IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

GRAND CHALLENGES
GREAT SOLUTIONS

ASA, CSSA, & SSSA International Annual Meeting
Nov. 2-5, 2014 | Long Beach, CA

Developing Credible Models to Adapt Crop Nutrient Management to Weather

Tom Bruulsema, Director, Northeast Region, IPNI

Agrium Inc.

Arab Potash Company

Belarusian Potash Company

BHP Billiton

CF Industries Holdings, Inc.

Compass Minerals Plant Nutrition

International Raw Materials LTD.

Intrepid Potash, Inc.

K+S KALI GmbH

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Qatar Fertiliser Company (QAFCO)

Shell Sulphur Solutions

Simplot

Sinofert Holdings Limited

SQM

Toros Tarim

Uralchem

Uralkali

Formed in 2007 from the Potash & Phosphate Institute, the **International Plant Nutrition Institute** is supported by leading fertilizer manufacturers.

Its mission is to promote scientific information on responsible management of plant nutrition.

Adapting Crop Nutrition to Weather
OUTLINE

1. **Scope of the weather effect on nitrogen**
2. **Experiences in on-farm validation & adaptive management**
3. **Phosphorus**
4. **Sustainability**

- *Slides: available at* ***http://nane.ipni.net***

nutrient stewardship

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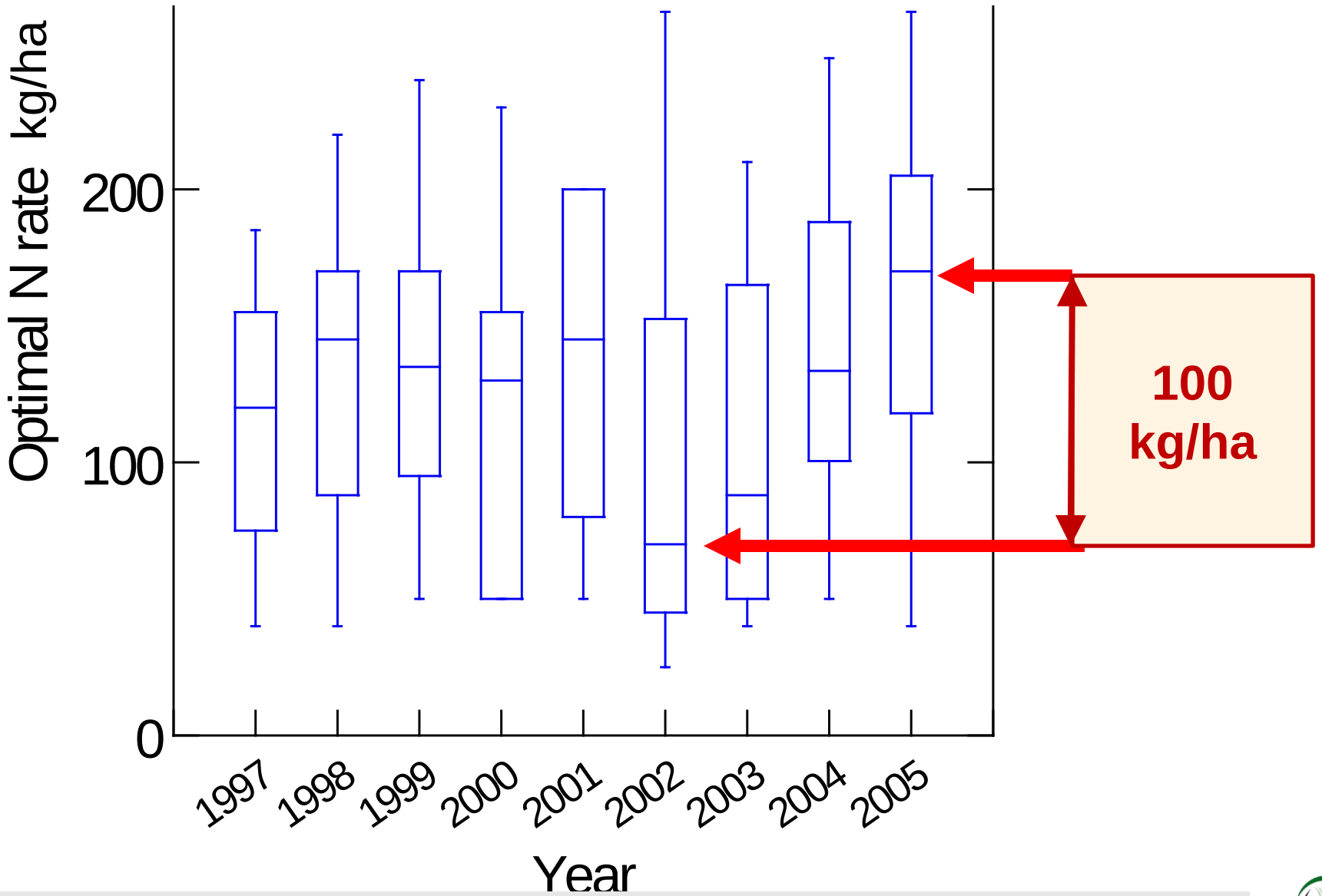
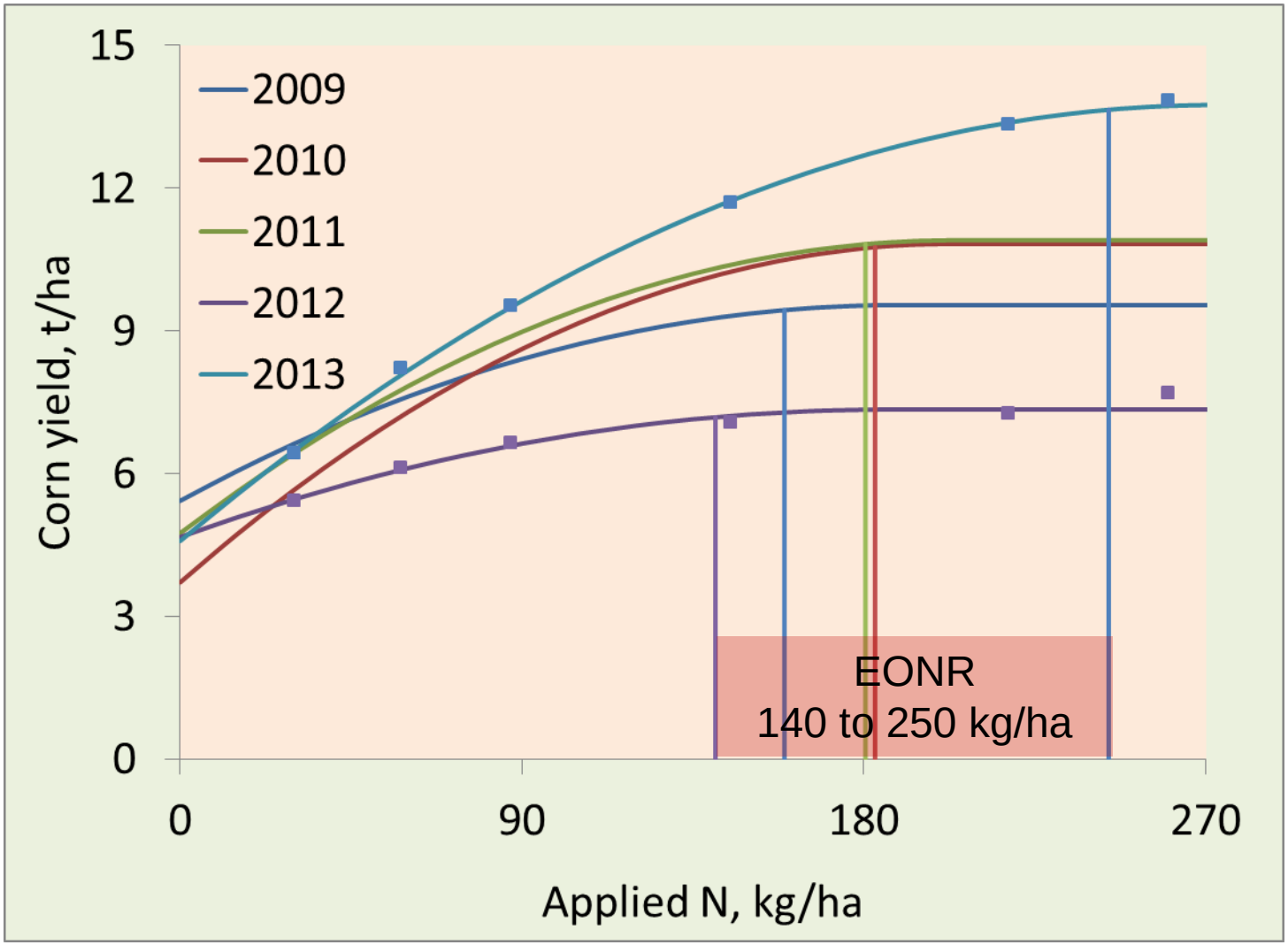
Median optimal N rates varied widely among years in Quebec corn response trials



