Spatial variations in inorganic soil nitrogen concentrations across an arid urban ecosystem

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Abstract

Using data from the Survey 200 probability-based integrated inventory, we explored the contribution of human-related variables to explaining observed variation in inorganic soil nitrogen (N) concentrations across the CAP LTER study region. Data were examined using spatial statistics on the desert and urban sites separately, as well as for the entire region. Latitude, land use history, population density, along with per cent cover of impervious surfaces and lawn, best explained the variation observed in soil nitrate concentrations across the entire region. Regional variations in soil ammonium concentrations were related to only latitude and population density. Within the developed urban area, patterns in both soil nitrate and ammonium were best predicted by elevation, type of irrigation and income level in the surrounding neighborhood. Concentrations of both forms of inorganic N were markedly higher and showed significantly greater spatial heterogeneity between urban sites, compared to the surrounding desert. Spatial autocorrelation of soil nitrate concentrations among desert sites was absent for the urban sites, suggesting that inorganic soil N concentrations become controlled by several key human-dominated 'local' or 'neighborhood' factors in the city.

Research Aims - we posed THREE main questions:

1) To what extent do *human variables* contribute to explaining spatial variation in inorganic soil nitrogen concentrations?

2) Exactly *which* variables best explain site-to-site variations in soil nitrate-N and soil ammonium-N concentrations?

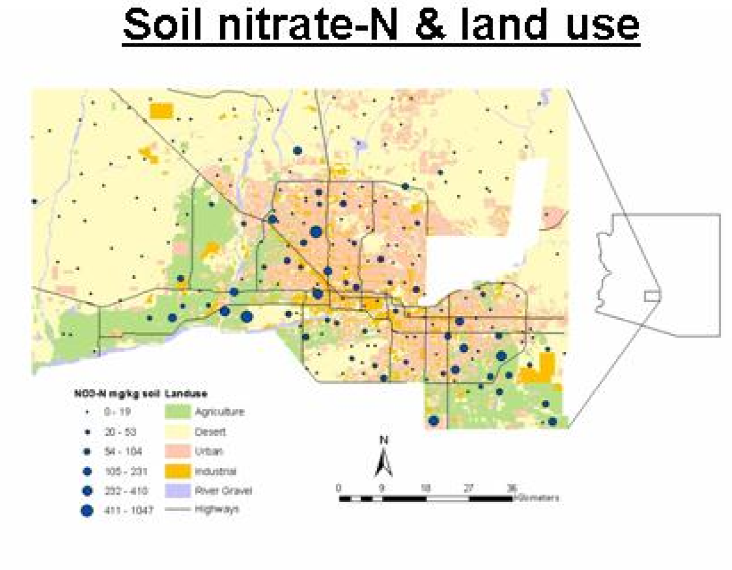
3) *How* do the apparent controls on soil nitrate-N and ammonium-N differ between the urban and desert parts of the system for these two inorganic N species?

Statistical analyses of soil nitrate-N and soil ammonium-N data

- mostly involved Ordinary Least Squares (OLS) regression
- a log transformation to normalize soil nitrate-N data
- a power ($e^{-0.333}$) transformation for the soil ammonium-N data
- distributional properties were investigated using residual and normal plots

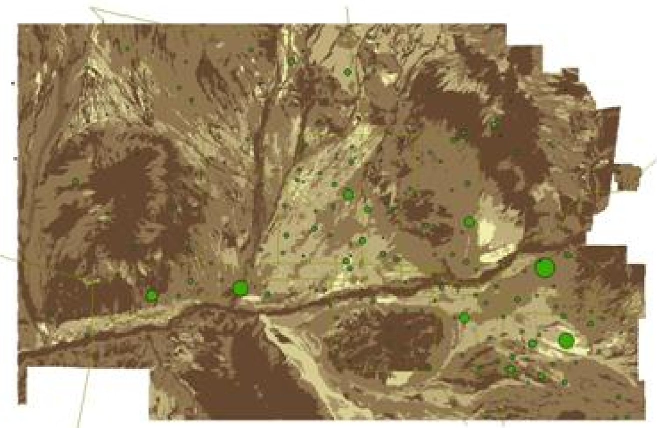
Spatial variation in nitrate-N and ammonium-N concentrations in soils across the CAP LTER study region

