IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

SOIL SCIENCE AUSTRALIA

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 (QAFCO)

Shell Sulphur Solutions

Simplot

Sinofert Holdings Limited

SQM

Toros Tarım

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***

International Fertilizer Industry Association

INTERNATIONAL PLANT NUTRITION INSTITUTE

ISSUE REVIEW Ref #14061

Nutrient Performance Indicators:

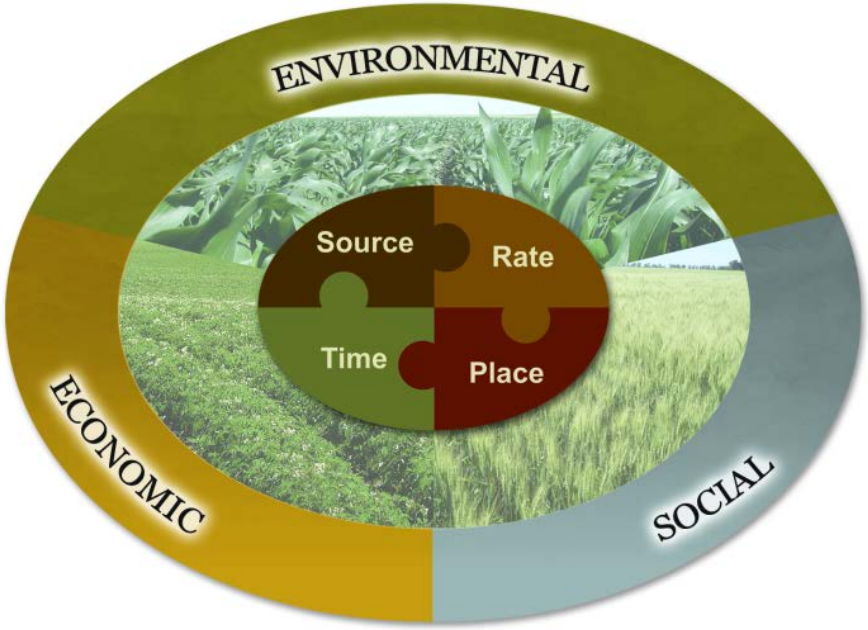
The importance of farm scale assessments, linked to soil fertility, productivity, environmental impact and the adoption of grower best management practices.

IPNI Scientists, August, 2014

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

4 nutrient stewardship

4R: “right” means sustainable



Field to Market™
The Keystone Alliance for Sustainable Agriculture

Walmart
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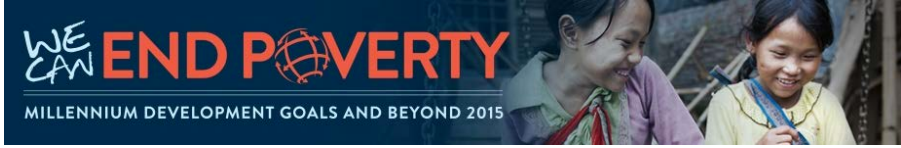
Home > How To Make A Difference > Fertilizer Optimization

How to Make a Difference - Fertilizer optimization

“Building public trust”

4R PLANT NUTRITION

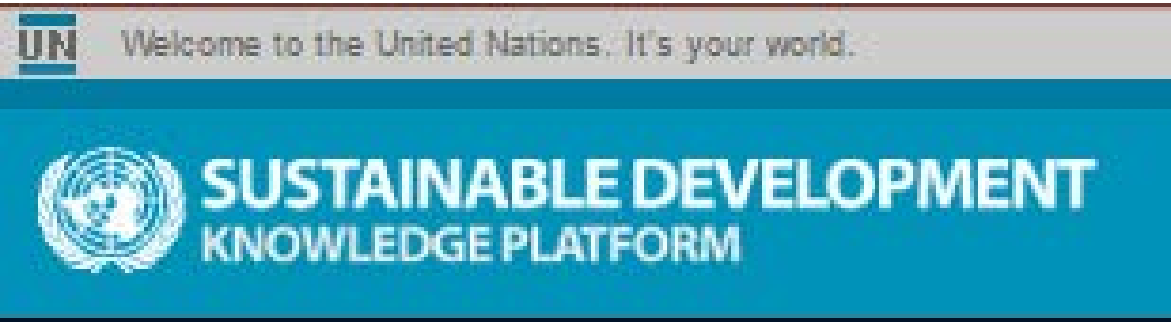
nutrient stewardship



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

Global Partnership on Nutrient Management
GPNM



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

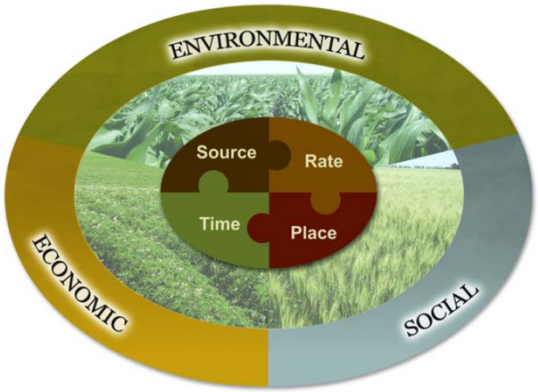
1. One of a complement (NUE + Yield + Soil Fertility)
2. Form - Partial Nutrient Balance (output/input ratio)
3. Data - availability and timeliness of reporting
4. Trend - past, present, future
5. Nutrient - N, P, others
6. Optimum - neither too high nor too low
7. Interpretation in site-specific context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

IFA, June 2014

DRAFT

Nutrient Stewardship Metrics for Sustainable Crop Nutrition

Enablers (process metrics)	*Actions (adoption metrics)*	*Outcomes (impact metrics)*
• Extension & professionals • Infrastructure • Research & innovation • Stakeholder engagement	[Require regional definition of 4R] • Cropland area under 4R (at various levels) • Participation in programs • Equity of adoption (gender, scale, etc.)	• Food & nutrition security • Productivity • Nutrient use efficiency • Land quality, soil health • Air & water quality • Economic value • Land conservation, natural habitat



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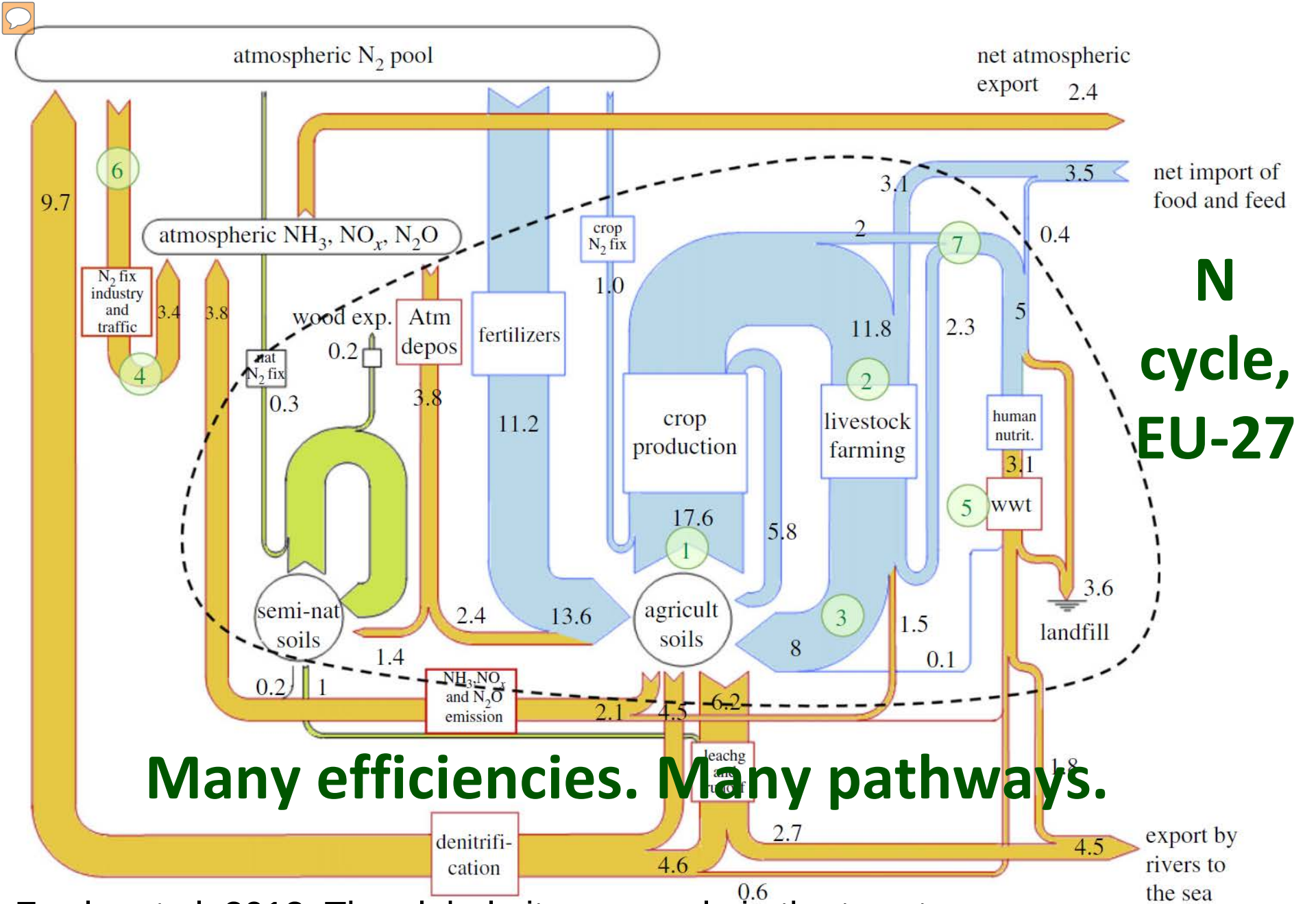

N cycle, EU-27

Many efficiencies. Many pathways.

