



National Soil Science
Conference
MCG, Melbourne, Victoria
23-27 November 2014



Increasing nutrient use efficiency in farming systems

27 November 2014

TW Bruulsema, Director, North America

RM Norton, Director, Australia/New Zealand



Agrium Inc.



Arab Potash Company



Belarusian Potash Company



BHP Billiton



CF Industries Holdings, Inc.



Compass Minerals Plant Nutrition



International Raw Materials LTD.



Intrepid Potash, Inc.



K+S KALI GmbH



The Mosaic Company



OCP S.A.



PhosAgro



PotashCorp



Qatar Fertiliser Company (QAFSCO)



Shell Sulphur Solutions



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. Performance metrics for sustainability initiatives
2. Forms of nutrient use efficiency
3. Environmental impact

“Nutrient use efficiency is a useful, complex, and incomplete indicator of crop nutrition performance”

Slides: available at <http://nane.ipni.net>

Nutrient Performance Indicators: The importance of farm scale assessments, linked to soil fertility, productivity, environmental impact and the adop- tion of grower best management practices.

IPNI Scientists, August, 2014

- IFA Nutrient Stewardship Working Group
- TFI Sustainability Task Force
- CFI Nutrients Committee

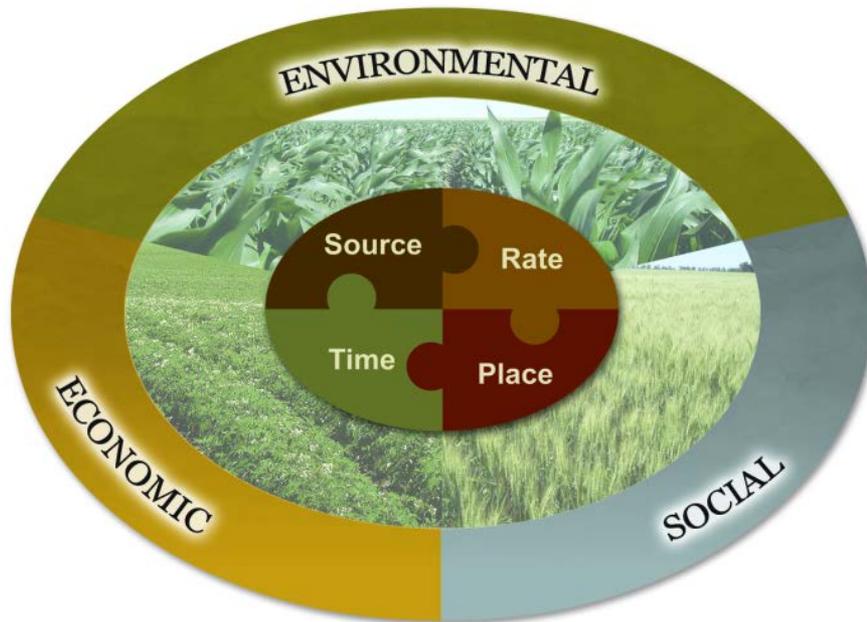


Addressing Nutrient Management Performance

June 2014

International Fertilizer Industry Association (IFA)

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**

“Building public trust”



UN Sustainable Development Goals 2015-2030

- Building on the 8 Millennium Development Goals
- Open Working Group proposal July 2014 – 17 goals
- Refers to nutrient [pollution in marine environment]
- “At most, only a very few (1-3) indicators specific to fertilizer are likely to be adopted by the UN...”
- SDSN goals and indicators – more specifically addressing nutrients and NUE



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SUSTAINABLE DEVELOPMENT
KNOWLEDGE PLATFORM



**SUSTAINABLE DEVELOPMENT
SOLUTIONS NETWORK**
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

SDSN suggested indicators, revised 25 November 2014



Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.

Indicator #	
10	Crop yield gap (actual yield as % of attainable yield)
12	[Crop nitrogen use efficiency (%)] – to be developed
13	[Excessive loss of reactive nitrogen [and phosphorus] to the environment (kg/ha)] - to be developed
15	Annual change in degraded or desertified arable land (% or ha) [soil health?]

<http://unsdsn.org/resources/publications/indicators/>



Eight key considerations for Nutrient Use Efficiency (NUE) as a performance metric

1. One of a complement (**NUE + Yield + Soil Fertility**)
2. Form - Partial Nutrient Balance (output/input ratio)
3. Data - availability and timeliness of reporting
4. Trend - past, present, future
5. Nutrient - N, P, others
6. Optimum - neither too high nor too low
7. Interpretation in site-specific context
8. Targets - set regionally, not globally

IFA, June 2014



DRAFT

Nutrient Stewardship Metrics for Sustainable Crop Nutrition

Enablers (process metrics)

- Extension & professionals
- Infrastructure
- Research & innovation
- Stakeholder engagement

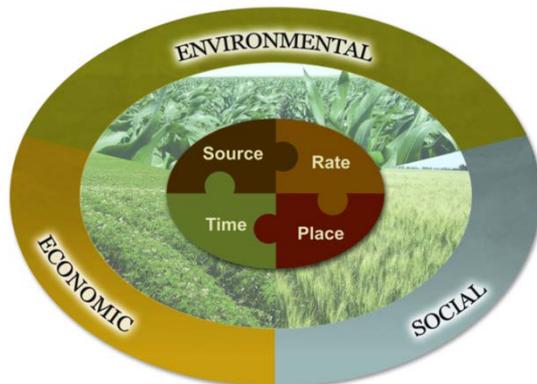
Actions (adoption metrics)

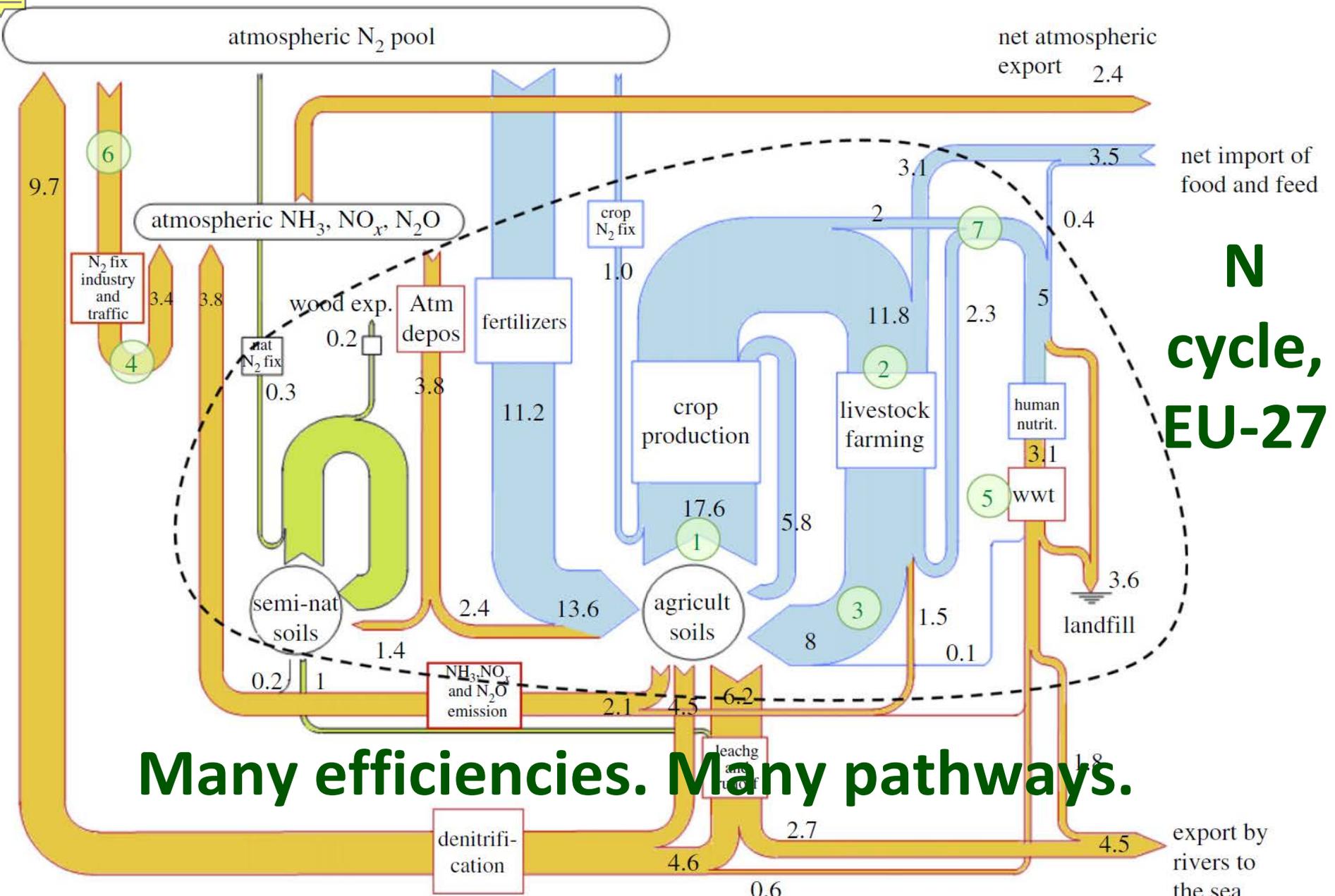
[Require regional definition of 4R]

- Cropland area under 4R (at various levels)
- Participation in programs
- Equity of adoption (gender, scale, etc.)

