Spatial modeling of elevated groundwater nitrate concentrations using random forests and regression kriging

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How do we find vulnerable areas to best focus projects?

Screening Approach:
Where do nitrogen sources and geologic vulnerability overlap?

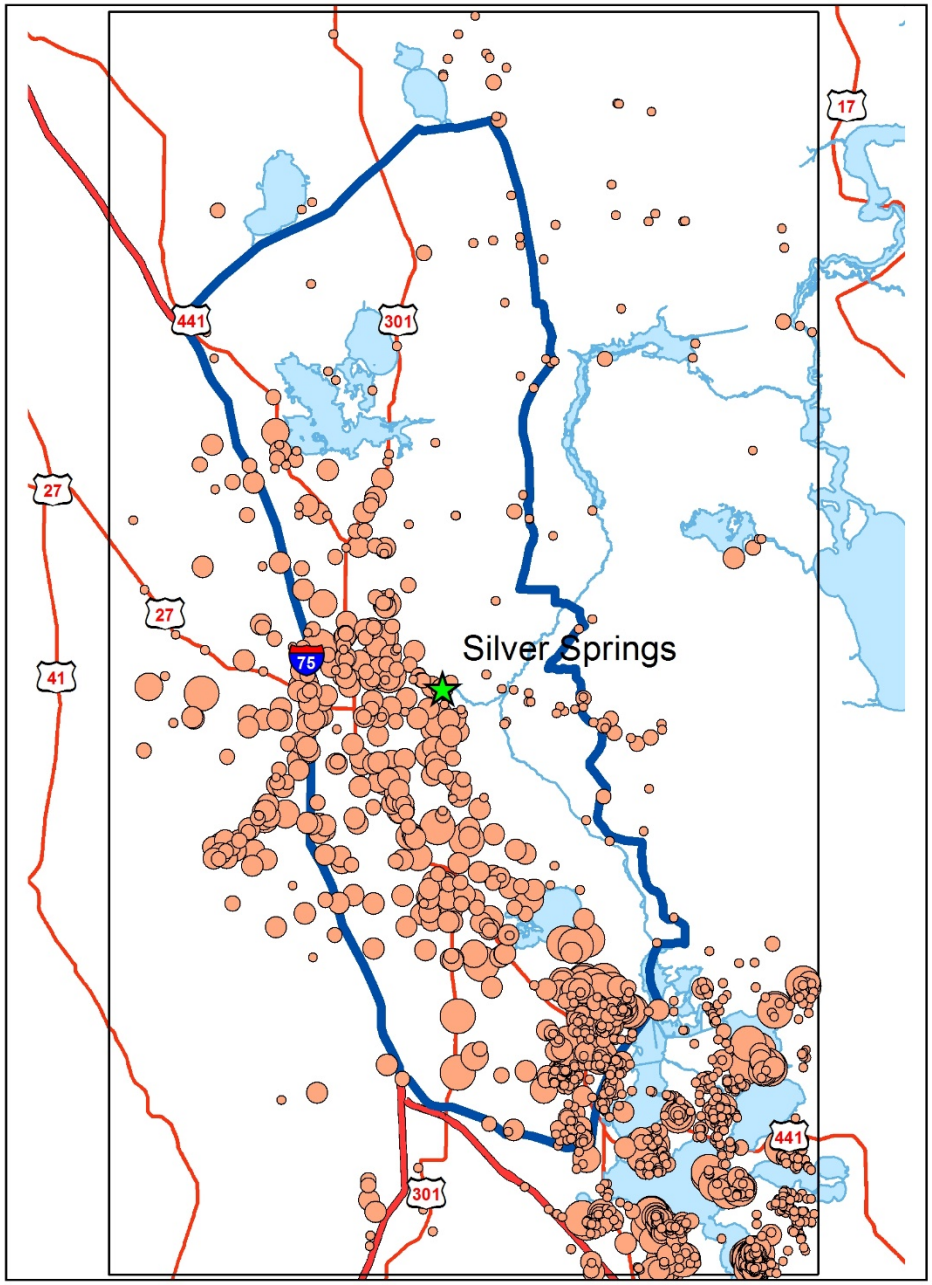
Can we use the wealth of nitrate data from well monitoring to focus efforts?

Mean Nitrate

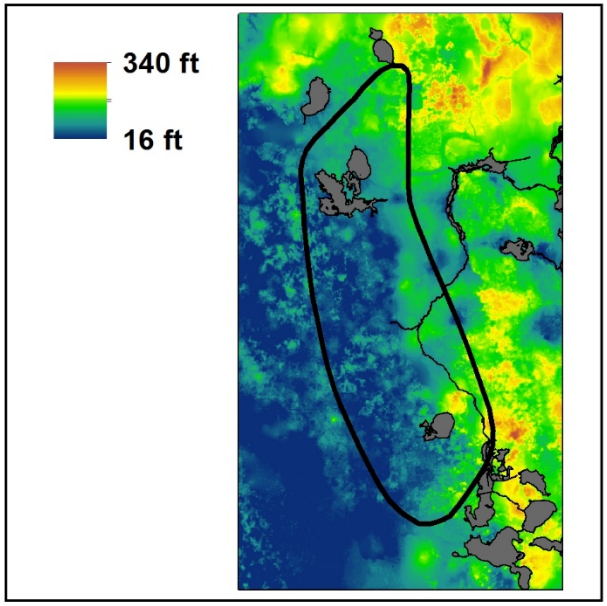
- 0.0 - 0.35 mg/L
- 0.35 - 1.0 mg/L
- 1.0 - 3.0 mg/L
- 3.0 - 5.0 mg/L
- 5.0 - 17.0 mg/L

Silver Springs BMAP Boundary

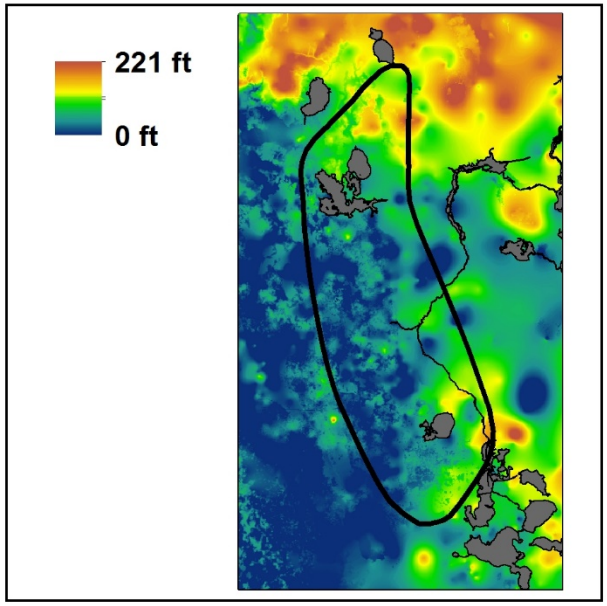
Dataset	# Wells	POR
FDEP Public Water System (PWS)	499	2009 – 2013
FDEP Water Supply Restoration (WSRP)	968	2000 – 2015
SJRWMD	44	2000 – 2013
SWFWMD	7	2000 – 2013
USGS (Phelps 2004)	36	2001 – 2002



