Groundwater nitrate dynamics at the Flickner Innovation Farm

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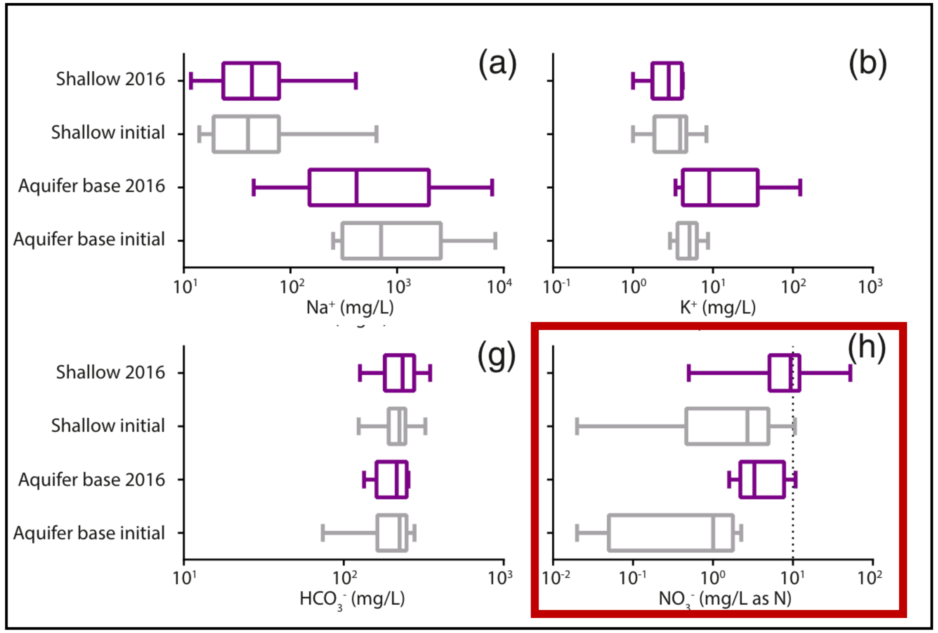
Groundwater nitrate contamination

Widespread changes in groundwater quality across the High Plains Aquifer over the past several decades

Groundwater nitrate concentrations have increased significantly (Lane et al. 2019)

Efforts to address nitrate contamination and understand its underlying causes have been stymied by high local variability



Lane et al. 2019

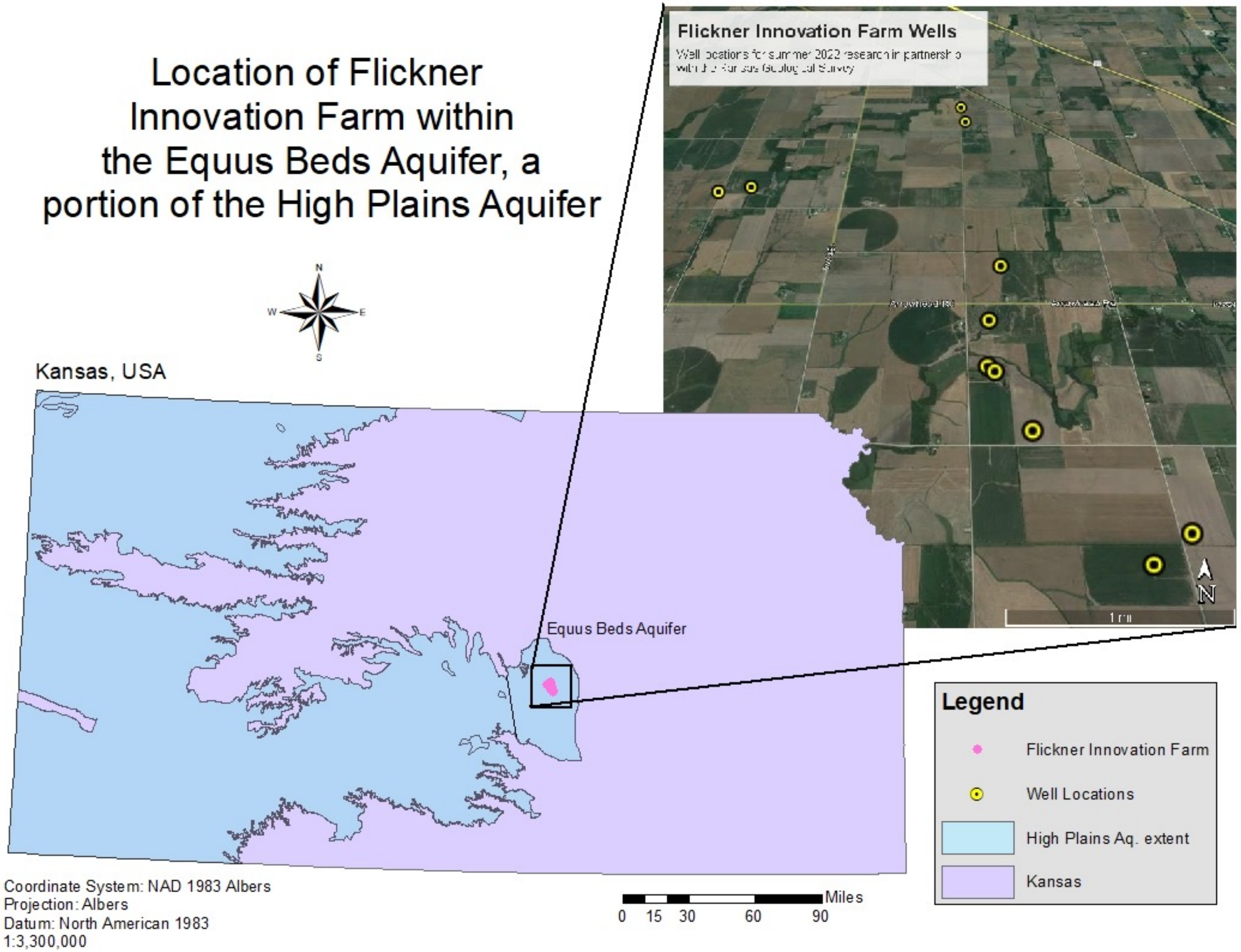
Project goals

1) Quantify nitrate concentrations in wells on the Flickner Innovation Farm.
   - Determine any spatial and temporal/seasonal variation

