IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

Nitrogen:
Implementing Management Improvements

Rob Mikkelsen, Western Director

IPNI Mission:

"to develop and promote scientific information about plant nutrient management for the benefit of the human family."

- Agrium Inc.
- Office Chérifien des Phosphates Group
- Arab Potash Company
- PotashCorp
- Belarusian Potash Company
- Saskferco
- Bunge Fertilizantes S.A
- Simplot
- CF Industries Holding, Inc.
- Sinofert Holdings Limited
- Intrepid Mining, LLC.
- SQM
- K+S KALI GmbH
- Terra Industries, Inc.
- Mosaic
- Uralkali

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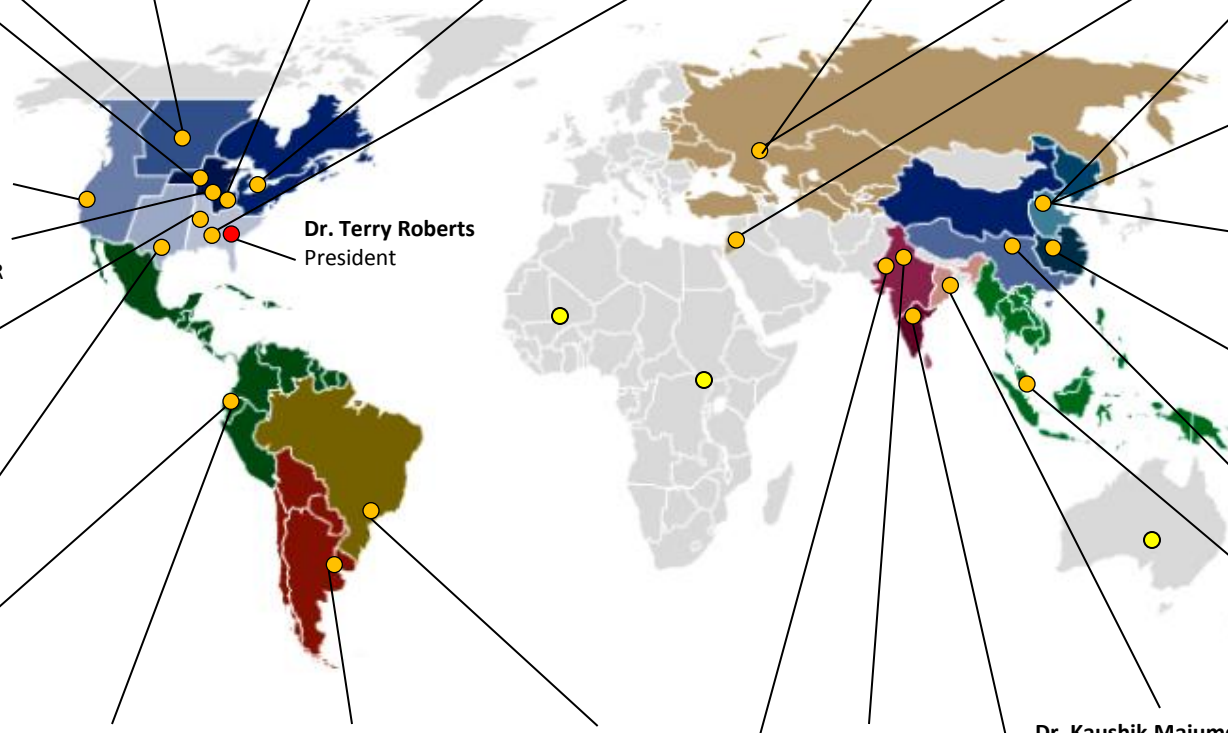

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NA Northcentral Region

Dr. Tom Bruulsema
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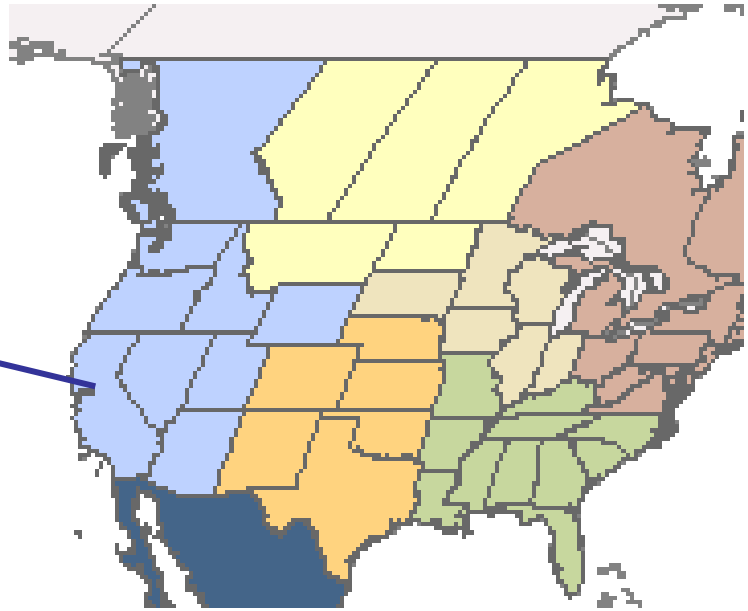
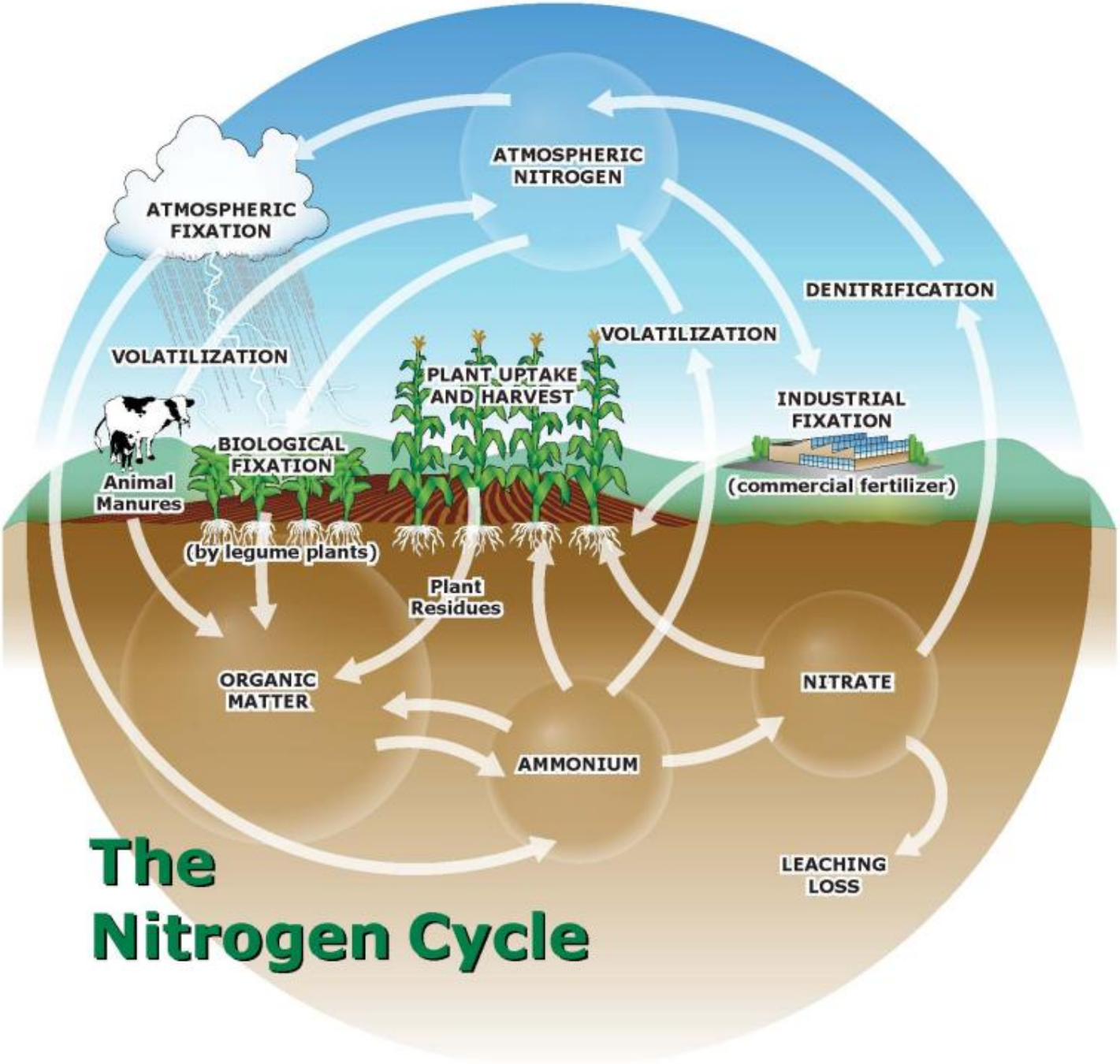
India West Zone