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

Dobermann, 2007

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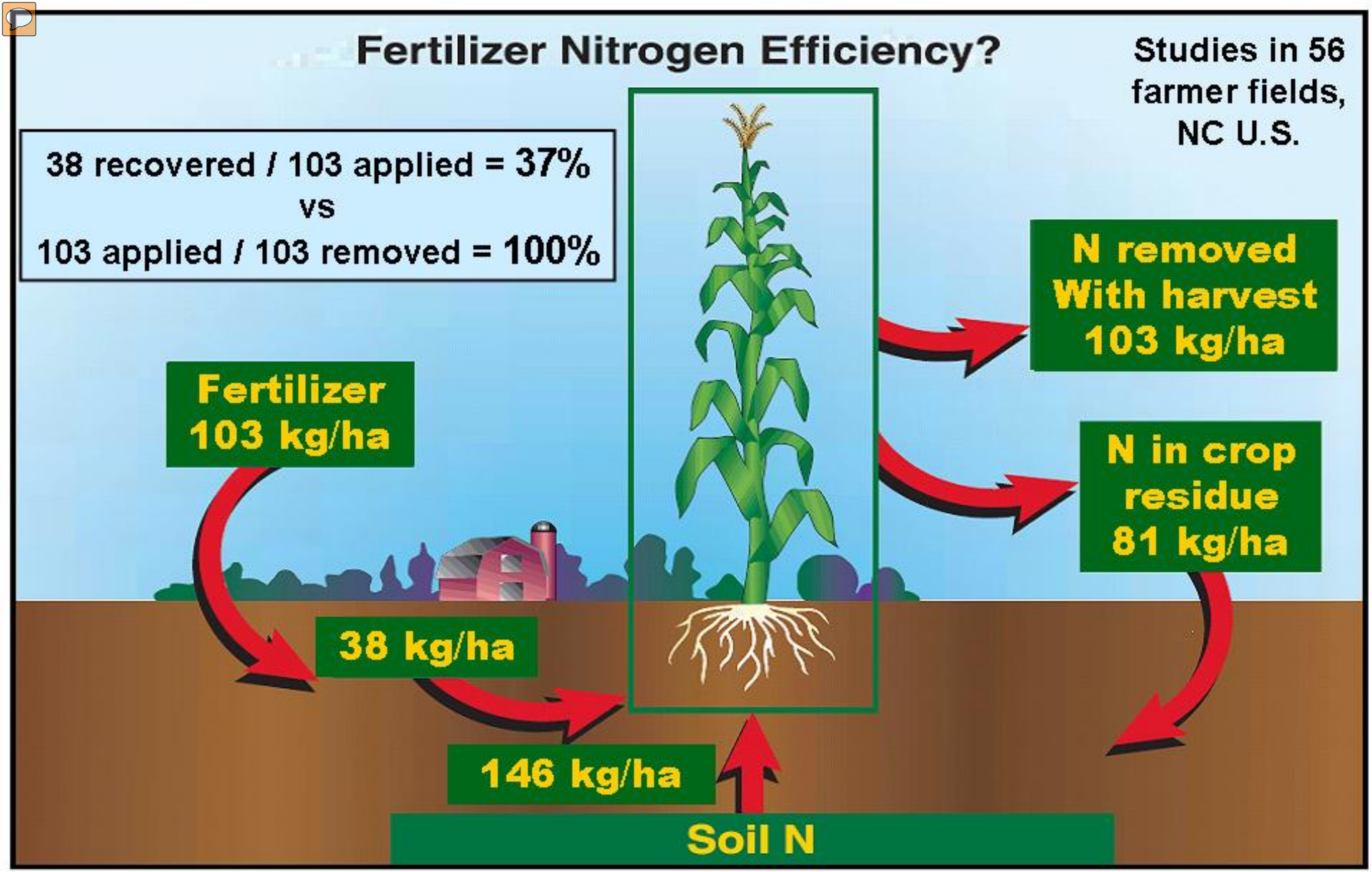

Assessing impact on short term crop uptake and long-term soil nutrient supply is critical in evaluation of system efficiency

Based on data from Cassman et al., 2002

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Efficiency versus Productivity

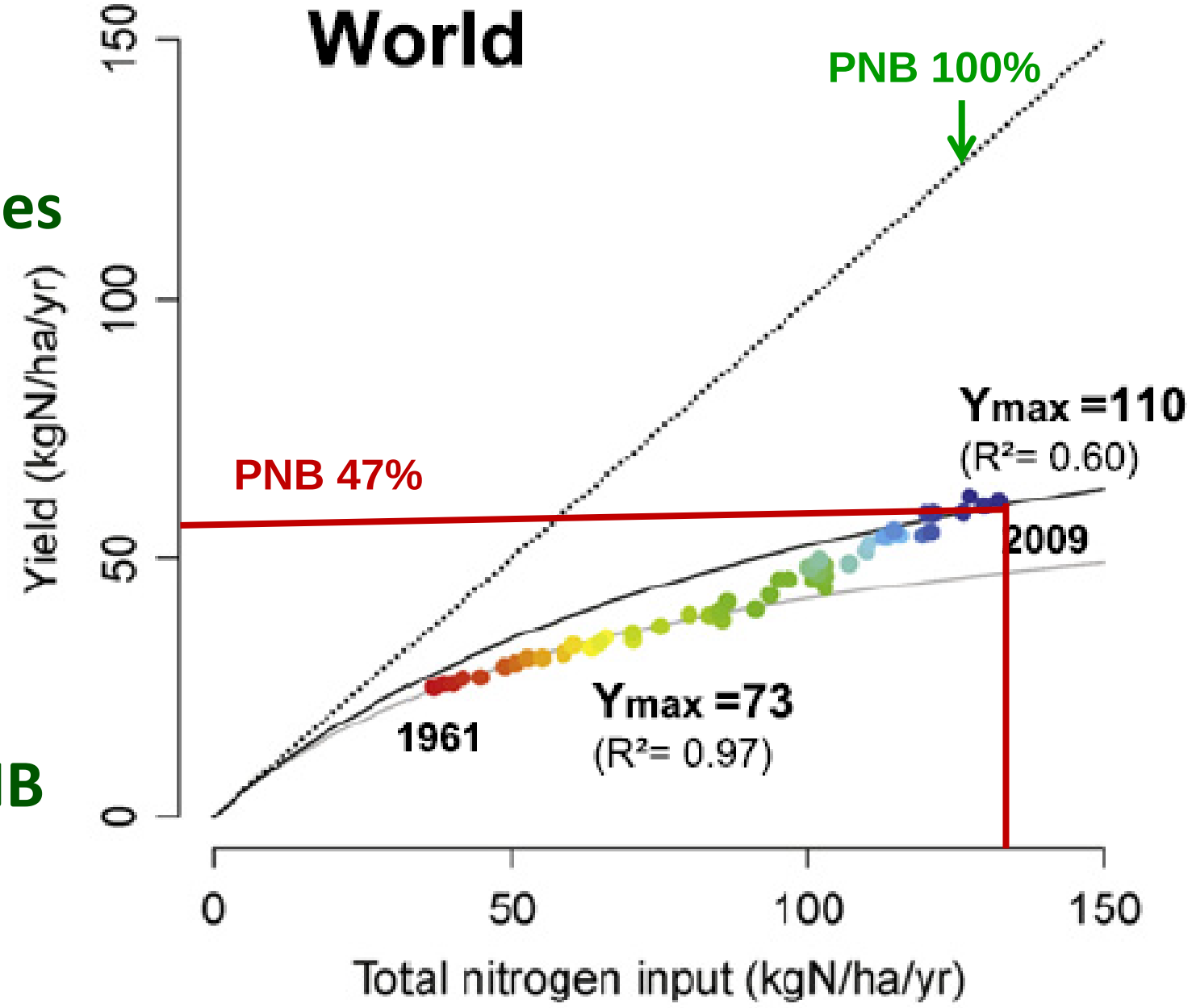
- Nutrient Use Efficiency:

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

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

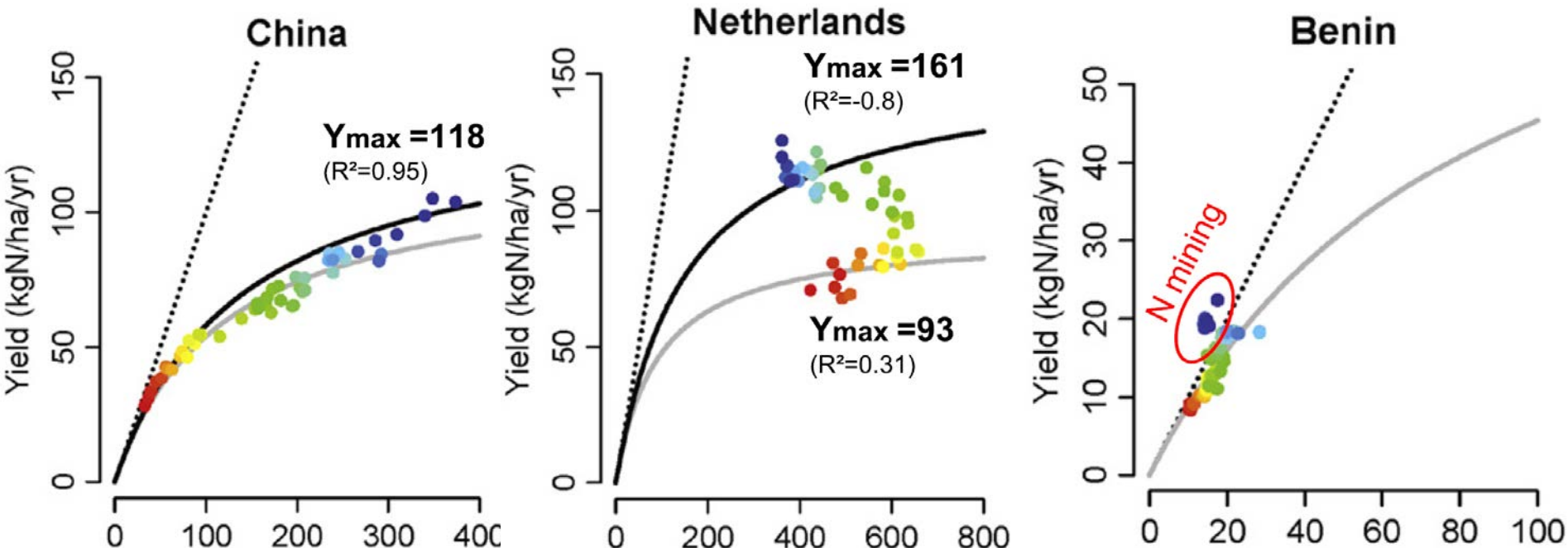
NUE trajectories over 48 years

↑ yield stable PNB



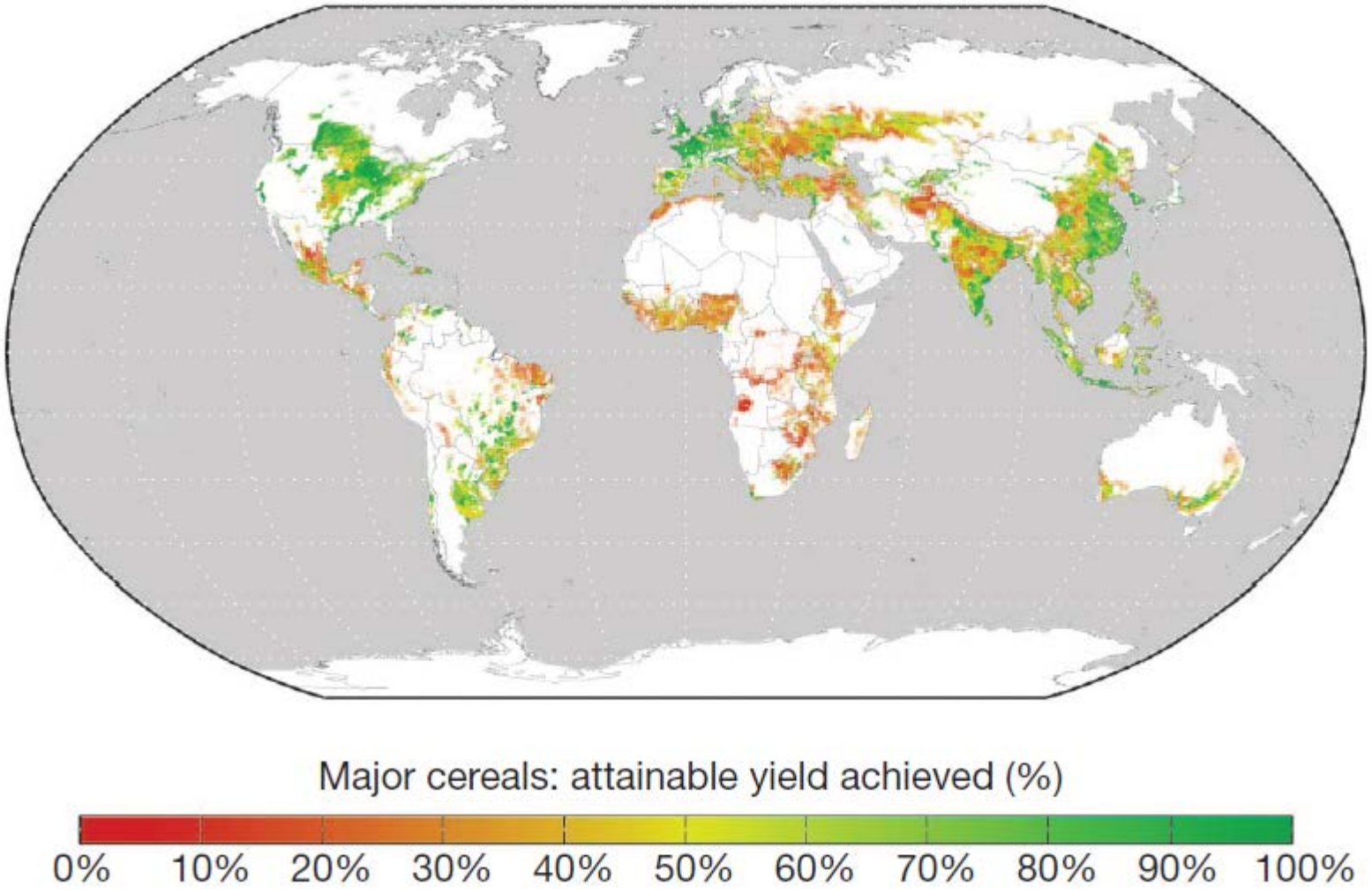
Lassaletta et al., 2014, Environ. Res. Lett. 9 (2014) 105011 (9pp)

Contrasting trajectories



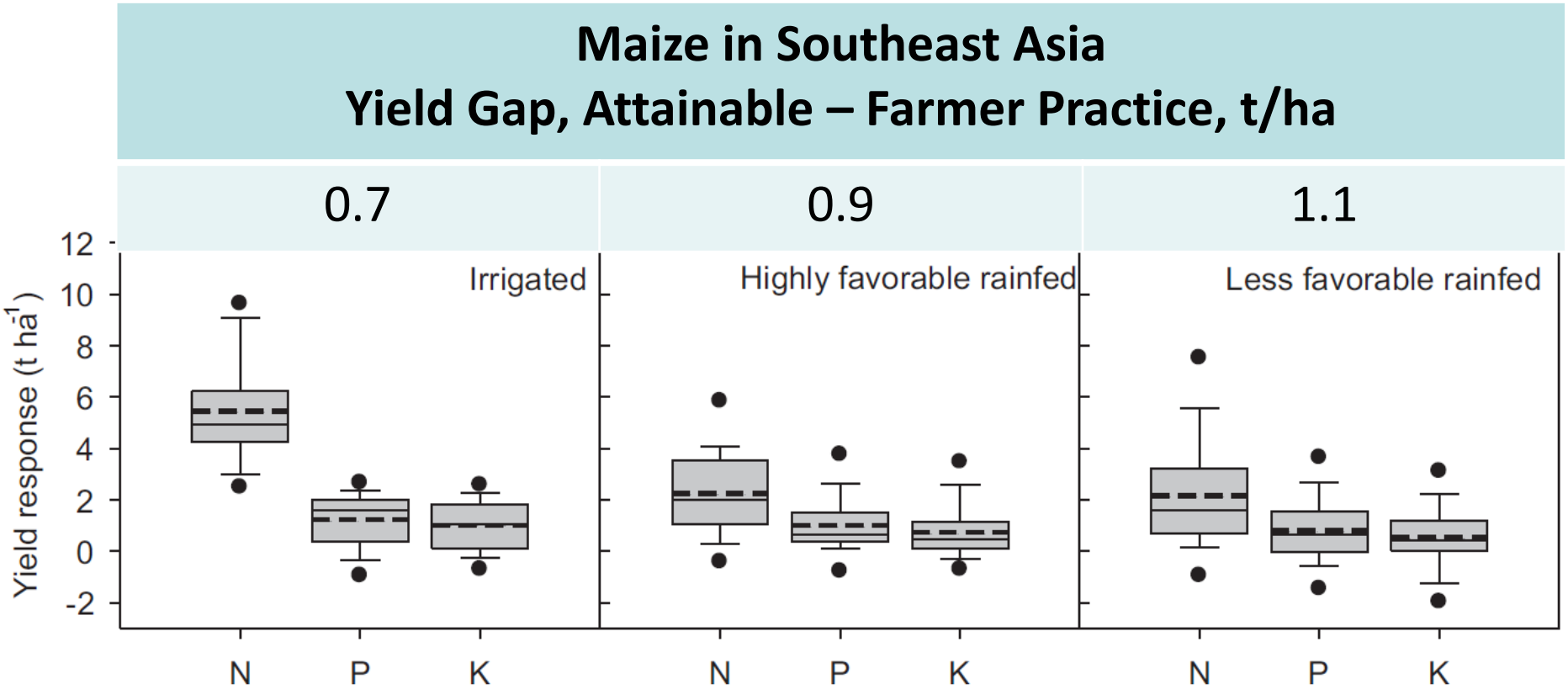
Lassaletta et al., 2014, Environ. Res. Lett. 9 (2014) 105011 (9pp)