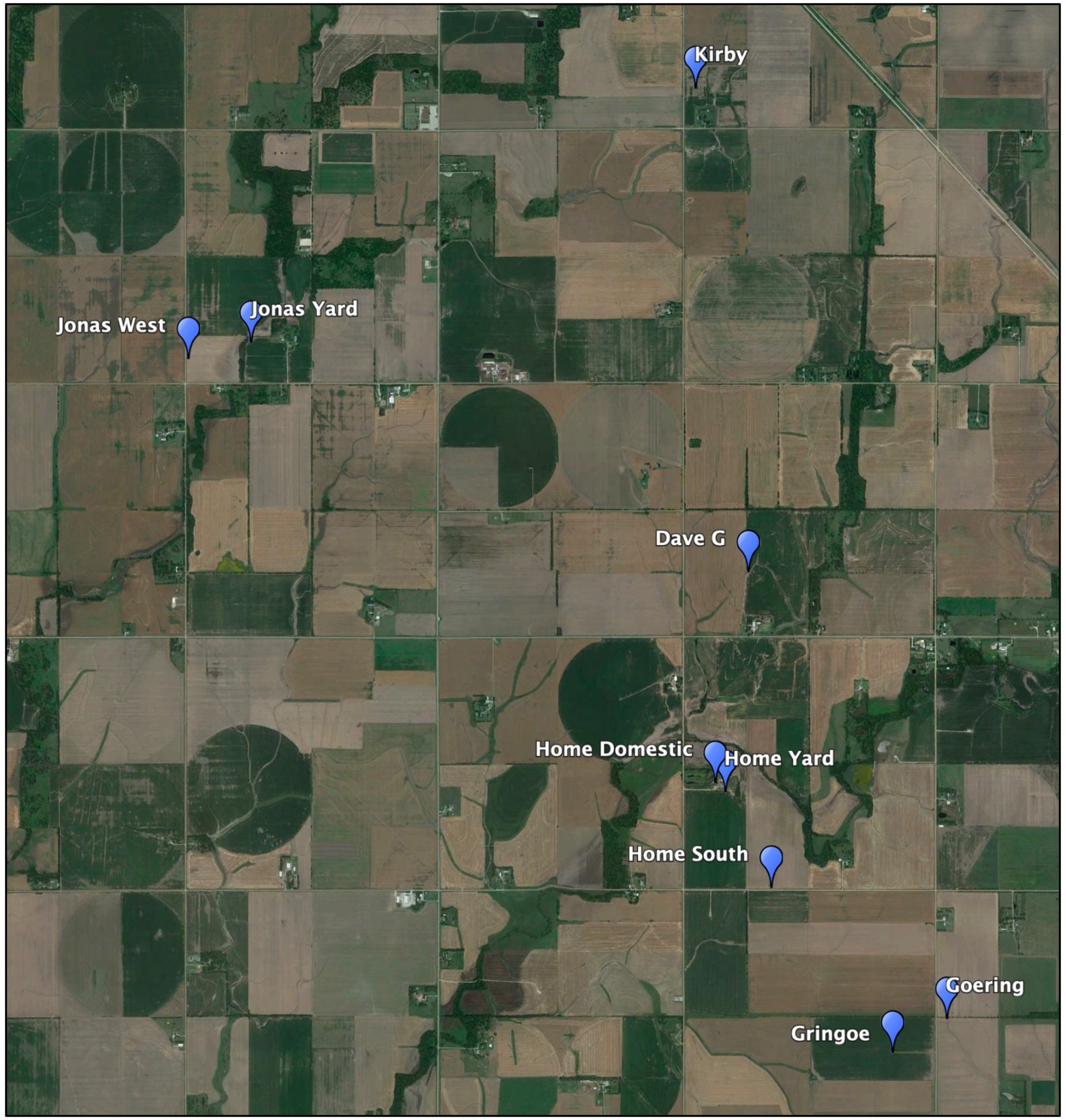
2) Identify source of groundwater nitrate

3) Explore potential drivers of nitrate patterns
   - Vertical lithologic controls
   - Well characteristics
   - Irrigation strategies

Study Site


Location of Flickner Innovation Farm within the Equus Beds Aquifer, a portion of the High Plains Aquifer
N
W
E
S
Kansas, USA
Equus Beds Aquifer
Flickner Innovation Farm Wells
N
Legend
Flickner Innovation Farm
Well Locations
High Plains Aq. extent
Kansas
Miles
0 15 30 60 90
Coordinate System: NAD 1983 Albers
Projection: Albers
Datum: North American 1983
1:3,300,000

Flickner Innovation Farm wells



Well name	Well depth (ft)	Screen Interval (ft)	Well Age	Irrigation	Num. Samples
Home South	N.D.	N.D.	1955	SDI	7
Home Yard	141	106-139	1977	SDI	10
Jonas Yard	101	61-100	1980	SDI	6
Gringoe	138	99-138	1984	SDI	7
Dave G	136	96-136	1993	Center Pivot	6
Jones West	112	72-112	1995	SDI	9
Goering	131	91-131	2011	SDI	6
Kirby	87-95	70-95	2017	Flood	8
Home Domestic	N.D.	N.D.	N.D.	N.A.	5