Dr. T. Satyanarayana
India South Zone

Dr. Rob Mikkelsen
Western Region
Merced, CA
rmikkelsen@ipni.net





The Nitrogen Cycle

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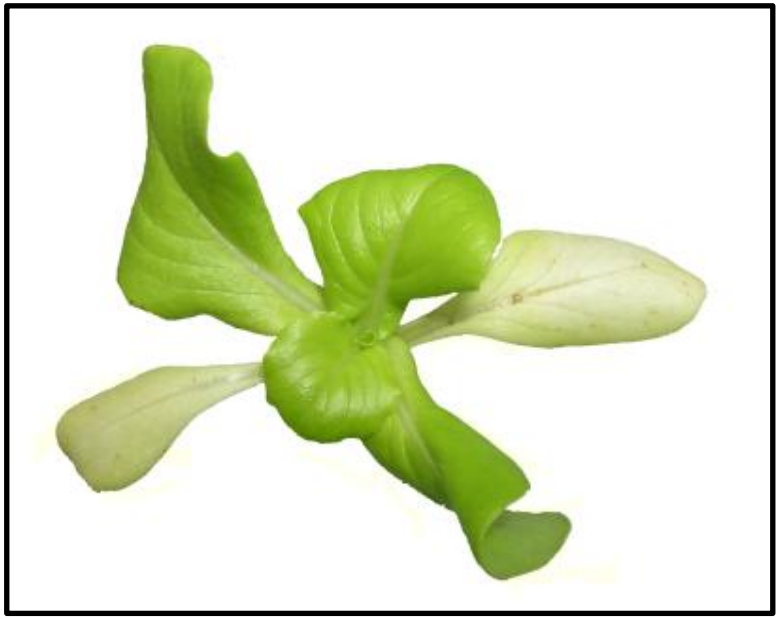
Nitrogen Fertilizer Plays a Vital Role in Civilization

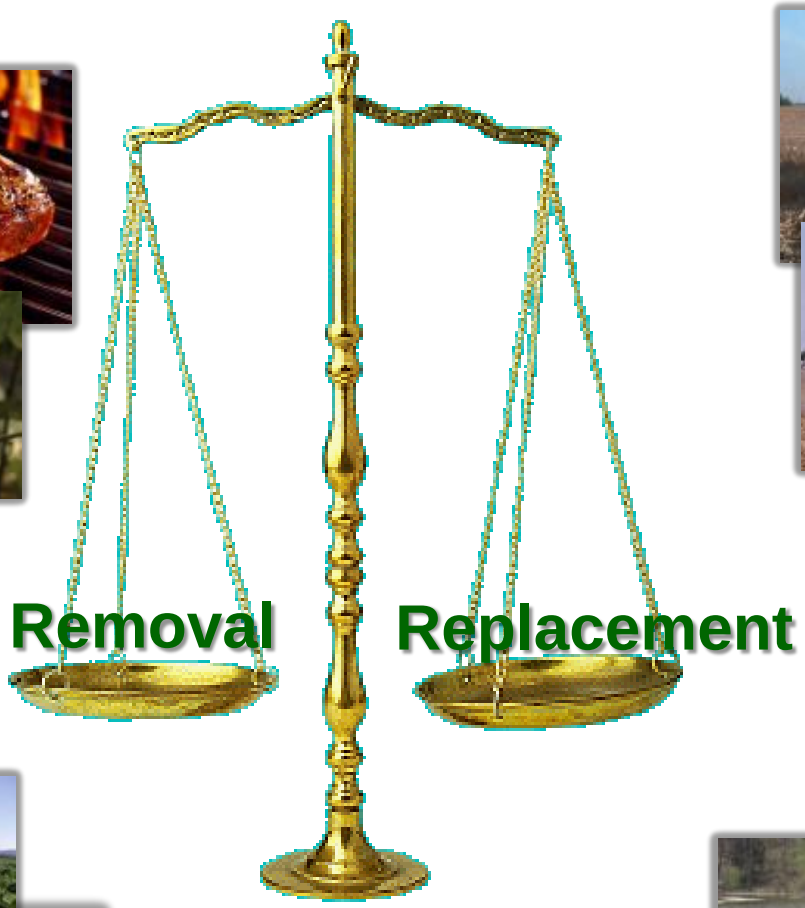
"Without the use of N fertilizers, we could not secure enough food for the prevailing diets of nearly 45% of the world's population, or roughly 3 billion people…" [Smil, 2011]

Smil, V. 2011. Nitrogen cycle and world food production. *World Agriculture* 2:9-13.

Nitrogen-deficient plants are stunted, yellow, and poor yielding



Nutrients … a matter of balance



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Why Improve Nitrogen Use Efficiency?

- **Economics**
- **Environmental impacts**
  - Nitrate in drinking water
  - Eutrophication & hypoxia
  - Biodiversity loss
  - Smog and $PM_{2.5}$ from ammonia emission
  - Ozone depletion – N_2O
  - Greenhouse gases – N_2O and CO_2

What are some of barriers impeding efficient use of N fertilizer?

Scarcity/Wealth of California Information

FREP

fresh approaches to fertilizing techniques 2011

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California: Top Crop Commodities

Crop	Production Value (Millions)
Grapes (all)	2,937
Almonds (shelled)	2,343
Nursery Products	2,273
Alfalfa and other hay	1,797
Lettuce, (all)	1,580
Strawberries	1,578
Tomatoes (all)	1,317
Rice	1,183
Flowers/Foliage	1,015
Broccoli	663
Oranges	608
Pistachio	569
Walnuts	558
Carrots	517
Lemons	473
Celery	354

Where is the data to support fertilizer recommendations?

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Nitrogen Use Efficiency

"…… estimated NUE for cereal production ranges from 30 to 35%."

Improving Nitrogen Use Efficiency for Cereal Production *(Agron. J. 91:357-363)*

Recovery of ^{15}N labeled fertilizer by *Vitis vinifera* L., cv. Cabernet Sauvignon: Effects of N fertilizer rates and applied water amounts

Alberto B. Iandolino[1,2] and Larry E. Williams[1,3]

range from: 5 to15%

: 27 to 33%

Spinach: 50 to 75%

http://cemonterey.ucdavis.edu/newsletters/_i__b_Monterey_County_Crop_Notes__b___i_38279.pdf

Common NUE Terms (Nitrogen Use Efficiency)

Term	Calculation	Total uptake needed?
Partial factor productivity	PFP = Y/F	No
Agronomic efficiency	AE = $(Y-Y_0)/F$	No
Partial nutrient balance	PNB = U_h/F	No
Apparent recovery efficiency by difference	RE = $(U-U_0)/F$	Yes
Internal utilization efficiency	IE = Y/U	Yes
Physiological efficiency	PE = $(Y-Y_0)/(U-U_0)$	Yes

F – Amount of nutrient applied (as fertilizers, manures, etc.)

Y – Yield of harvested portion of crop with applied nutrient

Y_0 – Yield in control with no applied nutrient

U_H – Nutrient content of harvested portion of crop

U – Total nutrient uptake in aboveground crop biomass with nutrient applied

U_0 – Total nutrient uptake in aboveground crop biomass with no nutrient applied

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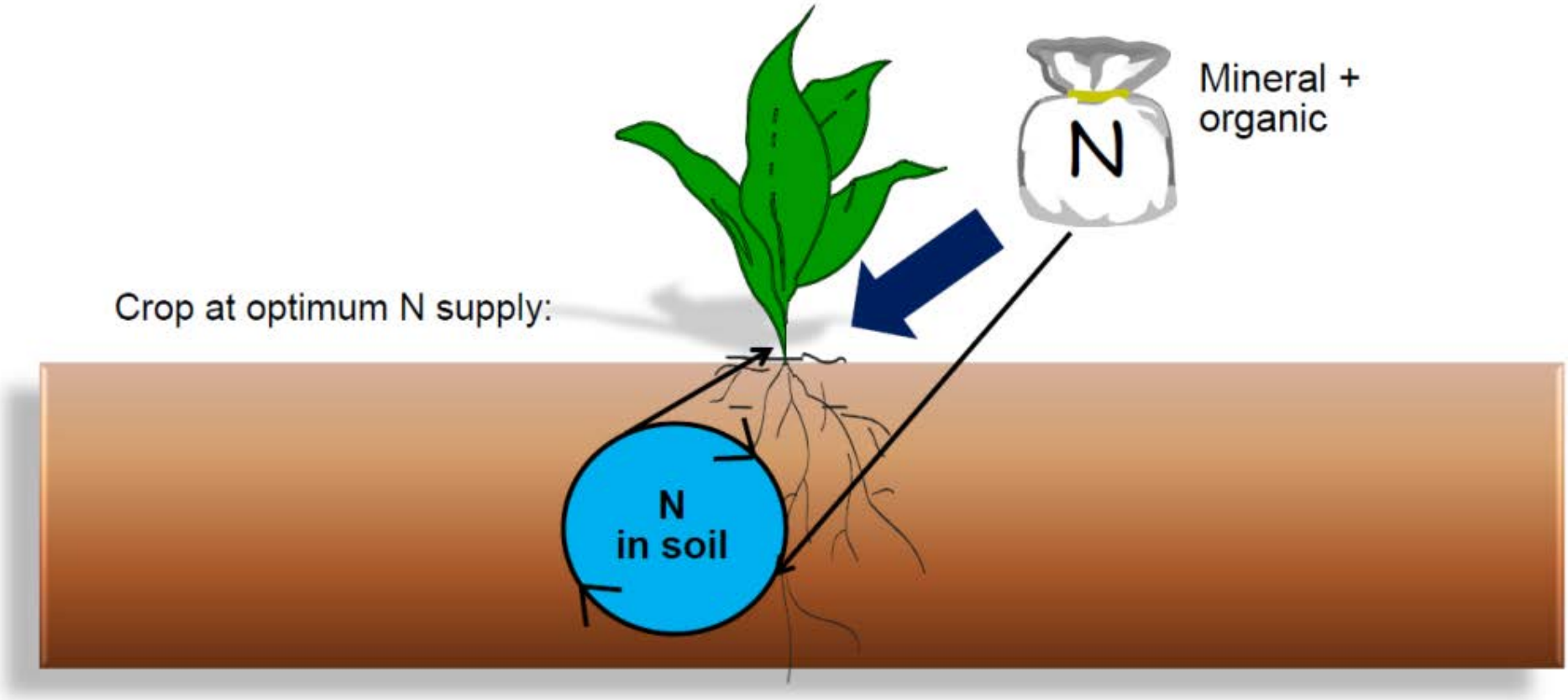
Fertilizer N supports crop growth and soil fertility