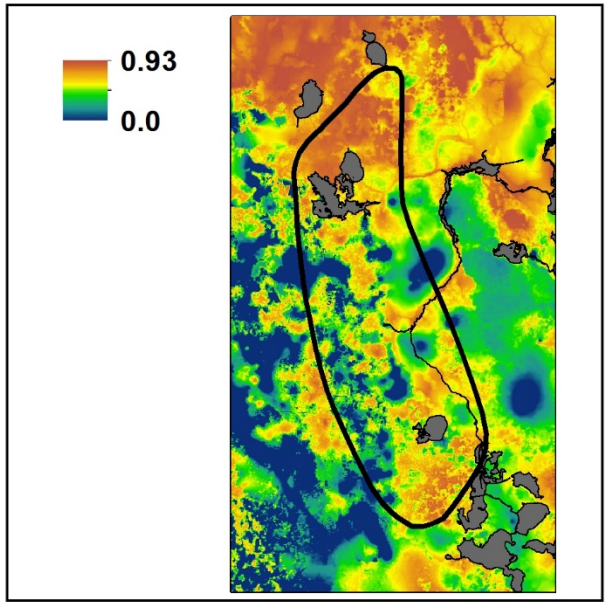
Depth to UFA



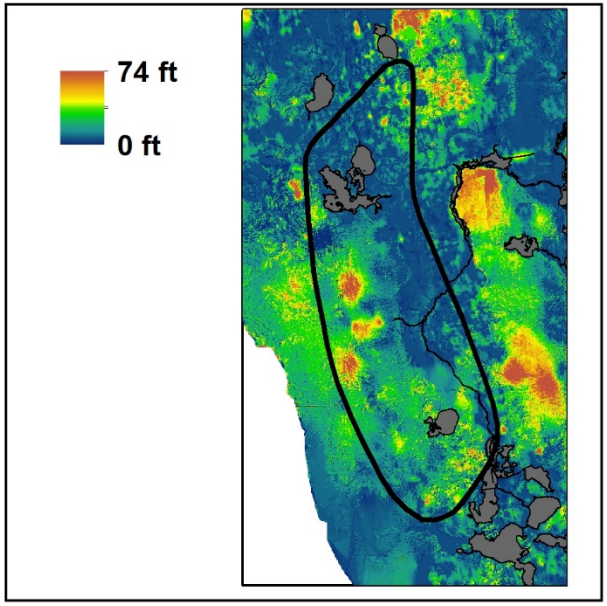
ICU Thickness



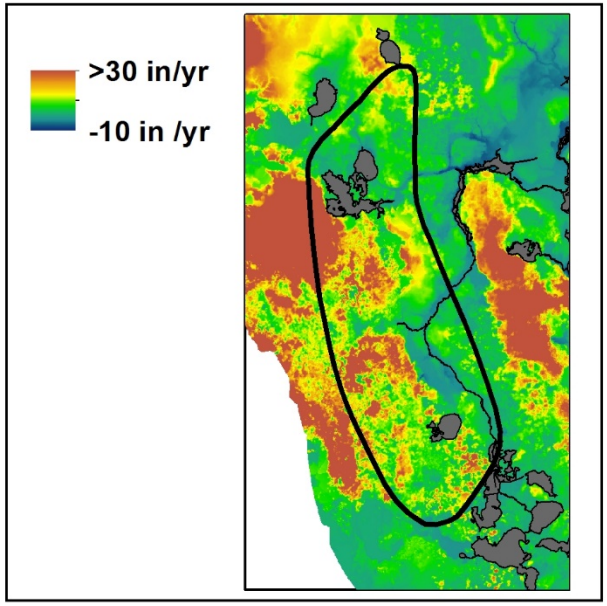
ICU to OB ratio



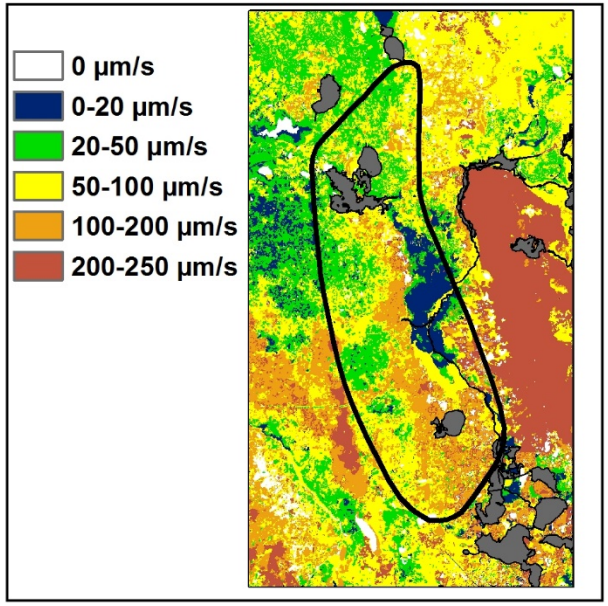
Water Table Depth



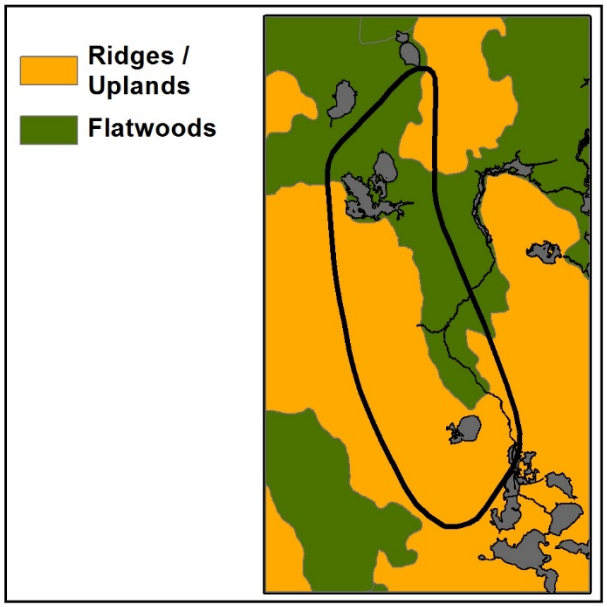
UFA Recharge



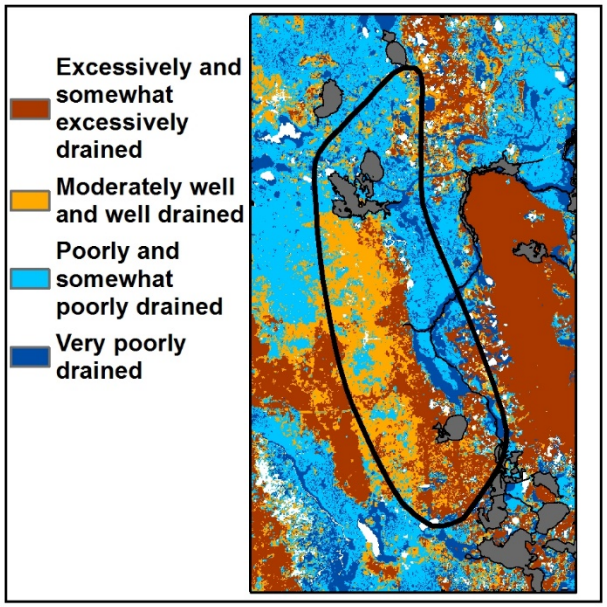
Soil Hydraulic Conductivity (Ksat)