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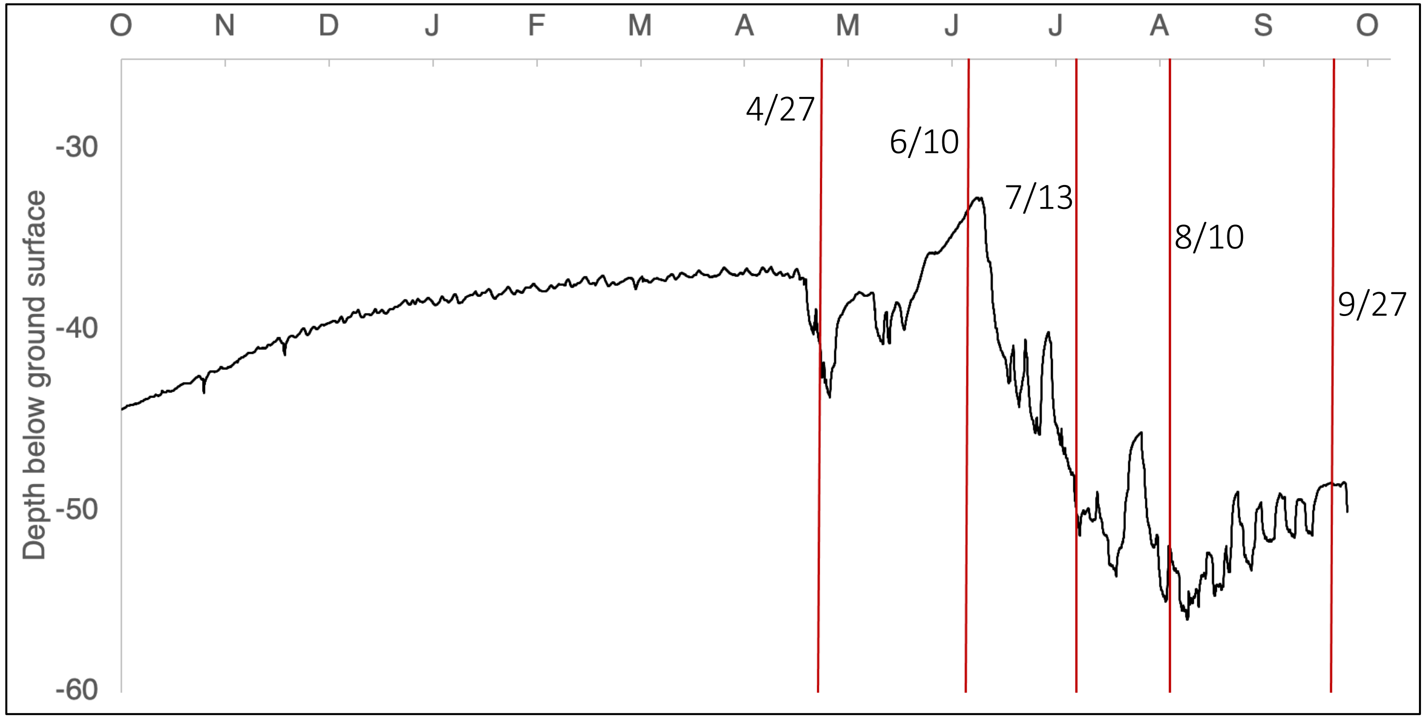
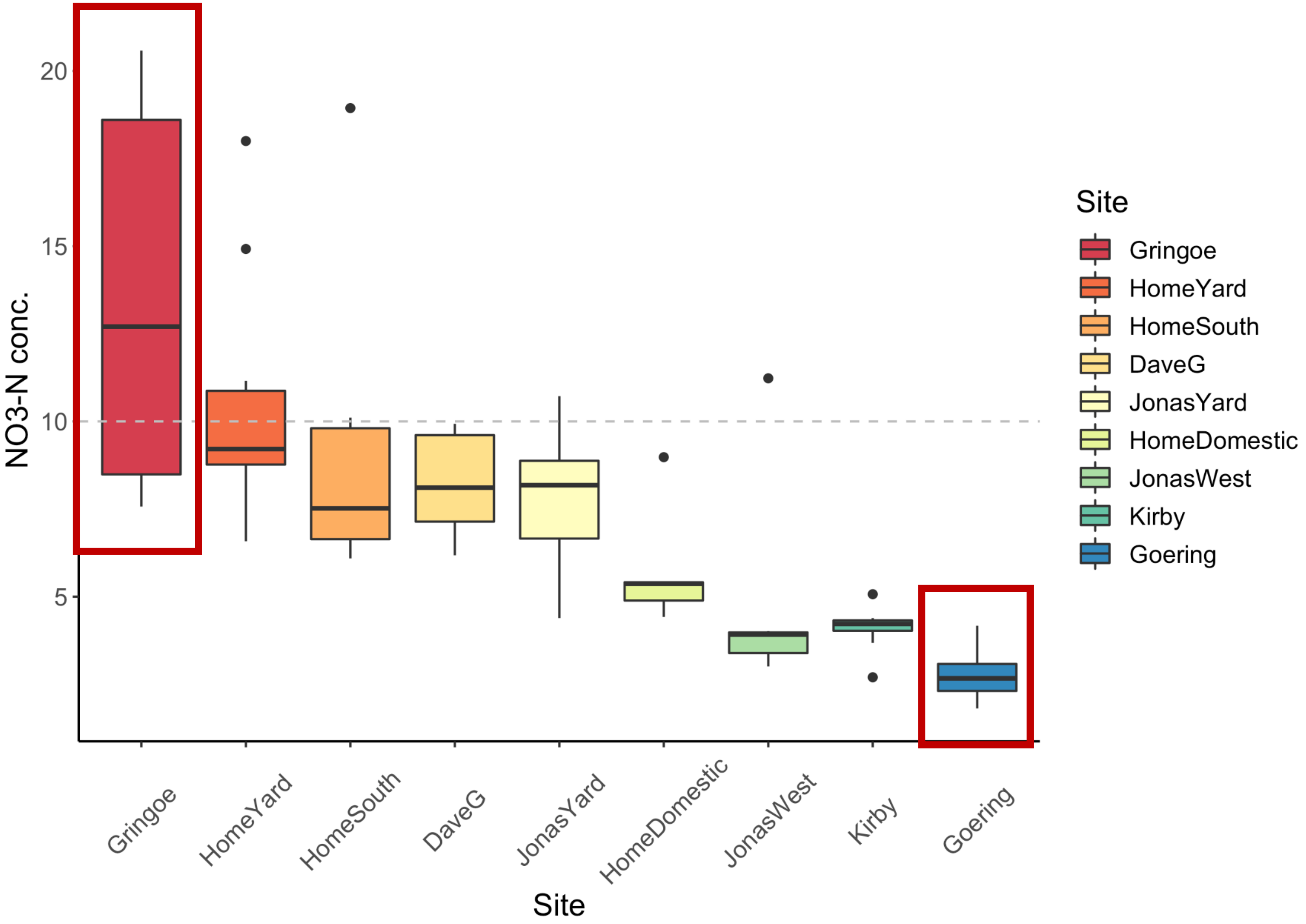
2022 sampling dates

2022 Water Level Data: Harvey County Index Well



Sampling date	Time point
4/27-29	Pre-planting
6/10	Post-planting/pre-fertilizer
7/13	Mid-season
8/10	Mature crop
9/27	End of season

