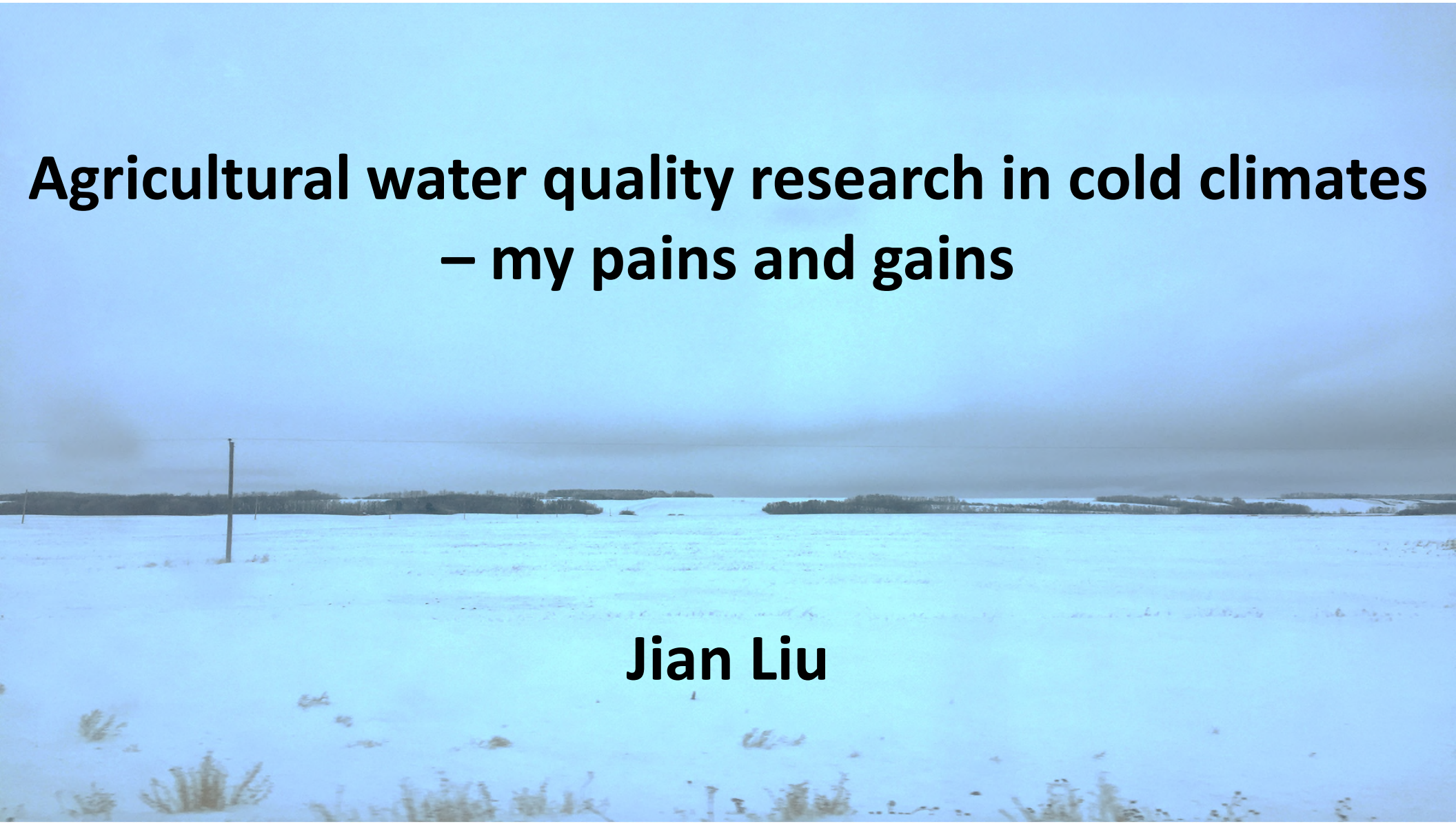
Agricultural water quality research in cold climates – my pains and gains



Jian Liu

What is my agricultural water quality research about?

Nutrient loss from land to water is affected by both source and transport factors, so how to manage these factors?

- **Source: soil, fertilizer, manure, vegetation, etc.**
- **Transport: snowmelt and rainfall runoff**

