Fertilizer Outlook and Technology Conference
Jacksonville, FL
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IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

U.S. Fertilizer Demand and Nutrient Use Issues:
Forecasting the Future of the NUE Trend

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4R nutrient stewardship

Agrium Inc.

Arab Potash Company

BHP Billiton

CF Industries Holdings, Inc.

Compass Minerals Plant Nutrition

International Raw Materials LTD

K+S KALI GmbH

LUXI Fertilizer Industry Group

The Mosaic Company

OCP S.A.

PhosAgro

PotashCorp

Qatar Fertiliser Company (QAFCO)

Shell Sulphur Solutions

Simplot

Sinofert Holdings Limited

SQM

Toros Tarım

Uralchem, JSC

Uralkali

The **International Plant Nutrition Institute** is supported by leading fertilizer manufacturers.

Formed in 2007 from the Potash & Phosphate Institute.

Mission: to develop and promote science for responsible management of crop nutrition

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Questions

1. What major factors caused the past increase in corn NUE?
2. Can we expect the trend to continue?
3. Will soil test trends force change in NUE trend for P&K?
4. Can we expect similar trends in crops other than corn?
5. How will the US contribute to increasing global food production 70% by 2050?

Efficiency is not Productivity

- Nutrient Use Efficiency:

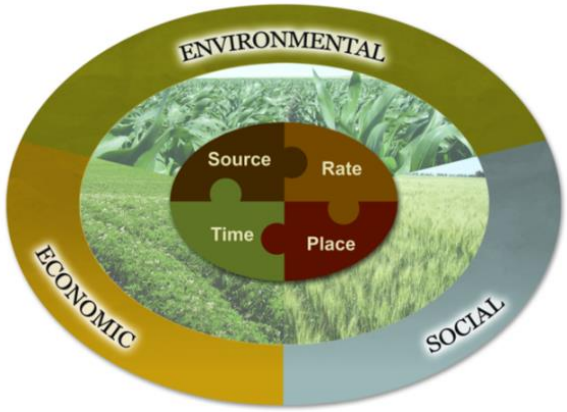
$$\frac{\text{output bu/}\cancel{A}}{\text{input lb/}\cancel{A}} = \frac{\text{output bu}}{\text{input lb}}$$

- ***Independent of per-acre productivity!***
- ***Productivity, not NUE, feeds the world***
- ***Productivity <u>with</u> NUE required for sustainability***

[DRAFT] Nutrient Stewardship Metrics for Sustainable Crop Nutrition

Enablers (process metrics)

- Extension & professionals
- Infrastructure
- Research & innovation
- Stakeholder engagement



Actions (adoption metrics)

[Require regional definition of 4R]

- Cropland area under 4R (at various levels)
- Participation in programs
- Equity of adoption (gender, scale, etc.)

Outcomes (impact metrics)

1. **Farmland productivity**
2. **Soil health**
3. **Nutrient use efficiency**
4. Water quality
5. Air quality
6. Greenhouse gases
7. Food & nutrition security
8. Biodiversity
9. Economic value

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Many factors have driven NUE trends

- Crop genetics – yield improvement
- Crop management
- Weather
- Economics
- Livestock nutrient management
- Water quality issues

Corn yield trend: genetics & management

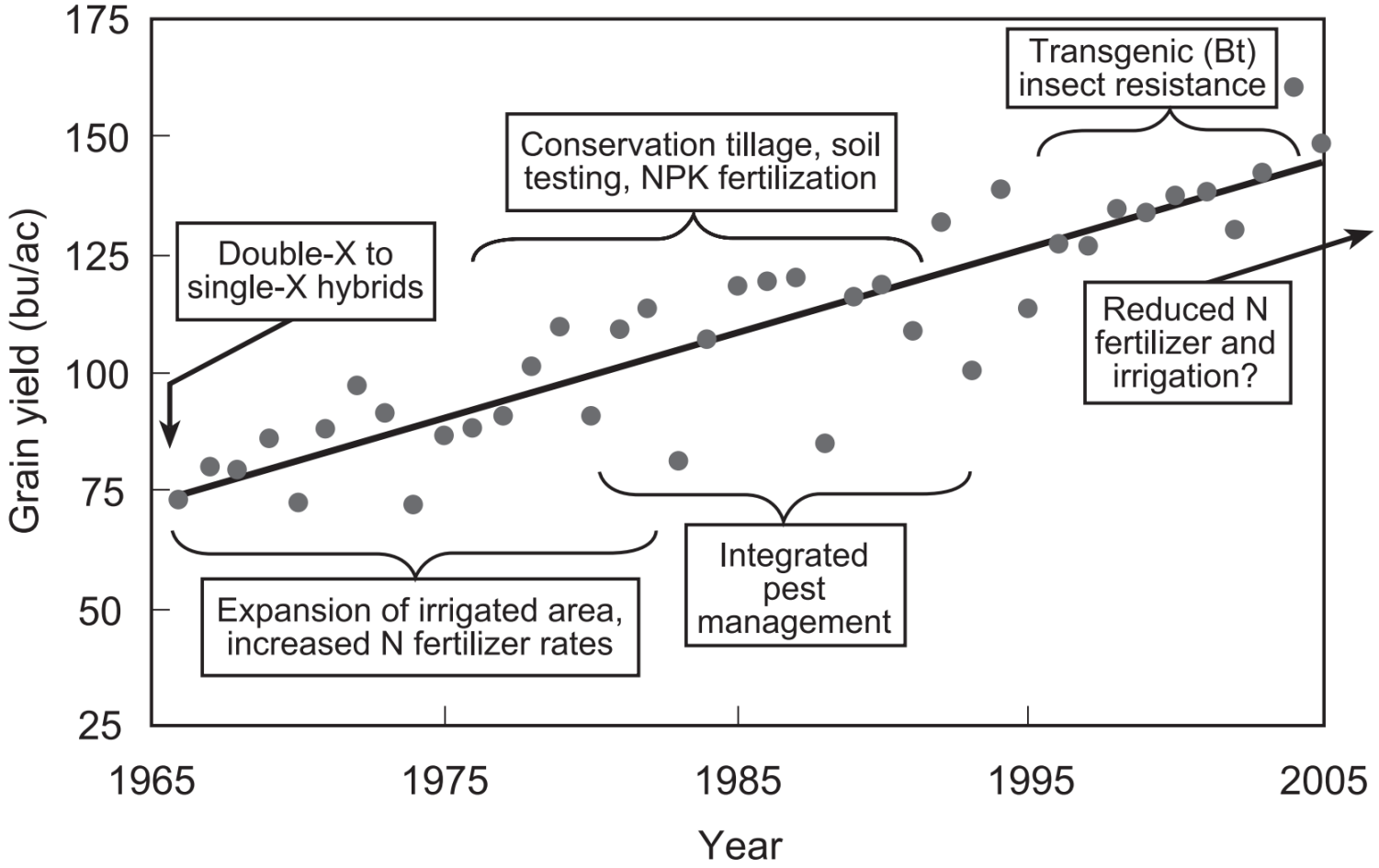

Figure 4. Corn yield trends in the United States from 1966–2005, and the technological innovations that contributed to yield increases. Rate of gain is 1.8 bushels per year ($R^2 = 0.80$).

Cassman et al., 2006. CAST Commentary.