Nitrate concentrations vary across wells



1. Large variation in concentration in nearby wells (Gringoe and Goering - quarter mile apart)

2. Wells with highest concentrations were also the most variable

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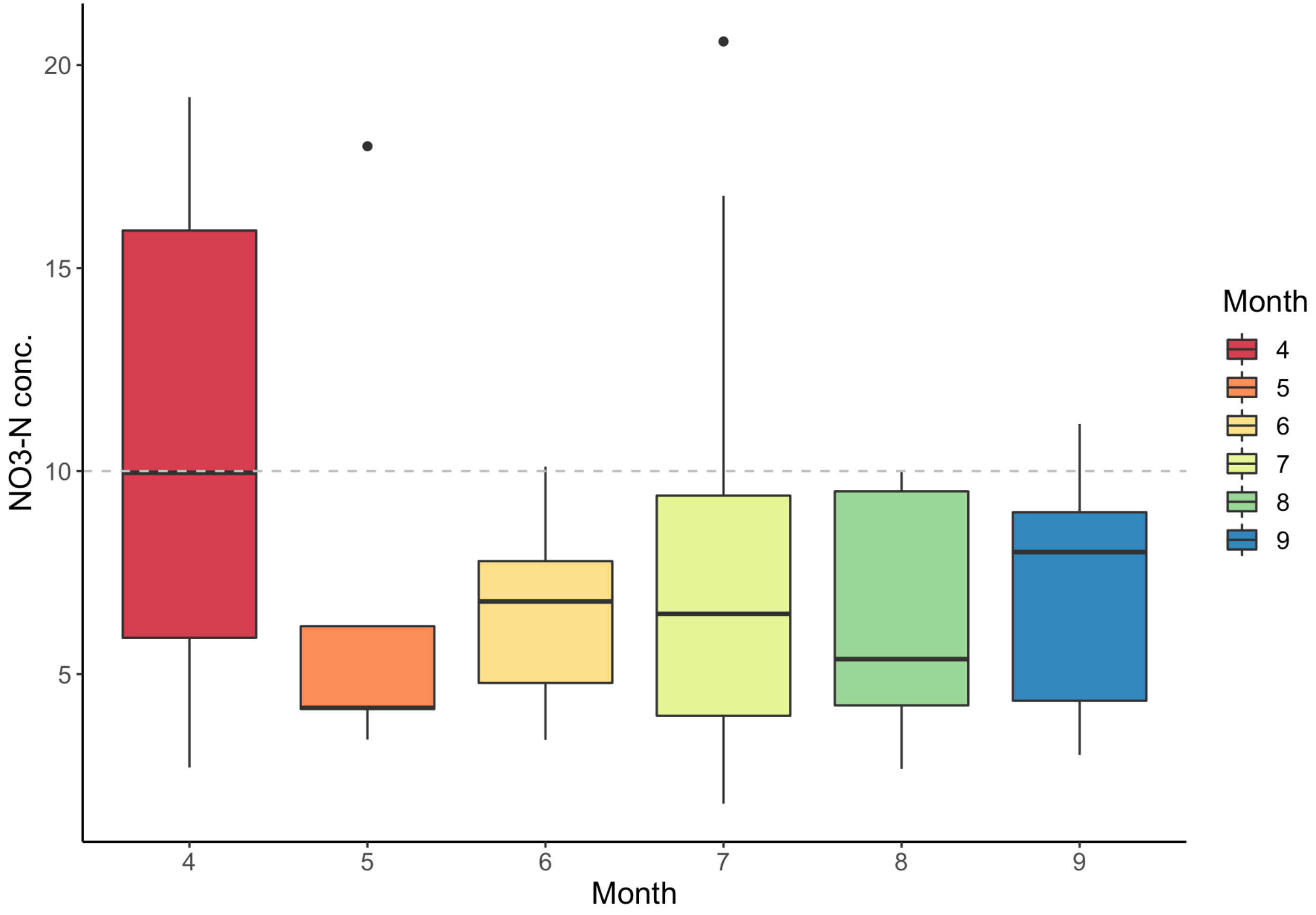
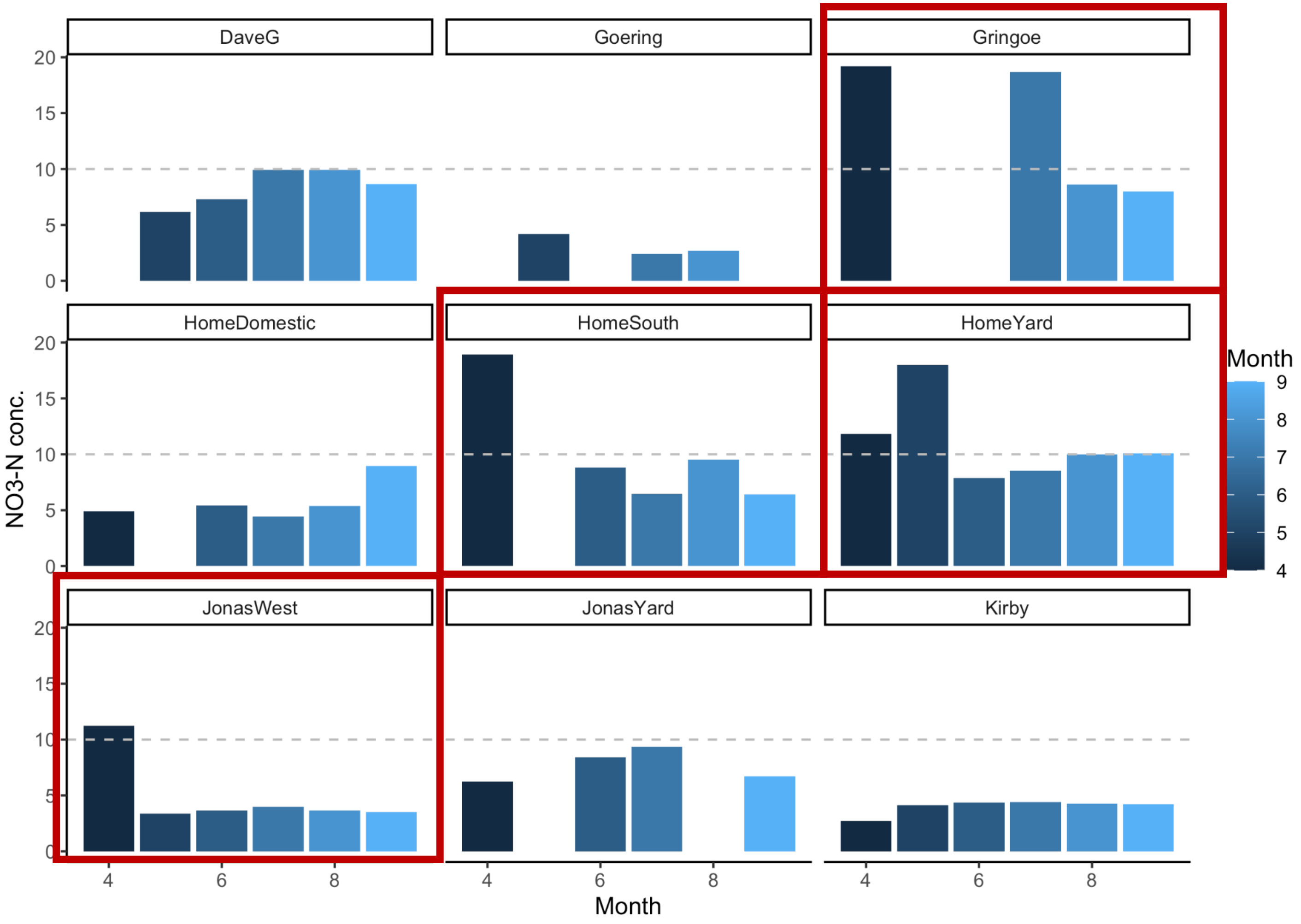
Nitrate concentrations are highest in spring



1. Greatest variability in concentrations occurs in spring (April)

2. Mean concentrations level off during pumping season

2022 seasonal patterns vary by well



Isotopic fingerprinting

Analyzing dual isotopes of oxygen and nitrogen in nitrate in water samples can be used to trace the source of nitrate in groundwater