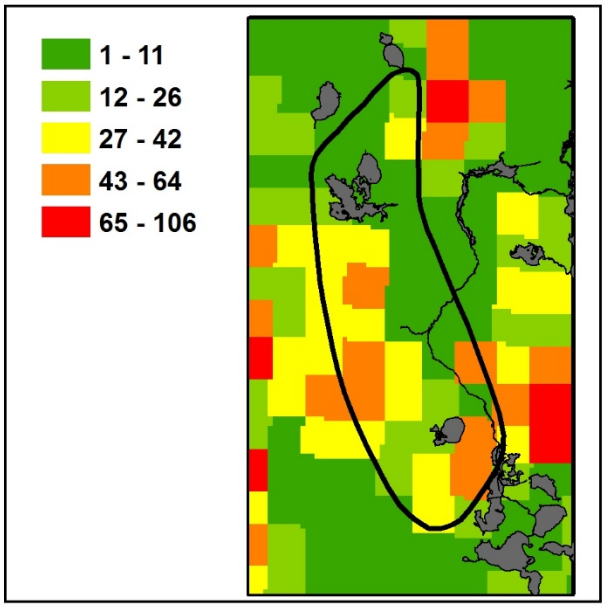
Ecoregions



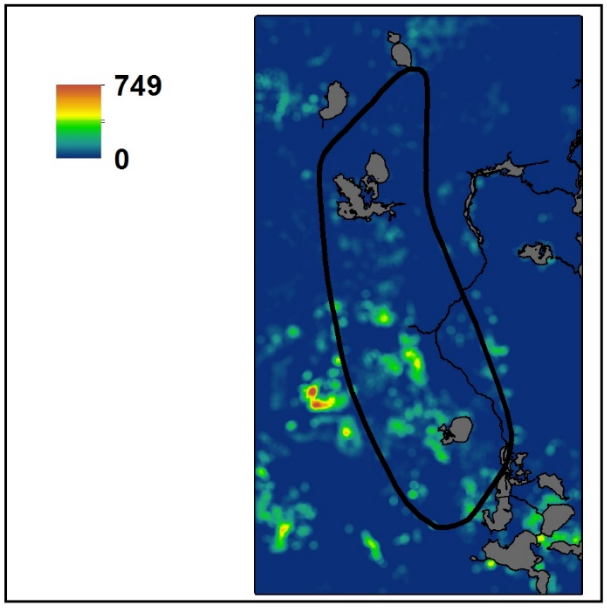
Soil Drainage Class



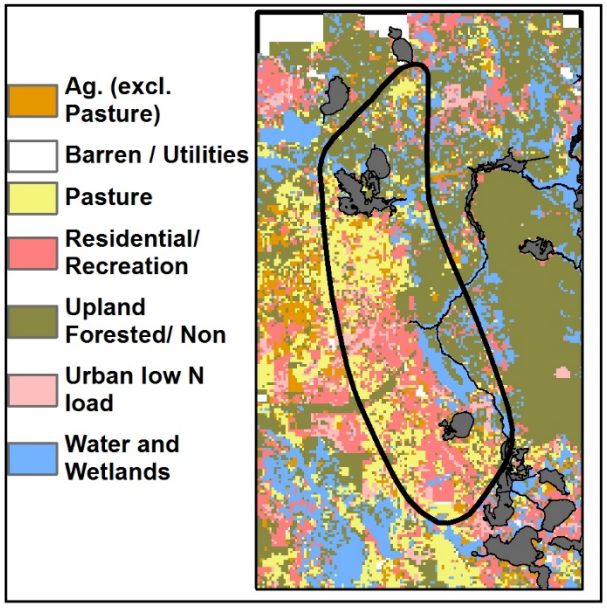
Sinkholes - Number per 25 sq mi



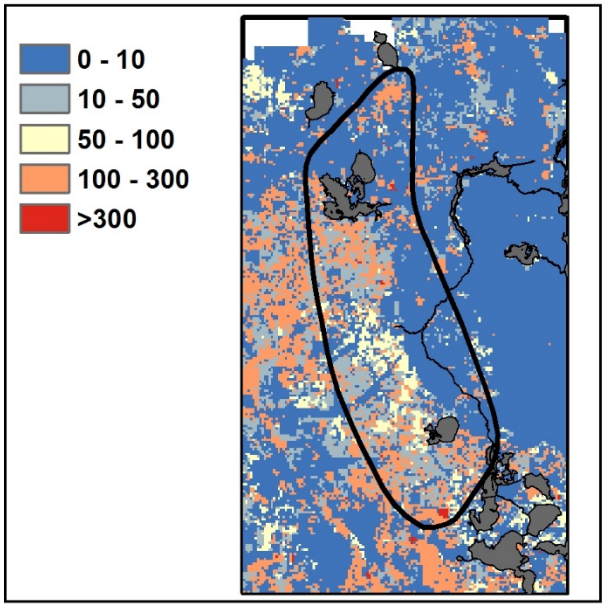
Septic Tanks- Number per sq. km



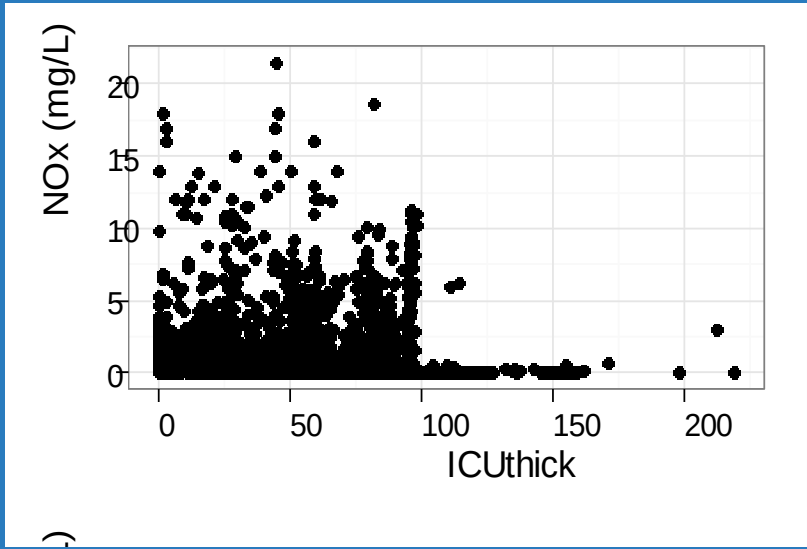
Dominant Land Use (25 ha Grid)

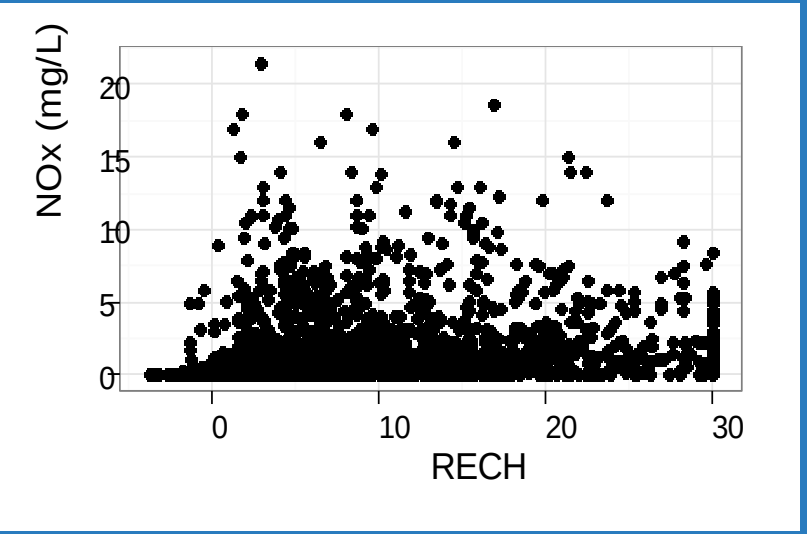


Land Surface N Load (Kg/Ha)

