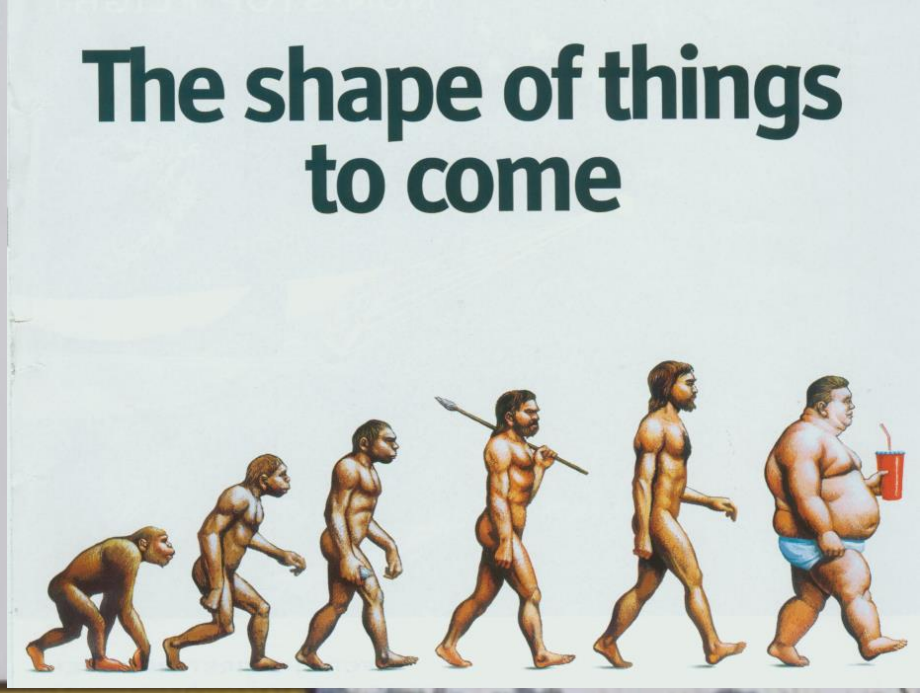
Global, National, and Local Trends of Nitrogen Use Efficiency in Agriculture