Efficient fertilizer Management

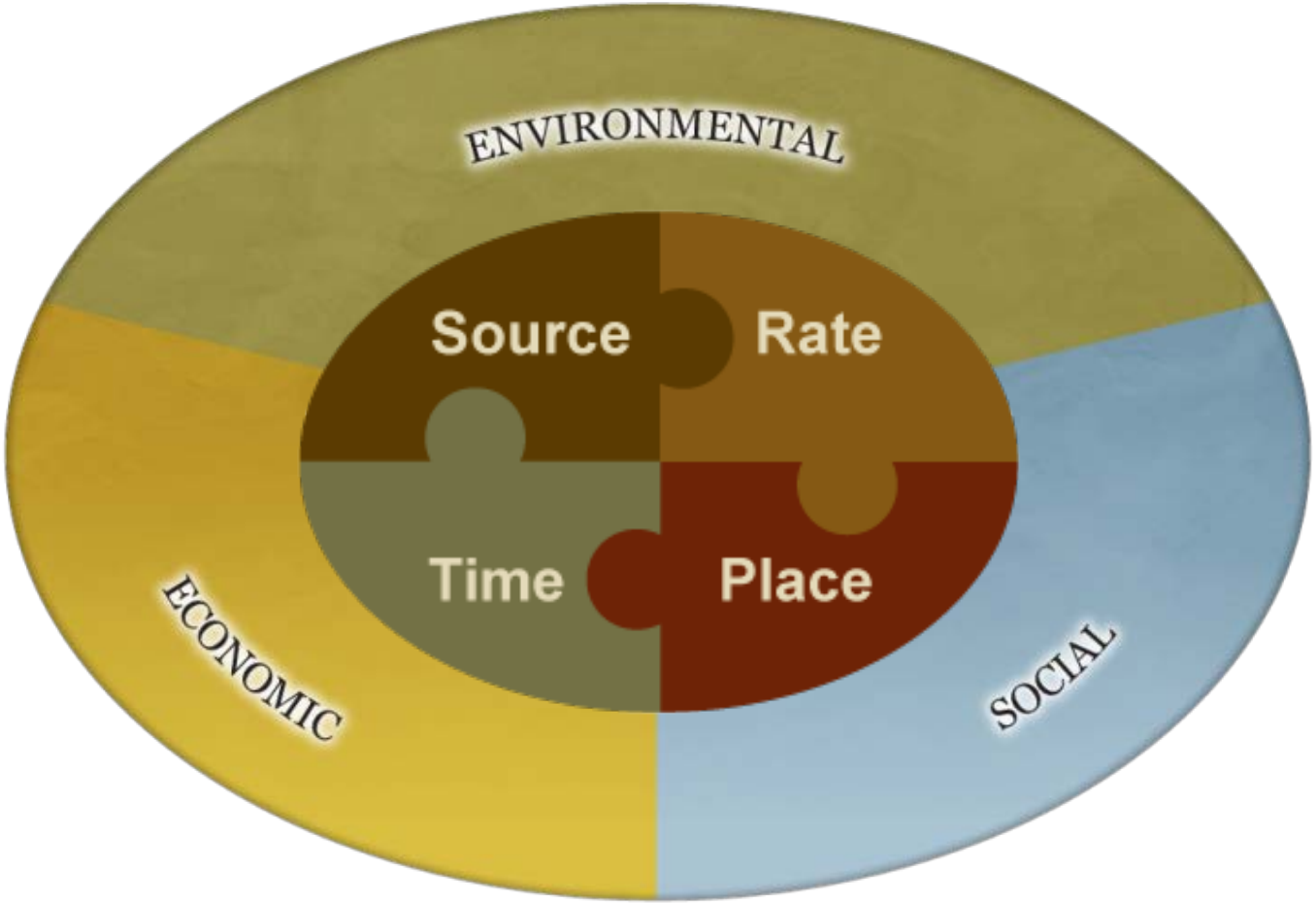
The **“4R” strategy**

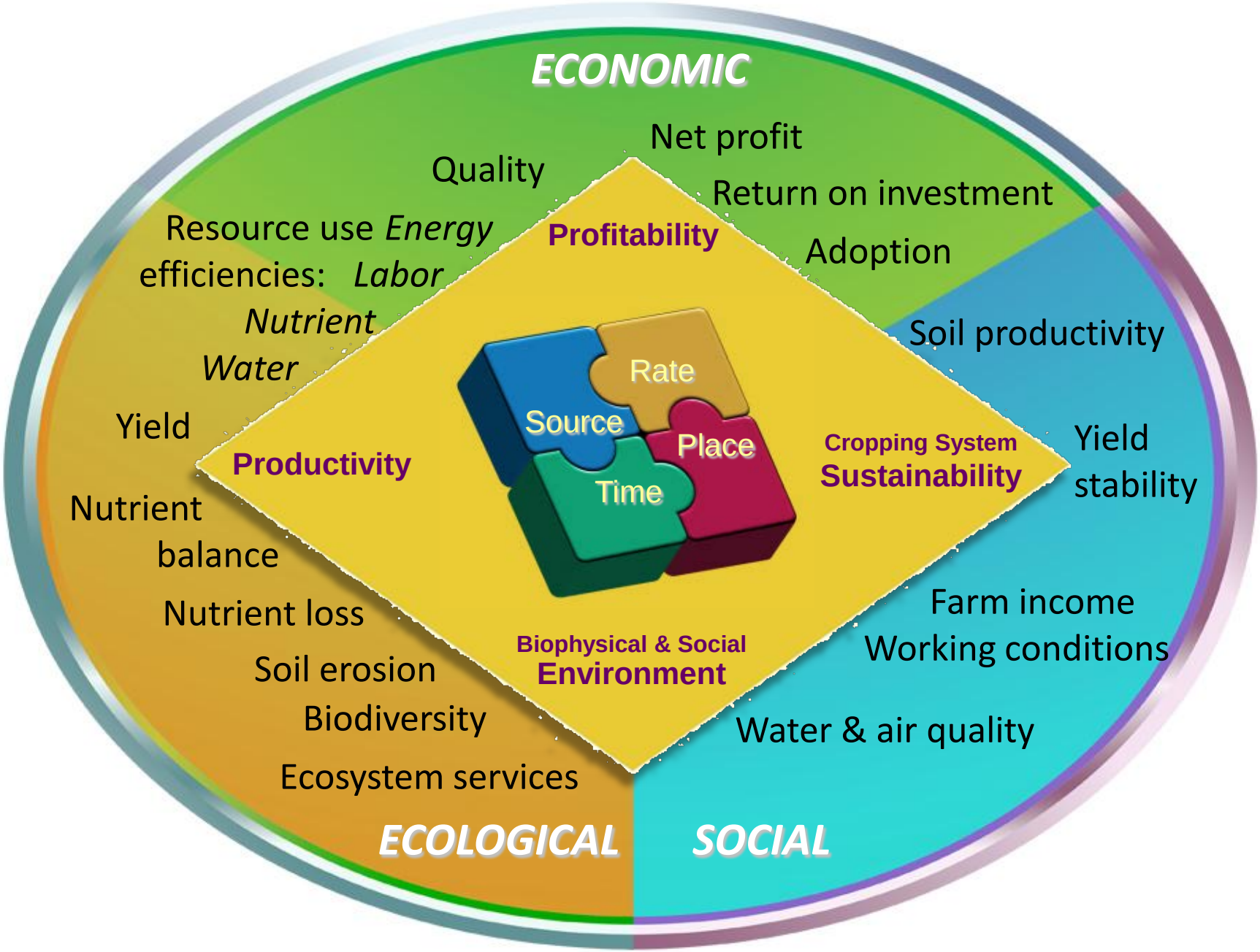
Right Source
Right Rate
Right Time
Right Place

For the crop, field or field zone, and nutrient

4R Nutrient Stewardship

- **Right Source, Right Rate, Right Time & Right Place**
  - **Linking practices to science for sustainability performance**

