Nitrogen Biogeochemistry

Summary: Year 1

UF/IFAS Soil and Water Science:

Patrick Inglett, Xiaolin Liao, Katelyn Foster

St Johns River Water Management District:

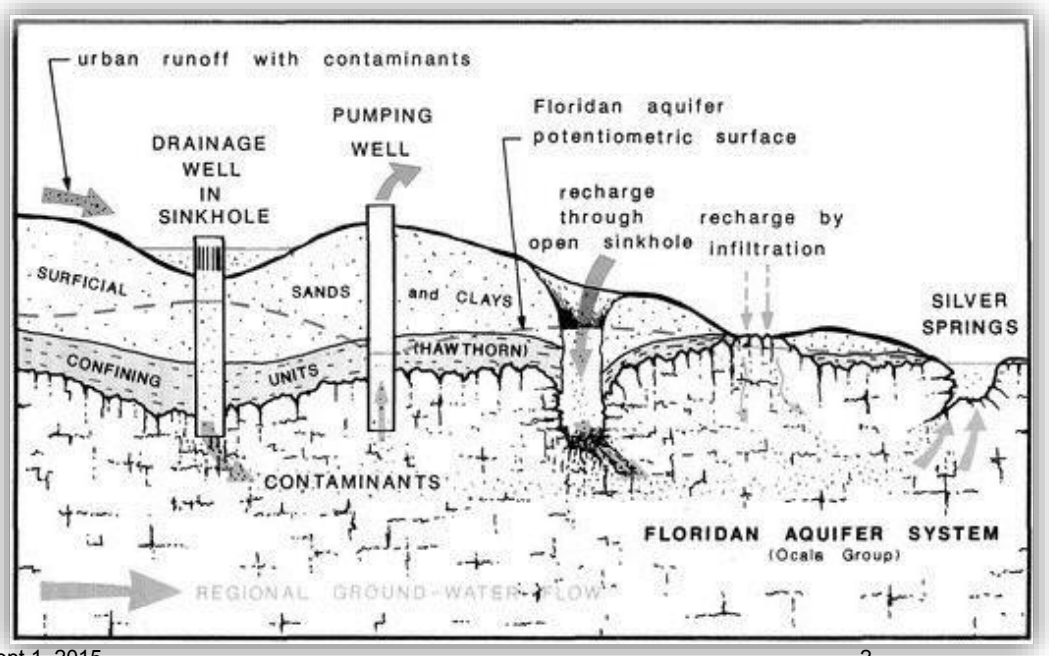
Dean Dobberfuhl, Andy Canion

Objectives

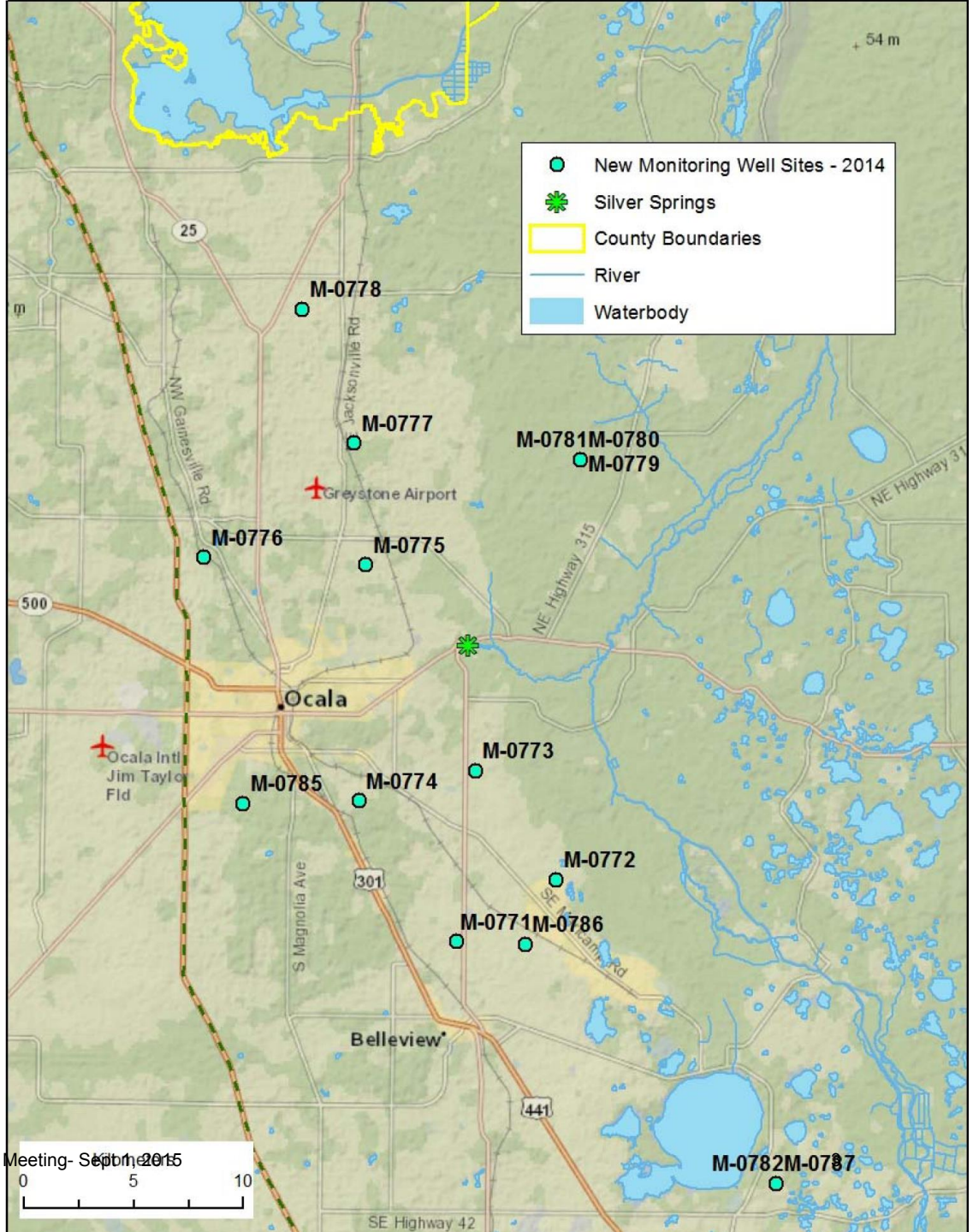
1. Characterize sources of N and potential denitrification loss in soils of major land uses

2. Determine the impact of denitrification within the Surficial/FAS on N loading to Silver Springs

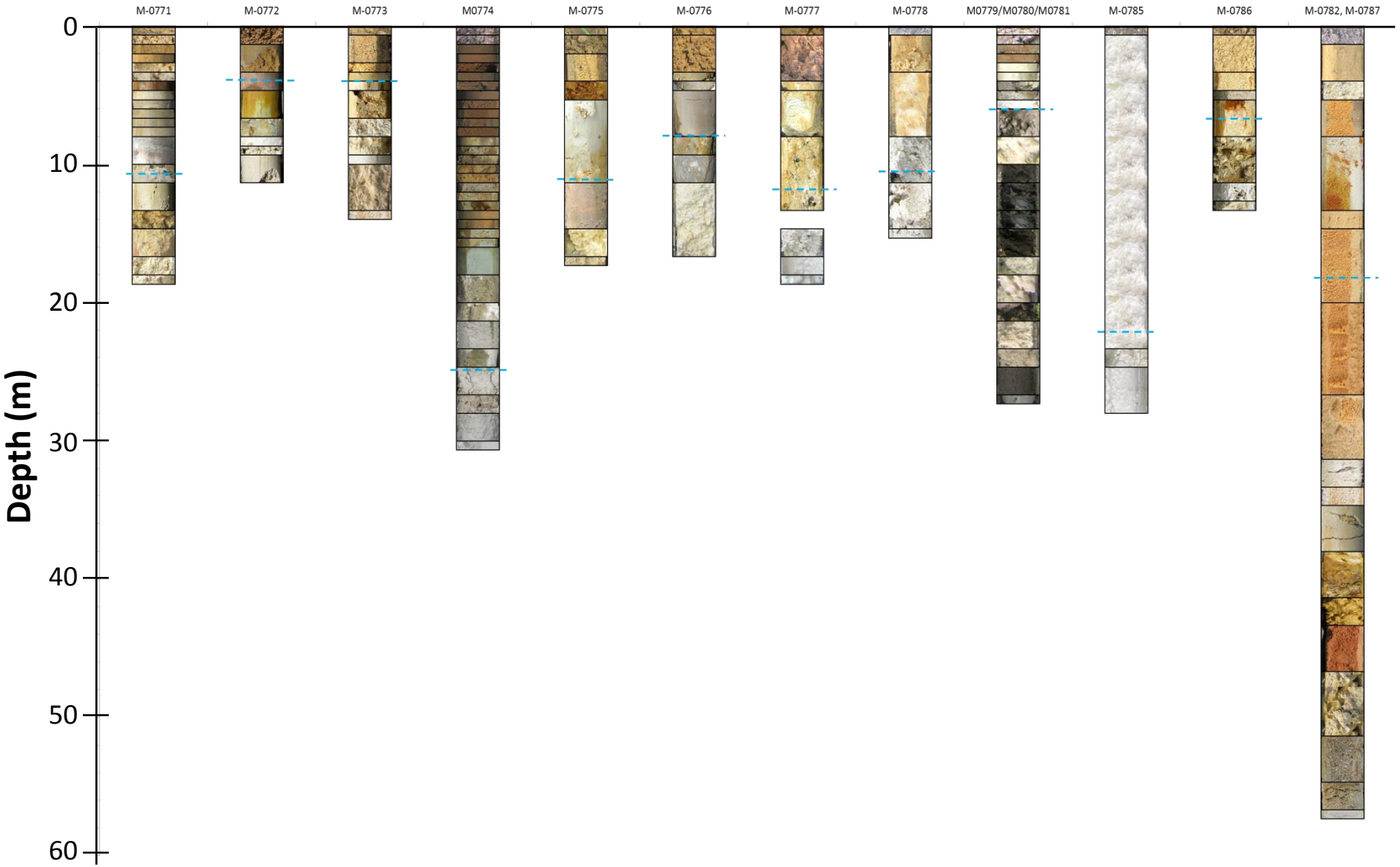
3. Identify hot spots and hot moments of N delivery and attenuation within the Silver Springs springshed