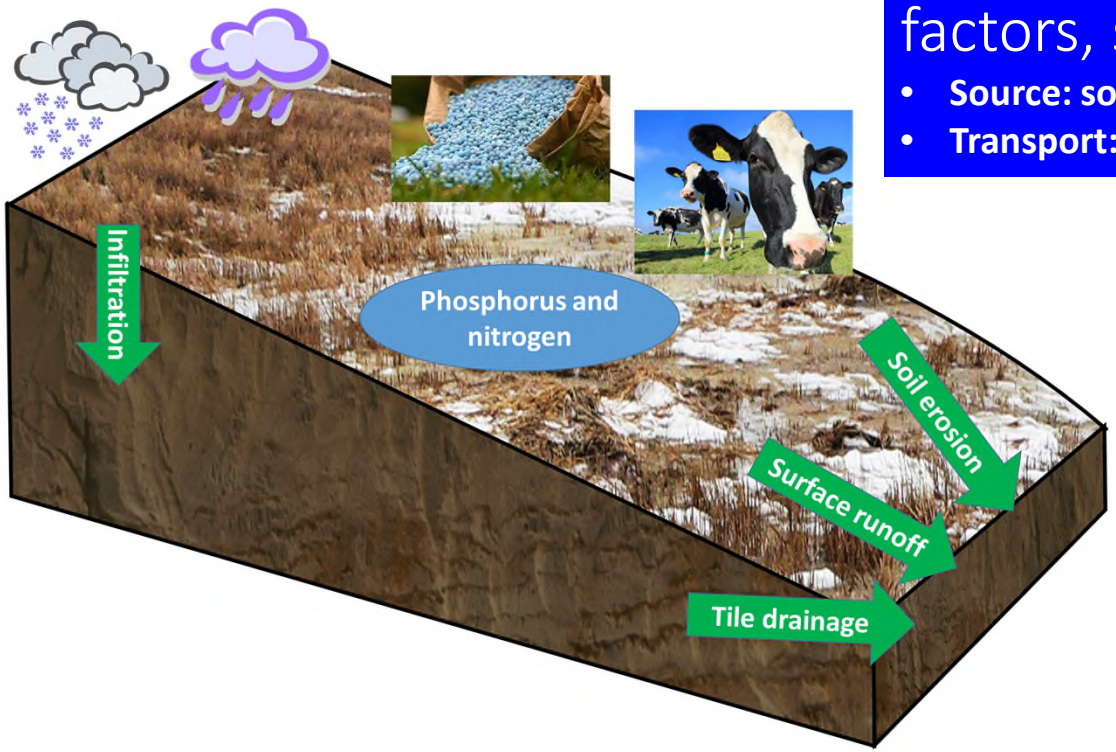
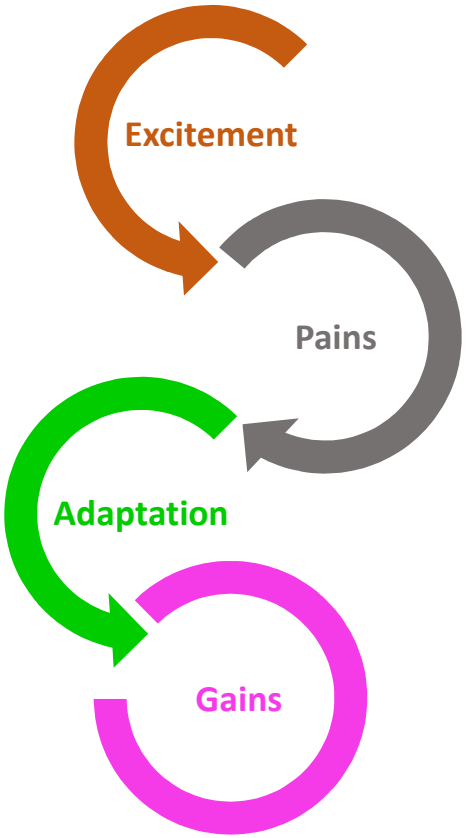


Photo: www.britannica.com/story/harmful-algal-blooms

My feelings of research on agricultural water quality in the Prairies have evolved like this…



A friend's feelings of immigration

"Canada is a gold country"

"Canada is cold and hard to get a secured job"

"I need to do something"

"I am settled in Vancouver now and am becoming a citizen soon"

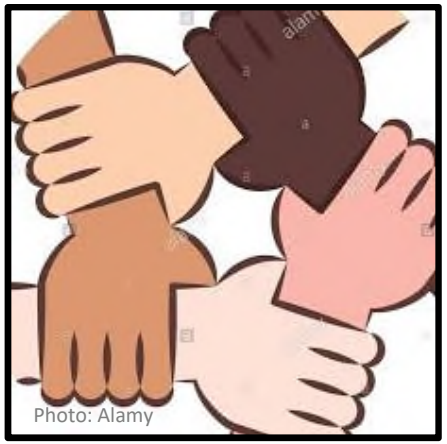
Excitement – many opportunities

Big research question and impact

Great research foundation and project

GIWS GWF

Inclusive & supportive work environment



Pains – Prairies is different from what I was familiar with

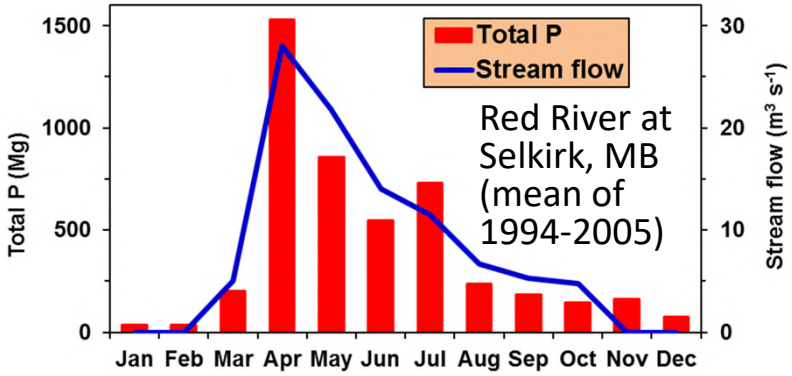
I. Landscape is FLAT (little erosion but much dissolved P)

II. It is very COLD and SNOW stays over winter

III. Snow MELTs fast in spring and can even cause flooding

V. Many MANAGEMENT options do NOT WORK for water quality, and agron. and environ. TRADE-OFFS widely exist

IV. Snowmelt dominates annual NUTRIENT losses



Adapted from Lake Winnipeg Stewardship Board (2006)

