The Role of Riparian Buffer Zones in the Mitigation of Groundwater Nitrate in the Cosumnes River Floodplain

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Introduction

Groundwater is an essential resource to California, as it is an important source for urban, residential and agricultural water. This study addresses nitrate contamination and depletion of California groundwater and mitigation strategies related to restoration of a natural floodplain. The study site is located on the Cosumnes River floodplain, which is currently undergoing restoration (Fig 1).

The objectives of this study are:

- Evaluate the role of riparian buffer zones in the mitigation of groundwater nitrate
- Estimate groundwater recharge of a restored floodplain.
- Compare nitrate and groundwater dynamics to established soil carbon stocks that were measured for an associated carbon sequestration study under the CRGIII.
- Evaluate how restoration of the Cosumnes floodplain affects nitrate removal and groundwater recharge.

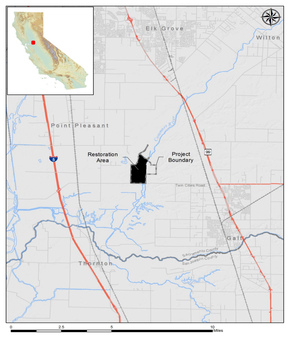

Fig 1. Cosumnes River Preserve, project area shown in black

Methods

Fig 2. Project area with floodplain groundwater monitoring wells indicated by red points and riparian wells indicated by blue points.

- Sampling of all 13 groundwater monitoring wells occurs monthly/ bimonthly.
- NO^{3-}-N (ppm) was determined by colorimetric analysis using VCl_3 to reduce nitrate to nitrite.
- Samples were analyzed at the UC Davis Stable Isotope Facility for $\delta^{15}N_{NO3}$ (‰) and $\delta^{18}O_{NO3}$ (‰).
- Soil texture was evaluated by hand and %C determined by an elemental analyzer

Project Background

This study is being conducted under the third phase of the Cosumnes River Group (CRGIII). CRGIII is running an experimental restoration on approximately 350 ha of flooded riparian forest habitat in the Cosumnes River Preserve by hydrologically reconnecting the floodplain just west of the Cosumnes River through levee breaching and removal. Vegetation of the floodplain to oak woodland and savannah ecosystems will follow the hydrologic reconnection. This study utilizes the monitoring framework already established for other CRGIII research projects to evaluate nitrate contamination,depletion of California groundwater, and mitigation strategies related to restoration of a natural floodplain.

Results and Discussion

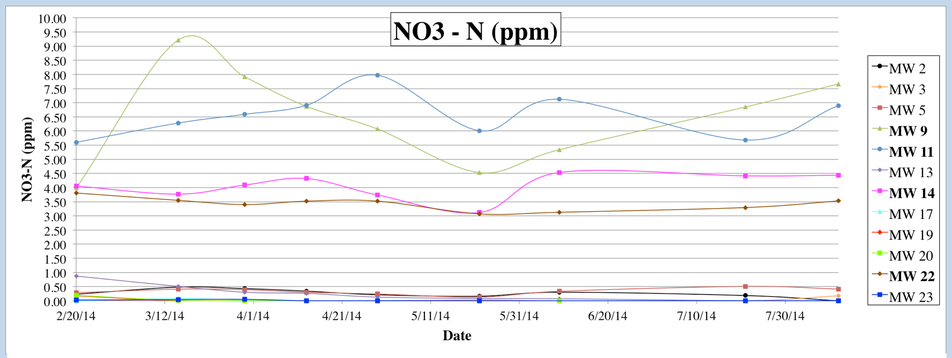

Fig 3. NO3-N concentrations (ppm) for all well sites over time.