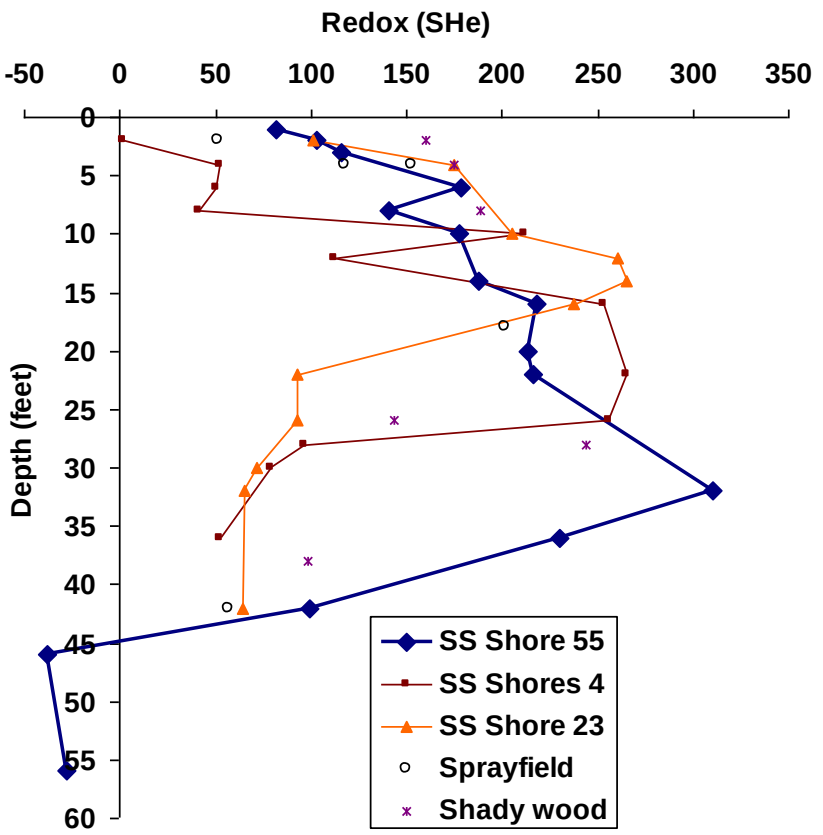
Florida Geological Survey Special Publication 31

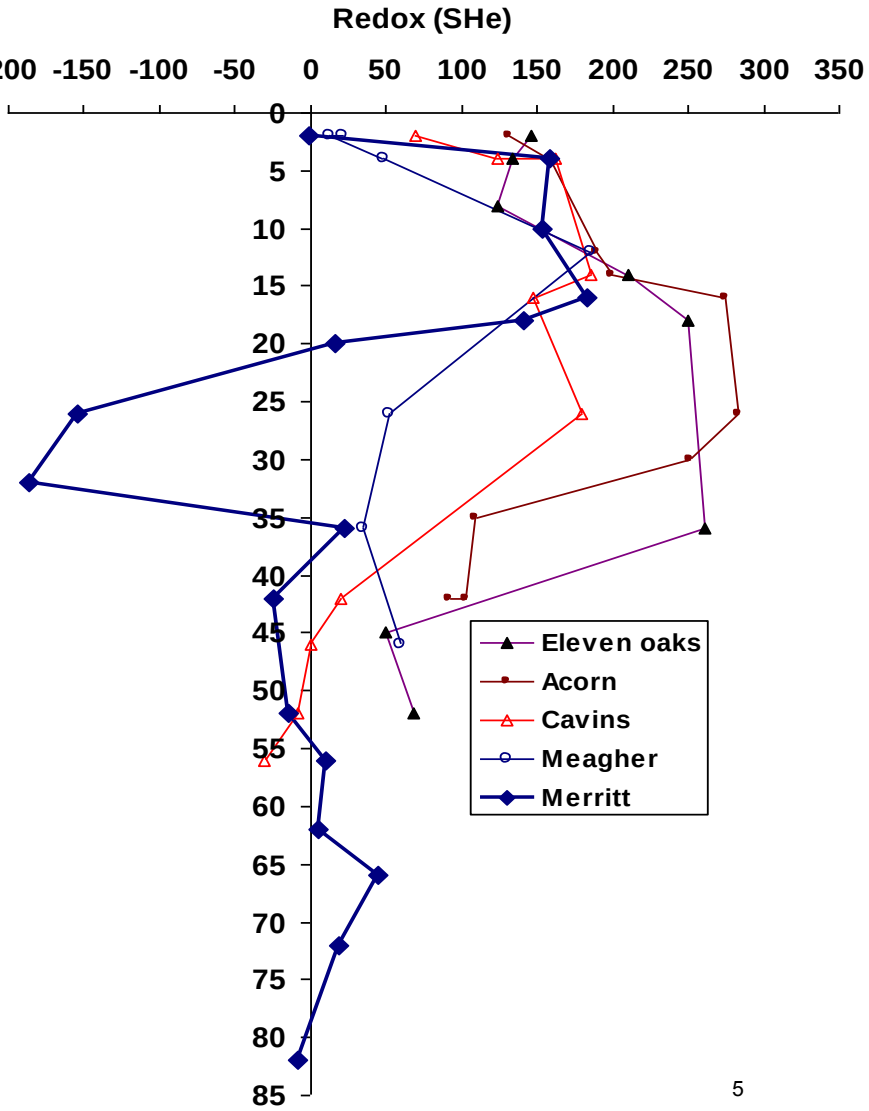

54 m
New Monitoring Well Sites - 2014
Silver Springs
County Boundaries
River
Waterbody
25
M-0778
NW Gainesville Rd
Jacksonville Rd
M-0777
M-0781
M-0780
M-0779
Greystone Airport
NE Highway 31
M-0776
M-0775
NE Highway 315
500
Ocala
Ocala Intl
Jim Taylor
Fld
M-0773
M-0785
M-0774
M-0772
301
S Magnolia Ave
SE Maricamp Rd
M-0771
M-0786
Belleview
441
M-0782
M-0787
SE Highway 42
0
5
10

Well profile photos

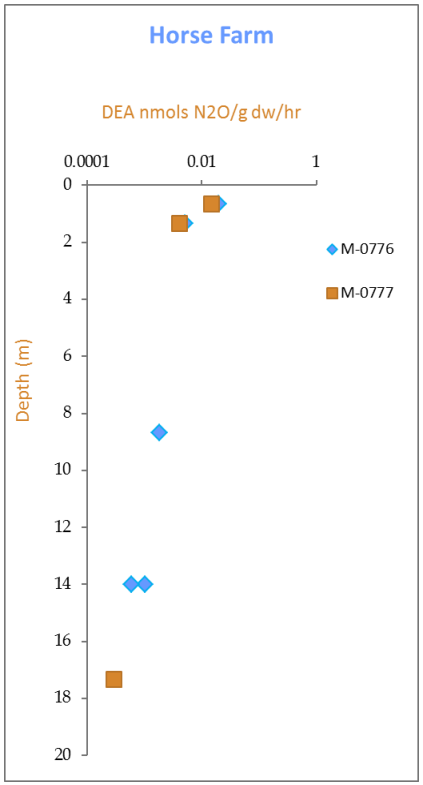


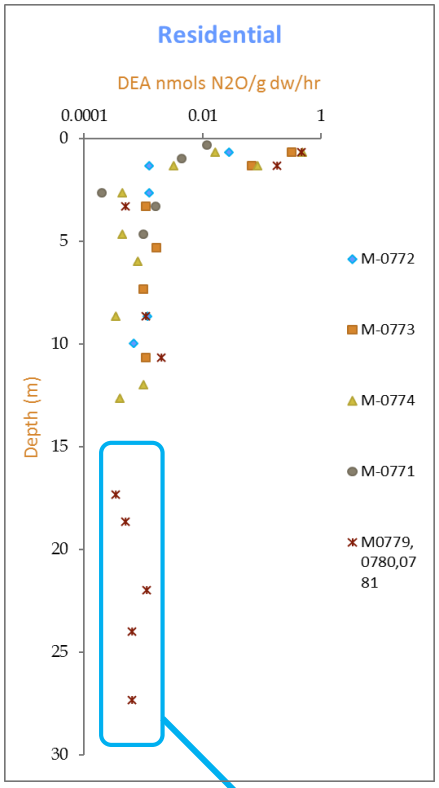
Redox

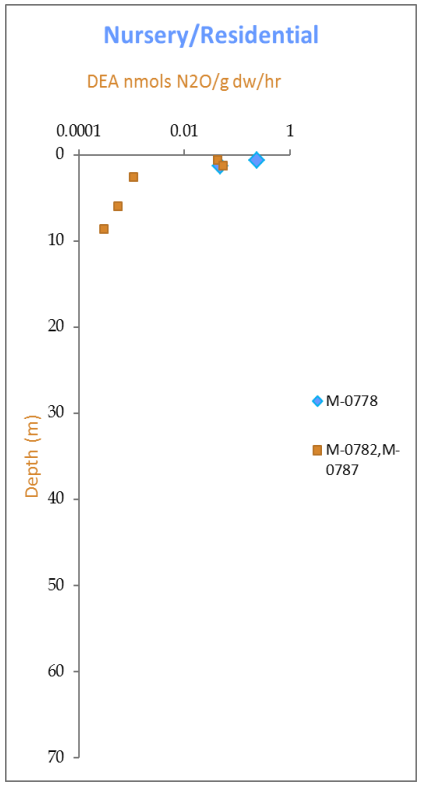

Redox (SHe)
-50
0
50
100
150
200
250
300
350
Depth (feet)
0
5
10
15
20
25
30
35
40
45
50
55
60
SS Shore 55
SS Shores 4
SS Shore 23
Sprayfield
Shady wood