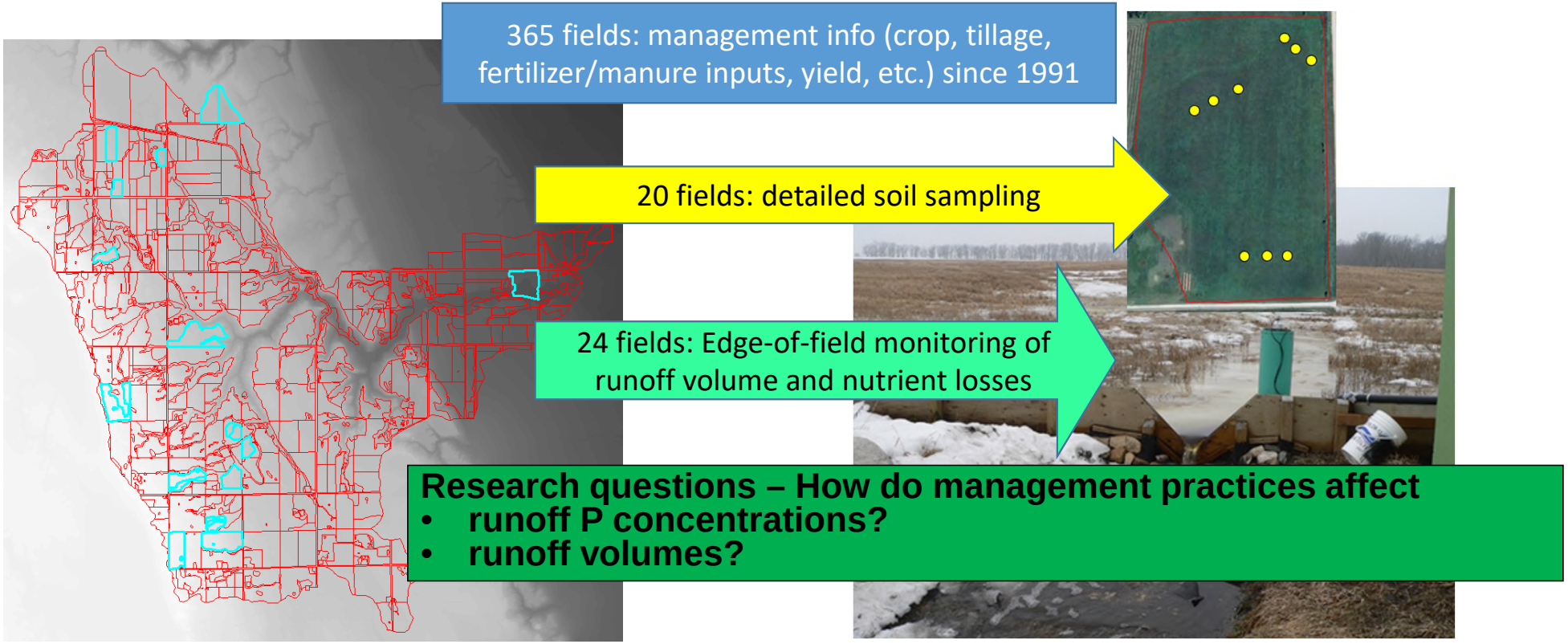
VI. Vulnerable to CLIMATE CHANGE

Adaptation – process and past experience

- **Contextualize and integrate obtained experience and skillset (and interest) in the new environment**
  - Understand the new challenges/problems
  - Reflect on your skillset and experience (and interest)
  - Think about new potential solutions
  - Test the potential solutions by integrating your experience and skillset (and interest) with available resources

- **Obtained experience and skillset:**
  - Nutrient management and water quality research in Sweden, United States and China
  - Field and lab experimentation, data mining, analysis and synthesis, understanding of models, and understanding of how nutrient losses occur.

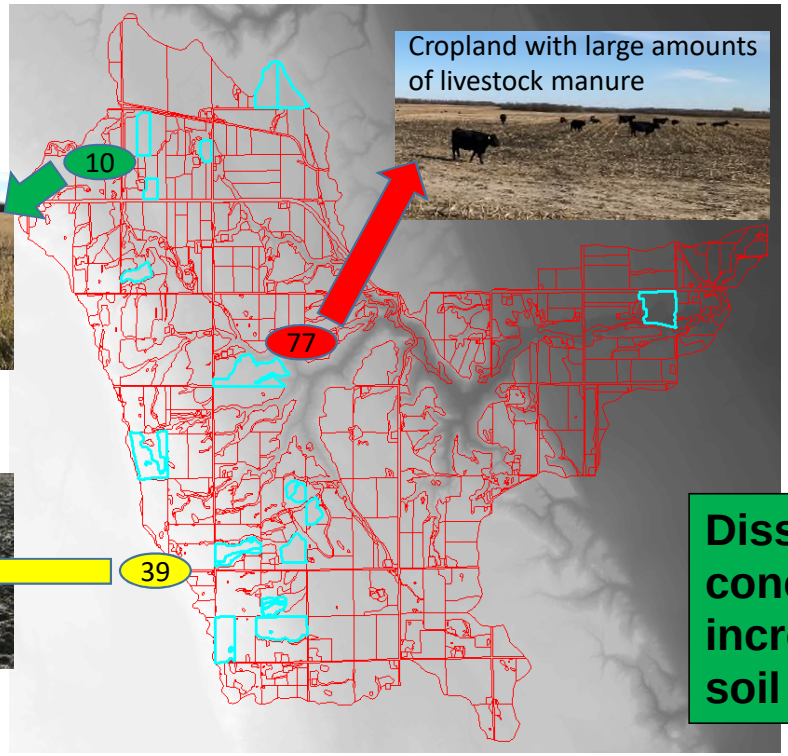
Great resources for understanding and managing source and transport factors to mitigate nutrient losses



