Prairie stream chemistry is unique and dependent on land use, soils, and water presence

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PRAIRIE WATER GLOBAL WATER FUTURES

Introduction

- The prairies are diverse – geology, land use practices and water coverage are heterogeneous across the landscape.
- Excess nutrients in the Prairies are causing water quality problems for our drinking water.
- What causes these excess nutrients to enter large water bodies?
- Small streams hold part of the answer – as concentrations of nitrogen, phosphorus and carbon vary dependent on local conditions.

Methods

- Using catchment characteristic data Jared Wolfe (Wolfe et al. 2019), and stream chemistry and flow data from 62 sites across the Prairie region (see Fig 1), we explored relationships between these response and explanatory variables.
- Generalized additive models (GAM) were used to assess the ways in which watershed characteristics (land-use, wetland area, etc.) might influence in-stream concentrations of total phosphorus (TP) and nitrate (NO_3^-).
- Model selection was done to avoid explanatory correlation (for example, fraction of cropland correlated negatively with the fraction of pasture), minimizing restricted maximum likelihood (REML) and to maximize variance explained (adjusted R^2).
- The data modeled here are annual median concentrations for the years of data available for that particular site.

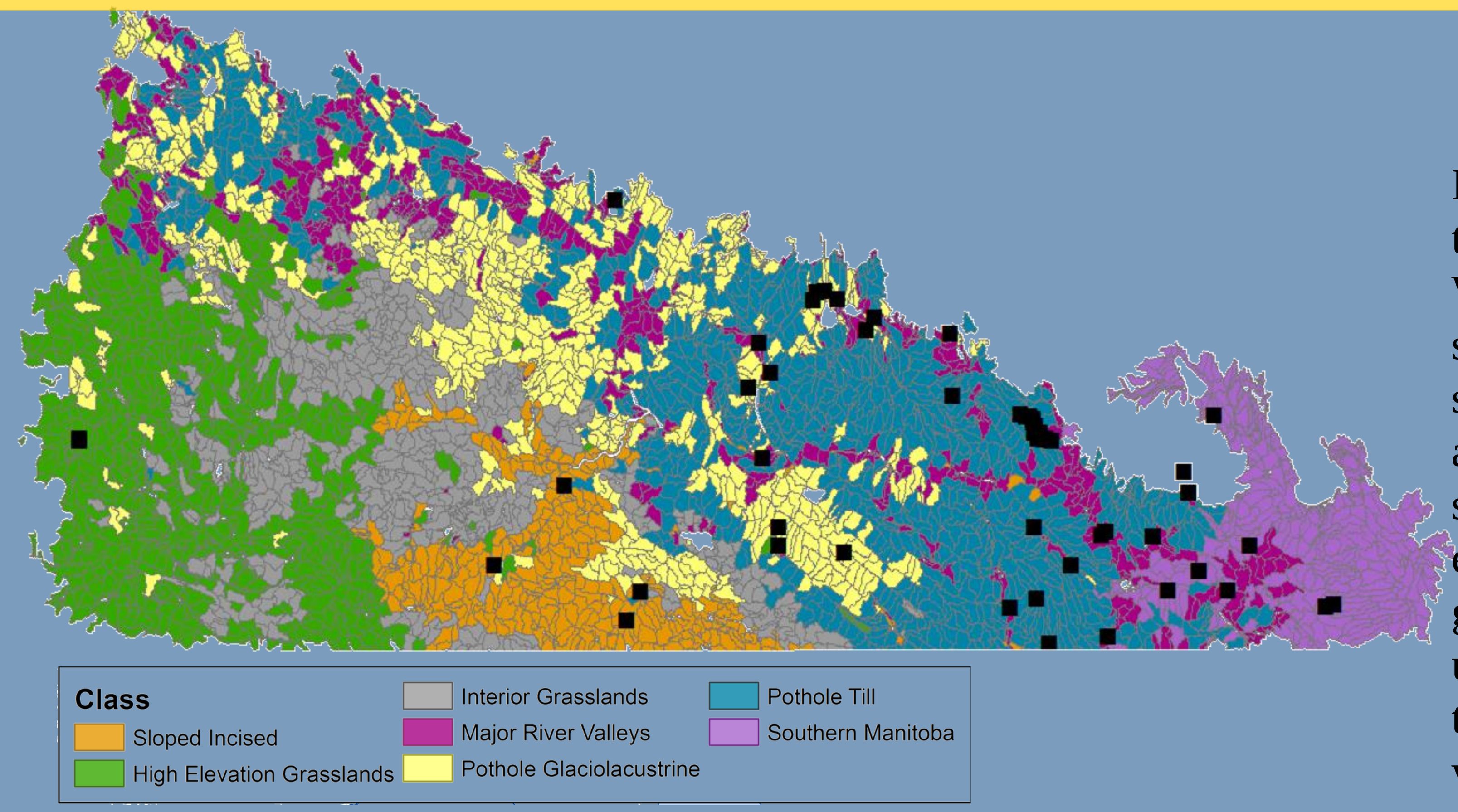

Fig. 1 Watershed classification in the Prairies as performed in Wolfe et al. 2019. The black squares represent several of the stream sites collated for this analysis. Note that there are no sites representing the high elevation grasslands and interior grasslands as data were unavailable. The single point in the HEG was removed due to waste water impact.