Outcomes (impact metrics)

- Food & nutrition security
- **Productivity**
- **Nutrient use efficiency**
- **Land quality, soil health**
- Air & water quality
- Economic value
- Land conservation, natural habitat





Fowler et al. 2013. The global nitrogen cycle in the twenty-first century. Phil. Trans. R. Soc. B 368: 20130164.

Nutrient use efficiency can be defined and calculated in many ways

NUE term	Calculated from	Typical levels for N (maize or wheat)
PFP	Y/F	40-80
AE	$(Y-Y_0)/F$	10-30
PNB	R/F	>100% = deficiency <100% = surplus
RE	$(U-U_0)/F$	50% (whole-plant) 33% (grain only)

Y=yield, F=fertilizer, R=removal, U=uptake

... but always, a ratio of output/input

Fertilizer Nitrogen Efficiency?

Studies in 56
farmer fields,
NC U.S.

38 recovered / 103 applied = 37%
vs
103 applied / 103 removed = 100%

**Fertilizer
103 kg/ha**

38 kg/ha

146 kg/ha

Soil N

**N removed
With harvest
103 kg/ha**

**N in crop
residue
81 kg/ha**

Assessing impact on short term crop uptake and long-term soil nutrient supply is critical in evaluation of system efficiency

Efficiency versus Productivity

- Nutrient Use Efficiency:

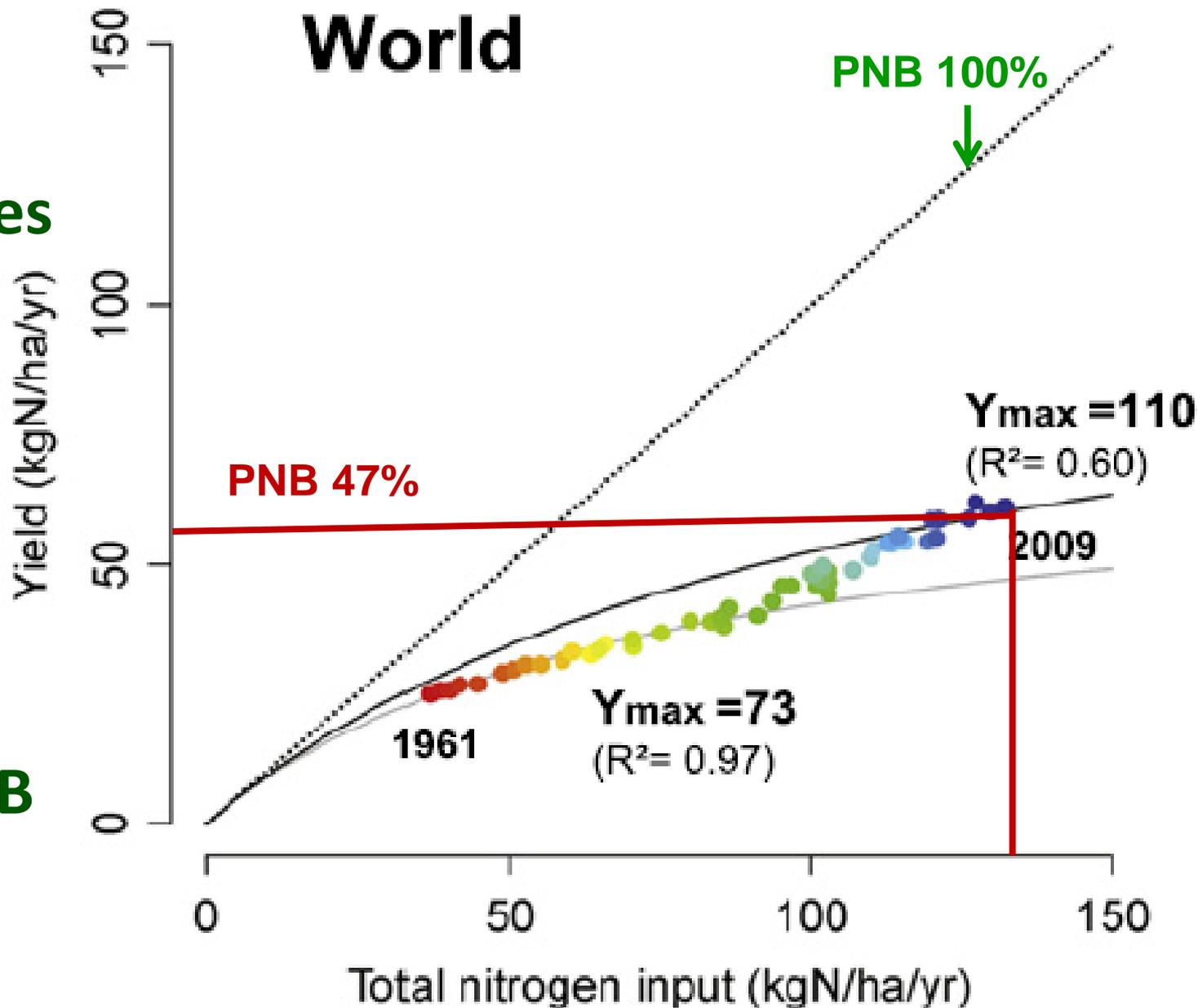
$$\frac{\text{output kg/ha}}{\text{input kg/ha}} = \frac{\text{output kg}}{\text{input kg}}$$

- ***Independent of per-hectare productivity!***
- ***Productivity, not NUE, feeds the world***
- ***Productivity with NUE feeds the world sustainably***

