Soil Science Society of America Special Session
Nitrogen-Climate Interactions and Soil Processes
Cincinnati, Ohio, USA
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Managing Crop Nitrogen to Mitigate and Adapt to Climate Change

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IPNI North America

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Formed in 2007 from the Potash & Phosphate Institute, the **International Plant Nutrition Institute** is supported by leading fertilizer manufacturers.

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Outline – Managing Crop Nitrogen to Mitigate and Adapt to Climate Change

1. Future climates, cropping systems and N
2. 4R for future climates
3. Reporting 4R Performance
4. 4R Research

4R nutrient stewardship

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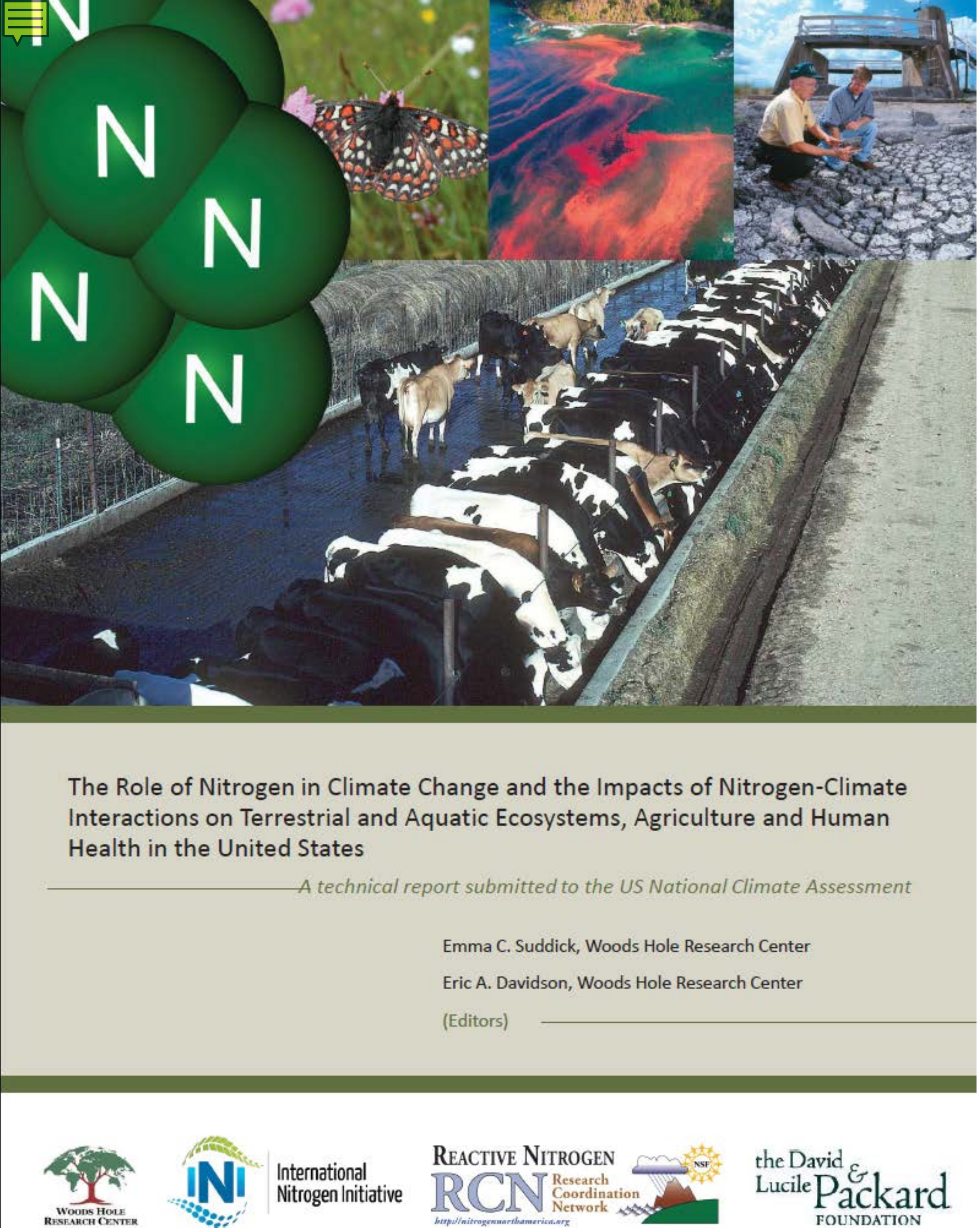
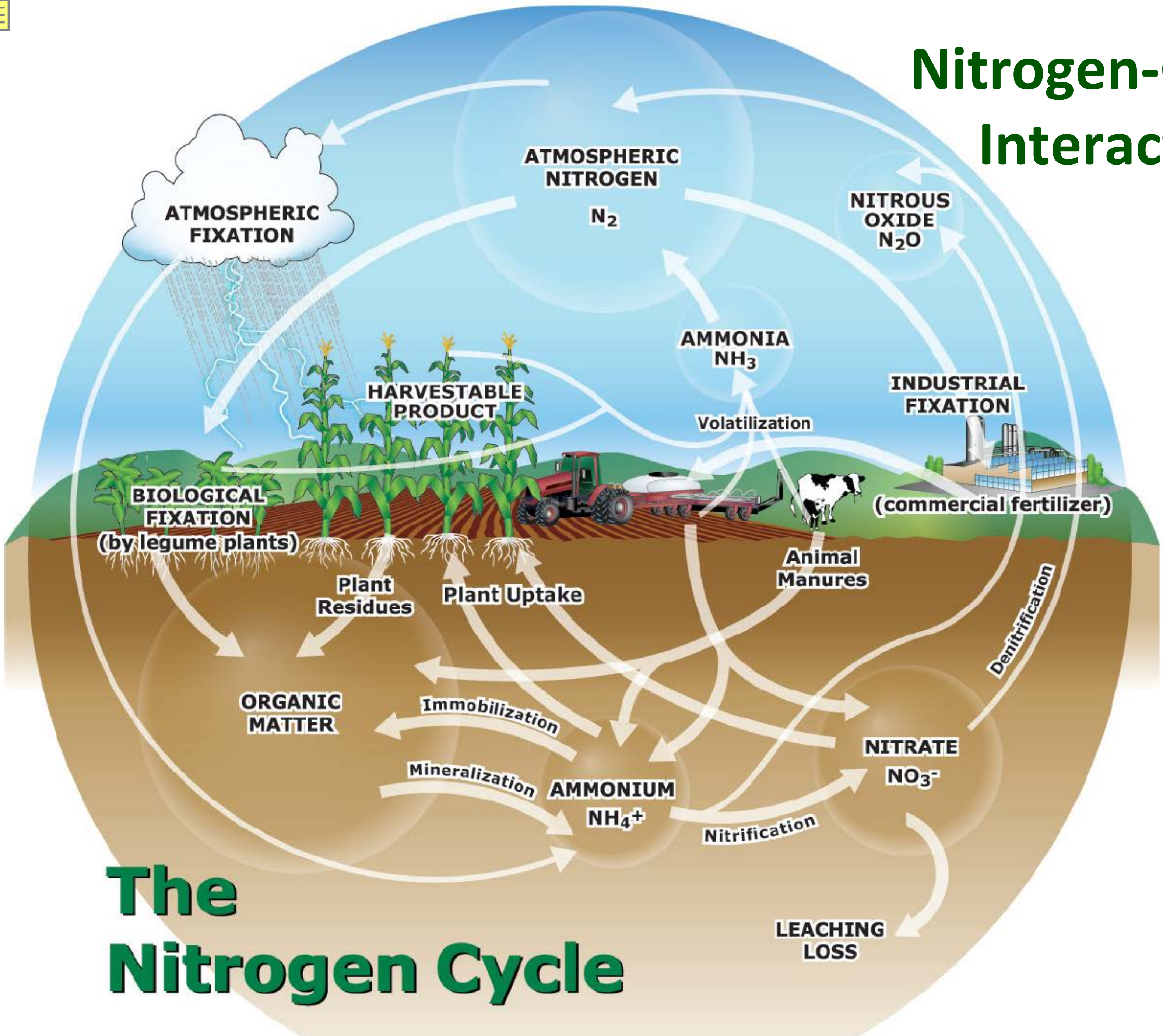


Nitrogen-Climate Interactions

- 7 chapters
- 208 pages
- "improved nutrient management will be increasingly challenging under climate change scenarios of more variable climatic patterns"

Nitrogen-Climate Interactions



MANAGING THE RISKS OF EXTREME EVENTS AND DISASTERS TO ADVANCE CLIMATE CHANGE ADAPTATION

IPCC SREX

594 pp

- It is *likely* that total rainfall from heavy rainfalls will increase in the 21st century over many areas of the globe
- Increased heavy rain events in winter months for most of the eastern and northern portions of the Corn Belt
- Longer and more severe droughts? Not in central North America
- Floods, tornadoes and hail? almost impossible to predict

