

Using Stable Isotopes for Helping Determine Sources of NO₃

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Stable Isotopes Used

- Measurements of nitrogen and oxygen isotope ratios, $^{15}\text{N}/^{14}\text{N}$ and $^{18}\text{O}/^{16}\text{O}_{\text{NO}_3}$, have been used for several years to help differentiate between sources of nitrate in ground water and to evaluate whether nitrogen concentration changes are due to the mixing of nitrate sources or to denitrification (or both)
- These ratios for nitrogen and oxygen isotopes are represented in the delta notation, $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$, respectively and are reported as parts per thousand (‰) deviations from recognized standards.

$\delta^{15}\text{N}$ – Typical Ranges for Sources

- **Inorganic nitrogen** sources like fertilizers and mineralized fertilizer residues have $\delta^{15}\text{N}$ values in the range of -2 to approximately 4‰
- **Organic sources of nitrogen** like septic tank effluent and animal manure have $\delta^{15}\text{N}$ values in the range of 7 to approximately 20‰
- **Soil nitrogen**, which includes the nitrogen that has been assimilated by the soil from a variety of sources, may be represented by $\delta^{15}\text{N}$ values ranging from -1 to 11‰

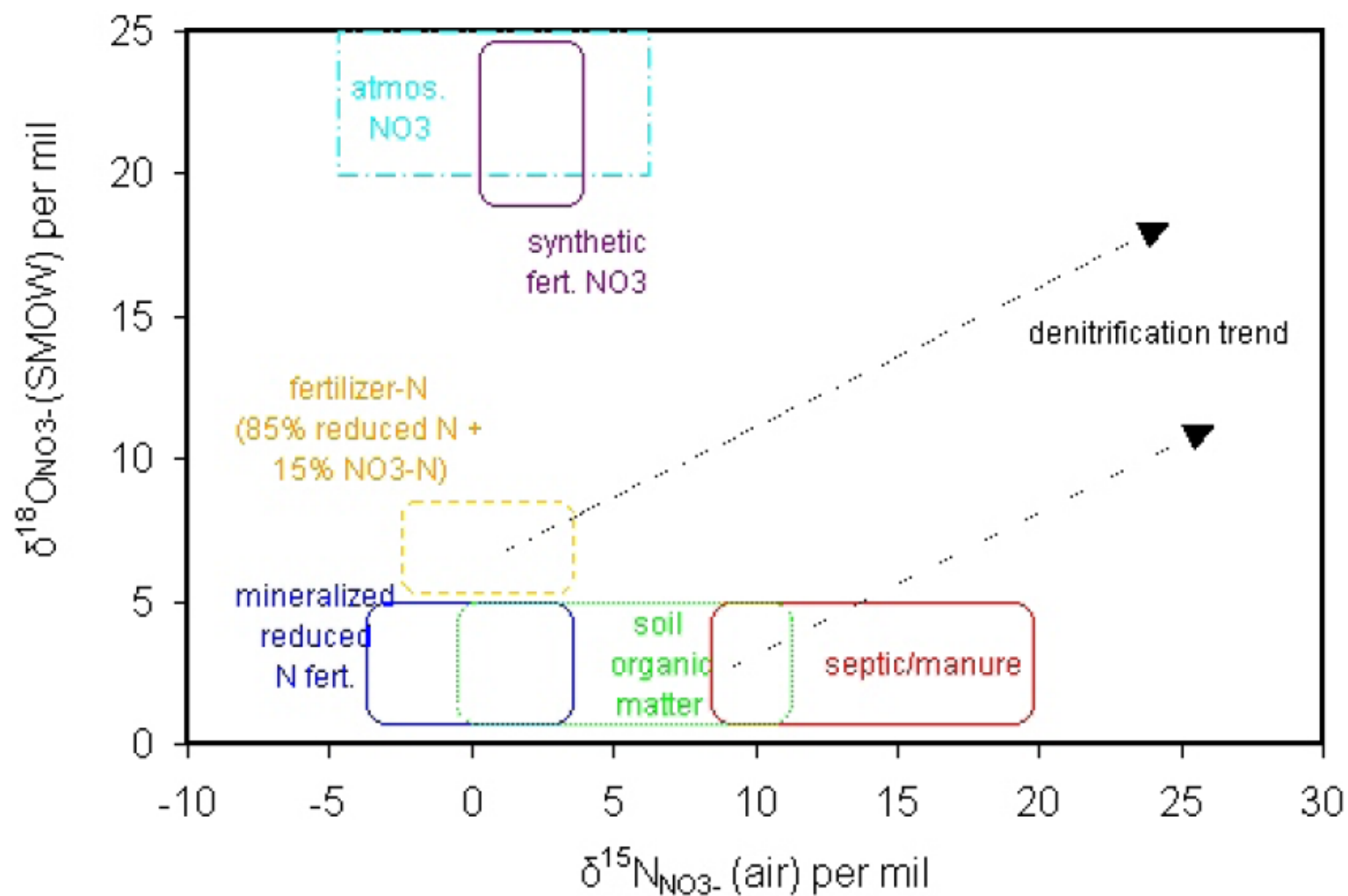


Figure 1. Crossplot of typical $\delta^{18}\text{O}_{\text{NO}_3-}$ and $\delta^{15}\text{N}_{\text{NO}_3-}$ values for different nitrate sources and the trend of isotopic compositions obtained due to denitrification processes (modified from Clark and Fritz, 1997).