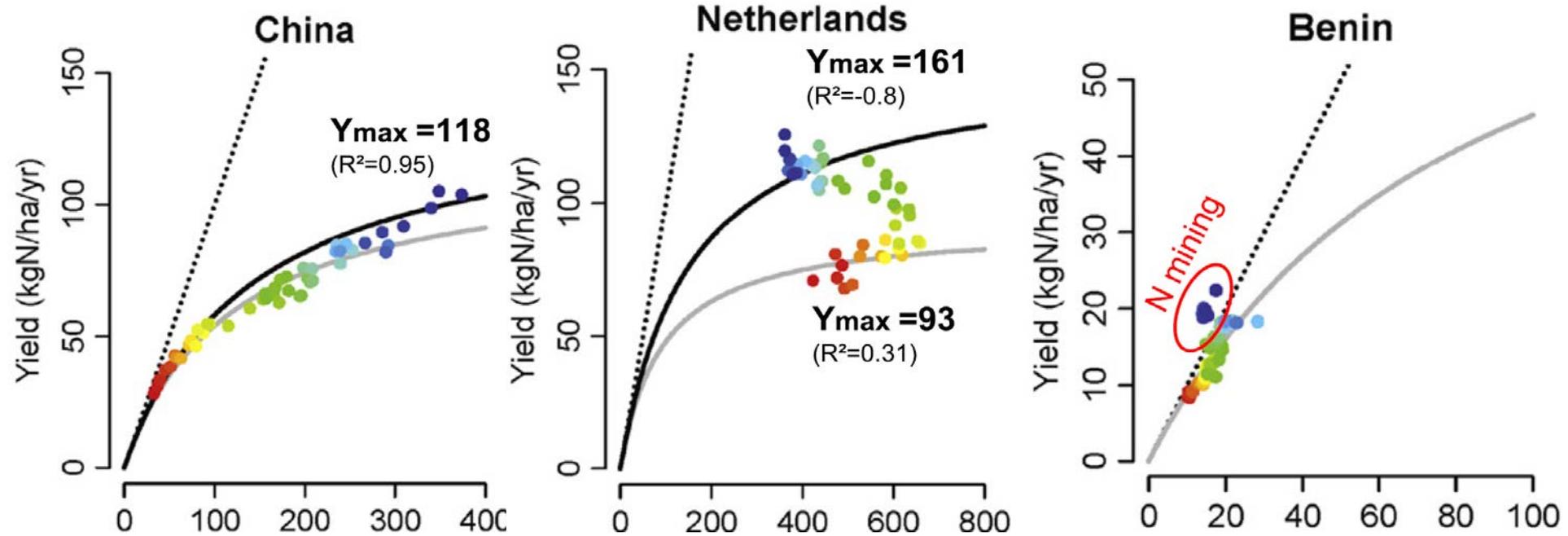


NUE trajectories over 48 years

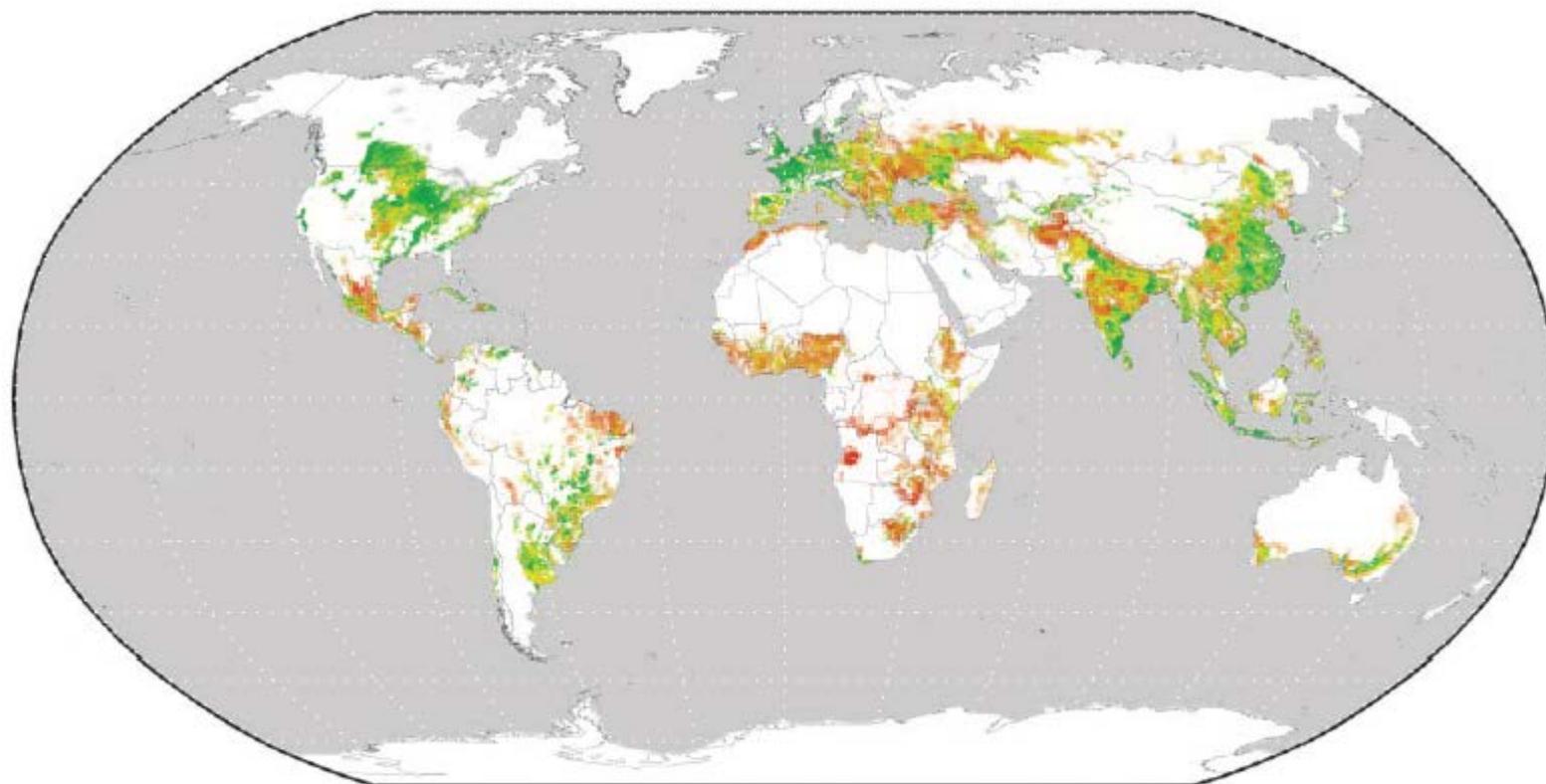
↑ yield stable PNB



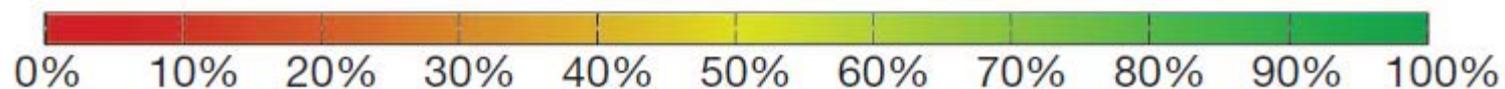
Contrasting trajectories



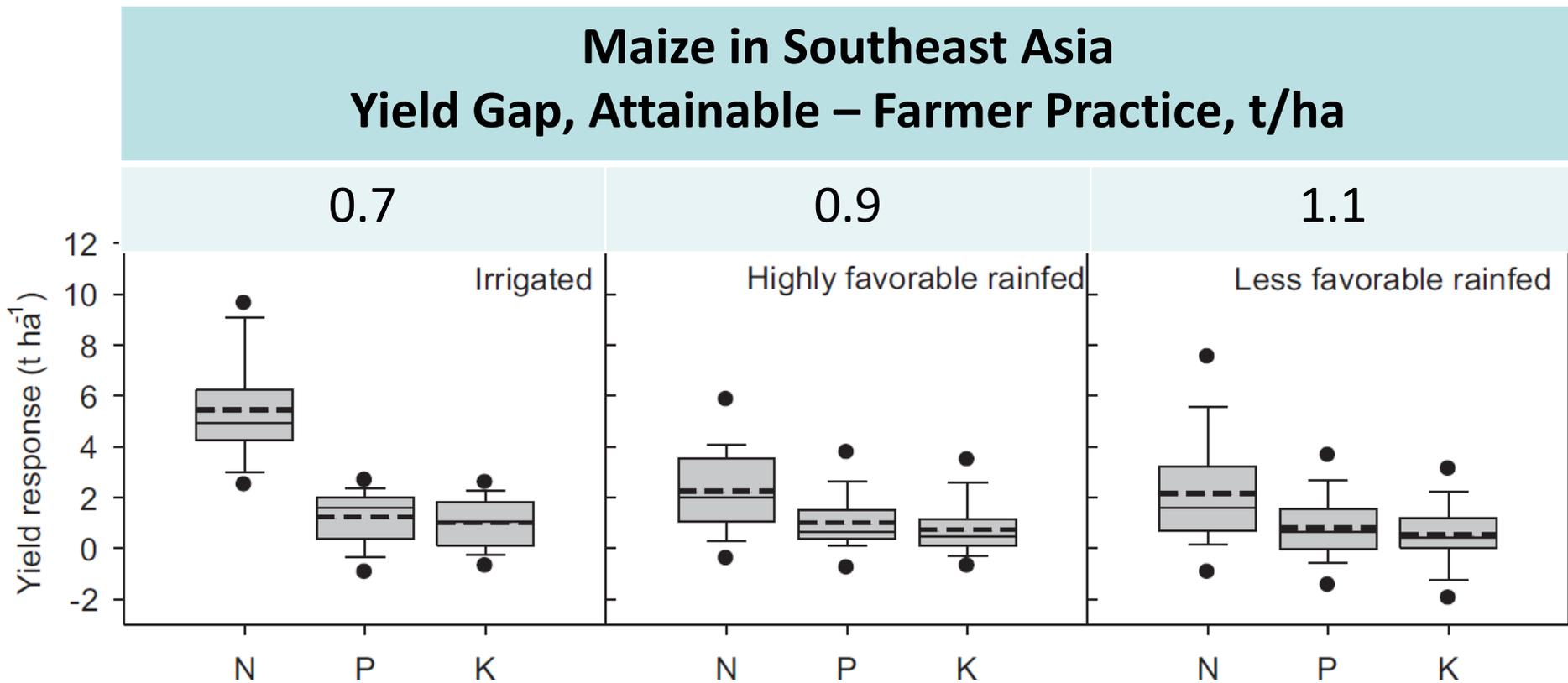
Yield gaps for maize, wheat and rice, year 2000



Major cereals: attainable yield achieved (%)

