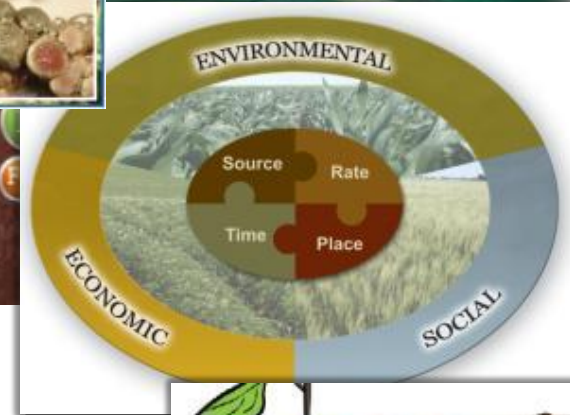


# 2017 Fluid Forum



## 35 Years of Positive Impact and Progress ... What's Next?

Paul Fixen and Dale Leikam  
IPNI & FFF



# Why 35 years?

1982

Today

Millennials: a life time



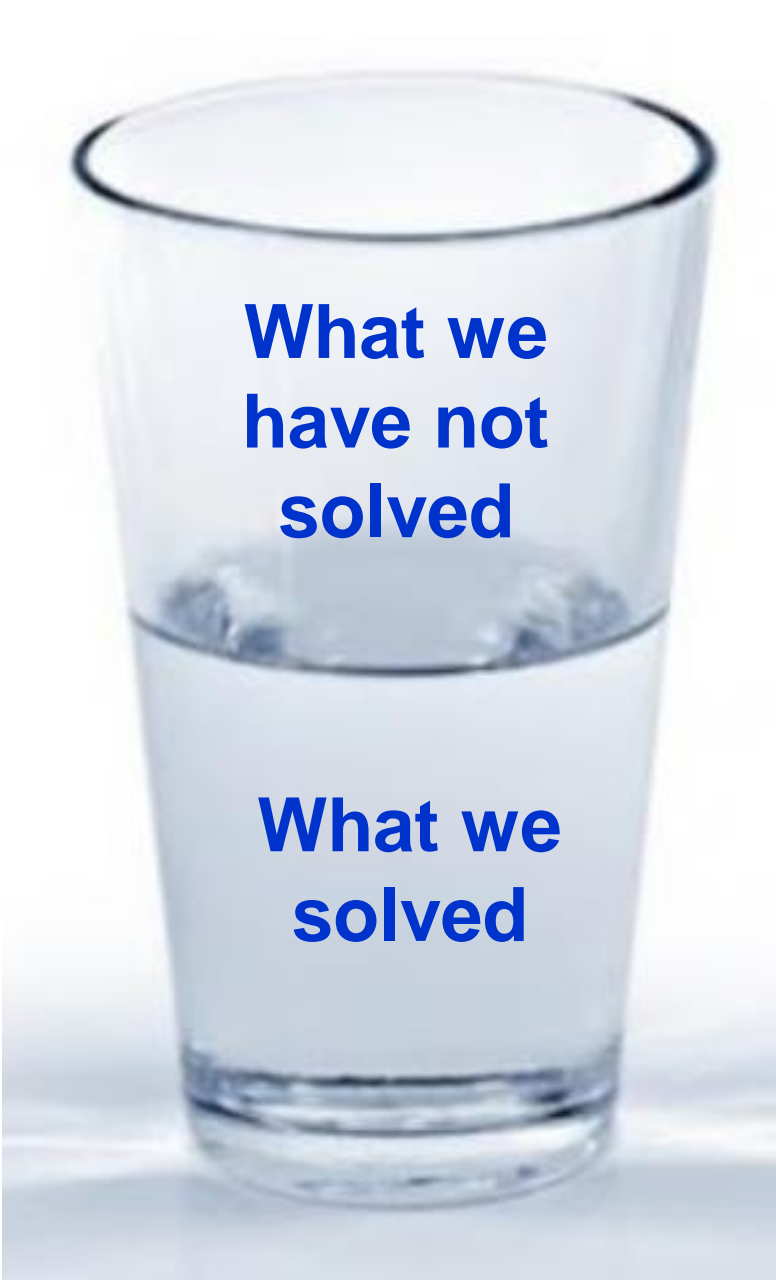
Baby Boomers: a career



# Why focus on impact & progress??

We tend to focus on the half empty glass ... on not being perfect

Predicting needs for individual **fields** in individual **years** is hard!



What we  
have not  
solved

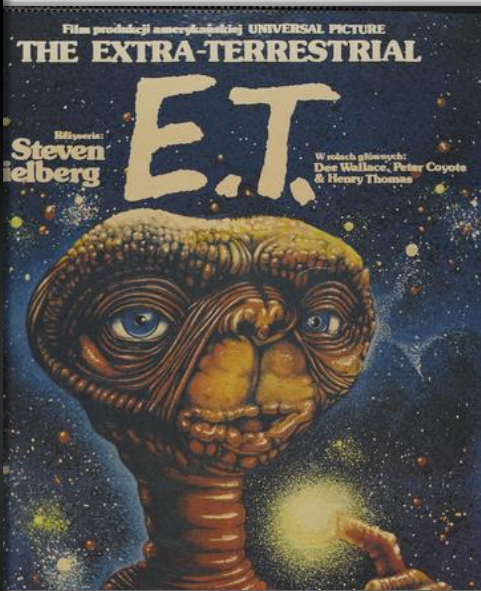
What we  
solved



# Life in 1982



Commercial cell phone



The Wave of The Future



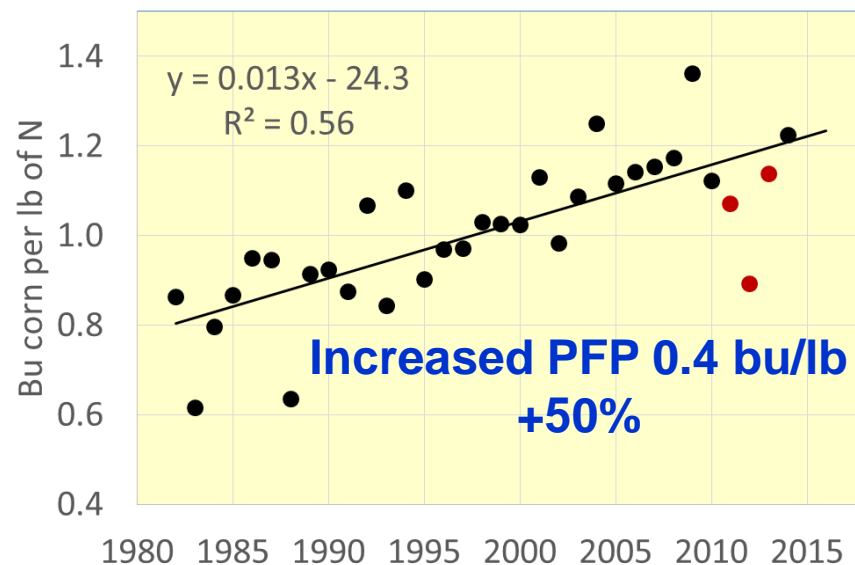
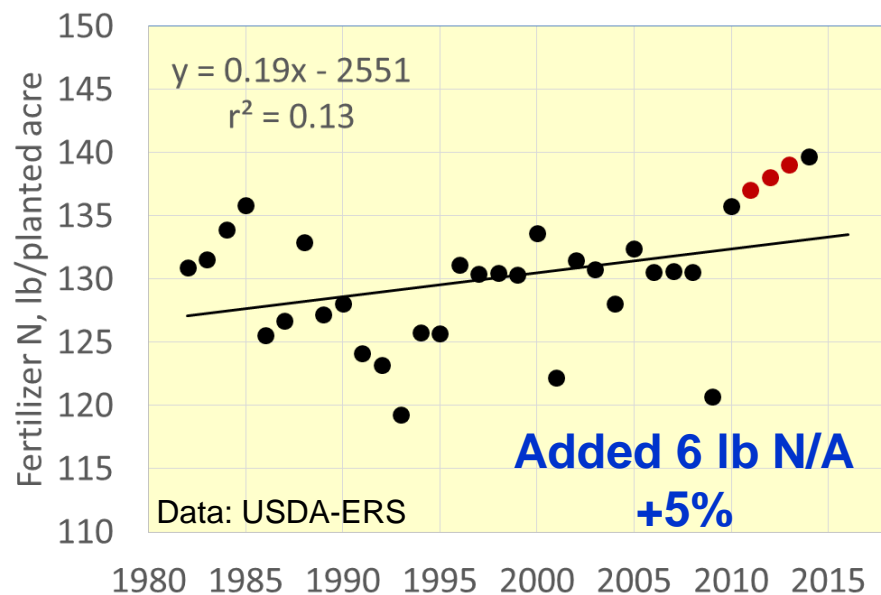
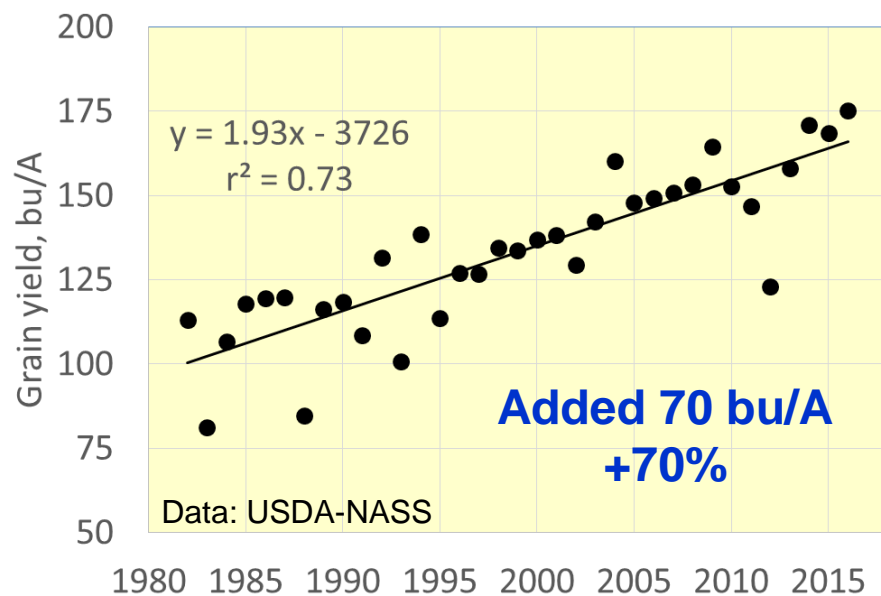


## Progress in crop yields

Crop	1982	2016	Change, %
Corn, bu/A	101	172	<b>70</b>
Soybean, bu/A	29.3	49.3	<b>69</b>
Wheat, bu/A	36.5	46.6	<b>28</b>
Cotton, lb/A	547	808	<b>48</b>

1982 = avg of 81-83; 2016 = avg of 14-16.

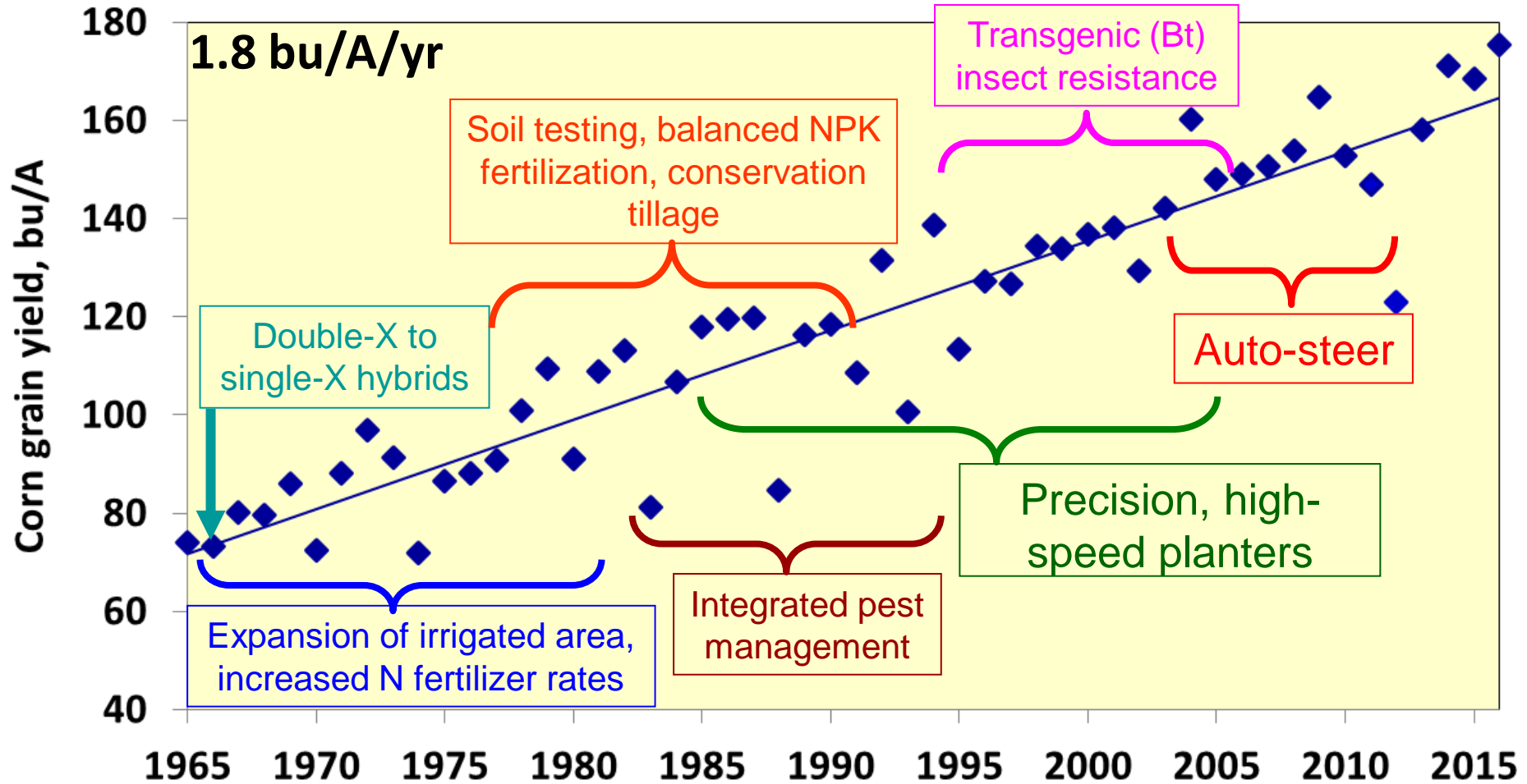
# Progress with corn yield and NUE, 1982 -2016