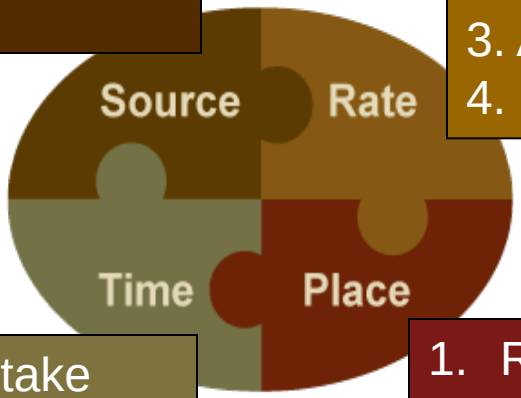



ECONOMIC
Net profit
Quality
Return on investment
Resource use *Energy*
efficiencies: *Labor*
Nutrient
Water
Profitability
Adoption
Soil productivity
Rate
Source
Place
Time
Yield
Productivity
Cropping System
Sustainability
Yield
stability
Nutrient
balance
Nutrient loss
Farm income
Working conditions
Biophysical & Social
Environment
Soil erosion
Biodiversity
Water & air quality
Ecosystem services
ECOLOGICAL
SOCIAL

The basic scientific principles of managing crop nutrients are universal

1. Supply in plant available forms
2. Suit soil properties
3. Recognize synergisms among elements
4. Blend compatibility

1. Appropriately assess soil nutrient supply
2. Assess all available indigenous nutrient sources
3. Assess plant demand
4. Predict fertilizer use efficiency



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

1. Recognize root-soil dynamics
2. Manage spatial variability
3. Fit needs of tillage system
4. Limit potential off-field transport

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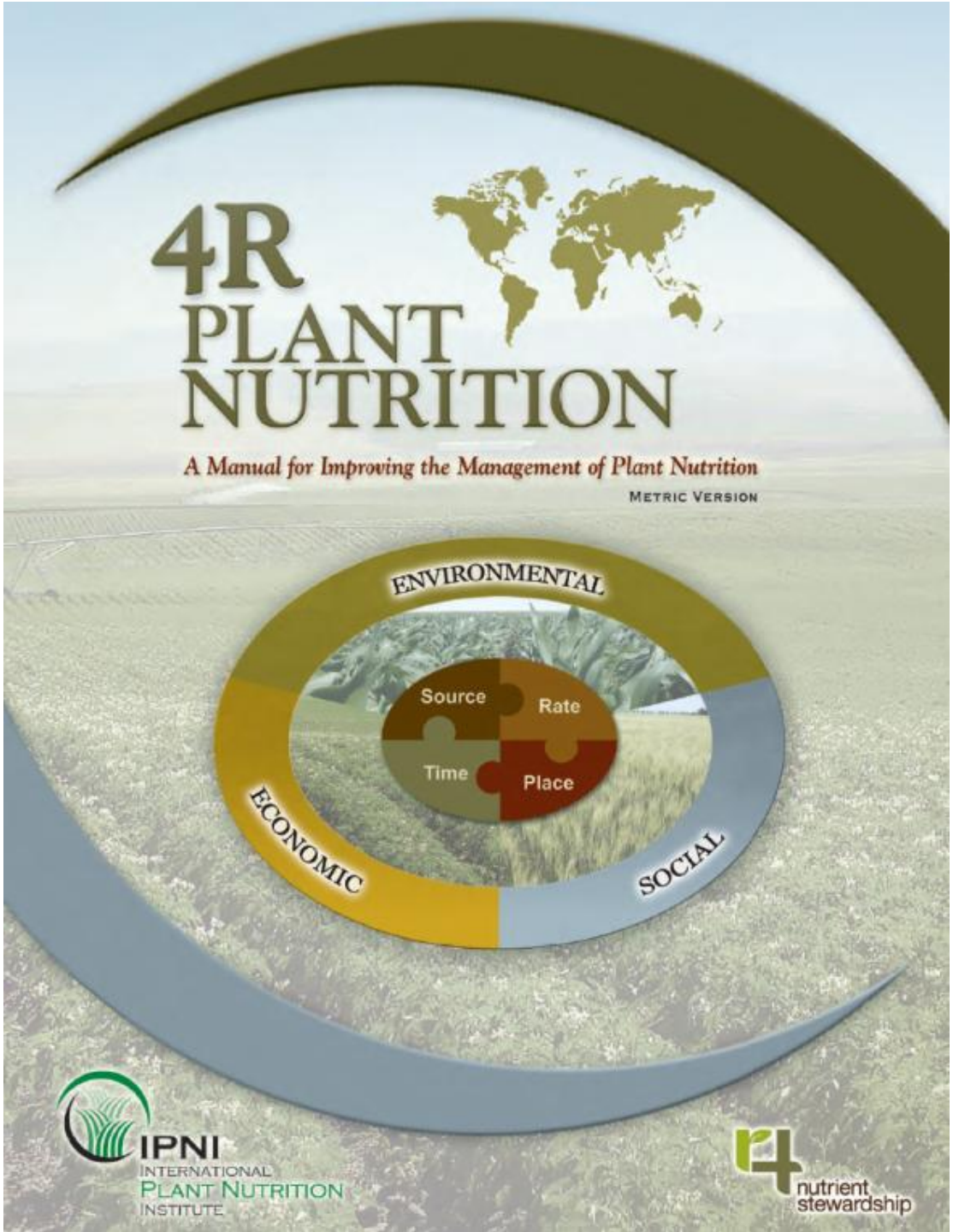

4R adopted by
the fertilizer industry

Adopted by NRCS

Promoted by international
ag agencies (FAO, IFA)

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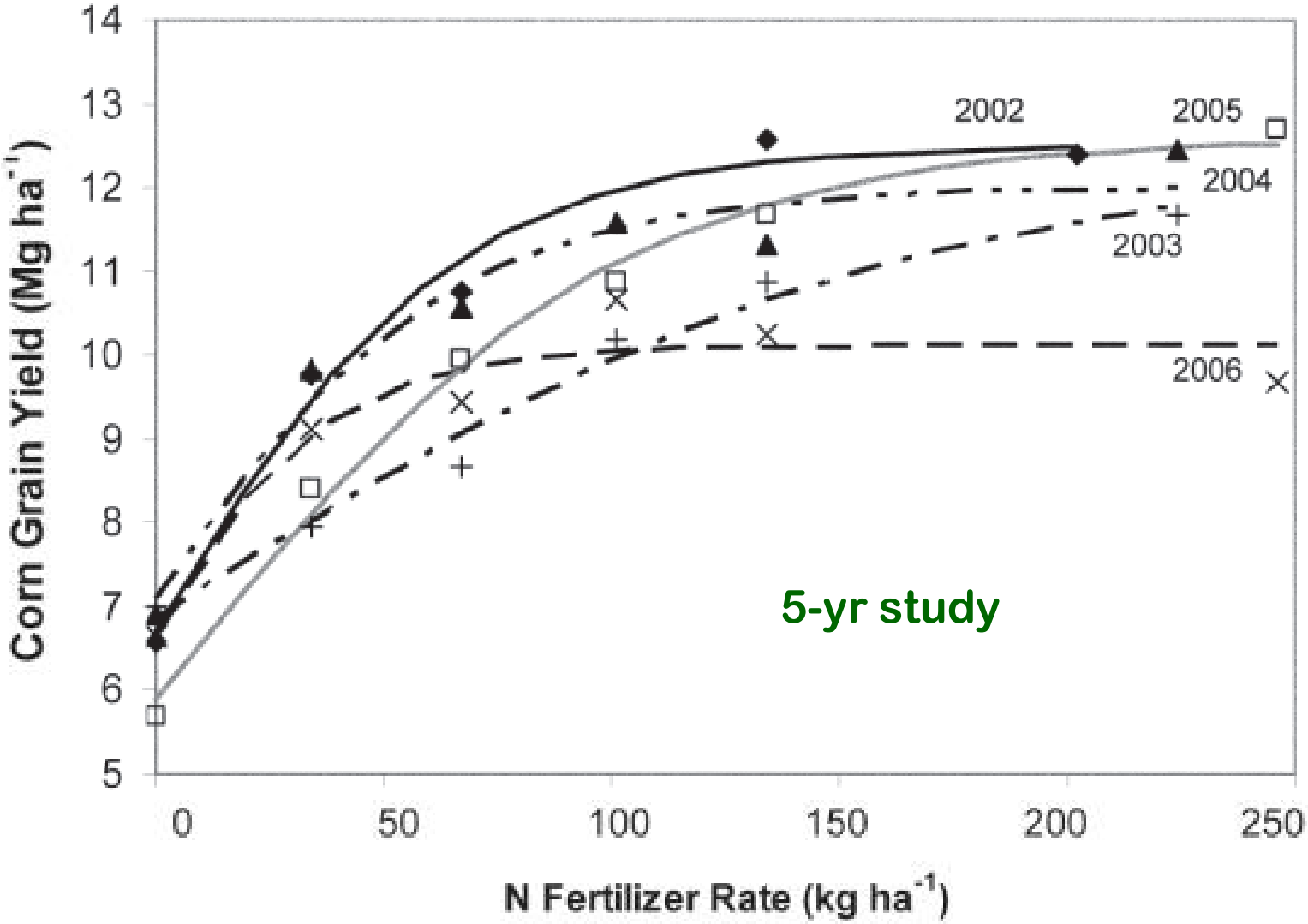
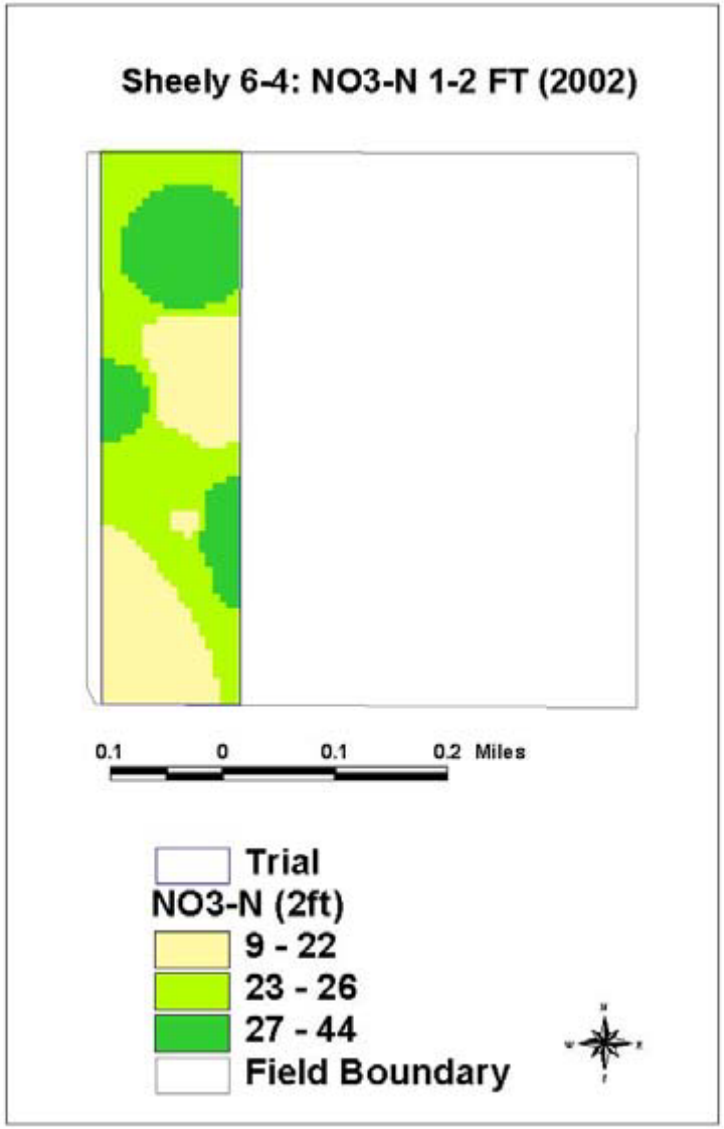
How to select the Right Rate?