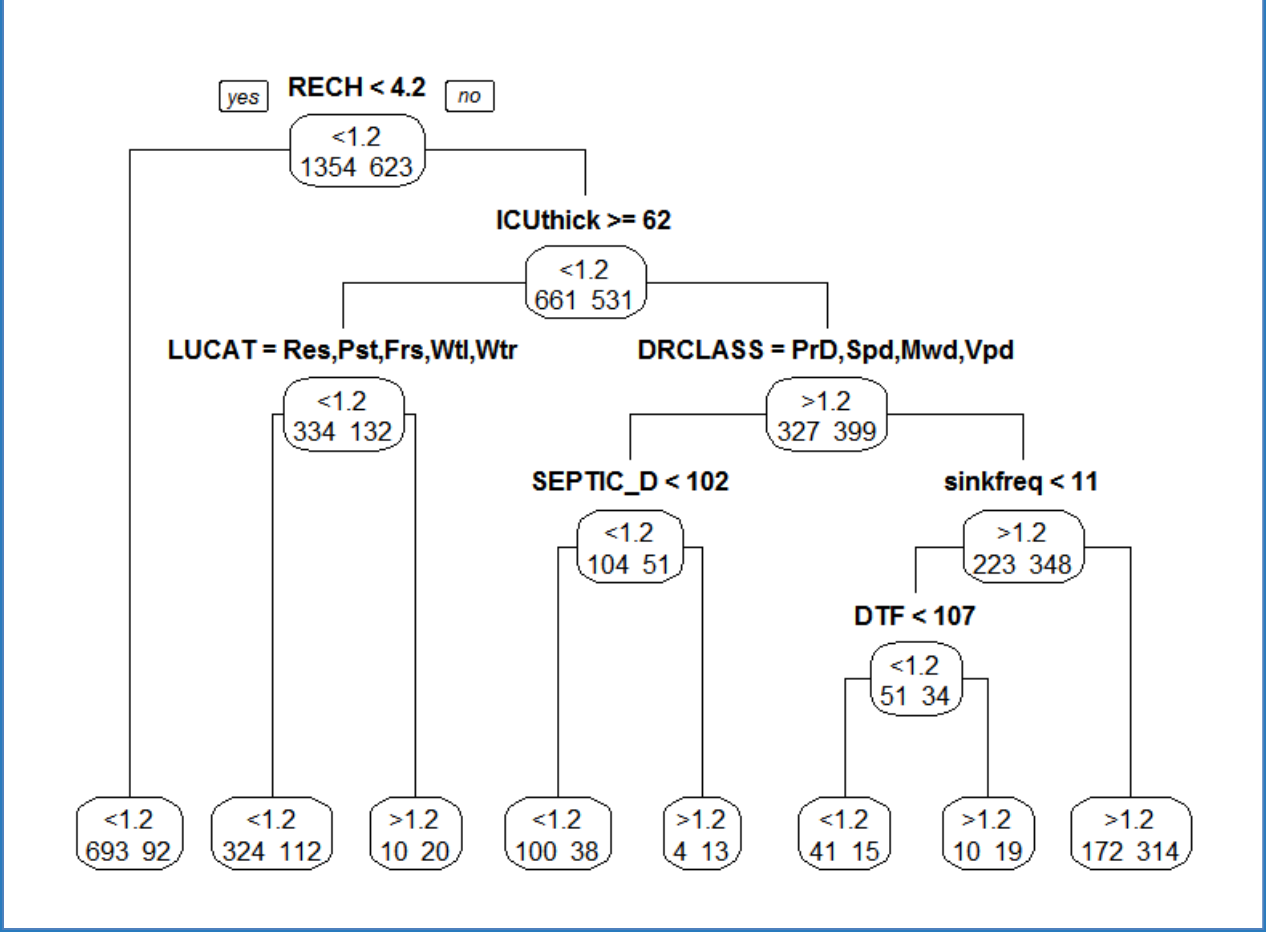


Is there information in the data?