Yield gaps for maize, wheat and rice, year 2000



Mueller et al., 2012, Nature 490:254-257

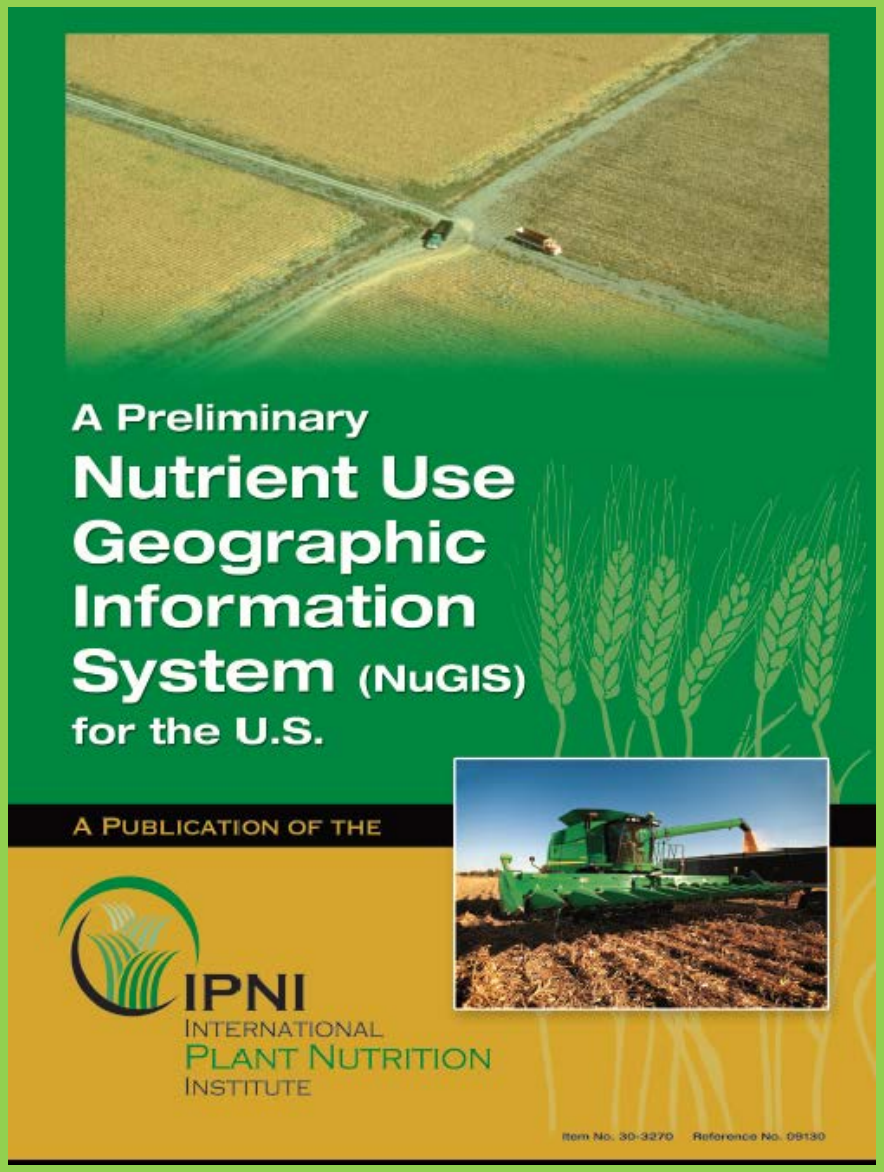
Metrics for productivity, yield gap, and yield gap arising from crop nutrition are difficult to measure

