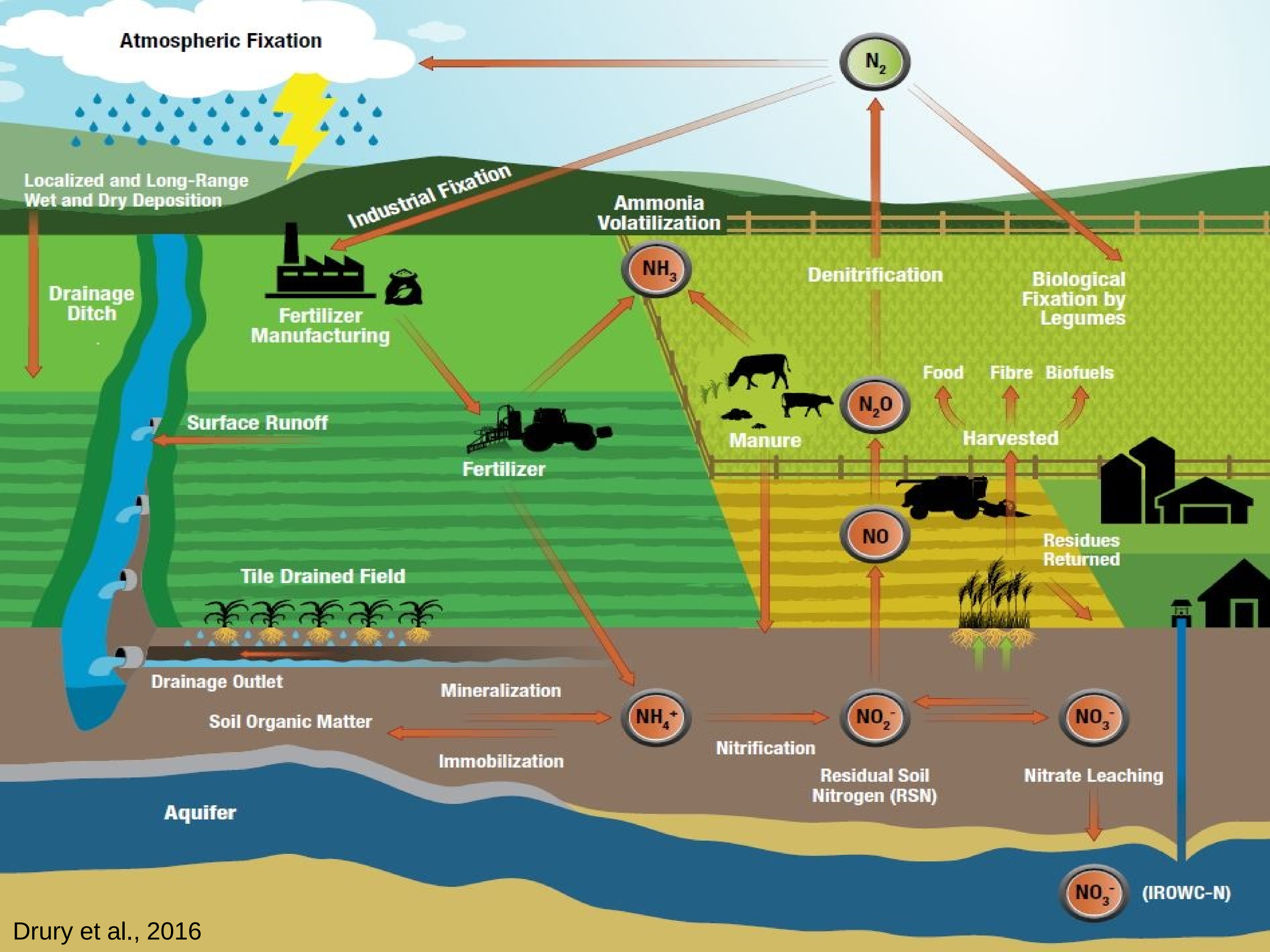
Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Canada

Combined Effects of N Fertilizer Placement and Enhanced Efficiency Fertilizers to Reduce N Losses from Corn Production

Craig F. Drury, Xueming Yang, W. Dan Reynolds, Wayne Calder, Tom Oloya and Alex Woodley

Agriculture & Agri-Food Canada, Harrow, Ontario
craig.drury@agr.gc.ca



Drury et al., 2016

Harrow Research & Development Center

Objectives

To determine:

1. The effectiveness of N application methods (broadcast, broadcast & incorporated, injected) on reducing NH_3 volatilization and N_2O emissions.

2. The effectiveness of a urease inhibitor† or a combined urease and nitrification inhibitor‡ on reducing ammonia volatilization and nitrous oxide emissions.

†Agrotain - active ingredient is NBPT
‡Agrotain Plus or SuperU - active ingredients are NBPT and DCD

TREATMENTS – PHASE 2

N Application at Planting

1. Control

2. Broadcast Urea
3. Broadcast Urea + Urease Inhibitor (UI)
4. Broadcast Urea + Urease & Nitrification Inhibitors (UI+NI)

5. Broadcast & Incorporated Urea
6. Broadcast & Incorporated Urea + UI
7. Broadcast & Incorporated Urea + UI +NI

8. Injection UAN
9. Injection UAN + UI
10. Injection UAN + UI + NI

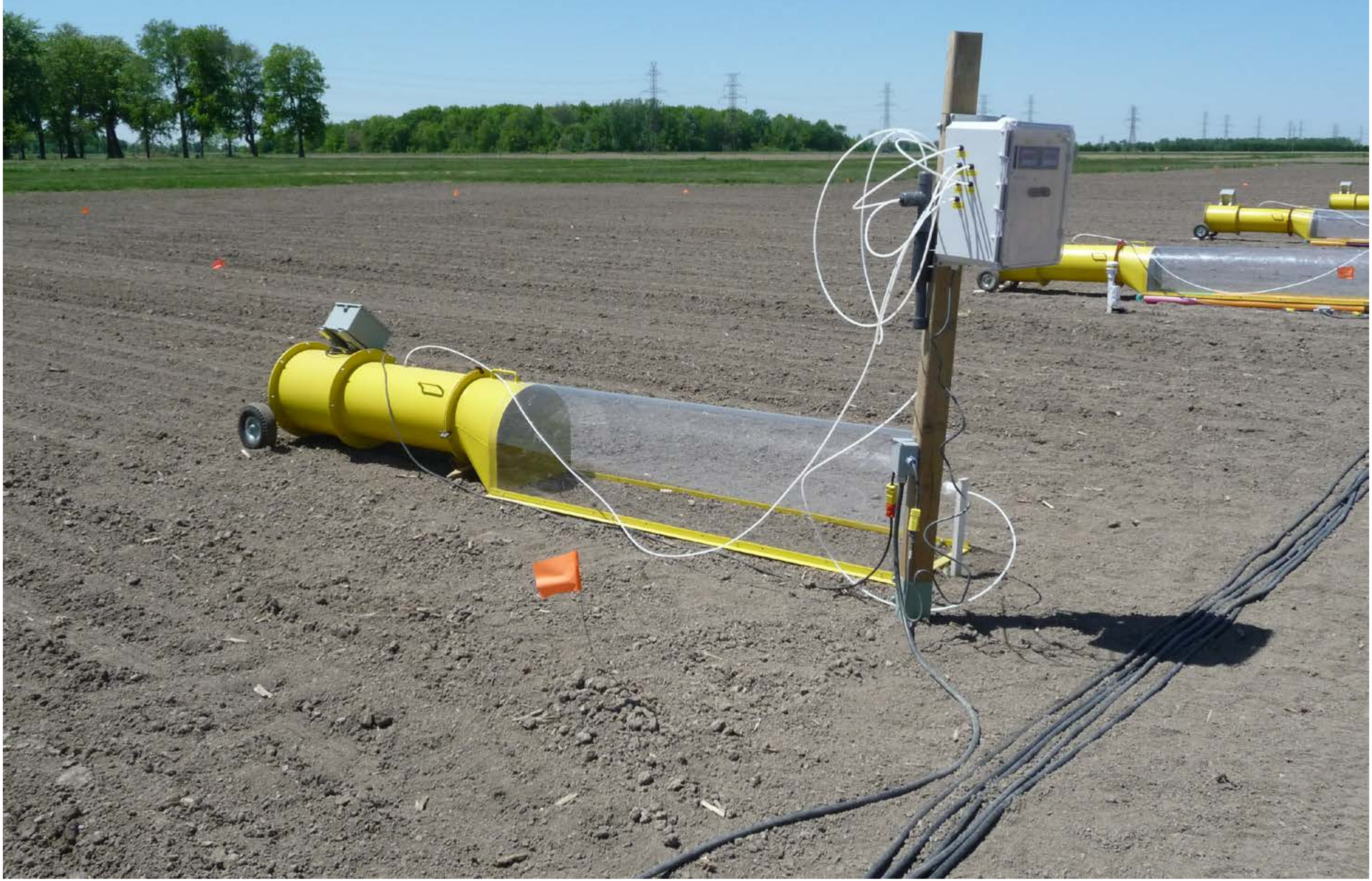
N Application 6-8 leaf stage (Sidedress)

11. Injection UAN
12. Injection UAN + UI
13. Injection UAN + UI + NI

Injecting UAN Solution

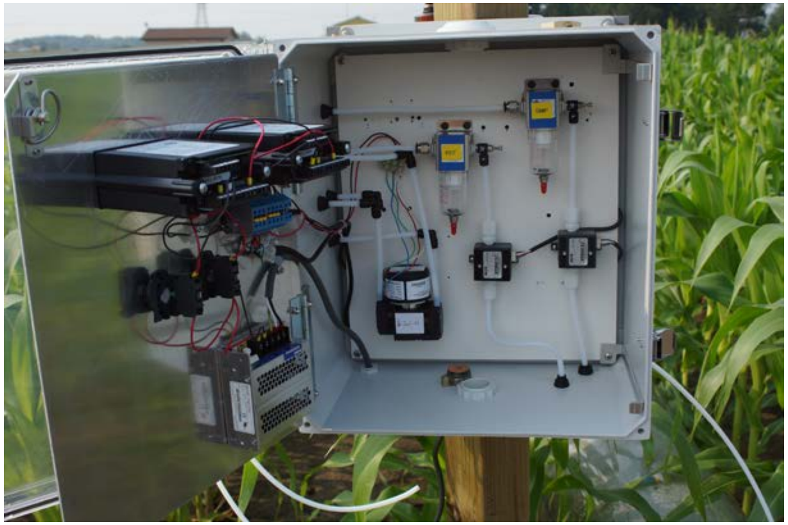
Broadcasting Granular Urea

Measuring NH_3 Volatilization with Wind Tunnels



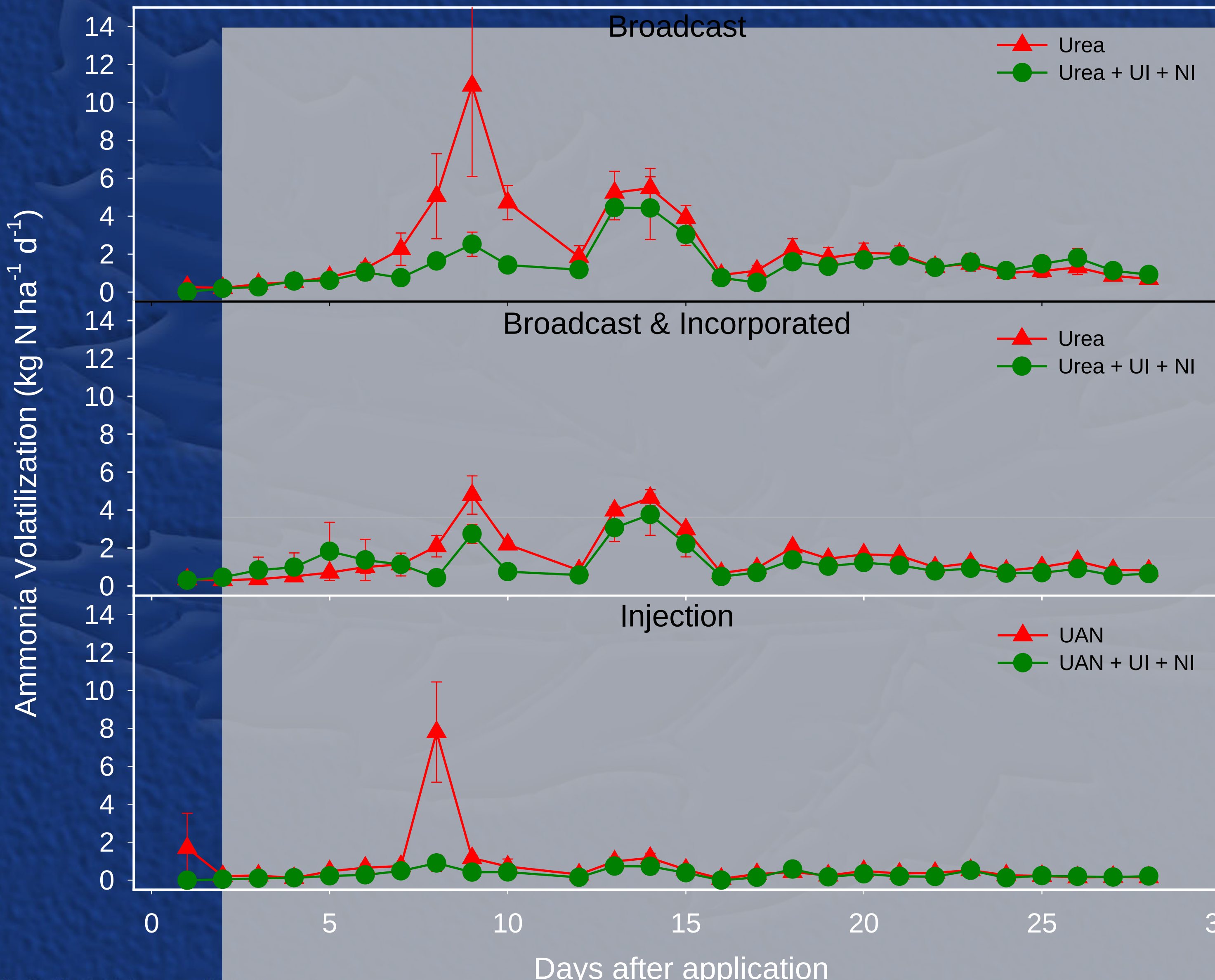
Wind Tunnel & Air Sampling Instrumentation

Acid traps for ammonia collection

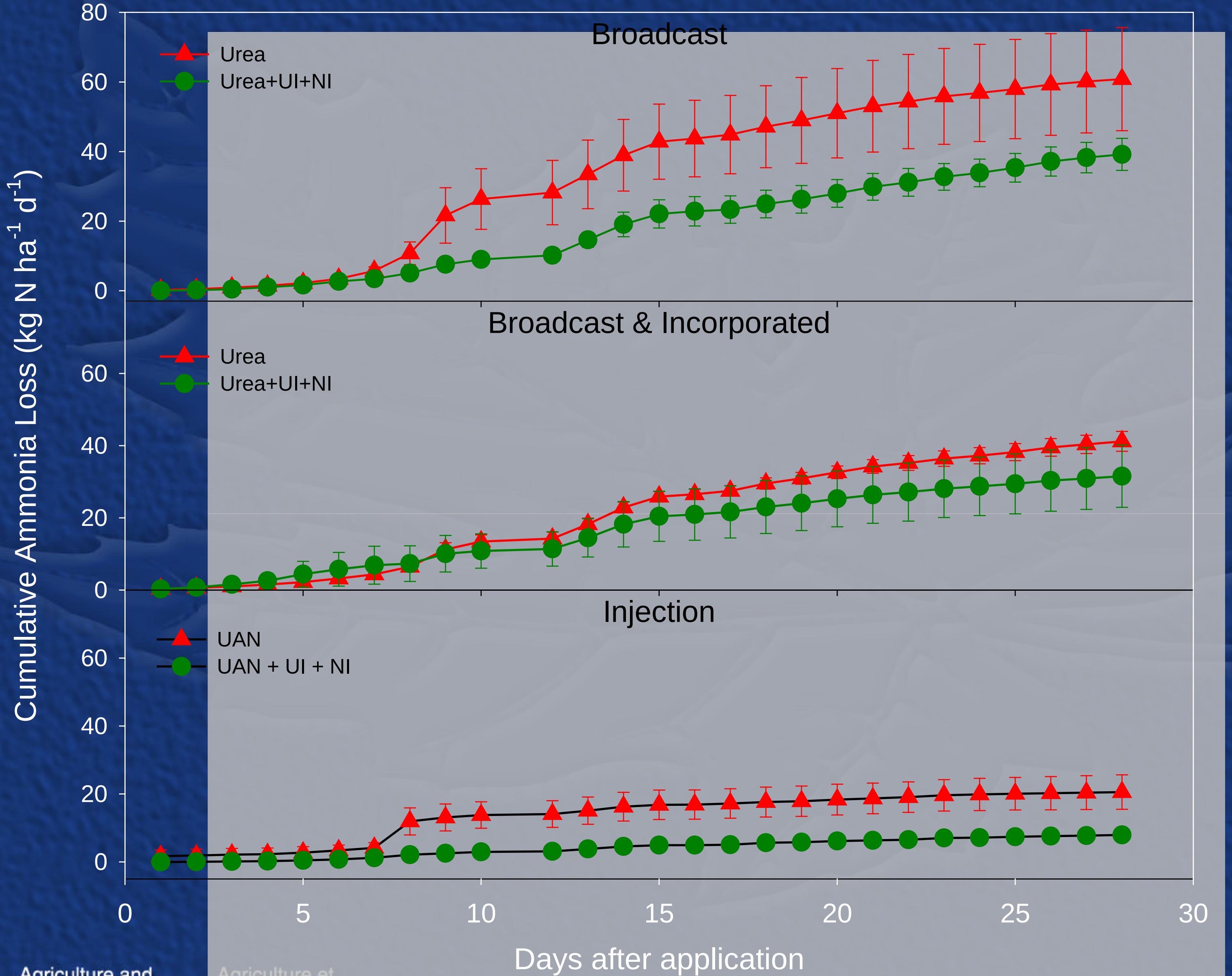


Anemometer for wind speed

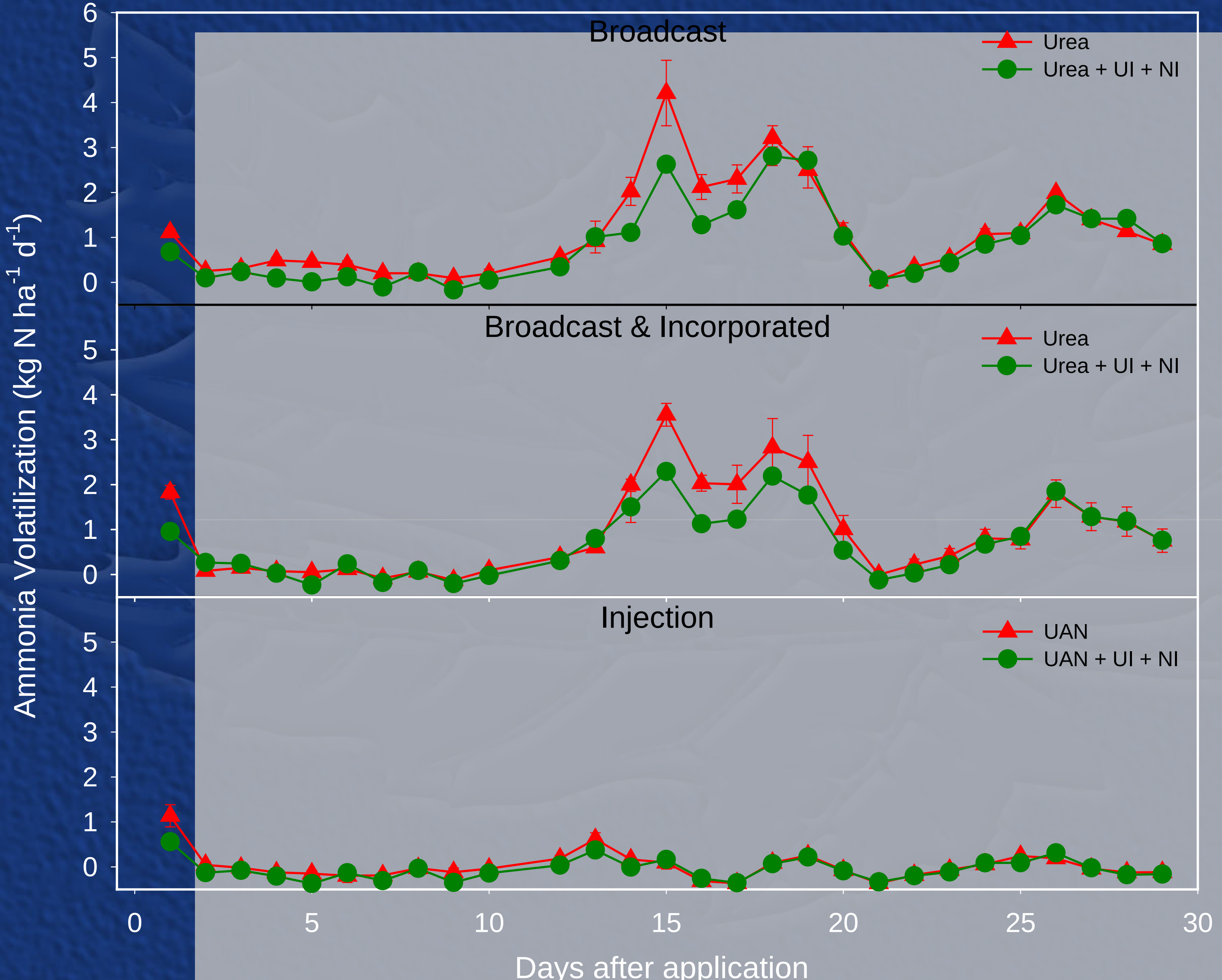
Ammonia Emissions – 2015



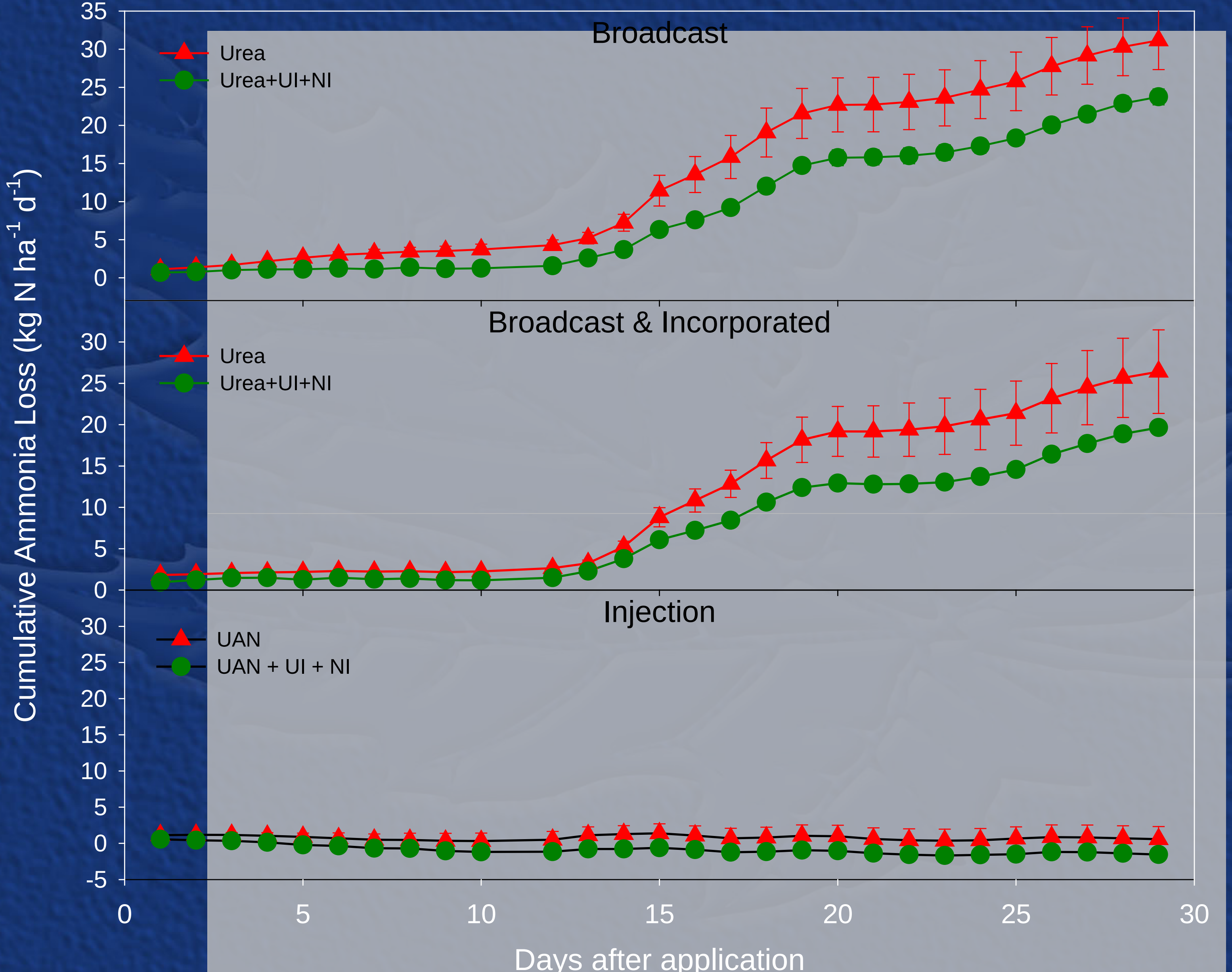
Cumulative Ammonia Emissions - 2015



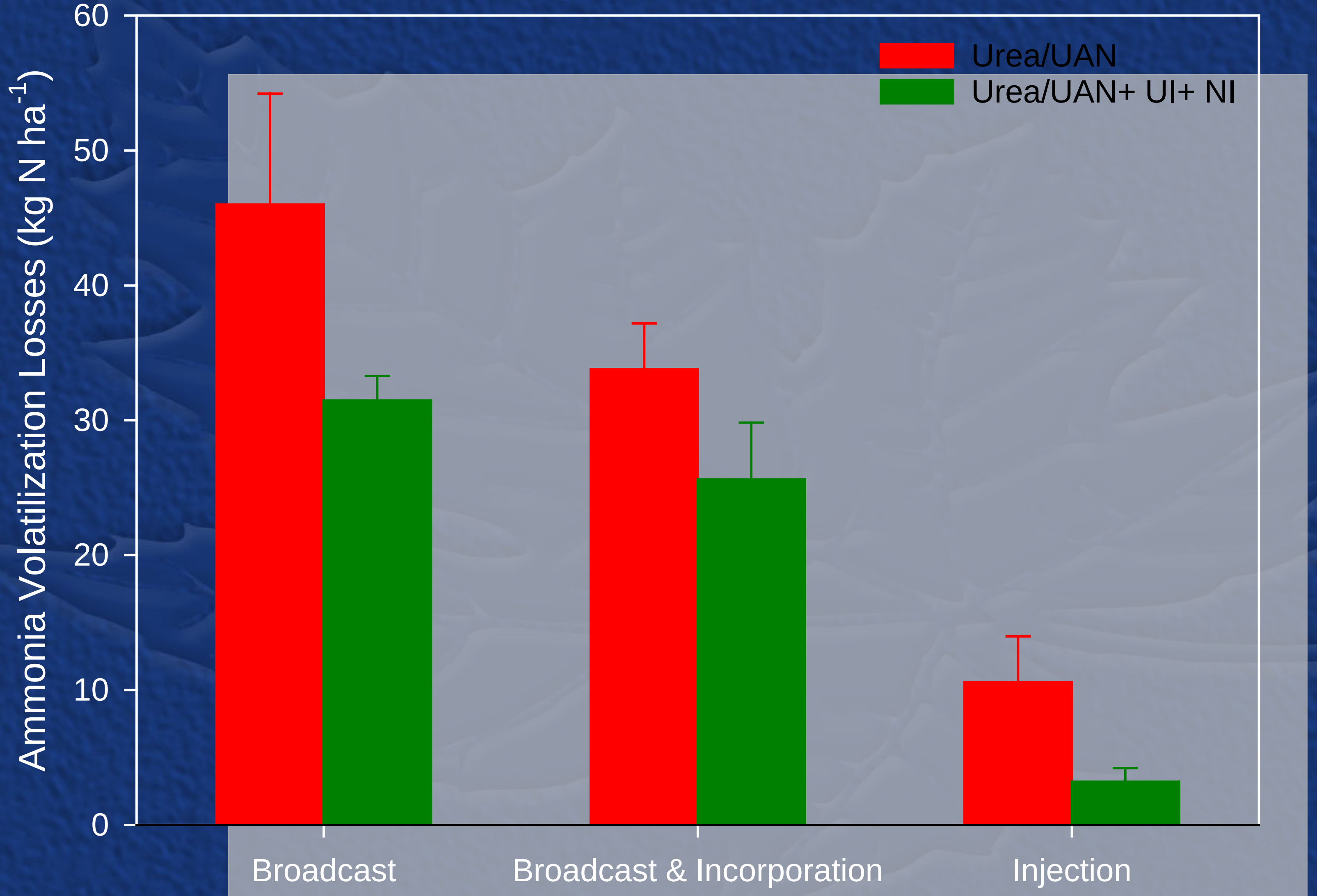
Ammonia Emissions - 2016



Cumulative Ammonia Emissions - 2016

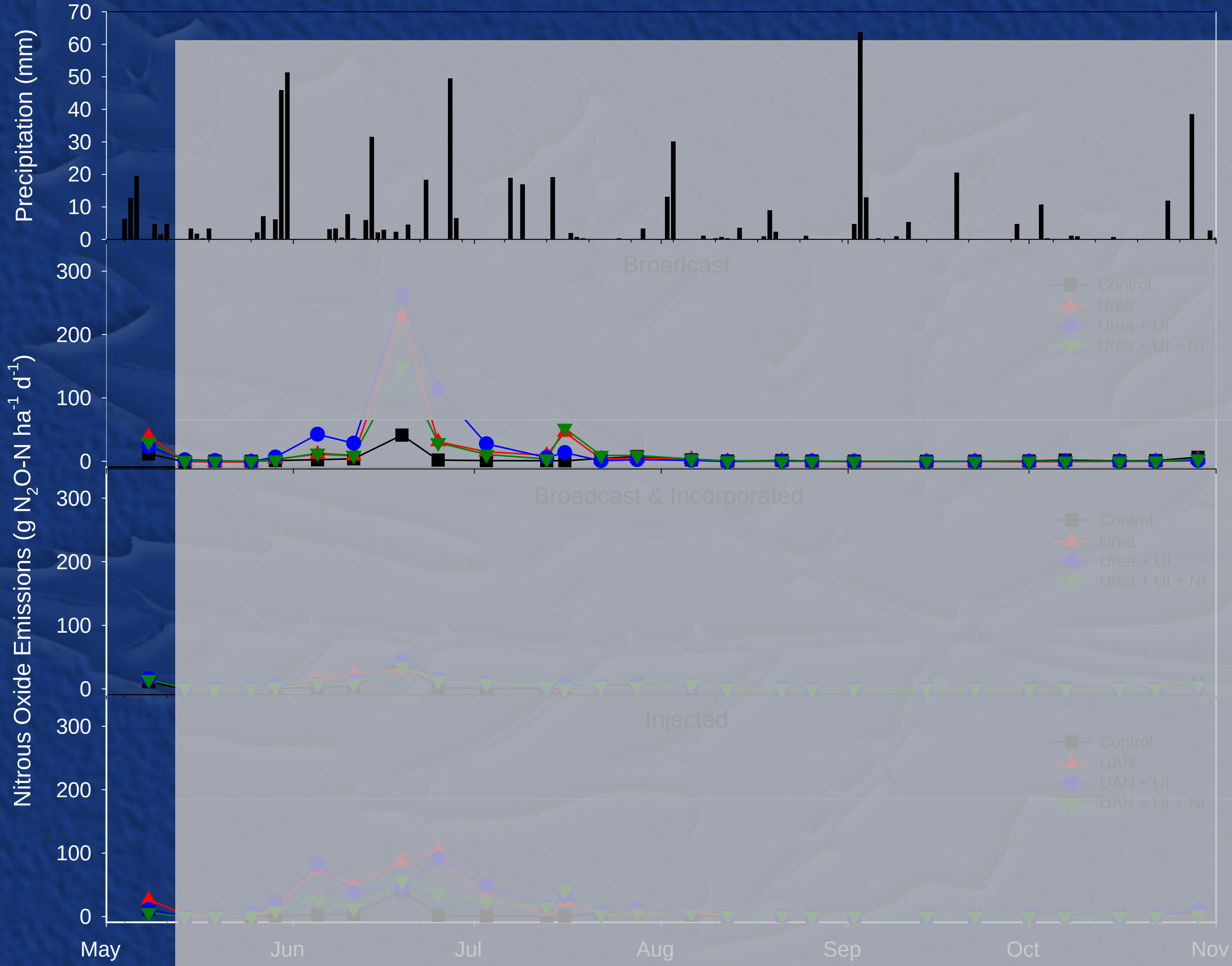


Ammonia Volatilization Losses (2015 & 2016)

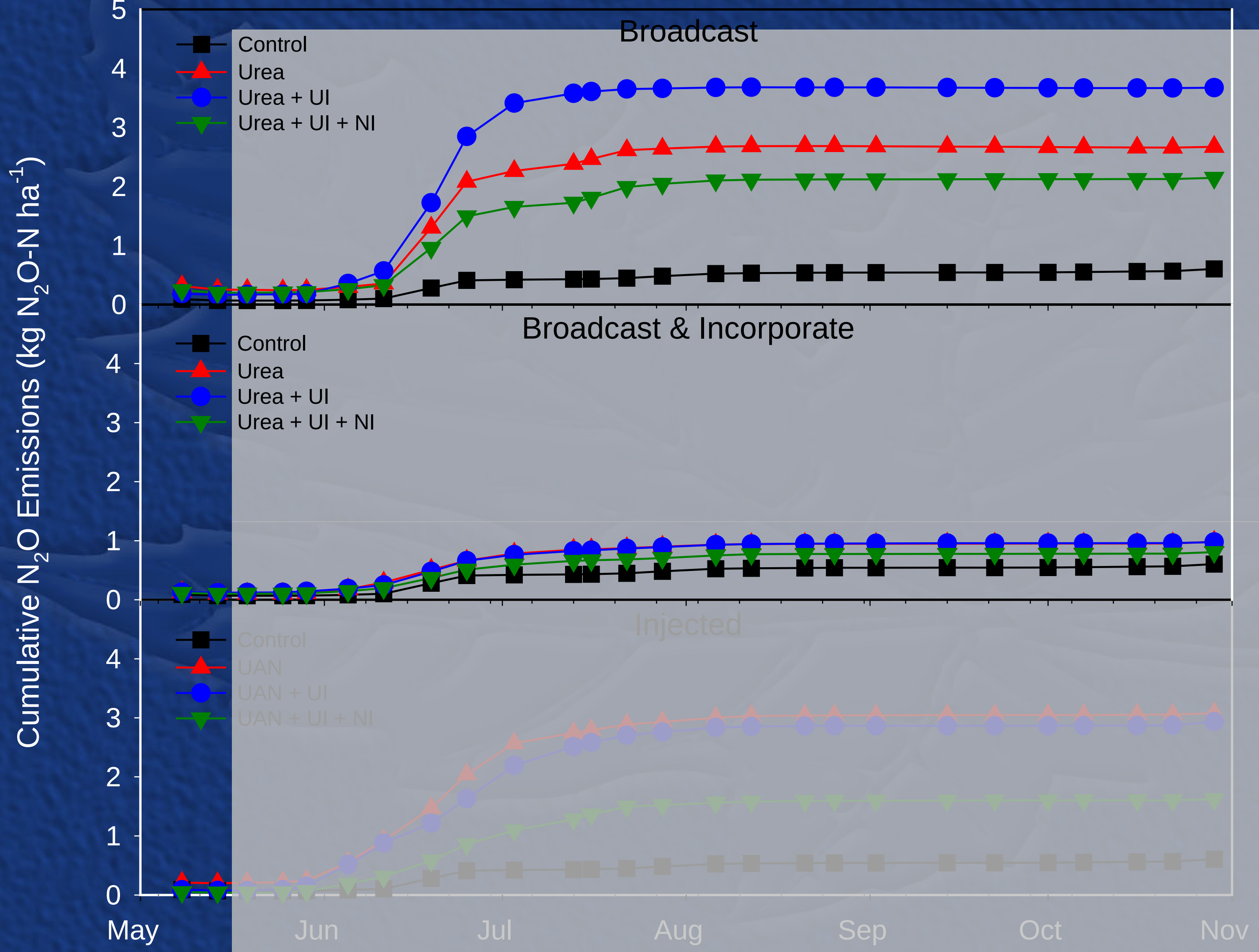


Measuring and Analyzing N_2O Emissions

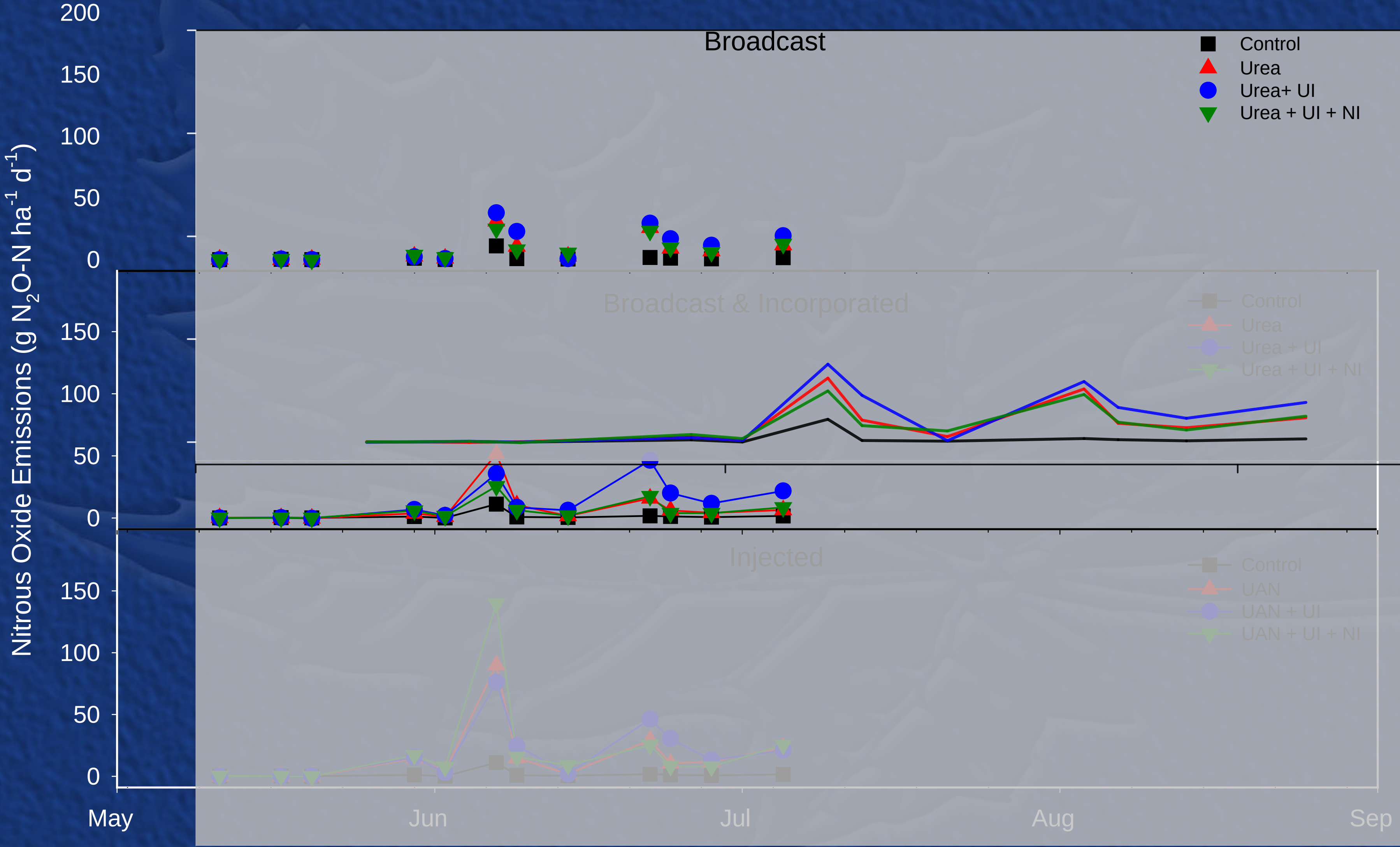
Daily Nitrous Oxide Emissions – 2015



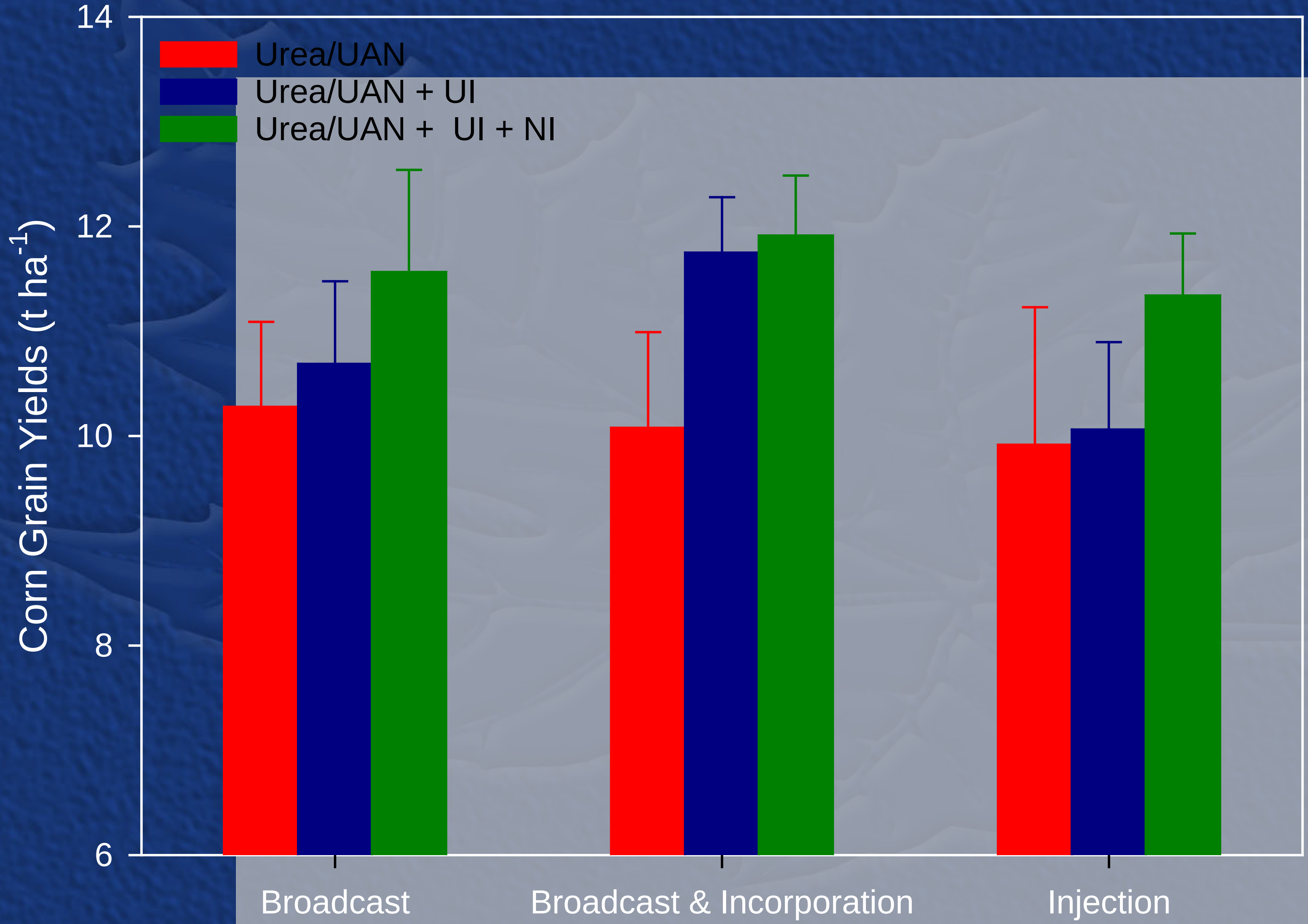
Cumulative Nitrous Oxide Emissions – 2015