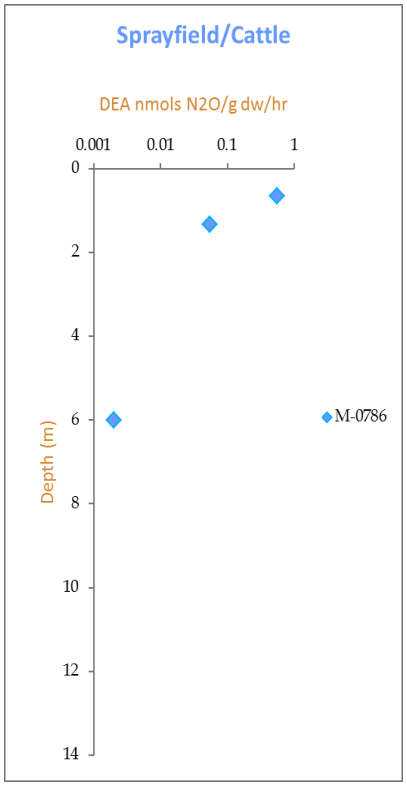

Redox (SHe)
-200
-150
-100
-50
0
50
100
150
200
250
300
350
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
Eleven oaks
Acorn
Cavins
Meagher
Merritt

Denitrification

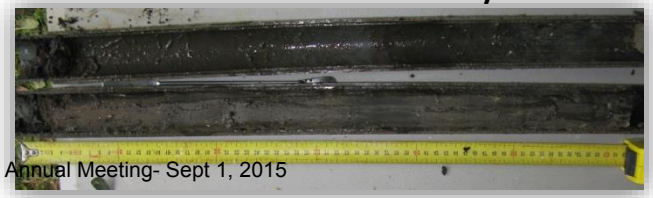




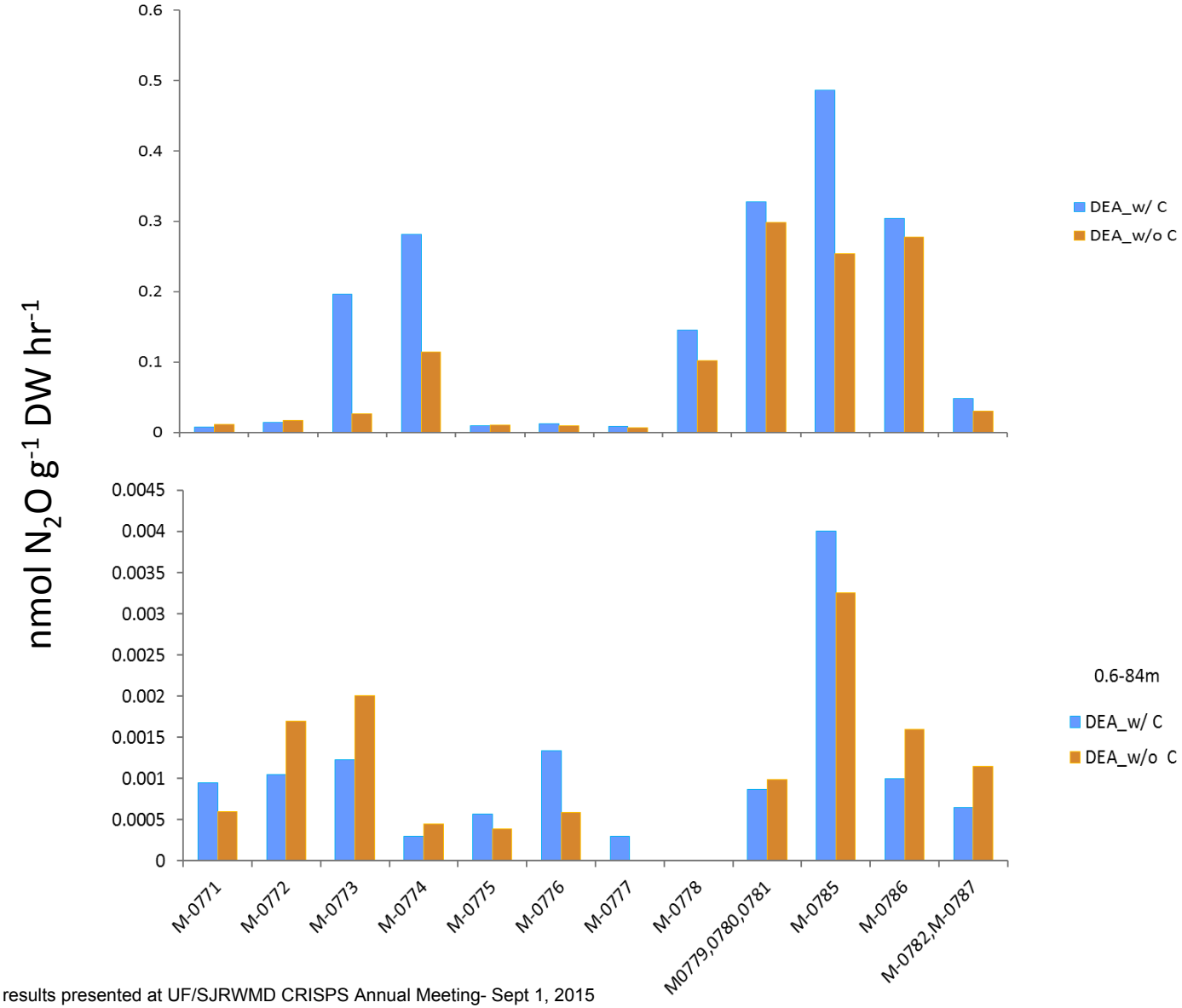




Relic marine layers

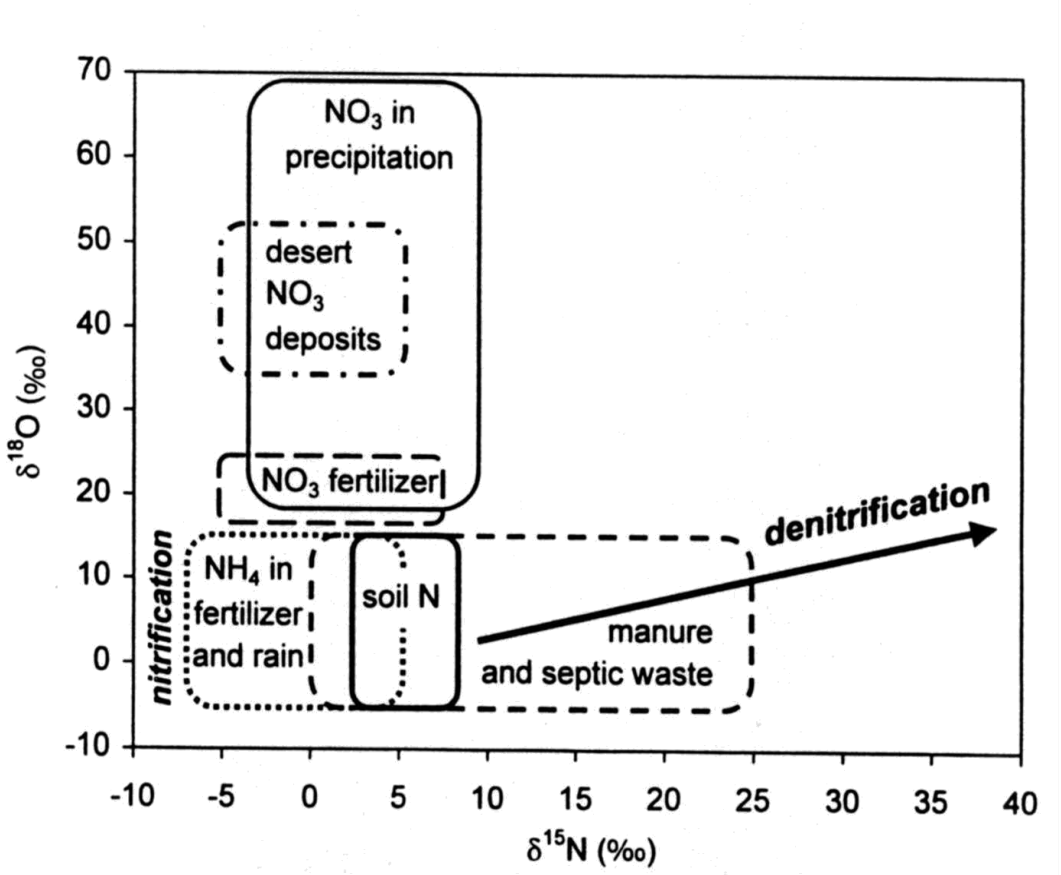


Denitrification

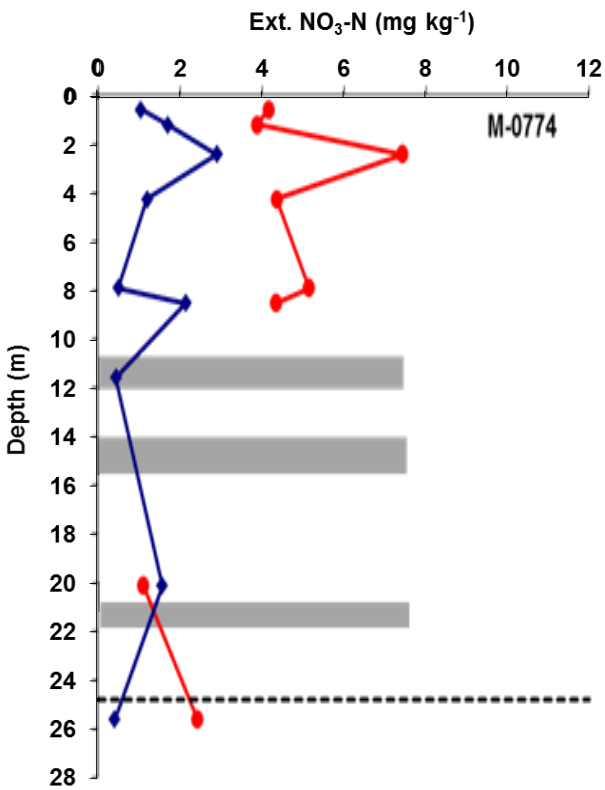