SPECIAL REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

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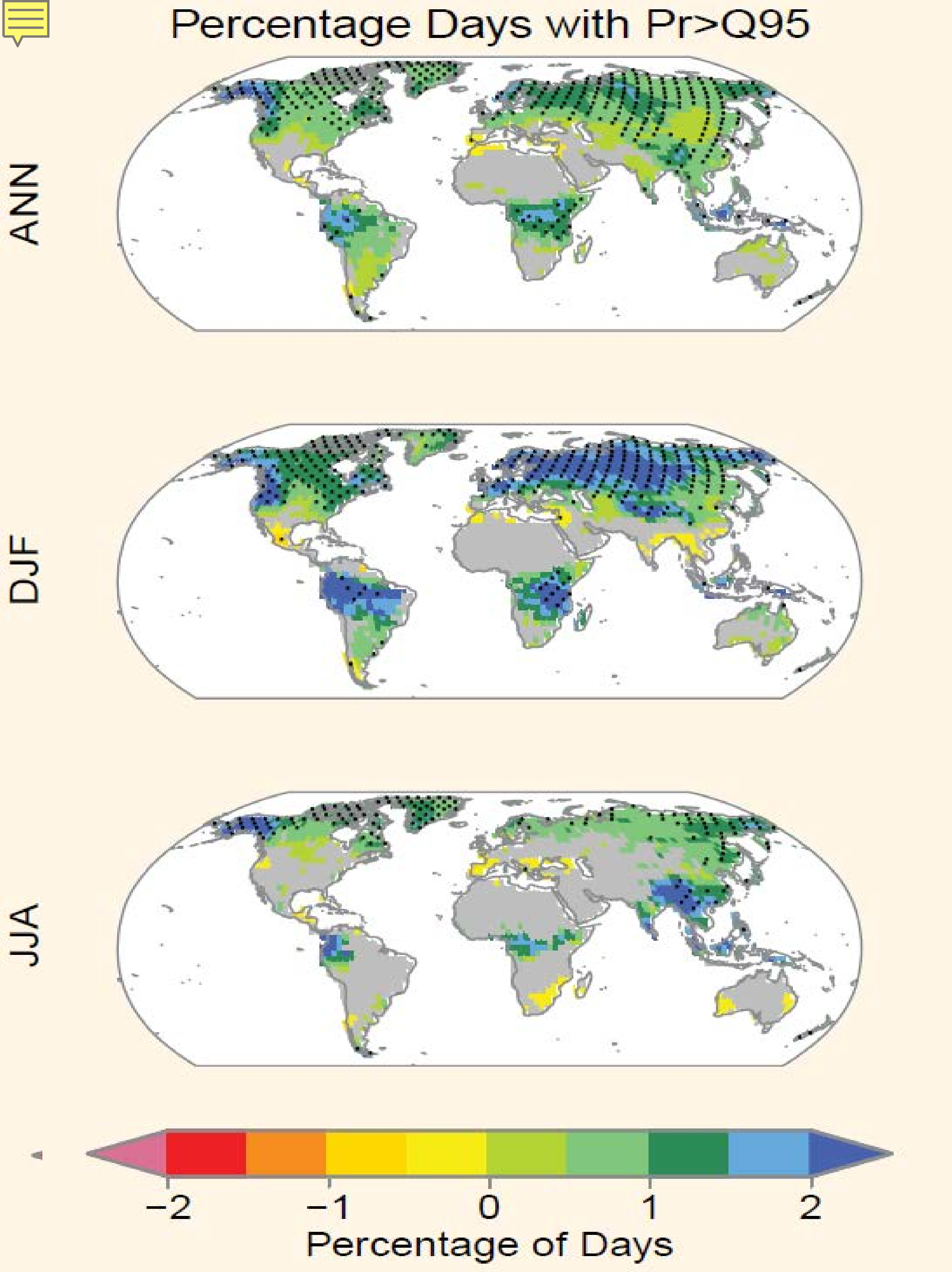


More intense precipitation in winter

Figure 3-6 | Projected annual and seasonal changes in % of days with Pr > Quantile 95 for 2081-2100 with respect to 1980-1999, based on 17 GCMs contributing to the CMIP3 (IPCC, 2012).

How will farmers respond?

- Changing climate will change the mix of crops and rotations, production potentials, and opportunities for cover crops.
- More intense winter rain could lead to greater importance for conservation tillage and cover crops.

Climate and soil organic N

- **Soil N mineralization** increased by temperature but reduced by higher C/N ratios (Brevik, 2012, Soil Horizons)
- **Nutrients:** “Soil C sequestration under elevated CO_2 is constrained both directly by N availability and indirectly by nutrients [P, K, Mo] needed to support N_2 fixation” (van Groenigen et al, 2006, PNAS)
- **Progressive N limitation:** “Soil N supply is probably an important constraint on global terrestrial responses to elevated CO_2” (Reich et al, 2006, Nature)

Nitrogen – Carbon Interaction

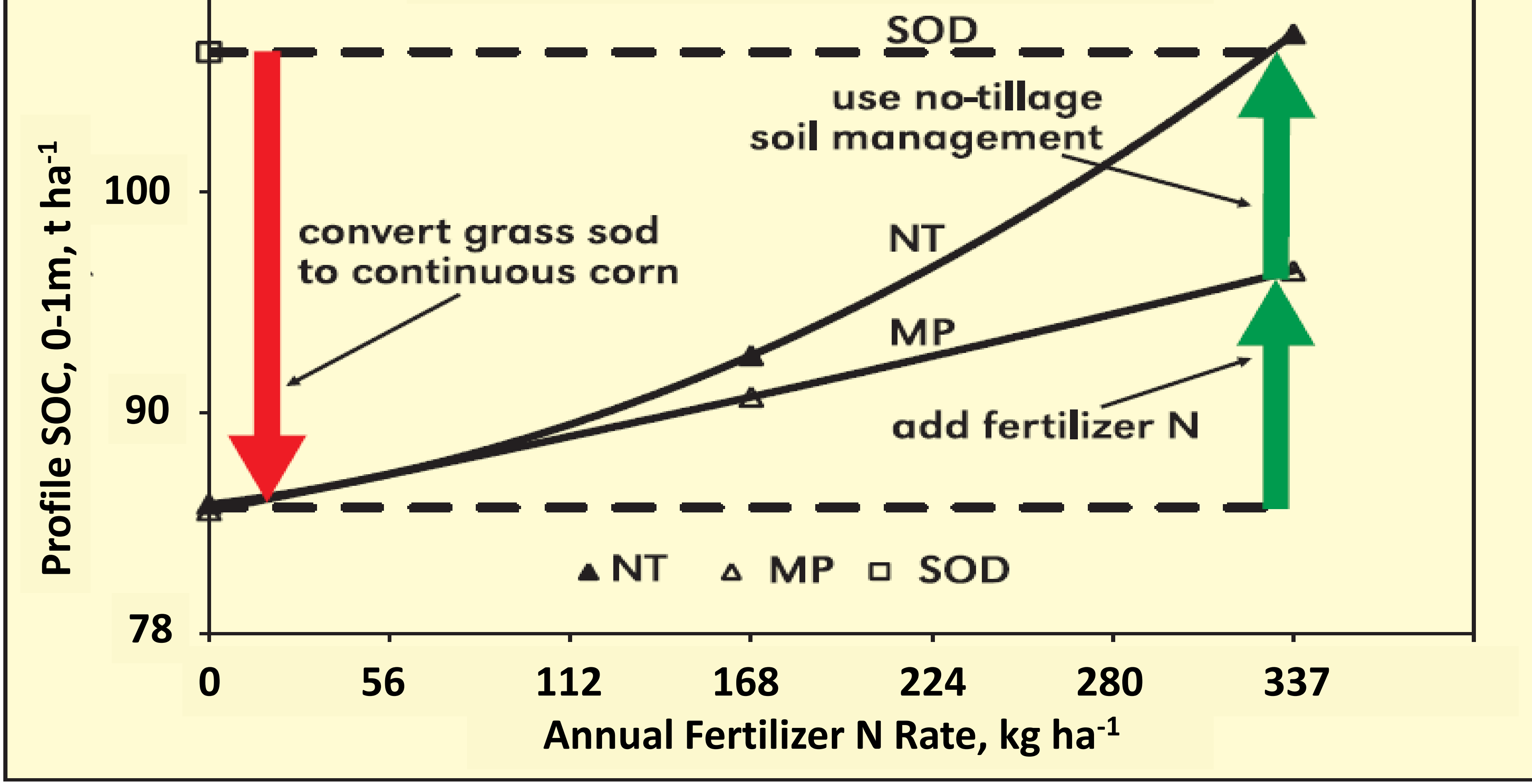


Figure 5. The impact of fertilizer N on total profile SOC levels found after 39 years of cropping to continuous corn with a winter cereal cover crop.

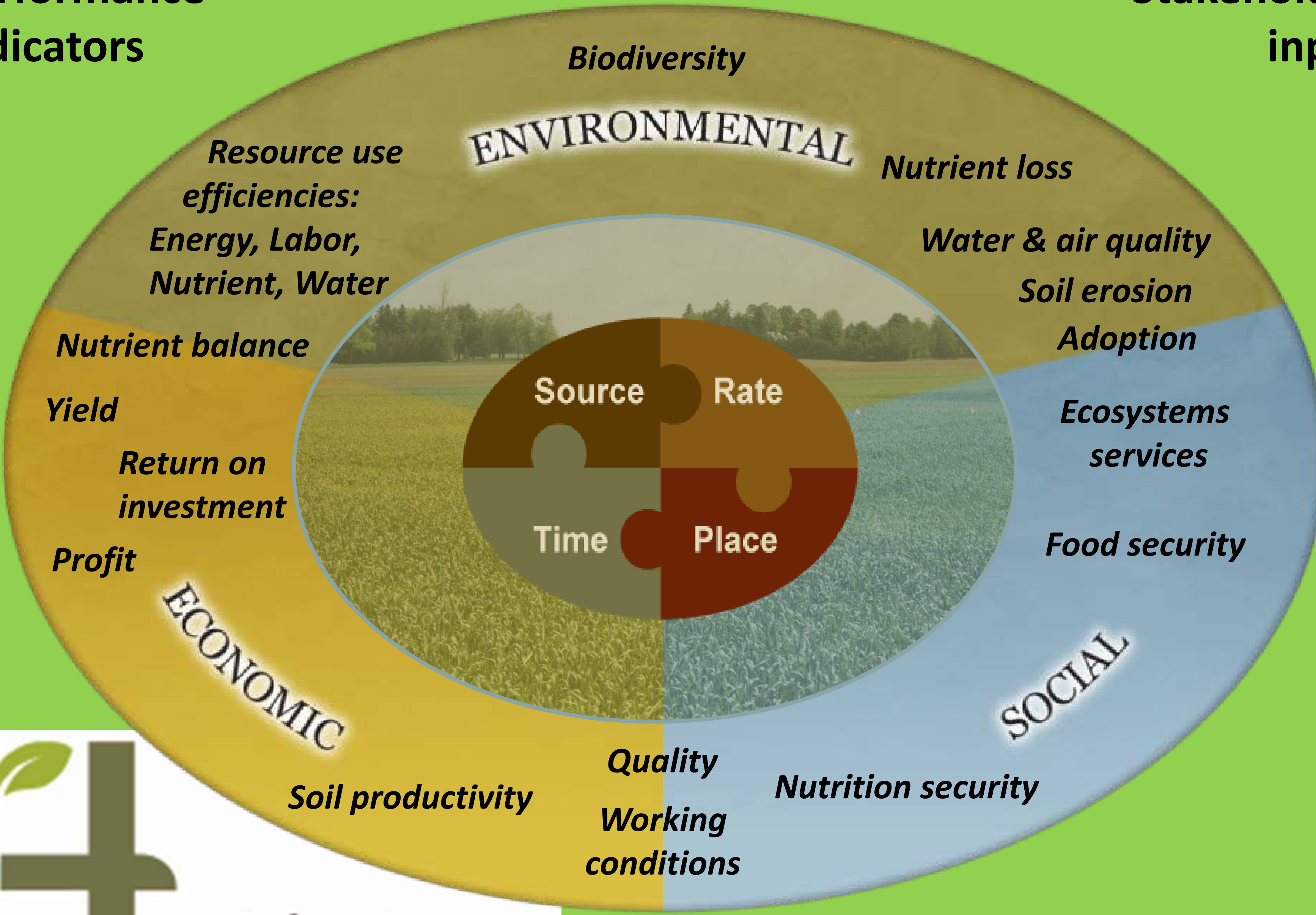
Grove et al. 2009. Better Crops with Plant Food 93(4):6-8 – Kentucky, USA