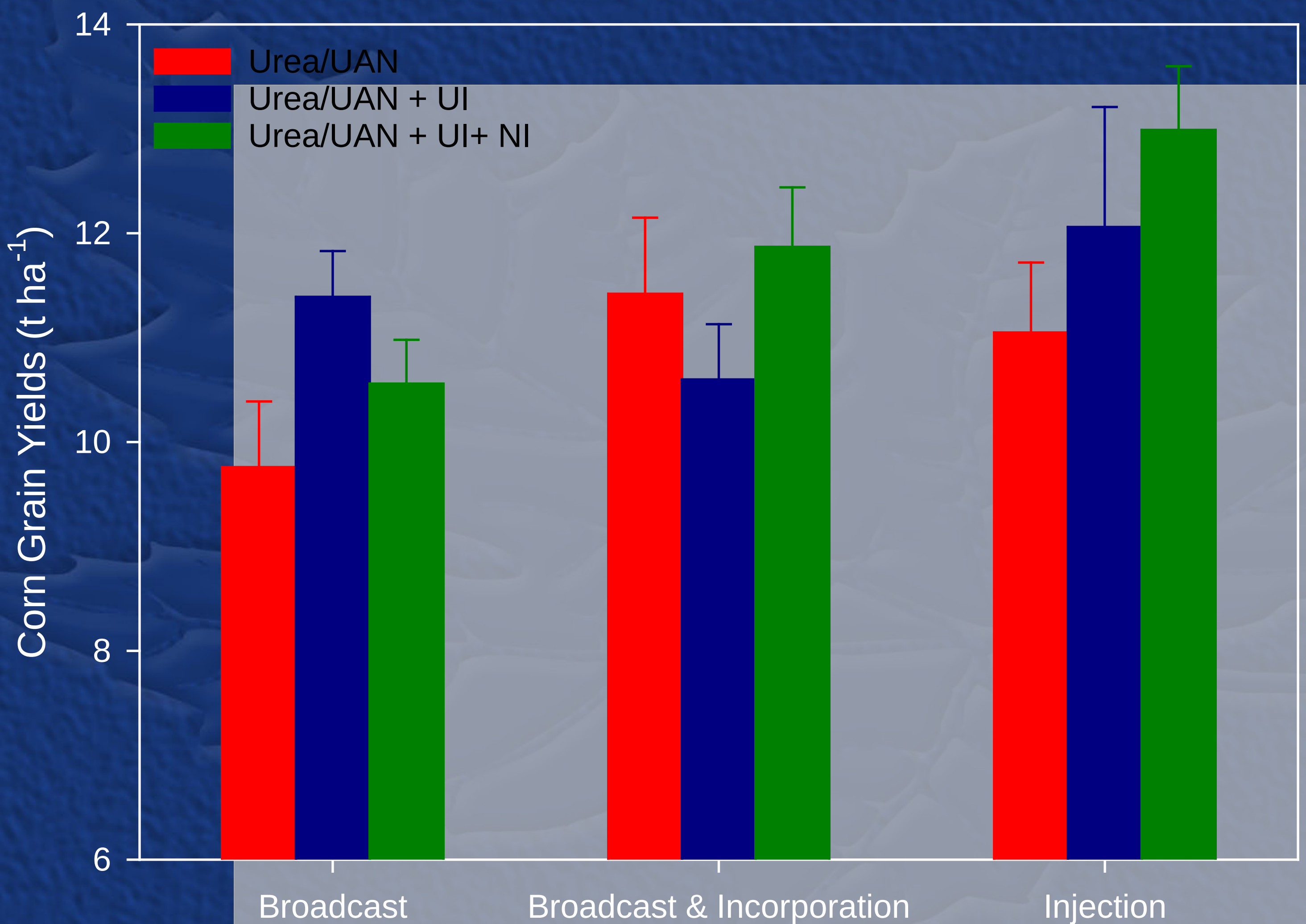
Daily Nitrous Oxide Emissions – 2016



Corn Grain Yields – 2015



'Estimated' Corn Grain Yields – 2016*



* Machine harvest has not yet occurred

Summary

- **Urease inhibitors decreased NH_3 volatilization by:**
  - 32% with Broadcast Urea
  - 24% with Broadcast & Injected Urea
  - 70% with Injected UAN

- **Broadcast & Incorporating urea decreased NH_3 volatilization by:**
  - 27% compared to Broadcast Urea

- **Injection decreased NH_3 volatilization by:**
  - 77% compared to Broadcast Urea

- **Injection & UI decreased NH_3 volatilization by 93% vs Broadcast Urea**

Take Home Message

- Incorporating fertilizer N and using urease inhibitors can help reduce ammonia volatilization losses.

- Urease inhibition alone can lead to increased N_2O emissions. However, combining UI and NI can reduce both NH_3 and N_2O.

- Corn grain yields respond well to the use of inhibitors and improved N placement.

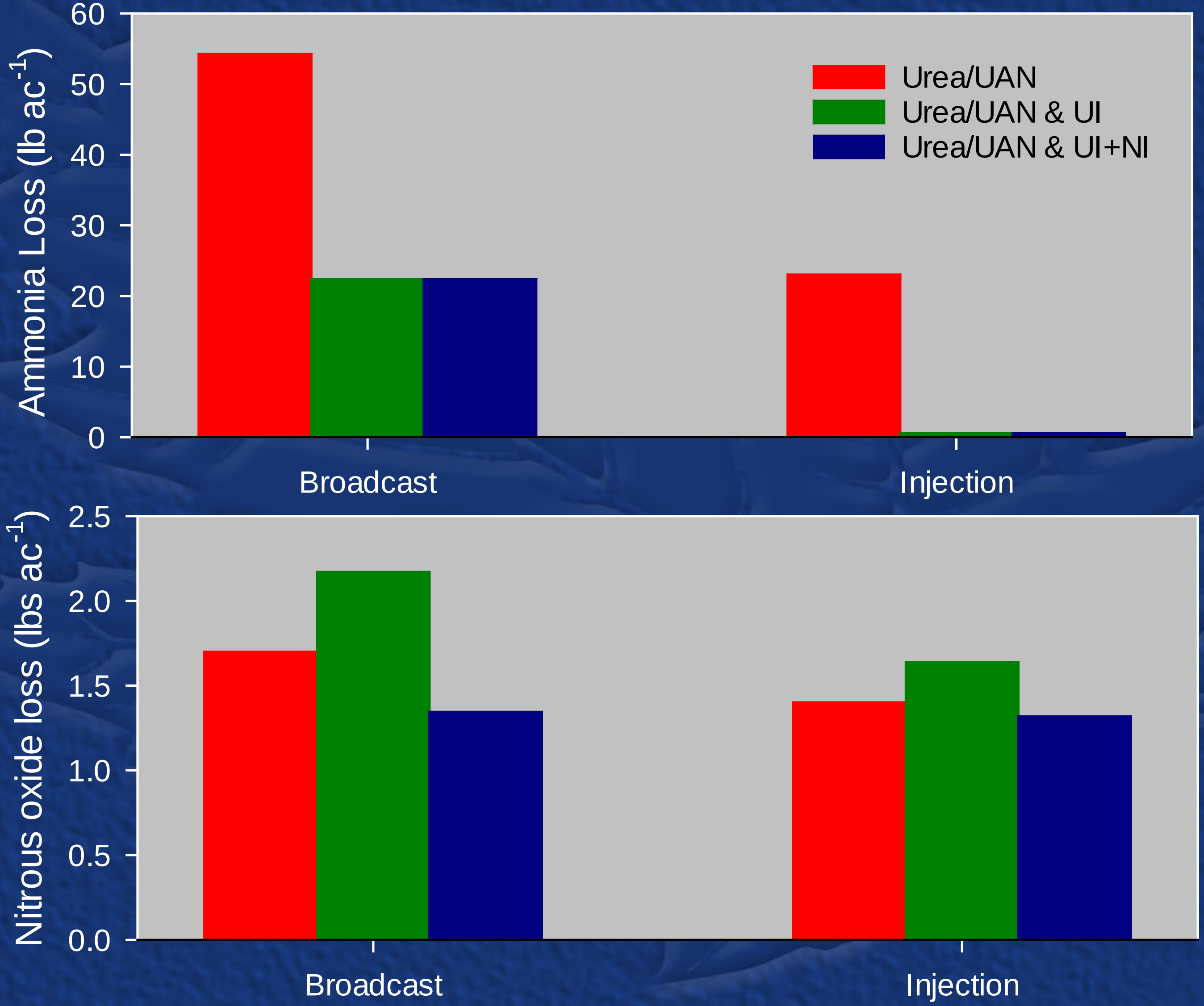
Acknowledgements

- Fertilizer Canada and the Agriculture & Agri-Food Canada Agroecosystem Productivity & Health Program for providing funding for this research.

- Dr. Rigas Karamanos (Koch Fertilizer Canada) for providing SuperU.

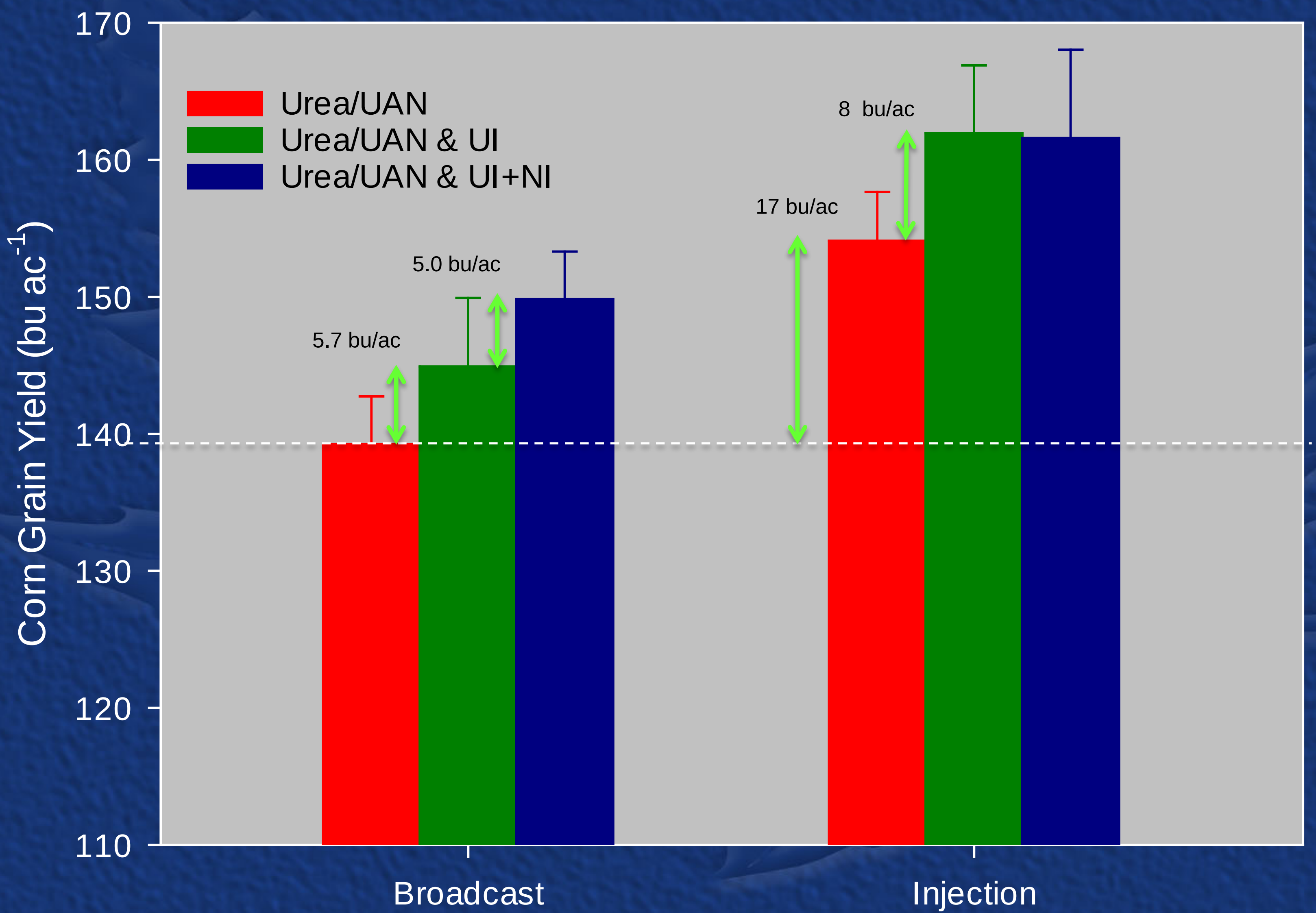

Thank you!

Ammonia vs N_2O Oxide Loss: Preventing pollution swapping

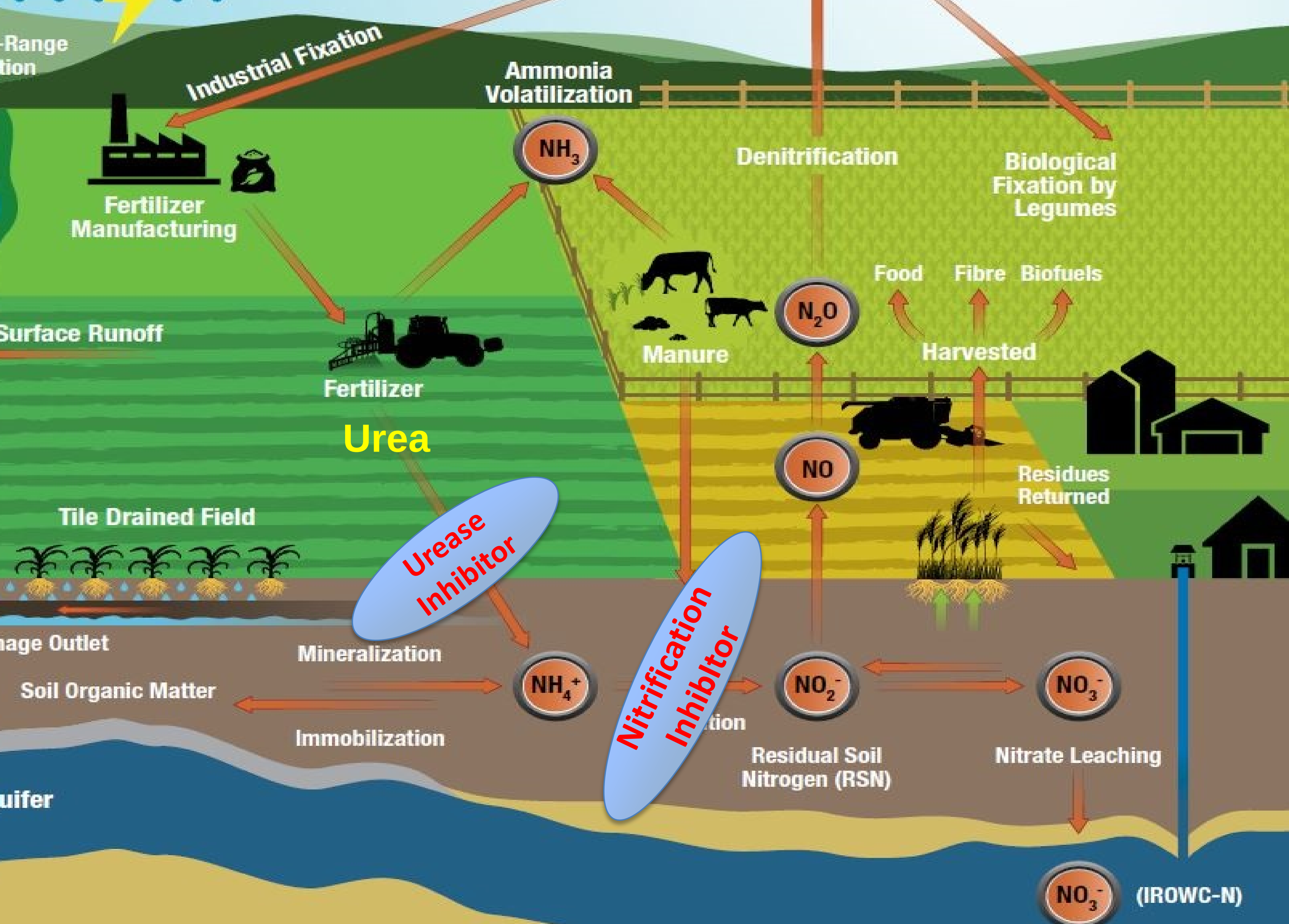


Drury et al., (in preparation)

Corn Grain Yields



Drury et al., (in preparation)



Drury et al., 2015

Saturday May 31, 2015 following 3.8 inches rain

Sunday June 1, 2015

The 4R Fund Research Repository (4R-RR)

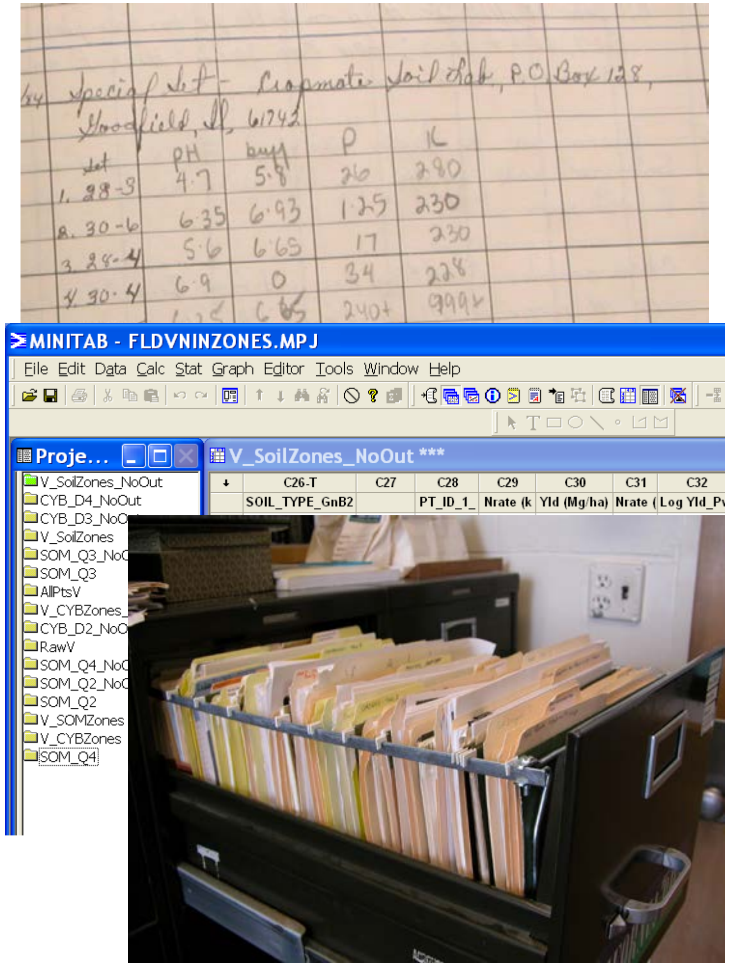
Sylvie Brouder, Jeff Volenec
Professors, Dept. of Agronomy, Purdue University

4R Meeting
Phoenix, AZ

Nov. 6, 2016

The WQFS: Trying to recover full value from the WQFS as an infield laboratory to study fate, loss of agricultural chemicals…

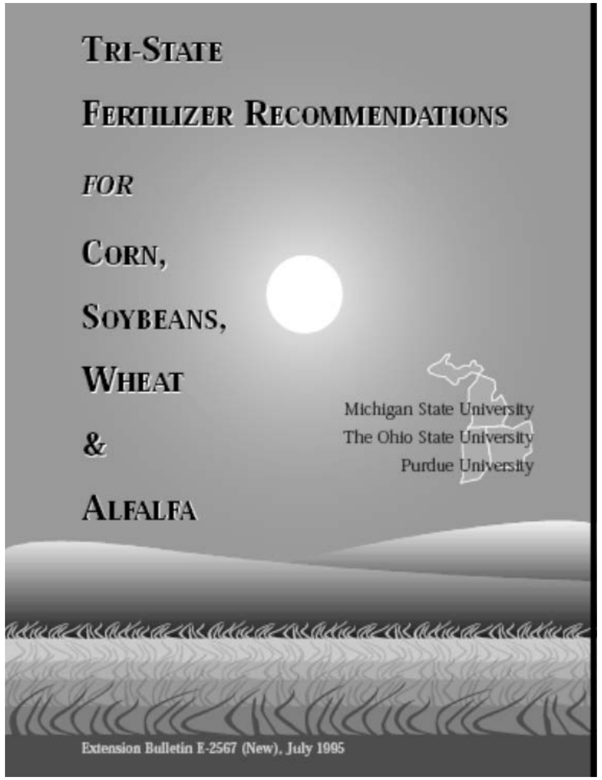
- Legacy data key attribute of facility’s value (model devel./calib./verif.)
- HR hardest thing to support long-term→ “corporate memory” is fragile
- Data preservation / curation (vs storage) requires HR & $$ beyond what is available (proposal $$ for data management still getting stripped out of awards)
- No policy for $$ contribution for data reuse



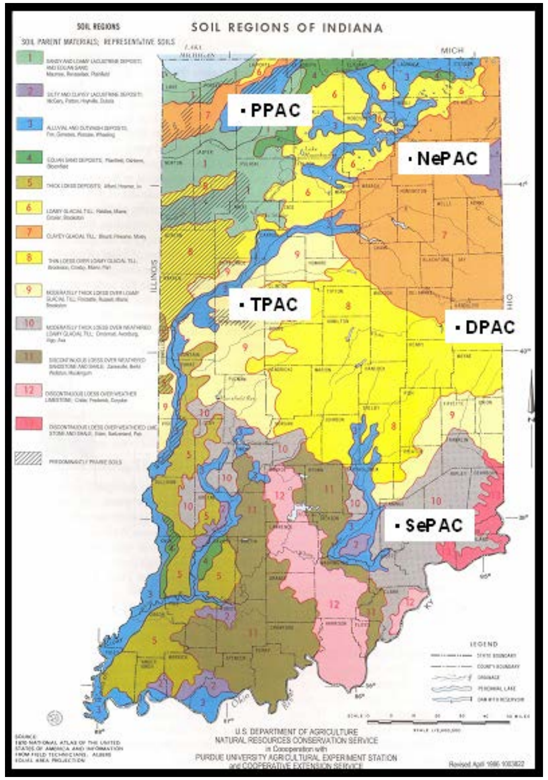
Is developing data management infrastructure just too easy or too hard….?

Why data? Professional “hats”…

The Tri-State Recommendations



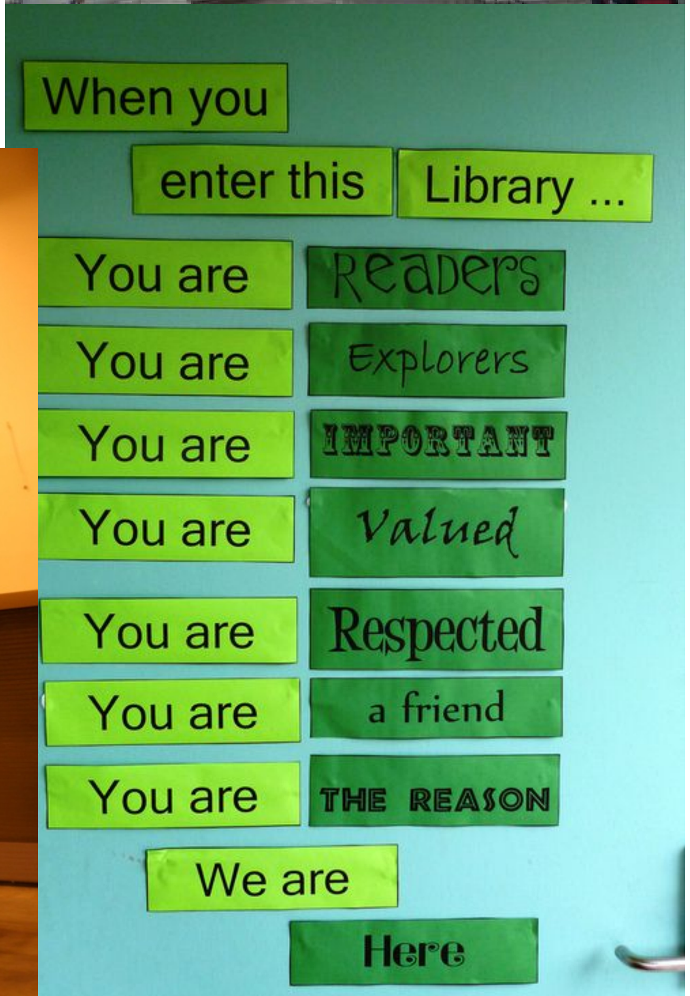
… and my 5-yr K experiment now entering its 19th year but still not enough data…



Regardless of HR/$$ issues, "storage" problematic…

- Can we put it in the Library?
  - Papers go there, why not data ~ natural E-evolution
  - Vision for professional credit: if data are in the library then they are a scholarly product
  - As an Assoc. Prof. it seemed to have at least some potential as a CYA strategy.
  - At Purdue, years of "baby-steps" thinking about a data sharing model via Libraries brings us to the 4R-RR within PURR

Why Libraries? The skill sets, the thought process, professional value system ("public good"), & public expectation of infallibility / persistence are right for the problem…



Impediments/Challenges Confronting Data Generators and Downstream Data Users

- Meta-data standards
- Data standards
- Minimum data sets
- Provenance
- Repositories
- Data publishing
- Dataset versioning

- Data discovery and retrieval
- Data granularity
- Scholarship of data publishing
- Data ownership
- Business models for data
- Education about data management, including re-education

Best practices for data sharing…

- **Discoverable** ~ findable with common search engines
- **Accessible** ~ downloadable and subject to manipulation
- **Intelligible** ~ human and machine readable, suitably described, access rights clearly stated
- **Assessable** ~ provenance clear & quality/reliability should be evident
- **Usable** ~ data should be in a generically “actionable” format (**not a pdf!**)
- **No-nos**:
  - Simply posting to a website (non-persistent)
- **Requirements**: New curriculum and infrastructure…

Repository Issues – No Perfect Solution (yet) for Data, a Public Good

- DataOne-NSF, Soft money-renewed for a second 5 yr term; become a node?
- DRYAD: http://www.datadryad.org/; requires linkage to a publication; what happens to unpublished, negative results critical to systematic reviews?
- ACSESS - expand repository? Enhance data discovery.
- New Ag Data Commons at NAL
- PURR: Attached to an Institution with a long legacy; Storage for at least 10 yrs -then what?

We are learning: Single biggest mistake “we” make remains build it and they will come

Pilots ongoing: Nat. Agricultural Libraries, Alliance of Crop, Soil & Environmental Science Societies, International Plant Nutrition Institute

Ex. IPNI pilot & the “Data Buddy”

- On-site visits with PIs to help transition their data from their computers to PURR
- Assist with standards: data and meta-data (“Data Dictionary”)
- Make certain minimum data sets are acquired.

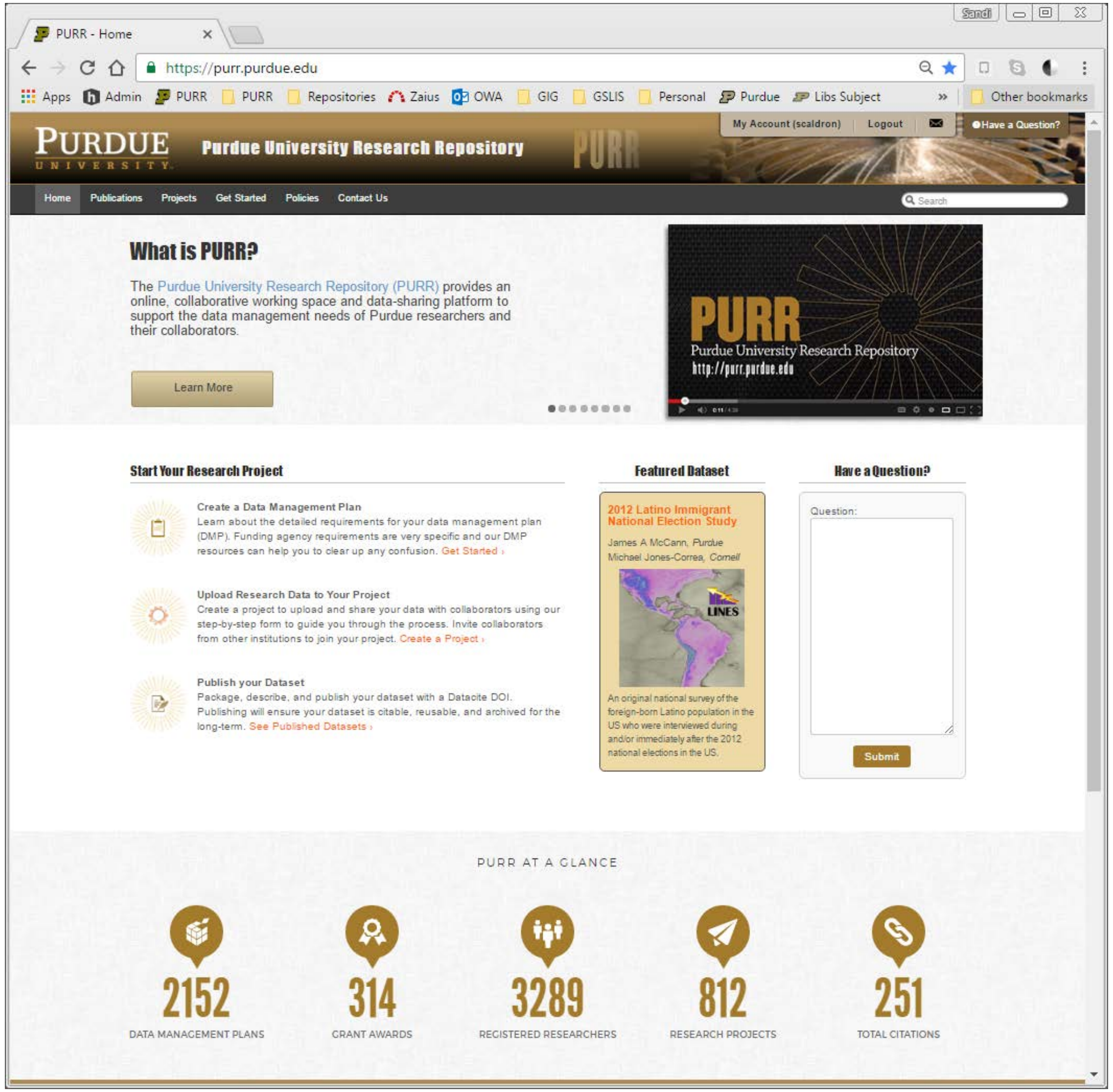
Meadow Creek Students Partner as Data Buddies
www.hebisd.eduhttp://www.hebisd.edu/media/images/articles/2763f.jpg

The 4R RR Project Team

The Agronomy Types: Sylvie Brouder, Jeff Volenec, Scott Murrell
The PU Library Information Scientist for Agriculture: Marianne Bracke
The PU Library Meta-Data Specialist: Amy Barton
The PU Libraries Data Repository Outreach Specialist: Sandi Caldrone
The Expert Assistant: Nayere Ghazanfarpour and …

Getting Start in PURR for users from outside Purdue

Sandi Caldrone
Data Repository Outreach Specialist
scaldron@purdue.edu

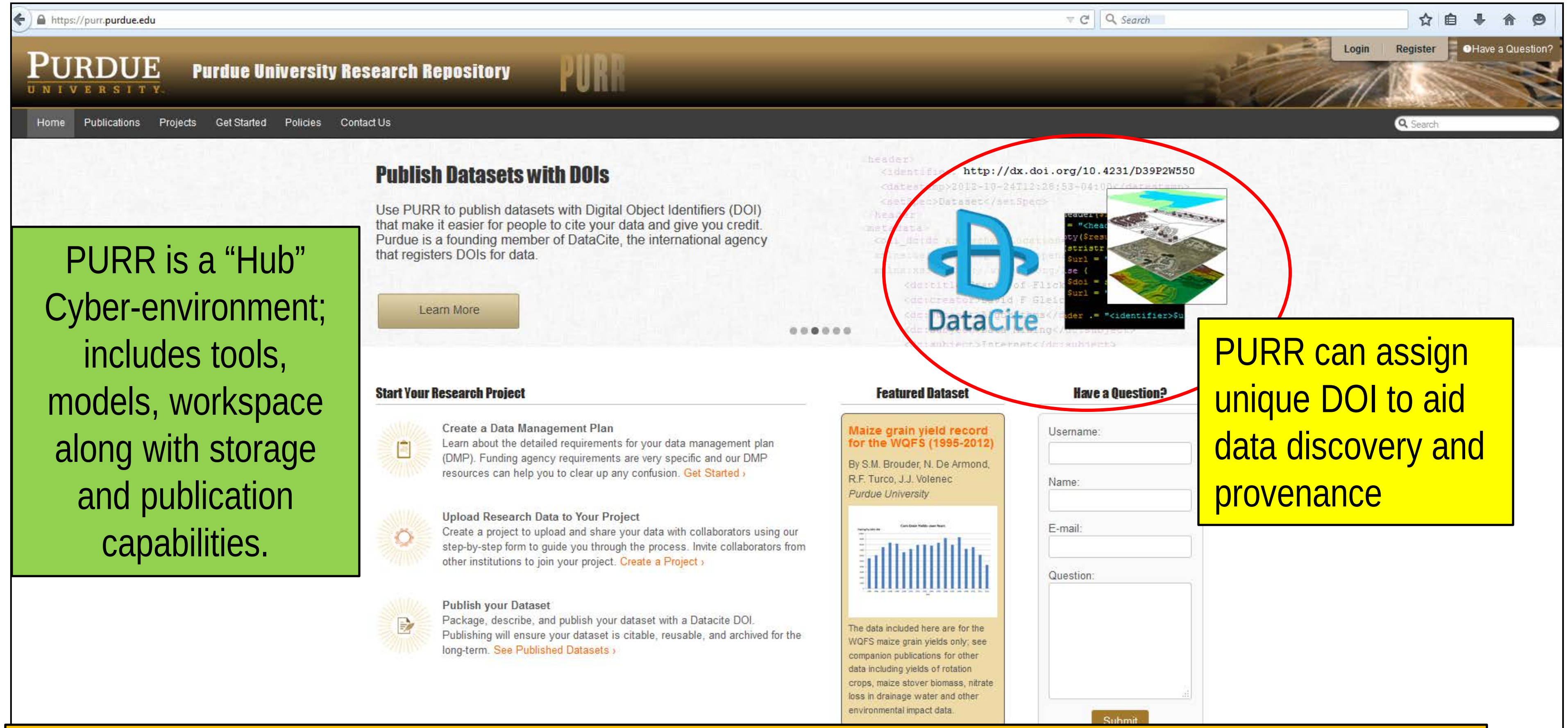


https://purr.purdue.edu

Purdue University Research Repository

- A core research facility
- A research collaboration and data publication tool
- Anyone can see and use published data
- Purdue faculty, staff and graduate students can create projects and publish data
- Project owners can invite collaborators from outside Purdue

Purdue University Research Repository (PURR) most useful agronomic tool since the RCBD

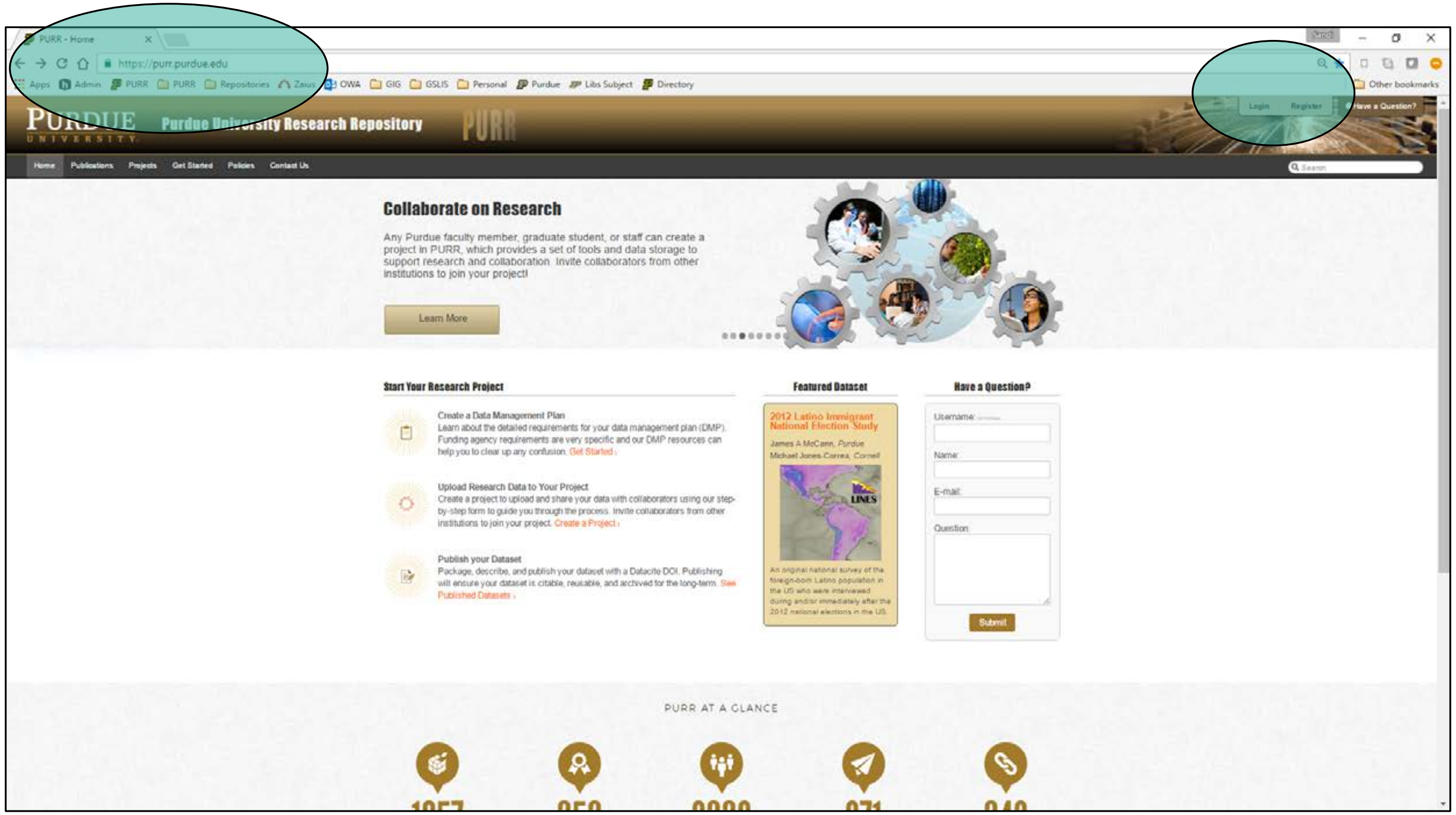


PURR is a "Hub" Cyber-environment; includes tools, models, workspace along with storage and publication capabilities.

