Managed Groundwater Recharge: Hydrologic Regime Change and Nitrogen Dynamics

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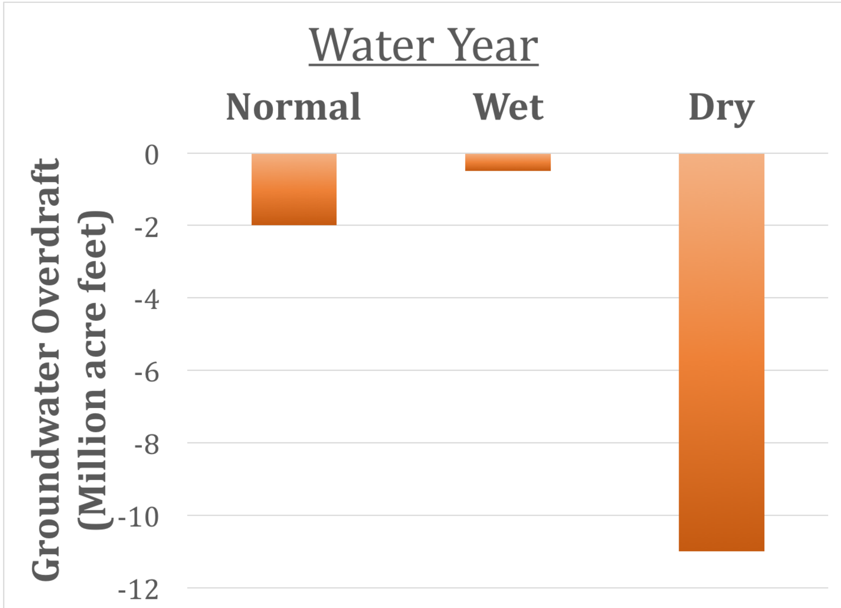
BACKGROUND

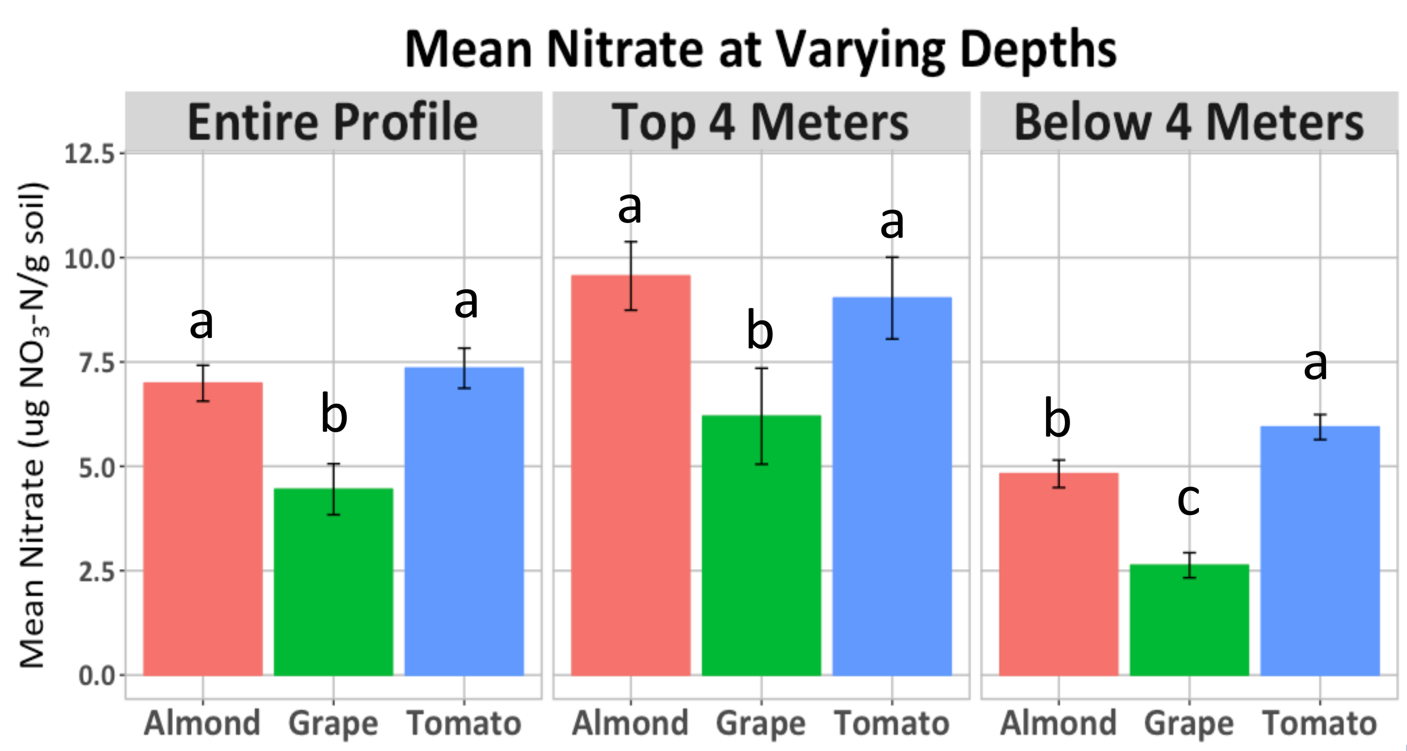
Groundwater overdraft is an increasing problem, especially during drought when surface water allocations are reduced. Application of flood flow to agricultural lands could recharge underlying aquifers and reduce flood damage to downstream areas. **However, uncertainties remain including the timing of groundwater recharge and the risk of nitrate (NO_3^-) leaching from cropping systems.** Denitrification represents a permanent sink of NO_3^- by converting it to N_2O and N_2 gas. Could denitrification attenuate NO_3^- on its path through the deep soil?