Tremblay, et al. 2007. Managing crop nitrogen for weather.

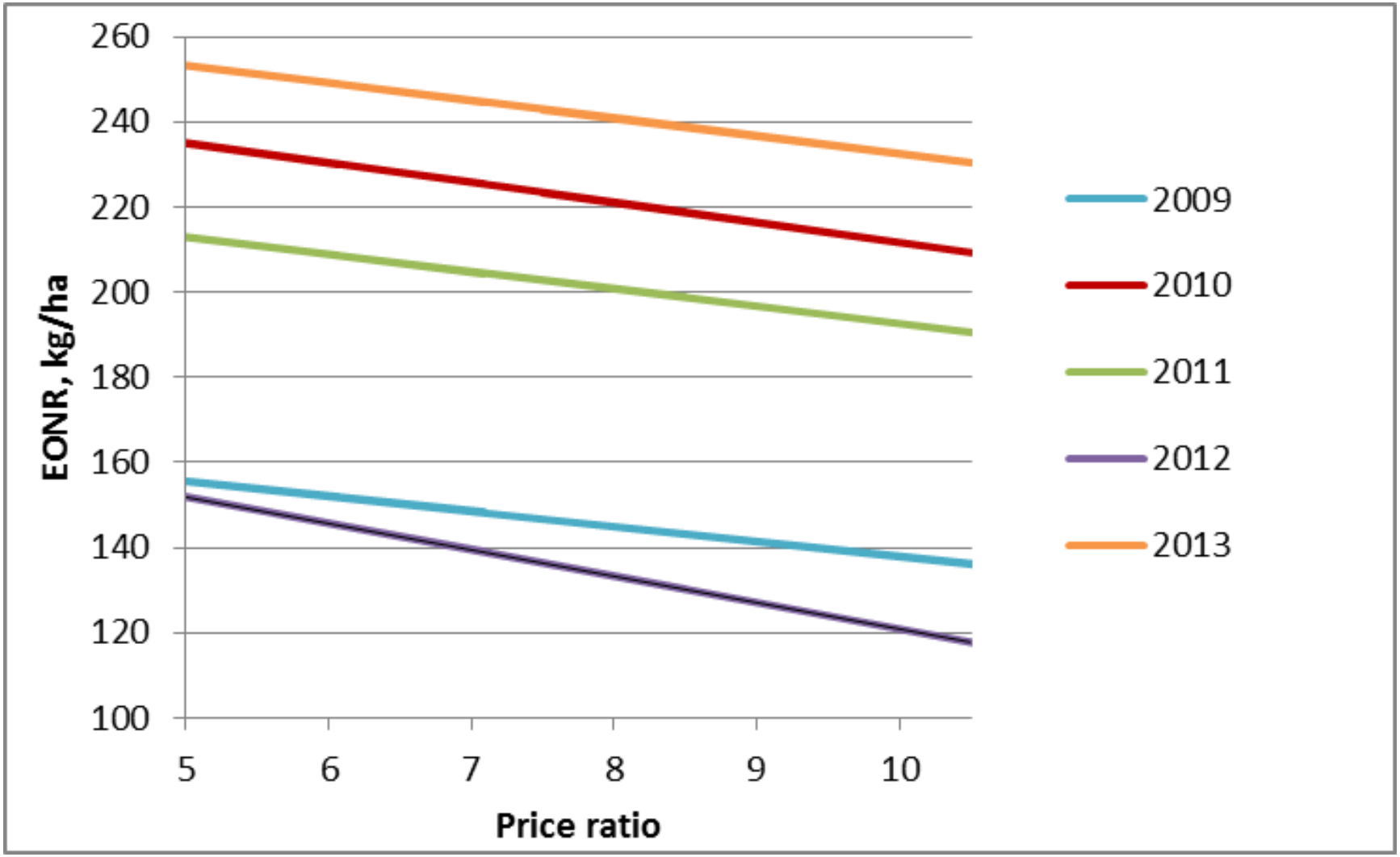
Weather influences corn yield response

first 5 years, Elora, Ontario (IPNI-2008-CAN-ON29)



Deen, Lauzon, Stewart, & Bruulsema; not yet published.