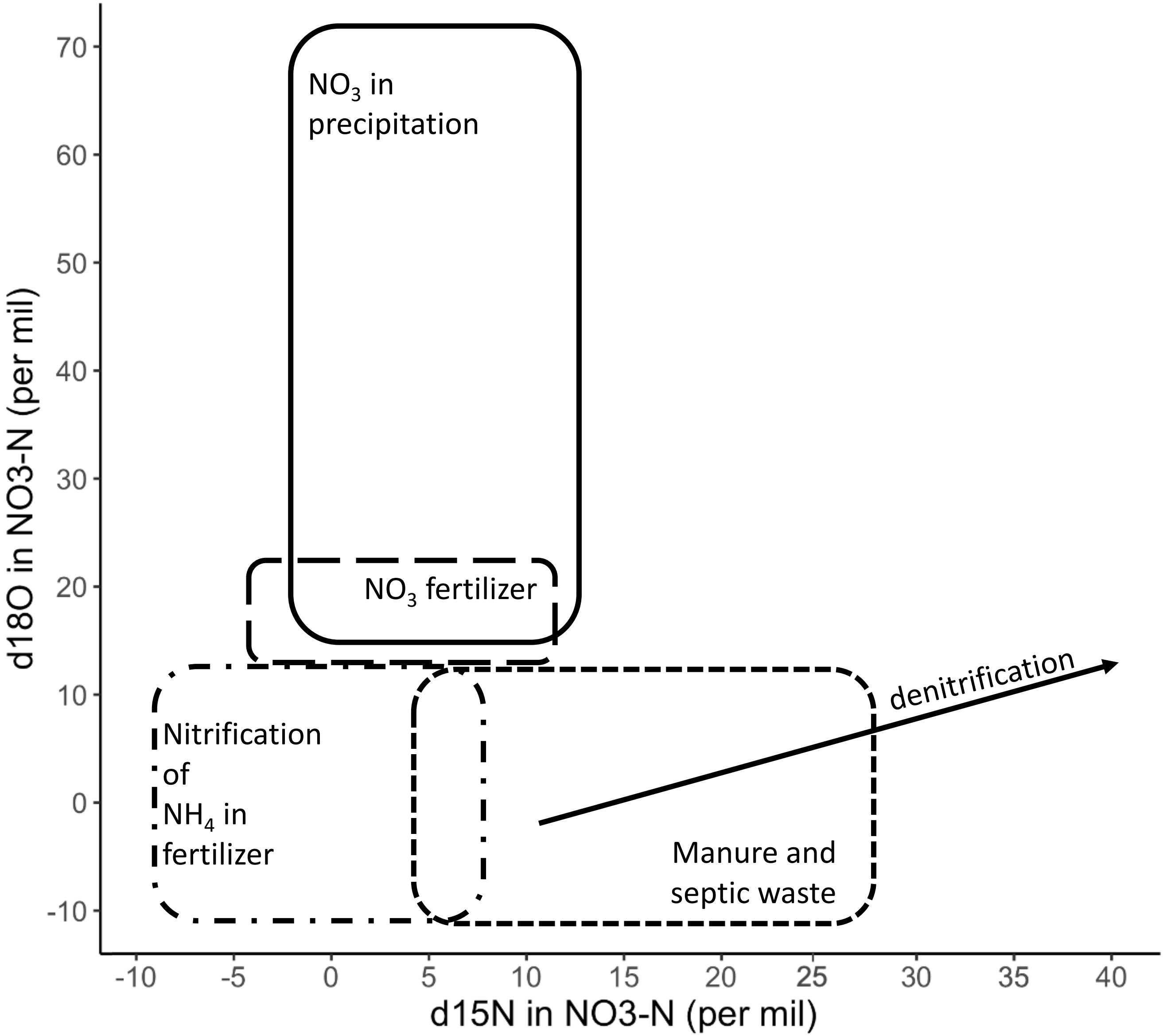
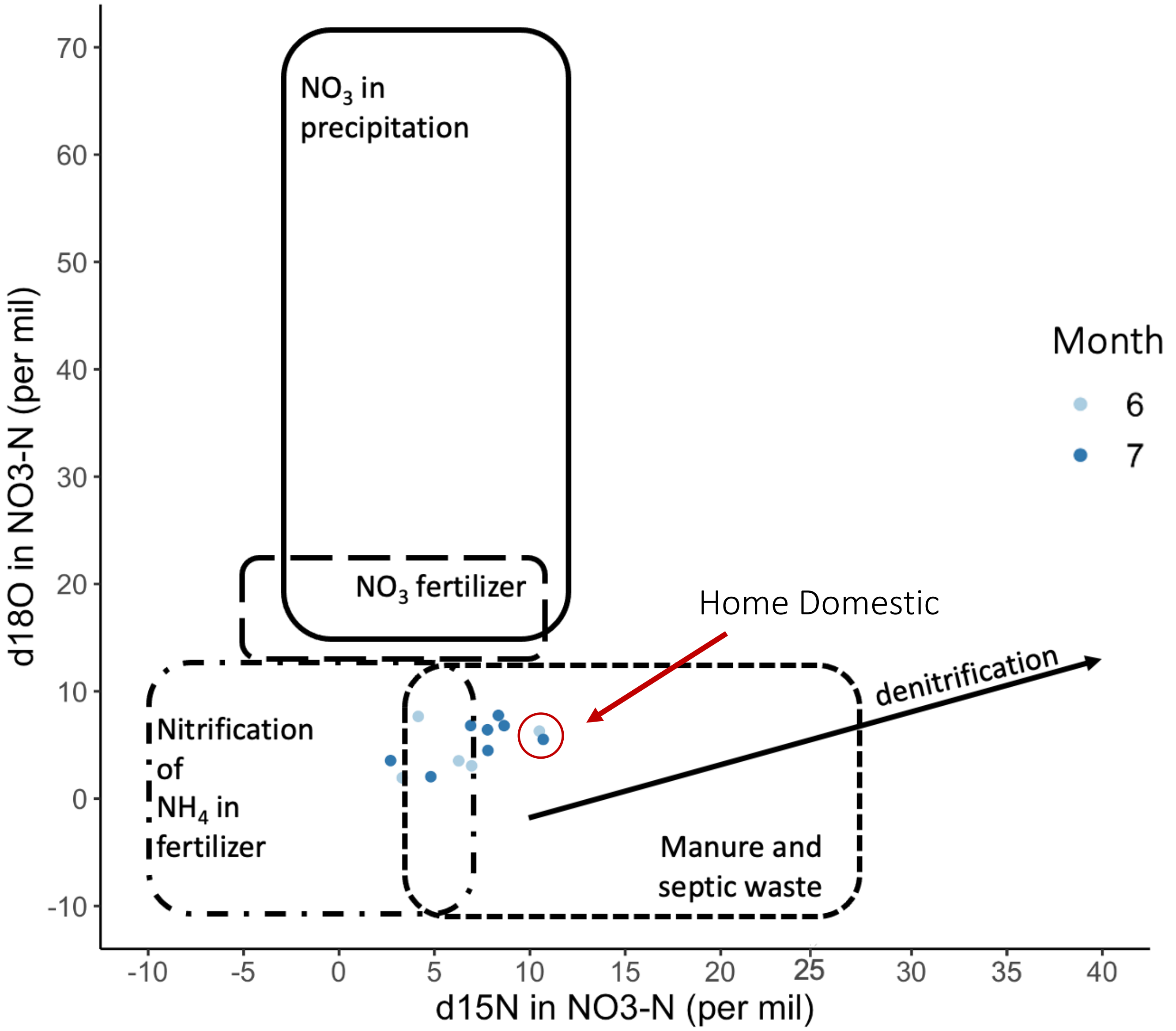


Figure adapted from Kendall et al. 2000

Isotopes indicate mixed fertilizer/manure source



No systematic change in nitrate source between June and July

Figure adapted from Kendall et al. 2000

Potential drivers of nitrate concentrations?

Nitrate concentrations vary among wells, even in close proximity.

Concentrations tend to be highest in spring, but the source is relatively consistent.

What factors might explain this heterogeneity?

- Subsurface structure
- Well characteristics

Direct push with EC profiling tool

Electrical conductivity (EC) logging provides lithologic information about soil conductivity and resistivity

Soil conductivity is function of both parent mineralogy as well as conductivity of pore fluids, and can be used to classify soils