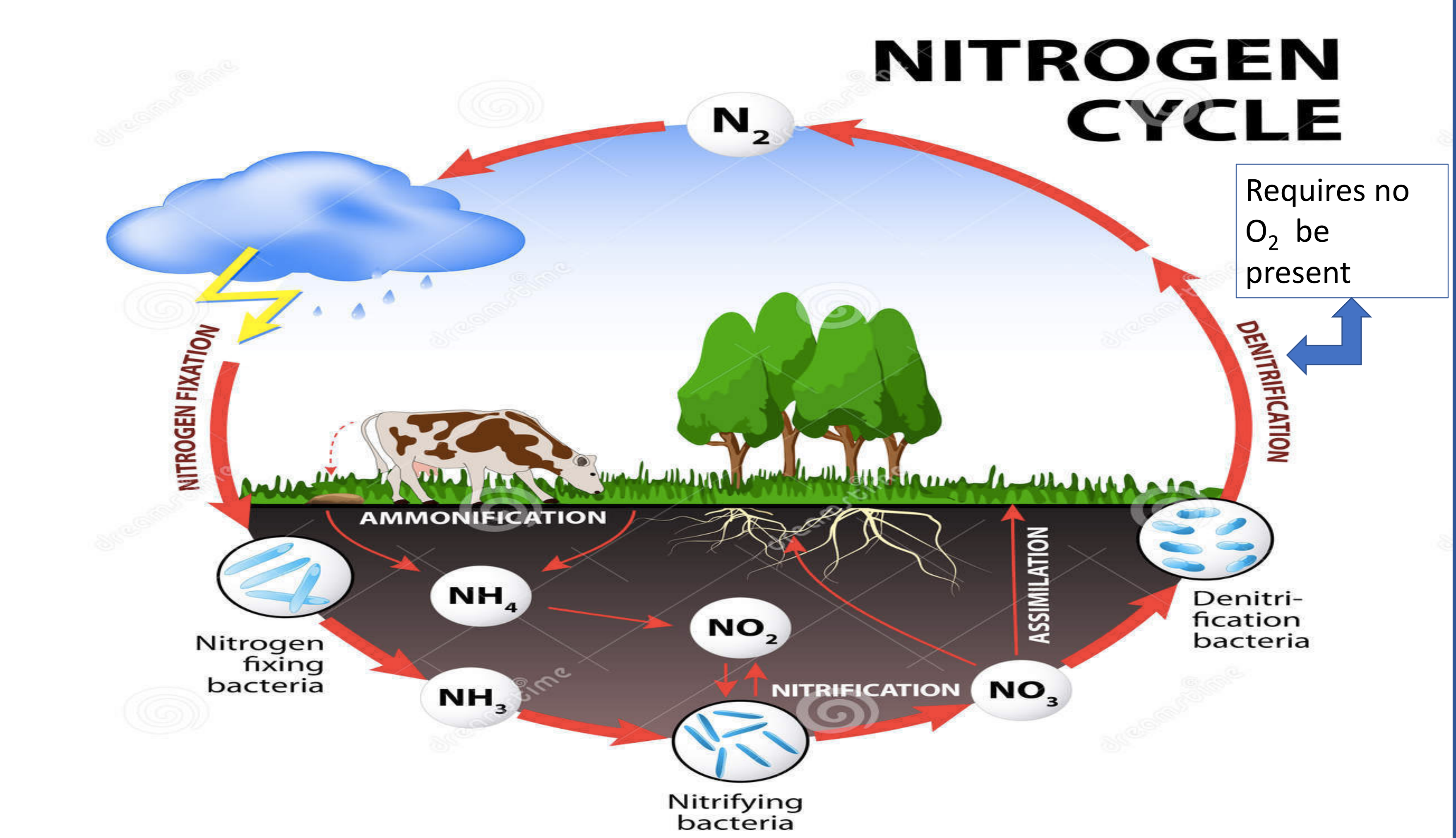
RESEARCH QUESTIONS

1. **How will groundwater banking affect NO_3^- loading to the underlying aquifer in almond cropping systems? How does this compare to other cropping systems?**
2. **How does groundwater banking influence N dynamics? Are N transformations occurring in the deep vadose zone?**
3. **What soil factors are influencing the fate of NO_3^- during groundwater banking?**

PREVIOUS RESULTS



- Grapes had the lowest mean NO_3^- concentrations compared to almonds and grapes, with no difference between almonds and tomatoes in the entire 9 meter profile and within the top 4 meters.
- The relationship between cropping system changed below 4 meters, with tomatoes having the highest NO_3^- concentrations.
- 78% of nitrate values were above EPA drinking water quality standard of 10 mg/L.
- Interaction between cropping system and soil type complicated interpretation: Almonds on hydrologic class A soils have lower NO_3^- levels than tomatoes on hydrologic class C soils