EONR response to price ratio, 2009-2013



Deen, Lauzon, Stewart, & Bruulsema; not yet published.

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Year-to-year differences in response affect potential profit more than price ratio differences

Year	2009	2010	2011	2012	2013	5-year mean
price ratio (PR)	10.5	5.4	5.1	6.2	6.1	6.7
EONR(PR), kg/ha	144	188	187	146	248	182
EONR(6.7), kg/ha	161	184	182	143	246	183
ONCR(PR), kg/ha	133	168	169	162	163	166
EONR(PR) - EONR(6.7), $/ha	$5.31	$ 0.48	$ 1.03	$0.16	$ 0.16	**$ 1.43**
EONR(PR) - ONCR(PR), $/ha	$2.12	$13.67	$11.51	$5.20	$204.28	**$47.35**

EONR = economically optimum N rate, by curve fit
ONCR = Ontario N calculator recommended rate

1. **Adjusting for price ratio if EONR is known provides little profit.**
2. **Improving ONCR to = EONR potentially provides 33X more profit.**

Deen, Lauzon, Stewart, & Bruulsema; not yet published.

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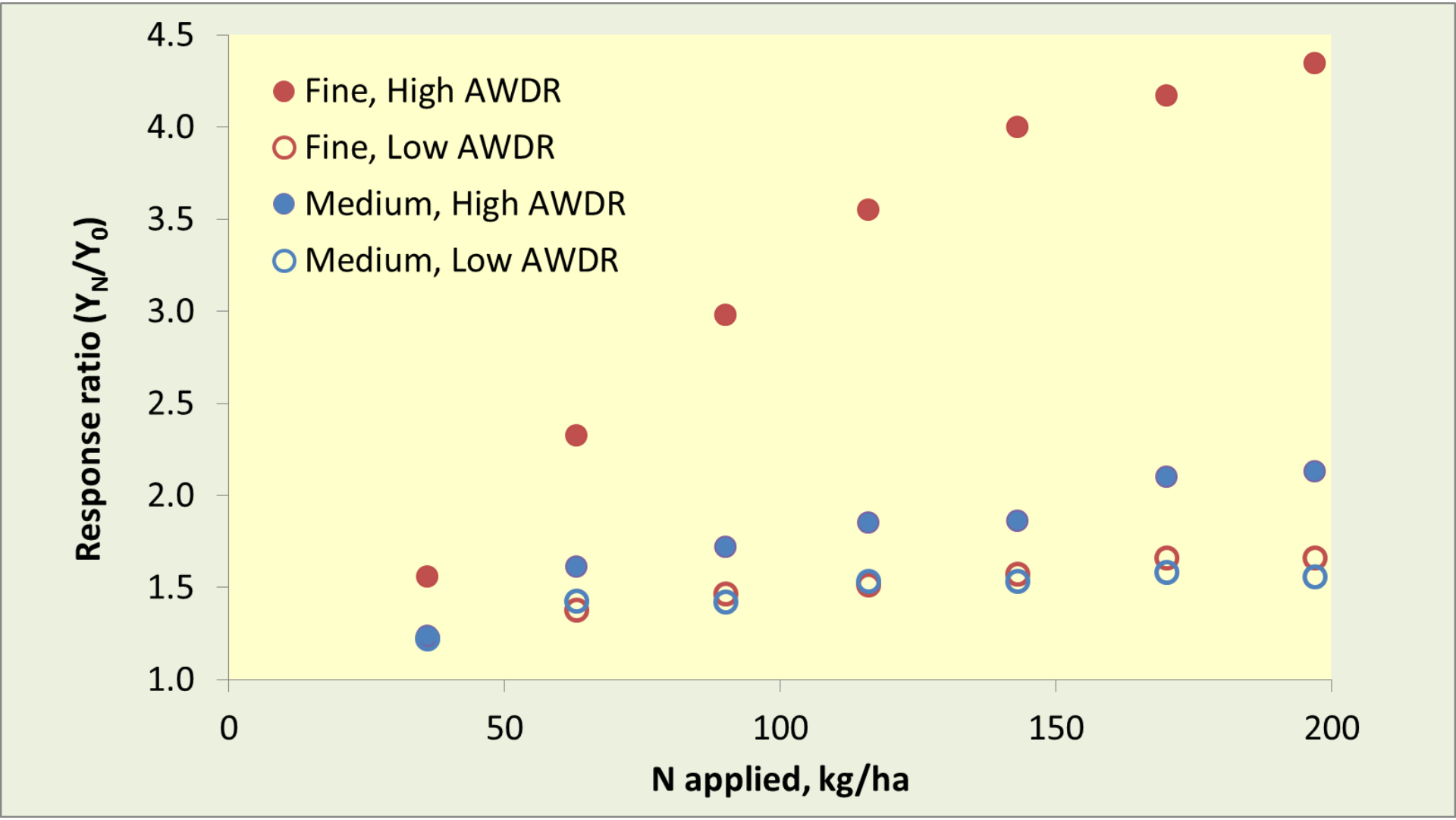
Different soils respond differently to weather

Meta-analysis of North American corn N responses



AWDR = abundant and well distributed rainfall in early growth period

Parent et al., 2013, Better Crops; Tremblay et al., 2012, Agron J 104:1658-1671

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Why a modeling approach?

