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Furthering 4R Nutrient Management for Sustained Productivity

Tom Bruulsema,
Plant Nutrition Canada

1

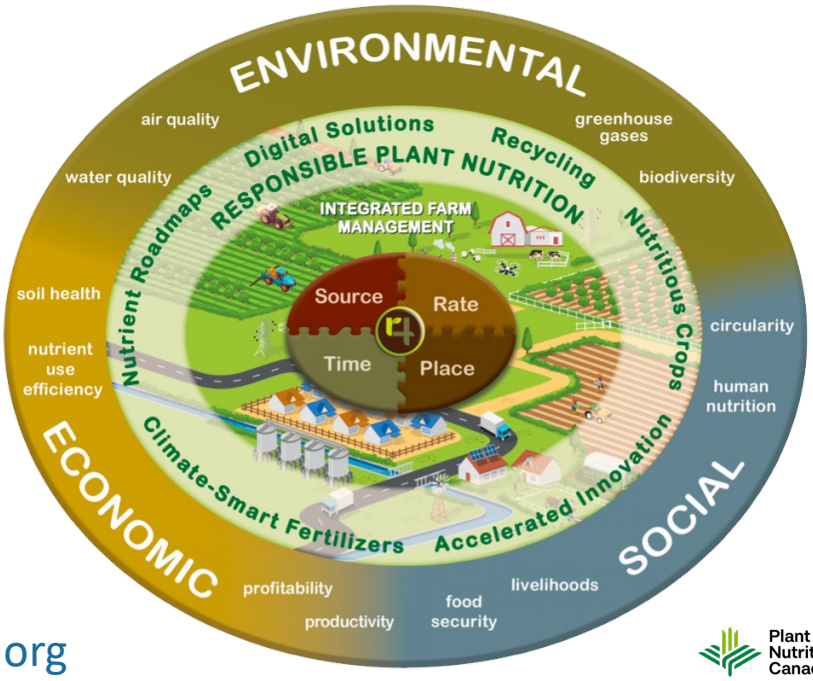
Furthering 4R

Relevant to each of the six actions of responsible plant nutrition.

Connected to performance outcomes, including NUE and N balance.

Site-specific.

Recognized.



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https://www.sprpn.org

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2

2

Furthering 4R Nutrient Management for Sustained Productivity

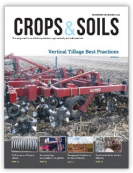
Reducing emissions from fertilizer use – while continuing yield increase

1. Scope: global, USA, Canada, Africa
2. Reducing nitrogen surplus
3. Including 4R in emission reduction programs

CROPS & SOILS

4R NUTRIENT STEWARDSHIP | Full Access

What's the Scope of 4R Practices for Reducing Emissions from Fertilizer?



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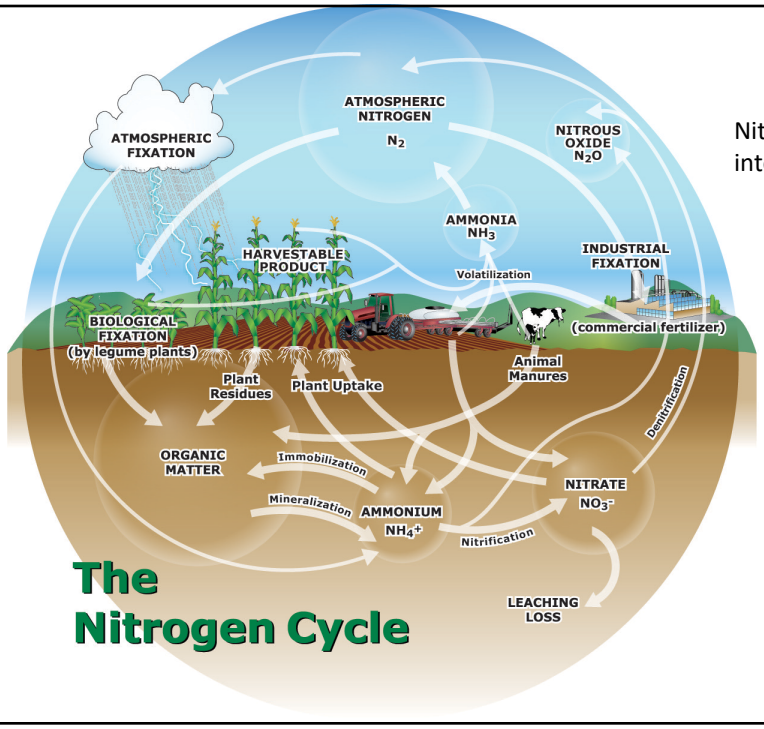
3