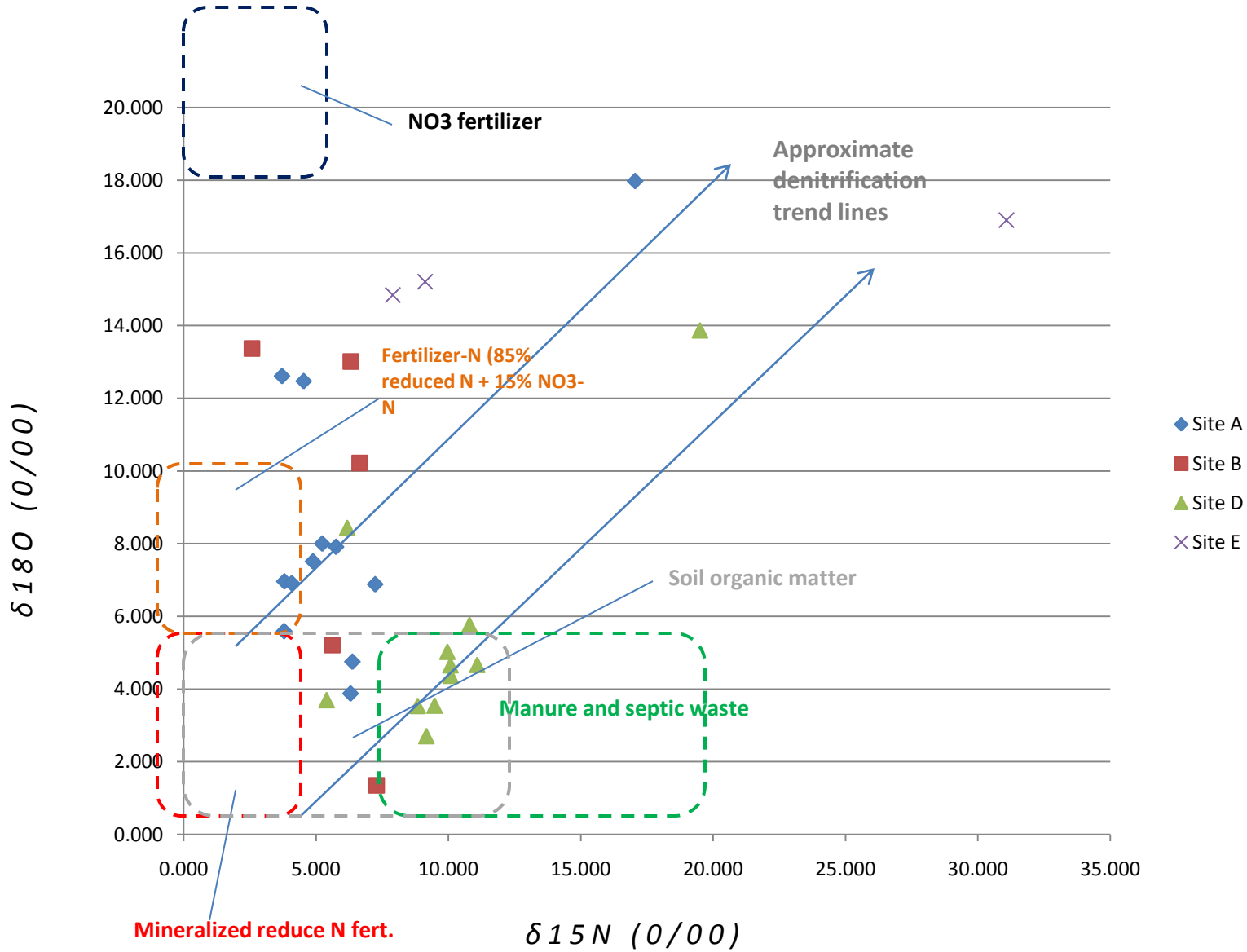
Denitrification

- Fractionation of isotopes (typically via denitrification) results in a change in the ratios resulting in **enrichment** of the larger one
- Example:
 - NO₃ leaching to ground water with an 15N/14N ratio of 3