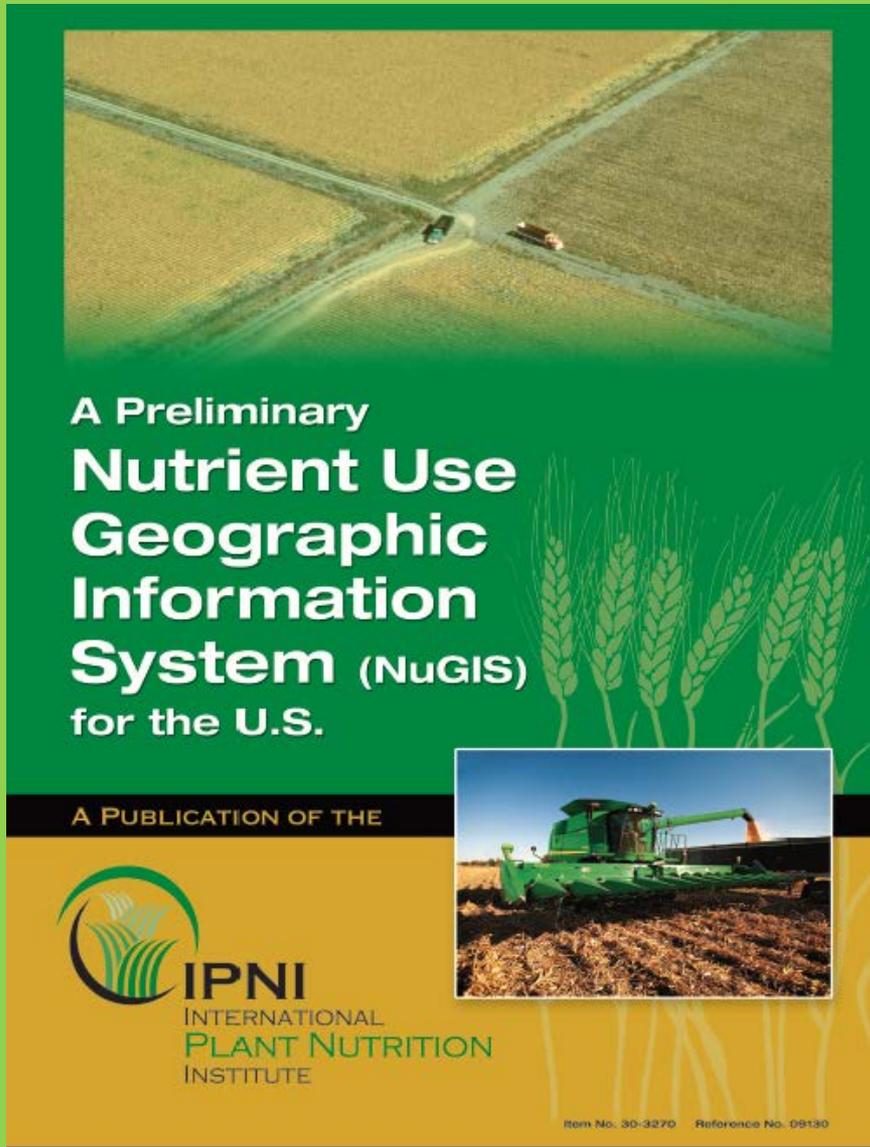


Metrics for productivity, yield gap, and yield gap arising from crop nutrition are difficult to measure



IPNI Metrics

- North America: NuGIS & Soil Test Summary



The cover features an aerial photograph of a farm with a central road and several fields. The background is a green gradient with a faint pattern of wheat stalks. The title is in large white letters, and the publisher's logo is at the bottom left. A small inset photo shows a green combine harvester in a field.

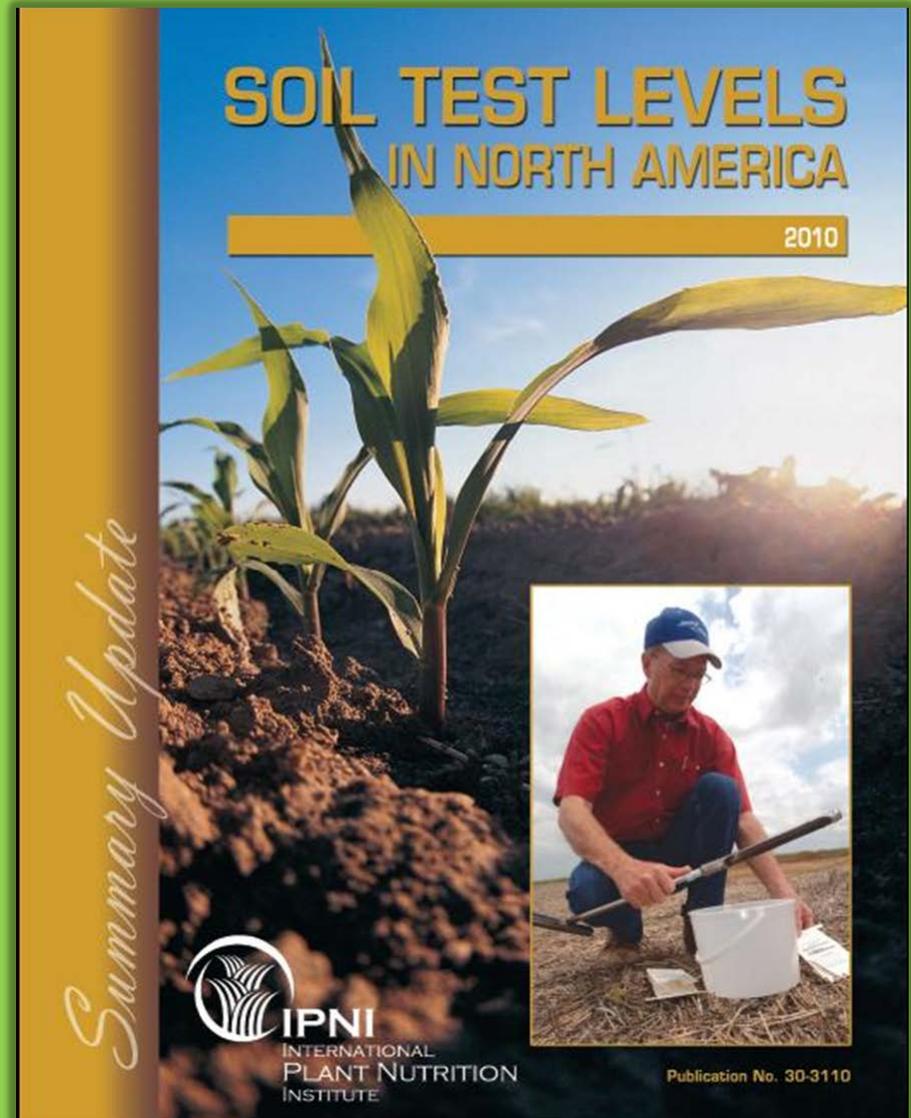
A Preliminary
**Nutrient Use
Geographic
Information
System (NuGIS)**
for the U.S.

A PUBLICATION OF THE



IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

Item No. 30-3270 Reference No. 09130



The cover features a close-up photograph of a young corn plant in a field. The background is a blue sky with a sun flare. The title is in large yellow letters. The year '2010' is in a yellow box. The publisher's logo is at the bottom left. A vertical banner on the left side says 'Summary Update'. An inset photo shows a man in a red shirt and blue cap kneeling in a field, using a tool to take a soil sample into a white bucket.