Nitrous oxide is emitted into a global pool

4

Emissions from fertilizer use in context

Current (2019-2020) GHG emissions, M tons CO_2e

	World	USA	Canada
Total GHG emissions	65,000±7,300	7,300	740
Total N_2O emissions	3,000±1,800	485	44
N_2O from agriculture	2,000±1,200	385	26
N_2O from fertilizer use	700	91	13
Fertilizer N use, M tons	122	13	3

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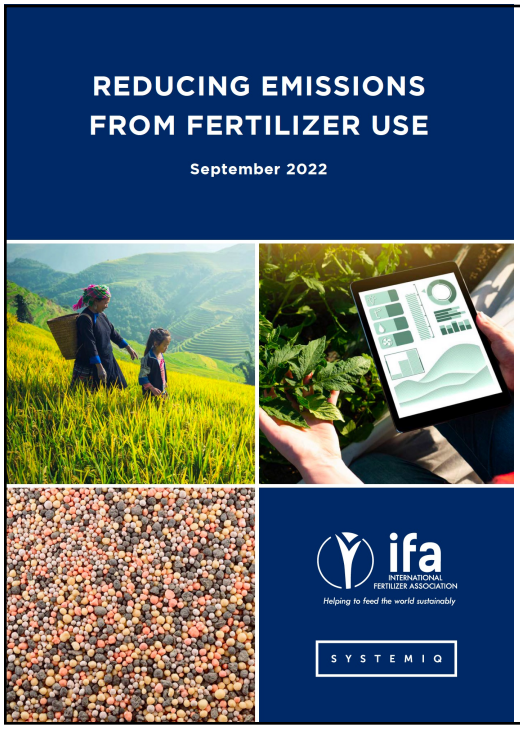
5



Global Scope – by 2050

- **Baseline** 2020 = 790 M tons CO_2e annually
- Increasing global **NUE** from 50% to 70% could reduce emissions by 350 M tons CO_2e
- **Inhibitors** could reduce emissions by a further 185 M tons CO_2e
- **Soil carbon storage** could remove 440 – 7,500 Mt CO_2e

(SystemIQ-IFA, 2022)

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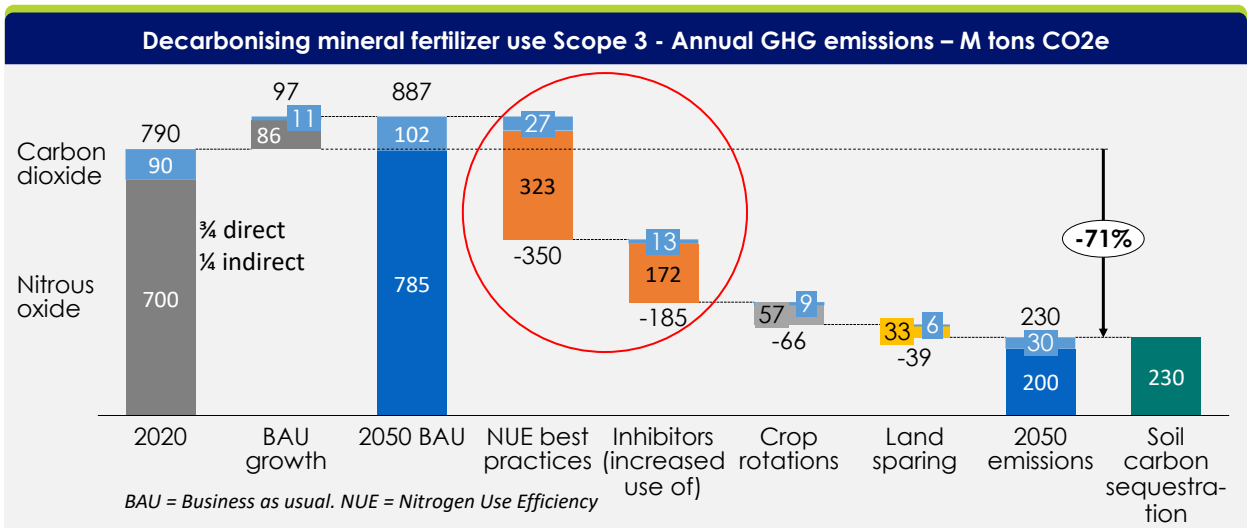
6