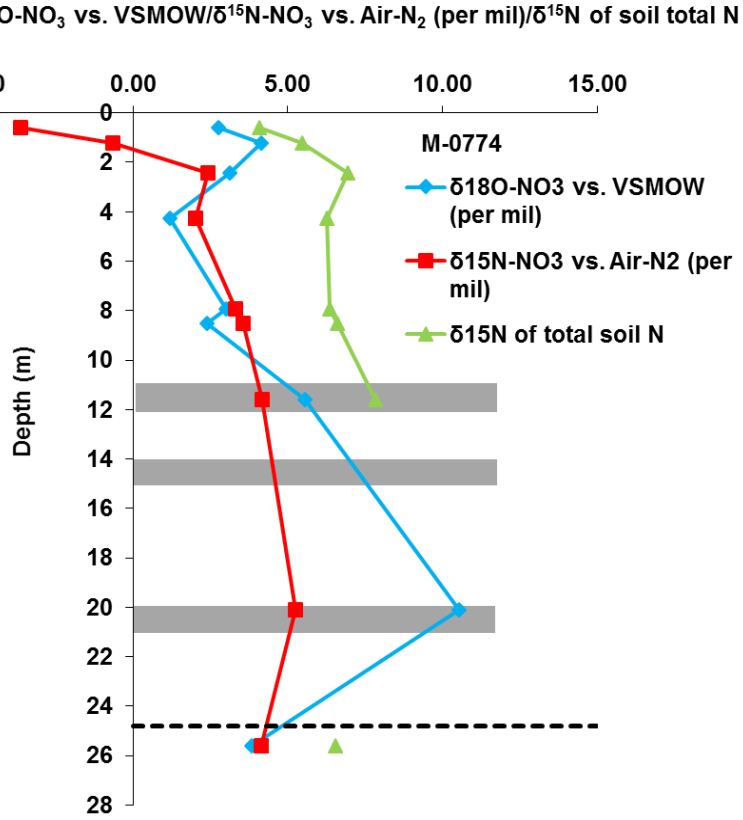
NO_3^- Stable isotopes ($\delta^{18}O$ and $\delta^{15}N$)

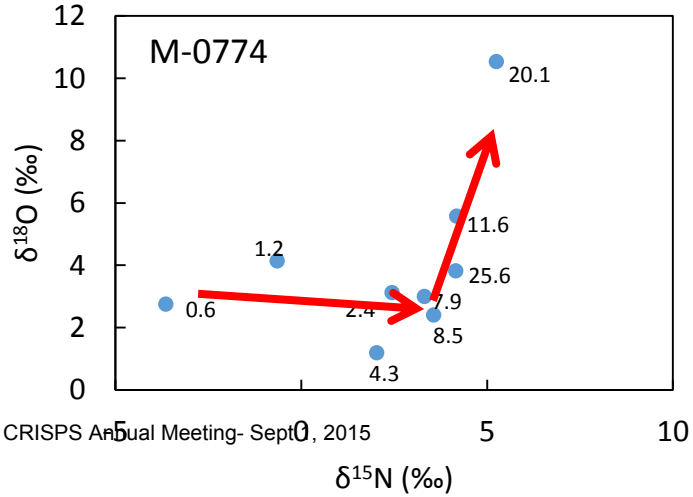
- Water extractable solution



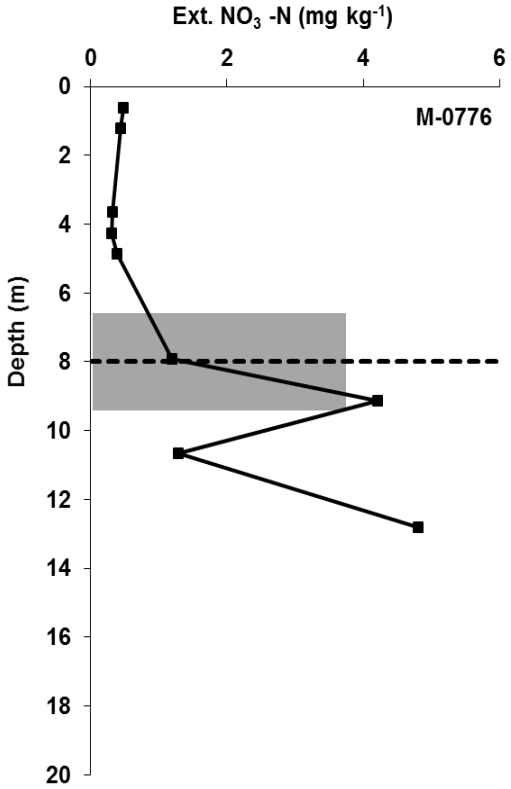
Schematic of typical ranges of $\delta^{18}O$ and $\delta^{15}N$ of nitrate from various sources as well as the isotopic effect of denitrification. (Adapted from http://www-rcamnl.wr.usgs.gov/isoig/isopubs/Fig16-9.jpg)