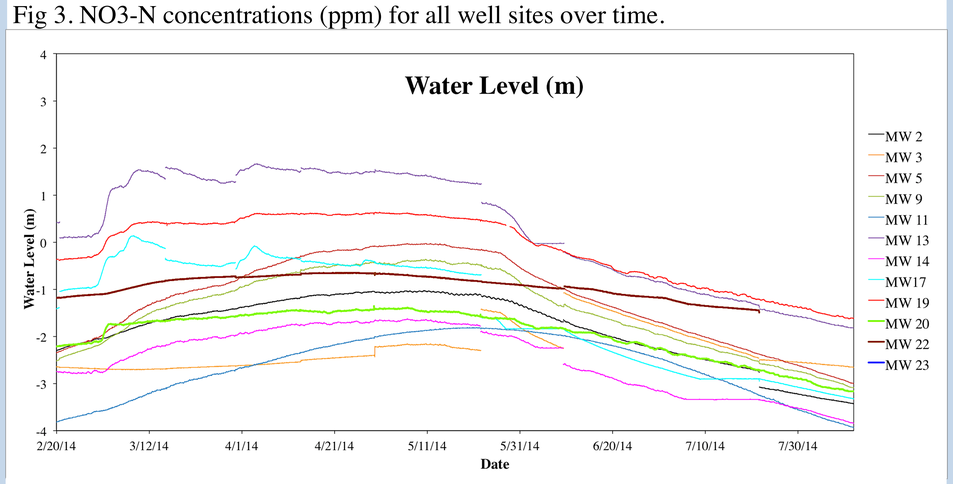

Fig 4. Water levels in each well over time.

- **Nitrate levels in the wells are significantly lower in the riparian areas than in the floodplain areas ($p = 7.85\times10^{-10}$ – Welch 2 Sample T Test).**
- **Generally NO^{3-} concentrations reached a minimum right before the water levels began to decline.**
- **Groundwater flow seems to affect seasonal fluctuations in NO^{3-} concentrations but does not explain the differences seen between ecosystems.**

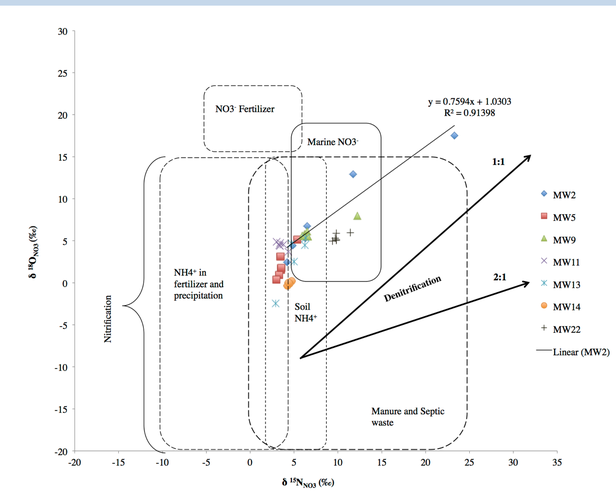

Fig 5. $\delta^{15}N_{NO3}$ vs $\delta^{18}O_{NO3}$ of NO^{3-} for sites with measureable concentrations. This plot uses the typical values of15N vs 18O for various sources based on Kendall et al., 2007.

- **Nitrate sources include nitrification from manure and septic waste, soil NH^4, and NH^4 from fertilizer.**
- **Analysis shows denitrification is occurring in MW 2 given the regression line with slope similar to the 1:1 denitrification ratio.**

Conclusions

Nitrate concentrations are significantly lower in riparian wells indicating riparian areas may be removing nitrate from the groundwater. Preliminary results suggest that riparian vegetation is the driving factor for overall nitrate concentration differences while groundwater flow affects seasonal fluctuations seen within the wells. More rigorous statistical work is needed to look into how soil texture, soil carbon, groundwater flow and vegetation play a role in the differences in nitrate concentrations of the wells. Isotopic analysis suggests the source for much of the nitrates is nitrification occurring in the soil. Denitirification is occurring in MW 2 which may be related to the very clay rich texture or possibly the microbial community associated with the Shaw Forest. We plan to run QPCR analysis on soils from MW2 to try and identify microbial denitrifiers.