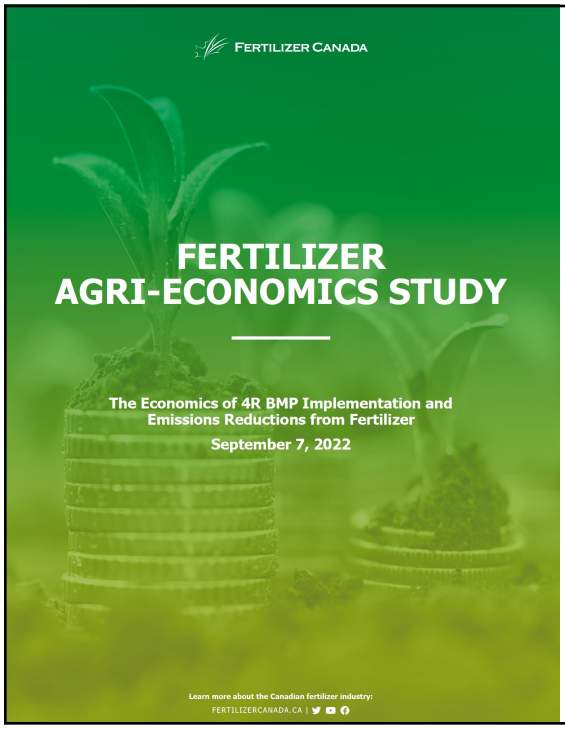
Scope 3 Emissions from the use of fertilizer can be more than halved by 2050 through increasing N use efficiency



ifa INTERNATIONAL FERTILIZER ASSOCIATION SYSTEMIQ

https://www.fertilizer.org/Reducing-Emissions

7



Scope in Canada

- Meeting the target of an ABSOLUTE 30% reduction would require either very large cost-share, or reduced production.
- Crop production and yields are on increasing trends
- 4R implementation can provide 14% reduction by 2030 while increasing crop yields

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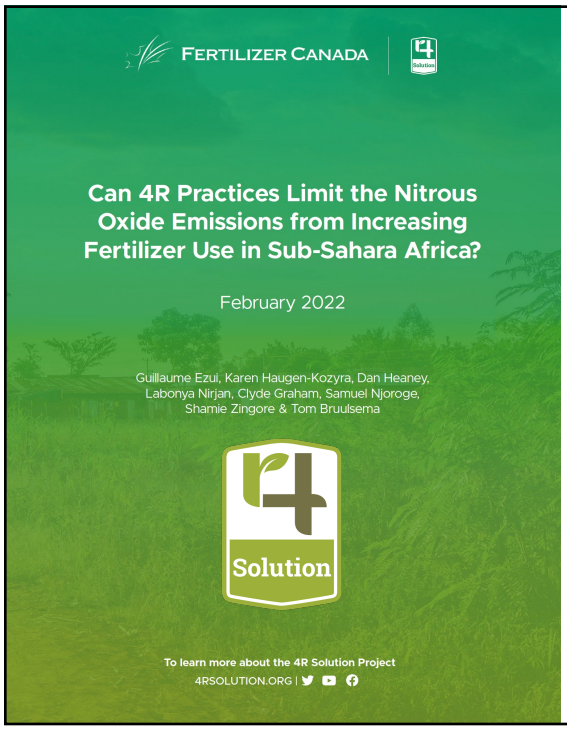
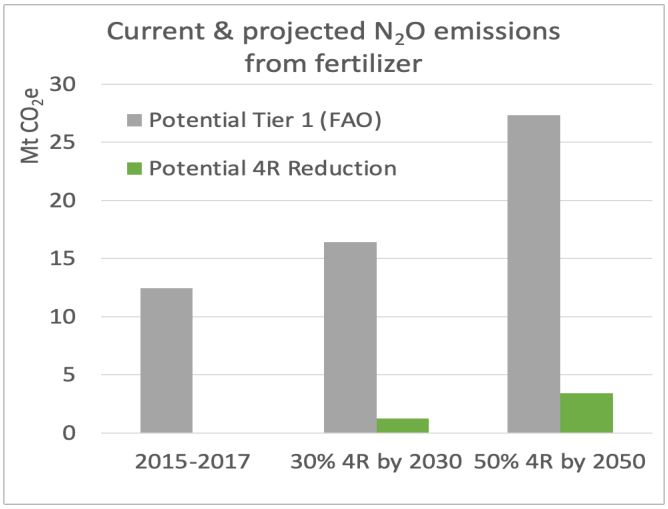
8