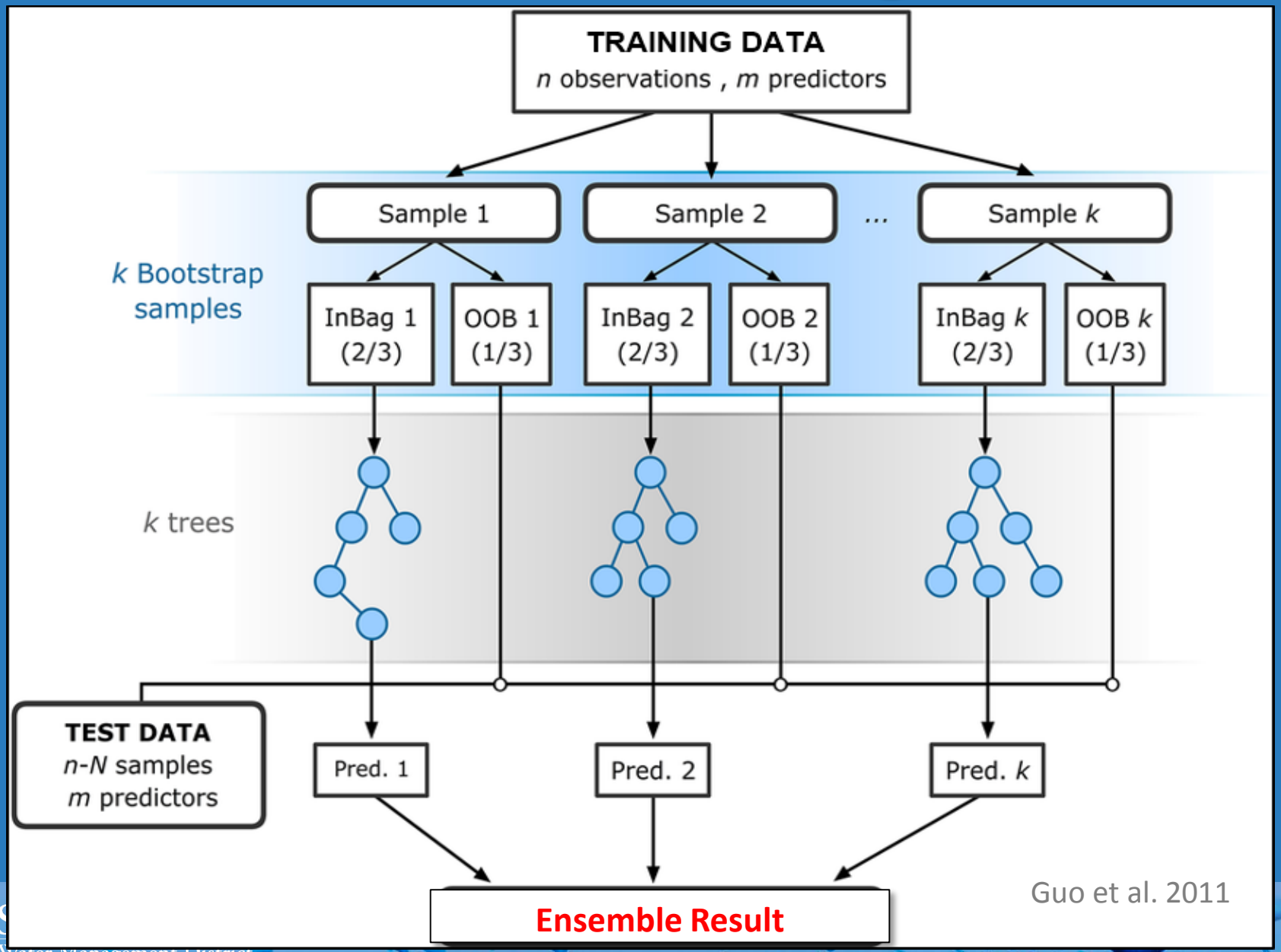




Regression Tree Approach



Random Forest Algorithm

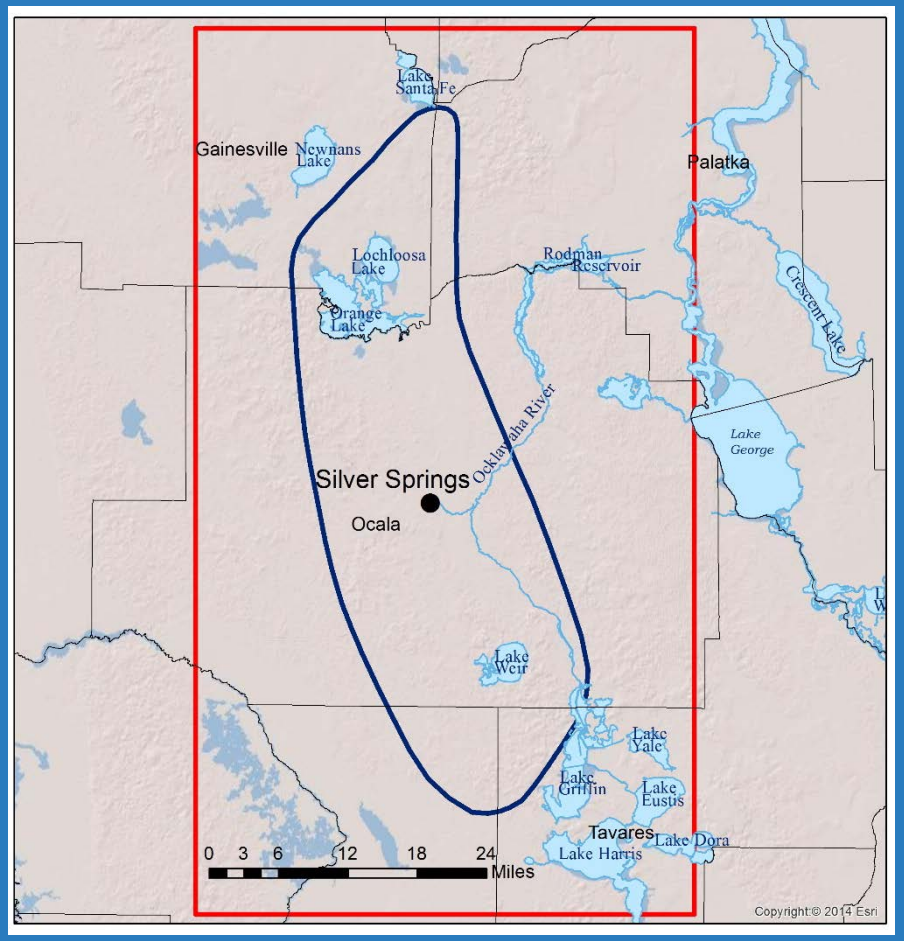


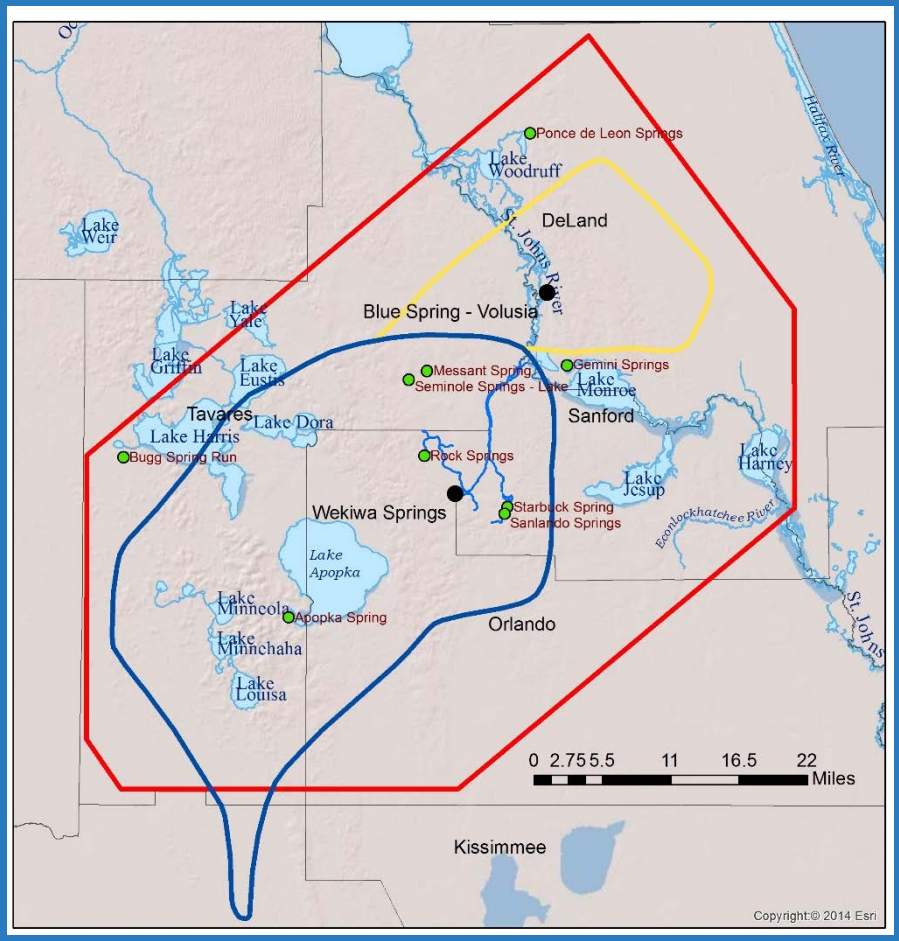
Guo et al. 2011

Random Forest Classification Model

Probability of nitrate exceeding a chosen threshold is predicted by:

- Well Depth
- Confinement
- Aquifer Depth
- Recharge
- Water Table Depth
- Soil Hydraulic Conductivity
- Soil Drainage Class
- Ecoregion
- Sinkhole Frequency
- Land Use
- Nitrogen Load
- Septic Density





Legend

- Silver Springs Main Vents
- County Boundaries
- Silver Springs Springshed
- Model boundary

