



FERTILIZER CANADA
FERTILISANTS CANADA

4R Nutrient Stewardship

A Flexible Approach to Reducing GHG Emissions from Nitrogen Fertilizers

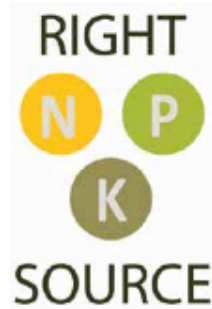
APAS April 2, 2019 Saskatoon

Dan Heaney PhD, CCA 4R, PAg



Right Source @ Right Rate, Right Time & Right Place

- » Right Source - What N sources reduce emissions?
- » Right Rate - How important is rate in determining emissions?
- » Right Time – Does time of application affect emissions?
- » Right Place – Does placement affect emissions?
- » Can I measure and monetize on my farm?



We're Growing Sustainability®

FERTILIZER CANADA ELEARNING

Getting started with Fertilizer Canada's eLearning platform is simple. The only requirement is a computer with internet access. Registration on the site only takes a minute and users will have immediate access to the training module. Students learn at their own pace and on their own schedule.

- 4R Essentials
- 4R Nutrient Stewardship Training (Parts 1-3)
- 4R GHG Reduction
- NERP
- 4R Saskatchewan

<https://fertilizercanada.ca/nutrient-stewardship/elearning/4r-nutrient-stewardship/>

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Fertilizer Canada's eLearning was developed to provide continuing education to fertilizer industry workers. Our goal is provide formal training, and to be seen as a guide, an informer, and a reference to you and all your Canadian fertilizer needs.

If you are a new eLearning member, please register at the link below – it only takes a second.
If you are a returning member, please use your username and password to login below.

- Go to elearning.fertilizercanada.ca
- Select "Register" at the bottom of the page
- Complete all the fields in order to register for eLearning
*Note: If you are not a Certified Crop Advisor, you may leave the "CCA Certification Number" blank
- Select "Submit Registration"
- You are now registered and can begin taking courses
- Fertilizer Canada's eLearning course list will appear on your screen
- You may begin taking the 4R Nutrient Stewardship Training - Part 1 by scrolling down to the course and selecting "Launch"

4R Nutrient Stewardship Training: Part 1, Part 2, Part 3

This 3 section course takes an in-depth look at the principles, practices and planning required to develop and implement a 4R Nutrient Stewardship plan on farm. Students wishing to obtain a certificate of completion and/or CCA CEUs must complete all of the section quizzes.

If obtaining CEUs are not a concern, the course is FREE with the following promo codes:
Part 1 Exam: Farmer1
Part 2 Exam: Farmer2
Part 3 Exam: Farmer3

A Certified Crop Advisor will get 5.5 Continuing Education Credits (CEUs) under Nutrient Management upon completion of all three modules of the course and the exam for a \$50 fee.


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4 nutrient stewardship



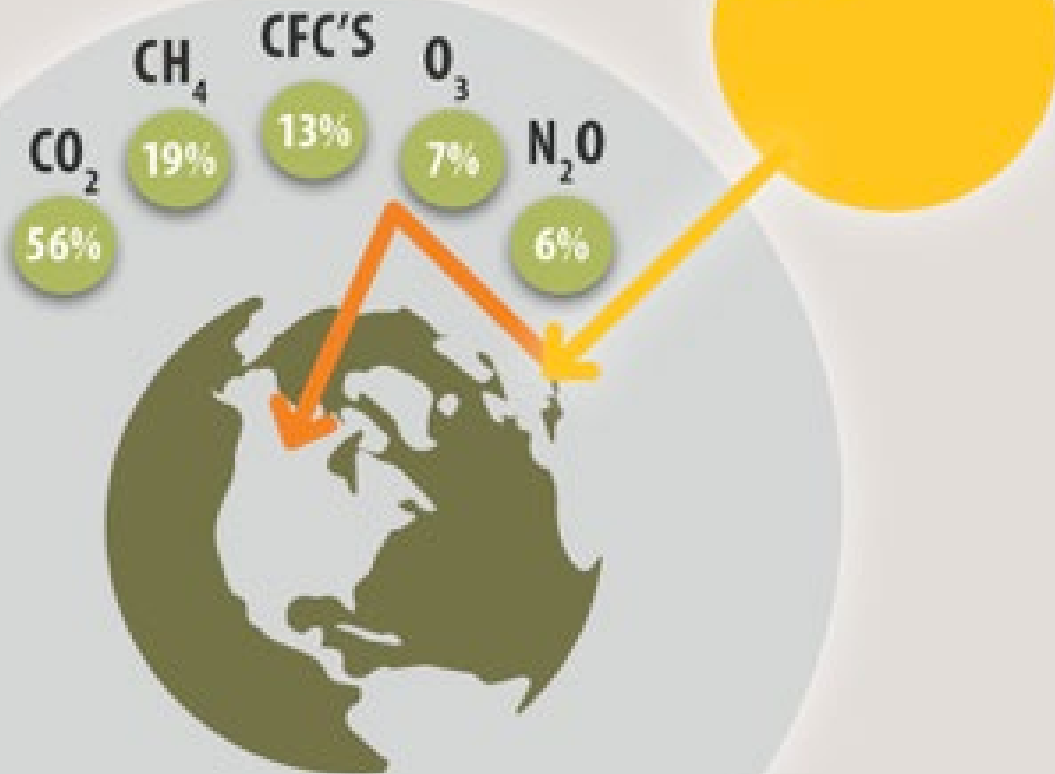
FAO CLIMATE-SMART AGRICULTURE

- HIGH PRODUCTION
- INTENSIFIED
- RESILIENT
- SUSTAINABLE
- LOW EMISSION

FAO	
HIGH PRODUCTION	4R SUPPORTS INCREASED PRODUCTION THROUGH BETTER MANAGEMENT
INTENSIFIED	4R ENCOURAGES HIGHER INTENSITY ON EXISTING FARMLAND
RESILIENT	4R PROMOTES CONSERVATION AGRICULTURE
SUSTAINABLE	4R SUPPORTS ECONOMIC VIABILITY, REDUCED ENVIRONMENTAL IMPACT AND SOCIETIES NEED FOR FOOD SECURITY
LOW EMISSION	4R REDUCES EMISSIONS PER UNIT OF CROP PRODUCED

