IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

Resilience Emerging
from Scarcity and Abundance

American Society of Agronomy
Crop Science Society of America
Soil Science Society of America

8 November 2016
Phoenix, Arizona

Defining 4R Phosphorus Practices to Contribute to Continental Improvement of Water Quality

4 nutrient stewardship

Tom W. Bruulsema, Phosphorus Program Director, IPNI, Guelph, ON, Canada
Lara B. Moody, The Fertilizer Institute, Washington, DC
Allison M. Thomson, Field to Market, Washington, DC

Agrium Inc.

Arab Potash Company

BHP Billiton

CF Industries Holdings, Inc.

Compass Minerals Plant Nutrition

International Raw Materials LTD

Kingenta Ecological Engineering Group Co., Ltd.

K+S KALI GmbH

LUXI Fertilizer Industry Group

The Mosaic Company

OCP S.A.

PhosAgro

PotashCorp

Shell Sulphur Solutions

Simplot

Sinofert Holdings Limited

SQM

Uralchem, JSC

Uralkali

Yara International ASA

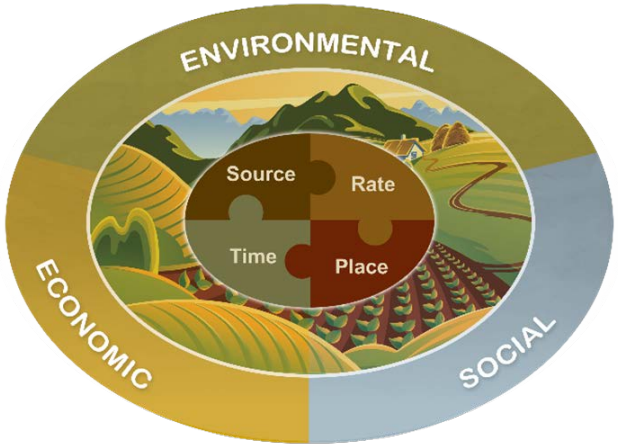
The **International Plant Nutrition Institute** is supported by leading fertilizer manufacturers.

Formed in 2007 from the Potash & Phosphate Institute, its mission is to develop and promote science for responsible management of crop nutrition

IPNI

Outline

1. **Agricultural Sustainability**
   - Comparing stakeholder perspectives
2. **4R Phosphorus Practice Definitions**
   - Scientific consensus process for commodity crops
   - Examples of results
3. **Knowledge Gaps: Further Opportunities**
   - Soil test interpretation, adaptive management, quantification.