 - NO₃ subject to denitrification causes fractionation of 14N preferentially
 - Results in enrichment of 15N and a ratio of 6

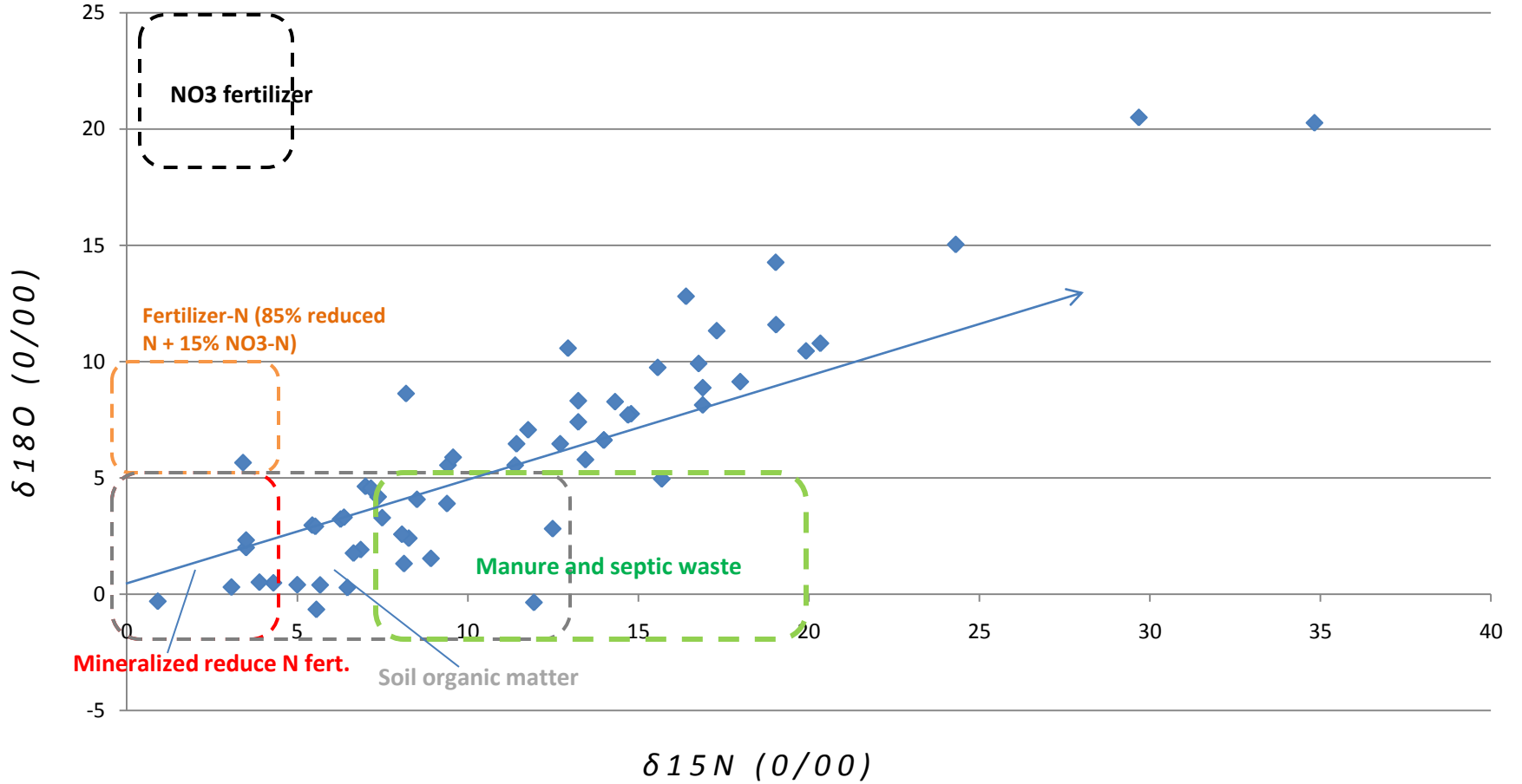
$\delta^{18}\text{O}$ in NO_3 – Used to Evaluate Denitrification