Soil Sci. Soc. Am. J. 74:2010

Assessing residual soil nitrate?

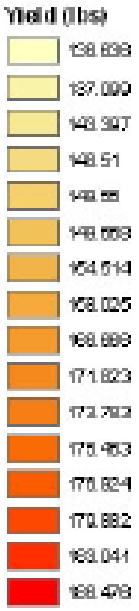


http://www.cdfa.ca.gov/is/docs/Rains97.pdf

Dealing with spatial variability: WHY?

Nitrogen Demand by 5 acre Plot

340 lbs	175 lbs	125 lbs	50 lbs
250 lbs	225 lbs	100 lbs	100 lbs
225 lbs	175 lbs	75 lbs	50 lbs
280 lbs	200 lbs	50 lbs	50 lbs



Pistachio Yield

Whole Field Average N Demand = **150 lb N/A**

P. Brown, UCD

Right Place:

Where are the roots?

How to manage 200 to 300 lb N/A

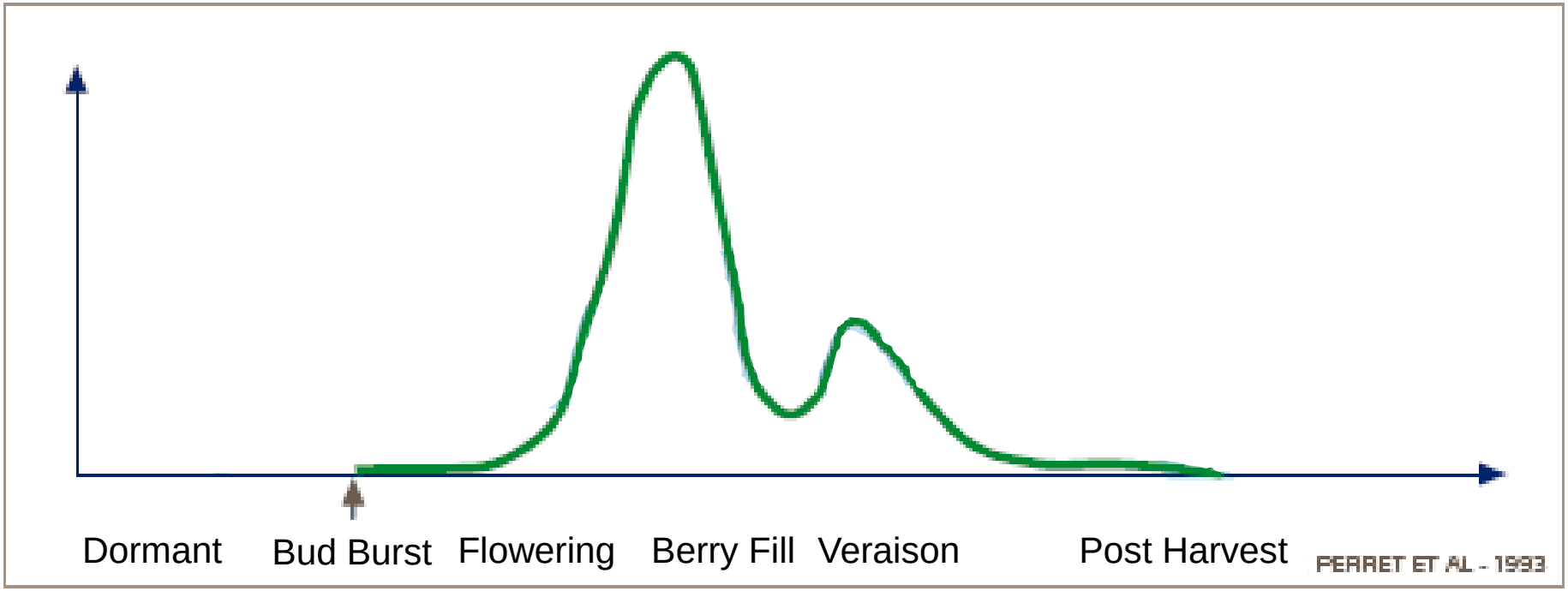
for a crop with a 6-inch rooting depth?

How to manage 200 to 300 lb N/A

for a crop with a 4-foot rooting depth?

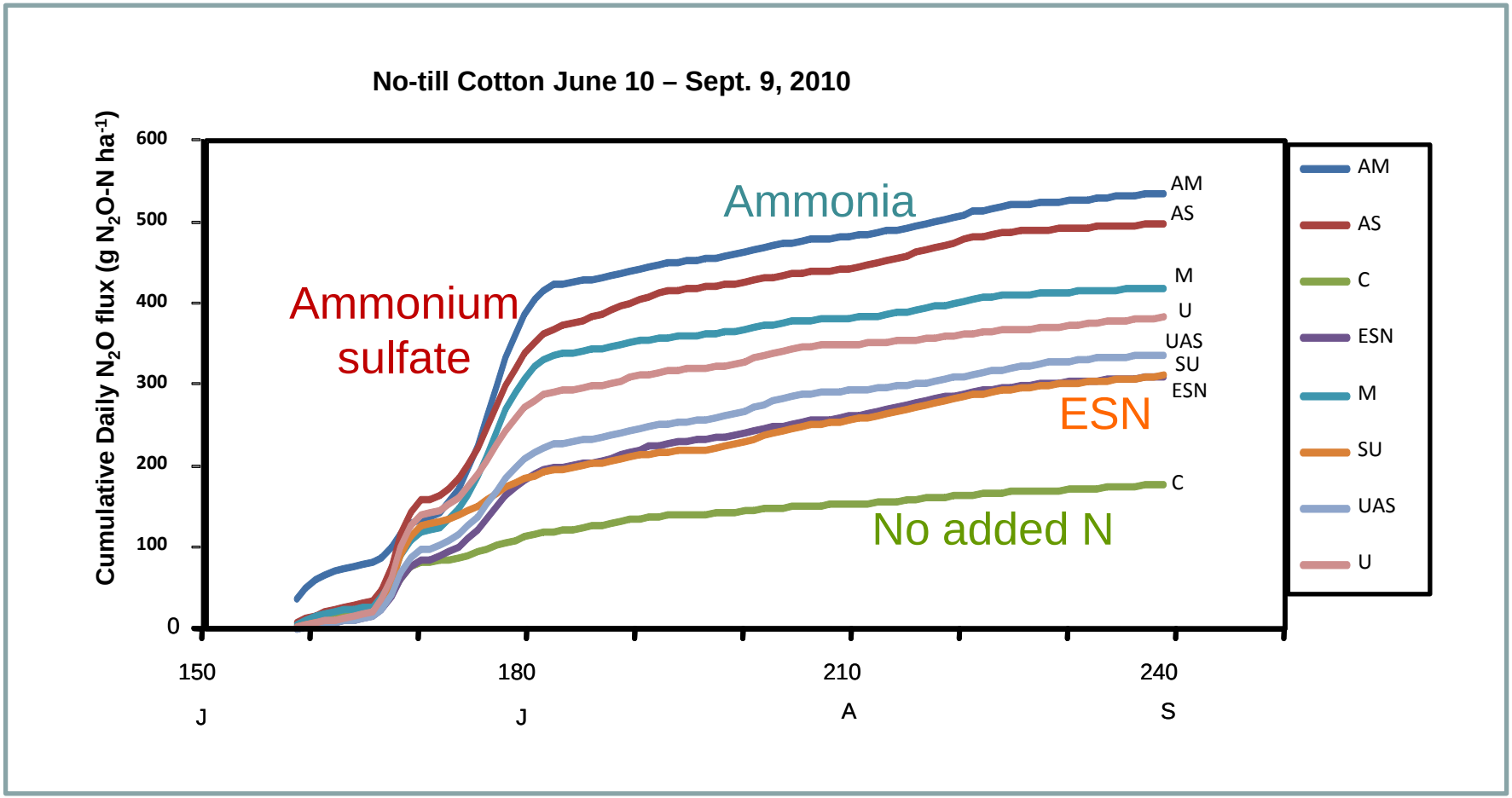
Right Time?
Grape Phenology & Nutrient Uptake

