Manitoba Soil Science Society (MSSS)
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MSSS Summer Tour 2026

Description: Today we will explore practical strategies to build resilience against both excess moisture and drought. The day begins at the MacMillan Grain and Livestock Farm, where we will learn about farm management practices, examine a soil pit in an alfalfa field to better understand soil development and properties, and view specialized micrometeorological equipment used to measure soil water and crop evapotranspiration. Following a lunch break at the Fort La Reine Museum, attendees will take part in the unveiling of the first Soil Monolith, highlighting the importance of Manitoba's soil resources. Then, we will stop near Elm Creek to view two soil pits with contrasting textures, where the soil transitions from clay to sand along the edge of Glacial Lake Agassiz. Finally, we will stop near Culross to discuss surface and tile drainage, water retention, and irrigation methods that help producers effectively manage water under increasingly variable weather conditions.

Tour Agenda:

8:00am	Depart Winnipeg (Sobey's at Kenaston)
9:00am	**Stop 1 – MacMillan Grain and Livestock Farms (120 mins)**
	• MacMillan Farm operations and soil management considerations
	• Soil pit
	• Eddy flux tower
11:00am	Travel to Fort La Reine
11:35am	**Stop 2 – Fort La Reine Museum (85 mins)**
	• Lunch
	• Unveiling of First Soil Monolith Museum Display
1:00pm	Travel to Elm Creek
1:30pm	**Stop 3 – Twin Elm Farms (90 mins)**
	• Two soil pits with contrasting textures
	• Strip tillage
3:00pm	Travel to Culross
3:15pm	**Stop 4 – Joel Classen Farm (60 mins)**
	• Water management via tile and surface drainage
	• Water retention and irrigation
4:15pm	Travel to Winnipeg
5:15pm	Drop-off at Sobey's on Kenaston

Thank you to our tour sponsors!



MacMillan Grain and Livestock

Meadow Lea, MB

MacMillan Grain and Livestock is a diverse, multi-generational farm in the R.M. of Woodlands, MB. Bryce and Kristen MacMillan and their 3 young children, farm together with Bryce's brother Brad and family, and their parents, Glen and Michelle. They grow wheat, canola, soybeans, corn, oats, peas, and perennial forages for hay production on 6,000 acres of land. Soils across the farm range from very fine sandy loam to clay and are highly calcareous with pockets of salinity.

Located in a transitional area of prairie cropland to mixed pasture-bush in the Lake Manitoba Plain, they also operate a 200 pair cow-calf beef herd and 110-cow dairy operation and. The farm has a team of people to make this happen, including 3 full-time and 4-6 part-time or seasonal positions.

Pioneers of the MacMillan family began farming in the Meadow Lea district in 1878, purchasing land once owned by the Hudson's Bay company. Coming up 150 years of farming history, the MacMillan family continue as stewards of their land and livestock for the sixth generation to continue.



Marquette and Meadow Lea Area: Landscape, Climate and Soils

The Marquette and Meadow Lea area lies northwest of Winnipeg on the western side of the Red River Plain, where level lake-laid sediments merge with slightly higher glacial till landscapes. This area is part of the Winnipeg map sheet described in the *Reconnaissance Soil Survey of Winnipeg and Morris Map Sheet Areas*.

Geology and Glacial History

The underlying geology of the area consists dominantly of limestone and dolomite with small amounts of red shale, gypsum and anhydrite. These formations area from the Mesozic era from the Jurassic period and the Palaeozoic era. The landscape is shaped by the legacy of the last continental glaciation and the formation of glacial Lake Agassiz. During deglaciation, meltwater from the retreating Laurentide Ice Sheet ponded across southern Manitoba, forming a large post glacial lake that deposited fine clay and silty sediments over glacial till materials.

This position gives the area a transitional character. It is not as uniformly deep-clayed as the central Red River Valley, but it is also not a typical exposed till plain. Instead, the land surface reflects a thin to moderate mantle of lacustrine clays and clay loams over glacial deposits, producing broad, nearly level fields with shallow depressions and subtle changes in drainage. These low-relief features influence where water collects, where salts accumulate, and where differences in crop growth may appear within the same field.

Climate and Vegetation

The area has a continental prairie climate, with cold winters, warm summers and most precipitation falling during the growing season. Average annual precipitation near Winnipeg is about 519 mm. Mean monthly temperatures are above freezing from April to October and below freezing from November to March, which reflects the short but productive growing season typical of southern Manitoba. The area receives approximately 1,814 growing degree days above 5C and 122 frost free days.

Native vegetation reflects the area's position near the transition from tall-grass prairie to aspen parkland. Better-drained sites supported tall prairie grasses and associated herbs, while local aspen invasion occurred where moisture conditions were slightly more favourable for tree growth. Poorly drained depressions supported meadow grasses, sedges and willow, while saline areas supported salt-tolerant plant communities. Much of this native vegetation has since been converted to annual cropland, hayland and pasture, but remnants of aspen bluffs, wet meadows and drainage corridors still reflect the original vegetation pattern.

