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PLANT NUTRITION
INSTITUTE

Are We Applying Our Nitrogen Inputs Wisely?

C.S. Snyder, PhD, CCA

Nitrogen Program Director, Conway, Arkansas, USA

USDA Agriculture Outlook Forum
Arlington, VA *February 20, 2014*

Clean Water, Clean Air, Productive Soil ……

- We all want these on our farm, in our community, in our world
- For us, our neighbors, our children, grandchildren, … and the global human family
- **Water quality (N and P)**
  - groundwater **nitrate-N** contamination
  - surface water **N and P** contamination
    - eutrophication: lakes, streams/ rivers, estuaries, and coastal waters
- **Ag needs profitability**

U.S. EPA Reports that Nutrients (N and/or P)

- **Are Causing Water Quality Impairments:**
- **>100,000 miles of rivers and streams,**
- **Approx. 2.5 million acres of lakes, reservoirs and ponds,**
- **> 800 square miles of bays and estuaries in the U.S.**
- **166 coastal hypoxic areas or "dead zones" nationwide**
- **"nutrient pollution is widespread": 27% have high N, 40% of river and stream miles have high P**
- **Stream biological condition:**
  - **55% poor, 23% fair;**
  - **9% more "good" N condition, 19% fewer "good" P condition**

Source: 2013 EPA website: http://water.epa.gov/type/rsl/monitoring/riverssurvey/index.cfm , http://www2.epa.gov/nutrientpollution/effects-environment , http://www2.epa.gov/nutrientpollution/where-occurs-lakes-and-rivers

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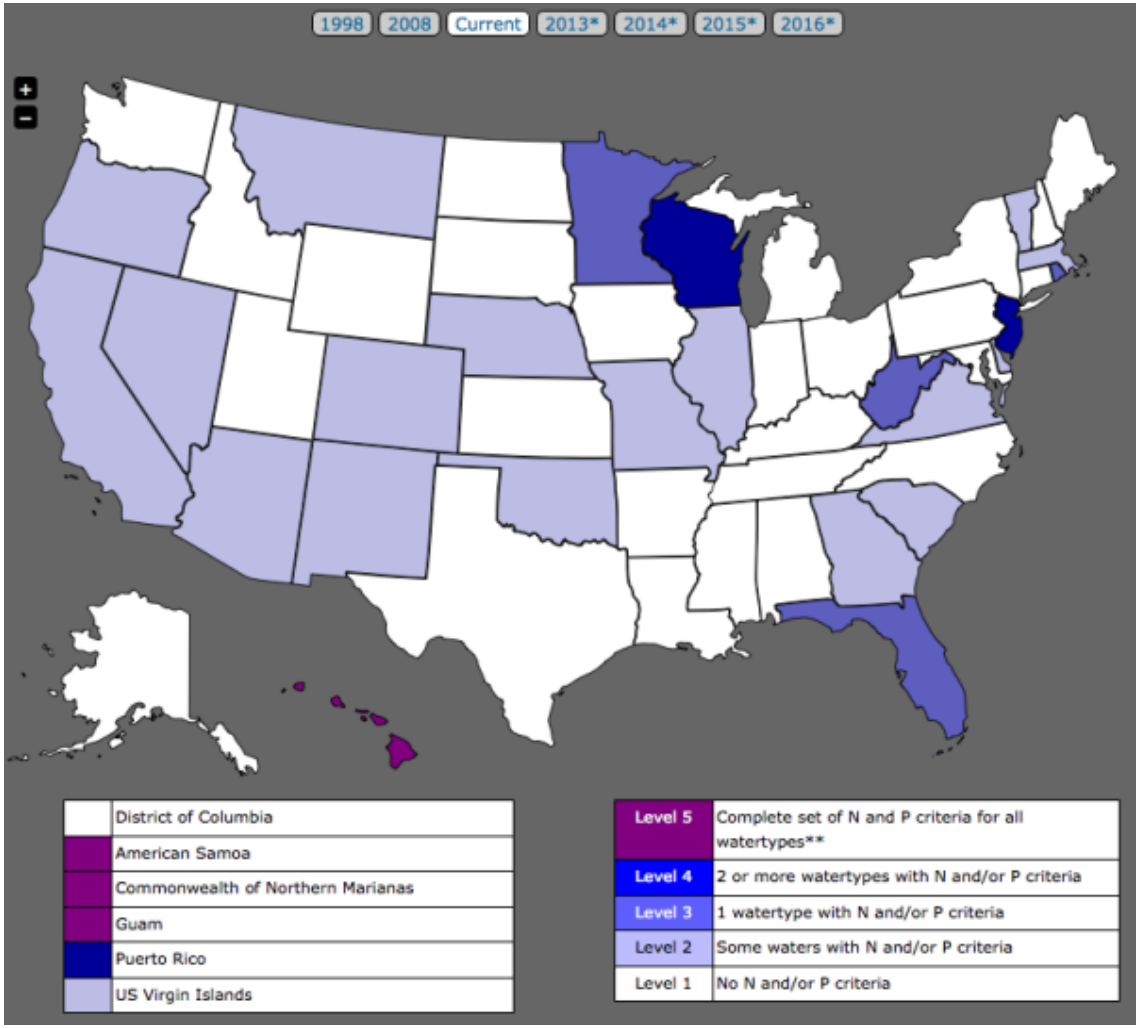
States with Numeric Nutrient Criteria - 2013



Several states have site-specific criteria for streams and rivers; only Wisconsin and Florida have statewide criteria supported by peer-reviewed and technical papers documenting the process of criteria development

6 states TN; 11 states TP

http://cfpub.epa.gov/wqsits/nnc-development/

Evans-White, Haggard and Scott. 2013. J. Environ. Qual. 42:1002-1014

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Good Nutrient Management Needed for Good Water Quality

- Ralph Rosenberg, Exec. Director of the Iowa Environmental Council and Shawn Richmond, CREP coordinator for the Iowa Dept. Ag. Land Stewardship
  - "**Just putting less fertilizer on won't fix the problem**. **We have to know all the practices that are contributing to the problem**,"
  - "Then we need to work with Iowa agricultural organizations, agricultural businesses and farmers to get these strategies implemented. Major cities and industries will be required to measure their contributions to this problem, too."

From High Plains Midwest Ag Journal Jan. 20, 2014
http://www.hpj.com/archives/2014/jan14/jan20/0107AgriWomenJCsr.cfm

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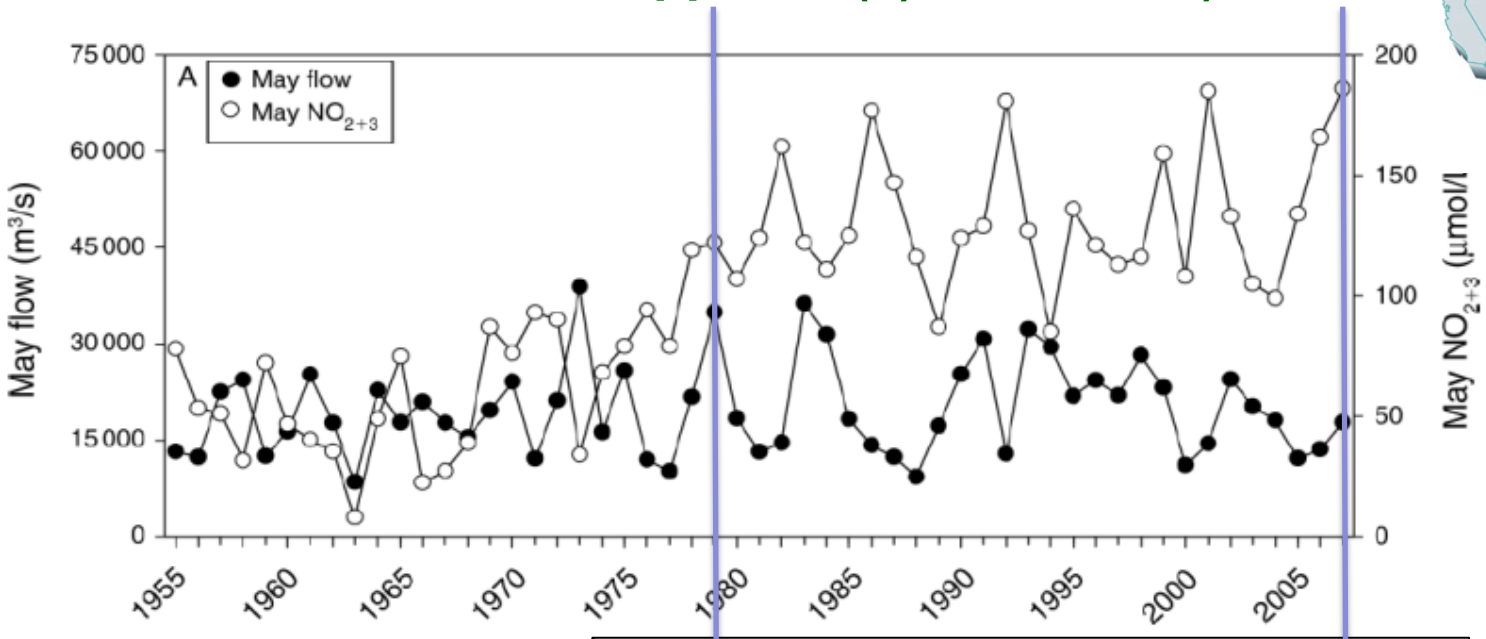
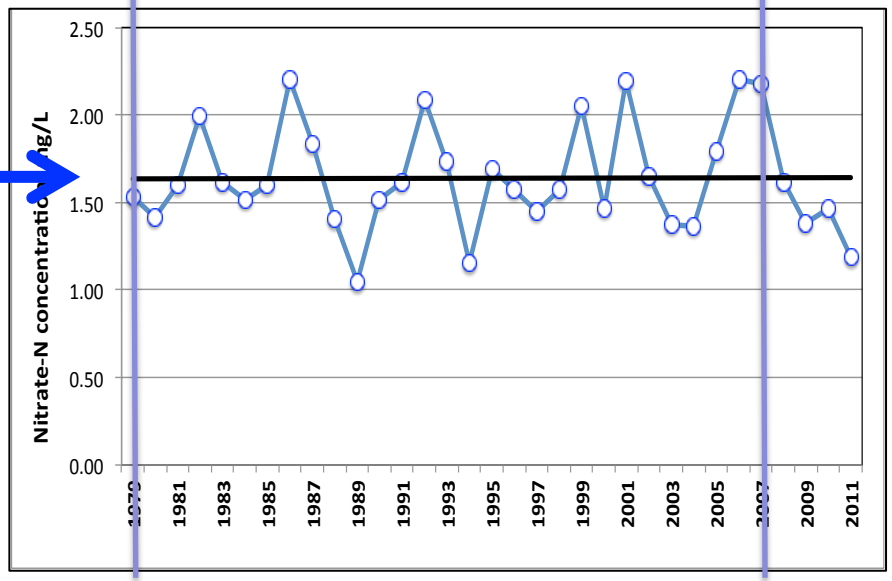
MARB River Flow and NO_3 Concentration in May

(Greene et al., 2009. Ecol. Applic.19(5):1161–1175)



Nitrate-N concentration

< 1.7 mg/L (ppm)



http://toxics.usgs.gov/hypoxia/mississippi/flux_ests/delivery/index.html

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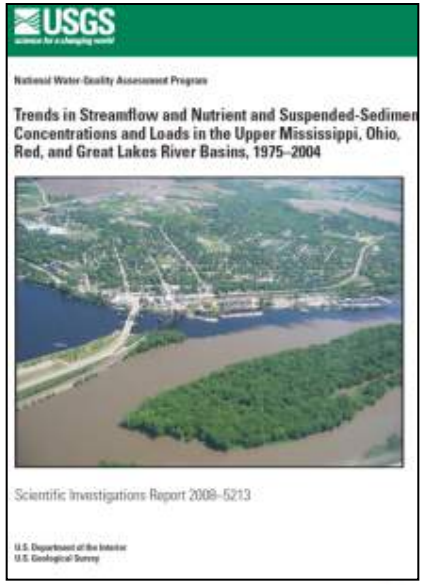
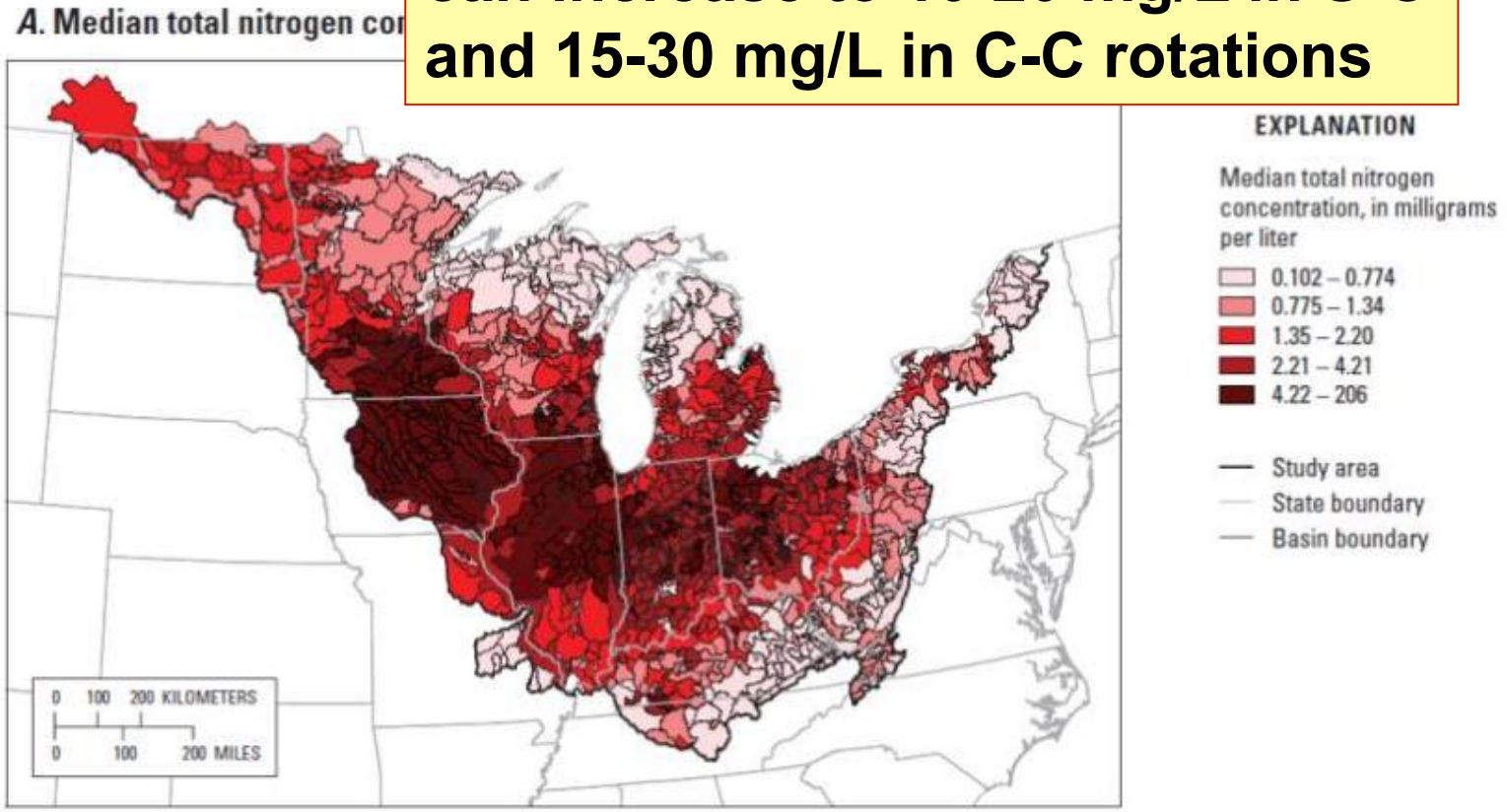