Genetic improvement of NUE can involve several plant traits

- Selection for yield → changes nutrient uptake pattern
- Root traits generally increase metabolic costs
  - Mycorrhizal associations, root exudates & deposits, root plasticity
  - Exception: aerenchyma
- Root architecture: optimum design may conflict for N, P, water
- Biochemical traits – e.g. alanine aminotransferase

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New hybrids take up more N after silking

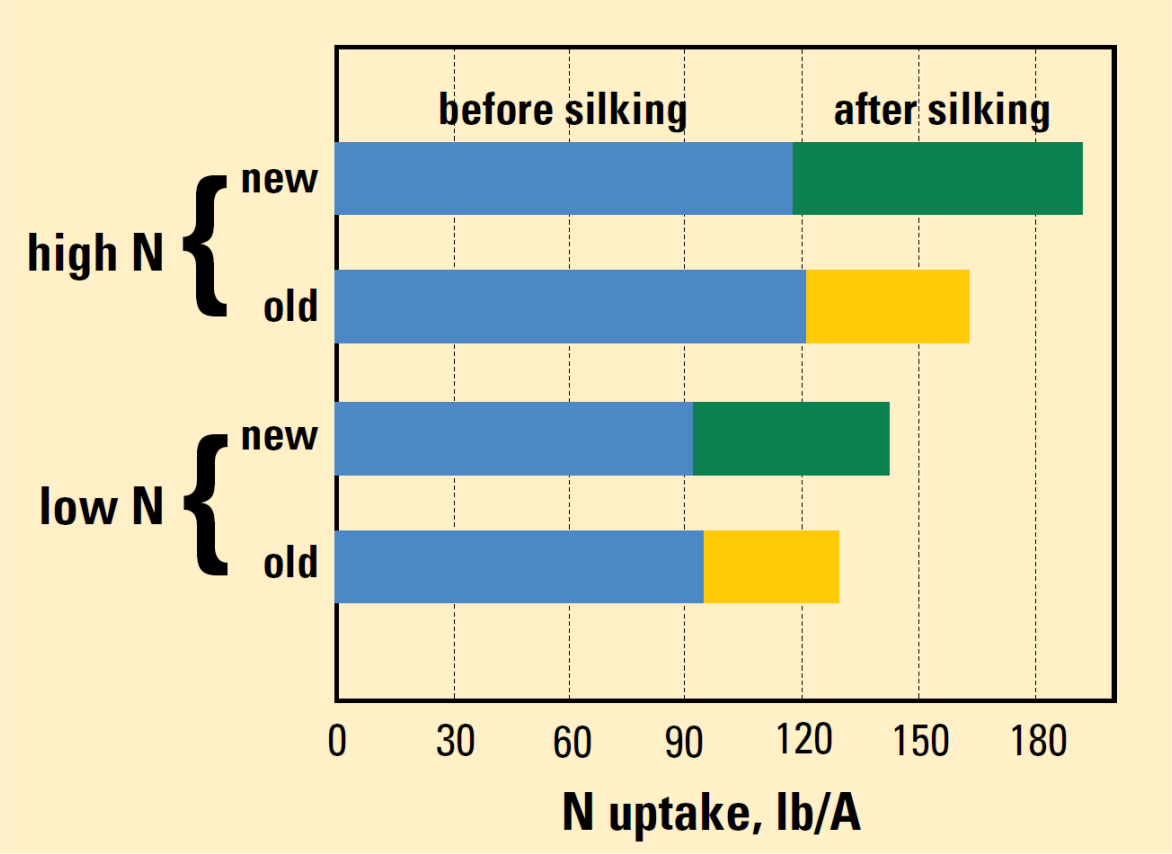
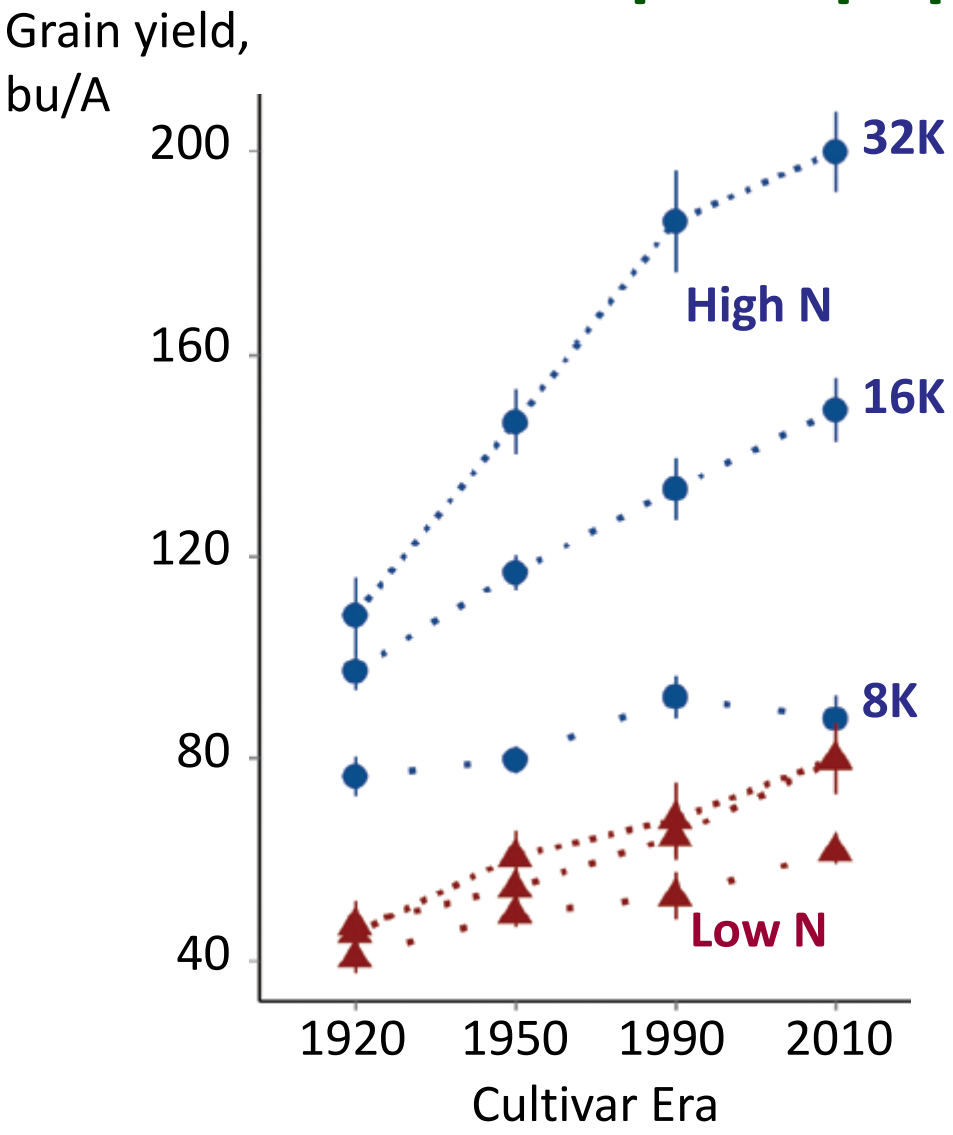


Figure 1. Corn N uptake in a new and an old hybrid in response to high and low soil N availability. Means over 3 years (1993-1995) at Elora, Ontario.

- Increases NUE by better using N mineralized from soil organic matter

Tollenaar et al., 1997. Better Crops 81(4):3-5.

Newer cultivars of corn respond to N and plant population



More recent cultivars had:

- **Shallower root angles**
- **One less nodal root per whorl**
- **Double distance to lateral root branching**
- **More and smaller root xylem vessels**
- **More root aerenchyma at higher plant density**

Root changes could explain 16% of the 80% genetic increase in growth/yield.