- Integrate crop demand, soil supply, soil loss
  - Complex processes
  - Each driven by past, current and forecast weather
- Ease of user experience
- Integrates information from sampling, testing, and sensing
- N and P differ
  - Economic and environmental impacts for N
  - Managing runoff risks for P

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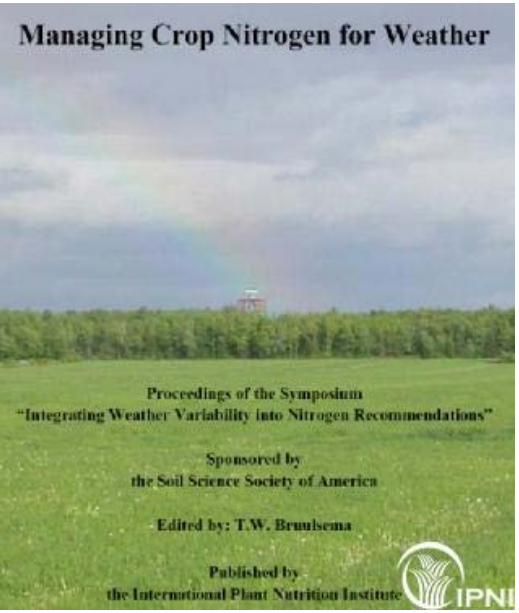
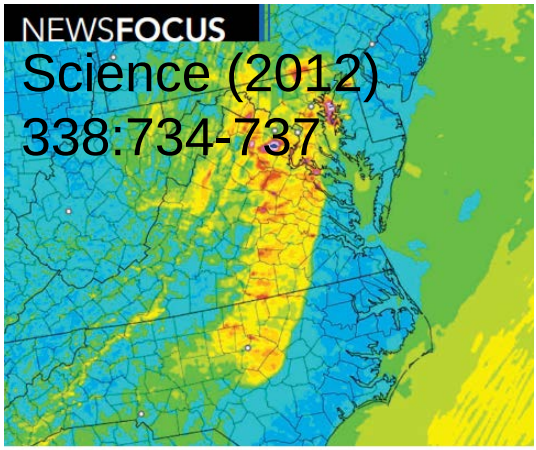
Improving nutrient use efficiency depends on adapting management to weather

❖**STRATEGY**

Support development of decision support systems that account for weather.





Weather Forecasts Slowly Clearing Up

Ever-increasing computer power and new kinds of observations are driving weather prediction to new heights, but some kinds of weather are still not yielding

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Current initiatives

- Empirical – Tremblay, Kitchen, et al (2012)
- NLOS – Bittman & Hunt, Agriculture and Agri-Food Canada
- Climate Corp – Monsanto
- Encirca – DuPont-Pioneer
- 360 COMMANDER – Gregg Sauder
- Adapt-N – Cornell U and Agronomic Technology Corp (ATC)

