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

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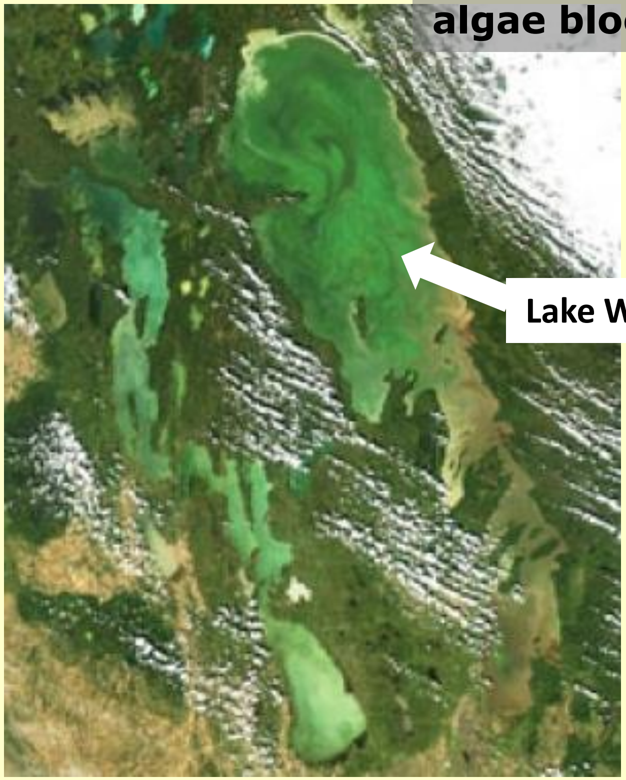
The Issue

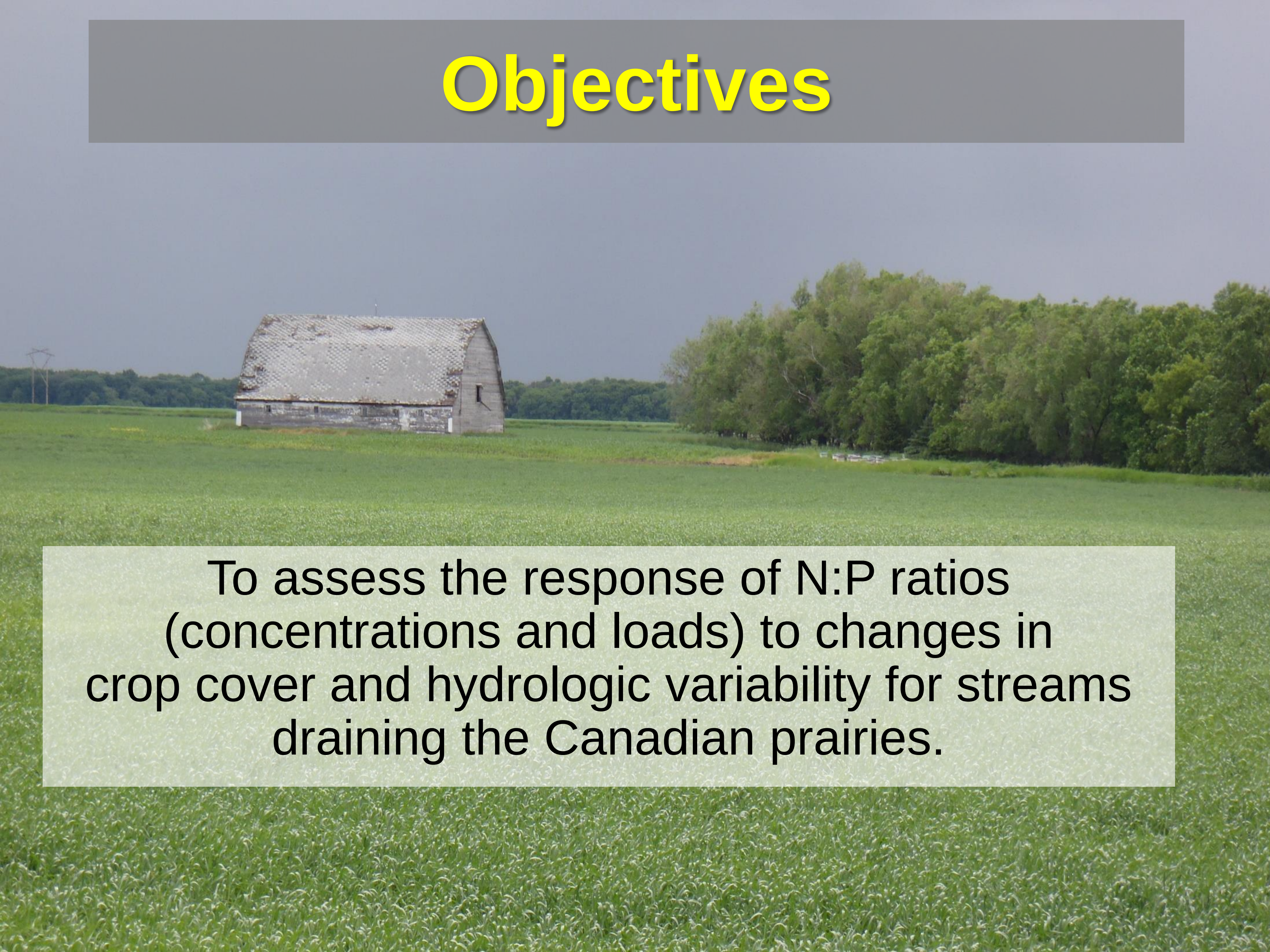
- Prairie streams are an important freshwater resource in North America Great Plains.
- Runoff/seepage from agricultural land introduces nutrients, resulting in eutrophication and loss of valuable ecosystem services.
- Concentrations and loads of nitrogen (N) and phosphorus (P), in both dissolved and 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.