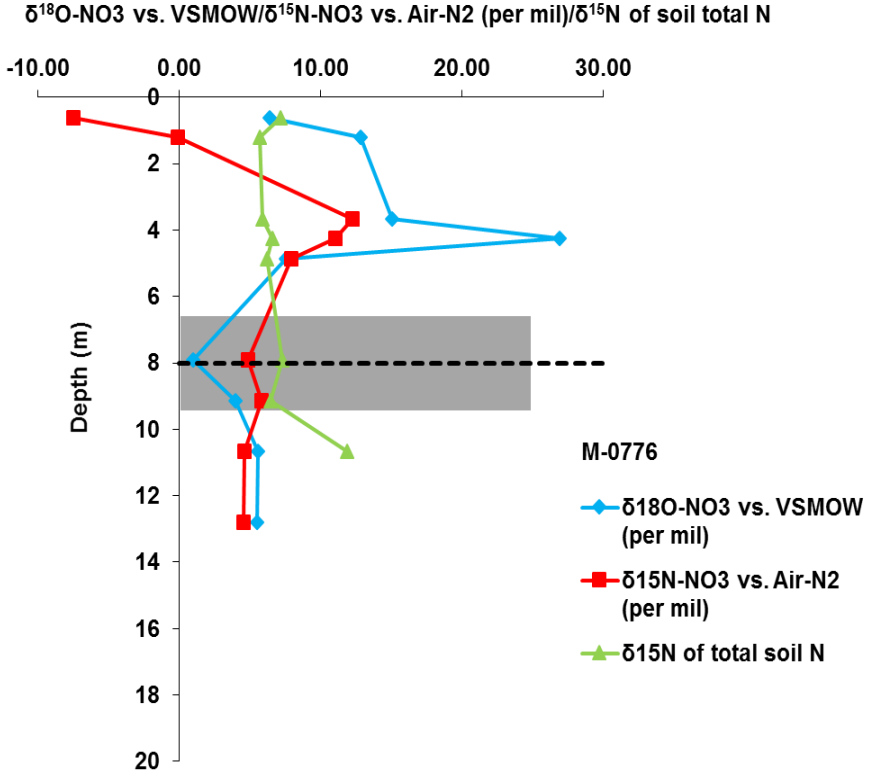


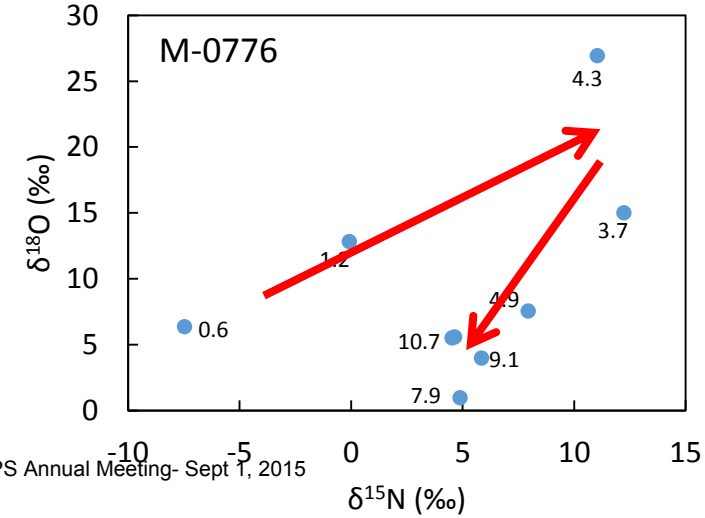




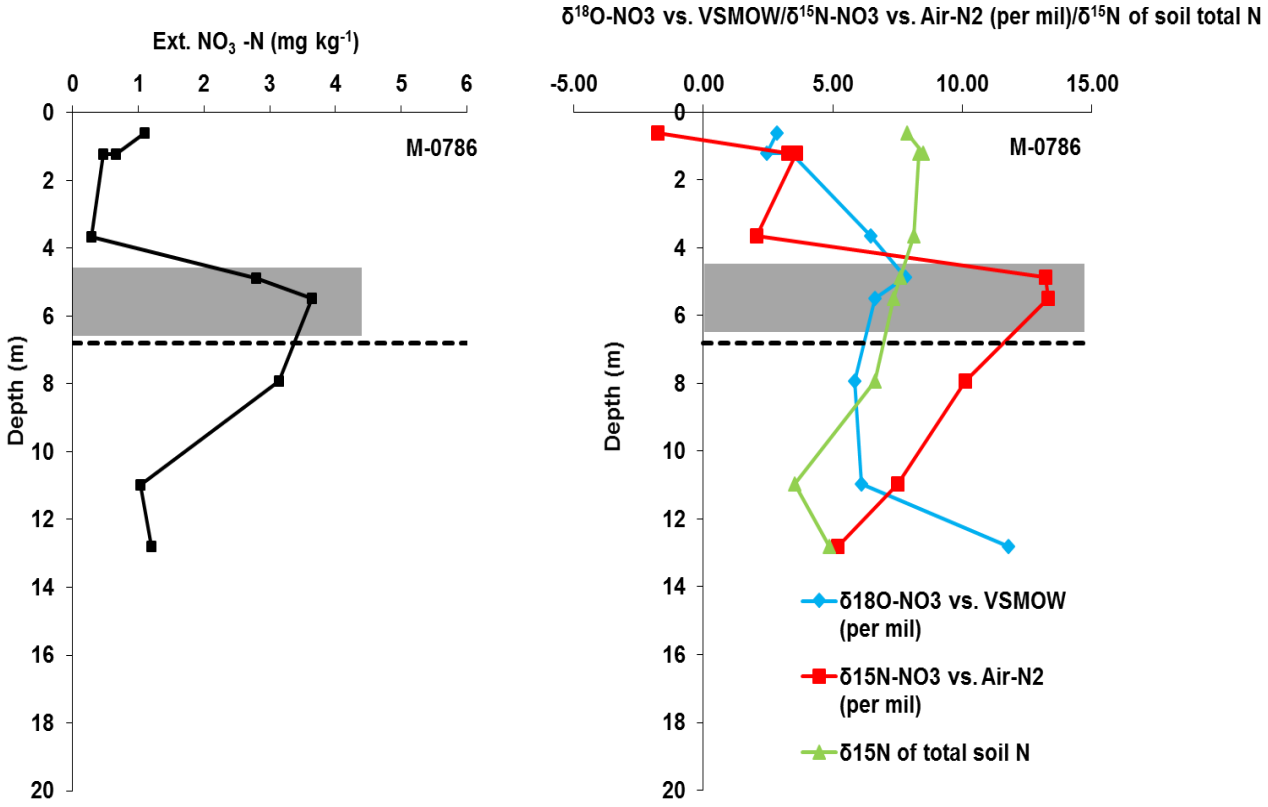
Residential

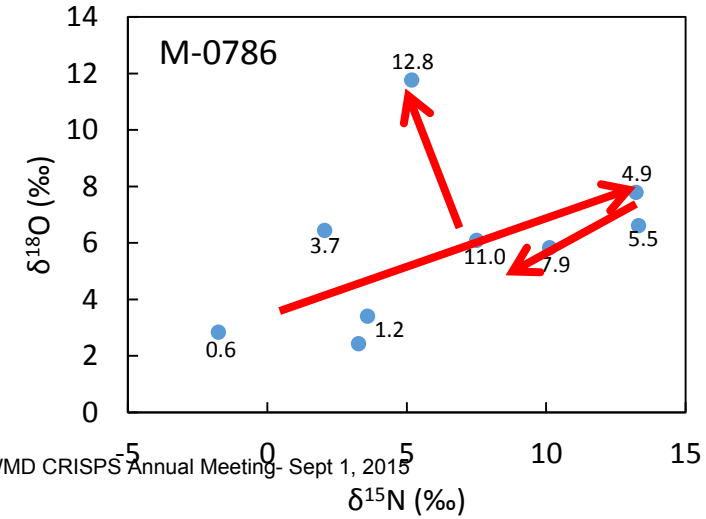




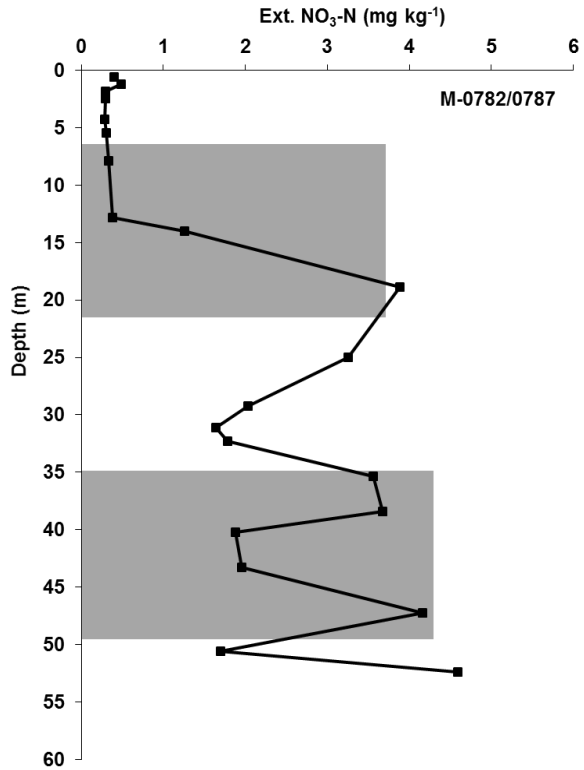


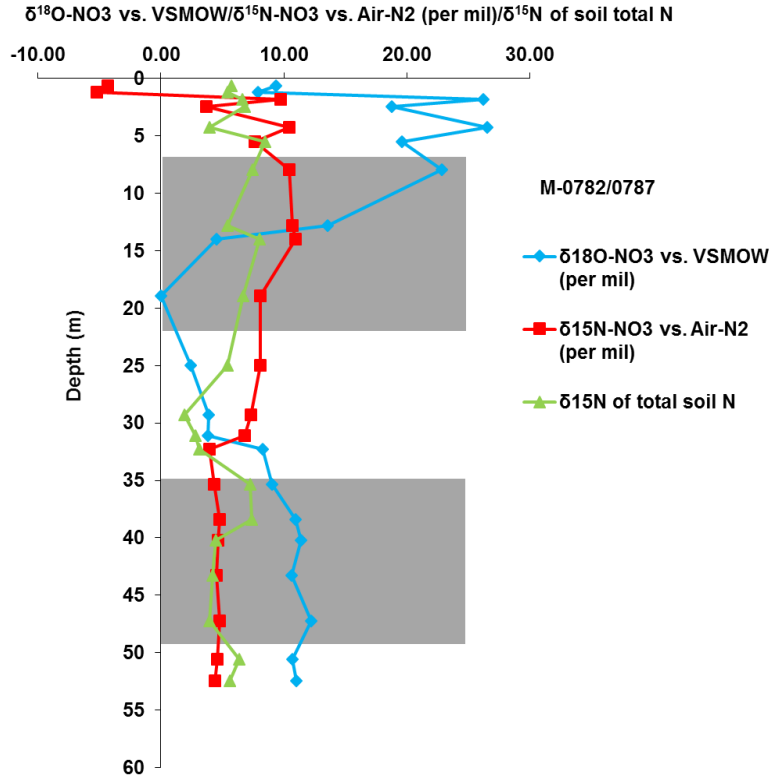
Mixed horse farm

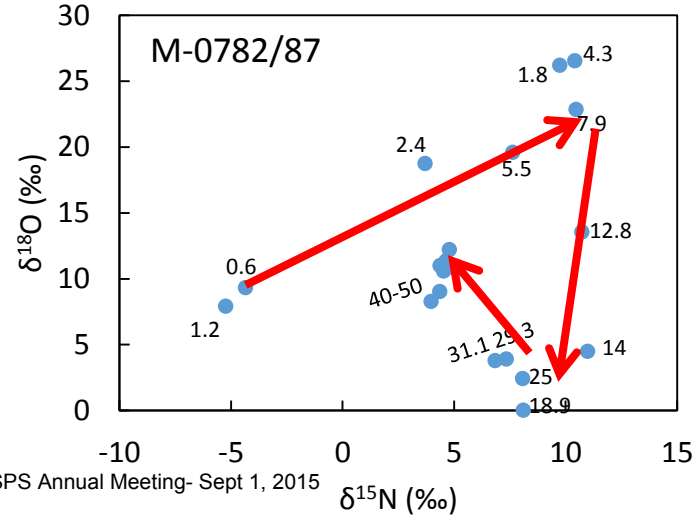

Ext. NO3 -N (mg kg-1)
M-0786
Depth (m)
δ18O-NO3 vs. VSMOW/δ15N-NO3 vs. Air-N2 (per mil)/δ15N of soil total N
M-0786
δ18O-NO3 vs. VSMOW (per mil)
δ15N-NO3 vs. Air-N2 (per mil)
δ15N of total soil N


M-0786
12.8
4.9
3.7
11.0
7.9
5.5
1.2
0.6
δ18O (‰)
δ15N (‰)