Eric A. Davidson

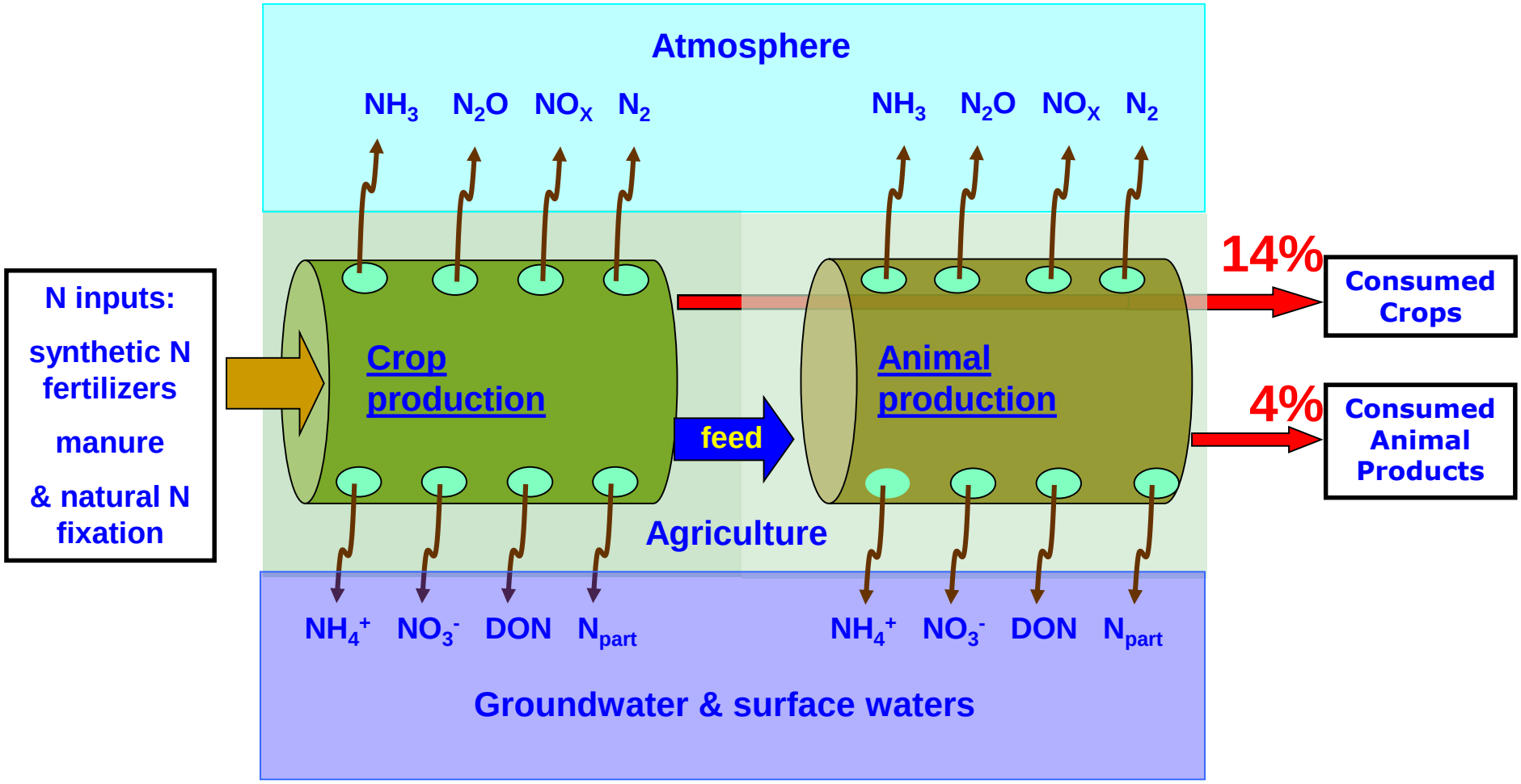
January 22, 2015

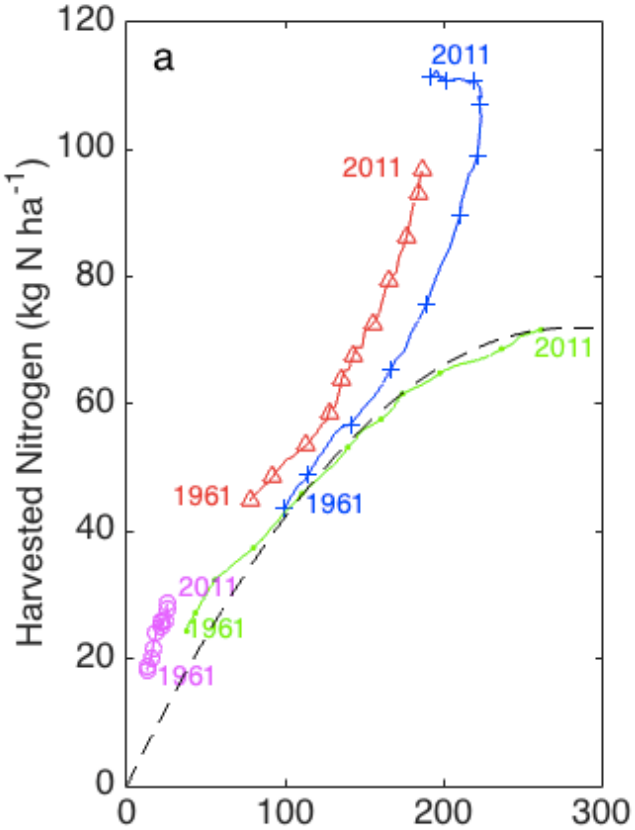
The Haber-Bosch process is one of the greatest public health boons in human history