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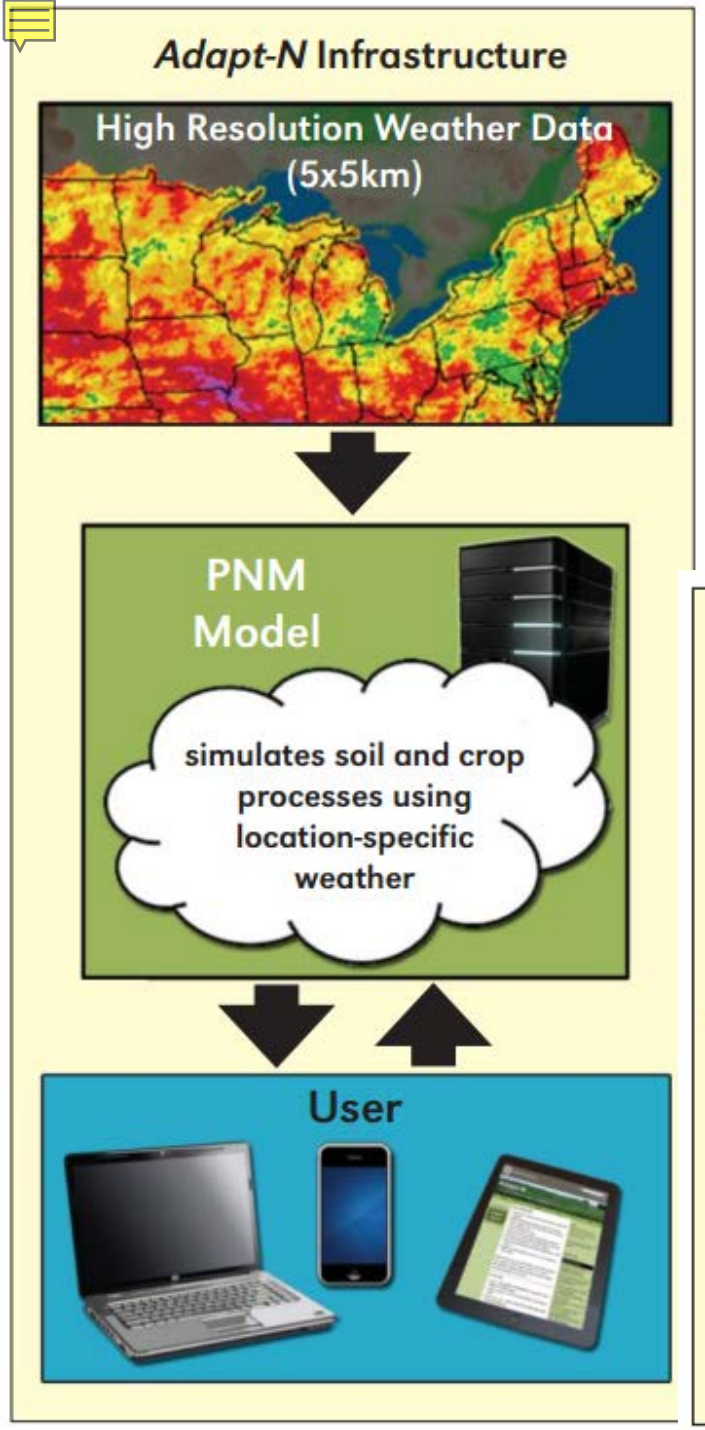
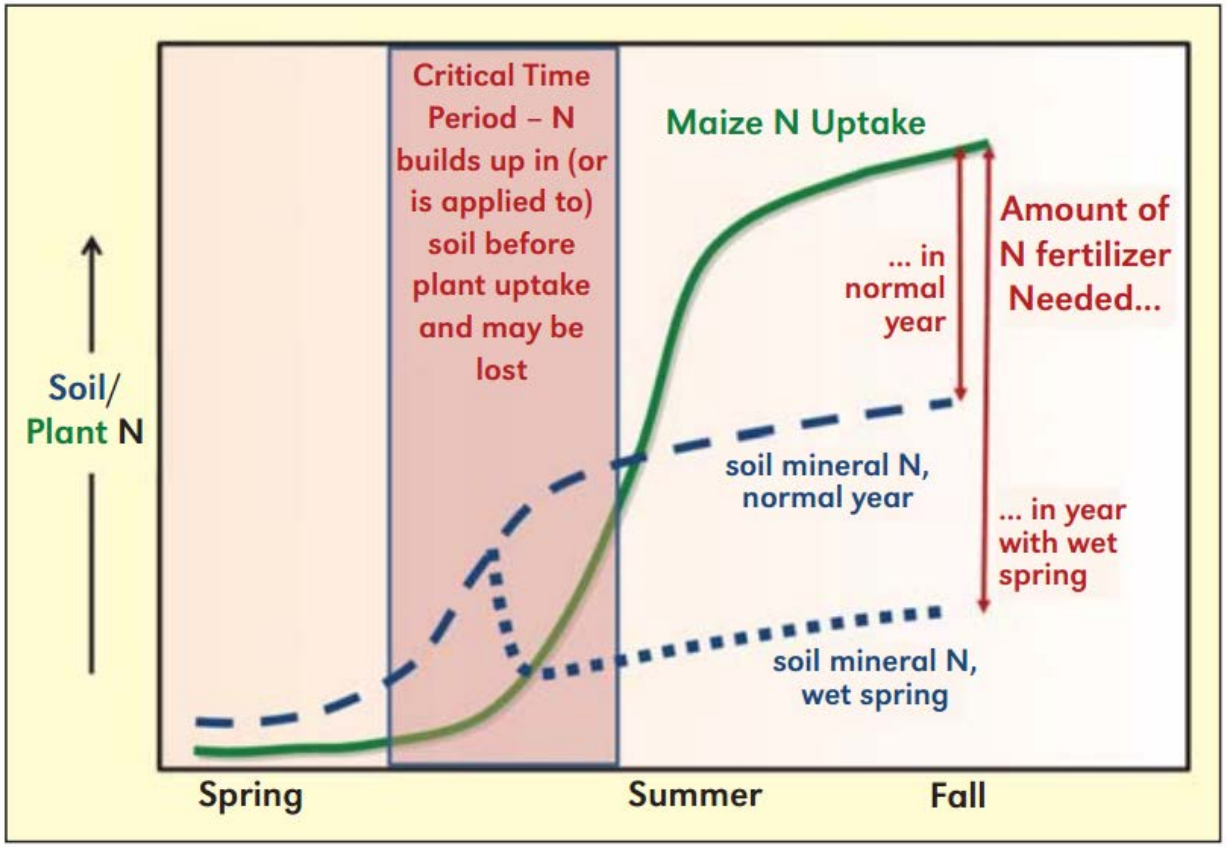
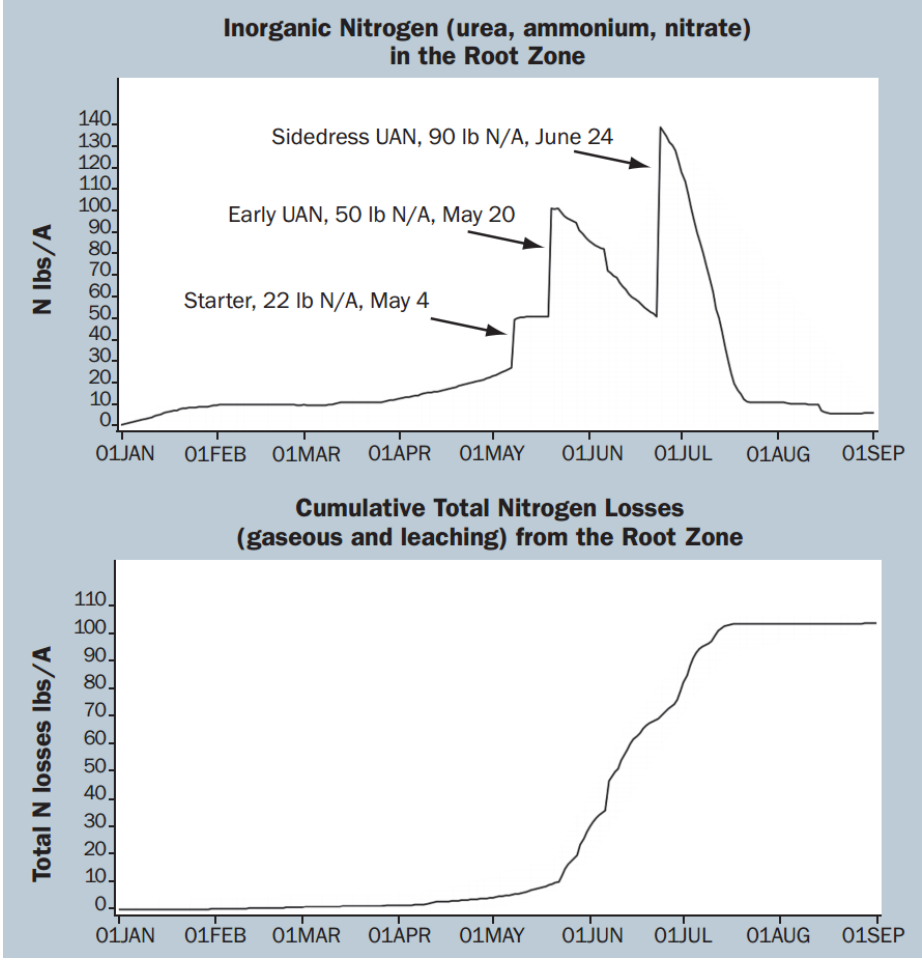
Common elements of model-based nitrogen decision support





Adapt-N validation in NY

The Richardson Farm crew (left to right): Arnold, Eric, and Ryan Richardson and Nick Humphrey.