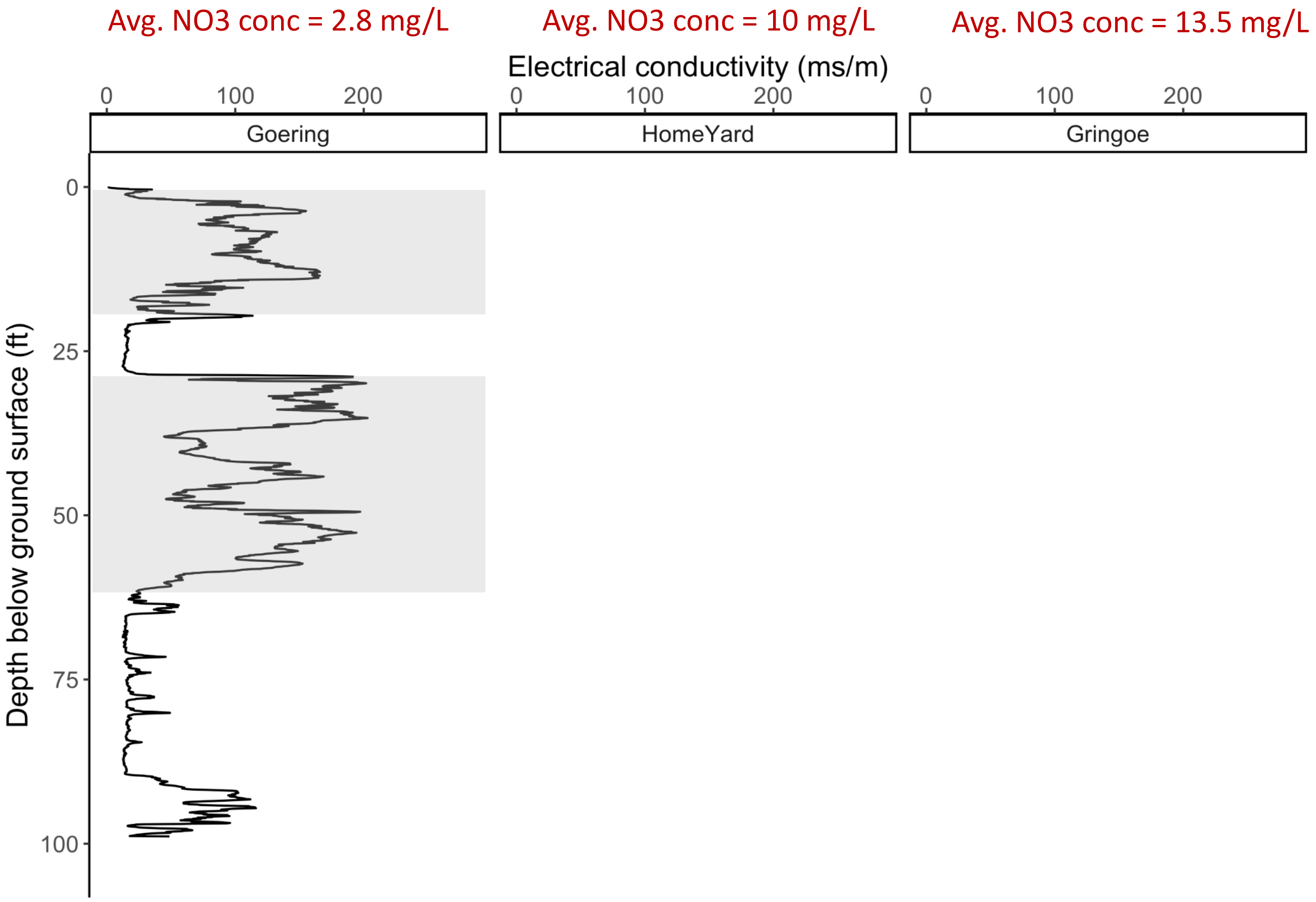
- Silts and clays exhibit higher electrical conductivity.
- Sands and gravels (water bearing units) exhibit lower conductivity.

Benefits and Limitations of HPT

Benefits of Direct Push:
- Minimally invasive + small footprint
- Relatively quick (~2 hours per 100 ft profile)
- Can be paired with hydraulic profiling tool to provide information on hydraulic conductivity

Limitations:
- Depth limited – max depths ~100ft.
- Can't be used in areas with very hard substrate (caliche or dense clay)