Satellite image of Lake Winnipeg algae bloom

Blue-Green Algae on Grand Beach

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.

Study Area

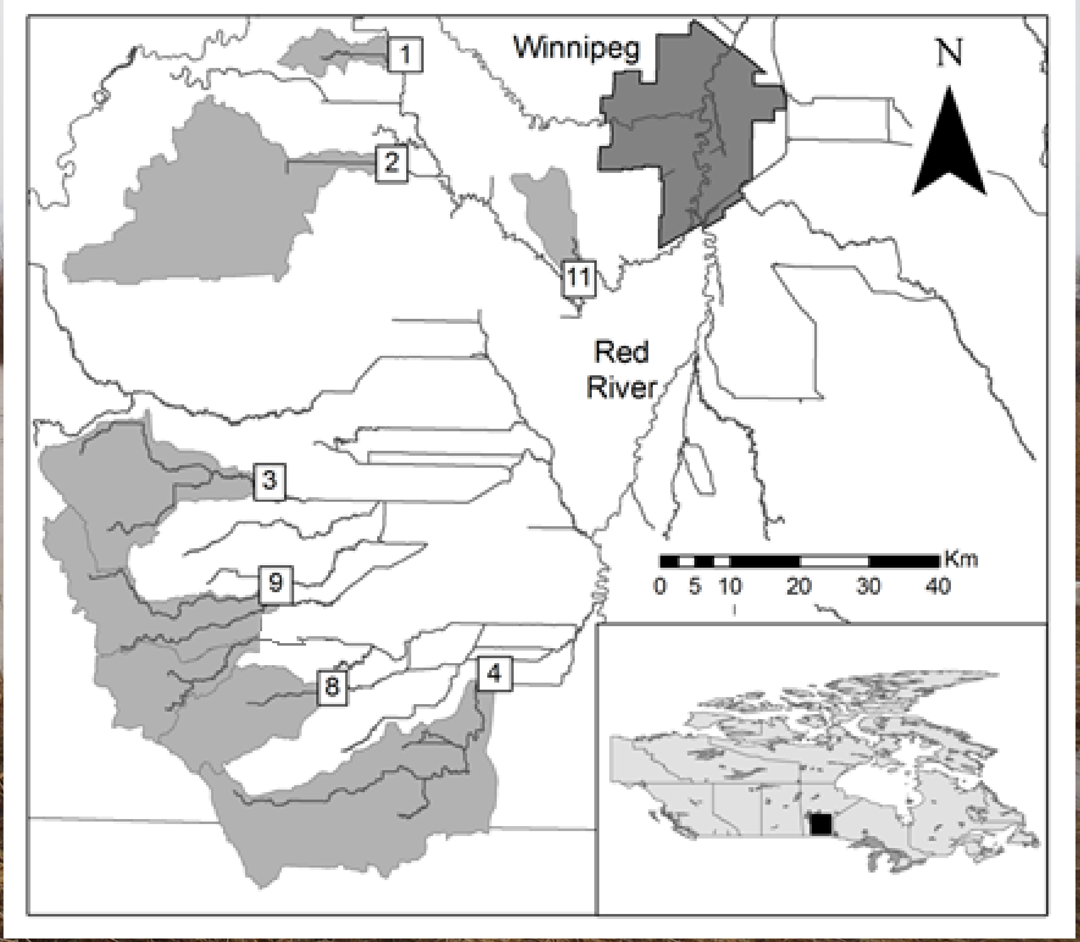
Seven sub-watersheds: 66 - 677 km^2

Continental Climate: Long cold winters (avg -15 ^{o}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).



Sampling and chemical measurements

Chemistry

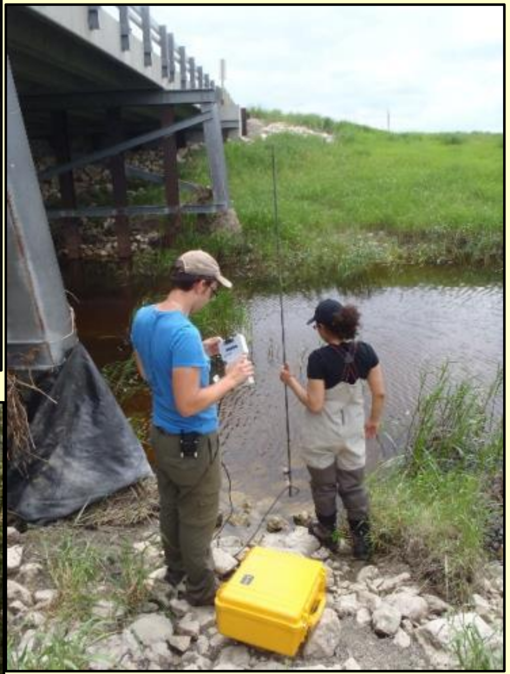
- Grab samples for total and dissolved P and N collected daily during the rising limb and peak of snowmelt, weekly during the falling limb and biweekly thereafter until ice cover, for two years (2013 and 2014).