Soils

The dominant soils associated with this landscape are mapped as the **Marquette Association**. These soils developed on approximately 16 to 30 inches of lacustrine clay / clay loam over calcareous till or stratified drift. Surface textures range from clay loam to clay, and the topography is generally level with larger shallow depressional areas.

Marquette are Chernozemic soils and have dark, organic-rich surface horizons formed under grassland vegetation. They are naturally fertile and suited to general crop production, but their clayey texture can make them sticky when wet, hard when dry and prone to clodding if worked under poor moisture conditions. Maintaining soil structure through crop residue return or perennial forages is important for keeping these soils friable and productive. Some areas have the McCreary soil series which are similar to the Marquette association and series but have a loamy surface texture.

Poorly drained Gleysolic Magnet or Kline soils occur in lower landscape positions where water remains closer to the surface. These soils often contain carbonate accumulations and varying degrees of salinity. In some depressions, a peaty surface layer may be present. Productivity in these areas is variable because excess water and salinity can restrict crop growth; some areas are better suited to hay or pasture unless drainage and salinity limitations can be managed. Some Magnet and Kline soils in this area have been drained over time to help improve internal drainage and productivity.

EDDY COVARIANCE

Measuring what you can't see



MSSS Summer Tour – August 20, 2026

University of Manitoba Micrometeorology Lab

Manitoba Soil Science Society

Prepared by Emily Robb and Dr. Henrique Carvalho

What is Eddy Covariance?

Eddy covariance (EC) is a micrometeorological technique that directly measures the **flux** of gases, energy, and momentum between Earth's surface and the atmosphere. This allows for the characterization of the exchange rates of trace gases over landscapes.

Measurements are **in-situ** and **non-destructive**.

Instruments collect data at high frequencies, allowing for **high temporal resolution**.

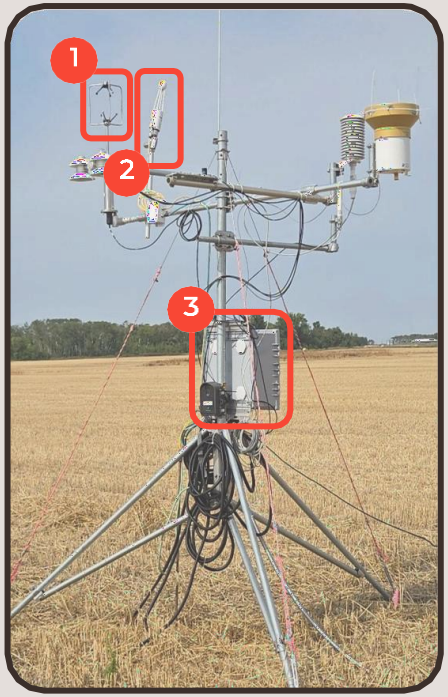
Large measurement footprints permit **ecosystem-level** observations.

EC has a **broad application scope** and can be used in many environments.

How Does EC Work?

As the sun heats the Earth's surface and atmosphere, air mixes into swirling pockets known as **eddies**. Eddies transport gases and heat vertically through the atmosphere.

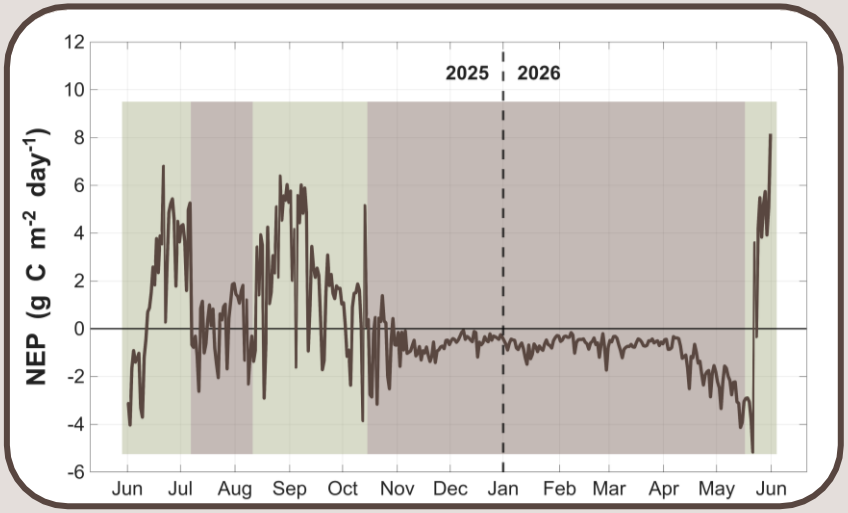
EC sensors simultaneously collect data on wind speed and gas concentrations (CO_2, H_2O) from eddies at 10 Hz. By calculating the covariance between high-frequency wind velocity and gas concentrations, a direct and continuous reading of an ecosystem's "breath" can be established.



1. The **3-D Ultrasonic Anemometer** measures wind speed in 3 directions.
2. The **Infrared Gas Analyzer** measures CO_2 and H_2O concentrations.
3. The **Enclosure** holds equipment for data collection and storage.

