

Lecture in Economic Growth and Environmental Quality  
Department of Economics  
University of Guelph  
25 November 2013



# Why the fertilizer industry promotes 4R Nutrient Stewardship

Tom Bruulsema, PhD, CCA  
Director, Northeast Region, North America Program



Agrium Inc.



Arab Potash Company



Belarusian Potash Company



CF Industries Holdings, Inc.



Compass Minerals Specialty Fertilizers



Incitec Pivot



International Raw Materials LTD.



Intrepid Potash, Inc.



K+S KALI GmbH



The Mosaic Company



OCP S.A.



PotashCorp



Qatar Fertiliser Company (QAFCO)



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.



# Outline

- 1. Food Security:** The fertilizer industry plays an important role; it keeps > half of humanity alive.
  - 2. Stewardship:** 4R Nutrient Stewardship is the industry's response to issues with water, air and climate.
  - 3. Sustainability:** Real improvement in performance requires higher levels of partnership and communication.
- *Slides: available at <http://nane.ipni.net>*

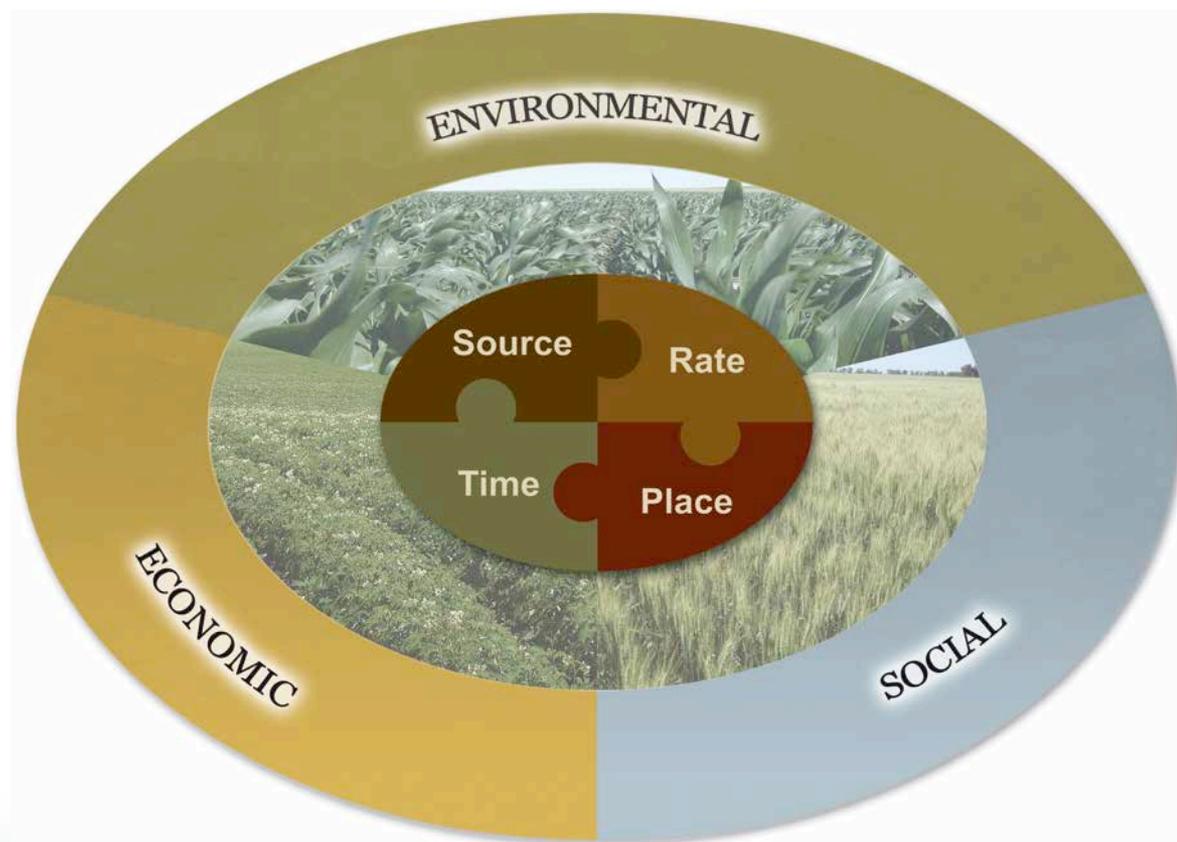


Right source

Right rate

Right time

Right place

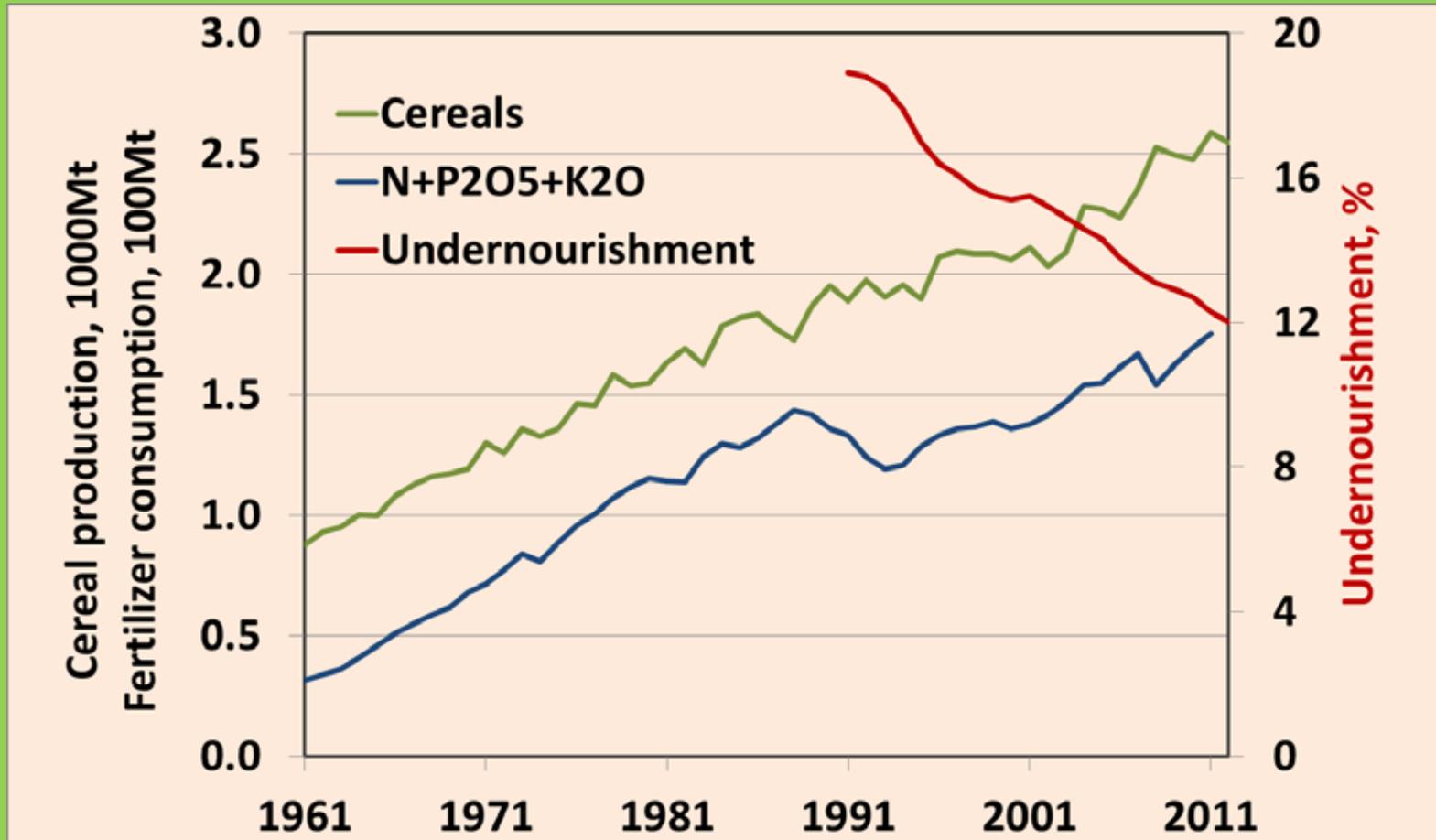


# Food and Nutrition Security

The logo consists of a circular emblem with a thick, dark green border. Inside the circle, the text "4R PLANT NUTRITION" is written in a serif font. The "4R" is significantly larger than the other text. The background of the slide is a photograph of a vast agricultural field with rows of crops stretching to the horizon under a clear sky.

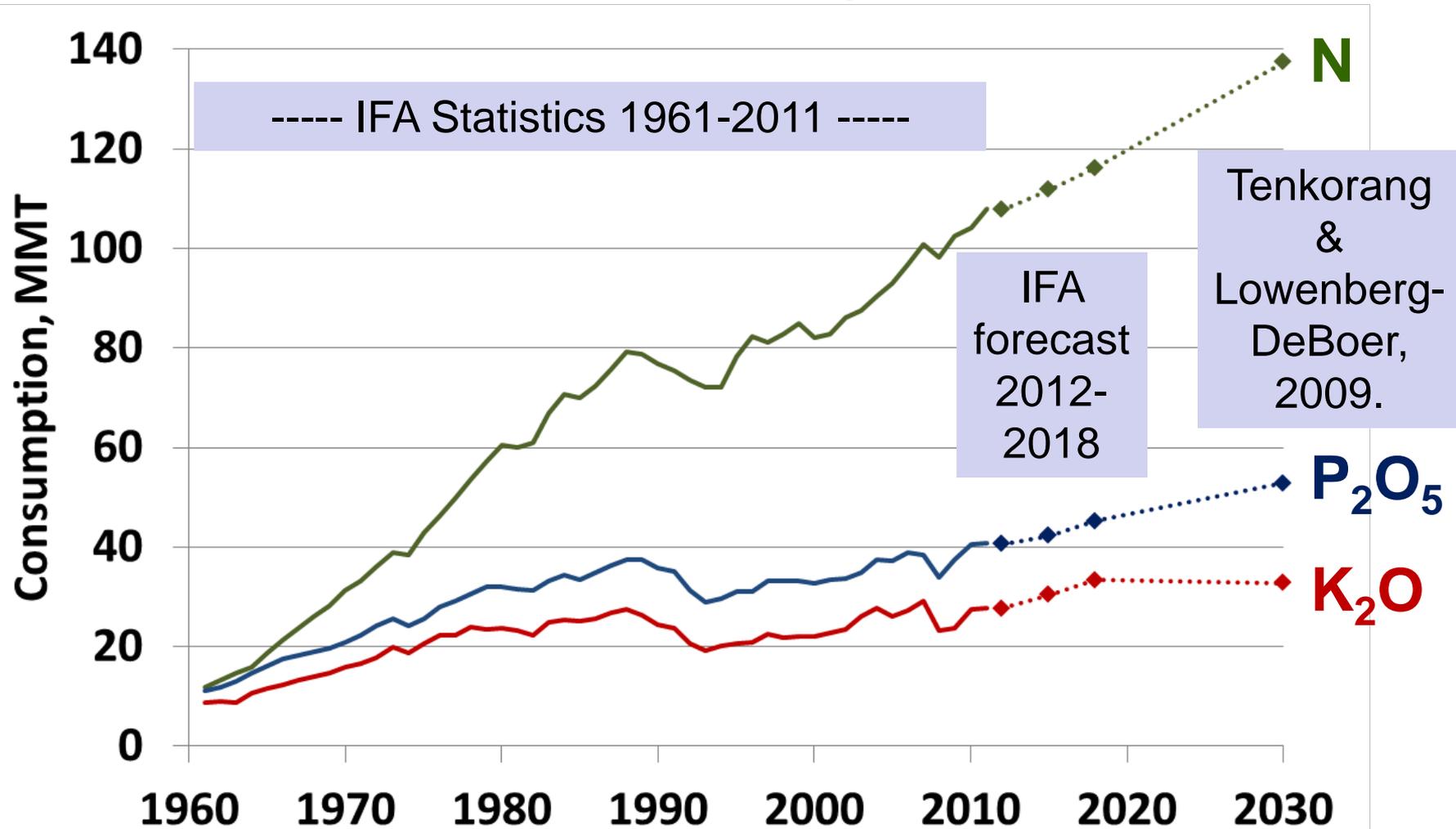
**4R**  
PLANT  
NUTRITION

# Increased fertilizer use has contributed to cereal production growth and reduced undernourishment



Data sources: FAO, IFA.