# US Average Corn Yields

*70% by 2050 requires 3.2 bu/A/yr*



# Corn Nitrogen Management Ladder (High Plains)

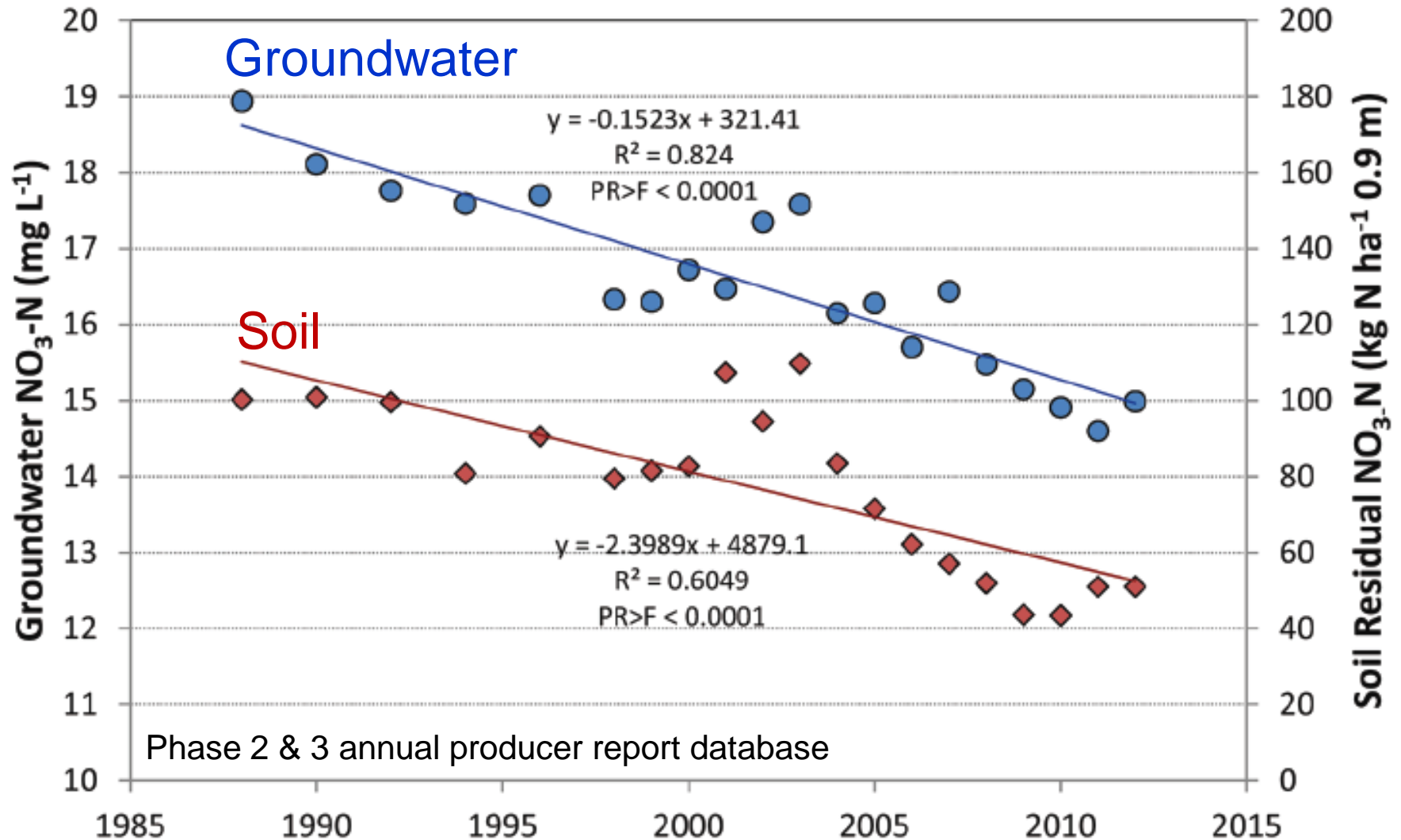
	lbs N/Bu	
Step 5	0.8	Pre-plant + Starter + Side-Dress/V6 Fertigation + Brown Silk Fertigation
Step 4	0.9	Pre-plant + Starter + Sidedress/V6 fertigation
Step 3	1.0	50% Pre-plant + 50% Sidedress
Step 2	1.1	100% Fertigation
Step 1	1.2	100% Pre-plant Band
Floor	1.3	100% Pre-plant Broadcast

Efficiency Rating





# Groundwater nitrate and soil nitrate in the Central Platte Natural Resources District



# Corn yield potential

Tollenaar, 1985

*U of Guelph*

“Therefore, my guess for the current upper limit of corn productivity at a Corn-Belt location is **500 bu/A.**”



David Hula: Charles City, VA

**2015 532 bu/A**

**2014 476 bu/A**



Randy Dowdy: Valdosta, GA

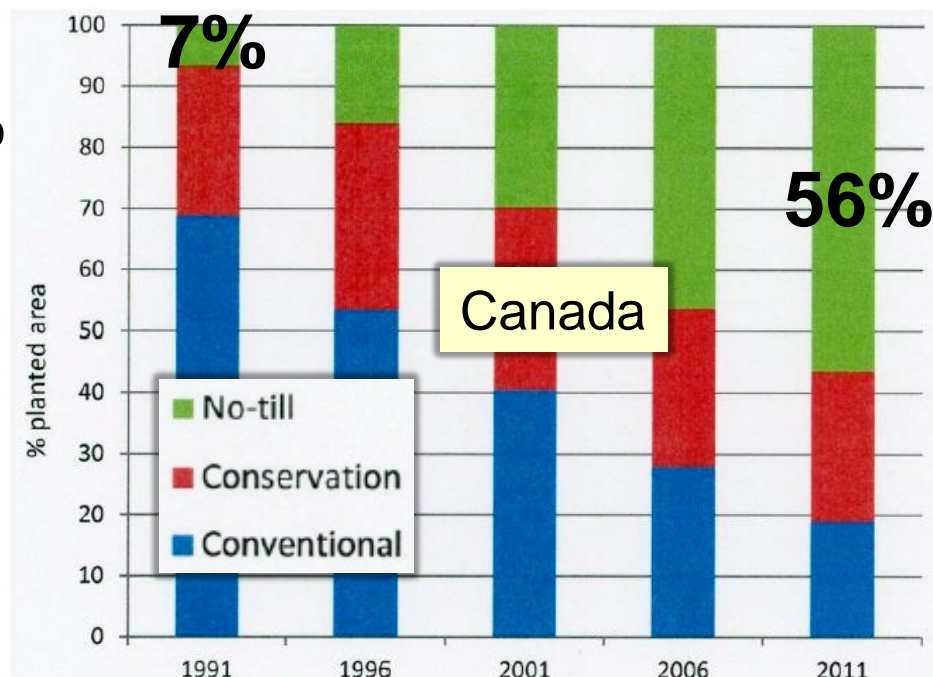
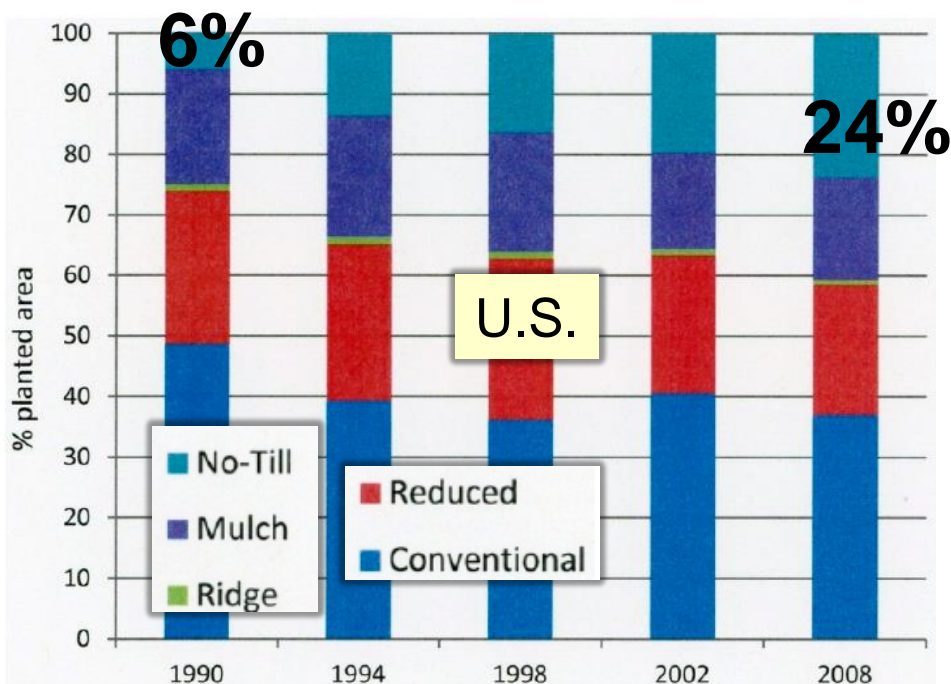
**2014 504 bu/A**

*(NCGA Yield Contest Winners)*

**Efficient use of inputs and appropriate practices without sacrificing yield potential:  
A CHALLENGE**



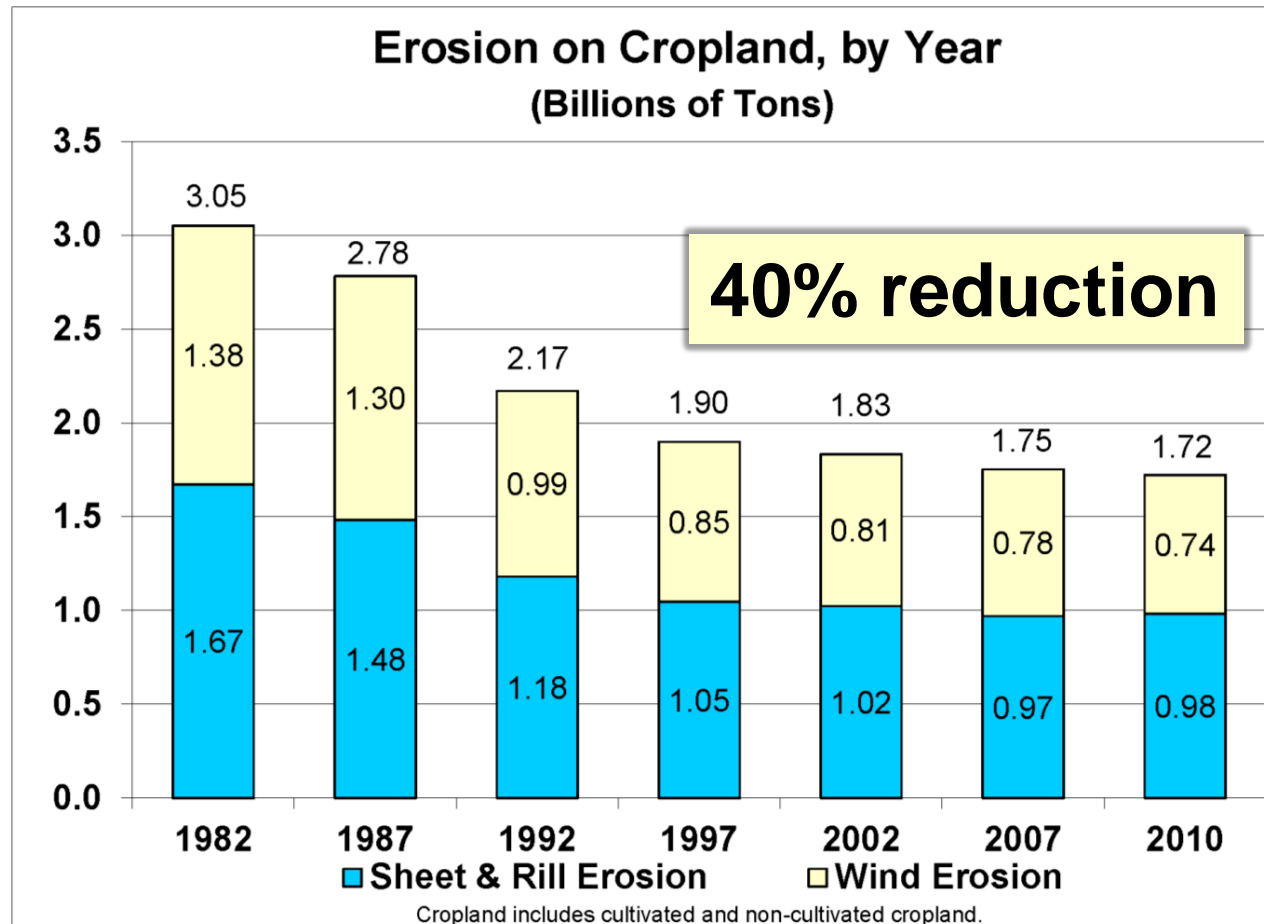
# Progress in conservation tillage



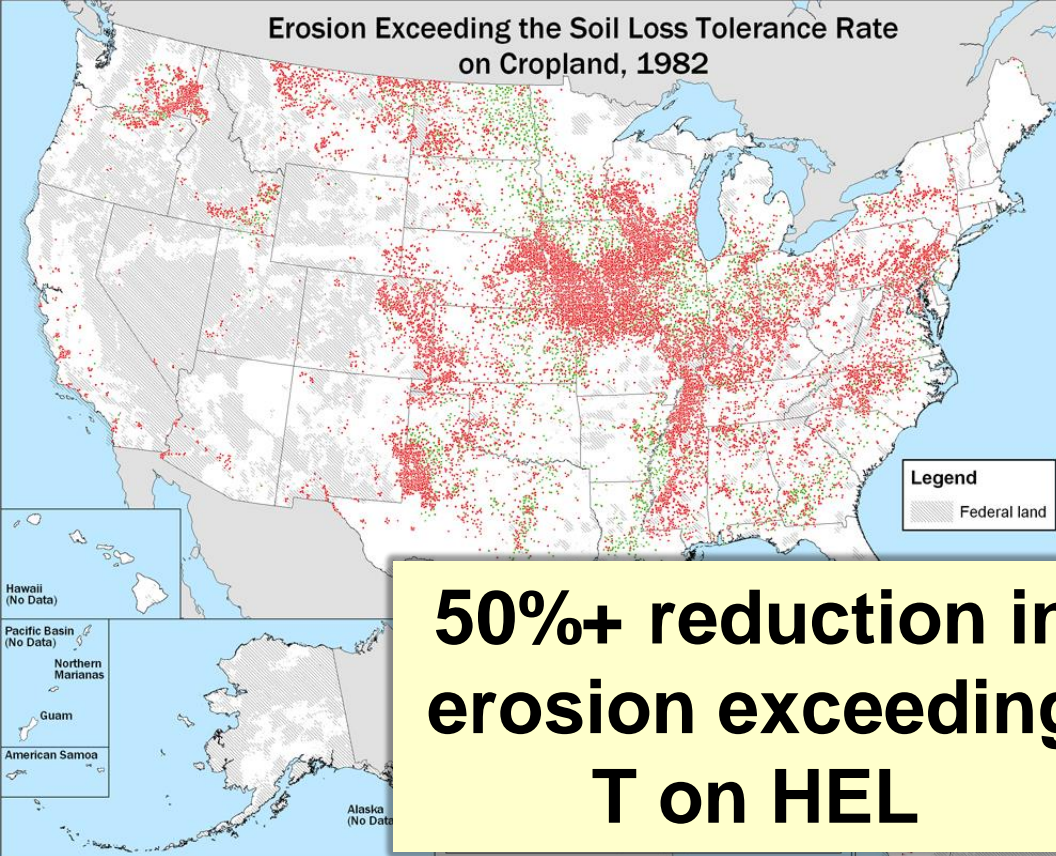
1982	1989	2008
% in conservation tillage		
18	26	42

CTIC & Schertz, 1988.