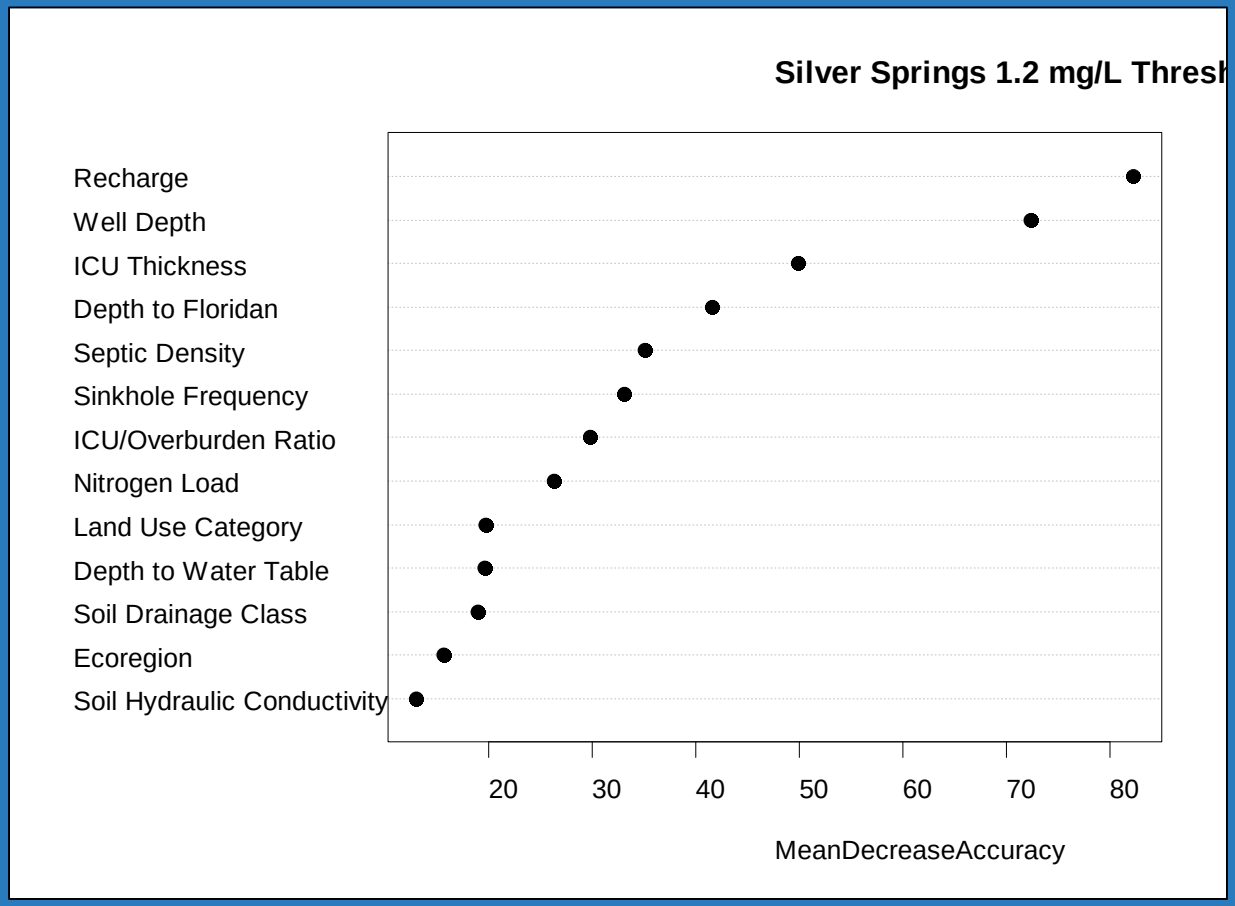
Legend

- Wekiwa and Blue Springs
- Other 2nd magnitude springs
- Wekiva River
- Wekiwa Springs Springshed
- Blue Springs (Volusia) Springshed
- Model Boundary
- County Boundaries

Model Diagnostics

Model Area	Nitrate Threshold (mg/L)	Predictor Variable Subset (m)	Number of Trees	Out-of-Bag Error	Area Under ROC Curve
Silver	0.35	2	1,000	17.31%	0.89
Silver	1.2	7	1,000	21.24%	0.84
Wekiwa/ Blue	0.35	2	1,000	21.25%	0.86
Wekiwa/ Blue	0.8	2	1,000	20.75%	0.86