# World Fertilizer Consumption Historical and Projected



# Fertilizer Industry Value

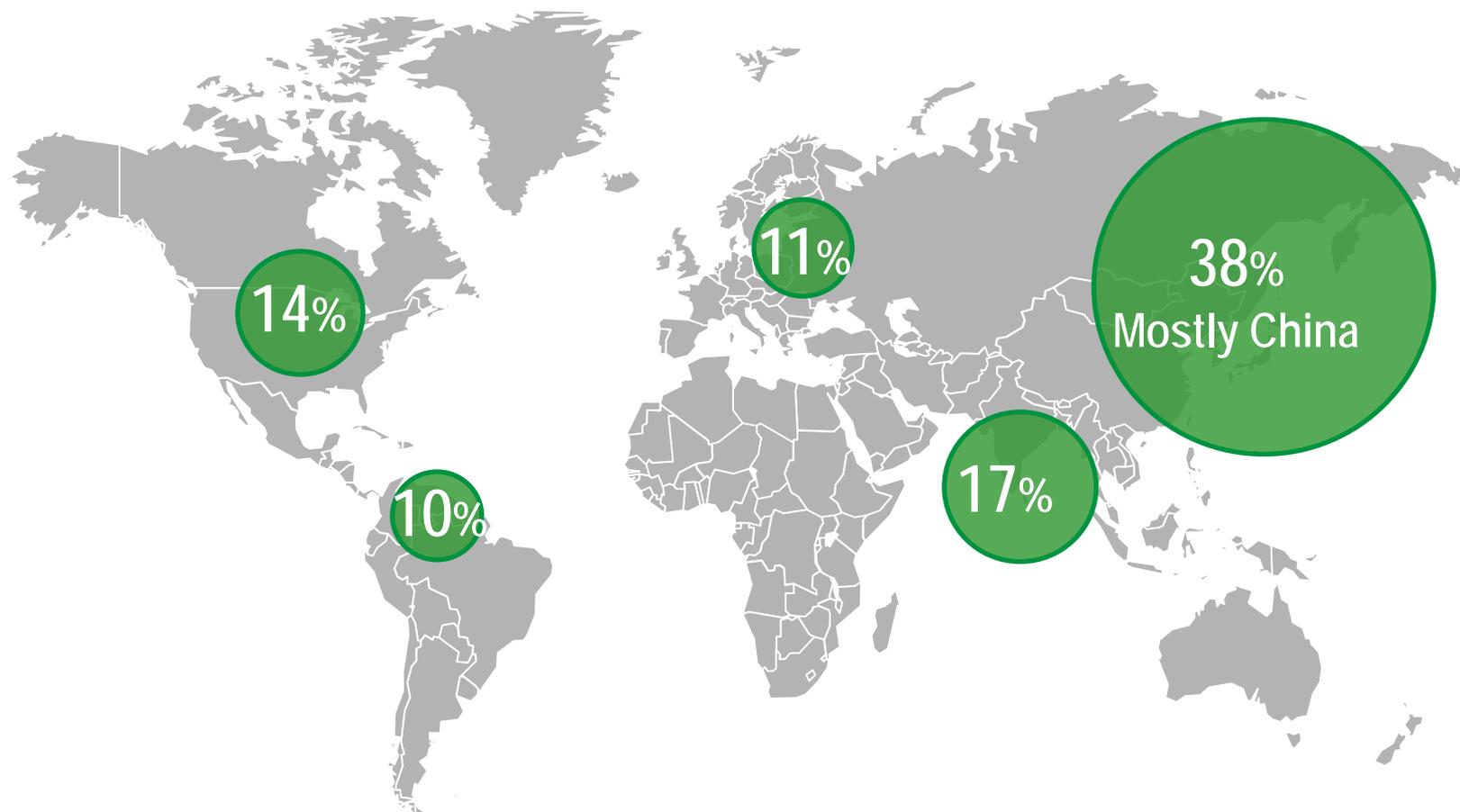
## Canada (2007-2012), per annum

- \$5-8 billion potash sales
- \$3-4 billion other fertilizers
- \$3-4 billion total farm spending on fertilizers

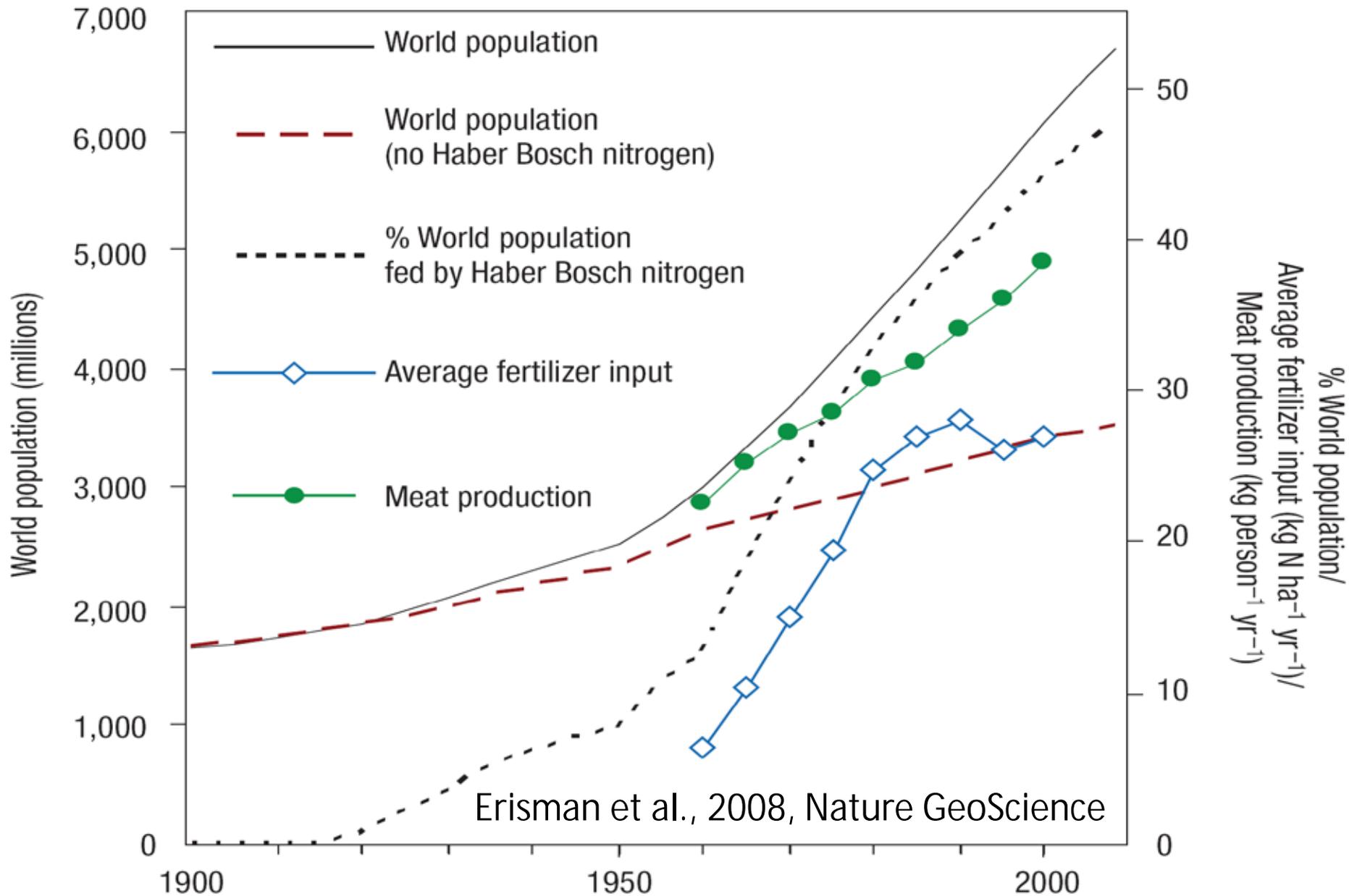
## World (2012), per annum

- ~\$100 billion N
- ~\$40 billion P
- ~\$20 billion K

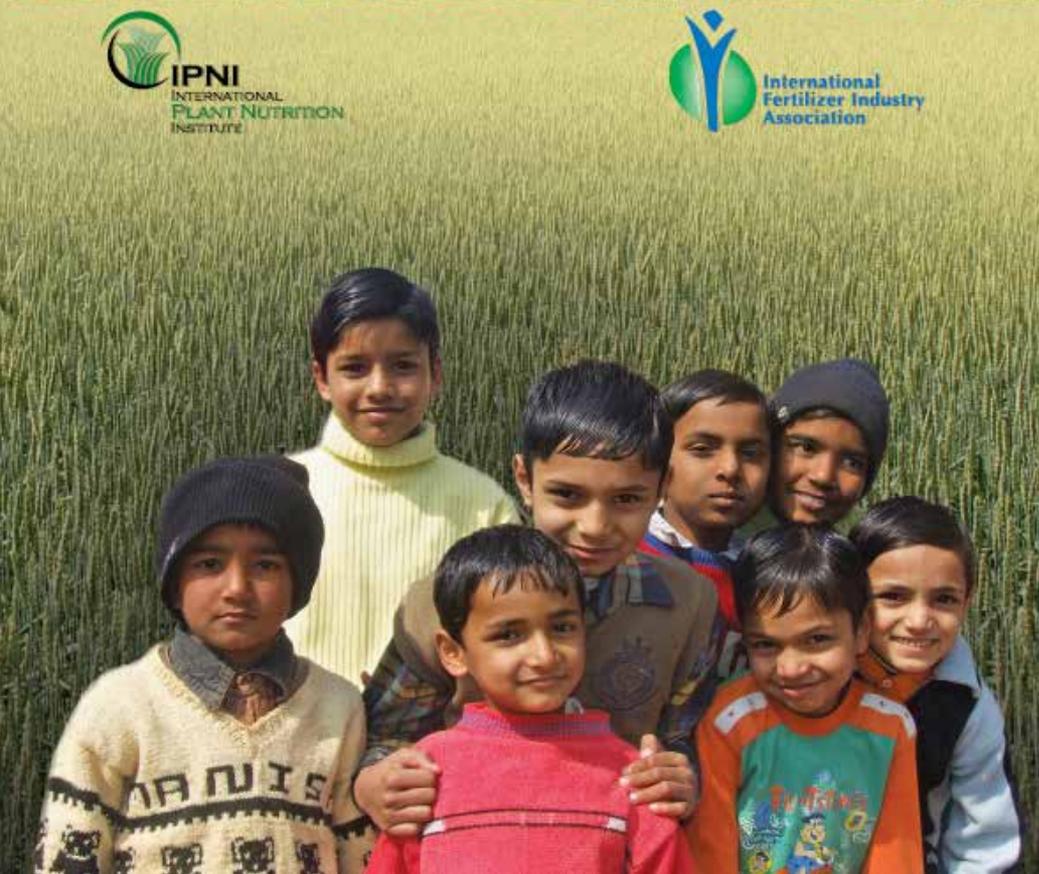
# Fertilizer consumption (2005/06 – 2007/08)