General Nitrogen Requirement of Grapevine



YARA

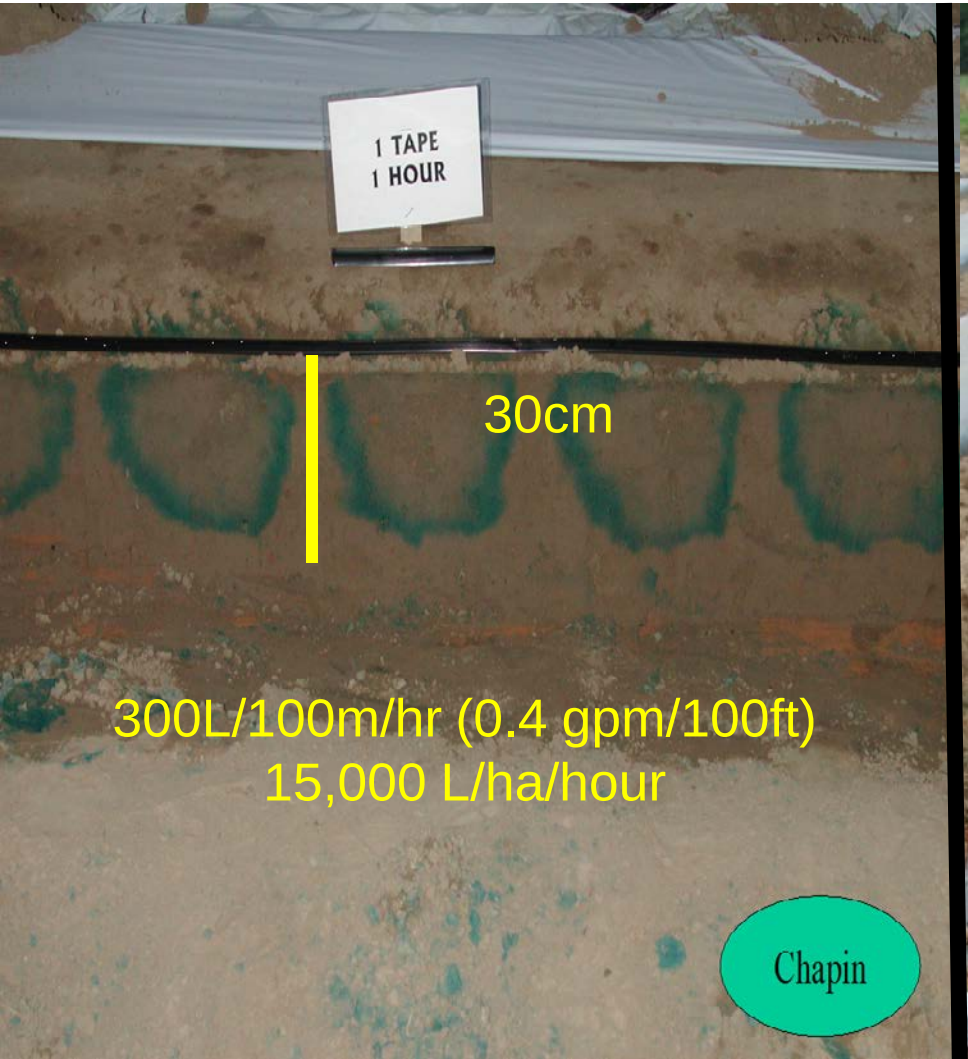
Right Source?
N Source and Nitrous Oxide Emissions



GA

Water Management is Key to Nitrogen Management

Water and nutrients must be carefully managed to avoid over-irrigation and poor nutrient application



Don’t forget other interactions!

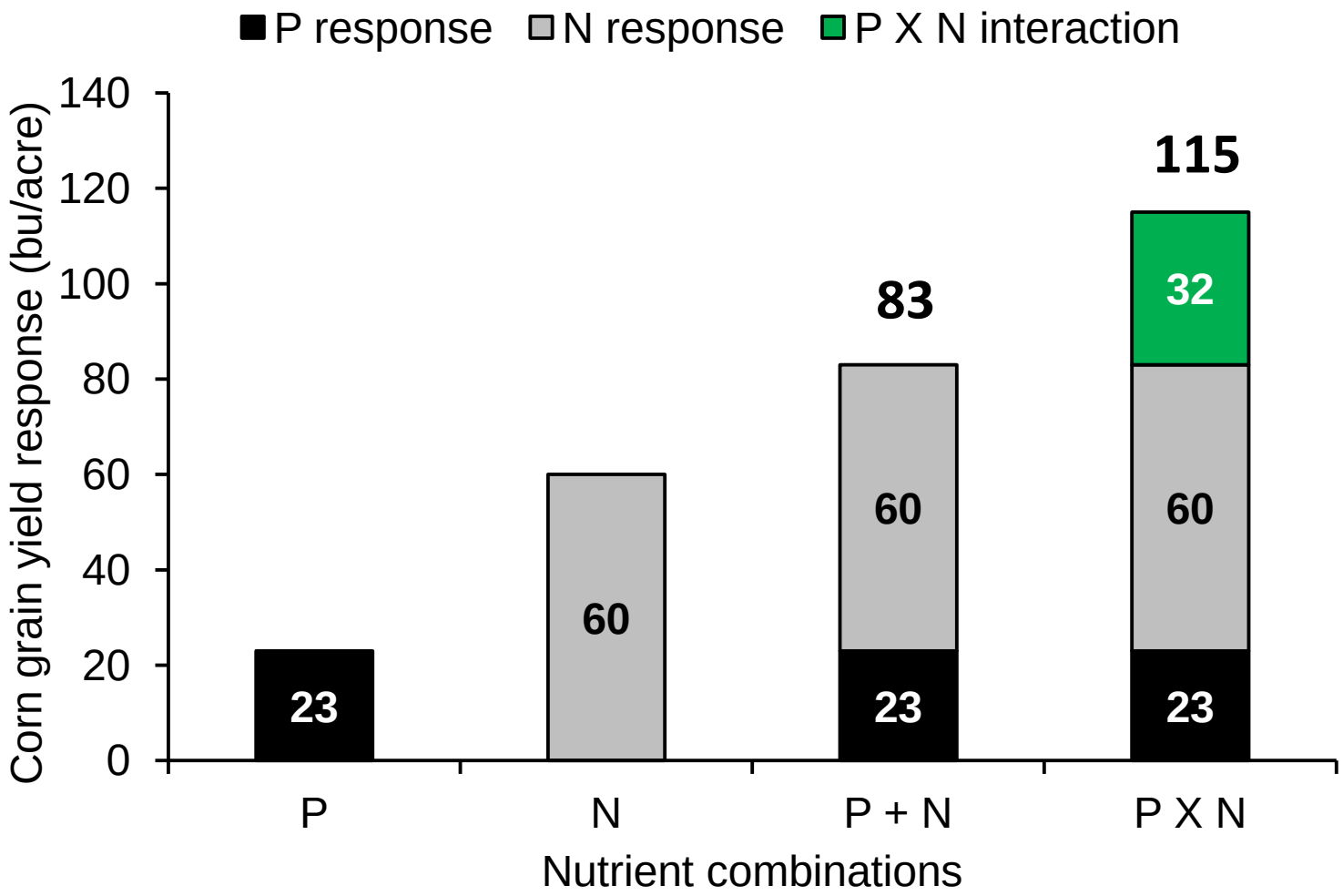
Nitrogen fertilization is only one of many factors that must be managed to meet goals:

Economic
Environmental
Social

A few examples…

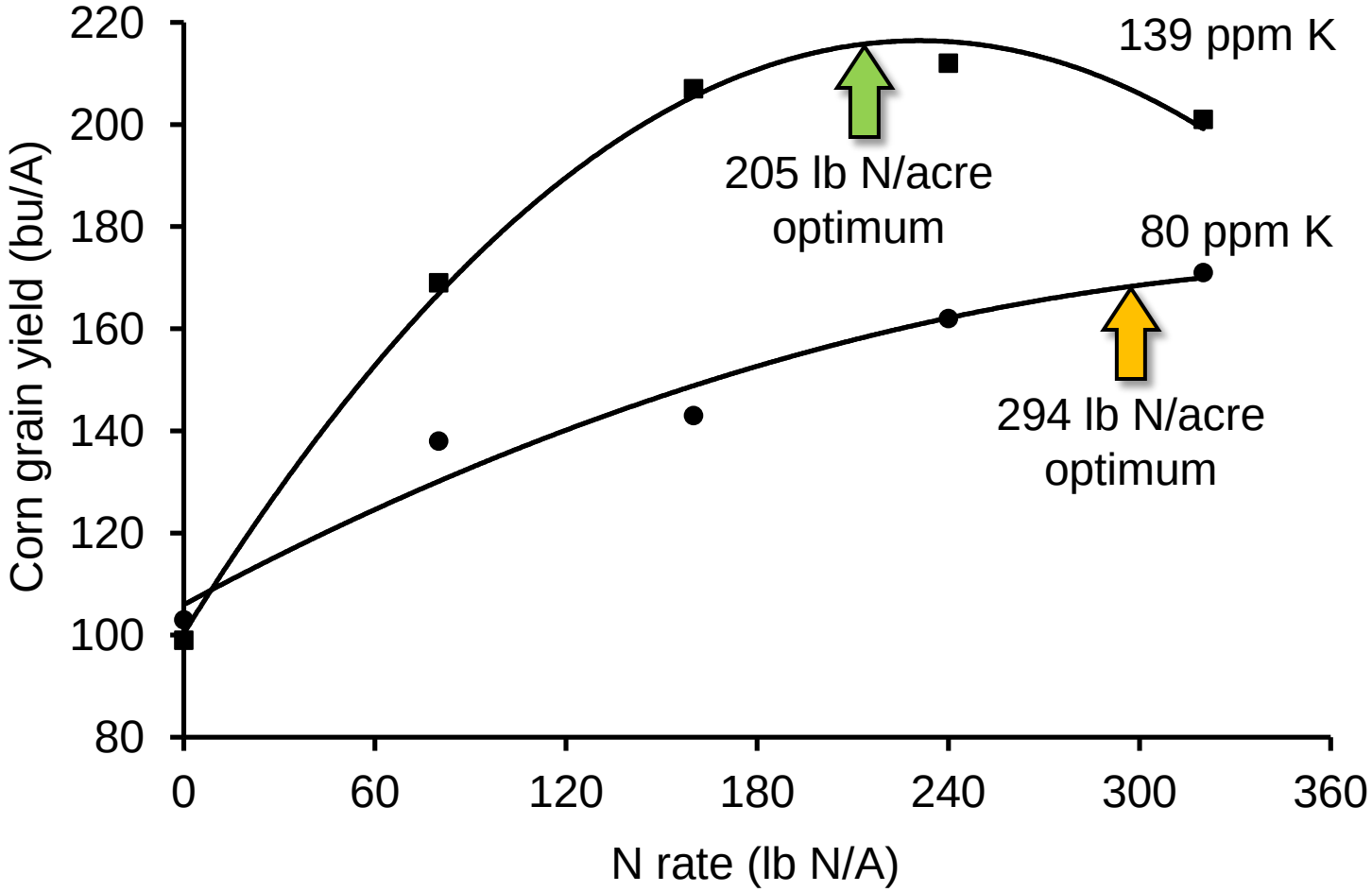
Data are from 30th year of a long-term, irrigated study in Kansas

(N: 161 lb/acre, P: 40 lb P_2O_5/acre, or both combined)



Schlegel et al. 1996. J. Prod. Agric. 9:114-118.

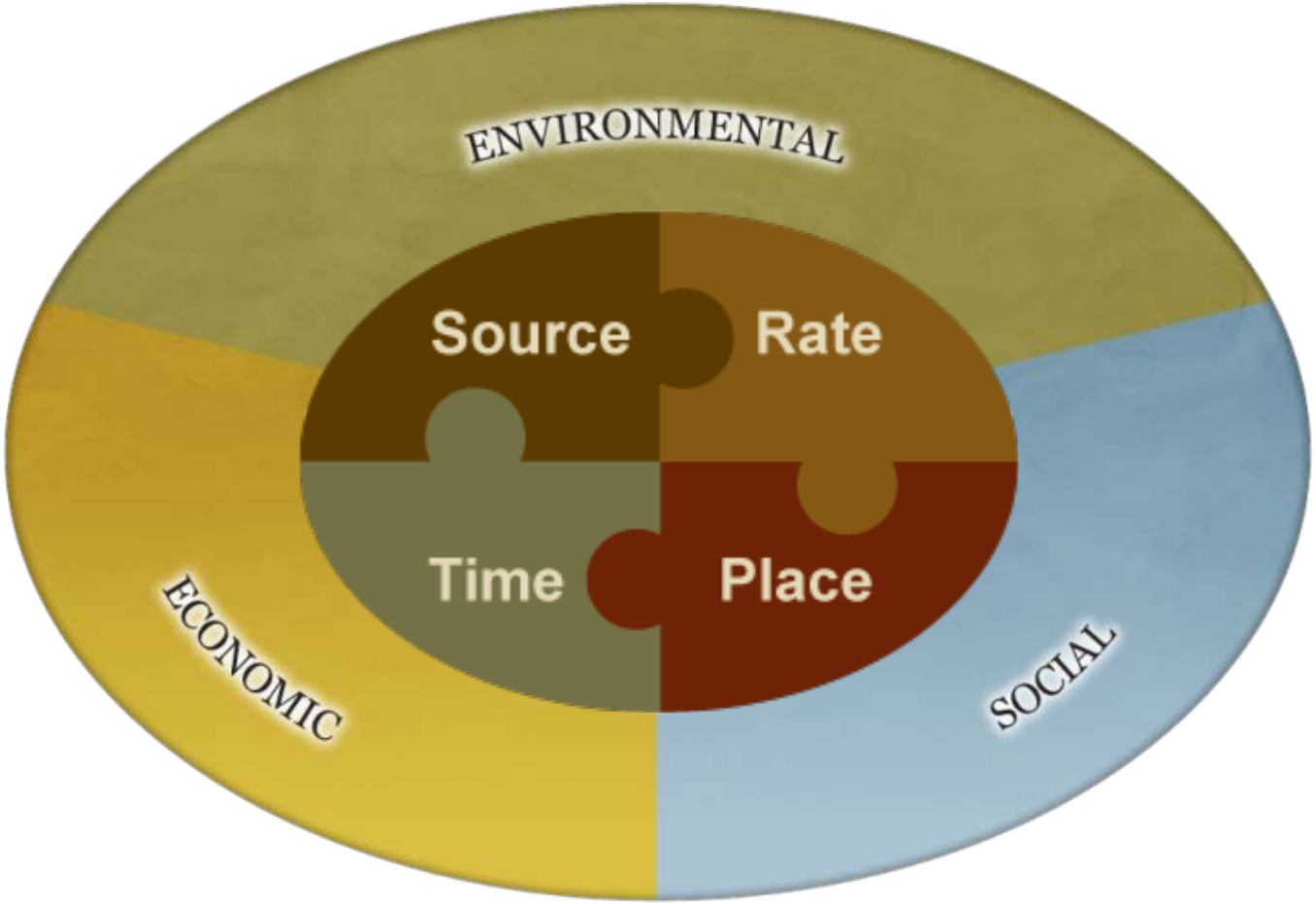
The difference non-limiting levels make to nutrient recommendations