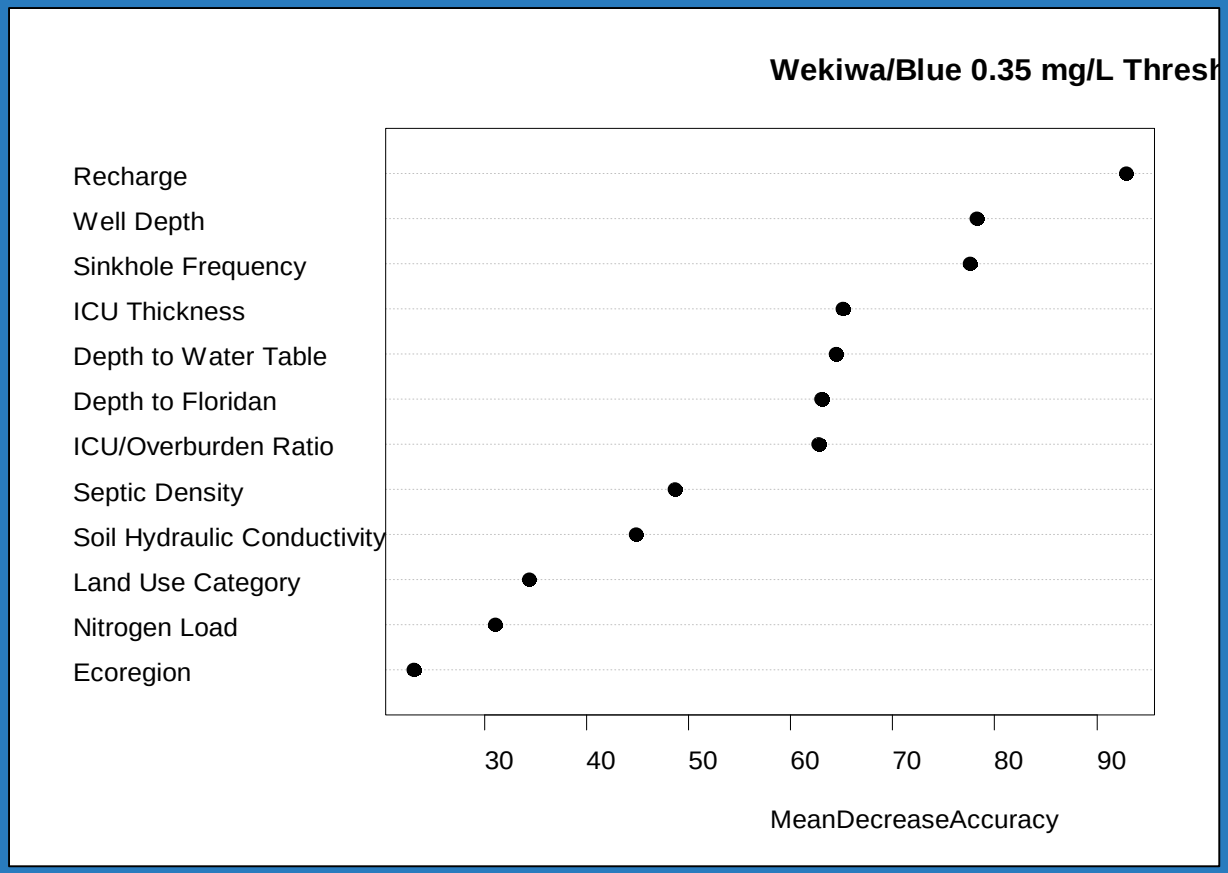
Model Diagnostics - Silver



Geology / Hydrogeology

Soils, Loading

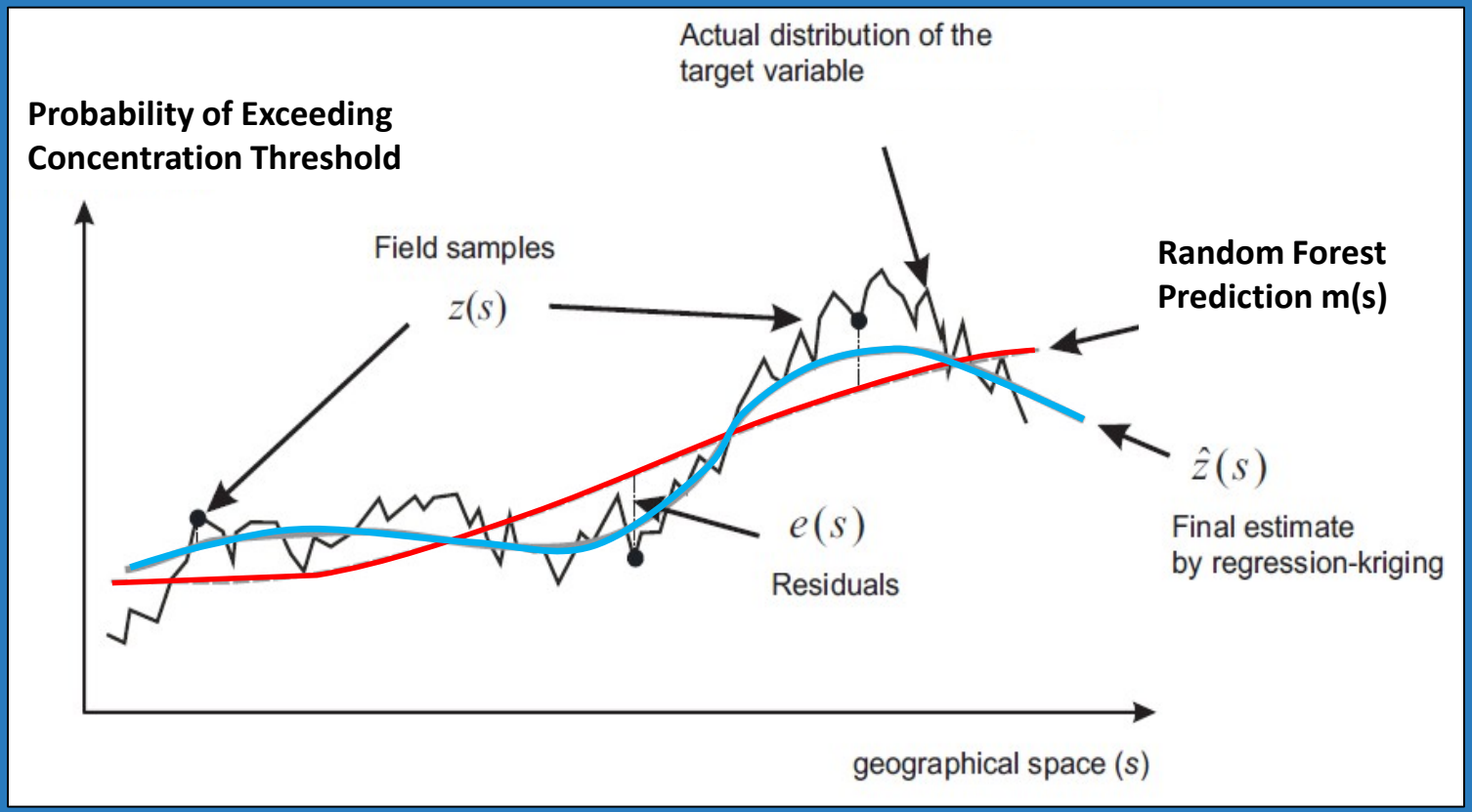
Model Diagnostics – Wekiwa/Blue

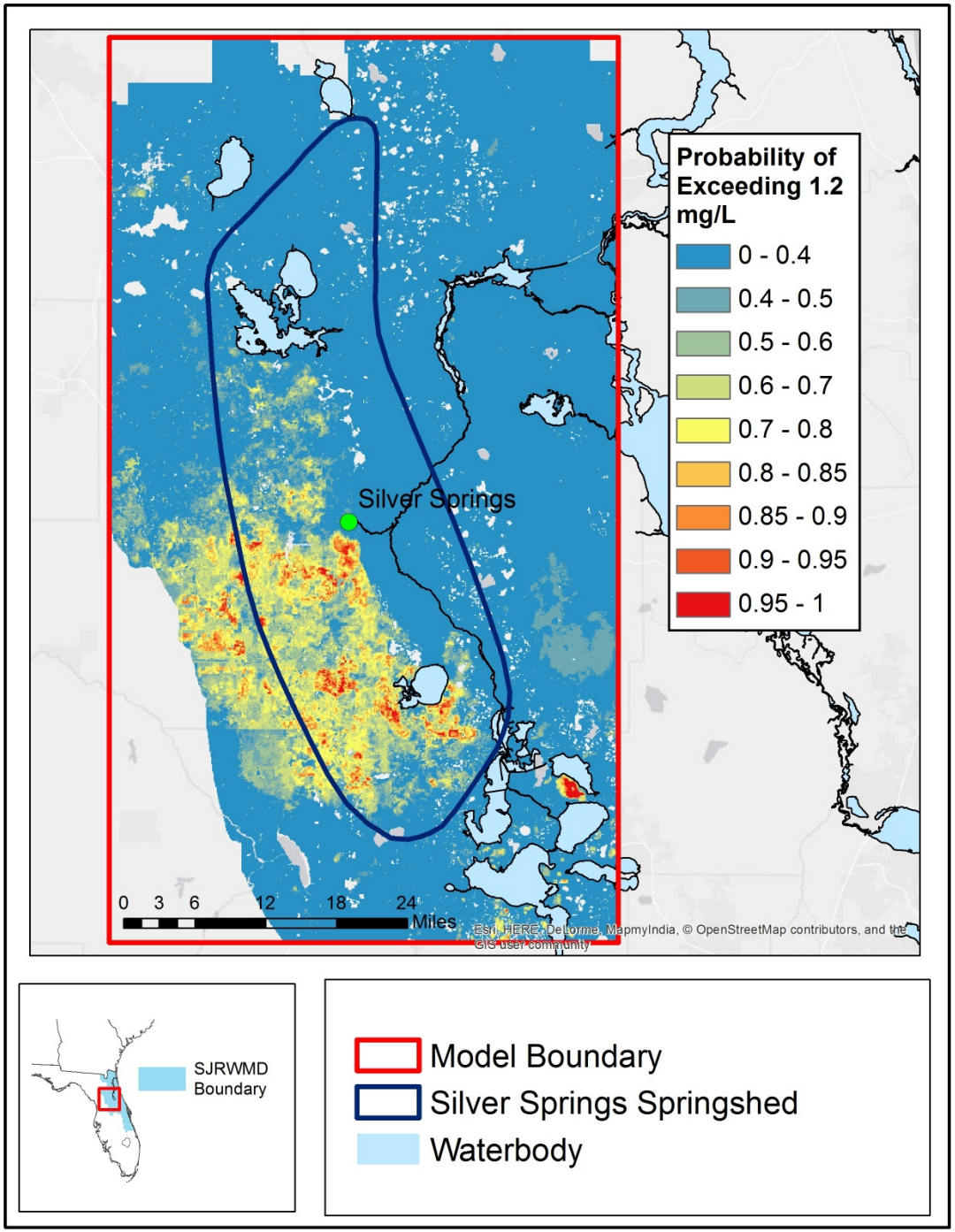


Geology / Hydrogeology

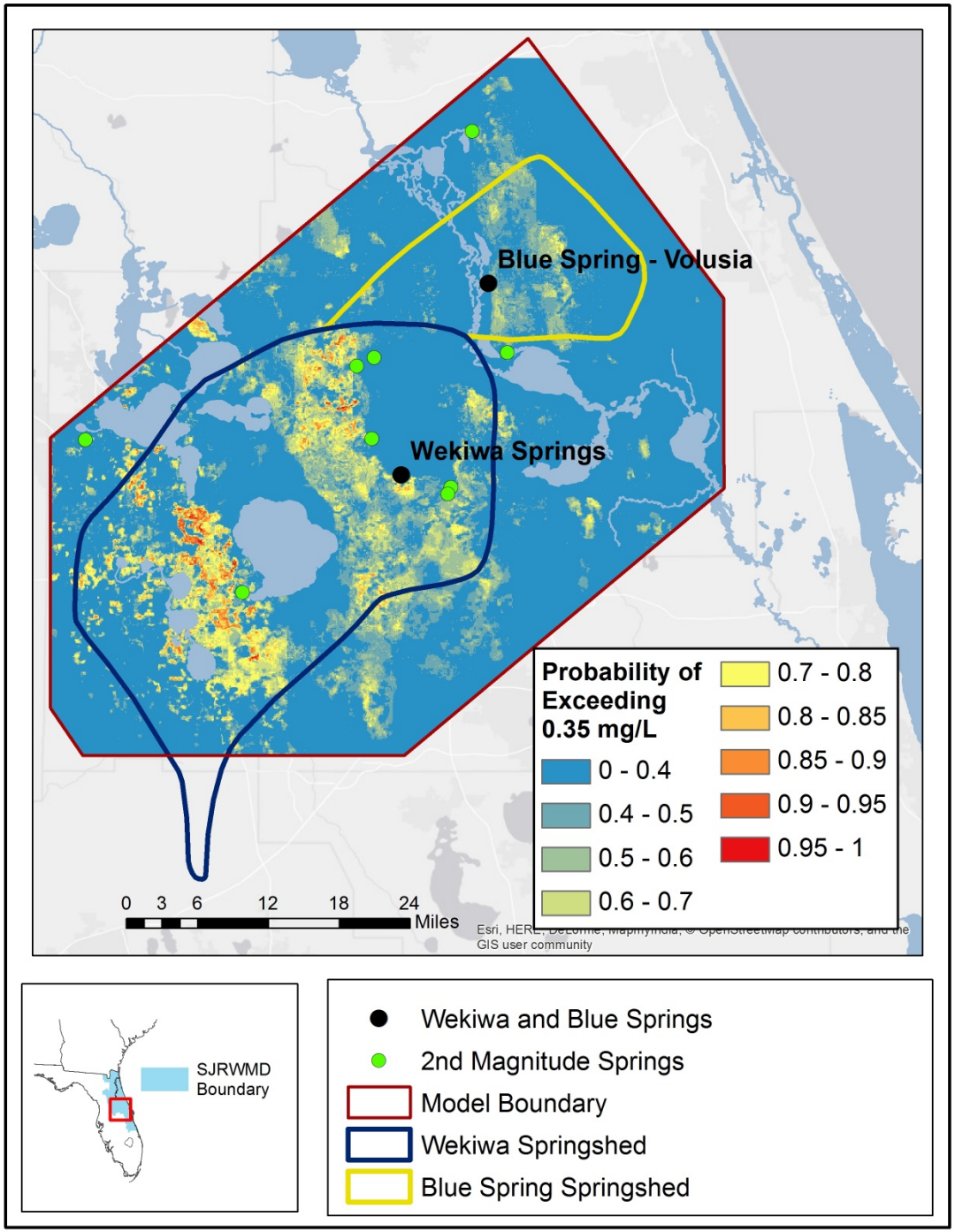
Soils, Loading

Kriging of Random Forest Residuals





Includes kriged residuals