# Human Population and N Use



# Fertilizing Crops to Improve Human Health: A Scientific Review



## Topics

- Food security
- Micronutrient malnutrition
- Functional foods
- Proteins, oils and carbohydrates
- Plant disease
- Farming systems
- Remediation of soil contaminated with radionuclides
- 11 chapters



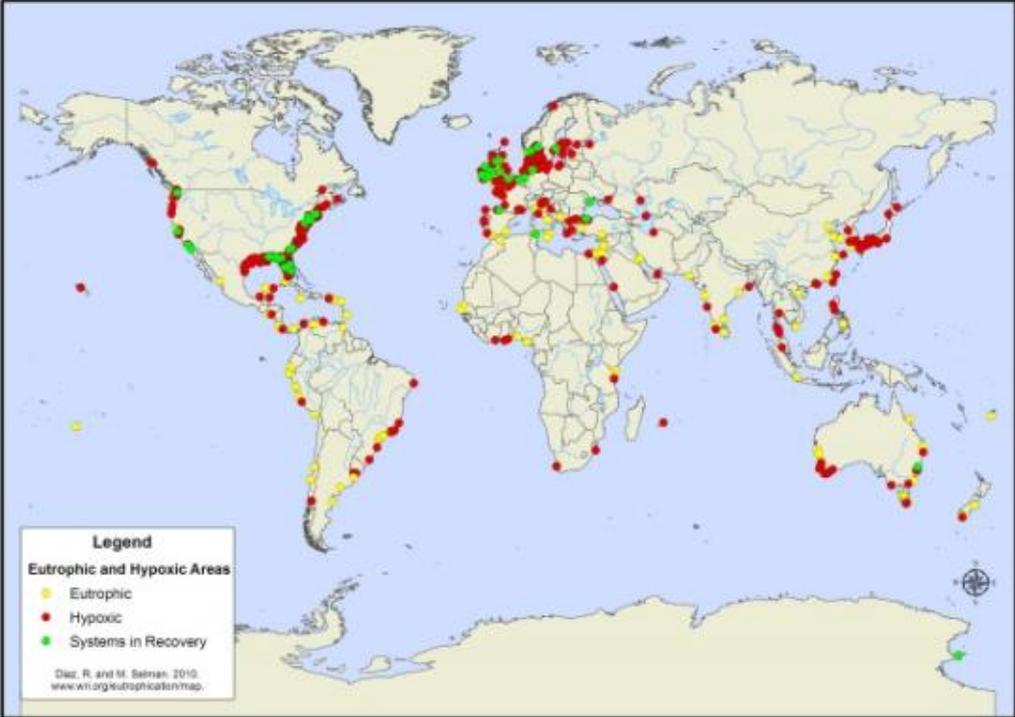
# Stewardship

A circular logo with a dark green border, partially overlapping the bottom-left corner of the slide. The text "4R PLANT NUTRITION" is centered within the circle.

**4R**  
PLANT  
NUTRITION

# Global Eutrophication Challenges

World Hypoxic and Eutrophic Coastal Areas



Houston ...