York et al., 2015. Journal of Experimental Botany, 66:2347-2358

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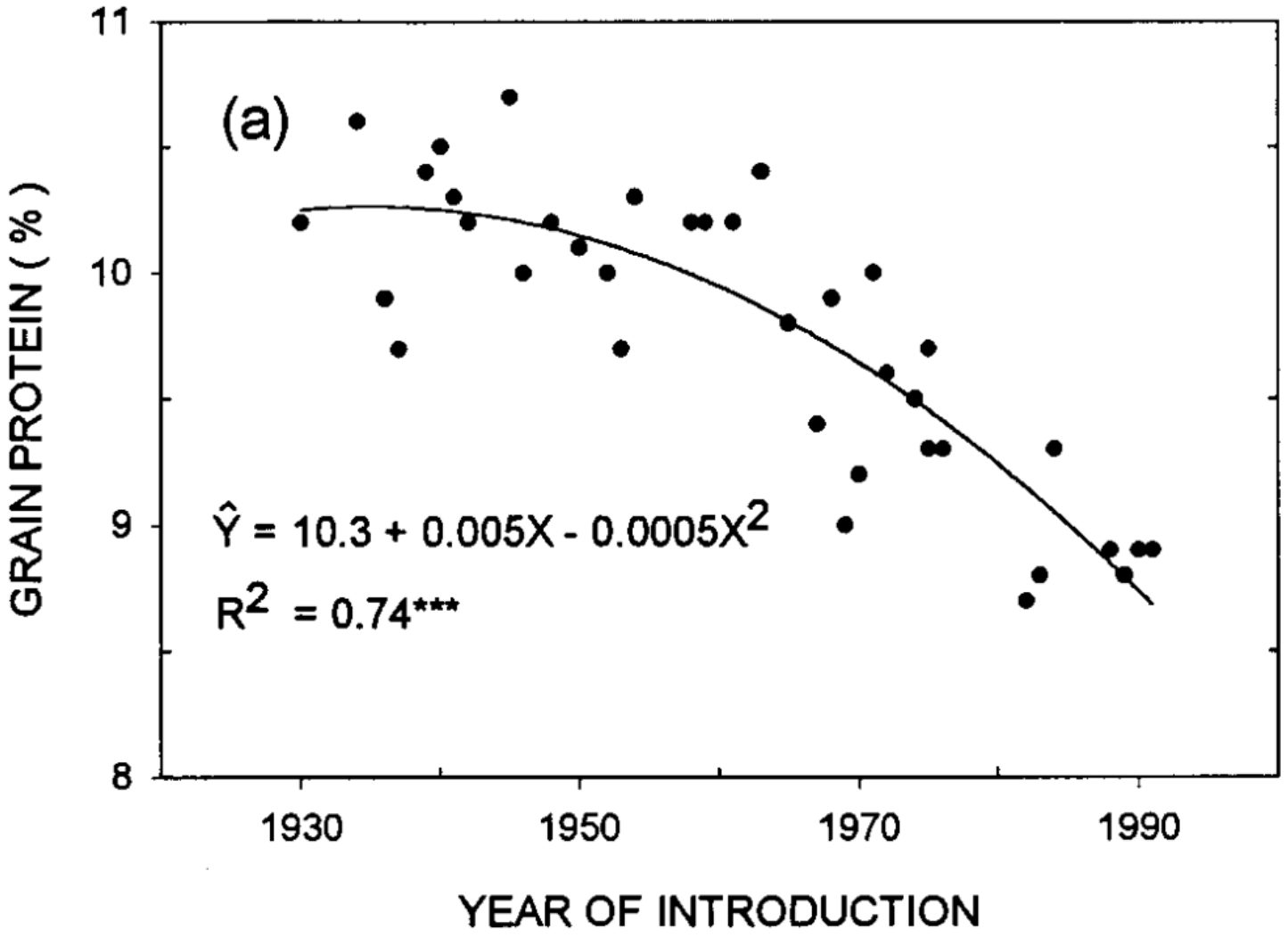
Newer corn hybrids contain less protein



Duvick & Cassman, 1999

So why has NUE increased?

In corn:

- Higher yields from better genetics and management, and higher plant populations
- Later N uptake
- Lower grain N

In other crops:

- Nutrient management planning
- Water quality issues

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NuGIS
Nutrient Use Geographic Information System

Home | Methods | Discussion | Applications | References | Interactive Map | Tabular Data | About IPNI | Login

Select a Year: 2011 | Animation | Seconds to display each map: 5 | Play | Reverse | Stop | Enter a County or Watershed name to search for: | County

navigate | Zoom in to box | identify a feature

2011 partial P balance, removal/use

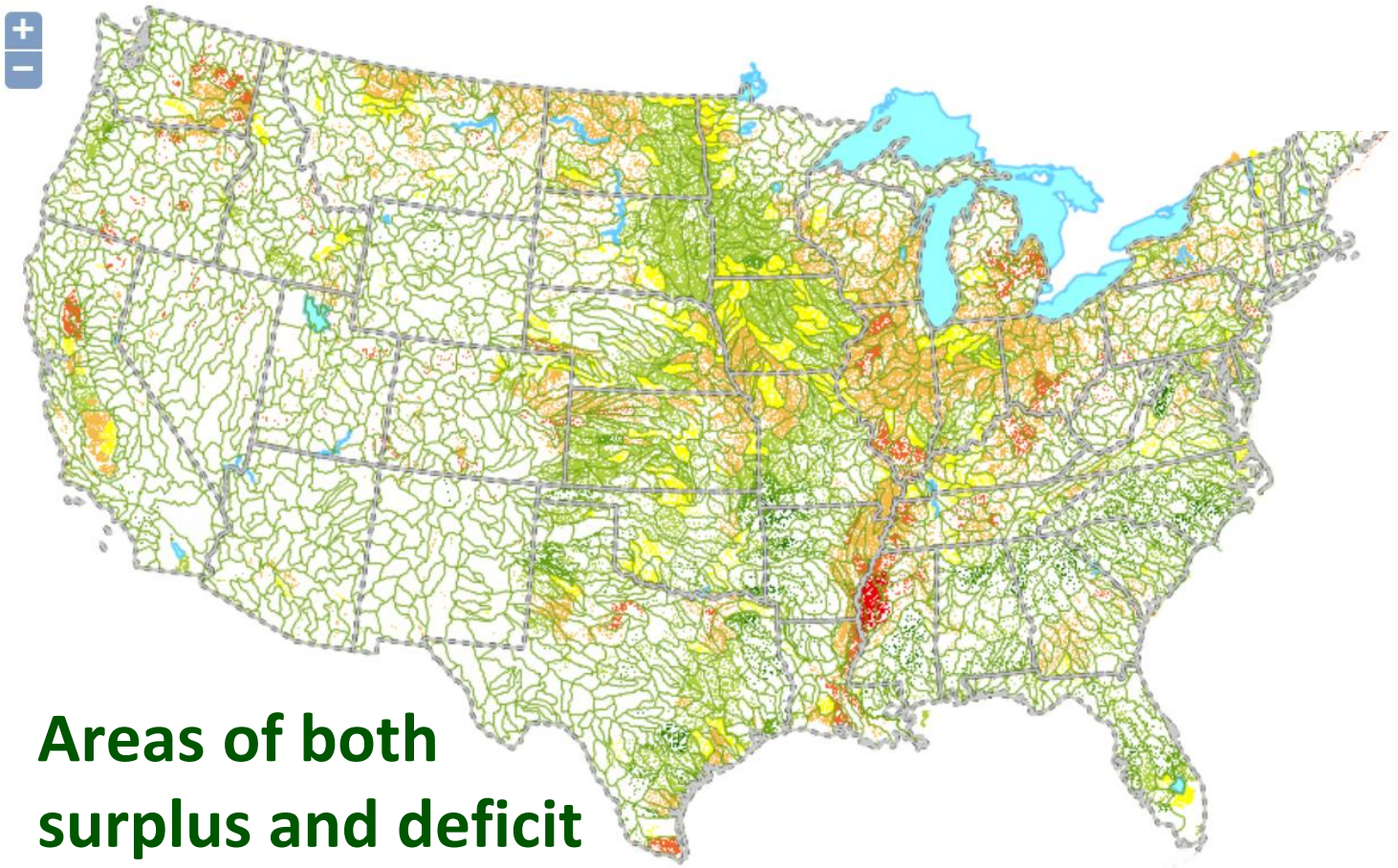
Table of Contents

- Layers
  - Overlays
  - Lbs / Cropland Acre Balances
  - Removal to Use Ratios
    - County Ratios
    - Watershed Ratios
      - Watershed N Ratio
      - Watershed P2O5 Ratio
      - Watershed K2O Ratio
    - Hydro Region Ratios
  - Lbs / Acre Inputs

Legend

- < 0.20
- 0.20 - 0.50
- 0.51 - 0.90
- 0.91 - 1.09
- 1.10 - 2.00
- 2.01 - 5.00
- > 5.00