PURR can assign unique DOI to aid data discovery and provenance

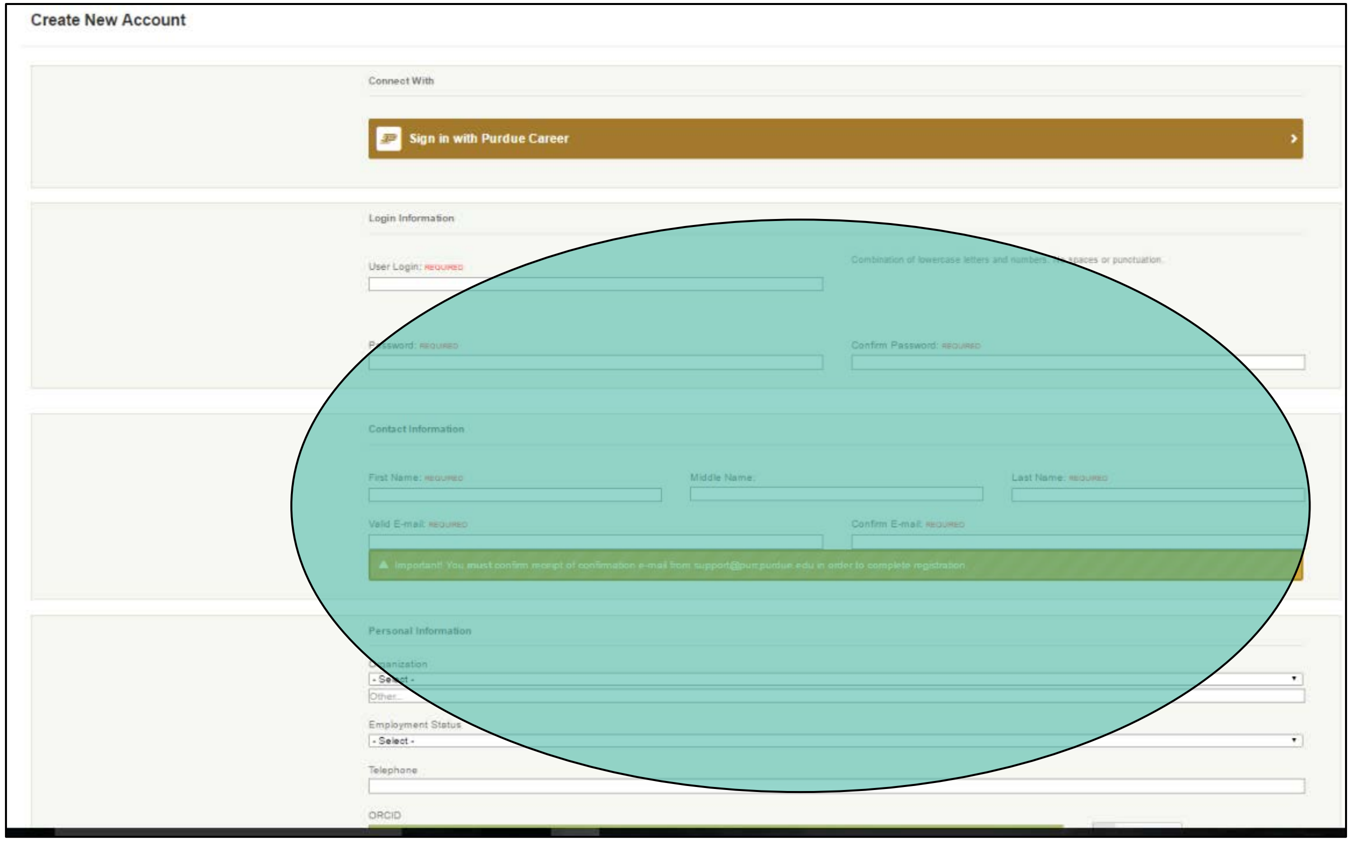
So much more than "data storage"….

Register for a PURR Account



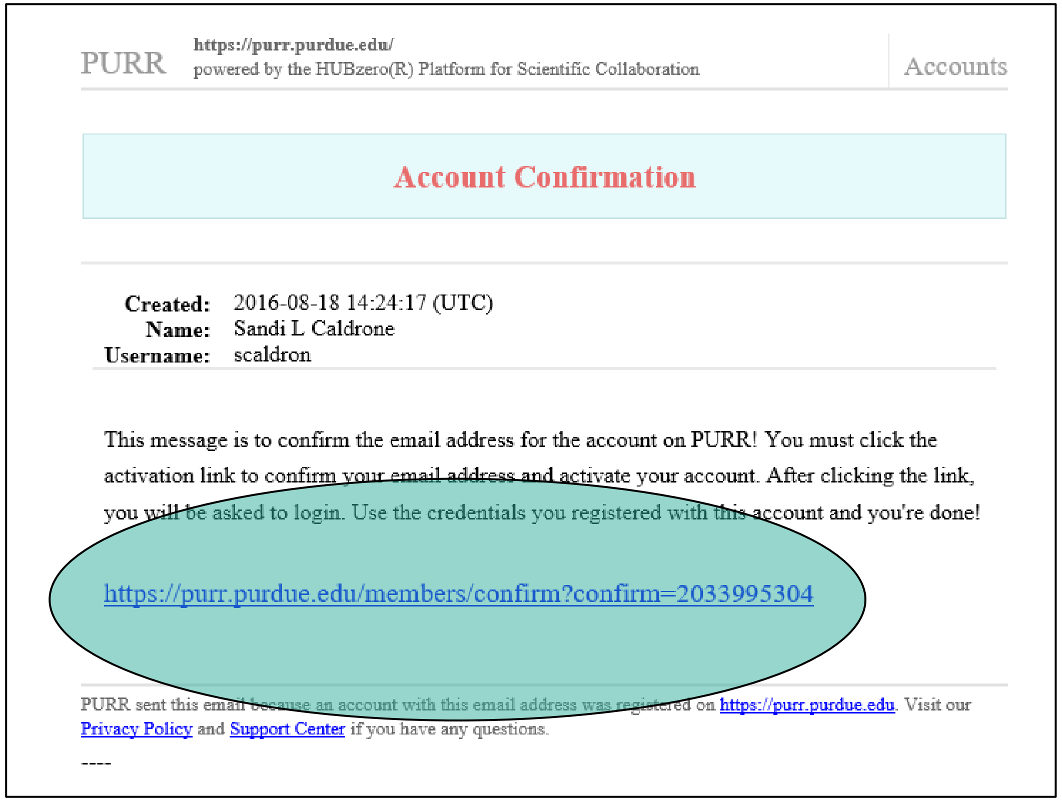
Go to https://purr.purdue.edu and click Register in the upper right.

Fill in Account Info



Remember to agree to the Terms of Use and click Create Account at the bottom.

Confirm Your Email



PURR https://purr.purdue.edu/
powered by the HUBzero(R) Platform for Scientific Collaboration
Accounts

Account Confirmation

Created: 2016-08-18 14:24:17 (UTC)
Name: Sandi L Caldrone
Username: scaldron

This message is to confirm the email address for the account on PURR! You must click the activation link to confirm your email address and activate your account. After clicking the link, you will be asked to login. Use the credentials you registered with this account and you're done!

https://purr.purdue.edu/members/confirm?confirm=2033995304

PURR sent this email because an account with this email address was registered on https://purr.purdue.edu. Visit our Privacy Policy and Support Center if you have any questions.

Check your email and click the confirmation link.
Don’t see an email from PURR? Check your junk mail, especially if you use Gmail.

Log In

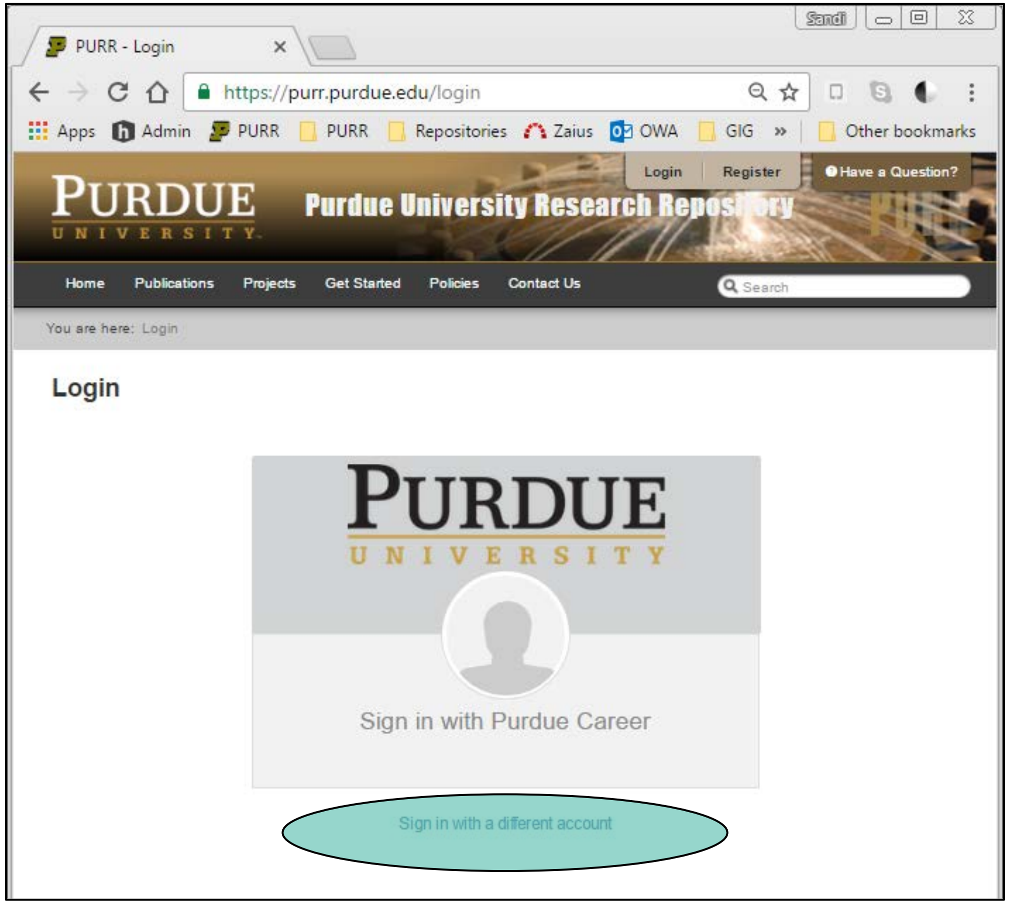
Logging in as an outside user takes just a few clicks.

Whenever given the option to log in with a Purdue Career Account or a PURR Account, choose the PURR Account.

Log In – Step 1

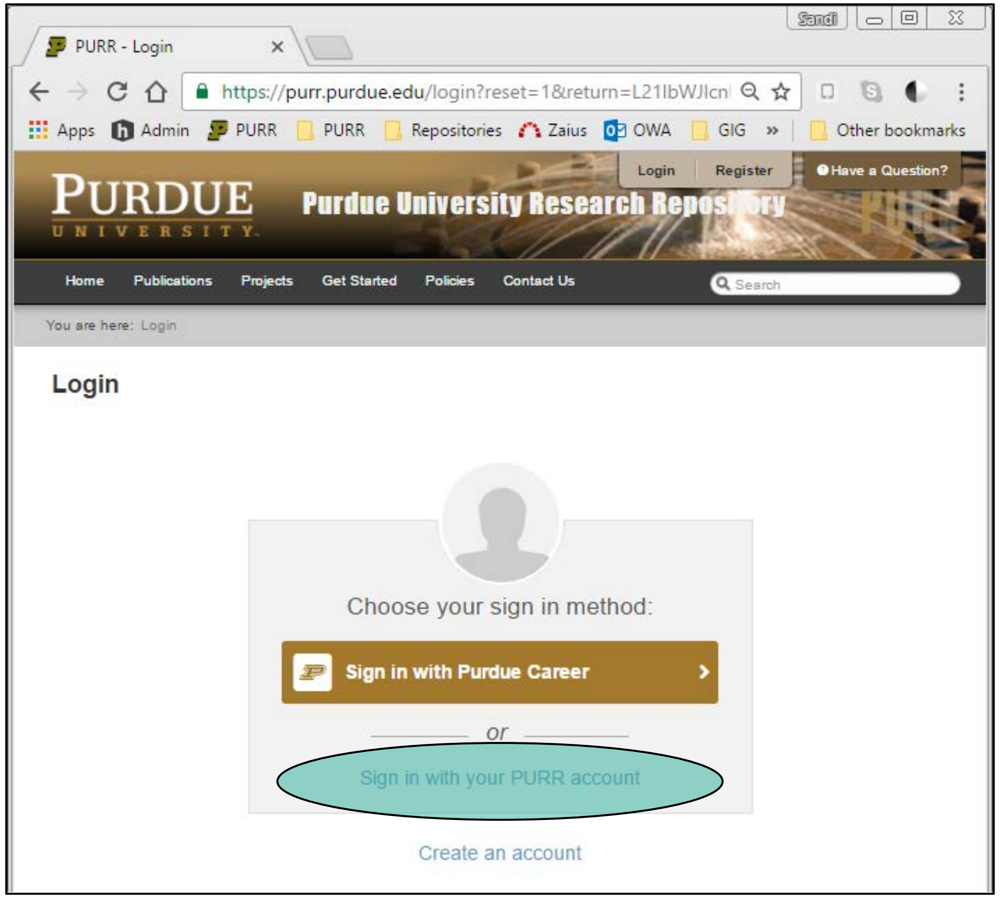
Click Login in the upper right.

Log In – Step 2

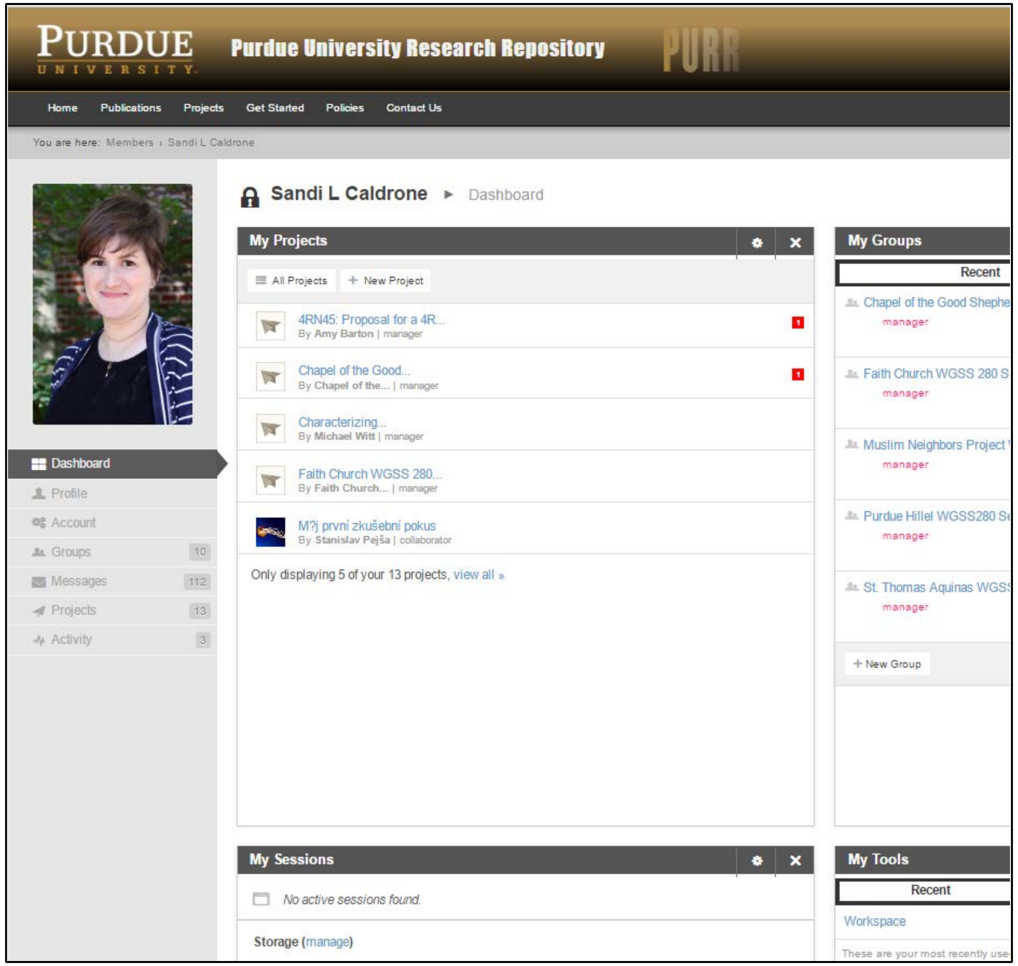


Choose 'Sign in with a different account.'

Log In – Step 3

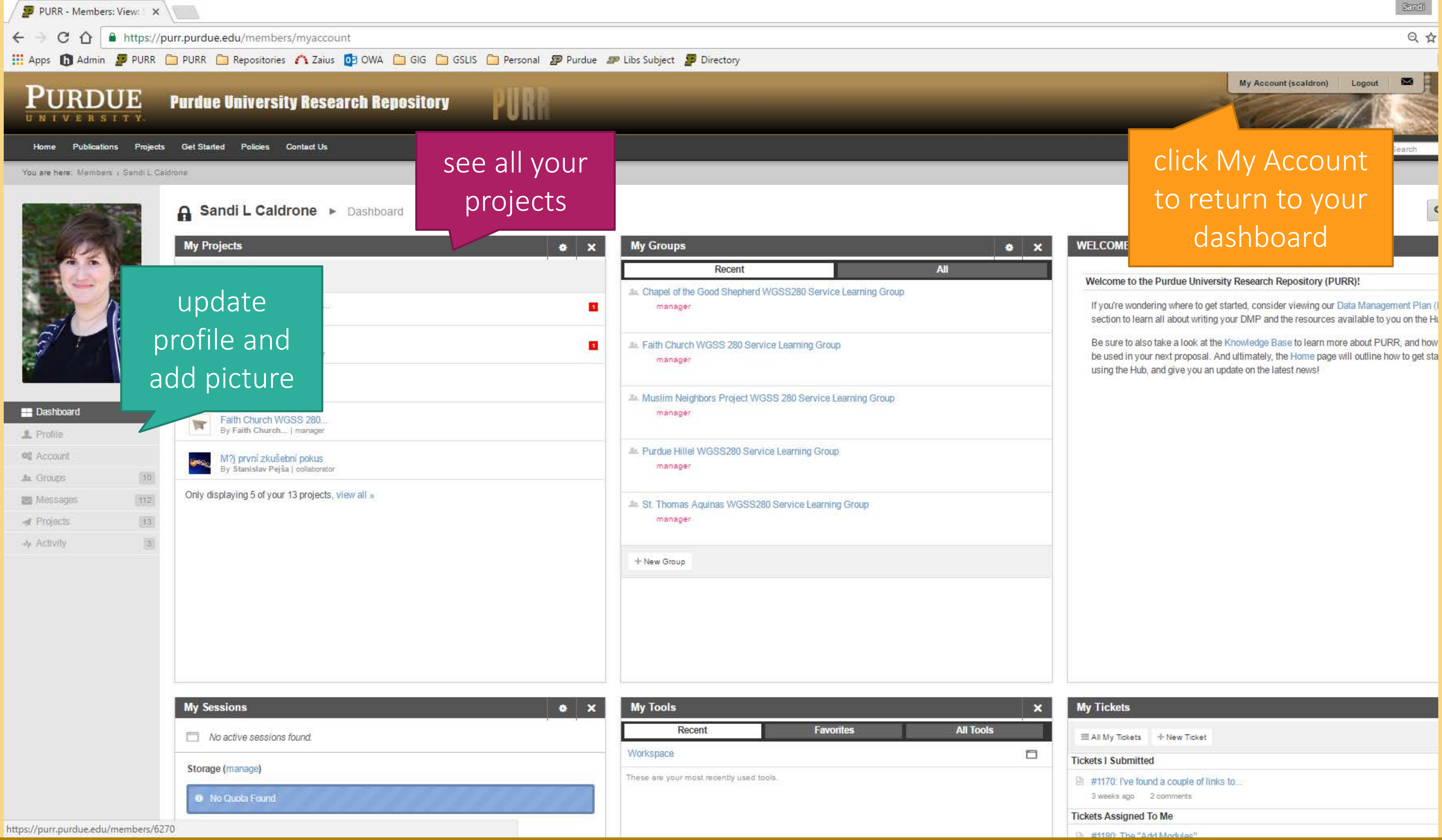


Choose 'Sign in with your PURR account.'



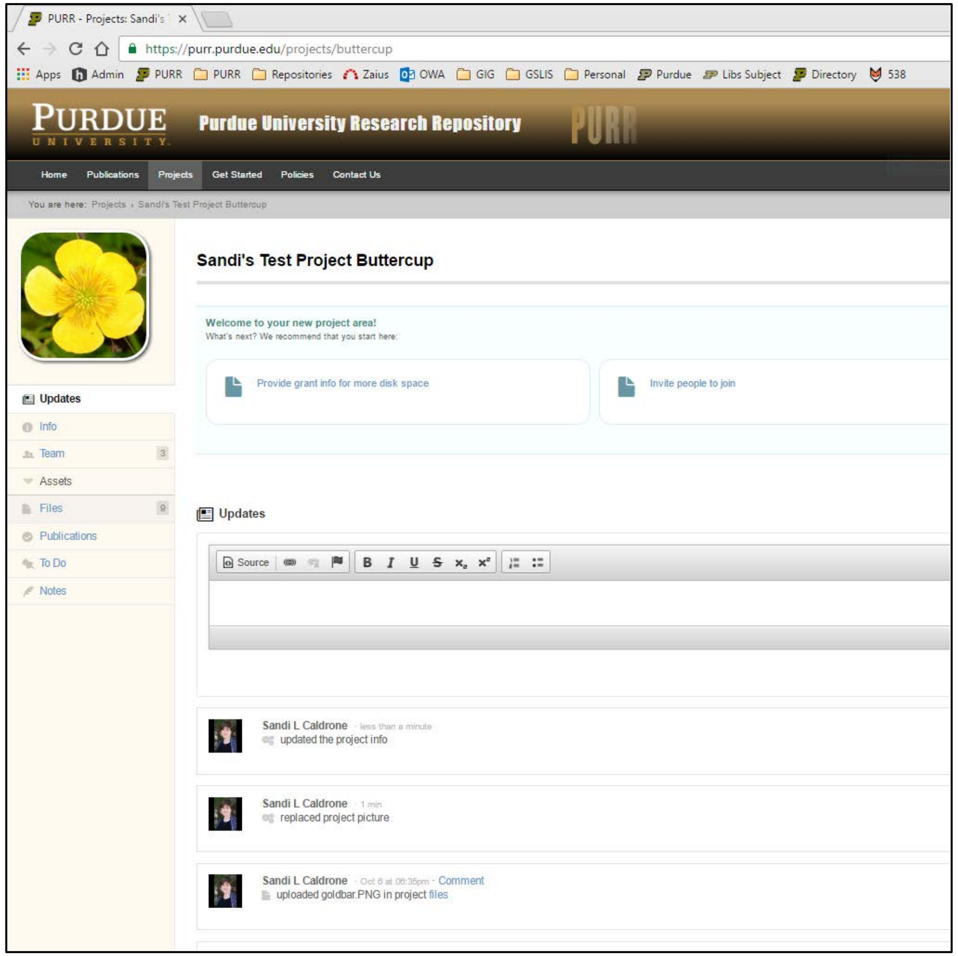
Your Dashboard

Your dashboard shows all of your PURR activity at a glance and makes it easy to move between different PURR projects.



Login and View Dashboard

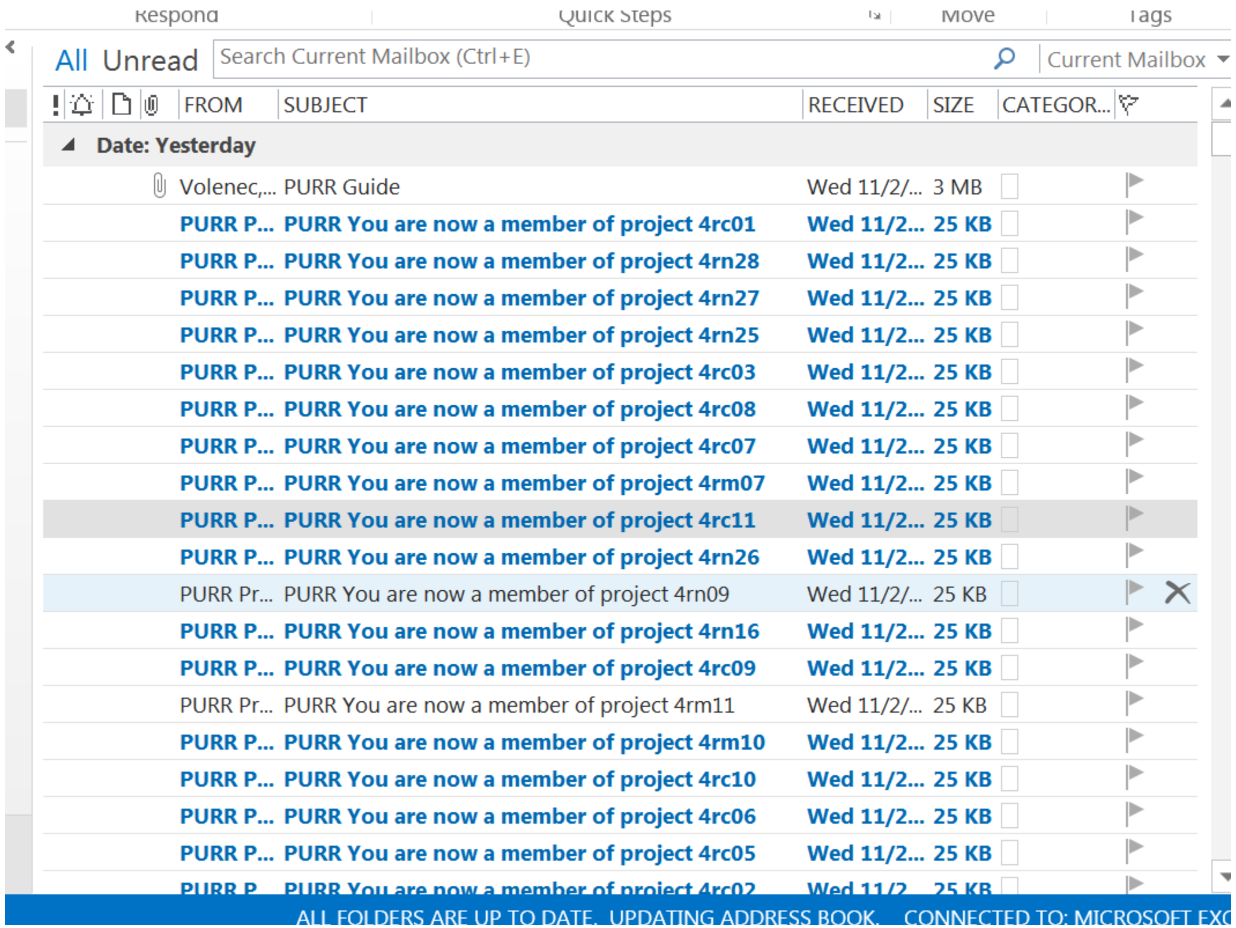
Drag and drop objects on your dashboard to rearrange them



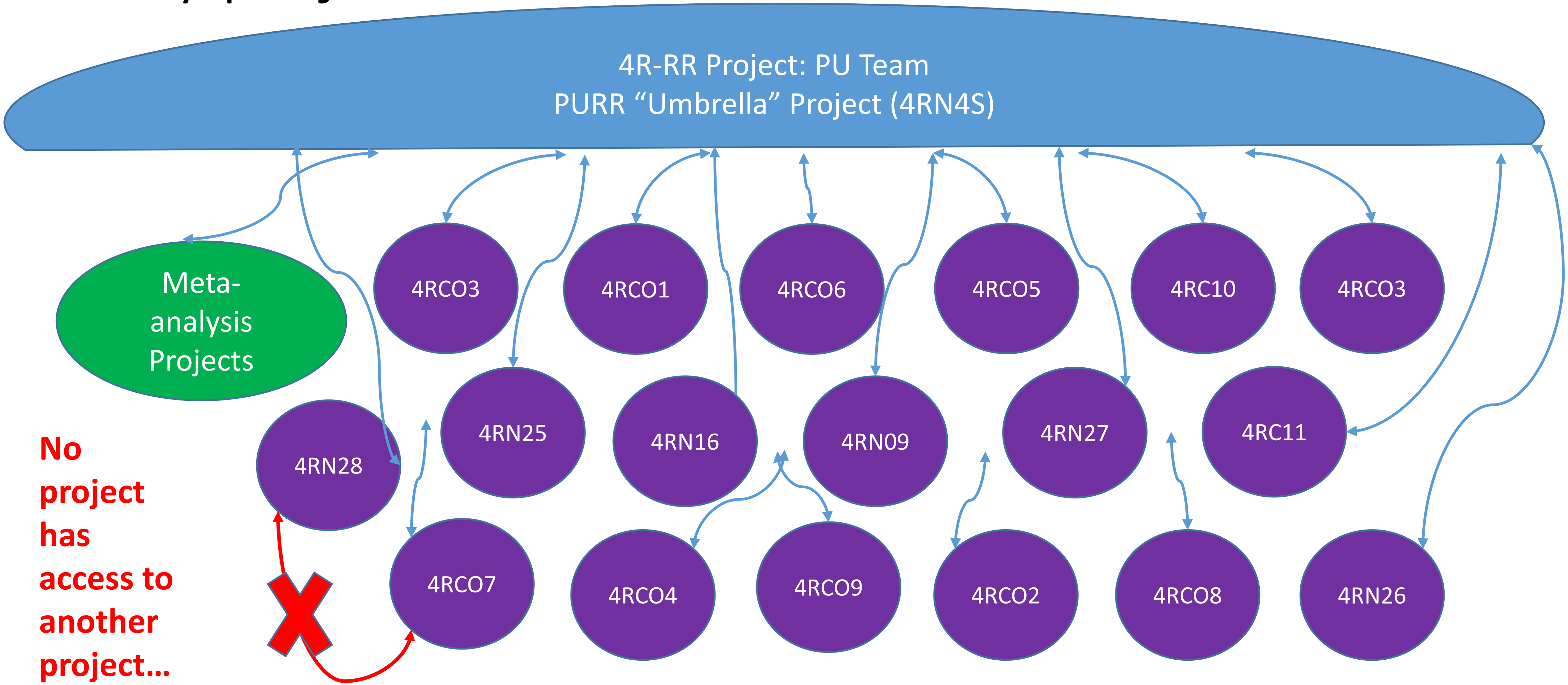
Accept a Project Invite

You will only have to join each project once. It is easiest to join a project if you are already logged in to your PURR account.

Step 4. Accept your email Invite: I'm invited to all of your projects…



The 4R-RR Structure: Who has access to what… The Umbrella project has access to every project and every project has access to the umbrella



The 4R-RR Structure: Who has access to what… Example ~ Cliff Snyder’s projects

Paul Fixen

Sylvie Brouder, Jeff Volenec, Marianne Bracke, Amy Barton, Nayere Ghazanfarpour, Sandi Caldrone, Scott Murrell, …

4R-RR Team

Mike Stewart, Tom Bruulsema

IPNI Staff

Cliff Snyder

IPNI Staff

Eagle, Christianson, Qian, Ruiz

Metadata projects

Vyn

4RN27; 4RN28

Helmers

4RN16

Once you have joined, you can invite your individual project CoPIs… or not…

Step 4. Accept your email Invite: I'm invited to all of your projects…

Wed 11/2/2016 4:26 PM

PURR Projects <support@purr.purdue.edu>

PURR You are now a member of project 4rm11

To Brouder, Sylvie M

If there are problems with how this message is displayed, click here to view it in a web browser.

PURR **https://purr.purdue.edu**
powered by the HUBzero(R) Platform
for Scientific Collaboration
Projects

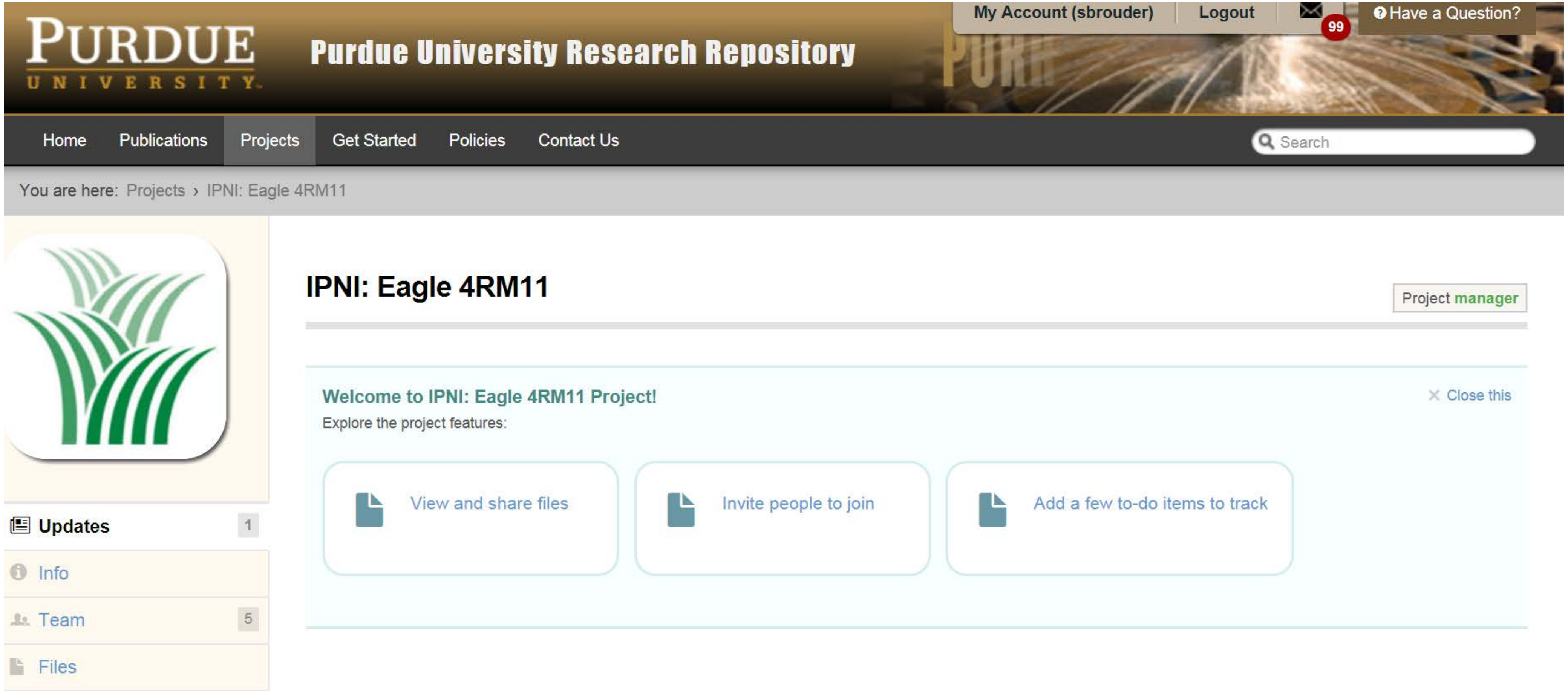
Sandi L Caldrone has added you to project "IPNI: Eagle 4RM11" in the role of a manager

Project:	IPNI: Eagle 4RM11(4rm11)
Created:	@ 2:59 pm on 01 Nov 2016
Owner:	Sandi L Caldrone
Link:	https://purr.purdue.edu/projects/4rm11

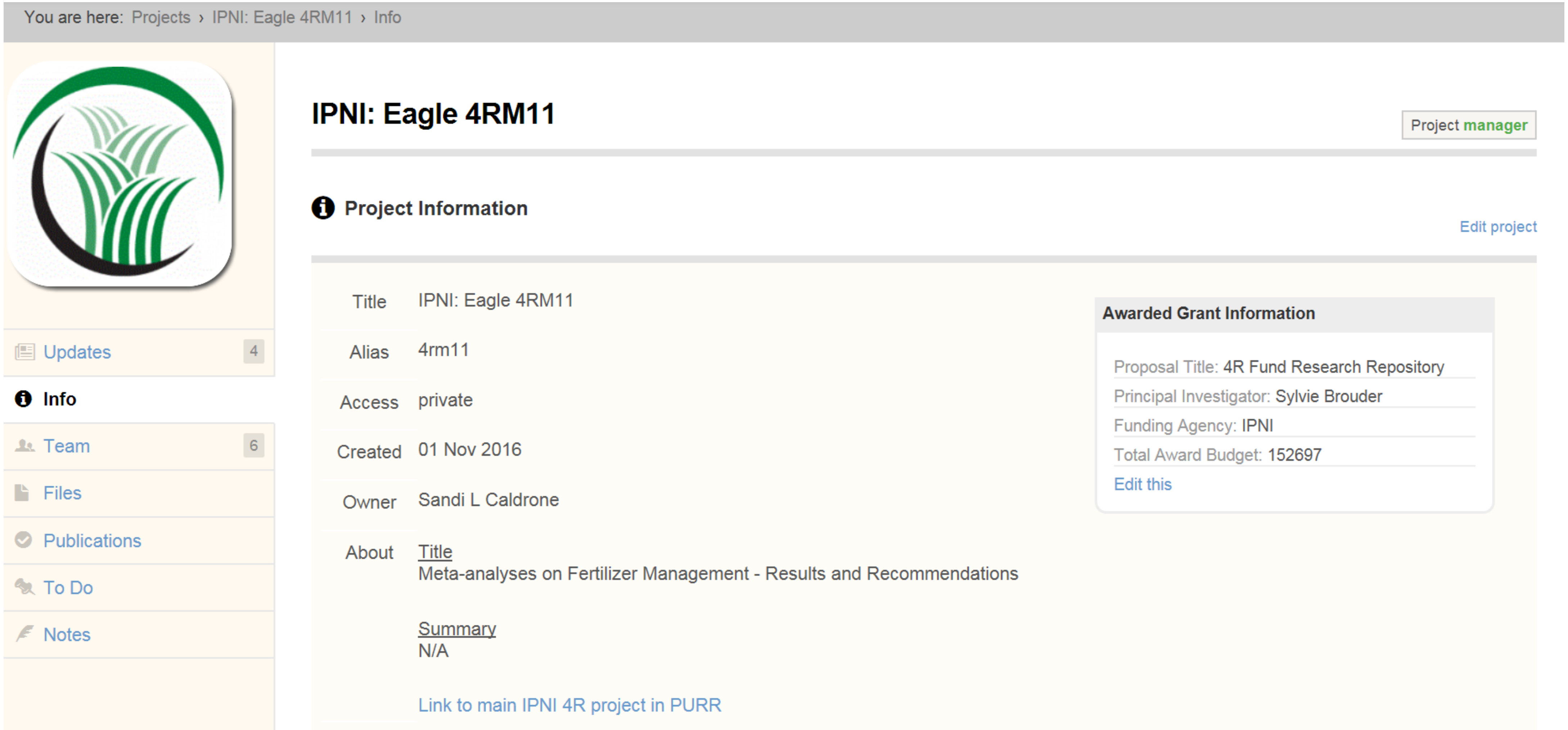
To access project, please follow link below:

https://purr.purdue.edu/projects/4rm11

Alison now not only has a PURR Account, she has a Project!