Scope in SS Africa



https://4rsolution.org/documents/

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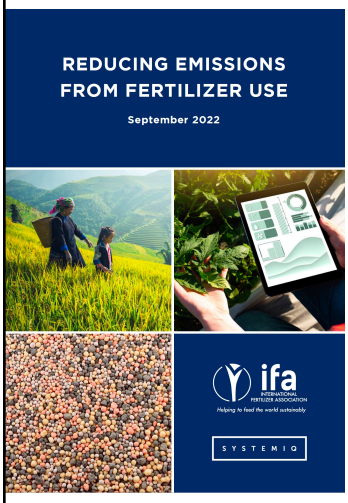
9

Scope in USA – case study



Annual emissions from use of N fertilizer **in corn**:

50 M tons CO_2e, mostly as N_2O

Possible reductions by 2050:

Eliminating N surplus: 7-13 M tons (yield loss 1%)

Doubling use of inhibitors: 9-13 M tons ($35-$85/ton)

30-50%, not 71%

(SystemIQ-IFA, 2022)

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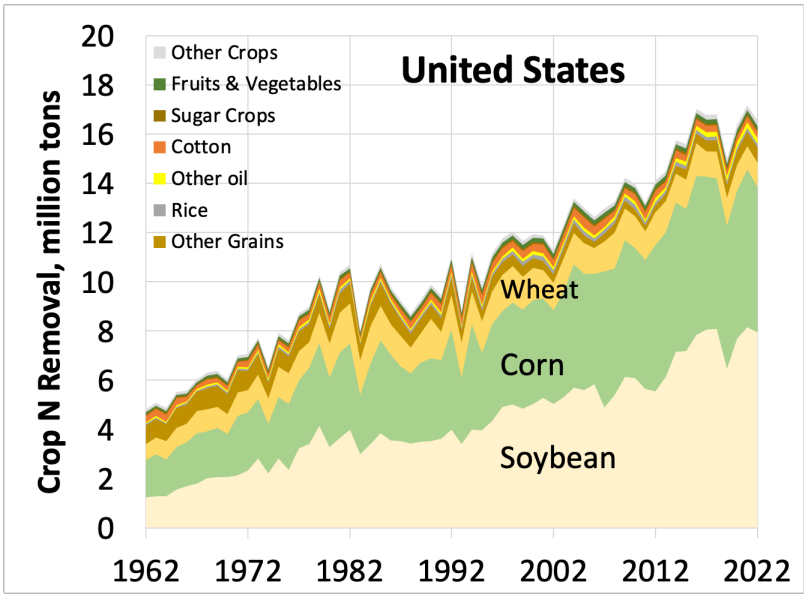
10



Increasing Trend in Crop Nitrogen Removal

Data sources: Xin Zhang et al., 2021; USDA-NASS with NuGIS coefficients.
Note: extrapolation for crops other than wheat, corn, and soybean from 2015.

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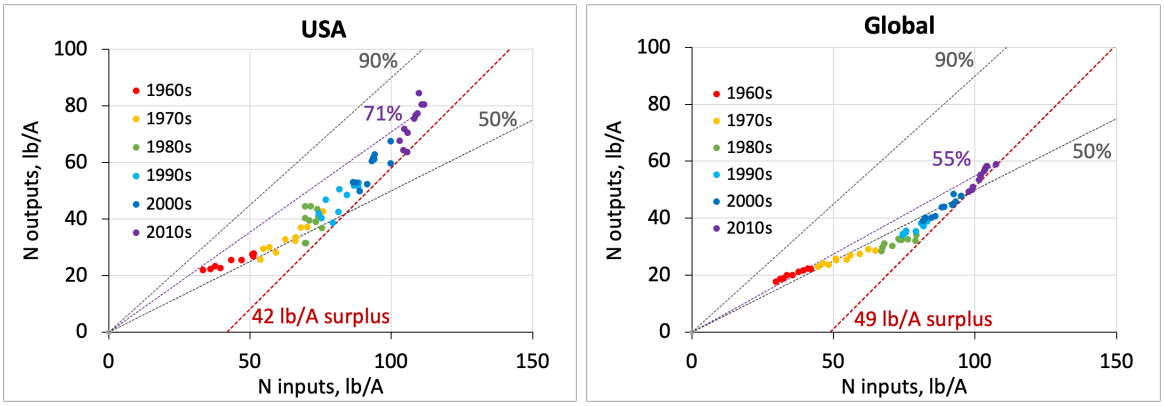
11