**SOIL TEST LEVELS
IN NORTH AMERICA**

2010

Summary Update



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INSTITUTE

Publication No. 30-3110

Cropland Nitrogen Balance, USA

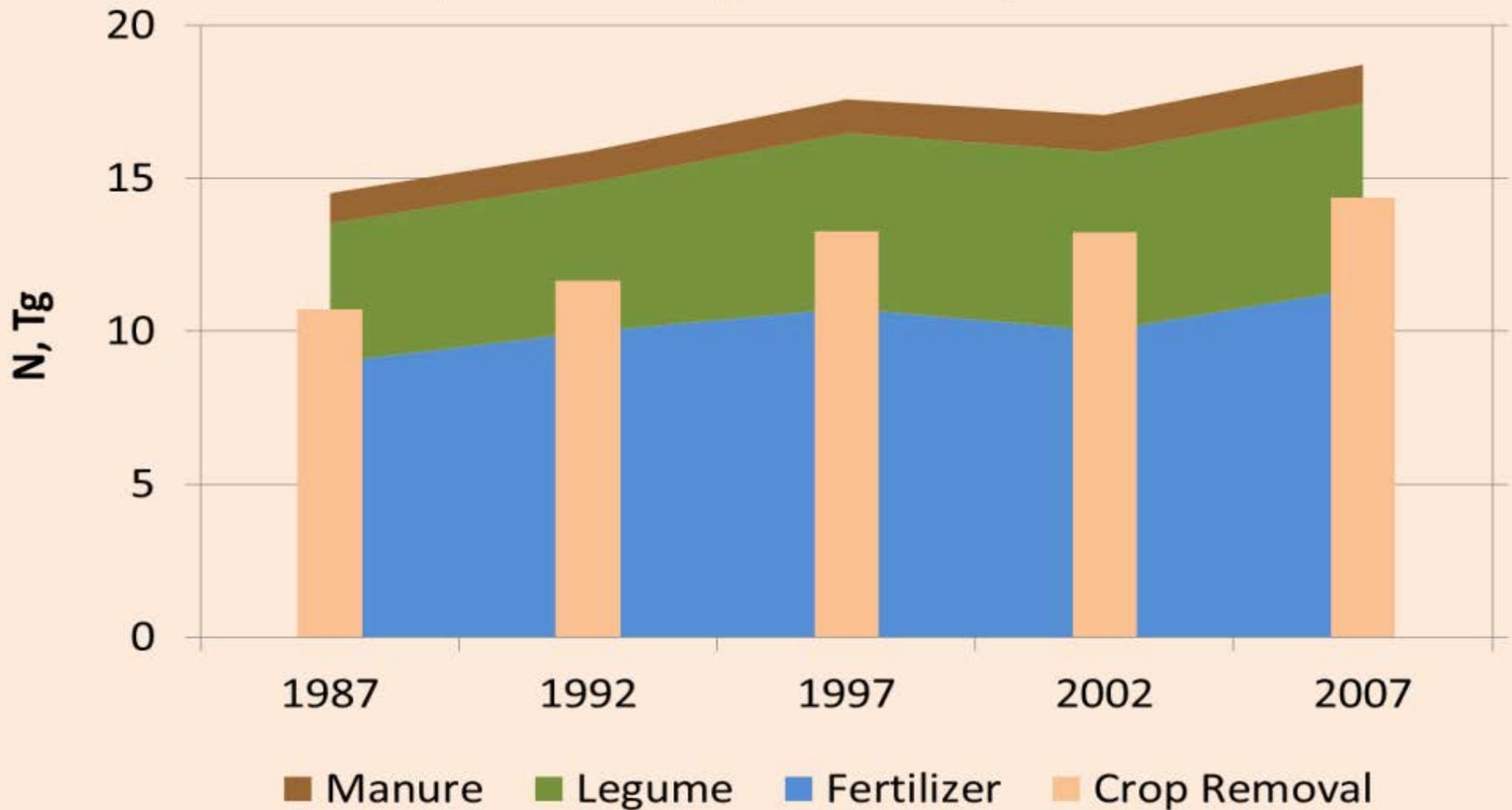
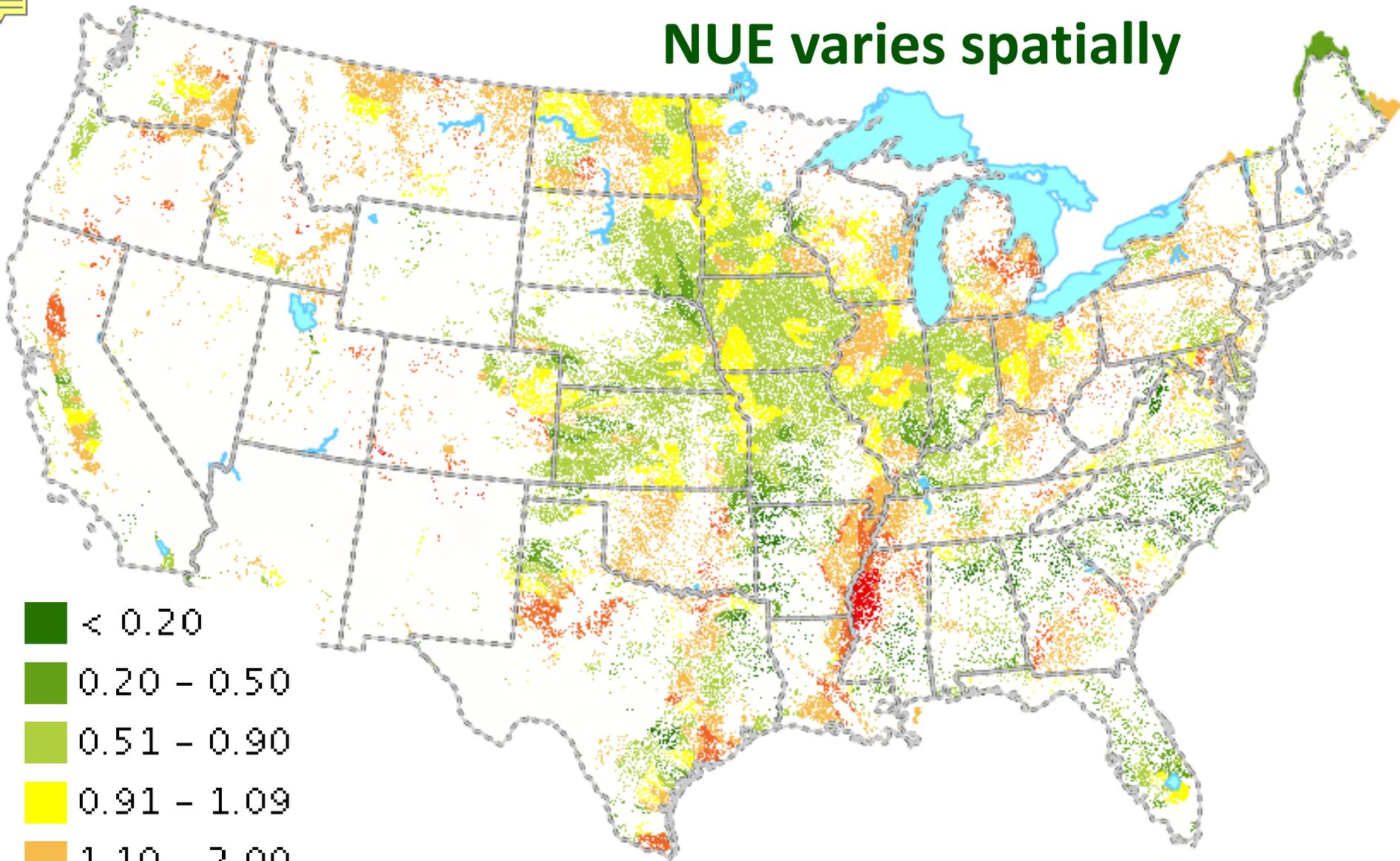


Figure 4.1: Inputs of N to US agricultural land, including recoverable manure, legume fixation, and commercial fertilizers, as compared to removal by crops (adapted from IPNI NuGIS, 2011). [In Robertson et al., 2012, Biogeochemistry]