# Progress in erosion reduction in the U.S.





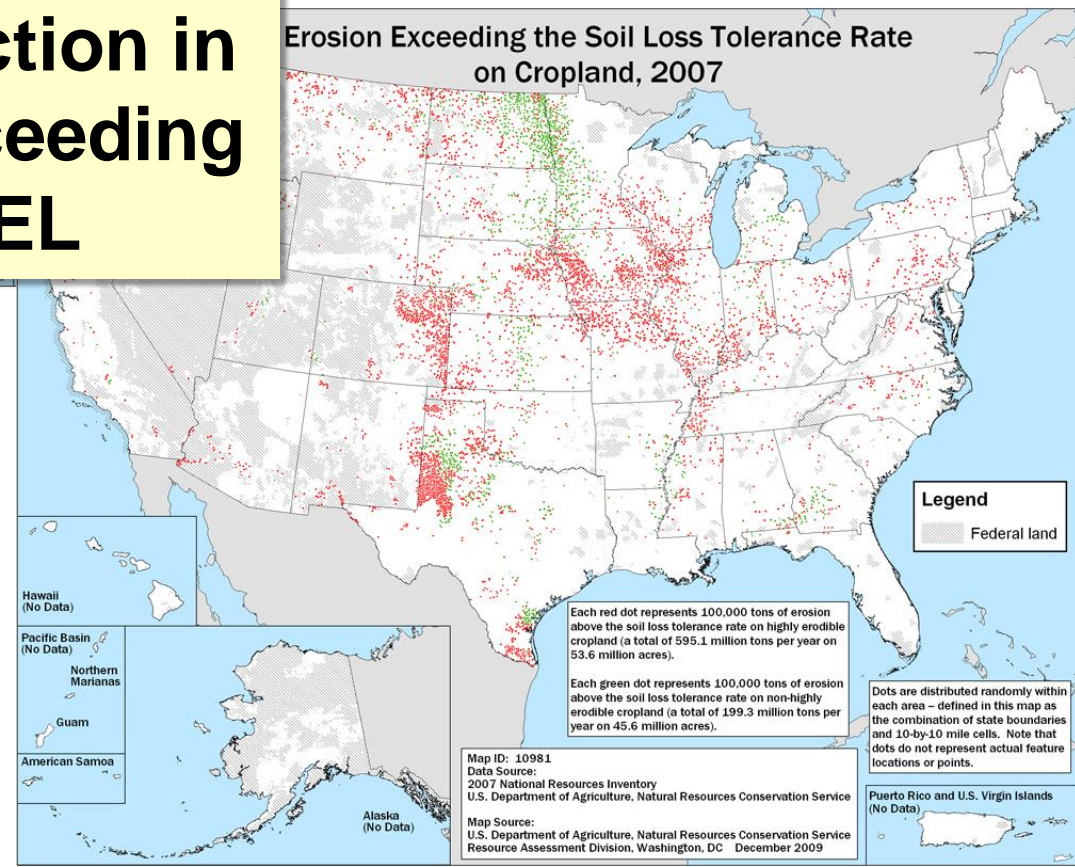


**Good progress, but  
erosion rates  
exceeding T remain**

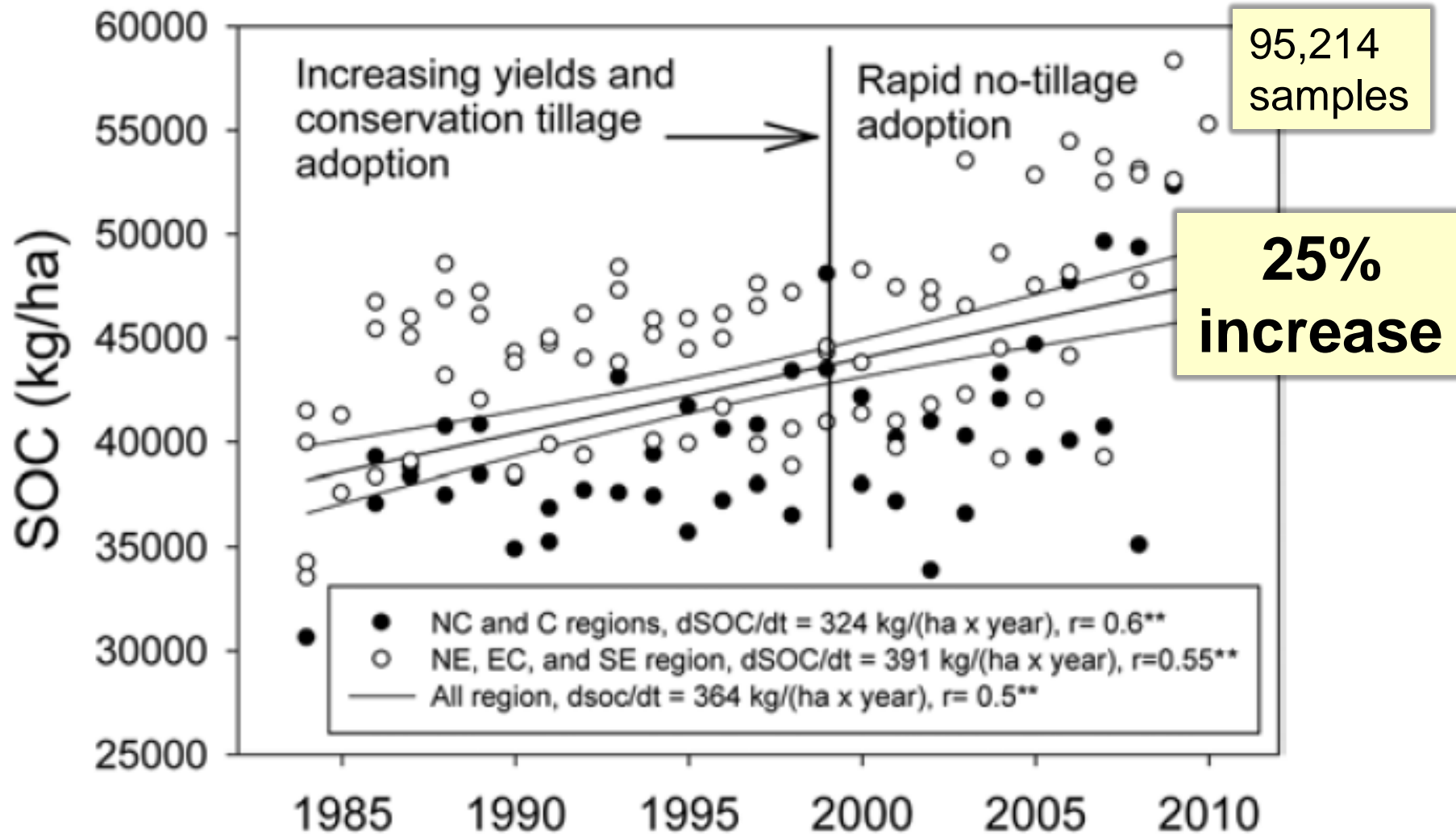
**50%+ reduction in  
erosion exceeding  
T on HEL**

### Erosion above T

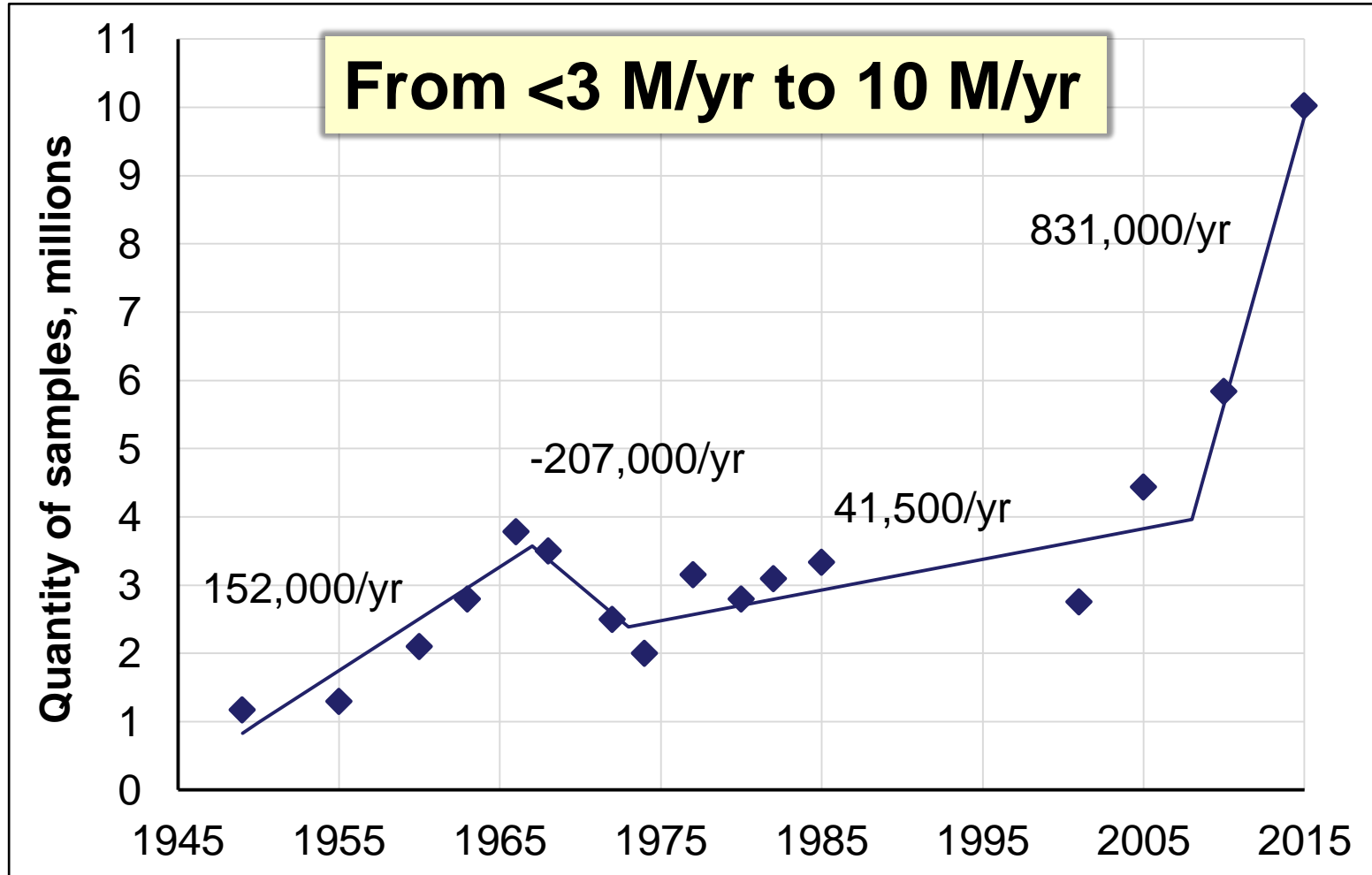
Land class	1982	2007
	million tons/yr	
Highly erodable (HEL)	1322	595
Non-HEL	422	199



# Organic carbon content of surface 6 inches based on producer soil samples submitted to the SDSU soil testing lab



# Progress in soil testing in the U.S. 1949-2015



Nutrient use has never been as measurement-guided as it is today

# Nutrient balance on US cropland

NUE Expression	1987	2012
N removal/use	0.74	0.75
N balance, lb/cropland A	19	27
P <sub>2</sub> O <sub>5</sub> removal/use	0.78	0.92
P <sub>2</sub> O <sub>5</sub> balance, lb/cropland A	5.2	2.2
K <sub>2</sub> O removal/use	1.13	1.44
K <sub>2</sub> O balance, lb/cropland A	-3.7	-13.6



# Advances in Technology in the Field

## Genetics



Photo by Bill Pan



Cornell University

Search

Adapt-N

FIELDVIEW pro

Nitrogen Advisor

South of Prairie  
Corn 159 ac (Monmouth, IL)

Target Yield	250 bu/ac	Edit
Soil	Silty Clay Loam	Edit
Planting	DRG-120455, 38,000 bu	Edit
Practices	Corn on Board Rotation	Edit
Show insights and events	On	0

Adapt-N  
Sign in

Top Product of the  
Encirca<sup>SM</sup> Yield Stand and Nitrogen Management

### News and events

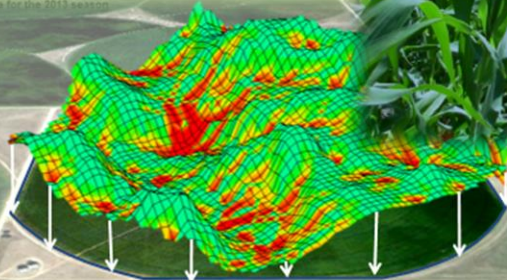
#### News from the blog

##### Adapt-N chosen 2012 Top Product of the Year

Adapt-N was selected as the Best New Product of the Year 2012 by AgProfessional magazine, the leading publication related to agronomic and business management for agricultural retailers/distributors, product managers and crop consultants. Adapt-N took a huge 52 percent of the vote, and it is the first time a commercial organization received the award. "The [...]"

##### Adapt-N is now available for the 2013 season

Hello Adapt-N!  
the 2013 season  
questions and



Water flow map





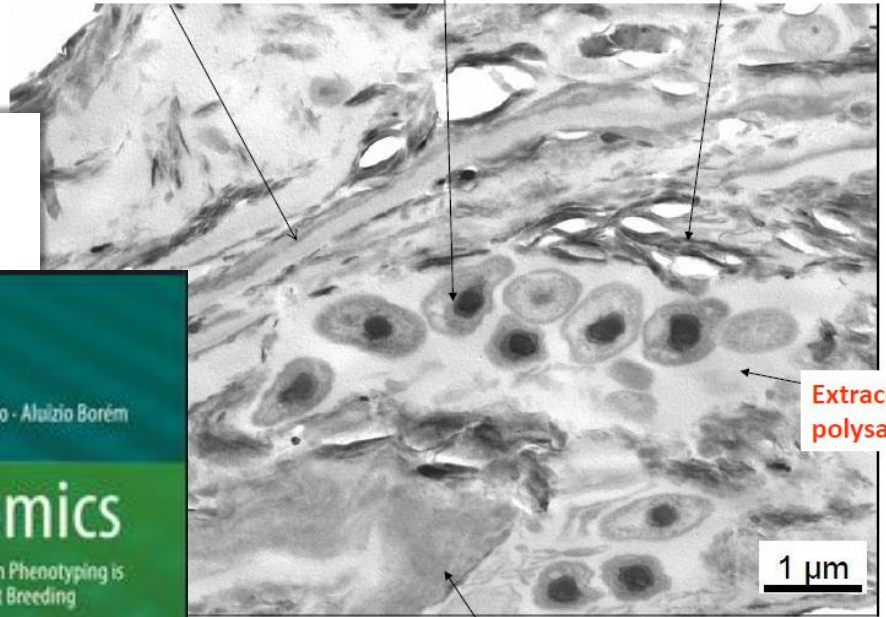
# Advances in Technology in Research



particulate organic matter (POM)

microorganisms

layer silicate clay



Extracellular polysaccharide

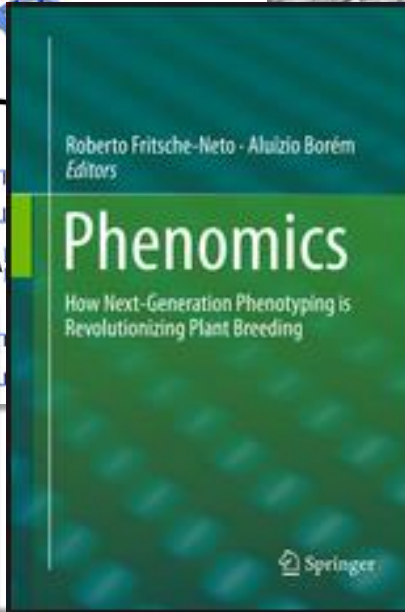
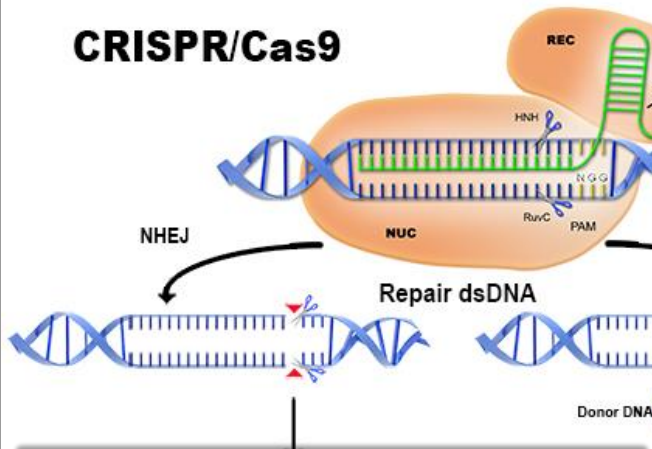
humified organic matter