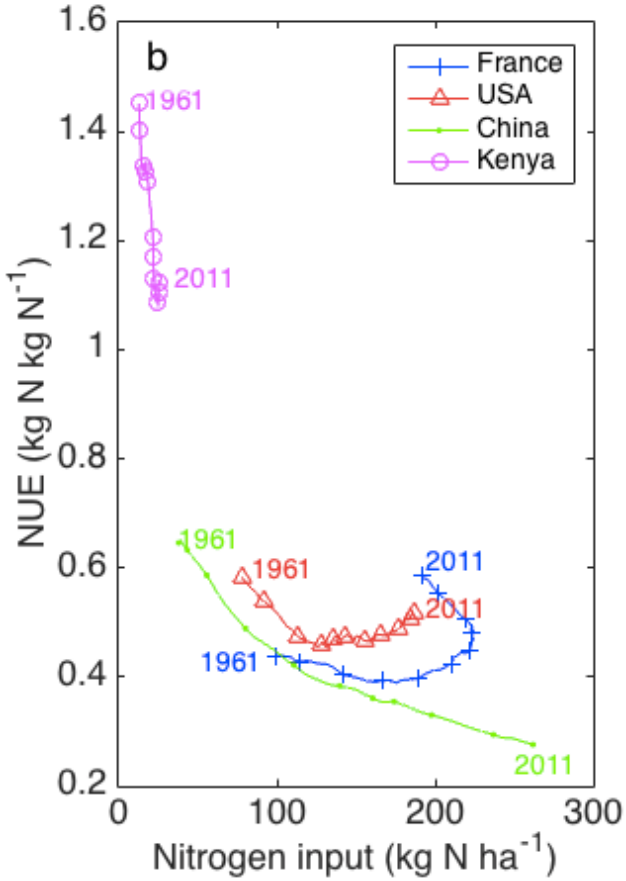


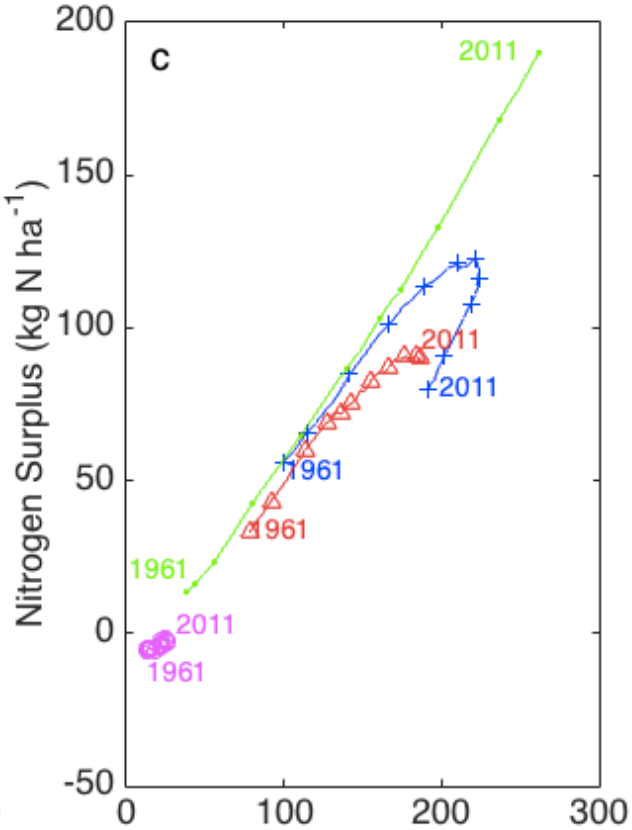
Mo Fo; Lo Po

Nitrogen: A Very Leaky Element







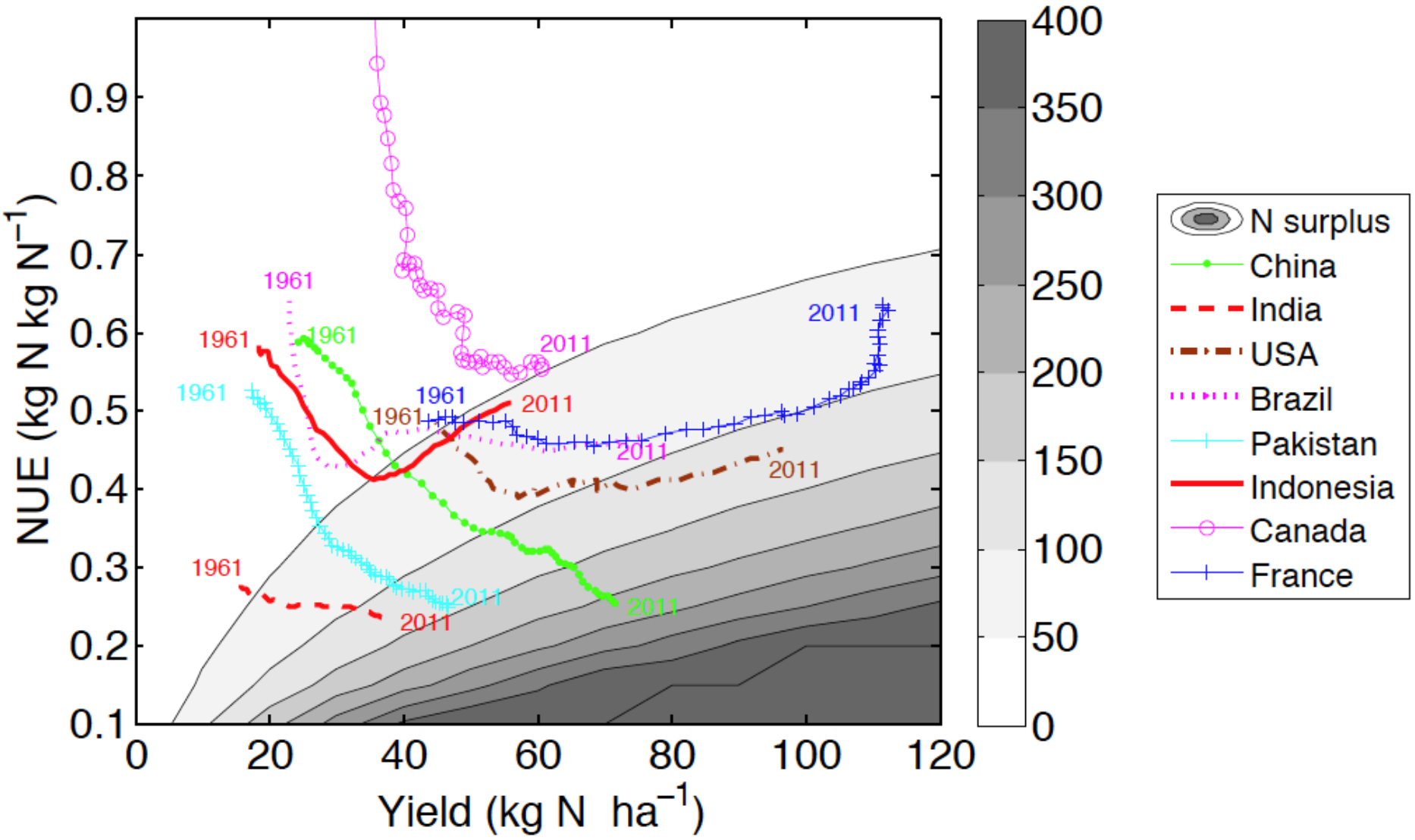


NUE = outputN/inputN

Surplus = inputN - outputN

Data Source: *FAOSTAT, FAOFertiSTAT*

Zhang et al., in preparation



Data Source: *FAOSTAT, FAOFertiSTAT*

Zhang et al., in preparation

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?

