Eric Davidson

Adjunct Senior Scientist, Woods Hole Research Center

International Nitrogen Initiative North America, Regional Director

our Challenges
our Image
our Future

A Scientific Perspective:

Overcoming Impediments to Improve Nitrogen Use Efficiency

Fertilizer Industry Round Table

The Fertilizer Institute
Nourish, Replenish, Grow

Overcoming Impediments to Improve Nitrogen Use Efficiency

Eric A. Davidson

November 19, 2014

The Haber-Bosch process is one of the greatest public health boons in human history

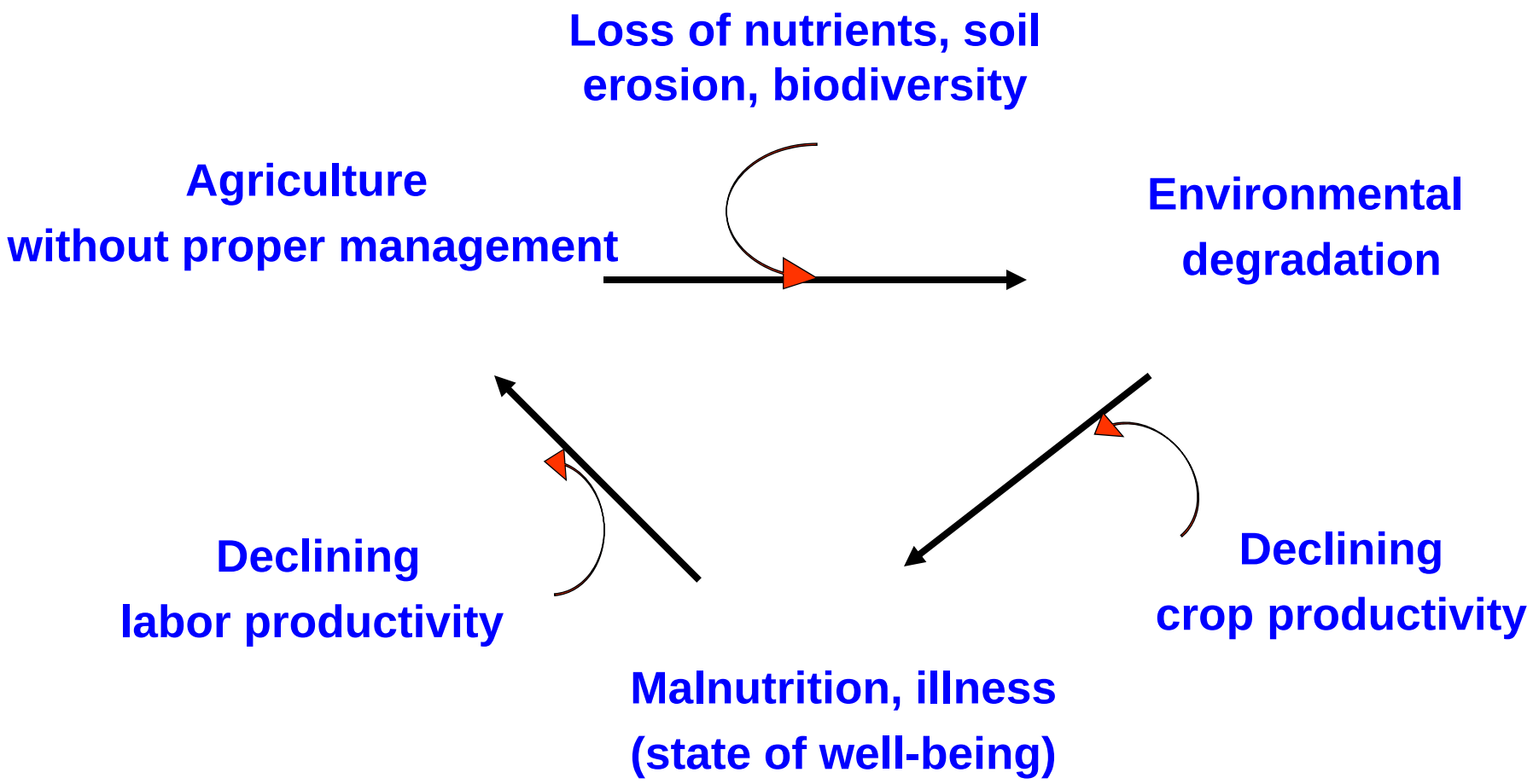
Mo Fo; Lo Po

UNHEALTHY SOILS -----UNHEALTHY PEOPLE

Sanchez and Swaminathan, 2005

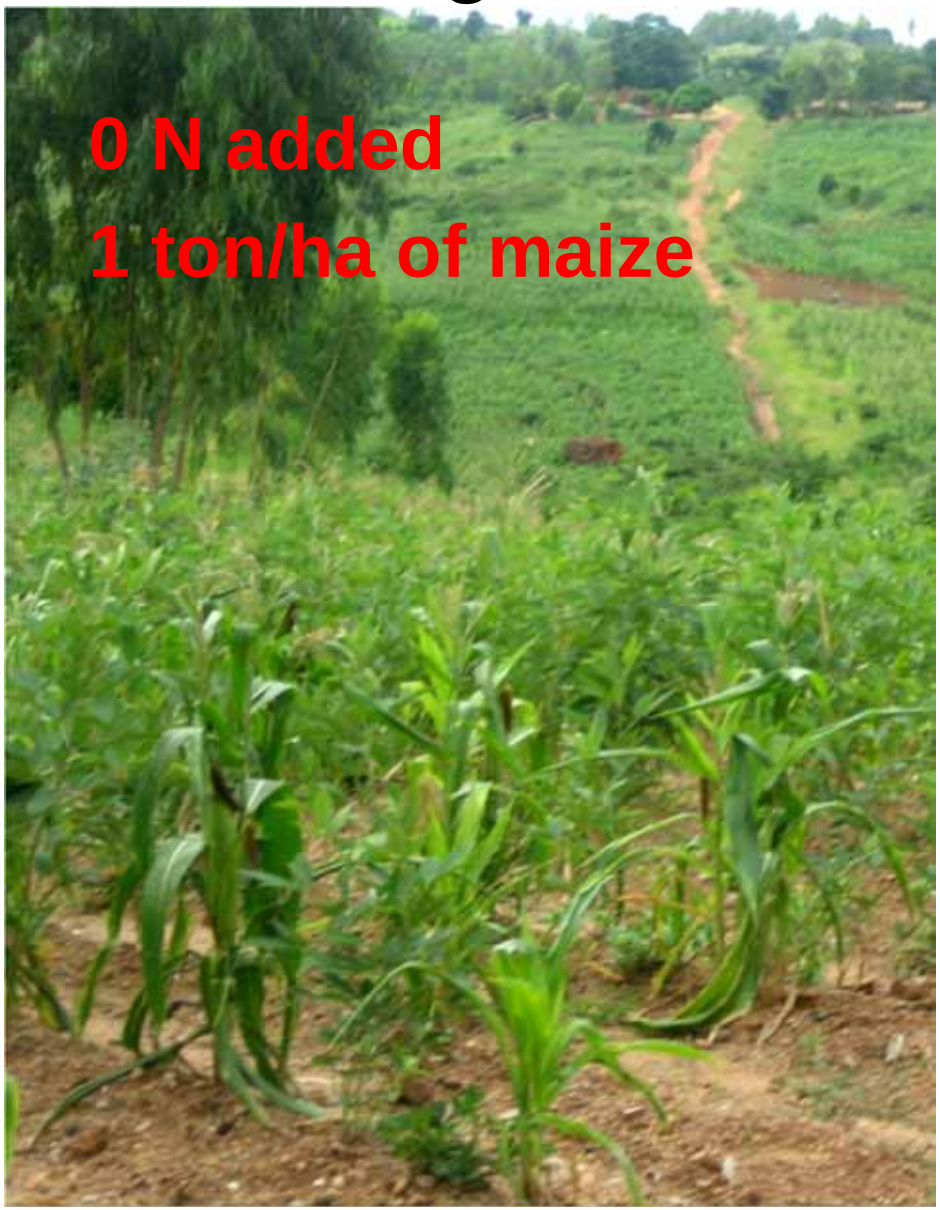
Consequences of Too Little N

Yields, Soil Health, Human Health, Economic Growth



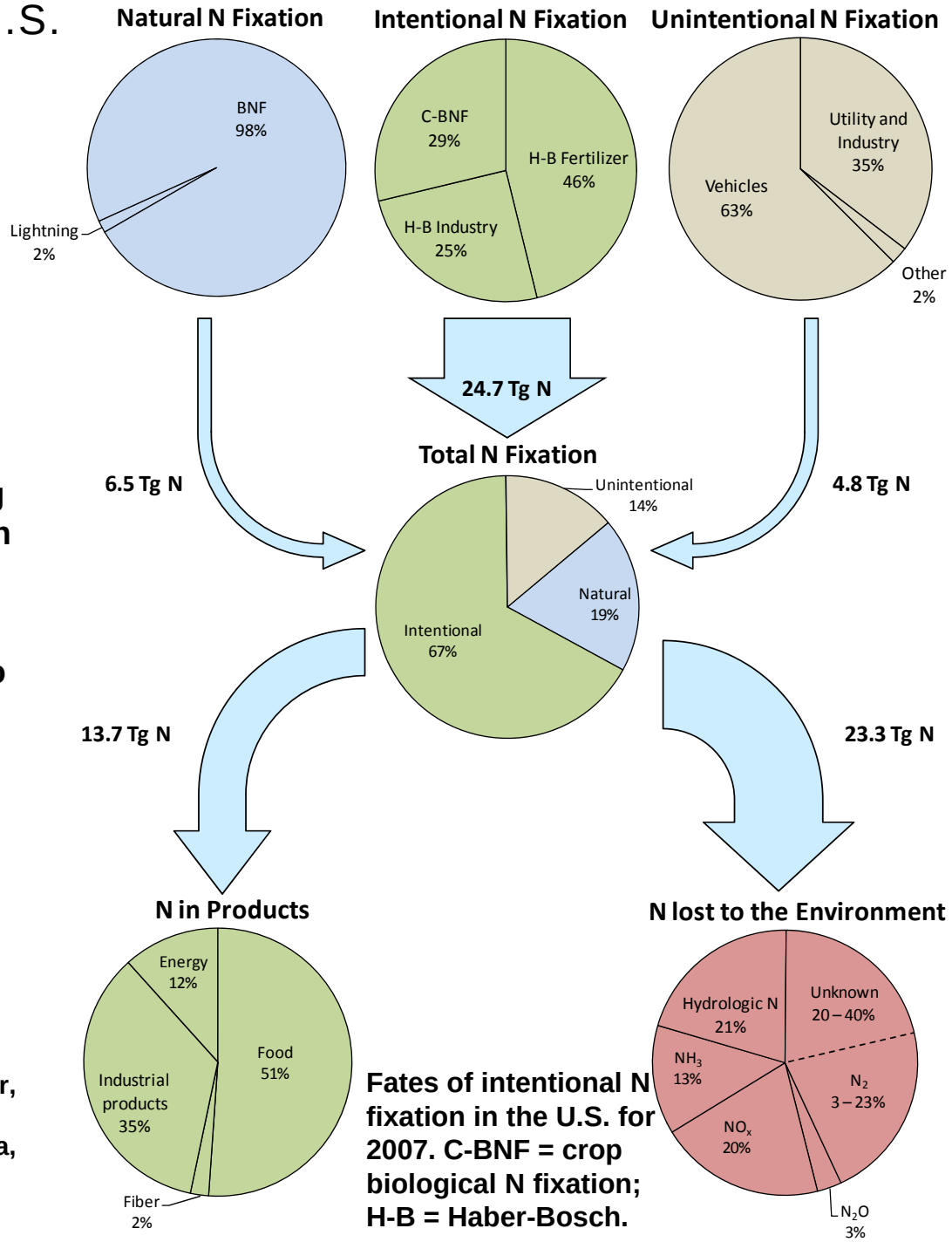
Deckelbaum et al., 2006

Initial Goal of African Green Revolution
Moving from 1 to 3 tons per hectare



Alteration of N Flows in the U.S.