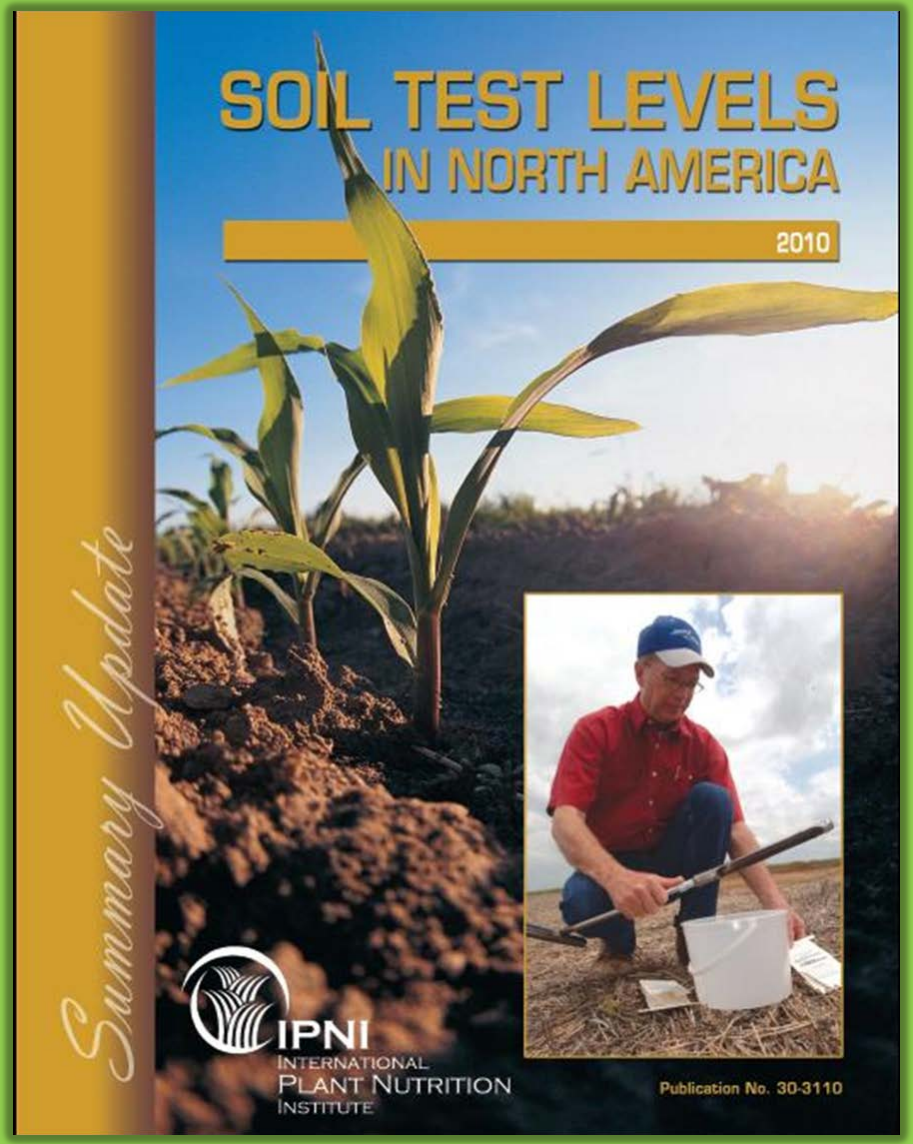


Pasuquin, JM et al. 2014 Field Crops Research 156:219–230

IPNI Metrics

- North America: NuGIS & Soil Test Summary





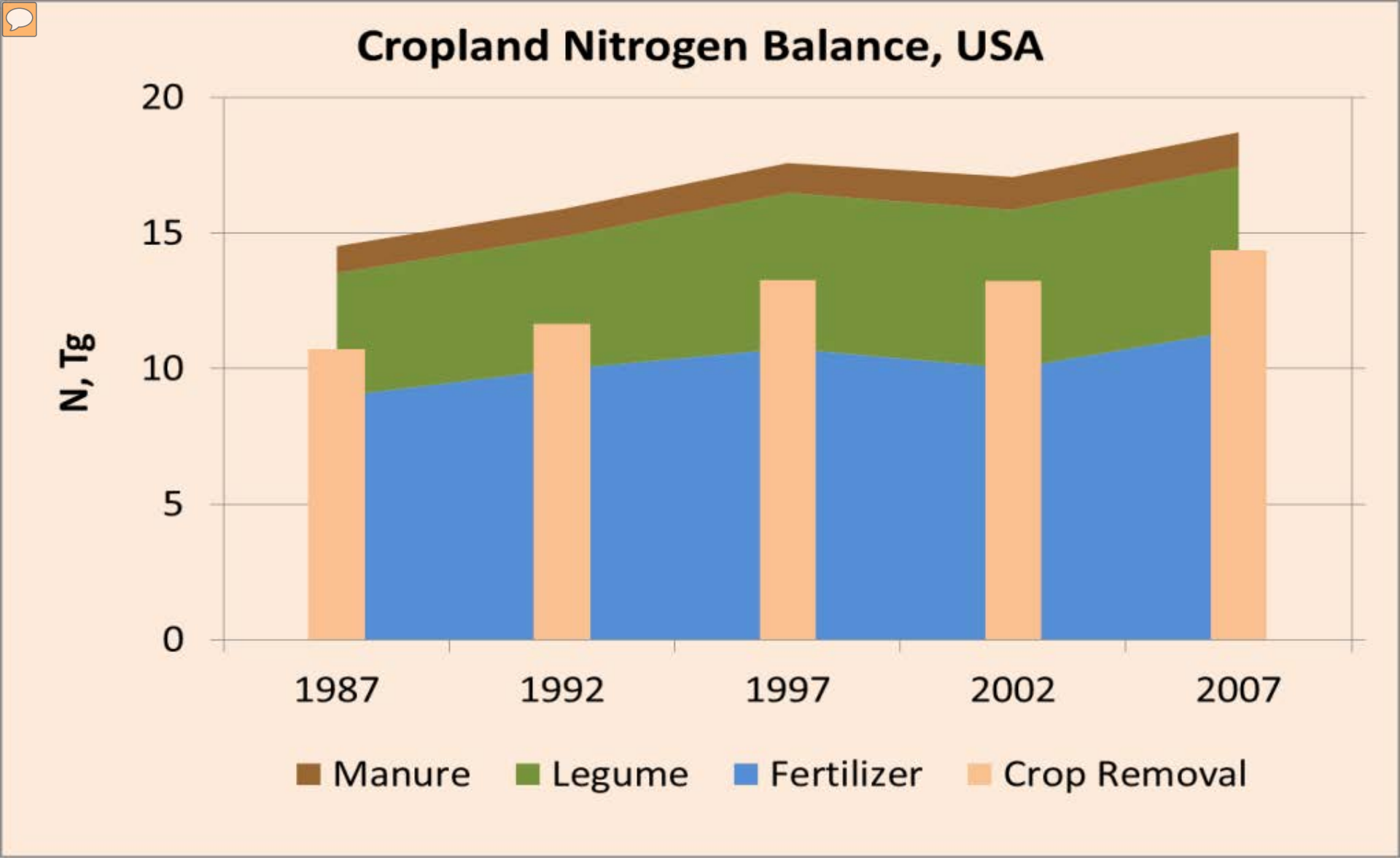
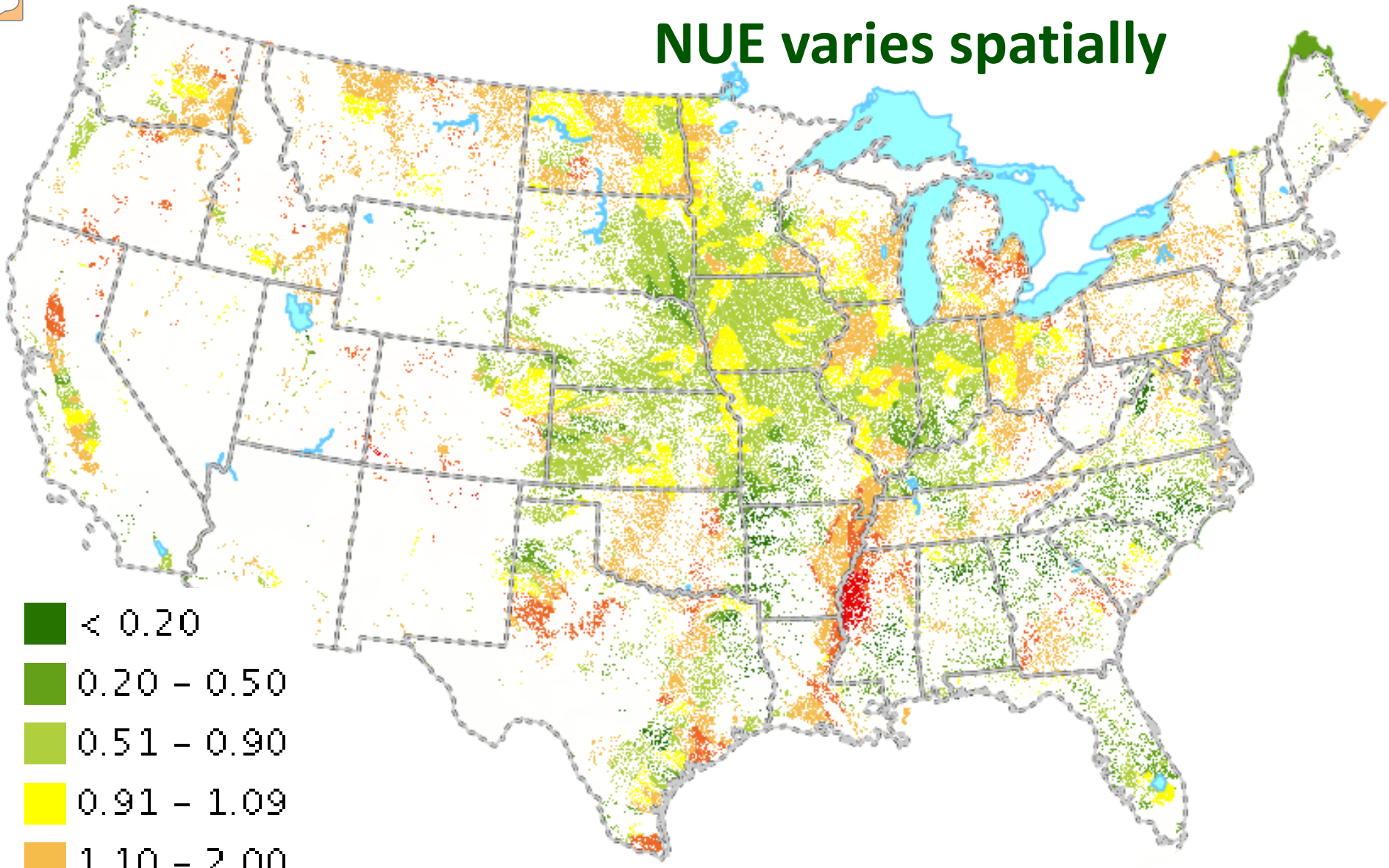


Figure 4.1: Inputs of N to US agricultural land, including recoverable manure, legume fixation, and commercial fertilizers, as compared to removal by crops (adapted from IPNI NuGIS, 2011). *[In Robertson et al., 2012, Biogeochemistry]*