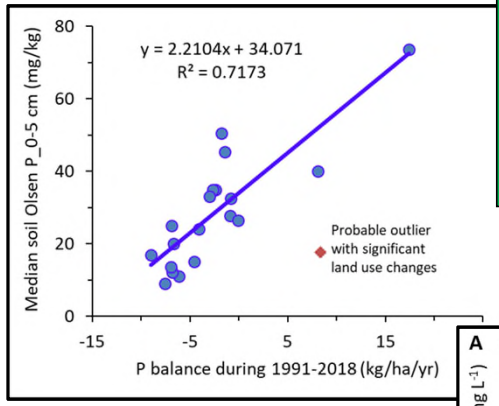
South Tobacco Creek watershed, Manitoba (76 km^2, 70% agricultural land)

Gain I: Better quantify field management – soil Olsen phosphorus – runoff phosphorus relationships

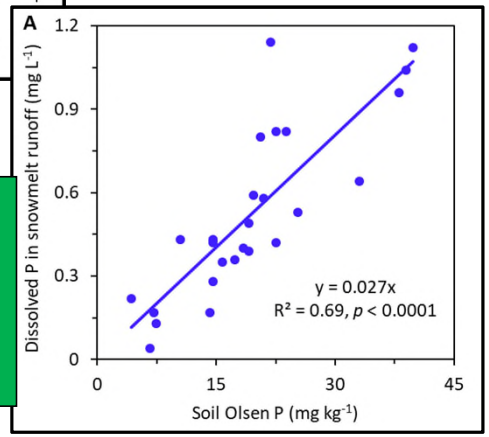
Soil Olsen P (mg/kg): an analytical method for plant available P in the soil.



P balance =
P input – crop P removal



Soil test P values increase with increasing soil P balance

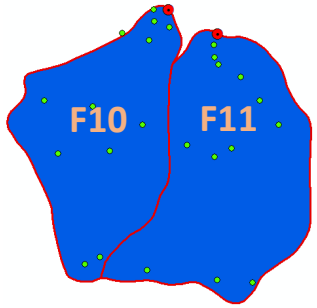


Dissolved P concentrations in runoff increase with increasing soil test P values.

(Liu et al., in preparation; Liu et al., 2021; Agr. Water Manage.)

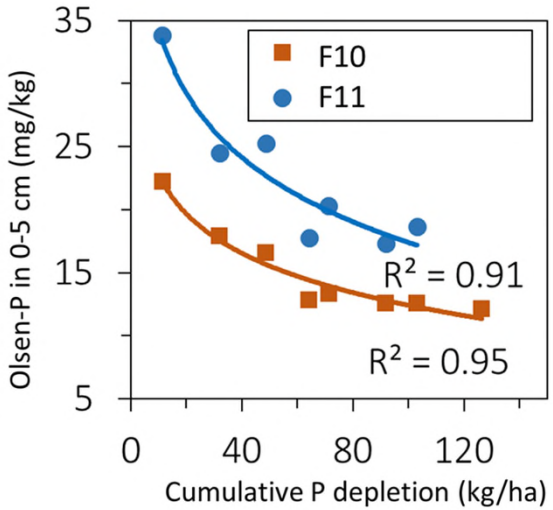
Gain II: Verify a soil P drawdown approach to improve water quality without impacting crop yield

Soil P drawdown: reduce P application rates but continue to remove P from the soil by harvesting crops



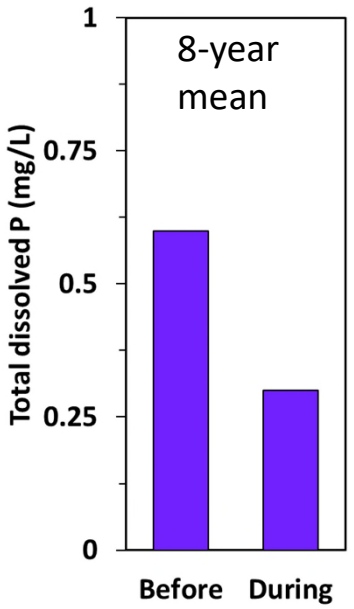
8 years **before** P drawdown
8 years **during** P drawdown