Take-home points: future climate

1. Rising CO_2 levels increase plant N demand.
2. Warmer wetter winters mean more opportunity for cover crops and more need for their roles in erosion prevention and soil carbon storage.

Performance indicators

Stakeholder input



4R nutrient stewardship

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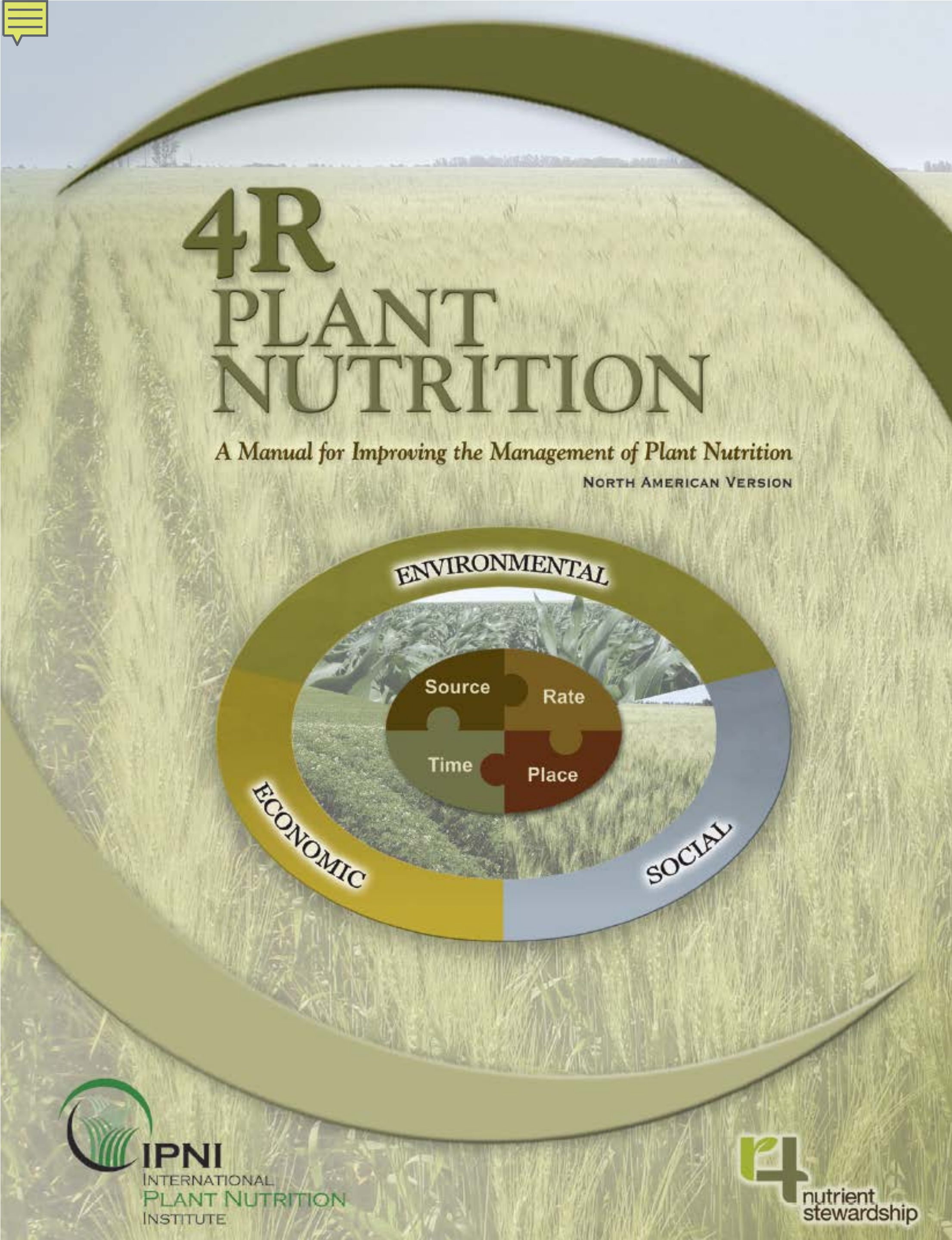

Chapter 1 Goals of Sustainable Agriculture ....

Chapter 2 The 4R Nutrient Stewardship Concept ....

Chapter 3 Scientific Principles Supporting — Right Source ......

Chapter 4 Scientific Principles Supporting — Right Rate ....

Chapter 5 Scientific Principles Supporting — Right Time........

Chapter 6 Scientific Principles Supporting — Right Place........

Chapter 7 Adapting Practices to the Whole Farm ....

Chapter 8 Supporting Practices........

Chapter 9 Nutrient Management Planning and Accountability.

http://nane.ipni.net

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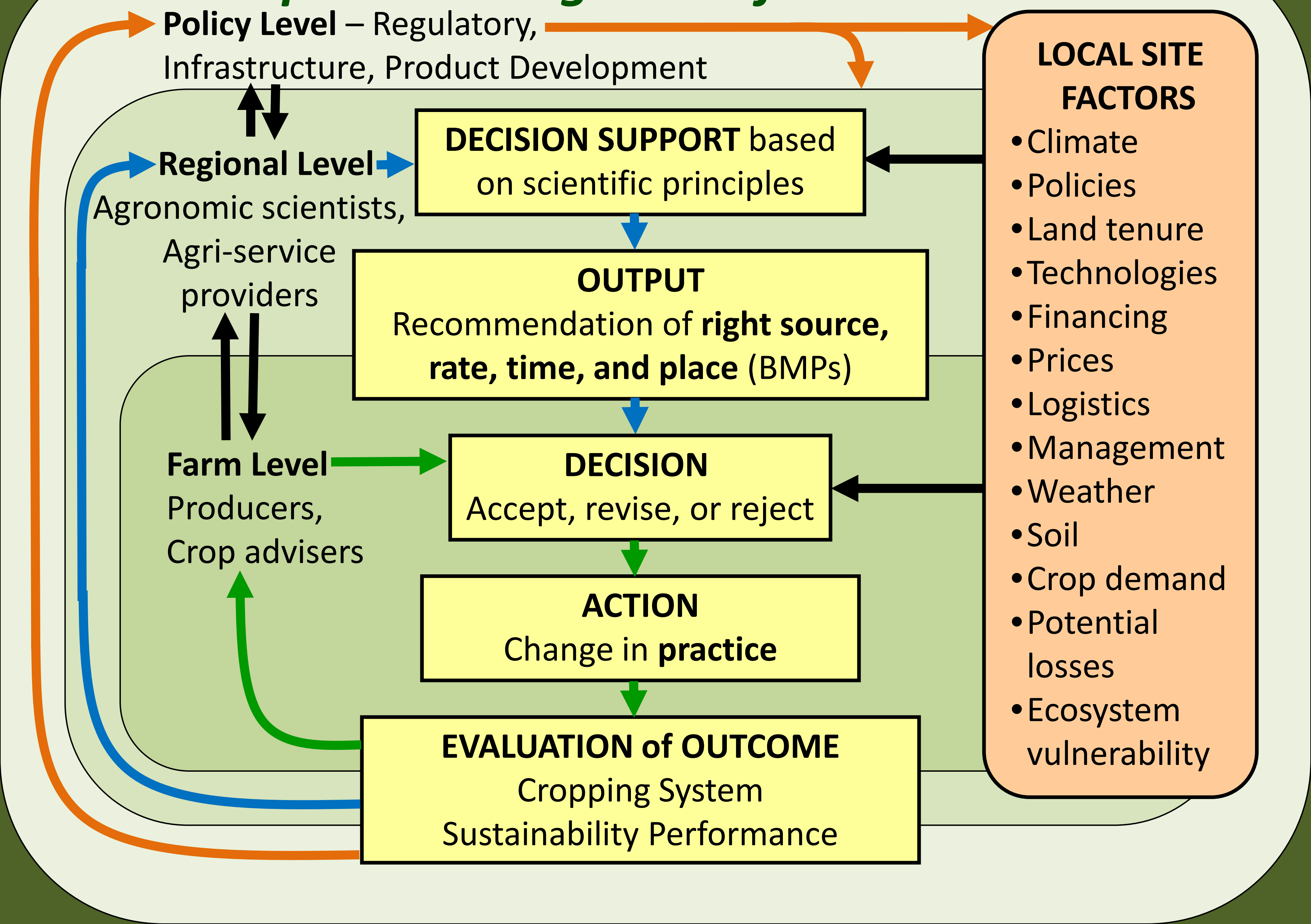
4R Adaptive Management for Plant Nutrition



Right Source

- **Form:** rising [CO_2] and implications for NH_4^+ versus NO_3^-
- Plant dependence on NH_4^+ versus NO_3^- changes with [CO_2] (Bloom et al, 2002; Epstein and Bloom, 2005)
- If preference for NH_4^+ increases, greater crop response may be expected from:
  - nitrification inhibitors (nitrapyrin, dicyandiamide)
  - other means of slowing the conversion of ammonium to nitrate (urease inhibitors, polymer coated urea, later time of application)
- Adapting to higher [CO_2] could thus lead to less nitrate leaching
- Forms suitable for placement in conservation tillage

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Right Rate

- A function of crop demand, soil supply, and soil losses
  - All 3 affected by weather
- Soil-crop system models using real-time data (e.g. Cornell University's Adapt-N), or crop sensors, can help adapt to weather
- Adapting N rates to weather:
  - More variable crop yield and rainfall-related N losses may make it more important.
  - Cover crop response to surplus N may make it less important.