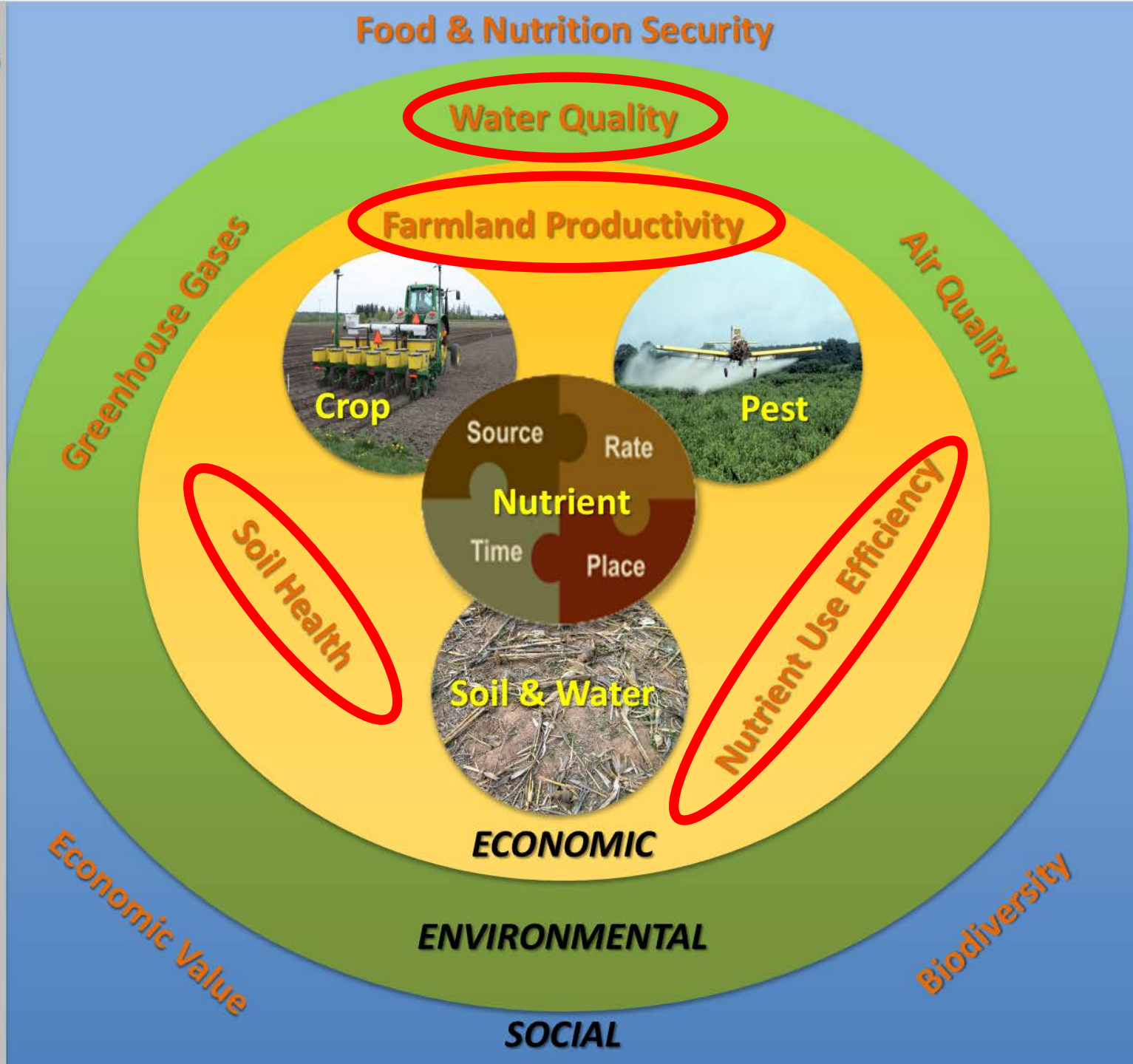


OUTCOMES

of

4R nutrient stewardship

are influenced by **crop and pest management,** and by **soil and water conservation practices** in the context of changing **weather and climate.**



Fieldprint® Calculator Sustainability Metrics

Field to Market®
The Alliance for Sustainable Agriculture

- Metrics that matter, usable at farm scale, linked to management with robust science
- Biodiversity, Energy Use, Greenhouse Gas Emissions, Irrigation Water Use, Land Use, Soil Carbon, Soil Conservation, **Water Quality**
- Current water quality metric is USDA NRCS WQI – qualitative
- Developing quantitative water quality outcome model to:
  - Better address regional concerns
  - Identify opportunities for practice improvement
  - Enable watershed data aggregation and analysis
- Model requires definition of baseline and better practices
  - Nutrients (N & **P**), sediment, and pesticides

IPNI

Comparing stakeholder perspectives

- Public
  - Water quality impact of agriculture is one concern among many
  - Expectation for evidence-based best practices
- Food industry
  - Desires clear simple metrics of sustainability impact, national in scope
  - Reflected in Fieldprint® Calculator
- Producers
  - Burden of reporting requirements of food supply chain
  - Can’t be environmentally responsible without profitability
- Scientists
  - Complex relationship between practices and P loss
  - Hesitant to quantify: small differences reverse outcomes
  - Inadequacy of current risk assessment tools – indexes & models

