Landscape factors affecting the spatial and seasonal variations of water quality in Portland, Oregon

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Background

In addition to exacerbating anthropogenic activities that produce higher local concentrations of various pollutants, urbanization exacerbates stormwater runoff by increasing impervious surface cover. The spatiotemporal mechanisms that produce variations in water quality are still being studied.

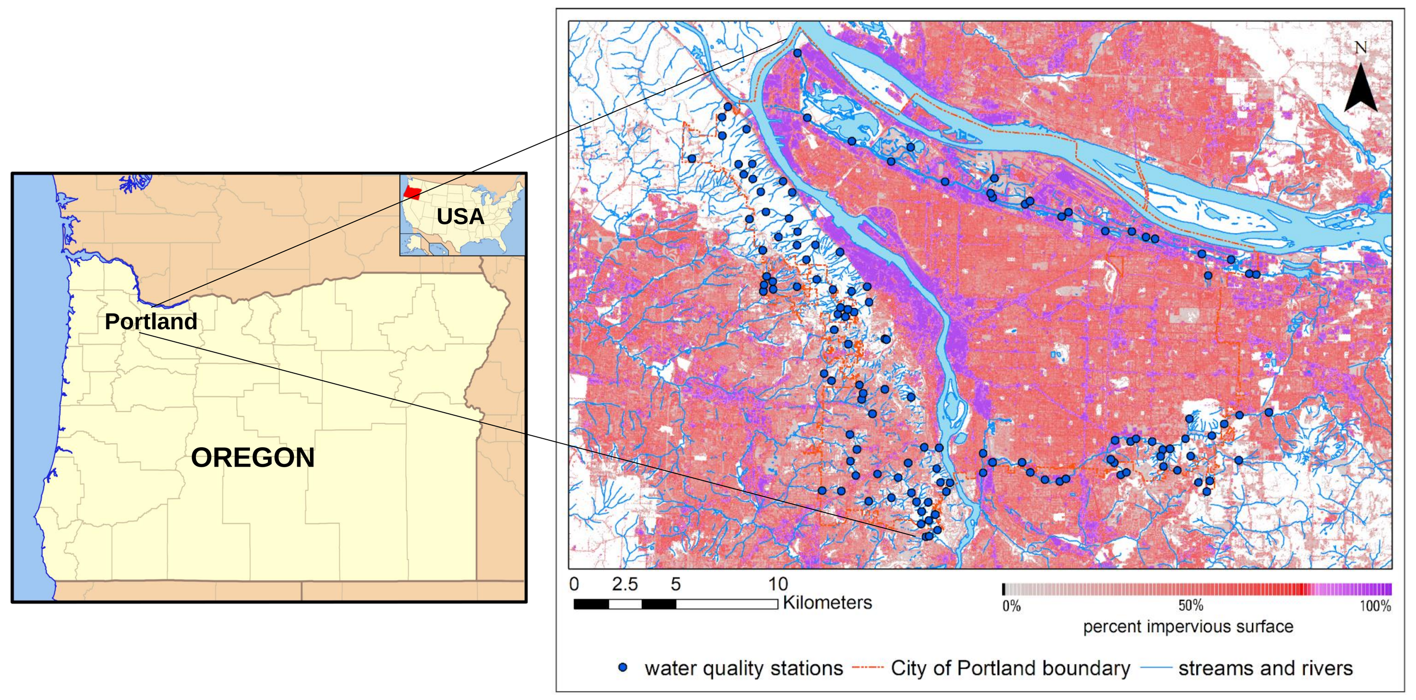

Figure 1. Study area in Portland, Oregon, USA and City of Portland water quality stations

Research Question

How do seasonality and landscape characteristics--including green infrastructure--affect water quality in the Portland metropolitan area at two microscale extents?