Image by ML Thompson

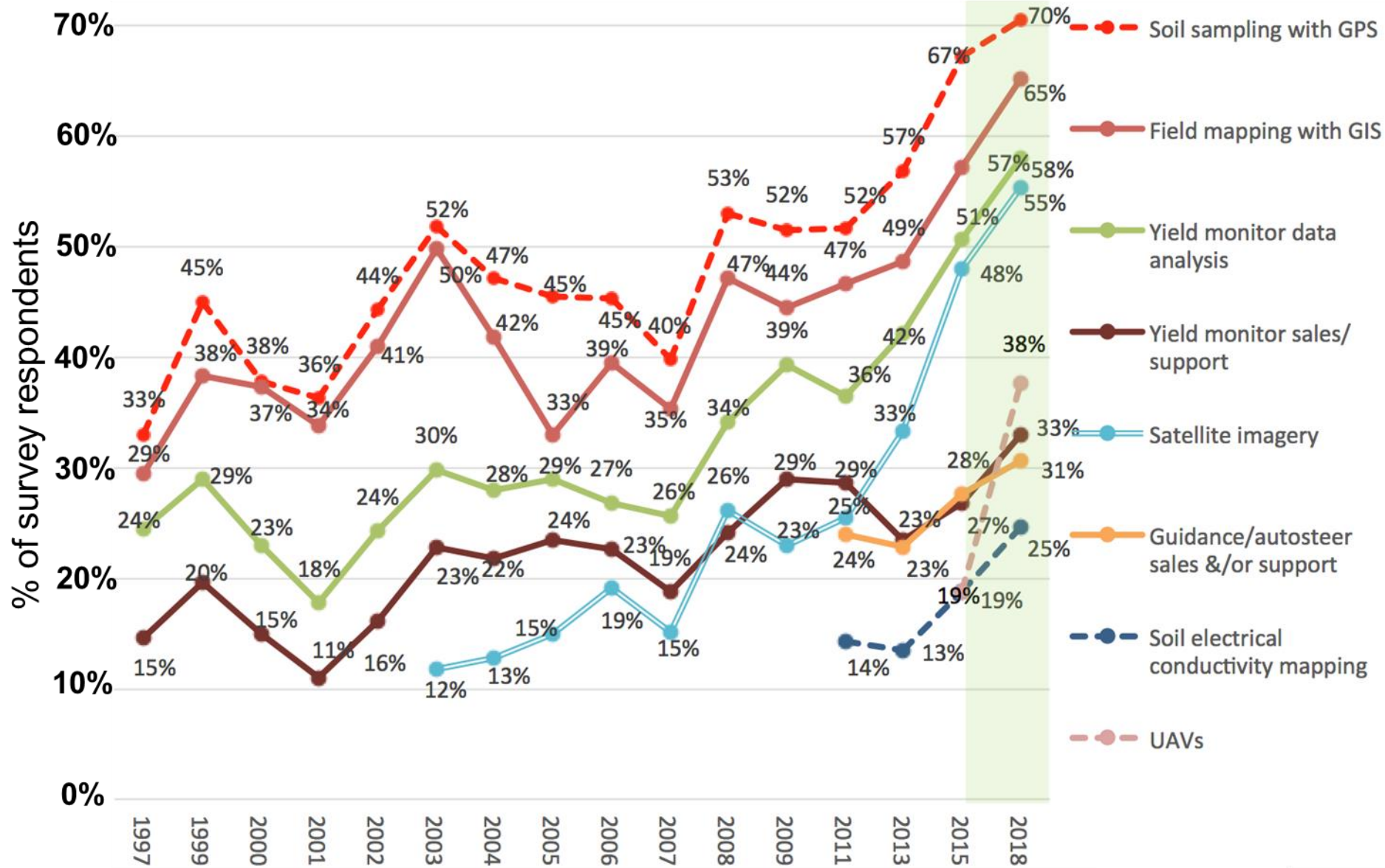
200 nm

PNI

## CRISPR/Cas9



# Precision services in US – rapidly increasing



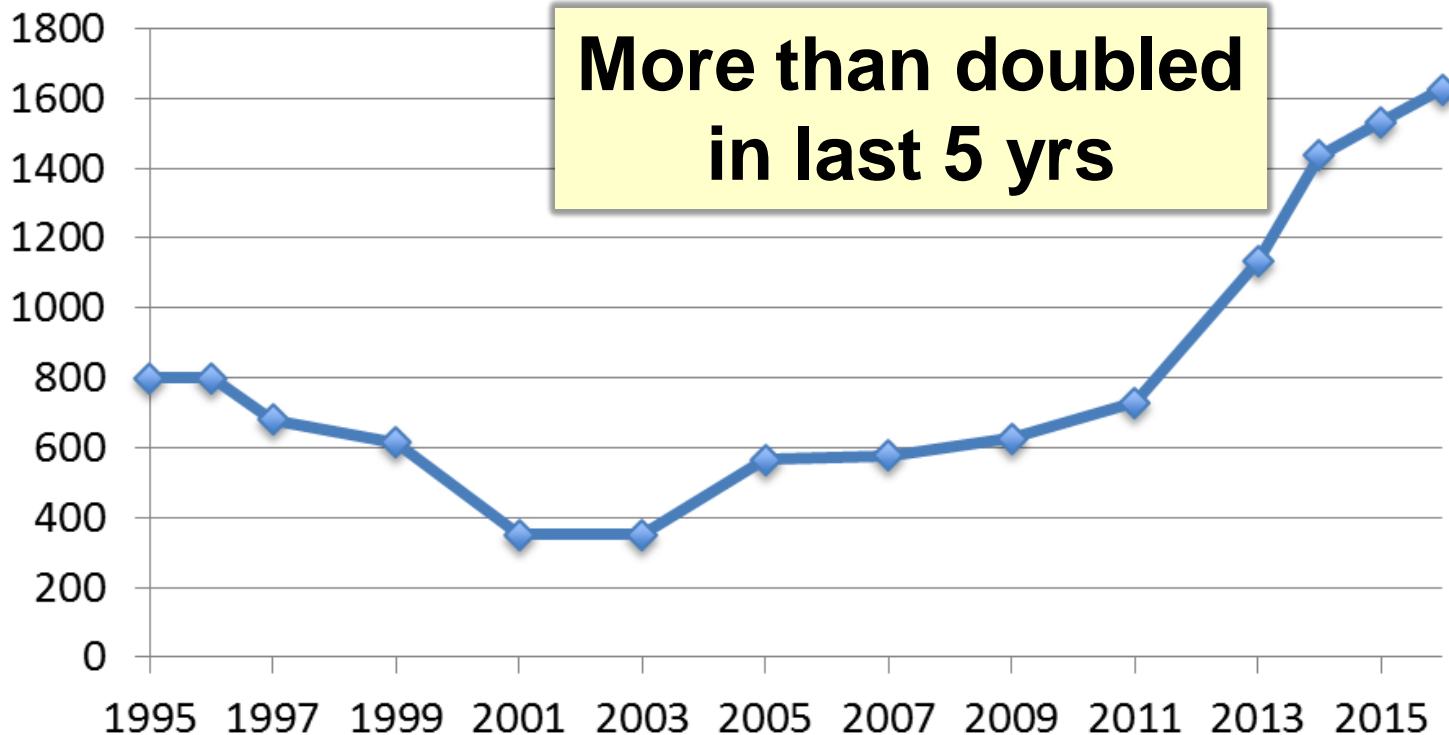


# INFORMATION AGRICULTURE CONFERENCE

June 28-30, 1995

Chancellor Hotel & Convention Center  
Champaign, Illinois

## InfoAg Attendance



Organized by the  
**Potash & Phosphate Institute**  
and the  
**Foundation for Agronomic Research**



**Data: major component of precision - in 1995 & even more so today**

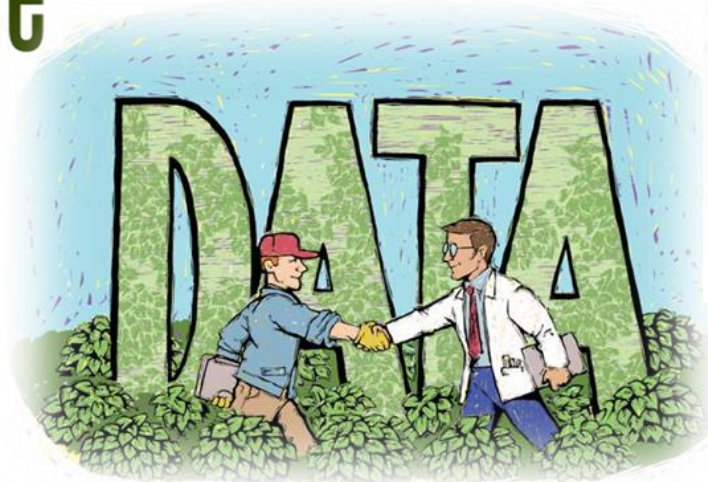
# 2015 InfoAg Topics



# 1995 InfoAg Topics

- **Data analysis** in site-specific systems – Don Bullock
- **Handling data** for site-specific management – Craig Elliot
- Requirements for integrating maps & **databases** – Ted Macy

- Agronomic lessons from **data analysis** – Dan Frieberg
- **Weather data** sources – Jim Angel & Tim Marquis
- **Yield data** mining– Raj Khosla
- **Big Data** in context – Lisa Prassack & Douglas Hackney
- **Data issues** – Mary Kay Thatcher & Matthew Darr
- **Data warehouses/exchanges** – Jason Tatge & John Fulton
- Using **satellite/NASA data** – Phyl Speser & Munch Moulton



**Data** has become a huge part of  
**agronomic practice**  
... and is becoming a more visible  
component of **agronomic science**

# **Examples of progress in knowledge and its application ...**

A composite image featuring a portrait of Mark Twain on the right side, wearing a dark suit and a bow tie. On the left side, there is a red background with the name 'Mark Twain' written in a cursive script. Below the script, the words 'the MAN' are written in a bold, white, sans-serif font.

the MAN

It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.

Mark Twain



**We 'Know' That Potassium Has To  
Be Placed Where We Want It In The  
Root Zone Since It Does Not Move  
In Soil ?**

**We 'Know' That Phosphorus Has To  
Be Placed Where We Want It, In The  
Root Zone Since It Does Not Move  
In Soil ?**

**We 'Know' That Starter Fertilizer  
Has To Be Placed Where We Want It  
In The Root Zone - With Or Below  
The Seed?**

**We 'Know' That Manure Should be  
Credited for its Nutrient Content  
which can be Estimated from  
Tabular Values?**



# A classical fertilizer recommendation paradigm



Concealed in the box:

*Calibration data*  
*Other data*  
*Data manipulation*  
*Tradition & philosophy*  
*Assumptions*

# Evidence-based Soil Test Calibration in Australia

## “Better Fertilizer Decisions for Cropping Systems (BFDC)”

- Searchable data repository
- 6,000 trial treatment series
- N,P,K,S for multiple crops
- Nation wide, shared work & funding

### Soil test-crop response trials

The database holds 5698 trial treatment series geographic locations, many being nearest town 1795 N, 2386 P, 365 K and 286 S trials.

### Searching the database

Trial sites are plotted on the map as grey dots. search criteria below and/or by drawing a polygon of interest. Always begin with a broad selection, then selection in more detail.

Nutrient:

P

From Year:

All

State:

All

Crop:

All  
cereal barley  
cereal barley feed  
cereal barley malting  
cereal maize  
cereal oats  
cereal sorghum  
cereal triticale

Farming System:

All

To Year:

All

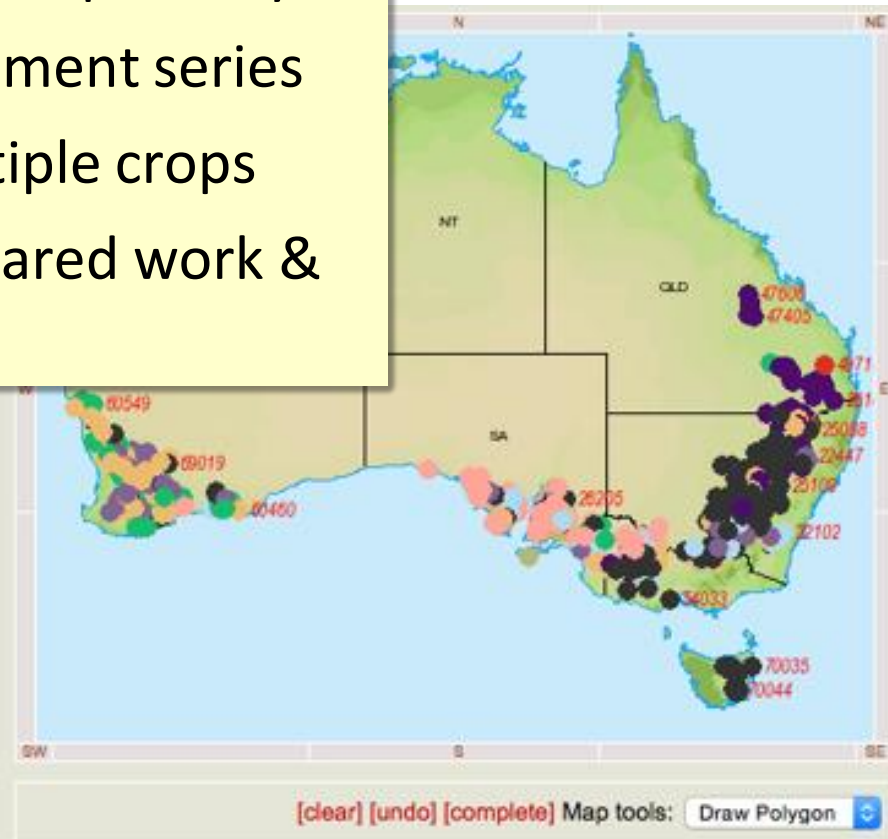
Season:

All

Australian Soil Class:

All  
Calcarosol  
Calcarosol calcic  
Calcarosol hypercalcic  
Calcarosol hypocalcic  
Calcarosol lithocalcic  
Calcarosol supraccalcic  
Chromosol