Capturing Carbon

Plants take up carbon (C) through photosynthesis, which is described by **Gross Ecosystem Productivity (GEP)**. Conversely, C is released through plant and soil respiration, which is described by **Ecosystem Respiration (ER)**. The difference between GEP and ER is described by the **Net Ecosystem Productivity (NEP)**, which characterizes an area's C balance.



+NEP



GEP exceeds **ER** during crop growth.

C is **gained** by the agricultural system.

-NEP

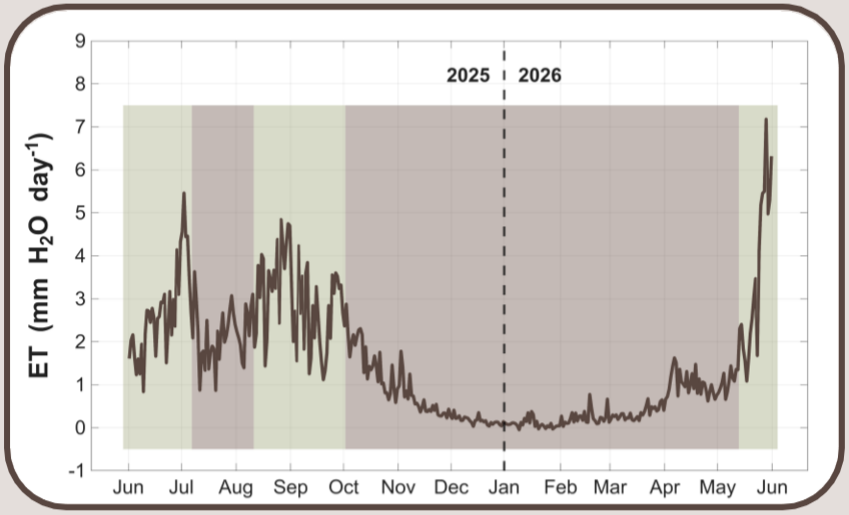


ER exceeds **GEP** after cutting forage for hay.

C is **released** from the agricultural system.

Moisture in Motion

Evapotranspiration (ET) describes the combined transfer of water from the land surface to the atmosphere through evaporation from soil surfaces and transpiration from plants. Together, these processes represent crop water use and provide valuable information on soil moisture depletion, crop growth, the exchange of energy, and overall field water balance.



↑↑ ET



Warmer weather and active crop growth encourage **ET**.

Water loss is **greater**.

↓↓ ET



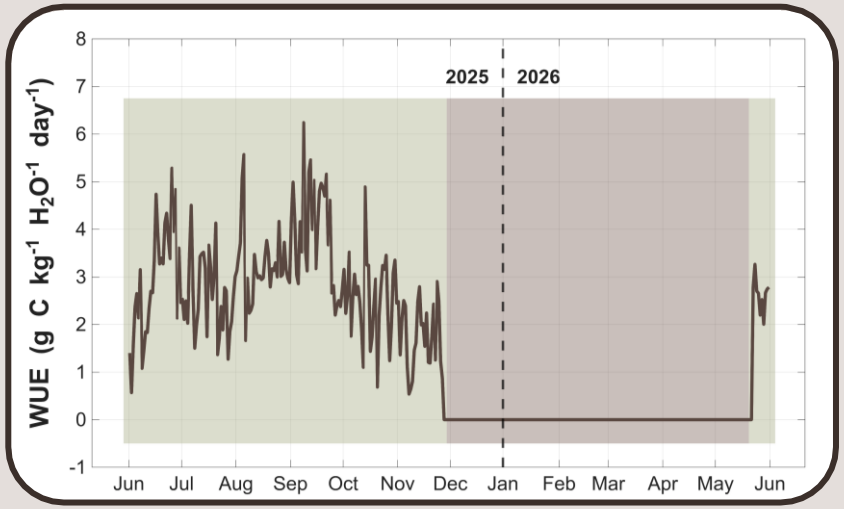
Cooler weather and reduced crop growth lessen **ET**.

Water loss is **limited**.

The Carbon-Water Connection

Water Use Efficiency (WUE) describes how efficiently crops use water to capture atmospheric C. It is derived by finding the ratio of C gained (GEP) to water lost (ET).

As WUE increases, crops are generally more productive, assimilating more C per unit of water consumed. Changes in WUE throughout the season reflect crop development, weather conditions, and water availability.





Crops are growing and using water above ~0°C.

WUE can be determined.



Crops are not growing or using water below ~0°C.

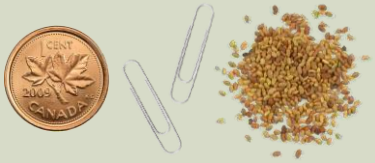
WUE is **not applicable.**

WUE in the Wild: A Case Study

From June 2025 to June 2026, this perennial forage system had an average **WUE** of **2.78 g C kg^{-1} H_2O^{-1} day^{-1}**.