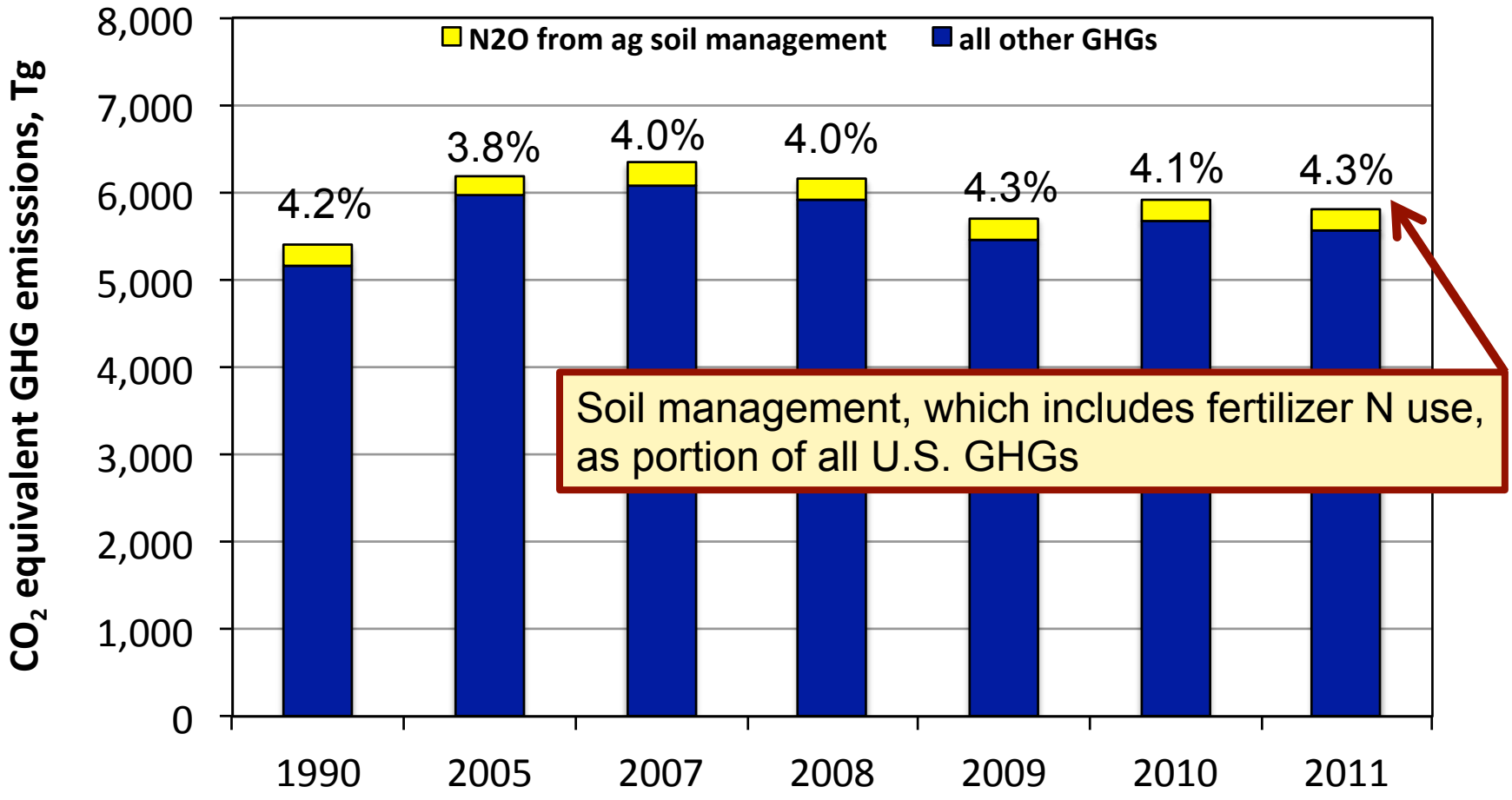
Trends in Streamflow and Nutrient and Suspended-Sediment Concentrations and Loads in the Upper Mis Great Lak 2004 (Lore

Sawyer and Randall. 2008. UMRSHNC Report (ASABE)

Corn systems where no fertilizer in 20^{+} years NO_3-N 3-10 mg/L , can increase to 10-20 mg/L in S-C and 15-30 mg/L in C-C rotations

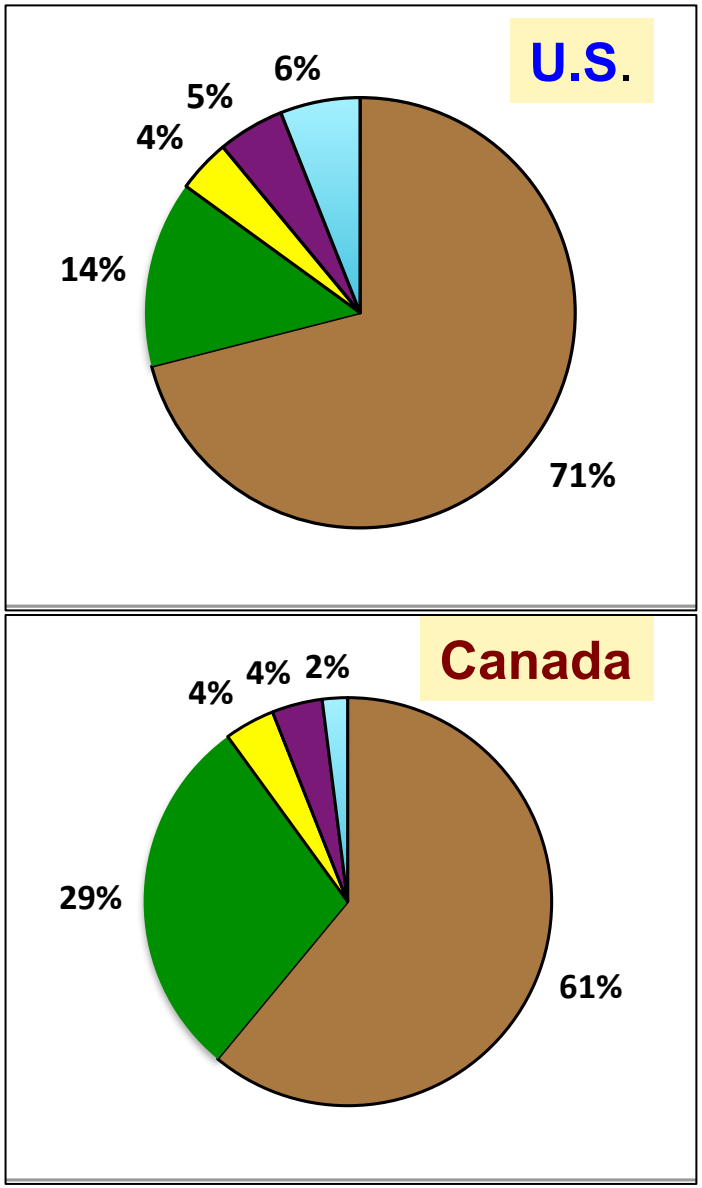


U.S. N_2O Emissions – Small Portion of All GHGs, and Little Increase Since 1990



Source: U.S. EPA Annual U.S. GHG Inventory, 2013 Report

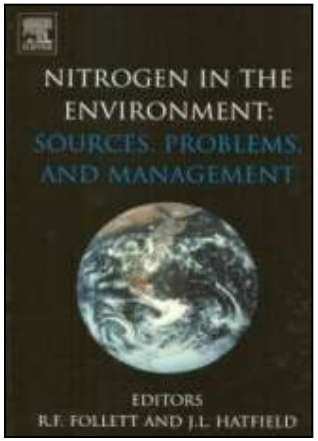
U.S. and Canada Ammonia Emissions

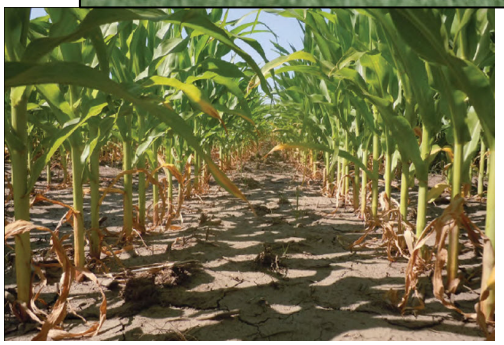


Bittman & Mikkelsen. 2009. Better Crops 93(1): 28-31
(data from USEPA, 2005; Environ. Canada, 2006)

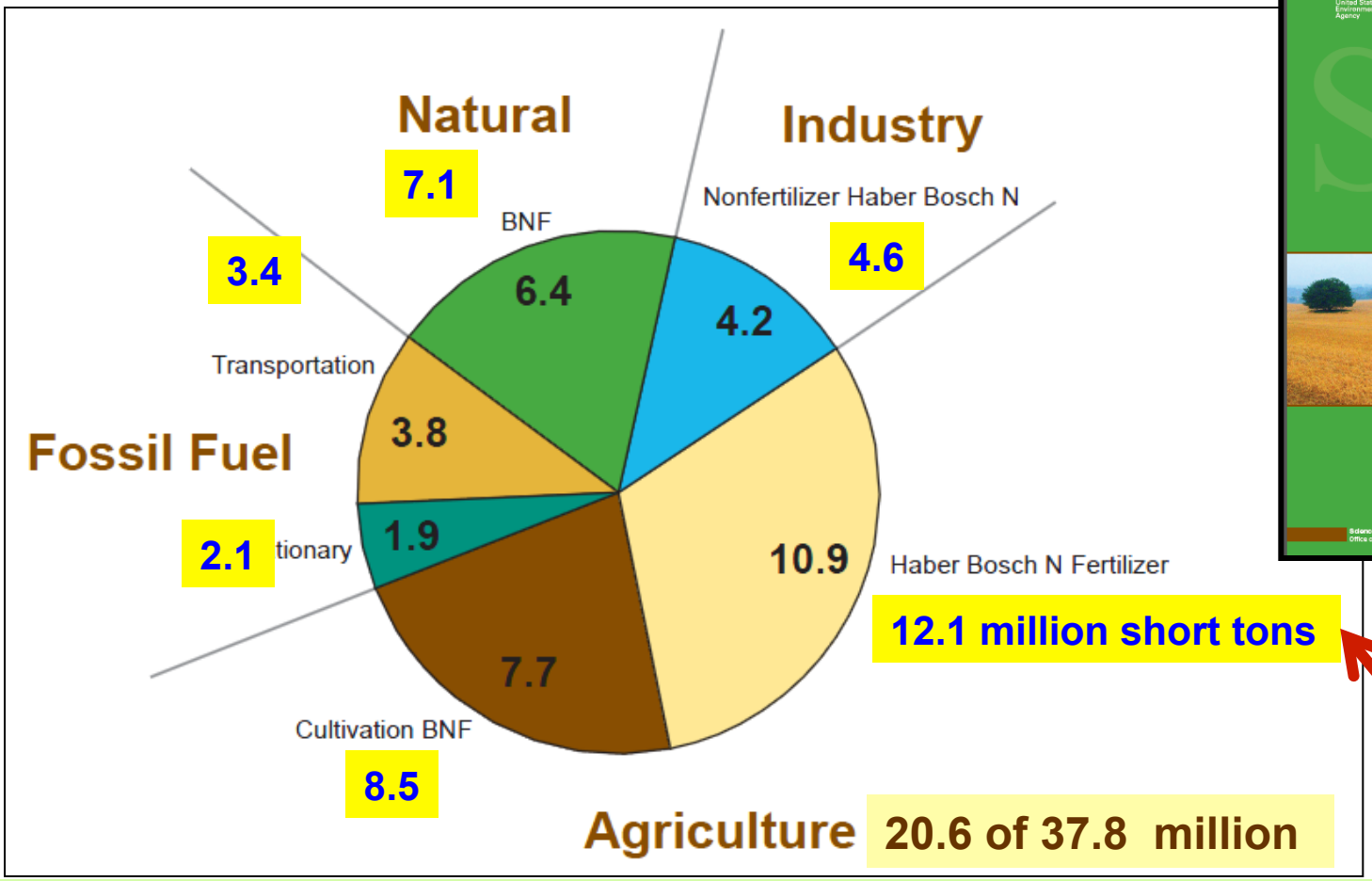
Nitrogen Recovery Efficiency by Major Cereals

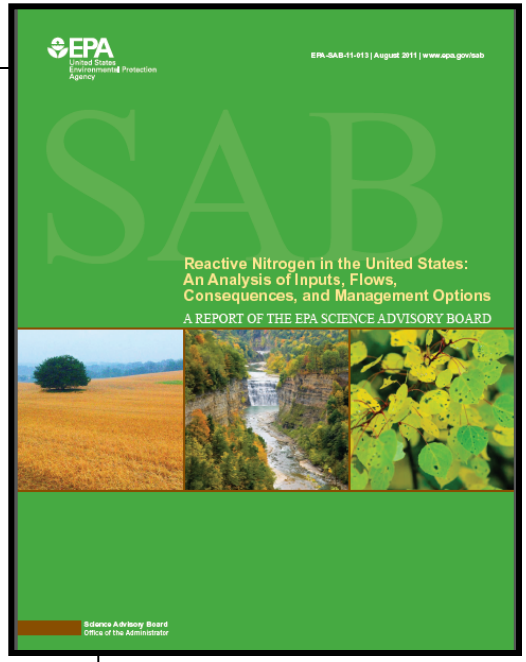
- **Nitrogen use efficiency** … "rarely exceeds 70% ……. often ranges from 30-60%"
- "conversion of N inputs to products for arable crops **can be 60-70% or even more**" (Kitchen and Goulding, 2001)