Soil nitrate-N & land use



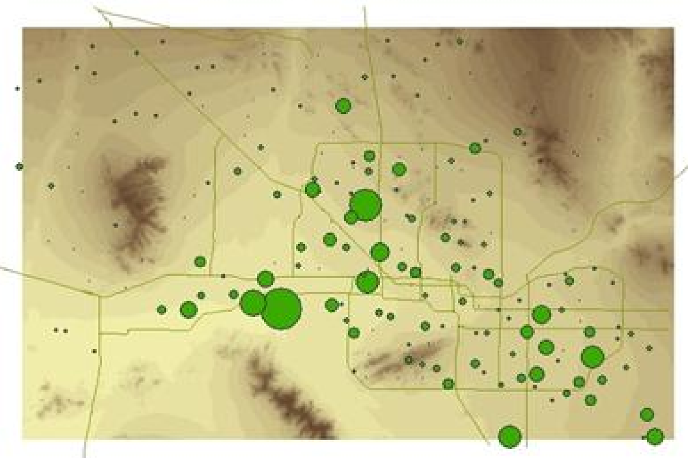
Variation in soil nitrate-N was lowest between desert sites and highest between transportation and mixed land use sites.

Soil ammonium-N & soil texture



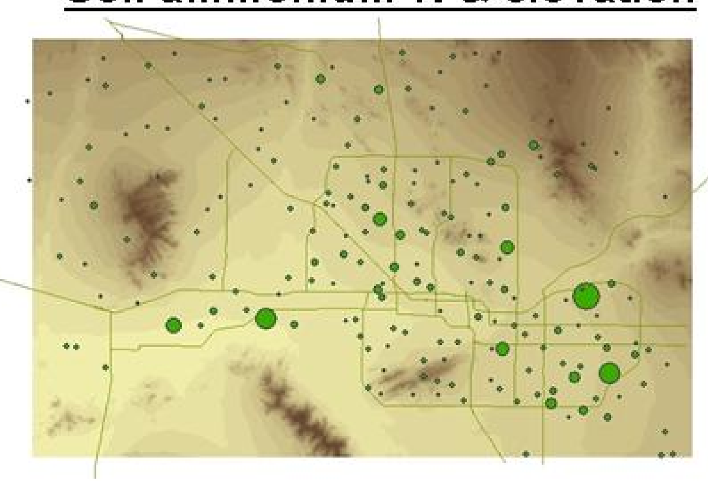
Soil ammonium-N increased with particle size at the desert sites, but showed the opposite trend among urban sites. (Paler colors represent finer textures).

Soil nitrate-N & elevation



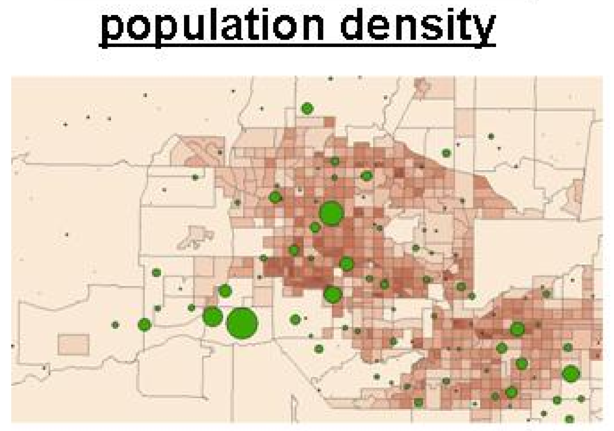
Soil nitrate-N concentrations decrease with increasing elevation (darker shading) at the urban sites.

Soil ammonium-N & elevation



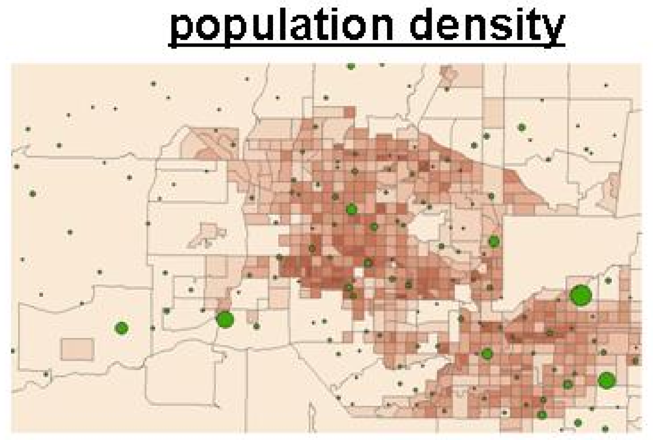
Soil ammonium-N concentrations increased with increasing elevation at the urban sites, but not in the desert or the region overall.