2011 NuGIS Data



Areas of both surplus and deficit

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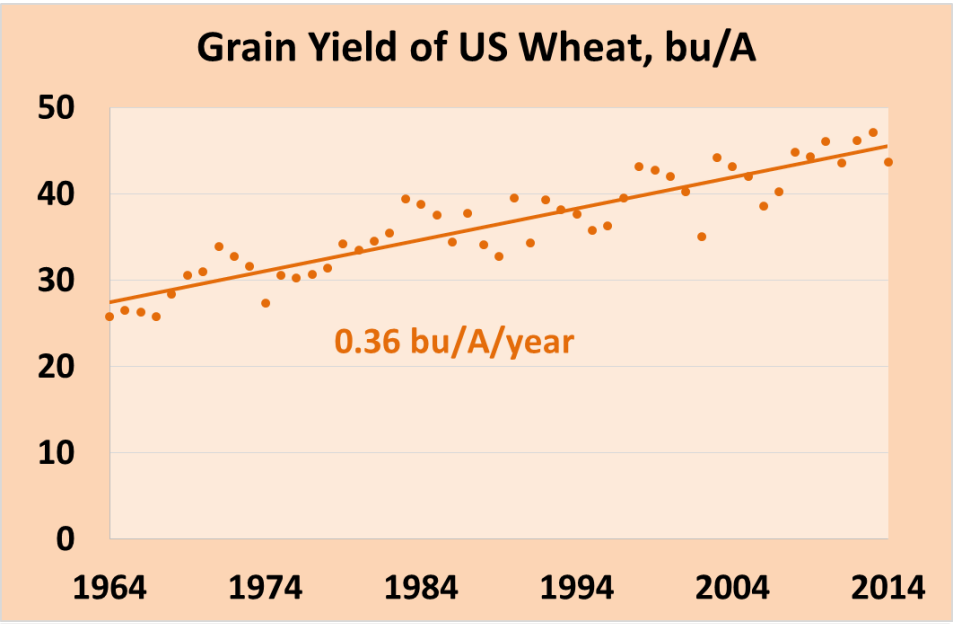


Wheat

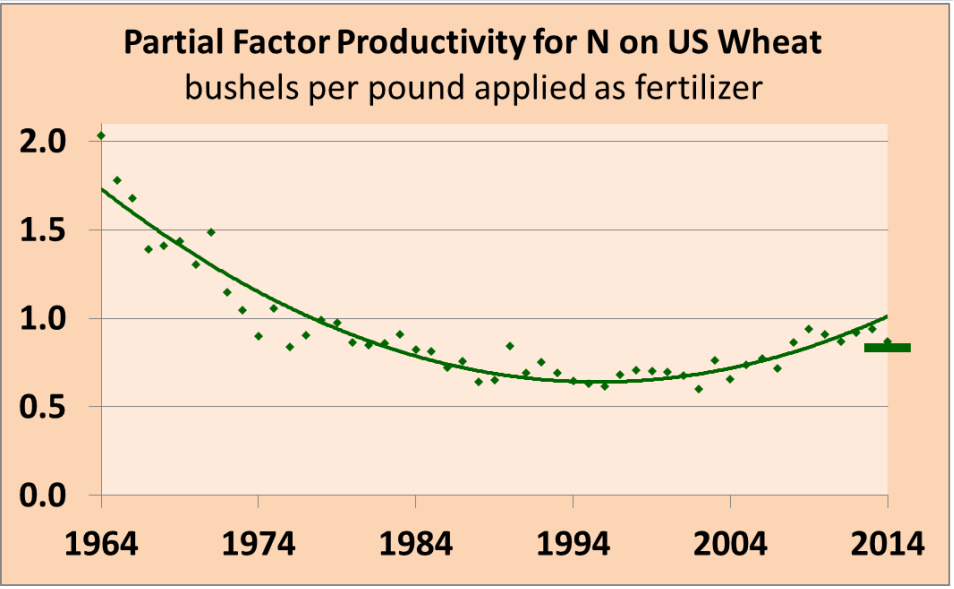
Yields increasing, but not as fast as those of corn.

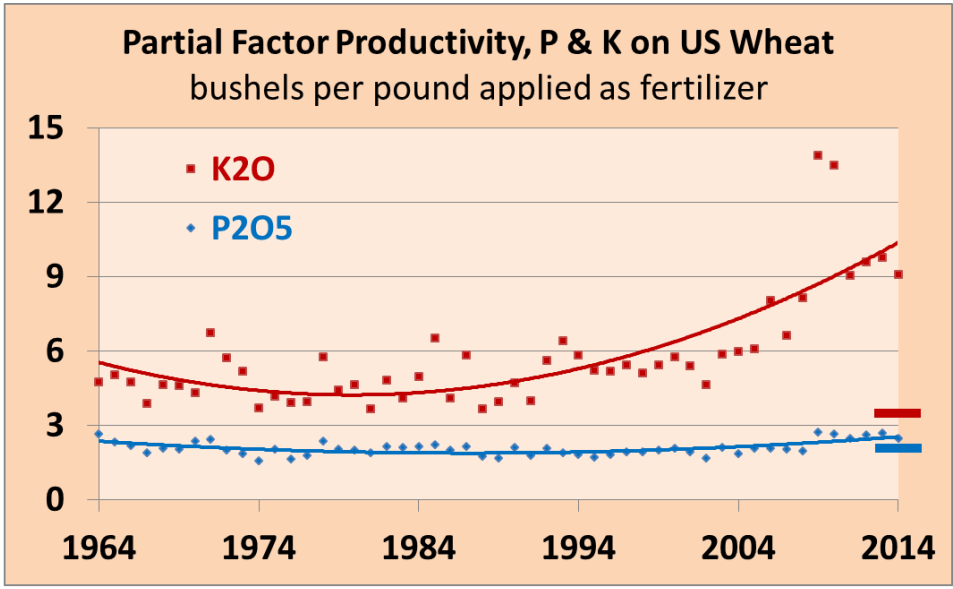
Nutrient use efficiency increasing only recently:

N – recovery from & return to mining

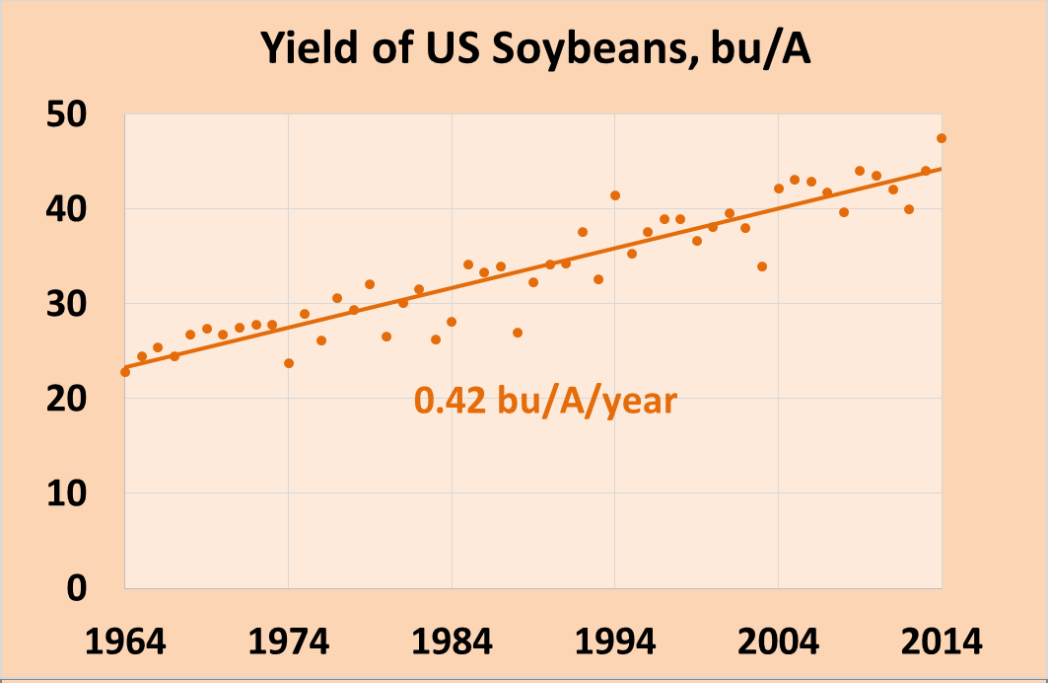
P – recent jump to modest mining

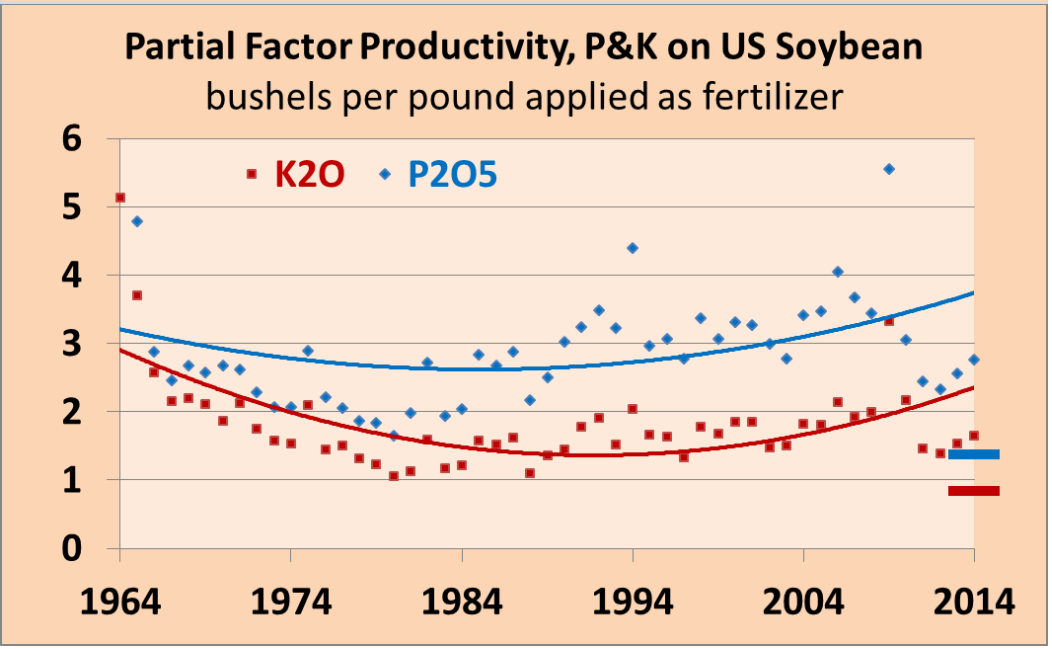
K – mining





Calculated from USDA-NASS and USDA-ERS data





Soybeans

1) Yields increasing like those of corn.

2) Nutrient use efficiency increasing only recently:

P – mining

K – mining

— bu soybean per lb of P_2O_5

— bu soybean per lb of K_2O

Calculated from USDA-NASS and USDA-ERS data

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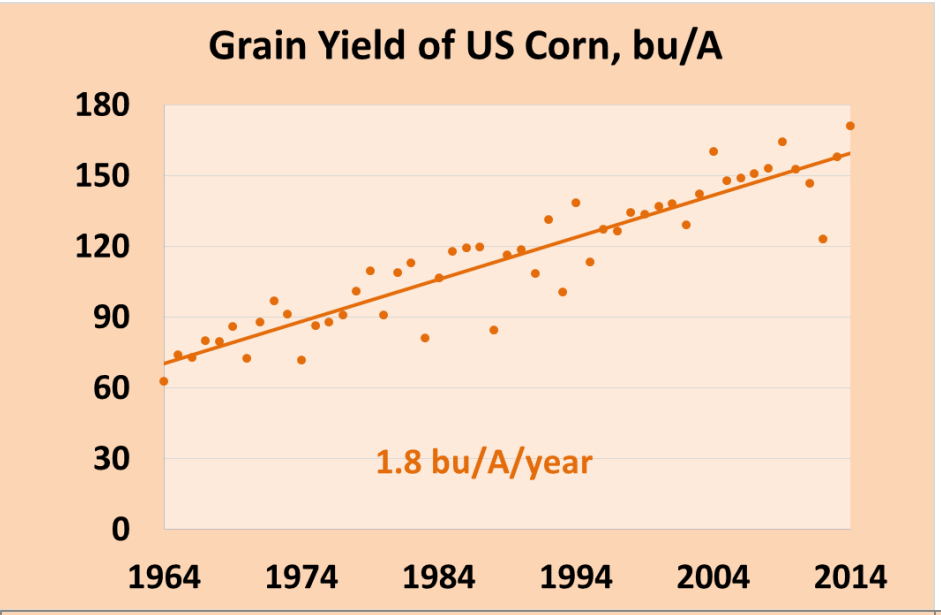


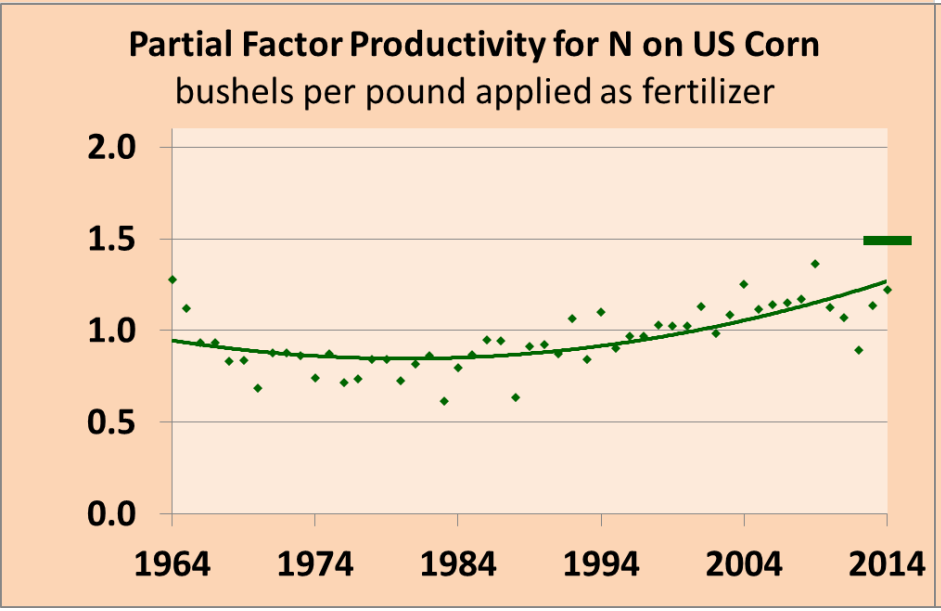
Corn

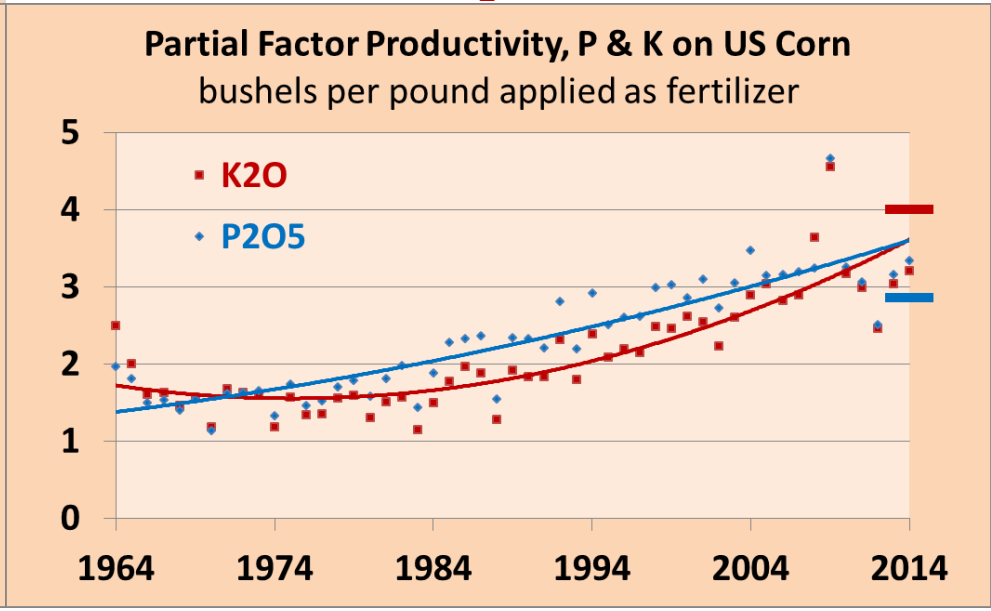
1) NUE trend driven by yield
2) removal < fertilizer for N & K
3) removal > fertilizer for P
4) other inputs – manure
5) corn-soybean system