IPNI

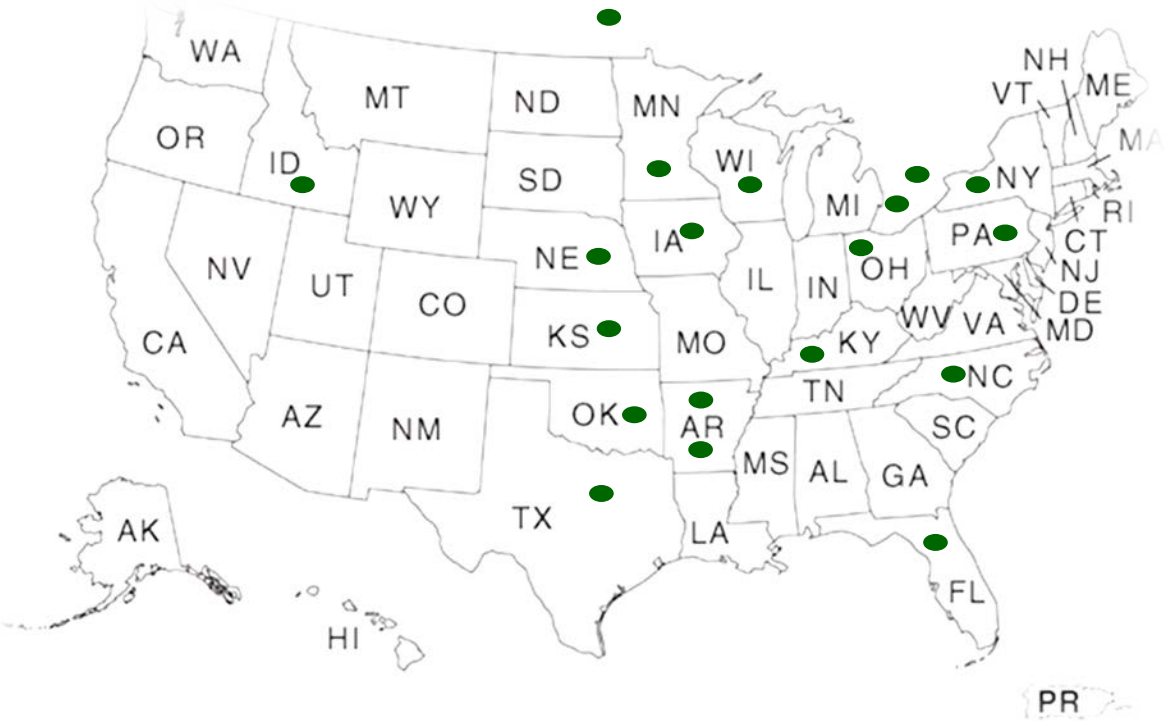
4R Phosphorus Practices – Process

- Invited leading scientists recognized for their expertise in agricultural phosphorus loss reduction.
- June 2016 workshop with conference calls before and after
- **Goal:** to define 4R P practices whose adoption would **reduce losses of P** that impact water quality, consistent with improvement in all Field Print sustainability metrics.
- Identified regions associated with Field to Market® commodity crops [Corn, Cotton, Potatoes, Rice, Soybeans, Wheat]
- Discussion topics included:
  - Quantification of impact – settled for 'directionally correct'
  - How do we define "right" practices, when "right" is site-specific? Among and within regions, cropping systems, farms and fields