**We have a Problem!**



Source: Russ Gibson, NPS Program Manager, Ohio EPA

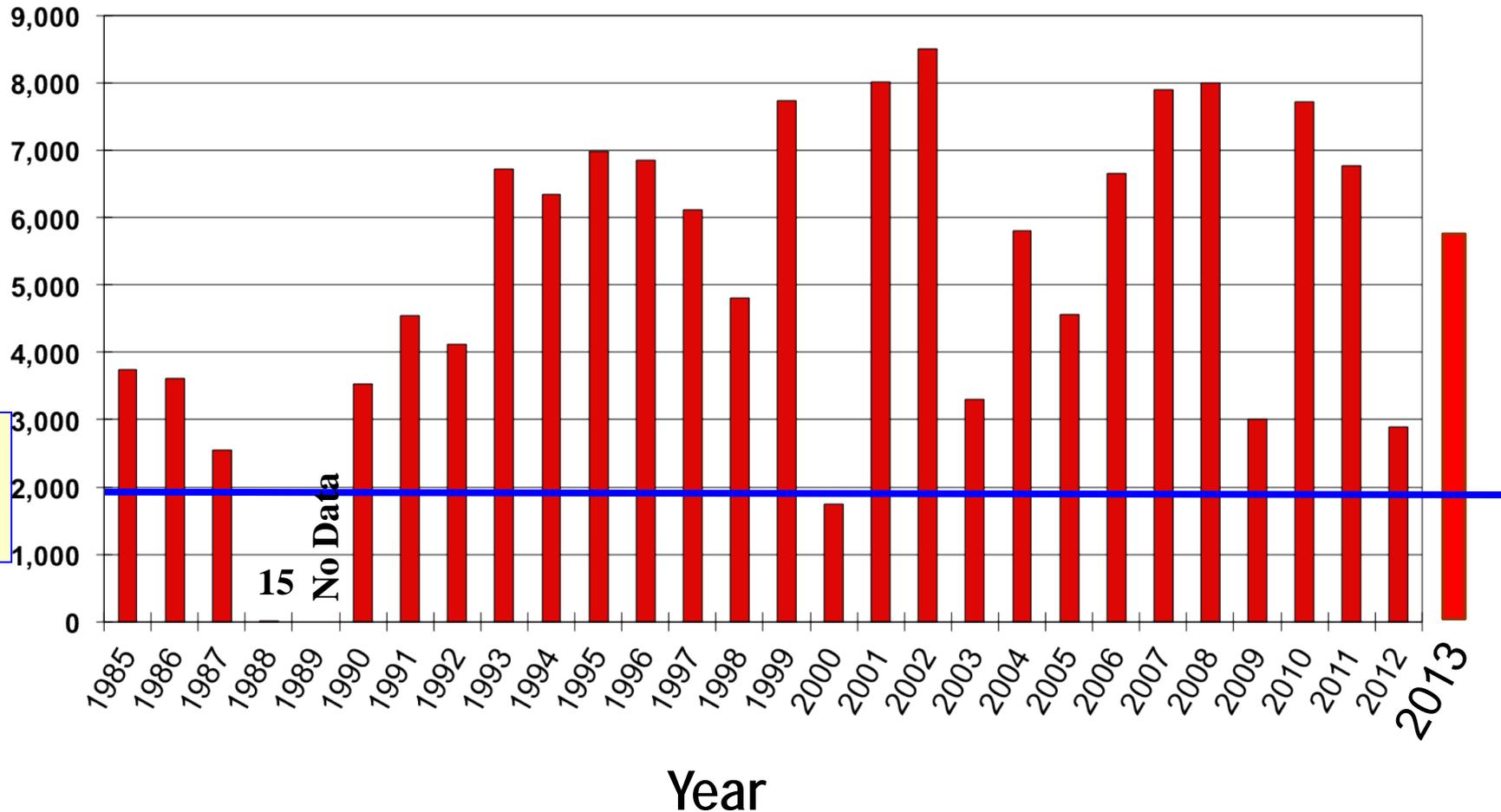


# Gulf of Mexico Hypoxia Area

Sq. mi. of hypoxia

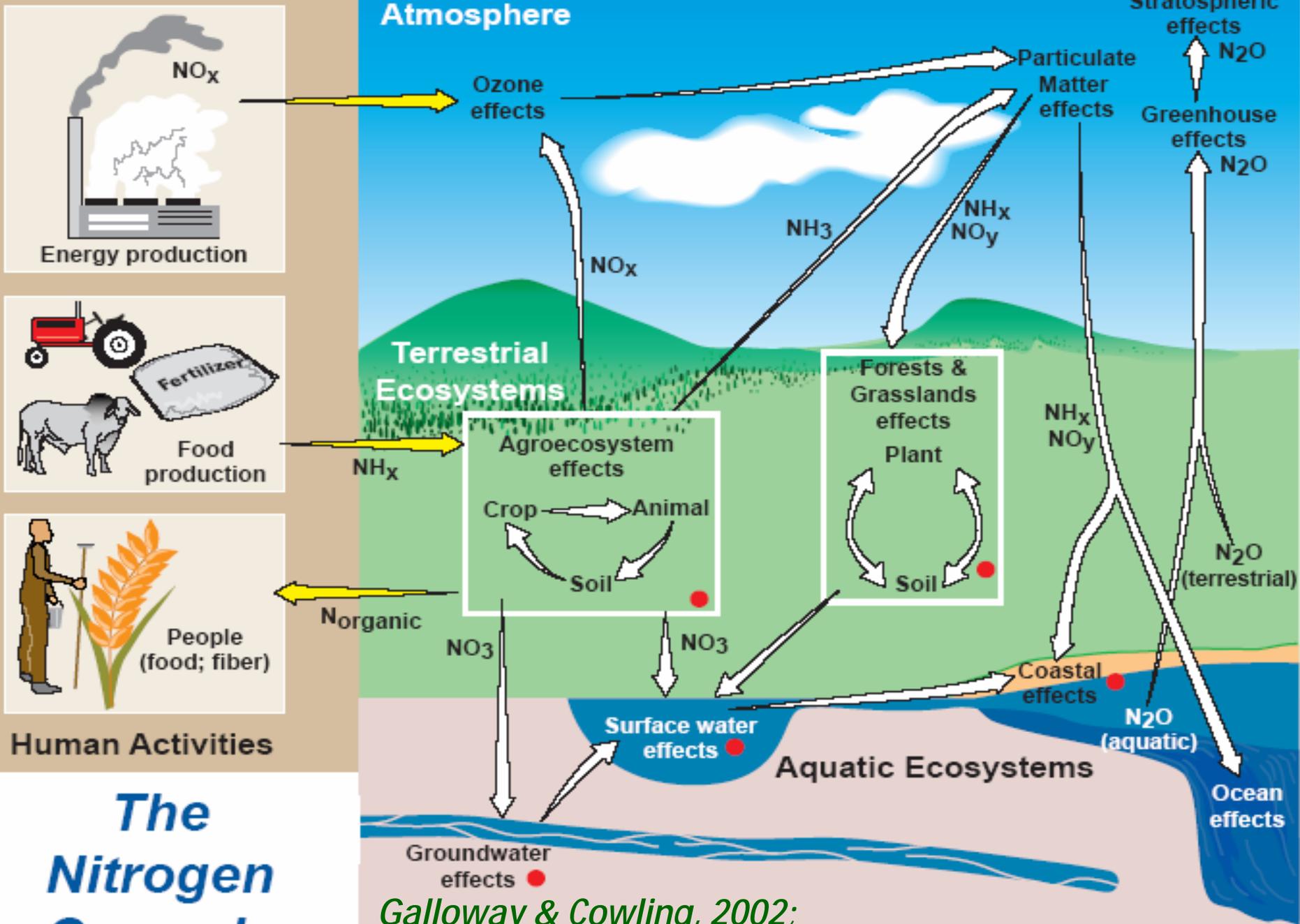
## Hypoxia Action Plan

Reduce N and P loading 45%



Hypoxia data from N. Rabalais, LUMCON





# The Nitrogen Cascade

Galloway & Cowling, 2002;  
 UNEP, 2003

● Indicates denitrification potential

# Our Nutrient World

The challenge to produce more food and energy with less pollution



- GPNM 2013, 128 pages
- Analysis of global N & P cycles
- Essential for food [fuel & fiber]
- Threats to WAGES
- Full-chain N use efficiency 8% [could be higher than 16%]
- Multiple definitions of crop NUE
- Deserves attention... and refinement

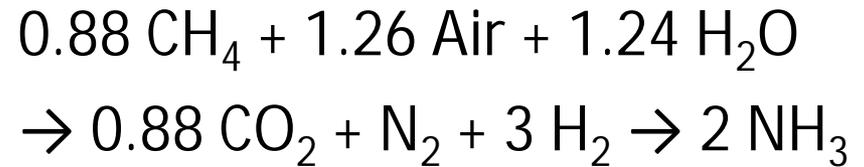
Prepared by the Global Partnership on Nutrient Management  
in collaboration with the International Nitrogen Initiative

# Greenhouse Gases and Fertilizer

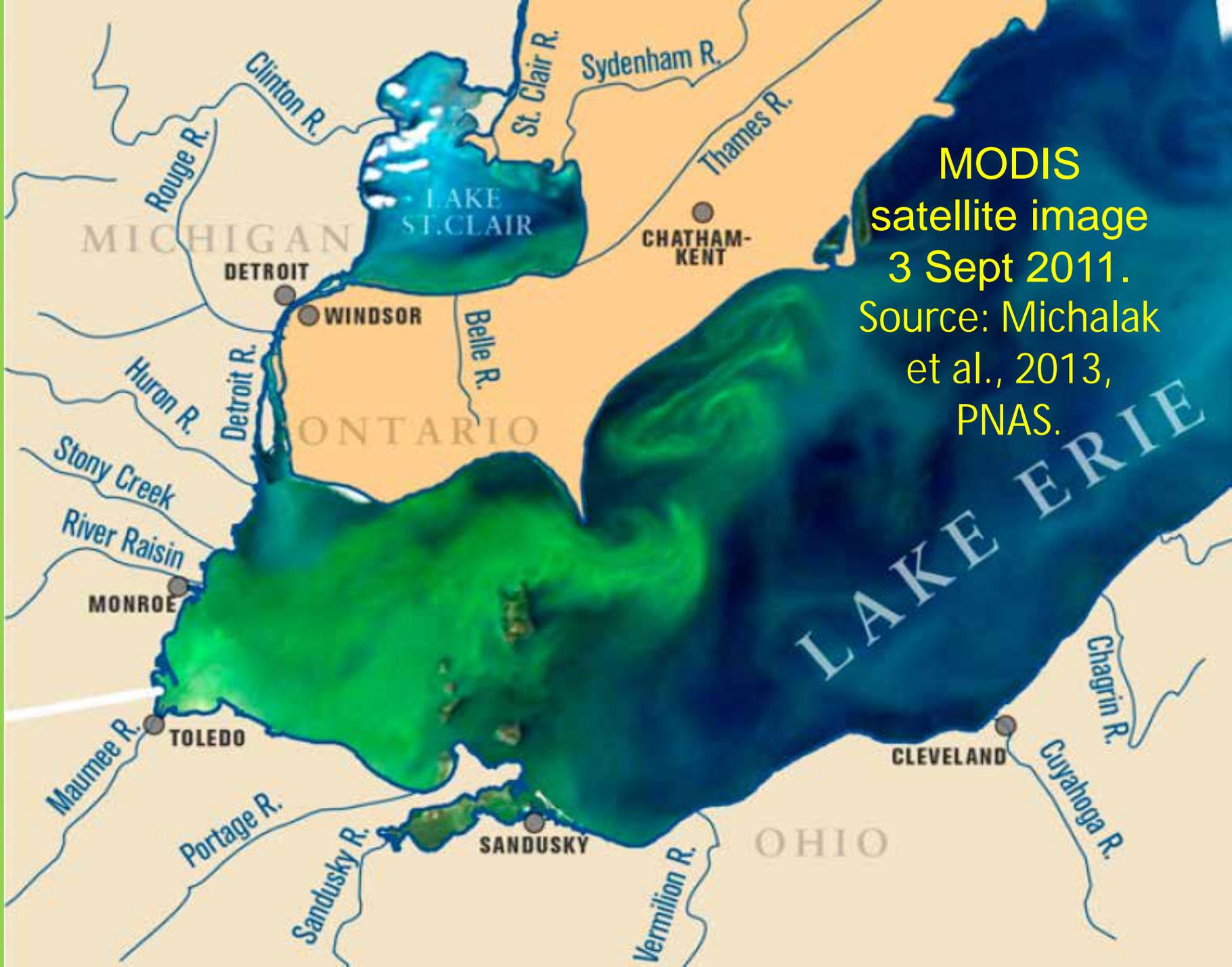
Greenhouse Gas Emissions from Cropping Systems and  
the Influence of Fertilizer Management

A Literature Review  
December 2007

By Dr. C.S. Snyder, Dr. T.W. Bruulsema, and Dr. T.L. Jensen  
International Plant Nutrition Institute (IPNI)



<b>GHG cost of N use</b>	<b>kg CO<sub>2</sub>-eq /kg N</b>
Manufacture & transport	3.0 – 4.5
Emission of N <sub>2</sub> O from soil	0.7 – 4.7
Lime requirement	0.0 – 0.4
<i>Soil C storage</i>	?