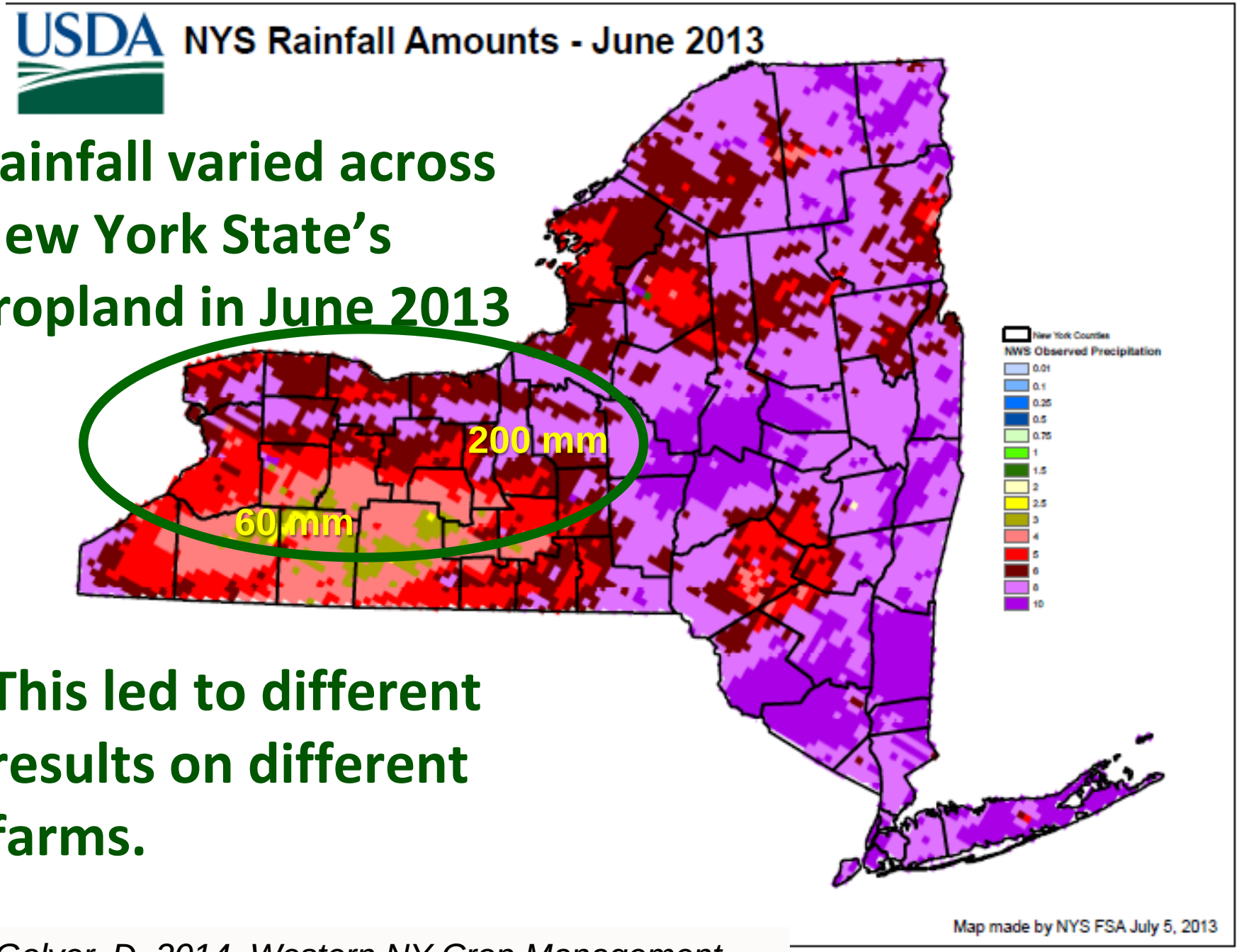
- 2013: ↑ N rates by 22-44 kg/ha, ↑ yields by 1.4-1.9 t/ha, ↑ profit $225-$300/ha.
- "Arnold and sons were struck by the tool's graphs of soil N availability and rainfall, which clearly showed the farm's weather-related early N losses."
- 2011-2012: ↓ <u>average</u> N rates by 74 kg/ha, ↑ profit by $77/ha.

Ball, Moebius-Clune, van Es & Melkonian. 2014. IPNI 4R Plant Nutrition Manual Case Study 7.4-4

“Sidedress”

- Traditionally, coulter injection at 15-30 cm plant height
- On-farm in NY – high-clearance drop tubes provide more flexibility in application timing
- UAN with urease inhibitor

DeGolyer, D. 2014. Western NY Crop Management



Rainfall varied across New York State's cropland in June 2013

This led to different results on different farms.

DeGolyer, D. 2014. Western NY Crop Management

Farm 1 (Branton): 400 mm rain in the month of June

TREAT MENT	N at planting, kg/ha	Yield goals, t/ha	Adapt N rec, kg/ha	Sidedress N rate, kg/ha	Grain yield, t/ha
CHECK	160	12.6	140	0	11.8
SIDEDRESS	160	12.6	140	67	13.9
CHECK	156	11.3	118	0	10.3
SIDEDRESS	156	11.3	118	67	12.9

With high June rainfall, response to sidedress is large, even with rates lower than recommended by Adapt-N.

DeGolyer, D. 2014. Western NY Crop Management

Farm 2: Dueppengiesser Dairy Company

- Approximately 250 mm rain from mid May through June.
- Excellent soil health (loaded with earth worms) zone till, cover crops system, manure no till injected
- Late June: Corn looks very good. Uniform green color. By crop observation, would judge no additional N needed

DeGolyer, D. 2014. Western NY Crop Management

Farm 2 field strip plot results

Field	Treat ment	Years since sod	Starter N rate, kg/ha	Spring Manure, L/ha	Adapt N rec, kg/ha	Sidedress N, kg/ha	Yield at 32% DM, t/ha
A	N	2	56	84,000	**NONE**	79	**62**
	CHECK	2	56	84,000	**NONE**	0	**48**
B	N	4	36	103,000	79	79	**73**
	CHECK	4	36	103,000	79	0	**63**
C	N	3	36	103,000	N/A	79	**48**
	CHECK	3	36	103,000	N/A	0	**46**

Adapt-N 1 for 2. Field A had some tiles, but inadequate drainage – Adapt-N now corrected.