Select trials that satisfy the selection criteria above



### Optional Layers | Legend

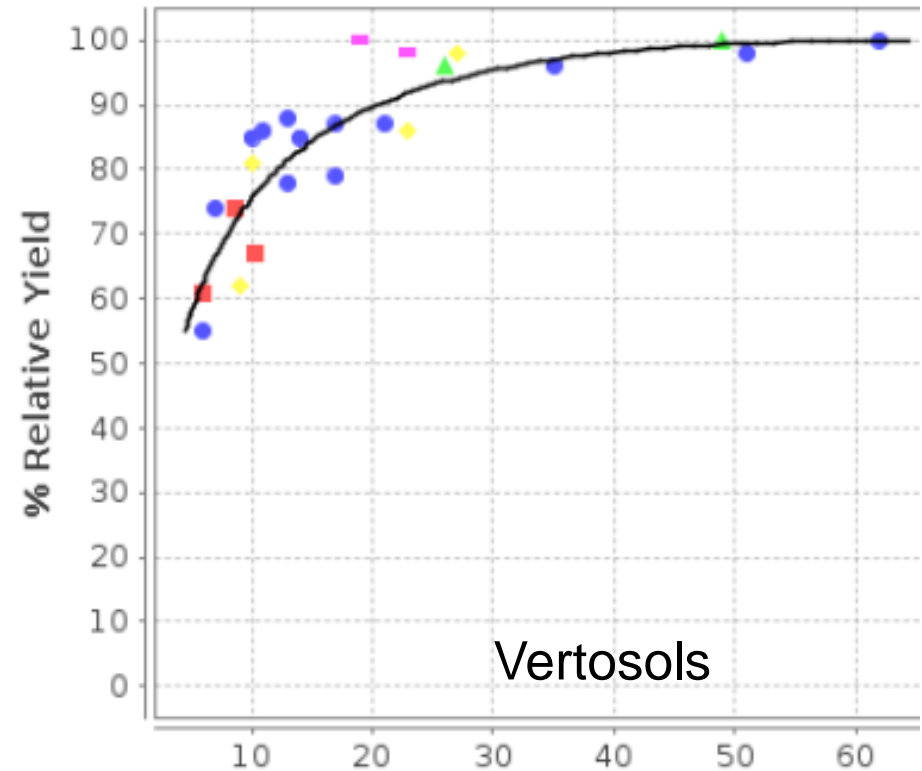
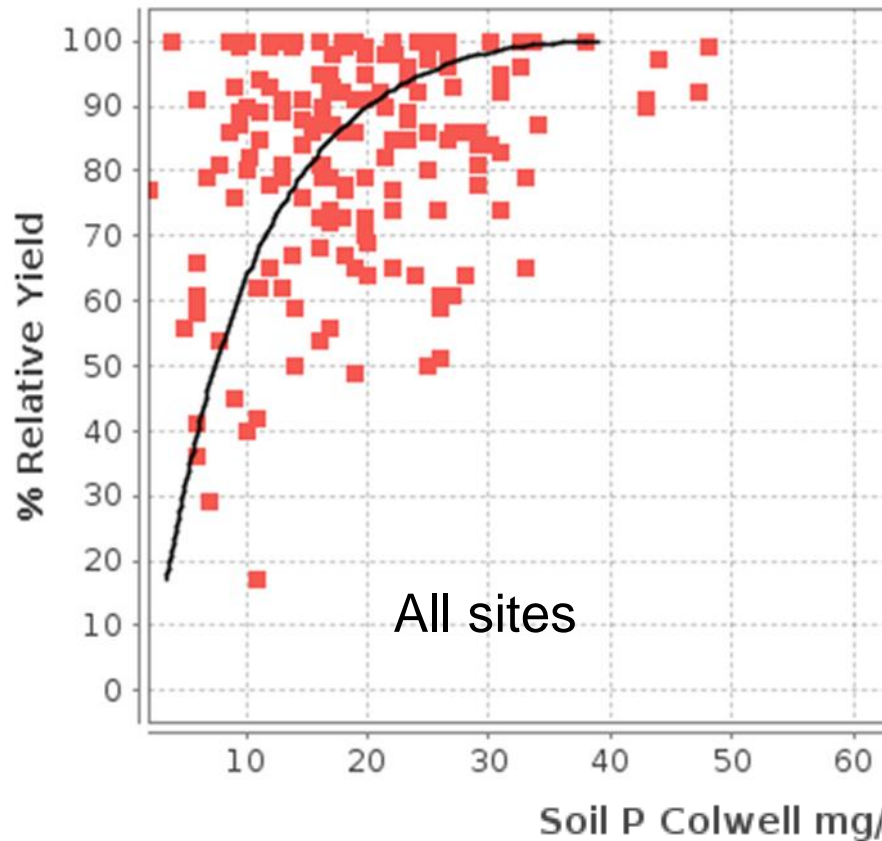
☐ Rainfall

☐ Road

☐ Vegetation

# Wheat response to P fertilizer in Australia

“Better Fertilizer Decisions for Cropping Systems (BFDC)”



Effort underway for a similar system for the U.S.

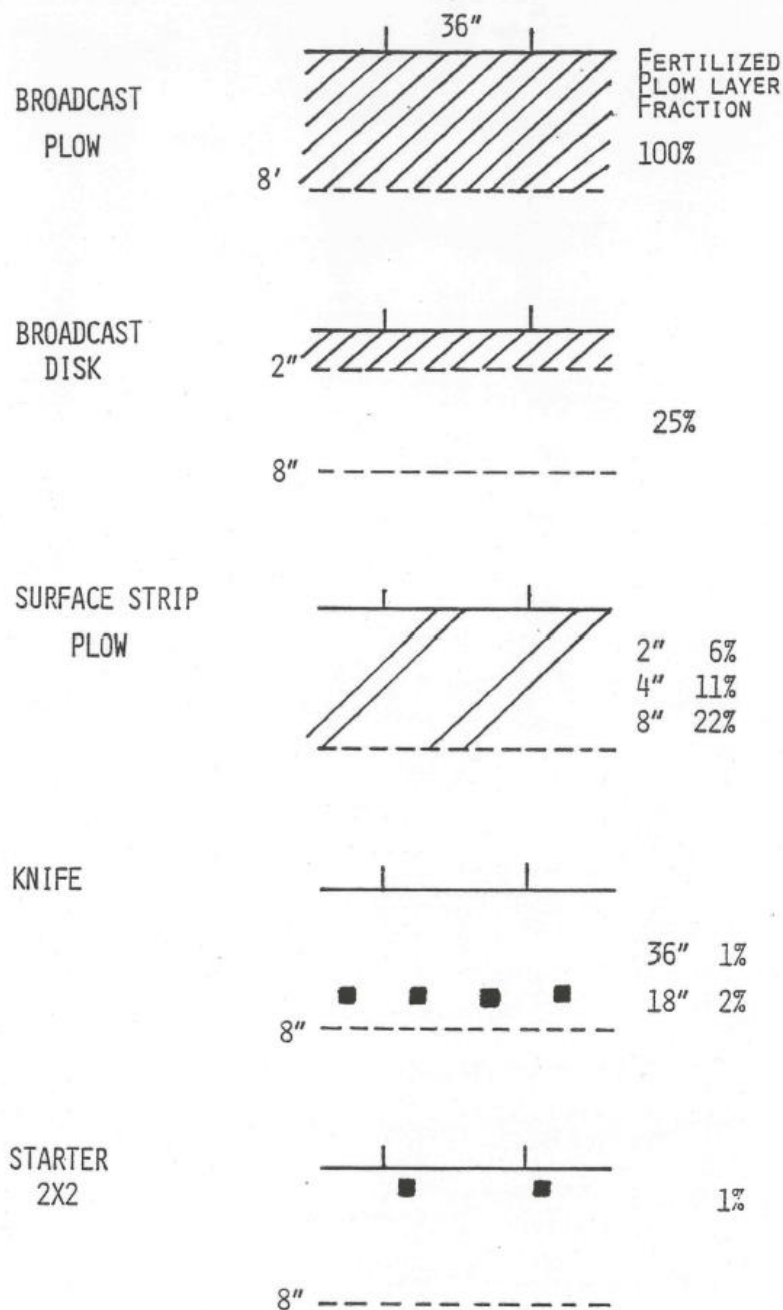
# Roots, soils and fertilizer nutrients



Dr. Stan Barber  
Winter 1994

- Corn or soybean roots occupy 1% of soil volume
- P movement depends on soil: faster & further in high P soils; that hold more water
- Fertilizing 5-20% of soil volume would be better than all or with conventional banding

## FERTILIZER PLACEMENT ALTERNATIVES





by Dr. Stanley A. Barber

# Timing And Placement One Key to High Yields

Purdue scientist shows how strip placement of fluids is superior to broadcasting.

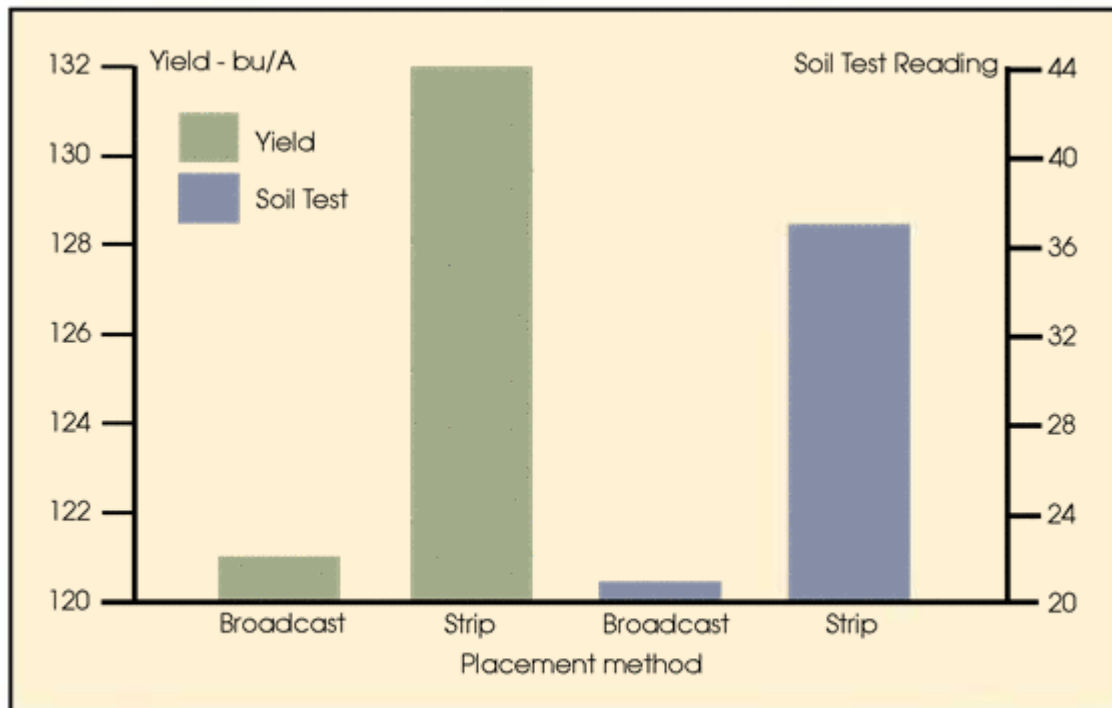


Figure 3. Average corn yields in a five-year comparison study of strip versus broadcast, Barber, Purdue University.

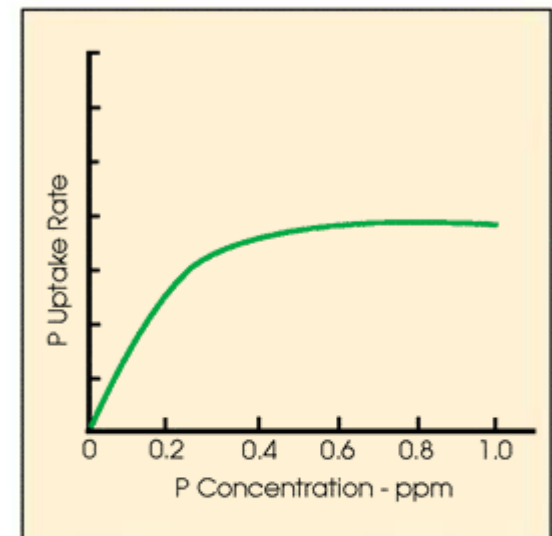
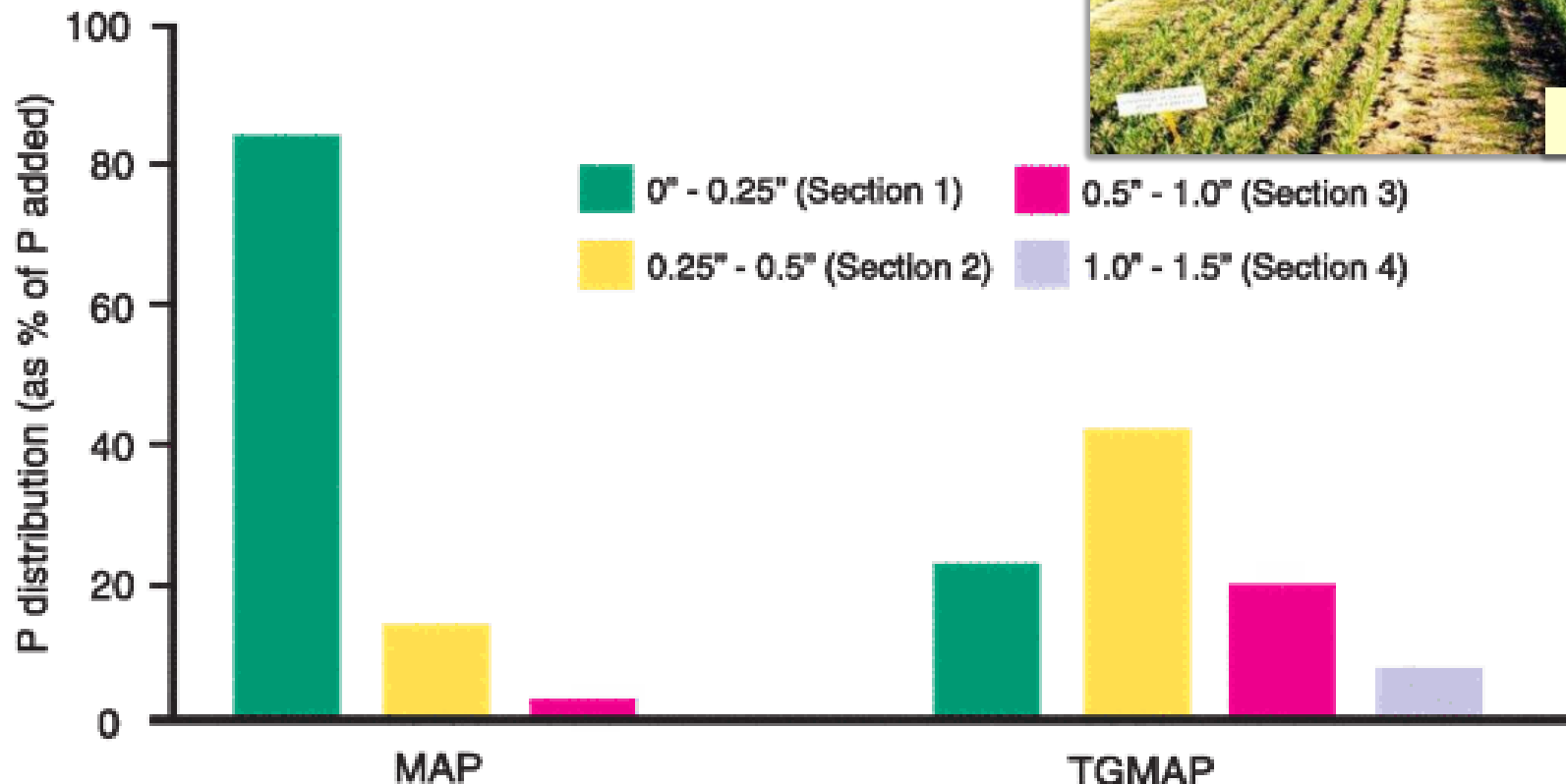


Figure 1. Relationship between phosphate in solution at the root surface and the rate phosphate is taken up by corn roots, Barber, Purdue University.

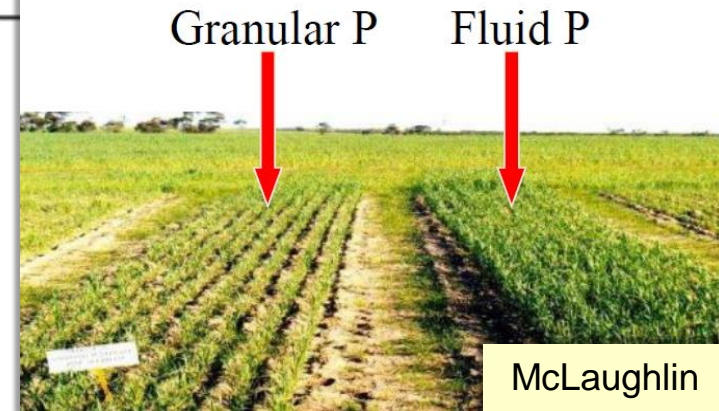
# Fluids Beat Granular in Soil

Granular fertilizers found to be inferior to fluids in calcareous soils

Increasing movement ... a placement effect



## Fluid P effective in calcareous soils



# Does Pattern of Root Development Explain Variances in Crop Response?

Minnesota ridge-till studies suggest corn hybrids with shallower root system patterns may respond better to potash applications in early growth stages.