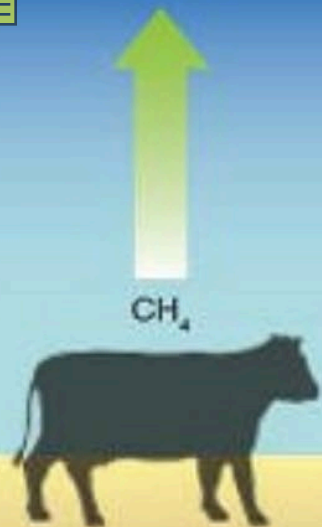
Important Greenhouse Gases

THE IMPORTANT HUMAN-PRODUCED GREENHOUSE GASES



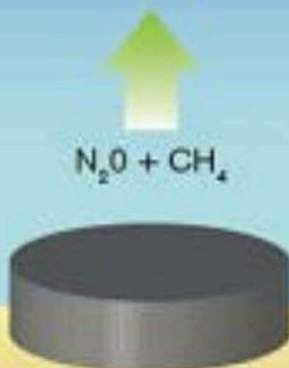
Global Warming Potential
1 kg N₂O = 298 kg CO₂

Carbon Dioxide Equivalents
or CO₂e



CH_4

Enteric Fermentation



$N_2O + CH_4$

Manure Management



N_2O

N_2O from Soils



CO_2

Soil CO_2 Exchange



N_2O

Indirect Emissions



ENTERIC
FERMENTATION



MANURE
MANAGEMENT



CROPPING
SYSTEMS



INDIRECT
EMISSIONS

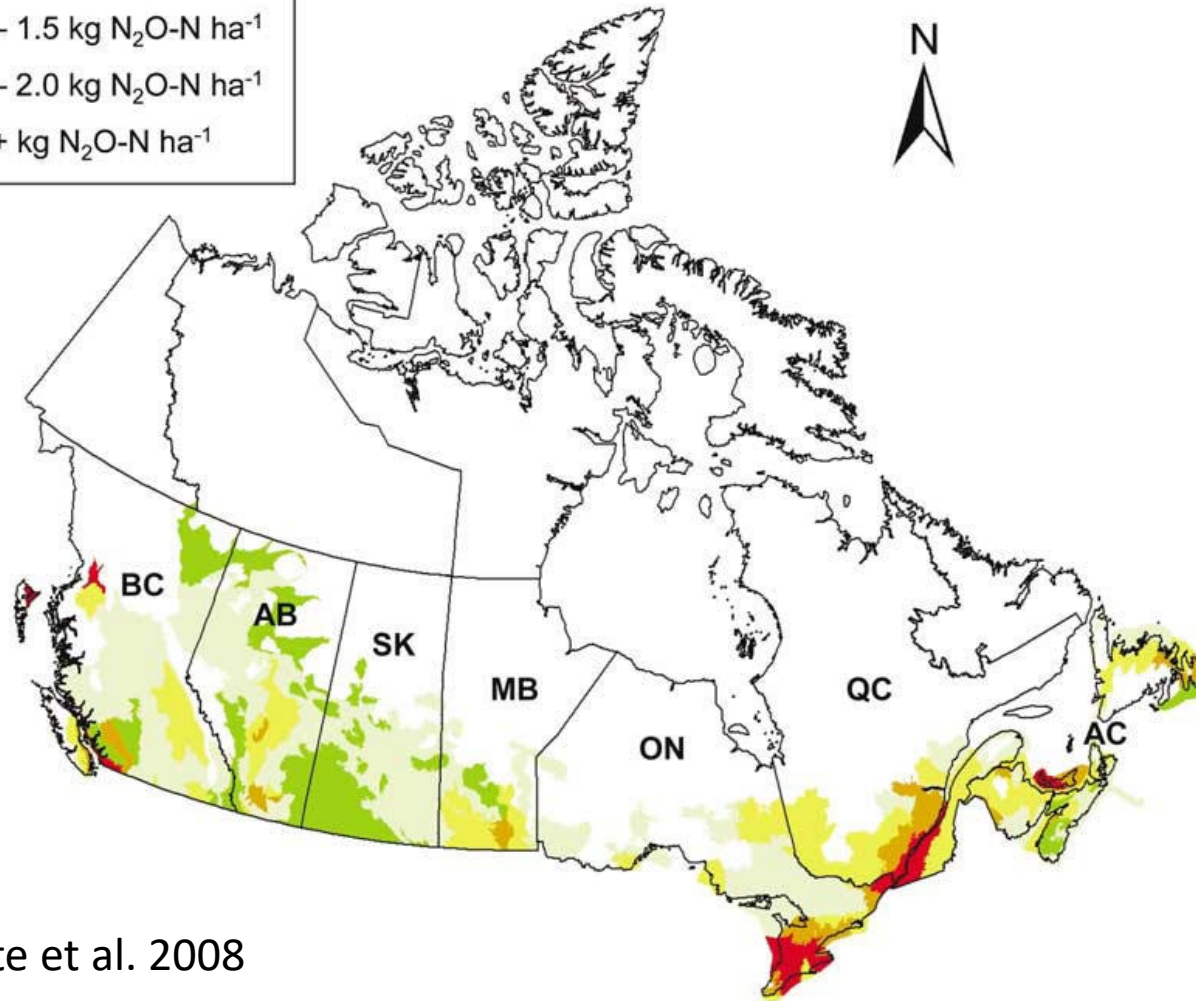
CANADIAN AGRICULTURE



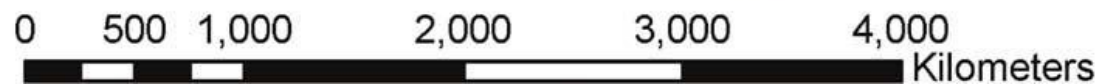
Legend

- 0 - 0.5 kg N₂O-N ha⁻¹
- 0.5 - 1.0 kg N₂O-N ha⁻¹
- 1.0 - 1.5 kg N₂O-N ha⁻¹
- 1.5 - 2.0 kg N₂O-N ha⁻¹
- 2.0 + kg N₂O-N ha⁻¹