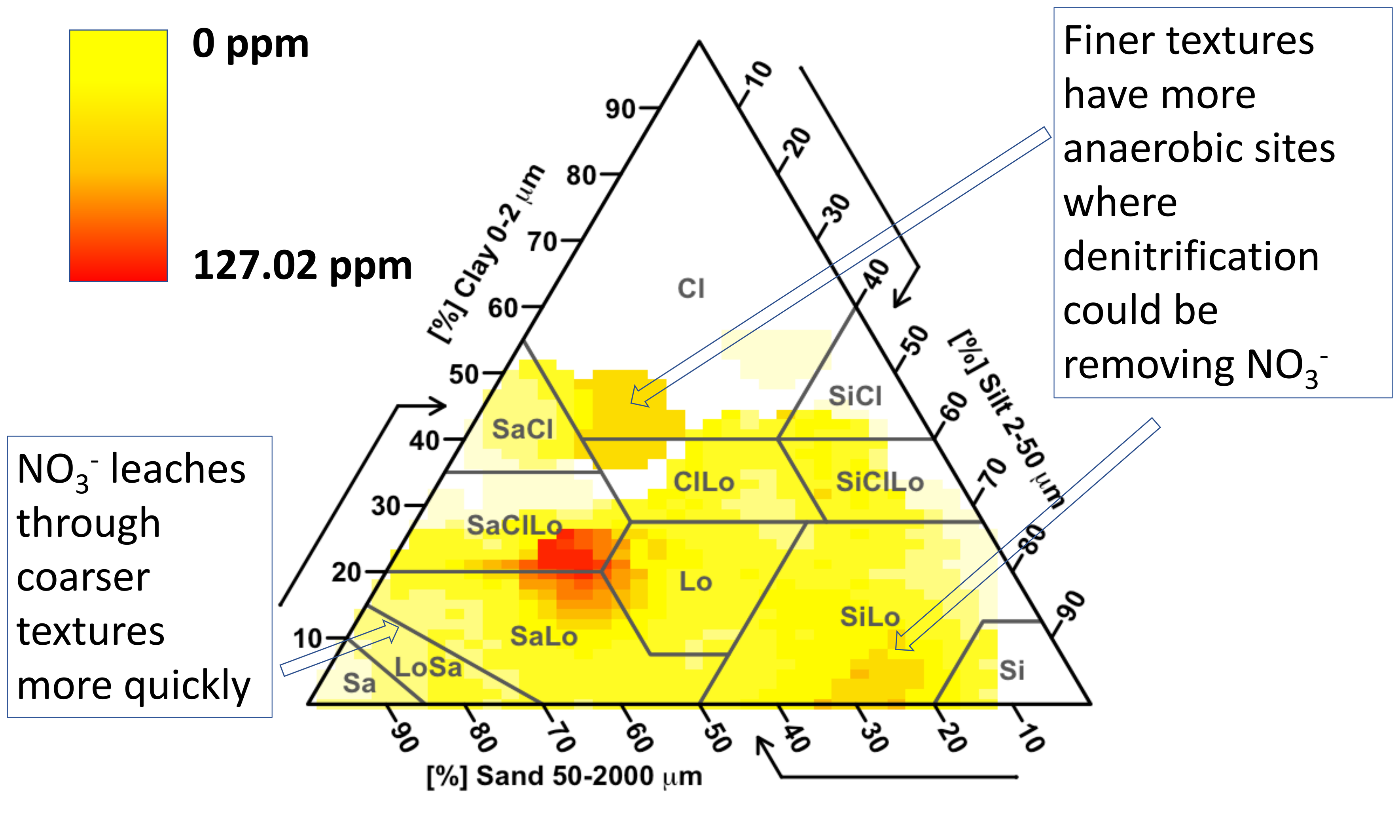


Evidence for denitrification?

Nitrate = DOC + Currently Available Iron + Potentially Microbially Available Iron + Silt + Clay		
	Coefficient Estimate	**Probability**
Intercept	2.138×10^{-16}	1.000
DOC	2.72×10^{-1}	0.001440 **
Currently Available Iron	-3.497×10^{-1}	0.108760
Potentially Microbially Available Iron	4.358×10^{-2}	0.827962
Silt	-1.99×10^{-1}	0.250041
Clay	3.872×10^{-1}	0.000183 ***
R^2 = 0.1531		
Significance Values: 0 (***), 0.001 (**)		

- Cores down to 30 ft were analyzed for dissolved organic carbon (DOC), Iron, and NO_3^- to determine what soil factors influence N dynamics
- DOC and clay are significantly, positively correlated with NO_3^- presence, with a slightly stronger effect from clay as determined by the standardized coefficient estimates
- Currently available Iron (II) is negatively correlated with NO_3^-, however the relationship is not significant

Nitrate by Soil Textural Class



DISCUSSION

- Groundwater banking temporarily changes the hydrologic regime of a cropping system and has the potential to affect nitrogen dynamics
- Ammonification (the conversion of organic N to inorganic NH_4^+) and denitrification are dependent on water content, electron donors (DOC, Iron), and substrate (NO_3^-).
- The presence of DOC and iron could indicate the potential for microorganisms to use them to convert NO_3^- to gaseous forms
- A significant positive relationship between DOC and NO_3^- are not indicative of denitrification - could this indicate ammonification in the deep vadose zone?