Some general info is already uploaded for you…



Alison has a project with a team…!

- Updates 1
- Info
- **Team** 5
- Files
- Publications
- To Do
- Notes

IPNI: Eagle 4RM11

Project **manager**

Team

Edit Team

Showing all **5** team member(s)

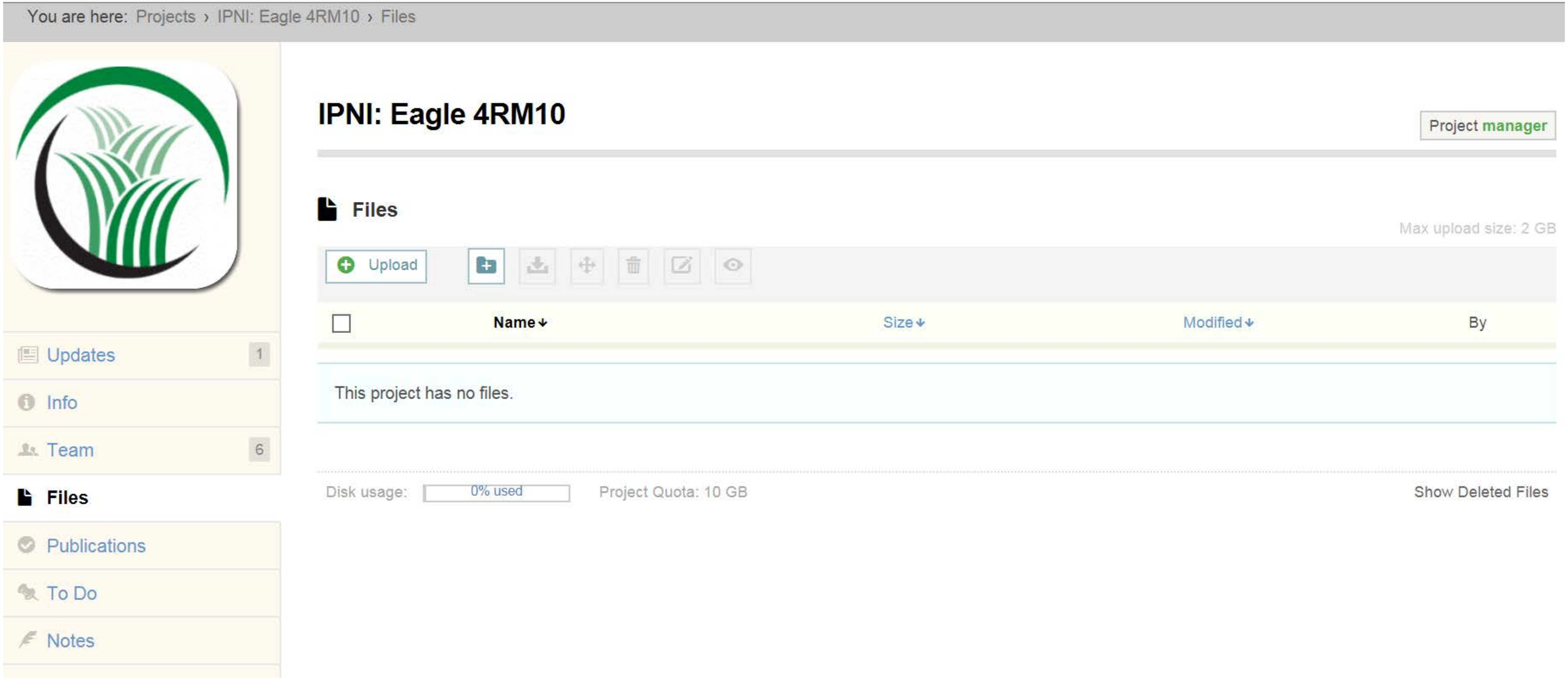
↓ Name ↓ Role ↓ Joined

Name	Role	Joined	Last visit
Jeffrey J. Volenec **jvolenec**	manager	Nov 02, 2016	**now online**
Sylvie M. Brouder **sbrouder**	manager	Nov 02, 2016	**now online**
Marianne Stowell Bracke **mbracke**	manager	Nov 02, 2016	Never
Nayereh Ghazanfarpour **nghazanf**	manager	Nov 02, 2016	Never
Sandi L Caldrone **scaldron**	**Owner**/manager	Nov 01, 2016	13 hrs ago

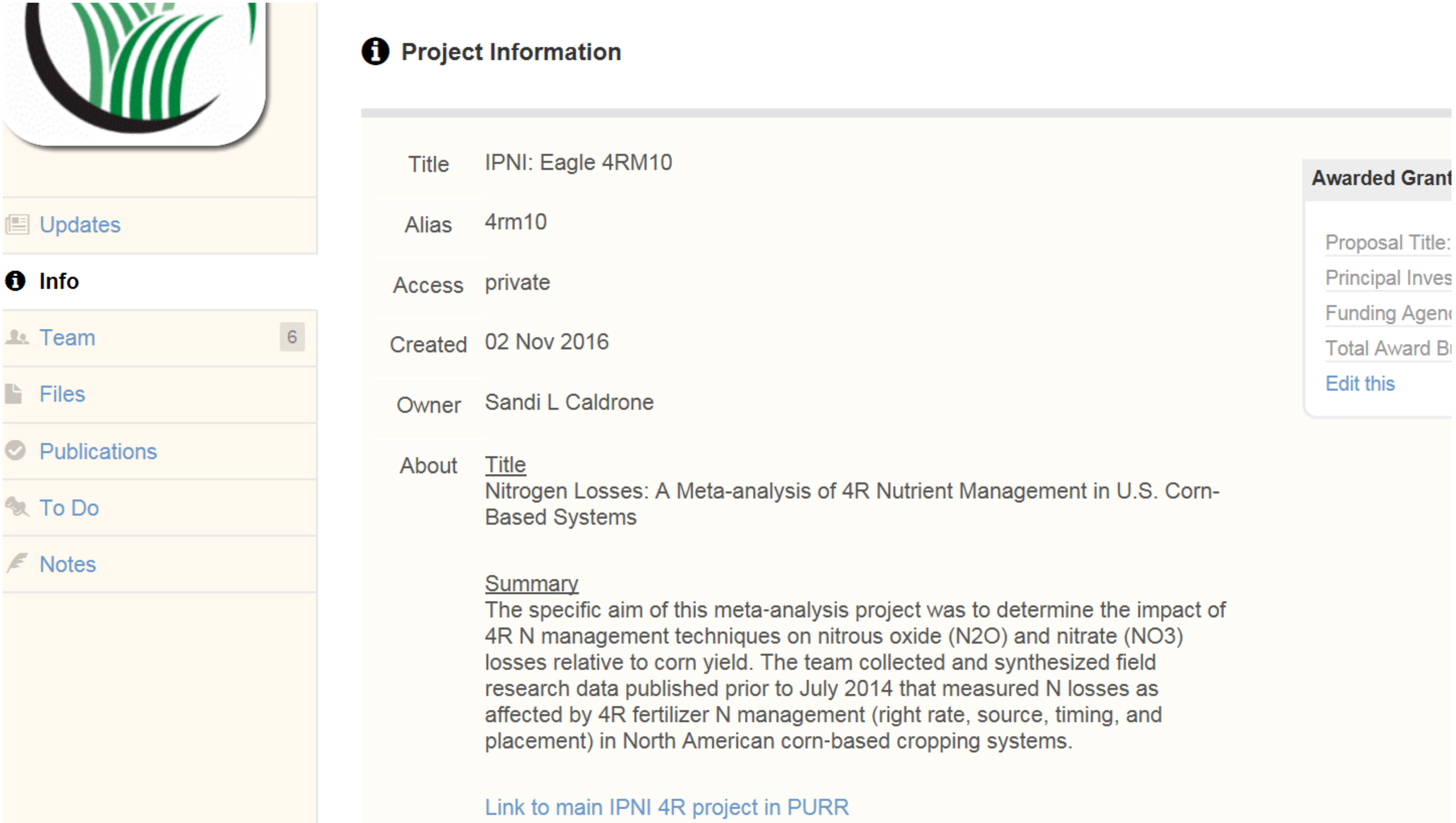
Start 1 End

Display # 20 Results 1 - 5 of 5

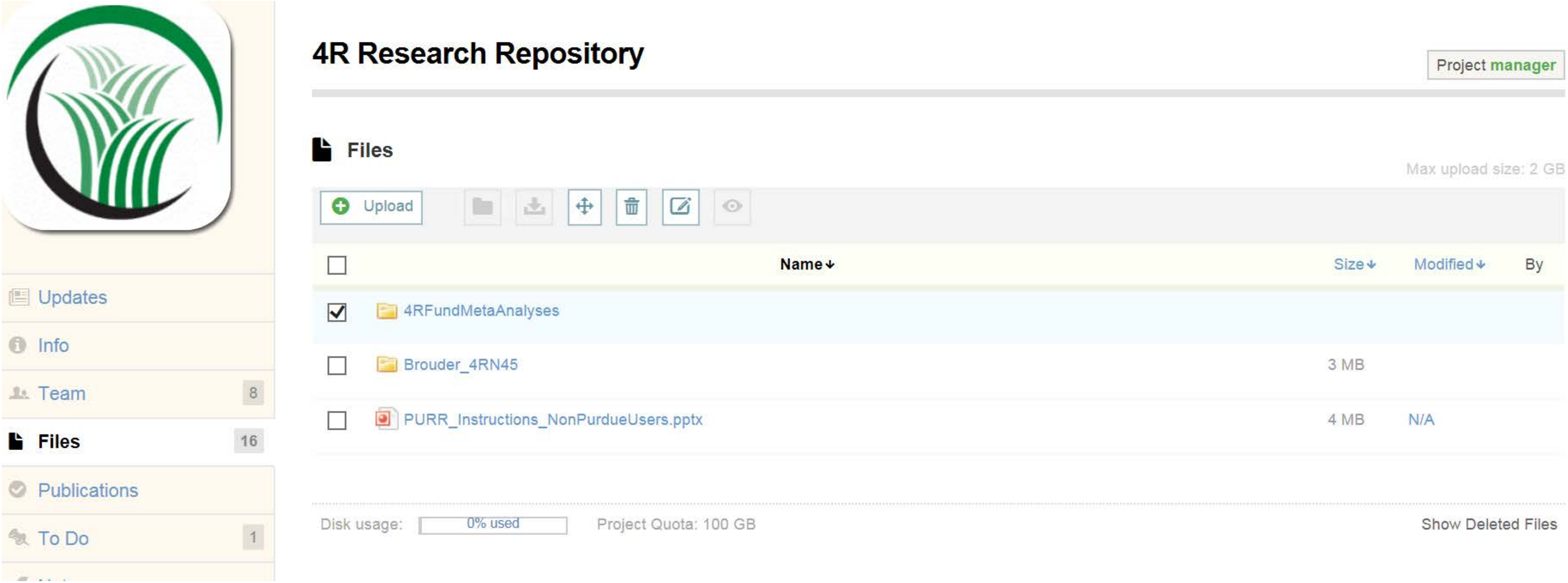
Alison has no files as of yet…

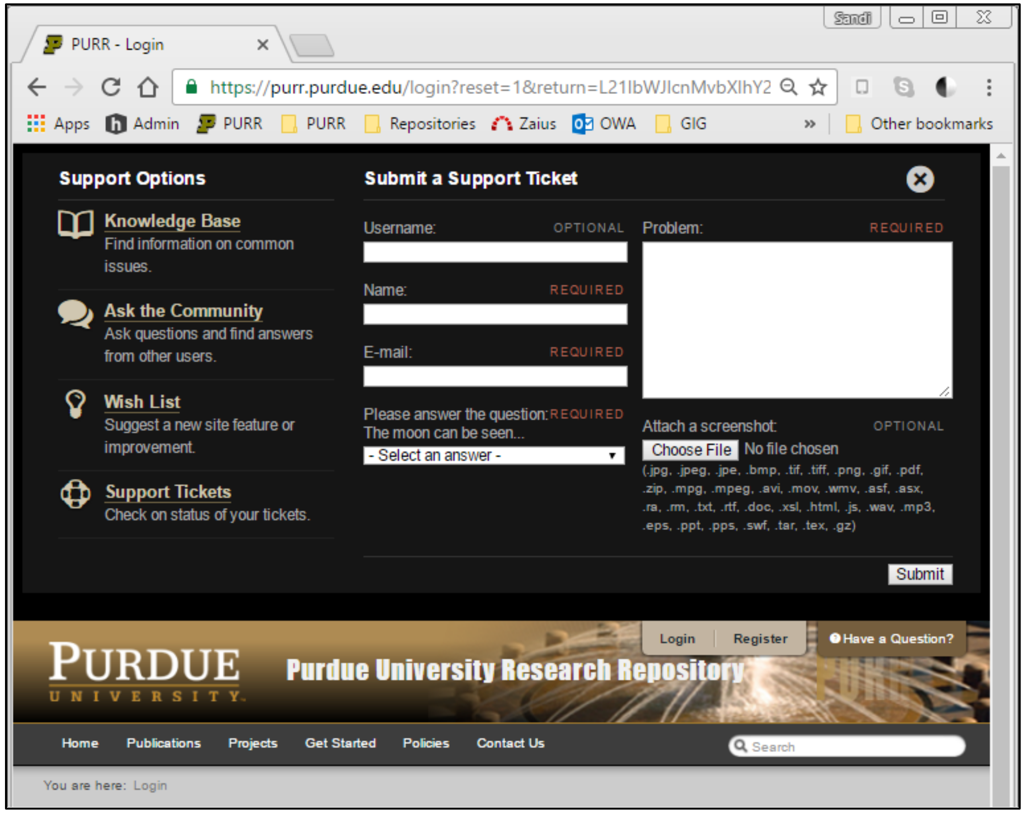


All 4R PIs have access to our repository project



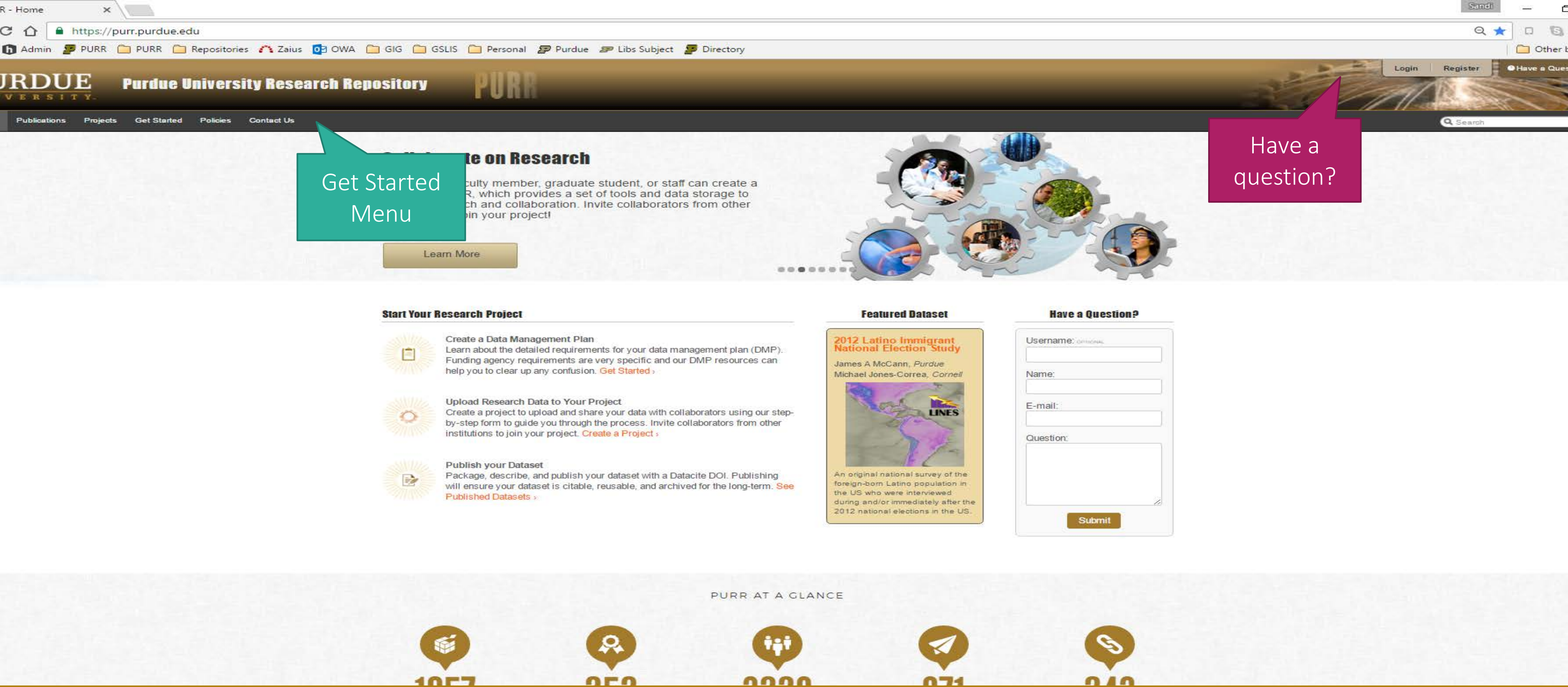
Our content is accessible to you but you will not be able to delete our stuff (at least without us knowing who you are and what you did) or invite people to our project…





Help!

Where to go for resources and tech support



Where to go for help

Check out the Get Started section for helpful resources, or click ‘Have a Question?’ to submit a support request.

Get Started Resources

Under Get Started we have extensive resources for data planning and grant writing, including text you are absolutely welcome to copy and paste into your grant proposals.

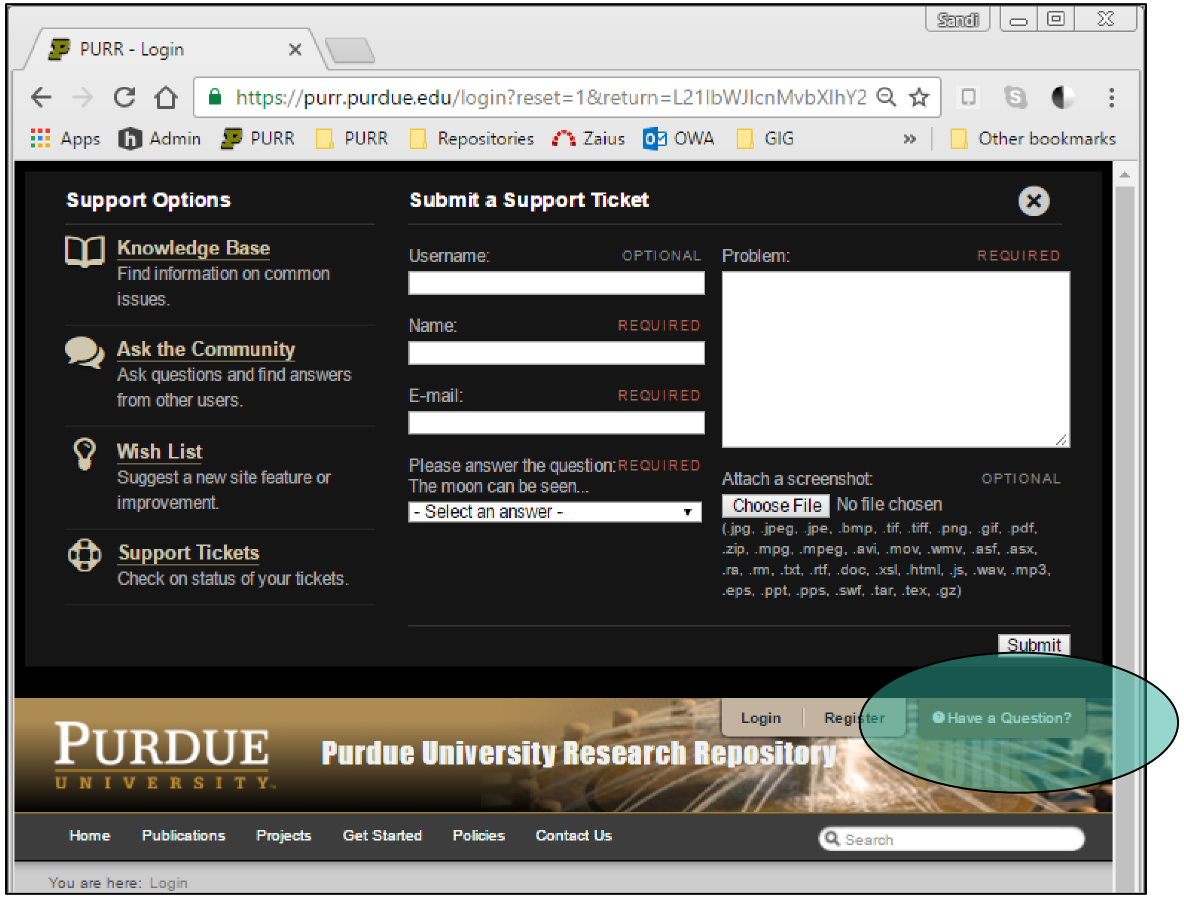
PURR Knowledge Base is similar to a Frequently Asked Questions list. We have lots of really quick bites of info PURR users might need.

4R-RR User's Manual

Minimum Datasets and Glossary Guide

Slide deck for step-by-step getting started

Tech Support



Click 'Have a Question?' in the top right to reveal the support ticket screen.
A member of the PURR team will respond to you as quickly as possible.

How safe is your stuff… LOCKSS

You are here: Knowledge Base › About PURR › How often is my data backed up?

Knowledge Base

How often is my data backed up?

While your project is active, all of your information is backed up daily, weekly and monthly by Hubzero, the platform supporting PURR. Daily backups are kept for 30 days. Weekly backups are kept for 12 weeks, and monthly backups are kept for 12 months.

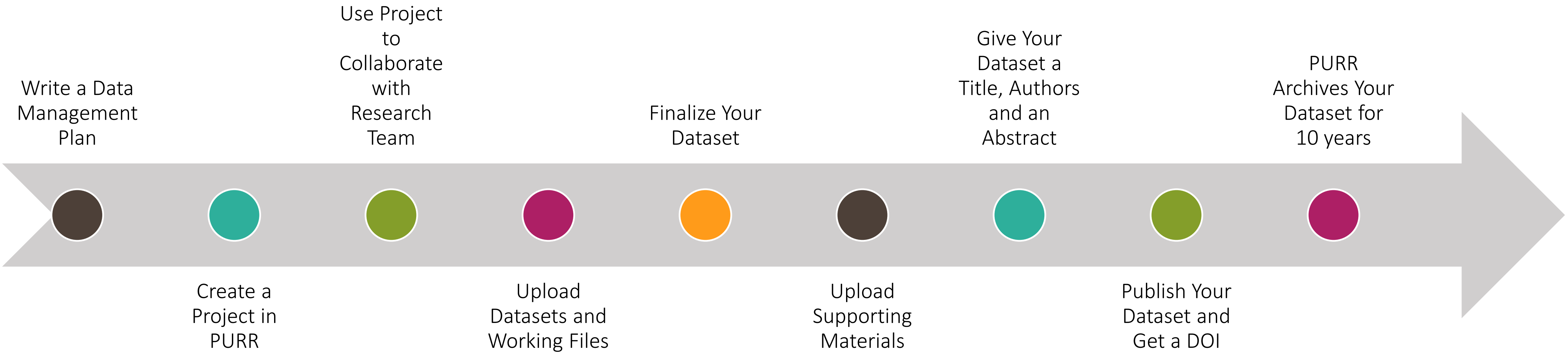
Once you publish a dataset on PURR, that publication gets backed up additionally. After a 30-da u can make any necessary minor adjustments to your publication, your published dataset will be a Library according to LOCKSS (Lots of Copies Keep Stuff Safe) standards and using the MetaAr our published dataset will be stored on geographically distributed servers for added security. All cop MetaArchive for quality control.

If you are concerned about your data security or have questions about accessing a backup copy PURR support team.

Per PURR Policy: You cannot post sensitive data unless you have removed identifiers…

Final Important Point: The PURR Process

plan – collaborate – publish – archive



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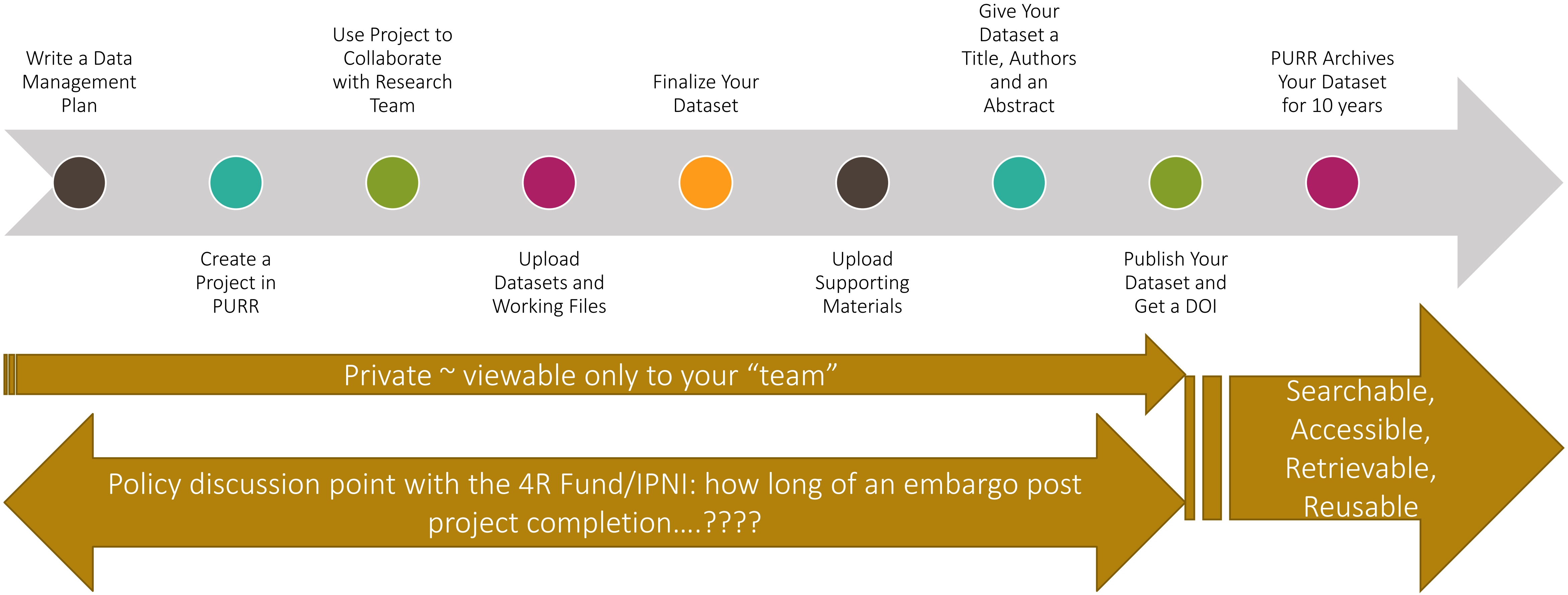
Final Important Point: You are not accessible to others until you “publish”



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dal.ca

Can the use of in-season foliar urea increase the efficiency of N use and reduce nitrous oxide emissions and nitrate leaching in potato production in Atlantic Canada?

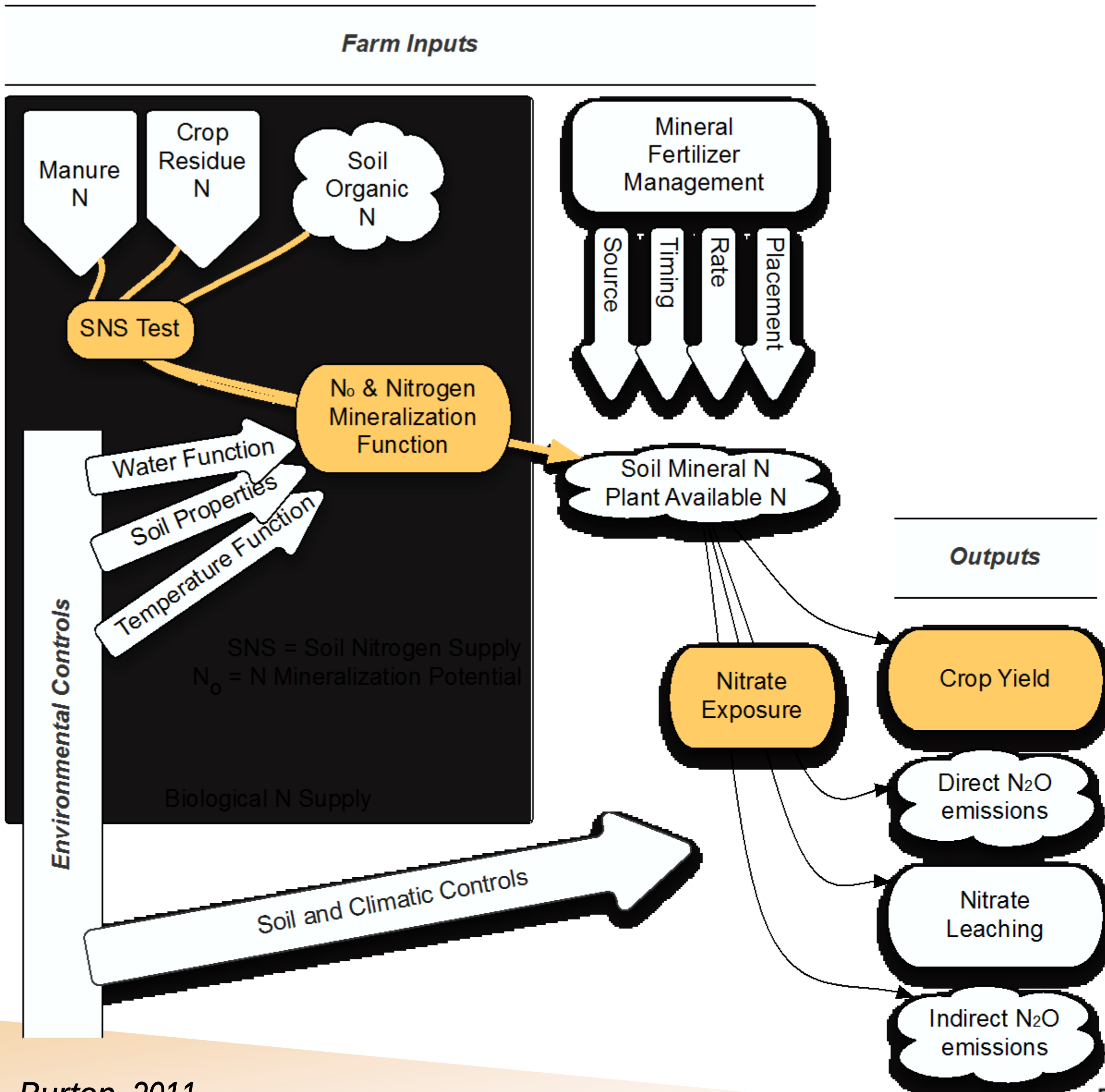
David L. Burton[1] and Judith Nyiraneza [2],

[1]Department of Environmental Science
[2]Agriculture and Agri-Food Canada

Background

- Potato producers in PEI are adding foliar urea with fungicide applications
  - Believed to “sustain” the crop during dry periods
- The N fertility program at planting is often not adjusted to reflect this additional N
  - The benefits to crop yield or potential for environmental impact have not been documented
- May be an opportunity to reduce N application at planting in systems where foliar urea is to be applied
  - Improved synchrony between plant N demand and N supply

Developing a predictive tool for soil nitrogen in Atlantic Canada



Burton, 2011

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Objectives

- To evaluate whether in-season foliar urea (Right Product, Right Time, Right Place) in combination with reduced N fertilizer rates (Right Rate) at planting is an effective BMP for sustaining potato yields and reducing nitrous oxide (N_2O) emissions and nitrate (NO_3^-) leaching.
- To evaluate the use of nitrate exposure (NE) and anion exchange membranes (IEMs) for assessing the potential for N loss
- To demonstrate the value of split N applications and/or timed release nitrogen products in decreasing N_2O emissions.
- To disseminate findings to producers

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Treatments

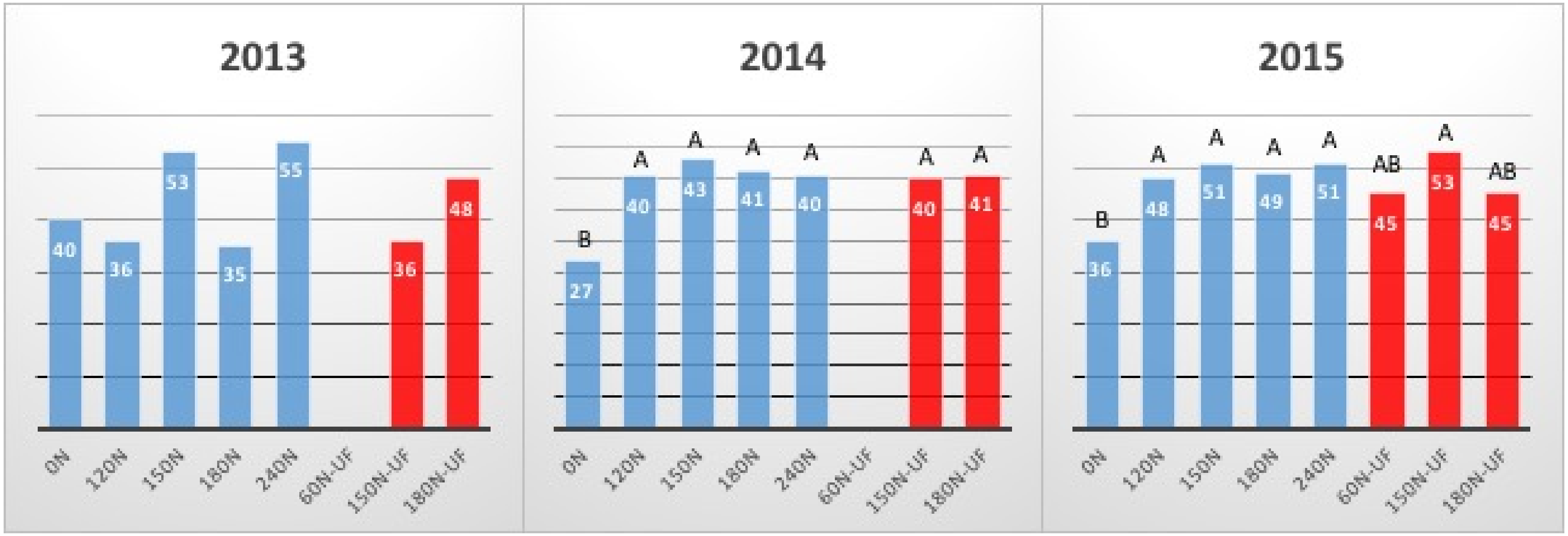
The existing AAFC study contains the following treatments:

1. *No nitrogen (control)*
2. *120 kg N/ha applied (2/3 recommended rate)*
3. *150 kg N/ha applied (5/6 recommended rate)*
4. *180 kg N/ha applied (recommended rate)*
5. *240 kg N/ha applied (1/3 greater than recommended rate)*

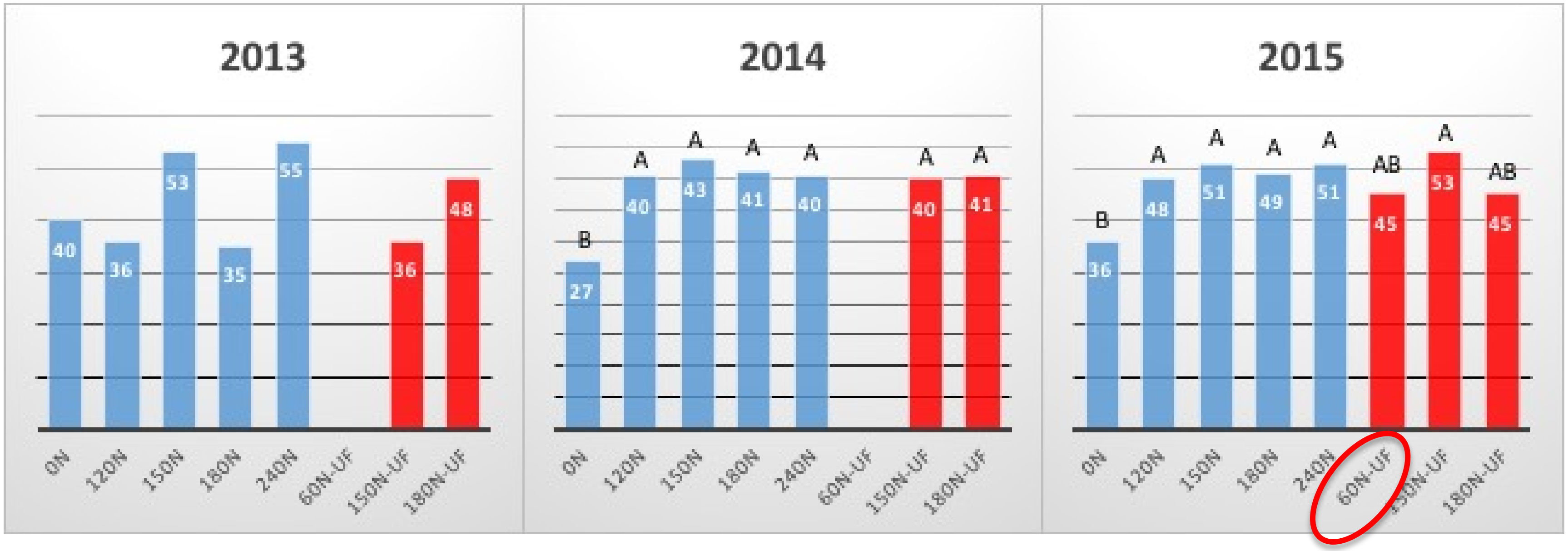
This project will add the following treatments:

1. 180 kg N/ha applied as granular fertilizer at planting and an additional 30 kg N/ha applied as foliar urea in 6 applications (5 kg N/ha each)
2. 150 kg N/ha applied as granular fertilizer at planting and an additional 30 kg N/ha applied as foliar urea in 6 applications (5 kg N/ha each)
3. (in 2015) 60 kg N/ha applied as granular fertilizer at planting and an additional 30 kg N/ha applied as foliar urea in 6 applications (5 kg N/ha each)

