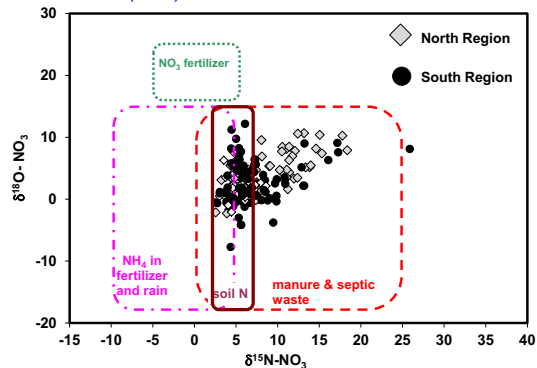
## Regional Differences for Domestic Wells



## North and South Region Domestic Wells

High  $\delta^{15}\text{N}$  values, indicating manure contributions, found in wells in both regions

See Ransom et al (2016) *Water Resources Research* for detailed discussion

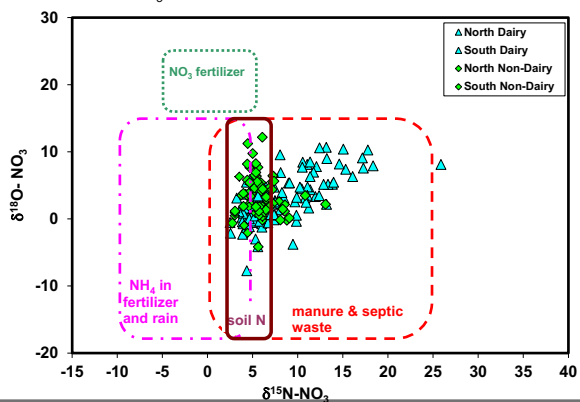


## Land Use and Nitrate Sources

Almost all elevated  $\delta^{15}\text{N-NO}_3$  values were found in wells within 2.4 km of a dairy.

Land use analysis: Ransom et al. 2013, Ransom et al 2016

$\delta^{15}\text{N-NO}_3$  was NOT correlated with nitrate concentration.



## Summary

- Monitoring wells within individual dairies showed wide ranges of isotopic compositions and nitrate concentrations.
  - ❖ Assuming a well-defined end member is probably inaccurate- source studies need to address variability and uncertainty. (see Ransom et al. WRR, 2016)
  - ❖ A single monitoring well may not be representative of groundwater conditions across an entire dairy.
- Variability in isotopic composition/ manure contributions to first encounter ground water appears to be driven by a combination of depth to groundwater and age of the dairy.
- In domestic supply wells,  $\delta^{15}\text{N-NO}_3$  values above +10 ‰ were found almost exclusively in wells within 2.4 km of a dairy, HOWEVER,  $\delta^{15}\text{N-NO}_3$  did not show any correlation to nitrate concentration.