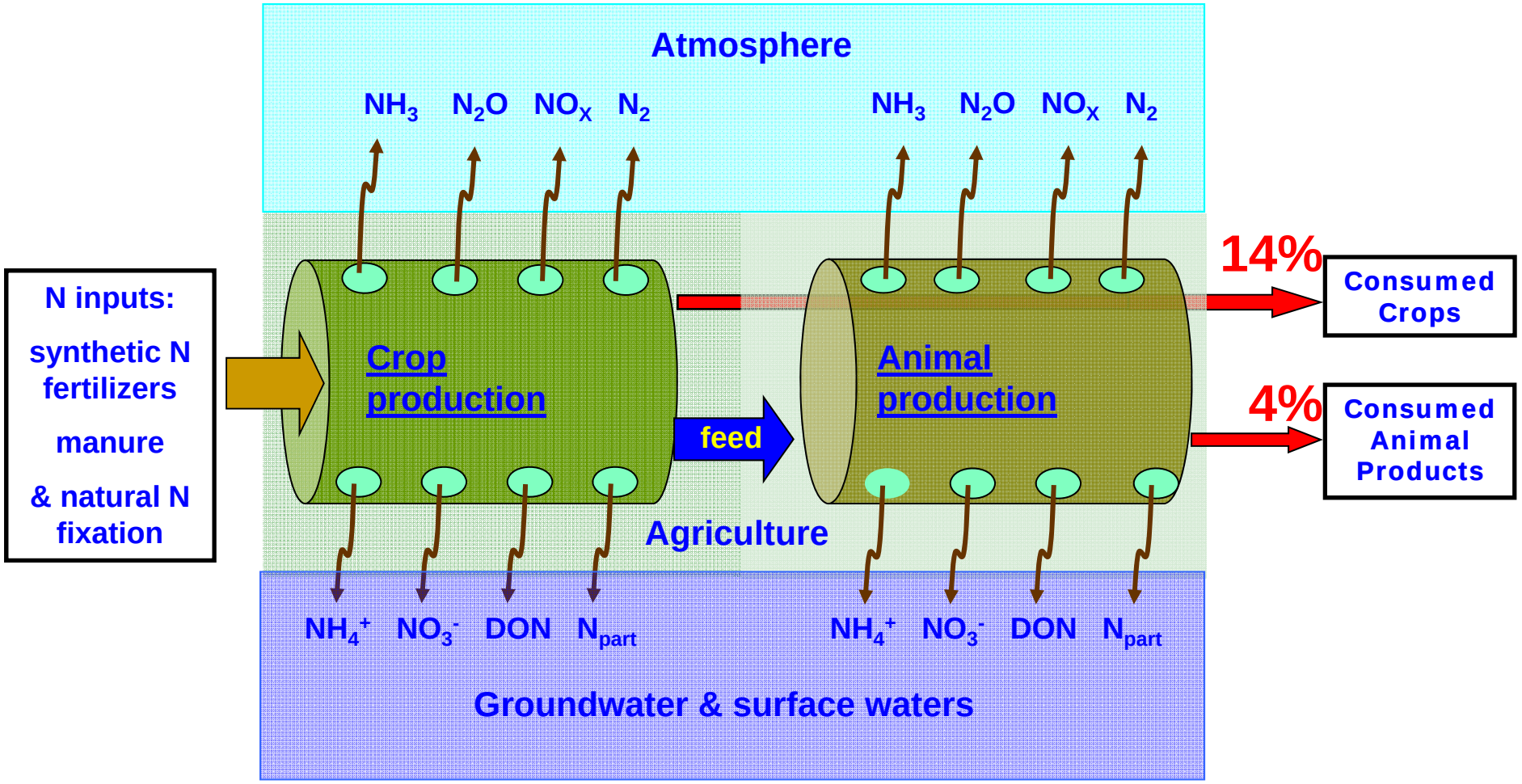
- **Intentional Nr creation accounts for 2/3^{rds} of total N_2 fixation in the U.S.**
- **Nearly 2/3^{rds} of unintentional Nr is from vehicle use, while a majority of the remainder is from stationary power plants and industrial boilers.**
- **About 3/4^{ths} of intentional Nr enters US agricultural systems. Synthetic fertilizer comprises 2/3^{rds} of Nr input to U.S. agriculture, with the remainder originating from C-BNF. Industrial products like nylon and explosives account for the remaining 25% of intentionally fixed Nr in the U.S.**
- **About 1/3rd of total Nr is incorporated into products, about 1/3rd is lost as Nr to the broader environment, about 1/3rd is denitrified or lost to unknown sinks.**
- **Nitrogen use efficiency is about 38% for agriculture and about 55% for all intentional Nr.**



Fates of intentional N fixation in the U.S. for 2007. C-BNF = crop biological N fixation; H-B = Haber-Bosch.

From chapter by Benjamin Z. Houlton, Elizabeth Boyer, Adrien Finzi, James Galloway, Allison Leach, Daniel Liptzin, Jerry Melillo, Todd S. Rosenstock, Dan Sobota, and Alan R. Townsend
***Biogeochemistry* (2013) 114:11-23**

Nitrogen: A Very Leaky Element



Improving Nitrogen Use Efficiency in Crop & Livestock Production Systems:

Existing Technical, Economic & Social Impediments and Future Opportunities

August 13-15, 2013

Marriott Country Club Plaza | Kansas City, MO

What are the technical, economic, and social impediments and opportunities for increased nitrogen use efficiency in crop and animal production systems?