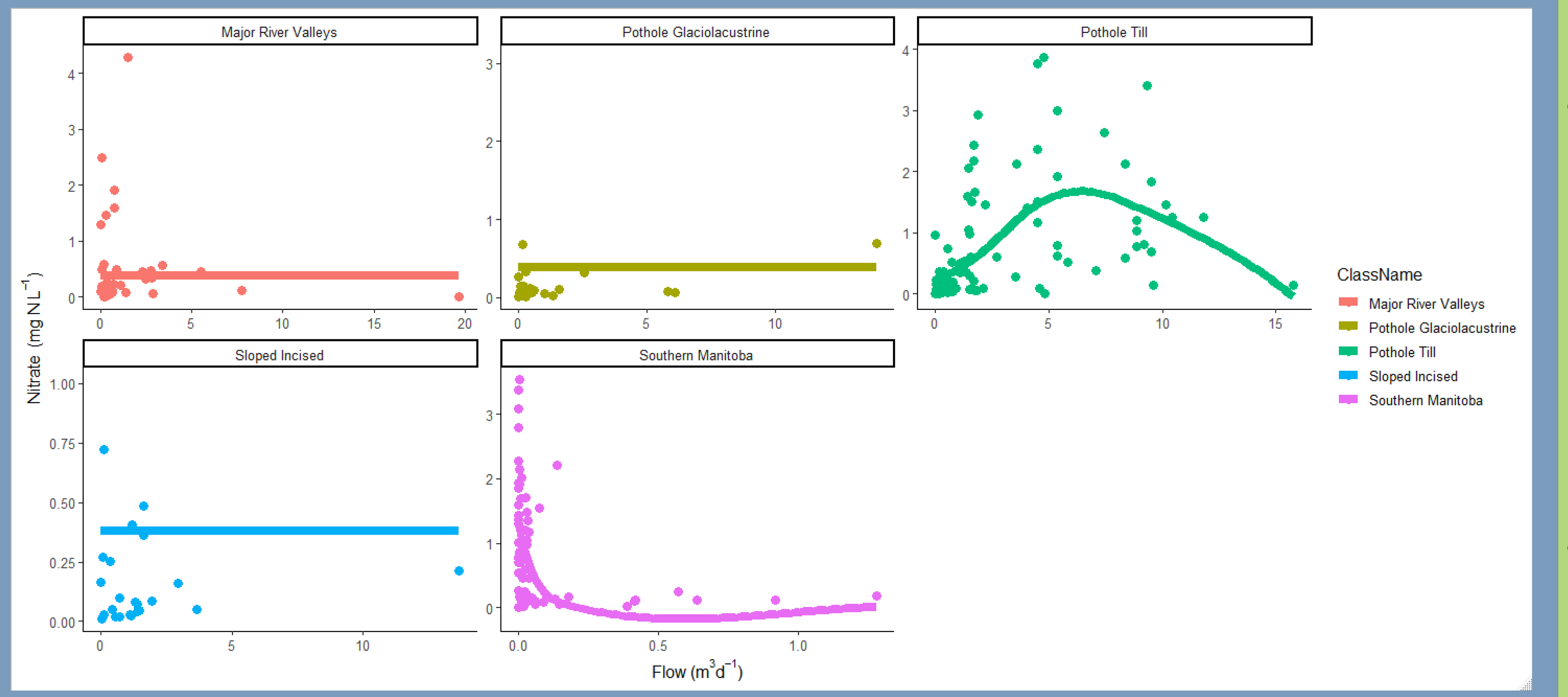

Fig. 2 Nitrate GAM of flow by class name. The x-axis is flow for each of the five represented catchment classes, while the y-axis is the smooth effect or predicted NO_3^- concentration for each catchment.