Discharge

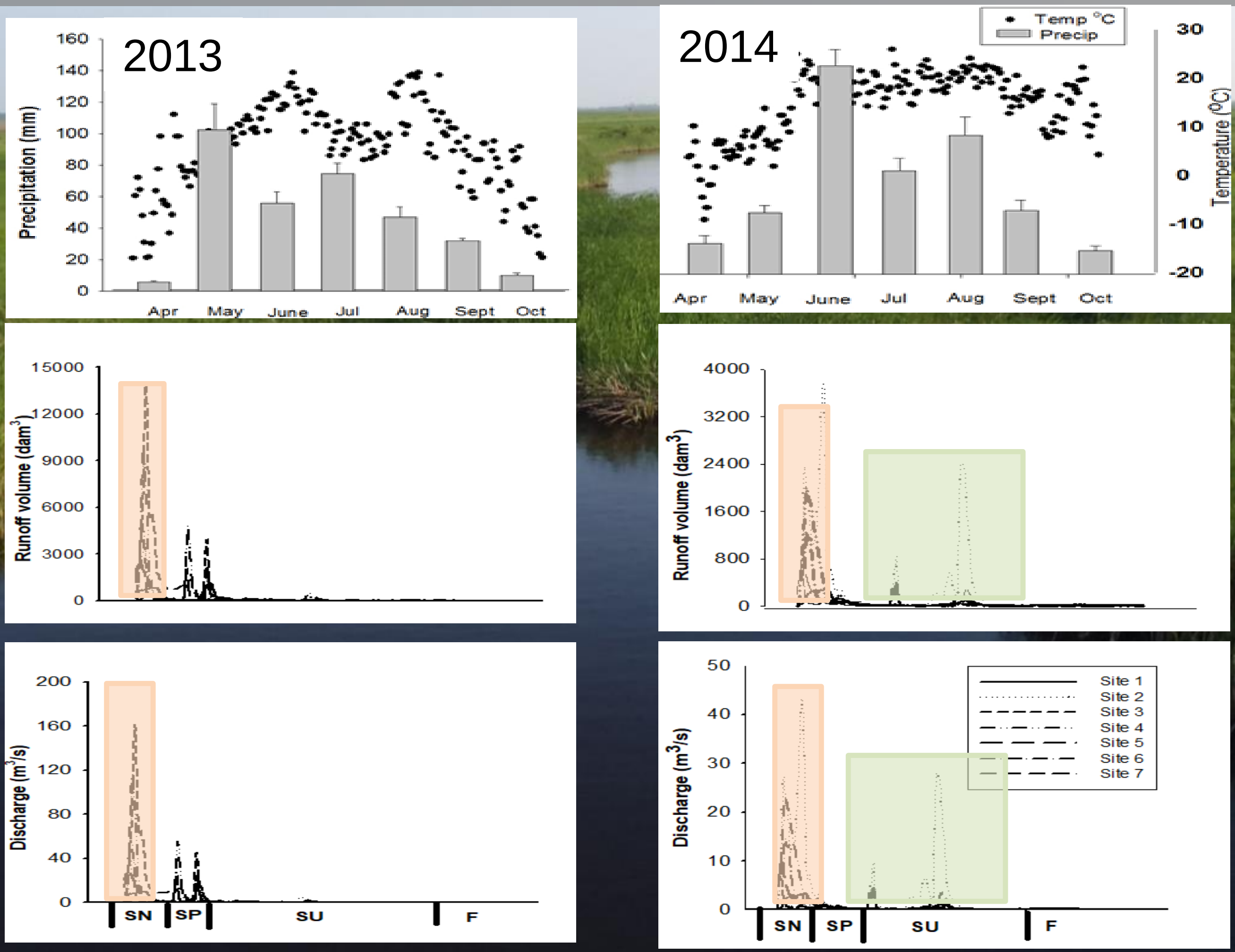
- Pressure transducer in each stream measuring water level.
- Discharge estimated from relationship between water level at site and discharge at long-term d/s government stations.

Loads

- Nutrient concentrations (measured or linearly interpolated between sampling dates) were multiplied by daily discharge and summed by season or year.

