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Fertilizer Canada
Agriculture & Agri-Food Canada
Dialogue Day
13 May 2021

Eastern Canadian Agriculture and Manure Management

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Outline – Carbon footprint of fertilizer use in Eastern Canada

1. Canada needs to do its part to contribute to world food security
   - Its NUE exceeds world average and EU
2. Right Source Solution
   - Nitrification inhibitors and controlled release coatings reduce N_2O emissions
   - Their societal value in reducing N_2O exceeds their value to the farmer
   - IPCC 2019 guidelines allow their recognition in the National GHG Inventory
3. Need to integrate N_2O reduction with SOC increase
   - Full cropping system focus
   - Decision support tools
4. Need to integrate crops and animals
   - 4R can apply to manure N too

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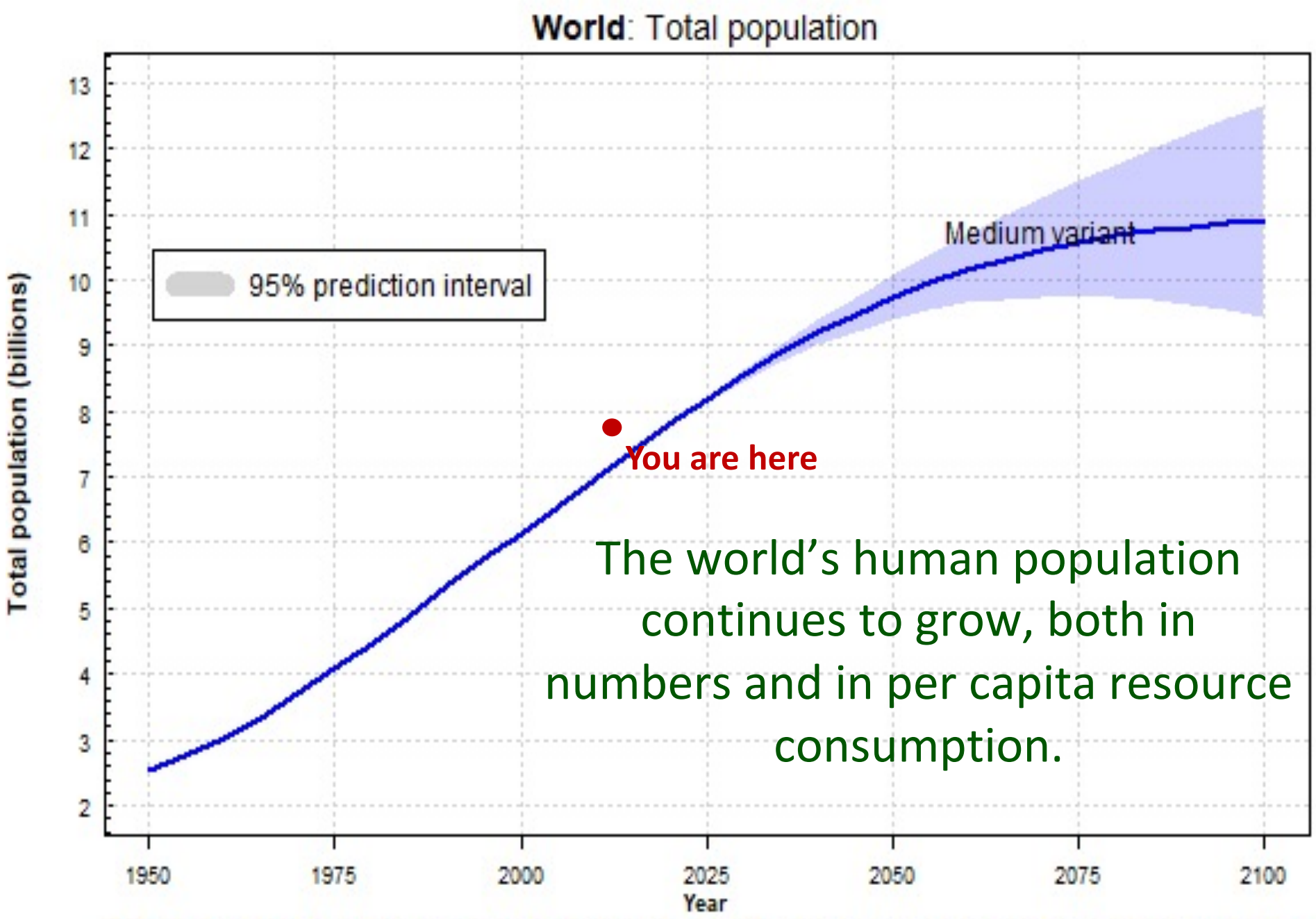

The world's human population continues to grow, both in numbers and in per capita resource consumption.

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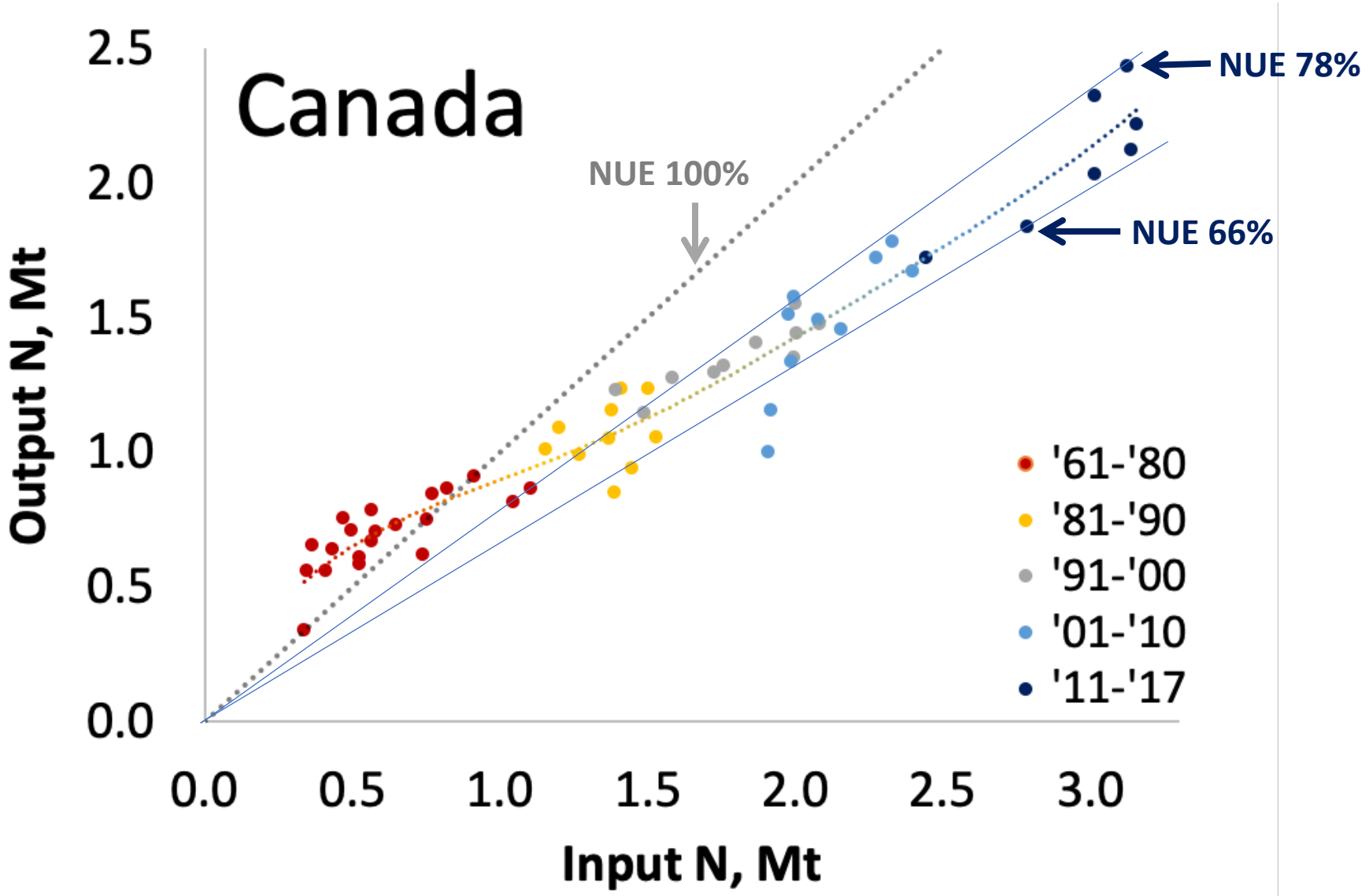
N use efficiency trajectories over 57 years (1961-2017)