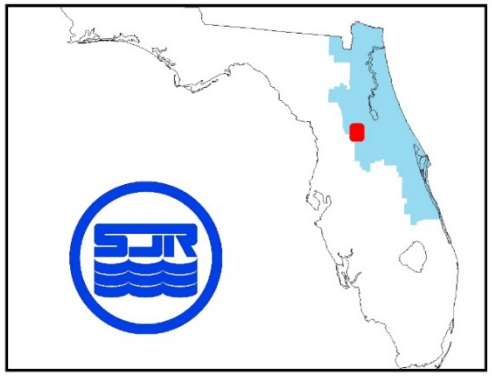
No spatial correlation in residuals – not kriged

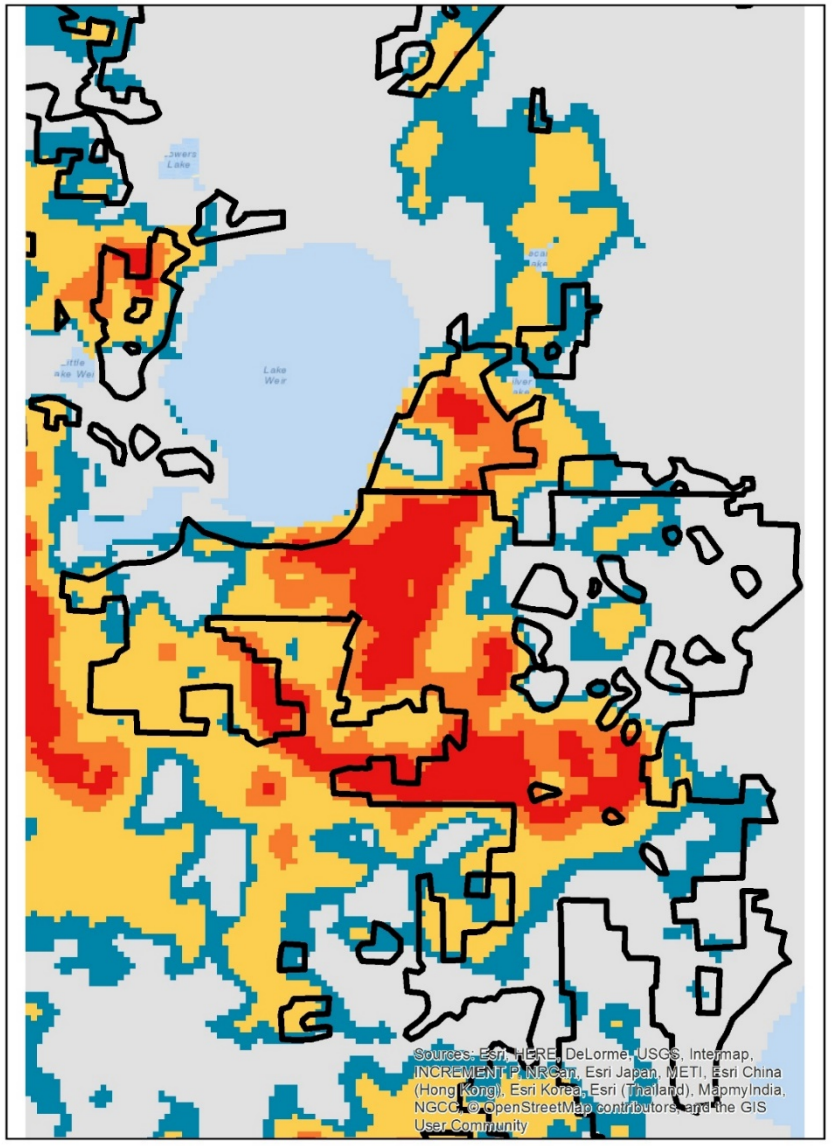
Legacy Nitrate

1970's Land Use - Orchards and Groves (USGS)

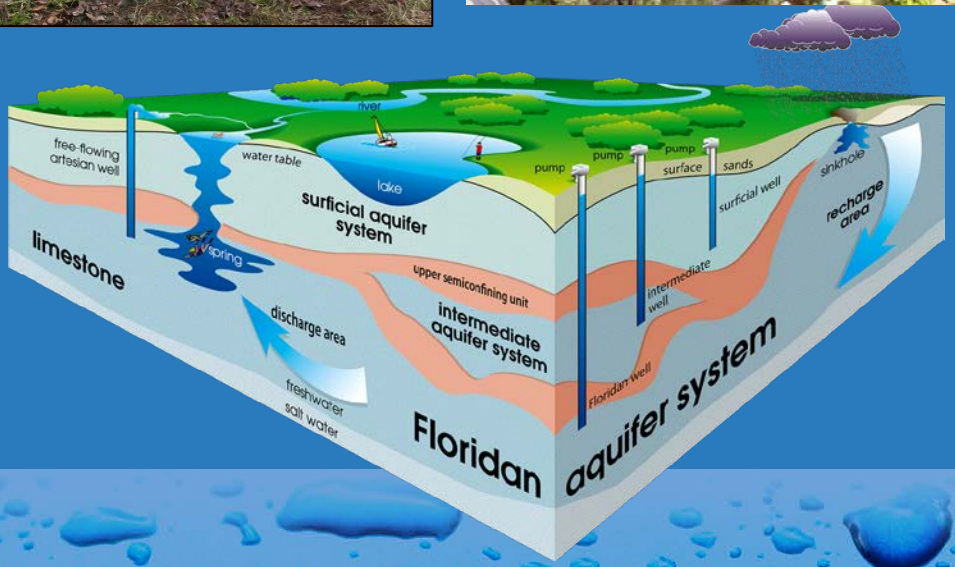
Probability of Exceeding 1.2 mg L^{-1} Nitrate

- < 40%
- 40 -50 %
- 50 - 70 %
- 70 - 80 %
- 80 - 100 %





Thank You



St. Johns River
Water Management District