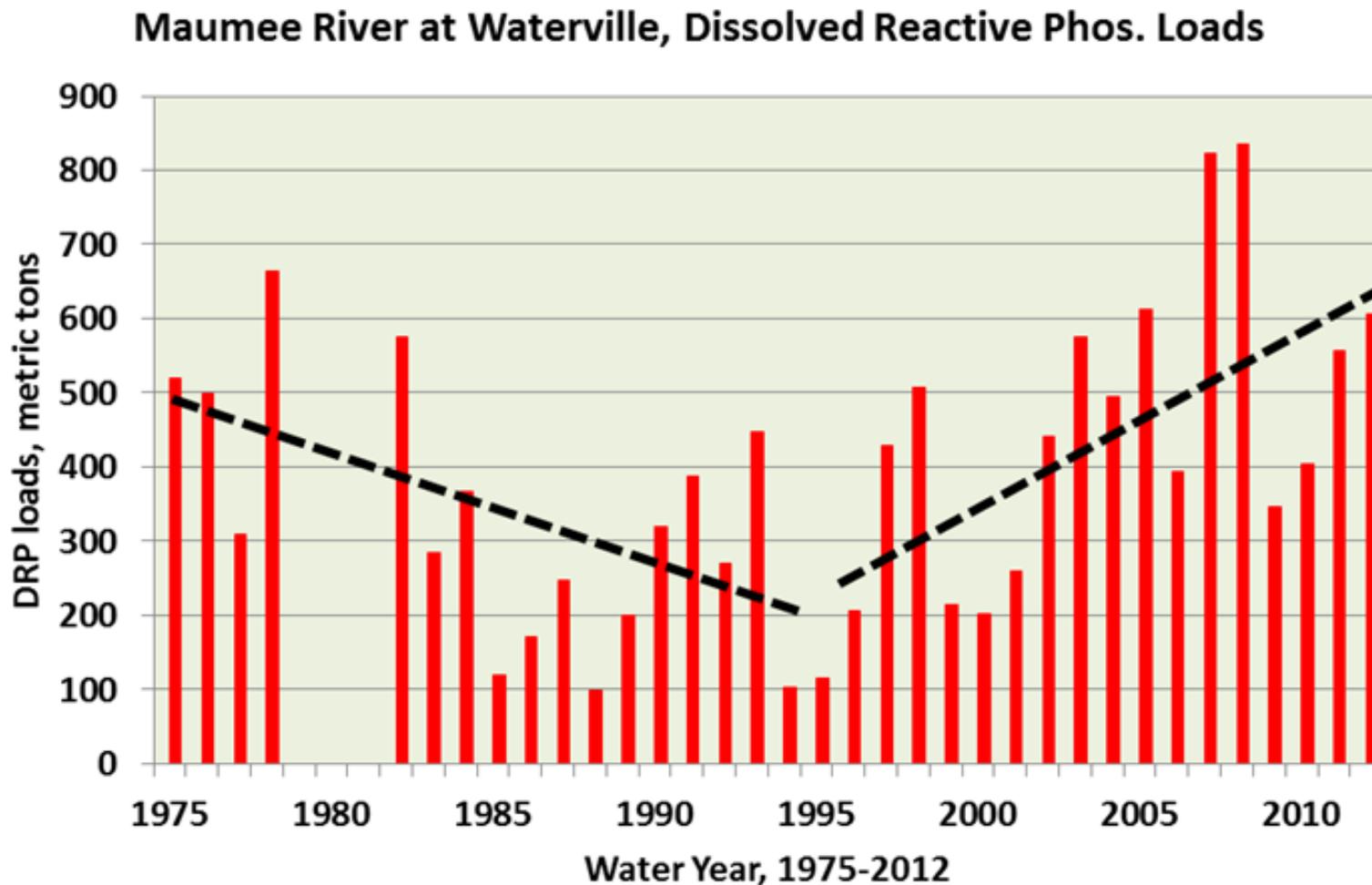


**MODIS**  
satellite image  
3 Sept 2011.  
Source: Michalak  
et al., 2013,  
PNAS.

Ohio Lake Erie  
Phosphorus Task Force II  
Final Report



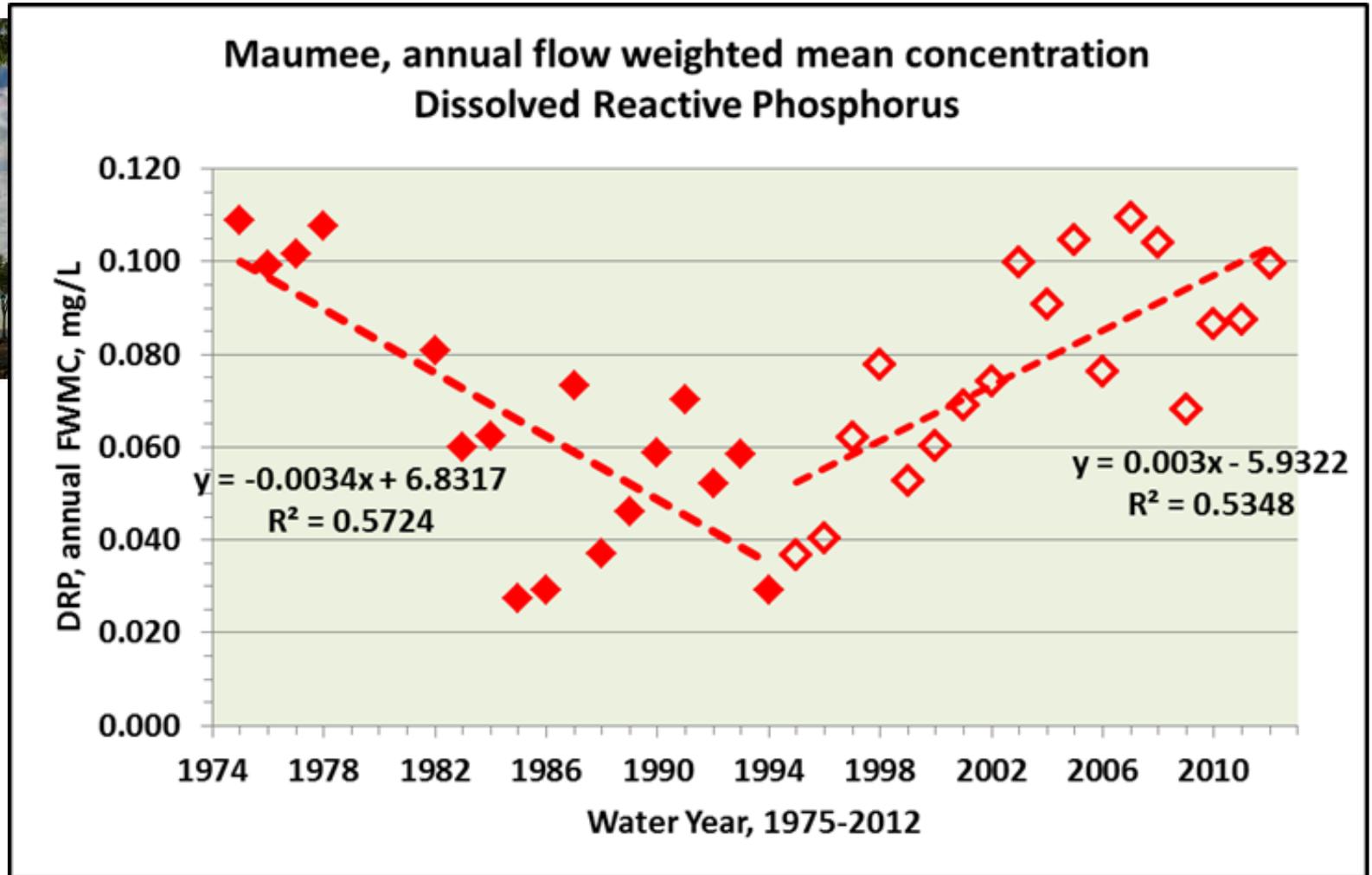
Final Report  
November 2013



# Ohio Lake Erie Phosphorus Task Force II Final Report



Final Report  
November 2013





December 2012

## Reducing Loss of Fertilizer Phosphorus to Lake Erie with the 4Rs

*Algal blooms in Lake Erie have been getting worse in the past few years. Phosphorus (P) has often been considered the nutrient controlling such blooms. The loads of dissolved P in the rivers draining into Lake Erie vary greatly year-to-year, but higher loads have become more frequent in recent years than in the mid-1990s. Agriculture is one of several sources of dissolved P.*

*This article outlines how crop producers in the Lake Erie watershed can reduce losses of P by adopting a 4R Nutrient Stewardship approach to guide their fertilizer application practices.*

### Background

Much of the cropland of the Lake Erie watershed is found in Ohio, with smaller areas in Indiana, Michigan and Ontario

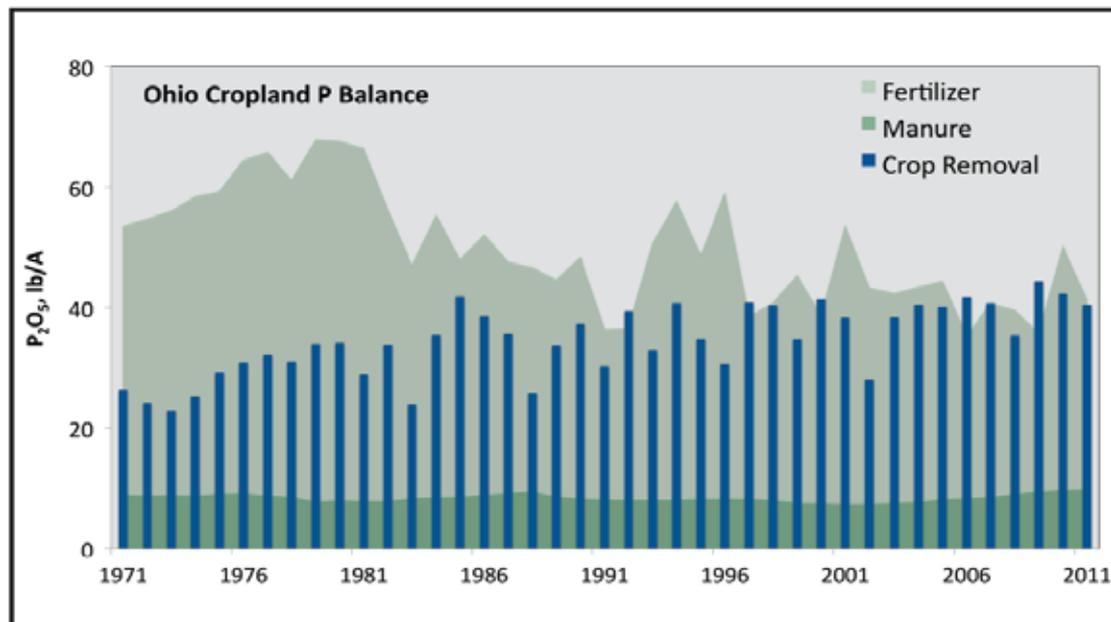


Figure 2. Phosphorus balance trend over time for Ohio cropland. \*2011 fertilizer estimated.



# 4R Nutrient Stewardship Certification Standard

---

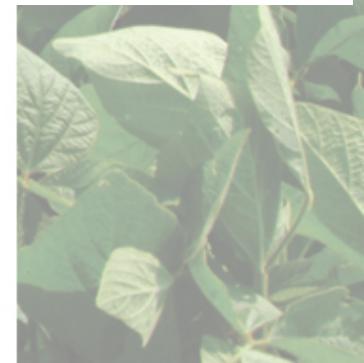
## *Requirements for Nutrient Service Providers in the Lake Erie Watershed*

1. Initial Training and Ongoing Education
  2. Monitoring of 4R Implementation
  3. Nutrient Recommendations and Application
- July/August: review of 4 Pilot Audits
  - Fall 2013/Winter 2014: Promotion
  - Summer of 2014: Certifications

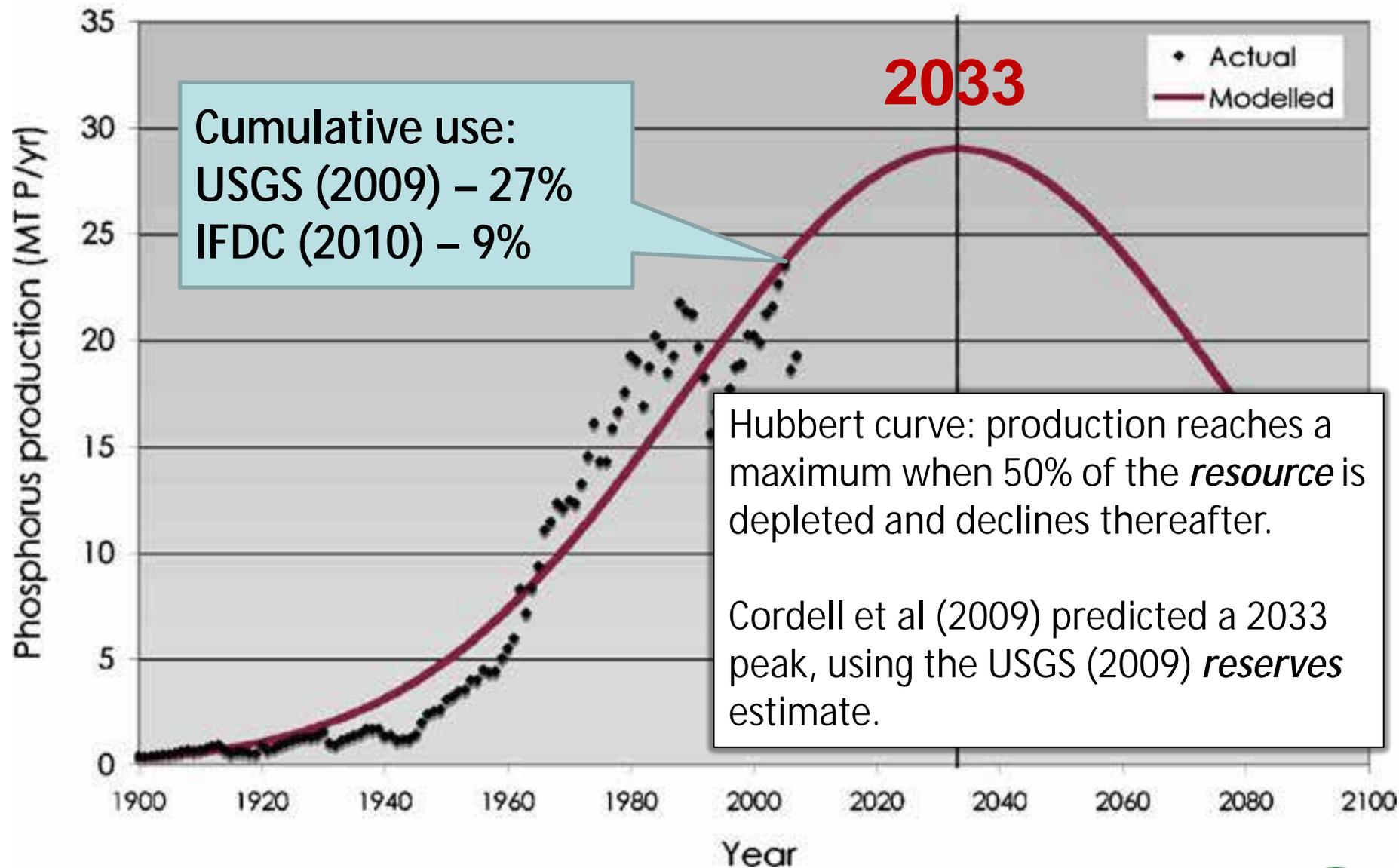


*Version 2.0*

September 2013



# Peak phosphorus ... like peak oil??



# World Phosphate Rock Reserves and Resources



Country	2011-12 Production	Reserves	Reserve Life
	Mt		Years
Morocco	28	50,000	1790
South Africa	2.5	1,500	600
Jordan	6.5	1,500	230
Russia	11	1,300	115
USA	29	1,400	49
China	85	3,700	43
World Total	204	67,000	328