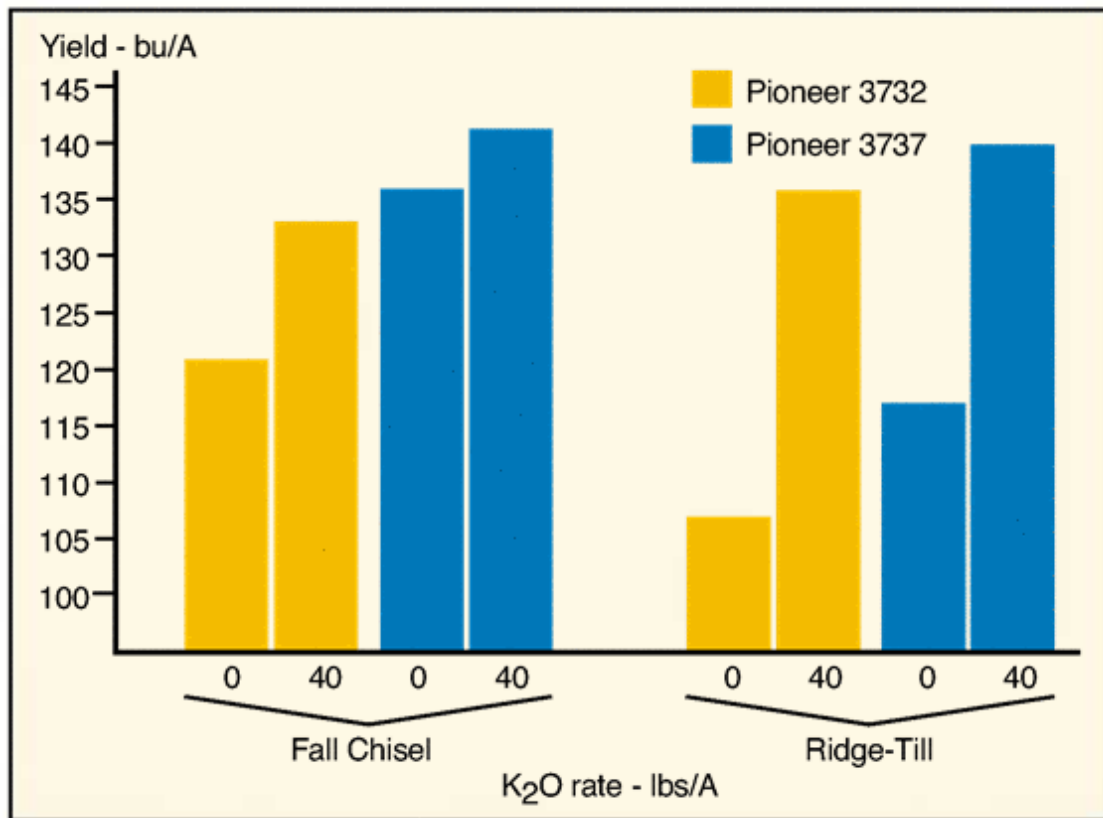


Figure 2. Corn yields in two tillage systems as affected by hybrid and banded potash, yields avg. of two years, Oldham and Rehm, University of Minnesota, 1991-92.

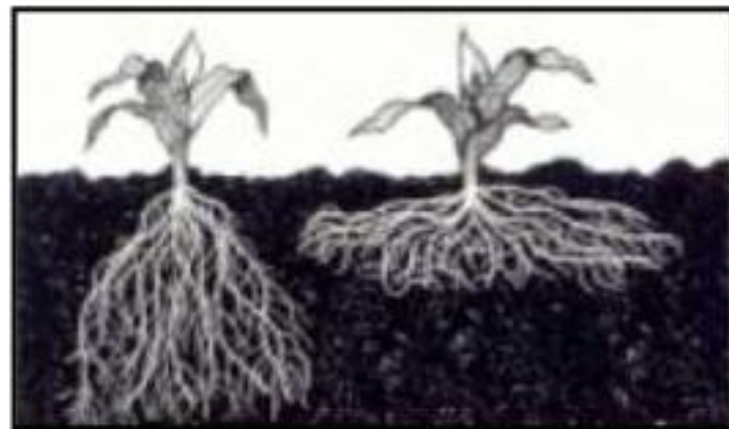
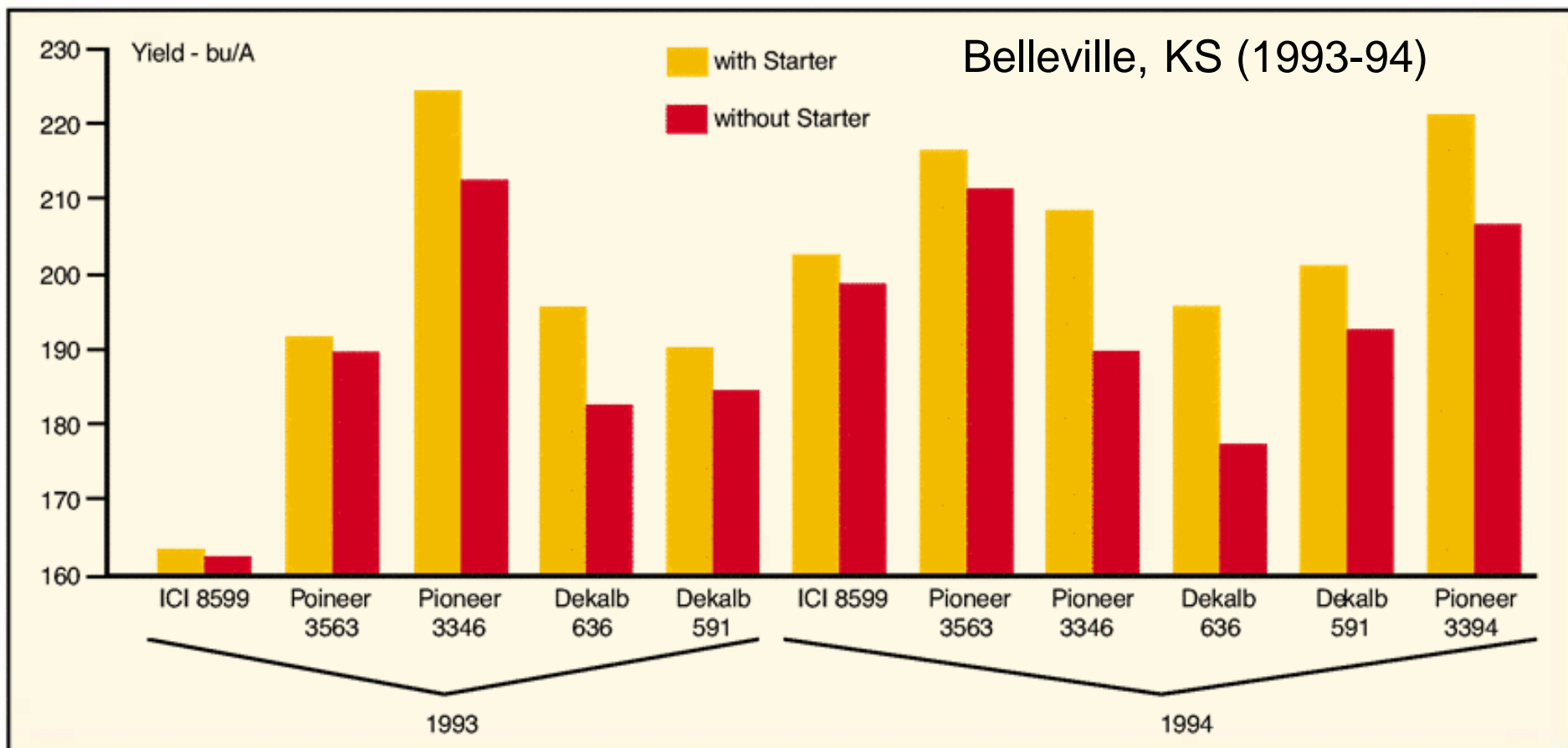


Figure 3. Root system patterns of two hybrids used in field research, Oldham and Rehm, University of Minnesota.

# Corn Hybrids Vary In Response To Starter Fertilizers

Possibility of different rooting characteristics in hybrids prompts this two-year study of selected corn varieties grown under no-till, dryland conditions.



# Achieving 300 Bu/A Corn Sustainability

*Involves agricultural intensification that pursues higher yields, biofuel production potential, and preservation of our soil and water resources.*

**Drs. Laura F. Gentry and Fred E. Below**

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Spring 2011 • Vol. 19, No. 3, Issue #73

**Table 3. Traditional vs. high-tech, two years.**

	Traditional		High-tech	
Factor	Yield	*	Yield	**
	Bu/A <sup>-1</sup>			
None or all	193		245	
Fertility	197	+4	236	-9
Nitrogen	198	+5	232	-13
Genetics	202	+9	225	-20
Population	187	-6	238	-7
Fungicide	198	+5	218	-27

*Data from Champaign and Dixon Springs*

\* *Difference when changed to high-tech level*

\*\* *Difference when changed to traditional level*

\*\*\* *Adapted from Ruffo, Henninger, and Below. A new experimental design to analyze the value of management factors contributing to high corn yield. Am. Soc. Ag. Mtg. Oct 31-Nov 4, 2010.*



# Higher Yields & High Population: Impact on Root Mass & Nutrient Uptake?

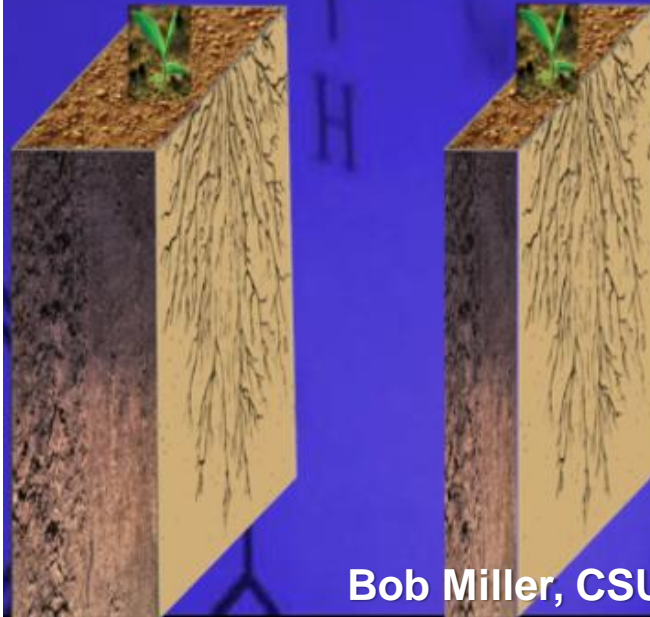
**High Plant Density = Smaller Roots**

**Normal Population  
32,000 plants/acre**

**High Population  
45,000 plants/acre**

1960 root soil  
volume per plant  
16,000 plts/ac

2013 root soil  
volume per plant  
32,000 plts/ac



Fred Below

**I** Crop  
Physiology

Bob Miller, CSU

# Meeting nutrient demand through entire increasingly variable growing seasons

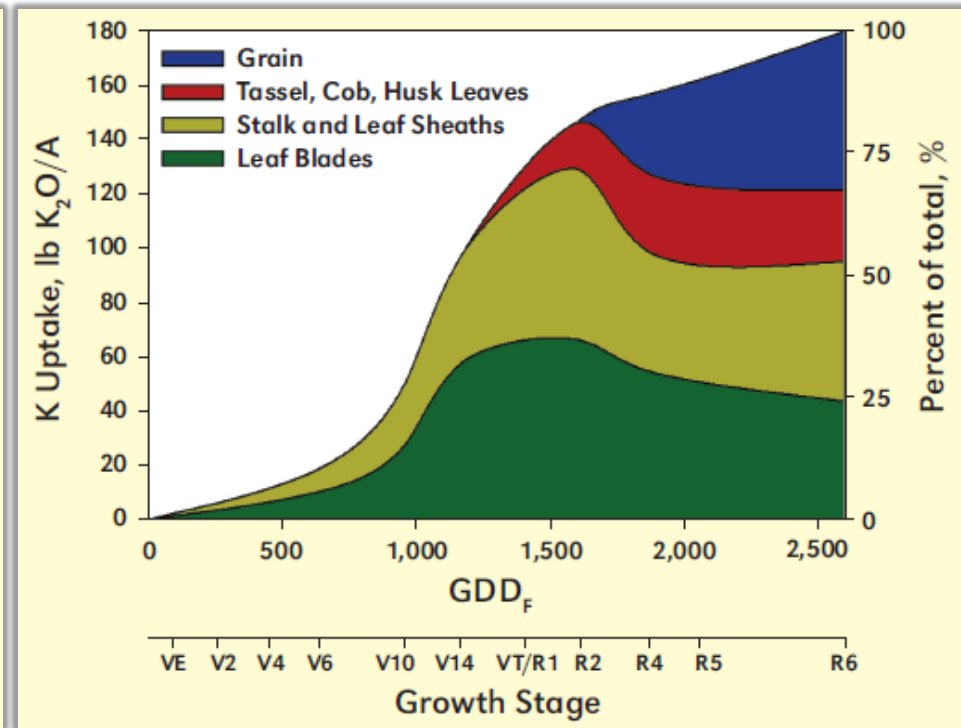
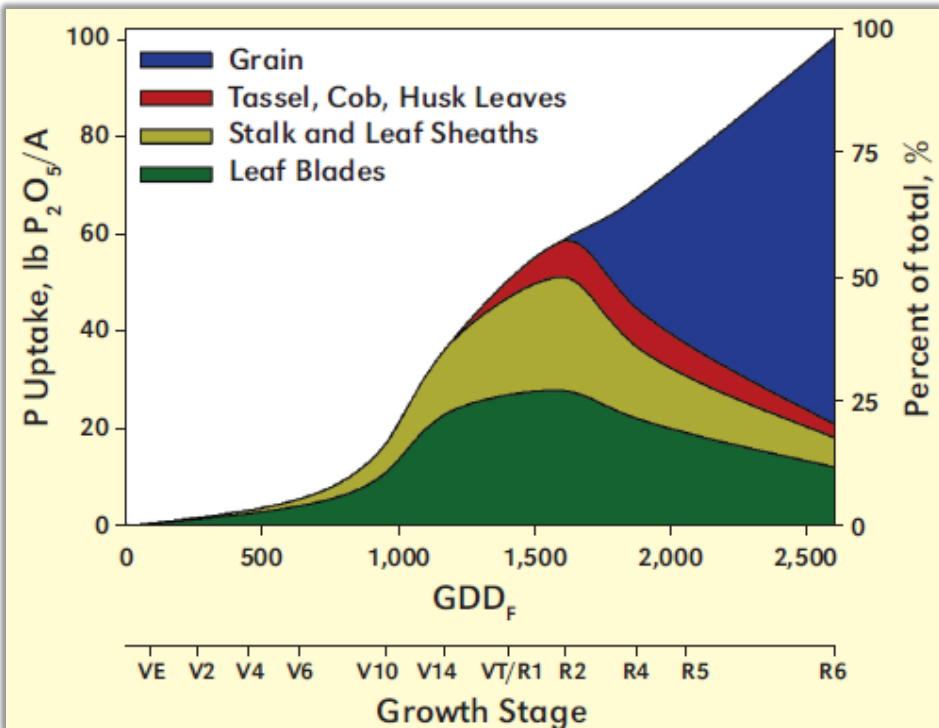
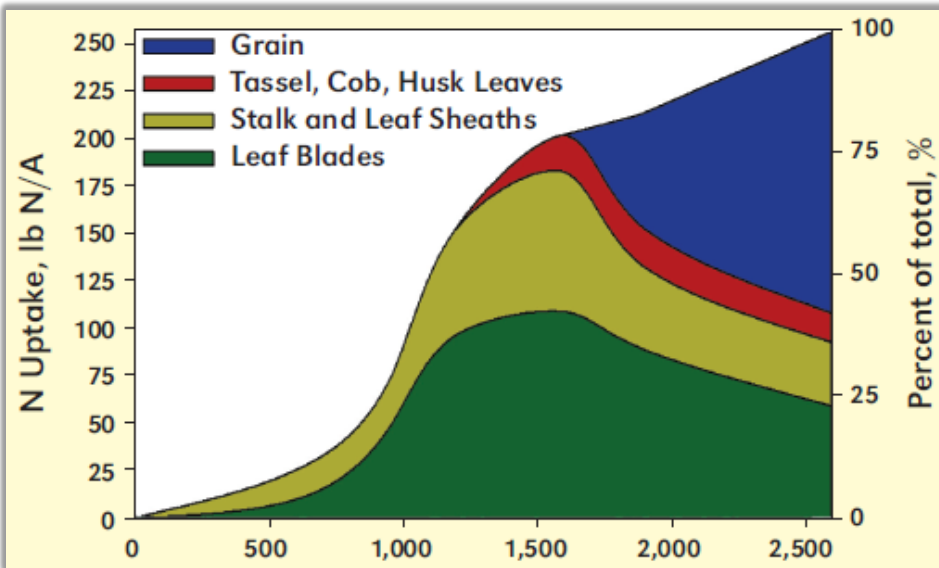