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The Woods Hole Research Center

The Fertilizer Institute — Nourish, Replenish, Grow

Co-sponsors

Soil Science Society of America

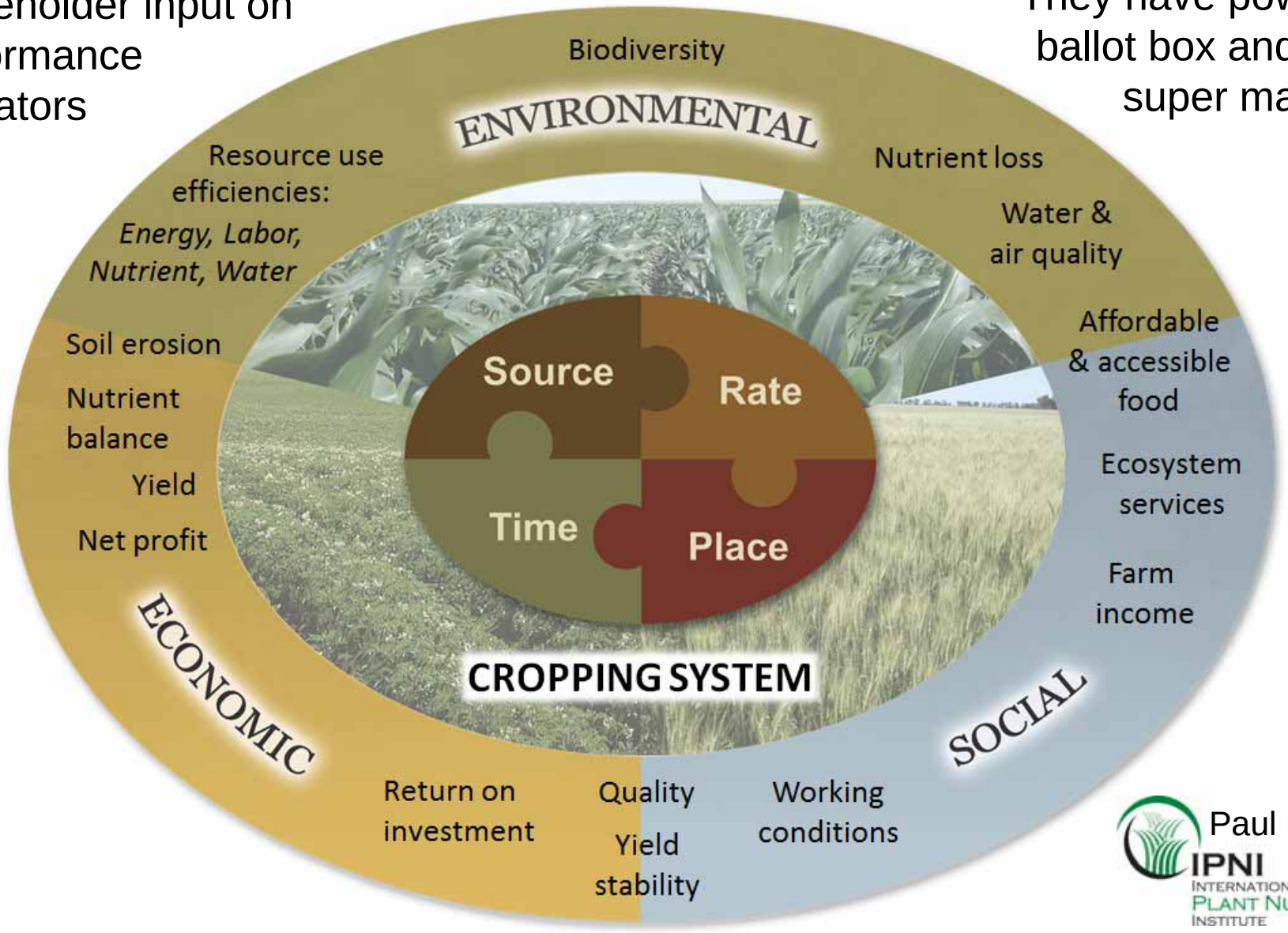
INI International Nitrogen Initiative

AGU American Geophysical Union

Reactive Nitrogen RCN Research Coordination Network

Stakeholder input on performance indicators

They have power - ballot box and the super market

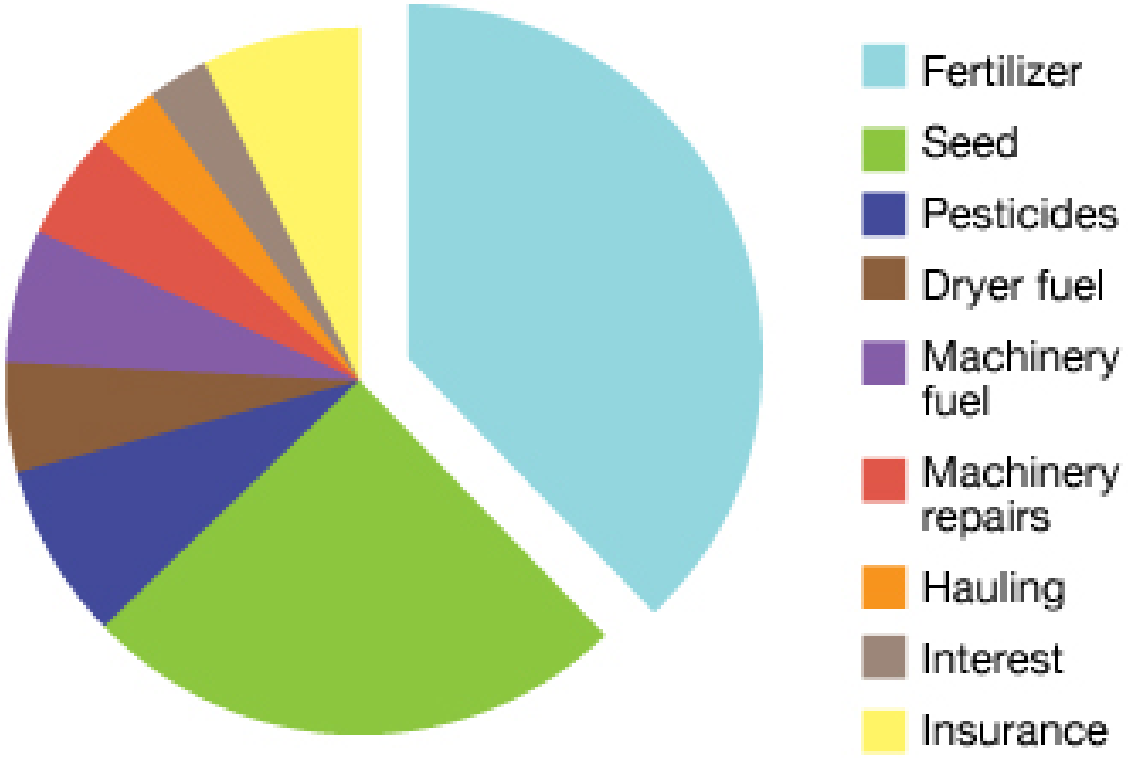


Paul Fixen
IPNI
INTERNATIONAL PLANT NUTRITION INSTITUTE

Applying the *Right Source* at the *Right Rate* at the *Right Time* and in the *Right Place, where Right* is defined by practice impact on system performance

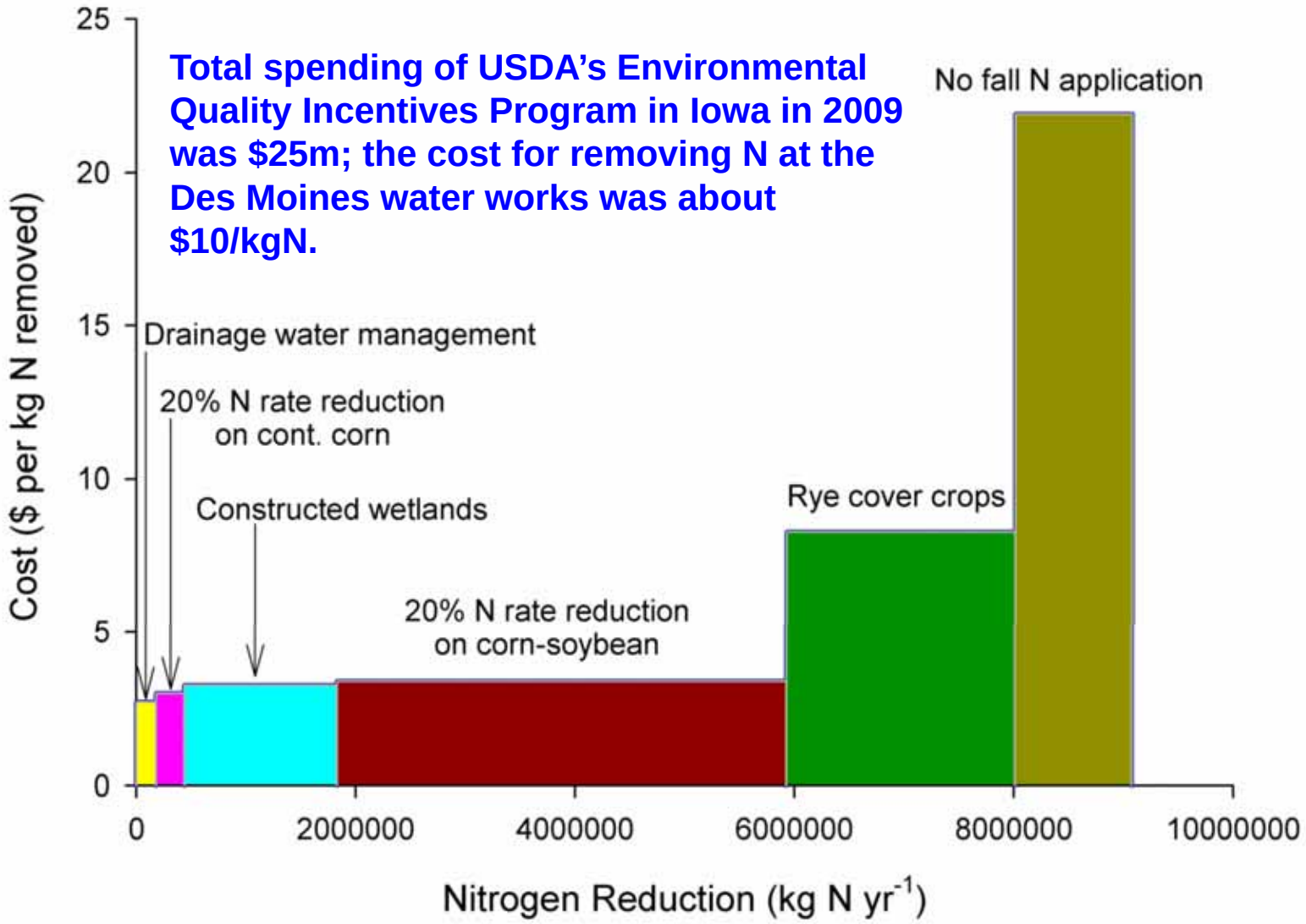
Estimated shares of variable costs per acre for rotation corn in Indiana in 2013

From 2013 Purdue Crop Cost & Return Guide. Purdue Extension publication ID-166-W.



Mixed economic signals

- **N fertilizer costs are high enough for many farmers to want to improve NUE.**
- **But most also agree that the economic risk of applying too little N is high.**
- **N application provides an important economic margin of safety, like relatively inexpensive insurance.**



Estimated costs for adopting several currently available management practices across the Ceder Creek Watershed, Iowa, for a 35% load reduction, implemented over a 20 year period. The total cost is $71 million per year, or $7.78 kg^{-1} N removed yr^{-1}, or $42 ha^{-1} yr^{-1} (from Dan Jaynes, USDA-ARS, and Mark David, Univ. Illinois).

Davidson et al. 2012. *Issues in Ecology*, Report Number 15, Ecological Society of America.