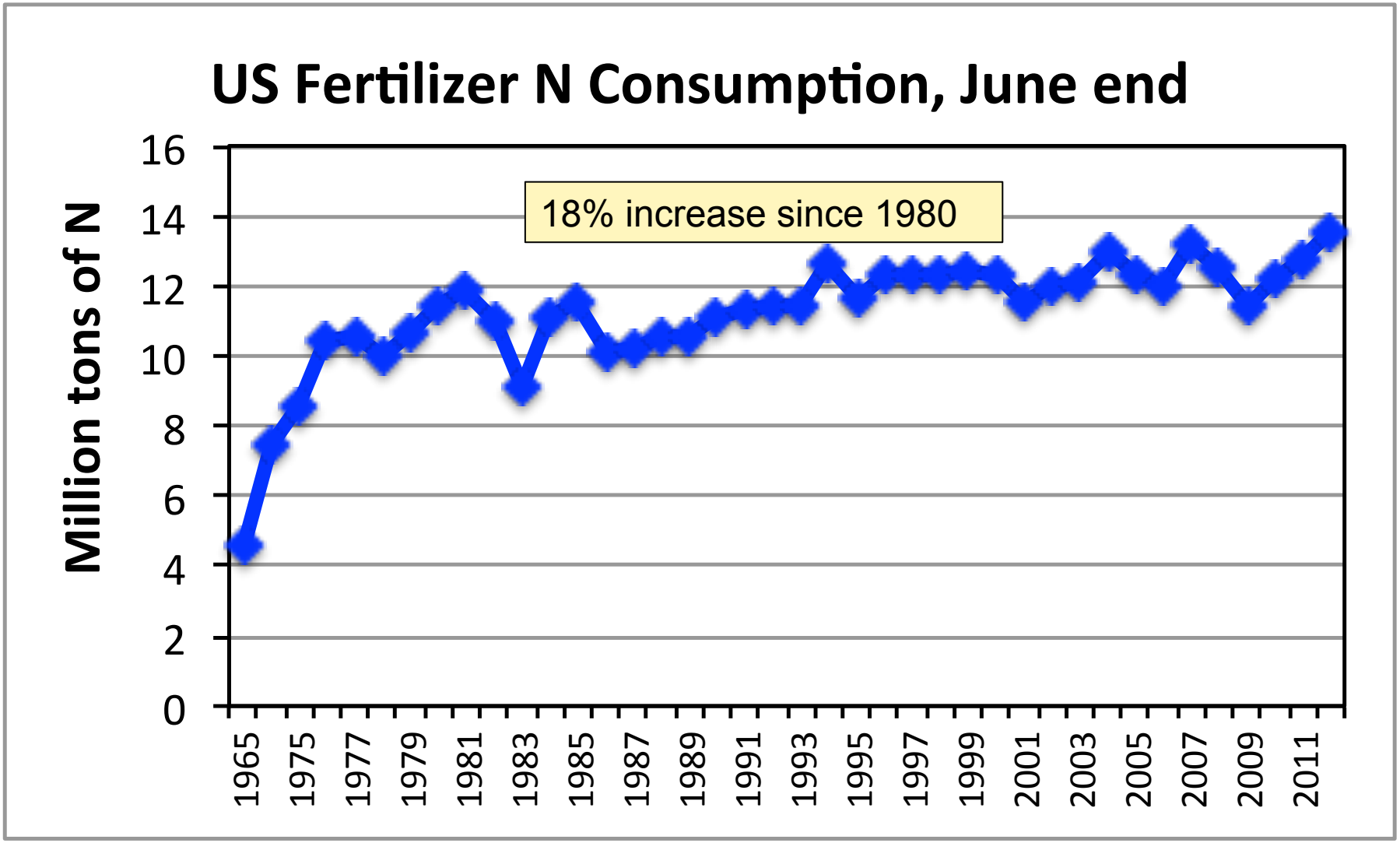
Sources of Reactive N (Nr) Introduced into U.S. in 2002 (Tg N/yr)





32% of N inputs

EPA SAB 2011 report: suggests crop N-uptake efficiencies be **increased by up to 25%** over current practices through a combination of knowledge-based practices and advances in fertilizer technology (such as controlled release and inhibition of nitrification).



Source: AAPFCO and TFI Commercial Fertilizers Report

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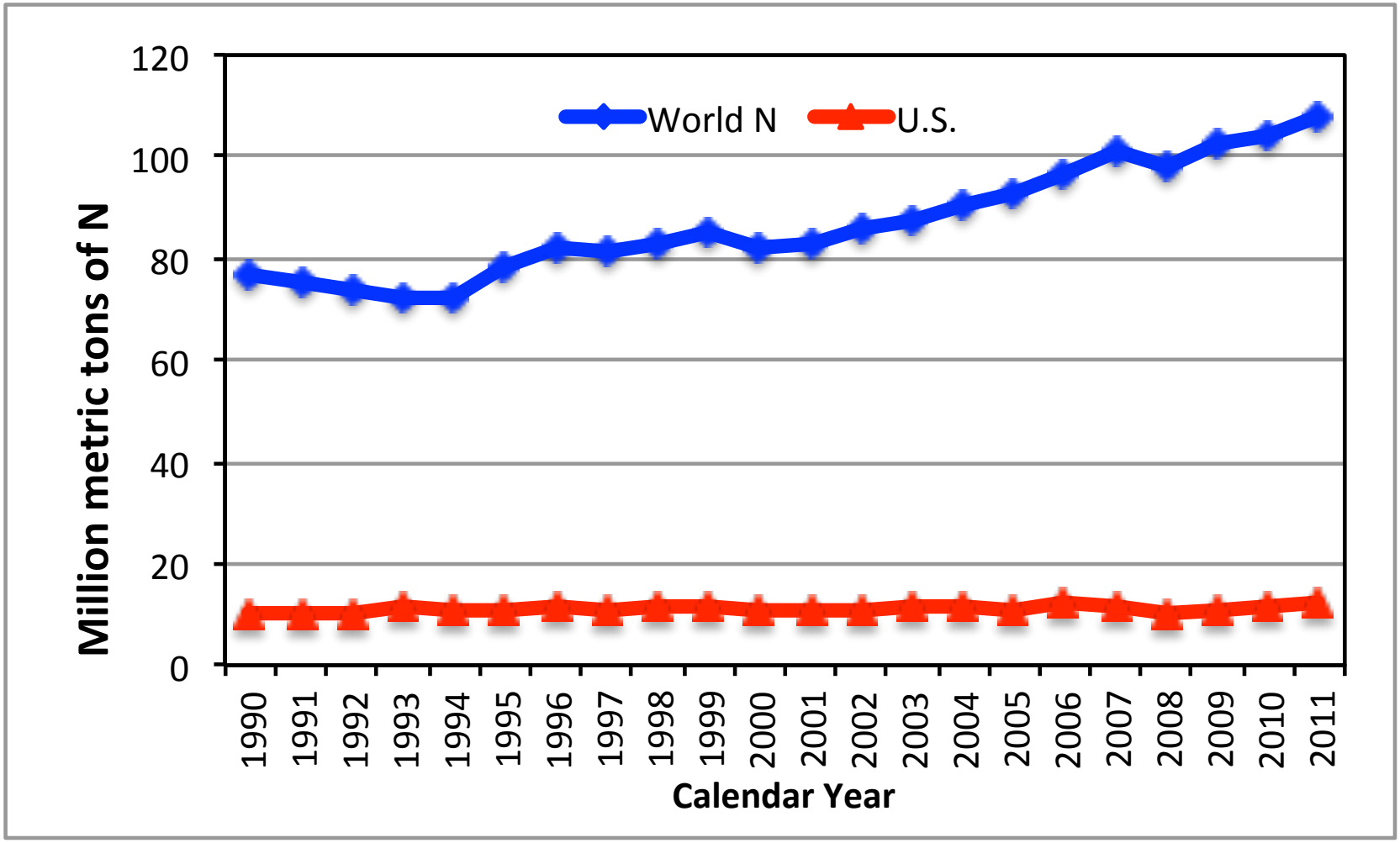
U.S. Fertilizer N Consumption is Becoming a Smaller Share of World Total



Source: IFA Statistics, 2014

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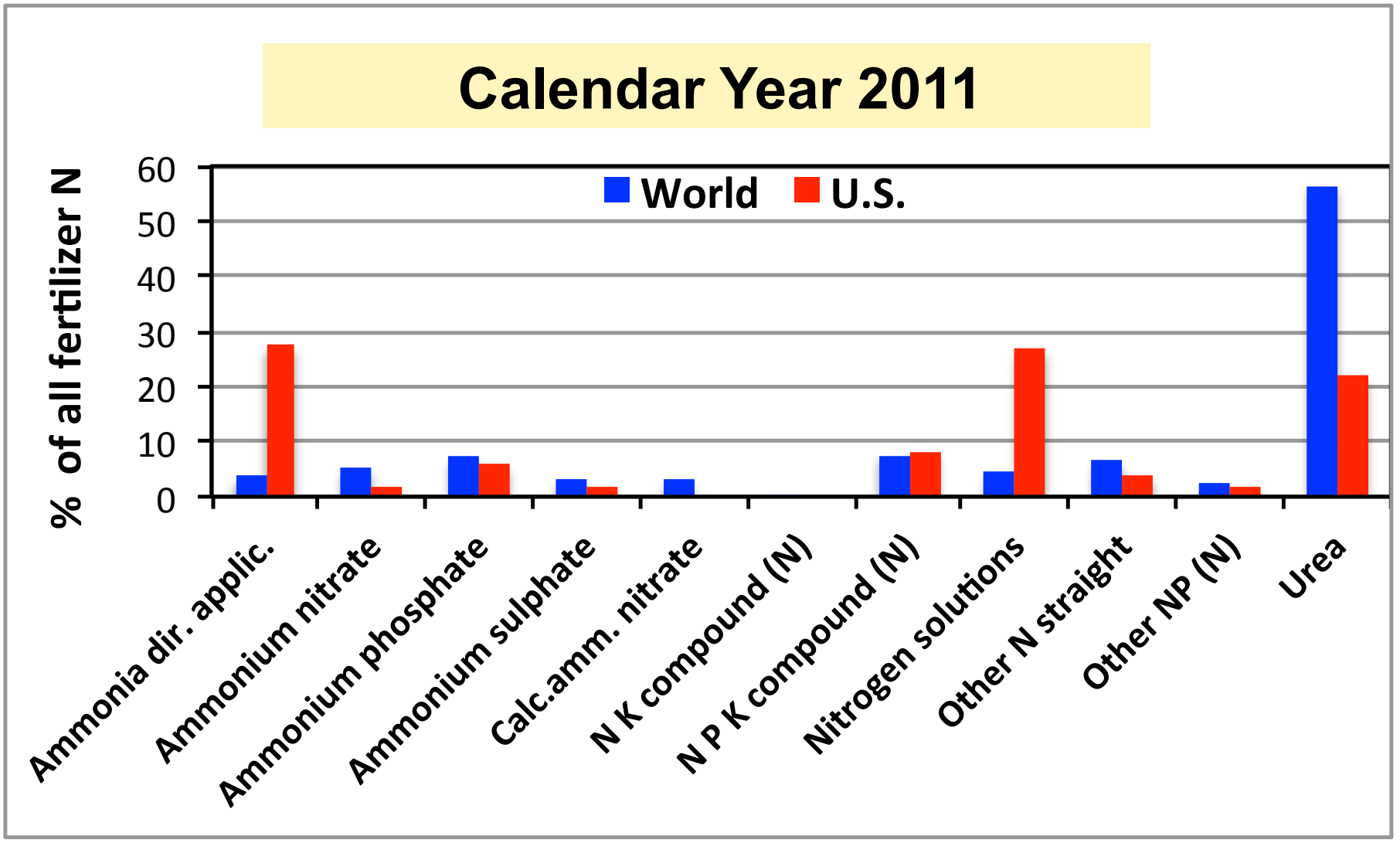
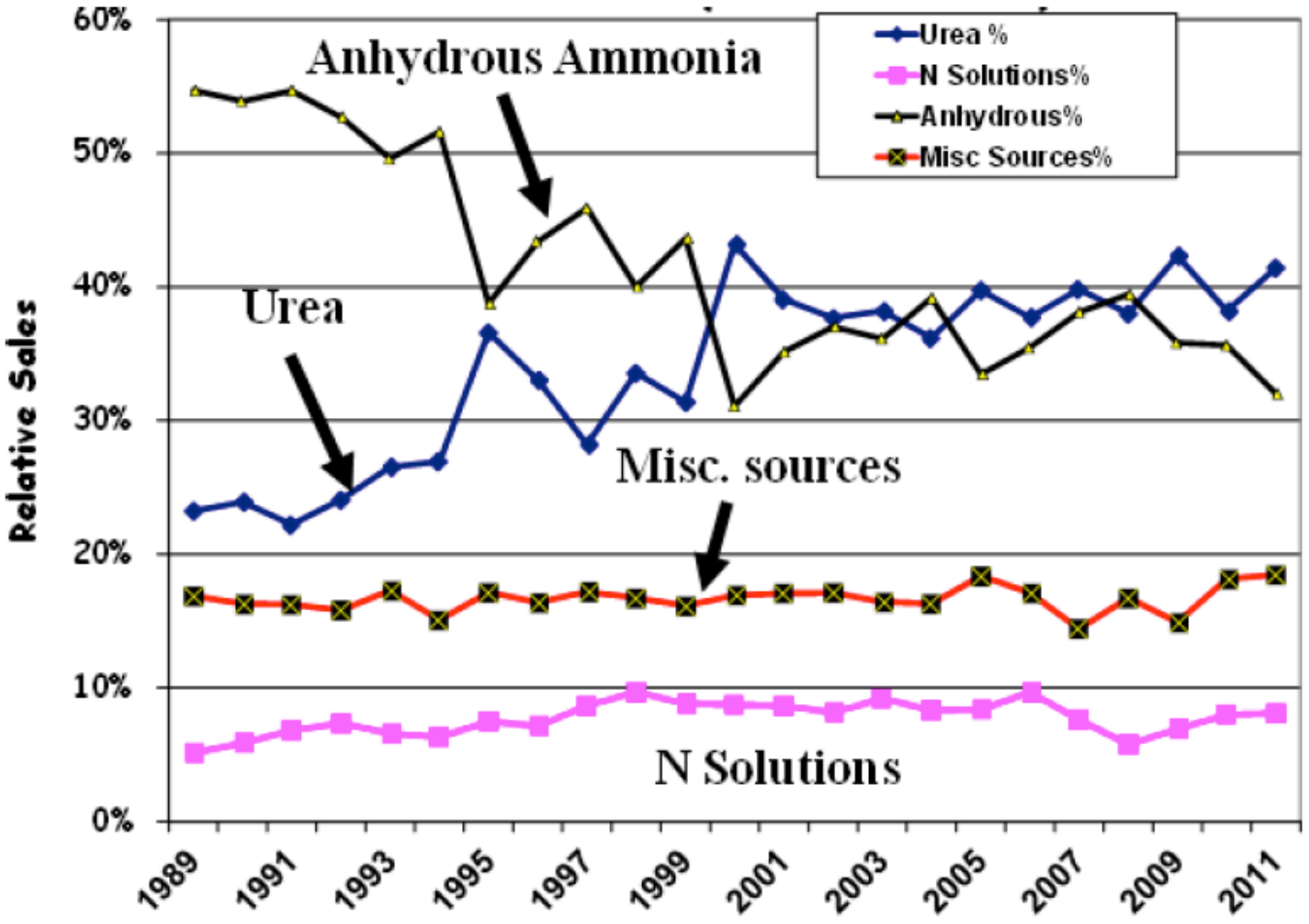
Fertilizer N Sources Used: World and U.S.