Soil test P

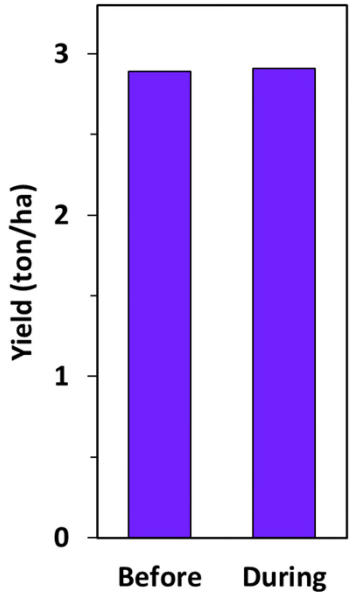


P depletion = harvest removal – P fertilizer

Snowmelt P runoff

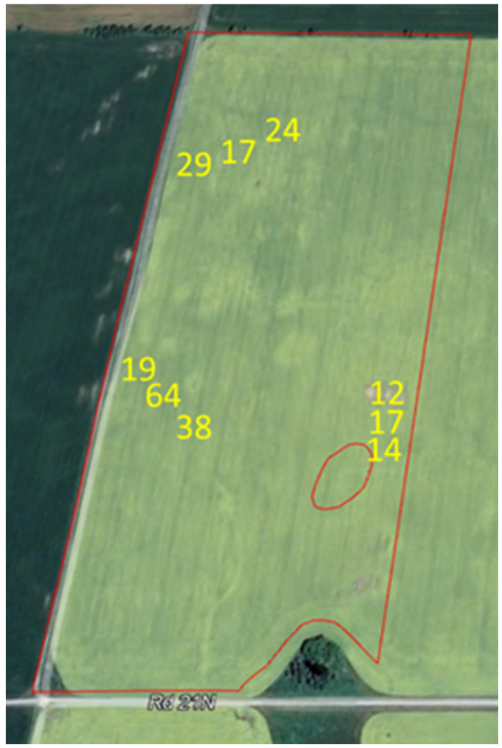


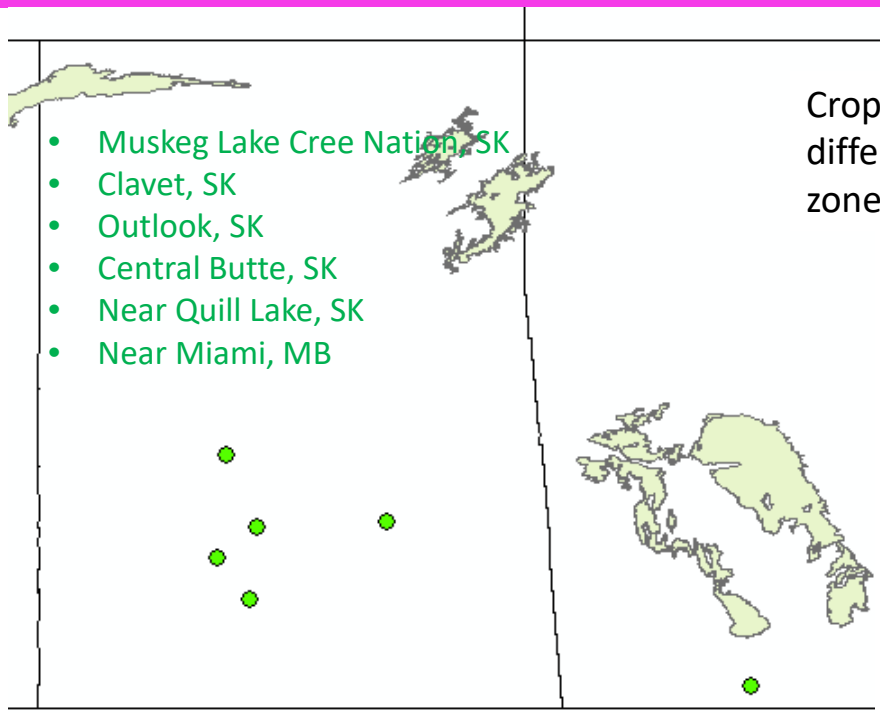
Canola yield



(Liu et al., 2019, J. Environ. Qual. 48:803-812)

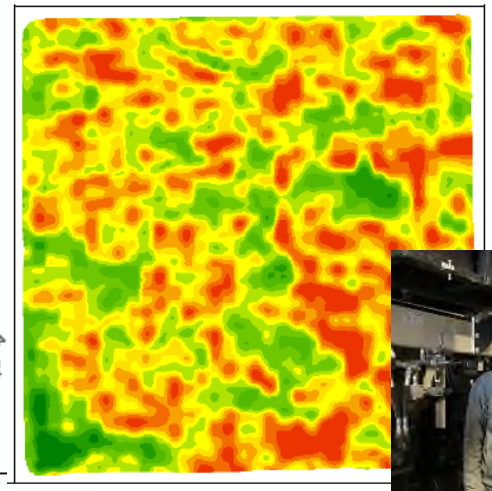
Gain III: Propose a place-based soil P management approach to achieve environmental and agronomic benefits





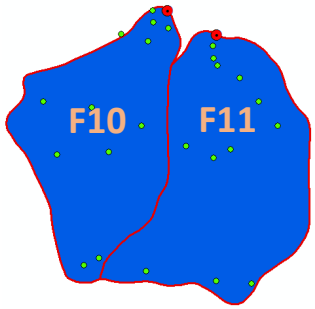
- Muskeg Lake Cree Nation, SK
- Clavet, SK
- Outlook, SK
- Central Butte, SK
- Near Quill Lake, SK
- Near Miami, MB

CropPro Soil Water and Topography maps: different colors mean different management zones with different soil test P values



(New project funded by Western Grains Research Foundation and Sask Wheat to Baulch, Liu, Elliott, Schoenau, Arcand, and Lobb)