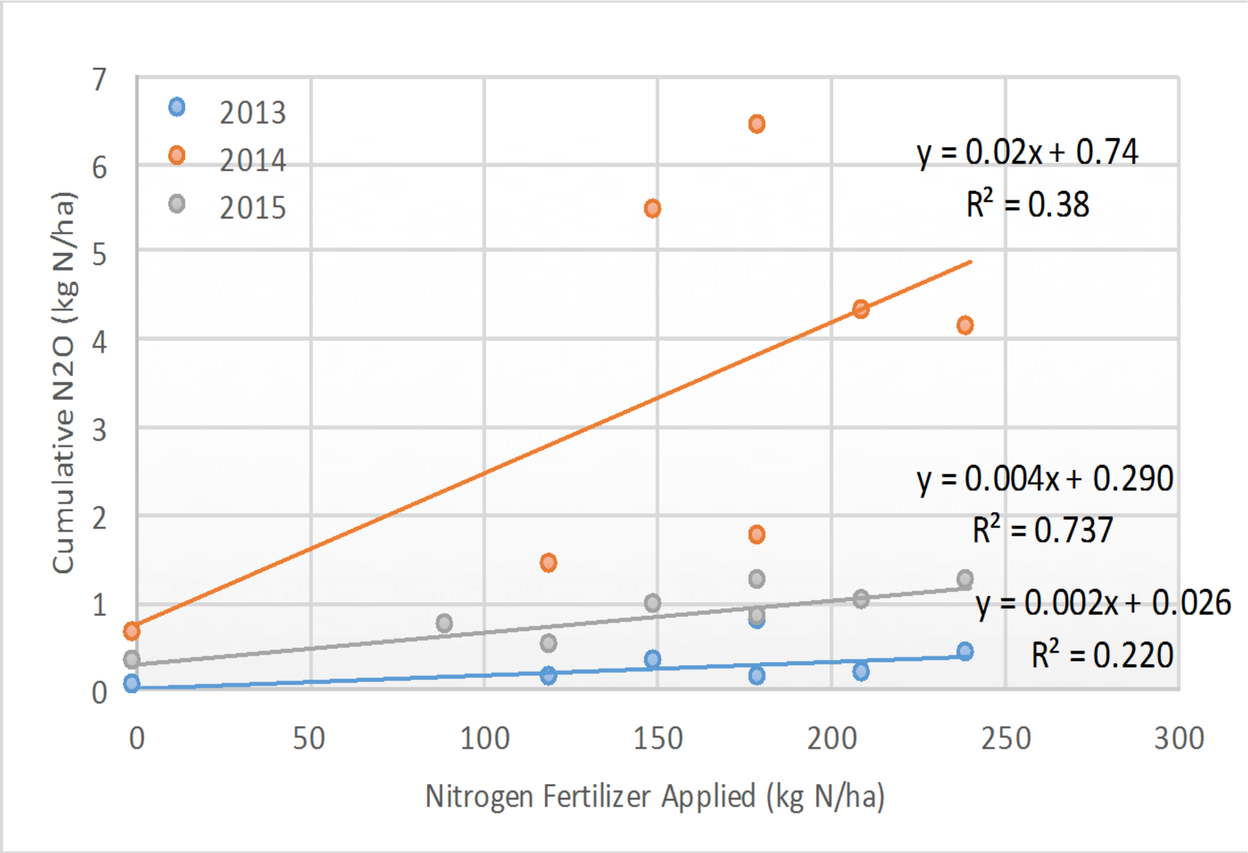
Potato Yield



Potato Yield



Annual variation in N_2O emissions vs. N rate



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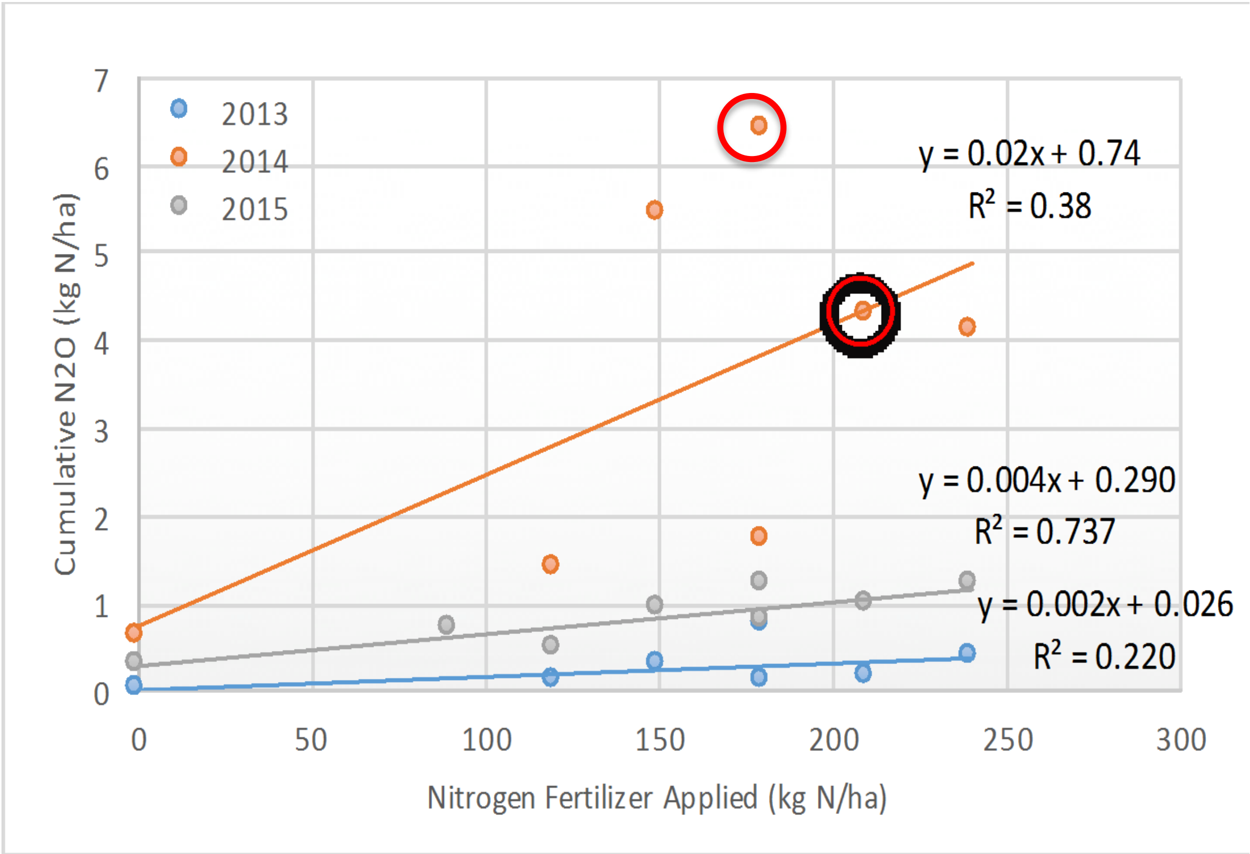
Annual variation in N_2O emissions vs. N rate



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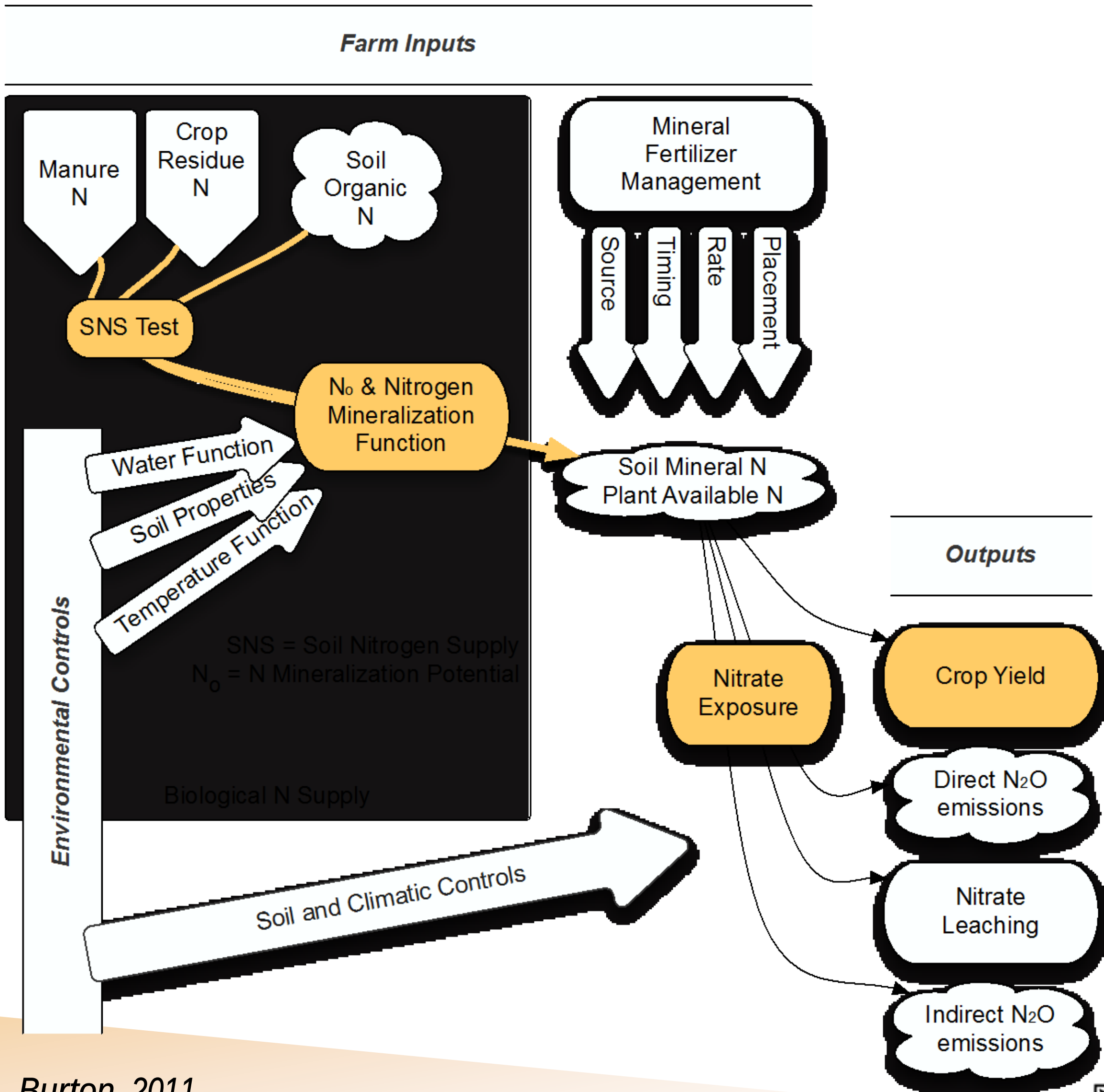
Developing a predictive tool for soil nitrogen in Atlantic Canada



Burton, 2011

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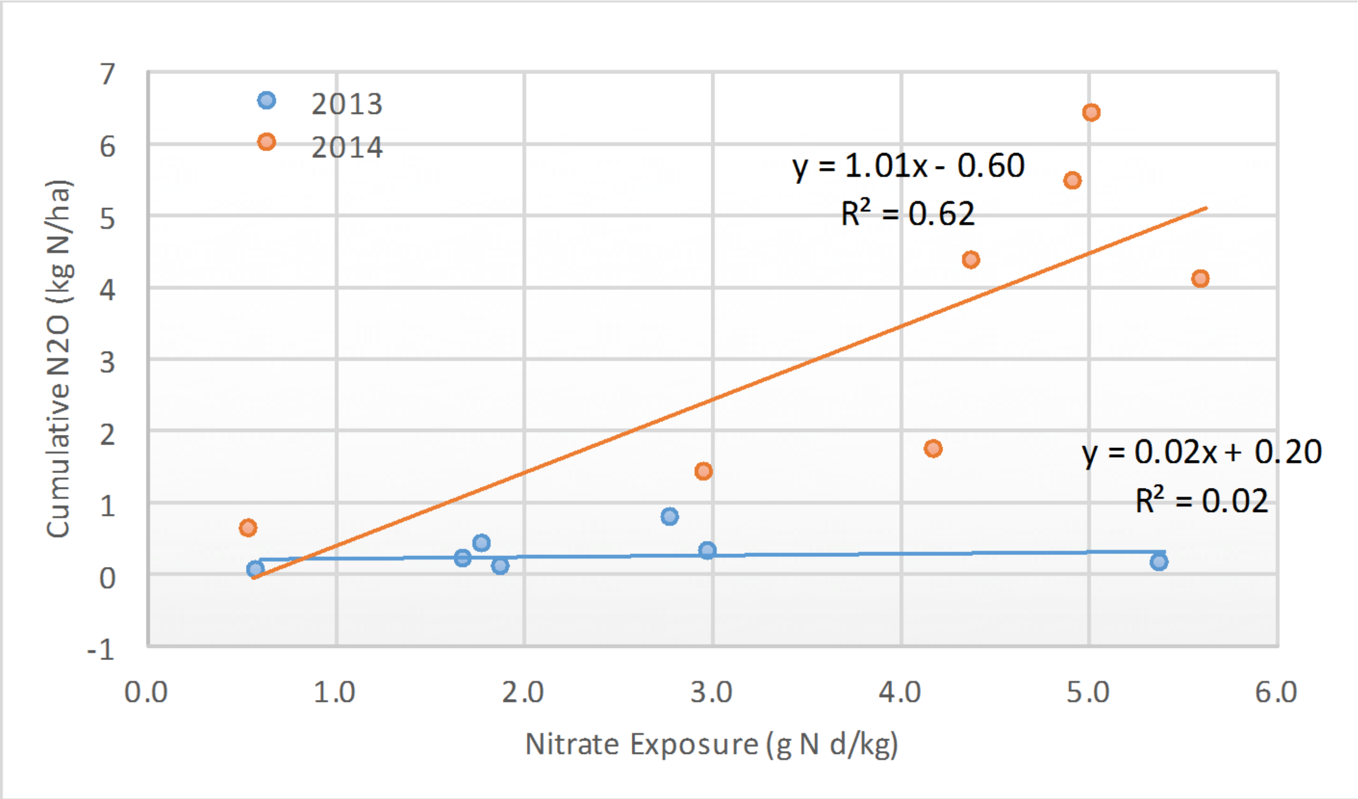
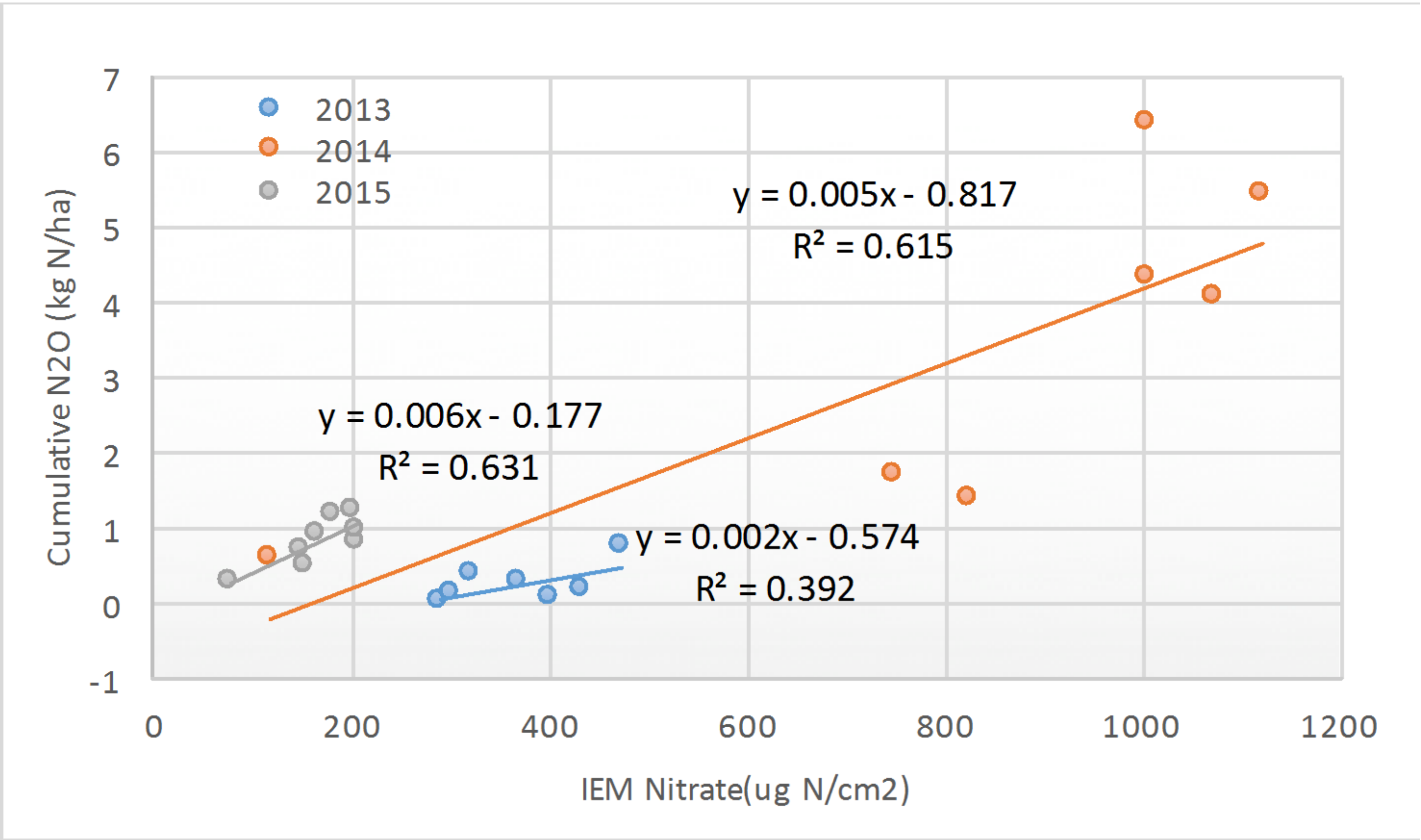
N_2O emissions vs. Nitrate Exposure



N_2O Emissions vs. IEM NO_3^-



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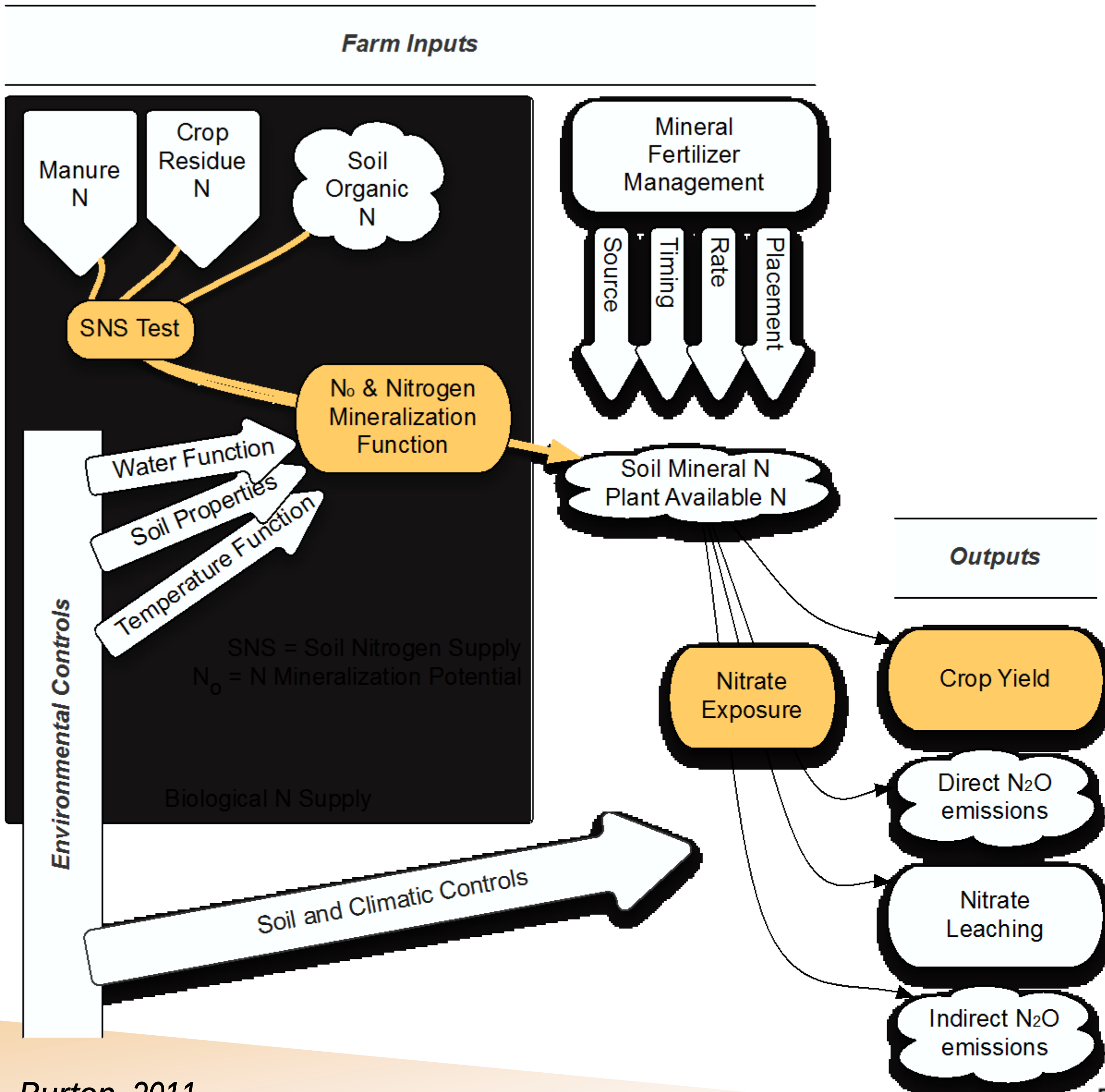
Developing a predictive tool for soil nitrogen in Atlantic Canada



Burton, 2011

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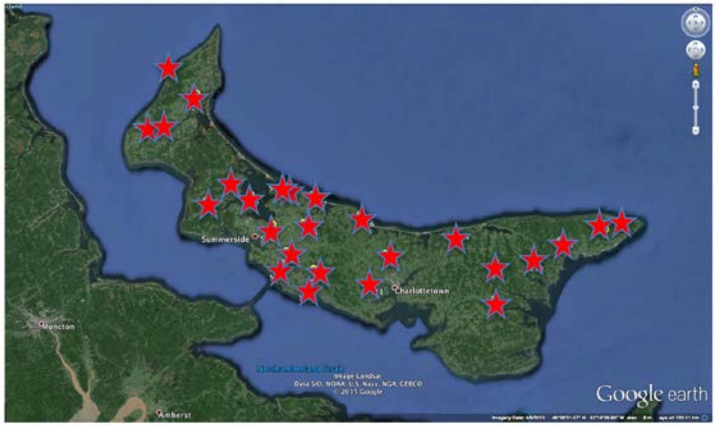
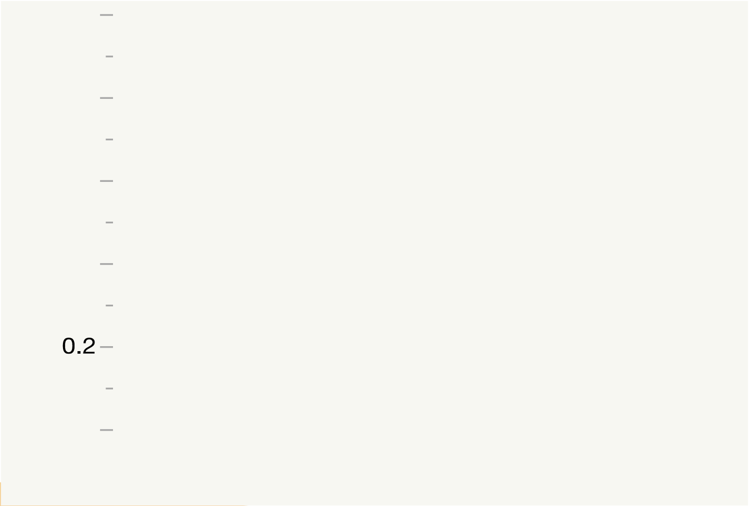
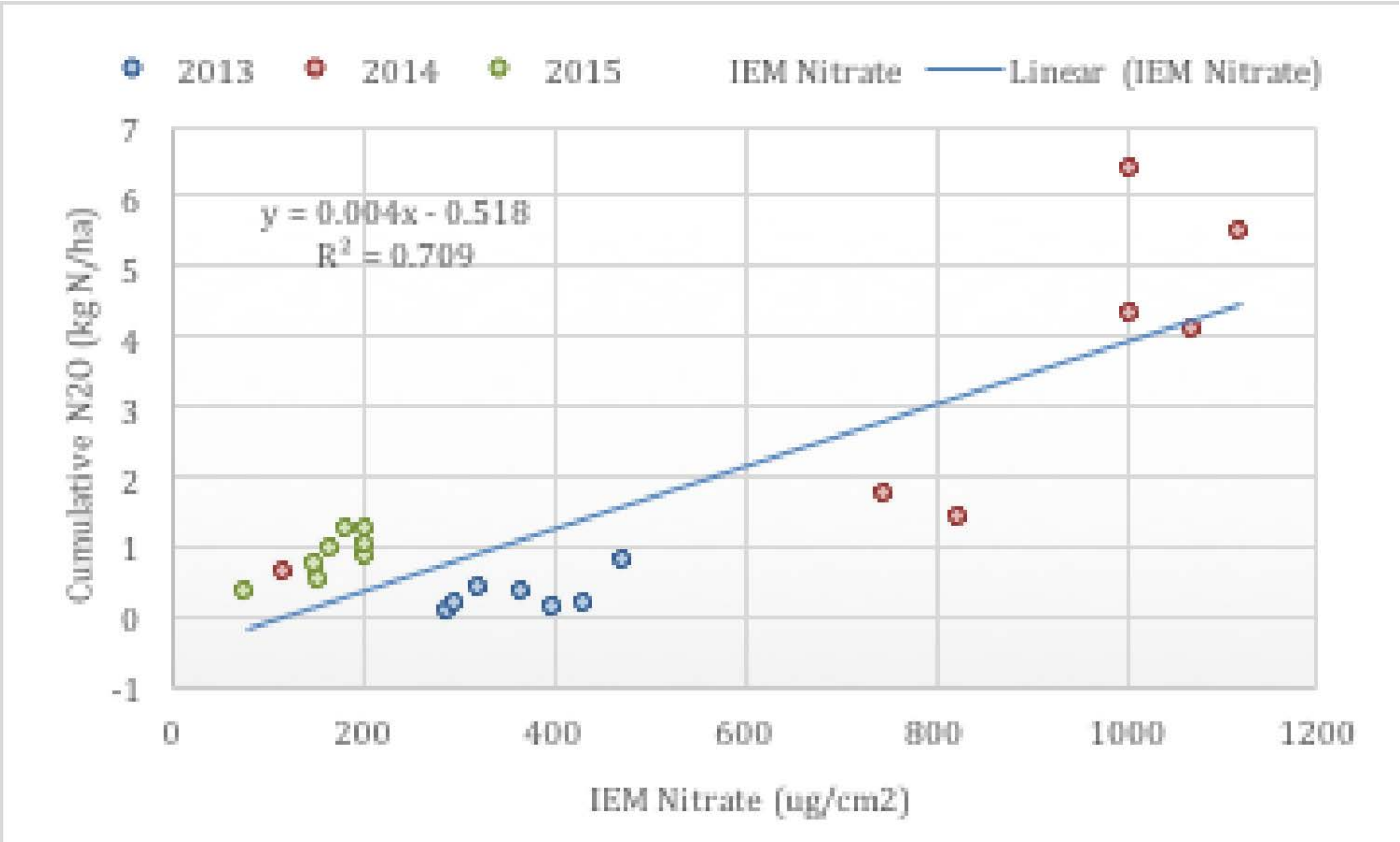
Survey of Soil Nitrogen Supply





- Conducted a survey of 26 potato rotations in PEI
- Range of values from 1.1 to 32 mg N/kg soil
- This site exceeds this range
  - 2013 – 27 mg N/kg soil
  - 2014 – 154 mg N/kg soil
  - 2015 – 36 mg N/kg soil

N_2O Emissions vs. IEM NO_3^- (all years)



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Producer fields

- Working with 4R Island CFI Project (Steve Watts)
- Examining split N applications on 4 producer fields
  - Involve various splits of N and the use of ESN
  - 1/3 preplant (urea/ESN)
  - 1/3 at planting (DAP)
  - 1/3 post planting (AN or foliar urea)
- Measuring GHG emissions using chambers
- Measuring NE using IEMs

Did 4R practices reduce N_2O emissions in producer fields?

Site	GSP	4R
	Cumulative N_2O Emissions ($kg\ N\ ha^{-1}$)	
R1*	1.6 b	4.5 a
R2	3.1 ab	2.0 b
R3	2.1 b	3.6 ab
R4	1.2 b	2.3 ab
R5*	1.8 b	3.4 ab
Mean	2.0 B	3.2 A

* sites where foliar N applications were included in the 4R program

Conclusions

- Little yield response to N applications greater than 120 kg N ha^{-1}
  - Need to reassess N rates? Or is this simply a very fertile site?
  - Can the SNS detect this?
- No significant effect of N rate on N_2O emissions above 120 kg N ha^{-1}
- Foliar urea appears to increase N_2O emissions
  - Lower rates resulted in comparable yield, but also comparable N_2O
- NE and IEM NO_3^- are correlated with cumulative N_2O emissions
  - High year-to-year variation in N_2O emissions… explained in part by IEM NO_3^-
- 4R programs in producer fields did not result in reduced N_2O emissions

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This research has been supported by...

FERTILIZER CANADA

Prince Edward Island
CANADA

Prince Edward Island
PEI
POTATOES

NSERC
CRSNG

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

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A Matter of Timing and Source: Enhanced Efficiency Nitrogen Fertilizers and Products to Reduce Nitrous Oxide Emissions in the Prairie Provinces

Mario Tenuta and many others
Department of Soil Science

Presentation to Canadian 4R Research Network Meeting
November 6, 2016 – Phoenix, AR

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EXPLORER INNOVATOR PIONEER ADVENTURER VISIONARY TRAILBLAZER

Activity 5 General

- PI: Mario Tenuta (UMan)
- Project Manager: Dr. Kevin Baron (UMan)
- Graduate Student: Matthew Wood (Uman)
- Collaborators: Richard Farrell (USask), Guillermo Hernandez-Ramirez (UofA), PAMI
- Funders: FC, AAFC, CCEMC, ACIDF, WGRF, Agrium, Koch, Dow, BASF
- Duration: October 2014 to September 2018

Activity 5 Objectives

- Fall vs spring application of urea granular fertilizer to spring wheat nitrogen use efficiency, yield and N_2O emissions.

- Stacking of newly available enhanced efficiency products to improve the performance of fall added urea granular fertilizers and reduce N_2O emissions during spring thaw.

- Determine fall and spring application of anhydrous ammonia effect on nitrogen use efficiency and spring wheat yield, and N_2O emissions.

- Can newly available enhanced efficiency additives to anhydrous ammonia increase the performance of fall-applied anhydrous ammonia?

- Determine if enhanced efficiency products and additives prevent spring thaw N_2O emissions of fall applied urea and anhydrous ammonia.

Activity 5 Approach

- Replicated plot design
- Static vented chambers for N_2O emissions
- Dosimeter tubes for qualitative NH_3 emissions
- Spring wheat
- Agronomic measures

Granular Urea

Treatment	Product	Application Timing Fall	Spring
1	urea	x	
2	SuperU™	x	
3	ESN	x	
4	urea + eNtrench	x	
5	urea + LIMUS®	x	
6	urea		x
7	SuperU™		x
8	ESN		x
9	urea + eNtrench		x
10	urea + LIMUS®		x
11	Check (0N)		

Anhydrous Ammonia (NH_3)

Treatment	Product	Application Timing Fall	Spring
12	NH_3	x	
13	NH_3 + N-Serve	x	
14	NH_3		x
15	NH_3 + N-Serve		x

Activity 5 Locations

- Manitoba
  - 2015: 2 sites
  - 2016 and 2017: 2 sites
- Saskatchewan
  - 2016 and 2017: 2 sites
- Alberta
  - 2016 and 2017: 1 site (plus two smaller network sites)

Activity 5 Under Takings

- First and second crop years with 2 sites completed in Manitoba (2015, 2016)
- Conducted grower tour at one site in Manitoba (2015, 2016)
- Many industry tours at Manitoba sites (2015, 2016)
- First crop year in Saskatchewan and Alberta completed (2015)
- First crop year in Alberta begun (Oct 15-Sept 16)
- Manitoba third crop year with 2 site just initiated (2017)
- Saskatchewan and Alberta second crop year just initiated (2017)


R-Tech
AMMONIA


(A) Testing and calibration of new anhydrous ammonia application equipment manufactured in the fall of 2014 in Manitoba (B) Seeding and fertilizer operations at Warren, MB in spring 2015. (C) Final seeding operations and placement of chambers at Warren, MB. (D) Final harvest operations with Wintersteiger plot combine at Warren in the fall of 2015.

Matthew Wood
Graduate Student

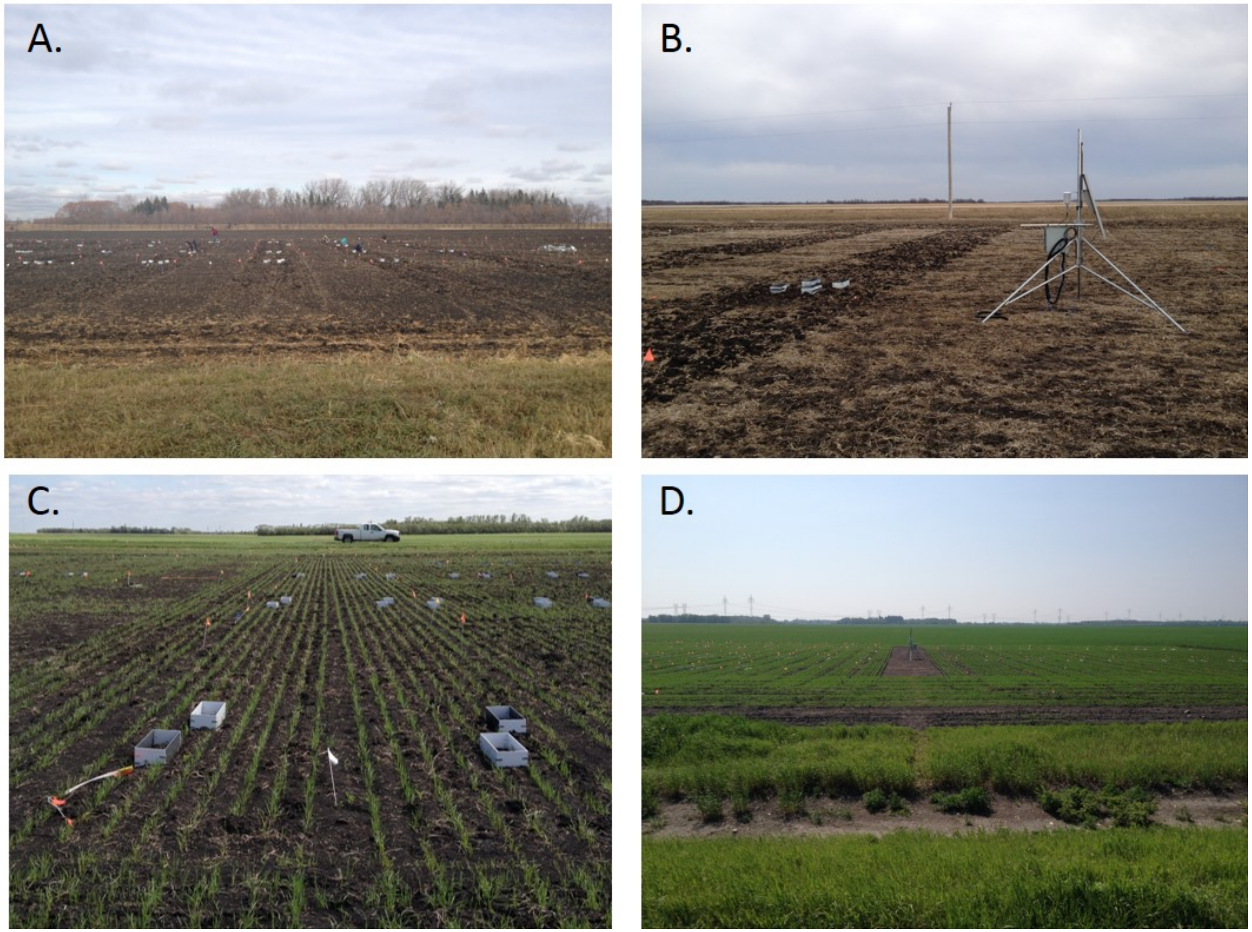


Figure 1. (A) Chamber installation following fall fertilizer application at Ste. Agathe in the fall of 2014. (B) Weather station and static-vented chambers for monitoring greenhouse gases at Warren location in spring 2015 before seeding wheat and applying fertilizer in one-pass operations. (C) Emergence of spring wheat and chamber orientation at Ste. Agathe late May 2015 after seeding and spring fertilizer application. (D) Emergence of spring wheat bordering the weather station (centre) at Warren location in late May 2015.

EXPL

Figure 2. (A) At Ste. Agathe in mid-summer (June) control plots of wheat receiving no fertilizer can be visually distinguished from adjacent plots receiving urea, NH_3 and enhanced efficiency fertilizer formulations. (B) At Warren, control plots can be identified amongst plots receiving NH_3 or NH_3 + N-Serve (C) Same wheat plots depicted in (A) demonstrate differences in canopy height and maturity preceding harvest operations – Ste. Agathe site (D) Similar differences in crop height and maturity observed at Warren site.



Table 1. Analysis of variance (ANOVA) and yield of wheat as influenced by nitrogen rate.

Analysis of Variance

Sources	df	Pr>F
Site	1	0.2201
Rate	3	<.0001
Site*Rate	3	0.1411

Wheat Yield (bu/ac)

Treatment	Average	SD	Grouping
0	28.2 ±	4.8	C
50% N Rate	50.7 ±	4.4	B
100% N Rate	57.5 ±	5.7	A
150% N Rate	62.3 ±	4.6	A

Table 2. Analysis of variance (ANOVA) and yield of wheat influenced by fall versus spring application of anhydrous ammonia and N-Serve.

Analysis of Variance

Sources	df	Pr>F
Site	1	0.0576
Product	1	0.4046
Timing	1	0.6384
Product*Timing	1	0.3325
Product*Site	1	0.5115
Site*Timing	1	0.0129
Product*Timing*Site	1	0.3762

Wheat Yield (bu/ac)

Treatment	Average	SD	Grouping
NH_3 Fall	58.4 ±	4.5	A
NH_3 Spring	56.7 ±	3.9	A
N-Serve Fall	58.2 ±	2.8	A
N-Serve Spring	58.8 ±	3.6	A

Table 3. Analysis of variance (ANOVA) and yield of wheat influenced by fall versus spring application of urea and granular enhanced efficiency fertilizer products.

Analysis of Variance

Sources	df	Pr>F
Site	1	0.7789
Product	4	0.5426
Timing	1	0.0005
Product*Timing	4	0.6528
Site*Product	4	0.0611
Site*Timing	1	0.2256
Site*Product*Timing	4	0.7113

Wheat Yield (bu/ac)

Treatment	Timing	Average	SD	Grouping
Urea	Fall	52.7 ±	3.2	A
ESN	Fall	54.4 ±	2.2	A
SuperU	Fall	54.6 ±	2.3	A
eNtrench	Fall	52.8 ±	4.1	A
LIMUS	Fall	55.0 ±	4.3	A
Urea	Spring	57.5 ±	5.7	A
ESN	Spring	56.5 ±	4.1	A
SuperU	Spring	55.9 ±	4.9	A
eNtrench	Spring	57.5 ±	6.4	A
LIMUS	Spring	59.6 ±	5.0	A

Wheat Yield (bu/ac)

Treatment	Average	SD	Grouping
Fall	53.9 ±	3.3	B
Spring	57.4 ±	5.2	A

NITROUS OXIDE (N_2O) EMISSIONS FROM WARREN, MB FIELD SITE IN 2014-2015

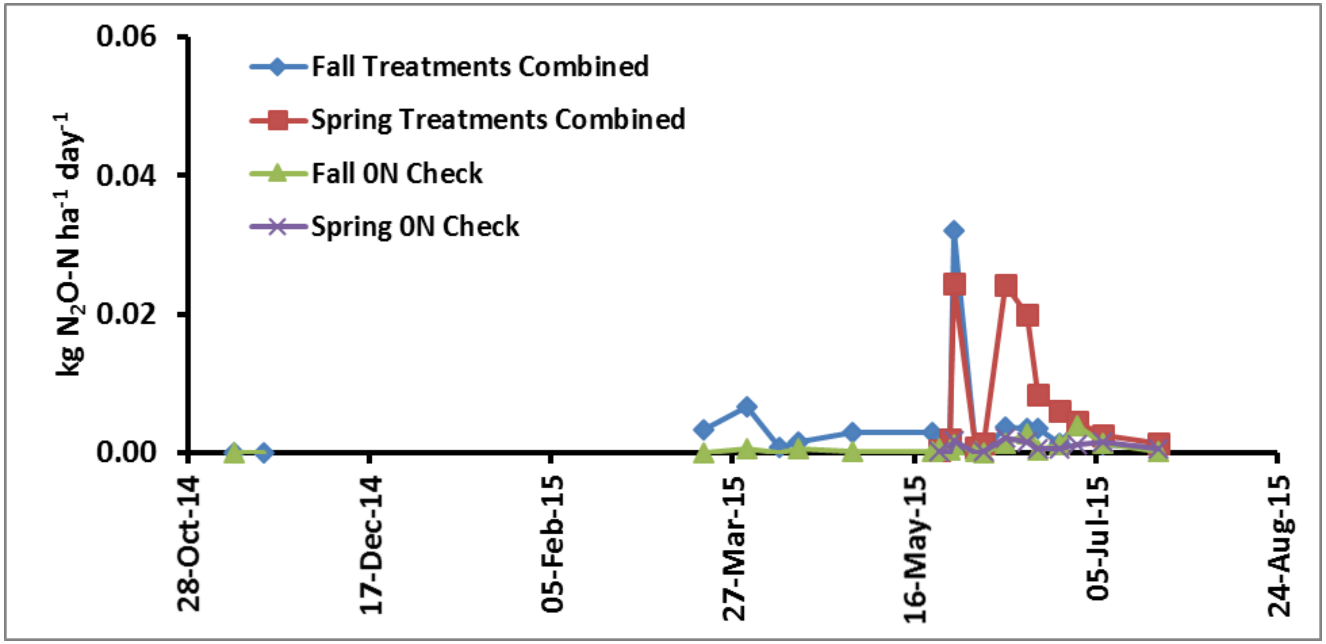


Figure 1. Daily emission of nitrous oxide (N_2O) from Warren field site over 2014-2015 growing season. Fall and spring treatments (combined) represent all urea, NH_3 and combinations of enhanced efficiency fertilizer products grouped by application timing (Fall vs Spring).