1 kg N₂O-N = 469 kg CO₂e

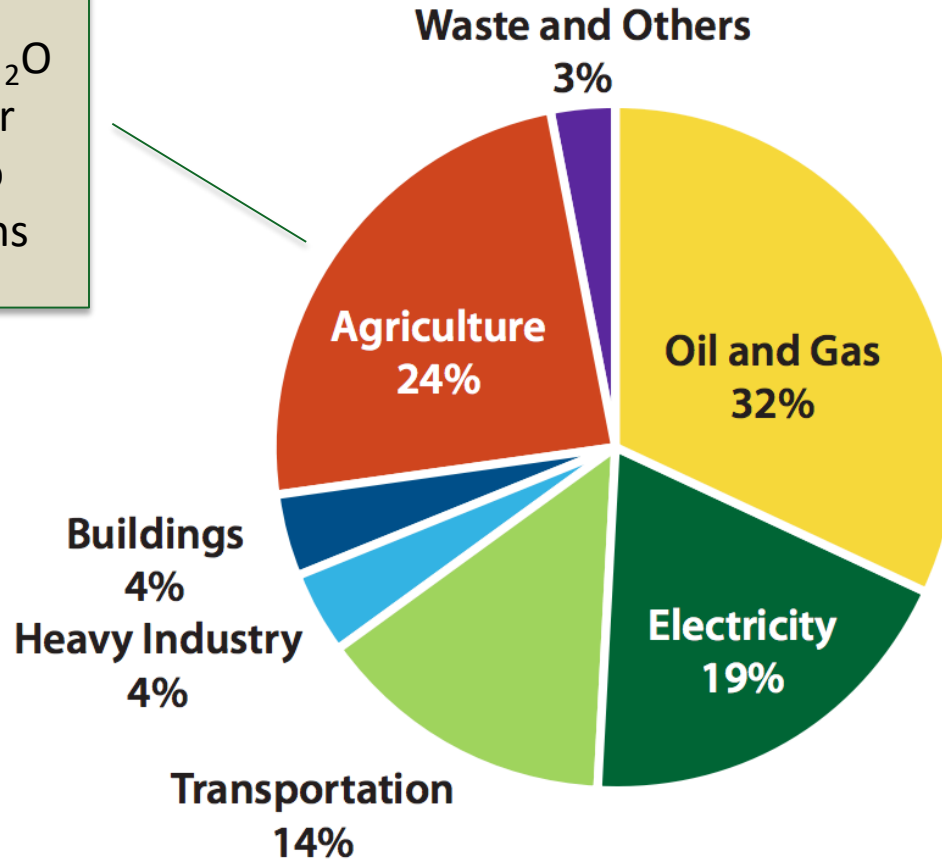


Source: Rochette et al. 2008



Saskatchewan's GHG Emissions by Economic Sectors (2015)

5-7 Mt CO₂e as N₂O from N fertilizer applications to cropping systems



0.15%

0.04%

0.015%

0.004%

Sask Total (2015) = 75.0 Mt CO₂e

Nitrous Oxide Emissions & Nitrogen Losses

Nitrous oxide emissions.....

- account for only a small fraction of N loss.
- are highly variable in space and time.
- are difficult (impossible on farm) to measure.
- are generally non-economic in Saskatchewan.

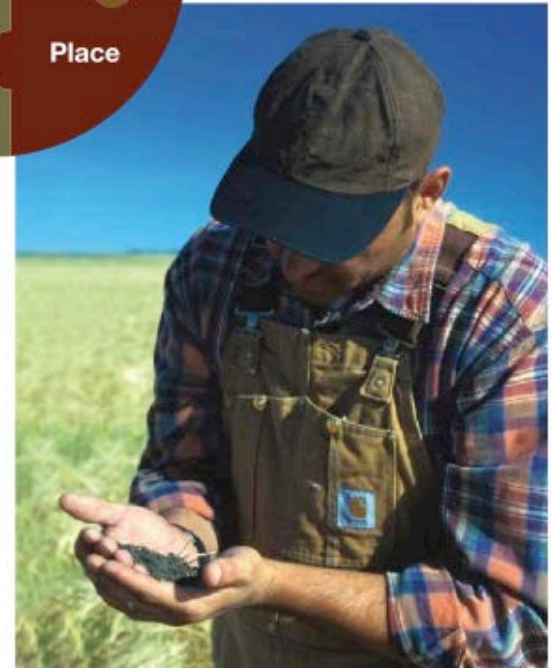
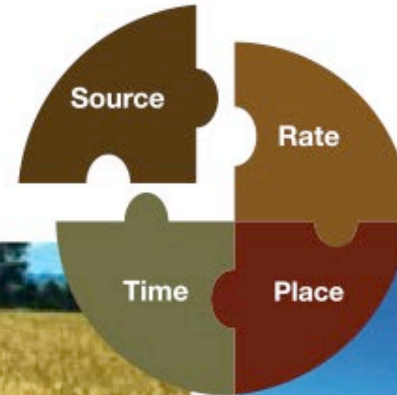
Nitrogen losses.....