Sponsors

IPNI International Plant Nutrition Institute

The Woods Hole Research Center

The Fertilizer Institute — Nourish, Replenish, Grow

Co-sponsors

Soil Science Society of America

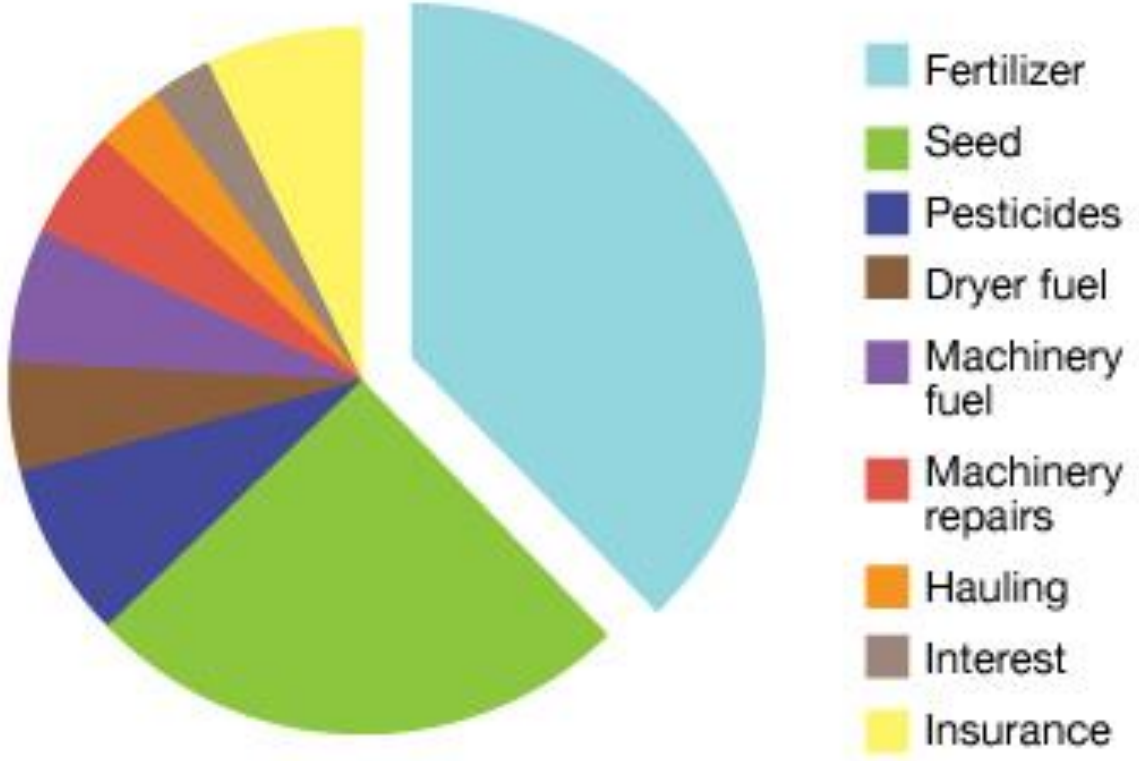
INI International Nitrogen Initiative

AGU American Geophysical Union

Reactive Nitrogen RCN Research Coordination Network

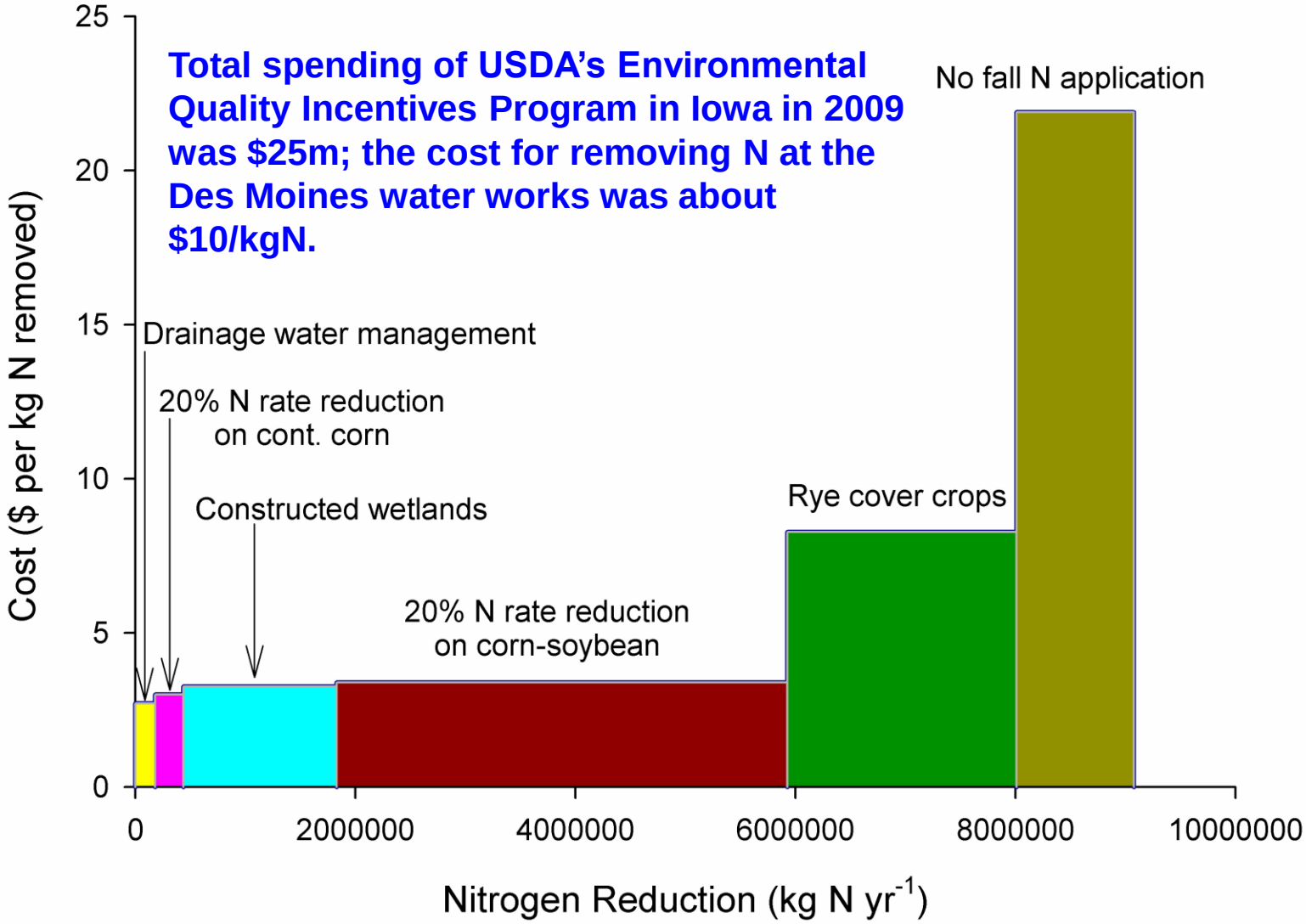
Estimated shares of variable costs per acre for rotation corn in Indiana in 2013