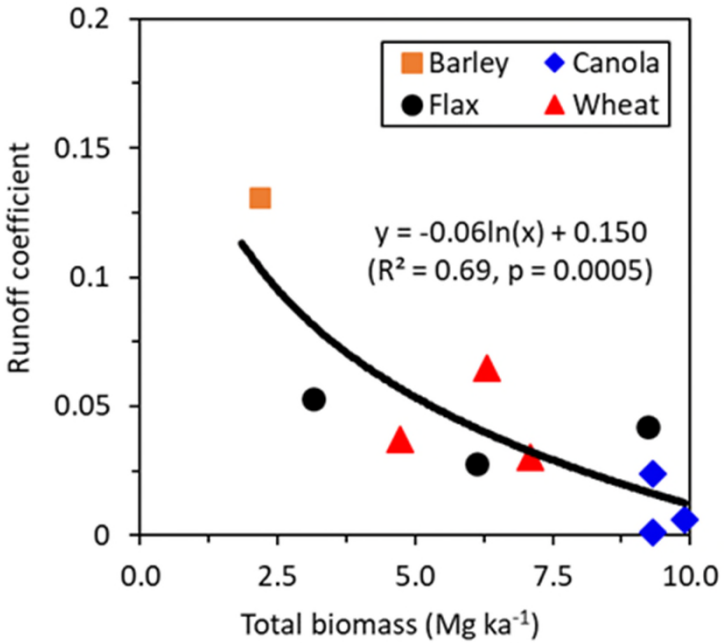
Gain IV: Assess crop management effects on runoff volume



-20-year runoff monitoring

-Different types of crops

Rainfall runoff



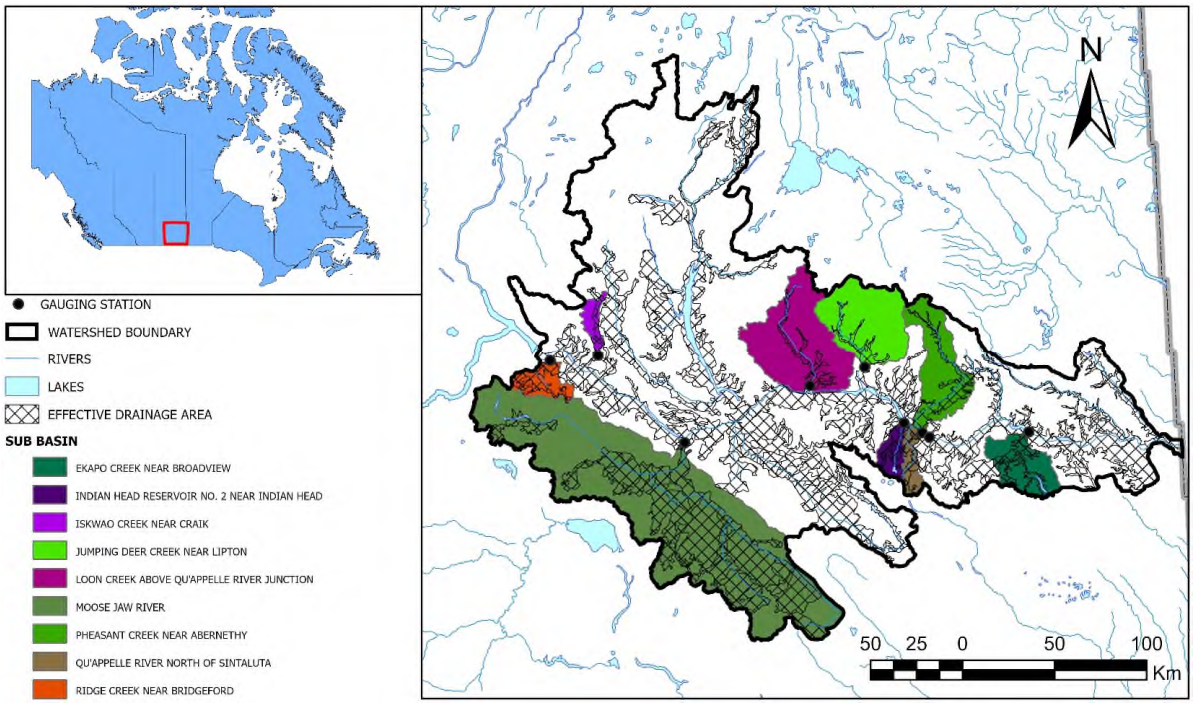
More straw means less rainfall runoff but greater snow retention and more snowmelt

Crop management: agron.-environ. trade-offs

(Liu et al., Agr. Water Manage., submitted; Liu and Lobb, 2021, Water)

Gain V: Support stakeholders in prioritization of management options – using nutrient export coefficient approach

