Changes in Nitrogen Management in Response to a Changing Climate

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In collaboration with…

- AAFC – Bernie Zebarth, Jacynthe Dessureault-Rompré, Judith Nyiraneza
- PEI Department of Agriculture – Kyra Stiles
- PEI Potato Board – Ryan Barrett
- Fertilizer Canada & Genesis Crop Systems – Steve Watts
- East Prince, Kensington North and Souris Watershed groups

FERTILIZER CANADA

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Prince Edward Island CANADA

Prince Edward Island PEI POTATOES

Nutrient Management

Can we efficiently deliver nutrients to the crop without impacting the surrounding environment?

How will a changing climate influence the efficiency of nutrient use?

What does the future look like?

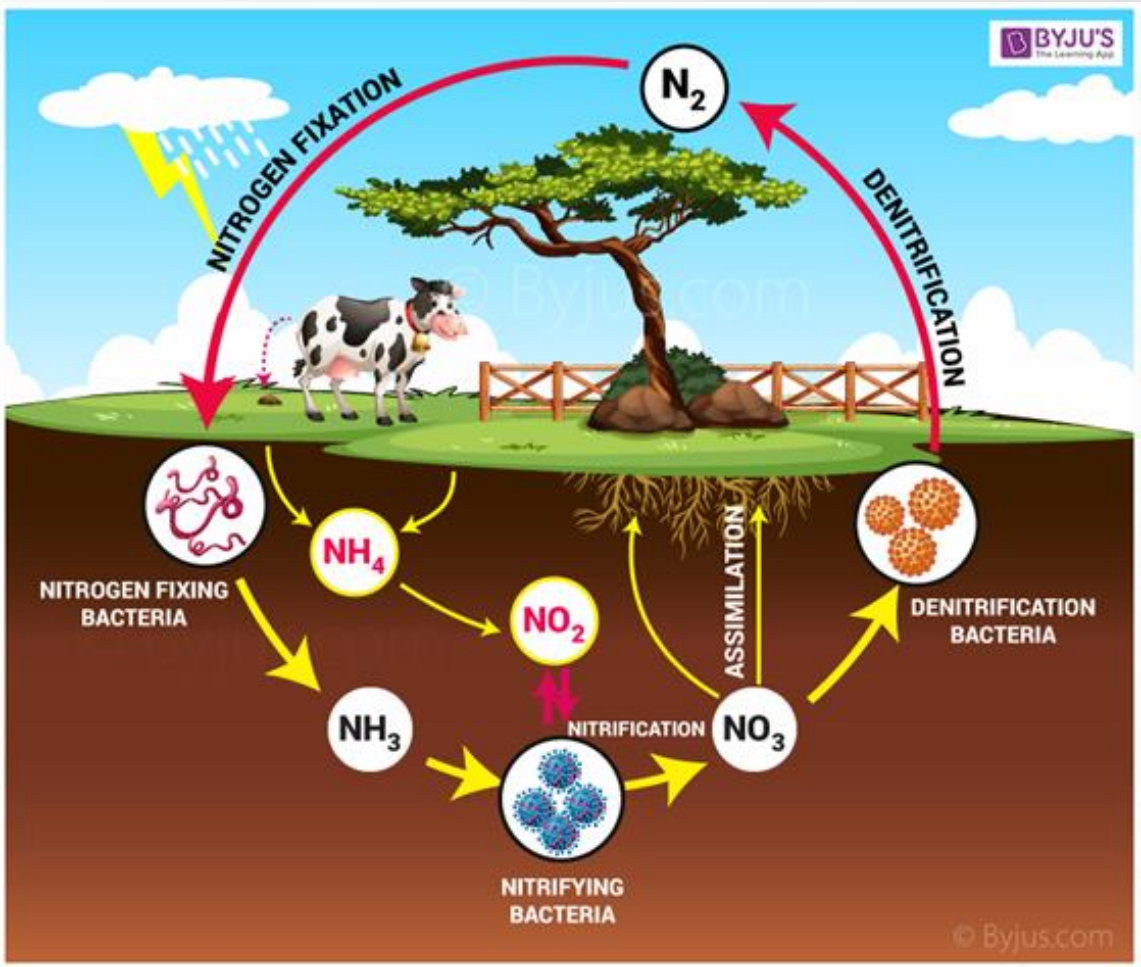
- For Atlantic Canada future climate projections suggest
  - Warmer (~4 ^{o}C by 2050)
  - Wetter (10% more rainfall by 2050)
  - More open winters – warmer and more rainfall (vs. snowfall)

- Perhaps more importantly, it is predicted that we will have greater variability in weather conditions
  - More extreme events (wet springs, summer droughts, early frost)
  - Less predictable growing conditions – less predictable nutrient use

- What does this mean for nitrogen management and the potential for nitrogen impacts on the environment?

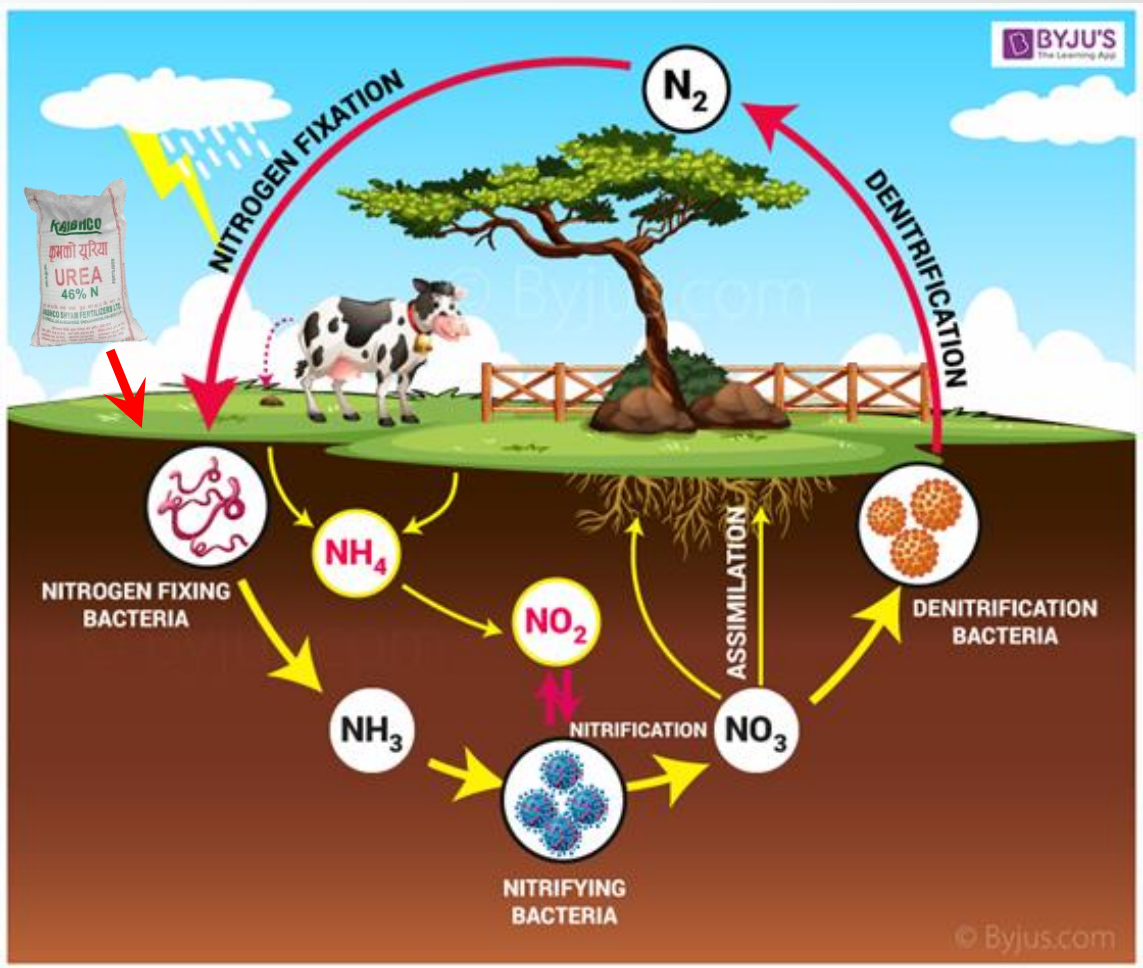
How does climate impact the nitrogen cycle

- Nitrogen cycle is mediated by soil microorganisms
- It involves mineral, organic and gaseous forms of nitrogen
- The nature and extent of these processes are influenced by climate



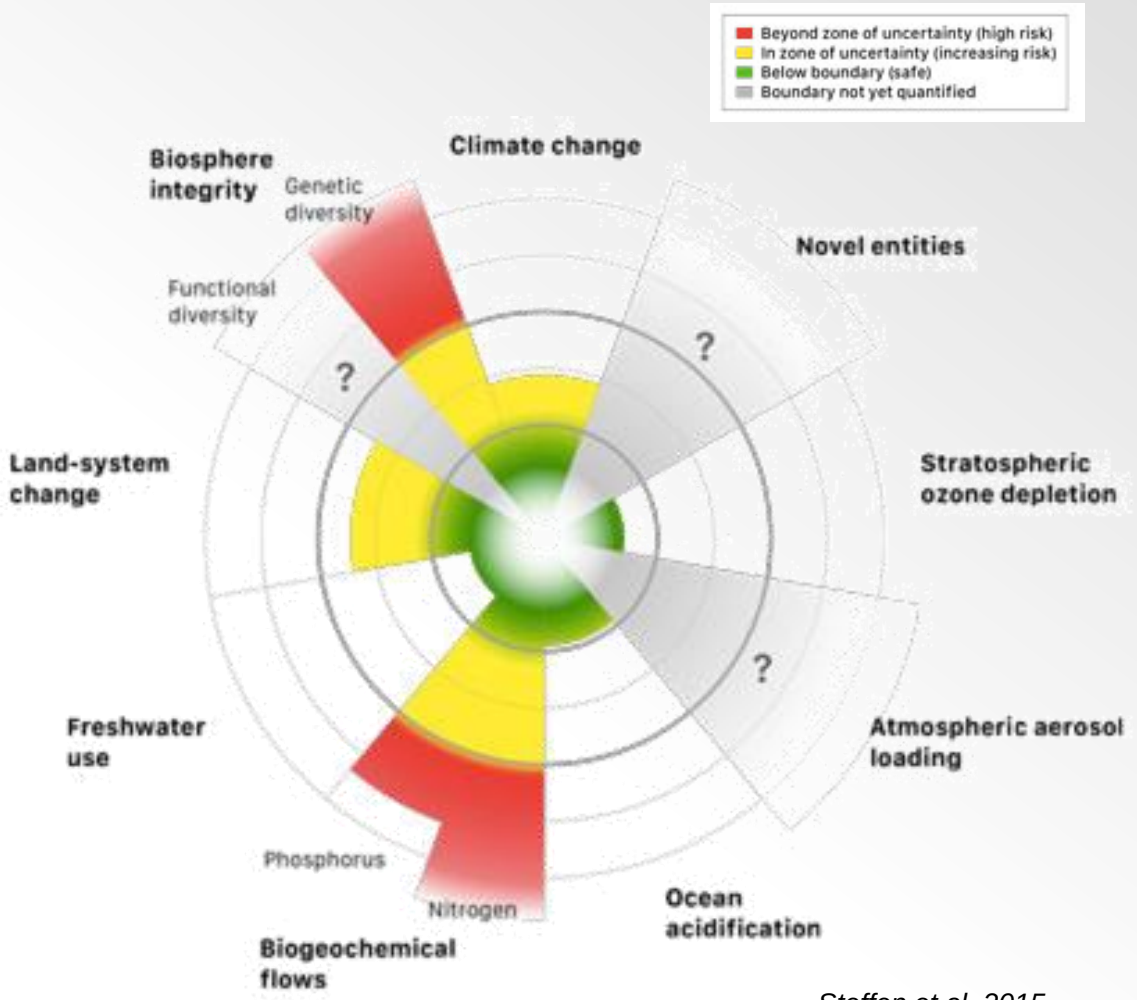
How does climate impact the nitrogen cycle

- Nitrogen cycle is mediated by soil microorganisms
- It involves mineral, organic and gaseous forms of nitrogen
- The nature and extent of these processes are influenced by climate
- Humans have acted to dramatically (2x) increase the amount of reactive N in the biosphere