For each litre of water consumed by this system, the weight of C captured is equal to:

~1 Canadian penny.
~2 paper clips.
~1,000 alfalfa seeds.



Assume that standard water resources allow for **5.0 tons of silage $acre^{-1}$** to be harvested during the first cut for this perennial forage system.

... if WUE = 2.78

Approximately **5.0 tons of silage $acre^{-1}$** could be produced.

... if WUE = 2.88

Approximately **5.2 tons of silage $acre^{-1}$** could be produced.

In this scenario, improving (increasing) WUE by 0.1 **improves** silage yield by **0.2 tons $acre^{-1}$** while water consumption does not change. On a quarter-section of land (160 acres), improved WUE could permit an additional **32 tons** of silage. Using management strategies to slightly modify WUE can significantly alter yield outcomes, especially in water-limited environments.

... But Wait, There's More!

6 EC sites are currently monitored by the University of Manitoba Micrometeorology Lab to collect bio-meteorological data 24 hours a day, 365 days a year.



Connect with us!

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Elm Creek Area: Geology, Glacial History, Vegetation, Climate and Soils

The Elm Creek area sits near the transition between the Lower Assiniboine Delta, where sandy deltaic deposits meet the finer-textured clay and silty clay sediments of the Red River Valley and the former Lake Agassiz basin. This makes the area a useful stop for observing how soil texture can change dramatically over a short distance, from heavy clay or silty clay to loamy fine sand and fine sand.

Geology and glacial history

The Elm Creek landscape formed at the meeting point of glacial, lake and delta processes. The area is underlain at depth by Cretaceous shale and sandstone formations, with overburden ranging from tens of metres near the Manitoba Escarpment to more than 100 metres farther east. During the last glaciation, the Laurentide Ice Sheet advanced over south-central Manitoba before retreating after about 11,000 years before present, allowing glacial Lake Agassiz to form along the Manitoba Plain east of the Escarpment.

As Lake Agassiz levels changed, it deposited a wide range of sediments. Fine silts and clays settled in quieter, deeper water, while sandier materials accumulated where meltwater spillways and river deltas entered the lake. The Lower Assiniboine Delta, which includes the Elm Creek area, is a level deltaic and lacustrine plain with local sand dunes. Near Elm Creek, the sandy deposits are thin, often less than one metre near adjacent clayey areas, but increase westward to about 11 to 12 metres thick. All of these sandy sediments are underlain by stratified silt and clay at depth.

Climate and vegetation

The area has a cool, subhumid climate that supports productive agriculture and the development of Chernozemic Black soils. Mean annual precipitation ranges from about 445 mm, the frost-free period ranges from about 116 to 140 days. Soil water deficits tend to be greater on sandy soils because of their lower water-holding capacity, while clayey soils generally hold more water but are more prone to seasonal wetness.

Native vegetation in the Lower Assiniboine Delta included mixed prairie grasses with groves of deciduous trees. On level to gently sloping land, aspen, willow, saskatoon, chokecherry and hazel were common, while duned landscapes supported bur oak with sparse grass, artemisia, cactus and juniper. Wet depressional areas supported willow, sedges, cattails, meadow grasses and other herbaceous plants. In the Red River Valley portion of the area can be exceptionally flat, and before drainage ditches were installed these areas were occupied by broad marshes or wet meadows.

Soils

The Elm Creek area is especially notable because heavy clay to silty clay soils can occur close to sandy or loamy fine sandy soils. This reflects the area's position along the margin of the Lower Assiniboine Delta, where sandy deltaic and wind-modified deposits overlap or overlie older lacustrine clays. In field terms, a person can move from a sticky, slowly permeable clay soil with high water-holding capacity to a loose, rapidly permeable loamy fine sand within a short distance.

Soils in the Elm Creek area were mapped at the detailed 1:20,000 scale a part of the Soils of the Rural Municipalities of Grey, Dufferin, Roland, Thompson, and the part of Stanley report.

Red River Association –

The soils designated as the Red River soil association consist of Chernozemic and Gleysolic soils that have developed on the lacustrine fine clay deposits in the central basin of glacial Lake Agassiz. To understand these soils it should be recognized that all the soils of this association at one time or another have been under the influence of excessive moisture, and (due to gradual improvement in drainage) are now passing slowly through various stages of transition from poorly drained to better-drained conditions.

The one outstanding characteristic that the Red River soils have in common is the fine texture of the parent clay but, due to differences in drainage or moisture regime, different soil types with varying morphological features have developed on the same soil parent material. The topography of the clay deposits, in general, is flat and very smooth, and although there is a fall from the western and eastern margins to the Red River channel, and from south to north along the axis of the plain, the grade over much of the area is less than two feet per mile.

Almasippi Association –

The Almasippi soils consists of Chernozemic, Regosolic, and Gleysolic are developed on the sandy deltaic deposits of the Lower Assiniboine Delta. These sandy sediments are underlain by a finer-textured substrate usually at about ten feet below the surface. The surface texture of the Almasippi soils ranges from fine sand to loamy fine sand.

