NITROGEN SURPLUS: AN ENVIRONMENTAL PERFORMANCE INDICATOR FOR SUSTAINABLE FOOD SUPPLY CHAINS

Eileen L. McLellan¹, Ken Cassman², Shai Sela³, Harold van Es³, Rebecca Marjerison³, Rodney Venterea⁴, Christina Tonitto³ and Peter Woodbury³.

¹ Environmental Defense Fund, Washington, D.C. 20009, www.edf.org, emclellan@edf.org
² University of Nebraska, Lincoln, NE 68583
³ Soil and Crop Sciences, Cornell University, Ithaca, NY 14853
⁴ USDA-ARS Soil and Water Management Research Unit, St. Paul MN 55108
SUPPLY CHAIN DEMAND FOR SUSTAINABLY PRODUCED GRAINS

Driving farm management change at scale
ACCOUNTABILITY: THE NEED FOR AN ENVIRONMENTAL PERFORMANCE INDICATOR

How to measure environmental performance?
• Direct measurement of losses by N species?
• Simulate impact of conservation practices via models?
• A robust “proxy” indicator of N losses from the farm?

The nitrogen cascade: need to consider all N species in an integrated way.
NITROGEN SURPLUS AS AN ENVIRONMENTAL PERFORMANCE INDICATOR

\[
N \text{ surplus} = (N \text{ inputs to the crop}) - (N \text{ removed in harvested materials}^*)
\]

* including grain, seed, tubers, hay and forage

Characteristics of a suitable indicator:
- **Simple** (easily collected field-level data)
- **Robust** (directly related to environmental outcomes)
- **Meaningful** to producers (related to other aspects of sustainability)
- **Scalable** (from field to sourcing region)
RELATIONSHIP BETWEEN N SURPLUS AND ENVIRONMENTAL OUTCOMES

Empirical relationship between N surplus and yield-scaled N$_2$O losses based on data from 12 field studies with maize in the U.S.
RELATIONSHIP BETWEEN N SURPLUS AND ENVIRONMENTAL OUTCOMES, cont’d

Results from Adapt-N model simulations showing the relationship between N surplus and yield-scaled total nitrogen losses.

\[ y = 12.2e^{0.0044x} \]

\[ R^2 = 0.59 \]
WHAT DO WE LEARN FROM THESE ANALYSES?

• Strong relationship between N surplus and yield-scaled N losses in U.S. maize systems
• Opportunity for farmers to reduce N losses by reducing N surplus *

• Possible threshold for these systems at N surplus ≈50 kg N/ha, above which N losses increase dramatically
• Greatest environmental benefit from targeting farmers and cropping systems with current large N surplus values *

• Models can be used to identify on-farm opportunities to reduce N surplus
• In U.S. maize systems, the biggest opportunities to reduce N losses are shifting fertilizer application from Fall to Spring, and applying N in split applications more synchronous with plant uptake*
AN N SURPLUS FRAMEWORK TO IMPROVE N MANAGEMENT IN FOOD SUPPLY CHAINS

**RETAILERS**
- Commit to reducing supply chain N losses

**FOOD COMPANIES**
- Set performance goals related to the N surplus of the grain they buy

**GRAIN BUYERS**
- Incentivize production of grain with acceptable N surplus

**FARMERS**
- Improve N management on farm to reduce N surplus within acceptable range
HELPING FARMERS REDUCE N SURPLUS IN CROP PRODUCTION

Model simulations of the impacts of various conservation practices

On-farm adaptive management in a social learning context

General guidance
Model suitability
Applicability of model outcomes across large areas

Farm-specific guidance
Social capacity to engage farmers
Upscaling community engagement
HOW MIGHT ON-FARM ADAPTIVE MANAGEMENT WORK?

N surplus

Benchmarking performance for e.g. maize within a single agro-ecoregion

Different nitrogen management practices

Fertilizer N inputs

4R approach
HOW MIGHT ON-FARM ADAPTIVE MANAGEMENT WORK?

- **N surplus**
  - Benchmarking performance for e.g. maize within a single agro-ecoregion

- **Fertilizer N inputs**
  - Comparing performance across different farming systems or agro-ecoregions
THE BENEFITS OF AN N SURPLUS FRAMEWORK

Farmers:
Increased sustainability
Increased public support for farming operations

Food companies and retailers:
Credible sustainability claims
Reduced supply chain risk
QUESTIONS?

For more information contact Eileen McLellan
Lead Senior Scientist, Environmental Defense Fund:
emclellan@edf.org