— **bu per lb of N**

— **bu per lb of P_2O_5**

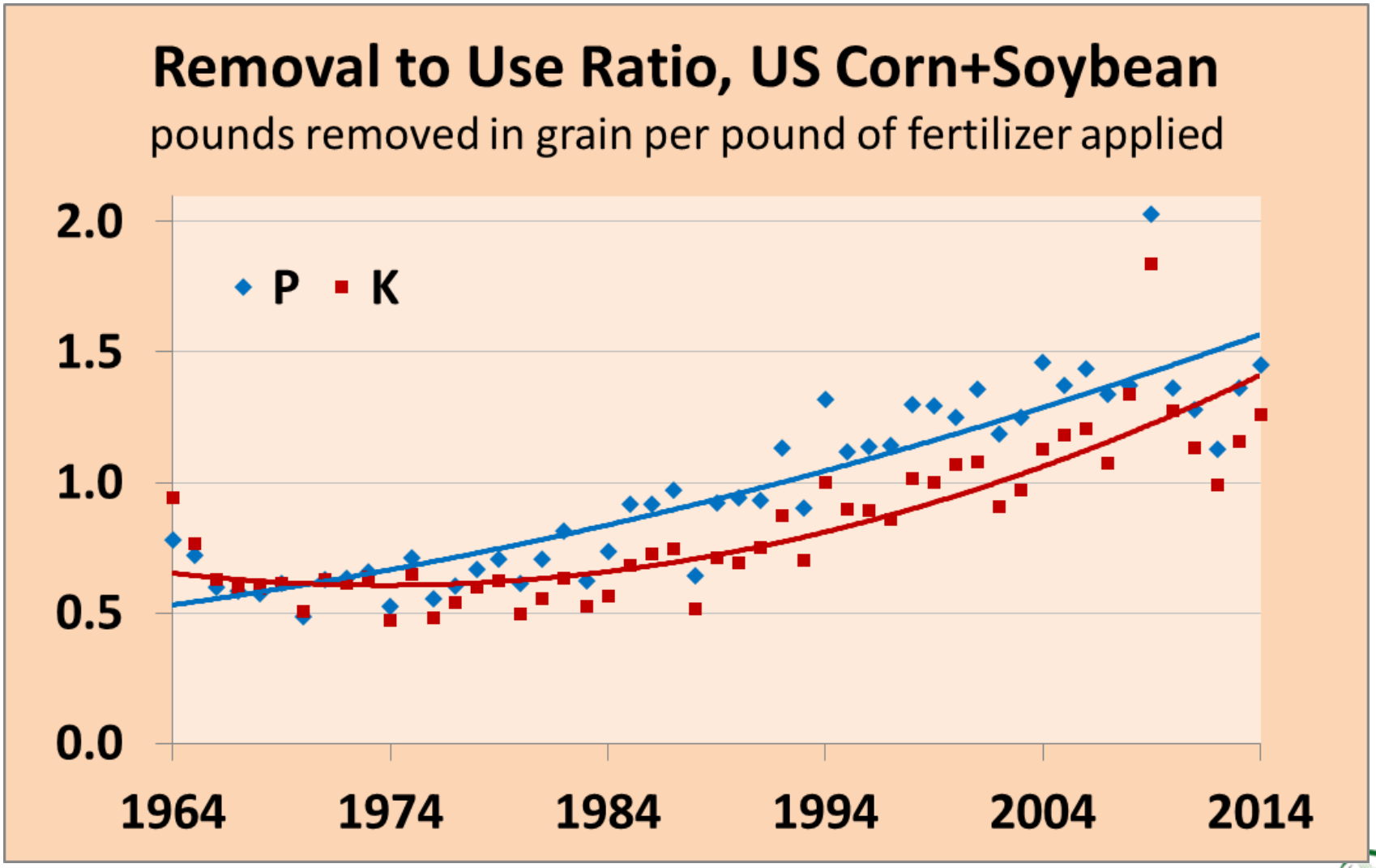
— **bu per lb of K_2O**





Calculated from USDA-NASS and USDA-ERS data

In the US corn-soybean cropping system, removals exceed P and K fertilizer application



Calculated from USDA-NASS and USDA-ERS data

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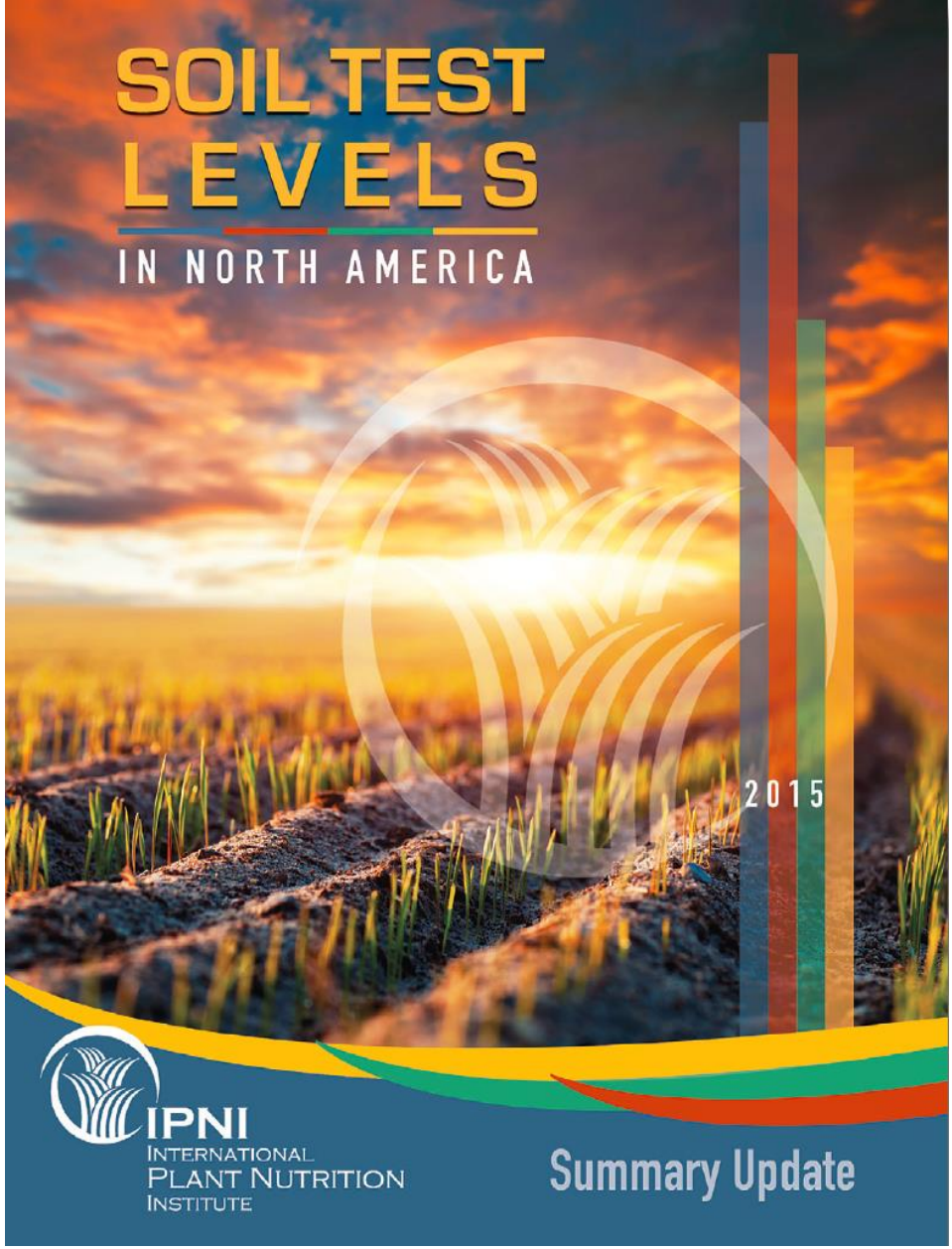
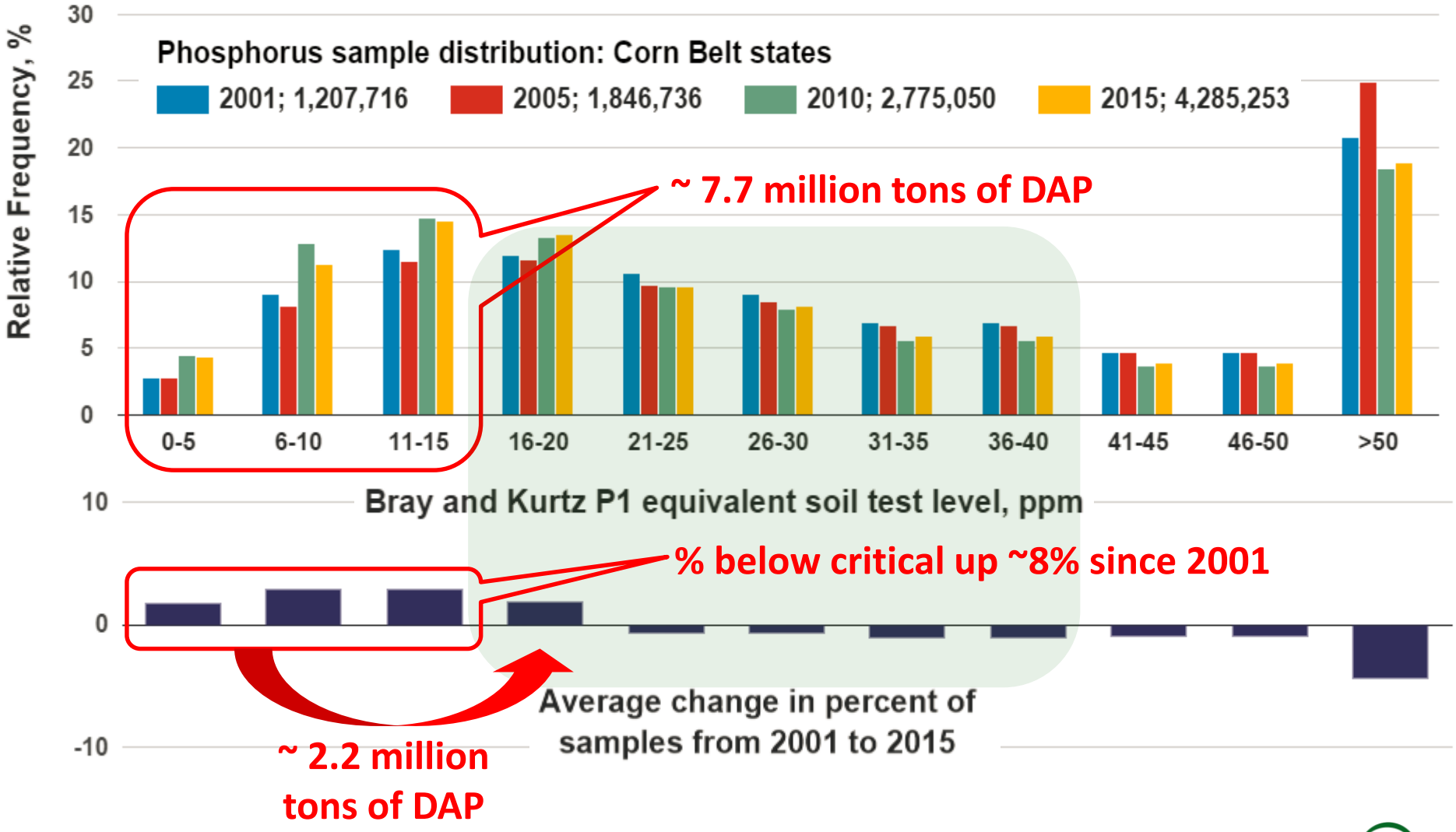
IPNI Soil Test Summary 2015