NUE varies spatially



NuGIS

USA 2012, partial P balance, removal/use

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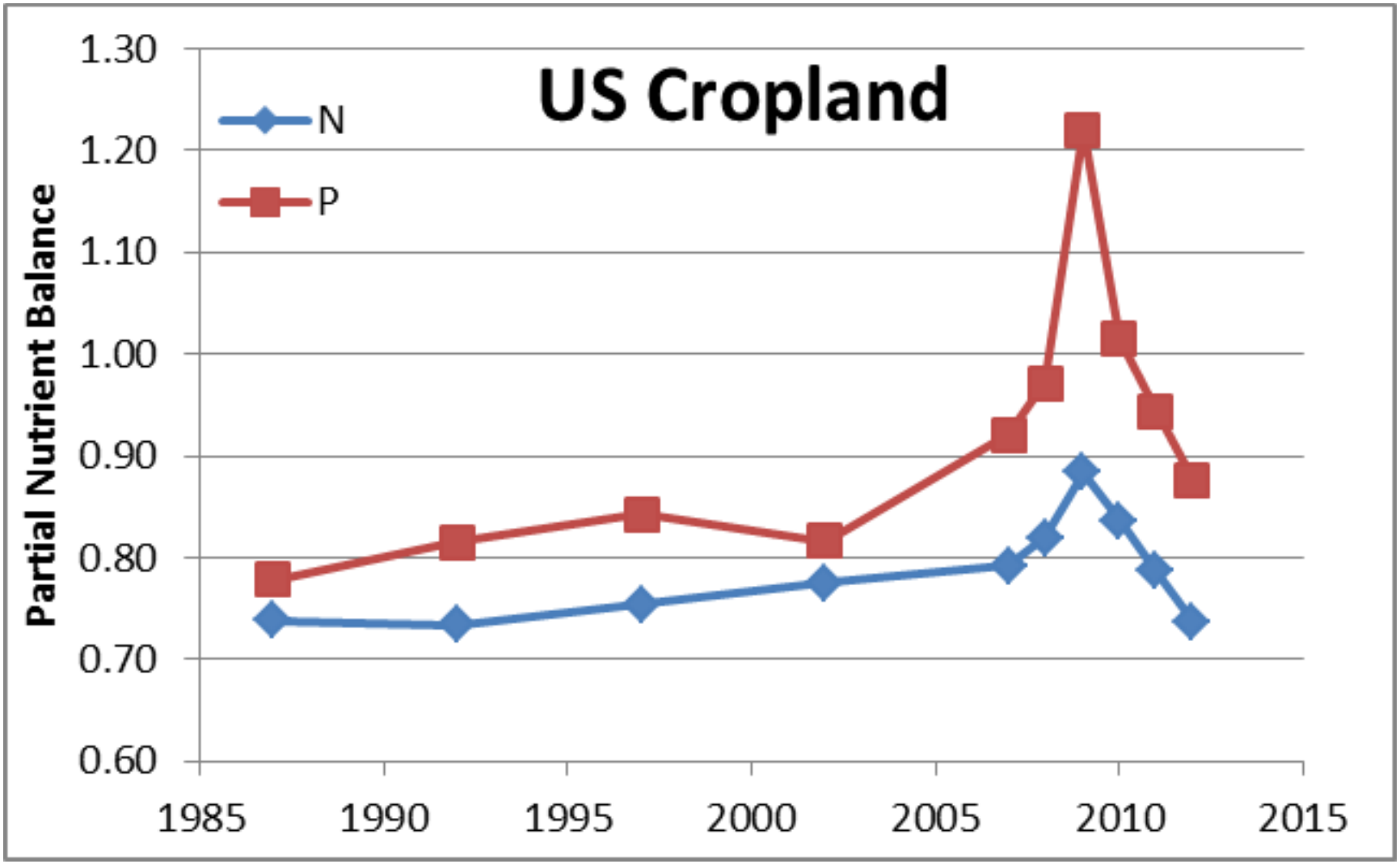
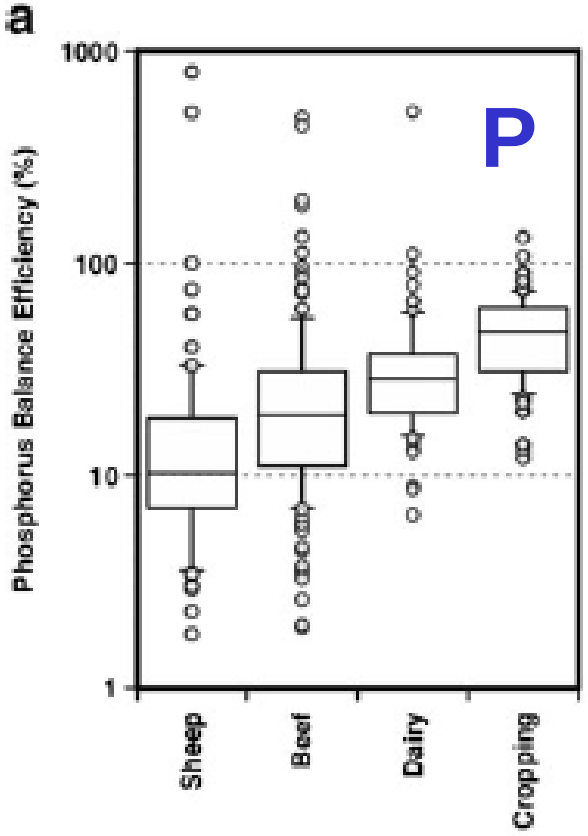
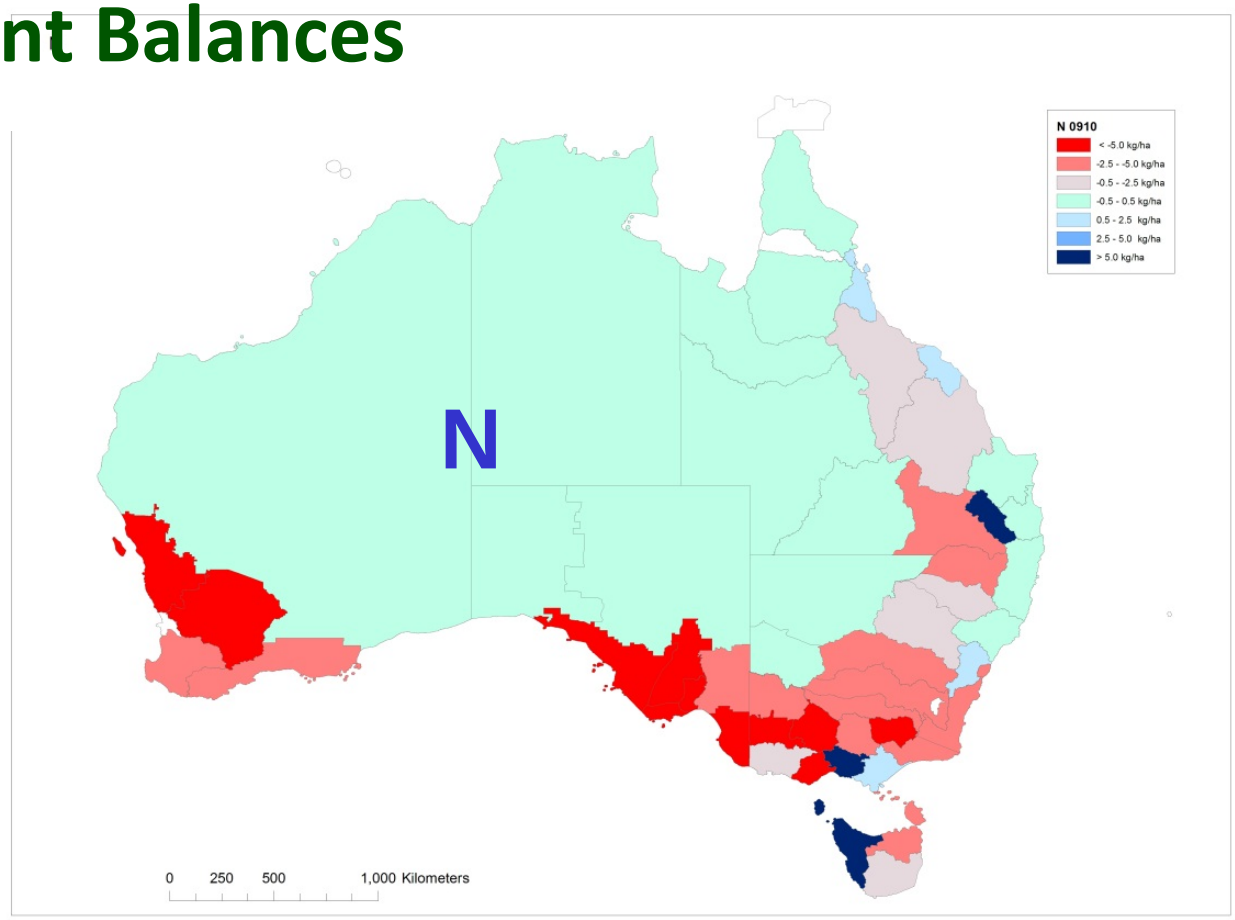
NUE varies temporally – prices and weather