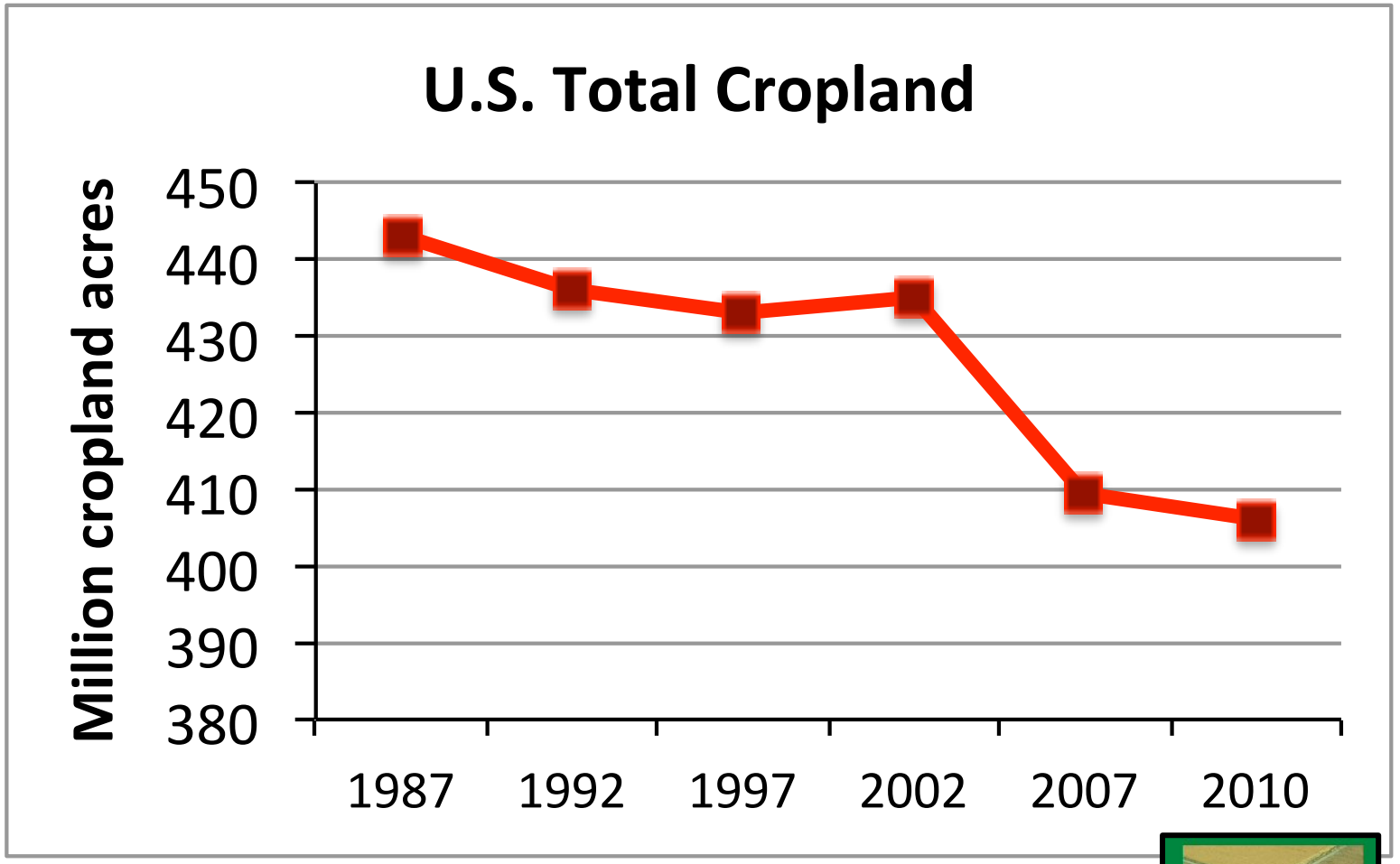
Data Source: IFA Statistics. 2014

Shifts in N Source Selection Are Occurring: in Minnesota for example

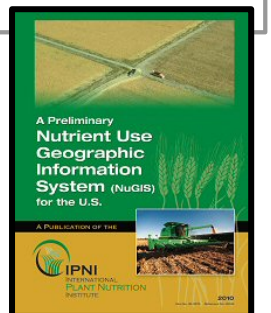


Source: Minnesota Department of Agriculture

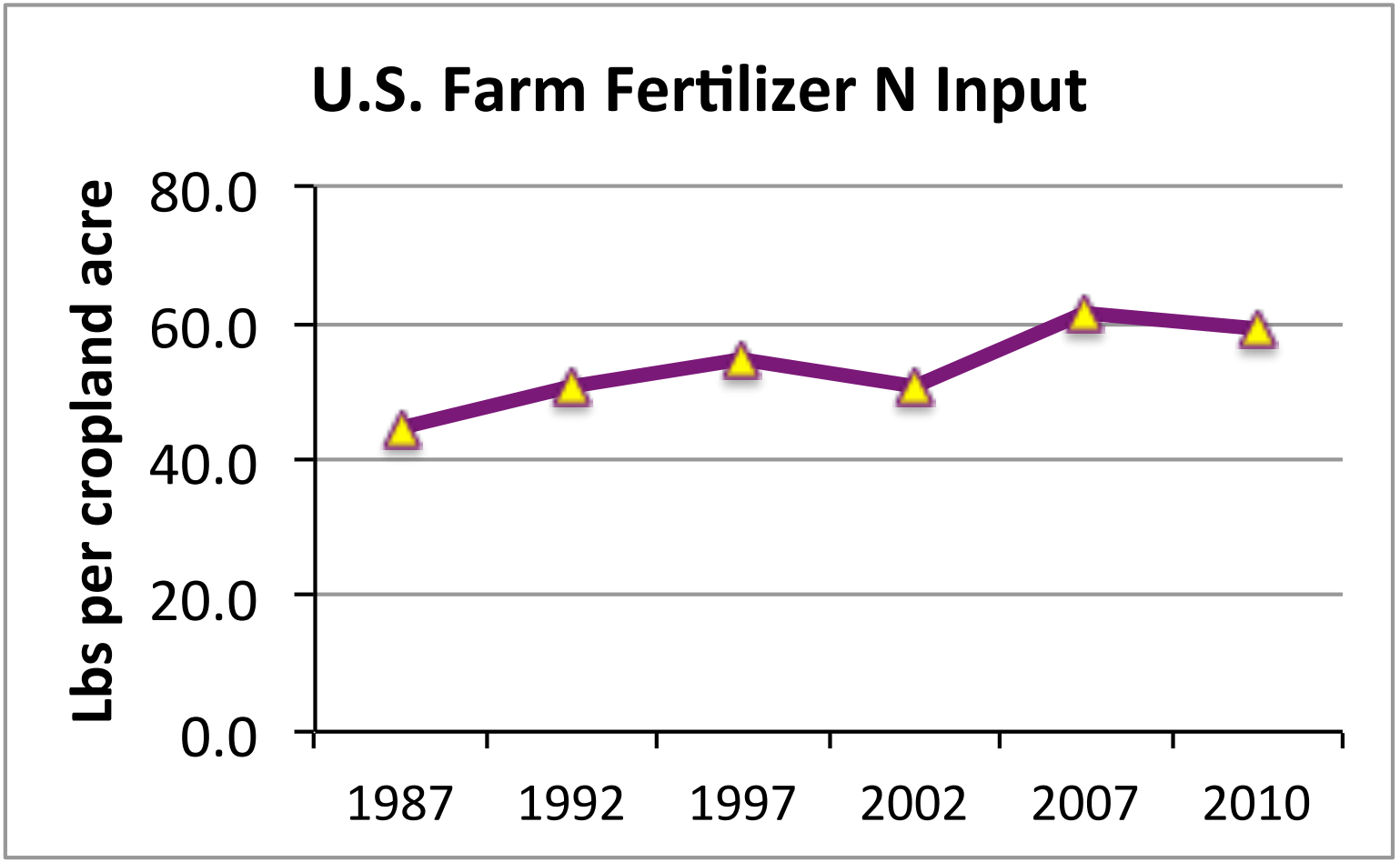
Total Cropland Acres Have Declined



Source: NuGIS, IPNI; using USDA data



Total Farm Fertilizer N Inputs Have Risen



Source: NuGIS, IPNI; using USDA data

Are Midwest Corn Farmers Over-Applying N?

States included in comparison:	Year			
IA, IL, IN, MI, MN, OH, WI	2000	2005	2010	**Avg**
	N, lb/A			
University recommended rate[1]	148	133	154	**145**
Avg USDA-surveyed rate[2]	138	143	138	**140**
Difference	**-11**	**10**	**-15**	**-5**

[1]Maximum rate of return using the 'Corn N Rate Calculator' for corn following soybeans. [2]For corn acres receiving N.

Iowa State U.

Hoeft– U. of Illinois

Snyder. 2012. Better Crops 96(2): 3-4

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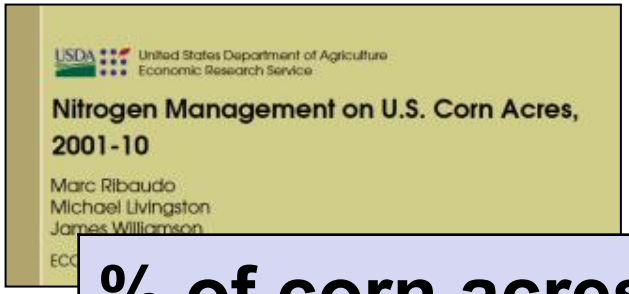

N rates >40% above crop grain harvest N removal were considered "excess"

% of corn acres not meeting N rate "criteria"

	2001	2005	2010
Appalachia	52	66	56
Corn Belt	46	38	30
Lake States	46	34	29
Southwest	31	32	28
TOTAL	**41**	**35**	**31**

"Despite improvements in N application rates, about 66 percent of corn acreage does not achieve the rate, timing, and method criteria that minimize environmental losses of N."

http://www.ers.usda.gov/publications/eb-economic-brief/eb20.aspx#.UkXILrx4MlY

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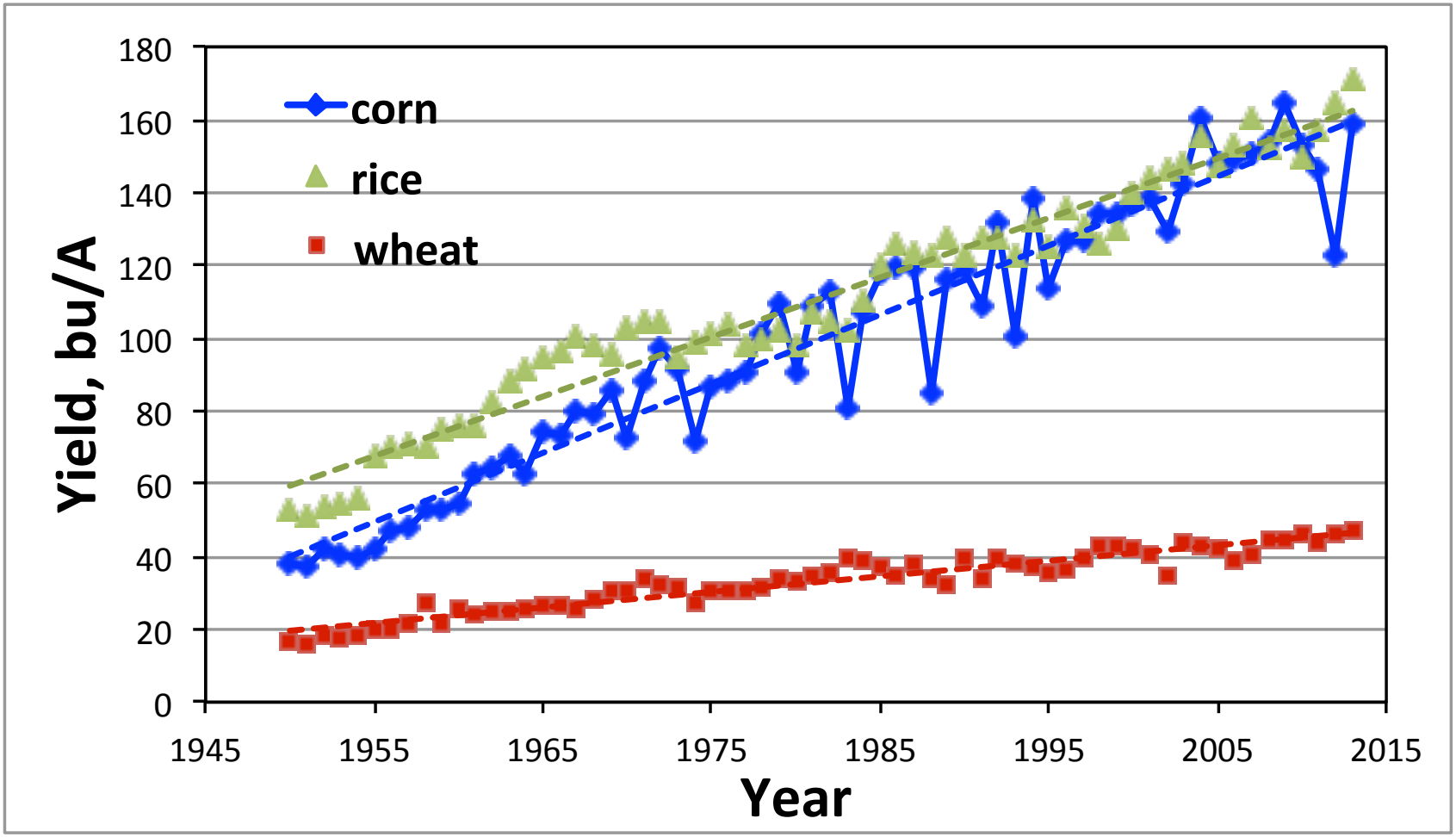
Yield Trends of Major U.S. Cereal Grains