- Almonds have mean DOC levels in the deep vadose zone compared with tomatoes (data not shown) which could influence nitrogen transformations at depth, implying that organic inputs at the surface could be affecting deep vadose zone processes

CONCLUSIONS

- Almonds have higher DOC levels at depth which could be the reason for the shift in differences of NO_3^- between cropping systems
- Significant interaction between soil hydrologic class and cropping system indicates a need to look at both for choosing appropriate sites for groundwater banking
- Groundwater banking temporarily changes the hydrologic regime of a cropping system and may have an impact on nitrogen dynamics

NEXT STEPS

- Conduct denitrification potential and mineralization potential assays at varying moisture contents reflective of normal irrigation practices as well as under groundwater banking management
- DNA analysis of microbial community in the deep vadose zone to see potential mediating pathways for N transformation
- Isotopic analysis of ^{15}N and ^{18}O for evidence of denitrification

REFERENCES AND ACKNOWLEDGEMENTS

- Bachand, Philip A. M., Sujoy B. Roy, Joe Choperena, Don Cameron, and William R. Horwath. "Implications of Using On-Farm Flood Flow Capture To Recharge Groundwater and Mitigate Flood Risks Along the Kings River, CA." *Enviromental Science & Technology Environ. Sci. Technol.* 48.23 (2014): 13601-3609.
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