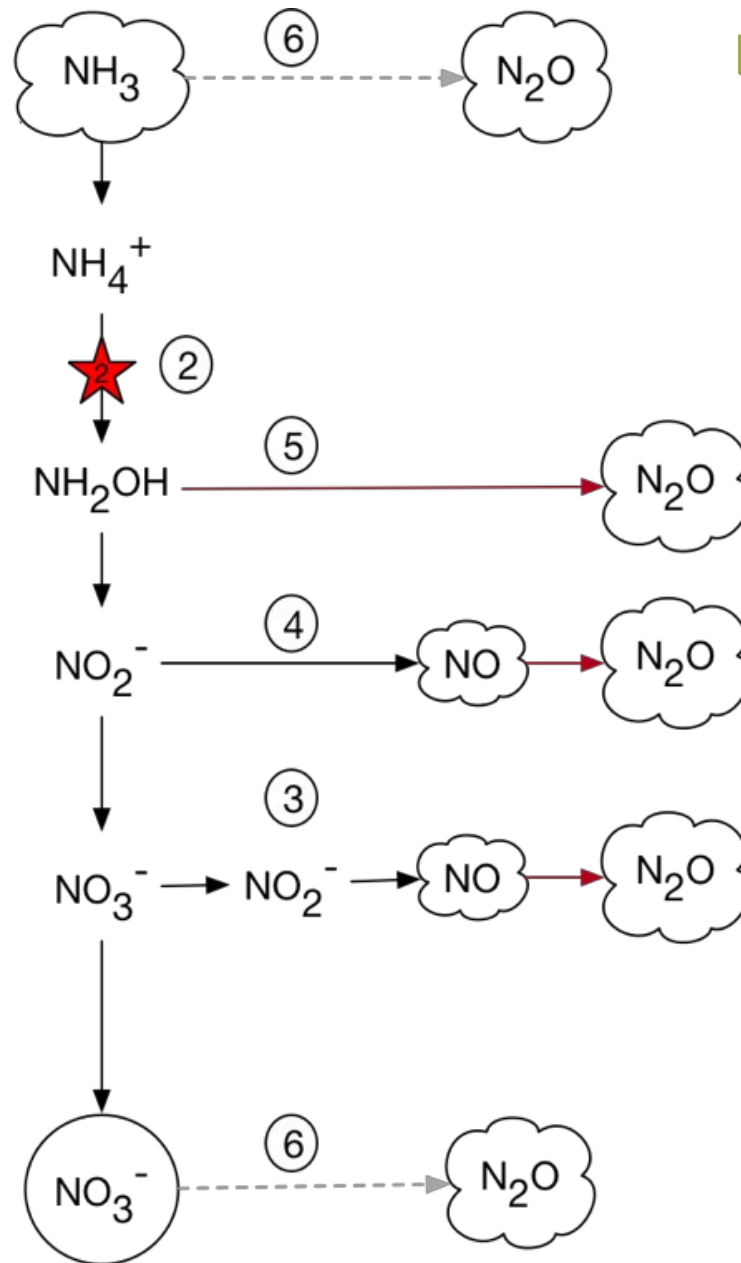
- contribute to indirect nitrous oxide emissions.
- are highly weather and landscape dependent.
- can be measured on farm.
- can have significant economic impact.



Right Source

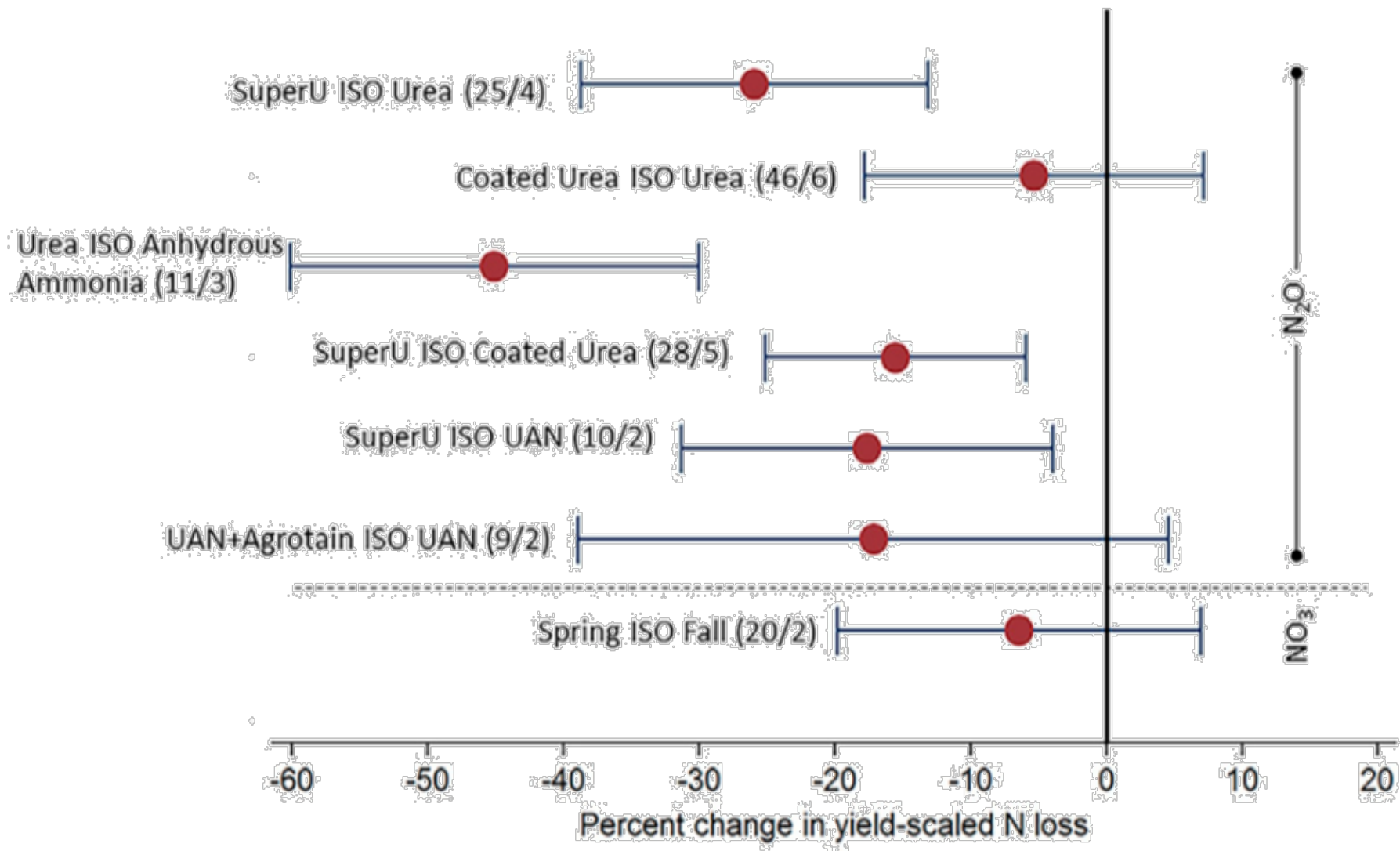
- » What sources reduce nitrous oxide emissions?
- » Are there any nutrient interactions (+ or -)?
- » The other 4Rs – Right Rate, Right Time, Right Place?