Source: USDA NASS data

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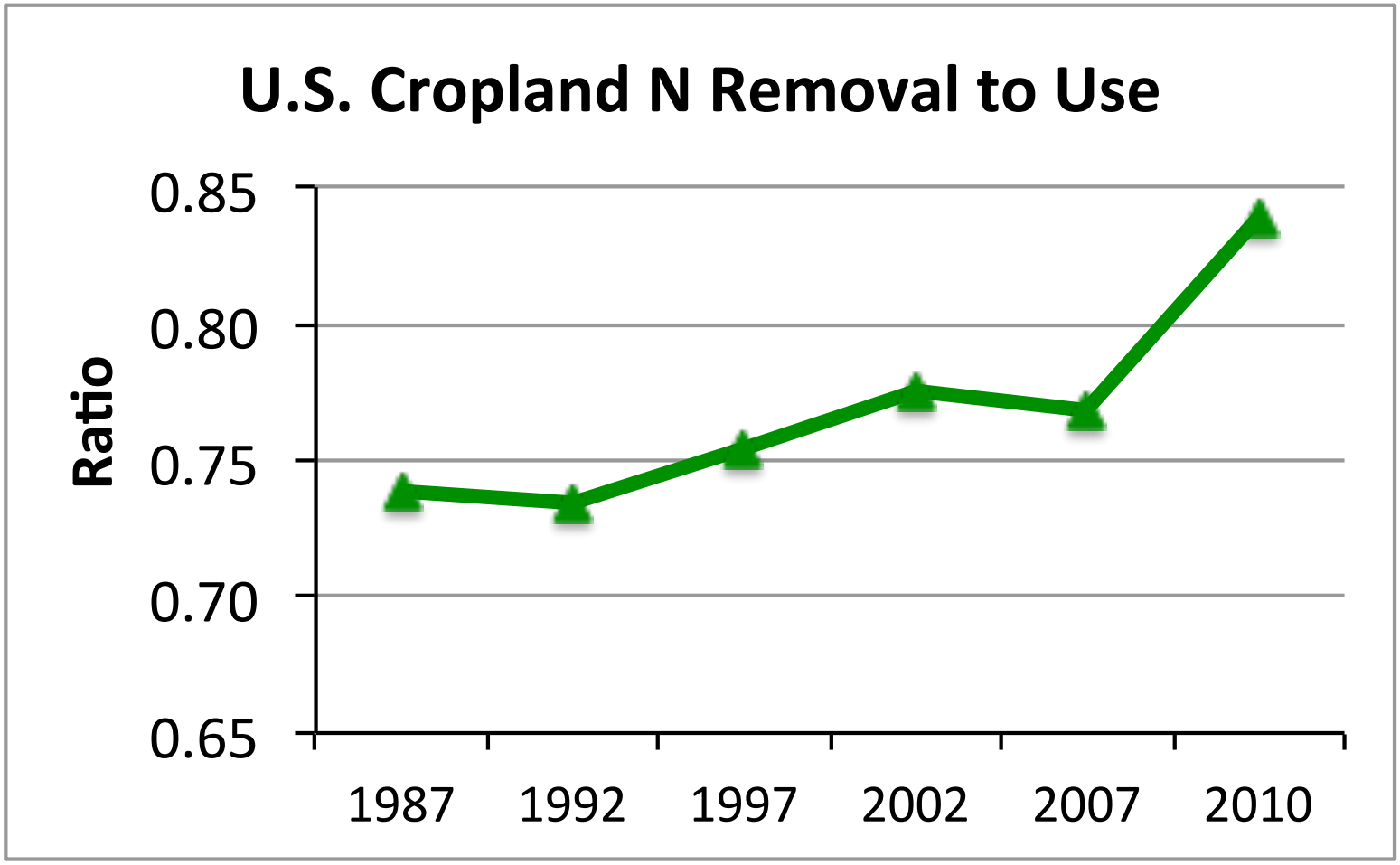
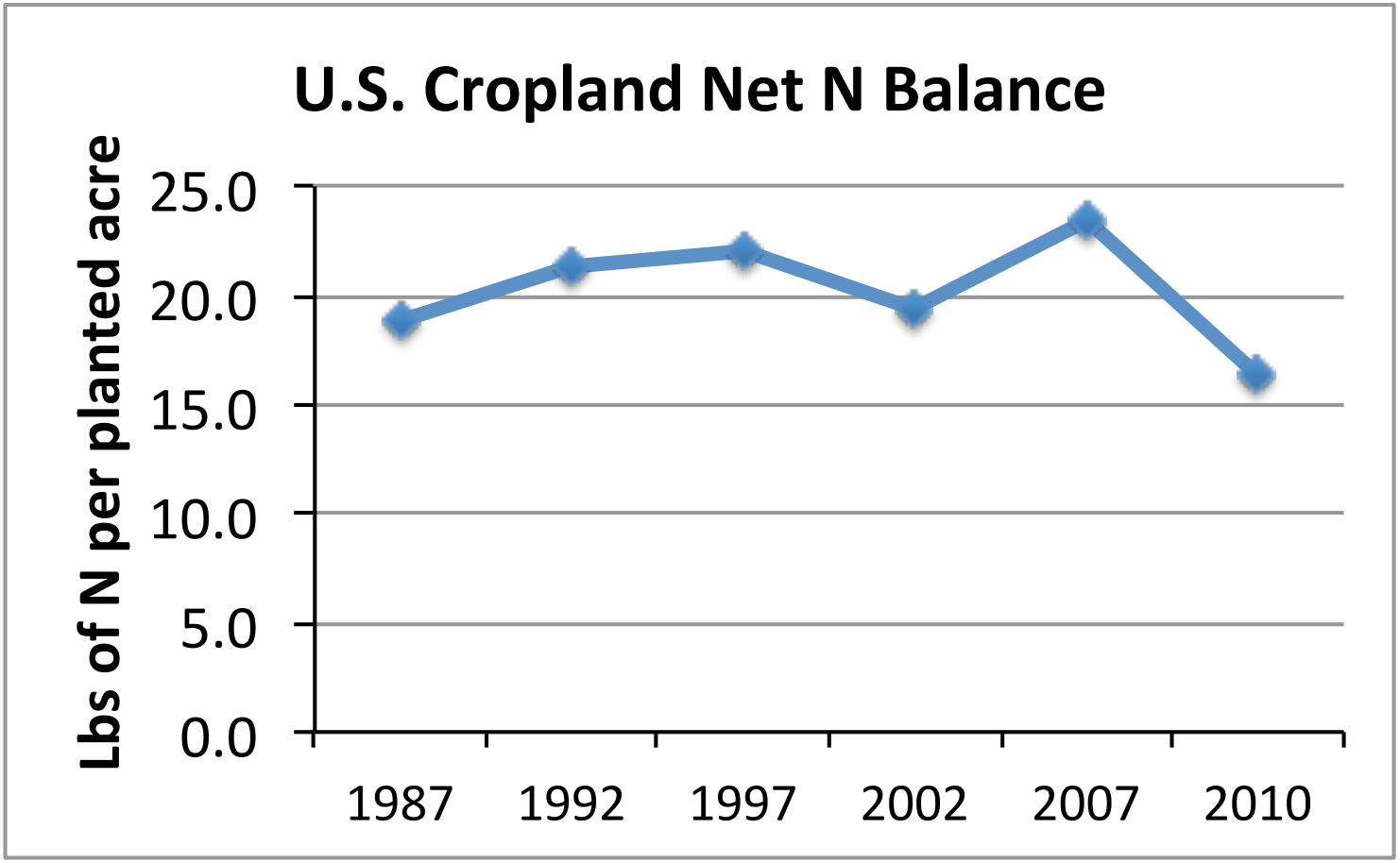
Crop N Removal to Use Ratio Has Increased



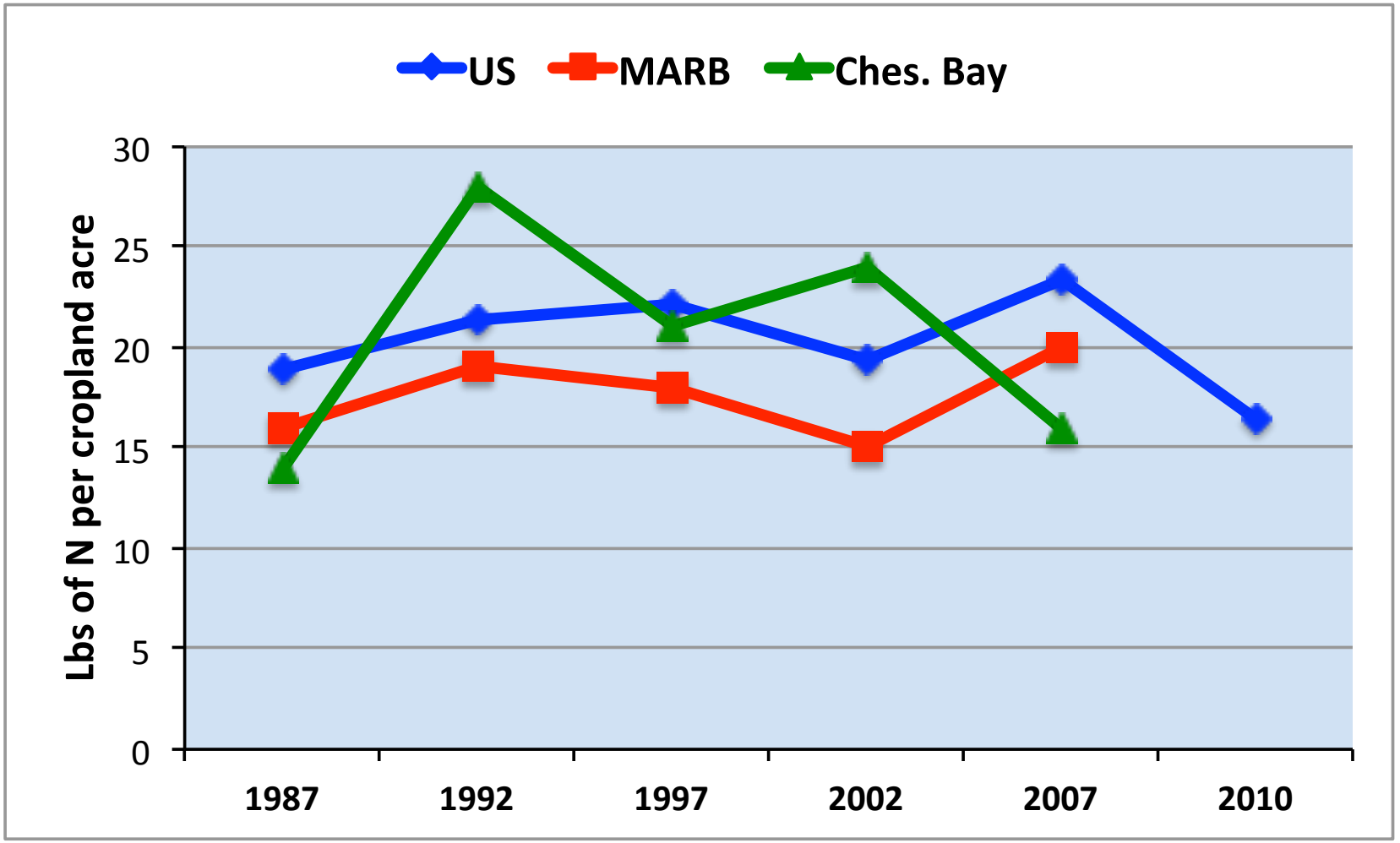
Source: NuGIS, IPNI; using USDA and AAPFCO data

Cropland Net N Balance Has Varied, but May be Trending Downward



Source: NuGIS, IPNI; using USDA and AAPFCO data

Cropland N Balance – Selected Watersheds



Source: NuGIS, IPNI; using USDA and AAPFCO data

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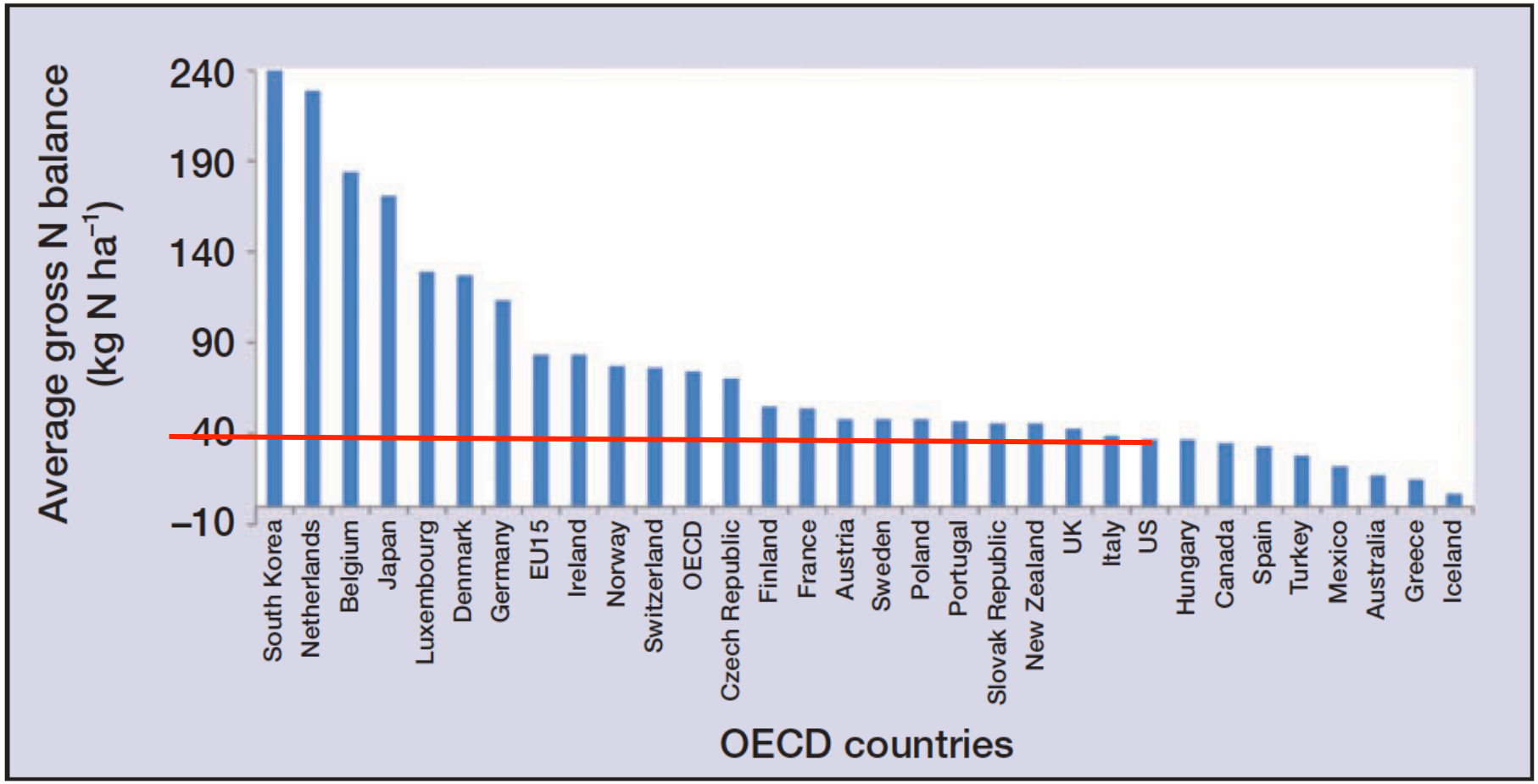
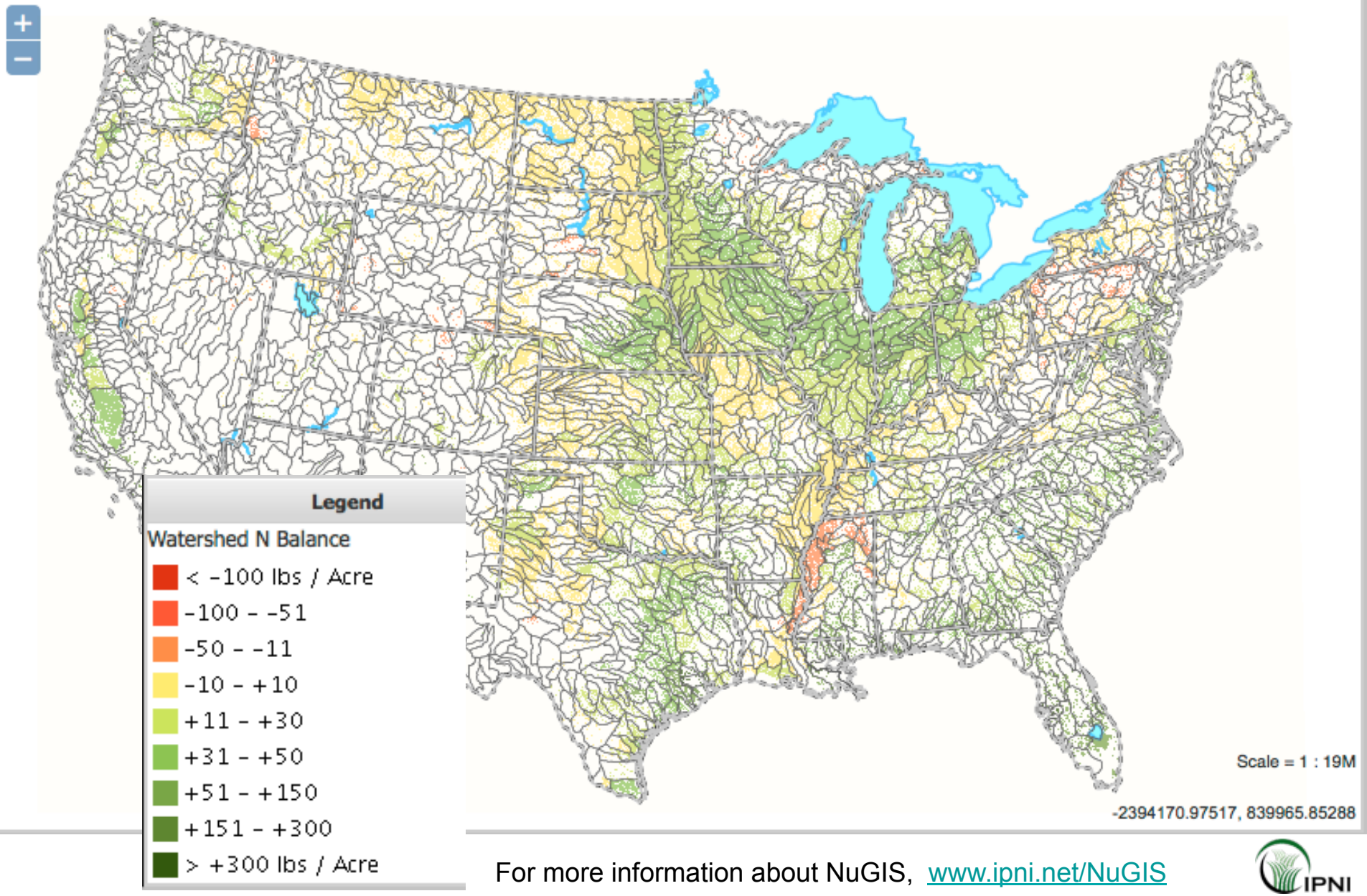
U.S. N Balance: Lower Than in Many Other Countries, 2002-2004 (OECD data)