DeGolyer, D. 2014. Western NY Crop Management

DeGolyer's conclusions: Going forward

1. High N needed, **split application is highly recommended.** With highboy spray applicators, N can be applied on corn up to [2m] tall.
2. For late N applications, at least [67 kg N/ha] up front (except alfalfa sods or spring injected manure). It is critical not to run out of N before pre-tassel.
3. Adapt N is still a tool. Will still need to scout!
4. In 2013, fields in the southern tier and southern Wyoming and Livingston counties required no additional N [after planting].
5. Stabilizers will preserve N 2-4 weeks at most. N applied in late April would not have been preserved from the heavy rains in June.
6. **Ultimately farms should have a plan to apply more N in event of excessive rains.**

DeGolyer, D. 2014. Western NY Crop Management

Willard Agri-Service – DE & MD

- John Dantinne and Mike Twining
- Branding: Eco-N (Adapt-N agreement with Cornell, ATC)
- Automation/integration with HighQ
- 2014: >150 fields, at least one field for each sales rep. Growers generally pleased with recommendations, yields up to 15 t/ha
- Compared to other approaches to N management (PSNT, CSNT, sensors): **more potential to implement commercially; more comprehensive**
- Toughest challenge: **tracking applications**
- Why Adapt-N? 1) university-based, 2) developed for East Coast, 3) scientist engagement – visits to the field
- Expect recs to improve within 3 years
- Nutrient interactions

Dantinne, J. October 2014.

Key learnings from experiences

- Corn growers are asking in June whether additional N is needed
- Many alternative methods (e.g. PSNT) are much more difficult to implement than a model
- Growers can learn from a process-based model
- Data management a big challenge
- Scientist developing the system needs to be engaged in the on-farm validation

Some comments on phosphorus

4R Nutrient Stewardship Certification Standard

Requirements for Certification of Nutrient Service Providers in the Lake Erie Watershed

Excerpt from recommendation standards:

3.5.7 Broadcast applications of nitrogen and phosphorus without immediate incorporation are neither made nor recommended unless the NOAA forecast indicates less than a ***50% chance of a rainfall event involving more than an inch of rain beginning in the next 12 hours.***

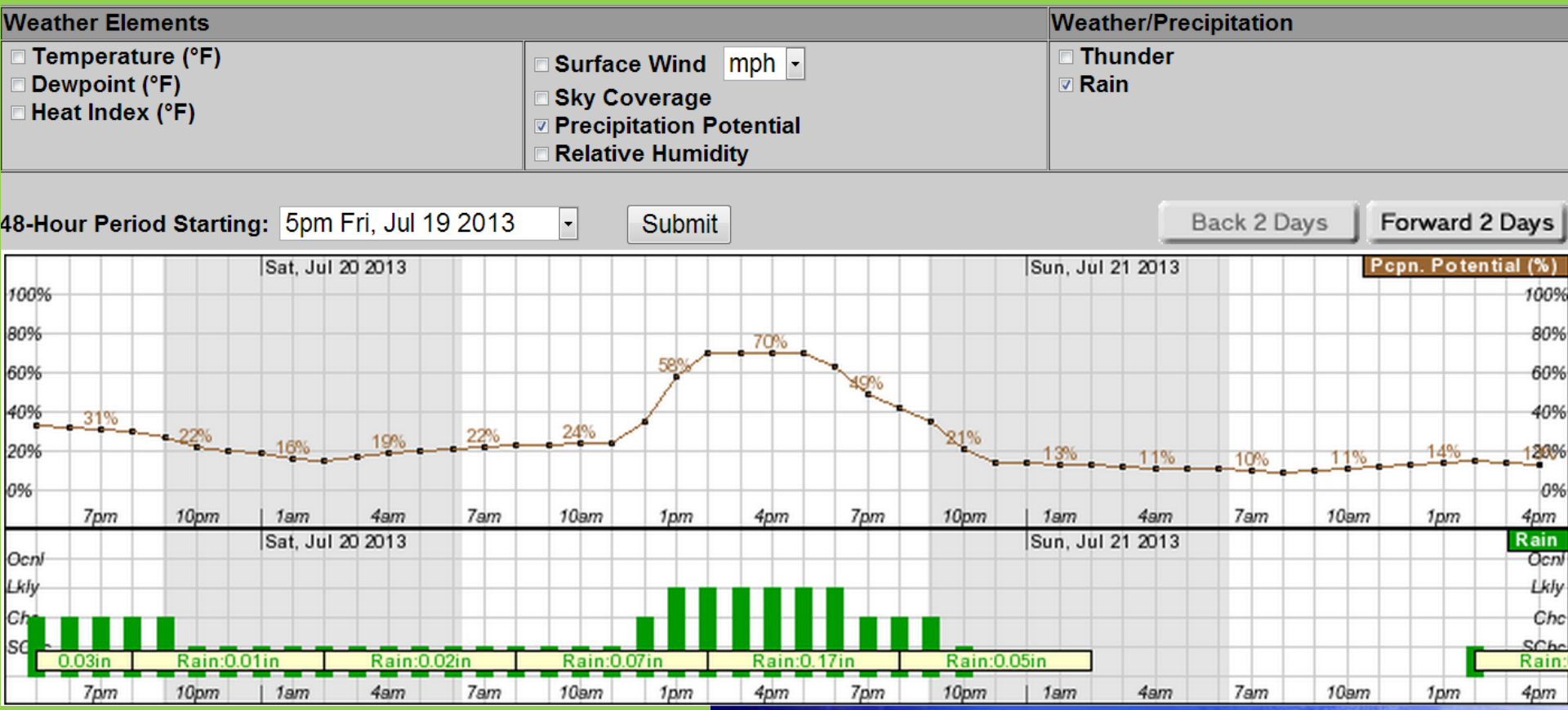
- Basis?
- Applicable to all soils?
- Important: >50% of applied P is broadcast

Version 2.1

April 2014

NUTRIENT STEWARDSHIP CERTIFICATION

Can weather forecast data be harnessed to drive a "safe time to broadcast P" decision support tool?



PoP x
Rainfall amount x
Soil infiltration capacity
= time to stop broadcast?

Opportunities for DSS for P

1. A web-based tool that integrates probabilities of rainfall that will or will not generate runoff specific to the field, could predict the risk of loss of P arising from a broadcast application.
2. On a larger scale, a modeling tool that assesses performance in retaining P given the weather conditions would help growers demonstrate the value of their BMPs including 4R nutrient stewardship.