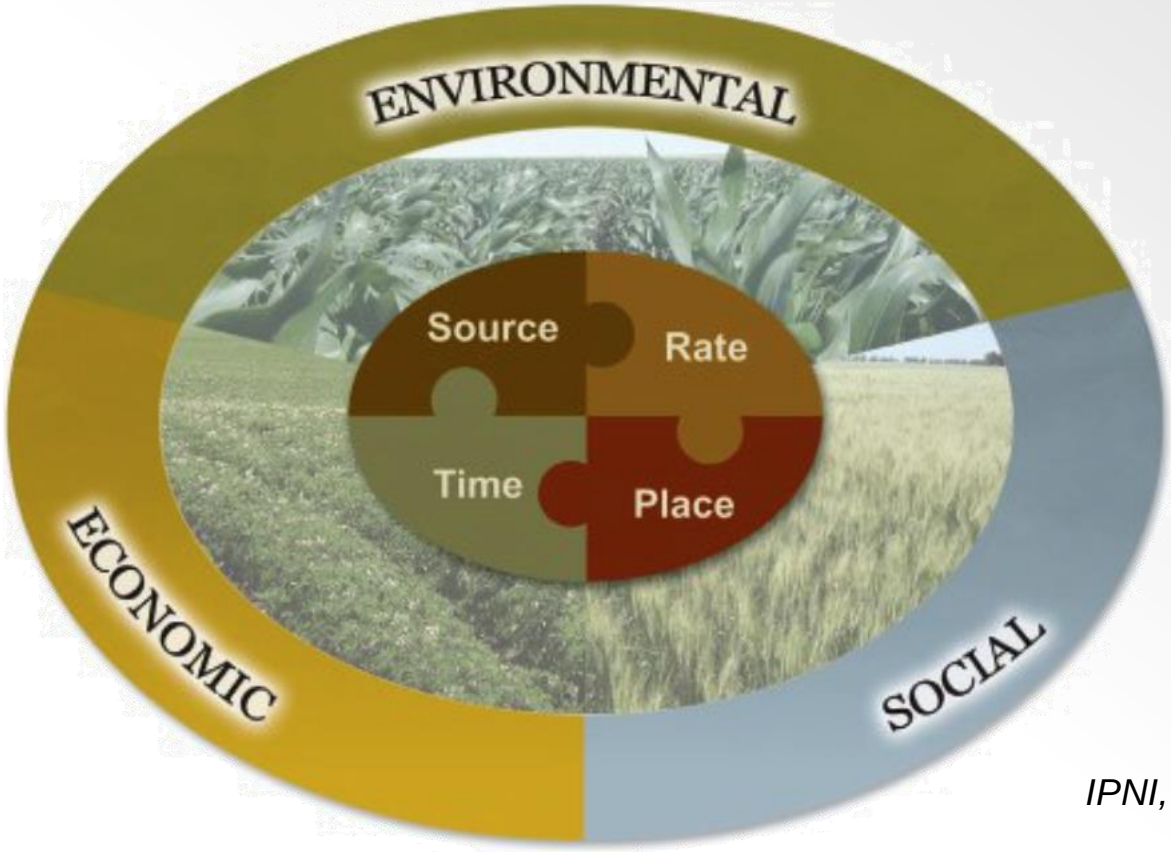
Nitrogen addition to ecosystem one the greatest exceedances of global boundaries

- Agricultural N inputs have resulted in a doubling of the amount of reactive N in the biosphere.
- We are now creating more reactive N than all natural biological processes on earth.
- We are typically only able to recover 50% of the reactive N applied into harvestable product.
- This has resulted in significant environmental impact.



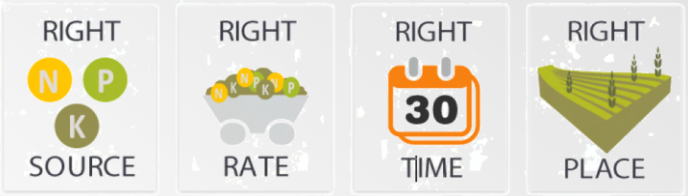
Steffen et al. 2015

To improve nutrient management the fertilizer industry has developed the framework of 4R management



IPNI, 2015

4R Frame work builds on science and offers practical solutions



	The Four Rights (4Rs)			
	Source	**Rate**	**Time**	**Place**
Examples of Key Scientific Principles	◆ Ensure balanced supply of nutrients ◆ Suit soil properties	◆ Assess nutrient supply from all sources ◆ Assess plant demand	◆ Assess dynamics of crop uptake and soil supply ◆ Determine timing of loss risk	◆ Recognize crop rooting patterns ◆ Manage spatial variability
Examples of Practical Choices	◆ Commercial fertilizer ◆ Livestock manure ◆ Compost ◆ Crop residue	◆ Test soils for nutrients ◆ Calculate economics ◆ Balance crop removal	◆ Pre-plant ◆ At planting ◆ At flowering ◆ At fruiting	◆ Broadcast ◆ Band/drill/inject ◆ Variable-rate application

IPNI, 2015

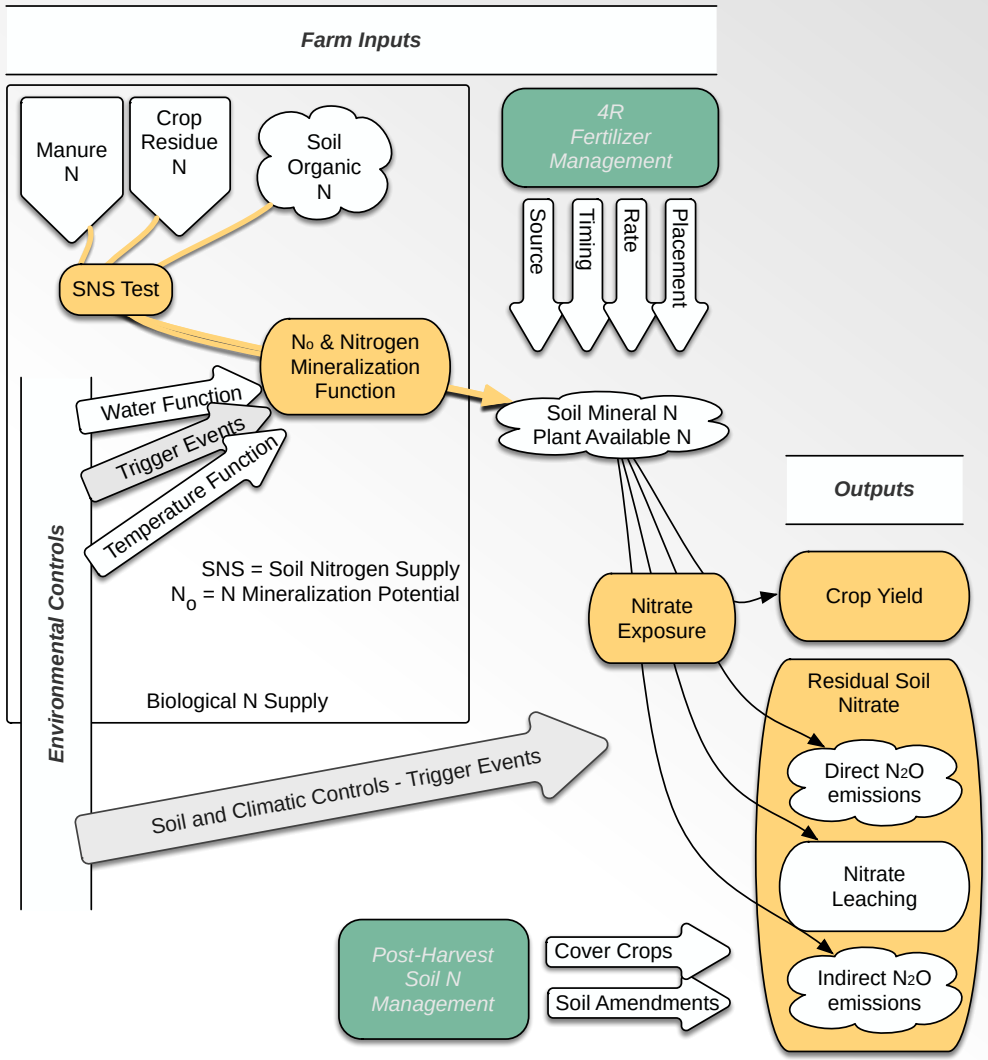
Tools to increase N use efficiency in Atlantic Canada

Need to quantify all sources of N.

Need site-specific information.

Therefore we need tools to measure all sources of N:

- soil N supply (SNS),
- climate impacts on N mineralization
- potential for N loss
  - Nitrate Exposure
  - Residual Soil N



What does a warmer future mean for the nitrogen cycle?

- Warmer temperatures
  - Biological reactions occur faster as temperature increases
  - Potential for greater soil organic matter decomposition – more nutrient release, but even lower organic matter levels
  - Potential for increased crop growth and the addition of more crop residues – if there is sufficient water

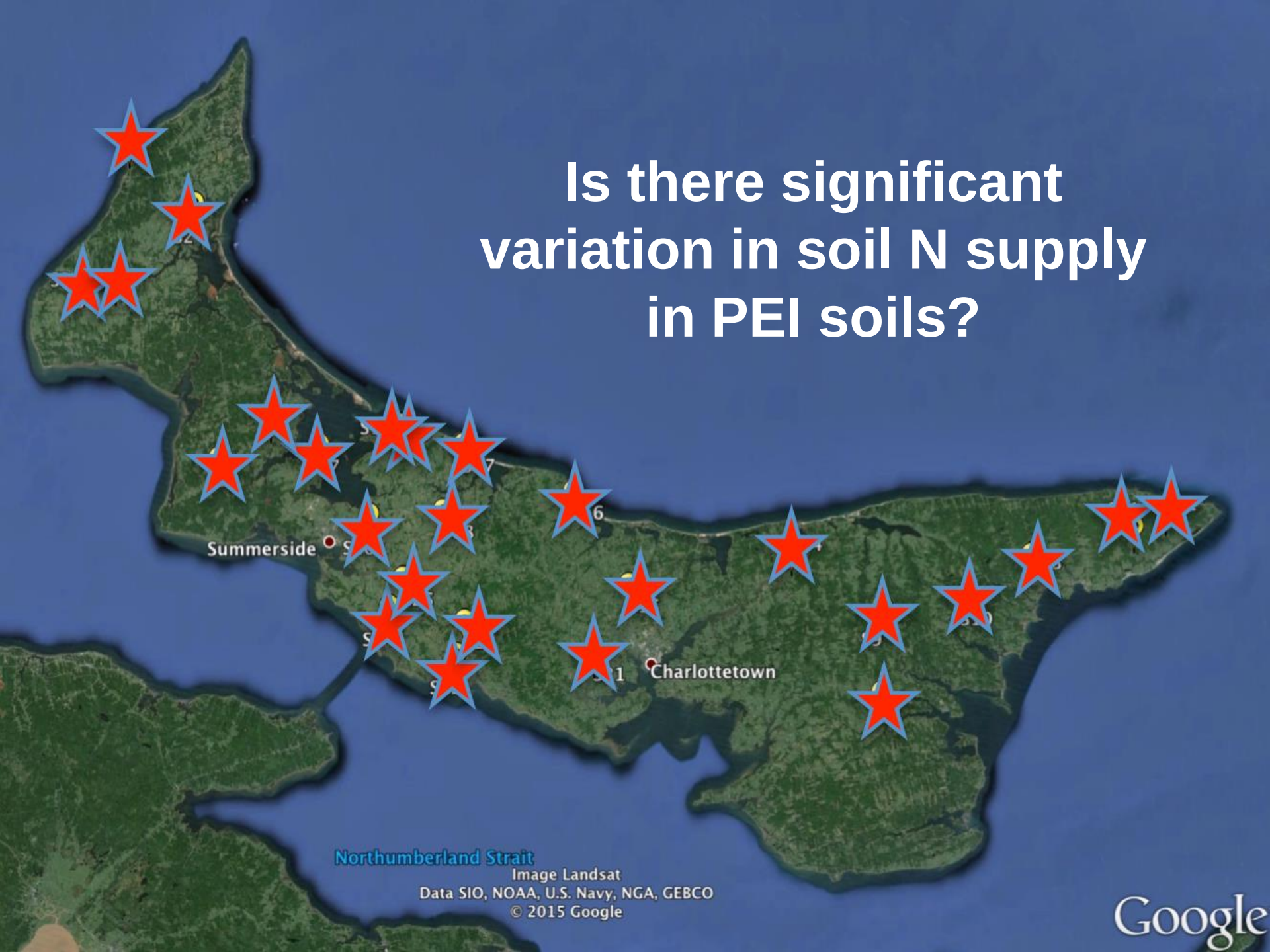
- More open winter – greater potential for N losses
  - Increased nitrate leaching – but we are leaching virtually 100% now
  - Increased CO_2 and N_2O emissions (greenhouse gases)
  - Increased soil erosion - C and N loss to water bodies

What are the implications of more extreme events

- Extreme rainfall events
  - Soil erosion - C and N loss and impacts on surface water
  - Greater in-season nitrate leaching

- Greater frequency of drought during the growing season
  - This results in greater uncertainty in N uptake by the crop
  - Greater potential for

- Trigger events result in bursts of microbial activity and nutrient release
  - The wetting of a dry soil following rainfall
  - The thawing of a frozen soil
  - Will more open winters, more extreme rainfall patterns result in a greater number of trigger events?