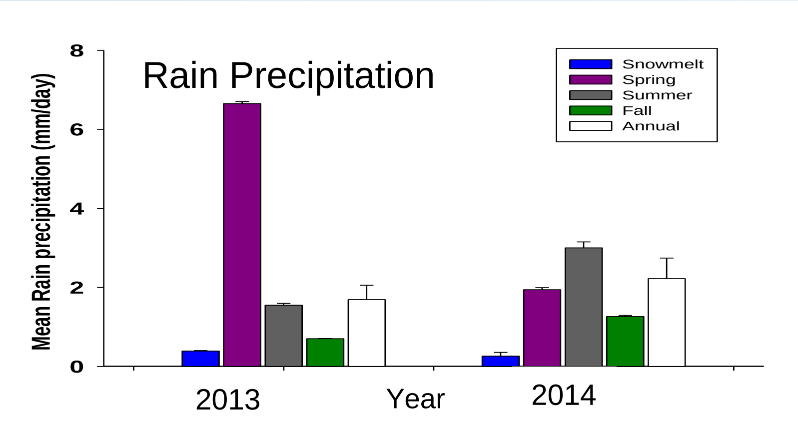


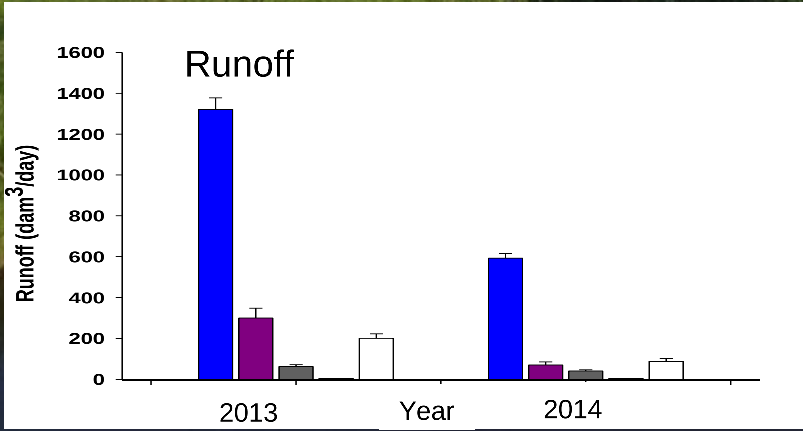
Hydrology and Climate

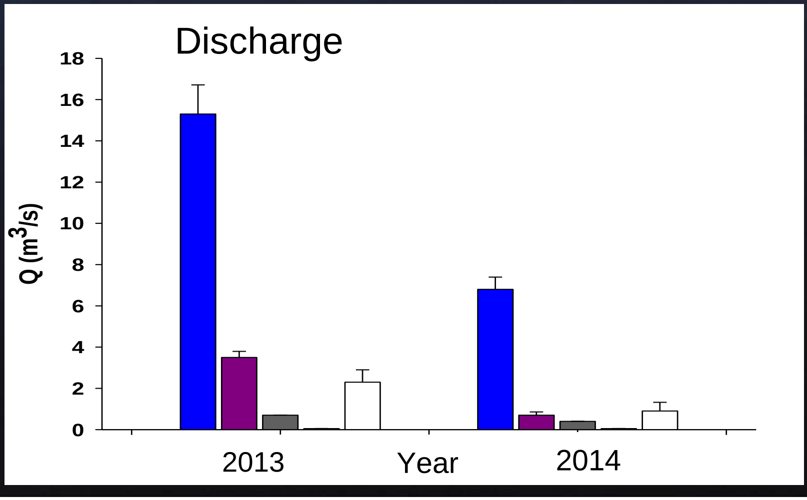


- In both 2013 and 2014, runoff volume and discharge peaked during snowmelt (orange bar) although snowmelt peaks were less in 2014 (note scale differences between years).
- 2014 also experienced more rain events, characterized by additional peaks in the hydrograph (green square).