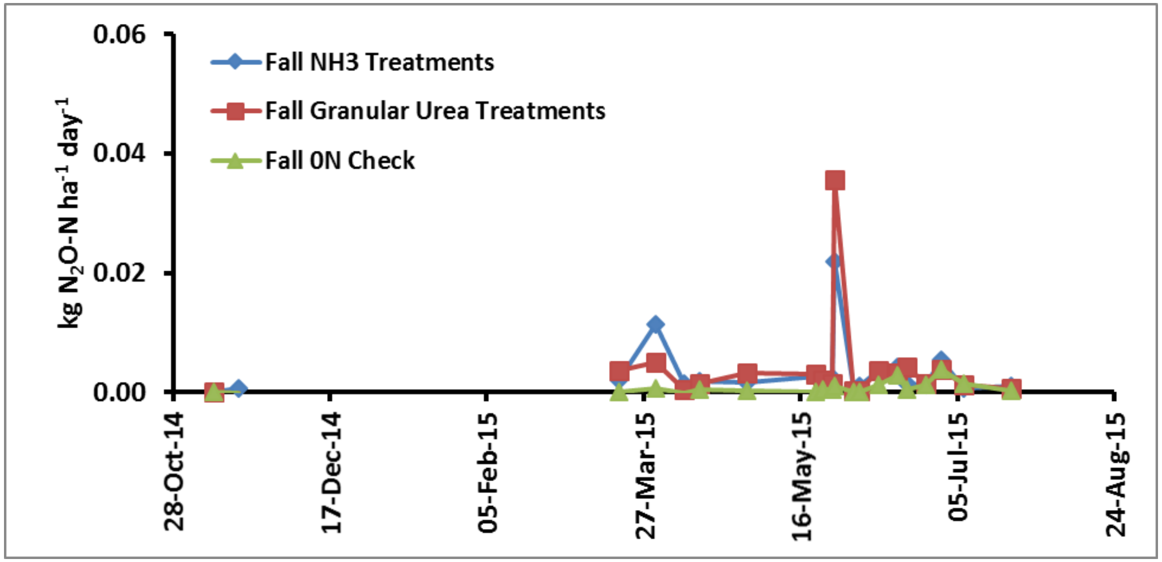


Figure 2. Daily emission of nitrous oxide (N_2O) from Warren field site over 2014-2015 season. Fall NH_3 and fall granular urea treatments (combined) represent combinations of 1) NH_3 & NH_3 + N-Serve or 2) urea, ESN, SuperU, eNtrench and LIMUS grouped for the fall application timing

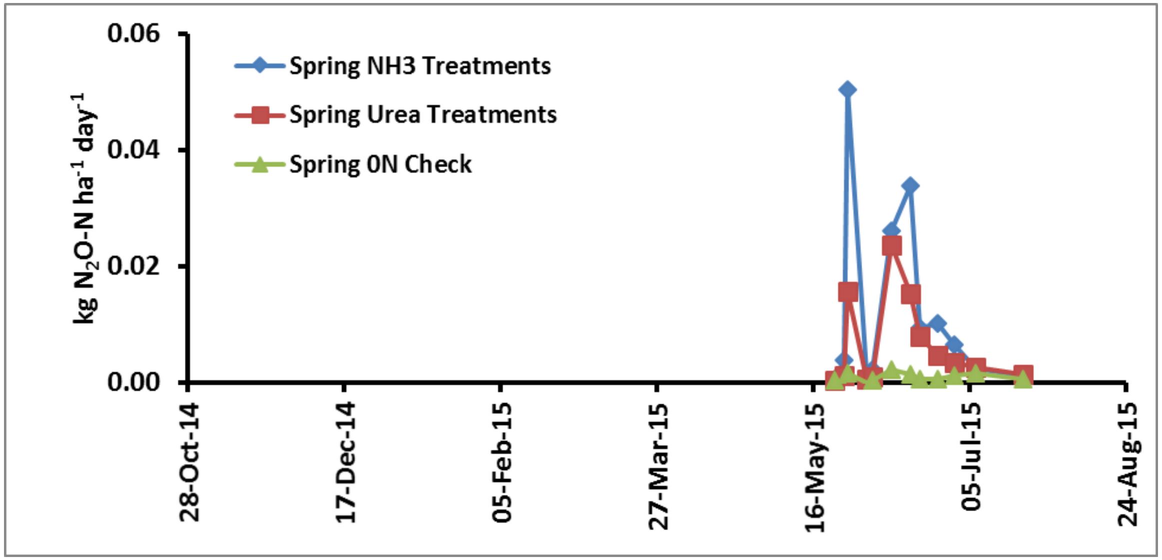


Figure 3. Daily emission of nitrous oxide (N_2O) from Warren field site over 2014-2015 season. Spring NH_3 or urea treatments encompass 1) NH_3 & NH_3 + N-Serve or 2) urea, ESN, SuperU, eNtrench and LIMUS grouped for the spring application timing.

NITROUS OXIDE EMISSIONS FROM STE.AGATHE, MB FIELD SITE IN 2014-2015

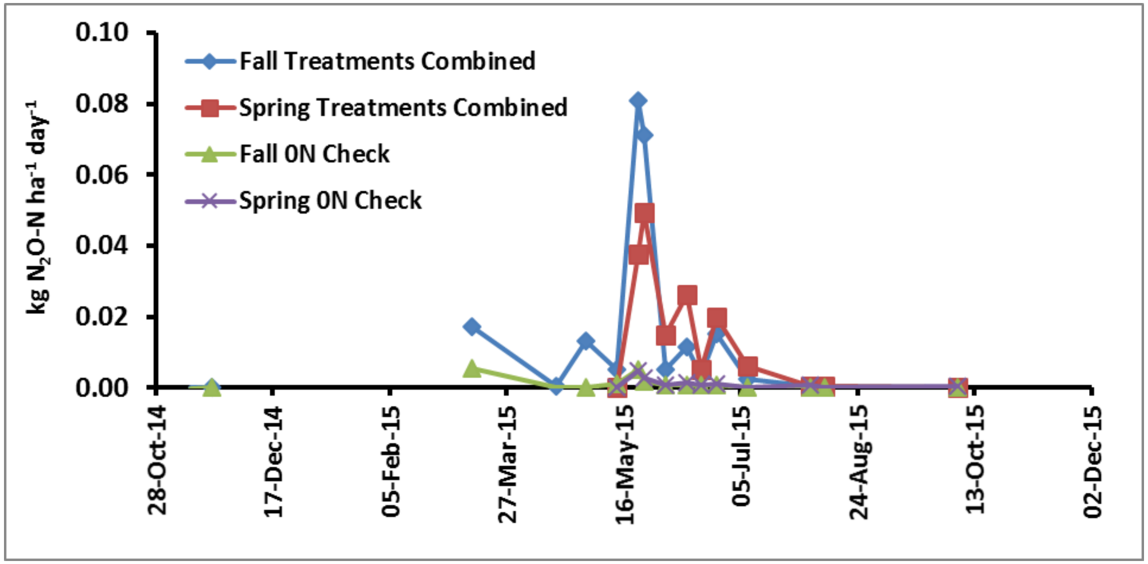


Figure 4. Daily emission of nitrous oxide (N_2O) from Ste. Agathe field site over 2014-2015 season. Fall and spring treatments (combined) represent all urea, NH_3 and combinations of enhanced efficiency fertilizer products grouped by application timing (Fall vs Spring).

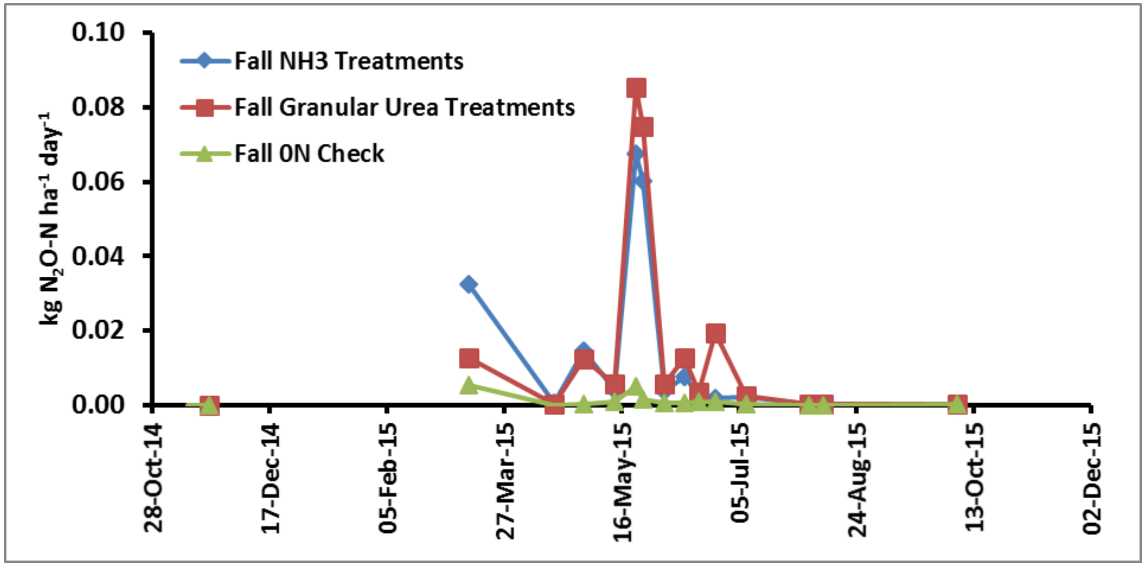


Figure 5. Daily emission of nitrous oxide (N_2O) from Ste. Agathe field site over 2014-2015 season. Fall NH_3 and granular urea treatments represent combinations of 1) NH_3 & NH_3 + N-Serve or 2) urea, ESN, SuperU, eNtrench and LIMUS grouped for the fall application timing.

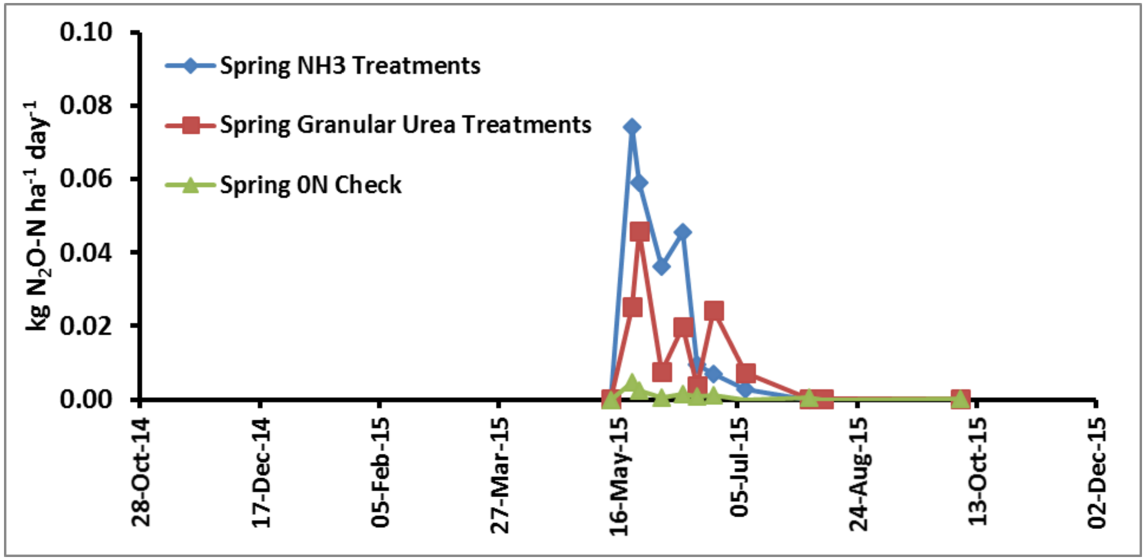
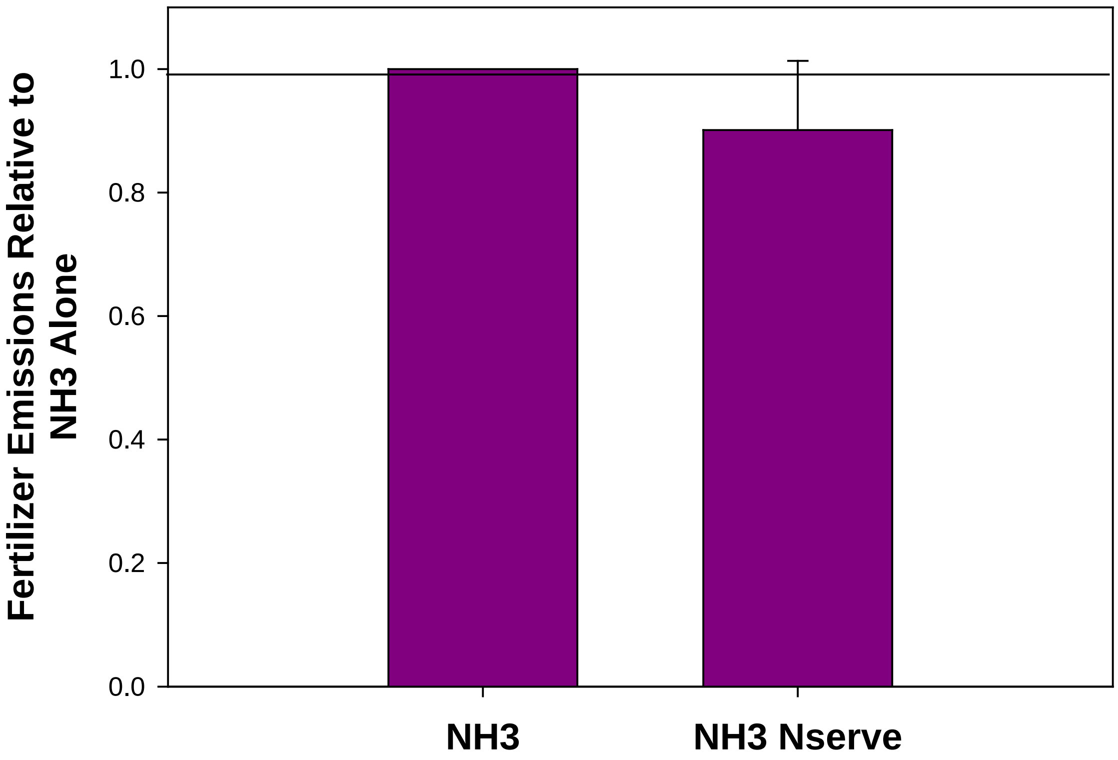


Figure 6. Daily emission of nitrous oxide (N_2O) from Ste. Agathe field site over 2014-2015 season. Spring NH_3 and granular treatments encompass combinations of 1) NH_3 & NH_3 + N-Serve or 2) urea, ESN, SuperU, eNtrench and LIMUS grouped for the spring application timing.

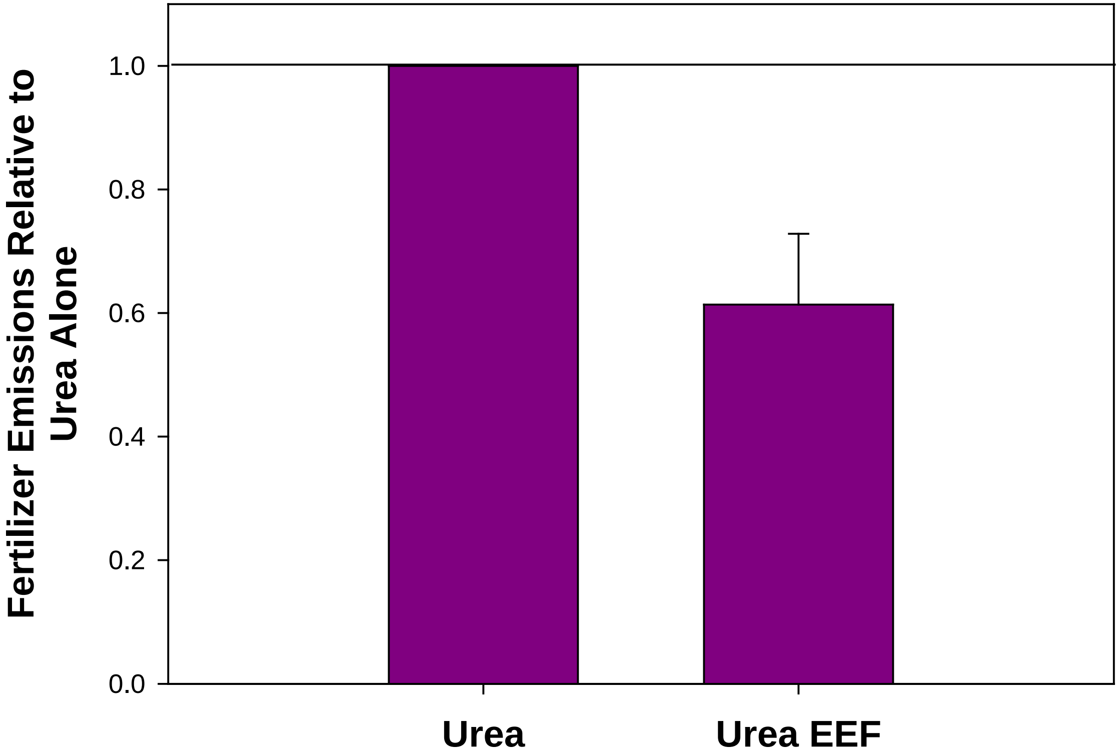
Anhydrous Ammonia and Nitrification Inhibitor (Nserve)



Nserve 10% decrease but variable

4 site years of data

Granular Urea and EEFs

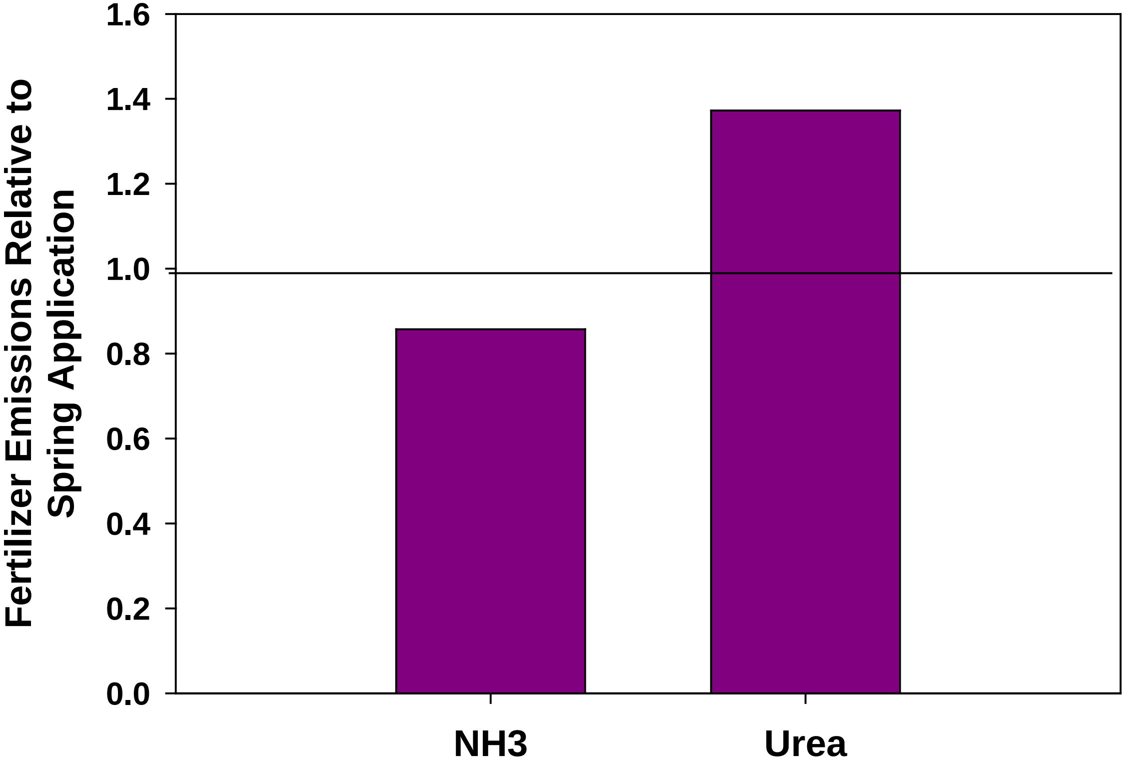


Urea EEFs 39% decrease

4 site years of data
EEFs= SuperU, Limus, ESN, enTrench

Fall vs Spring Application

NH3 Fall application 14% decrease
Urea Fall application 37% increase



2 site years of data

Coordinated nitrogen and sulfur management in S-deficient soils and in-crop N fertigation in irrigated systems to reduce N losses in the western prairie environment of Alberta

Miles Dyck

Department of Renewable Resources

University of Alberta

Acknowledgements

- Dick Puurveen – Breton Plots Manager
- Mekonnen Giweta – PhD Student
- Kyle Kipps – MSc Student and Research Assistant
- Leah Predy – undergraduate student
- Jennifer Martin, Syed Mostafa – technical help
- Past Breton Plots Academic Leads and Support Staff
- Breton Plots Donors

- Funders: Shell Canada, Canadian Fertilizer Institute, International Plant Nutrition Institute, ACIDF, Alberta Wheat Commission, NSERC

Activities 6 & 7

- Activity 7:
  - Long-term N & S, rotation management → growing season N2O emissions @ Breton Plots
  - In-crop N applications through fertigation @ Lethbridge (Guillermo Hernandez; Doon Pauly, Len Kryzanowski, AAF)
- Activity 6 (Linda Hall):
  - N stabilization products, rate and time of placement.
  - Two sites: Ellerslie and Lethbridge

Activity 7 Progress

- 2016 growing season N2O emissions measured (data processing)
  - started in 2013 → 4 growing seasons (bridge funding and previous AAFC-CFI funding)
- Laboratory incubation (Fall, 2015)
- Mekonnen Giweta, PhD student, successful defence of thesis (September, 2016)
- Submission of two manuscripts to CJSS special AGGP edition.

Activity 7 Progress: Lethbridge Fertigation

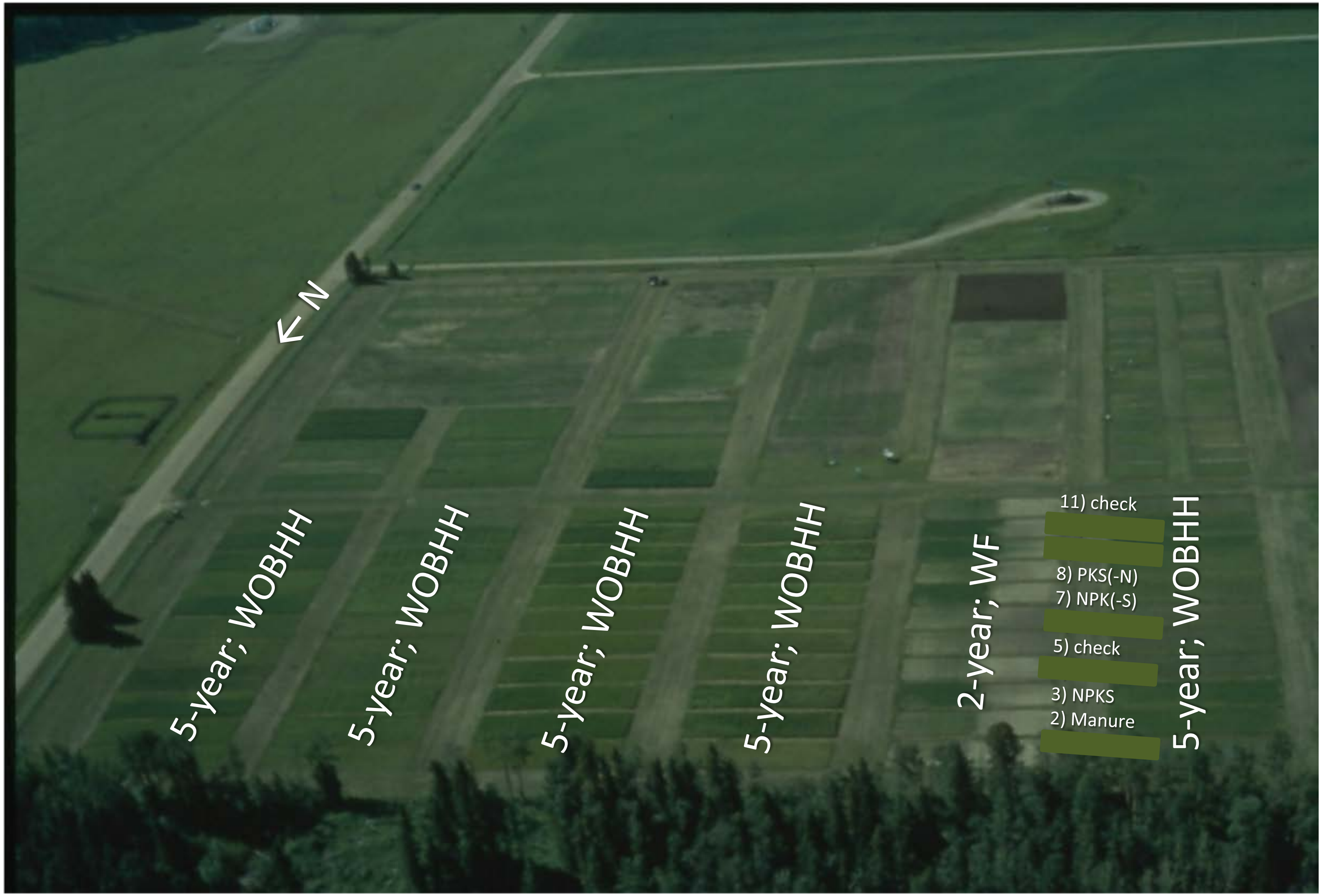
Completed Tasks

- ☑ Recruited MSc student, Leanne Chai
  - ☑ Co-supervised with Guillermo H.-Ram.
- ☑ Soil samples taken 2015 and 2016
- ☑ Gas samples taken 2015 and 2016
- ☑ 2015 gas samples analyzed
- ☑ Lab incubation completed

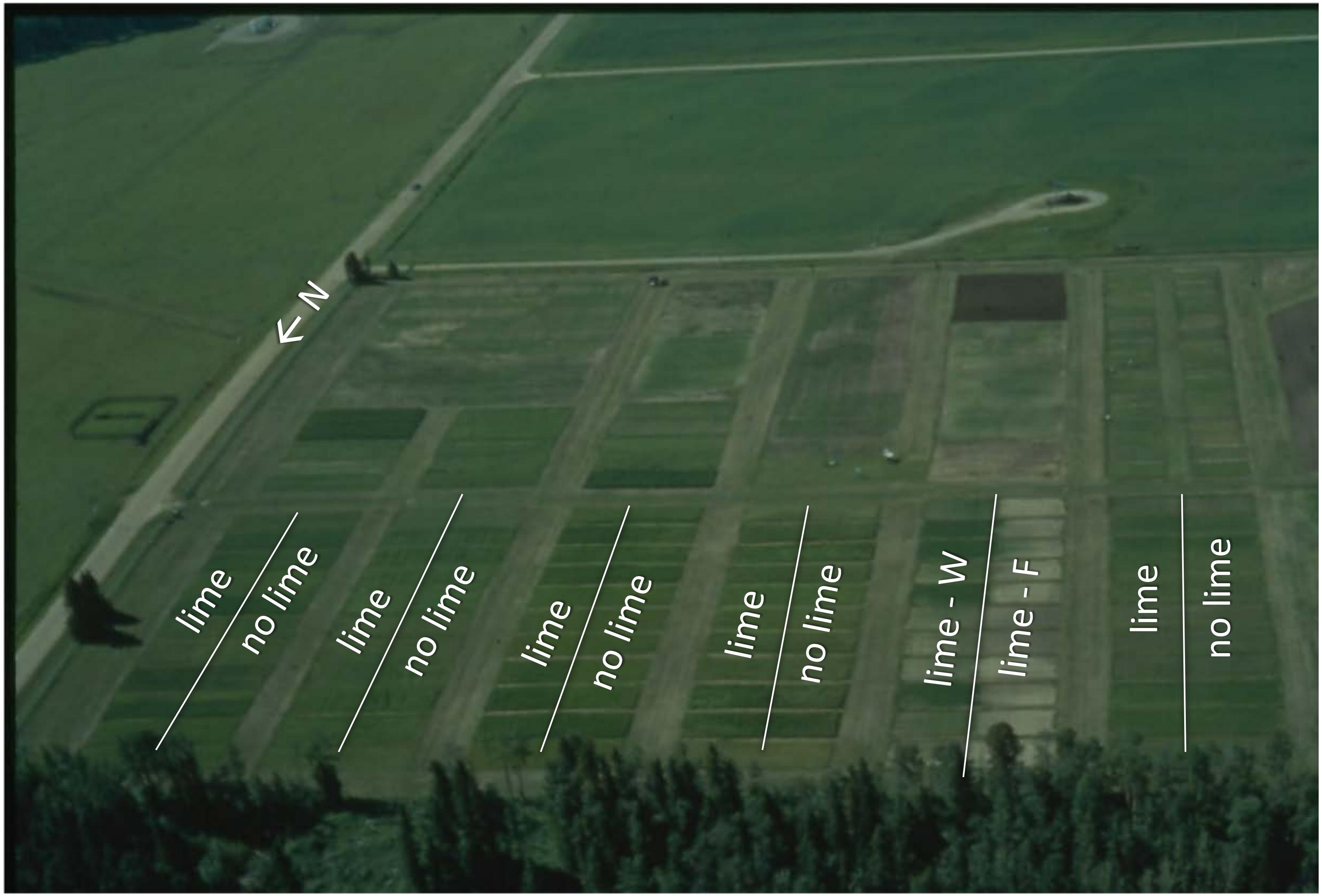
In Progress

- ❑ 2015 and 2016 nutrient analysis (NH_4-N, NO_3-N)
- ❑ 2016 gas sample analysis
- ❑ Lab incubation gas sample analysis

Breton Classical Plots



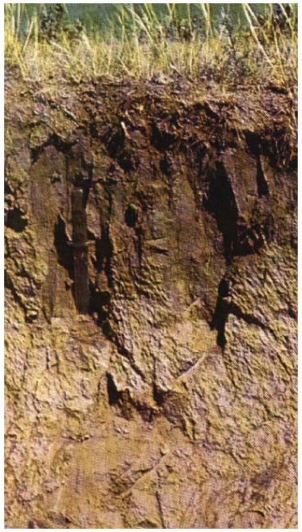
Breton Classical Plots



Gray Luvisolic Soils

Gray Luvisol

D. Brown Chernozem



Nutrient sources and rates

Nutrient (trt numbers)	Source	Target Rate (kg ha^{-1})					
		Rotation-phase					
		WF-wheat	WF-fallow	WOBHH-wheat	WOBHH-oats	WOBHH-barley (underseeded)	WOBHH-hay
Manure N[z] (2)	Cattle manure	90[y]	0	87.5[x]	87.5[y]	0	0
Fertilizer N (3,4,7,9,10)	Urea 46-0-0-0	90	0	50	75	50	0
Fertilizer P[w] (3,7,8,9,10)	TSP 0-45-0-0	22.5 (52)	0	22.5 (52)	22.5 (52)	22.5 (52)	22.5 (52)
Fertilizer K (3,4,7,8,9)	Potash 0-0-60-0	50	0	50	50	50	50
Fertilizer S (3,4,8,9,10)	Elemental S 0-0-0-90	20	0	20	20	20	20

[z] Actual application rate of manure is determined by laboratory analysis of total N and moisture in manure. Rates of P, K and S applied with the manure vary according to their concentrations and rate of manure application and are therefore not consistent over time. Applicable only to plot 2 in each series.

[y] manure for WOBHH-oats and WF-wheat is applied in the spring prior to planting

[x] manure for the wheat phase is applied in the previous fall prior to hay plough-down

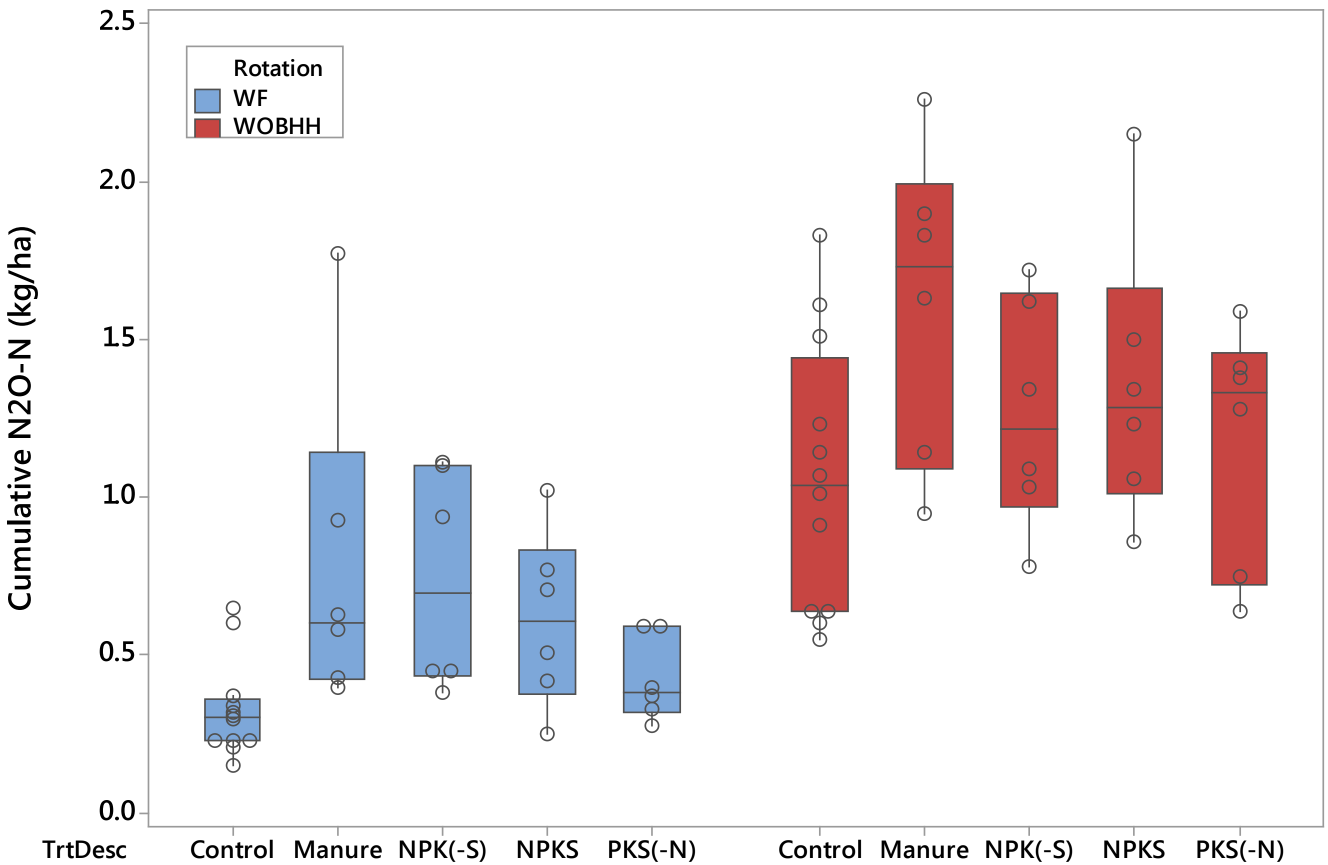
[w] rate is expressed as kg P/ha (kg P_2O_5/ha)

Growing Conditions 2013-2015

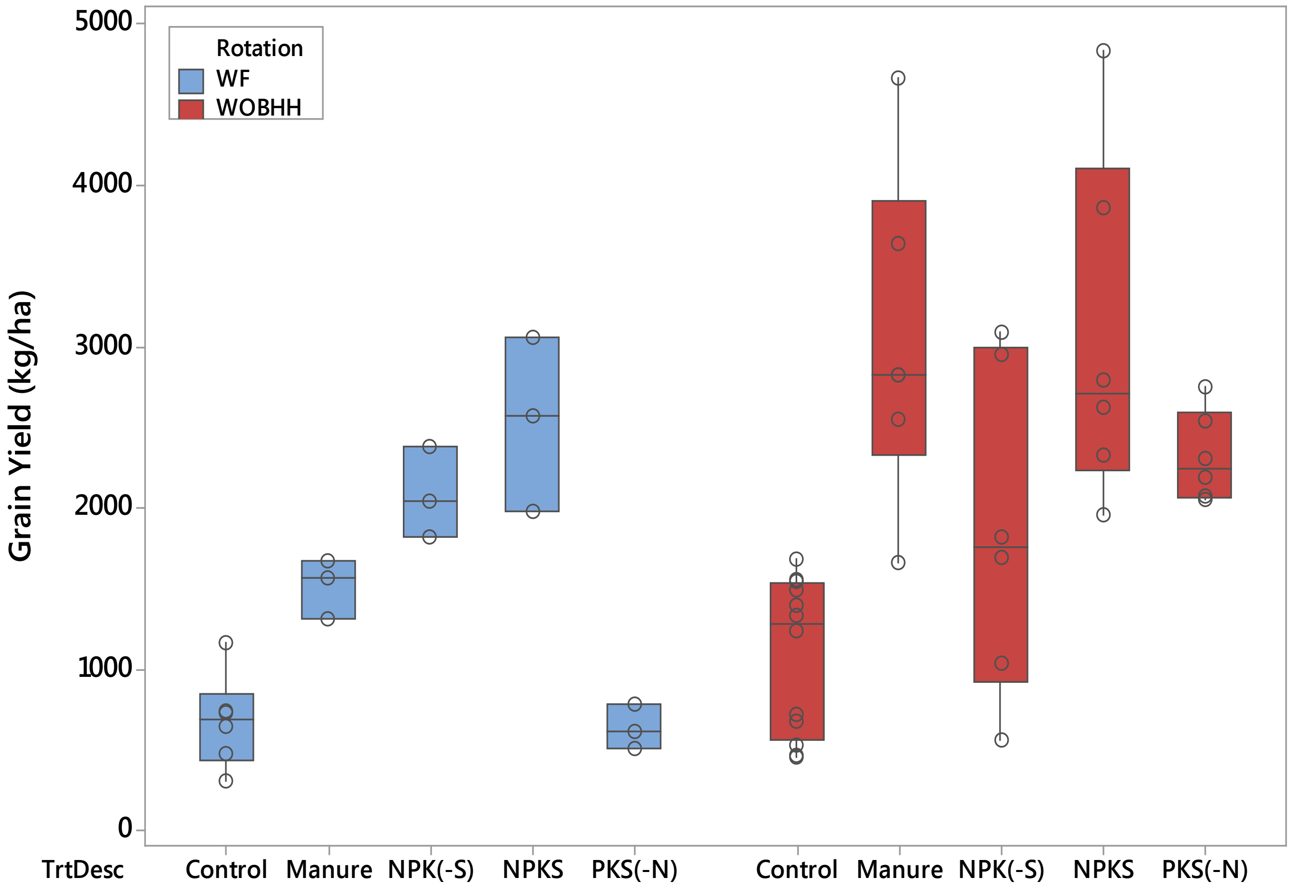
Year	Growing Season* Precipitation (mm)	Average Growing Season* Air Temperature (ºC)	Growing Season* Growing Degree Days	Growing Season* Reference ET (mm)
2013	258	14.0	1123	442
2014	249	13.8	1085	437
2015	160	14.3	1137	491