Is there significant variation in soil N supply in PEI soils?
Summerside
Charlottetown
Northumberland Strait
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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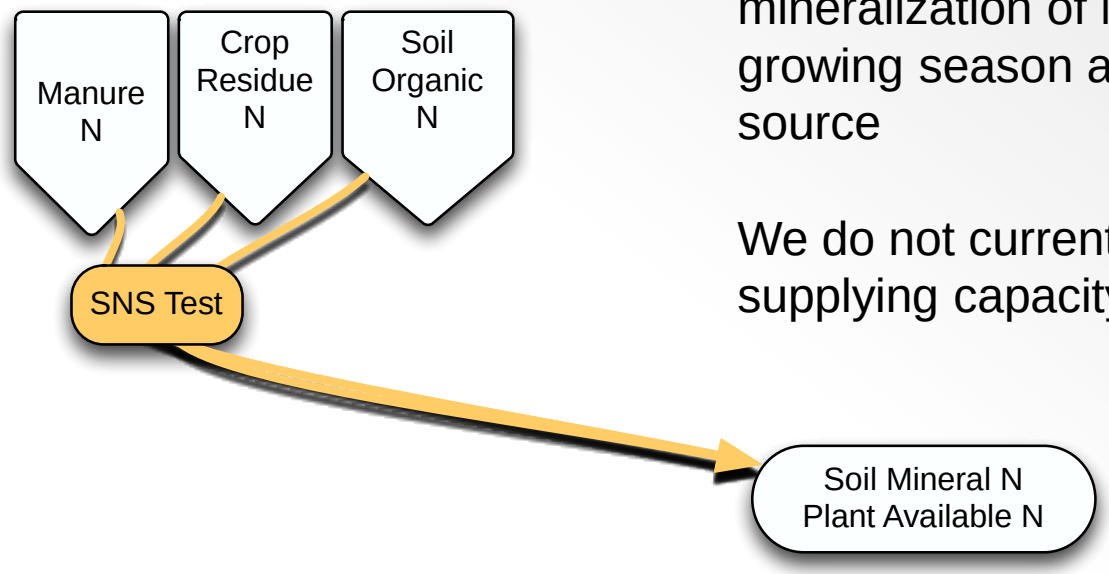
Measuring soil nitrogen supply



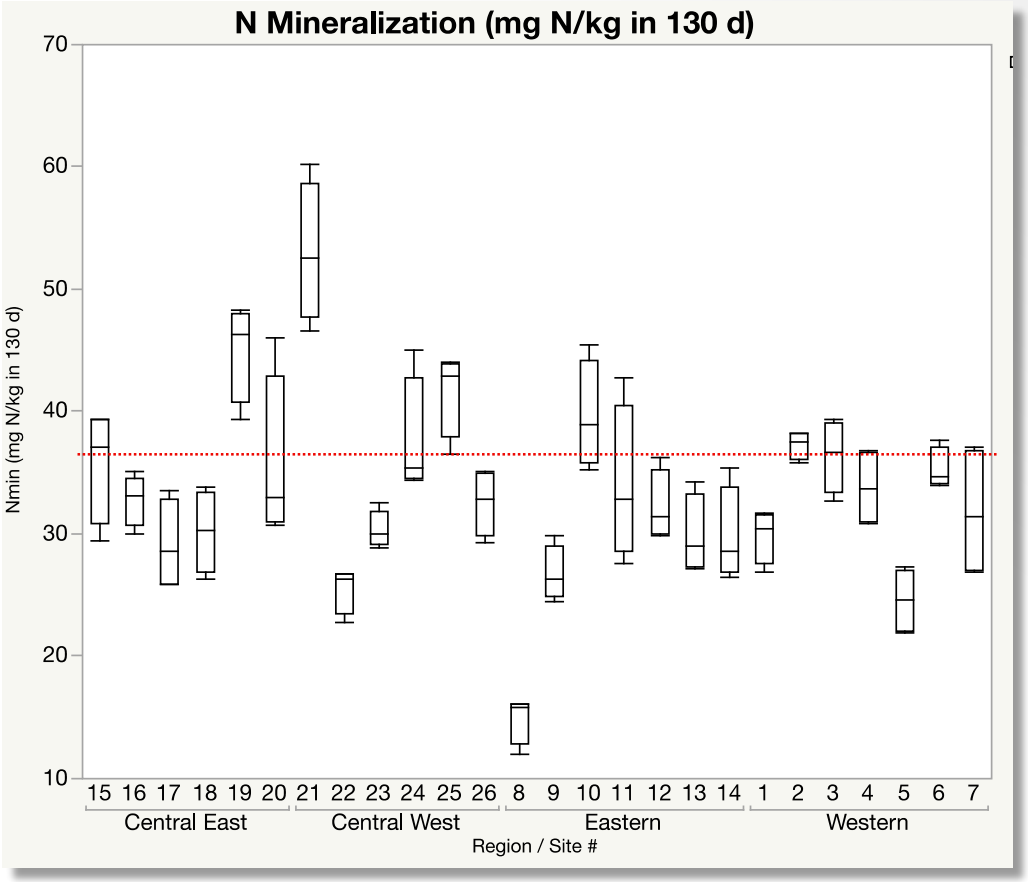
In Atlantic Canada high potential for over-winter nitrate loss makes the mineralization of N during the growing season an important N source

We do not currently measure the N supplying capacity of the soil

Can a simple, practical test be developed and implemented in regional soil test labs?

Sharifi et al. 2009
Dessureault-Rompré et al. 2011, 2012

Considerable farm-to-farm variation in estimated N mineralization of 130-day growing period



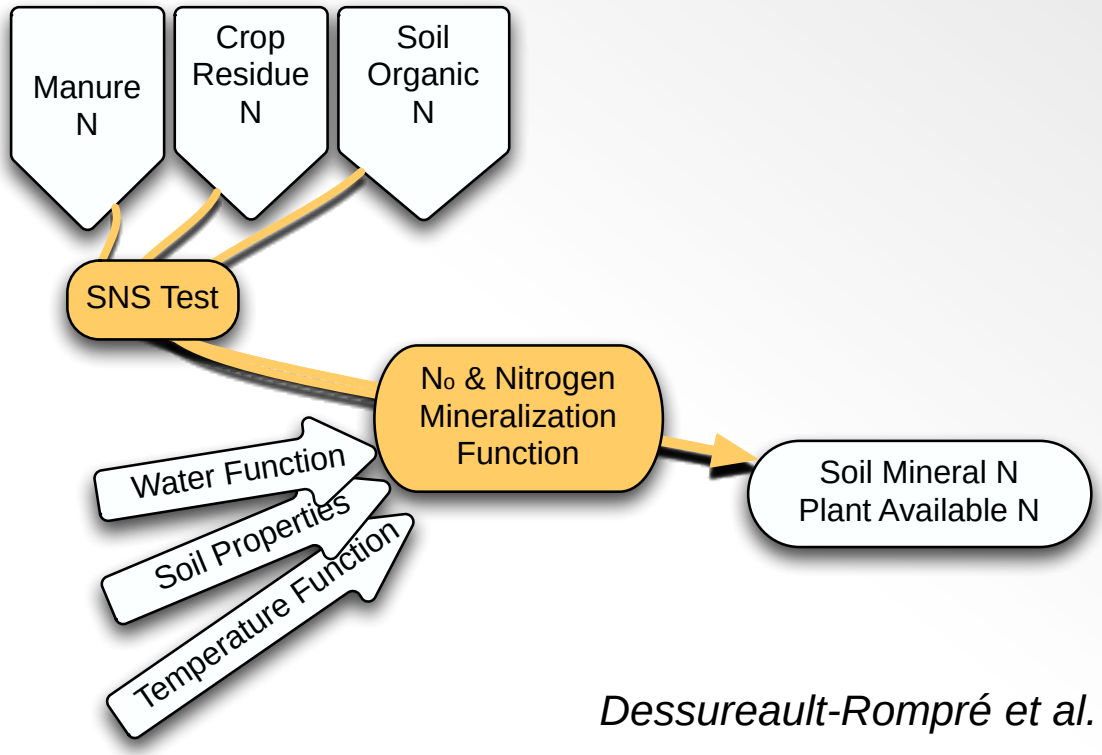
~ 65 kg N/ha

Significant variation between farms

N mineralized over 130 days (N_{min}) ranged from 31 – 111 kg N ha^{-1}

This variation is currently being ignored.

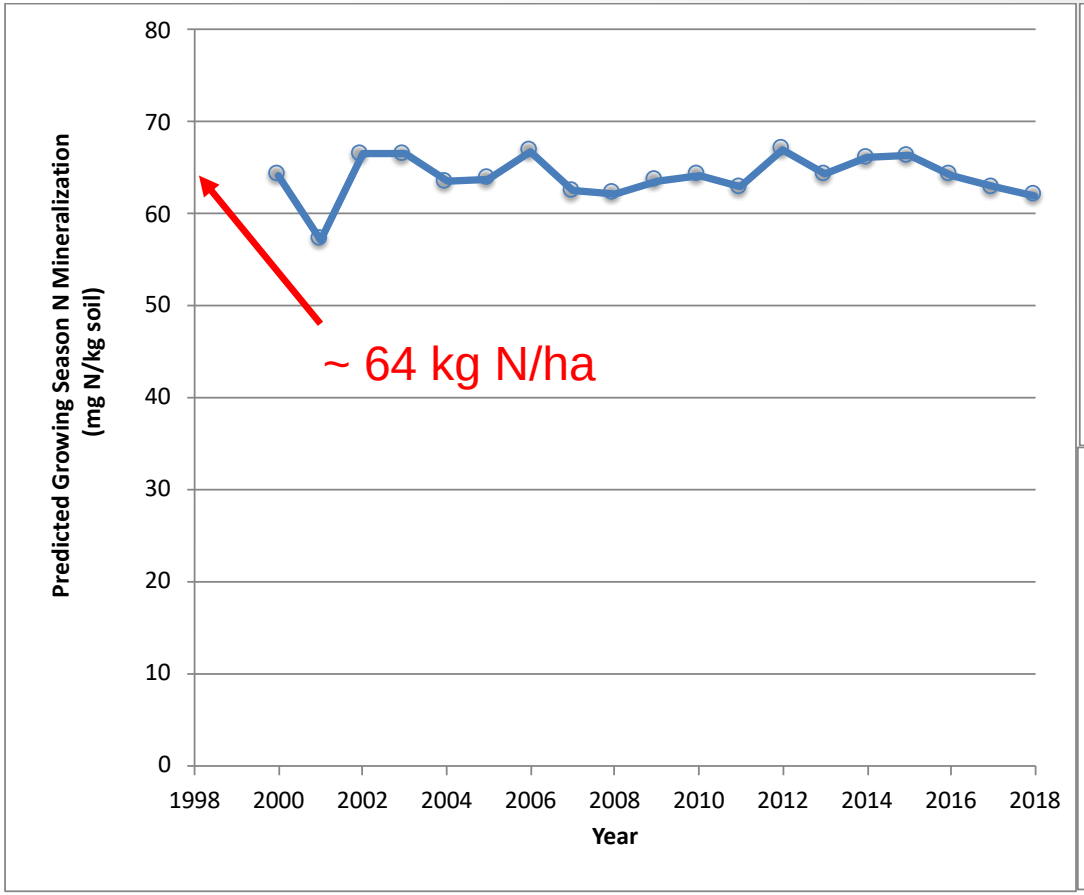
Soil Properties (Total N and N flush) and climate data (air temperature and precipitation) can be used to predict N mineralization