- Conduct every 4 or 5 years
- 2015 - the 4th summary that provides descriptive statistics of soil test levels for
  - P, K, and pH
  - Mg, S, Zn, Cl
- Very intensive summary
  - 2010: 4.4 million samples from 63 labs
  - 2015: >5 million from similar number of labs



IPNI Soil Test Summary 2015 – preliminary results

Ten Corn Belt states (IL, IN, IA, KS, MI, MN, MO, NE, OH, WI)



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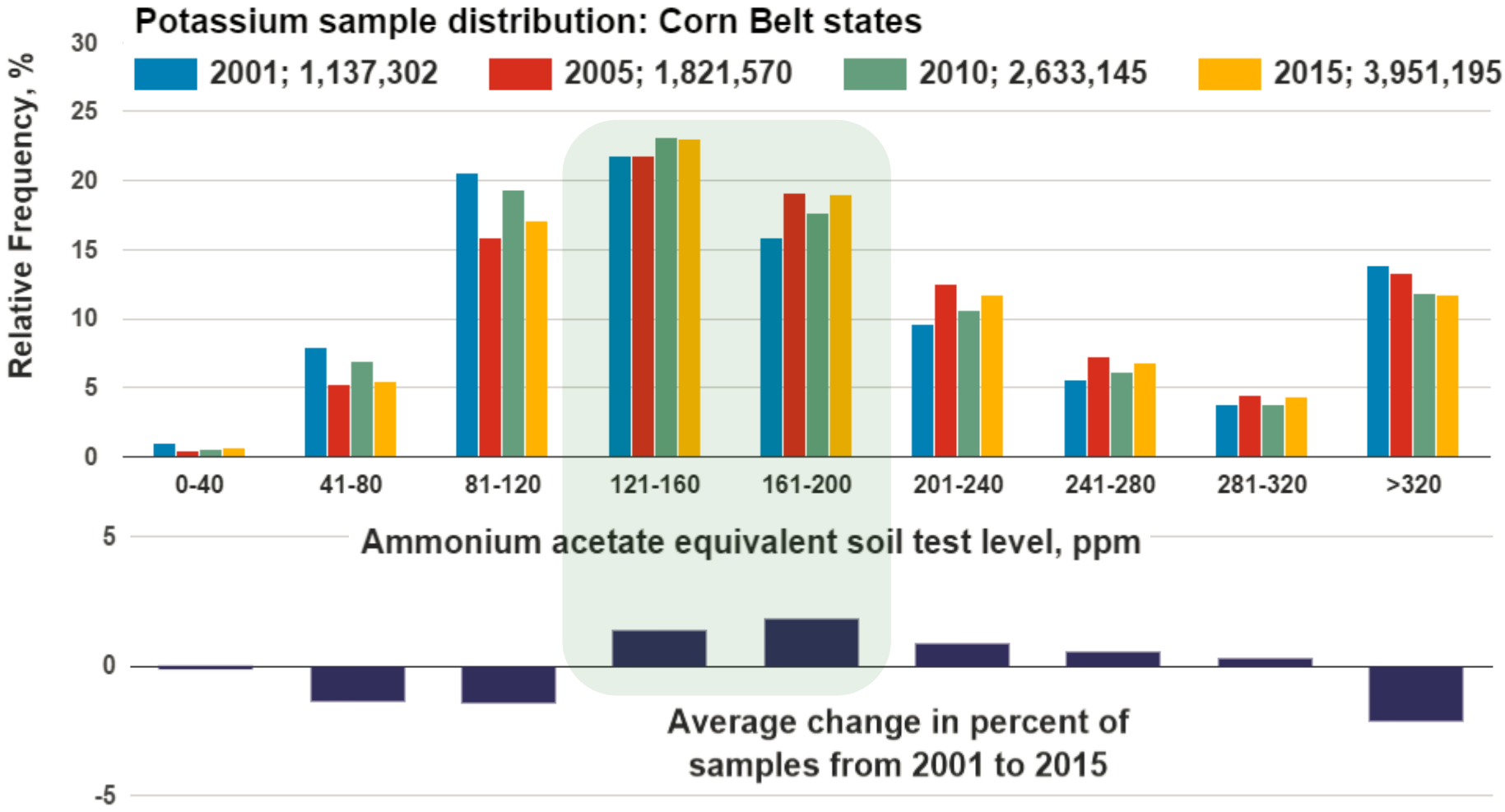
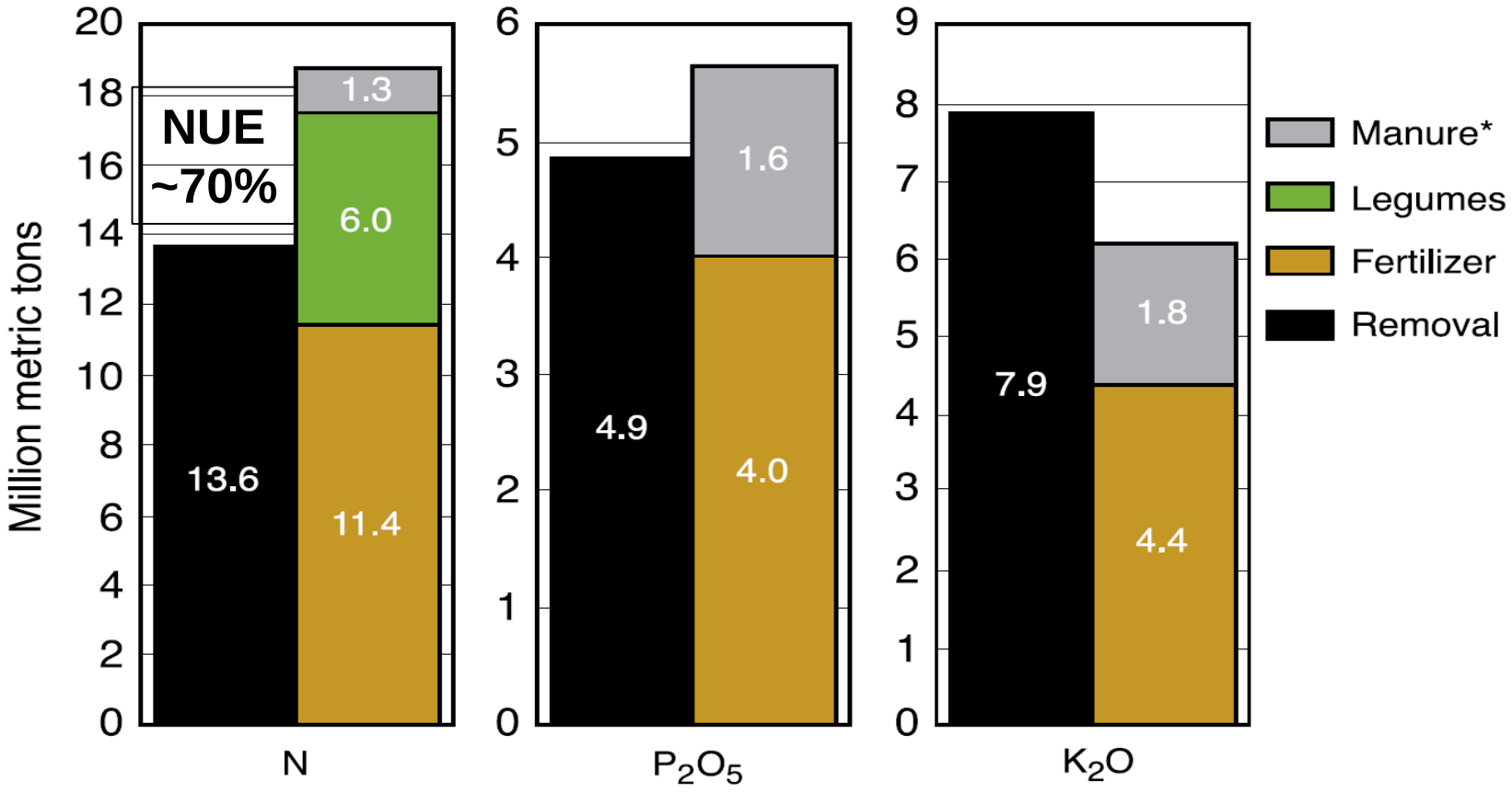