Hydrology & Climate



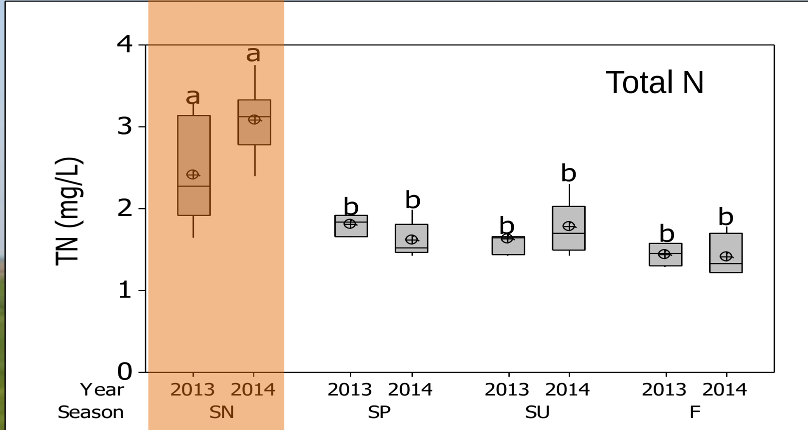


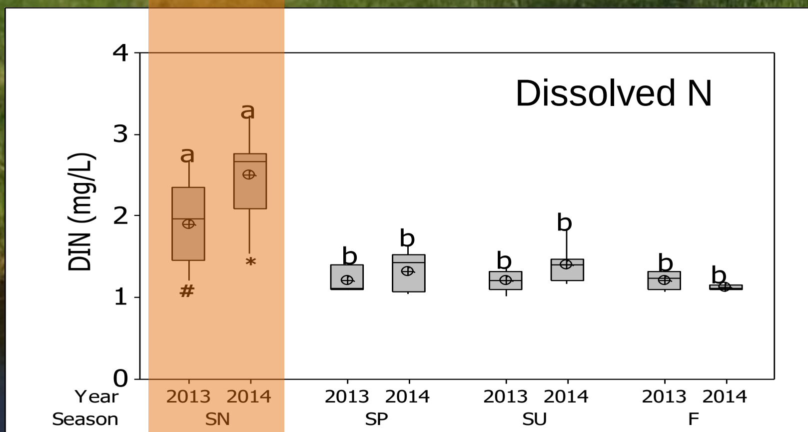


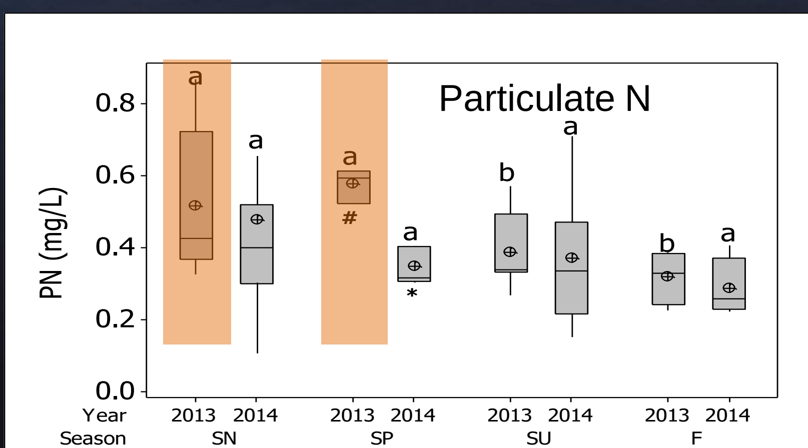
- In 2013, mean precipitation was greatest during the spring. Runoff and discharge were greatest during snowmelt. Summer and fall were only 21% of annual runoff.