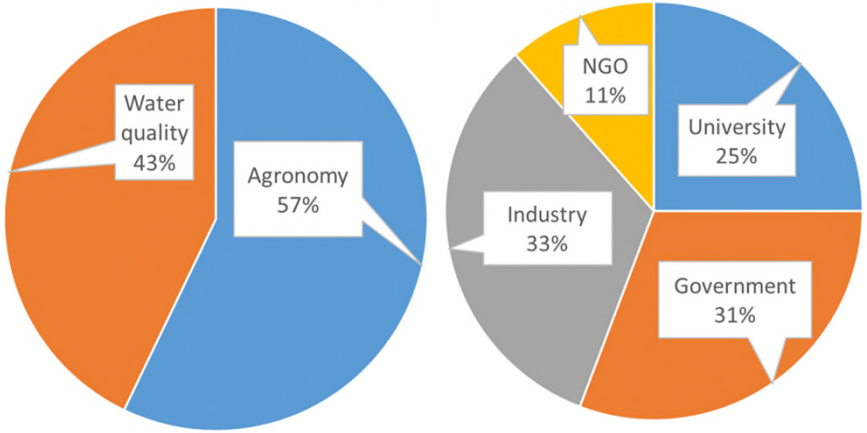
Qu'Appelle Watershed, Saskatchewan



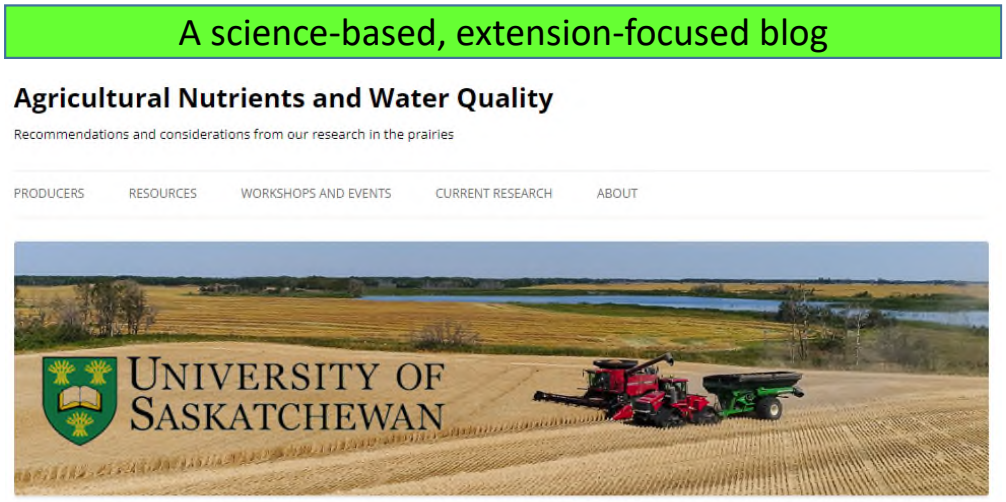
(Liu et al., 2022, Can. Water Res. J.)

Gain VI: Increase water quality awareness and enhance collaborations across the Prairies

A Prairie-wide workshop: "Keeping Phosphorus on the Land"



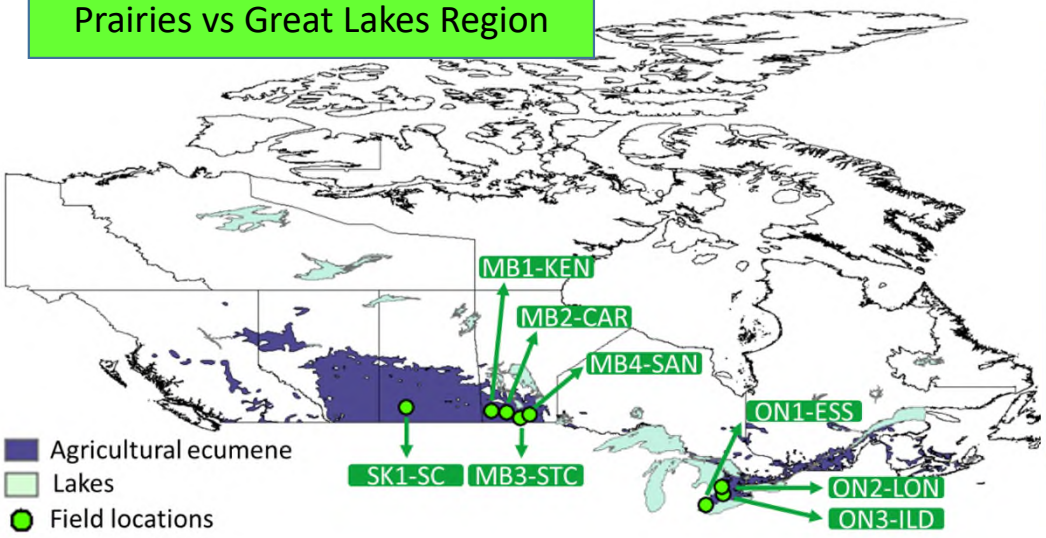
A science-based, extension-focused blog



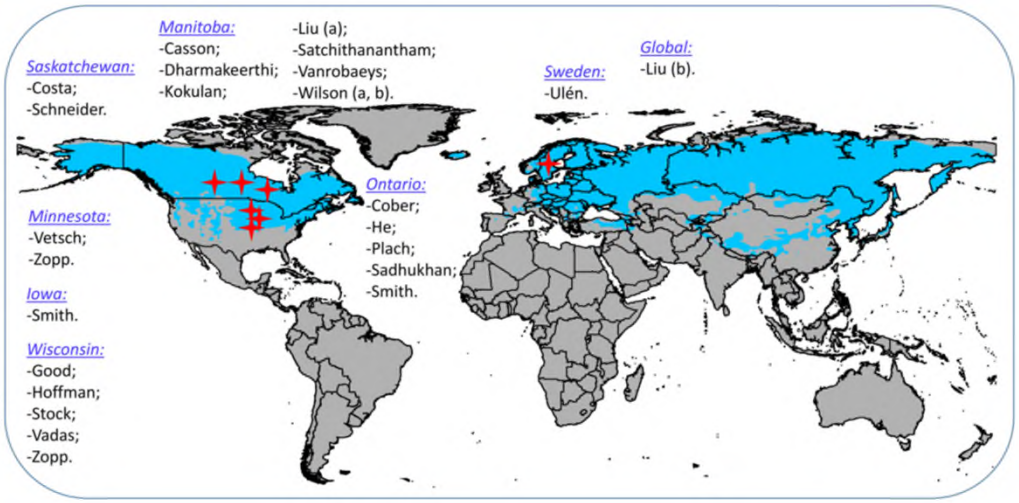
https://words.usask.ca/agwaterquality/

Gain VII: Put the Prairie agricultural water quality research into a larger context of cold climate regions