Source: USGS, 2013

“No matter how much phosphate rock exists, it is a non-renewable resource”  
IFDC, 2010



# World Potash Reserves

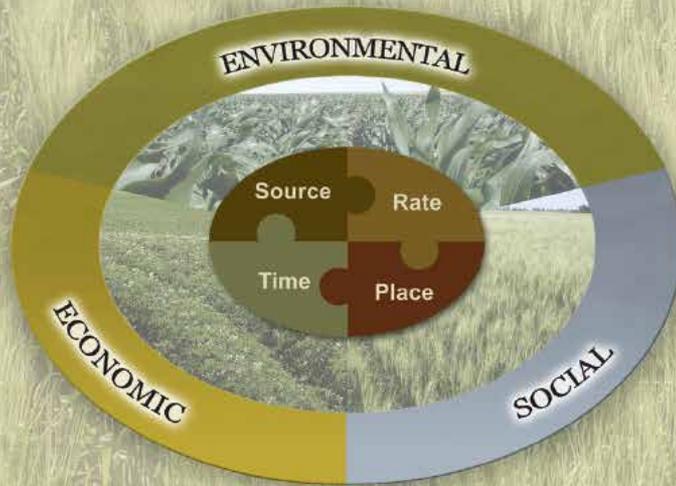
Country	2012 Production	Reserves	Reserve Life	Resources
	Million tonnes K <sub>2</sub> O		Years	Mt K <sub>2</sub> O
Canada	9	4,400	490	
Russia	7	3,300	470	
Belarus	6	750	125	
Germany	3	140	45	
USA	1	130	130	7,000
<b>World</b>	<b>34</b>	<b>9,500</b>	<b>280</b>	<b>250,000</b>

USGS Mineral Commodities Summaries, 2013



# 4R PLANT NUTRITION

*A Manual for Improving the Management of Plant Nutrition*  
NORTH AMERICAN VERSION



<b>Chapter 1</b>	Goals of Sustainable Agriculture .....
<b>Chapter 2</b>	The 4R Nutrient Stewardship Concept .....
<b>Chapter 3</b>	Scientific Principles Supporting — Right Source .....
<b>Chapter 4</b>	Scientific Principles Supporting — Right Rate .....
<b>Chapter 5</b>	Scientific Principles Supporting — Right Time .....
<b>Chapter 6</b>	Scientific Principles Supporting — Right Place .....
<b>Chapter 7</b>	Adapting Practices to the Whole Farm .....
<b>Chapter 8</b>	Supporting Practices .....
<b>Chapter 9</b>	Nutrient Management Planning and Accountability .....

<http://nane.ipni.net>

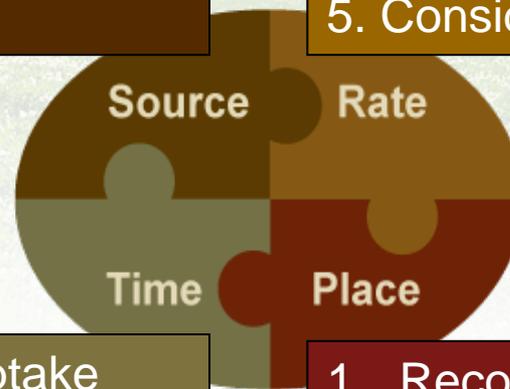
# Source, rate, time, and place describe any nutrient application



# The basic scientific principles of managing crop nutrients are universal

1. Provide essential elements
2. Supply plant-available forms
3. Suit soil properties
4. Synergisms, blend compatibility
5. Associated elements

1. Assess plant demand
2. Assess soil supply
3. Assess all available sources
4. Predict fertilizer use efficiency
5. Consider resources and economics



1. Assess timing of crop uptake
2. Assess dynamics of soil supply
3. Assess timing of weather factors
4. Evaluate logistics

1. Recognize root-soil dynamics
2. Consider soil chemical reactions
3. Manage spatial variability
4. Fit needs of tillage system

# 4R Adaptive Management for Plant Nutrition

**Policy Level – Regulatory,**  
Infrastructure, Product Development

**Regional Level**  
Agronomic scientists,  
Agri-service providers

**Farm Level**  
Producers,  
Crop advisers

**DECISION SUPPORT** based  
on scientific principles

Recommendation of **right source,**  
**rate, time, and place (BMPs)**

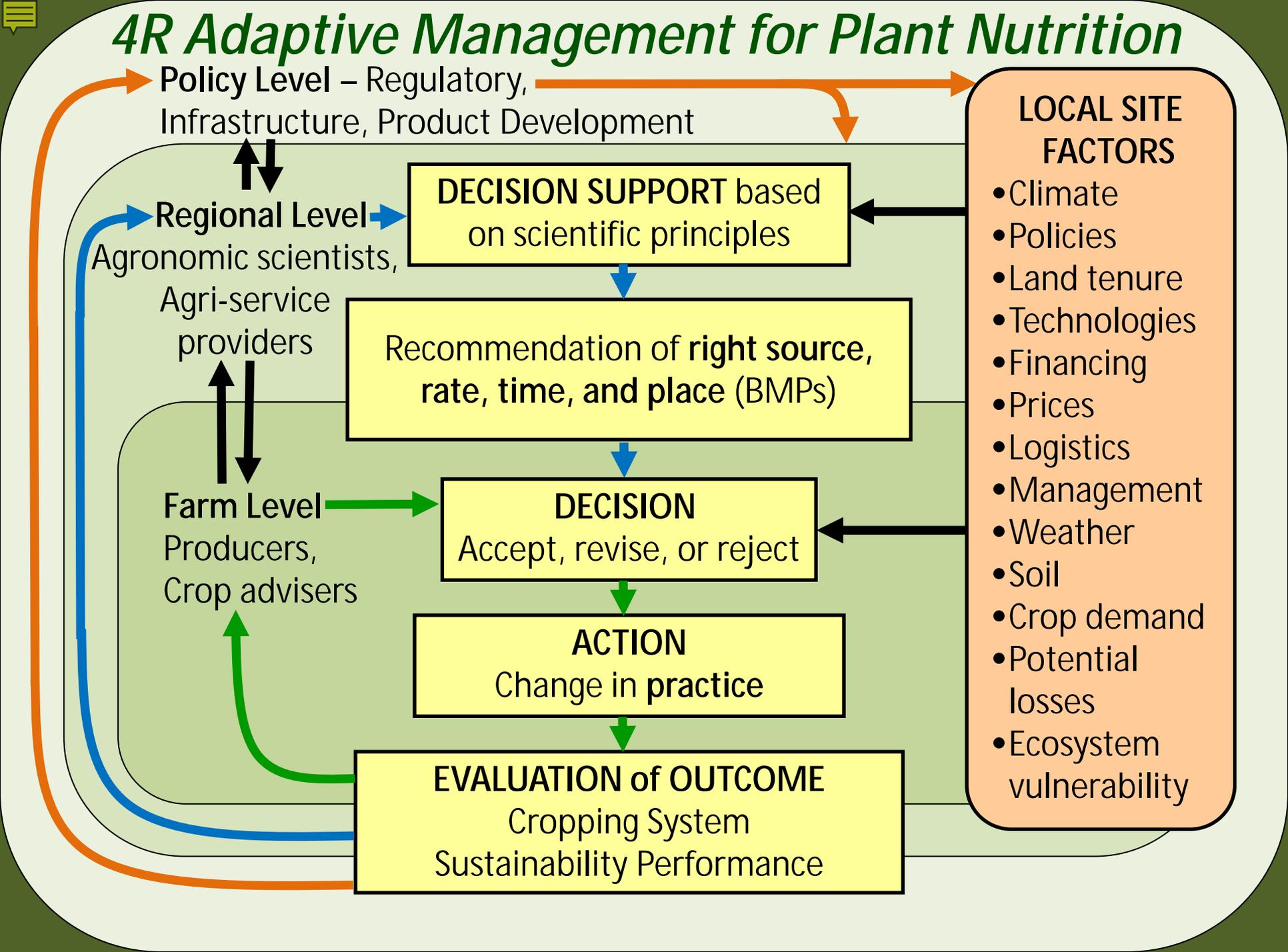
**DECISION**  
Accept, revise, or reject

**ACTION**  
Change in **practice**

**EVALUATION of OUTCOME**  
Cropping System  
Sustainability Performance

## LOCAL SITE FACTORS

- Climate
- Policies
- Land tenure
- Technologies
- Financing
- Prices
- Logistics
- Management
- Weather
- Soil
- Crop demand
- Potential losses
- Ecosystem vulnerability



# Sustainability

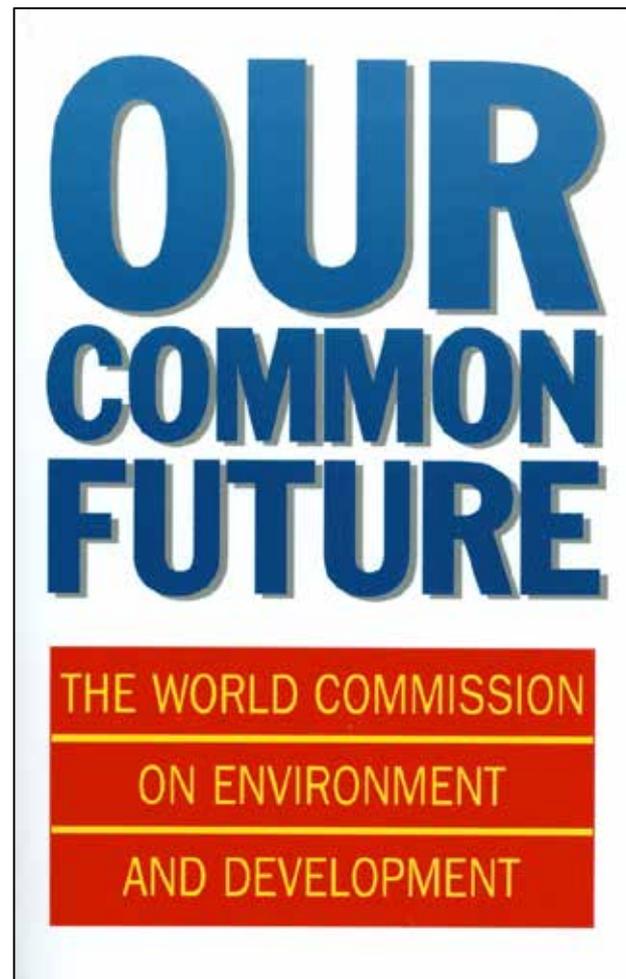


**4R**  
PLANT  
NUTRITION

# Brundtland report

- *Our Common Future* (1987) addressed concerns “about the accelerating deterioration of the **human environment** and **natural resources** and the consequences of that deterioration for **economic** and **social development**.”
- This report provided the basis for sustainable agriculture.