Right Time

- If winter rains increase in amount and intensity, fall application may be less effective.
- Split applications allow more decision points to help deal with variability in crop yield potential and loss mechanisms.

Right Place

- Greater benefits to subsurface placement for urea with conservation tillage?
- If winter rains are more frequent and intense, more need for varying N rate by landscape position?
- Crop sensors for variable rate?

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nutrientstewardship.com

nutrient stewardship

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Search... GO

WHAT ARE THE 4RS | IMPLEMENT THE 4RS | 4R TRAINING

4R CONSISTENT SYSTEMS

These systems are consistent with the 4Rs and can help you create a comprehensive 4R nutrient stewardship plan. Learn more about what it means for a nutrient management system to be 4R-Consistent.

WILBUR-ELLIS COMPANY
14300 Nicollet Ct., suite 203
Burnsville, MN 55306
ph: 952-898-5562

THE ANDERSONS, INC.
The Andersons, Inc PO Box 119
Maumee, OH 43537
ph: 800-537-3370

SIMPLOT
999 Main Street, Suite 300AVAIL
Boise, ID 83702

IMPLEMENT THE 4RS

4R Nutrient Stewardship represents an innovative approach to fertilizer best management practices (BMPs). The 4Rs imply there are four aspects to every fertilizer application and it provides a framework to assess whether a given crop has access to the necessary nutrients. Asking "Was the crop given the right source at the right rate, at the right time, and in the right place?" helps identify opportunities to improve fertilizer efficiency and prevent nutrient movement from each field.

To learn more, please download our brochure: Implementing 4R Nutrient Stewardship on the Farm Right Now

This is an example of an unpublished revision.

RIGHT SOURCE | RIGHT RATE | RIGHT TIME | RIGHT PLACE

PARTNERS WITH THE PRODUCTS AND SERVICES YOU NEED TO FOLLOW THIS PART OF YOUR 4R PLAN

The Fertilizer Institute
Nourish, Replenish, Grow

CANADIAN FERTILIZER INSTITUTE
INSTITUT CANADIEN DES ENGRAIS

IPNI
INTERNATIONAL PLANT NUTRITION INSTITUTE

International Fertilizer Industry Association

The Fertilizer Institute | 425 Third Street, S.W., Suite 950 | Washington, D.C. 20024 | ph. 202.962.0490 | fax: 202.962.0577

“4R Inside” Checklist

1. Balance economic, social, environmental areas.
2. Include BMPs addressing SRTP.
3. Provide site-specific recommendations.
4. Balance essential elements.
5. Assess nutrient requirements.
6. Consider all sources.
7. Comply with regulations.
8. Measure effectiveness of BMPs.
9. Use terminology consistent with 4R standards.
10. Document plans and implementation.

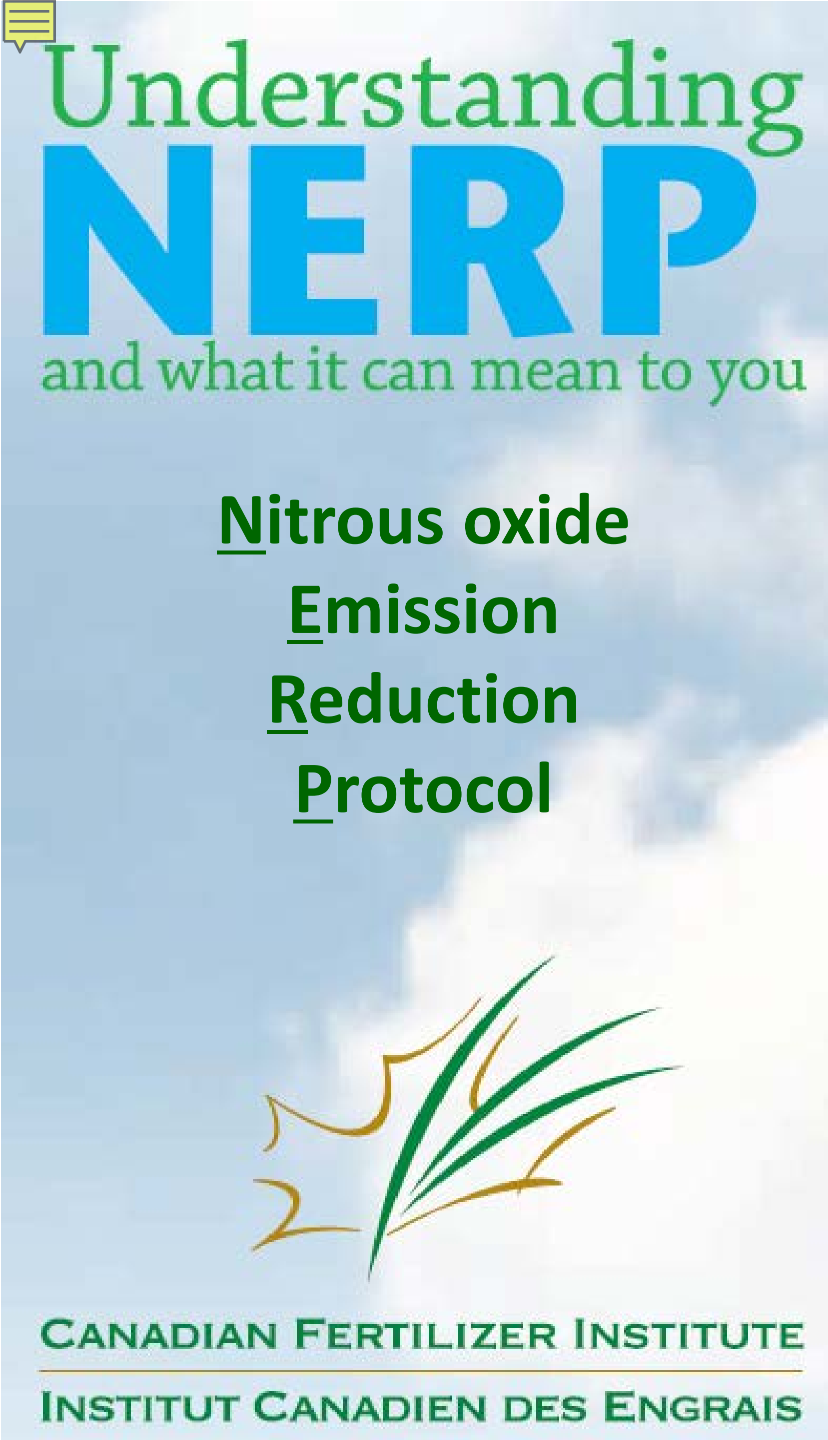
The Fertilizer Institute

nutrient stewardship

YouTube Browse | Movies

4R Advocate Winners 2012

FertilizerInstitute | Subscribe | 1 video



Benefits

Farmers

- Offset credit for reduced GHGs

Industry

- Source of credits

Government

- Tool to meet emission reduction targets
- ISO 14064-2 criteria for "real, measurable, additional, verifiable"
- Approved October 2010 by Alberta Environment

Researchers

- Advance science relating farm practices to N_2O emissions

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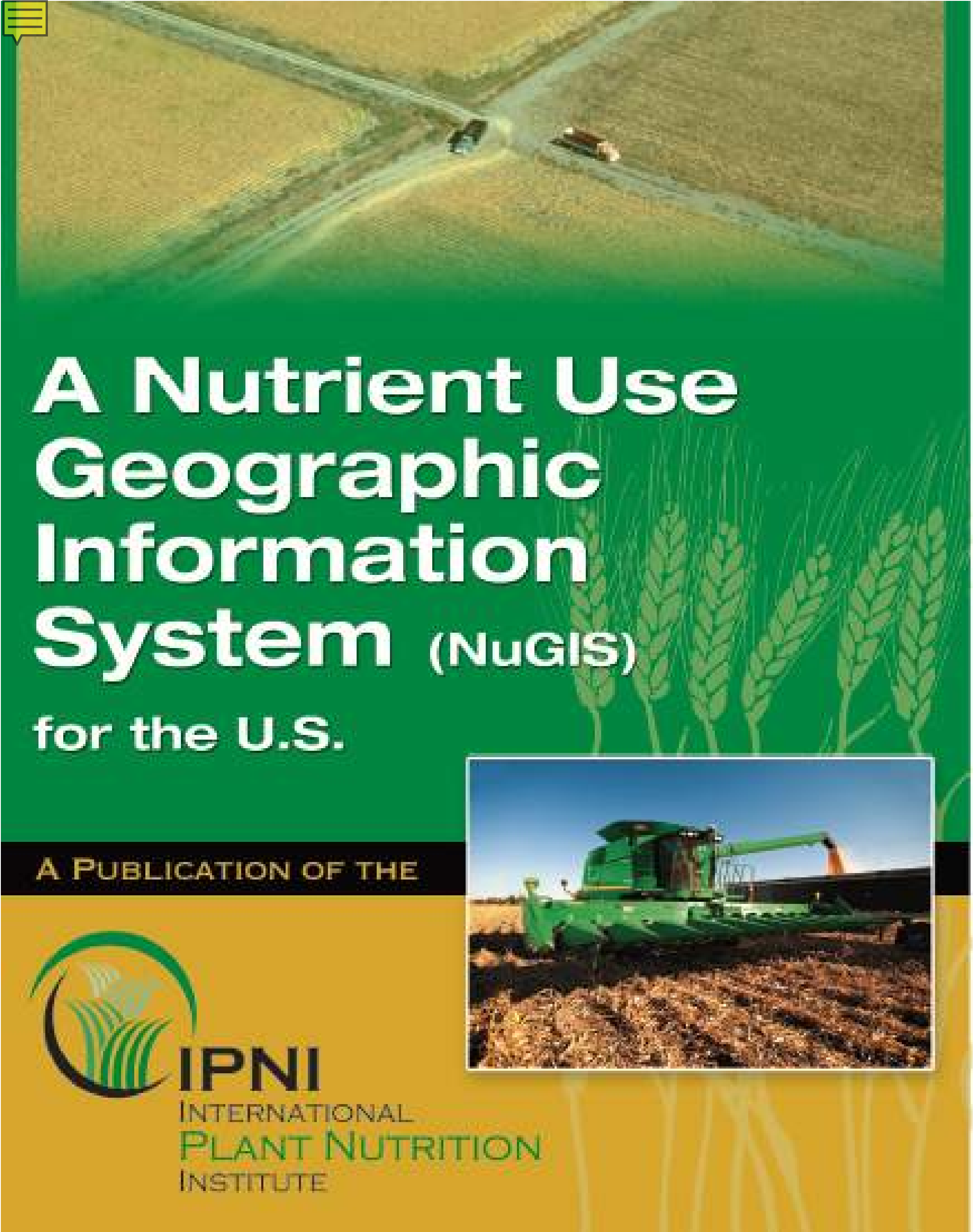
Take-home points: 4R Nutrient Stewardship