- **Local impacts are not visible enough.**
- **Lack of visible or tangible local environmental and economic consequences of N management.**

RECOMMENDATIONS:

- **Tie nutrient management to performance-based indicators, including clearly defined NUE indicators on the farm, with strong incentives for participation and reporting of data.**
- **Well-defined environmental quality indicators downwind and downstream are also needed and should be tied to monetary values where appropriate and feasible.**

Please indicate how influential the following groups and individuals are when you make decisions about agricultural practices and strategies. (16 options)

Family, chemical dealers, and seed dealers are most influential

RECOMMENDATIONS:

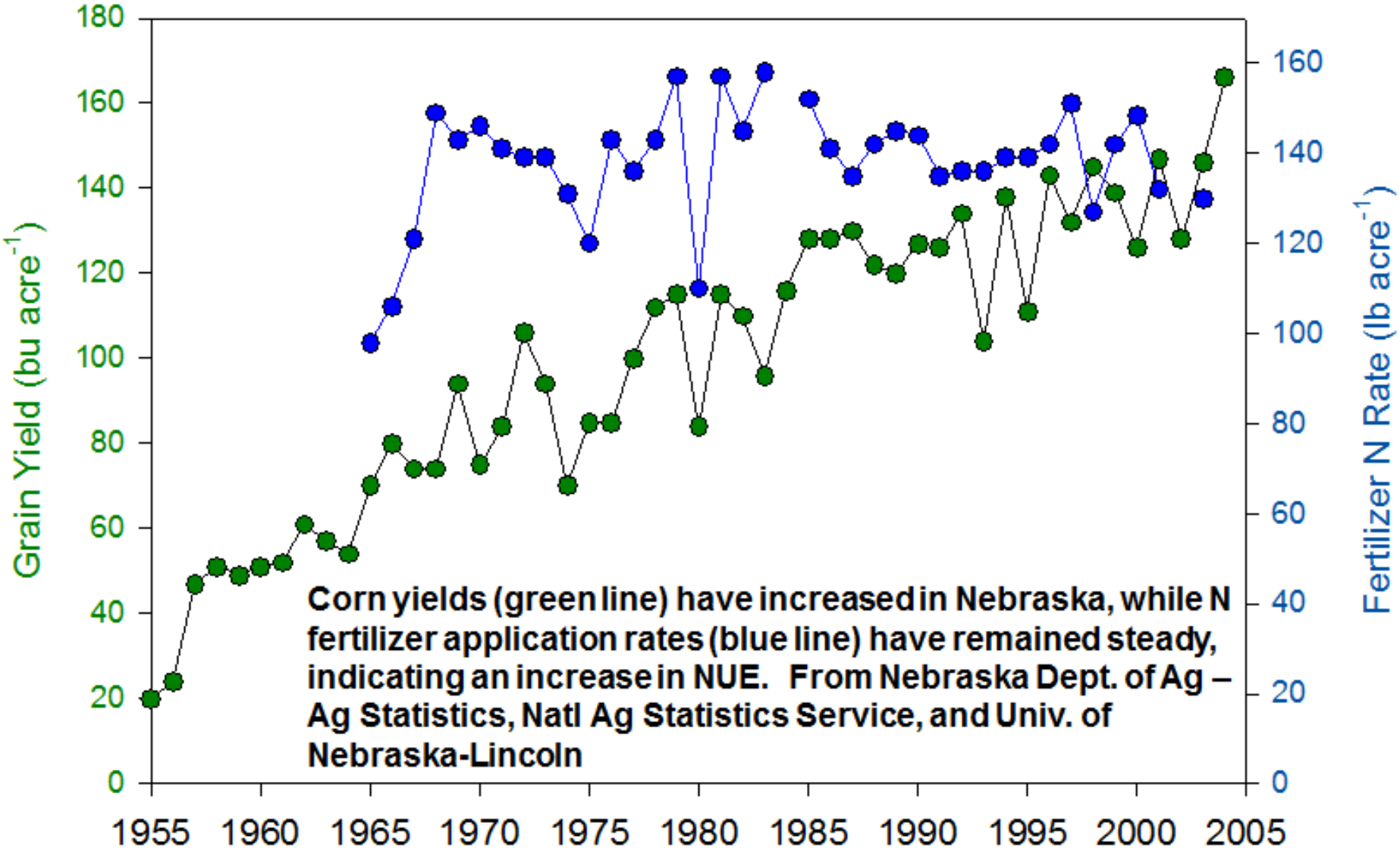
- **Develop partnerships & networks between industry, universities, governments, NGOs, crop advisors, and farmers to demonstrate the most current, economically feasible, best management practices.**
- **Provide improved, continuing education to private sector retailers and crop advisors through professional certification programs by university and government extension**
- **Provide science-based recommendations through trusted sources of information to help reduce the perception of risk and the perceived need to apply additional N for "insurance" purposes.**