Output increasing, NUE stable and > world average



IFA, 2020 – Nutrient Use Efficiency database. Input = fertilizer + fixation + manure; Output = harvest

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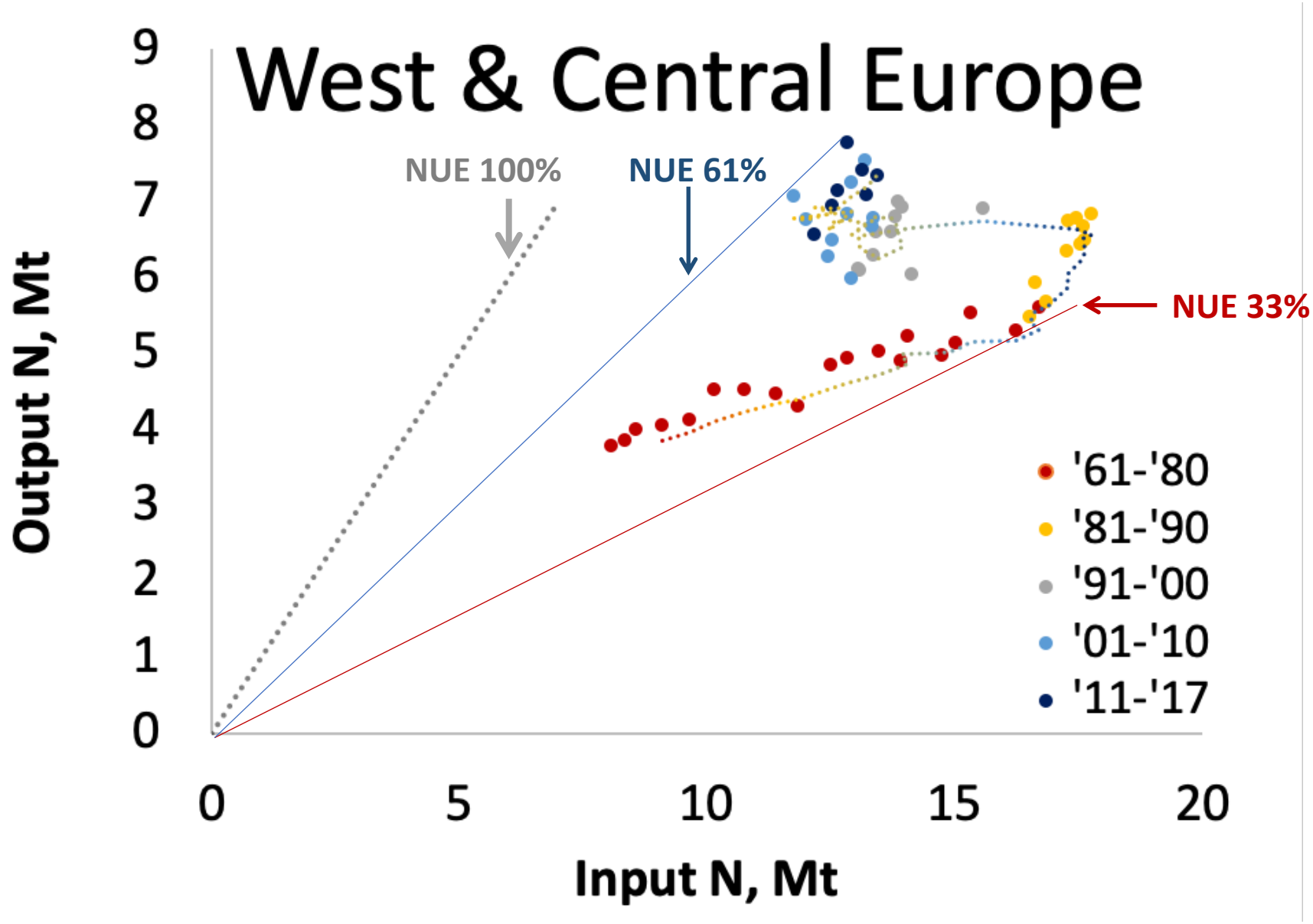
N use efficiency trajectories over 57 years (1961-2017)

output stable, NUE risen to world average



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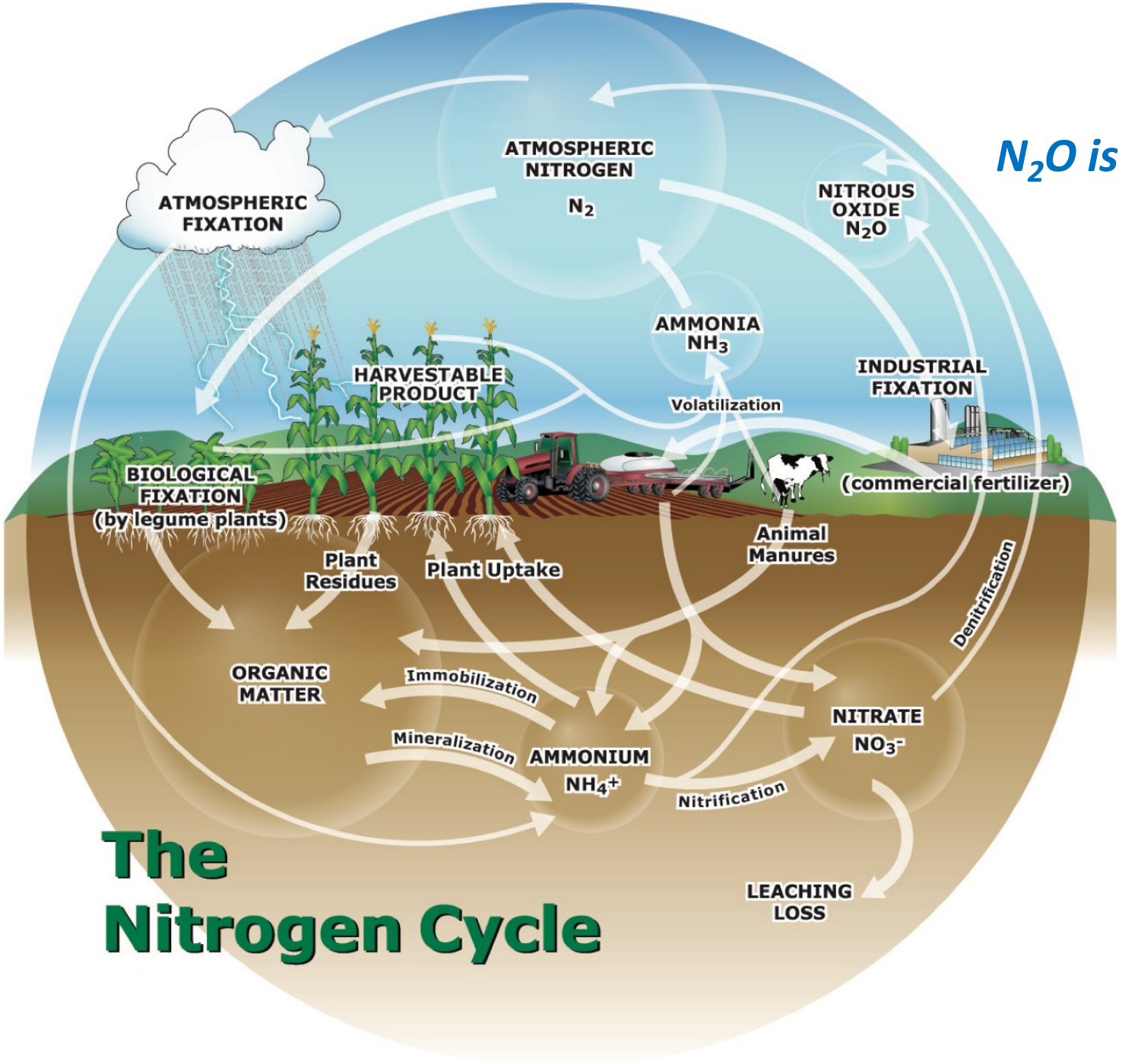

N_2O is emitted into a global pool

Many forms of nitrogen can be lost to air or water.