The topography is level, except in areas which have been blown into sand dunes. The Almasippi soils have developed under varying degrees of imperfect drainage, as surface runoff is slow and internal drainage is impeded by the finer texture substrate.

University of Manitoba
Faculty of Agricultural and Food Sciences

Effects of drainage systems on phosphorus transport and crop yields in the Red River Valley, Manitoba

Ehsan Zarrinabadi and David A. Lobb
Department of Soil Science, University of Manitoba, Winnipeg, Canada

THE FERTILIZER INSTITUTE

- Canola (2022): Tile and surface drainage yielded 0.17 and 0.15 kg m^{-2}, respectively (CV: 20% and 18%), showing no meaningful yield difference between drainage types.
- Wheat (2023, 2025): Surface and tile drainage yielded 0.31 and 0.29 kg m^{-2} (CV: ~11% for both), the most stable yields of the three crops.
- Soybean (2024): Uniform yields (~0.11 kg m^{-2}) across drainage types, with higher variability under tile drainage (CV: 21.7%) than surface drainage (CV: 18.3%).
- Canola grain phosphorus was slightly higher and more consistent under surface drainage, while canola residue phosphorus was higher but more variable under tile drainage.
- Wheat and soybean grain and residue phosphorus levels were similar between drainage types, with no consistent drainage effect.

