N:P stoichiometry in Canadian prairie streams: effects of land cover and hydrologic variability

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Prairie streams are an important freshwater resource in North America Great Plains.

Runoff/seepage from agricultural land introduces nutrients, resulting in eutrophication and loss of valuable ecosystem services.

Concentrations and loads of nitrogen (N) and phosphorus (P), in both dissolved and particulate fractions, are sensitive to land cover and hydrologic variability.

Temporal variation in N:P ratios affects lake food webs, particularly the productivity and composition of algal communities.

Yet little is known about riverine N:P ratios, particularly the effects of changing land use and hydroclimatology on the mobilization and delivery of N relative to P in tributaries.
Objectives

To assess the response of N:P ratios (concentrations and loads) to changes in crop cover and hydrologic variability for streams draining the Canadian prairies.
Seven sub-watersheds: 66 - 677 km²

**Continental Climate:** Long cold winters (avg -15 °C) followed by warm summers with precipitation falling predominately during summer months.

**Soils:** clay and silt.

**Topography:** low relief with natural land cover consisting of grasslands with permanent and temporary wetlands.

**Land use:** row crops (small grains, canola) and livestock (cattle, poultry, swine).
**Chemistry**
- Grab samples for total and dissolved P and N collected daily during the rising limb and peak of snowmelt, weekly during the falling limb and biweekly thereafter until ice cover, for two years (2013 and 2014).

**Discharge**
- Pressure transducer in each stream measuring water level.
- Discharge estimated from relationship between water level at site and discharge at long-term d/s government stations.

**Loads**
- Nutrient concentrations (measured or linearly interpolated between sampling dates) were multiplied by daily discharge and summed by season or year.
2013 and 2014, runoff volume and discharge peaked during snowmelt (orange bar) although snowmelt peaks were less in 2014 (note scale differences between years).

2014 also experienced more rain events, characterized by additional peaks in the hydrograph (green square).

- In both 2013 and 2014, runoff volume and discharge peaked during snowmelt (orange bar) although snowmelt peaks were less in 2014 (note scale differences between years).
- 2014 also experienced more rain events, characterized by additional peaks in the hydrograph (green square).
In 2013, mean precipitation was greatest during the spring. Runoff and discharge were greatest during snowmelt. Summer and fall were only 21% of annual runoff.

In 2014, rain precipitation was greatest in summer. Runoff and discharge were still greatest during snowmelt. Summer and fall comprised 45% of annual runoff.
Nitrogen Fractions

- For TN and DIN, concentrations were greatest during snowmelt for both 2013 and 2014 (orange bar).

- For PN, concentrations were greatest during snowmelt and spring in 2013 (orange bars). Concentrations did not differ seasonally in 2014.

- Letters (a,b,c,d) above bars identify seasonal means that differ (p<0.05) within a year; symbols (*,#) below bars identify seasonal means that differ (p<0.05) between years.

- SN = snowmelt, SP = spring, SU = summer, and F= Fall
Phosphorus Fractions

• Like N, total and dissolved P concentrations were highest during snowmelt (orange bar).

• Like PN, PP was greatest during snowmelt and spring in 2013 (orange bars). Concentrations showed less seasonal change in 2014.

• In 2013 (a typical snowmelt-driven year), nutrients were largely exported in particulate forms.

• Under “wetter” (i.e., rainier) conditions of 2014, more nutrients were exported in the dissolved form.

• Letters (a,b,c,d) above bars identify seasonal means that differ (p<0.05) within a year; symbols (*,#) below bars identify seasonal means that differ (p<0.05) between years.

• SN = snowmelt, SP = spring, SU = summer, and F = Fall
Particulate N:P Load Ratios

- Results from a two-way ANCOVA (season and year as factors, crop cover as co-variate) showed that PN:PP ratios differed on an annual and seasonal basis.

- Annually, PN:PP ratios were greater in 2014. Within years, values were greater during seasons when the soil was wet but not frozen (spring 2013; summer 2014). These findings suggest that under wetter soil conditions, greater quantities of PN were exported relative to PP.

- Export of PN:PP was not associated with the extent of crop cover in the watershed.
Total and dissolved N:P load ratios showed associations (p<0.05) with season and crop cover for both 2013 and 2014.

Total N:P ratios were higher (p<0.05) during summer and fall. DIN:SRP load ratios were lowest during fall.

The seasonality in total and dissolved N:P load ratios likely relates to the fact that delivery of P to streams is influenced by hydrological activity whereas N moves through the landscape in dissolved forms.

The positive correlation between N:P load ratios and crop cover indicates greater N loss, relative to P, under intensive crop cultivation.
Conclusions

• Dissolved versus particulate N:P load ratios responded differently to land use and hydrologic variability:
  – land use was the major driver of dissolved N:P load ratios
  – hydrology was the main driver in particulate N:P load ratios.

• Predicting stoichiometry is important because of its strong effects on ecological processes such as primary production.

• Improved knowledge of the dominant nutrient forms and their transport pathways will assist in determining appropriate mitigation practices to reduce nutrient loads under a changing climate.
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