Many processes are involved in nitrogen use efficiency.

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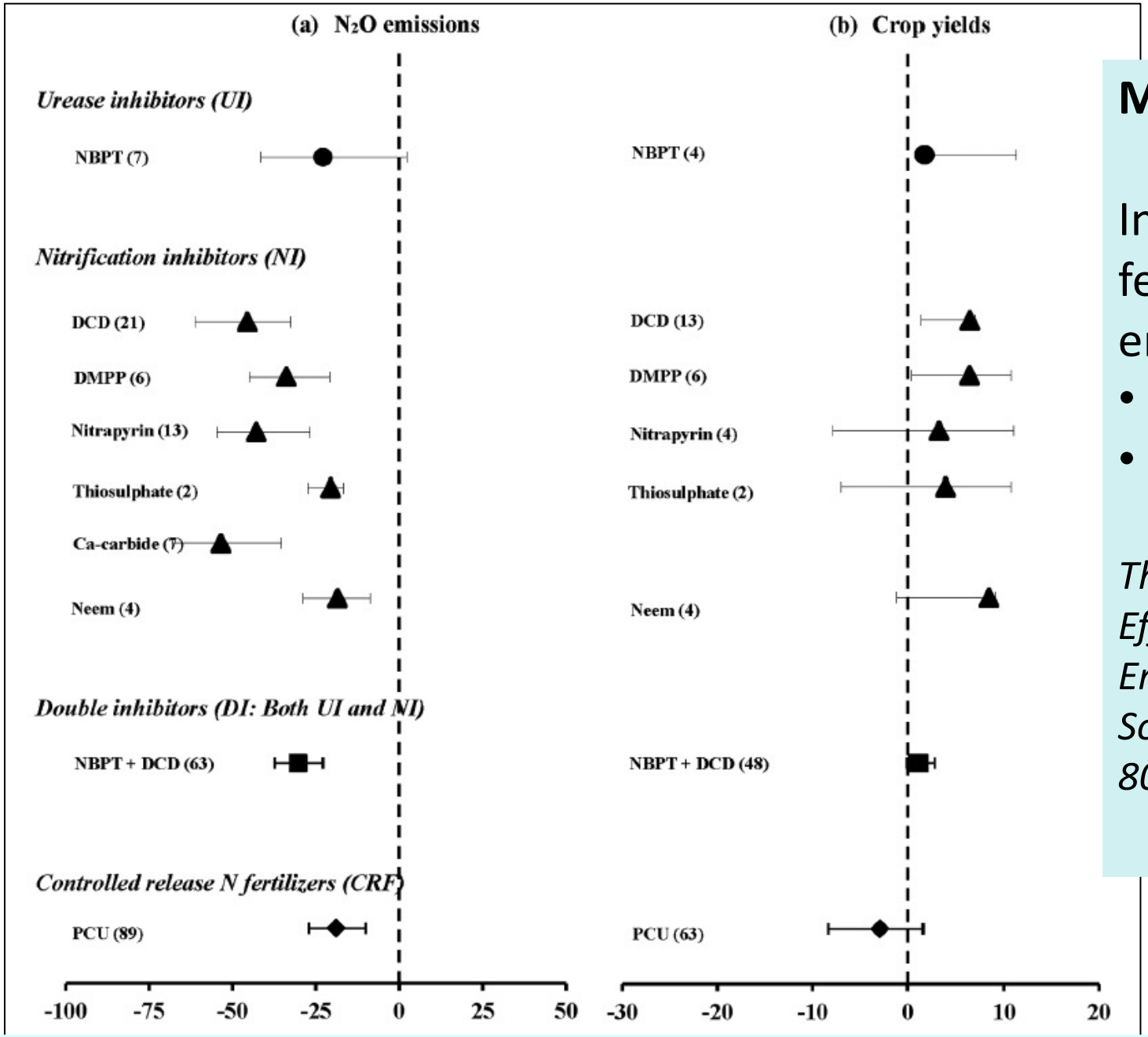

Effect of individual enhanced efficiency fertilizer (EEF) types (%)

Meta-analysis

Inhibitors and controlled-release fertilizers have more impact on emissions than on yield

- N_2O emission: **19-40%** reduction
- Yield: **0-10%** increase

Thapa et al. (2016). Effect of Enhanced Efficiency Fertilizers on Nitrous Oxide Emissions and Crop Yields: A Meta-analysis. Soil Science Society of America Journal 80:1121–1134

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2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

"Compilers can develop Tier 2 emission factors specific to mitigation options such as the application of **nitrification inhibitors** (Akiyama et al. 2010, Ruser & Schulz 2015, Gilsanz et al. 2016)."

Meta-analysis results:

Akiyama et al 2010 – 38%
Ruser & Schulz 2015 – 35%
Gilsanz et al 2016 – 34% to 42%
Abalos et al 2016 – 26%
Thapa et al, 2015 – 20% to 40%
DeCock, 2014 – 18% to 55%
Eagle et al, 2017 – 15% to 39%

Maaz, Sapkota, et al. 2021. Meta-analysis of yield and nitrous oxide outcomes for nitrogen management in agriculture. Glob. Chang. Biol.

- "we found the use of EEFs (e.g., urease inhibitors, nitrification inhibitors, neem, or polymer coated urea) reduced N_2O emissions. The current finding of a **reduction of 24%** falls within the range reported by other meta-analyses (Eagle et al., 2017; Lam et al., 2017; Li et al., 2018; Qiao et al., 2015; Snyder et al., 2009; Thapa et al., 2016; Xia et al., 2017). **Unlike other predictors, EEFs appear to have a consistent effect under a range of conditions and thus generalizable**."

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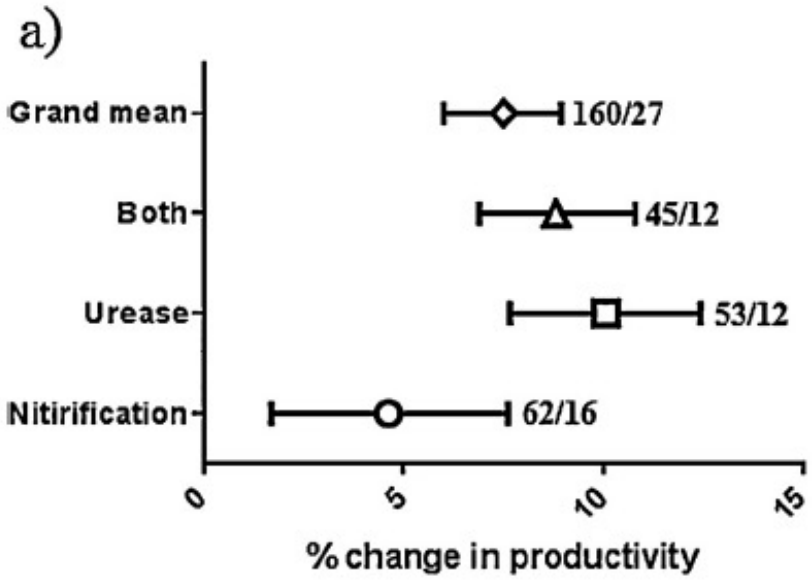