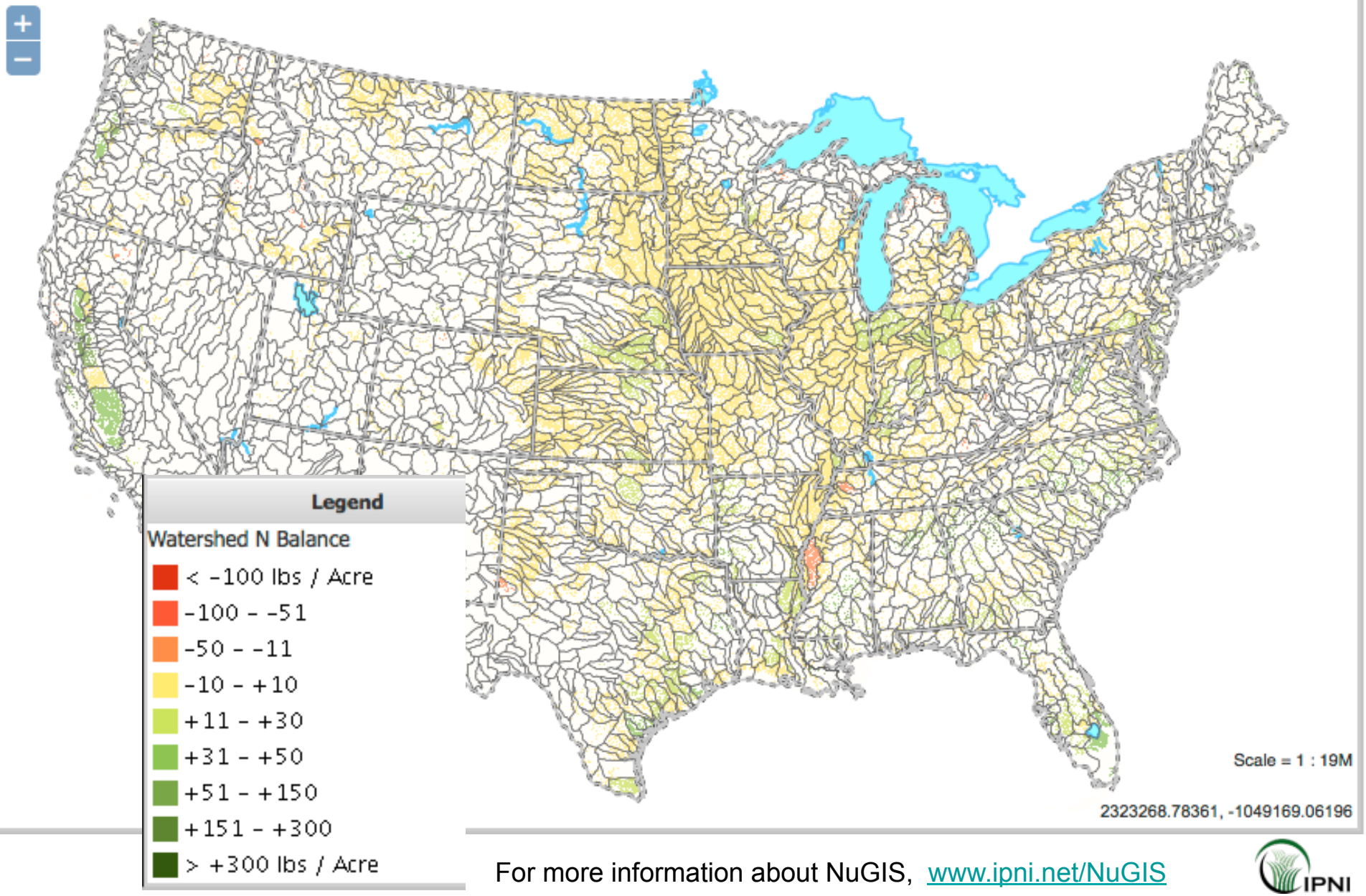
Average gross N balance estimates for OECD countries, 2002–2004.
Source: Cavigellii et al. Front Ecol Environ 2012; 10(10): 537–546,
Gross N balance = ([fertilizer N + manure N + legume N fixation + N deposition] – N removal by crops)

Watershed N Balance,1987



For more information about NuGIS, www.ipni.net/NuGIS

Watershed N Balance, 2010



For more information about NuGIS, www.ipni.net/NuGIS

Grain per Unit of N Applied is Increasing

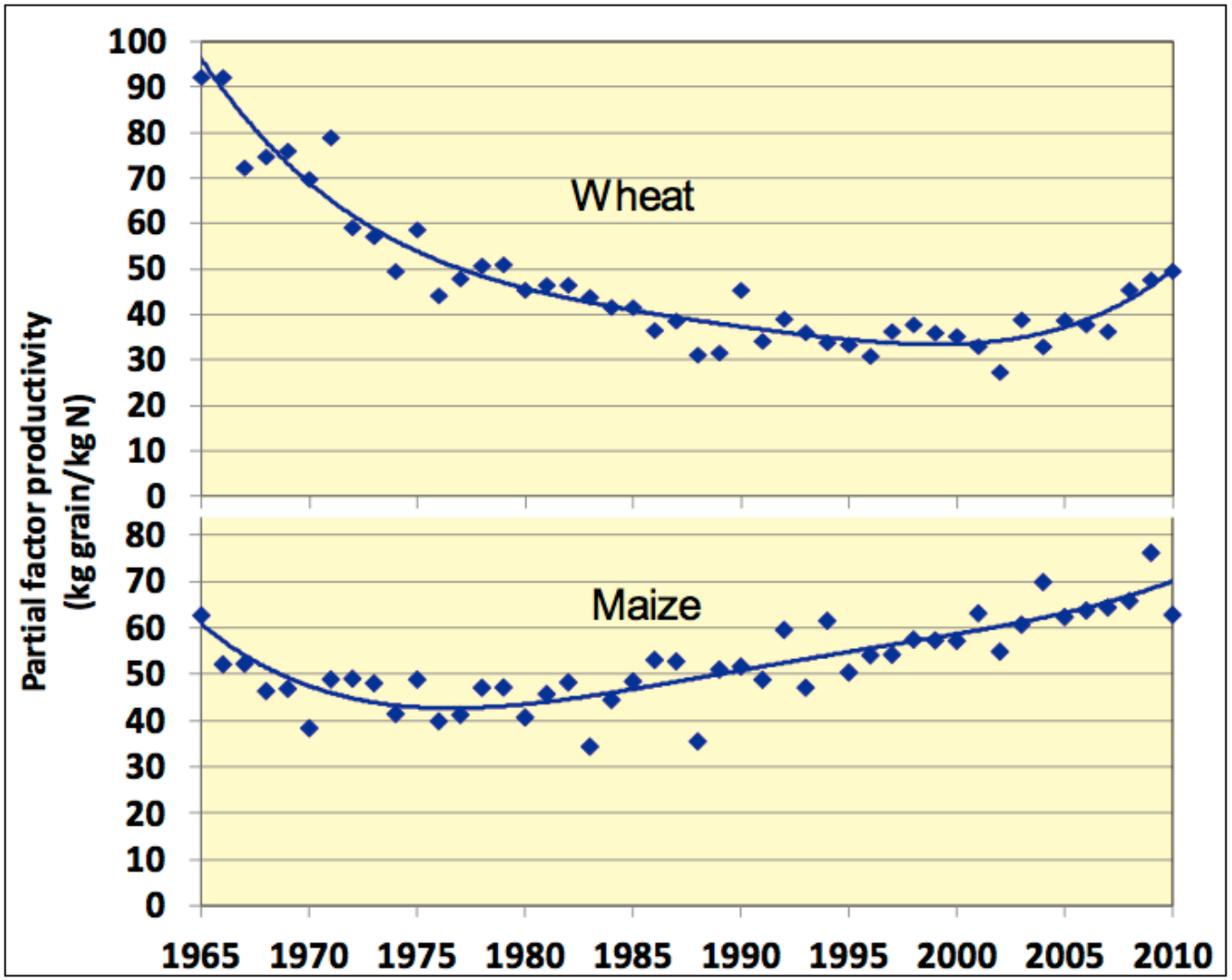


Figure 4. Partial factor productivity in the U.S. for fertilizer N used on maize and wheat from 1965 to 2010 (Adapted from USDA-ERS and USDA-NASS, 2011).

Fixen et al. 2014. accepted for publication, IFA

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N Use Efficiency ≠ N Performance

- Crop nutrients are applied to increase overall cropping system performance
- NUE is only one aspect of that system performance
- NUE offers no insights into soil fertility, soil organic matter, or other soil quality characteristics
- Each NUE term provides unique indication of potential for improved fertilizer management, but none alone provide a full representation of the impact on overall performance

Source: P. Fixen, with adaptation, 2014

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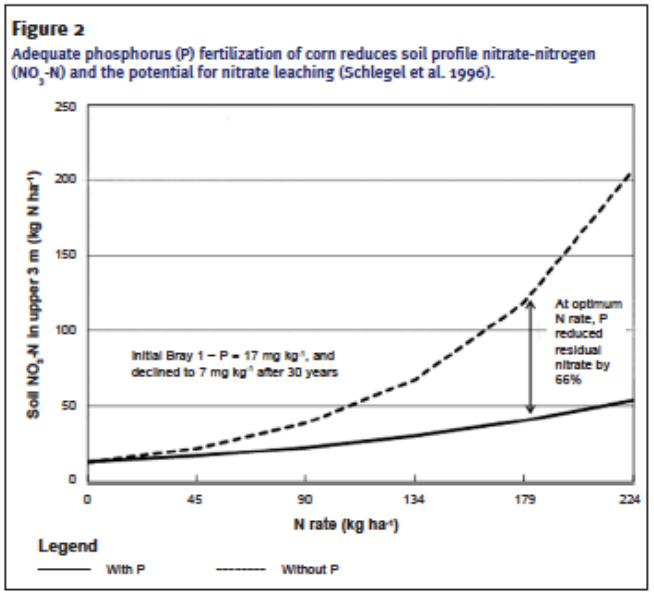
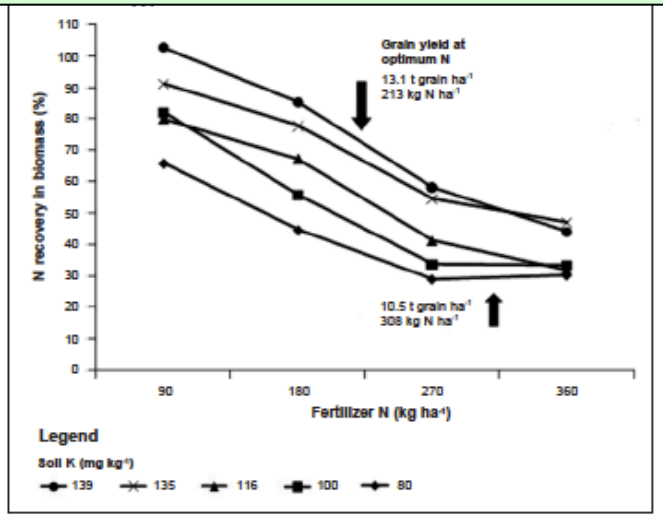
N Management and Balanced Nutrition

- **P and K soil fertility levels are below optimum and need improved (IPNI, 2010)**
  - 2010 median **soil P**=25 ppm: a 6 ppm decline since 2005; approximately 42% of samples <20 ppm agronomic optimum
  - 2010 median **soil K** =150 ppm: a 4 ppm decline since 2005; approximately 34% of samples <120 ppm agronomic optimum



Optimum P and K enhance crop N recovery



Snyder & Fixen. 2012. J. Soil Water Conserv.