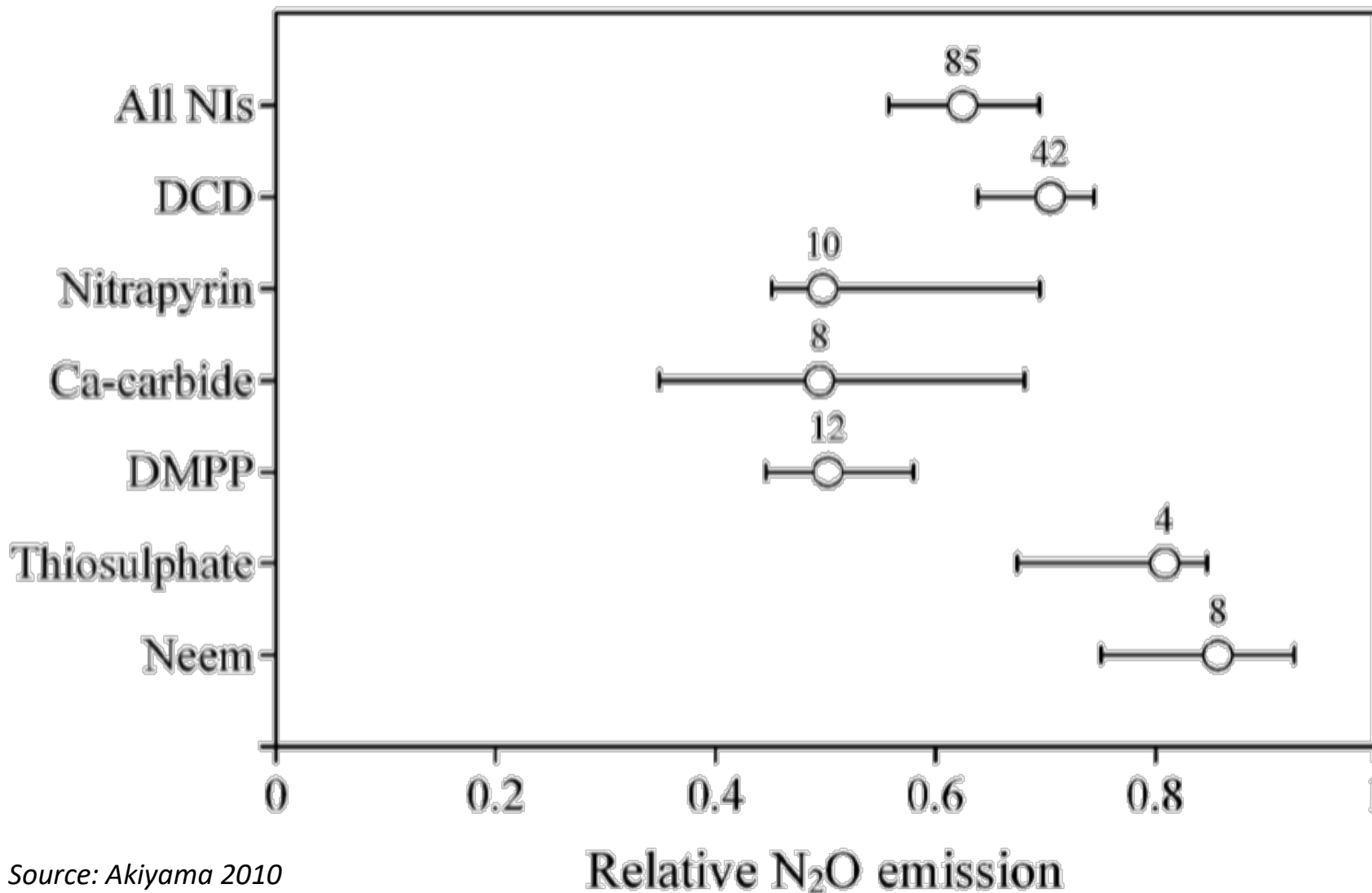
Source: Burton 2018

N Product Comparisons



Source: Eagle et al. 2017

Nitrification Inhibitors



Source: Akiyama 2010

Nitrous Oxide Reductions

Source	Reduction
Nitrification Inhibitors	35%
Urease Inhibitor* + NI	25%
Urease Inhibitor*	Highly Variable
Polymer Coated Urea	10%

Source: Burton 2018

❖ Right Time

- Crop stage and timing of plant uptake.
- Dynamics of soil nutrient supply.
- Timing of nutrient mobility and loss.
- The logistics of on-farm field operations.