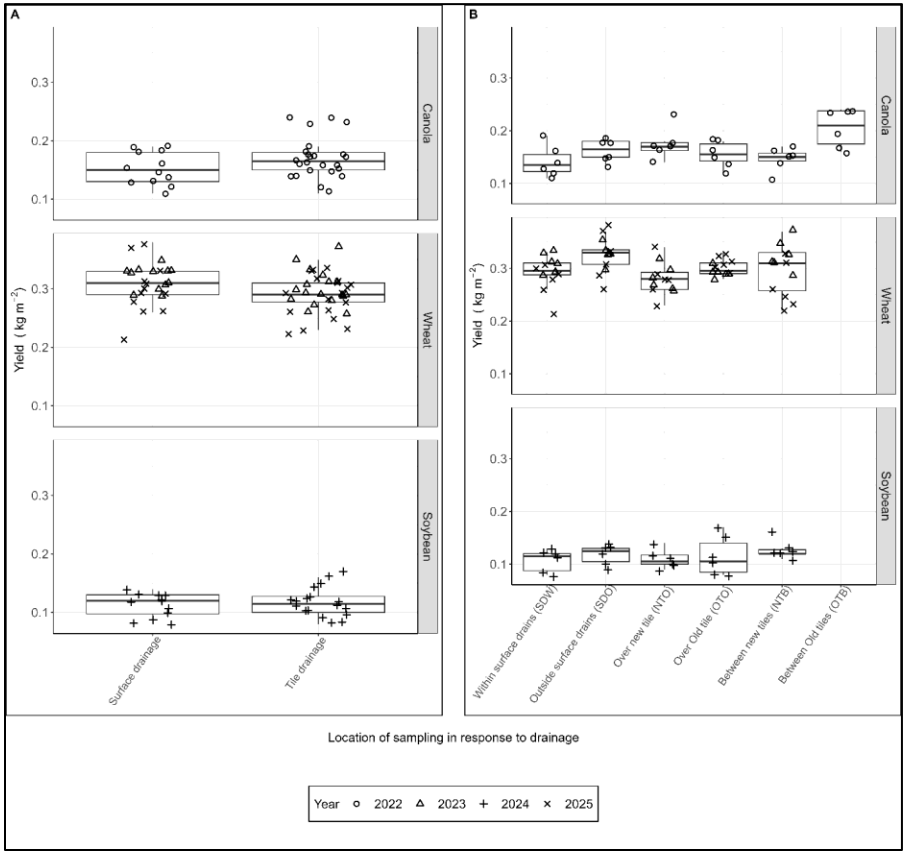


Figure H1

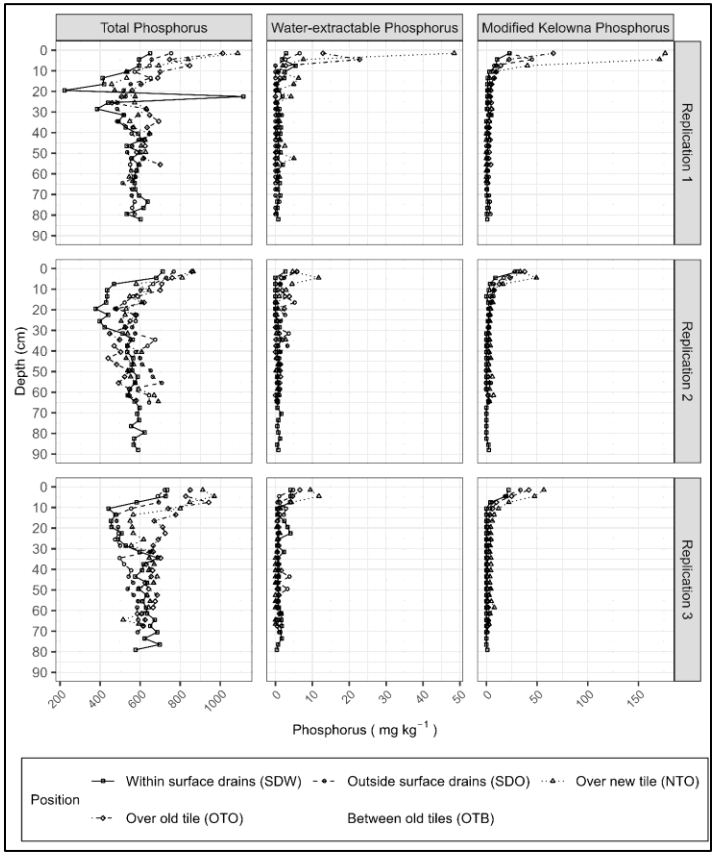


Figure H2

Yield variation (FigureH1) and soil phosphorus distribution (Figure H2) across sampling locations and drainage types (2022-2025).

Effects of drainage systems on phosphorus transport and crop yields in the Red River Valley, Manitoba

Ehsan Zarrinabadi and David A. Lobb
Department of Soil Science, University of Manitoba, Winnipeg, Canada

- Higher concentrations of modified Kelowna Phosphorus (MKP) and Water Extractable Phosphorus (WEP) were consistently observed in the 0-5 cm soil layer, particularly in tile-drained plots.
- Both phosphorus forms decreased from 0-5 cm to 5-15 cm depth across, indicating minimal downward phosphorus mobility.
- WEP was lowest within surface drains and highest over/between tile drains, showing horizontal variability.
- The highest WEP in bare plots over old tiles indicates intense surface phosphorus availability and runoff risk.
- Even at their highest, MKP and WEP concentrations remained near or below Manitoba's environmental phosphorus thresholds (108-143 and 15-20 mg kg^{-1}, respectively), with only one surface sample marginally exceeding the WEP threshold.
- Water discharge was similar between the May and August storm events, but sediment exports were far lower in August.