Sprayfield







Mixed nursery/pasture

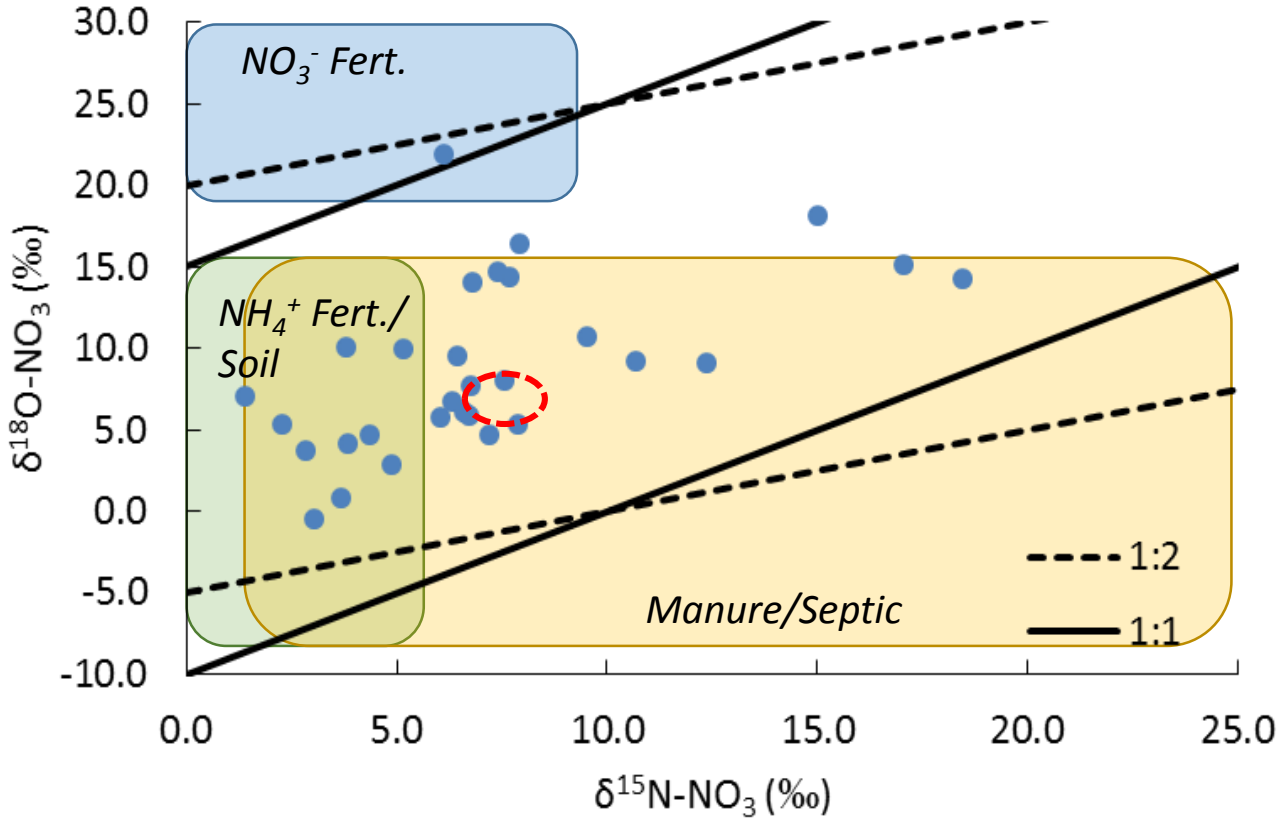


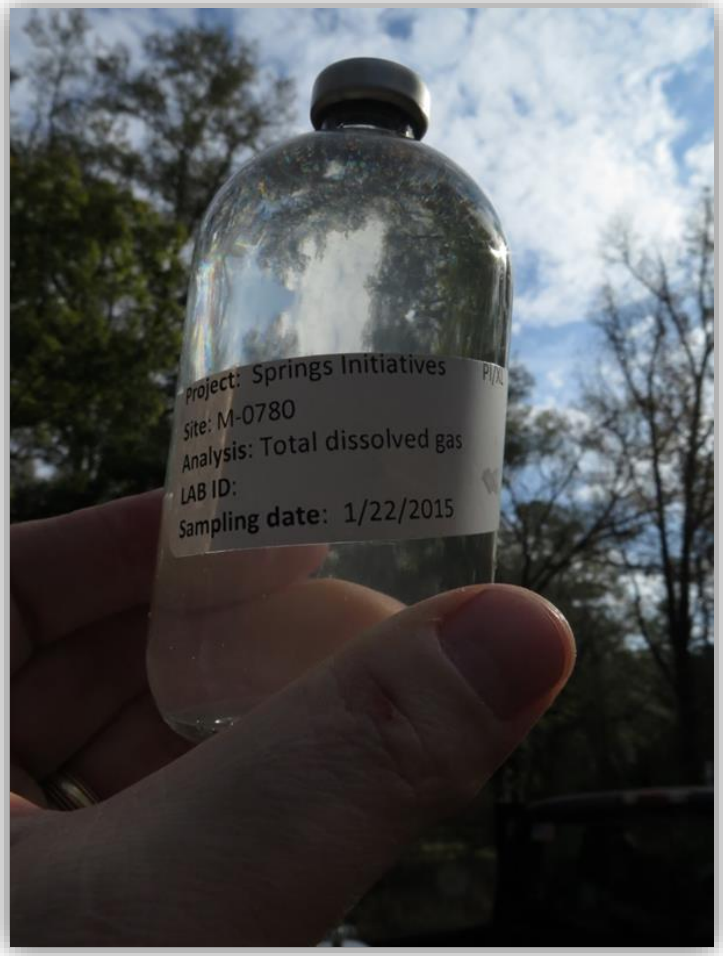
Figure 20. The $\delta^{18}O$ and $\delta^{15}N$ of nitrate from the 15 wells and other 46 old wells (* currently data not completed). Solid and dotted lines represent theoretical upper and lower bounds for enrichment due to denitrification based on the $\delta^{18}O$-NO_3: $\delta^{15}N$-NO_3 fractionation ratio of 1:1 and 1:2, respectively.

Conclusions/Next steps

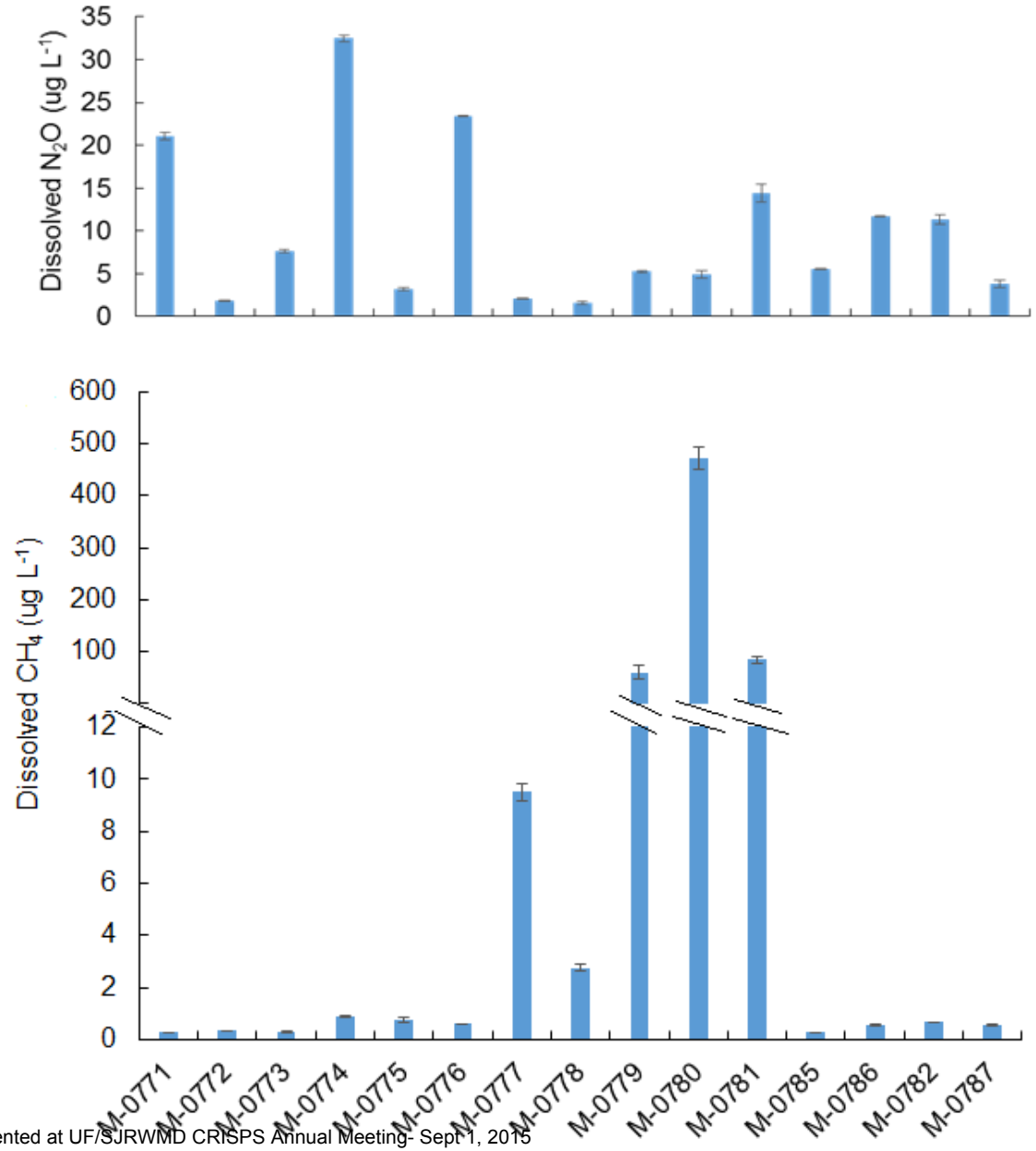
- Low denitrification in measured soils/vadose zone
  - Low C, electron donors at depth
  - Low loading rates, N limitation in surface
- Dynamic processes in the soil/vadose zone
  - Denitrification (enrichment of NO_3^- leached)
  - Mineralization/Nitrification (depletion of NO_3^- leached)
  - Soil adsorption (both?)
- Derivation of soil relationship with N loading/level, moisture, temperature
- Isotope fractionation tests with soil/vadose materials

Dissolved gases

- CH_4/N_2O
  - N transformations
- Dissolved N_2
  - Produced by denitrification
- Dissolved noble gas (Ar, Ne, …)
  - Recharge temperature
  - Excess air



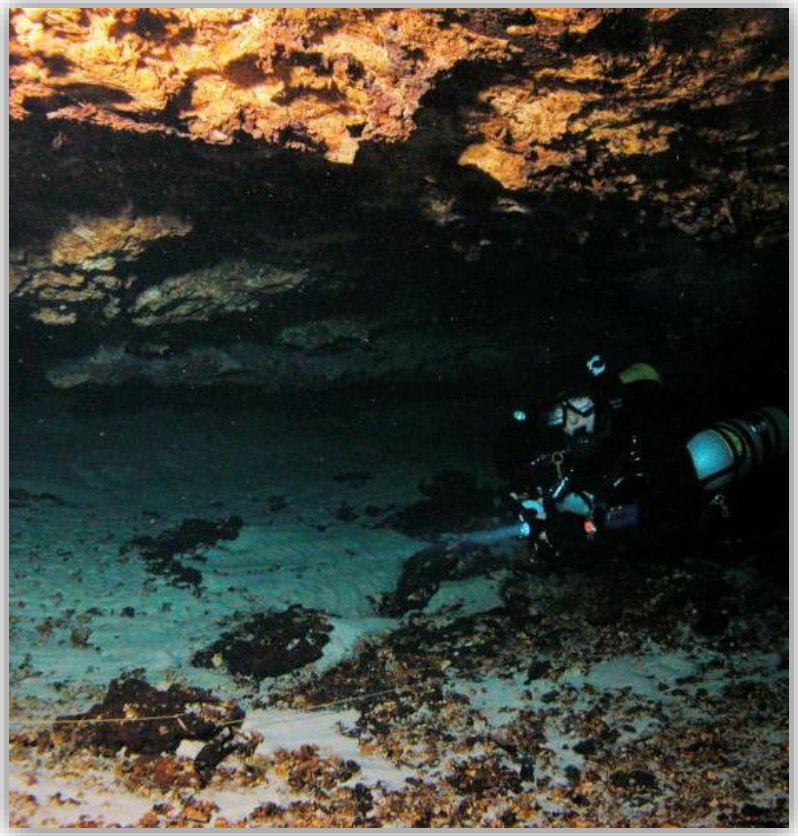

TRACKER


Dissolved N_2O (ug L^{-1})
35
30
25
20
15
10
5
0
Dissolved CH_4 (ug L^{-1})
600
500
400
300
200
100
12
10
8
6
4
2
0
M-0771
M-0772
M-0773
M-0774
M-0775
M-0776
M-0777
M-0778
M-0779
M-0780
M-0781
M-0785
M-0786
M-0782
M-0787