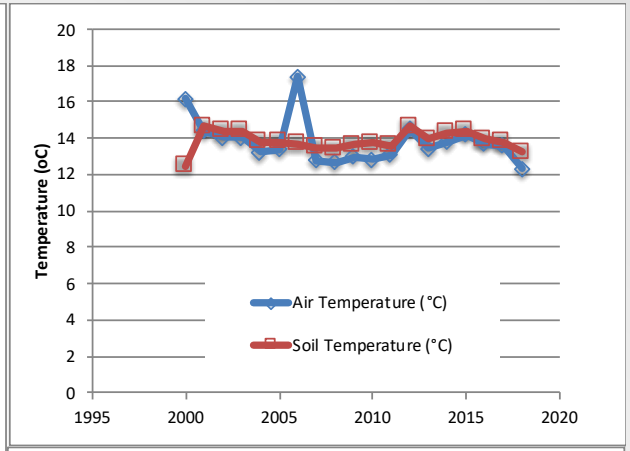


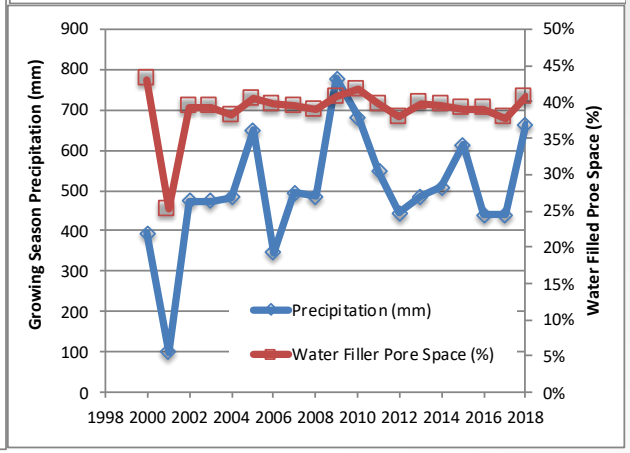
Dessureault-Rompré et al. 2010a,b, 2011

Leads to a better understanding the impact of soil properties and climate on soil N supply

Yearly variation in N mineralization near Summerside, PEI based on climatic variation

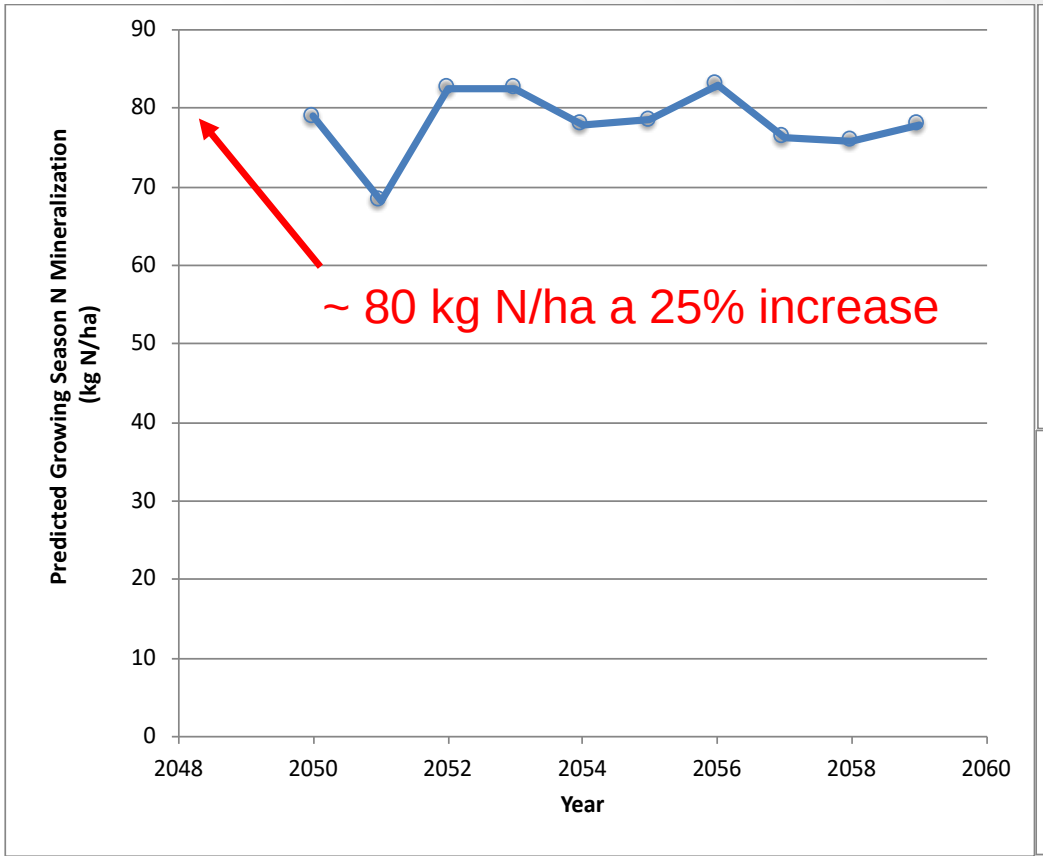


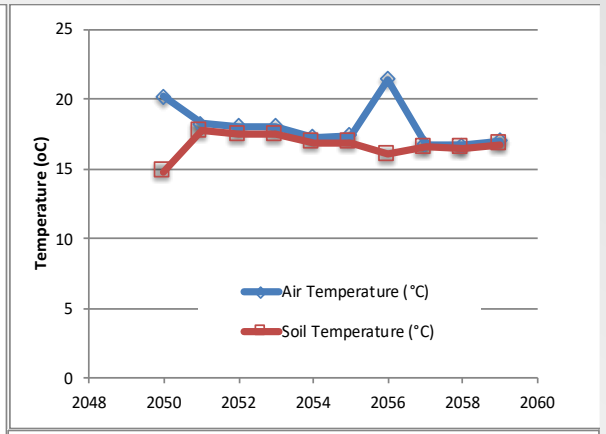


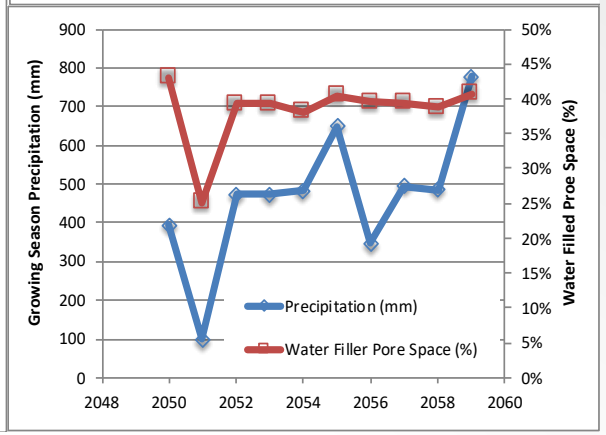


[1] estimates *based on Dessureault-Rompré et al. 2011, 2013 and Georgallas et al. 2012*

Yearly variation in N mineralization near Summerside, PEI based on climatic variation + 4 °C







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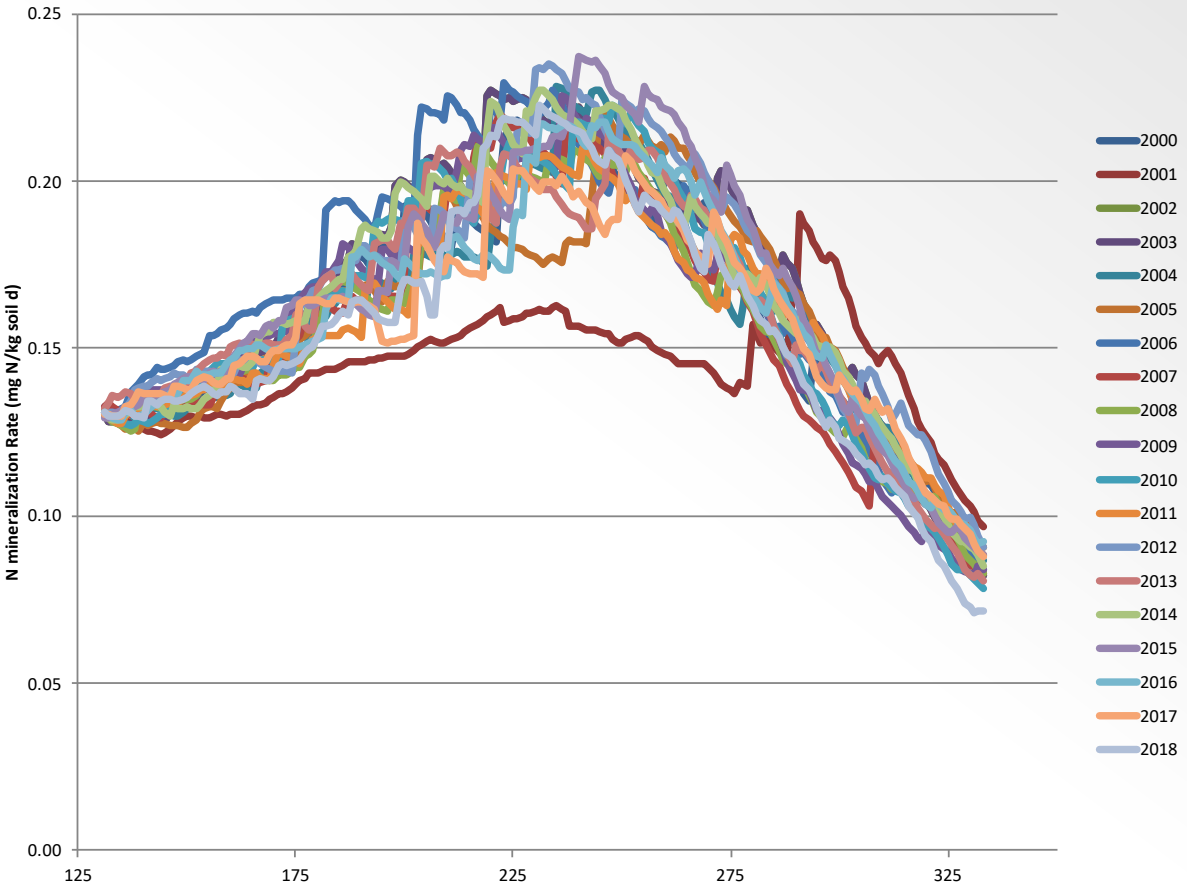
Annual variation in N mineralization