Photo by Alyssa Abbott, DuPont/Pioneer Account Manager;  
NE IL

■ Dr. Newell R. Kitchen

## What's Right Amount of N? Using Sensors May Provide Better Answer

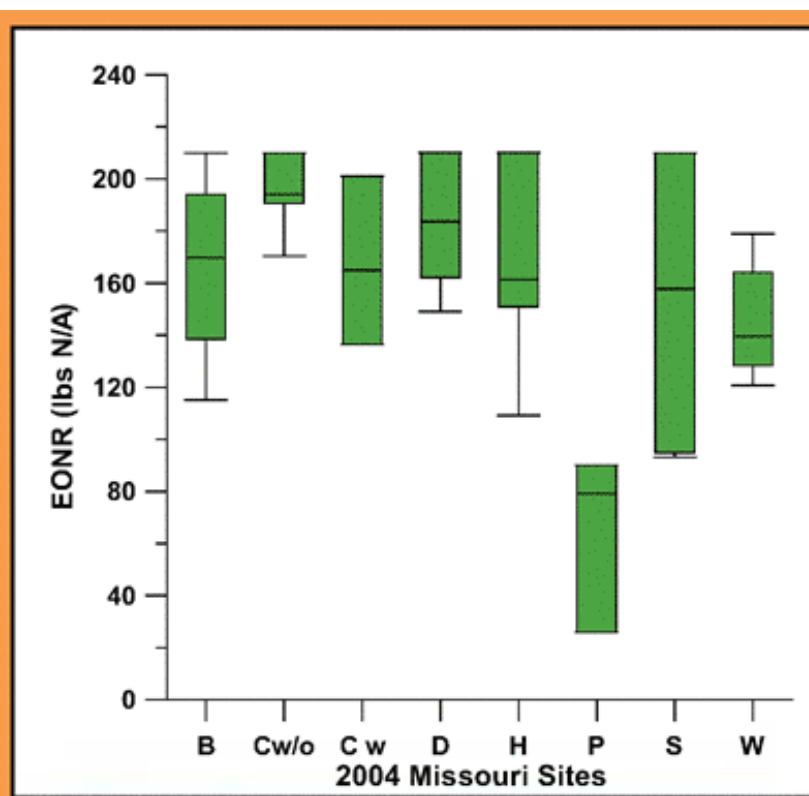


Figure 1. Economic optimal N rate (EONR) varies tremendously between farmers' fields and within fields (box represents the 25th to 75th percentile).



# Nitrogen Source Effects on Soil Nitrous Oxide Emissions

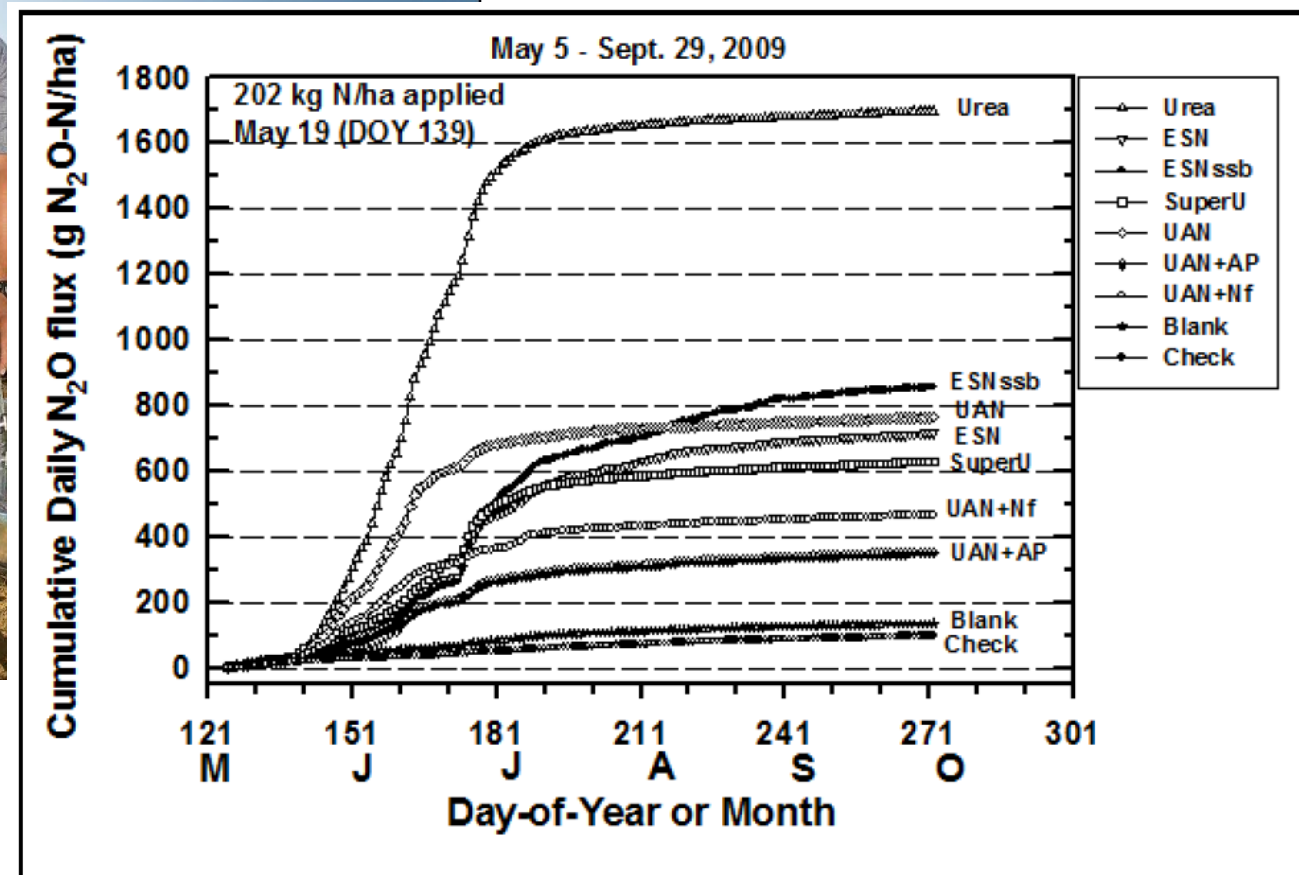
can be a mitigation practice for reducing  $N_2O$  emissions in irrigated corn.

Drs. Ardell Halvorson, Stephen Del Grosso, and Claudia Jantalia

Journal of the Fluid Fertilizer Foundation • Late Spring 2013 • Vol. 21, No. 3, Issue # 81

↓ [DOWNLOAD PDF](#)

(N)  
generally  
nitrous  
s.  
le  
N fertilizers  
their potential  
ons from  
pared with  
granular  
nium  
s in an  
corn  
All other N  
ntly lower  
emissions  
with UAN  
UAN +  
emissions  
ads were  
ssing  $N_2O$   
yield and  
of  $N_2O$ -N  
plied was  
0.5% for  
corn grain  
ent among  
than  
applied.



**Figure 6.** Cumulative daily  $N_2O$ -N emissions during the 2009 growing seasons for each N treatment: urea, urea-ammonium nitrate (UAN), ESN, ESN subsurface band (ESNssb), SuperU, UAN+Nfusion (Nf), UAN+AgrotainPlus (AP), blank, and check.



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## Special section: Breakthrough of the Year

Science's editors and writers  
choose their scientific  
breakthrough of 2016

© Rich Frishman

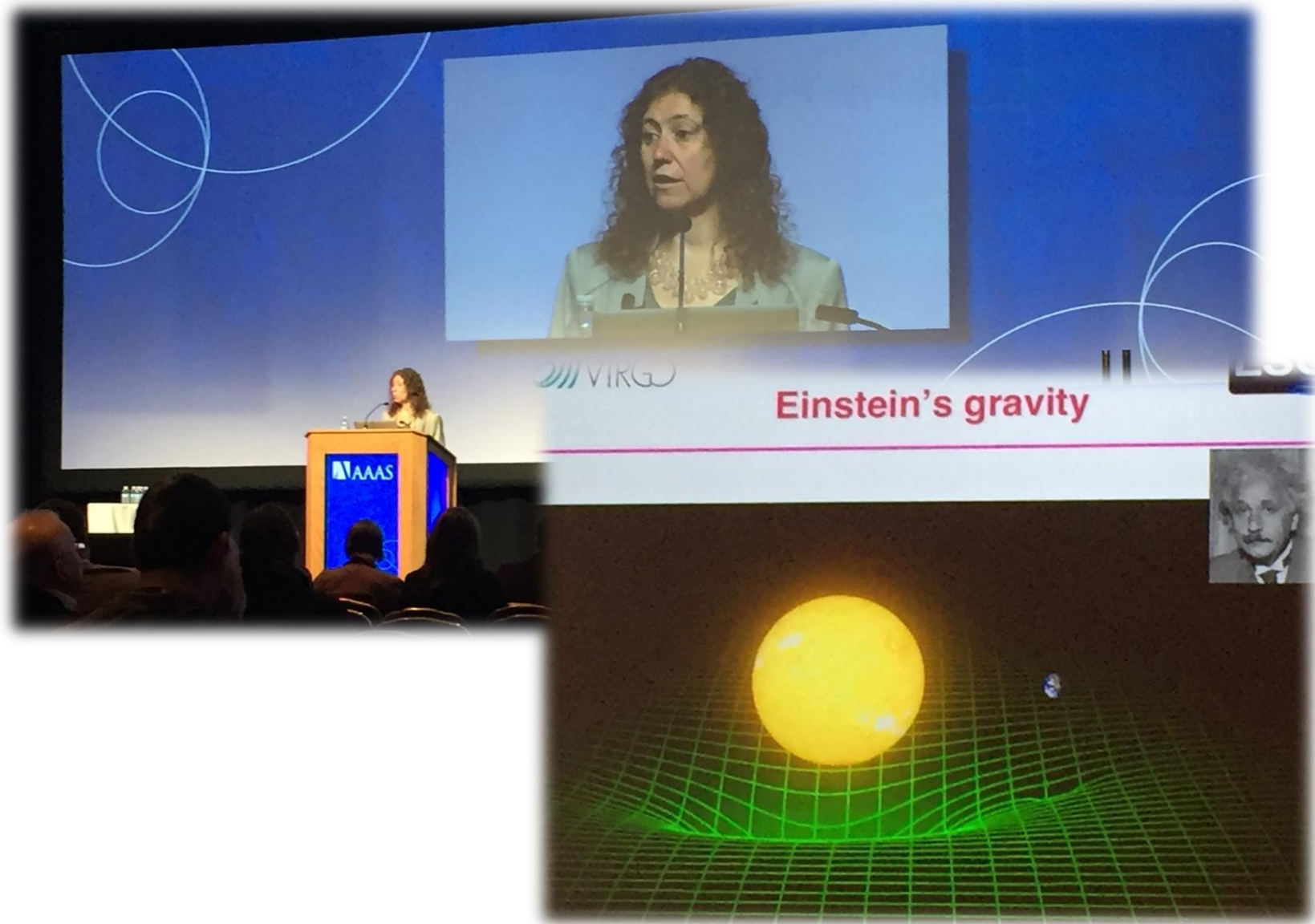
# 2016

## BREAKTHROUGH *of the* YEAR

# The cosmos aquiver

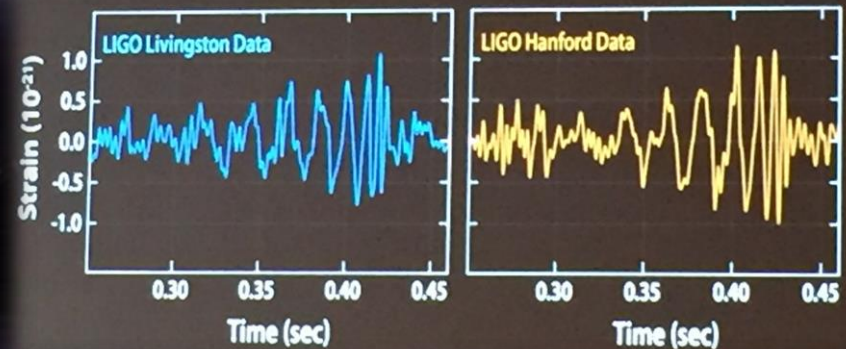
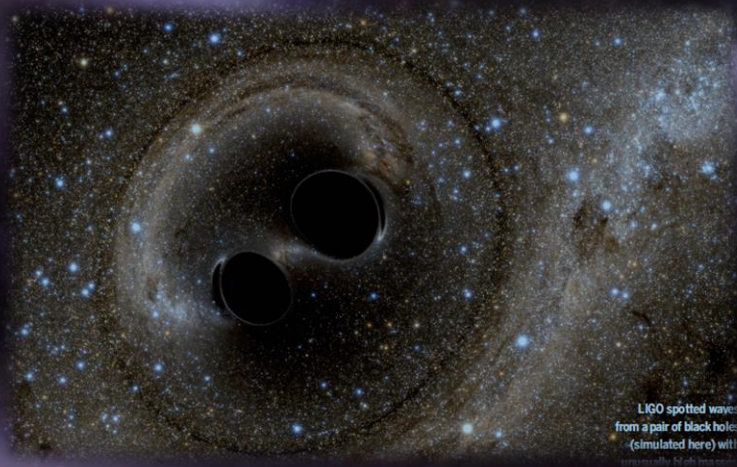
Detections of gravitational waves foreshadow a new way to eavesdrop  
on the most violent events in the universe *By Adrian Cho*

# AAAS Annual Meeting, February 2016





# Gravitational Waves



NASA/CXC/GSFC/T. Strohmayer

- 1.3 billion light years away – two black holes merged
- On 9/14/2015 the impact on space-time was **MEASURED** on Earth ... Einstein in 1916 was right!