- The 4R Nutrient Stewardship concept is:
  - raising awareness among agri-service providers about sustainable management of N application.
  - Providing tools to engage producers and stakeholders



3.
Reporting 4R Performance

4R nutrient stewardship

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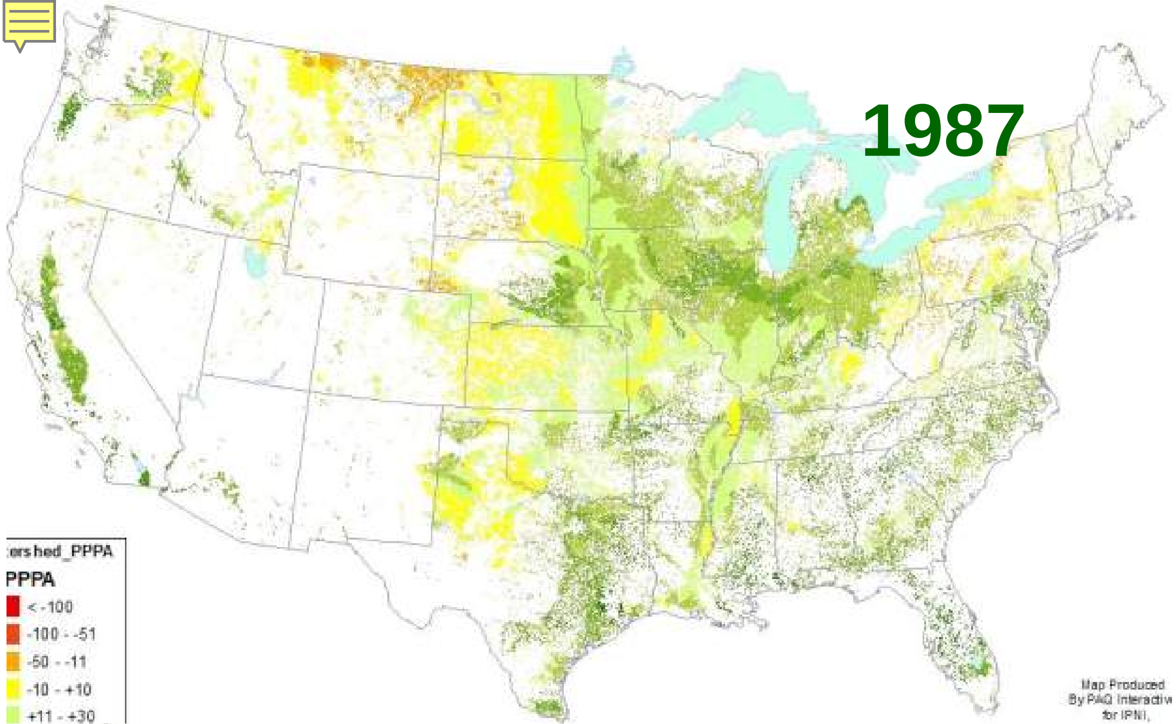
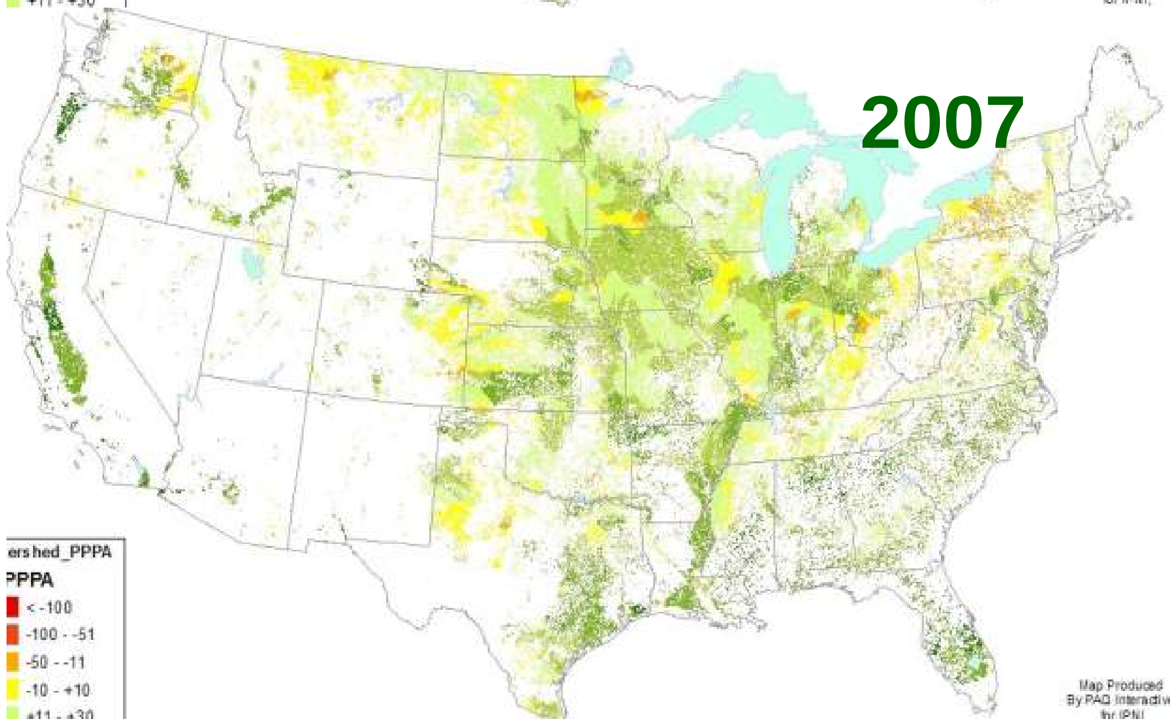
Partial N balance by 8-digit hydrologic unit





lb N/planted acre

- < -100
- -100 - -51
- -50 - -11
- -10 - +10
- +11 - +30
- +31 - +50
- +51 - +150
- +151 - + 300
- > +300

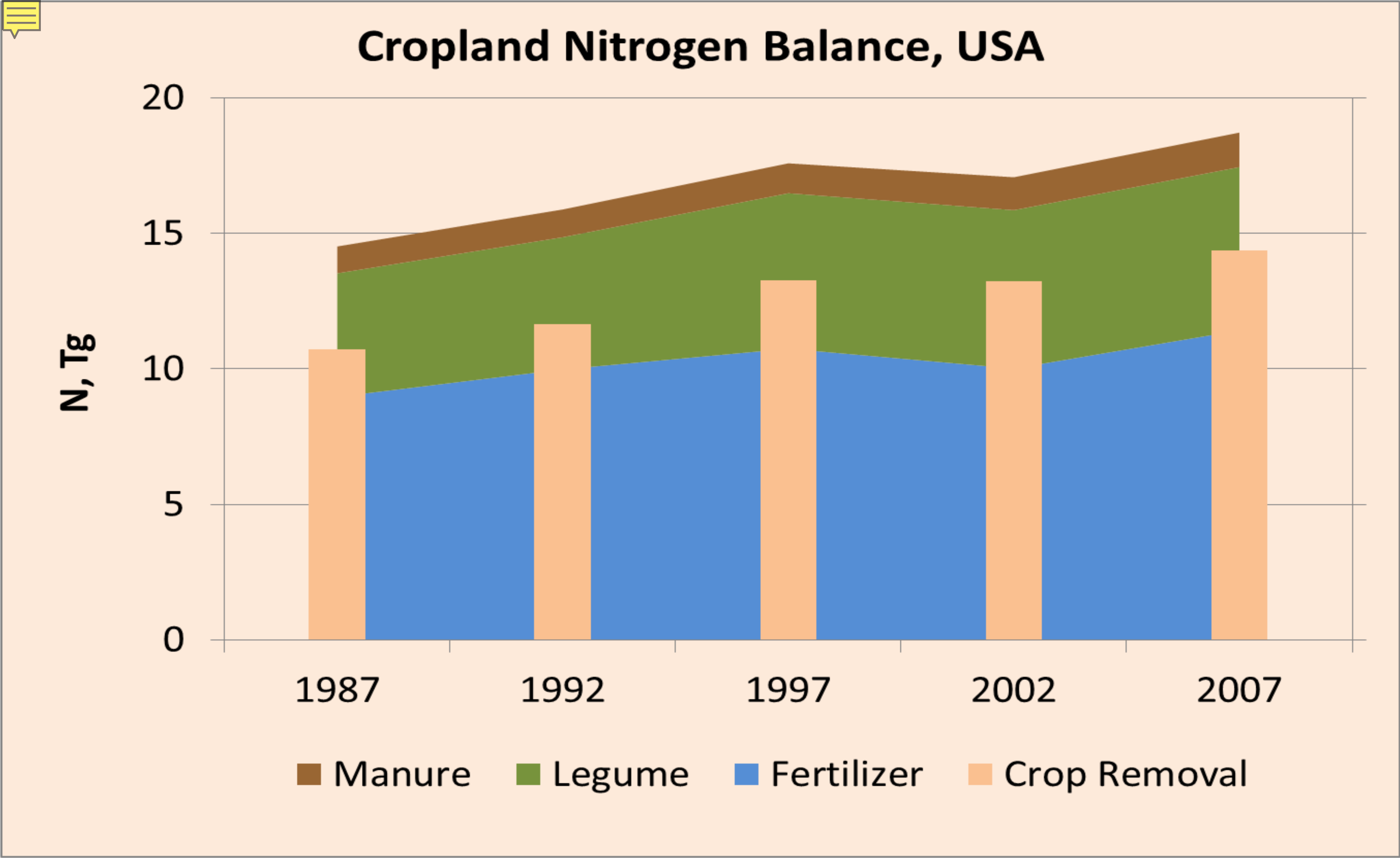


Figure 4.1: Inputs of N to US agricultural land, including recoverable manure, legume fixation, and commercial fertilizers, as compared to removal by crops (adapted from IPNI NuGIS, 2011). *[In Robertson et al., 2012, Biogeochemistry, in press]*