In estimating the potential for NO_3^- leaching, when N is mineralized matters



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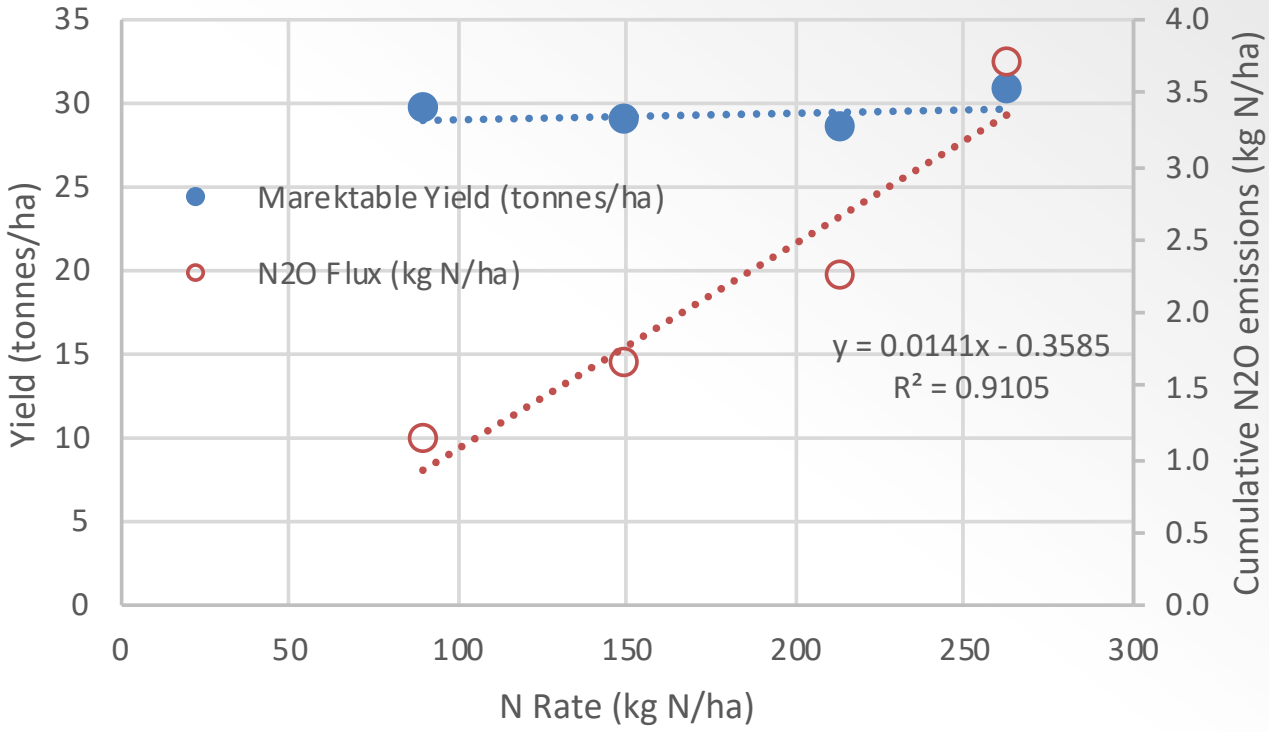
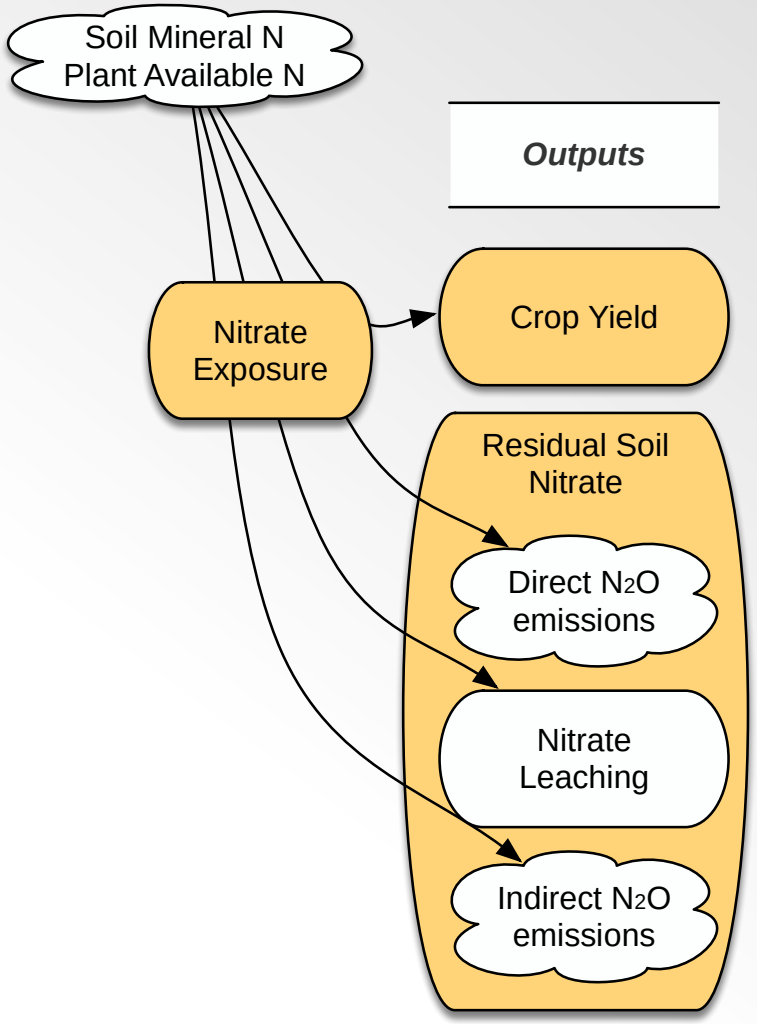
2017 Yield Response Trial



Monitoring the Potential for N Loss

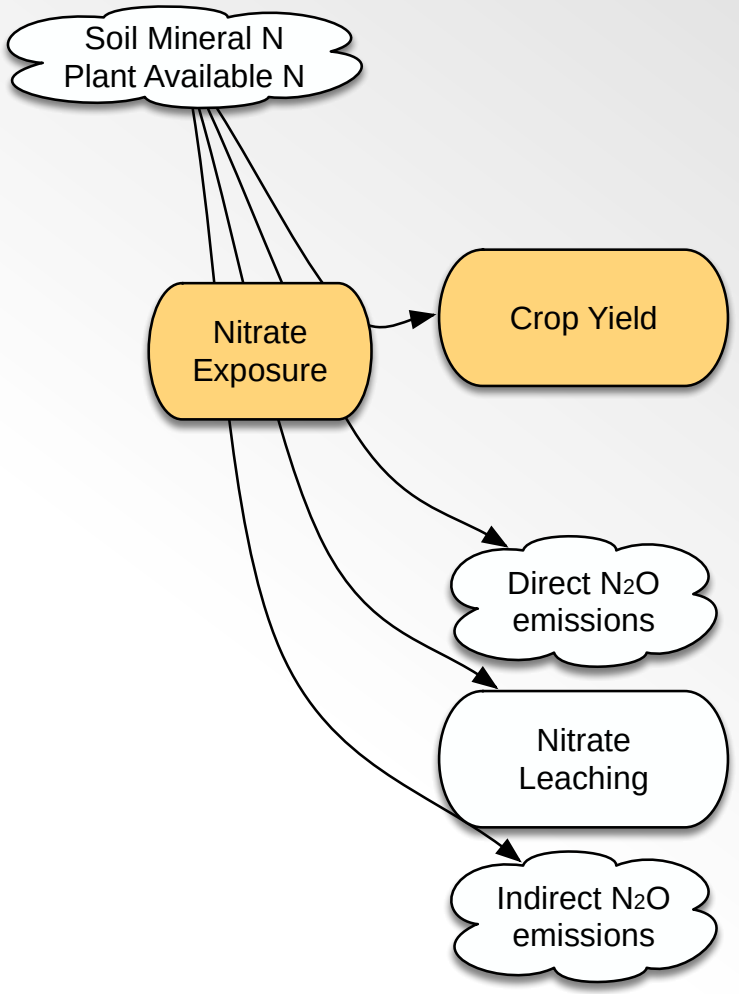
- Need a means of practically measuring the potential for N loss
  - N_2O emissions
  - Nitrate leaching

- Can assess how well management is doing in reducing nitrate accumulation
  - Feedback to producer
  - Documentation of success of mitigation strategies



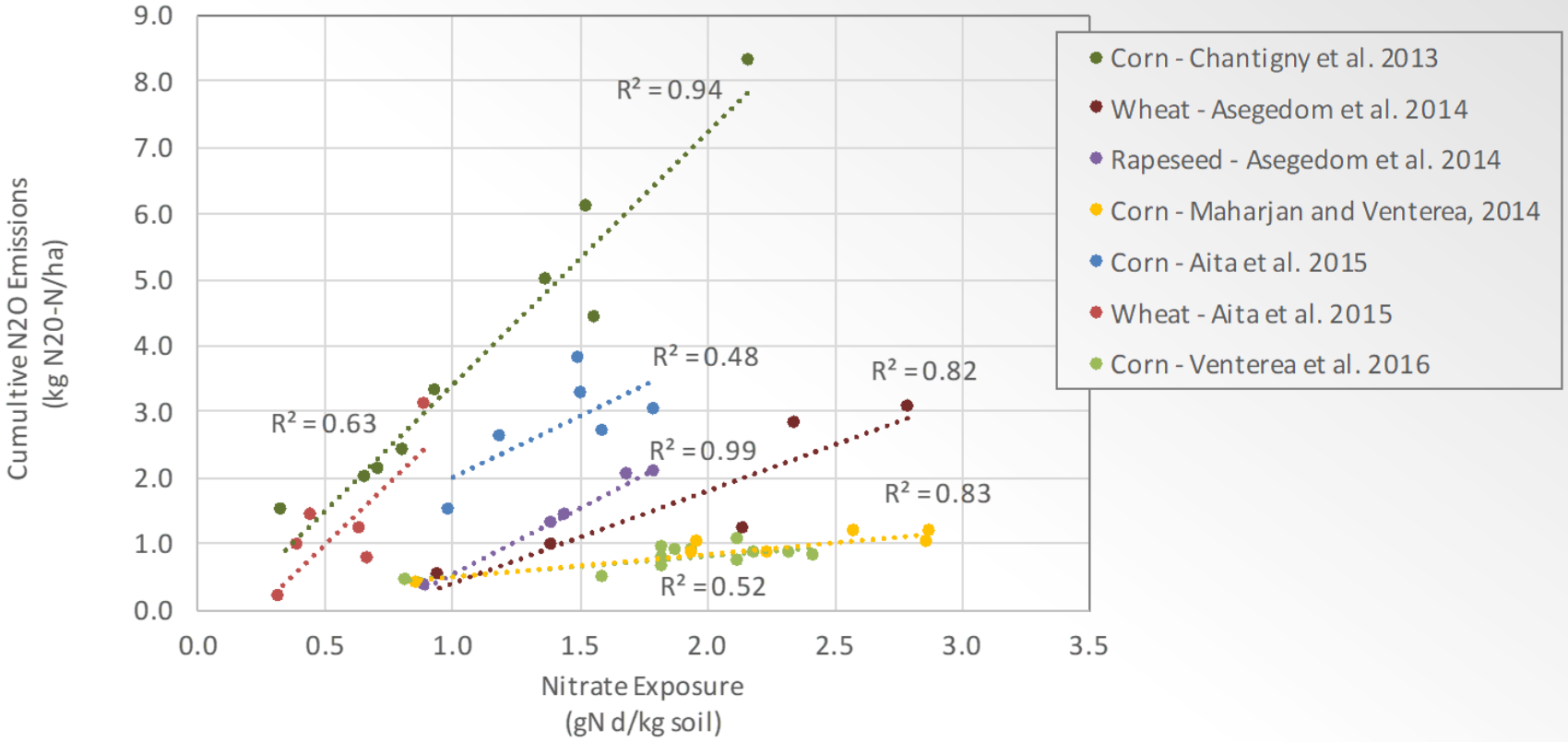
Nitrate Exposure is a means of evaluating the synchrony of N supply and plant N demand

- Nitrate exposure is the amount of nitrate per day over the growing season
- Nitrate is the major pool from which N losses occur
- Greatest N use efficiency occurs when soil N supply is in synchrony with plant N uptake and therefore little nitrate accumulates
- Nitrate exposure is therefore a measure of the potential for loss during the growing season