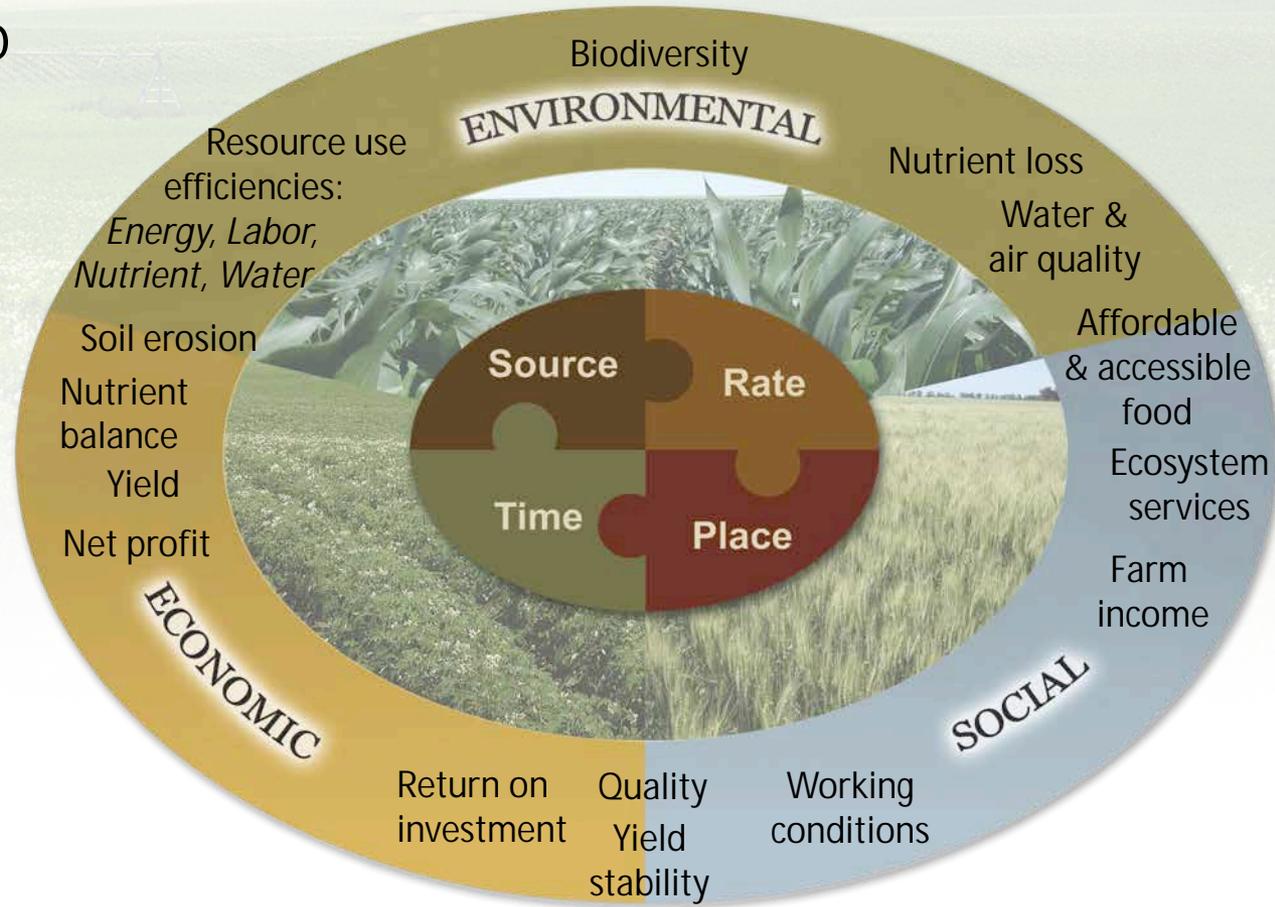
Source: Advisory Panel on Food Security, Agriculture, Forestry, and Environment. World Commission on Environment and Development. 1987.



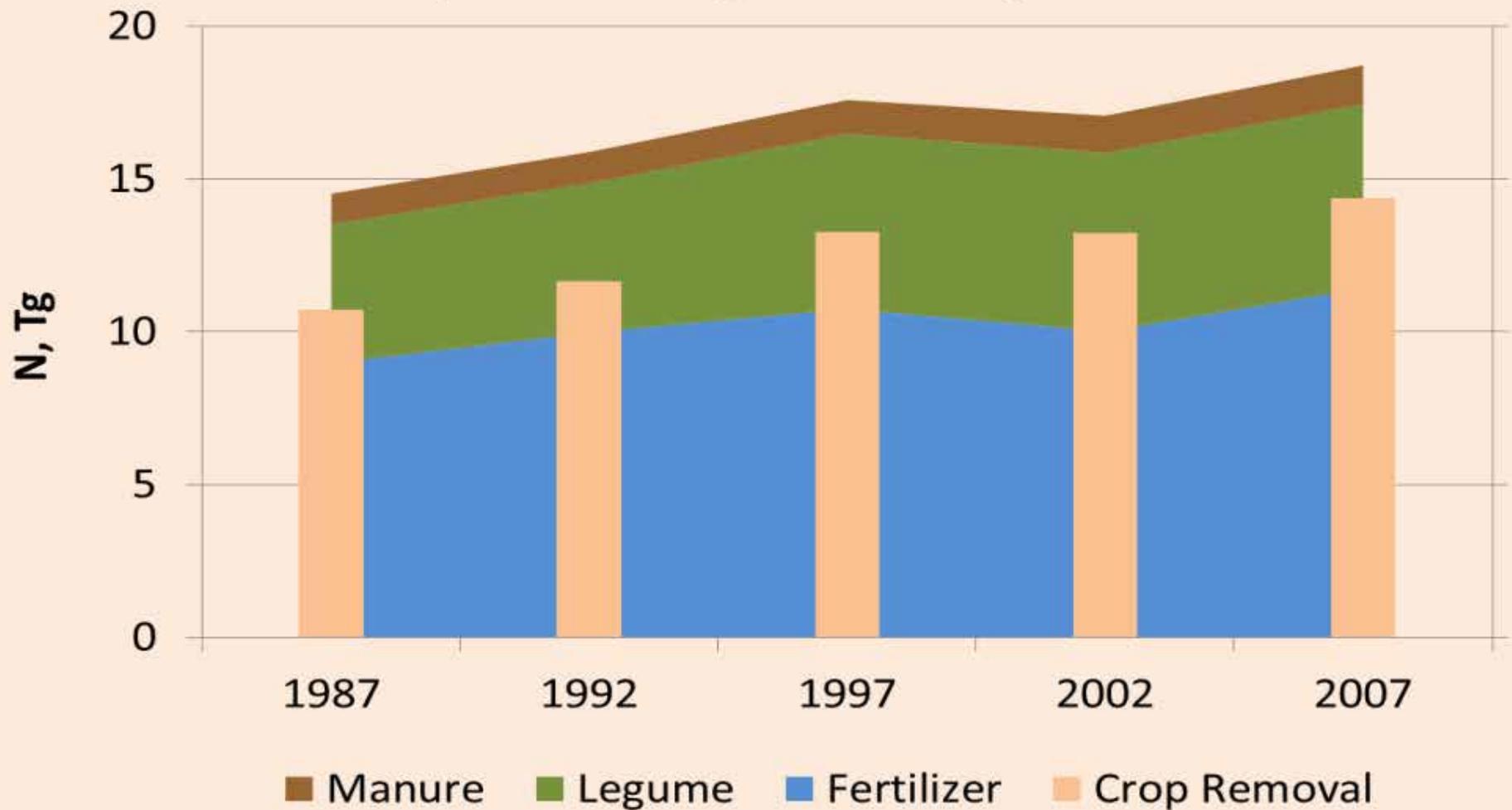


# The 4Rs influence many performance indicators

- social, economic and environmental performance
- influenced by crop and soil management as well
- whole system outcomes