NuGIS, 2014

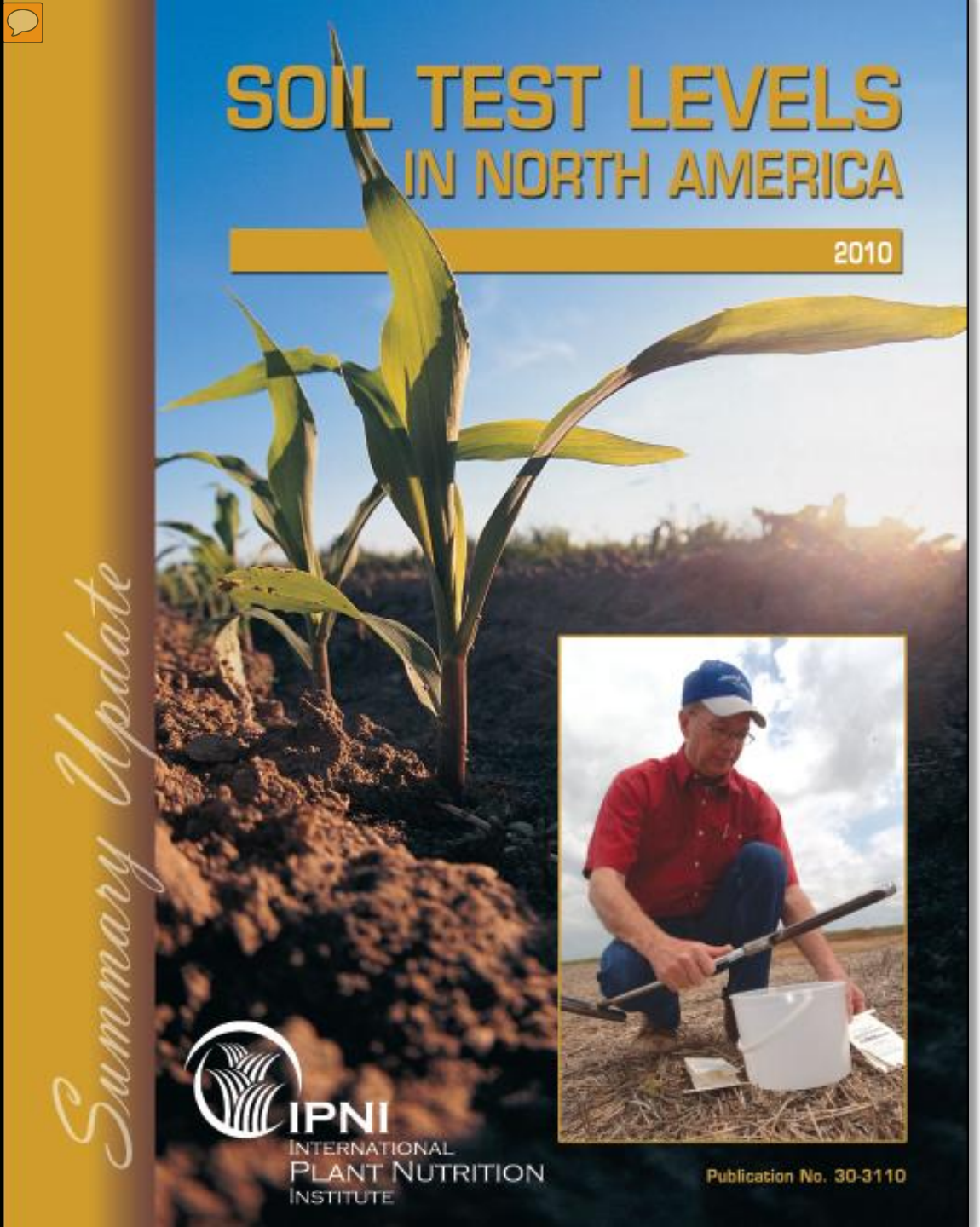
Australia Nutrient Balances





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**



One important component of soil health

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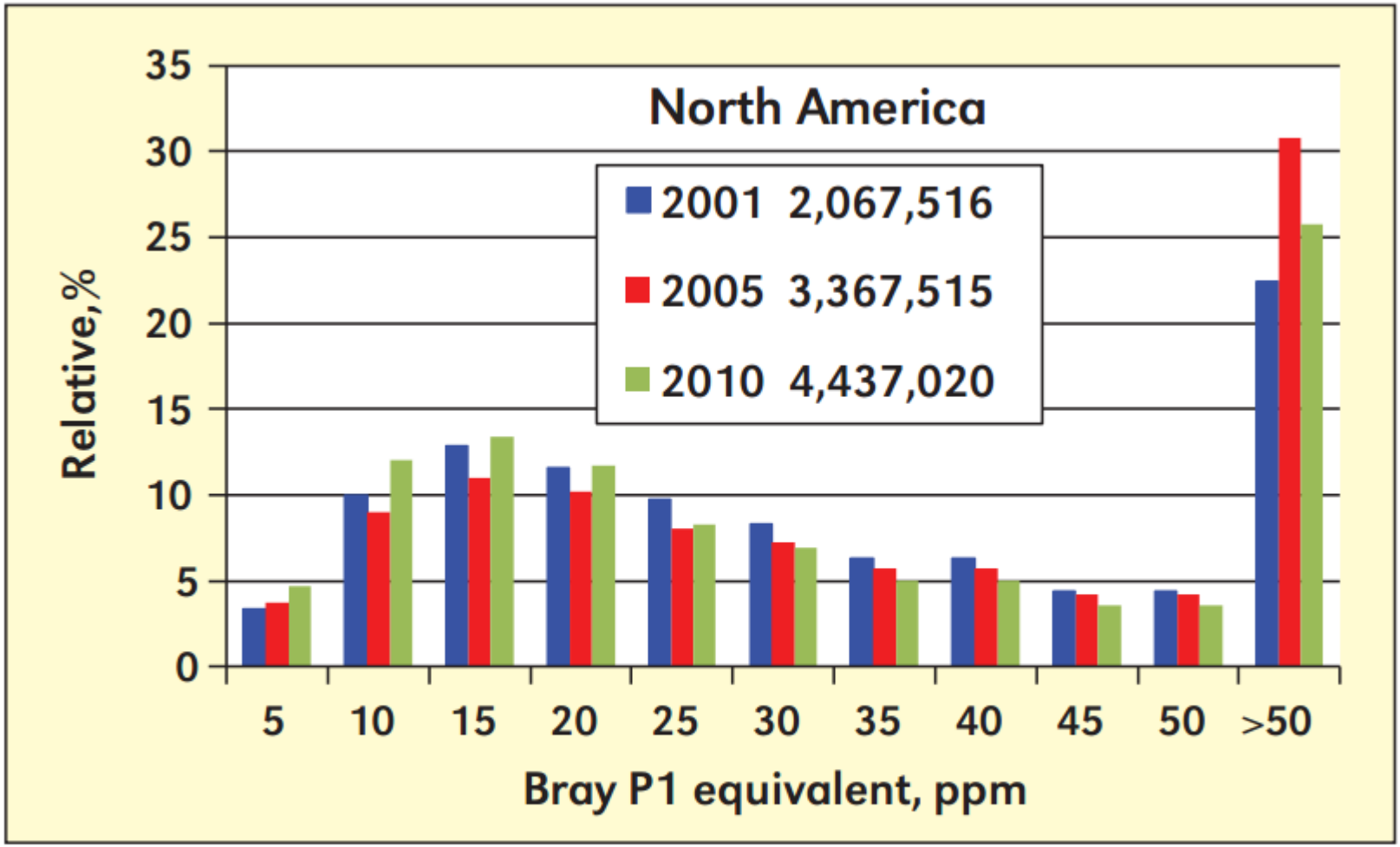
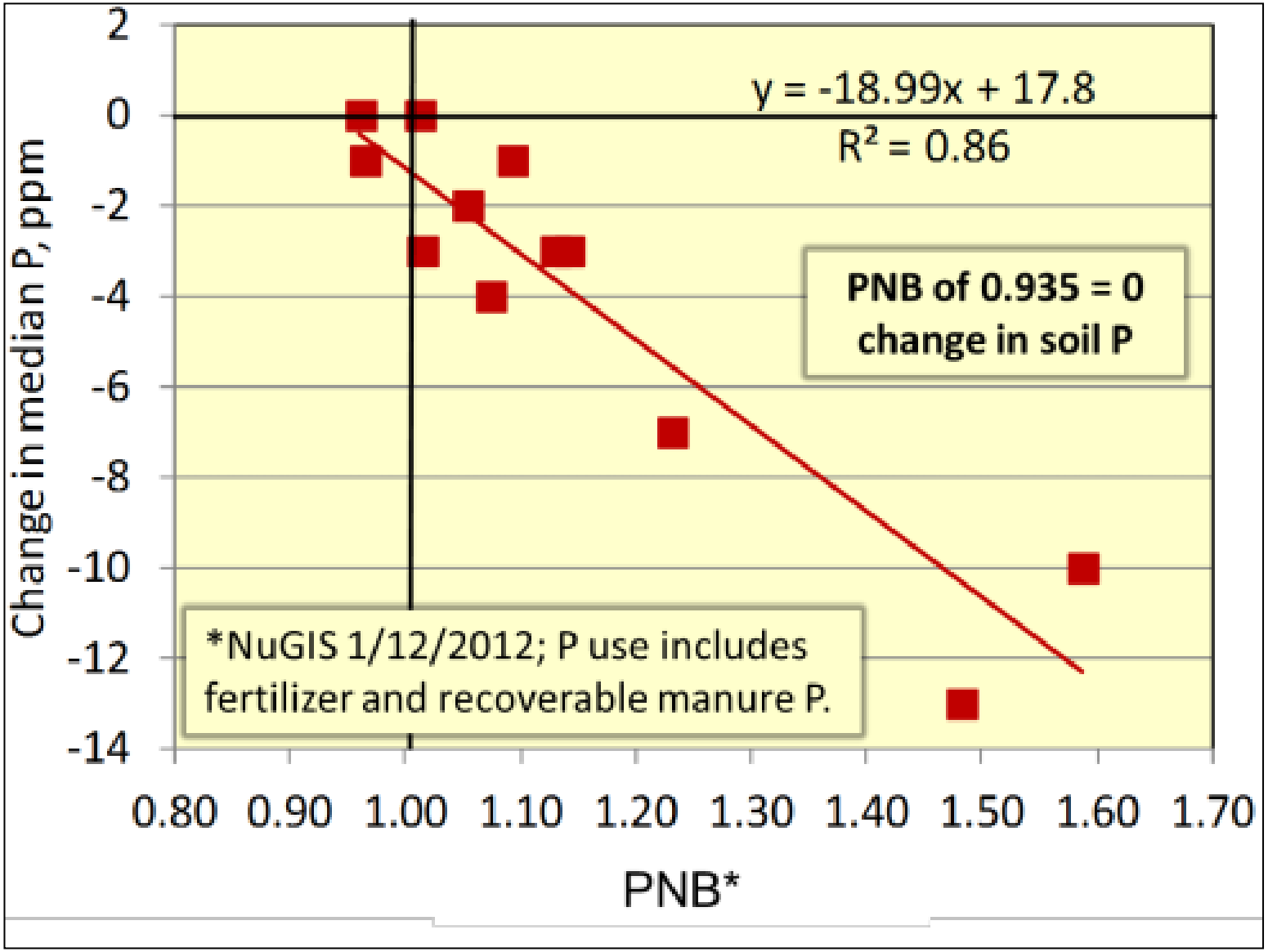
Frequency distribution of soil test P



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

Relationship of ΔSTP with PNB, 12 corn belt states



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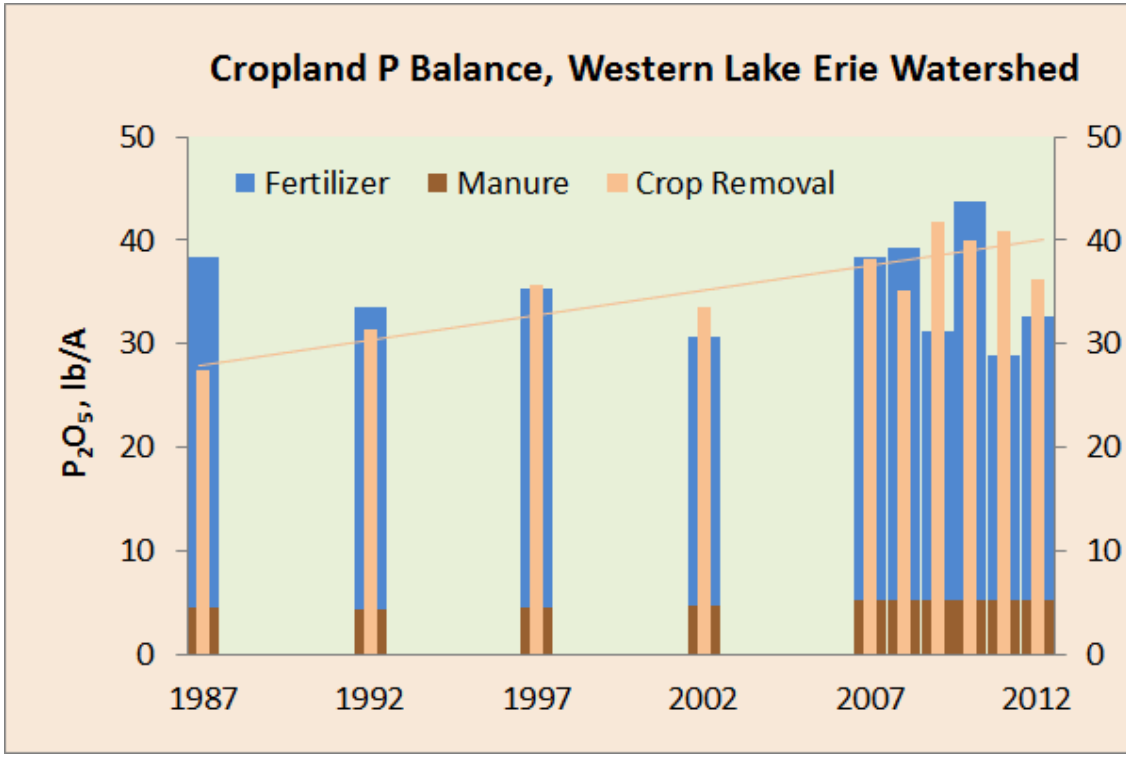
INSIGHTS
INTERNATIONAL PLANT NUTRITION INSTITUTE

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.