NUE varies spatially

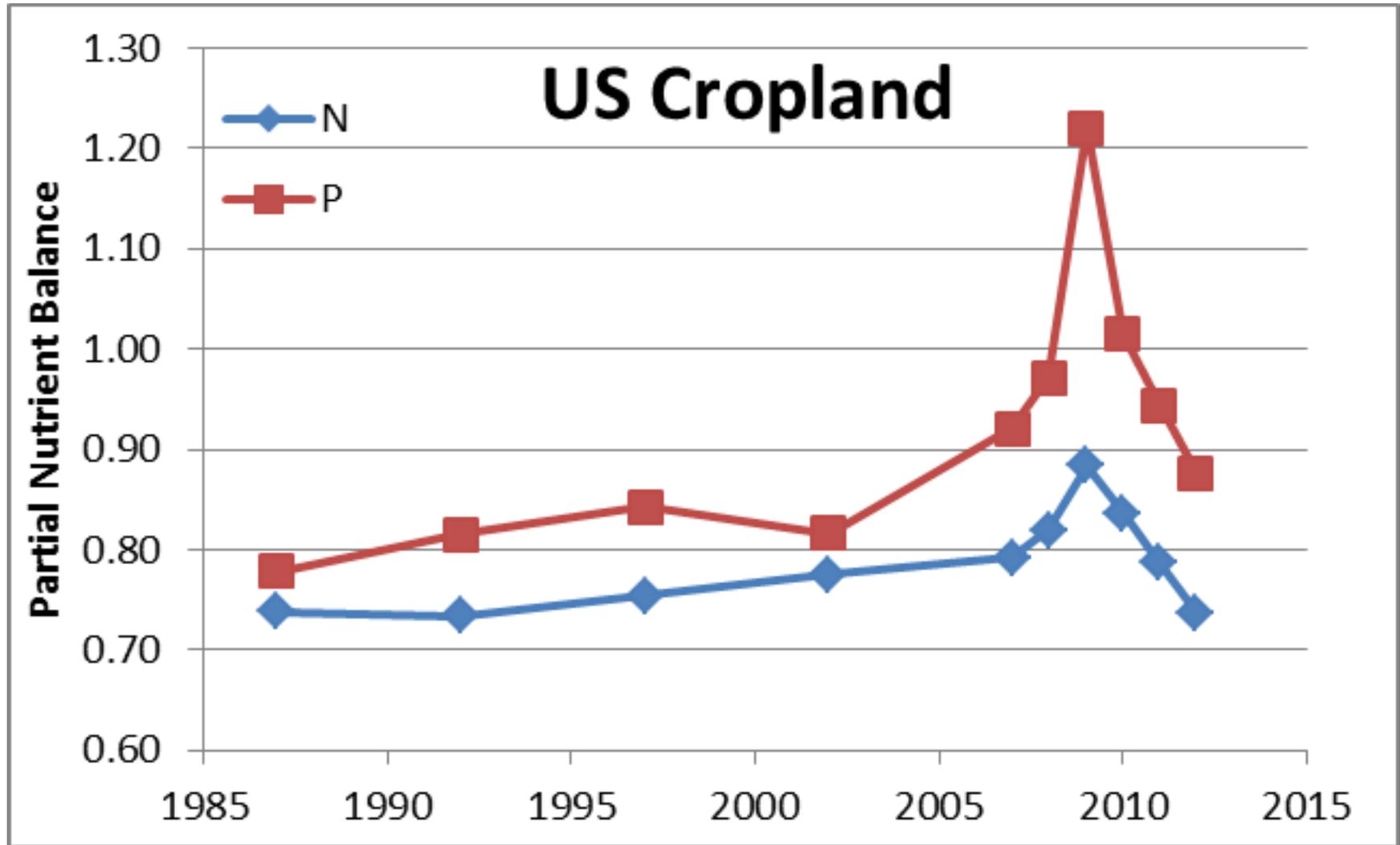


- < 0.20
- 0.20 - 0.50
- 0.51 - 0.90
- 0.91 - 1.09
- 1.10 - 2.00
- 2.01 - 5.00
- > 5.00

NuGIS

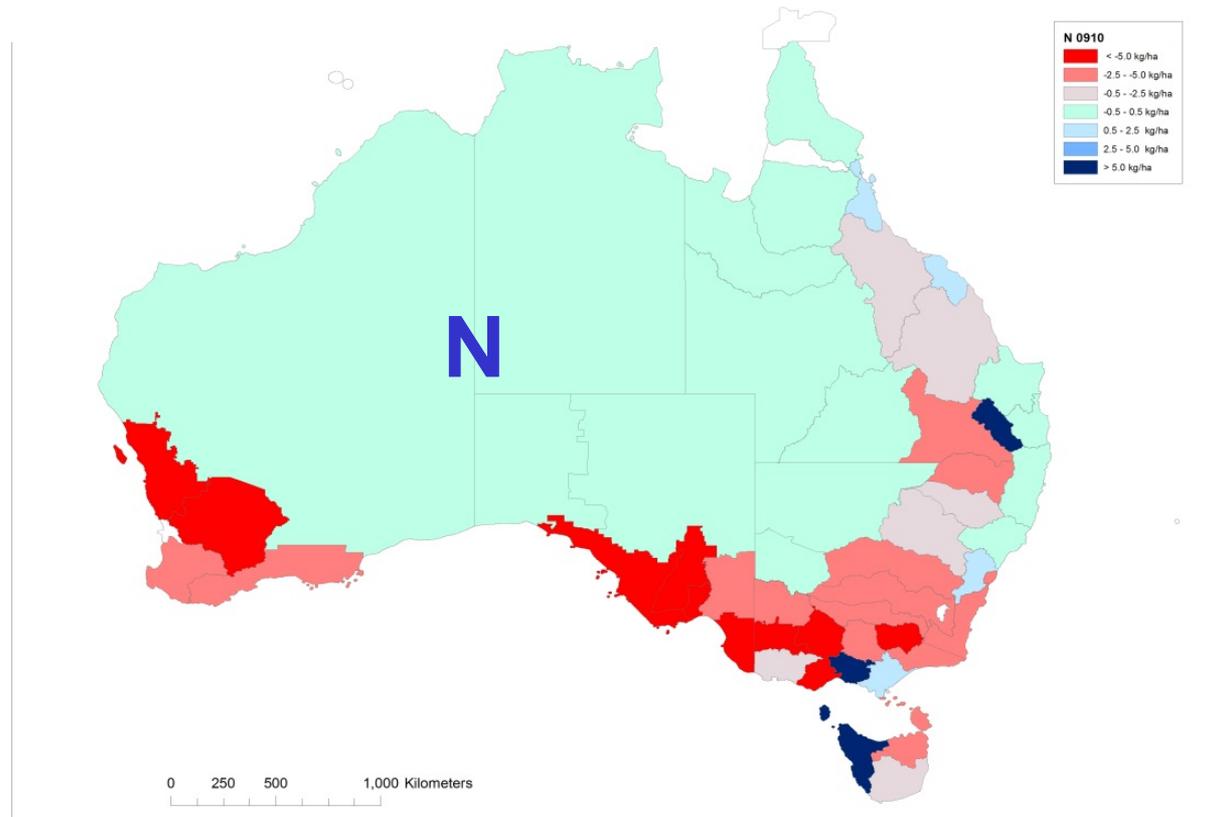
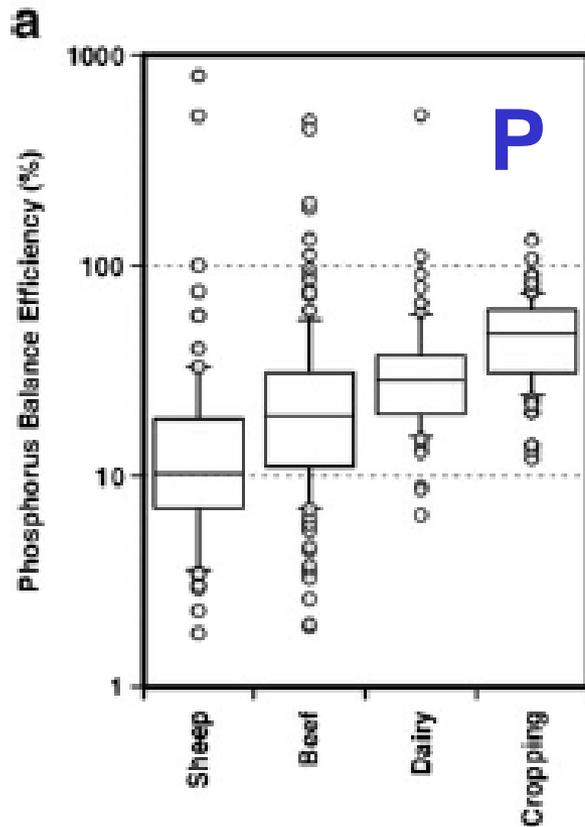
USA 2012, partial P balance, removal/use

NUE varies temporally – prices and weather



NuGIS, 2014

Australia Nutrient Balances



Removal/Fertilizer, N

New South Wales	Victoria	Queensland	Western Australia	South Australia	Tasmania	NT	Australia
2.05	2.49	1.08	1.48	2.28	1.25	4.20	1.76