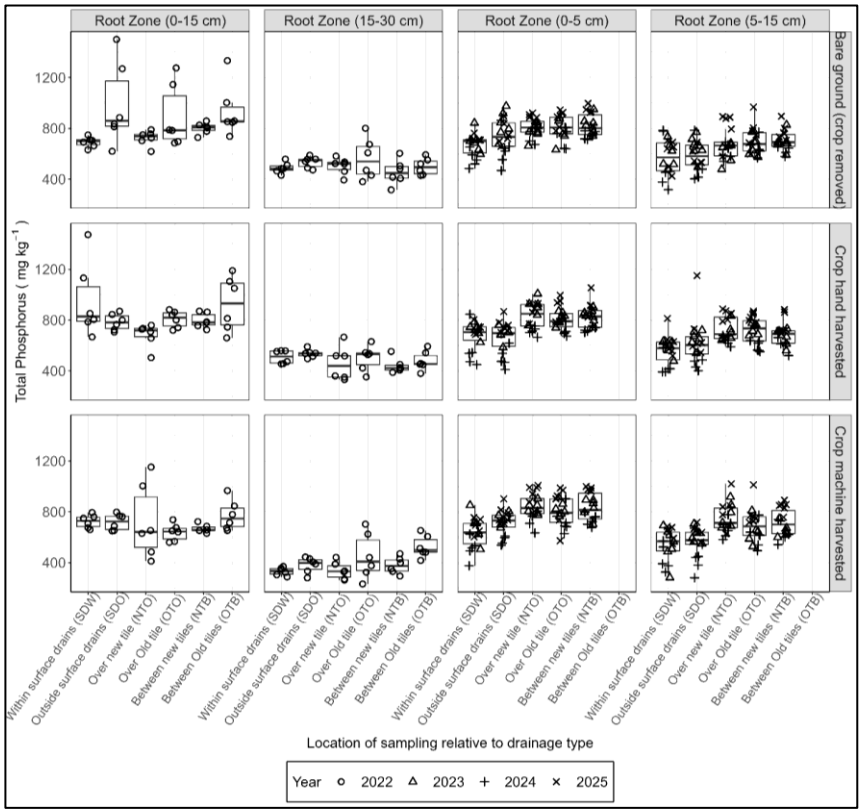


Figure H3

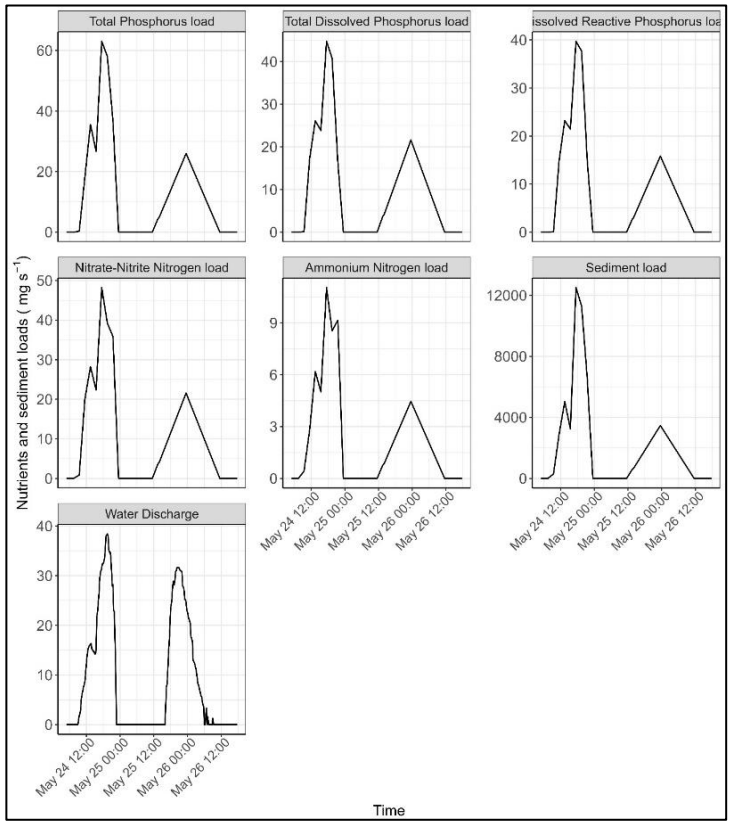


Figure H4

Soil total phosphorus by depth, location, and harvest treatment (2022-2025) (Figure H3), and storm nutrient/sediment loads (Figure H4) during a runoff event.

Spatial and temporal phosphorus dynamics in a cropped field in the Red River Valley

- Phosphorus (P) concentration in soil, and uptake and removal of P by vegetation (crops and weeds) were evaluated to create a phosphorus budget that assesses the risk of phosphorus losses in space and time.
- Plants and their parts were analyzed for their total P content and were categorized into groups - crops (soybean, wheat, canola), summer annuals (green foxtail and redroot pigweed), and perennials (Canada thistle, Canada goldenrod, and quack grass).
- The result showed that seeds were the largest phosphorus sink of all the plant parts, and whole crop biomass had a higher P uptake than whole weed biomass.
- Peak P uptake from all the plant species and their parts occurred in the summer, and nutrient levels in the plants were depleted in the post-harvest season.

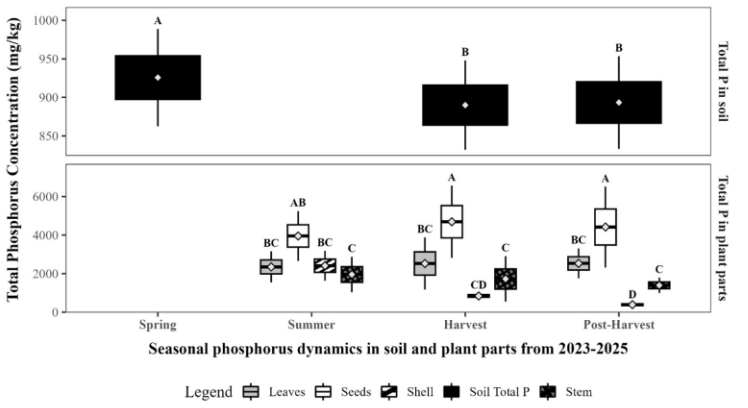


Figure 1a: Temporal release of phosphorus from soil and plant parts across seasons of vegetative growth

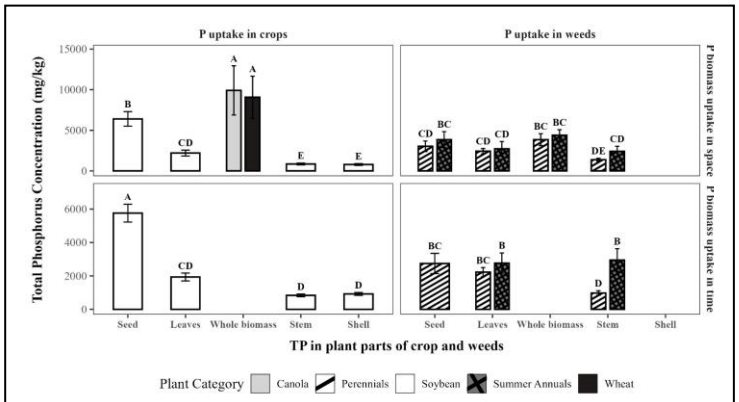


Figure 1b: Mean of phosphorus uptake and removal from crops and weeds averaged across moisture zones (space) and seasons (time) from 2023-2025