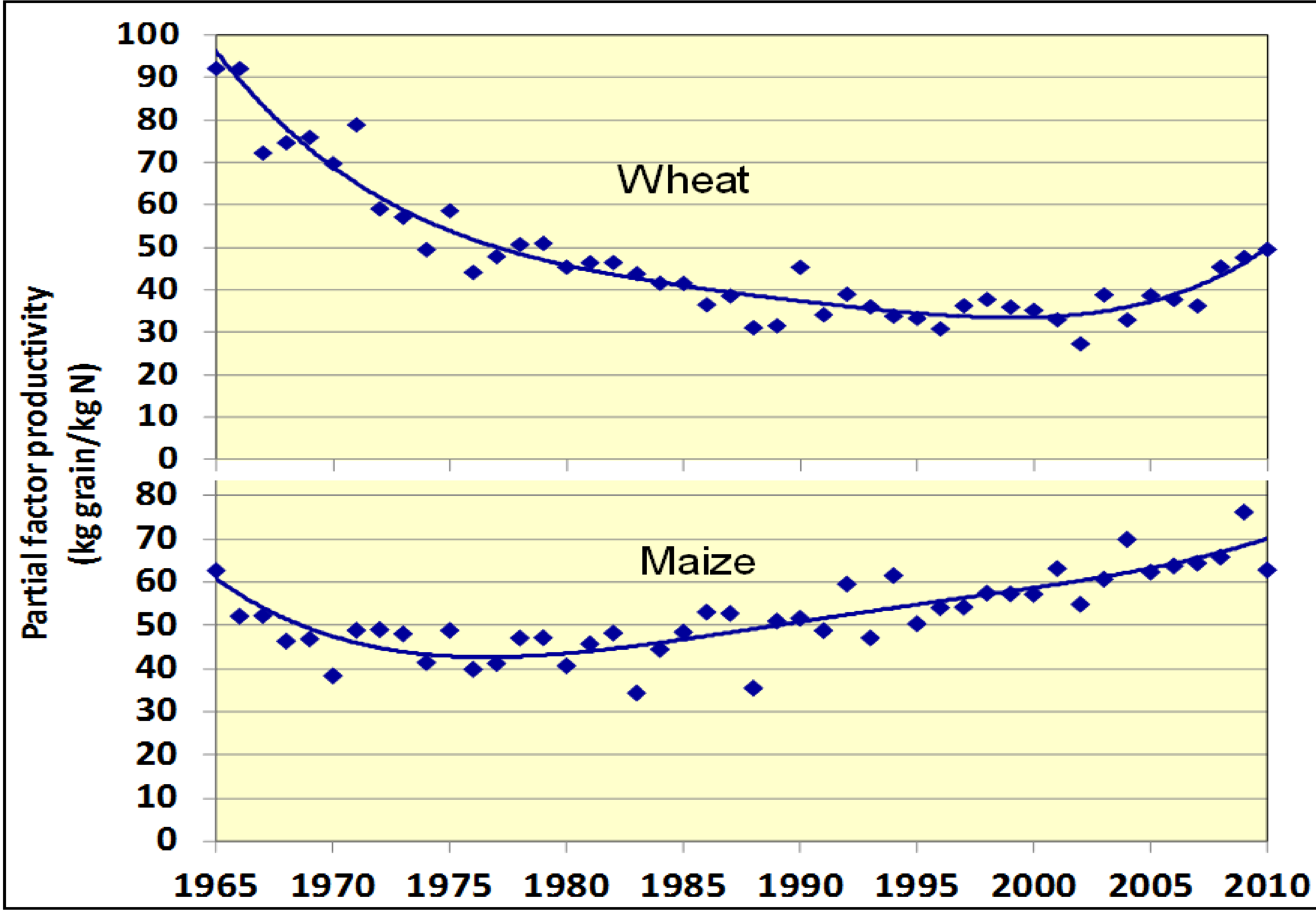
Crop N Use Efficiency Challenges

- Inefficient N use can result in increased environmental N losses, reduced crop yields, and lost profits for farmers
- Global N use efficiency by cereal crops is <40 to 50% (Balasubramanian et al., 2004; Ladha et al., 2005),
  - but typical on-farm N recovery efficiency by cereal crops could be raised to 50 to 70% or more with more intensive nutrient and cropping system management (Dobermann and Cassman, 2002, Kitchen and Goulding, 2001).

25% improvement above current apparent plant N recovery efficiency, has been called for by an EPA SAB integrated N management committee (EPA 2011)