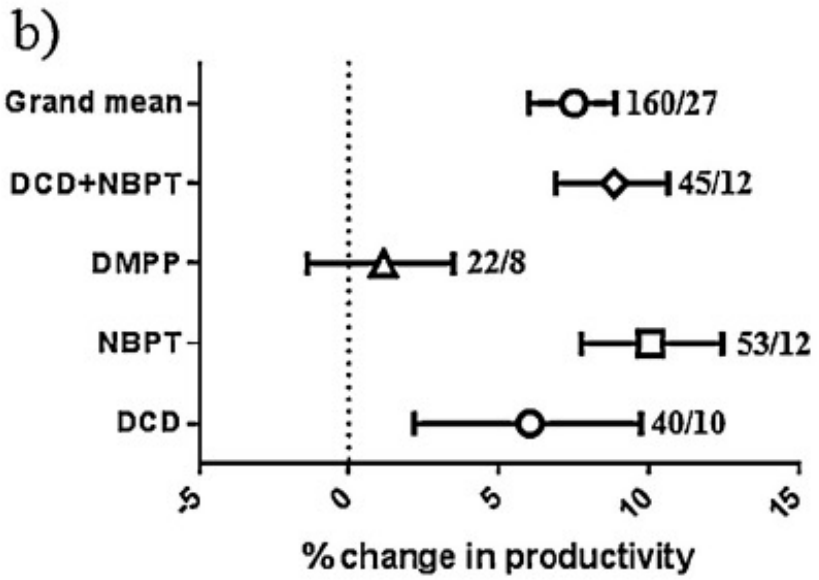

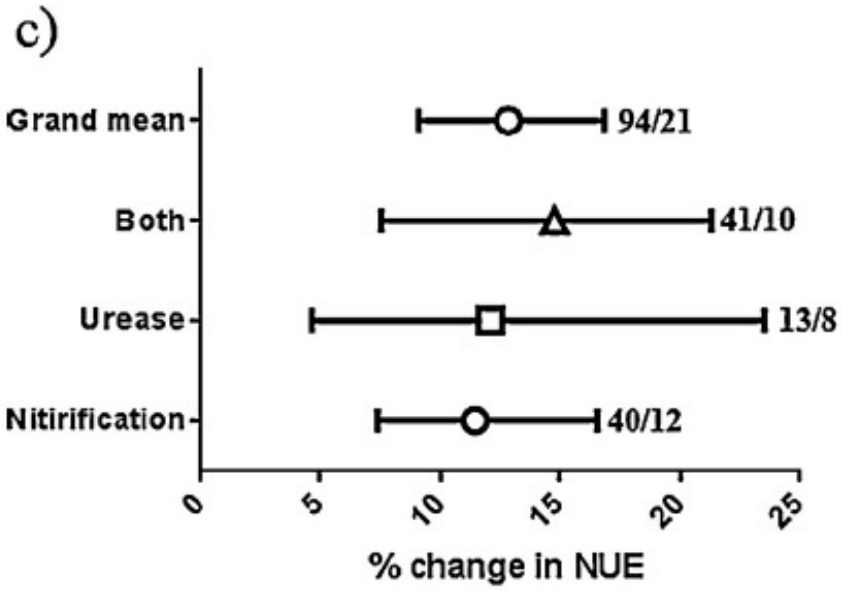

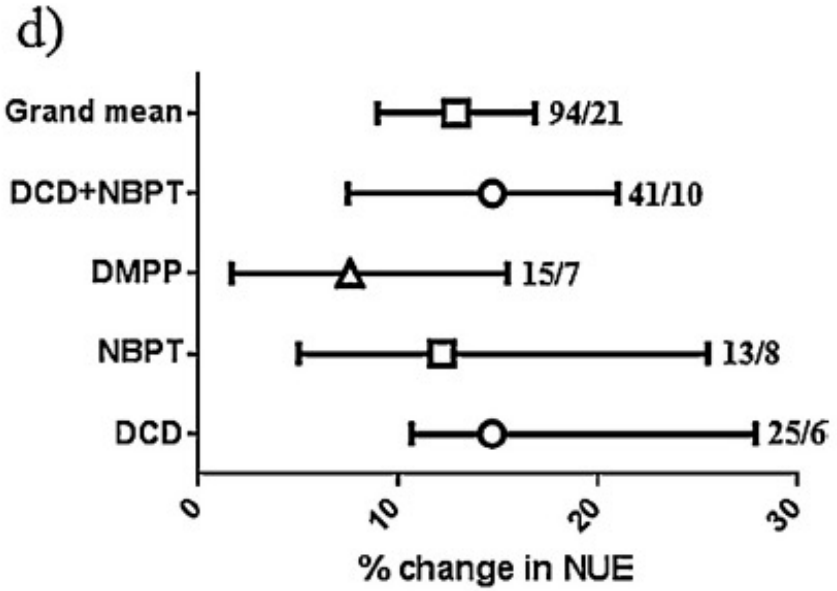

Inhibitors improve Nitrogen Use Efficiency more than Yield

- **1-10% yield gain**
- **8-15% NUE gain**
- **19-40% less N_2O**

Abalos et al. (2014) Meta-analysis of the effect of urease and nitrification inhibitors on crop productivity and nitrogen use efficiency. Agriculture, Ecosystems and Environment 189: 136–144

NUE= % of fertilizer N applied, taken up in the grain or above-ground biomass

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Benefit of inhibitors to yield, NUE, GHG emissions

Ontario grain corn example

10	CO_2eq from N_2O, lbCO_2e/lbN
182	2020 Ontario average grain yield, bu/A
172	2020 Ontario average N rate, lb/A
5.46	corn price, $/bu
0.65	fertilizer N price, $/lb
170	carbon price, $/t$CO_2$e

yield increase		1%		2%	10%
NUE increase		8%		10%	15%
GHG reduction		19%		30%	40%
yield increase	$	9.95	$	19.90	$ 99.48
reduced N rate	$	8.93	$	11.16	$ 16.74
GHG reduction	$	25.93	**$**	**40.95**	$ 54.60