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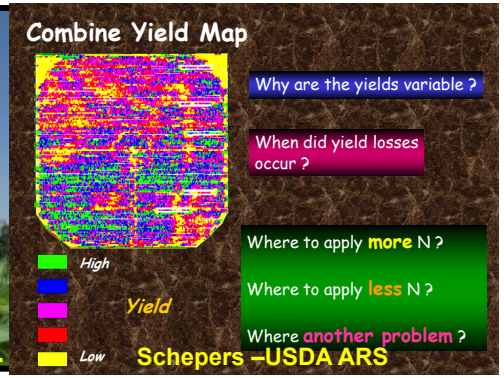
Many Factors Are Contributing to Changes in Nutrient Management and Educational Needs



Major changes in fertilizer costs or crop prices

Climate change induced shifts in cropping patterns, yields, soil processes

Genetic changes that alter crop yields and NUE

Changes in crop species due to bioenergy

Changes in plant parts harvested due to bioenergy

Manure composition changes due to distillers grains

Application of bioash

Government policy

Fertilizer and equipment technology & tools

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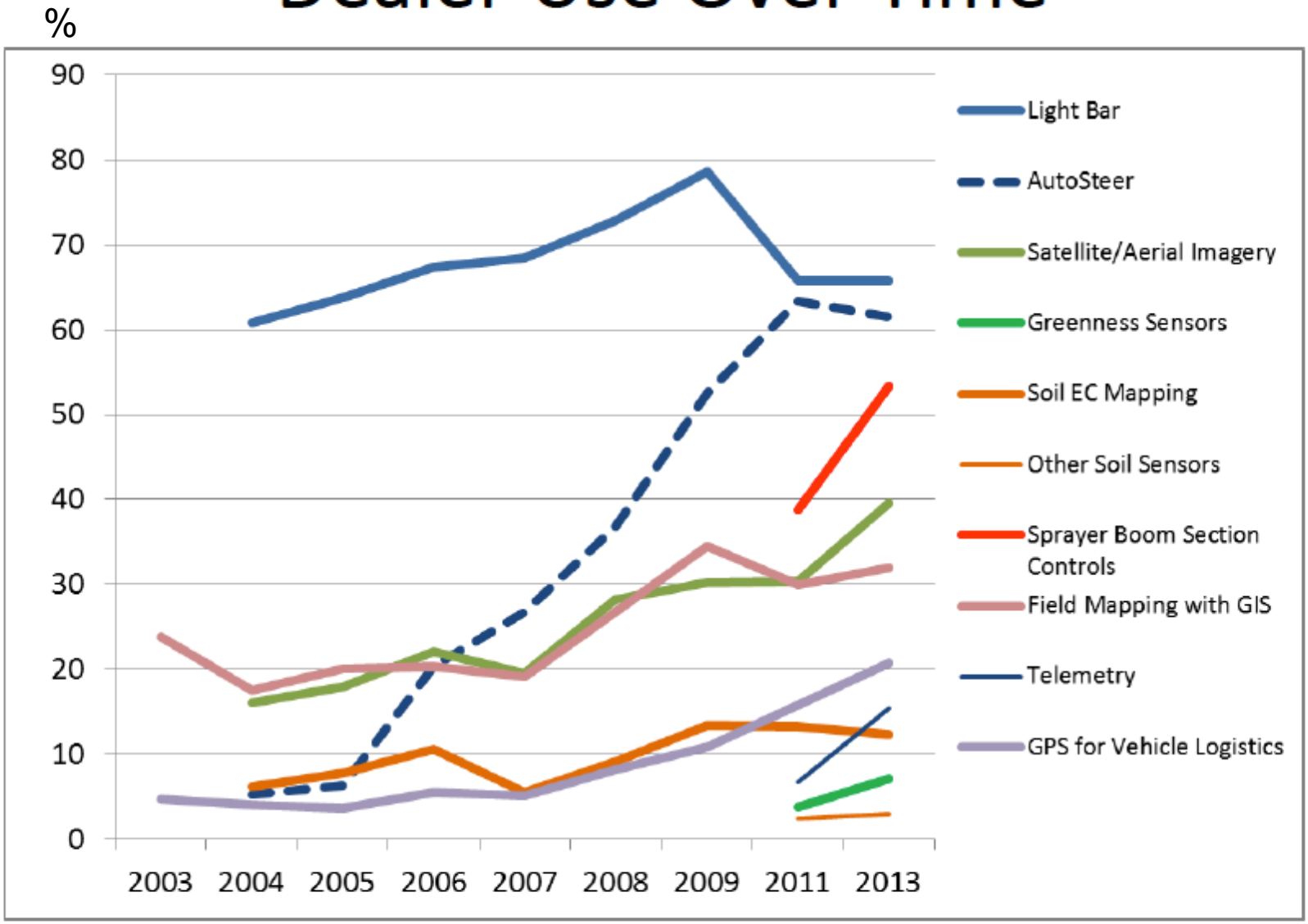
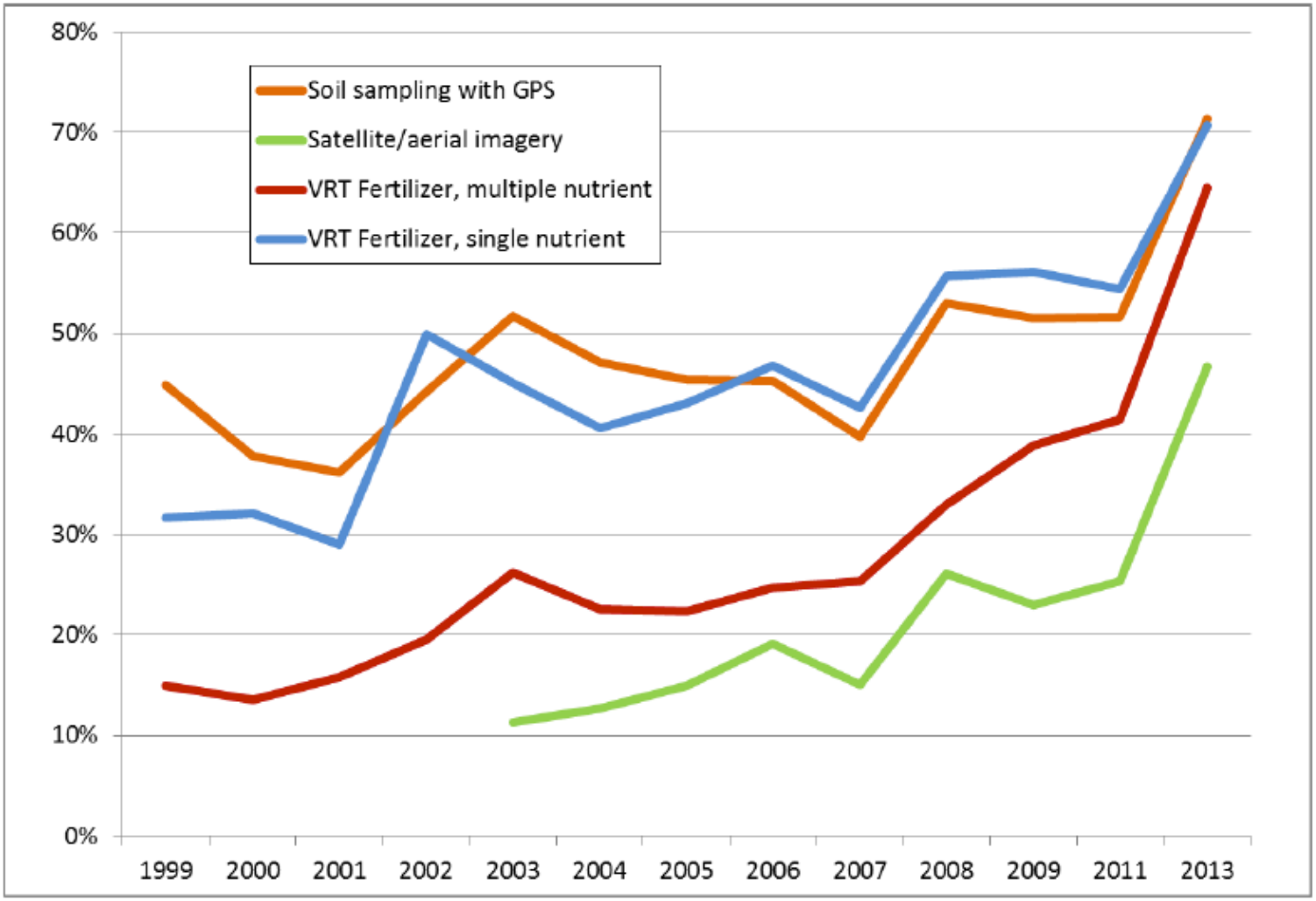
Dealer Use Over Time



Purdue/CropLife Precision Dealer Survey

Source: Bruce Erickson, Am. Soc. Agron. –InfoAg 2013

Dealer Offering Over Time



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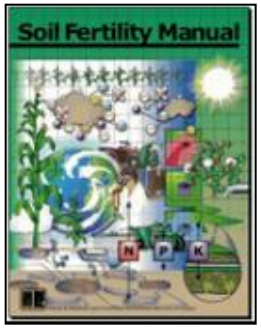

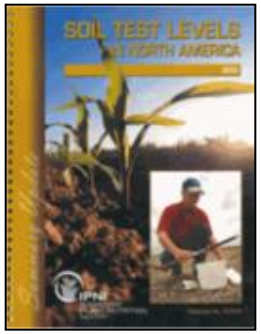

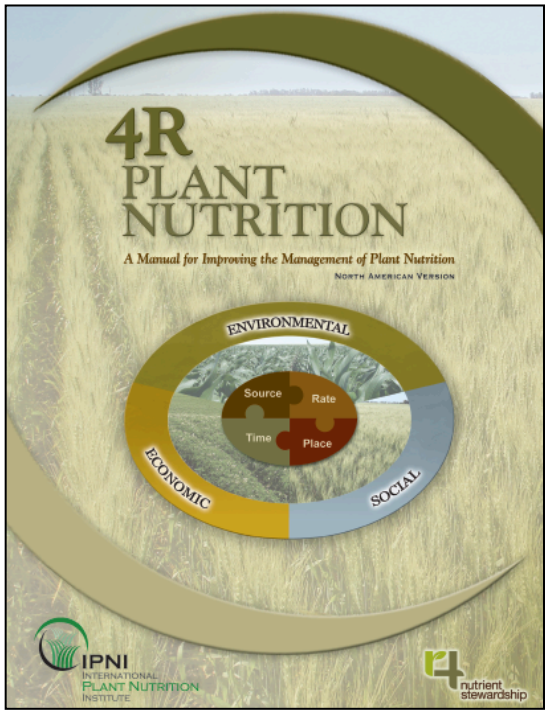

nutrient stewardship

4R Nutrient Stewardship Education & Outreach

- Intensified education: North America and globally
- CCA and ag professional training
- Working with state & provincial fertilizer associations, & water quality agencies in key watersheds
- Involved in:
  - USDA NRCS: CEAP Assessment reviews
  - UNEP & USDA Climate Change Office: N_2O mitigation science committees
  - EPA: annual GHG inventory review
  - U.S. Research Coordination Network for Reactive N in Environment

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Crops & Soils

agronomy for practicing professionals

American Society of Agronomy

Agronomy Feeds the World

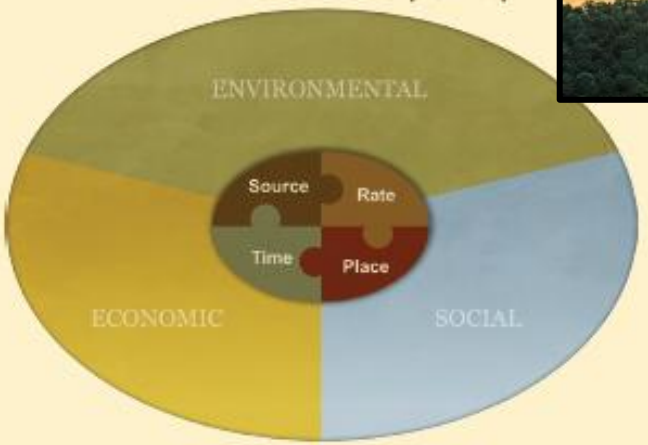
2009
42:2-5

Know your fertilizer rights

IPNI International Plant Nutrition Institute

A five-part series created by the International Plant Nutrition Institute

The 4R Nutrient Stewardship Concept



An American Society of Agronomy Publication

ASHS American Society for Horticultural Science

The "4R" Nutrient Stewardship Framework for Horticulture

Robert L. Mikkelsen[1]

5 articles

HortTechnology. 2011. 21(6)

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Soil Science Society of America

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NITROGEN USE EFFICIENCY

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PAST CONFERENCE (AUGUST 2013)

IMPROVING NITROGEN USE EFFICIENCY IN CROP AND LIVESTOCK PRODUCTION SYSTEMS: EXISTING TECHNICAL, ECONOMIC, AND SOCIAL IMPEDIMENTS AND FUTURE OPPORTUNITIES

Kansas City Marriott Country Club Plaza, Kansas City, MO

Sponsored by

IPNI International Plant Nutrition Institute

Reactive Nitrogen RCN Research Coordination Network

CONFERENCE WRAP UP

View the **World Cafe Discussion** results.

View the **poster abstracts** that were presented at the Nitrogen Use Efficiency Conference.

View the **oral presentation slides** that were presented at the conference.

WHO SHOULD ATTEND ?

This conference will bring together agronomists, biogeochemists, farmers, economists, sociologists, extension … blic and private sectors to identify the major impediments to improved nutrient management and to make recommendati…

Also sponsored by

Soil Science Society of America

AGU American Geophysical Union

The Woods Hole Research Center

INI International Nitrogen Initiative

The Fertilizer Institute Nourish, Replenish, Grow

» **View the Program Agenda** (PDF)

» **View the Poster abstracts**

» Print and share the **Nitrogen Use Efficiency Flyer** (PDF)

APPROVED CEUS

Nutrient Management: 5.5

https://www.soils.org/meetings/specialized-conferences/nitrogen-use-efficiency

IPNI

A Growing Interest in Cover Crops

IPNI INSIGHTS
INTERNATIONAL PLANT NUTRITION INSTITUTE

September 2012

Capturing Residual Soil Nitrogen with Winter Cereal Cover Crops

Snyder and Meisinger

American Society of Agronomy

"Cover Crops"
March 6-27, 2014

FREE Public Informational Webinar Series

FREE TO PUBLIC

Commodity Classic
Where America's farmers meet with success.