SOIL TEST LEVELS IN NORTH AMERICA

2010

Summary Update



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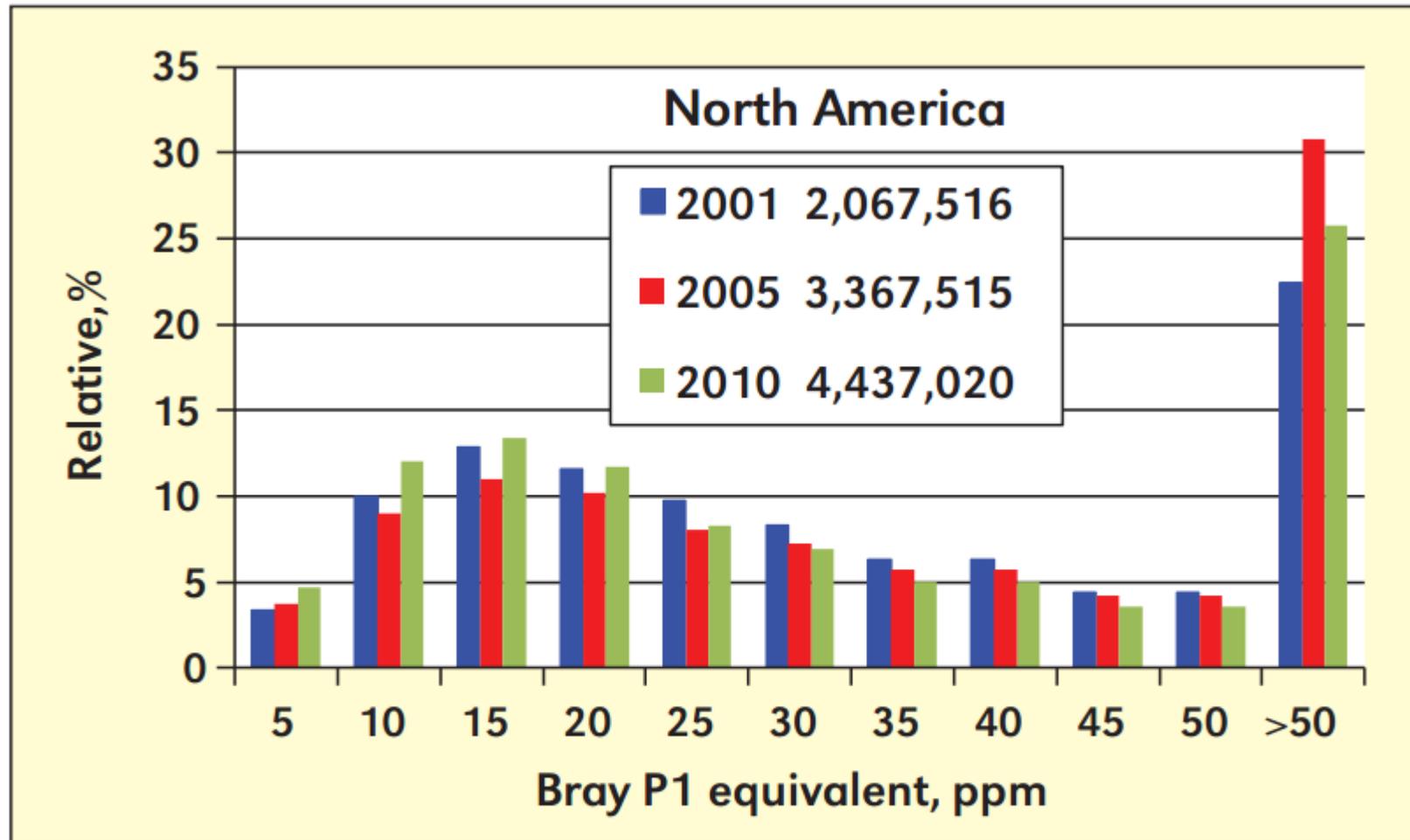


Publication No. 30-3110

**One important
component of
soil health**



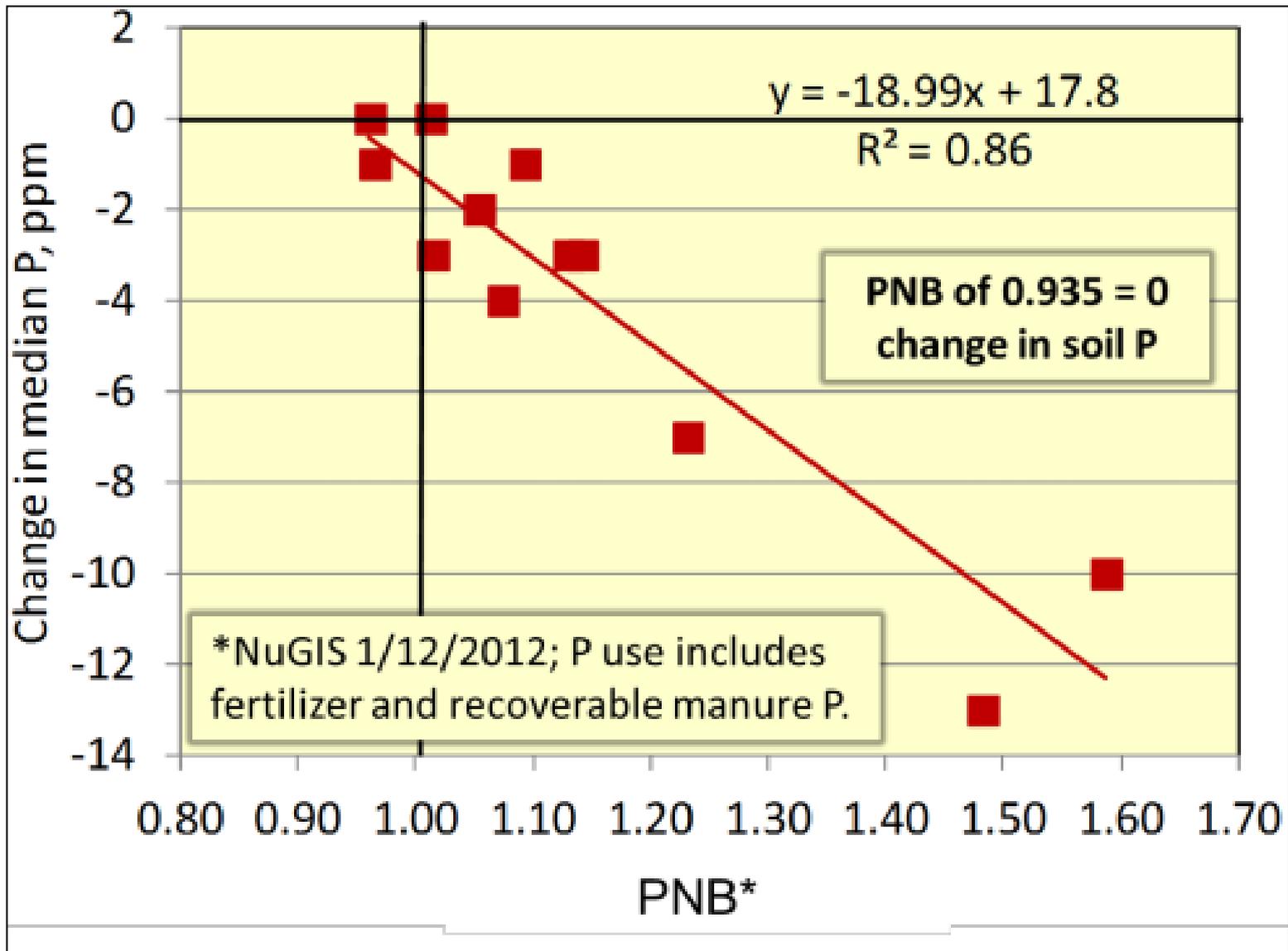
Frequency distribution of soil test P



The median P level for NA (U.S. and Canada) declined from 31 ppm in 2005 to 25 ppm in 2010.



Relationship of Δ STP with PNB, 12 corn belt states





December 2012

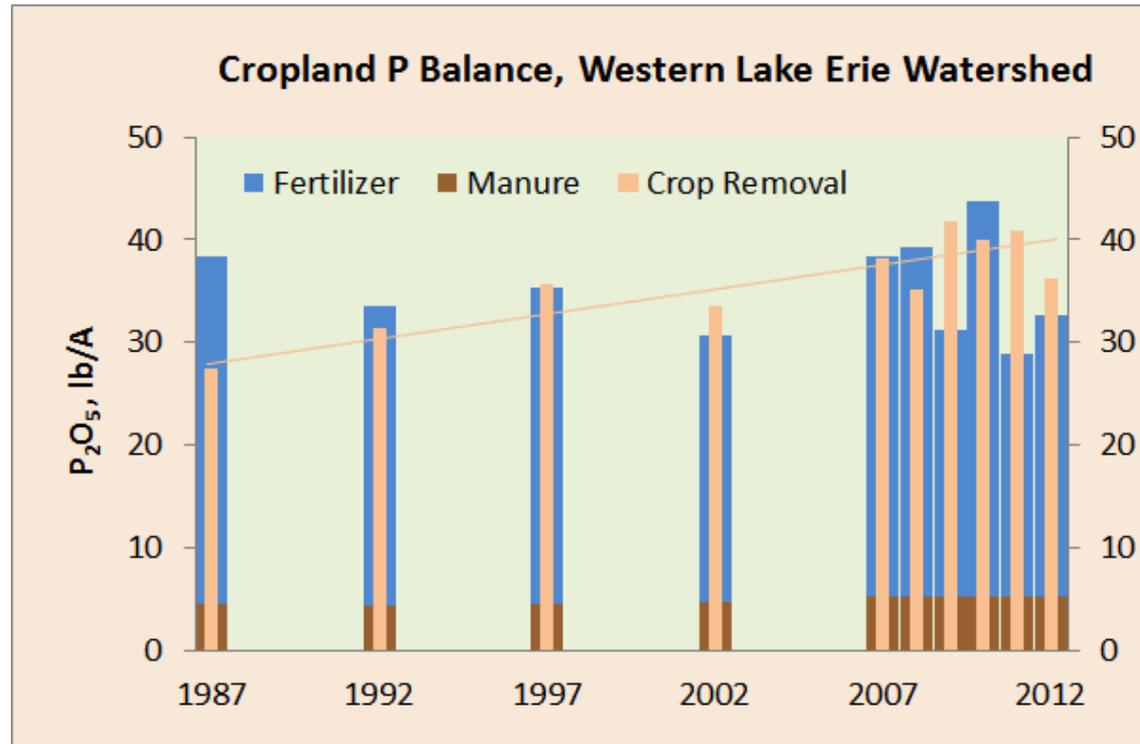
Reducing Loss of Fertilizer Phosphorus to Lake Erie with the 4Rs

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.