Nitrogen Use Efficiency in Nebraska's Central Platte Valley

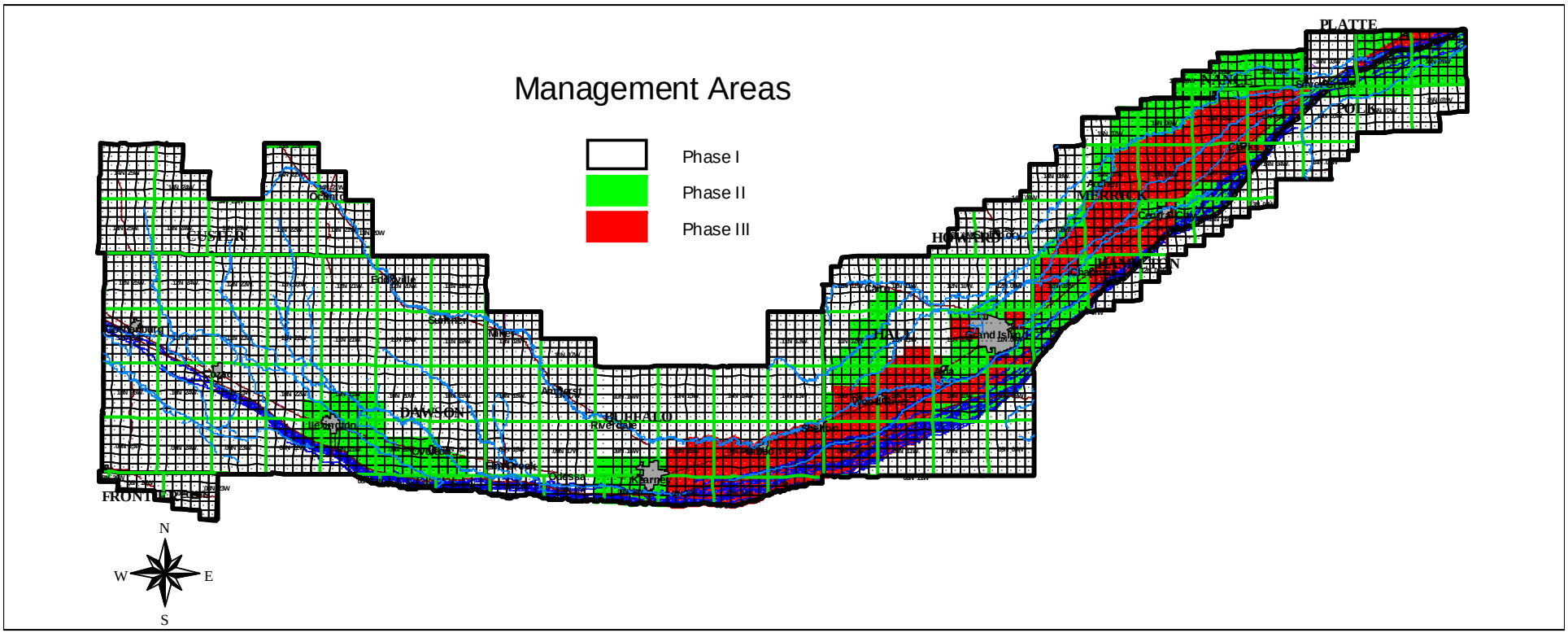
Groundwater Quality and Nitrogen Use Efficiency in Nebraska's Central Platte River Valley

OPEN ACCESS:
Journal of Environmental Quality 2014

Richard B. Ferguson
Professor of Soil Science
Department of Agronomy & Horticulture
University of Nebraska-Lincoln


Grain Yield (bu acre-1)
Fertilizer N Rate (lb acre-1)
0
20
40
60
80
100
120
140
160
180
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Corn yields (green line) have increased in Nebraska, while N fertilizer application rates (blue line) have remained steady, indicating an increase in NUE. From Nebraska Dept. of Ag – Ag Statistics, Natl Ag Statistics Service, and Univ. of Nebraska-Lincoln

Central Platte Natural Resources District Groundwater Management Area (GWMA)



First GWMA in Nebraska, established in 1988 following passage of enabling legislation.

Central Platte NRD Groundwater Management Area (GWMA)

Phase I (0-7.5 ppm NO_3-N)

- Fall & winter N application banned on sandy soil.
- N application allowed on heavier-textured soils after November 1.

Central Platte NRD GWMA

Phase II (7.6 – 15 ppm NO_3-N)

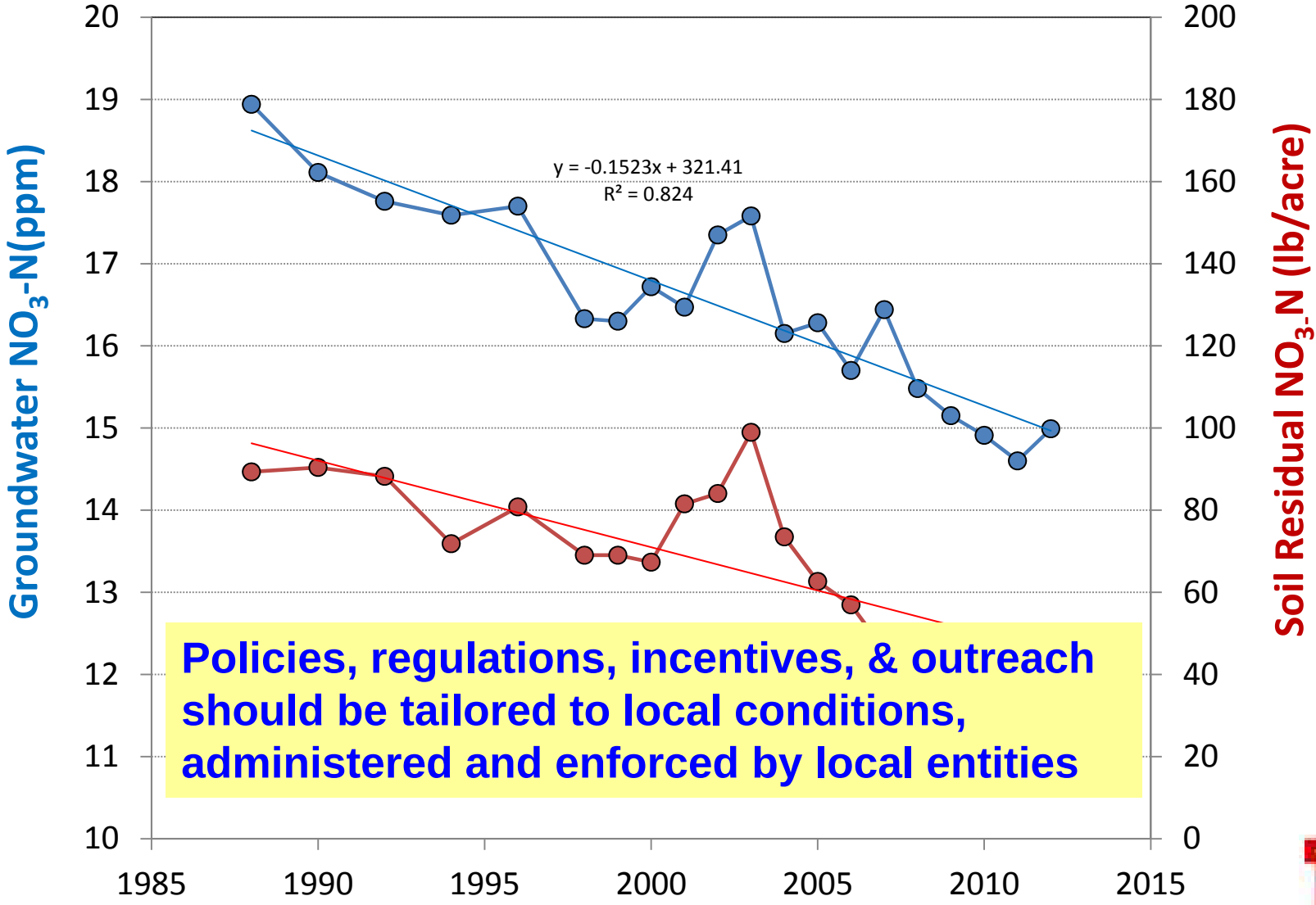
- No N fertilizer application allowed until after March 1.
- Annual soil and irrigation water tests required.
- Lab analysis and nutrient accounting is required if manure is to be applied.
- Legume credits must be considered.
- Certification by the NRD every 4 years.
- Measurement of irrigation water applied to each field.
- Annual reporting to the NRD of crop grown, N credits, recommended N rate, nitrification inhibitor use, soil & water analyses, N fertilizer and water applied, and crop yield.