America's largest farmer-led, farmer-focused convention & trade show.

February 27-March 1 2014 San Antonio On Board for Profits

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Cover Your Assets: Improve Productivity, Efficiency and Soil with Cover Crops

Soil and Water Conservation Society
Healthy Land Clean Water For Life

Effective Cover Cropping in the Midwest

CONSERVATION COVERS December 7-8, 2011
EFFECTIVE COVER CROPPING IN THE MIDWEST

See a map of where the attendees came from...

EFFECTIVE COVER CROPPING IN THE MIDWEST

Click to watch conference videos

INDIANA ECONOMIC DIGEST
Daily News on Business and Economic Events throughout Indiana

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home : most recent : agriculture | share | January 28, 2014

10/14/2013 5:48:00 PM

Farmers increasingly turning to 'cover crops'

Teresa Auch Schultz, Post-Tribune

Porter Township farmer Keith Gustafson is spending his fall as most farmers do.

He's harvesting his crops.

As he reaps his corn and soybeans, however, he's also watching as new plantings — clover, wheat and even more soybeans — start to grow. That's because Gustafson, like a growing number of farmers in Indiana, has returned to planting a second round of crops in the fall. Those crops, left through the winter, are called cover crops.

+ click to enlarge

Dave Rodibaugh planting a cover crop of rye and radishes in field of cleared corn. Photo by Jerry Schultheiss.

USDA Natural Resources Conservation Service
United States Department of Agriculture

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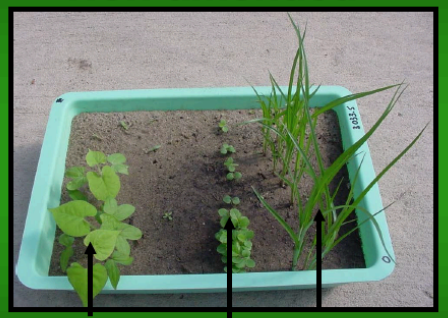
Land Use
- Cropland
  - Erosion
  - Nutrient & Pest Management
  - Organic Farming
  - Resources & Publications
- Farmland Protection Policy Act
- Forestry
- Range & Pasture

Cover Crops and Soil Health

IPNI

Cover Crops
(Weed Control)

Non-amended



Wild radish amended

Interest in cover crops should be tempered by local science that addresses:

- full cropping system benefits,
- suppression of problem weeds,
- soil fertility impacts, and
- environmental benefits

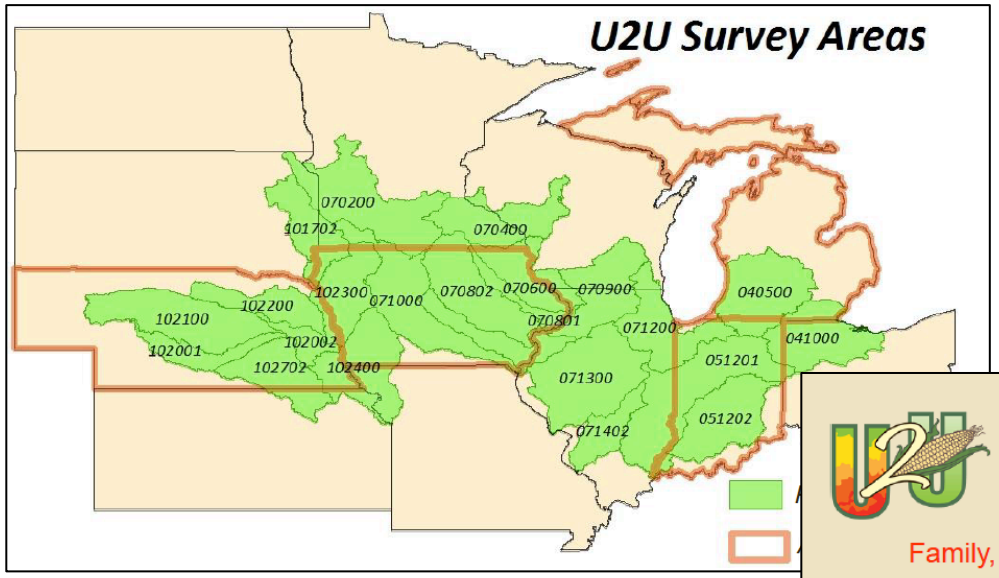
Cover Crops
(Crop Tolerance)

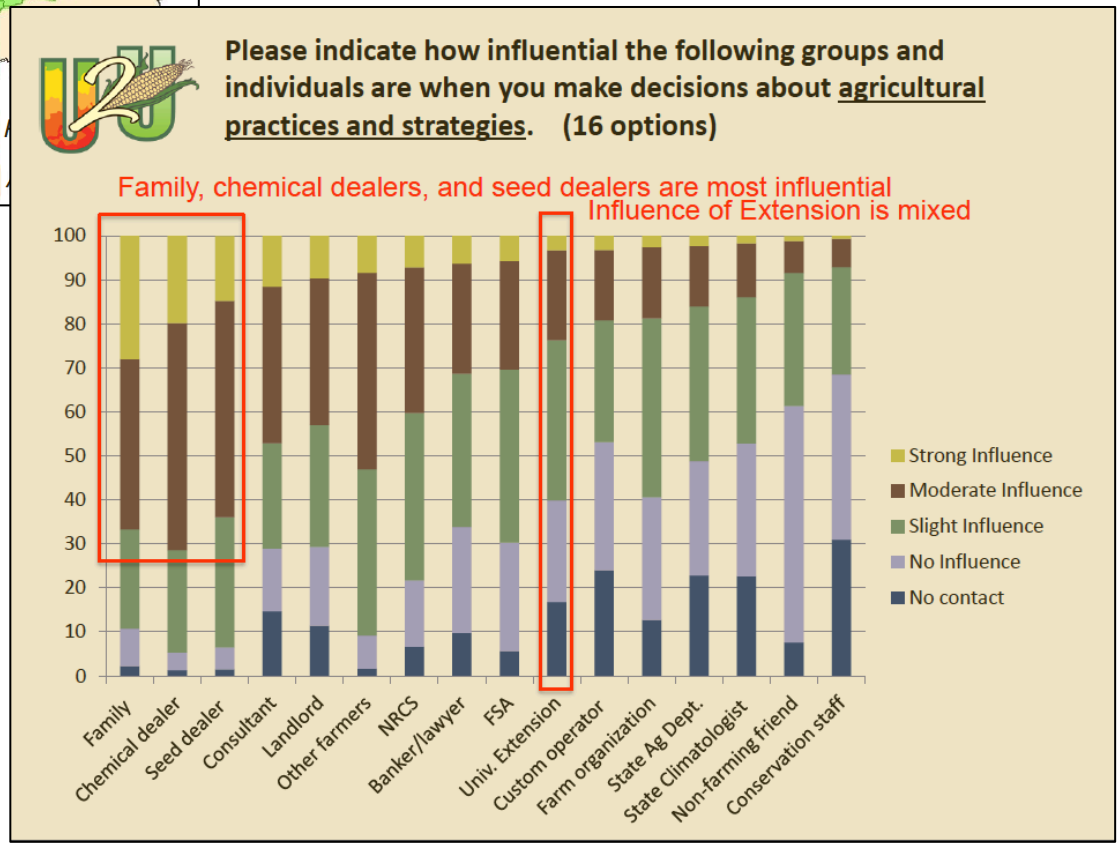
Non-amended

Wild radish amended

Norsworthy 2003

Many Farmers Get Their Nutrient Management Advice from Ag Retailers





Source: Linda Prokopy, Purdue U., Nitrogen Use Efficiency Conference, August 2014

4R Nutrient Stewardship Retailer Certification Program – Western Lake Erie Basin

Source: Lara Moody, TFI

Who is working on 4R Certification?

Source: Lara Moody, TFI

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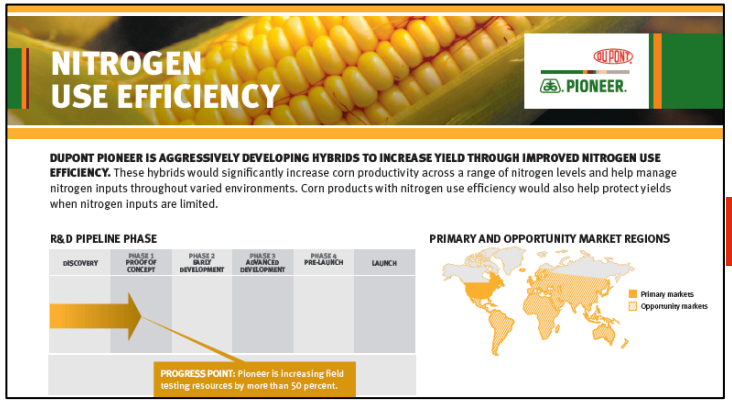
Genetic Improvement of N Use Efficiency ……. and N-Fixation in Cereals ??



Farm Industry News - Aug. 21, 2012

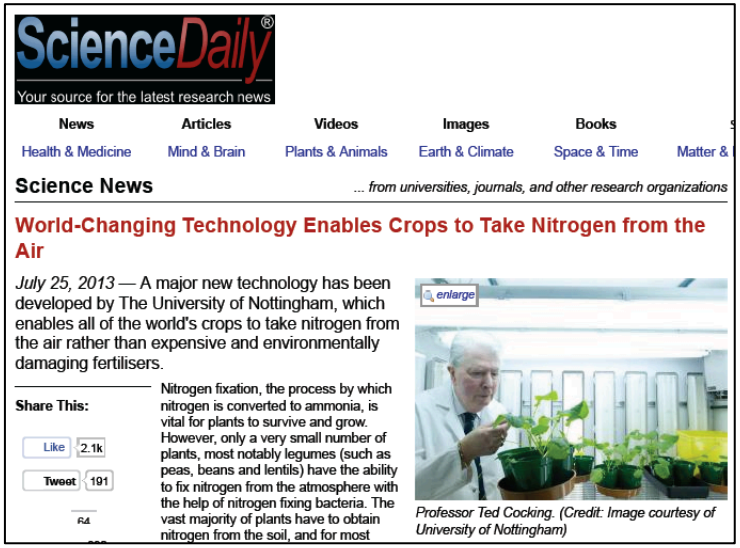
Seed companies developing hybrids that use nitrogen more efficiently

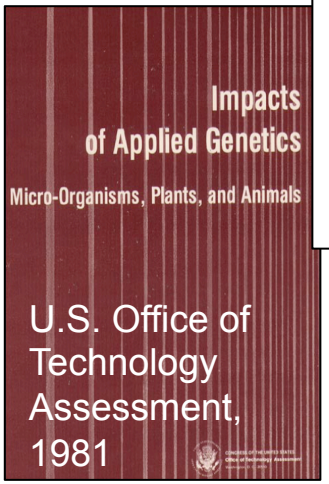
Monsanto, DuPont Pioneer, & Syngenta

Science

20 Sep. 2013

Nonlegumes Respond to Rhizobial Nod Factors by Suppressing the Innate Immune Response





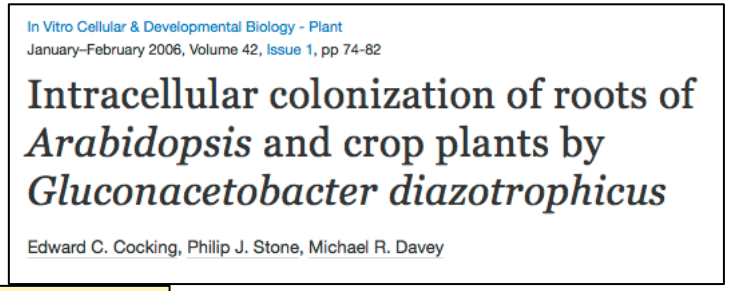
National Science Foundation
WHERE DISCOVERIES BEGIN

21 Aug. 2013

Press Release 13-147

US AND UK SCIENTISTS COLLABORATE TO DESIGN CROPS OF THE FUTURE

Three Ideas Lab projects and a fourth NSF-sponsored project aim to transform future farming while reducing pollution and energy consumption



The N-Fix technology licensed by Univ. of Nottingham to Azotic Technologies

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Potential for Further Reductions in Nutrient Loads to Rivers and Streams through Comprehensive Conservation Treatment - USDA CEAP Reports

- Upper Mississippi River Basin: N 44%, P 27%
- Ohio-Tennessee River Basin: N 41%, P 58%
- Great Lakes Basin: N 37%, P 33%
- Missouri River Basin: N 13%, P 12%
- Lower Mississippi Basin: N 48%, P 62%
- **NIFA CEAP Watershed Assessment - Lessons Learned**
  - "Practices based on management changes, such as nutrient management, were less likely to be sustained by farmers than structural practices"
  - " … many conservation practices designed to control nutrients are disliked (nutrient management and buffers)";
  - " farmers cannot readily observe nutrient losses whereas they can observe soil losses." (Osmond et al. 2012)

Fertilizer N BMPs Help Minimize Potential for Residual NO_3-N Accumulation & Losses

- **N source, rate, timing, and place of application …. which may include**
  - **Urease inhibitors**
  - **Nitrification inhibitors**
  - **Slow-release materials**
  - **Controlled-release materials**
- **In combination with appropriate, site-specific cropping system and conservation practices**
  - **(e.g. conservation tillage, cover crops, vegetative buffers, riparian areas, managed drainage, wetlands, bioreactors, etc.)**
- ***What could we accomplish if in-field, edge of field, and above-stream BMPs are coupled?***

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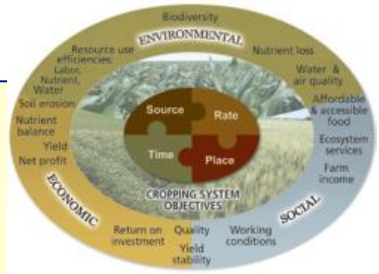
Bottom Line



- Use appropriate fertilizer N & balanced fertilization (P, K, Mg, S, Zn, etc.) to
  - enhance N use efficiency and effectiveness
  - increase crop biomass, help restore/maintain/increase soil carbon (*soil organic matter*) and "soil "health"
- Remember, N (and P) losses can vary among 4R factors …depending on site-specific conditions, weather, cropping, and tillage systems
- Work more pro-actively with state and local partners to advance **4R Nutrient Stewardship**
- **Track and record performance indicators**
  - **for example: trends in harvested nutrients, yield per unit of nutrient applied, soil organic matter increase, etc.**

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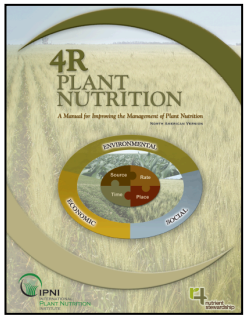
We Can Improve N Use Efficiency and Effectiveness

by implementing nutrient BMPs …

Right source @ Right rate,
Right time, and Right place



In conjunction with other proven conservation practices

4R Nutrient Stewardship

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Thank You

Better Crops, Better Environment … through Science

www.ipni.net