- Is also fractionated via denitrification and ^{16}O is preferentially consumed in comparison to the larger isotope ^{18}O
- Research has shown that when plotted against one another, the enriched $\delta^{18}\text{O}$ can indicate that the corresponding $\delta^{15}\text{N}$ value is influenced by denitrification.

Private well sampling, Wekiva River BMAP

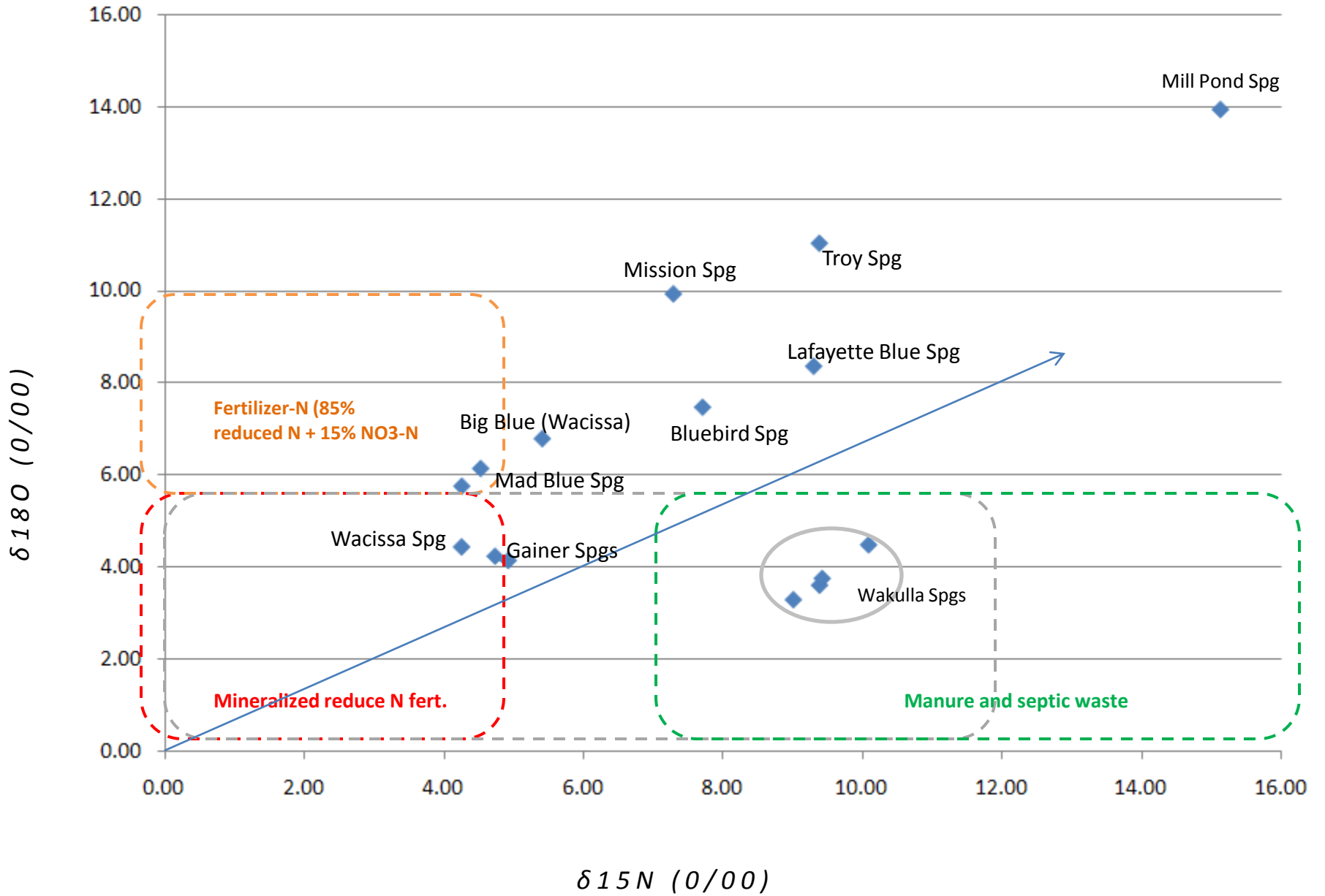


Septic Tank Study, Jacksonville



| | NO3 | $\delta^{15}\text{N}_{\text{Air}}$ | $\delta^{18}\text{O}_{\text{VSMOW}}$ |
|--------------------------|------|------------------------------------|--------------------------------------|
| Gainer #1C Spring #9739 | 0.23 | 4.91 | 4.13 |
| Gainer #1C Spring #9739 | 0.23 | 4.73 | 4.23 |
| Wakulla B Tunnel | 0.86 | 9.38 | 3.60 |
| Wakulla C Tunnel | 0.76 | 10.08 | 4.48 |
| Mill Pond Spring | 0.24 | 15.13 | 13.94 |
| Mission Spring | 0.46 | 7.28 | 9.93 |
| Blue Spring Madison | 1.40 | 4.52 | 6.14 |
| Blue Spring Madison | 1.40 | 4.25 | 5.75 |
| Bluebird Spring | 0.47 | 7.70 | 7.47 |
| Big Spring | 0.18 | 5.40 | 6.78 |
| Wacissa Head / Spring #2 | 0.45 | 4.25 | 4.43 |
| Blue Spring Lafayette | 2.20 | 9.29 | 8.36 |
| Troy Spring | 1.90 | 9.38 | 11.03 |
| Wakulla Main Spring | 0.47 | 9.42 | 3.74 |
| Wakulla Main Spring | 0.47 | 9.00 | 3.28 |
| | | | |

Springs



Santa Fe data

- We are still waiting on the isotope results
- This gives us a tool to help target source types
- With adequate coverage of wells, we should be able to get a better understanding of the sources of NO₃ in specific areas
- With springs, we can better document which source types dominate