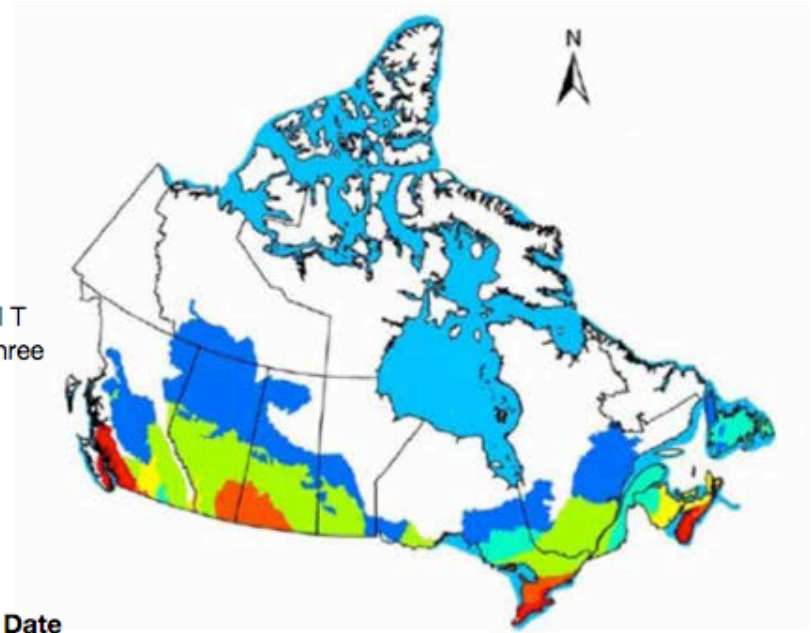
Nutrient Uptake & Loss

»Weather (moisture and temperature)







»Soil physical and chemical properties

»Best Management Practices

Average Date for Soil T less than 10 °C for Three Consecutive Days



Legend ecoregions Date

	Sept 26 to Oct 7		Oct 8 to Oct 12
	Oct 13 to Oct 17		Oct 18 to Oct 22
	Oct 23 to Oct 27		Oct 28 to Nov 4



Denitrification Losses

» Spring flooding can cause losses of fall applied N and residual N by denitrification.

» Soils can lose 2 – 4 lbs N/acre/day at 5°C.

» 15 – 30 lbs of $\text{NO}_3\text{-N}$ /acre/week could be lost.



Picture source: Farmwest

Right Time

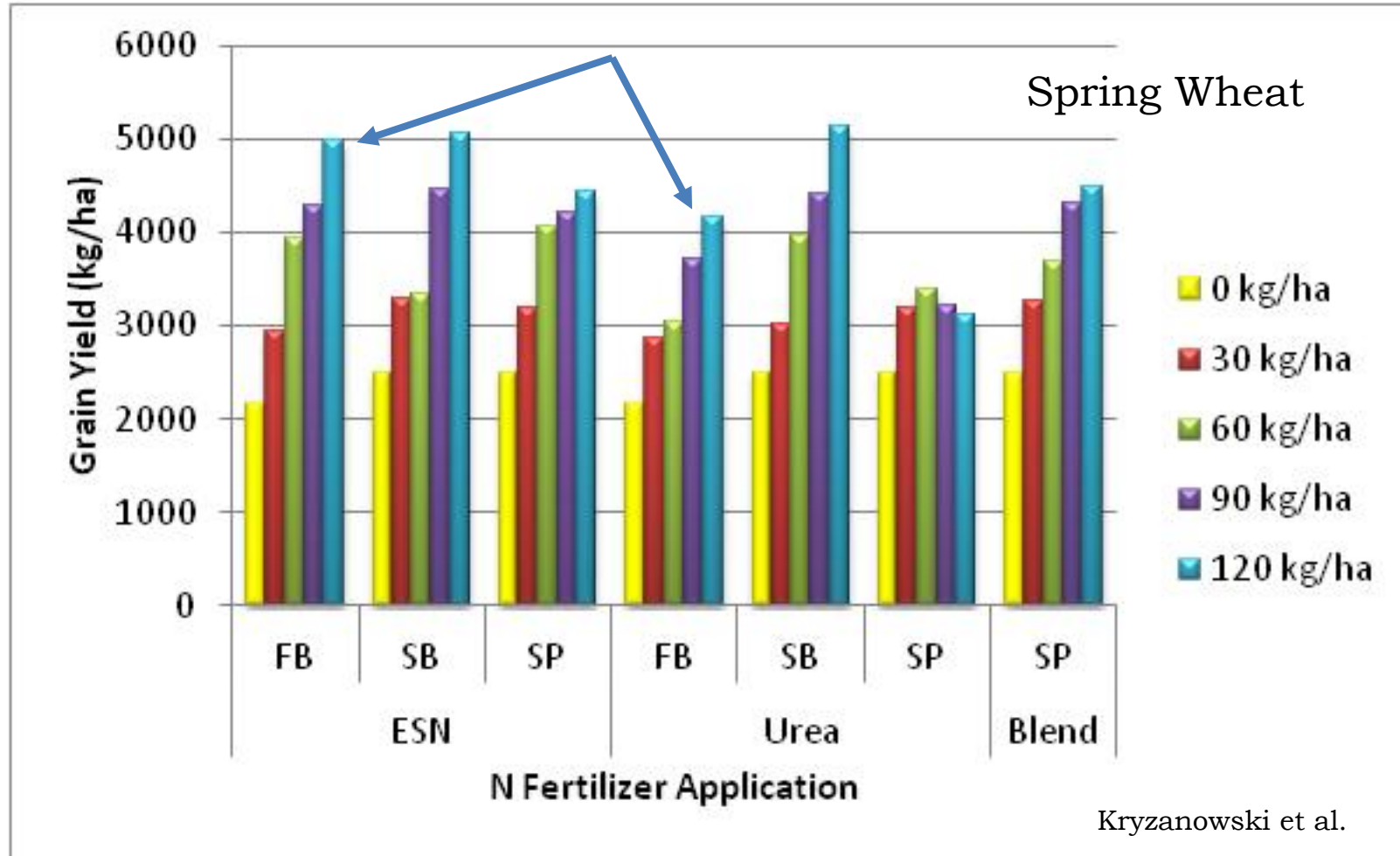
BMP	ISO	GHG Reduction
Delay fall application of N until the soil has cooled to below 10° C or the use of an inhibitor.	Early fall-application of unprotected N.	30%
Switch to spring application.	Early fall-application of unprotected N.	20%
Split Application.*	All N at or before seeding.	15%

* With sub-surface placement or EEF source.