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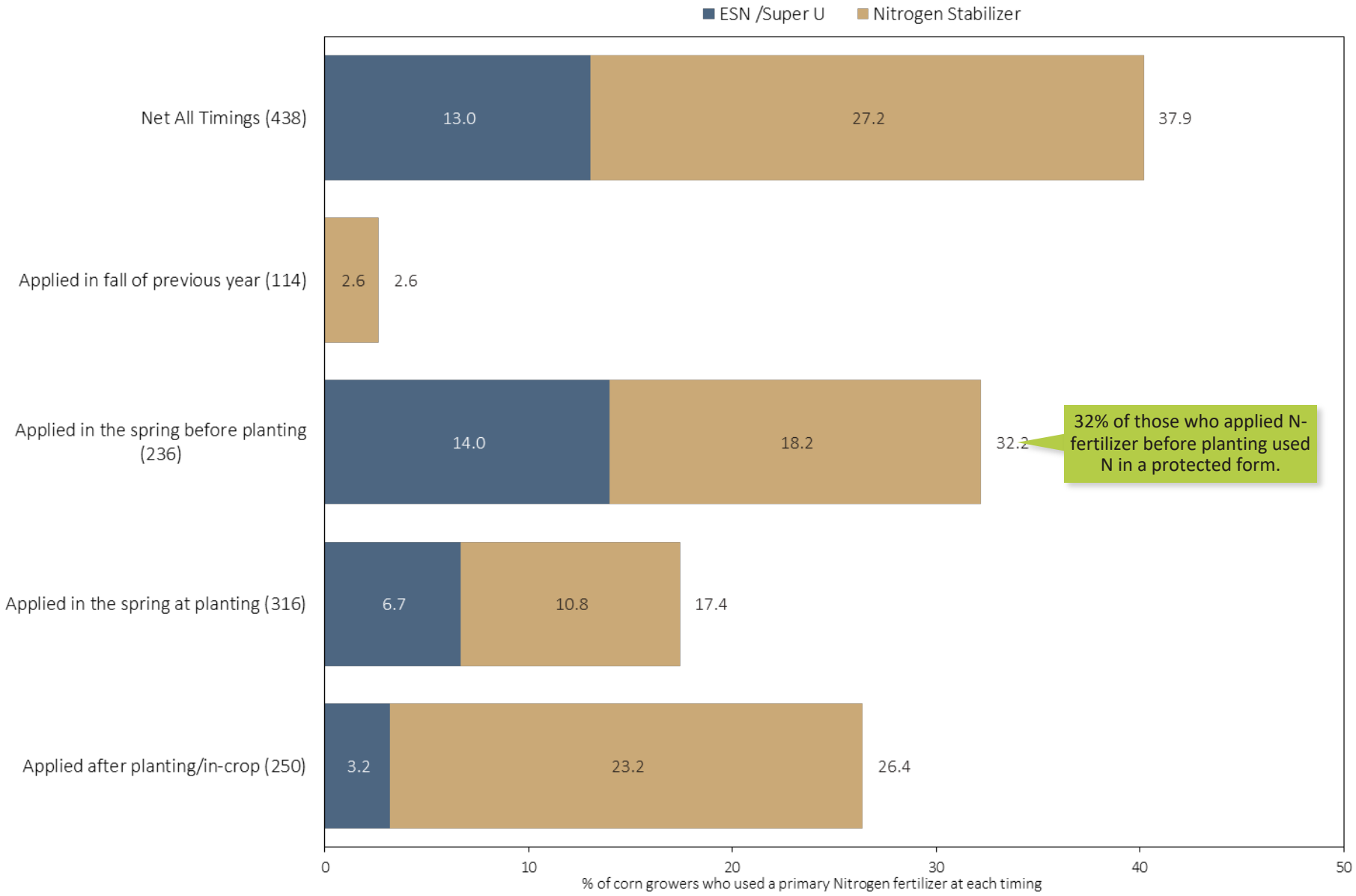
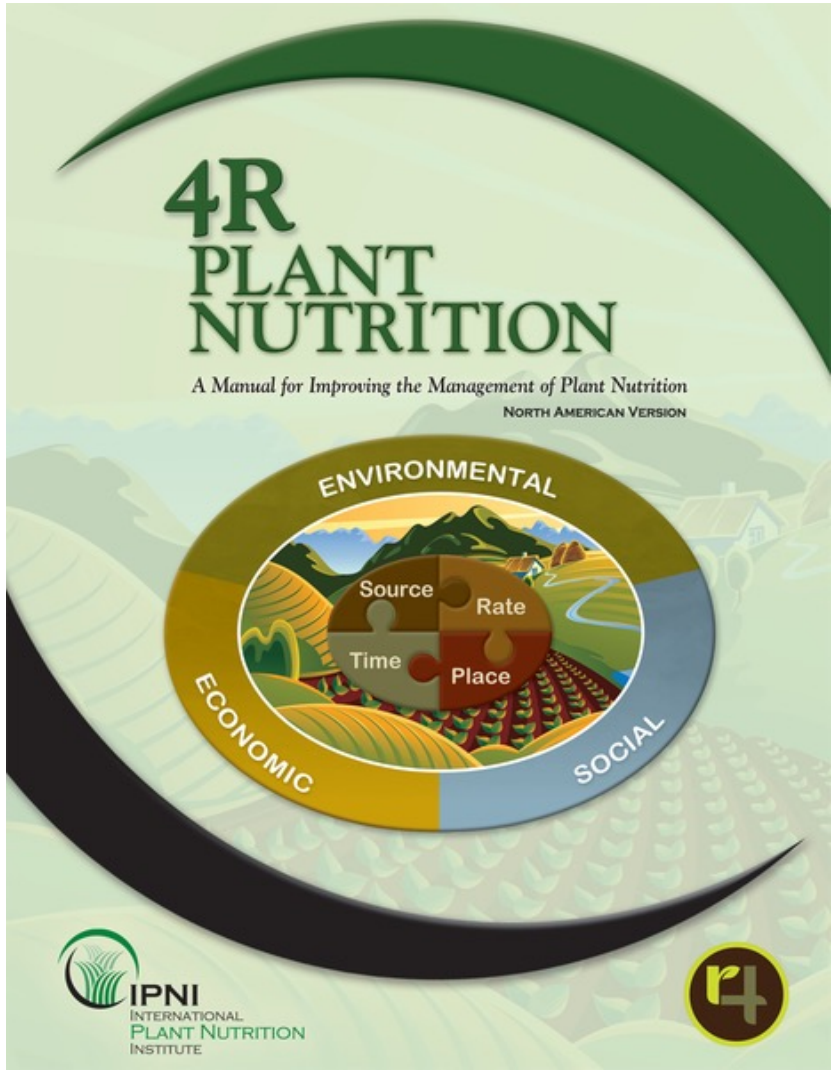
Use of EEFs by Timing - % of Growers



Why require a 4R framework to recognize the effect of source?

- The research generally applied the inhibitors and controlled-release forms close to right rate, time, and place.
- The 4R framework requires a 4R plan – accountability.
- The 4R plan should include farm-level measures of performance – yield, soil health, NUE.
- Climate is not the only issue. 4R connects to everything associated with nutrient application.



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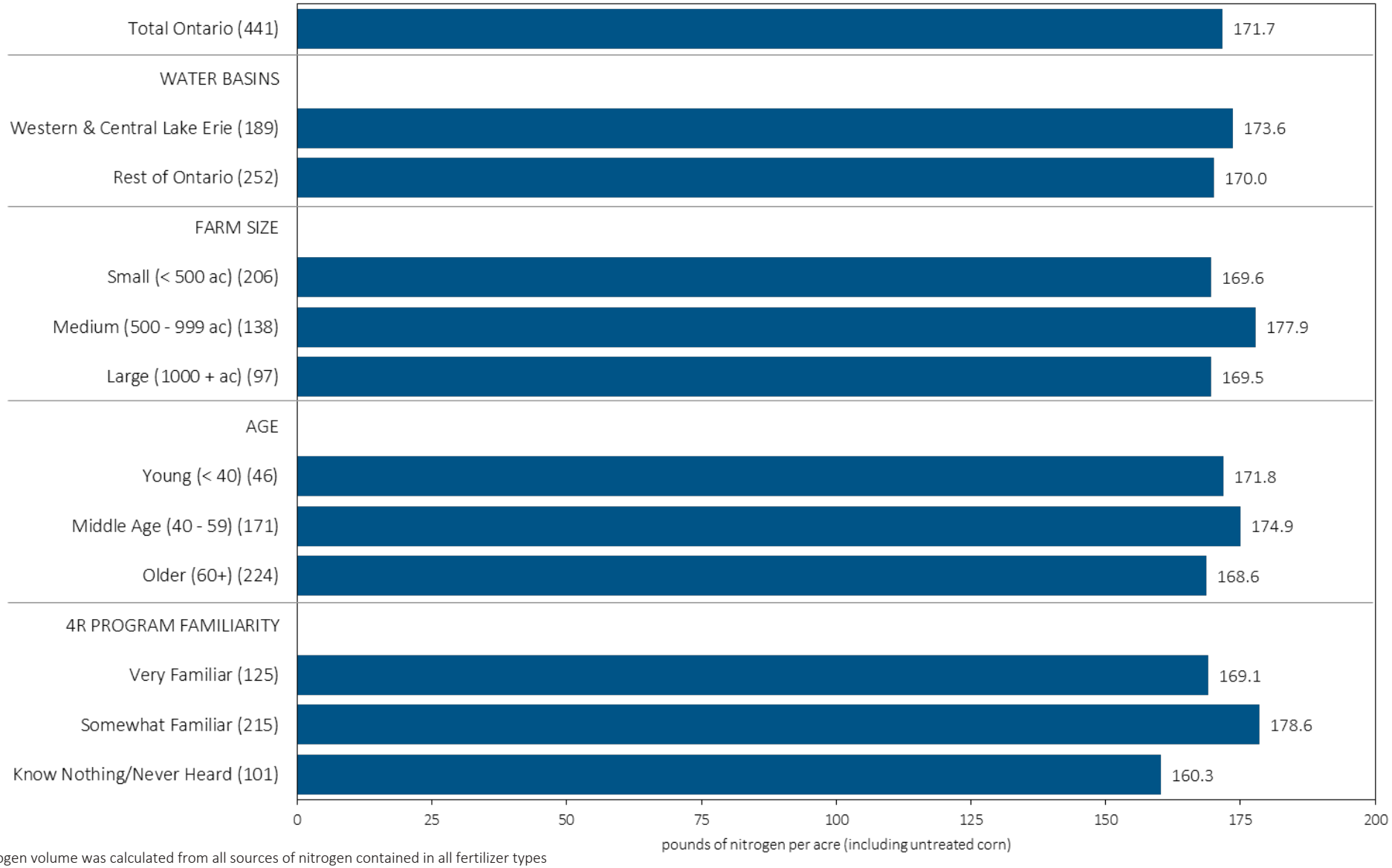
Nitrogen Rates in Corn - Average Rate in 2020