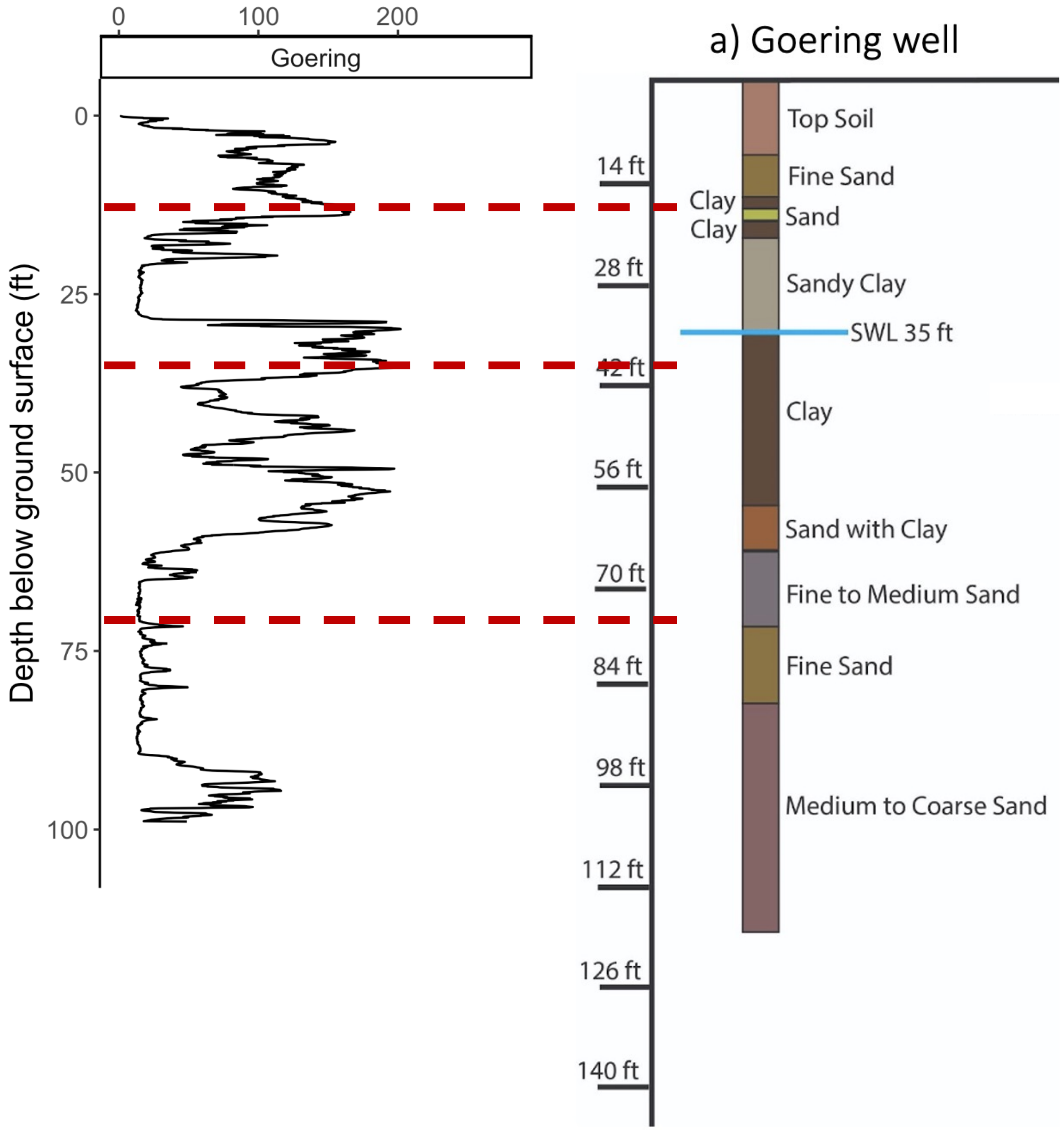
EC profiles across N gradient



High conductivity = lower permeability zones

Driller logs corroborate EC profiles

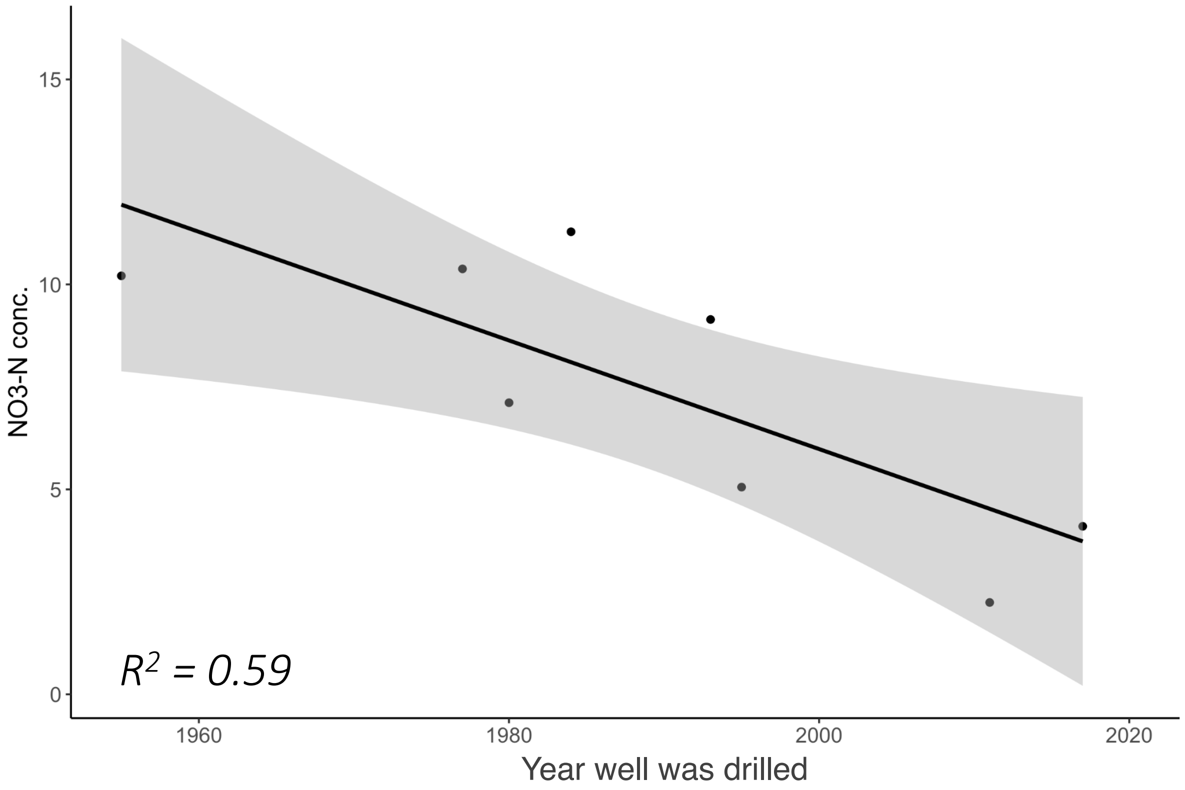
Avg. NO3 conc = 2.8 mg/L

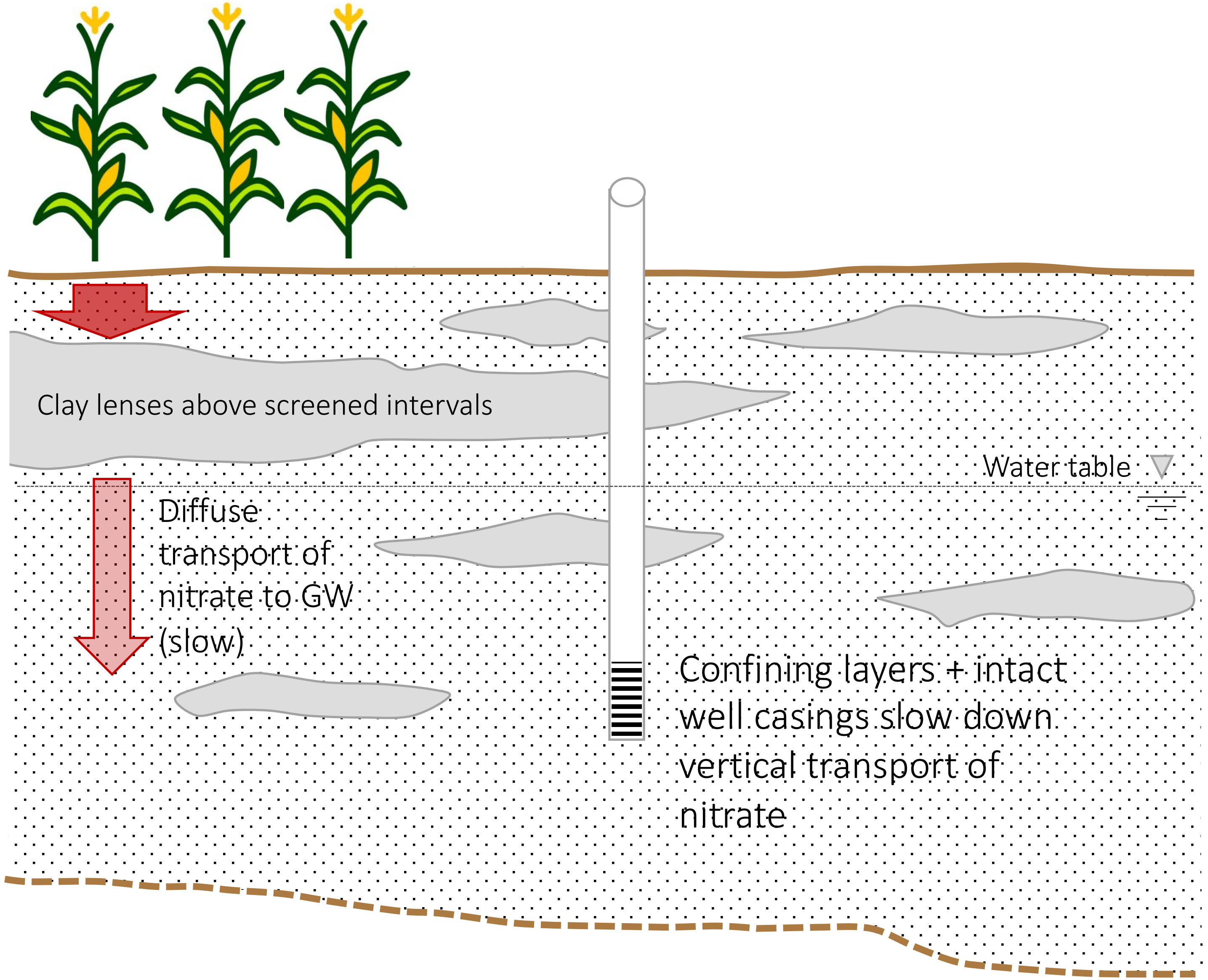


Well age is a strong predictor of avg. nitrate concentation

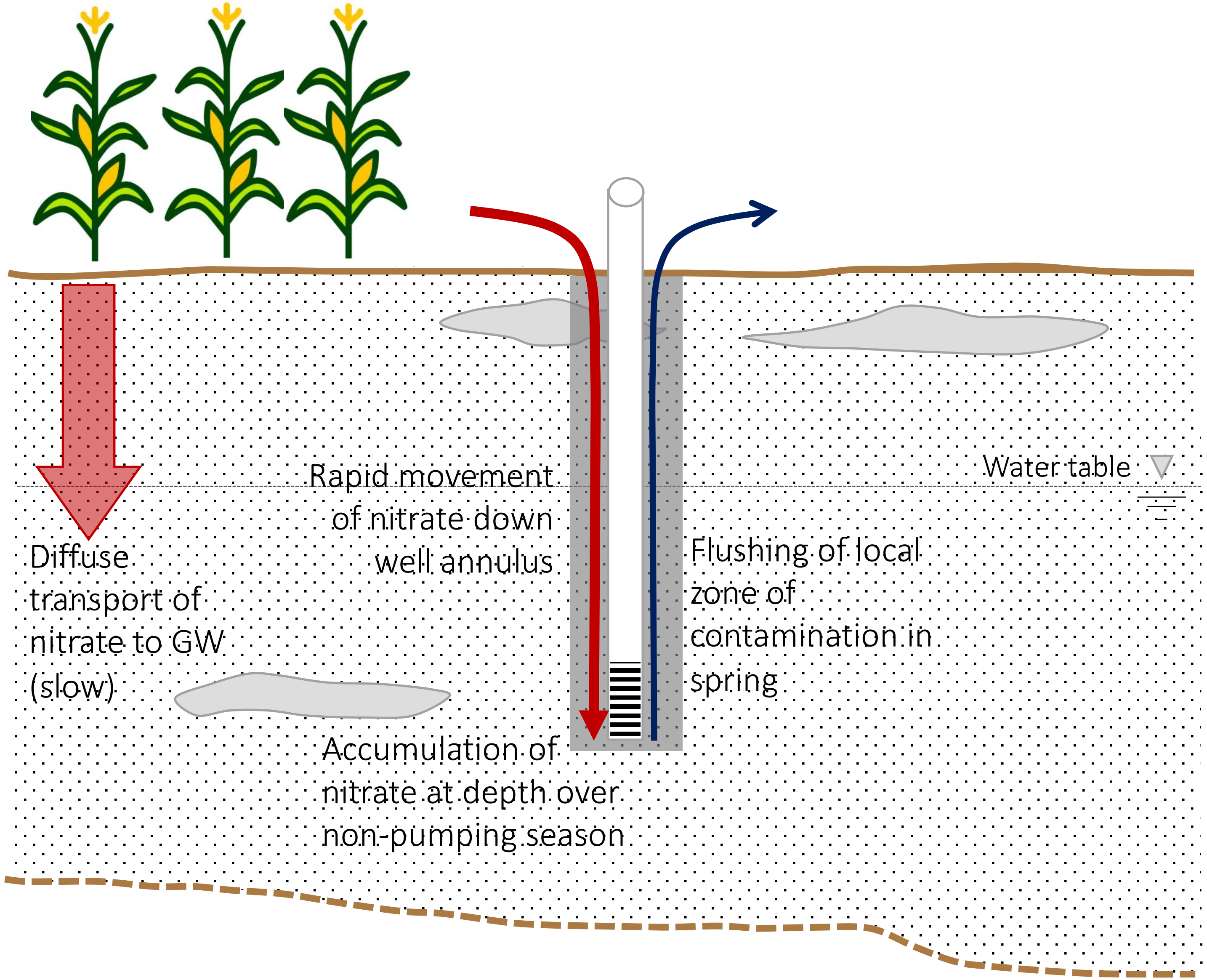
Well age was best single predictor of average nitrate concentration

No apparent relationships with screen interval/depth, etc.





Clay lenses above screened intervals
Water table
Diffuse transport of nitrate to GW (slow)
Confining layers + intact well casings slow down vertical transport of nitrate



Adapted from Townsend 2000

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Next steps and discussion