IPNI

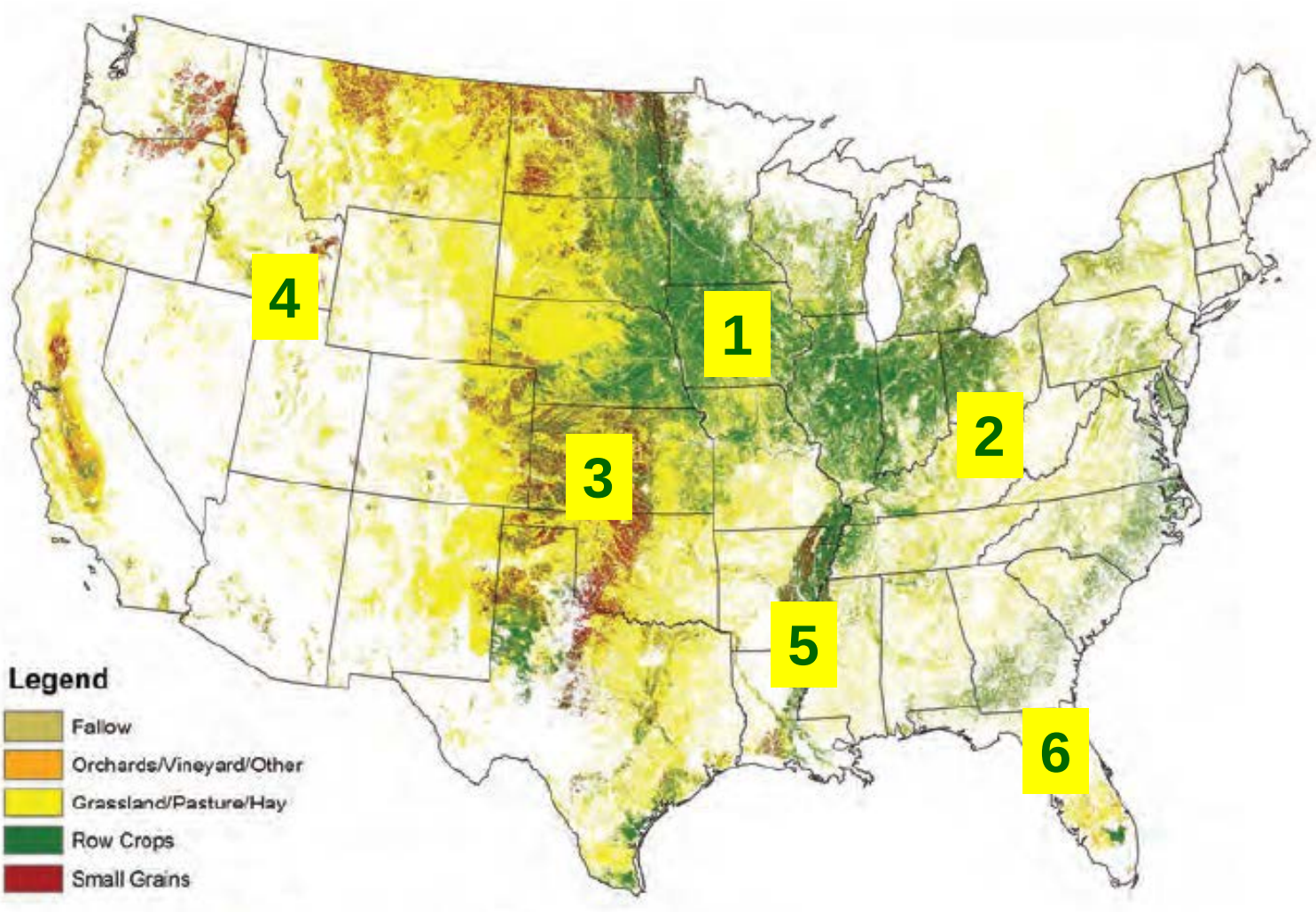
Participating Scientists

1. **Brian Arnall**, Oklahoma State U
2. **Doug Beegle**, Penn State U
3. **Don Flaten**, U of Manitoba
4. **Laura Good**, U of Wisconsin
5. **Kevin King**, USDA-ARS, Columbus, OH
6. **Quirine Ketterings**, Cornell U
7. **Josh McGrath**, U of Kentucky
8. **Antonio Mallarino**, Iowa State U
9. **Rao Mylavarapu**, U of Florida with input from other colleagues.
10. **David Mulla**, U of Minnesota
11. **Nathan Nelson**, Kansas State U
12. **Keith Reid**, Agriculture and Agri-Food Canada
13. **Nathan Slaton**, U of Arkansas
14. **Charles Shapiro**, U of Nebraska
15. **Andrew Sharpley**, U of Arkansas
16. **Doug Smith**, USDA-ARS, Temple, TX
17. **Ivan O'Halloran**, U of Guelph
18. **Deanna Osmond**, North Carolina State U
19. **David Tarkalson**, USDA-ARS, Kimberly, ID