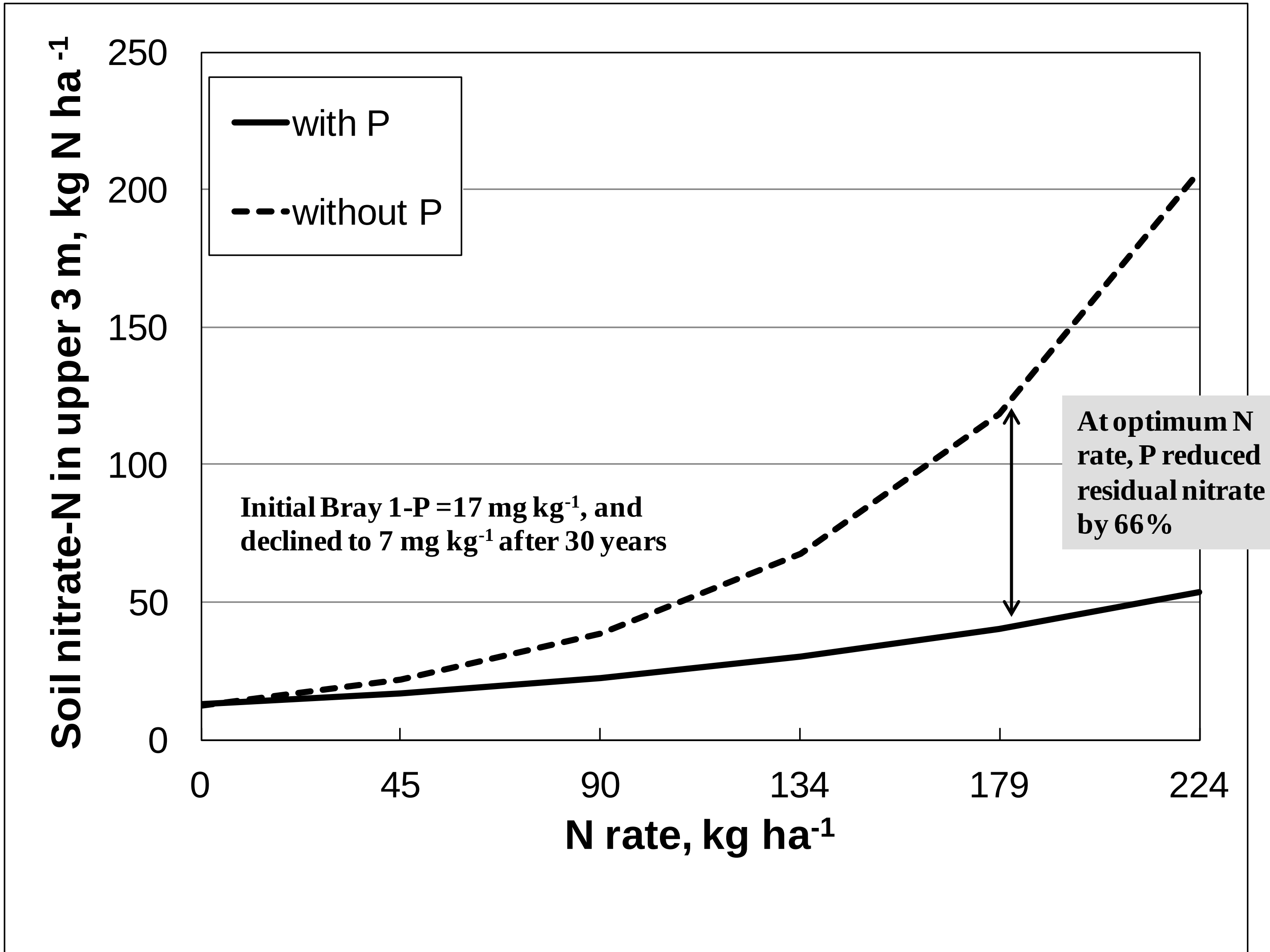
Photo courtesy P. Scharf

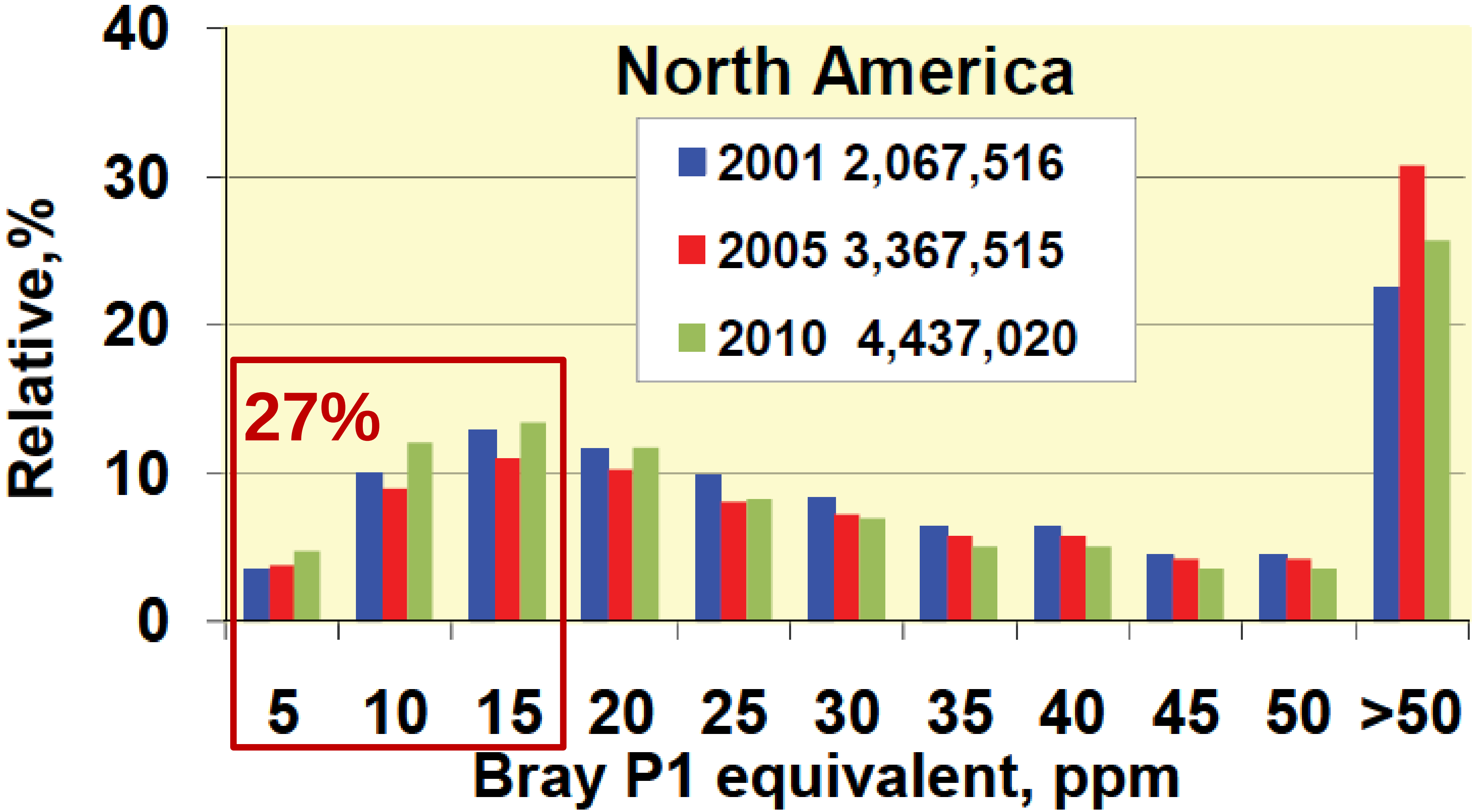
Photo courtesy S. Murrell



Partial factor productivity in the U.S. for fertilizer N used on maize and wheat from 1965 to 2010 (Adapted from USDA-ERS and USDA-NASS, 2011).
[From Fixen et al., 2012, article in preparation]

Adequate P fertilization of corn reduces soil profile nitrate and the potential for nitrate leaching (Schlegel et al. 1996)

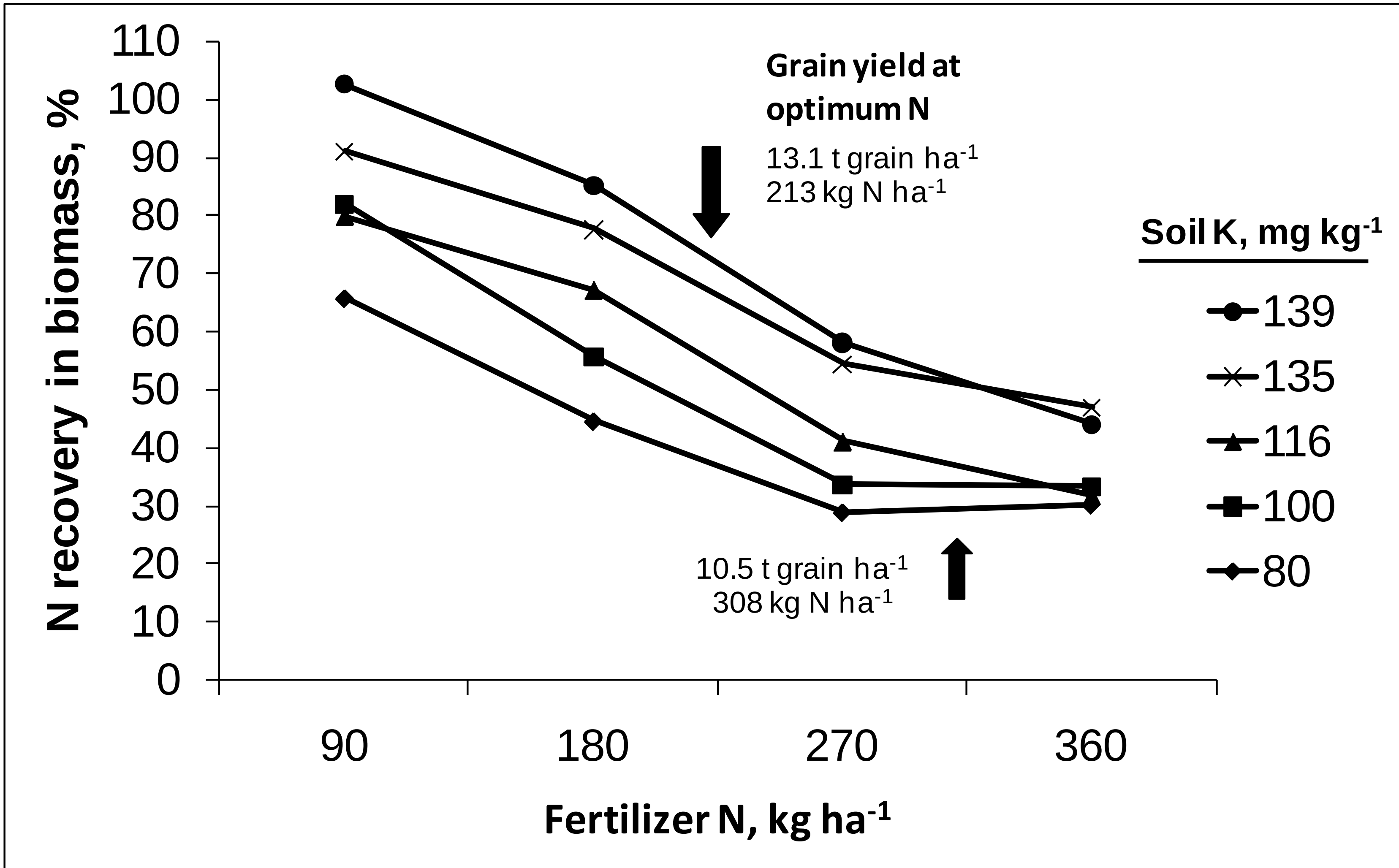


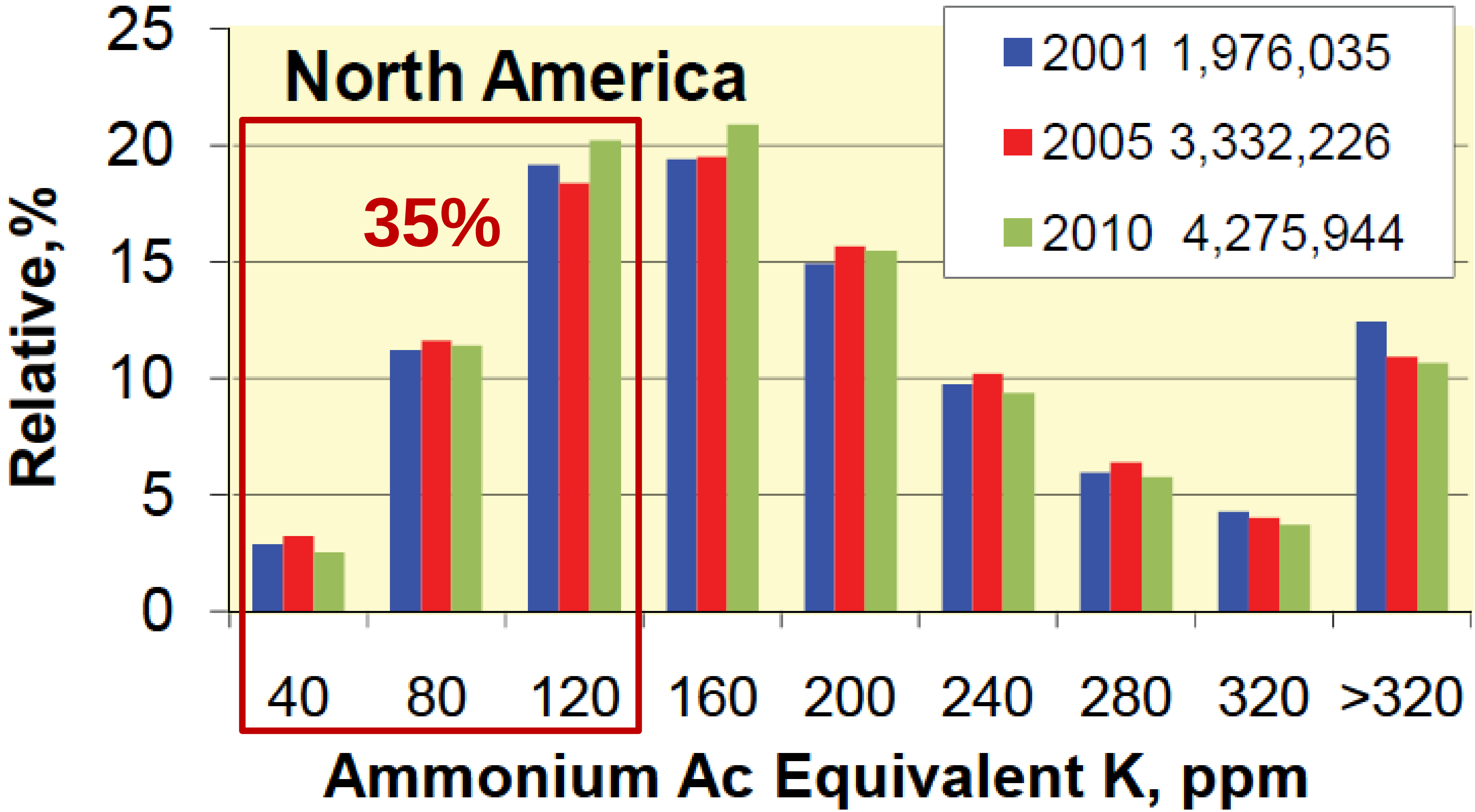


North America
2001 2,067,516
2005 3,367,515
2010 4,437,020
27%
Relative, %
40
30
20
10
0
5
10
15
20
25
30
35
40
45
50
>50
Bray P1 equivalent, ppm