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.

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:

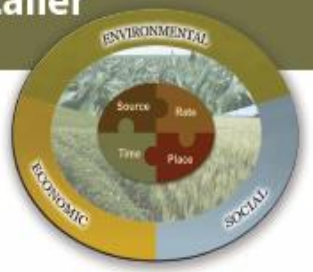
- **Develop partnerships & networks between industry, universities, governments, NGOs, crop advisors, and farmers to demonstrate the most current, economically feasible, best management practices.**
- **Provide improved, continuing education to private sector retailers and crop advisors through professional 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.**

Retailer & Conservationist Survey

nutrient stewardship

Conservationist and Agricultural Retailer 4R Nutrient Stewardship Survey

Right Source - Right Rate - Right Time - Right Place



Purpose of the Survey

Nutrient stewardship is an important issue facing agricultural producers because of costs, effect on crop yields, and environmental benefits. Five organizations have partnered to create a survey to:

- Identify areas for focusing and targeting outreach
- Better quantify existing implementation of 4R practices
- Identify opportunities for retailers and conservationists to work cooperatively to help ensure that the agricultural community leverages the full power of voluntary nutrient stewardship.

Sponsoring Organizations

NCFC National Council of Farmer Cooperatives

The Fertilizer Institute Nourish, Replenish, Grow

Agricultural Retailers Association

National Association of Conservation Districts

CERTIFIED CROP ADVISER

Results – 4R Awareness and Working Relationships

- 4R Awareness
  - Retailers:
    - 2% first learned of 4Rs in Survey
    - Knowledge of 4R - 7.2 (scale of 1-10)
  - Conservation Districts:
    - 37% first learned of 4Rs in Survey
    - Knowledge of 4R - 4.6
- Awareness of each other
  - Retailers:
    - Awareness of district activities – 5.4
    - Awareness of technical/financial assistance – 4.6/4.9
  - Conservation Districts:
    - Awareness of retailer activities – 3.3
    - Awareness of technical/financial assistance – 8.9/8.9

Retailers top partners are CCAs and other private ag industry folks

Conservation district top partners are NRCSC and state ag & environmental agencies

And the Survey Says…..

Most recommended practices by retailers

- Aerial photography
- Ag drainage practices
- Applying buffer strips
- **Auto steer (71%)**
- Band fertilizer placement
- Conservation tillage
- **Mapping soils/yields (69%)**
- Crop rotation
- Nutrient injection
- Manure testing
- Mapping sensitive areas
- Planting cover crops
- PSNT
- **Split nutrient applications (80%)**
- **Plant tissue testing (75%)**
- **Soil fertility testing (98%)**
- **Use N Stabilizers (91%)**
- Use P efficiency products
- **Proper nutrient source (75%)**
- Nutrient budgets
- **VRT nutrient application (86%)**
- **Yield maps analysis (73%)**
- Grassed waterways

And the Survey Says…..

Most recommended practices by conservationists

- Aerial photography
- Ag drainage practices
- **Applying buffer strips (65%)**
- Auto steer for application
- Band fertilizer placement
- **Conservation tillage (71%)**
- Mapping soils/yields
- **Crop rotation (49%)**
- Nutrient injection
- **Manure testing (48%)**
- Mapping sensitive areas
- **Planting cover crops (75%)**
- PSNT
- Split nutrient applications
- Plant tissue testing
- **Soil fertility testing (74%)**
- Use N Stabilizers
- Use P efficiency products
- Proper nutrient source
- Nutrient budgets
- VRT nutrient application
- Yield map analysis
- **Grassed waterways (55%)**