- 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



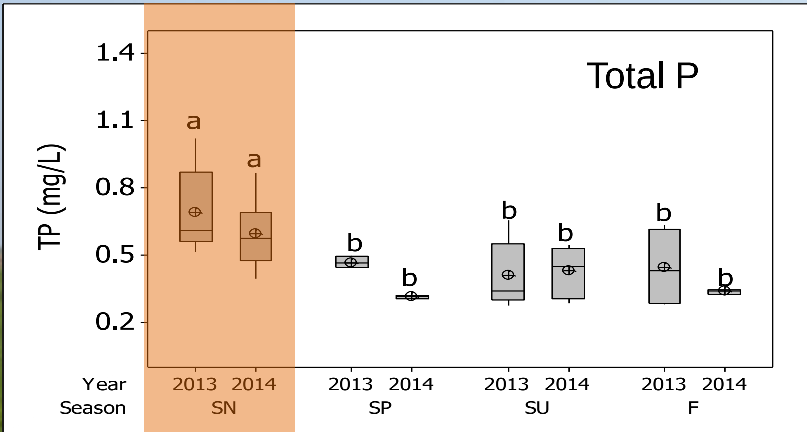


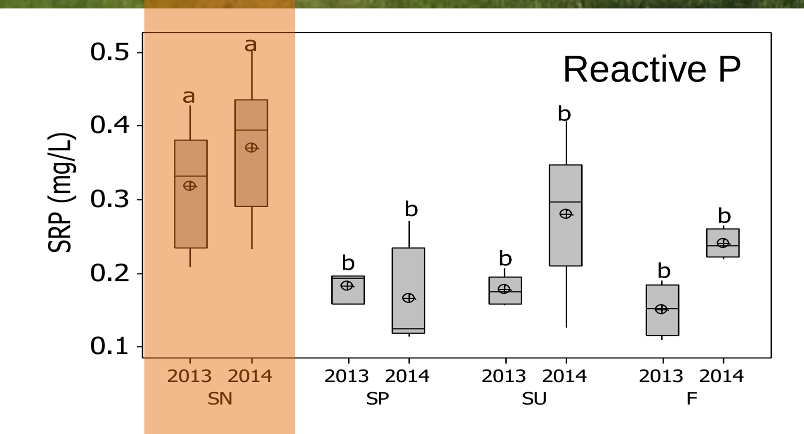


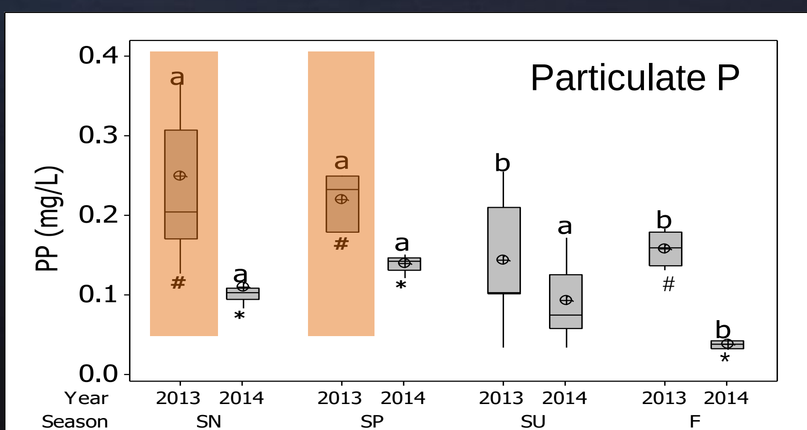
- For TN and DIN, concentrations were greatest during snowmelt for both 2013 and 2014 (orange bar).
- For PN, concentrations were greatest during snowmelt and spring in 2013 (orange bars). Concentrations did not differ seasonally in 2014.

- 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