* May 1 – August 31

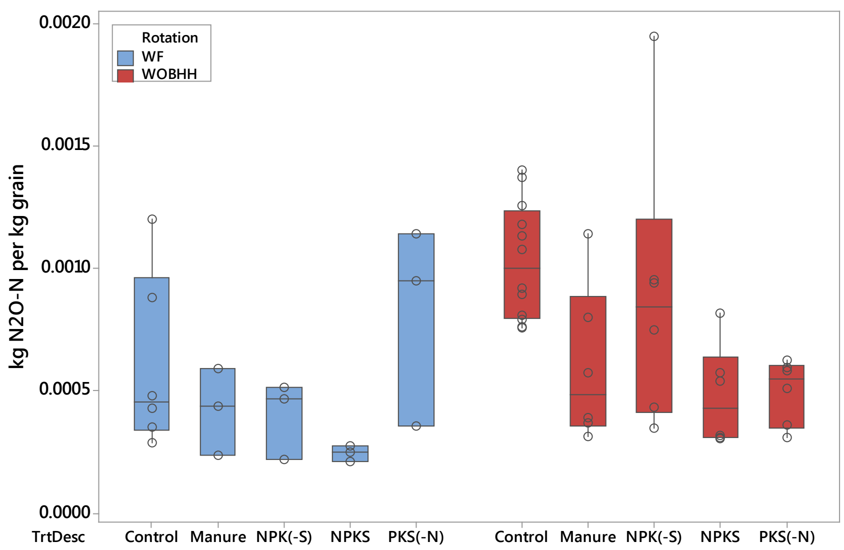
Cumulative N_2O (2013-2015)

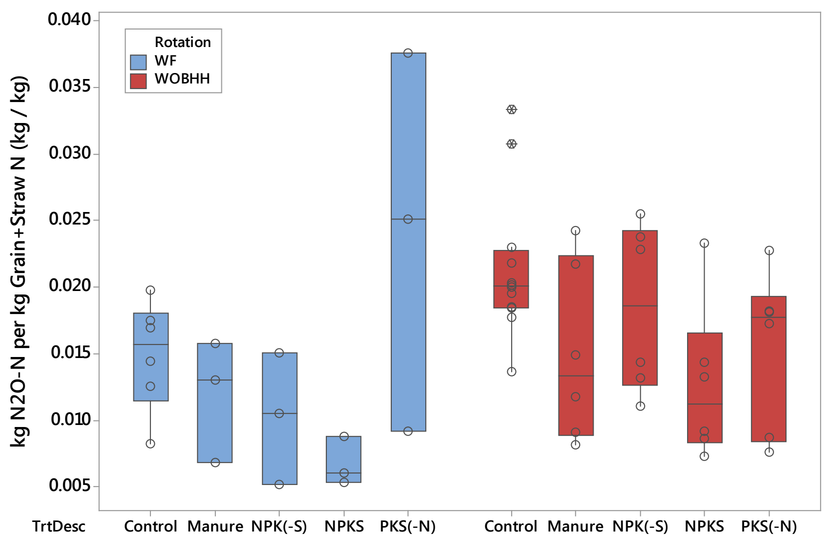


Wheat Grain Yields (2013-2015



N_2O intensity

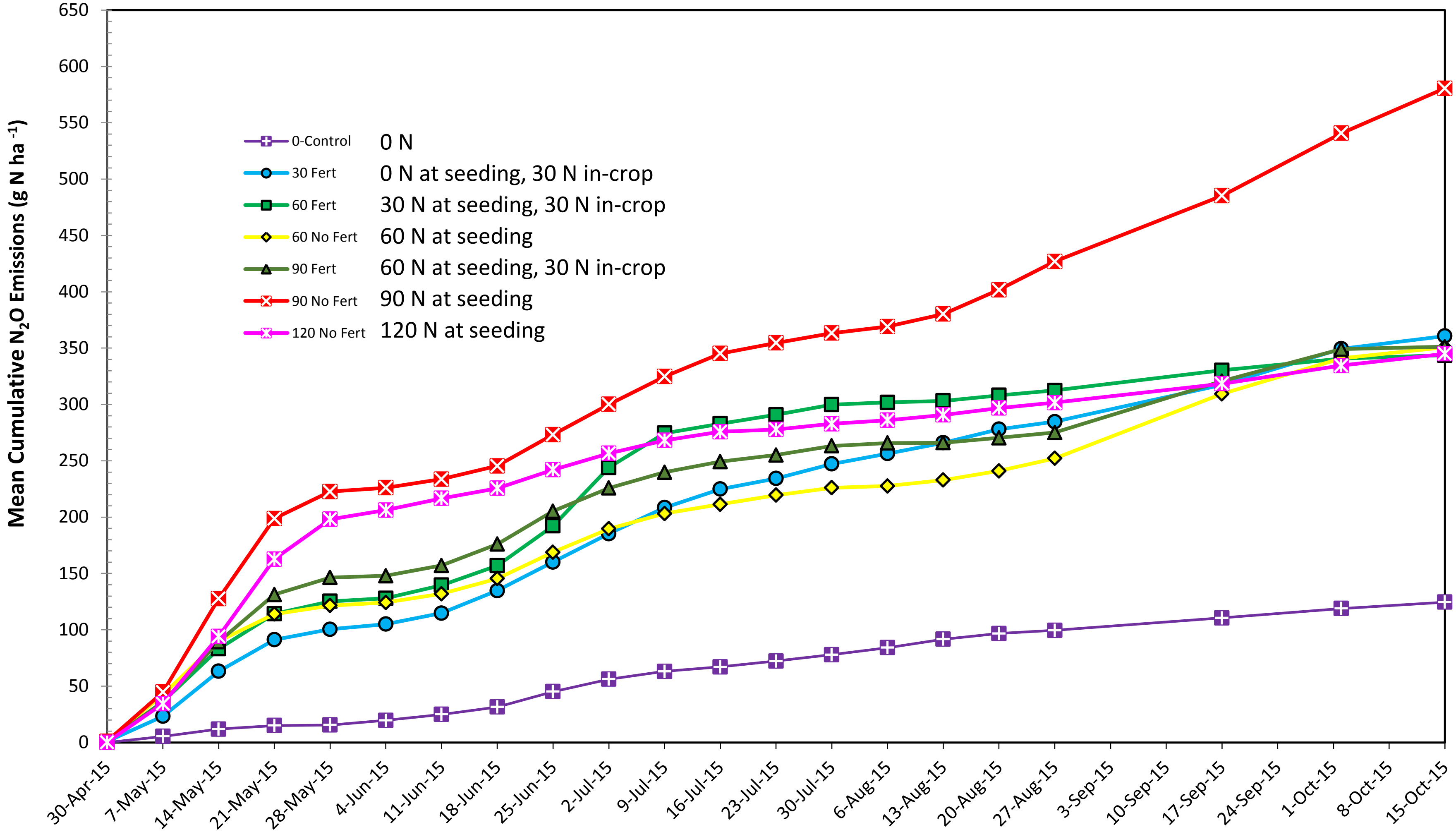




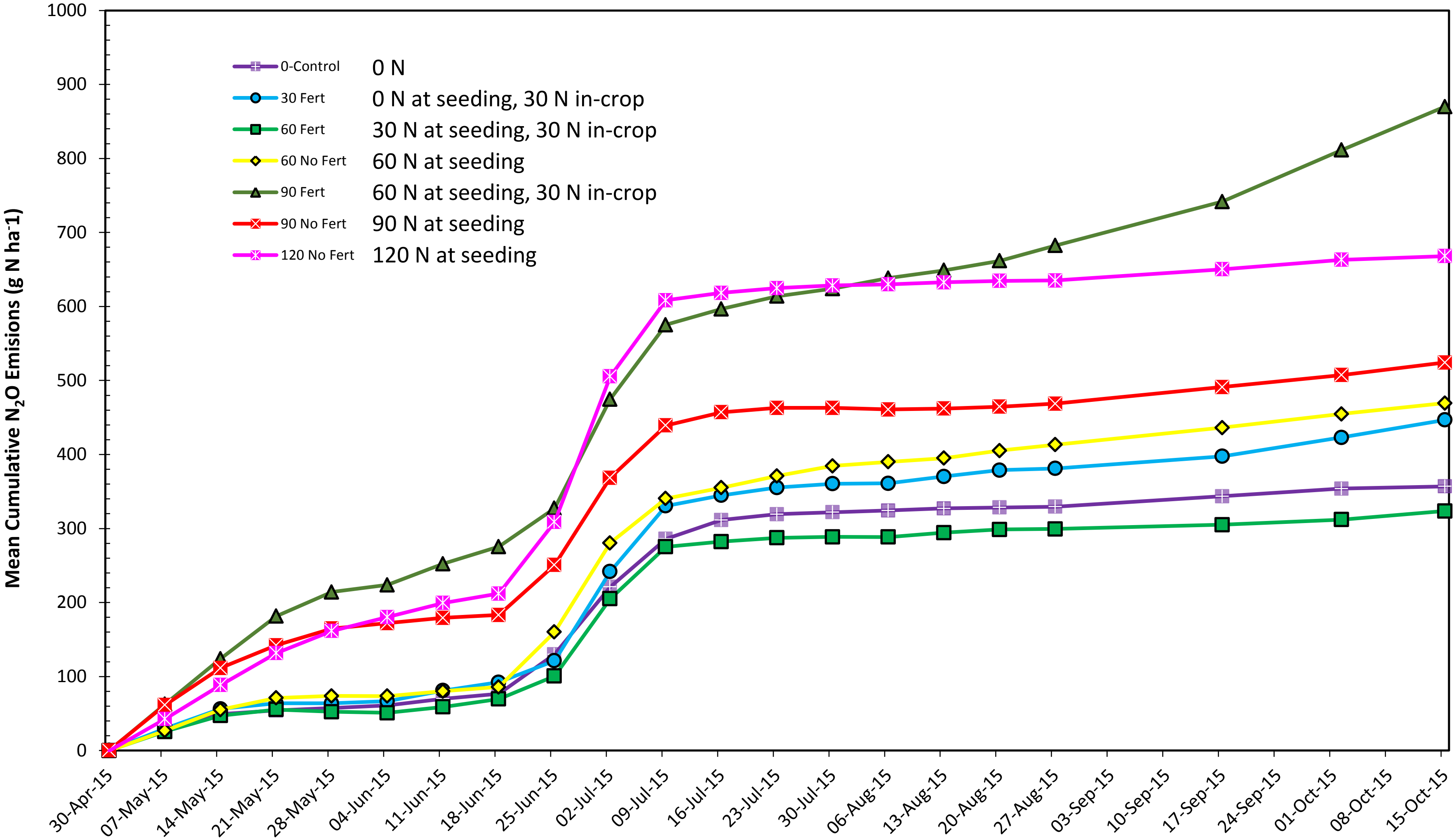
In-crop N application via fertigation (Lethbridge)

- Factors:
  - Crop → Canola and Wheat
  - N rate: 0, 30, 60, 90, 120
  - N application: banded at seeding (urea); in-crop fertigation (UAN)
  - In-crop applications at tillering (wheat); 5-leaf stage (Canola)

2015 Cumulative Emissions- Canola



2015 Cumulative Emissions- Wheat



Activity 6: N stabilization

Activity 6 Progress

- Factors:
  - N rate (0, 40, 80, 120 kg N / ha)
  - Fall or Spring Banding
  - Product: NTrench-treated Urea, SuperU, ESN, Urea
- Fall 2015; 2016 growing season N2O emissions measured (data processing) at Lethbridge and Ellerslie
- Mineral N on soil samples during growing season
- No results to report yet.

Generated Hypotheses:

- Long-term rotation and fertilization practices that increase soil N over the long-term seem to increase total growing season N_2O
    - Higher yields and N uptake correlated with greater nitrification of fertilizers, crop residues and SON; nitrification produces N_2O.
    - Management history more significant than current fertilizer applications?
- However, decreased intensity of emissions under long-term rotations and fertilizer treatments that increase yields, N uptake and NUE
- Increased crop uptake of NO_3 likely won't result in decreased total growing season N_2O
    - use of nitrification inhibitors may decrease total growing season N_2O through increased uptake of NH_4

FERTILIZER CANADA
FERTILISANTS CANADA

4R NUTRIENT STEWARDSHIP

Extension and Communications Report

Amanda Giamberardino
Manager, 4R Nutrient Stewardship
ASA Meeting 2016

Vision 2020

We will advance the safe, secure and sustainable production and use of fertilizer through proactive science-based programs, innovation, and advocacy – benefiting Canada and the world.

FERTILIZER CANADA

Nutrient Stewardship

Targets:

- The Canadian and global standard

- 20 Million 4R Designated Acres

4R Nutrient Stewardship Metrics for Sustainable Crop Nutrition

Enablers (Process Metrics)

Actions (Adoption Metrics)

Outcomes (Impact Metrics)

Priority Metrics for U.S. Fertilizer Industry

Enablers (Process Metrics)

Extension & Professionals
- No. of agronomy professionals (TFI SOI)
- No. of certified professionals (TFI SOI)
- Farmer outreach & awareness (TFI SOI)
- Training materials
- Available continuing education

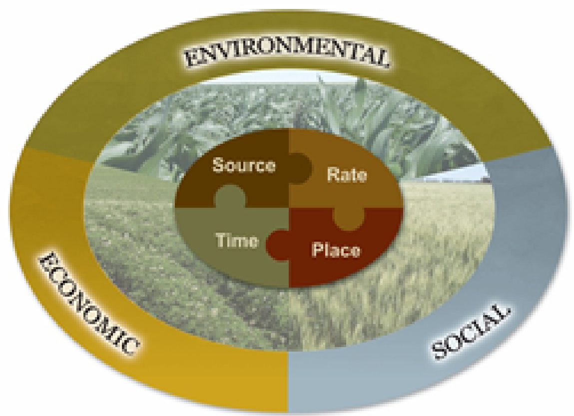
Research & Innovation
- Industry support for 4R research (TFI)
- No. of universityresearchers supported by 4R Research Fund
- Amount spent on private & government crop nutrition research
- Amount spent on product innovation

Stakeholder Engagement
- Formal Recognition of 4R Partnerships
- Regional 4R Programs (Priority Setting, Certification, etc.)
- Actions with supporting organizations
- Awareness creation

Infrastructure
- Enhanced Efficiency Fertilizer Sales (attempted through TFI SOI)
- Warehouse Capacity
- Number of Agri-Retailers / Distance to Retailer / Time
- Fertilizer Consumption / Need
- Number of Products / Custom Blends
- Application Capacity/ Infrastructure
- Services available to growers

Actions (Adoption Metrics)

- Cropland under 4R (at various levels) [requires regional definition of site-specific 4R practices]
- Participation in regional or national nutrient stewardship programs
- Equity of adoption (gender, scale, etc.)



Outcomes (Impact Metrics)

Most Directly Related to 4R

Farm Land Productivity
- Yield per unit area of crop area (USDA-NASS)
- Crop yield owing to each nutrient (IPNI Stewart & Dibb)
- Quality of crop products

Soil Health (Fertility Component)
- Proportion of soils in optimum range, by nutrient (IPNI soil test summary)

Nutrient Use Efficiency
- Partial nutrient balance (IPNI NuGIS)
- Partial factor productivity (within crops)
- Whole farm nutrient balance

Water Quality
- N & P loss, Edge of Field (modeled)
- N & P tributary concentration (monitored)
- Nitrate groundwater concentration (monitored

Air Quality
- Ammonia emissions reductions
- Ambient ammonia, PM2.5

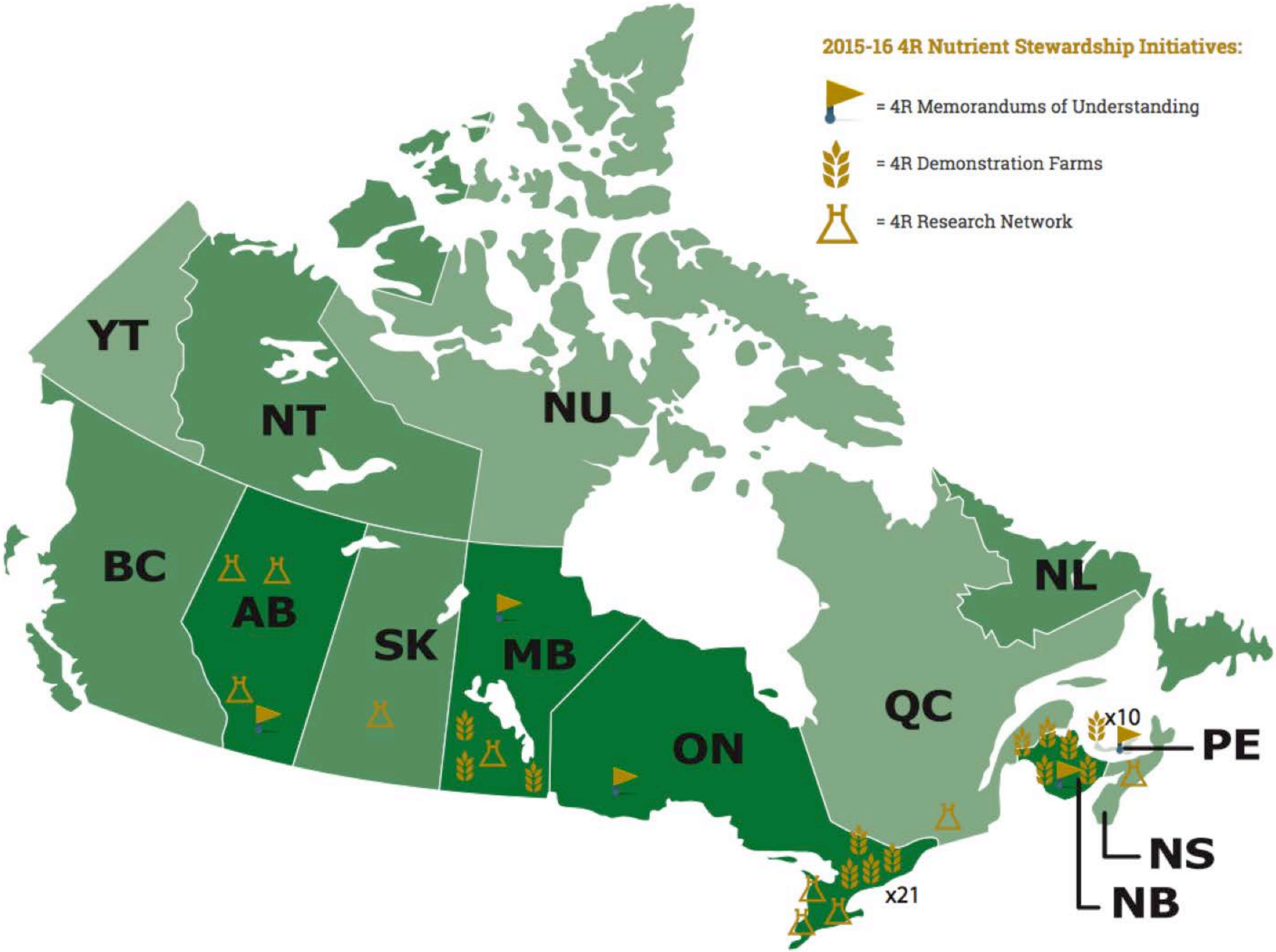
Greenhouse Gas Emissions
- Nitrous oxide emission (modeled)
- Ambient nitrous oxide concentrations

Food & Nutrition Security
- % of Undernourished Population (FAO)
- Food insecurity (FAO)
- Proportion malnourished

Economic Value
- Farm revenue resulting from crop nutrients
- Income equality
- Downstream value of agri-products

Land Conservation & Habitat
- Natural land spared from agriculture

T. Bruulsema (IPNI), L. Moody, P.Harper (TFI), C.Graham (Fertilizer Canada)


2015-16 4R Nutrient Stewardship Initiatives:
= 4R Memorandums of Understanding
= 4R Demonstration Farms
= 4R Research Network
YT
NT
NU
BC
AB
SK
MB
ON
QC
NL
PE
NS
NB
x10
x21

Canadian Roundtable for Sustainable Crops

- National forum to co-ordinate and collaborate initiatives underway, across the value chain, that will minimize the amount of burden on producer, but still meet end user or consumer requirements.

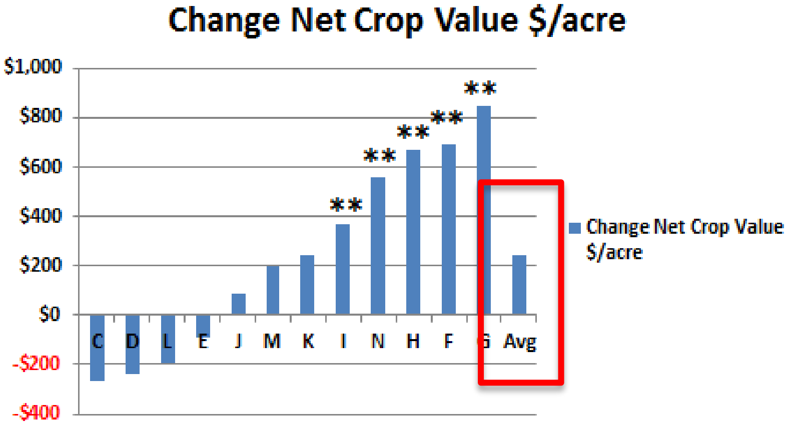
- Developing a unified approach to sustainability instead of 20 separate projects for grain, oilseeds and pulse crops.

4R nutrient stewardship

4R Nutrient Stewardship can **help** grow crops sustainably

Putting Principles to Practice- 4R Demonstration Farms

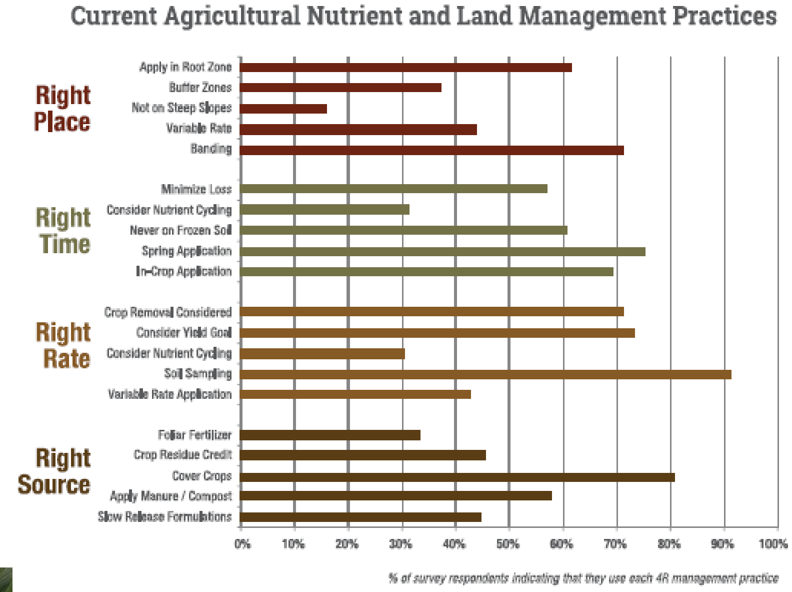
- Atlantic Canada- What do 4R practices look like on PEI potato farms?
  - Split nitrogen applications, reducing N application by 10-20% in some sites
  - Reduced P_2O_5 application to match soil needs
  - Supplement micronutrients where soil tests indicate a potential crop response would be possible (Mg, B, Zn)
  - Avoid foliar fertilizer applications if possible
  - Use of enhanced efficiency and controlled release nitrogen fertilizers (*ie*: ESN Urea)



Values followed by ** are statistically different at 95% confidence level; those followed by * at 90%

4R Demonstration Farms (cont'd)

- Ontario - six farms (Lake Erie and St. Clair basins), including grain crops produced in rotation, tomato production, sugar beet production and grain production on a livestock farm.
  - Precision farming being examined as a tool
  - Timing of fertilizer delivery has shifted to delivery during the cropping season beginning with seeding to late summer.
  - Studying the soil profiles on field edges can give insight to soil health



4R Demonstration Farms (cont'd)

- Manitoba
  - Urea trials, applying different rates for wheat and soybean

- Farm Tour Videos online

(via YouTube channel)

No longer enough to *'Do the Right Thing'*

Public is demanding credible evidence that farmers are making sound crop management decisions for the economy, society and environment

4R Designation

Key Elements:

- Grower and Agri-retailer develop voluntary 4R plan
  - Consistent with regional economic, social and environmental goals
- Sign off by trained professional: CCA, 4R training
  - provincial qualifications as required (P.Ag, Nutrient Management Planner)
- Acres, Crop and Eco-district data filed confidentially to registry
- Grower and Agri-Retailer receive 4R Designation and recognition
- Registry reports acres under 4R management by crop and Eco-district

Origins of the Canadian Research Network: the N_2O Science Cluster - 2010

- Source, rate, timing and placement BMPs that encouraged reduction of N_2O emissions.
- Supports the Nitrous Oxide Emissions Reduction Protocol (NERP)

Outreach and Impact of 4R Research

- Key takeaways of the September questionnaire:
  1. The North American 4R Research Fund leveraged about **$5 Million** CAD (or, approx. $4 Million USD) in other funding.
  2. Of the 124 Research staff employed by the research leads, **91 work directly on 4R Research projects**. So, about 3 out of 4 employees receive experience/training on 4R Nutrient Stewardship.
  3. At least **7,740 people reached** on 4R Nutrient Stewardship research. (This <u>does not</u> include IPNI/TFI/Fertilizer Canada communications on the initiative)

Coming Soon...

- Article series on Canadian 4R Research Network
- Agri-webinars (with Farm Management Canada)
  - November 2016 – January 2017.
- Panel Session on 4R and NERP (December)
- Science for Stewardship- February 2017 in Scottsdale, AZ
- Other joint communication work with TFI and IPNI to follow
  - Video development (smile!)

The Ask

- Help us communicate to farmers the benefits of the 4R system and assist them on the ground level with planning and implementation so we can make sure their acres are counted

- Assist us in getting more acres under 4R management for reporting purposes and to meet external stakeholder demands

- Enable advisers to train and help growers complete a 4R consistent plan for sustainable nutrient management.

Website

4R.fertilizercanada.ca

Learn More >

Download Resources v

4R Designation

Help your grower customers get their acres counted

Sustainable farming is the future. In many cases, that future is already underway. 4R Nutrient Stewardship (Right Source @ Right Rate, Right Time, Right Place ®) lets the world know when food has been sustainably grown.

We want to demonstrate this to the world, by getting Canadian agri-retailers and crop advisors 4R Designated and counting millions of acres under 4R Nutrient Stewardship, to demonstrate how Canada is a leader in sustainable farming.

1. Complete the 4R Nutrient Stewardship eLearning Course

Getting started is simple. Fertilizer Canada's 4R Nutrient Stewardship three-part training takes an in-depth look at sustainable fertilizer principles, which earns a Certified Crop Advisers 5.5 continuing education credits.

Get started ›

2. Make sure your farmer customers' plans fit 4R Nutrient Stewardship

The following checklist outlines the requirements for compliance with 4R Nutrient Stewardship standards.

Verify here ›

3. Get Your Acres Counted

Counting acres under the 4R Nutrient Stewardship framework is the best way to demonstrate to customers and stakeholders what our industry is doing to be forward thinking.

Access the form here ›

eLearning portal (eLearning.fertilizercanada.ca)

- 4R Nutrient Stewardship: Full Certification Training (CEUs are available for CCAs)
- 4R Essentials: A Short Course & Regional 4R Nutrient Stewardship Training
- NERP Training & NERP Lite

FERTILIZER CANADA

FERTILISANTS CANADA

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Benefits of 4R Nutrient Stewardship to Farmers

- Farmers can prove to external stakeholders what they're doing to be good environmental stewards of their land - the 4R plan backs their actions with hard data
- End-use customers are beginning to require proof and 4R delivers that
- Grower associations have asked for this and are endorsing it
- This science and fact-based approach meets government and environmental organization demands and exceeds them
- Improves grower's efficiency and their bottom line

Benefits of 4R Nutrient Stewardship to Agri-Retailers

- By helping growers complete a 4R plan to get their acres counted, a retailer is getting the first and best opportunity to fully understand their fertility requirements
- 4R is based on best agronomic practices; the agronomy team will be motivated to participate
- Becoming 4R Designated allows retail locations to use the 4R sustainability designation and communicate to farmers and external stakeholders that they are becoming part of the solution
- Staff earns CCA credits for training
- It’s the right thing to do at the right time

1. Leverage totals for 4R Nutrient Stewardship Research

- (i.e. when asked what other funds have been received in connection with or as a result of their project)
- Canada: $3.3 Million
  - $1.1 Million (federal government grant-AAFC)
  - plus, $2.2 Million from other funding sources
- US: $2.1 Million (Or, $2.7 Million CAD) from other funding sources
- North American total (in CAD): nearly $5M (Or, ~$4M USD)

2. Professional Development in 4R Nutrient Stewardship

- 124 Research Assistants who work for the Research Leads (83 Cdn, 41 US)
  - 43 undergraduate students (23 Cdn, 20 US)
  - 47 graduate students (33 Cdn, 14 US)
  - 14 post-doctoral fellows (9 Cdn, 5 US)
  - 2 Visiting scientists (US)
  - 12 Technicians (Cdn)
  - 6 Research Associates (Cdn)
- 91 of these Research Assistants work directly on 4R Research projects (51 Cdn, 40 US)
  - 42 Undergraduates/Baccelaureates (21 Cdn, 21 US)
  - 21 Graduate Students/MSc.PhDs (12 Cdn, 9 US)
  - 13 Post-doctoral fellows (6 Cdn, 7 US)
  - 1 Visiting Scientist (US)
  - 11 Technicians (9 Cdn, 2 US)
  - 3 Research Associates (Cdn)
- So, by these numbers, nearly 3 out of 4 employees receive experience/training on 4R Nutrient Stewardship.

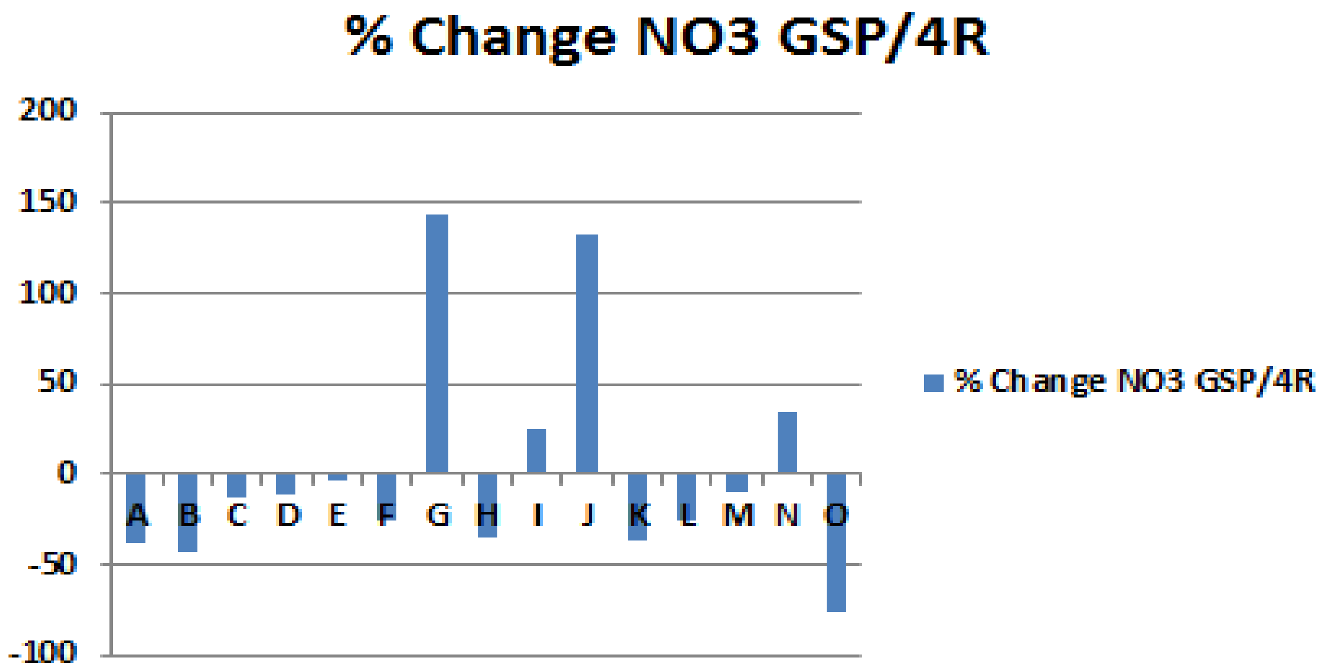
3. Communications of 4R Nutrient Stewardship Research

- 11 Manuscripts in Academic Journals (9 Cdn, 2 US)
- 5 Dissertations/Theses (3 Cdn, 2 US)
- 1 Citation (Cdn)
- 108 Oral Presentations (41 Cdn, 67 US)
- 8 Articles (5 Cdn, 3 US)
- 19 Poster Presentations (14 Cdn, 5 US)
- 25 Field Tours (11 Cdn, 14 US)
- 24 Workshops/Meetings (18 Cdn, 6 US)
- 20 listed as 'other methods' (e.g. videos, web resources, social media mentioned)
- At least 7,740 people reached on 4R Nutrient Stewardship research (6895 Cdn, 845 US)
- 4. Other success stories commented on by the researchers, as a result of their research on 4R Nutrient Stewardship:
- Over 2,000,000 crop acres have been captured as being under 4R Nutrient Stewardship in the Western Lake Erie Basin.
- Many Indiana farmers are adopting the concept of late-split N for the last 30-50 pounds applied after the V-10 stage. Lots of farmer enthusiasm, despite the low commodity prices.
- Awareness of 4R nutrient management from an agronomic and GHG perspective have improved across Canada. Provincial Governments looking closer at how 4R Nutrient Stewardship research can lead to incentives to reduce GHG emissions from agriculture.

4R farms demonstrate an environmental and economic advantage for PEI

- 4R Nutrient Stewardship practices for Right Source, Rate, Time, and Place work in harmony with other good stewardship practices including:
  - Crop rotations
  - Cover crops
  - Organic Matter improvement
  - Liming
  - Buffer Zones
  - Soil conservation tillage practices
  - etc…

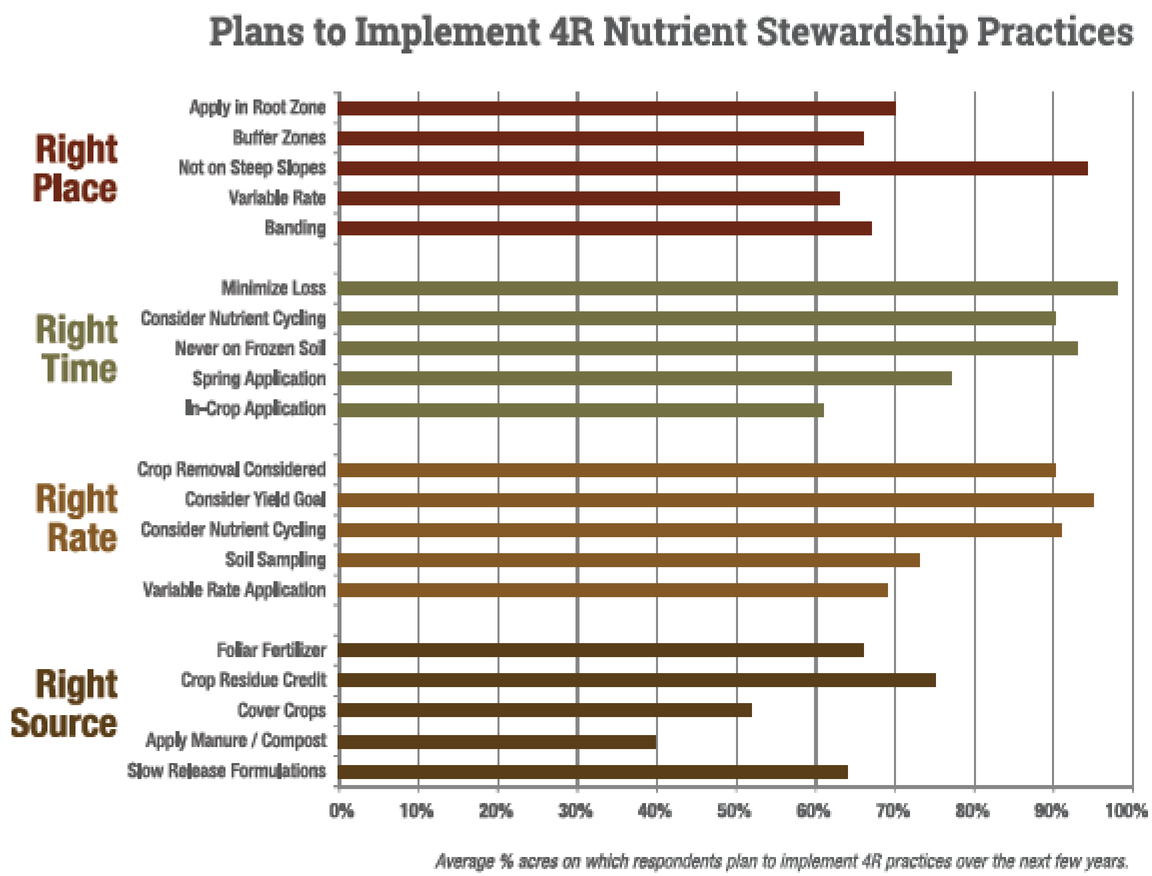
4R farms demonstrate an environmental and economic advantage for PEI



Percent change in post-harvest residual soil NO_3 level at 18" depth from 4R demonstration sites, showing general standard practice (GSP) / 4R in 2015 demonstration farm trials.

Negative % change indicates decrease residual soil NO_3 with 4R practices. Results from 2014 growing season trials show the same trends.