Note: Nitrogen volume was calculated from all sources of nitrogen contained in all fertilizer types

Note: Rates include growers who did not apply any nitrogen

Fertilizer 4R survey: Why is 4R familiarity associated with higher N rates for corn?

4R Concept Familiarity		2015	2016	2017	2019	2020
Very Familiar	rate, lb/A	166	165	161	174	169
Somewhat familiar	rate, lb/A	143	151	162	177	179
Know nothing/never heard	rate, lb/A	153	139	132	138	160

1. Farmers with more manure may be less familiar with 4R.
   - Less fertilizer N need
2. Farmers in the southwest of Ontario may be most familiar with 4R.
   - Western Lake Erie watershed
   - Highest yield region in Ontario, may need higher rates
3. Self-rated “4R Program Familiarity” may not be a great criterion.
   - Respondents were asked: “Which of the following best describes how familiar you are with the concept of 4R nutrient stewardship, meaning right source, right rate, right time, right place?”

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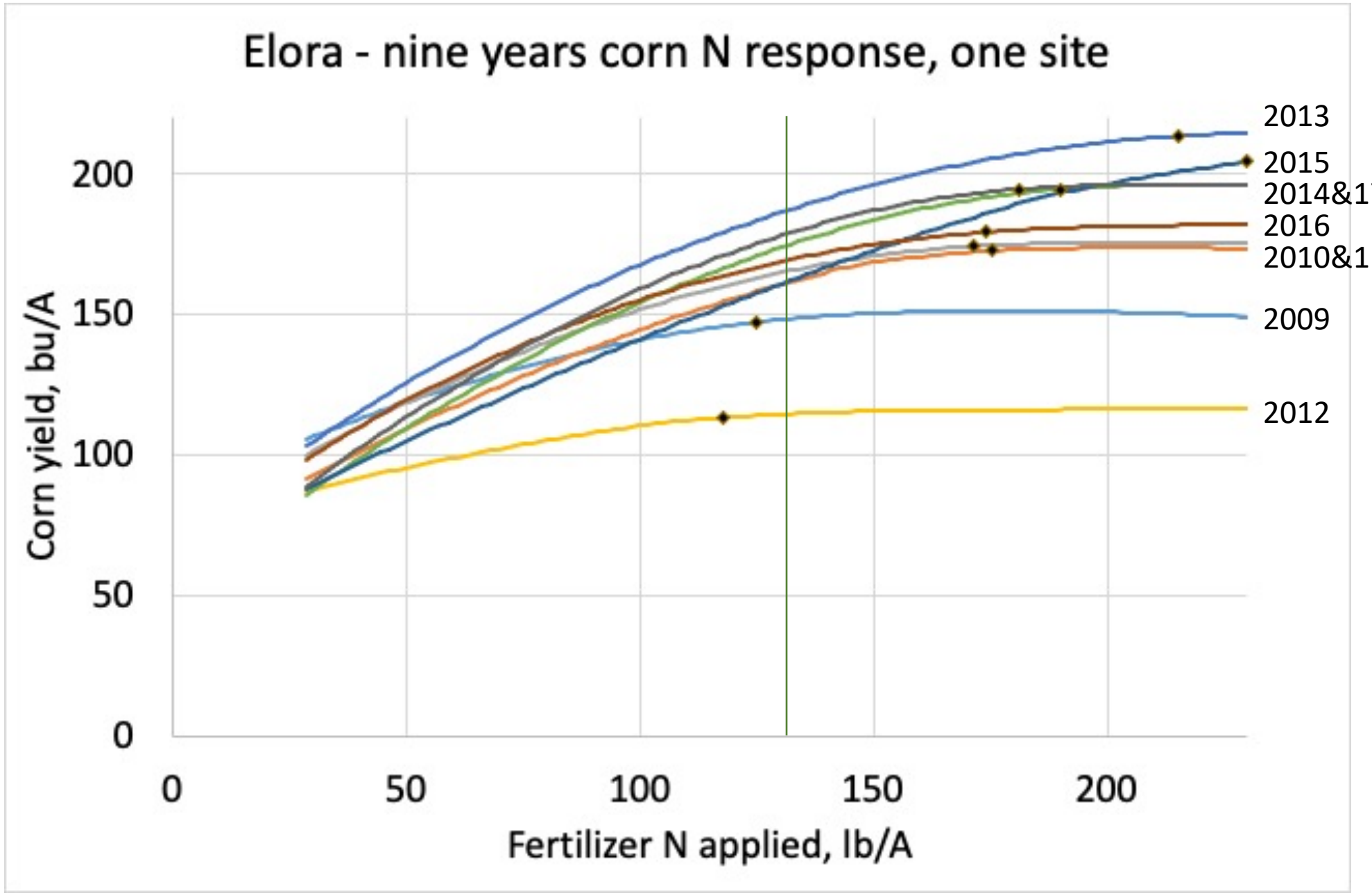

Optimal Rates for Corn Nitrogen Depend on Weather

S: UAN
R: 27-232 lb/A
T: PL, SD
P: injected

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Yield and Economic Return in Relation to N rate, average over 9 years, 2009-2017

Rate Scenario	Fertilizer N rate	Corn Yield		Gross return minus N cost	
	lb/A	bu/A	%	$/A	Δ, $/A
Ontario N Calculator - 30%	91	142	80%	715	-137
Ontario N Calculator	129	161	91%	797	-55
year-specific MERN	**176**	**177**	**100%**	**852**	**-**
single-rate MERN	184	176	99%	840	-12
maximum yield rate	232	179	101%	826	-26