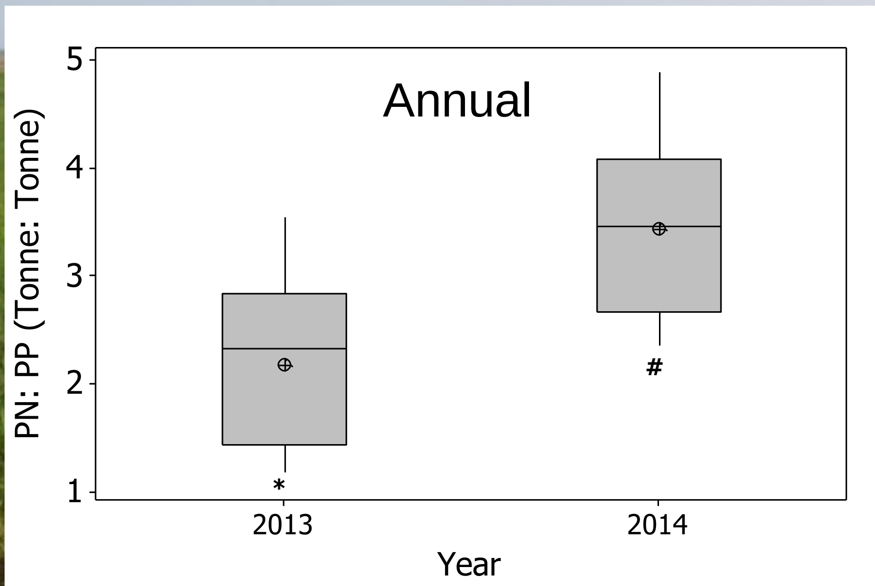


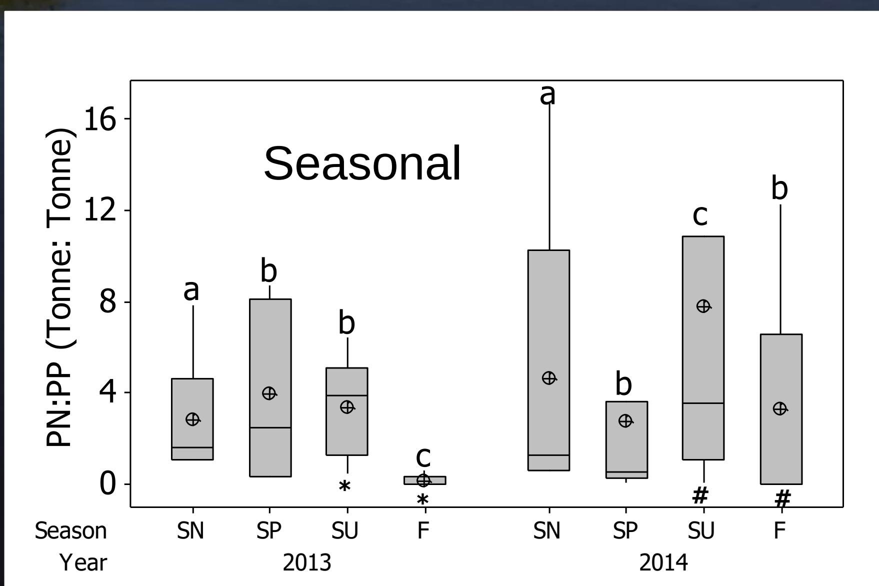


- Like N, total and dissolved P concentrations were highest during snowmelt (orange bar).
- Like PN, PP was greatest during snowmelt and spring in 2013 (orange bars). Concentrations showed less seasonal change in 2014.
- In 2013 (a typical snowmelt-driven year), nutrients were largely exported in particulate 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