Ontario- report excerpt



Manitoba – preliminary 2016 4R wheat trial information

4R Demonstration Site: Trial Description	Yield (Bushels/ Acre)	Acres	MPH	Wheat Protein	Weight (lbs/ bushel)	FUS	Moisture	Grade
85 lbs/acre Super U mid-row banded	52	1	2	15.1	59	1.3	14.5	3 RS
50 lbs/acre Urea mid-row banded 35 lbs/acre ESN seed-placed	60.68	0.9	2.3	14.6	60	0.95	14.5	3 RS
120 lbs/acre urea	45.6	1	1.8	15.9	58	1.25	14	3 RS
100 lbs/acre urea	52	0.9	2	15.5	59	1.4	14.2	3 RS
80 lbs/acre urea	51	1	2.1	15	59	1.15	13.8	3 RS
Check (no N)	40	0.2	3	13.2	61	0.45	14	2 RS

Effect of Placement Method on Fate of Applied P Fertilizer in a Saskatchewan Landscape

Jeff Schoenau, Blake Weiseth, Jordan Wiens
Department of Soil Science
University of Saskatchewan

Blake Weiseth MSc project

(Successfully Defended November 2015)

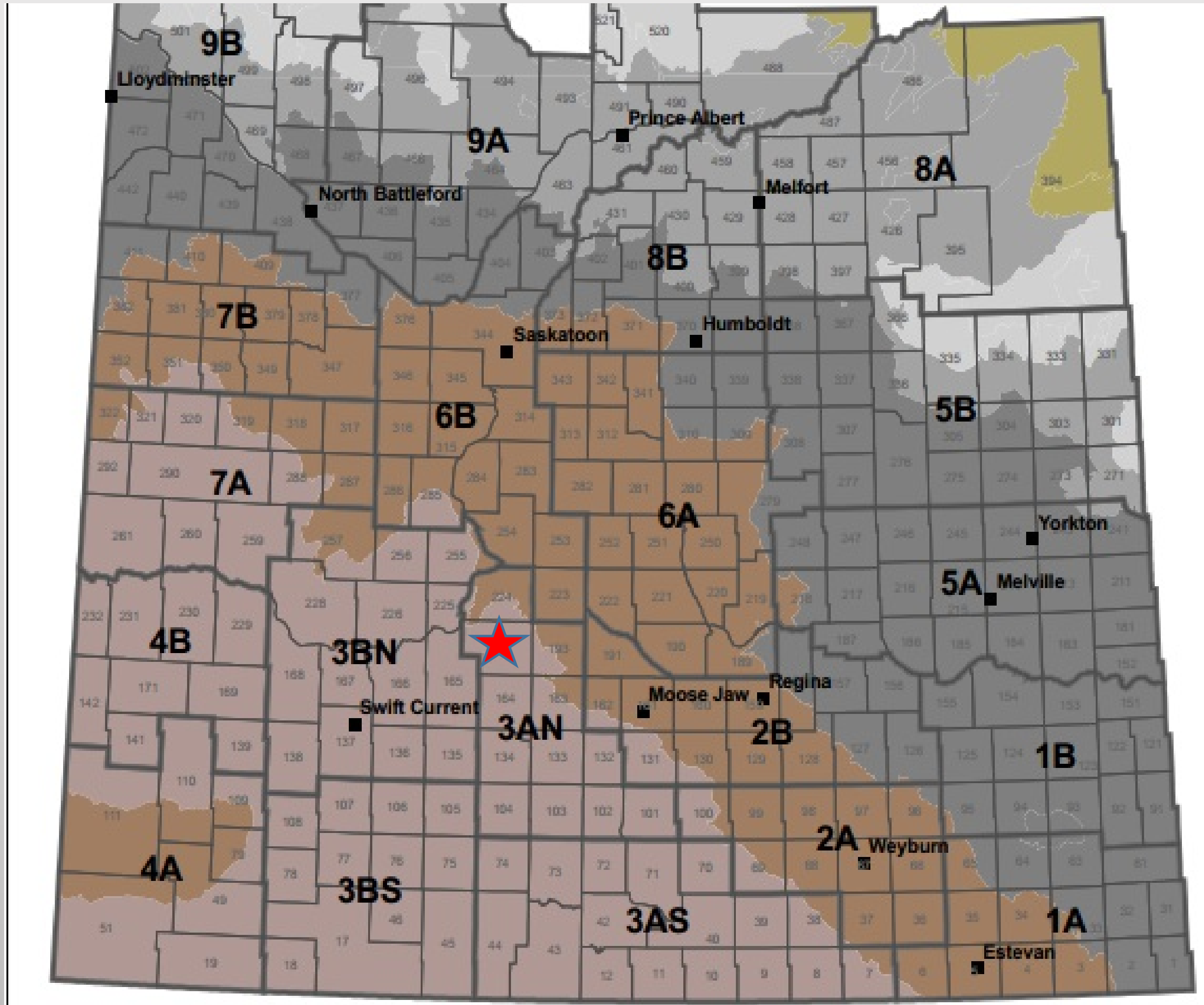
Jordan Wiens MSc project

(Started May 2015, Defence Summer 2017)

Hypotheses

1) In-soil placement of fertilizer P at the time of seeding in spring will increase crop uptake and recovery of P and reduce P transport in spring snowmelt compared to the surface broadcast method of fertilizer P application.
2) Distribution and speciation of fertilizer P reaction products in soil will be influenced by method of fertilizer P application in calcareous soils common to the Canadian prairies.

Site Description



Effect of Varying Rates of Seed-Placed Fertilizer P on Soybean Seedling Emergence and Biomass Yield.

- Application of fertilizer P above 20 kg P_2O_5 ha^{-1} significantly reduced soybean emergence.

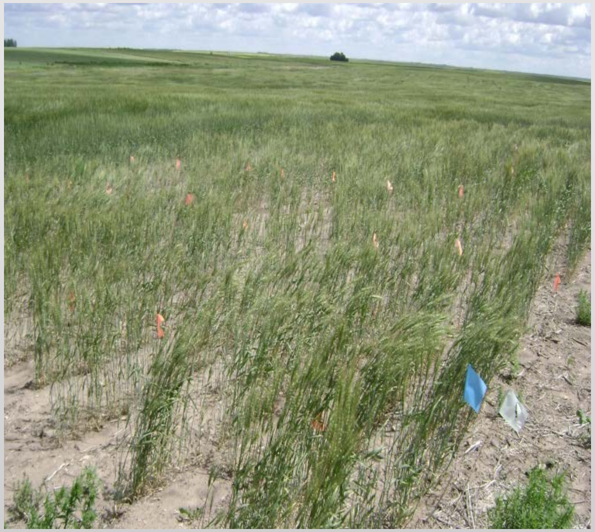
- However, soybean biomass production was negatively affected only when fertilizer P was applied at 80 kg P_2O_5 ha^{-1}

- At least 20 kg P_2O_5 ha^{-1} can be safely seed-placed with soybean. Helps P balance.

Effect of Fertilizer P Application Method on Yield, Uptake and Residual Soil P Distribution.

2014 Soybean
Normal moisture

2015 Wheat
Dry spring and summer



2016 Canola
Wet summer and fall

Response experiments conducted at two sites within the landscape:
Upper slope and Lower slope

Treatments

C 1) No P fertilizer

SP 2) Seed placed P at 20 kg P_2O_5 ha^{-1}

DB 3) Banded P below seed at 20 kg P_2O_5 ha^{-1}

B/I 4) Broadcast P at 20 kg P_2O_5 ha^{-1} with incorporation;

B(20) 5) Broadcast P at 20 kg P_2O_5 ha^{-1} without incorporation;

B(40) 6) Broadcast P at 40 kg P_2O_5 ha^{-1} without incorporation; and

B(80) 7) Broadcast P at 80 kg P_2O_5 ha^{-1} without incorporation.

Summary to date

- In-soil P placement superior to broadcast in enhancing crop yield.

- Seed-placed and deep banded fertilizer P application resulted in greater grain P uptake and recovery of applied P compared to broadcast treatments.

- Broadcast application of fertilizer P at elevated rates resulted in greater STP values measured at the soil surface (0-5 cm) relative to in-soil application.

P-31 NMR in Dr. Barbara Cade-Menun's lab, Swift Current SPARC (2015-2016)

- Placement of fertilizer P in the soil caused a greater proportion of applied P to remain in the plant available form compared to broadcast application.
- Broadcast applications were associated with increases in proportion of P in organic forms that can be attributed to microbial immobilzation of fertilizer P.
- ^{31}P NMR spectroscopy was a useful tool in revealing how P fertilizer application method influences soil P speciation and fate.

P Export in Simulated Snowmelt Runoff

Summary to date

Broadcast fertilizer P application resulted in greater TDP export compared to in-soil placement.

TDP export similar to the unfertilized control treatment for P fertilizer that was placed in-soil.

In-soil placement may be considered an effective strategy to limit off-site transport of applied P.

2016 Field Work

- Canola in plots harvested and soils sampled this fall. Analyses in progress.
- Soil monoliths removed for determination of P distribution in profile.
- Soil slabs taken from upper slope position site for simulated snowmelt runoff study this winter.

  - have also included slabs from an adjacent foliar P fertilizer treatment study.
- Intact soil cores removed from lower slope position site for controlled environment leaching study in spring of 2017.

Appreciation to Fertilizer Canada, AAFC, IPNI, NSERC for their support!

Agriculture et Agroalimentaire Canada
Agriculture and Agri-Food Canada

Development of decision support mechanisms for 4R optimization of nitrogen fertilization placement, rate and timing based on the integrated use of soil, weather and market data

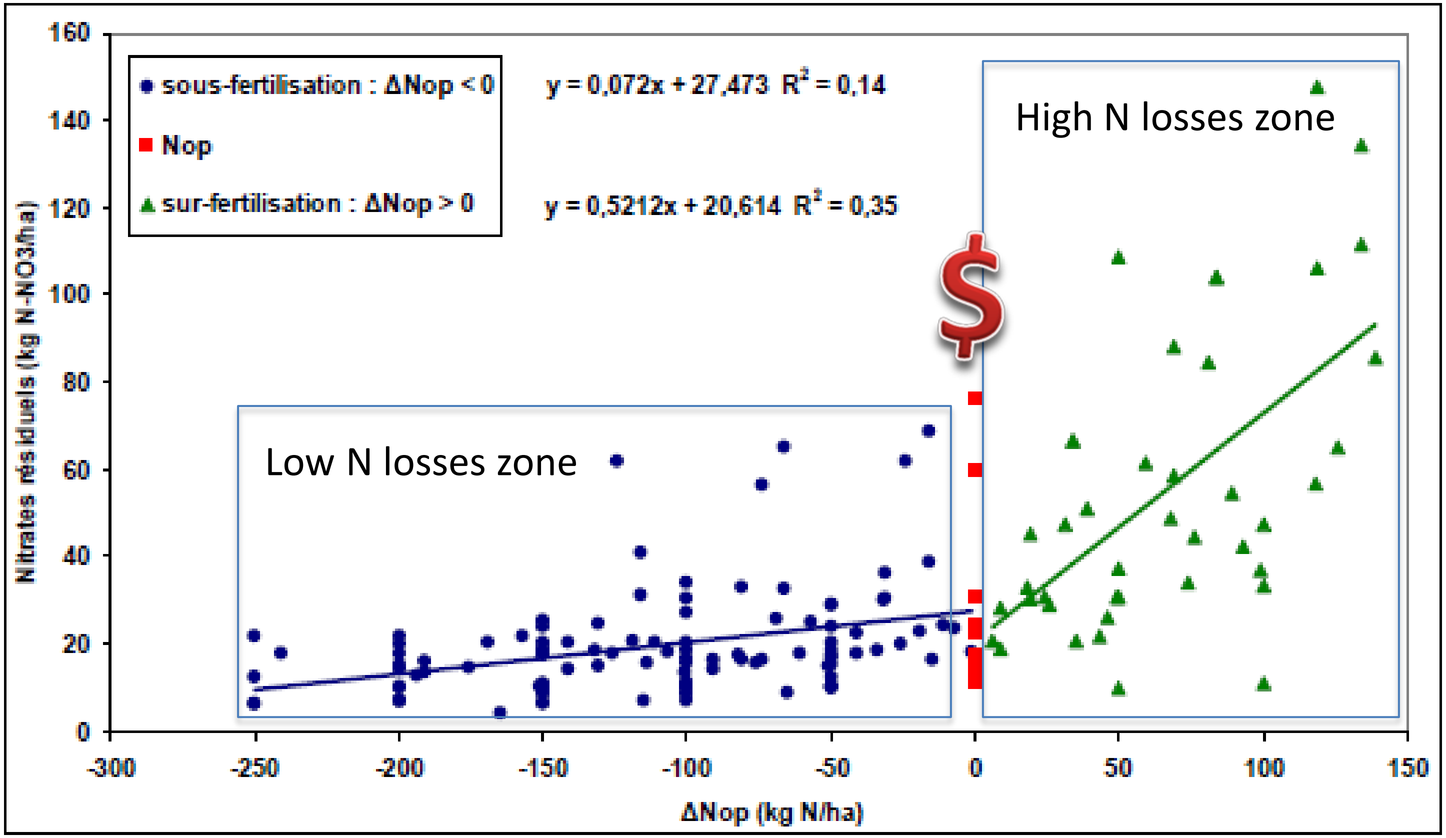
Nicolas Tremblay, agr., Ph.D., Research Scientist

Crop Nutrition and Management Team

St-Jean-sur-Richelieu

Canada

Profits & Environment: No Conflict



Data from Quebec (Giroux et al. 2009)
Similar results for N_2O (Van Groenigen et al. 2010)

Need to address uncertainties

- Farmers are risk averse: they want to secure yield
  - Insurance (excessive) rates $\rightarrow$ environmental + $ losses
- They have lost faith in <u>general</u> scientific results as a personalized solution to their problems
- Bases for lack of relevance = uncertainties
  - Seasonal (weather)
  - Field characteristics (soil properties)
  - Economics (market price, yield expectations)
- Personalize recommendations in farmer’s context

Meta-analysis, a way to personalize

Translating Science into Practice

Of course, a global average of minus 5.7% is just that: an average. Some farmers will achieve the same or higher yields with no-till, while others will see losses greater than 6%. The question then becomes: What's the probability of experiencing a yield decline on any particular farm? Fortunately, meta-analysis can assist here, as well. Not only can it provide the global expected value (e.g., 5.7% yield reduction), but also the distribution of variability around that value, and moderator variables, such as soil moisture or farm practices, that explain the variation in response.

Nicolas Tremblay

What this means, in effect, is that "you can [calculate] the probability that an individual grower will achieve a certain change in yield: a 5% decrease, a 10% decrease, or a 5% increase," Madden explains. "You can give that value to them. We have done this in a number of our investigations."

Someone who is also using meta-analysis to inform farmer decision-making is Nicolas Tremblay of Agriculture and Agri-Food Canada. Having conducted fertilization trials since "forever," the ASA, CSSA, and SSSA member jokes, he long suspected weather was behind the year-to-year differences he and his colleagues observed in crop responses to fertilizers. "But because we were looking at so few years and in such a defined location, we could not really understand what was going on," Tremblay says. "So our conclusions were always partial."

To try to understand things better, Tremblay eventually joined 11 scientists from Canada, the U.S., and Mexico who likewise were grappling with sizable inconsistencies between trials in nitrogen availability and crop yield. They set up a joint experiment looking at corn response to nitrogen in several North American regions, agreeing upfront to use the same experimental protocols, fertilizer applications rates, etc.

They figured the standardization would reduce the overall variation, allowing the important factors to emerge. But when they pooled their data after four years and charged a colleague with making sense of them, the differences among the experimental locations still defied explanation. Finally, Tremblay turned to meta-analysis, using it to methodically sort through the variability and its causes. And when he did, he says, "we soon figured out everything. All the explanations for the differences were popping out like magic."

The main conclusion of their paper, which appeared in *Agronomy Journal* in 2012, is that corn's changeable response to nitrogen is largely dictated by the interaction between rainfall and soil: Not a surprising finding, necessarily, "but it was never really formalized and quantified," Tremblay says. Now that it has been quantified, he adds, his group has taken a vital next step. They're developing a web-based application where farmers will enter certain characteristics of their farms. The tool will then calculate, based on rainfall, soil type, and other parameters, a suitable nitrogen rate.

"And this is all based on the results of the meta-analysis because it opened our eyes to the key parameters" for predicting the rate, he says. "So it really started the whole process of transfer to the user."

But Tremblay also wants to see information flow the other way: from the user/farmer to the researcher. Scientists have traditionally eschewed on-farm trials and farmer-generated data in favor of highly controlled experiments, he explains—the idea being that the former contain too much local variation, making treatment effects difficult to detect. The unintended consequence of controlled experimentation, however, is that findings become so divorced from the changeable conditions of the real world that farmers can't apply them in their own settings.

What's needed, then, to make scientific results more relevant to the practitioner is to embrace variability in a systematic way, so that it informs rather than confounds. And Tremblay knows just the tool. "Meta-analysis," he says, "can be very instrumental for bridging this gap."

We Want Your Feedback

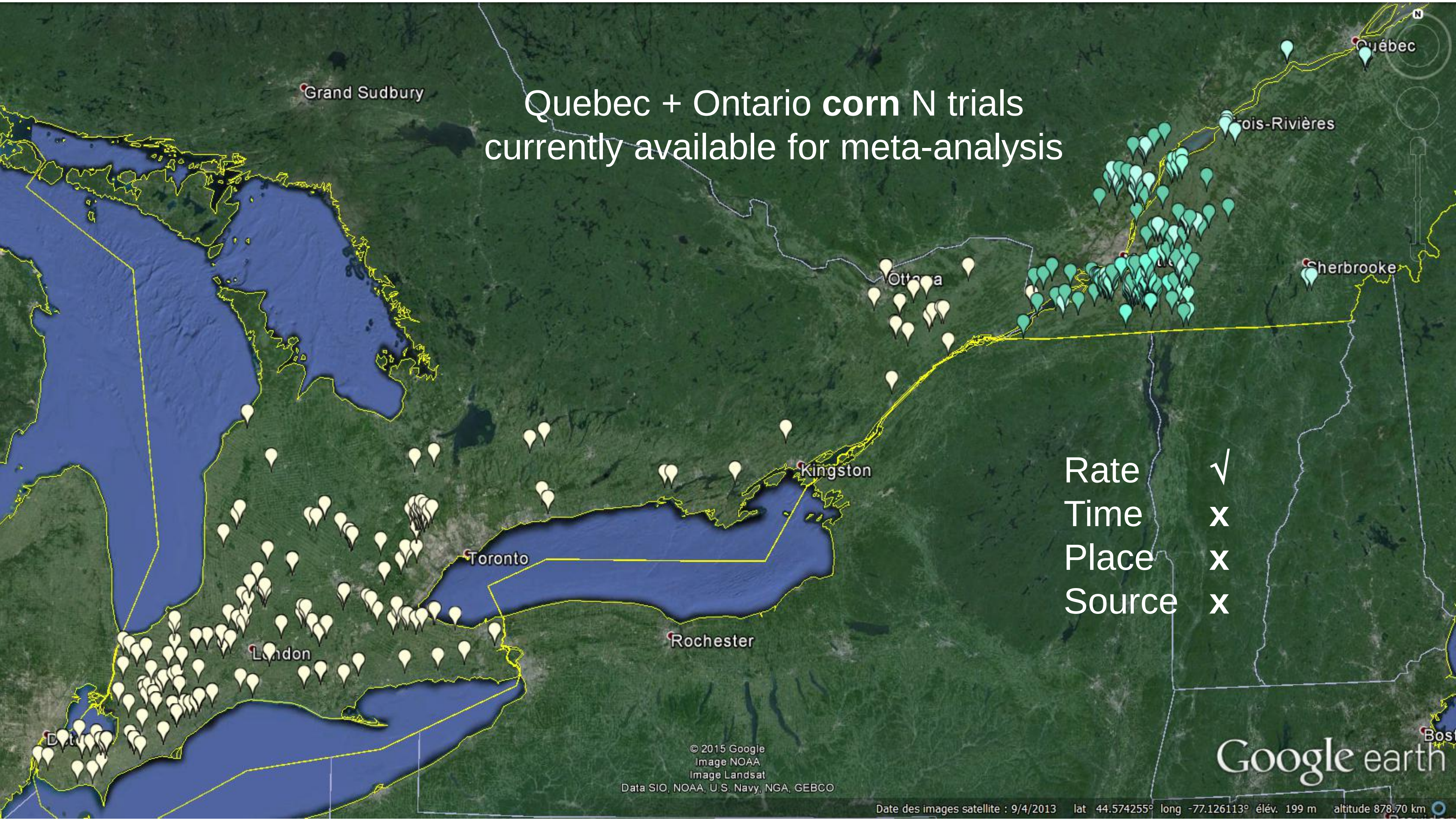
Help us better develop articles for you, our members, by letting us know what you thought about this article. Did you like it? Was it sufficiently technical? Would it be an article you would want to share with colleagues? Would you like to see a webinar on this topic? **Email news@sciencesocieties.org.**

Annual Meeting Program

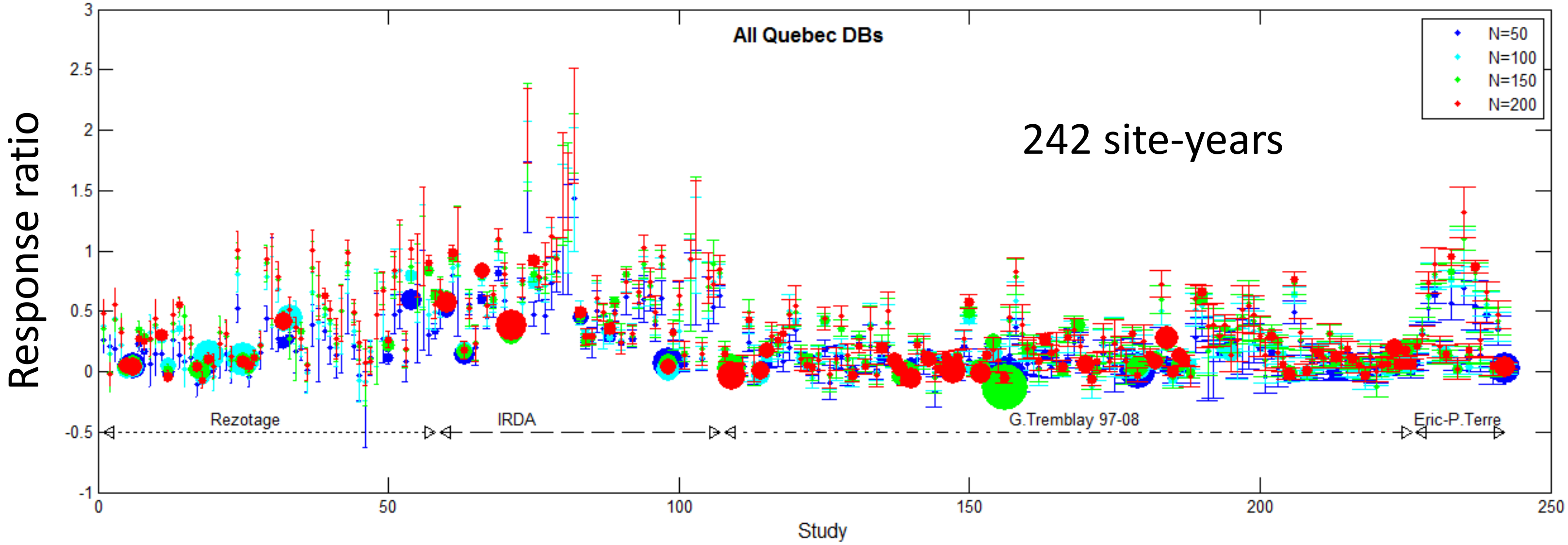
Plan to attend the meta-analysis and data stewardship activities at this year's Annual Meeting in Minneapolis, MN. The events include:

- "Meta-Analysis Applications in Agricultural Research" (symposium)
- "Meta-Analysis for the Synthesis of Evidence in Agriculture" (Sunday workshop)
- "Getting More from Data: Science for Sustainable Solutions" (Plenary special session sponsored by ASA, CSSA, SSSA, and ESA)

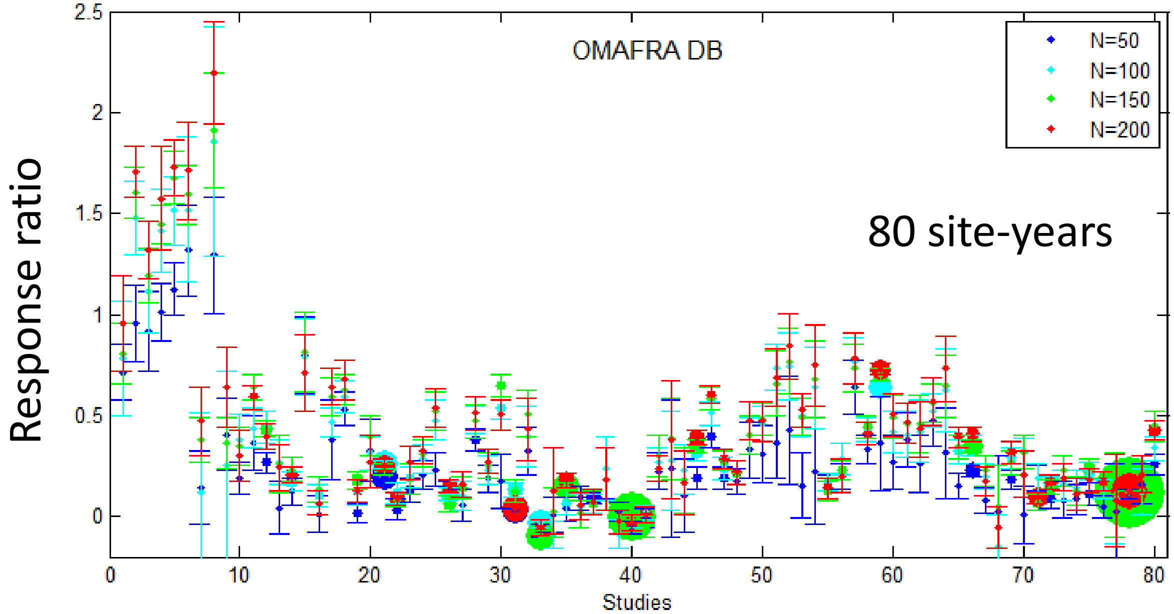
Lots of trials needed



All studies

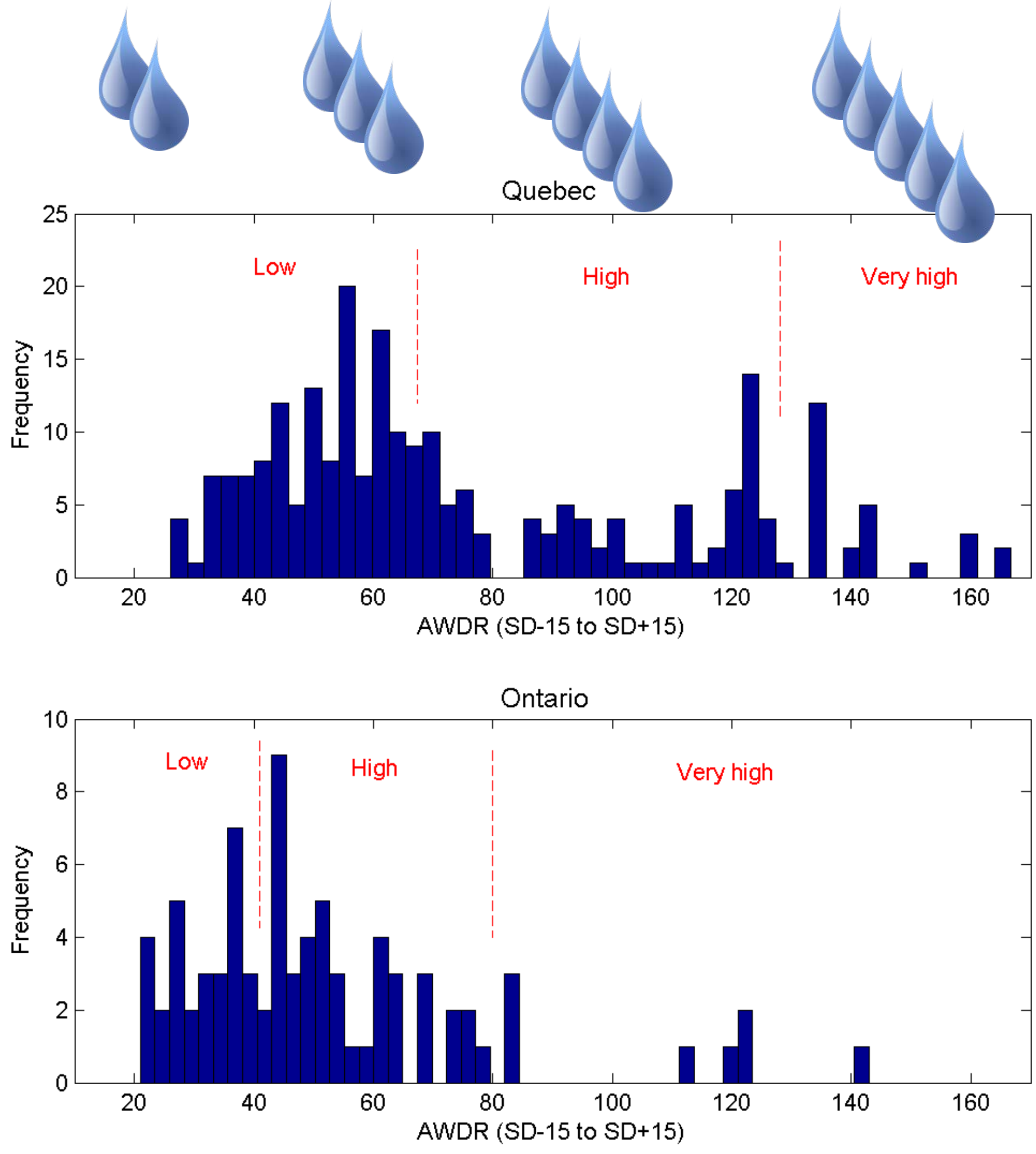


All Quebec DBs
N=50
N=100
N=150
N=200
242 site-years
Response ratio
Rezotage
IRDA
G.Tremblay 97-08
Eric-P.Terre
Study



OMAFRA DB
N=50
N=100
N=150
N=200
80 site-years
Response ratio
Studies

Rainfall conditions different in Qc vs On



Rainfall data needed for N recommendations

- “There is a great need to use rainfall data to explain the results of N response trials and integrate rainfall data into N fertilizer recommendations. Currently, rainfall data are not considered in N fertilizer recommendations for corn, although rainfall profoundly influences the magnitude of yield response to N fertilizer and the percentage of N loss from the soil and fertilizer.”
  - Kyveryga et al. 2013

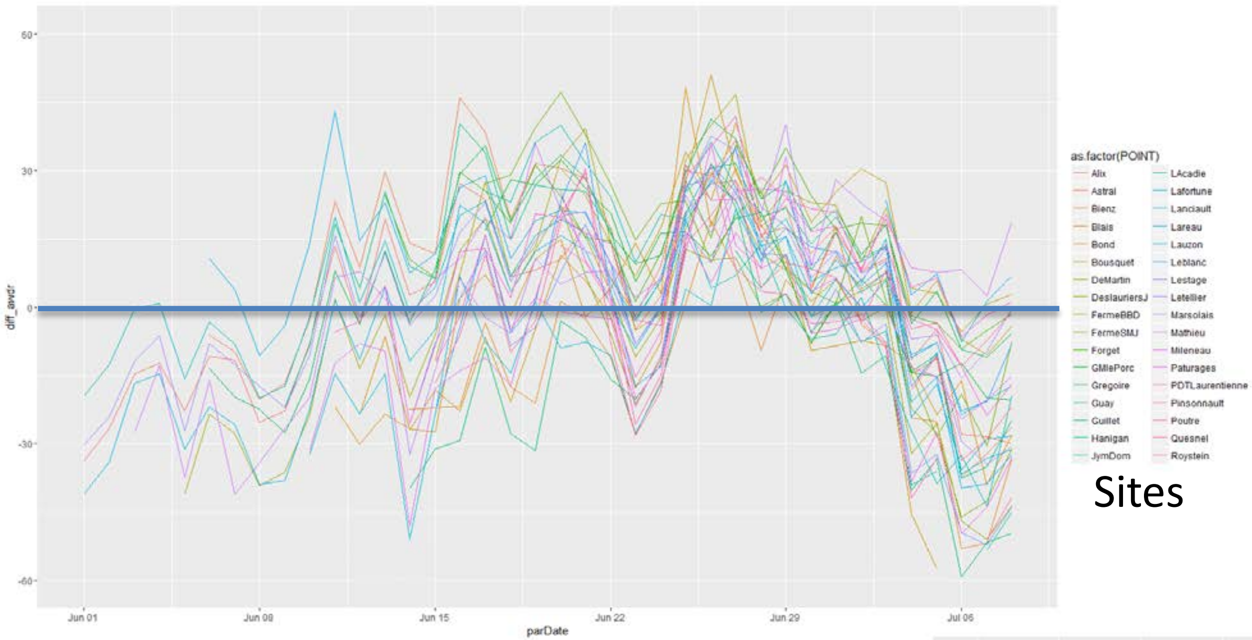
Adapting N to season: not done

- "Changing nitrogen fertilizer rate, (…), is usually easy to accomplish, but in practice is not done much. Some producers will alter nitrogen rate based on the previous crop, some will modify rate from year to year based on price signals, and others may adjust nitrogen rates based on varying yield potentials between fields. However, **it is common for producers to use the same nitrogen rate for a given crop over all fields and from year to year**."

Numerical optimization of AWDR

- Archived daily NAEFS forecasts
  - 5923 files (1.27 GB) retrieved in the different steps
- Coupled to 34 sites fitted with rain gauges in 2015
- 3009204 observations
- 91188 combinations of parameters and points
- Optimization elements
  - % of NAEFS members predicting rain
  - Minimal mm to call for rain
  - Centile mm of the members

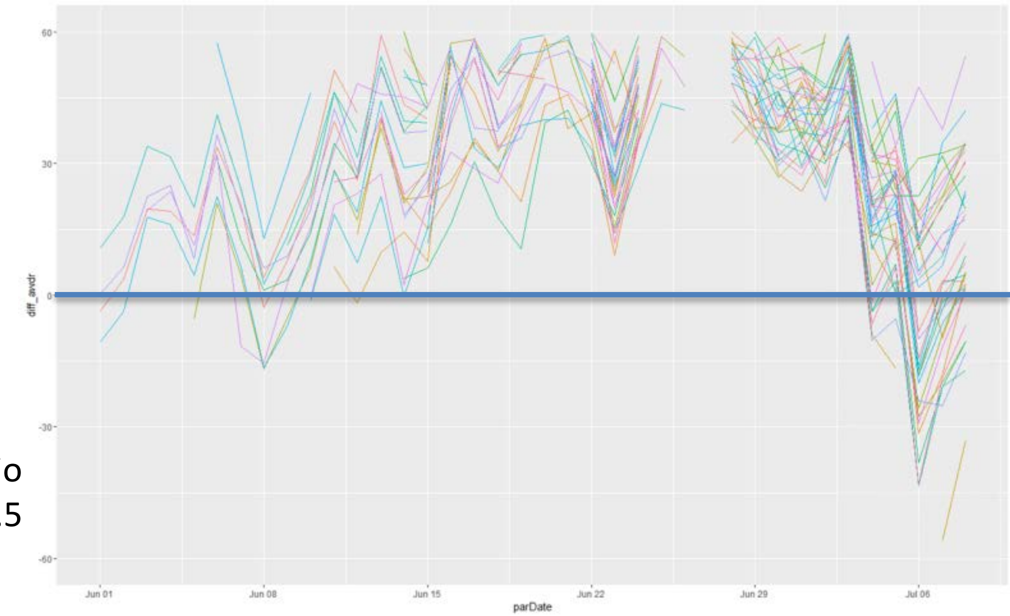
Difference forecast *vs* actual AWDR



Sites

Date

Best scenario
Mean difference actual vs predicted AWDR: 0.2



Bad scenario
Mean difference actual vs predicted AWDR: 40.5

McGill University Contribution

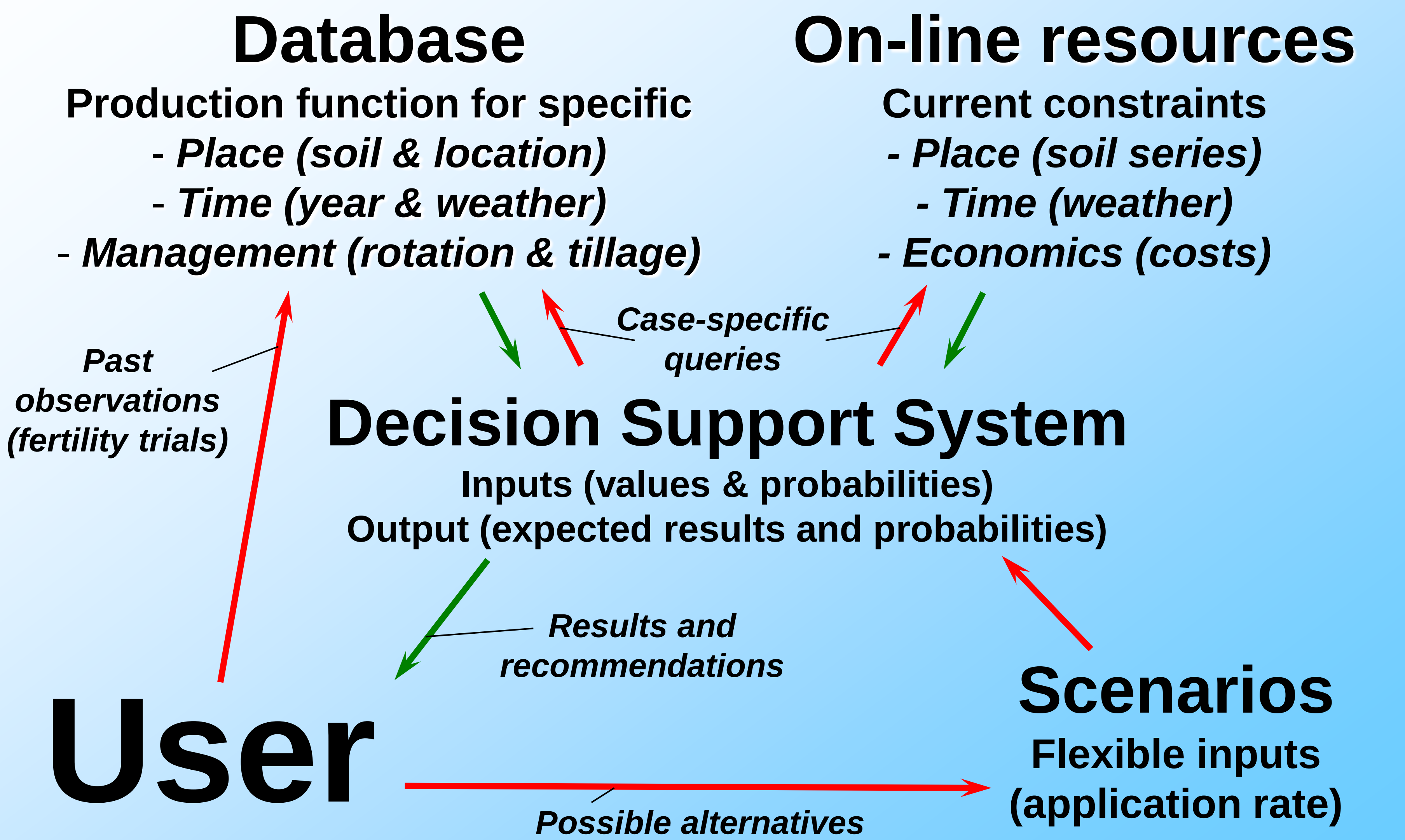
Activity: Optimization of nitrogen fertilization in response to production system uncertainties such as soils, weather and economics across Canada under 4R stewardship

Viacheslav Adamchuk	– associate professor, project coordination
Sadanand Shinde	– MS student, software development
Rene Lacroix	– research associate, decision support system architecture
Hsin-Hui Huang	– PhD student, numeric simulation of N fertilization

valacta

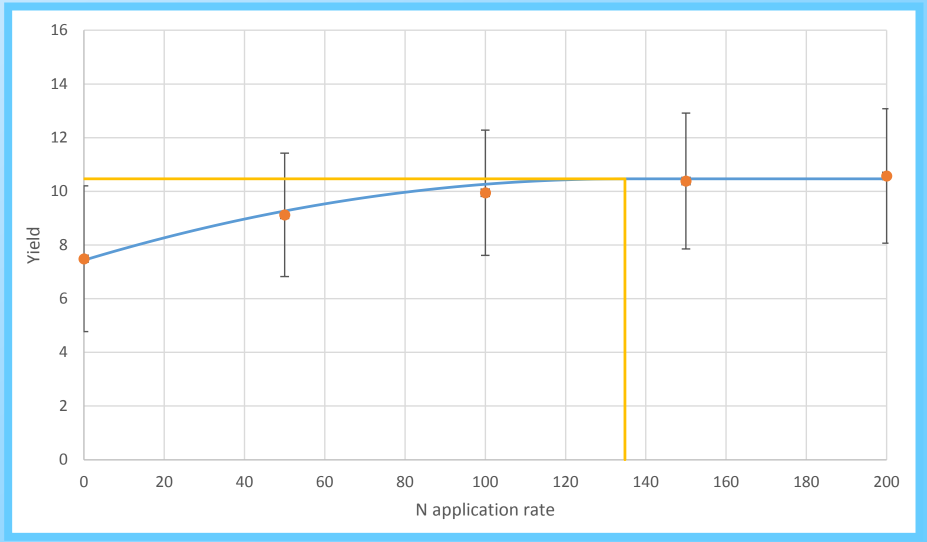
McGill

On-Line Decision Support System



Database

- **Production function**
  - Maximum yield
  - Minimum fertilizer rate to achieve maximum yield
  - Maximum yield increase due to the use of fertilizer
- **Metadata**
  - Geographic location
  - Key soil attributes
  - Landscape parameters
  - Weather summary
  - Cultivar and rotation
  - Other descriptors



On-line Resources

- Regional geo-database
  - Soil series
  - Soil organic matter
- Climate assessment
  - Summary of present conditions
  - Weather forecast
- Economics
  - Price of yield
  - Cost of fertilizer

with uncertainties

Numeric Simulation

- **Inputs**
  - **Given place and management resulting in an estimated production function with uncertainties**
  - **Given time resulting in adjusting production function and derivation of the profit function, with uncertainties, for current conditions**
- **Outputs**
  - **Probability of a positive net return over cost of fertilization for each possible rate**
  - **Rate of fertilization with the greatest expected net return over cost of fertilization (e.g., profit)**

Objective function:

$/ha → MAX

Activity

- Work on uncertainties affecting N management decisions
  – Weather, soil, economics
- Interactions with management
  – Source, time, place, rate, amendment, tillage
- Tools
  – Meta-analyses, sensitivity analyses, modeling
- Results expected
  – Guidelines for better successes in N decisions