Assumptions:
Corn price = $5.46/bu
Fertilizer N price = $0.65/lb

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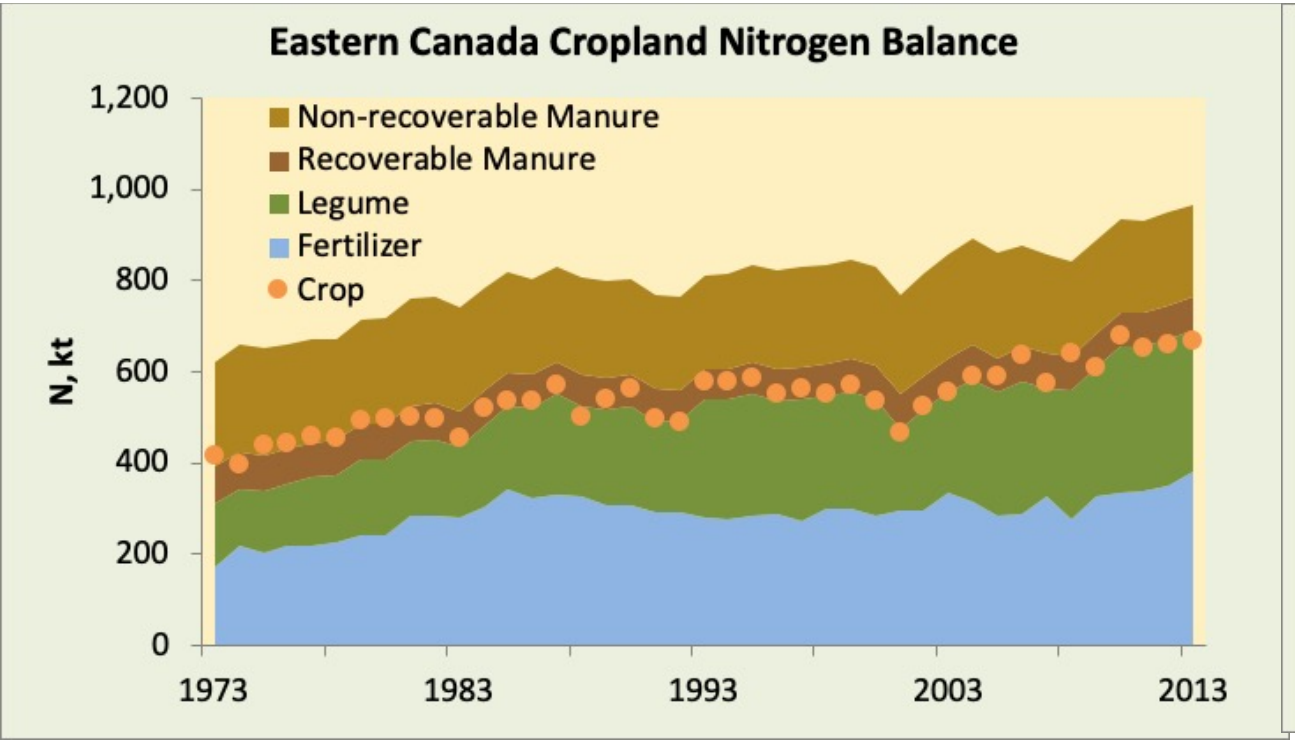
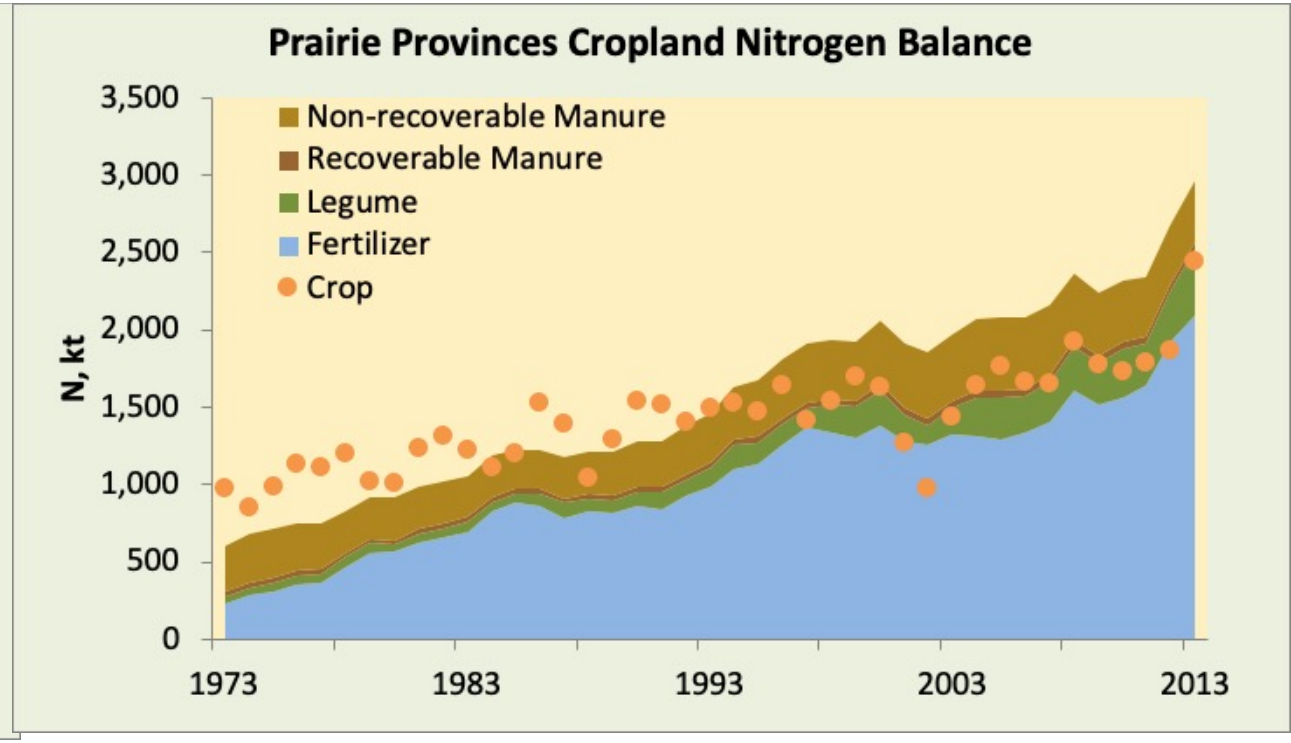
Eastern Canada manure is potentially a substantial source of nitrous oxide emissions