Nitrogen Use Efficiency in Nebraska's Central Platte Valley

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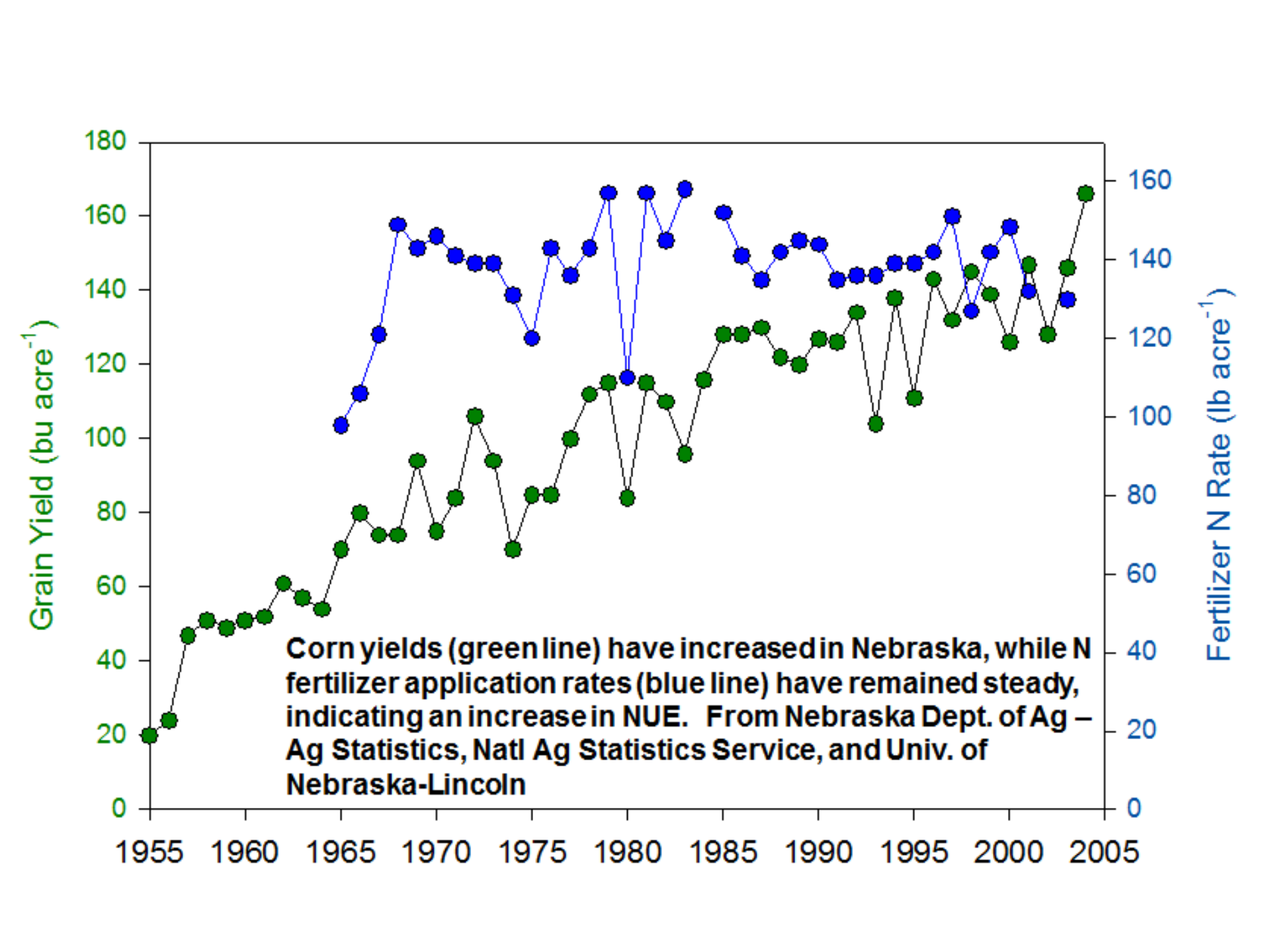
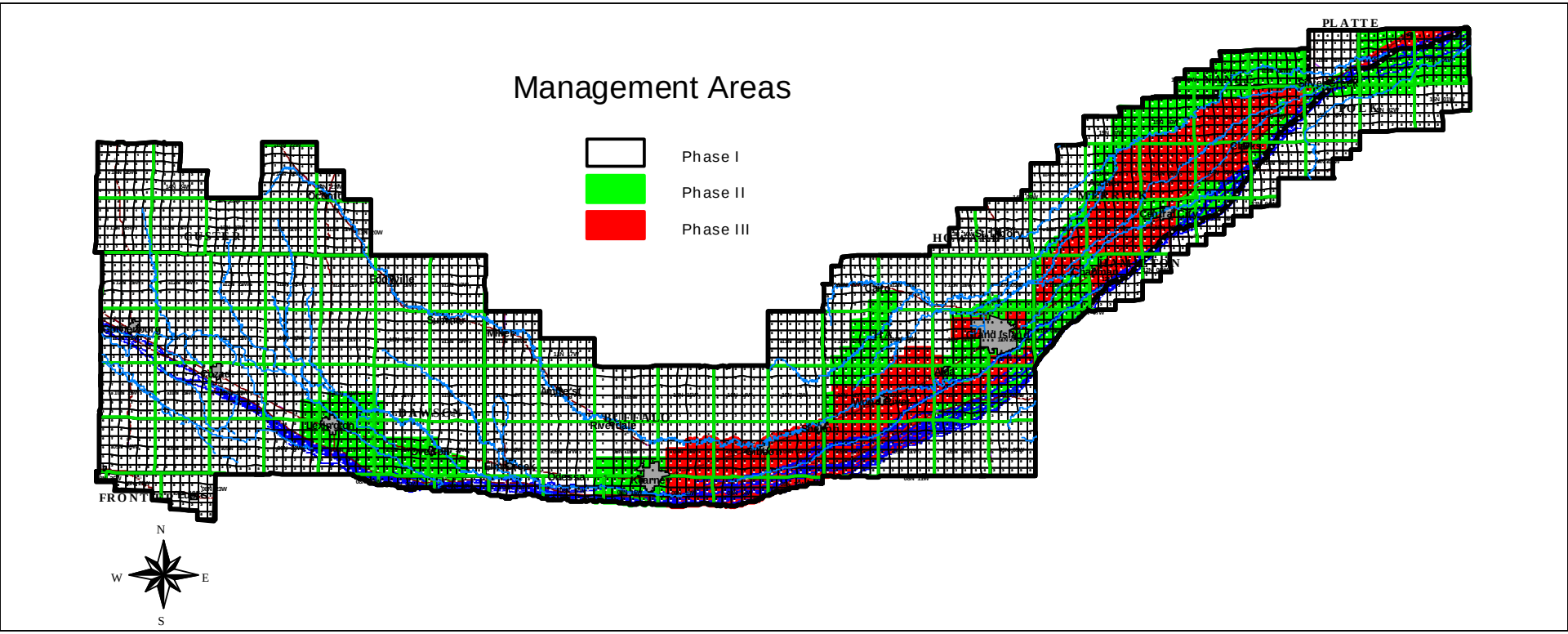
Department of Agronomy & Horticulture
University of Nebraska-Lincoln