Correlation of dissolved CH_4 and N_2O with selected properties of ground water sampled in the study wells (based on incomplete dataset). **-*P* < 0.01, *-*P* < 0.05

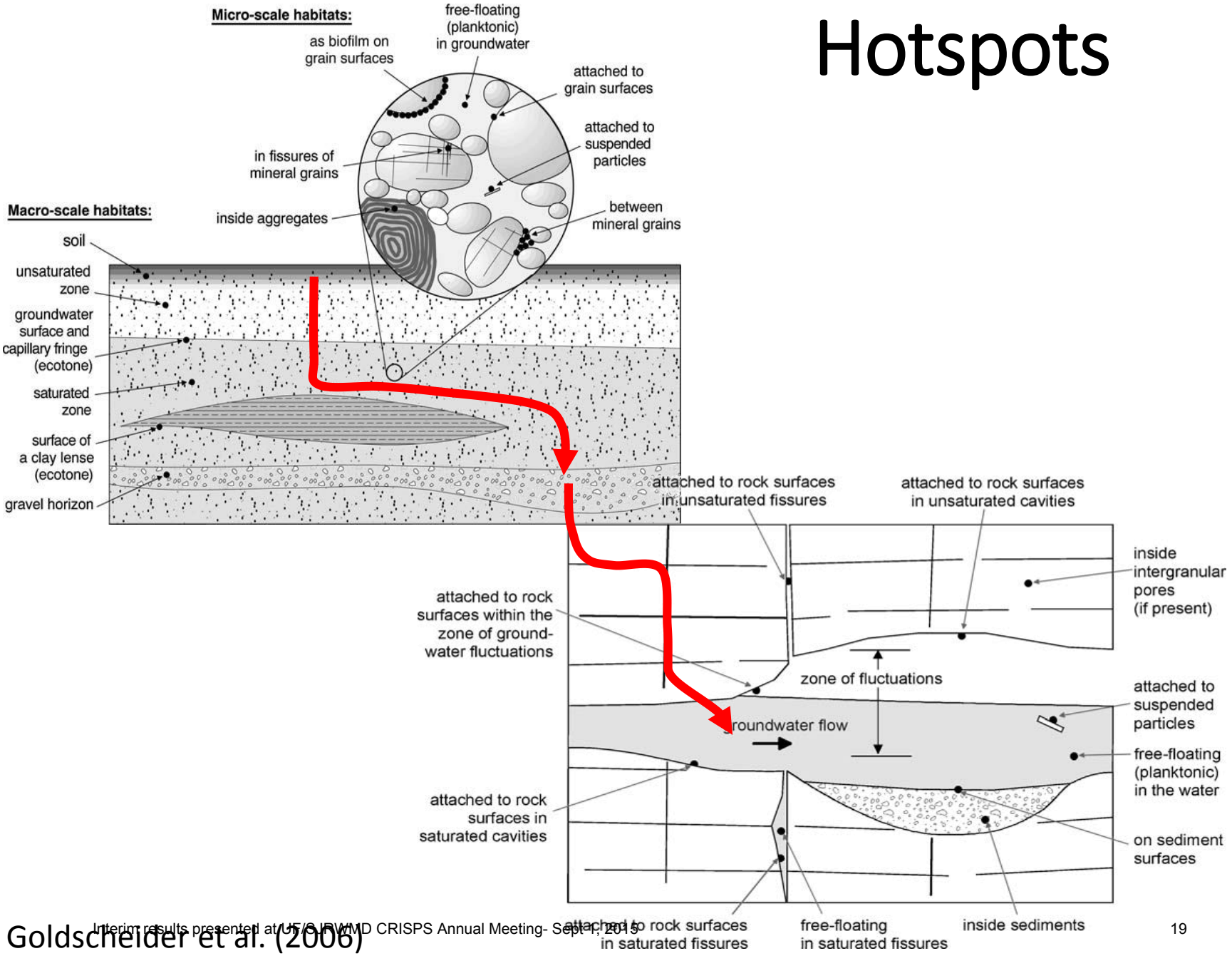
Parameter, y	Parameter, x	Spearman ρ	Prob>|ρ|
Dissolved N_2O	Cl^-	0.8182	**
Dissolved CH_4	DO	-0.5827	*
	TOC	0.7133	**
	NH_4-T	0.7321	**
	NOx-T	-0.6857	**
	Water Temp	-0.6679	**
	Alkalinity	0.5214	*

$$CH_4 + 4NO_3^- \rightarrow CO_2 + 4NO_2^- + 2H_2O$$
$$3CH_4 + 8NO_2^- + 8H^+ \rightarrow 3CO_2 + 4N_2 + 10H_2O$$
$$CH_4 + NO_3^- + 2H^+ \rightarrow CO_2 + NH_4^+ + H_2O$$



http://www.cambrianfoundation.org/

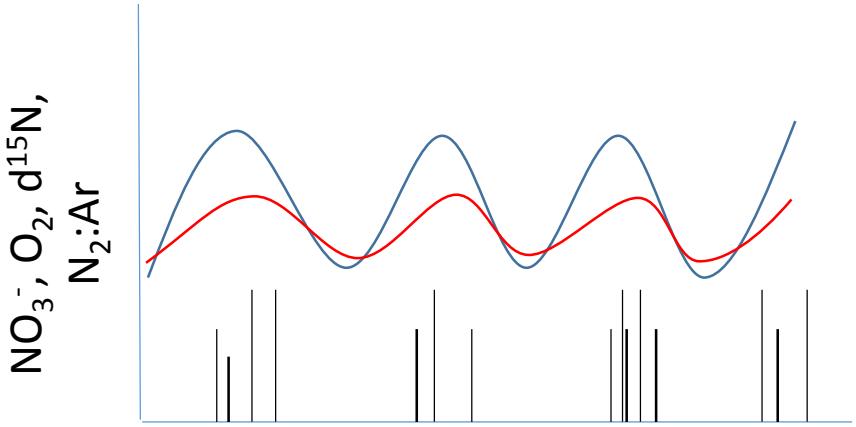
Hotspots

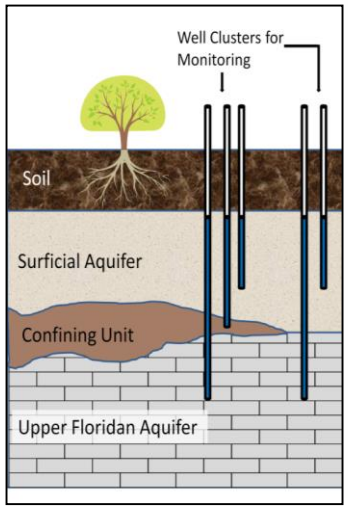


Goldscheider et al. (2006)

Hot Moments

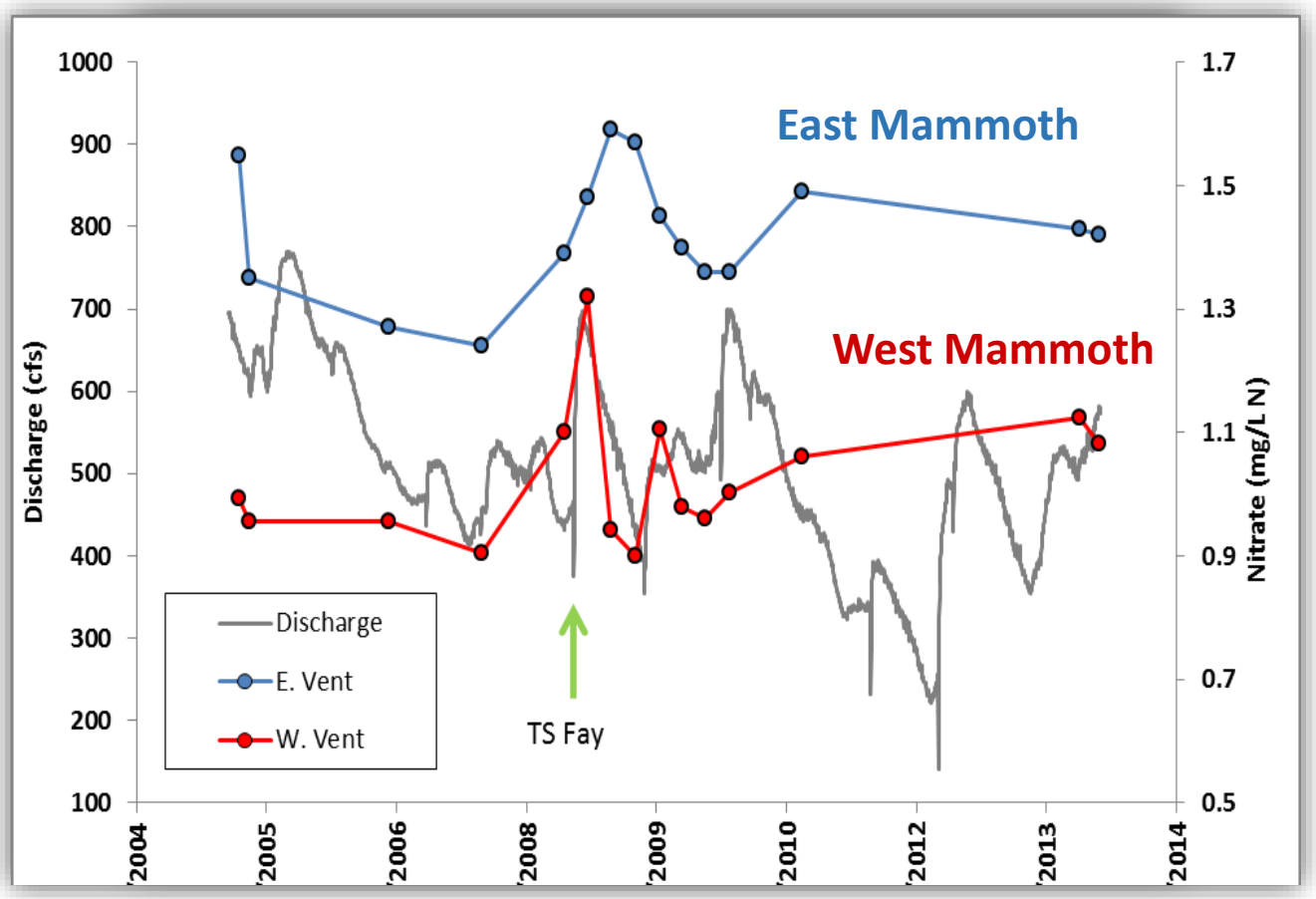
- Seasonal
  - Wet/Dry season changes
  - Growing cycles, Land use activities
- Events
  - Storm events, stormwater discharges