Removals: < inputs for N&P, > inputs for K



*Based on 2007 livestock census using Kellogg et al. (2000) procedure.

Figure 14. Comparison of nutrient removal by crops in the United States to nutrient applied as fertilizer, recoverable manure, or fixed by legumes (average of 2006–2008).

Zilberman et al., 2013. CAST Issue Paper Number 51.

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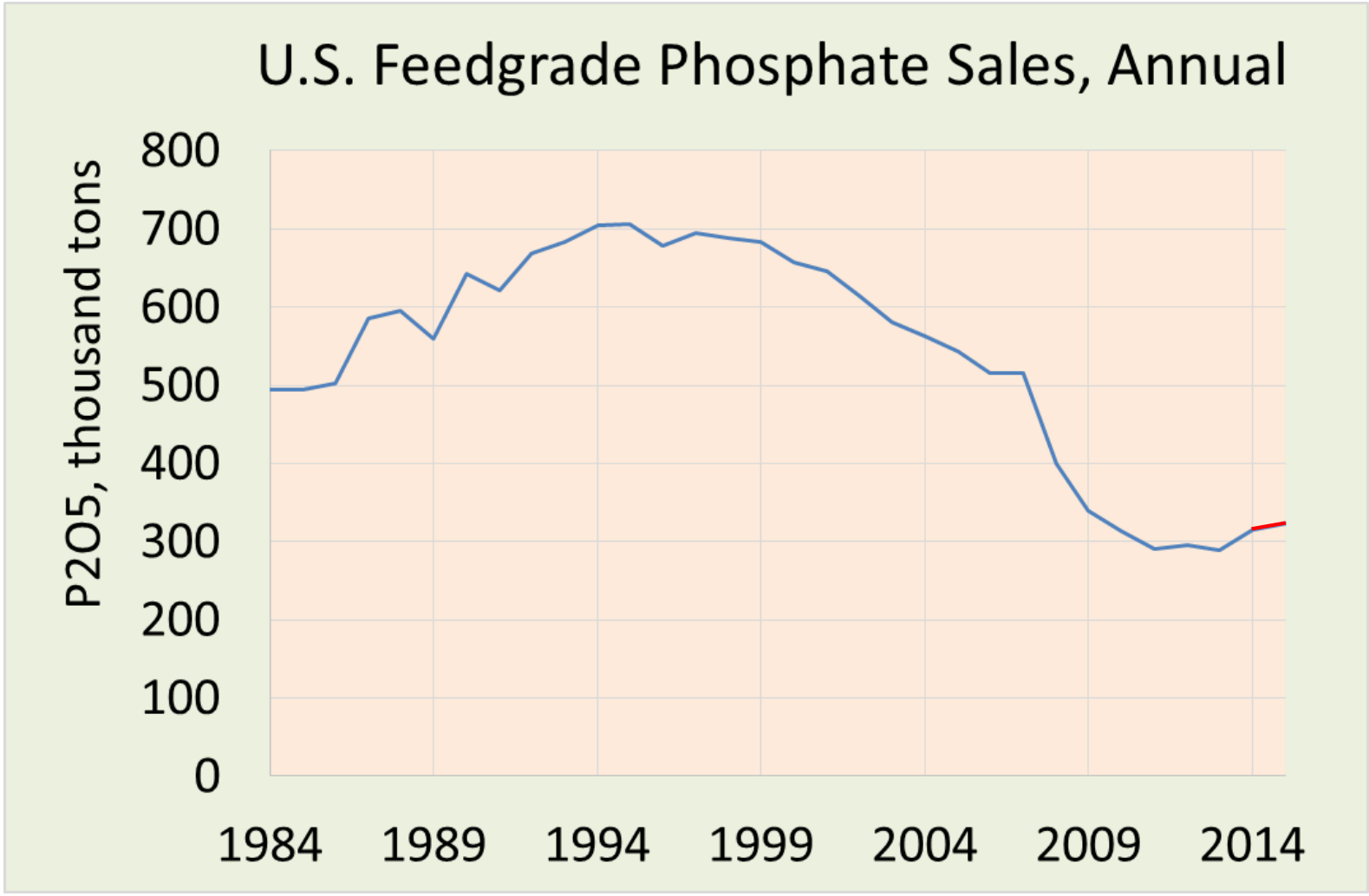
The livestock industry changed its P use efficiency after 2008, but grain P is still a valued nutrient



Feedgrade Phosphate Report, H. Vroomen, The Fertilizer Institute

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Summary

1. What major factors caused the past increase in corn NUE?
   Crop genetics & management → increasing yield
2. Can we expect the trend to continue [for nitrogen]?
   – still room for NUE improvement in corn;
   – more in crops other than corn, soybean and wheat.
3. Will soil test trends force change in NUE trend for P&K?
   P – soil test limits NUE increase in 30-50% of soils; K – possibly less
4. Can we expect similar trends in crops other than corn?
   a) Depends on breeding effort
   b) Sustainability of livestock linked to more nutrient recycling
5. How will the US contribute to increasing global food production 70% by 2050? ***Show leadership in sustainable intensification – higher yields, improved soil health, more optimal NUE, reduced environmental impact → full implementation of 4R Nutrient Stewardship***

4R nutrient stewardship

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