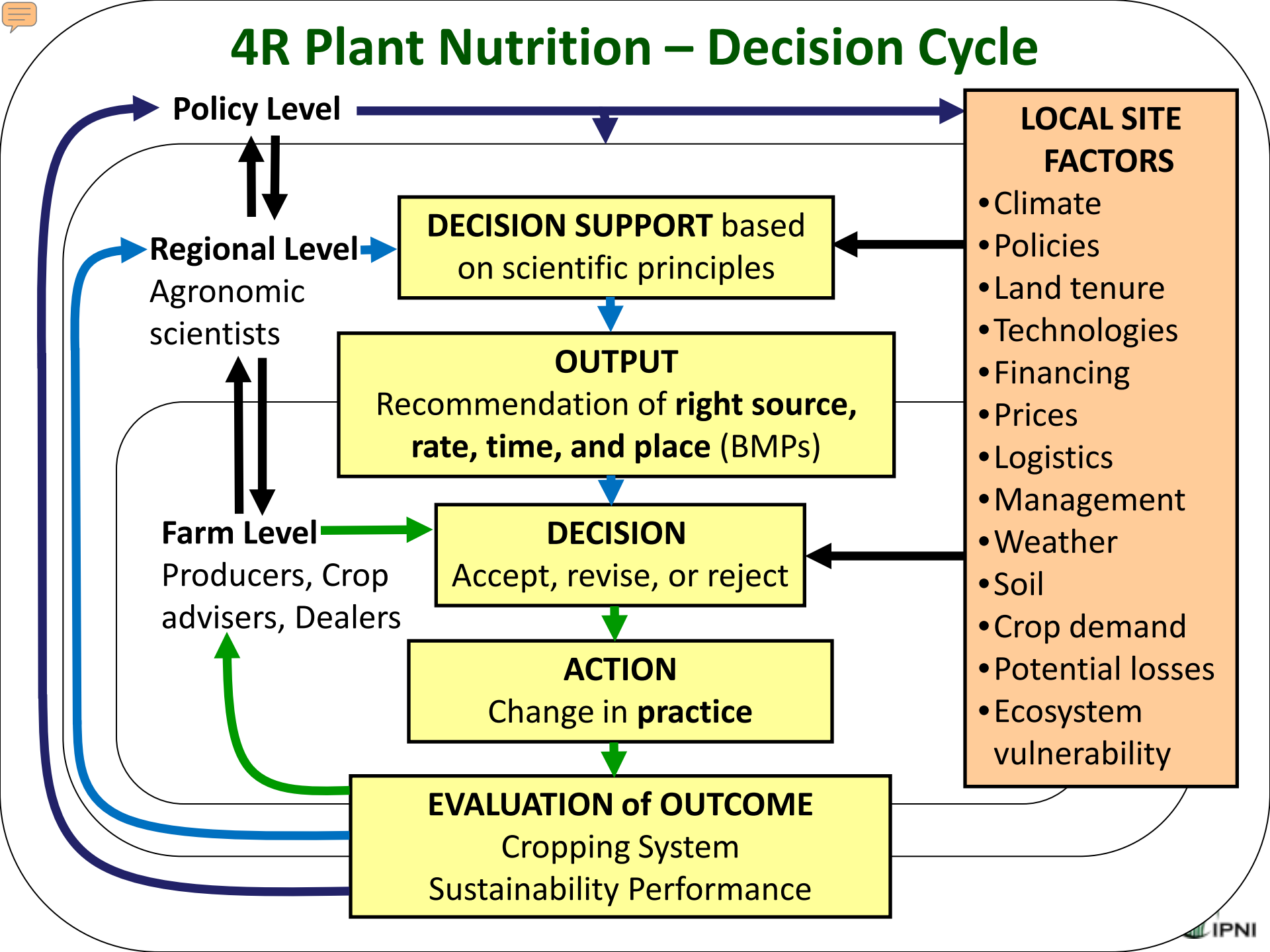
Johnson et al. 1997. Better Crops 97:3-5.

4R Nutrient Stewardship

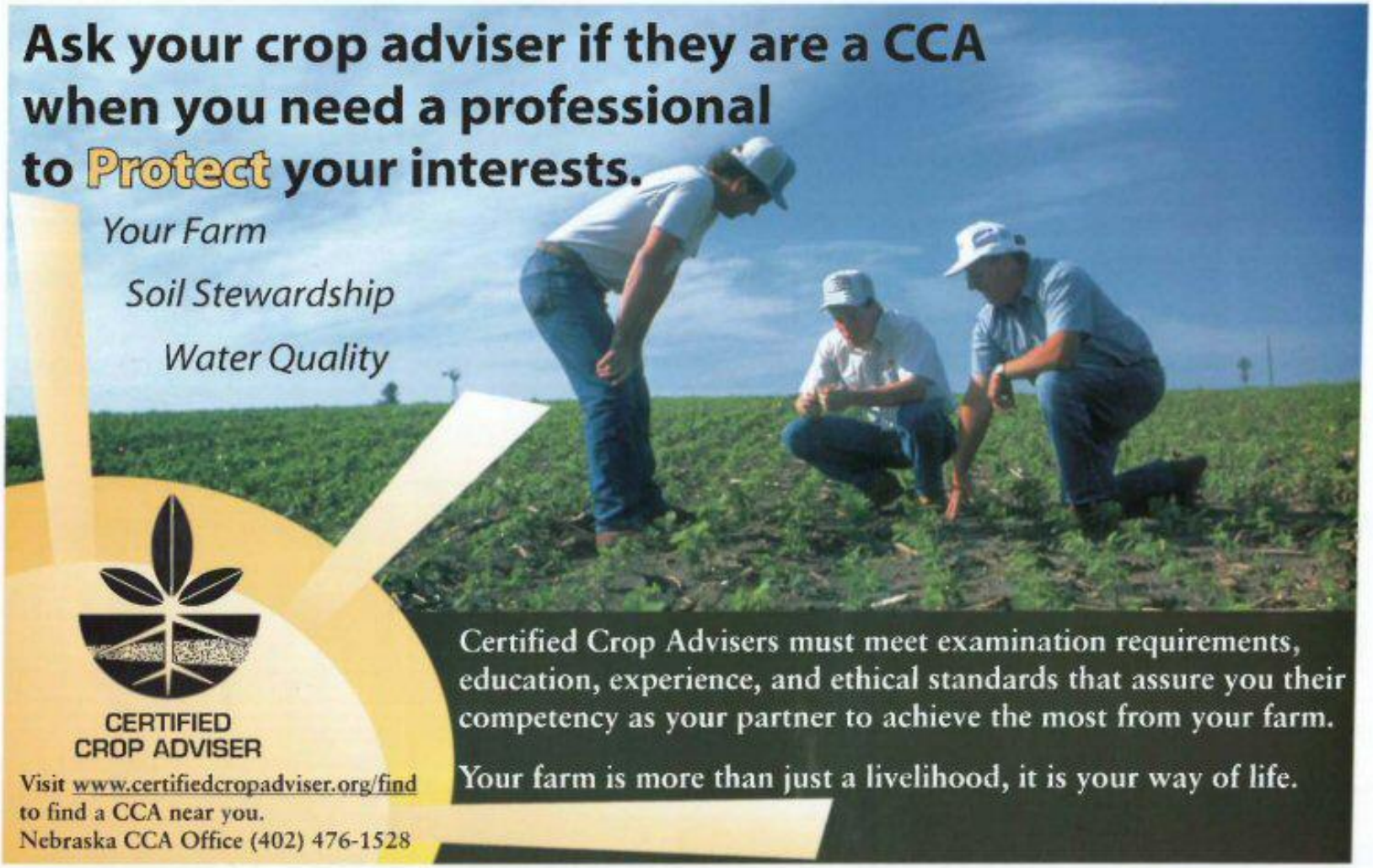
- **Right Source, Right Rate, Right Time & Right Place**
  - **Linking practices to science for sustainability performance**



4R Plant Nutrition – Decision Cycle



How to Reach the 80,000 Farmers?
Certified Crop Advisor



What Does The 4R Strategy Offer?

- **Source, rate, time, and place** “right” goals for sustainable production
- Checklist for proper nutrient management and opportunities to improve
- Balance the 4 “rights” to achieve appropriate performance indicators
- Involves academics, industry, and regulators
- Clear and simple communication

Who decides What Is RIGHT?

• “a team of farmers, researchers,
•regulators, extension staff and agribusiness professionals.” -???

• An **ethical question, more than scientific**

• Input from ALL stakeholders on Performance Indicators, Benchmarks, Targets

Farmer (land manager) selects the PRACTICE

Dynamic site-specific decision on <u>source, rate, time and place</u>
Decision support for highest probability of performance
Adaptive management

Know your fertilizer rights

By Tom Bruulsema, International Plant Nutrition Institute, Guelph, ON, Canada; ***Jerry Lemunyon***, USDA-NRCS, Fort Worth, TX; and ***Bill Herz***, The Fertilizer Institute, Washington, DC

The four fertilizer rights: Selecting the right source

By Robert Mikkelsen, International Plant Nutrition Institute, Merced, CA; ***Greg Schwab***, University of Kentucky, Lexington; and ***Gyles Randall***, University of Minnesota, Waseca

Selecting the right fertilizer rate: A component of 4R nutrient stewardship

By S.B. Phillips, International Plant Nutrition Institute, Owens Cross Roads, AL; ***J.J. Camberato***, Purdue University, West Lafayette, IN; and ***D. Leikam***, Fluid Fertilizer Foundation, Manhattan, KS

The four fertilizer rights: timing

By W.M. Stewart, International Plant Nutrition Institute, Norcross, GA; ***J.E. Sawyer***, Iowa State University, Ames, IA; and ***M.M. Alley***, Virginia Tech, Blacksburg, VA

The four fertilizer rights: placement

Scott Murrell (IPNI),Tony Vyn (Purdue), Guy Lafond (AAFC), Dave Finlayson (CFI),

more information about
4R nutrient stewardship:

nutrientstewardship.com

ipni.net