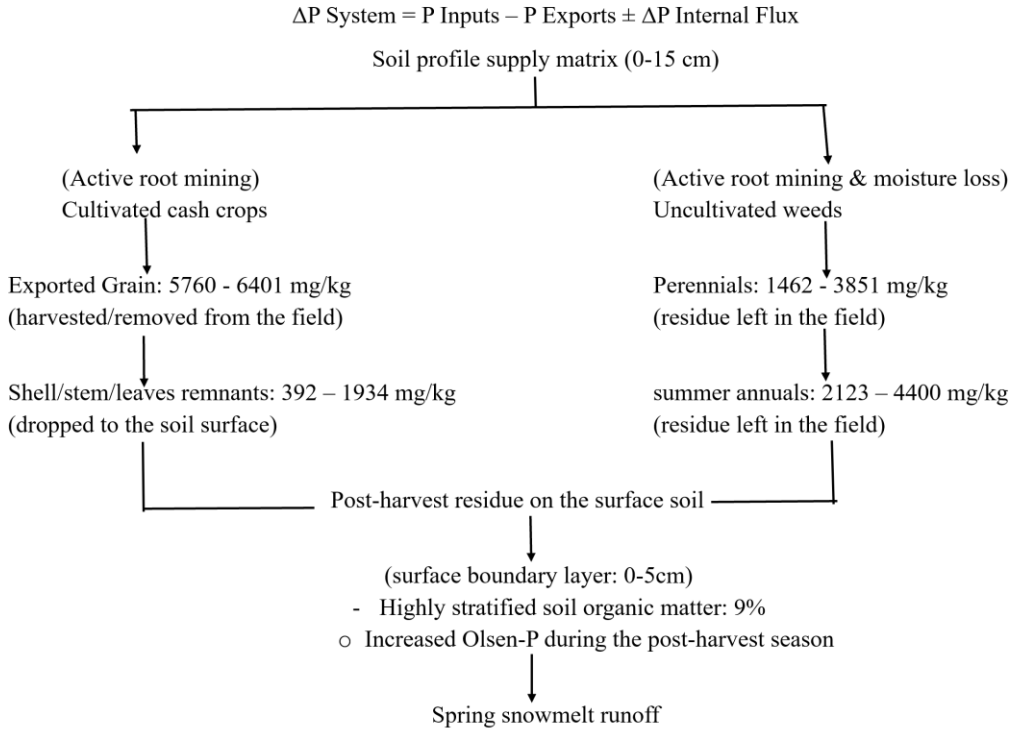


Figure 2: Skeletal field P balance sheet based on the results in this report

- The dry zone had higher soil organic matter and phosphorus concentration than the wet zone.
- There was higher TP concentration in the spring, than at harvest and post-harvest, and this could be due to the fertilizer applied during seeding in the spring.
- During the post-harvest season, there was higher Olsen P concentration, and soil organic matter than in the spring and harvest, and this could be due to the mineralization of crop residues after harvest.
- The surface soil released higher P concentration and soil organic matter than the subsurface soil.
- The plant species draw down P from the subsurface layer during the summer peak growth period.

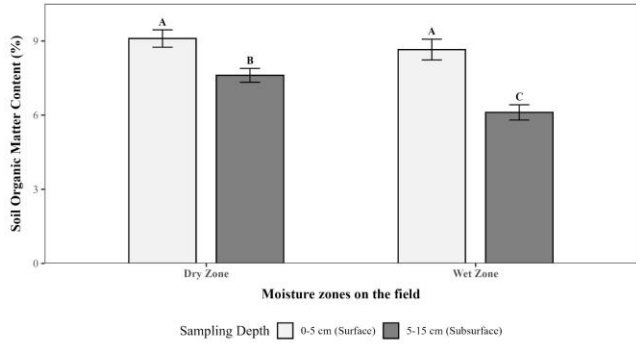


Figure 3a: Soil organic matter content in the moisture zones at surface and subsurface soil depths

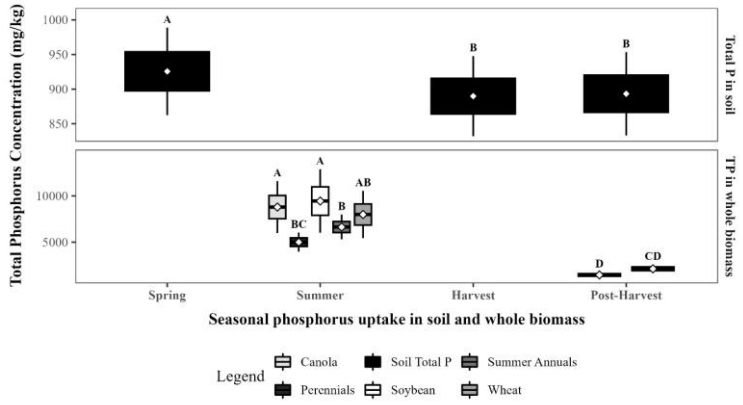


Figure 3b: Phosphorus uptake by whole biomass across the seasons of vegetative growth



Figure 4a: Drone image showing wet areas or surface drains (with green patches) and dry areas of the field during wheat harvest in August 2025



Figure 4b: Drone image showing green weed patches (bottom left corner) at the edge of the field, beside the dry and ready to be harvested wheat crop