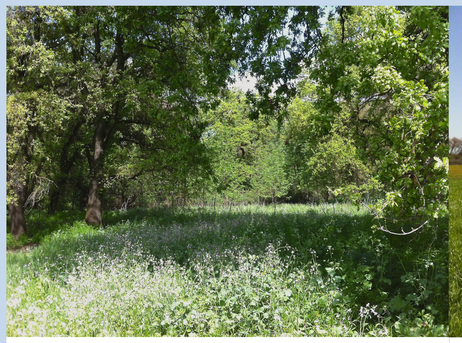

Fig. 6 Riparian habitat (MW 2)

Fig. 7 Floodplain with perennial grasses, forbes, and invasive weeds. (MW 9)

- **MW2 has more established vegetation with a deeper rooting zone.**
- **The vegetation could account for the differences seen in the nitrate concentrations of the riparian and floodplain wells.**

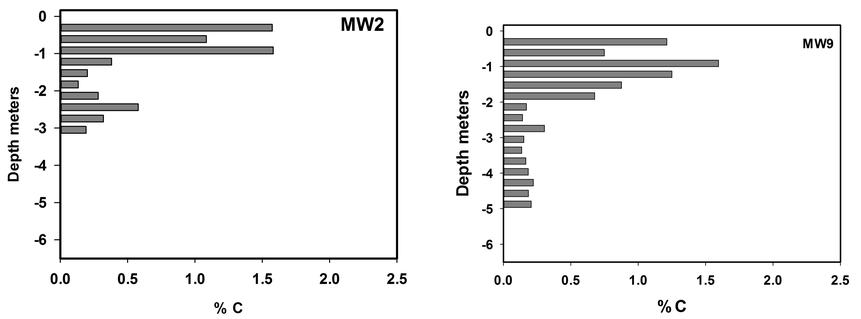

Fig 8. Percent Carbon graphs with depth for both MW2 and MW9.

- **More carbon tends to be stored in the floodplain soil than in the riparian soils because flooding events can bury a surface horizon which limits C decomposition and use**

Soil Series (same for both sites): Columbia – Aquic Xerofluvent

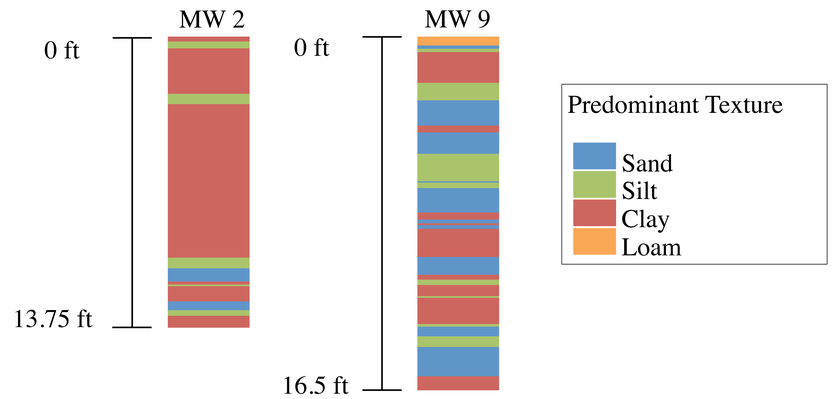

Fig 7. Dominant soil texture with depth for MW 2 and MW9.

- **MW2 has significantly finer texture than MW9**
- **The water table is higher at MW2 than at MW9**
- **The fine texture of MW2 may promote the denitrification seen in the isotopic analysis**

Acknowledgements

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References: Kendall, C., et al. (2007), Tracing anthropogenic inputs of nitrogen to ecosystems, in Stable Isotopes in Ecology and Environmental Science, edited by R. H. Michener and K. Lajtha, 592 pp., Blackwell, Malden, Mass.