Cross-region comparisons in drivers of phosphorus losses: the Prairies vs Great Lakes Region



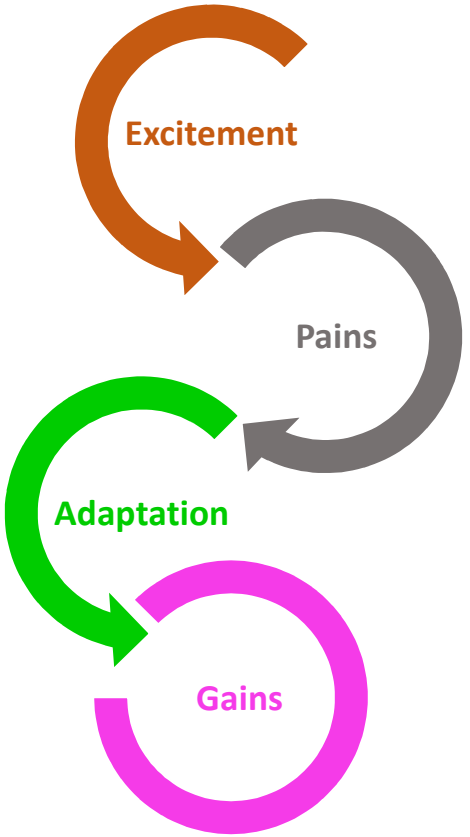
A journal special issue on agricultural water quality in cold climate regions



(Liu et al., 2021, Agr. Water Manage.; Liu et al., 2019, J. Environ. Qual. 48:792-802)

Conclusions – gains will follow pains (despite gains may come late sometimes)

- Big challenges and variable climate require more thought, and more work on solutions for water quality management.
- Although it is not easy to identify solutions and trade-offs are hard to tackle, potential solutions do exist to improve agricultural water quality in the Prairies.
  - For example, place-based and/or climate-based nutrient management.
- My final gain – the NIBIO position.



Acknowledgement

- **Jane Elliott** (ECCC) and **Helen Baulch** (GIWS)
- **Henry Wilson** (AAFC), **David Lobb** (U. Manitoba), **Merrin Macrae** (U. Waterloo), **Don Flaten** (U. Manitoba), **Jennifer Roste** (WSA), **Etienne Shupena-Soulodre** (WSA), **John-Mark Davies** (WSA), **Diogo Costa** (ECCC), **Jeff Schoenau** (U. Sask.), **Melissa Arcand** (U. Sask.)
- **Baulch's lab and many colleagues and friends at GIWS**
- **Also many other external collaborators**

- **GWF – Agricultural Water Futures, GIWS/GWF – Capacity Building Award, Agriculture and Agri-Food Canada, Environment and Climate Change Canada (multiple projects), Saskatchewan Government, Manitoba Government, Ducks Unlimited Canada, Western Grains Research Foundation, and Saskatchewan Wheat Development Commission**

My list of Prairie-related publications

1. Liu et al. 2018. A global review of regulations and guidelines related to winter manure application. Ambio 47:657-670.

2. Liu et al. 2019. Agricultural water quality in cold climates: Processes, drivers, management options, and research needs. J. Environ. Qual. 48:792–802

3. Liu et al. 2019. Impacts of cover crops and crop residues on phosphorus losses in cold climates: A review. J. Environ. Qual. 48:850–868

4. Liu et al. 2019. Impacts of soil phosphorus drawdown on snowmelt and rainfall runoff water quality. J. Environ. Qual. 48:803–812

5. Liu et al. 2021. Phosphorus runoff from Canadian agricultural land: A cross-region synthesis of edge-of-field results. Agr. Water Manage. 255:107030

6. Liu et al. 2021. Phosphorus runoff from Canadian agricultural land: A dataset for 30 experimental fields. Data Brief 38:107405

7. Liu and Lobb. 2021. An overview of crop and crop residue management impacts on crop water use and runoff in the Canadian prairies. Water 13(20):2929

8. Liu et al. 2022. Screening and scoping-level assessment of beneficial management practices in a Canadian prairie watershed. Can. Water Res. J. 47(1):83–109

9. Liu et al. Submitted. Runoff as influenced by rainfall characteristics and field management. Agr. Water Manage.

10. Liu et al. In preparation. The need of balancing soil phosphorus for improving water quality and crop production: Evidence from multiple scales

11. Liu et al. In preparation. Phosphorus rich or phosphorus poor: Managing soils to keep phosphorus on prairie lands

12. Costa et al. 2019. Temporal dynamics of snowmelt nutrient release from snow–plant residue mixtures: An experimental analysis and mathematical model development. J Environ. Qual. 48:869–879

13. Costa et al. Accepted. Impact of climate change on catchment nutrient dynamics: insights from around the world. Environ. Rev.

14. Hoggarth et al. In preparation. Vegetation management and water quality in agricultural ditches