Soil nitrate-N & human population density



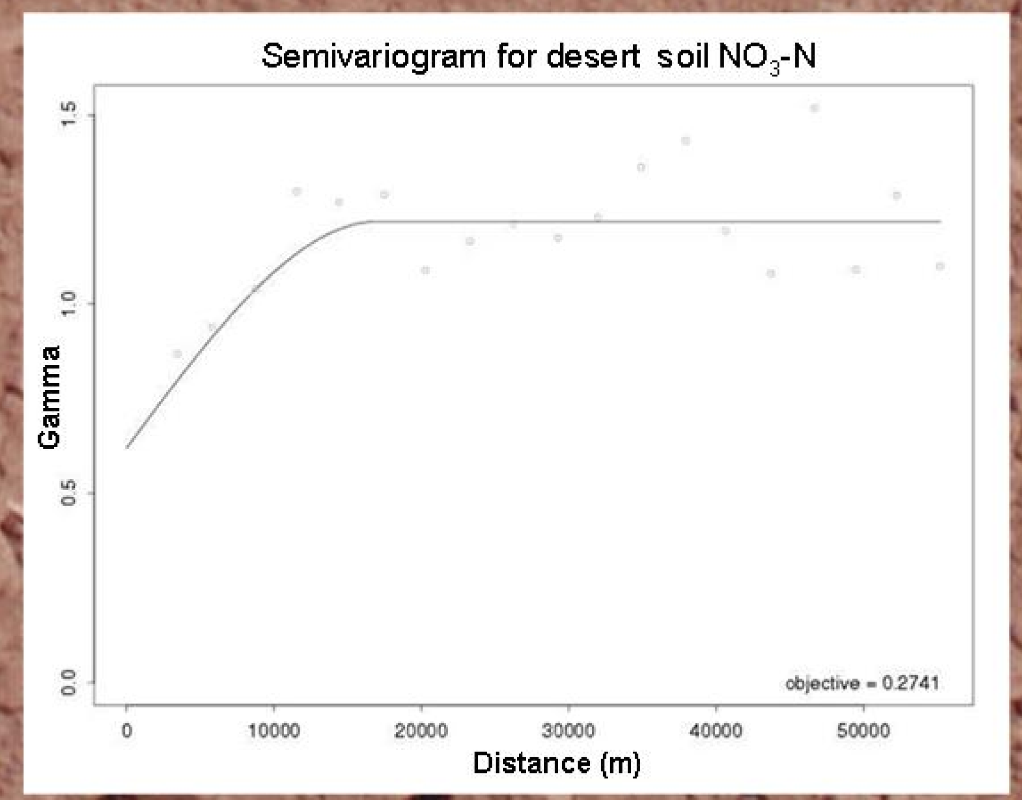
Soil nitrate-N concentrations tend to be higher in neighborhoods with higher human population densities (darker pink tones).

Soil ammonium-N & human population density



Soil ammonium-N concentrations tend to be lower in neighborhoods with higher human population densities.

Spatial autocorrelation was present only for the soil NO_3-N concentrations between neighboring desert sites, where the model residuals were best fit by a spherical model.



Results of Statistical Analyses – Best Fit Models

Variables	Estimate	P-value
NO3-N		
All Sites (n=204)		
Latitude	-2.058	0.014
Land Ever in agriculture	0.913	0.001
Population density	0.000	<0.001
Percent impervious surface	-0.011	0.008
Lawn cover	-0.017	0.029
Urban sites		
Elevation	-0.011	0.002
Population density	0.001	0.029
Percent impervious surface	-0.016	0.013
Income per capita	0.000	0.011
Irrigation (other)	-1.293	0.016
Desert sites	Spatially autocorrelated	
NH4-N		
All Sites (n=204)		
Latitude	0.2439	<0.001
Population density	-0.000	<0.001
Percent Clay	-0.004	0.012
Urban sites only (n=91)		
Elevation	0.001	0.023
Population density	-0.000	0.029
Lawn cover	-0.002	0.035
Irrigation (other)	0.123	0.014
Desert sites only (n=73)	No spatial autocorrelation	
Percent clay	0.022	0.038

Conclusions

- Inorganic N concentrations in **desert soils** were unrelated to most of the variables quantified in this study.
- **Spatial variation** of inorganic **N in urban soils is extremely high** & related both to landscape position and human-related variables including population density, current management regime & land use history.
- **Abrupt changes** in deliberate and inadvertent inorganic **N inputs at very local scales** *may* be a general phenomenon of urban soil ecology.