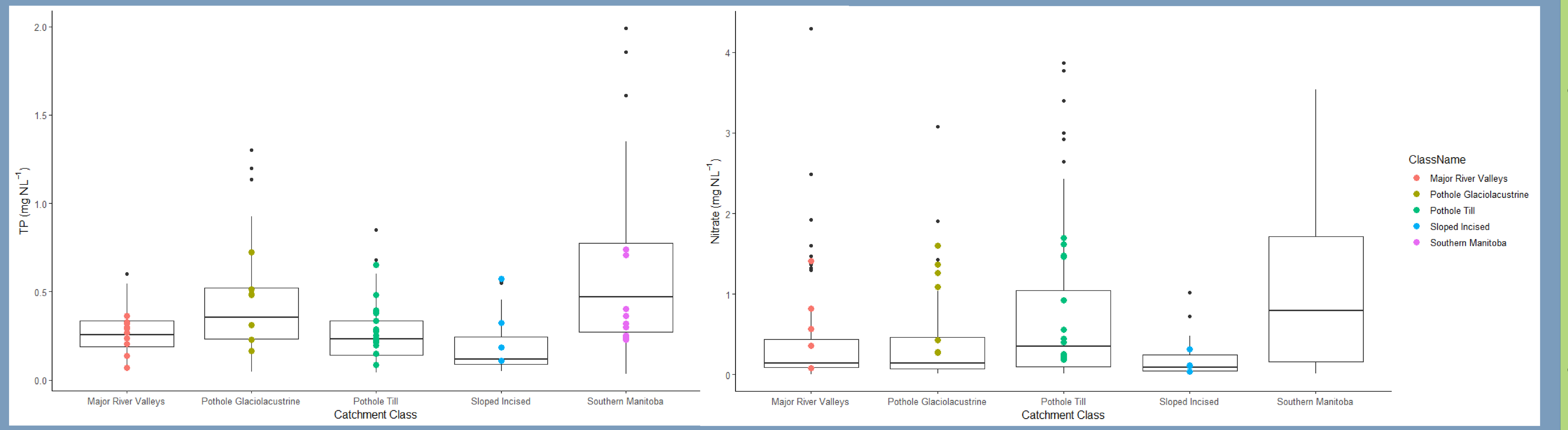

Fig. 3. The boxplots show the distribution of a) TP or b) NO_3^- among catchment classes while the specific points are the modeled a) TP or b) NO_3^- concentrations.

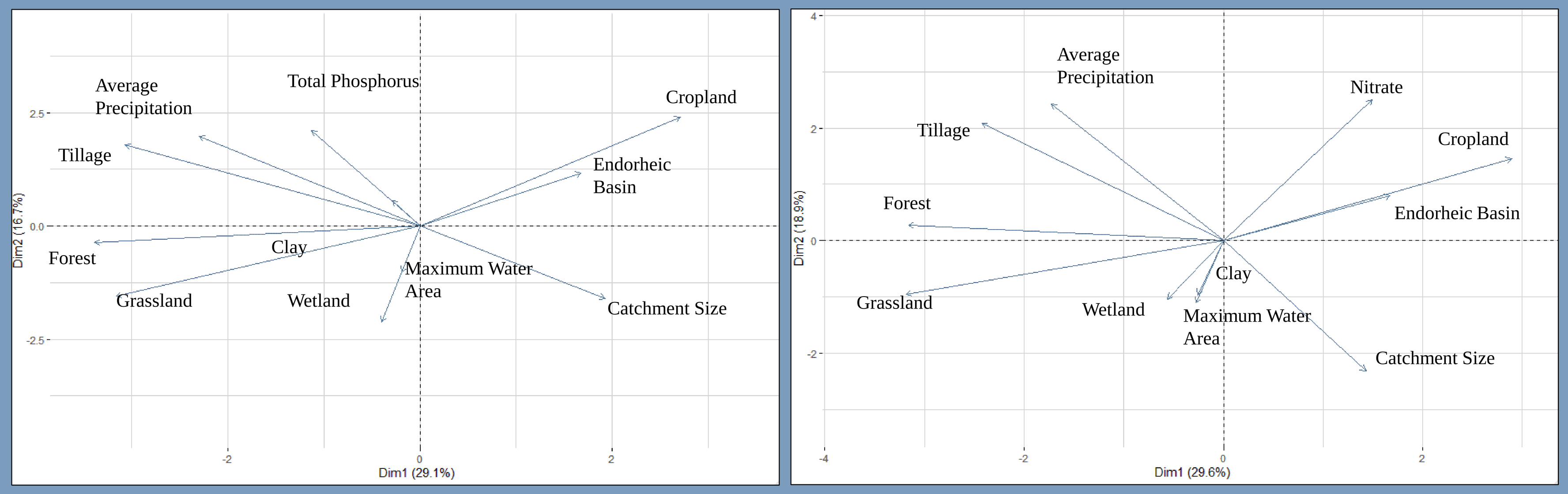

Fig 4 a) Principal component analysis (PCA) showing the relationship between covariates and response variables: a) TP and b) NO_3^-. TP correlates positively with clay and negatively with catchment size. Nitrate correlates inversely with wetland (fraction of area of catchment covered by wetlands).

Findings

- Flow relationships with concentrations were notably different among the catchment classes (Fig 1). Most watershed classes were chemostatic; no relationship is apparent between flow and NO_3^- concentration.
- Nitrate concentrations in Southern Manitoba, and Pothole Till were negatively and positively correlated, respectively, with flow (note: tail end of pothole till class has fewer data; Fig 2).
- Concentrations of nutrients differed among the classes, with much higher concentrations of TP found in Southern Manitoba (Fig 3a), while NO_3^- concentrations were highest in the Pothole Till and Southern Manitoba regions (Fig 3b)
- Land use was a significant predictor of NO_3^- and TP (Fig 4 a&b), with cropland and pasture being the strongest predictors.

Significance

- Changing flow in the future under climate and drainage scenarios likely will play a large role in the magnitude of the nutrient loading from these small watersheds.
- Land-use type does matter and can control nutrient release to these small streams.
- Wetlands and other small waterbodies play a disproportionate role in nutrient retention and retaining them on the prairie landscape could reduce nutrient export.

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Citations

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