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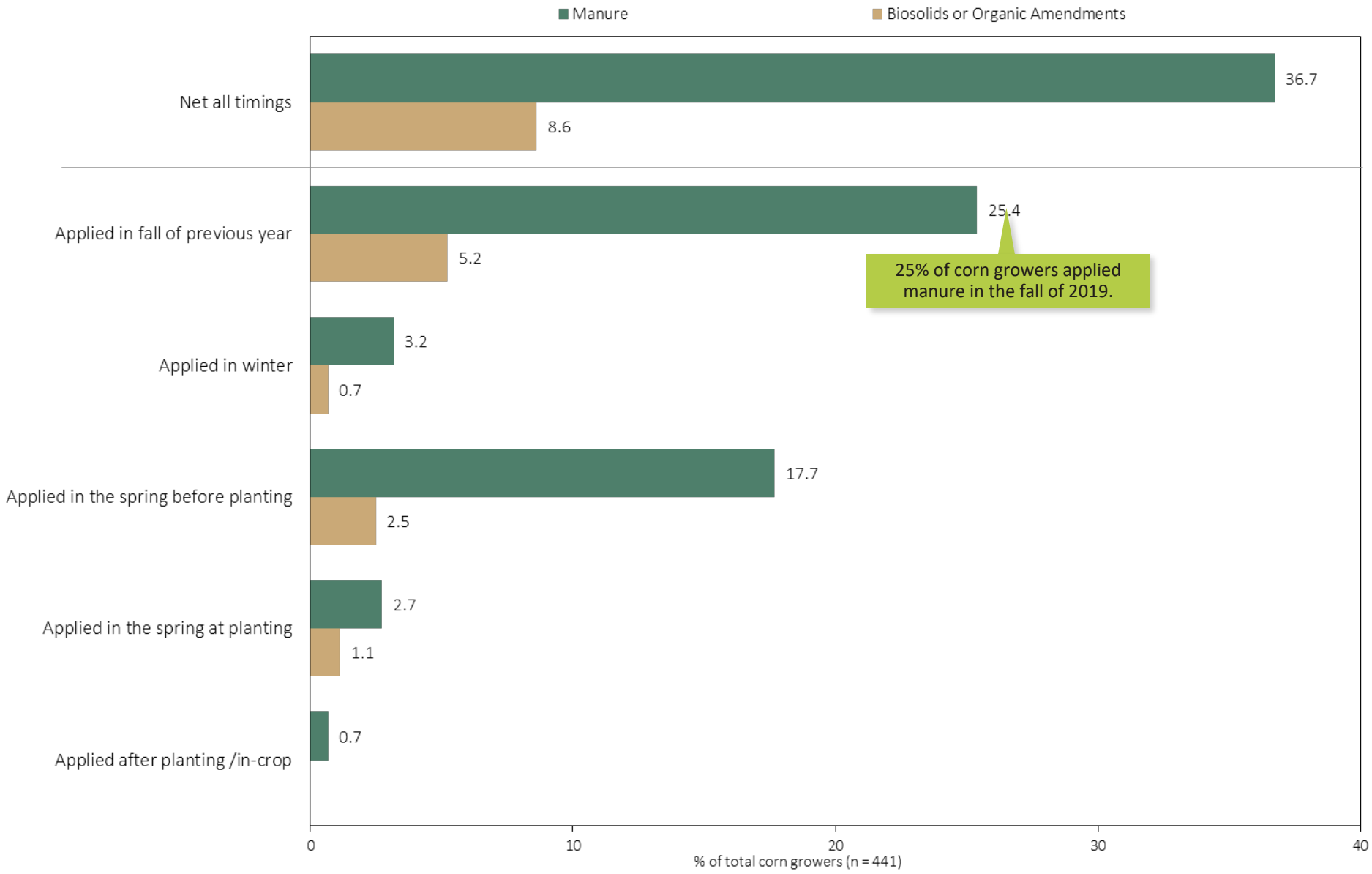
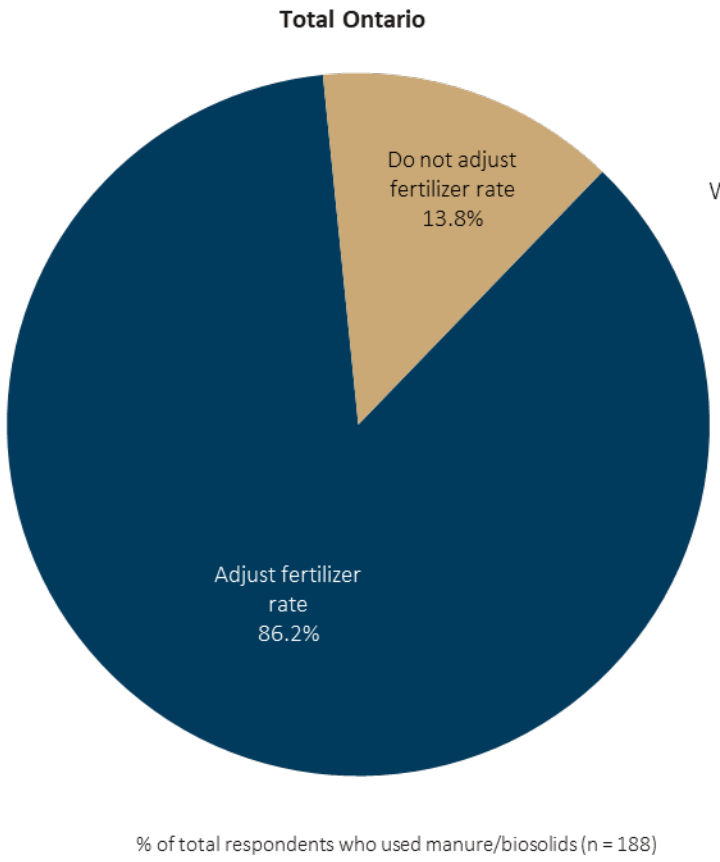
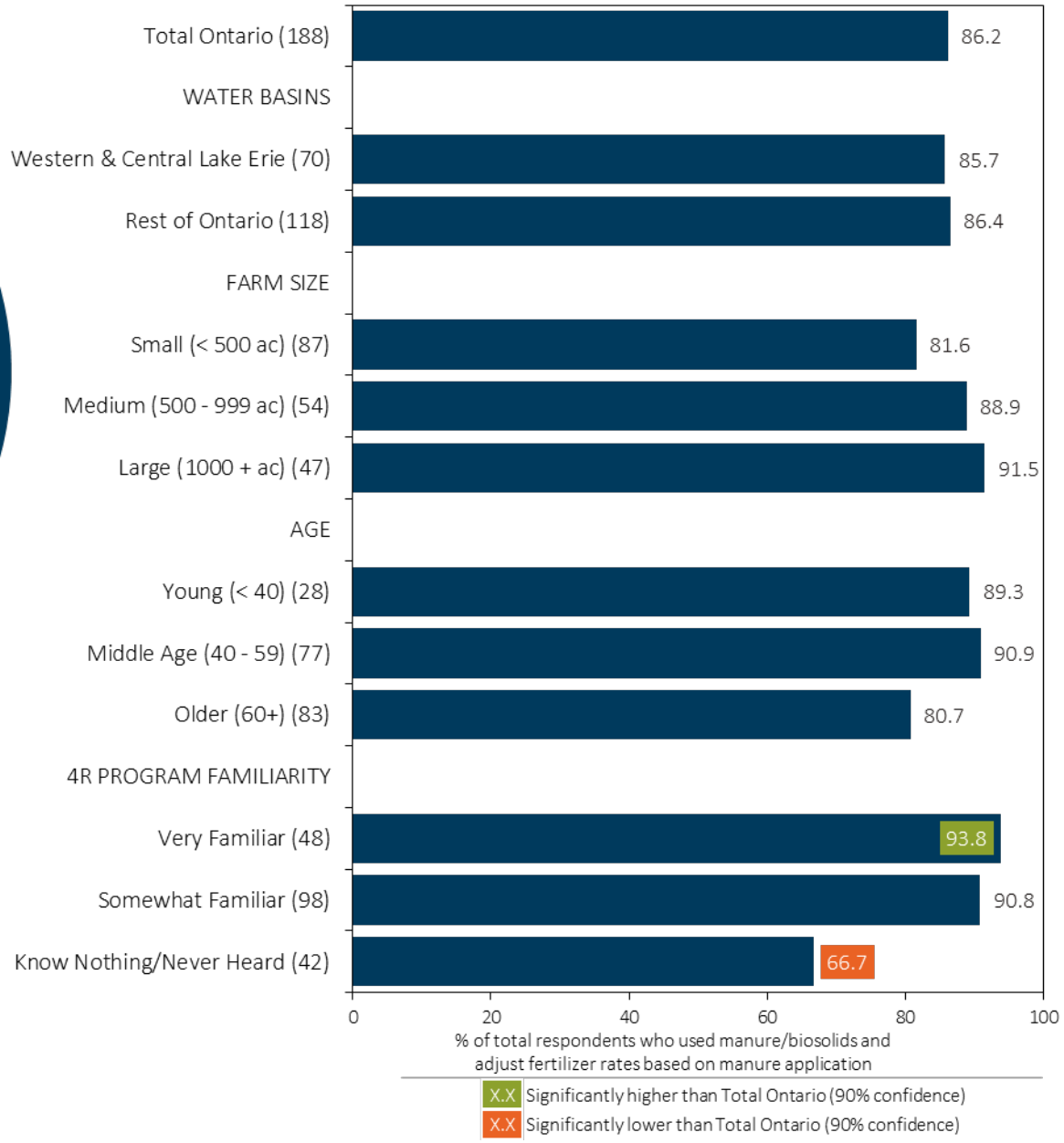
Use of Manure or Biosolids/Organic Amendments



Adjust Fertilizer Rate Based on Manure/Biosolids Application



% of total respondents who used manure/biosolids (n = 188)



Barriers to 4R Adoption

- Source (inhibitors, controlled release):
  - Economic benefit smaller than environmental
- Rate optimization:
  - Requires a concerted multi-stakeholder effort to develop, validate and verify N rate decision support in-season
  - Also likely to require investment
- Timing & placement:
  - New equipment

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Integration

1. Need to integrate N_2O reduction with SOC increase
   - Full cropping system focus
   - Crop rotations and cover crops
   - Decision support tools
2. Need to integrate crops and animals
   - 4R applies to manure N

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Conclusions

1. Canada needs to do its part to contribute to world food security
   - NUE of Canadian crop production exceeds world average and EU
2. Right Source Solution
   - Nitrification inhibitors and controlled release coatings reduce N_2O emissions
   - Their societal value in reducing N_2O exceeds their value to the farmer
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