IPNI, 2010

Adequate K fertilization increases apparent nitrogen recovery by corn (Johnson et al. 1997)





North America
35%
2001 1,976,035
2005 3,332,226
2010 4,275,944
Relative, %
0
5
10
15
20
25
40
80
120
160
200
240
280
320
>320
Ammonium Ac Equivalent K, ppm

Take-home points: Performance

1. N use efficiency is improving and can be further improved.
2. We as agronomists need to improve our clarity in communicating current levels of efficiency to the public.

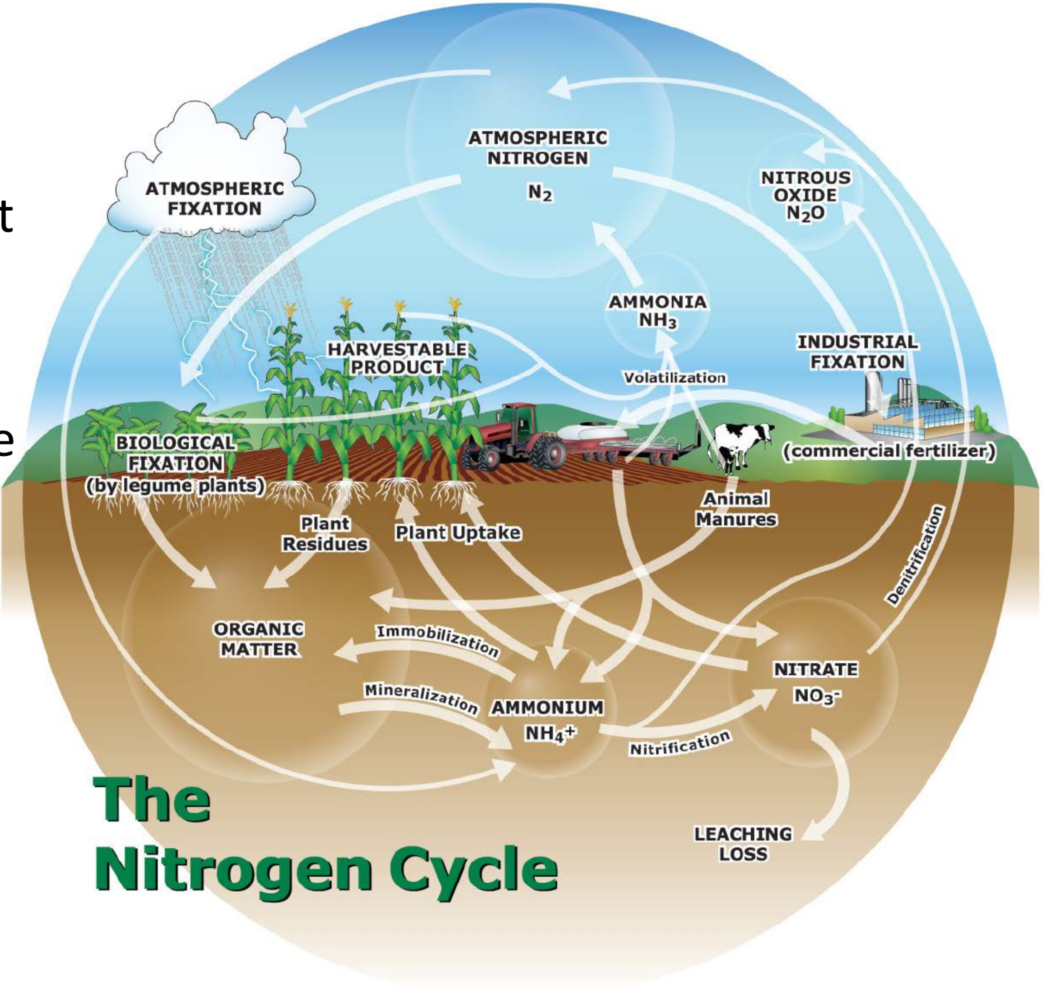
5. 4R research

4R Applied Research Needs for N – North America

…validation of efficacy of specific application practices (SRTP)

…environmental impact per unit of economic and social value

1. Adapting N management to weather
2. Ammonia emissions from wheat
3. Integrated management for ecological intensification
4. Nitrate leaching from high-value fruit, vegetable and tree crops
5. Nitrate leaching from wheat
6. Nitrate leaching index
7. Nitrous oxide emissions
8. Practice indicators
9. Research infrastructure
10. Sensor-based variable-rate N



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Summary – Managing N with Climate Change

1. Climate change offers opportunities as well as challenges for N management
2. The 4R Nutrient Stewardship concept is raising awareness among agri-service providers about sustainable management of N application.
3. N use efficiency is improving and can be further improved.
4. 4R research needs to focus on validating sustainability performance of site-specific practices.

4R nutrient stewardship

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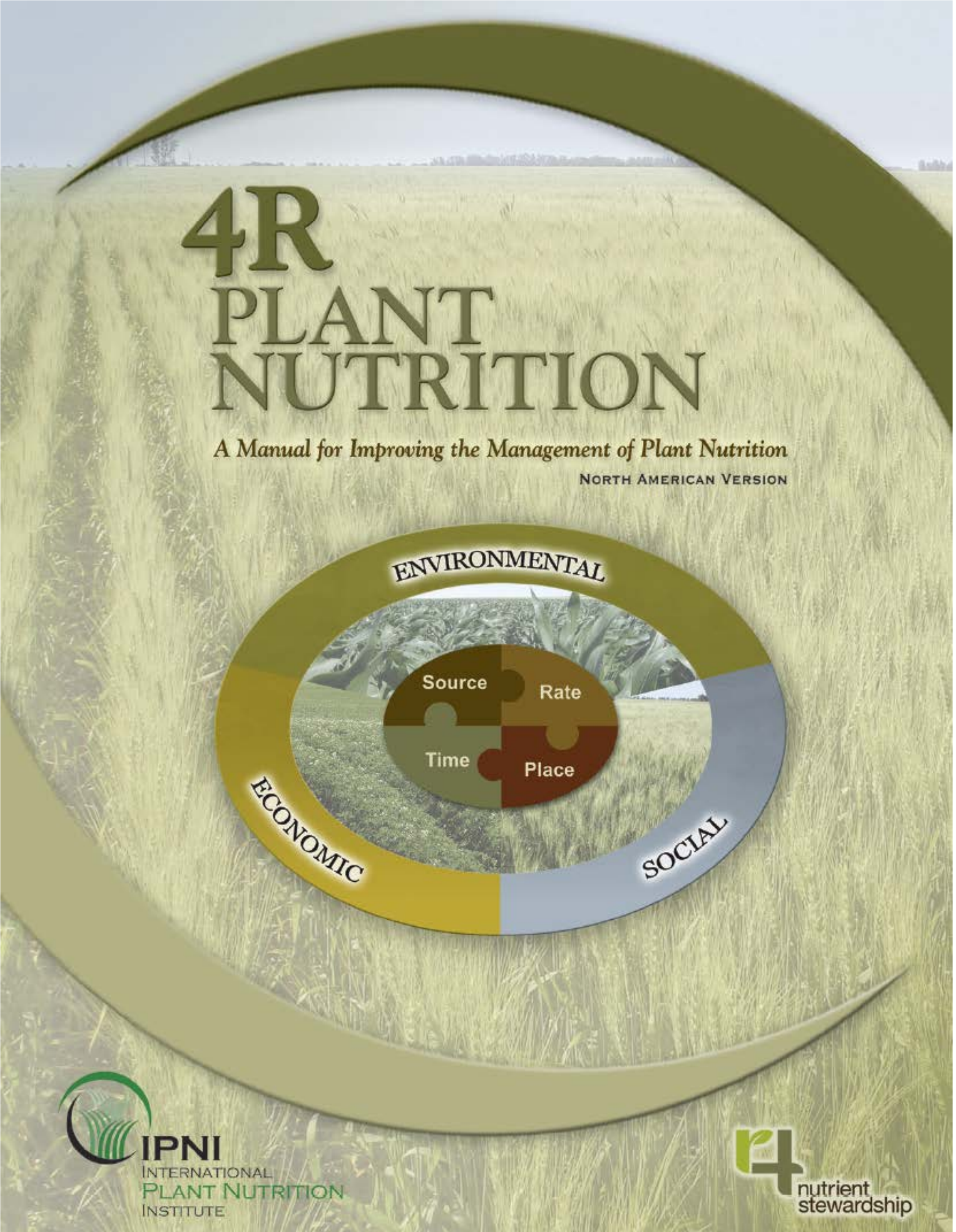
4R
PLANT
NUTRITION
A Manual for Improving the Management of Plant Nutrition
NORTH AMERICAN VERSION
ENVIRONMENTAL
Source
Rate
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Place
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