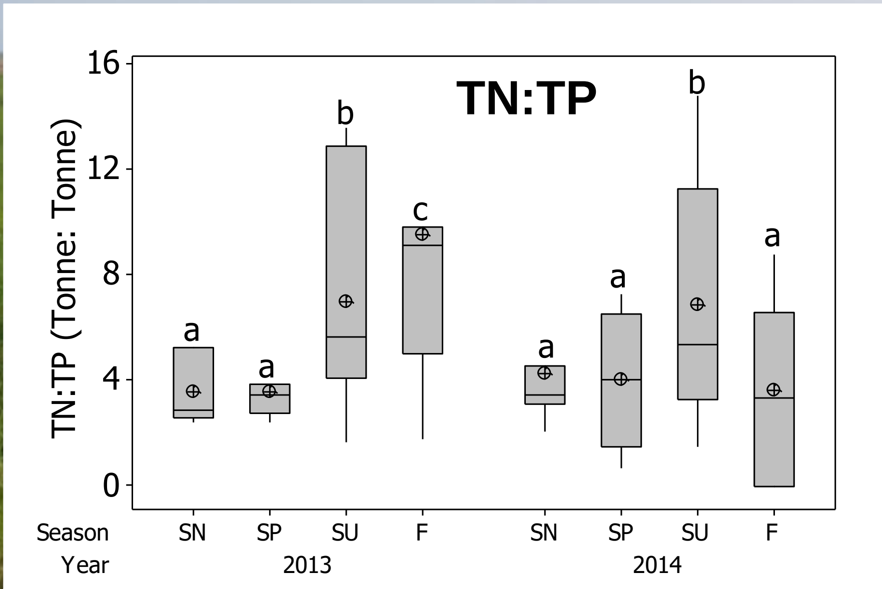


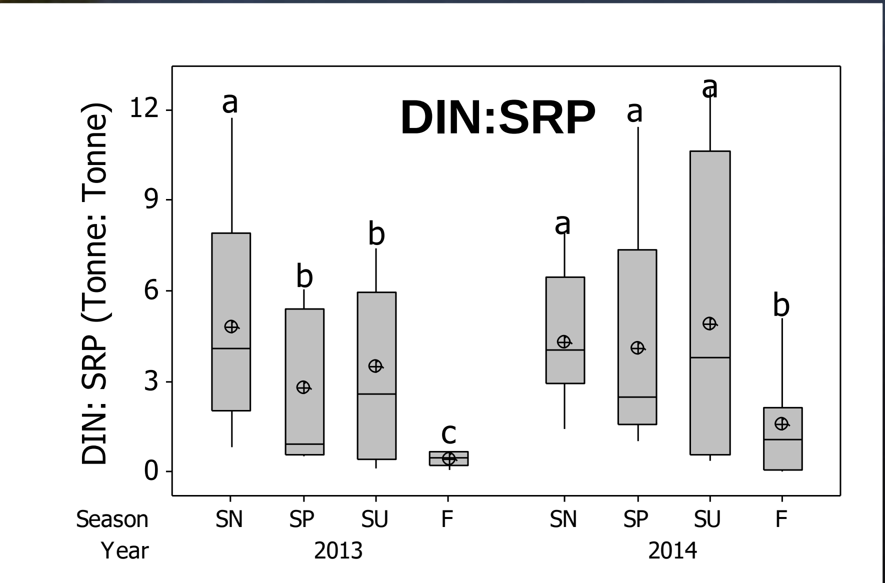
- Results from a two-way ANCOVA (season and year as factors, crop cover as co-variate) showed that PN:PP ratios differed on an ***annual*** and ***seasonal*** basis.

- 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





- 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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Thank You!

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