FAO-IFA Cropland Nitrogen Use Efficiency Trends



Nitrogen outputs (crop removal) plotted against inputs (fertilizer, manure, legume fixation, and atmospheric deposition) to cropland from 1961 through 2020. The slopes of lines from the origin represent N use efficiency lower and upper reference values, and for 2020.
Source: FAO, 2022. FAOSTAT and IFA Cropland Nutrient Budget database
http://www.fao.org/faostat/en/#data/ESB

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12

Reducing N surplus

N surplus = N applied – N removed

STRENGTHS

- Measurable
- Relates to every loss pathway
- Applies no limit to yield gain
- Includes upstream emissions

LIMITATIONS

- Neglects inhibitor effects
- Neglects source effects
- Trade-offs with soil carbon
- Limited emission reduction

4R builds on the strengths, and addresses most of the limitations

Eagle, A. J., McLellan, E. L., et al. (2020). Quantifying On-Farm Nitrous Oxide Emission Reductions in Food Supply Chains. *Earth's Future*, *8*(10), e2020EF001504. https://doi.org/10.1029/2020EF001504

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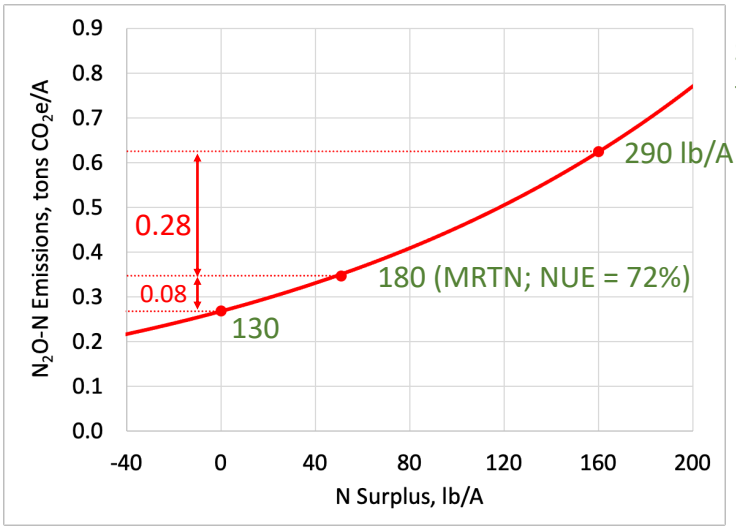
13

Reducing Nitrogen Surplus – limited opportunity below MRTN



Scenario: 195 bu/A corn following soybean

Generalized relationship between nitrous oxide emissions and nitrogen surplus across 286 sites, mainly in the North American Corn Belt. Adapted from Eagle et al., 2020.

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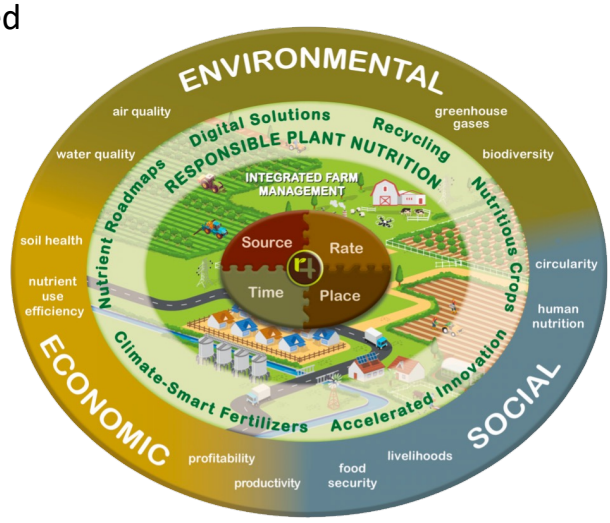
14