Data and Methods

- Derived landscape variables using ArcGIS 10.7
- Exploratory regression using ArcGIS
- Spatial regression analysis in GeoDa 1.18

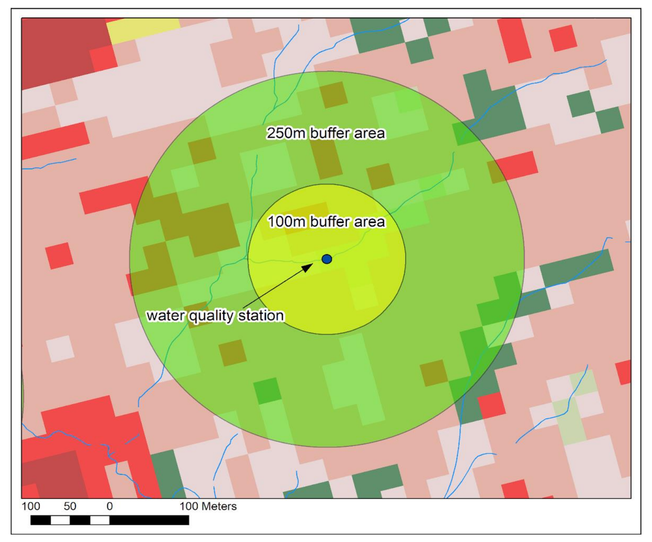

Figure 2. Creation of 100-meter and 250-meter circular buffers around water quality sampling station

Response variables	Explanatory variables	
Anthropogenic: Lead (ug/L), Zinc (ug/L), *E. coli* (MPN/100 mL)	***Land cover***	Impervious surface (%) Developed (%) Forested (%)
	Infrastructure	Distance to nearest GI (meters) Pipe length (meters) Road length (meters)
Natural + Anthropogenic: Nitrate (mg/L), Orthophosphate (mg/L), Total suspended solids (mg/L)	***Soil and geomorphology***	Mean slope (meters) Standard deviation in slope (meters) Mean elevation (meters) Standard deviation in elevation (meters) Hydrologic soil group C (%) Stream order

Figure 3. Selected pollutants and derived landscape variables

Spatial Distribution of Pollution

- Clear seasonal and spatial differences in pollutant concentrations
- Overall, water quality tended to be lower in the southern and southwestern regions of the study area
- High variability in *E. coli*, zinc, lead concentrations