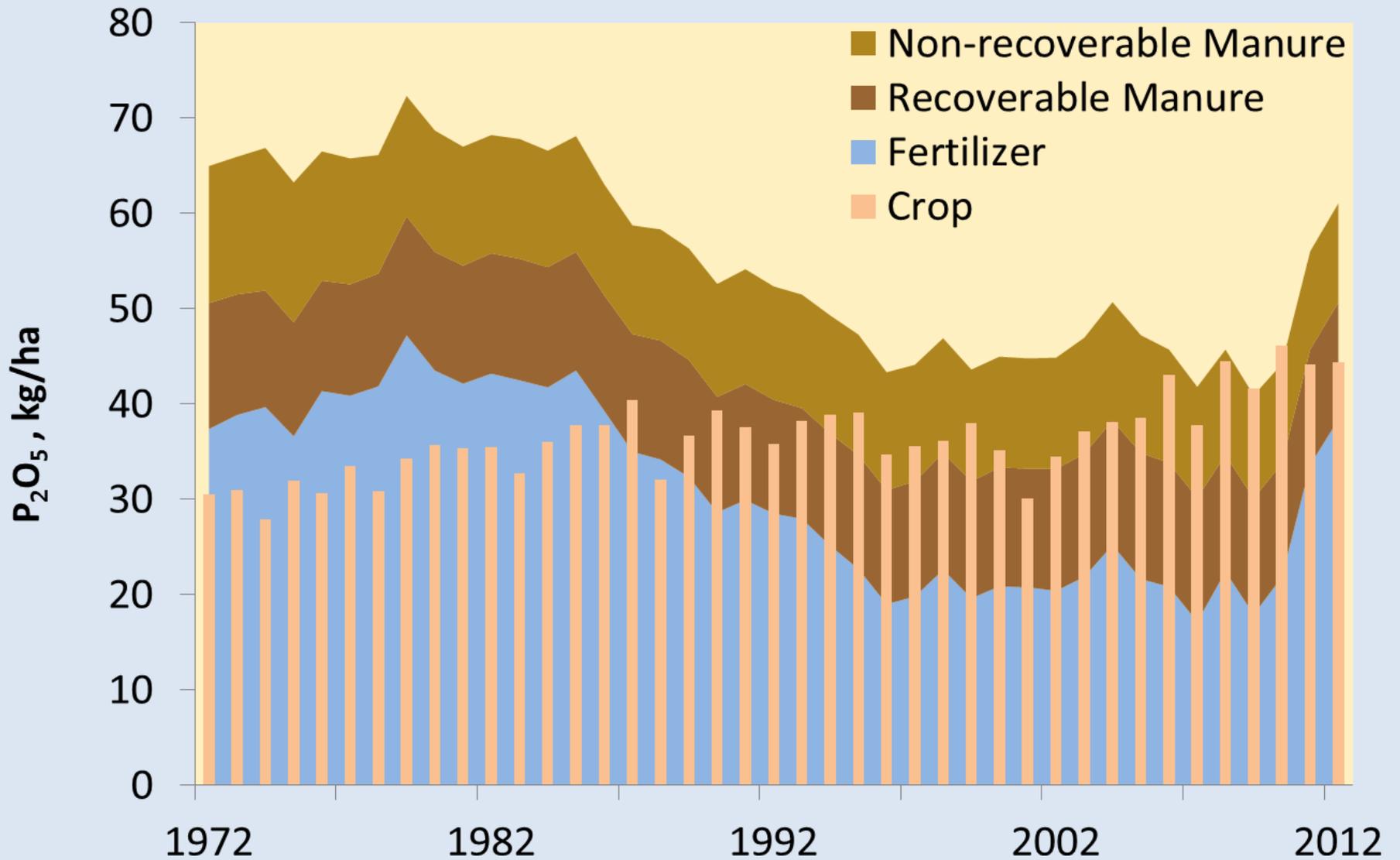


# Cropland Nitrogen Balance, USA

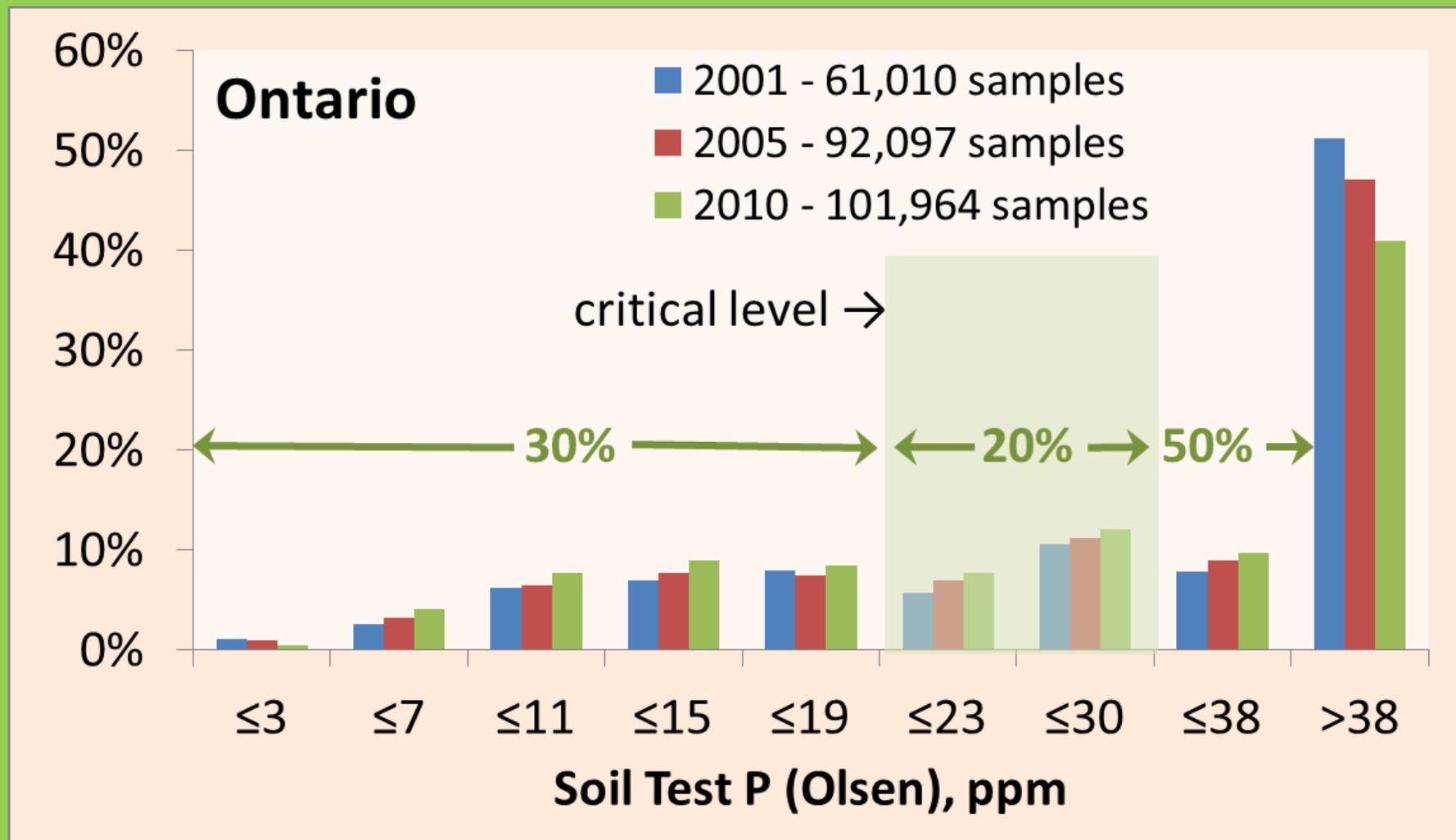


**Figure 4.1:** Inputs of N to US agricultural land, including recoverable manure, legume fixation, and commercial fertilizers, as compared to removal by crops (adapted from IPNI NuGIS, 2011). [In Robertson et al., 2012, Biogeochemistry, in press]

# Ontario Cropland Phosphorus Balance

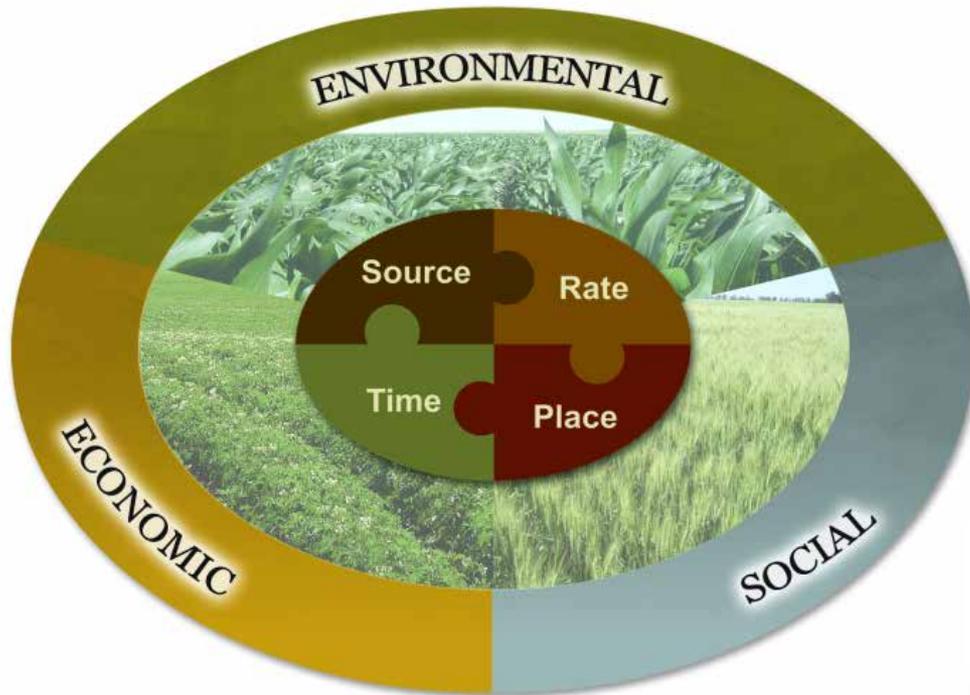


# Soil test P distribution, 2001-2010



See <http://nane.ipni.net>

# 4R: "right" means sustainable



**Field to Market™**  
The Keystone Alliance for Sustainable Agriculture



[Home](#) [Our Goals](#) [How To Make A Difference](#) [Share What You've](#)

[Home](#) [How To Make A Difference](#) [Fertilizer Optimization](#)



## How to Make a Difference - Fertilizer optimization





# Adapt-N

A tool for adaptive nitrogen management in corn

- Home
- About
- Adapt-N Manual
- News & Events
- Publications & Resources
- People

## News and events

Web-based nitrogen management decision tool

**Adapt-N  
Sign in**

[Get account](#) | [View manual](#)

### News from the blog

#### Adapt-N chosen 2012 Top Product of the Year

Adapt-N was selected as the Best New Product of the Year 2012 by AgProfessional magazine, the leading publication related to agronomic and business management for agricultural retailers/distributors, professional farm managers and crop consultants. Adapt-N took a huge 52 percent of the vote, and it is the first time a non-commercial organization received the award. "The [...]"

#### Adapt-N is now available for the 2013 season

Hello Adapt-N Users, The conversion to 2013 was completed over the weekend, and Adapt-N is now available for the 2013 season. Retrospective runs for 2012 remain available as well. As always, please do not hesitate to send questions and feedback. Bianca Moebius-Clune [bnm5@cornell.edu](mailto:bnm5@cornell.edu)

Top Product of the Year, 2012 – Ag Professional Magazine

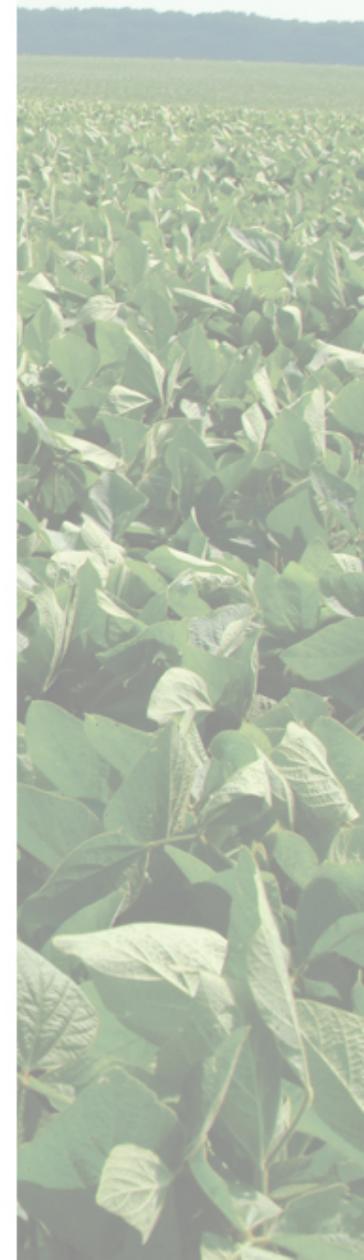




## 4R Research Fund – *environmental, social, economic impacts of 4Rs on sustainability*

**4R**  
PLANT  
NUTRITION

- **\$7M** over 5 years across North America
- **Meta-analyses:** Review and analysis projects.
- **New Projects** – Measurement.
- Both to contribute measures of performance for 4R Nutrient Stewardship.
- For additional information:  
[www.nutrientstewardship.com/funding](http://www.nutrientstewardship.com/funding)



# Summary

1. The fertilizer industry plays an important role in food security; it keeps > half of humanity alive.
2. 4R Nutrient Stewardship is the industry's response to issues with water, air and climate.
3. Real improvement in sustainability performance requires higher levels of partnership, research and communication.



Thank you

[nane.ipni.net](http://nane.ipni.net)

# 4R PLANT NUTRITION

*A Manual for Improving the Management of Plant Nutrition*

NORTH AMERICAN VERSION