Source: Burton (2018)



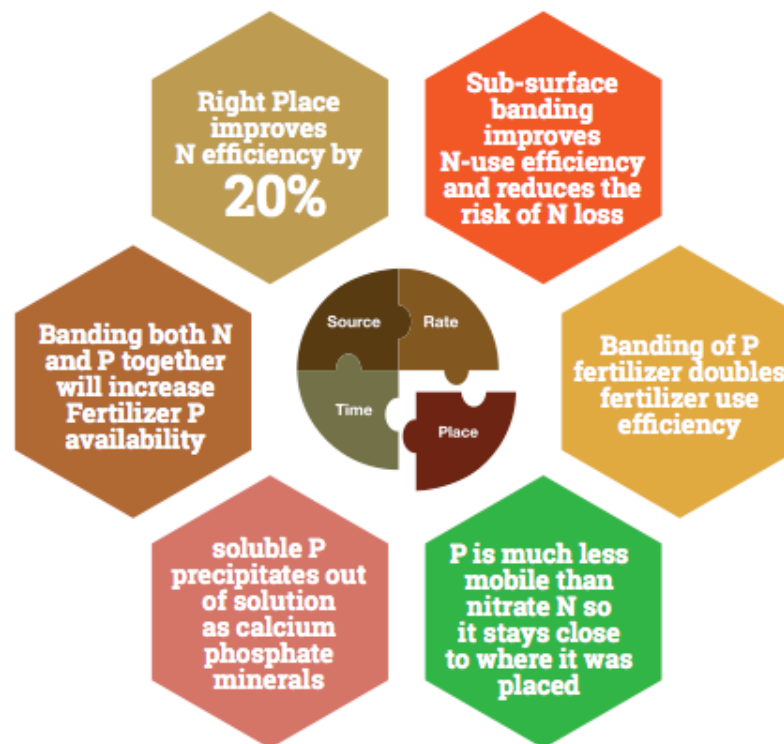
Time-Place Interaction and Crop Yield





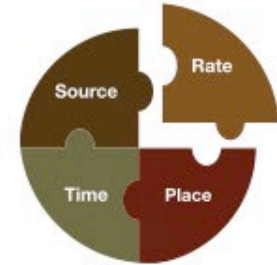
Fertilizer Placement

- » Sub-surface banding improves N-use efficiency and reduces the risk of N loss.
- » Depth > 5 cm are effective at reducing N₂O emissions.