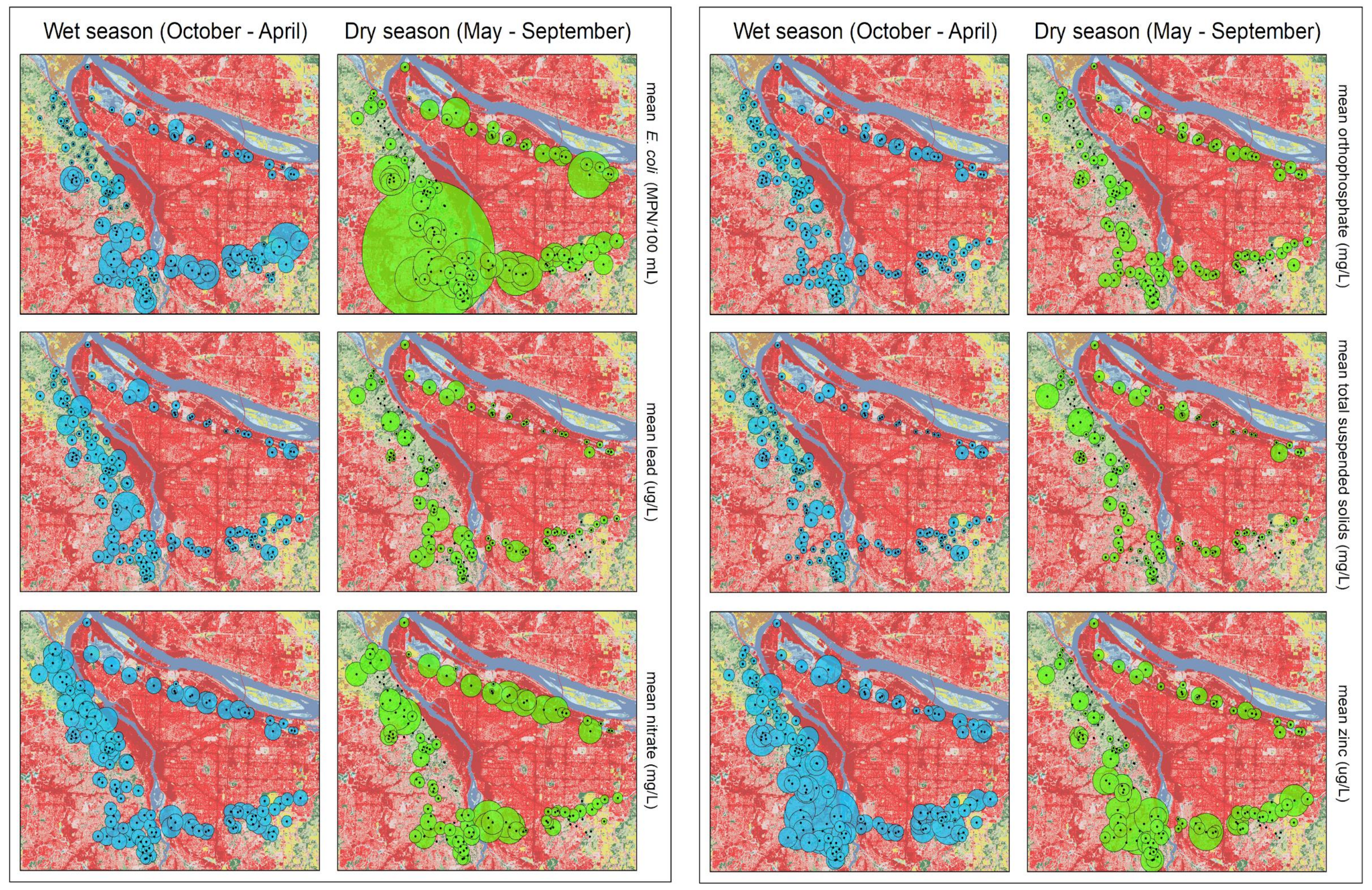

Figure 4. Pollutant concentrations for each water quality station. Larger circles correspond to higher mean concentrations.

Factors Affecting Water Quality

Anthropogenic

E. coli — explained by — slope (+)

Lead — explained by — road length (+)

Zinc — explained by — developed (+), impervious (-), soil type C (+)

Natural + anthropogenic

Nitrate — explained by — forest (+), impervious (+), developed (-)

Orthophosphate — explained by — soil type C (+/-), elevation (-)

TSS: Low R^2 — unexplained

Figure 5. Summary of landscape variables that predict pollutant concentrations. Green text = wet season predictor; yellow text = dry season predictor

- Some predictors were significant in both the wet and dry seasons while others were significant in one season and not the other (see Nitrate, Fig. 5)
- Model for *E. coli* in the wet season had the highest R^2value
- No suitable dry season models found for either *E. coli* or lead
- Surprising negative relationship found for impervious surface cover

Discussion

Pollution levels especially for E. coli and zinc tended to worsen in the southwestern portion of the study area. This may be due to:

- Downstream accumulation effects
- Overlap of natural areas popular for hiking* (*E. coli*) and proximity of the Interstate-5 highway, a major trucking route (zinc). However, the northwestern part of the study known exhibited minimal *E. coli* pollution, even though it is largely forested.

Seasonal differences in landscape variables for some pollutants and not others is to be expected. The negative correlation observed between impervious surface cover and some pollutants needs to be further examined.

Role of Green Infrastructure

As distance to the nearest green infrastructure increases, *E. coli* concentrations on average increase, but lead concentrations on average decrease. Although the GI coefficient for lead is small, observed trends allude to uneven effects of green infrastructure on water quality.

Figure 6. Rain garden in Portland, Oregon

Conclusions

- Clear seasonal and spatial differences in pollutant concentrations
- Different land cover variables explain water quality over time at different microscales
- Surprising trends for distance to green infrastructure and impervious surface cover

Next steps include conducting a multi-scalar analysis incorporating census block group scale to capture sociodemographic variables, as well as integrating spatial and temporal analyses to include antecedent precipitation data.

References

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Acknowledgements

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