Future Farming Systems Integration

- Farming systems in transition – regenerative, circular, nature-based
  - Soil conservation
  - Integration with livestock
  - Sustainable intensification
  - Better human nutrition, biofortification
- Data-driven digital solutions
  - GPS guidance
  - Decision support tools
- Adaptive management for accelerated innovation
  - Weather-responsive sensing tools and crop models



15

Core principles for Right Source

1. **[new] Supply nutrients in quantifiable and available forms.**
2. **[new] Use climate-smart forms.**
3. **[new] Use recycled forms where feasible.**
4. **[new] Consider biological inoculants**.

5. [original] Suit soil physical and chemical properties.
6. [original] Recognize synergisms among nutrient elements and sources.
7. [original] Recognize blend compatibility of materials.
8. [original] Recognize benefits and sensitivities to associated elements.
9. [original] Control effects of non-nutritive elements.

16

New source principle #2: Use climate-smart forms.

Climate-smart fertilizers reduce greenhouse gas emissions.

Three attributes:

1. Lower manufacturing CO_2 emissions
   - "green" and "blue" ammonia
2. Inhibit loss of nitrous oxide (N_2O)
   - nitrification inhibitors and polymer coated urea
3. Improve nitrogen use efficiency (NUE)
   - controlled-release, stabilized, "smart fertilizers"

Photo credit: TFI, 2022

17

17

Climate-smart fertilizers emit less N_2O

Inhibitors and polymer coatings

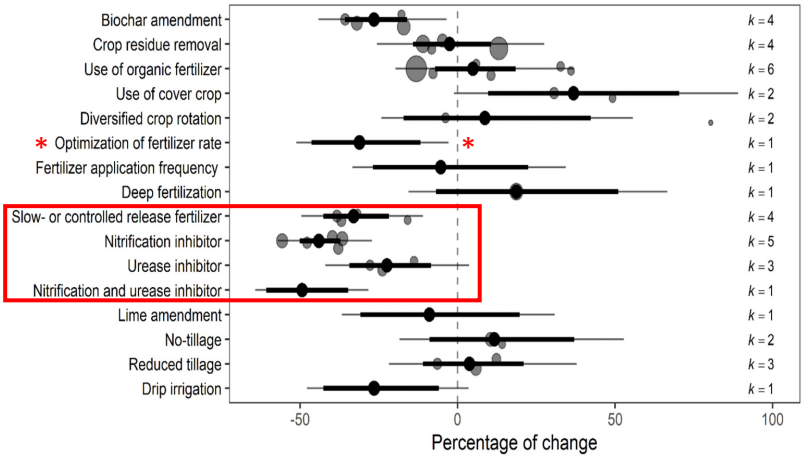
0-7% yield gain

0-15% NUE gain

20-50% less N_2O

Thapa et al. (2016) Effect of enhanced efficiency fertilizers on nitrous oxide emissions and crop yields: a meta-analysis. Soil Sci Soc Am J 80:1121–1134

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



Grados, et al. (2022). Synthesizing the evidence of nitrous oxide mitigation practices in agroecosystems. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/AC9B50