Nitrate Exposure and Cumulative N_2O Emissions

North American Cropping Systems



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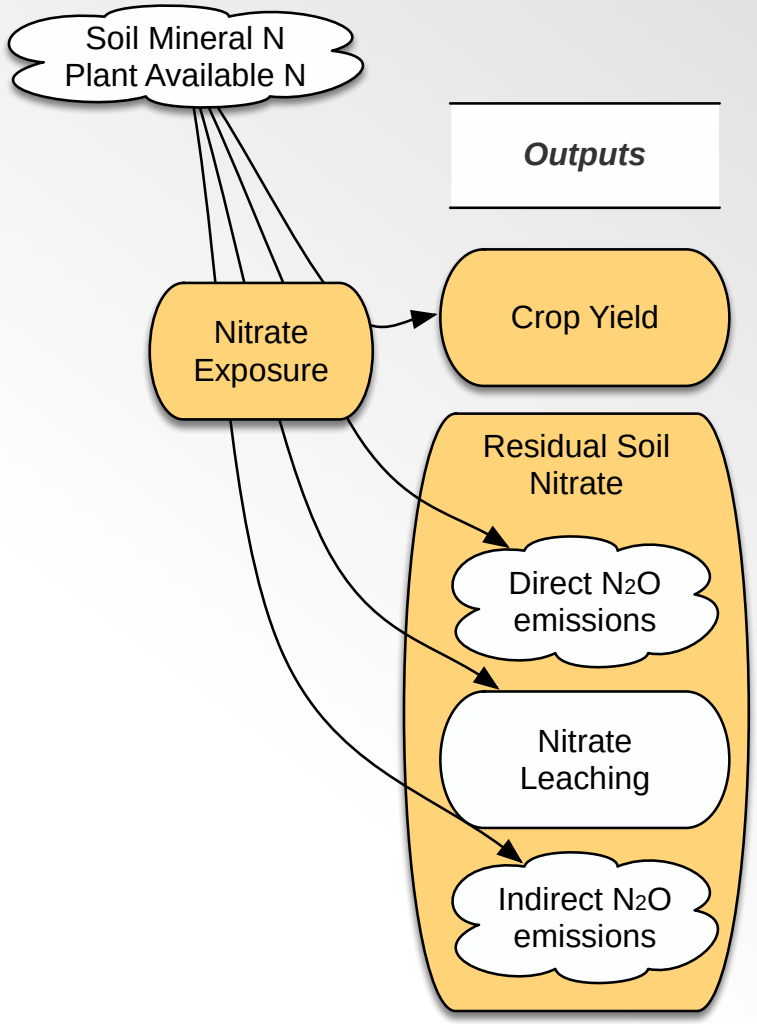
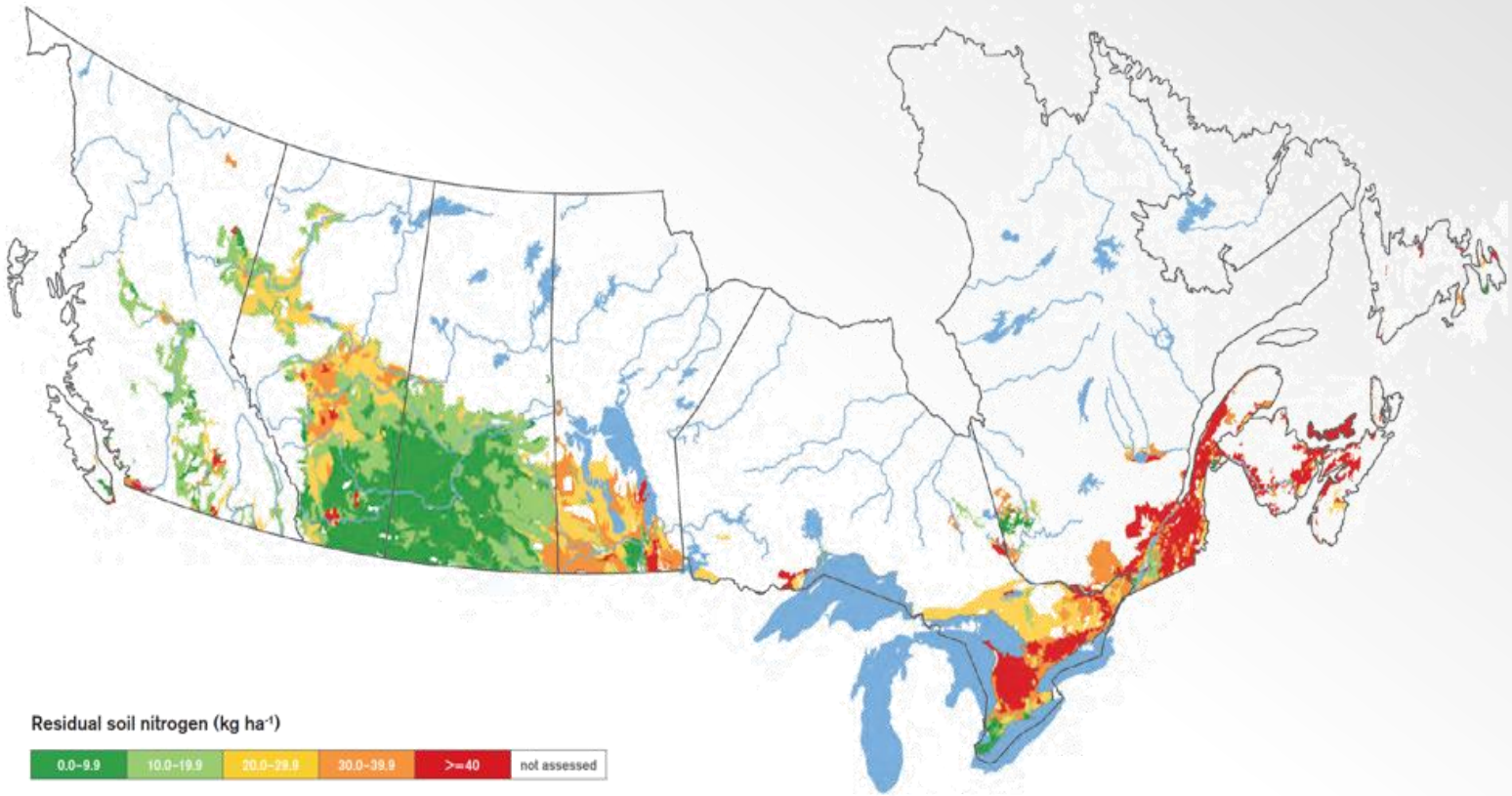


Agri-Environmental Indicators
Residual Soil Nitrogen



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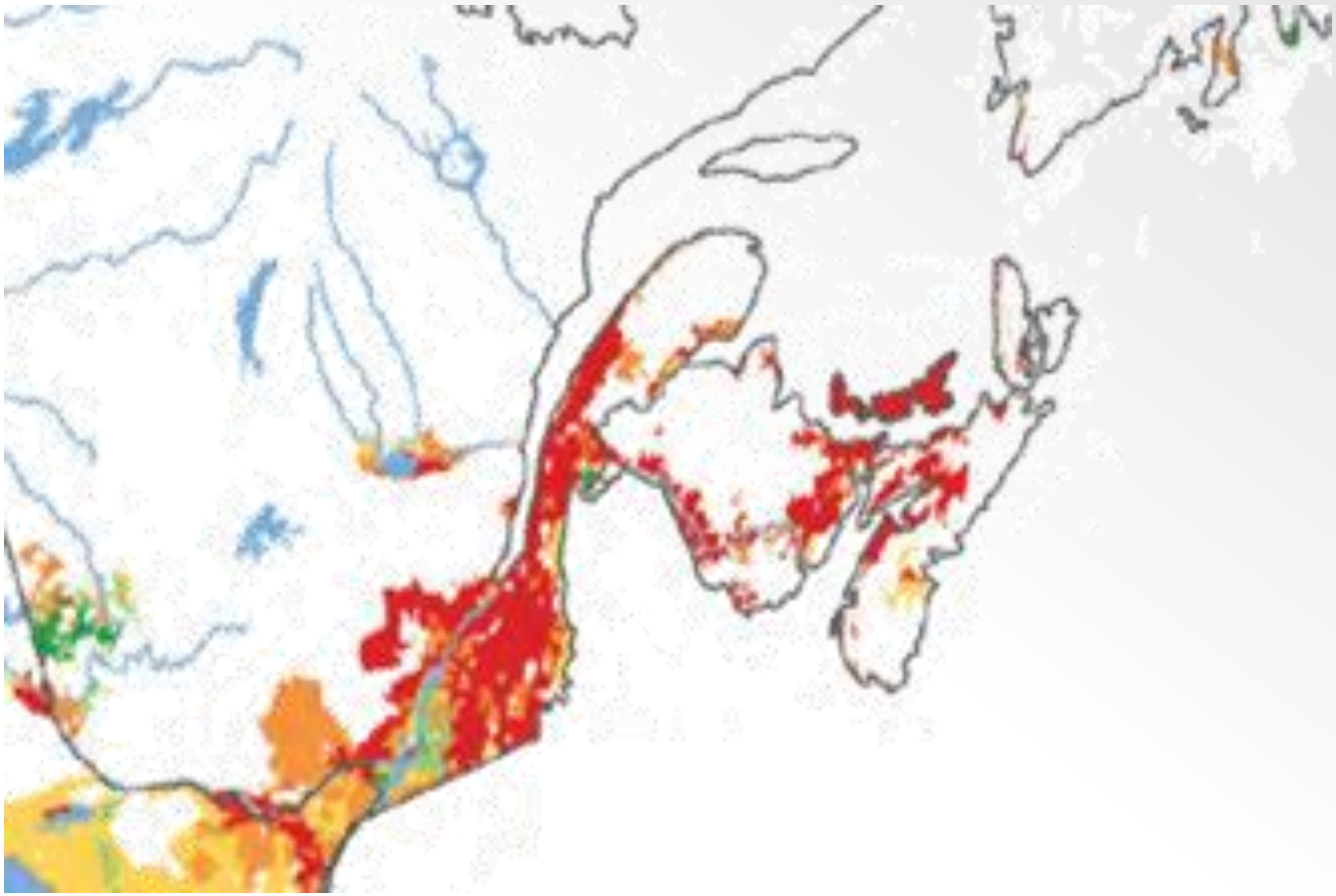
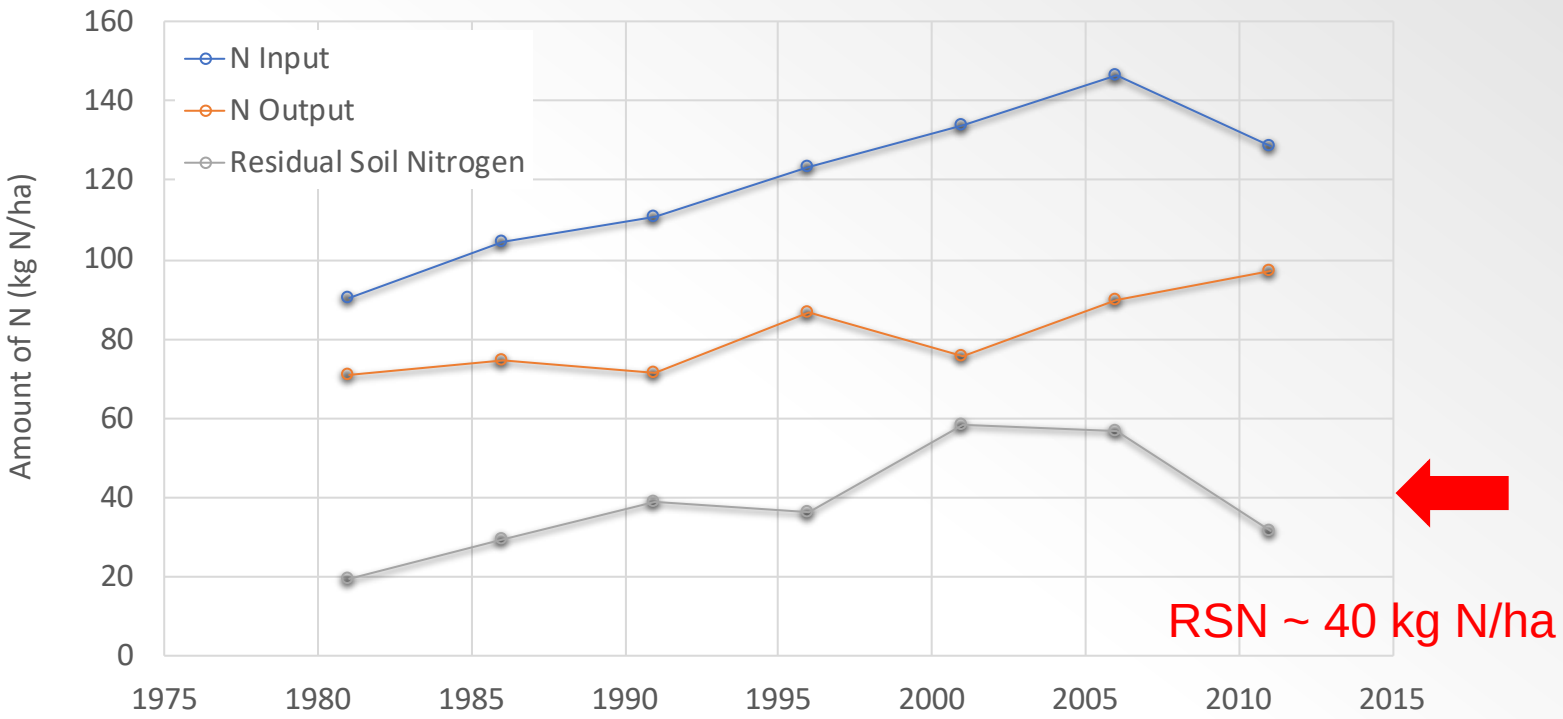
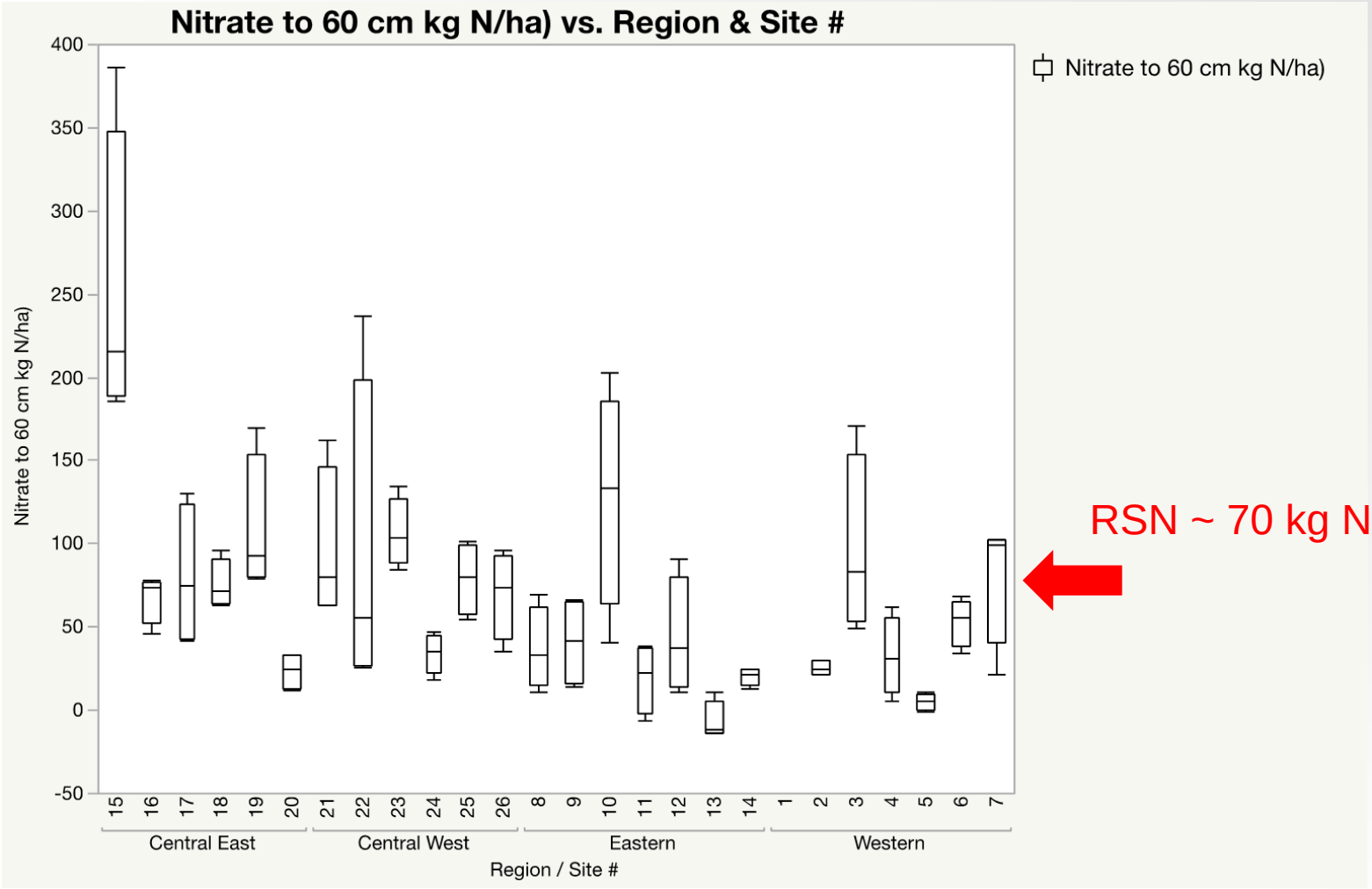