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)

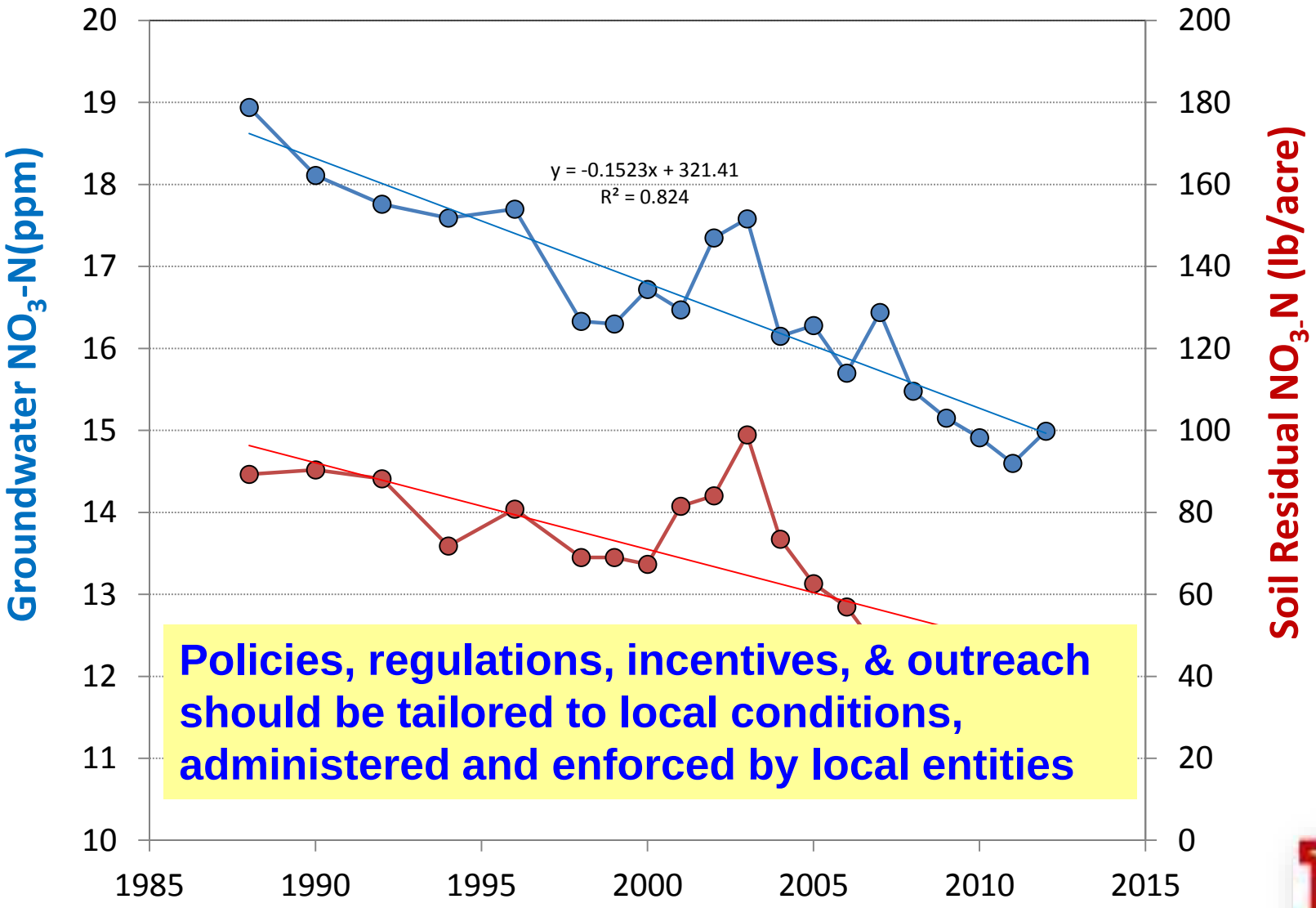
- No N fertilizer application allowed until after March 1.
- Annual soil and irrigation water tests required.
- Lab analysis and nutrient accounting is required if manure is to be applied.
- Legume credits must be considered.
- Certification by the NRD every 4 years.
- Measurement of irrigation water 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)