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18

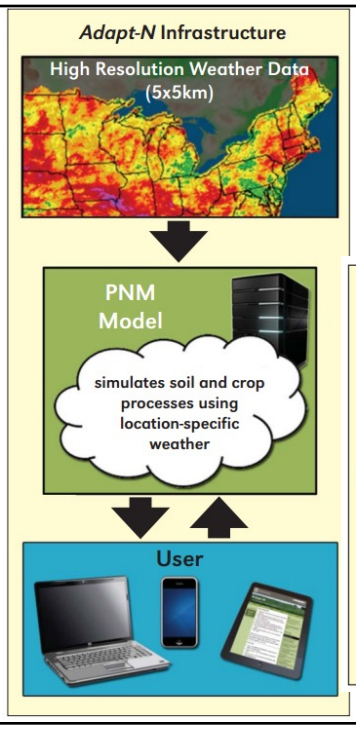
New Core Principles

RIGHT RATE: Address variability in crop response

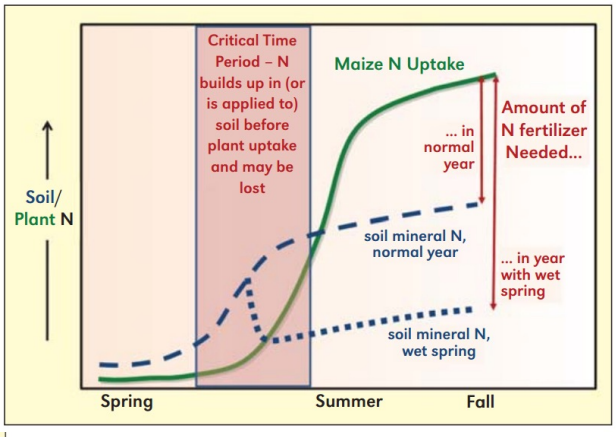
RIGHT TIME: Address changes through the growing season

RIGHT PLACE: Place nutrients to avoid loss

19



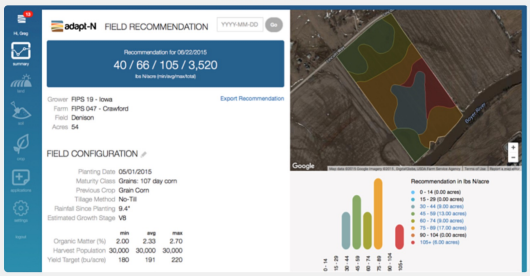
Common elements of model-based nitrogen decision support



20

adapt-N N-Recs Field Modes Features Science In Action Webinars Sign Up Login

Yara International has acquired Adapt-N to strengthen its Digital Farming offering.
Read more here.



Digital Solutions for Nitrogen Management

CLIMATE FIELDVIEW™

GET YOUR DATA IN ONE PLACE

USE DATA TO MAKE BETTER DECISIONS

OPTIMIZE YOUR INPUTS

Granular Agronomy

Make Every Input Count

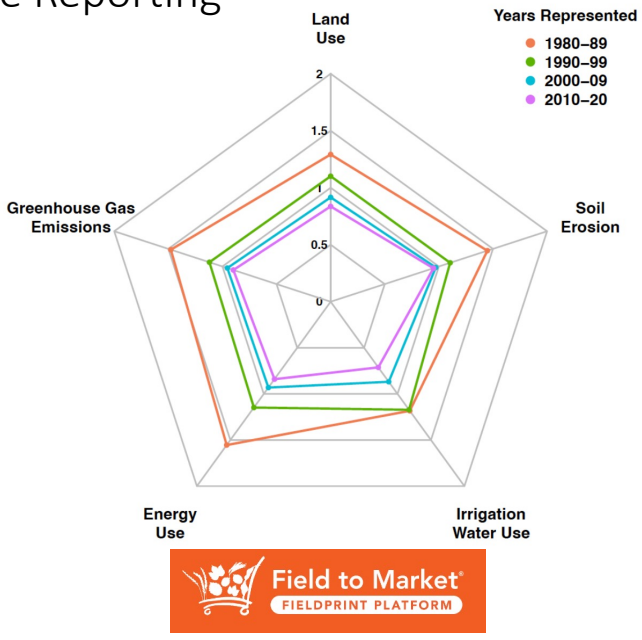
Take control of field variability with expert advice and custom prescriptions all season long.

IPNI

21

Sustainability Performance Reporting

- Track practices at farm level
- Share tracked data to report performance



ESMC Ecosystem Services Market Consortium

Field to Market® FIELDPRINT PLATFORM

22

Who needs to do what?

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- **Fertilizer Industry** – collaborate to put 4R practices into sustainability standards
- **Agri-service providers** – facilitate farm reporting of 4R practices and outcomes
- **Farmers** – share data on 4R practices and their outcomes
- **Governments** – recognize, incentivize, and reward 4R practice adoption; facilitate collection of statistical data on 4R practices
- **Scientists** – define & describe 4R practice standards and quantify their outcomes
- **Food industry** – Recognize and reward 4R practices in sustainability standards
- **Investors** – Invest in technologies, businesses and organizations that support 4R

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23

Furthering 4R Nutrient Management for Sustained Productivity

1. The scope is substantial.
2. 4R principles and practices deliver recognized benefits.
3. 4R tracks practices AND outcomes:

   NUE, nitrogen surpluses, soil health (soil carbon as GHG sink)
4. Monitoring, reporting, validation require collaboration.

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24