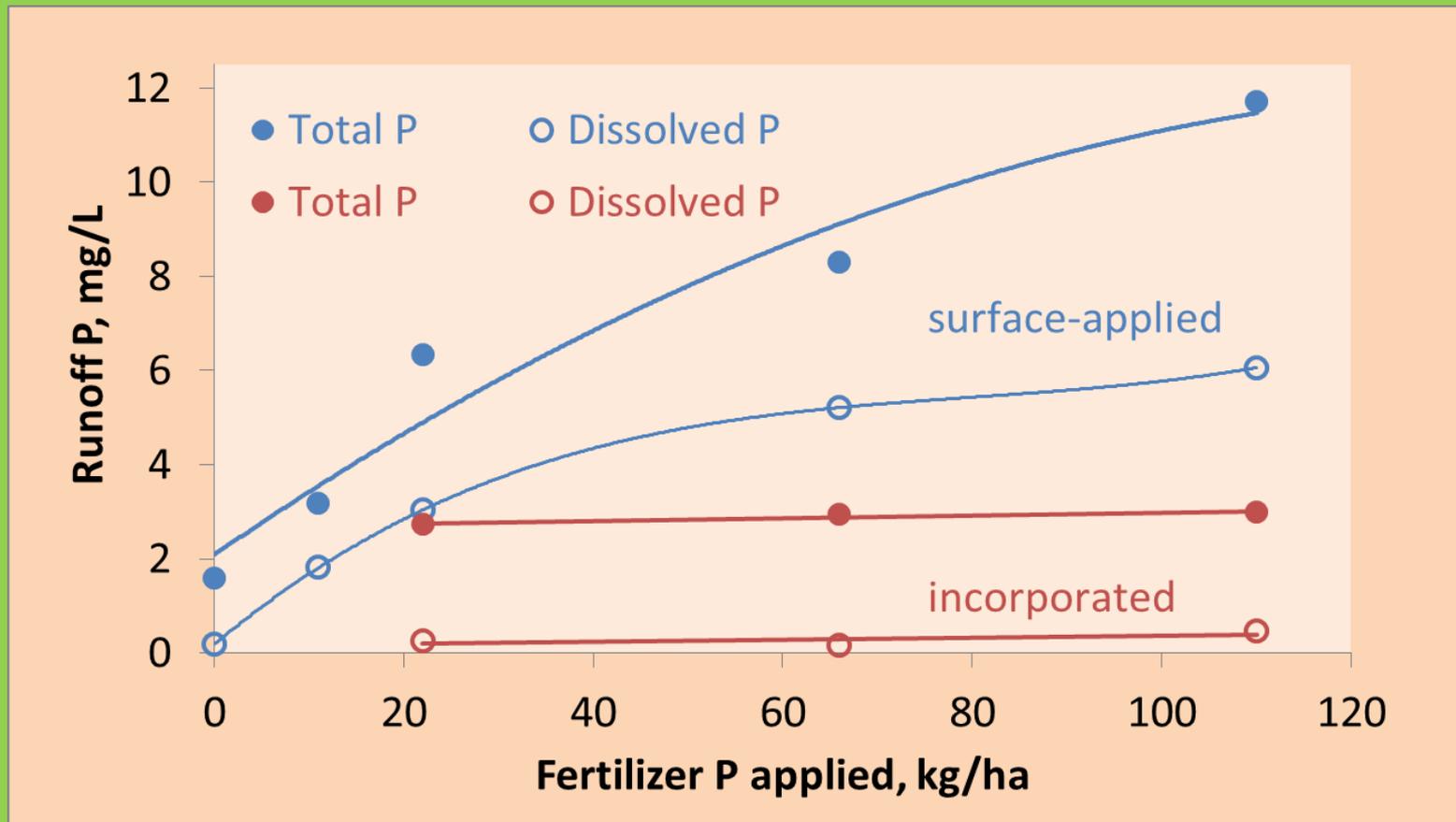
This article outlines how crop producers in the Lake Erie watershed can reduce losses of P by adopting a 4R Nutrient Stewardship approach to guide their fertilizer application practices.

Background

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



Placement, not rate, reduces P loss from a single immediate runoff event



Concentration of dissolved and total P in runoff from a clay loam soil in North Carolina, from artificial rainfall immediately following application of superphosphate fertilizer. Incorporation to a depth of 5 inches by rotary tillage following application. Data from Tarkalson and Mikkelsen (2004).



Summary

- Global sustainability initiatives demand metrics
- Nutrient performance is more than NUE; it includes productivity and soil health; requires complementary metrics
- Forms of nutrient use efficiency vary – clarify units
- Source, time and place, as well as rate, impact nutrient performance
- *“Nutrient use efficiency is a useful, complex, and incomplete indicator of crop nutrition performance”*

Invitation from Canada

Soil Interfaces for Sustainable Development

- 5-10 July 2015, Montreal, Canada
- CSSS, AQSSS, IUSS – ISMOM



ISMOM 2015

5 - 10 JULY 2015
MCGILL UNIVERSITY
MONTRÉAL, QUÉBEC, CANADA

**SOIL INTERFACES
FOR SUSTAINABLE DEVELOPMENT**

7TH INTERNATIONAL SYMPOSIUM OF INTERACTIONS OF SOIL
MINERALS WITH ORGANIC COMPONENTS AND MICRO-ORGANISMS
COMMISSION 2.5 – INTERNATIONAL UNION OF SOIL SCIENCES
- SOIL CHEMICAL, PHYSICAL AND BIOLOGICAL INTERFACIAL REACTIONS

SCIENTIFIC AREAS

1. MACRO AND MICRONUTRIENTS DYNAMICS IN SOIL
2. DYNAMICS OF POLLUTANTS IN SOIL
3. SOIL MICROBIOLOGY
4. ORGANO-MINERAL INTERACTIONS IN SOIL
5. ANALYTICAL AND METHODOLOGICAL ADVANCES IN SOIL

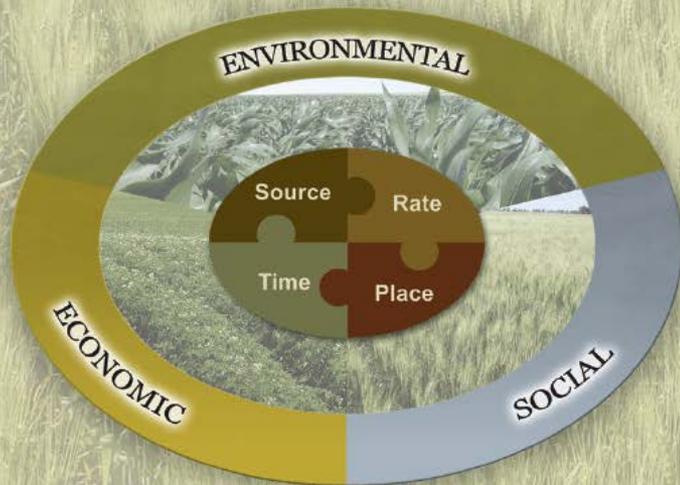
International Union of Soil Sciences
Le Sol - Fondement de la Vie
IUSS / ICSI
Soil - Foundation of Life
AQSSS
McGill
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Website: ismom2015.conference.mcgill.ca Contact: joann.whalen@mcgill.ca

4R PLANT NUTRITION

A Manual for Improving the Management of Plant Nutrition

NORTH AMERICAN VERSION



Thank You

www.ipni.net