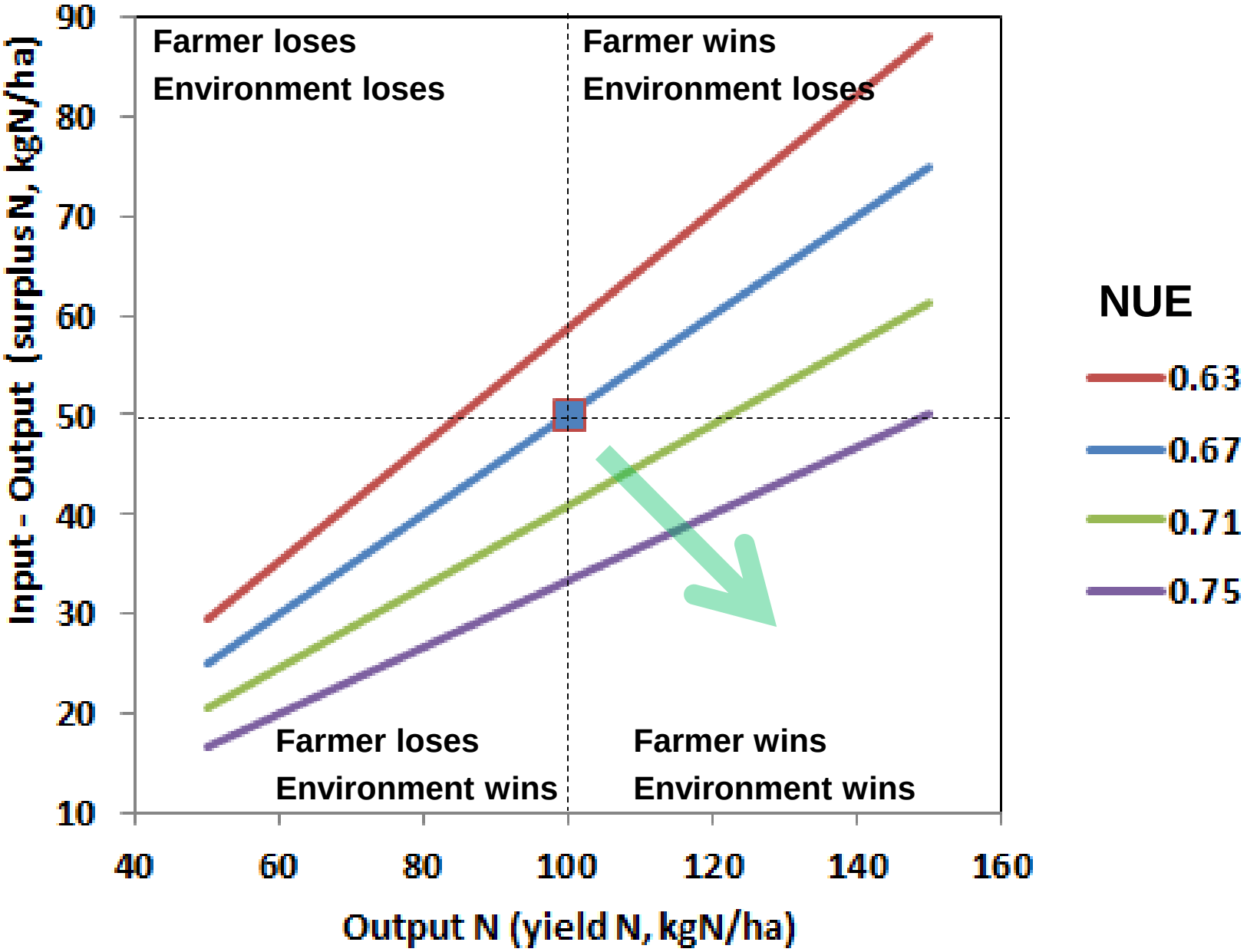
- All requirements of Phase II, plus –
- Split N application, or use of a nitrification inhibitor, or sidedress application.

Trends in the Central Platte Valley



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

IANR


Farmer loses
Environment loses
Farmer wins
Environment loses
Farmer loses
Environment wins
Farmer wins
Environment wins
Input - Output (surplus N, kgN/ha)
90
80
70
60
50
40
30
20
10
40
60
80
100
120
140
160
Output N (yield N, kgN/ha)
NUE
0.63
0.67
0.71
0.75

The Kansas City Consensus on Nitrogen Use Efficiency 2013

In August 2013, agronomists, environmental scientists, extension agents, crop advisors, economists, farmers, and other agricultural experts gathered at a conference in Kansas City, Missouri, to discuss a vexing challenge: How can we promote better management of nitrogen fertilizers and manures in order to reduce unintended environmental impacts of nitrogen pollution, while still enabling modern agriculture to meet the growing demand for affordable food and biofuels?

Existing knowledge and technology, although imperfect and incomplete, are already advancing the dual goals of making agriculture productive and environmentally sustainable. Unfortunately many economic and social barriers stand in the way of more widespread adoption by farmers of existing and emerging technologies. In the meantime, concerns about environmental pollution, from nitrate in drinking water to toxic algae in waterways, are increasing pressures to reduce nitrogen losses from agricultural fields. View the complete consensus statement at

http://nitrogennorthamerica.org/pdf/KansasCityConsensus_Final_Nov_2013.pdf

The Fertilizer Institute · RCN · IPNI · AGU · Soil · International Nitrogen Initiative

Contact: Emma Suddick, Woods Hole Research Center, esuddick@whrc.org

Kansas City Nitrogen Use Efficiency Consensus Statement and Brochure

http://nitrogennorthamerica.org/pdf/KansasCityConsensus_Final_Nov_2013.pdf

International Nitrogen Initiative North America Nitrogen Center website:

http://nitrogennorthamerica.org/