Residual Soil Nitrogen for PEI

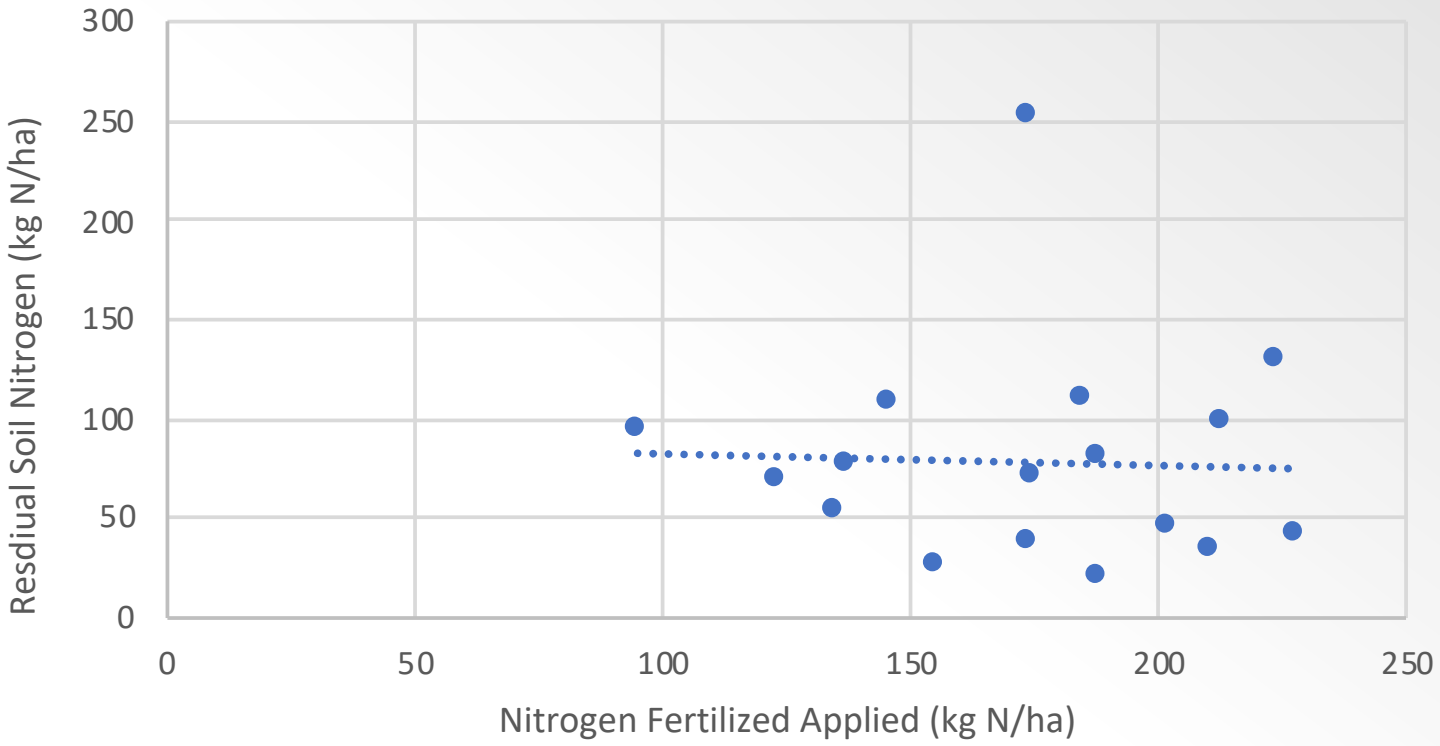


Measured Residual Soil Nitrogen (Fall 2015)

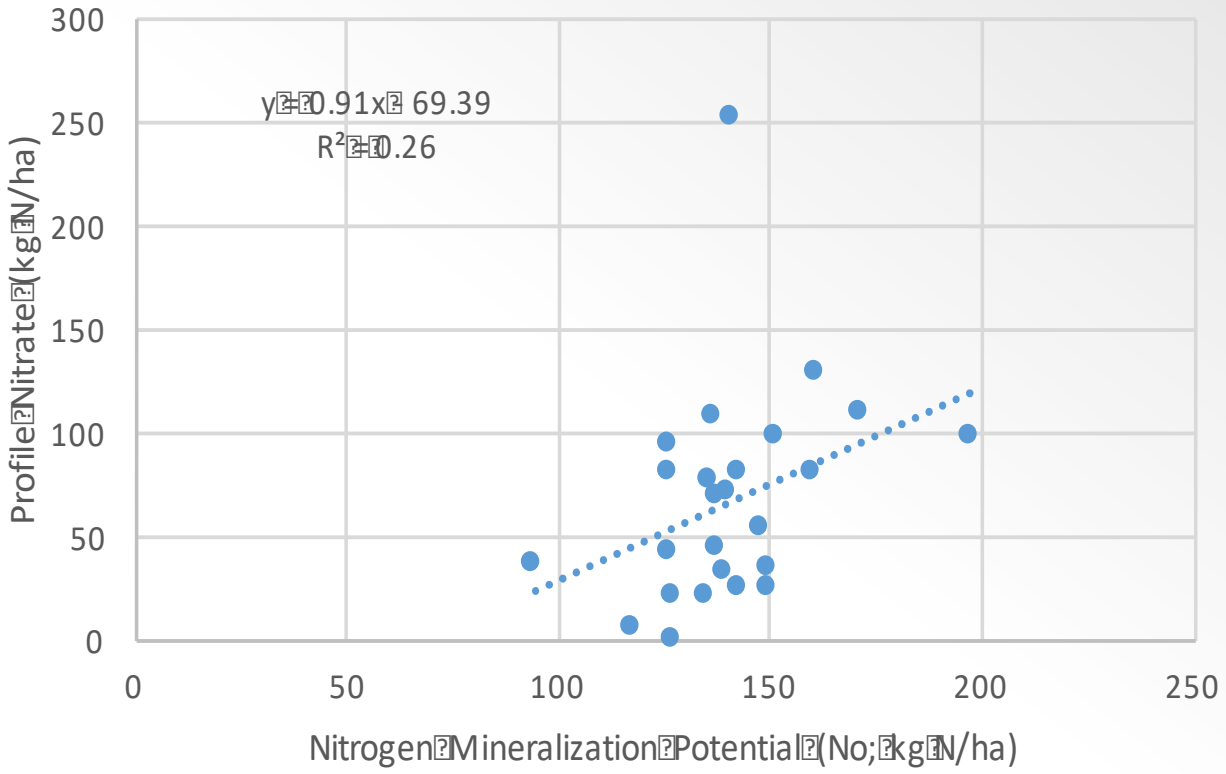


RSN ~ 70 kg N/ha

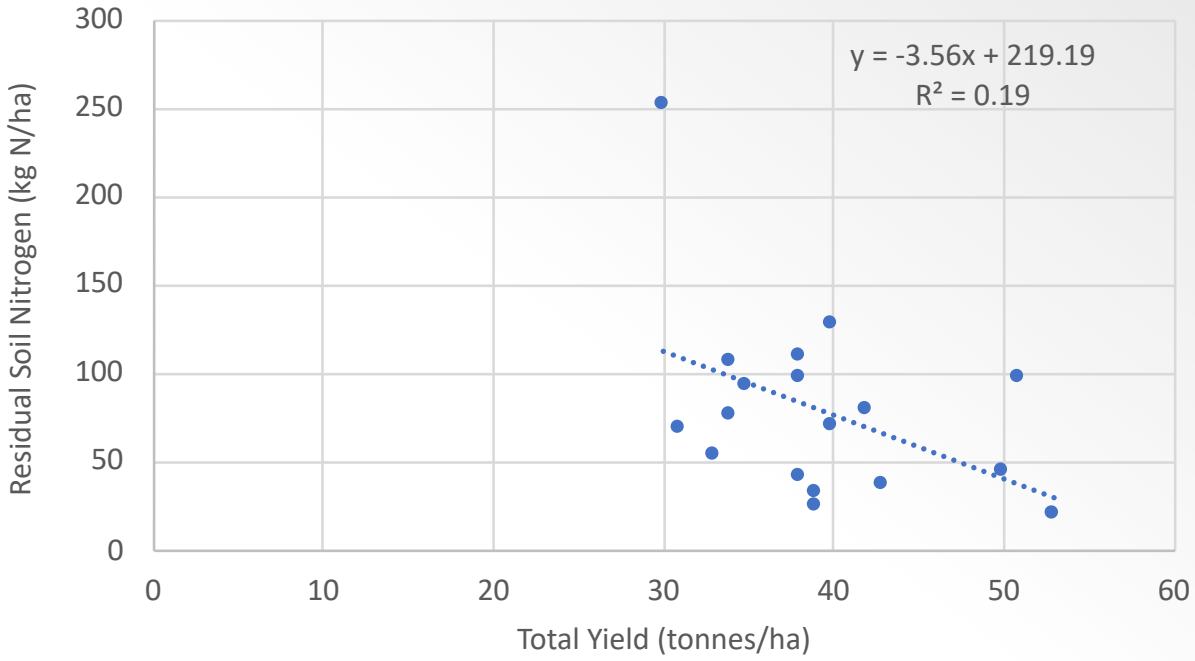
Residual Soil Nitrogen was not a function of fertilizer N application…