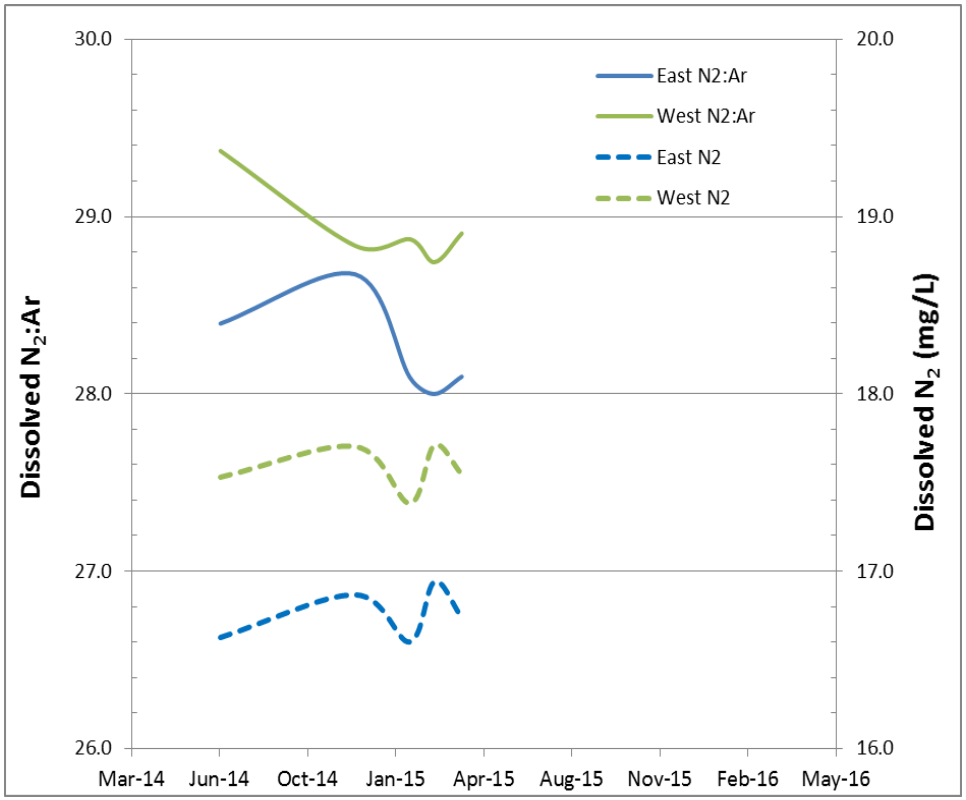
http://www.audubonaction.org/

Vent Patterns

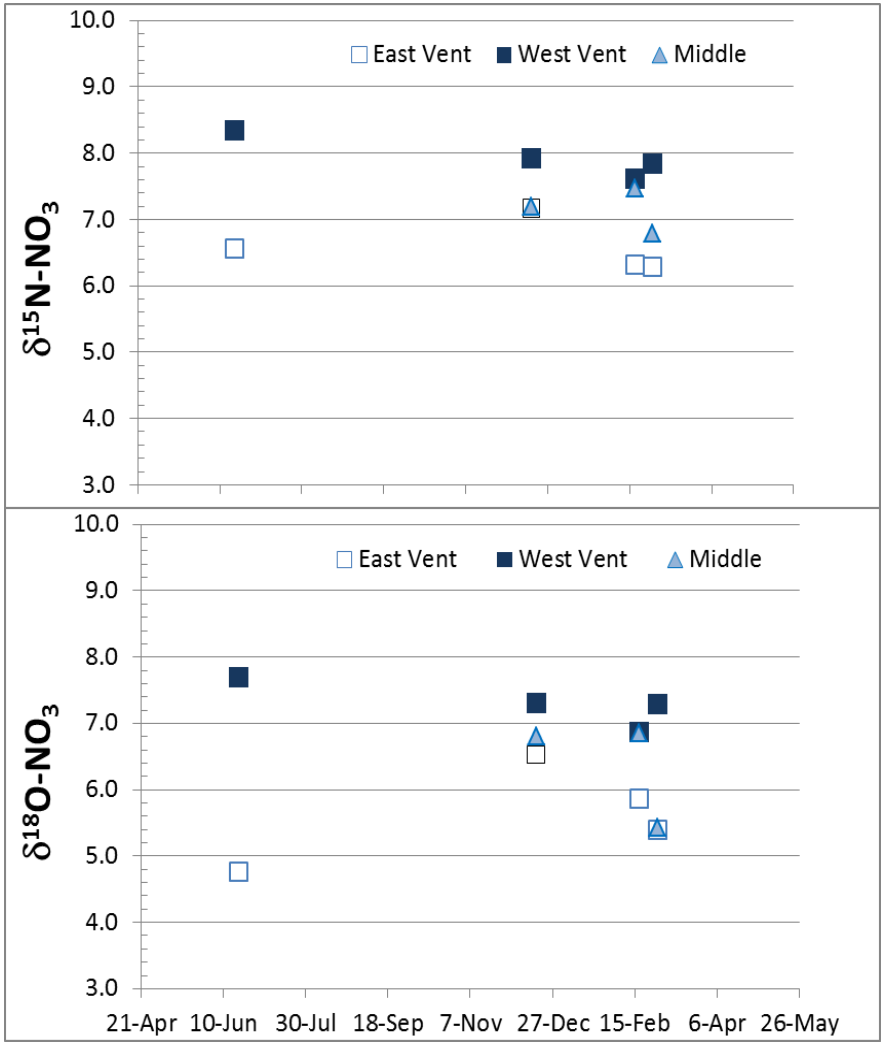


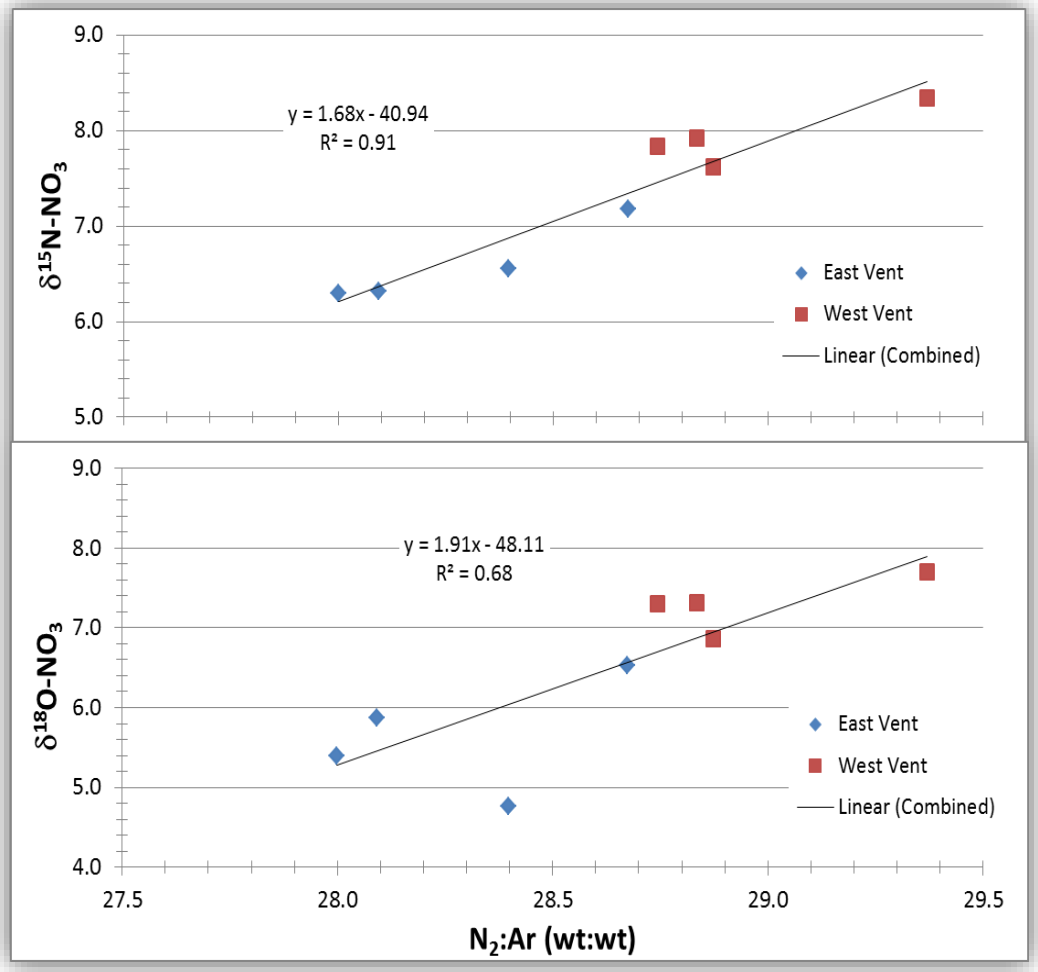
Figures and Analysis by Andy Canion

Dissolved Gases



NO_3^- Stable Isotopes




9.0
8.0
7.0
6.0
5.0
$\delta^{15}N\text{-}NO_3$
y = 1.68x - 40.94
R² = 0.91
East Vent
West Vent
Linear (Combined)
9.0
8.0
7.0
6.0
5.0
4.0
$\delta^{18}O\text{-}NO_3$
y = 1.91x - 48.11
R² = 0.68
East Vent
West Vent
Linear (Combined)
27.5
28.0
28.5
29.0
29.5
N_2:Ar (wt:wt)

Conclusions/Next steps

- Potential for non-C-based nitrate attenuation pathways
  - N_2O-source indicator?
  - CH_4-hotspots?
- Finish analysis of well and vent samples for isotopes and noble gases
  - Estimate denitrification spatially and temporally (hotspots, hot moments)
- Estimate average N source for the spring vent
- Continue seasonal sampling and target some wells for time-dependent responses