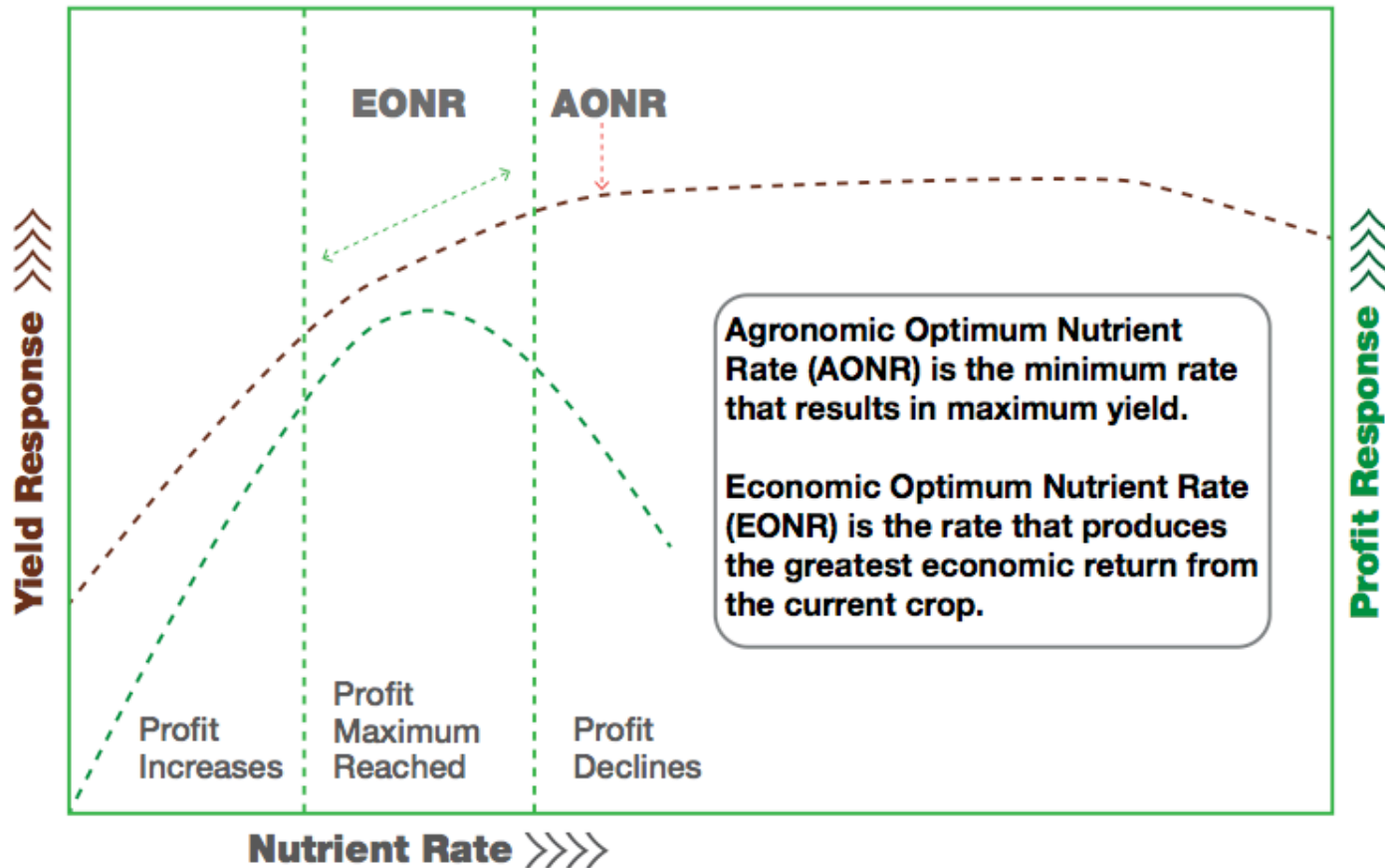
Right Rate



- >> Source, Time, Place BMPs may allow for reduced rates.
- >> Excess rates result in higher N₂O emissions and higher N losses.
 - overwinter losses
 - in-season losses
 - residual post-harvest losses
- >> Resilient cropping systems mineralize more N.
- >> Fertilizer N is more efficient under better moisture.

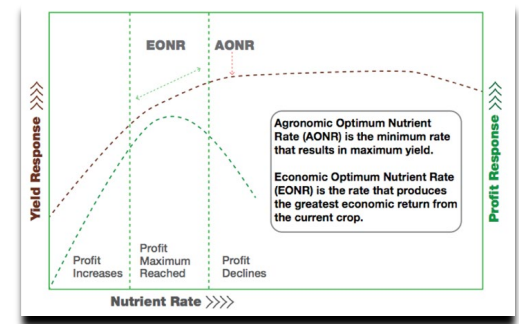
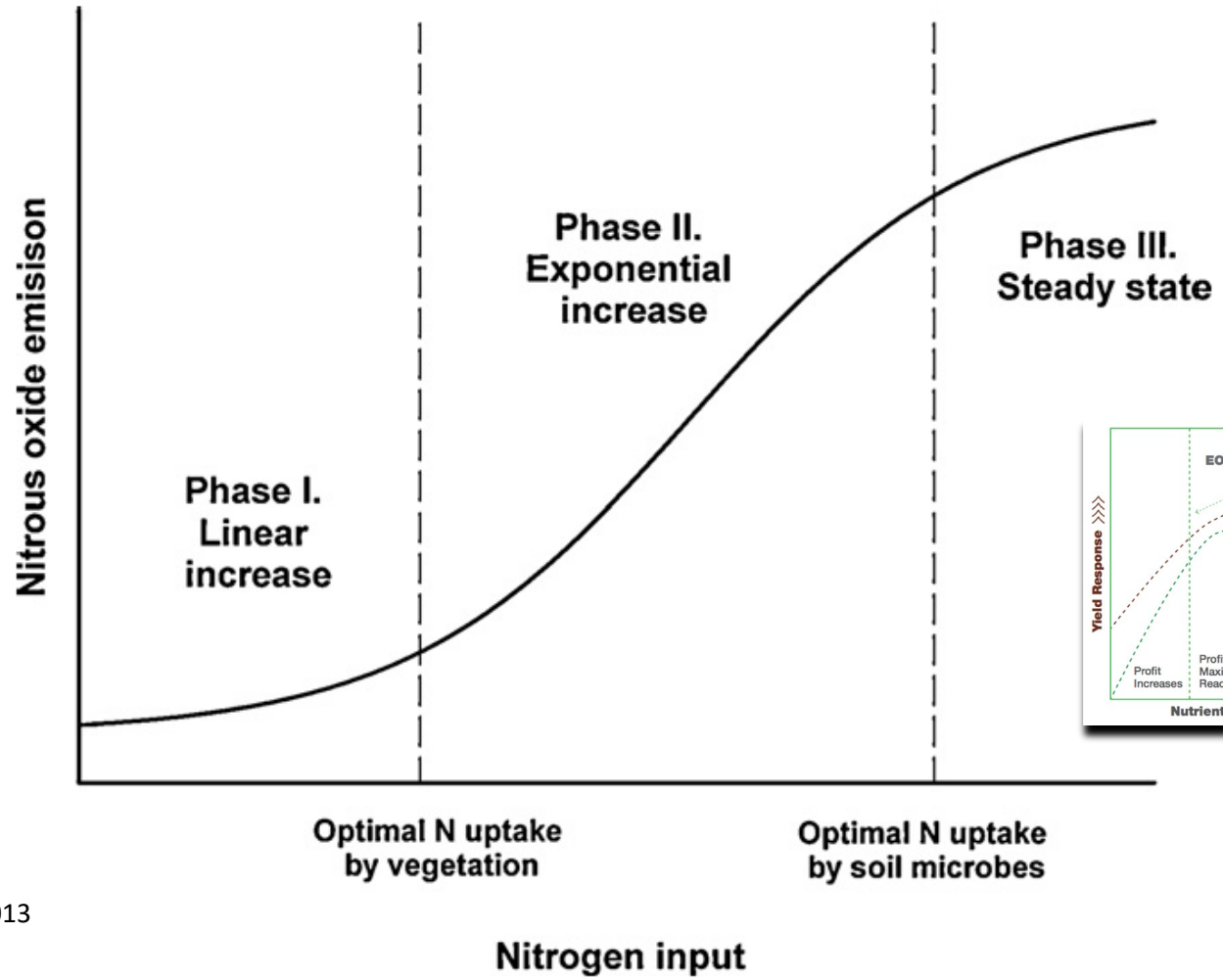


Maximize Profit Not Yield





N Rate and Nitrous Oxide Emissions



Kim et al. 2013



NERP

Nitrous Oxide Emission Reduction



General Emission Equation

$$N \times F_1 \times F_2 \times \frac{44}{28} = N_2O$$

- N is nitrogen inputs from fertilizer, manure, crop residue.
- $F_{1\&2}$ are emission and/or partitioning factors
- 44/28 is the N to N_2O conversion factor



QUESTIONS?



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