Central Platte NRD GWMA

Phase III (> 15 ppm NO_3-N)

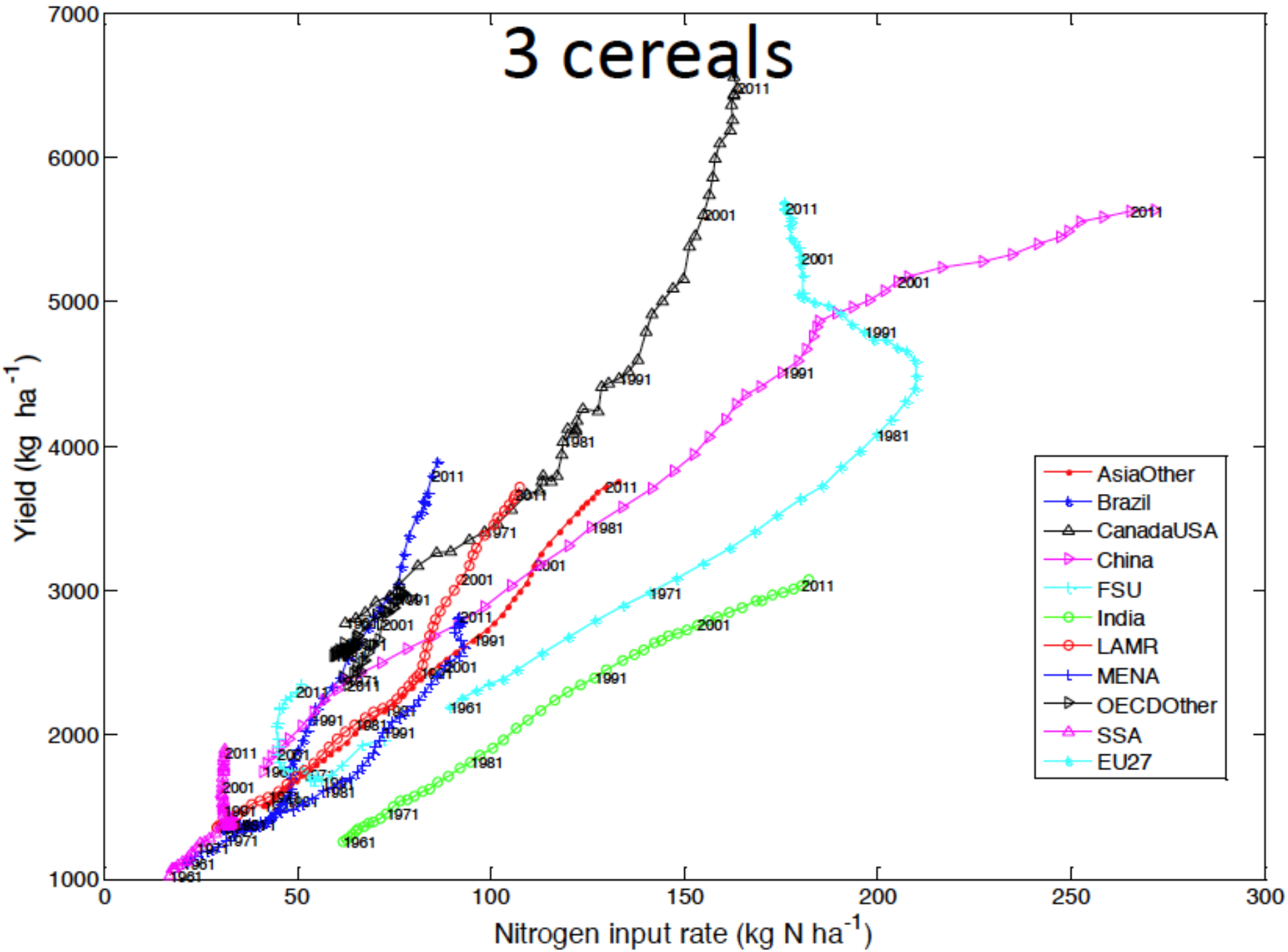
- All requirements of Phase II, plus –
- Split N application, or use of a nitrification inhibitor, or sidedress application.

Trends in the Central Platte Valley



Average of values from producer reports in GWMA, representing ~ 300,000 acres

IANR


3 cereals
Yield (kg ha-1)
Nitrogen input rate (kg N ha-1)
7000
6000
5000
4000
3000
2000
1000
0
50
100
150
200
250
300
AsiaOther
Brazil
CanadaUSA
China
FSU
India
LAMR
MENA
OECDOther
SSA
EU27