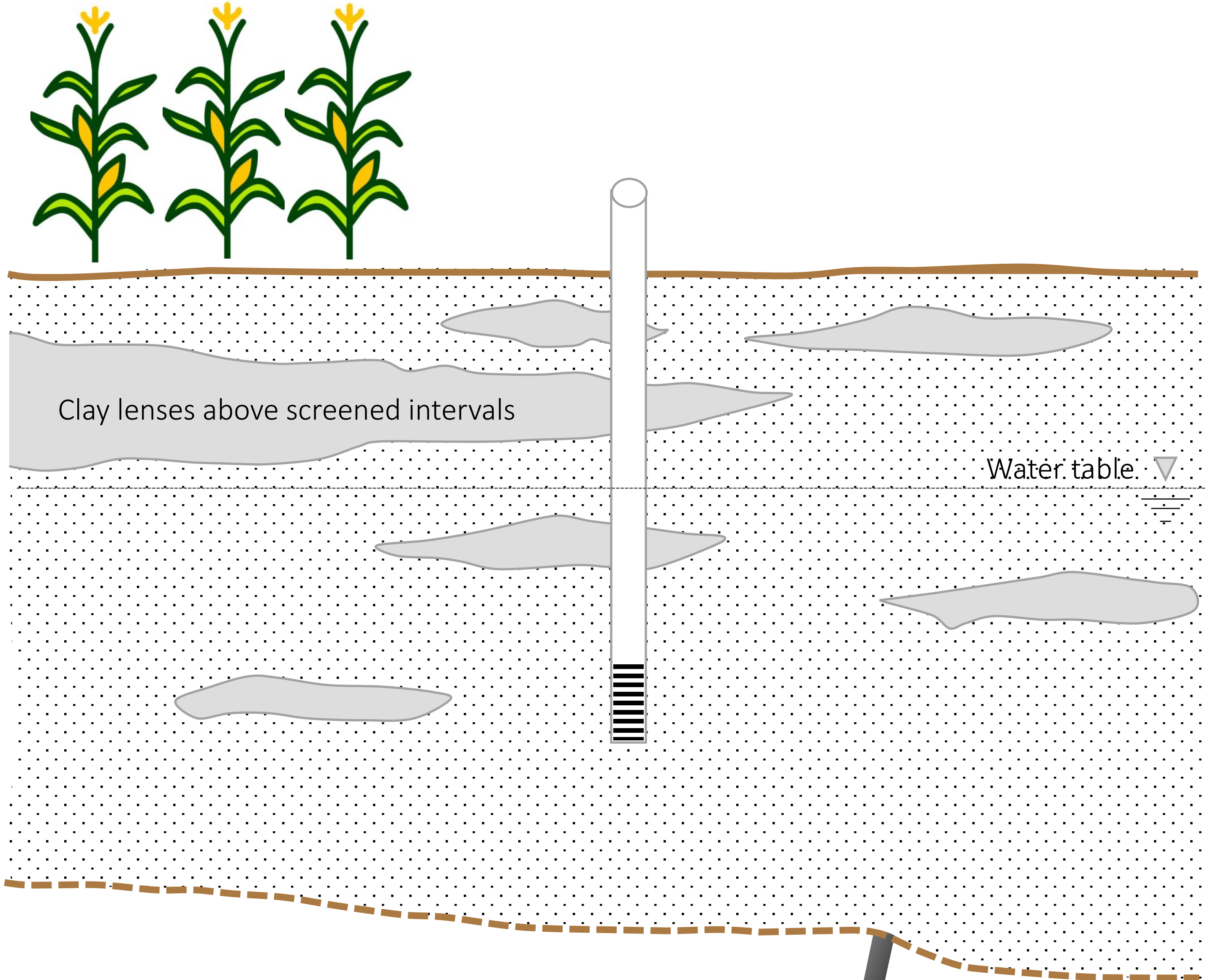
Well construction methods are important.

Water conservation measures might also be important for reducing vertical transport of nitrate.

Source of nitrate is linked to fertilizer – precision methods will help over time.

Direct push can be useful “rapid” screening tool to identify sites with shallow confining layers.

Next step: Can we use broader sampling campaign combined with the WWC5 database (well age and presence/depth of confining layers) to predict which wells may have higher nitrate concentrations?



Questions?

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- the Kansas Water Office for funding this research!
- Jim Butler, Steve Knobbe, Brook Armijo, and Masi Veisi