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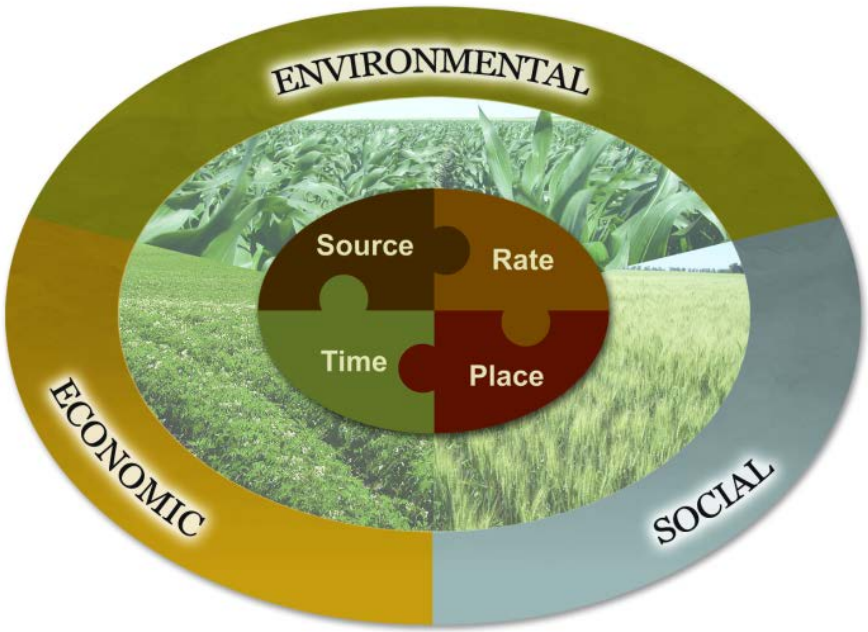
4R: “right” means sustainable



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4R PLANT NUTRITION

r4 nutrient stewardship

Summary – nutrient tools for weather

- On-farm validation through adaptive management is an essential step in the development of credible models that support responsible management of crop nutrition.
- It will take thousands of people with crop expertise to do this job, applying models over the wide range of farming conditions that exist.
- Everyone involved needs some level of understanding of the processes represented in the model.
- Key criteria for success:
  - engagement of the scientist in on-farm adaptation
  - transparency on how the model works
  - openness to local data sources

4 nutrient stewardship

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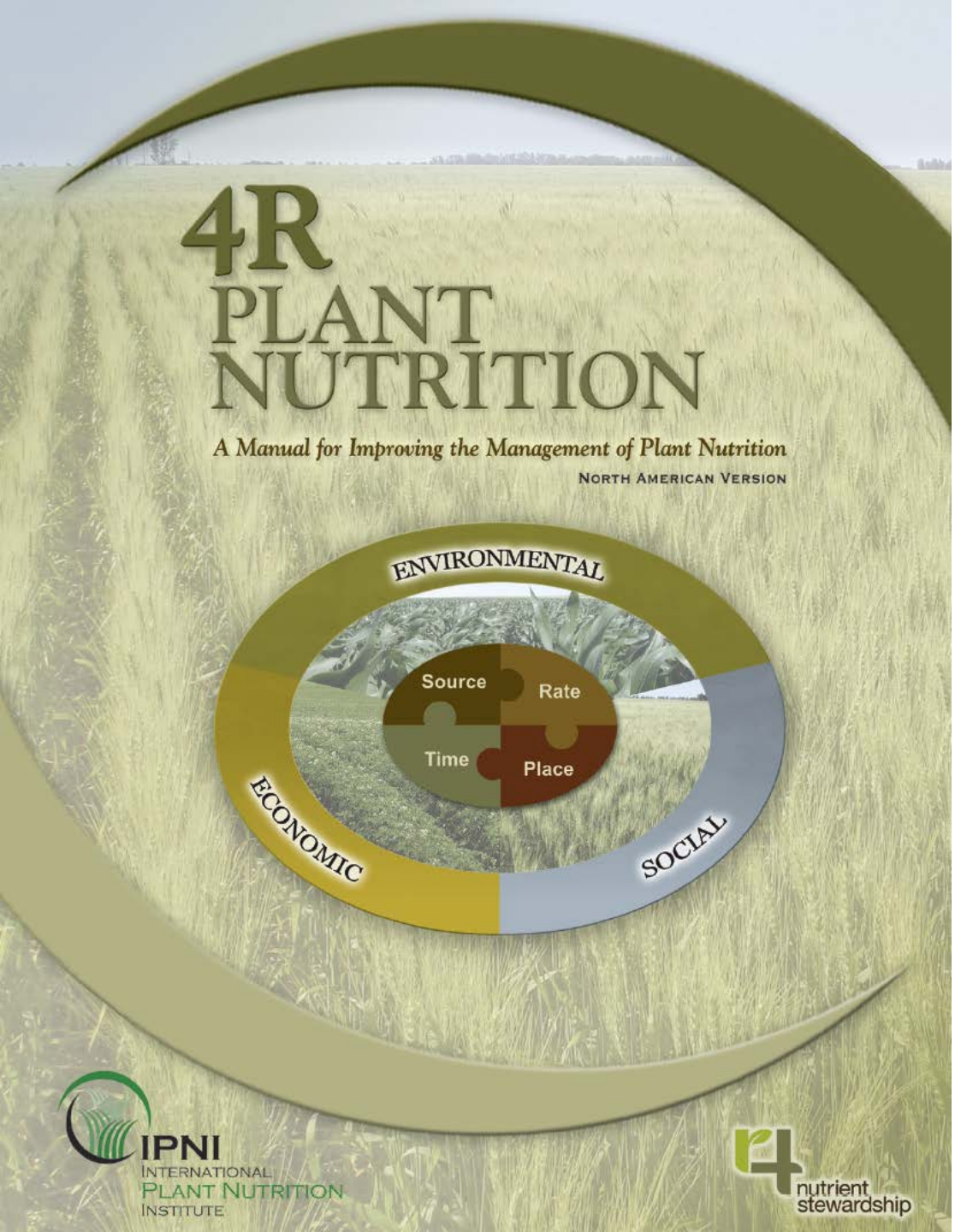

Thank You

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