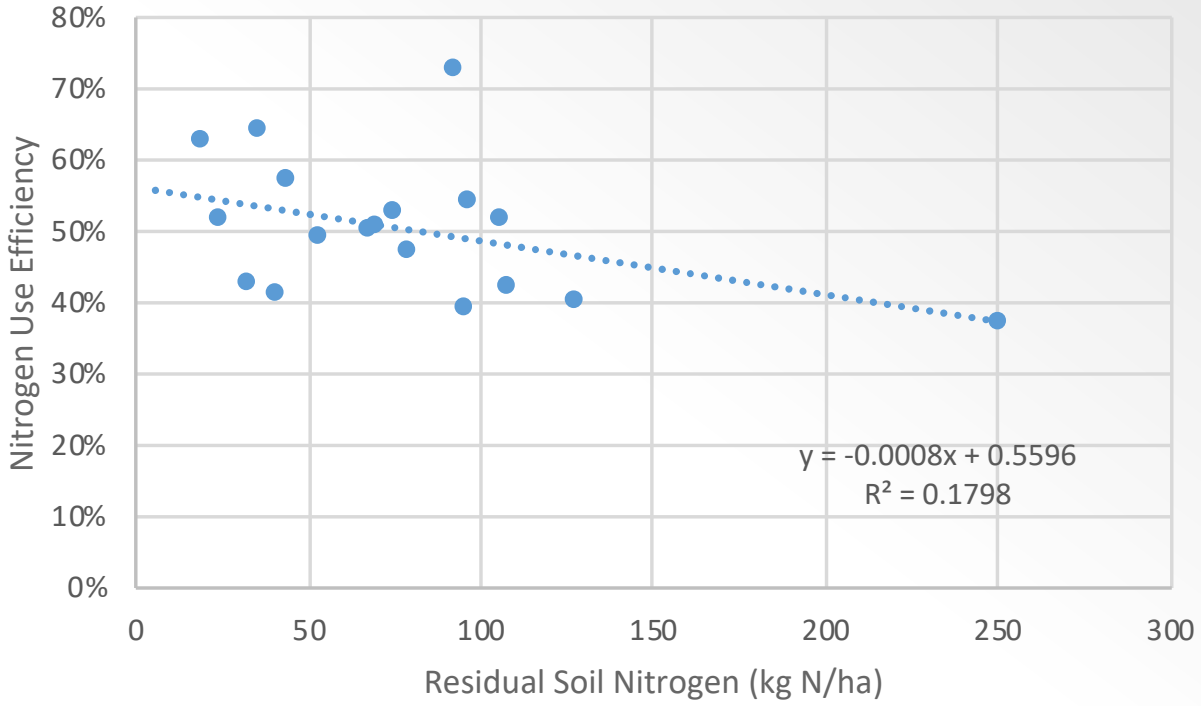
Residual Soil Nitrogen was a function of soil N mineralization potential



Residual Soil Nitrogen was inversely related to total yield



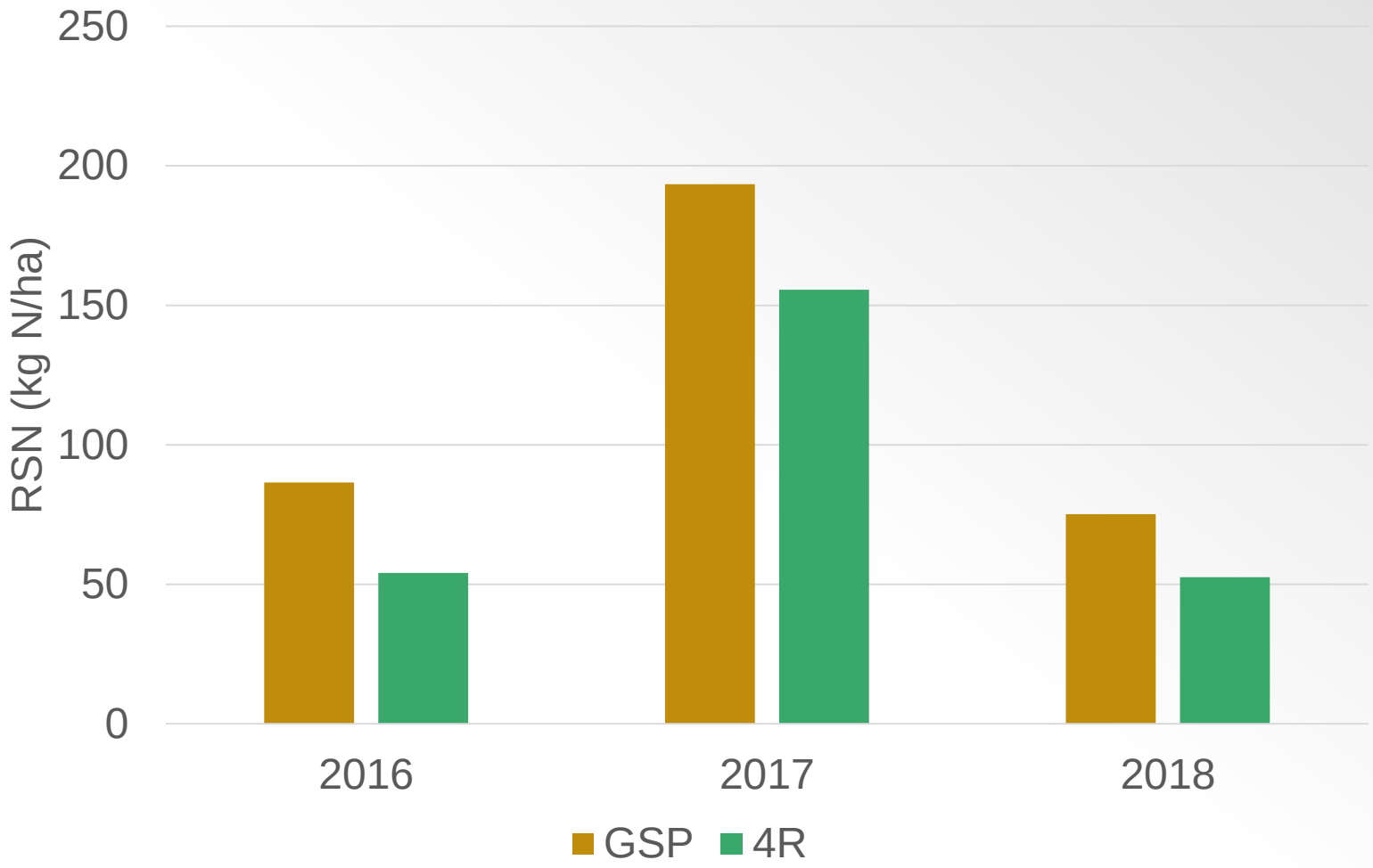
Residual Soil Nitrogen vs. Nitrogen Use Efficiency



How do we manage nitrogen in a changing climate?

- Need reduce risk
  - Economic risks… more judicious use of inputs
    - Realistic yield goals
  - Implement 4R nutrient management
  - Use of irrigation to reduce risk of drought
  - Environmental risks… potential for nutrient impacts
    - On-farm assessment of nitrogen use efficiency
    - Need to reduce residual soil nitrogen

Can 4R management reduce Residual Soil Nitrogen?



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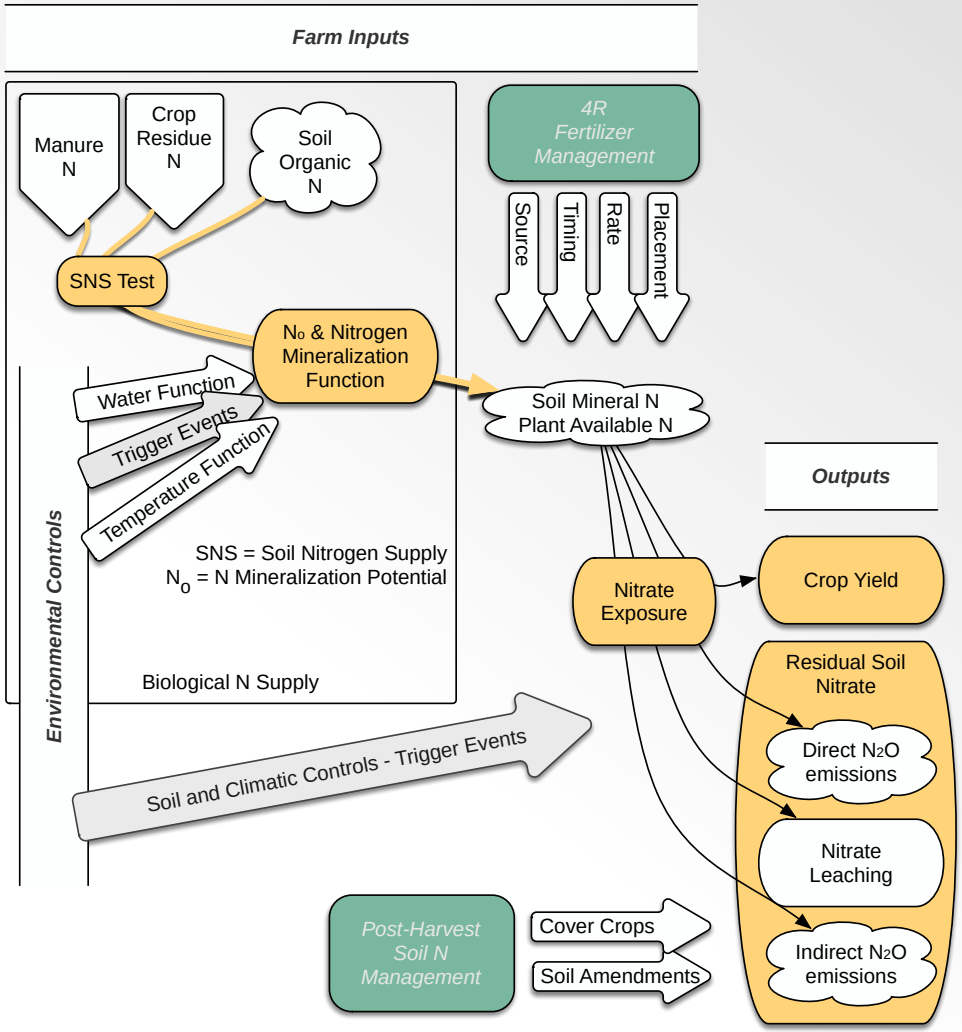
- Need to increase the resiliency of the agricultural enterprise
  - Need to increase soil resiliency – build soil organic matter
    - Reduced soil disturbance
    - Increased soil cover (cover crops)
    - Extended rotations – more soil building crops

Implement site specific N management tools

Need tools to:

- measure soil N supply (SNS),
- predict climate impacts on N mineralization,
- measure potential for N losses
  - Nitrate exposure
  - Residual soil nitrogen
- Recognize and value increased NUE



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