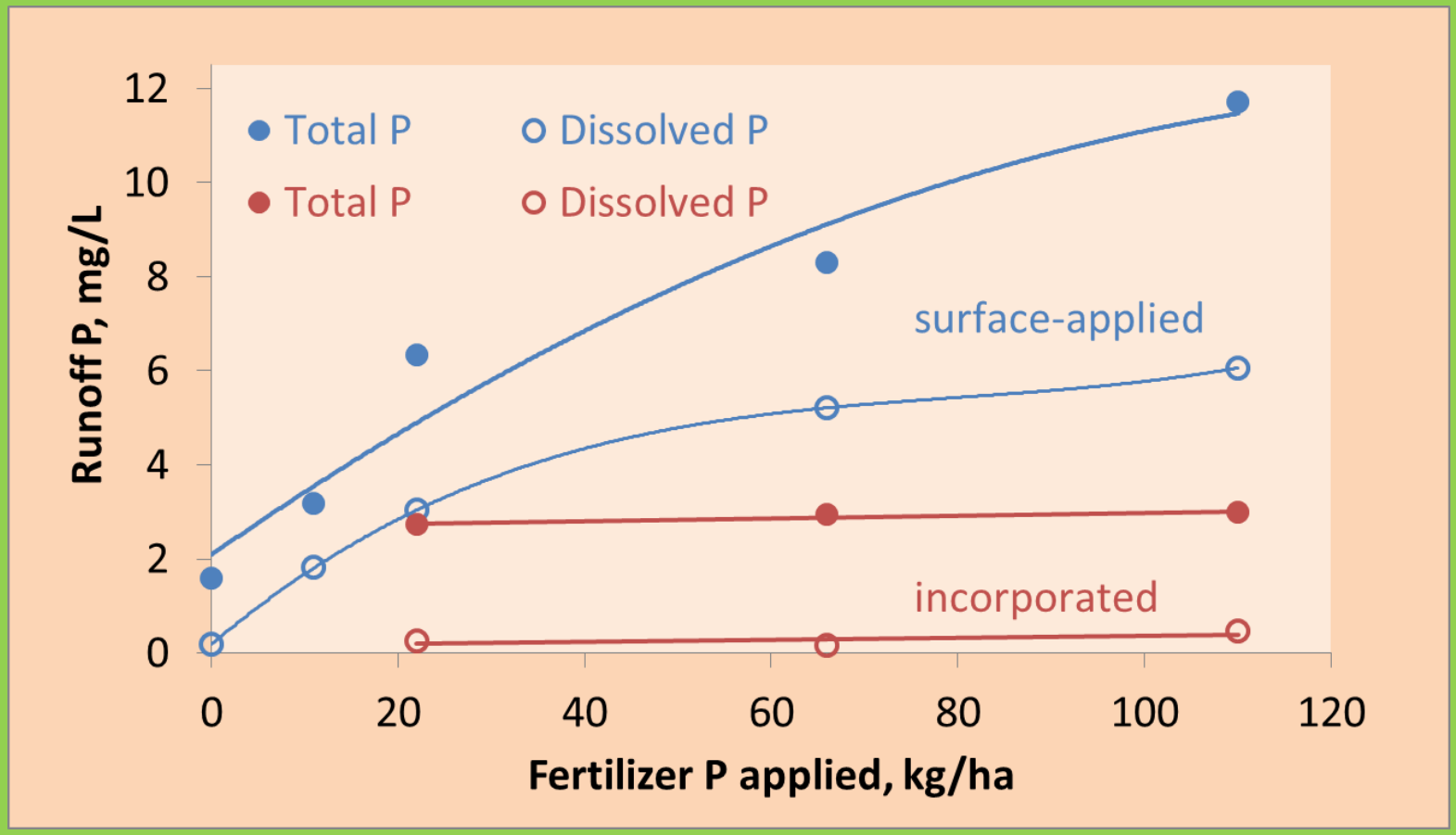
This article outlines how crop producers in the Lake Erie watershed can reduce losses of P by adopting a 4R Nutrient Stewardship approach to guide their fertilizer application practices.



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



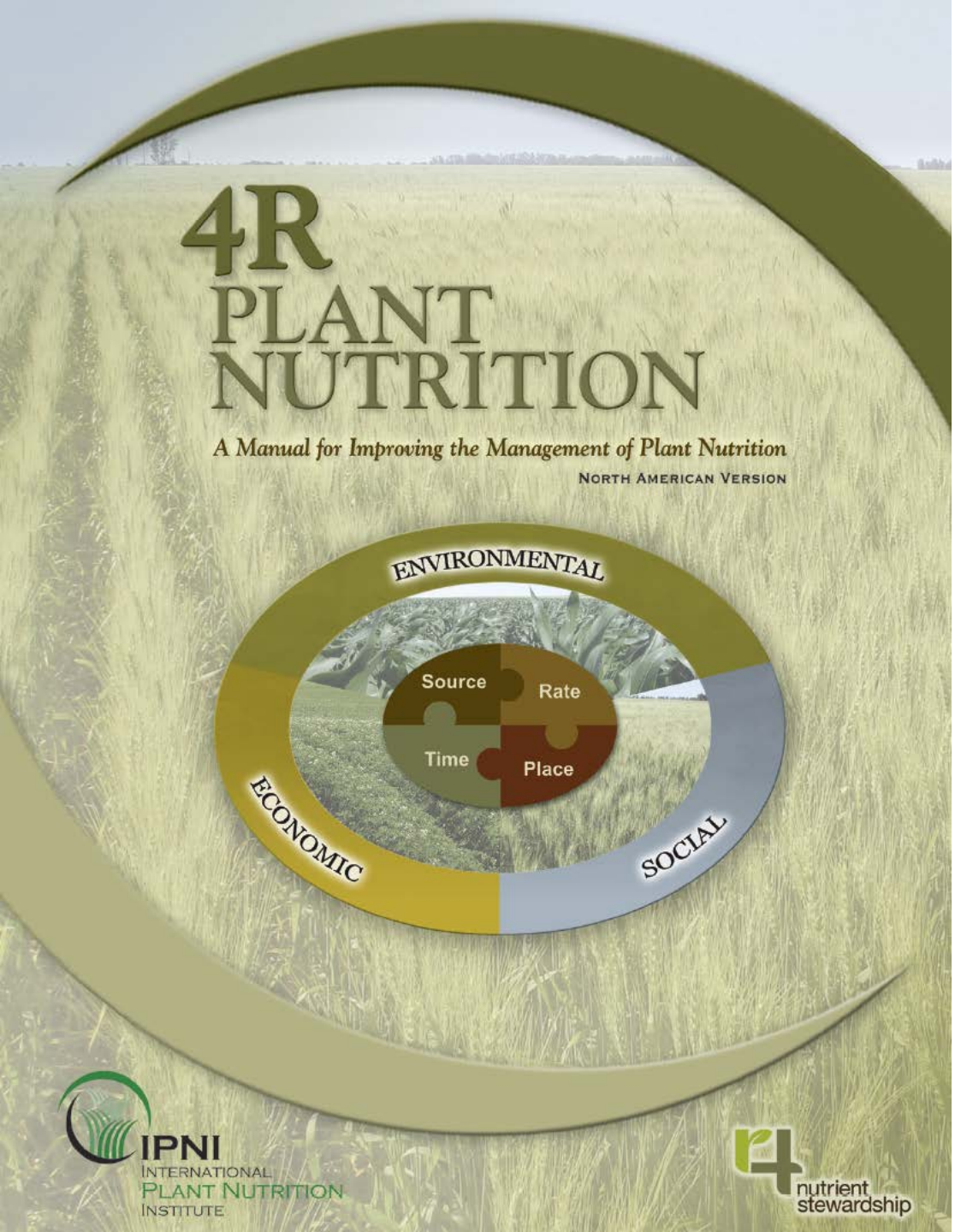
Concentration of dissolved and total P in runoff from a clay loam soil in North Carolina, from artificial rainfall immediately following application of superphosphate fertilizer. Incorporation to a depth of 5 inches by rotary tillage following application. Data from Tarkalson and Mikkelson (2004).

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



Thank You

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nutrient stewardship

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