Regions and Cropping Systems

1. Western Corn and Soybean
2. Eastern Cereals and Oilseeds
3. Wheat in the Great Plains
4. Irrigated Potatoes in the Northwest
5. Rice
6. Irrigated vegetables



2011 National Land Cover Database - http://www.mrlc.gov

Core 4R Phosphorus Practices

Level	Source	Rate	Time	Place
Basic (~50% of producers assumed to be at this level)	• All sources applied have known or guaranteed analysis. • Manures applied have current nutrient analysis or current book values.	• Rates are based on current soil tests using **recognized** sampling & analytical procedures, and **recognized** evidence based recommendations • All P sources are accounted for. • Application equipment is maintained and calibrated.	• Applications are not made when soils are frozen or snow covered unless based on **recognized** guidelines.	• Banding or injecting below the soil surface is encouraged. • Where P is broadcast, it is either incorporated into the soil before runoff occurs, or applied only where low risk of runoff is **recognized**.
Inter-mediate (~25%)	• As in basic, plus: • Manures have farm-specific nutrient analyses using **recognized** sampling procedures.	• As in basic.	• Applications are not made when soils are frozen or snow covered.	• As in basic.
Advanced (~5%)	• As in intermediate.	• As in intermediate, plus: • Fields are subdivided to receive zone-specific rates.	• As in intermediate.	• As in intermediate.

IPNI

Core 4R Phosphorus Practices

General Comments

1. All nutrient management practices meet or exceed requirements of locally applicable **regulations**.
2. Management of soil pH, lime and other nutrients is assumed to follow locally appropriate practices.
3. **Conservation practices** (field and farm specific) are used to minimize sediment and nutrient loss in surface runoff and tile discharge.
4. The term "**recognized**"—when used in reference to recommended practices, tools or interpretations—is taken to mean recognized as an agency entrusted with the task of providing such recommendations. These may include land grant universities appropriate to each state, government extension agencies in Canadian provinces, or multi-stakeholder bodies (including universities and/or government extension agencies) established to provide recommendations relevant to soil fertility and plant nutrition.
5. The producer or adviser involved in making the practice decisions is encouraged to meet or exceed a **knowledge standard** equivalent to that of a Certified Crop Adviser or Certified Nutrient Management Planner, preferably with demonstrated knowledge of principles of 4R Nutrient Stewardship.

IPNI

Further Opportunities

- **Definition of optimum soil test P.** Each state and province has different approaches to identifying soil test critical levels and naming the ranges of soil tests.
- **Adaptive management**. Participating scientists were unable to define a set of criteria for groups or private companies developing recommendations independent of those "recognized" (LGU and government).
- **Quantification**. Participating scientists agreed that the practices identified reduce losses of P that harm water quality, but expressed caution on use of current indexes and models to quantify such losses.

IPNI

4R efficacy for reducing P loss, % reduction

- ranges found in field experiments across the USA and Canada

Practice	Dissolved P	Particulate P
Source	---	---
Rate	60 to 88%	negligible
Time	41 to 42%	negligible
Place	20 to 98%	-60% to NS
Soil inversion	NS to 92%	-59% to NS
Conservation tillage	-308 to -40%	-33 to 96%

Dodd & Sharpley, 2015. Nutrient Cycling in Agroecosystems.

1. **Wide range of efficacies demands more site-specific focus.**
2. **Trade-off between dissolved and particulate is important.**

IPNI

Summary

- The sustainability movement can increase public appreciation of the benefits of science aimed at quantifying impacts of 4R phosphorus practices.
- Consensus was achieved among 19 scientists defining basic, intermediate and advanced 4R phosphorus practices with high potential for reducing losses in regional cropping systems.
- Opportunities remain to better define optimum soil test P, to recognize adaptive management, and to quantify impact of specific 4R practices for specific conditions.