# Observation of Gravitational Waves from a Binary Black Hole Merger

B. P. Abbott *et al.*\*

B. P. Abbott,<sup>1</sup> R. Abbott,<sup>1</sup> T. D. Abbott,<sup>2</sup> M. R. Abernathy,<sup>1</sup> F. Acernese,<sup>3,4</sup> K. Ackley,<sup>5</sup> C. Adams,<sup>6</sup> T. Adams,<sup>7</sup> P. Addesso,<sup>3</sup> R. X. Adhikari,<sup>1</sup> V. B. Adya,<sup>8</sup> C. Affeldt,<sup>5</sup> M. Agathos,<sup>9</sup> K. Agatsuma,<sup>9</sup> N. Aggarwal,<sup>10</sup> O. D. Aguiar,<sup>11</sup> L. Aiello,<sup>12,13</sup> A. Ain,<sup>14</sup> P. Ajith,<sup>15</sup> B. Allen,<sup>16,17</sup> A. Allocca,<sup>18,19</sup> P. A. Altamirano,<sup>20</sup> S. B. Anderson,<sup>21</sup> W. G. Anderson,<sup>22</sup> K. Arai,<sup>1</sup> M. A. Arain,<sup>5</sup> M. C. Araya,<sup>23</sup> C. Arceneaux,<sup>24</sup> J. S. Areeda,<sup>25</sup> N. Arnaud,<sup>26</sup> K. G. Arun,<sup>24</sup> S. Asci,<sup>27</sup> S. M. Aston,<sup>28</sup> P. Aston,<sup>28</sup> P. Aufmuth,<sup>5</sup> C. Aubert,<sup>8</sup> S. Babak,<sup>29</sup> P. Bacon,<sup>30</sup> M. F. Baccetti,<sup>32,33</sup> G. 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Bogan,<sup>8</sup> A. Bohe,<sup>29</sup> P. Bojtos,<sup>54</sup> C. B. Bond,<sup>55</sup> R. Bork,<sup>1</sup> V. Boschi,<sup>18,19</sup> S. Bose,<sup>56,57</sup> Y. Bouffanis,<sup>58</sup> A. Bozzi,<sup>34</sup> C. V. B. Braginsky,<sup>49</sup> M. Branchesi,<sup>57,58</sup> J. E. Brau,<sup>59</sup> T. Briant,<sup>60</sup> A. Brillet,<sup>59</sup> M. Brinkmann,<sup>61</sup> A. F. Brooks,<sup>1</sup> D. A. Brown,<sup>33</sup> D. D. Brown,<sup>33</sup> N. M. Brown,<sup>10</sup> C. Buchanan,<sup>2</sup> A. Buik,<sup>62</sup> A. Buonanno,<sup>29,62</sup> D. Buskulic,<sup>3</sup> C. Buy,<sup>30</sup> R. L. Byer,<sup>60</sup> M. Cabero,<sup>8</sup> L. Cadonati,<sup>63</sup> J. Calderón Bustillo,<sup>66,67</sup> T. Callister,<sup>1</sup> E. Calloni,<sup>67,74</sup> B. Camp,<sup>68</sup> K. C. Cannon,<sup>69</sup> J. Cao,<sup>70</sup> F. Carbognani,<sup>33</sup> S. Caride,<sup>71</sup> J. Casanueva Diaz,<sup>72</sup> C. Casentini,<sup>25,13</sup> S. Caudill,<sup>18</sup> R. 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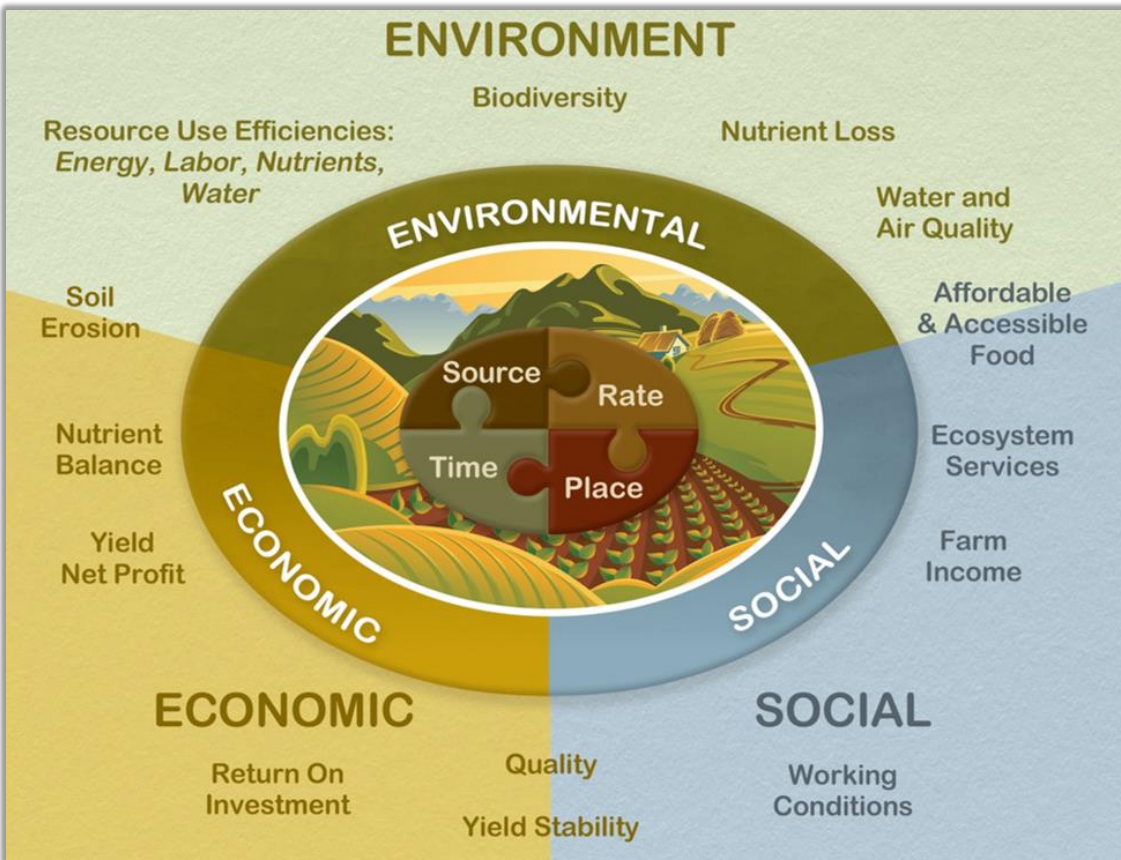


# Collaboration in Agronomy

- Meeting pre-competitive needs
- To focus resources on common science-based needs – short & long term
  - 1977 Potash & Phosphate Institute (PPI)
  - 1980 Foundation for Agronomic Research (FAR)
  - 1982 Fluid Fertilizer Foundation (FFF)
  - 1992 Certified Crop Adviser program (CCA)
  - 2007 International Plant Nutrition Institute (IPNI)
  - 2013 4R Research Fund



- Launched in 1992 ... 1<sup>st</sup> exam in 2/93 (Passing rate <50%)
- Requested by and led by the industry
- 13,000+ certified professionals providing science based guidance to producers
  - Instrumental in the progress made in nutrient stewardship & agronomic practice
  - Even more so in the future



**The greatest sign  
of stewardship  
progress in 35 yrs?**

- **2007:** Presented in raw form as a global framework for adapting fertilizer BMPs to local conditions
- **In 10 yrs:** a remarkable impact on the mind set of producers, advisers, NGOs, and researchers



# What's next?

## We do not know!

- Fluids and 4Rs
- Genetic improvement
- Nutrient sources
- Soil fertility
- Evidence
- Communication



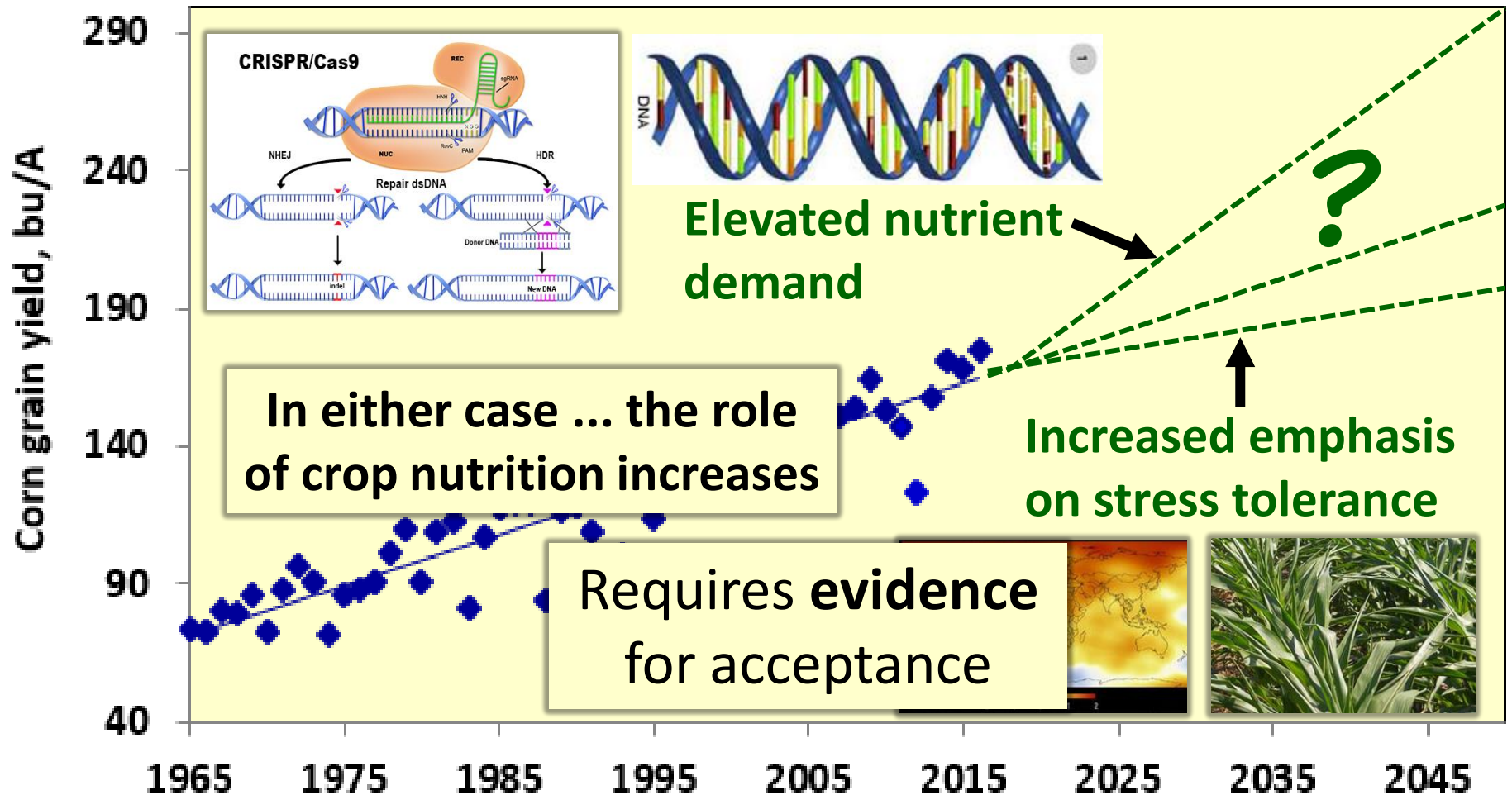
# Fluids and 4Rs – great opportunity (right source, place, time ... and rate)



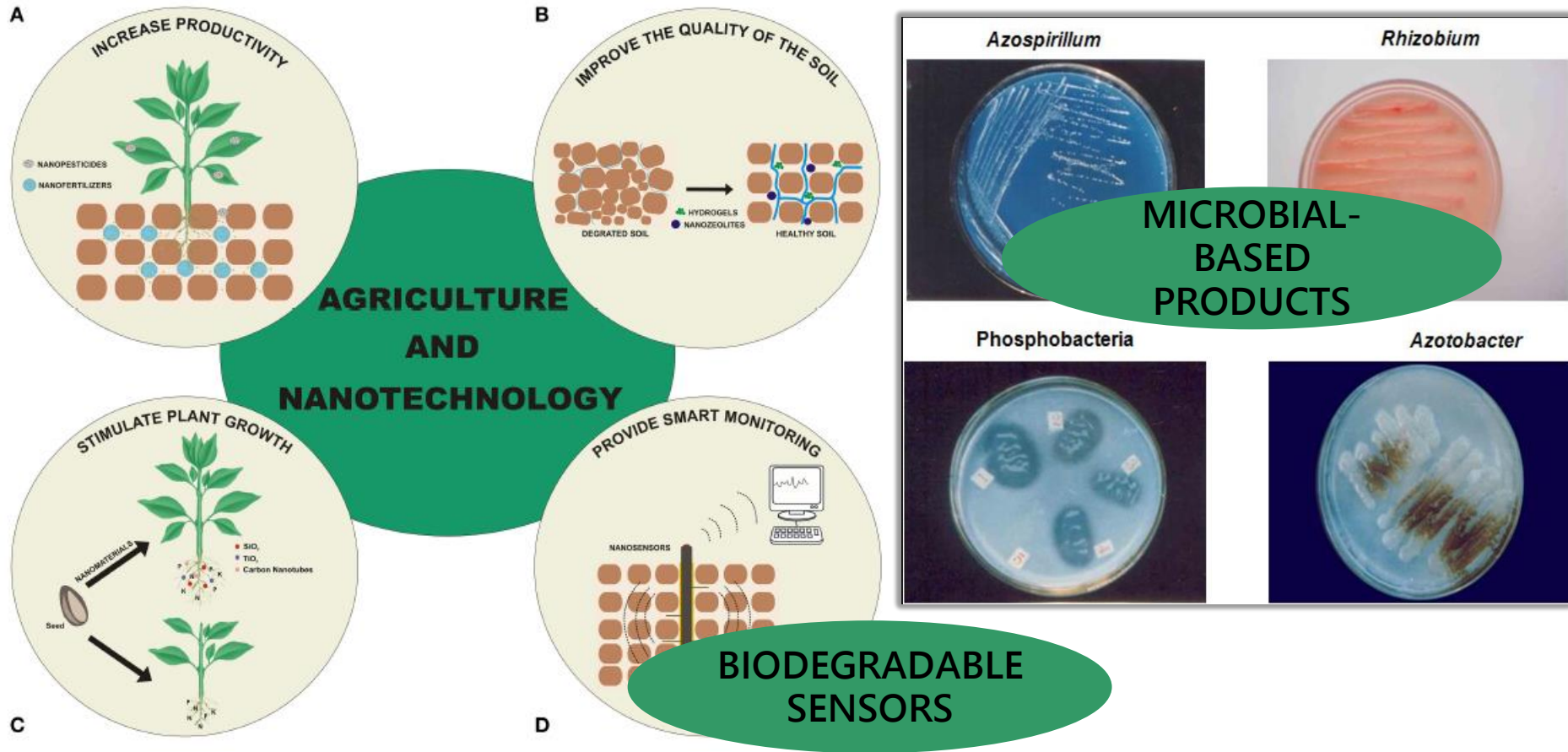
Meeting crop needs  
Reducing nutrient losses

Requires **evidence**  
for adoption

# Accelerated genetic improvement? Negative impacts of climate change?



# Advances in nutrient sources?



**Whether investing, purchasing or advising:**

Insist on reliable data ... look for **evidence** ... evaluate cost/benefit  
... beware of miracles ... consider long-term impacts

**See next topic ...**



# SOIL HEALTH



## Physical

- Aggregation and Structure
- Surface Sealing
- Compaction
- Porosity
- Water Movement and Availability

## Chemical

- pH
- Soluble Salts
- Sodium
- Nutrient Holding Capacity
- Nutrient Availability

## Biological

- Macrofauna
- Microfauna
- Microorganisms
- Roots
- Biological Activity
- Organic Matter

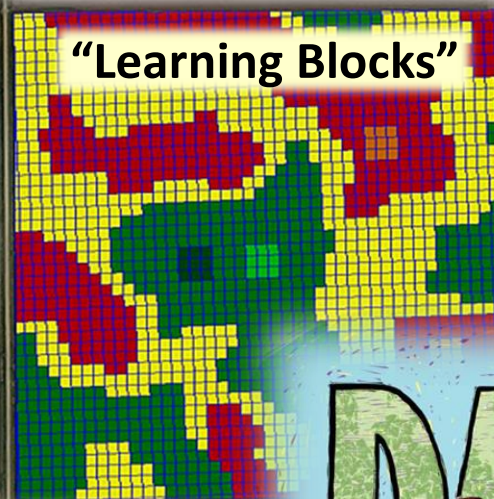
**Re-energized  
management  
for optimal  
soil fertility**

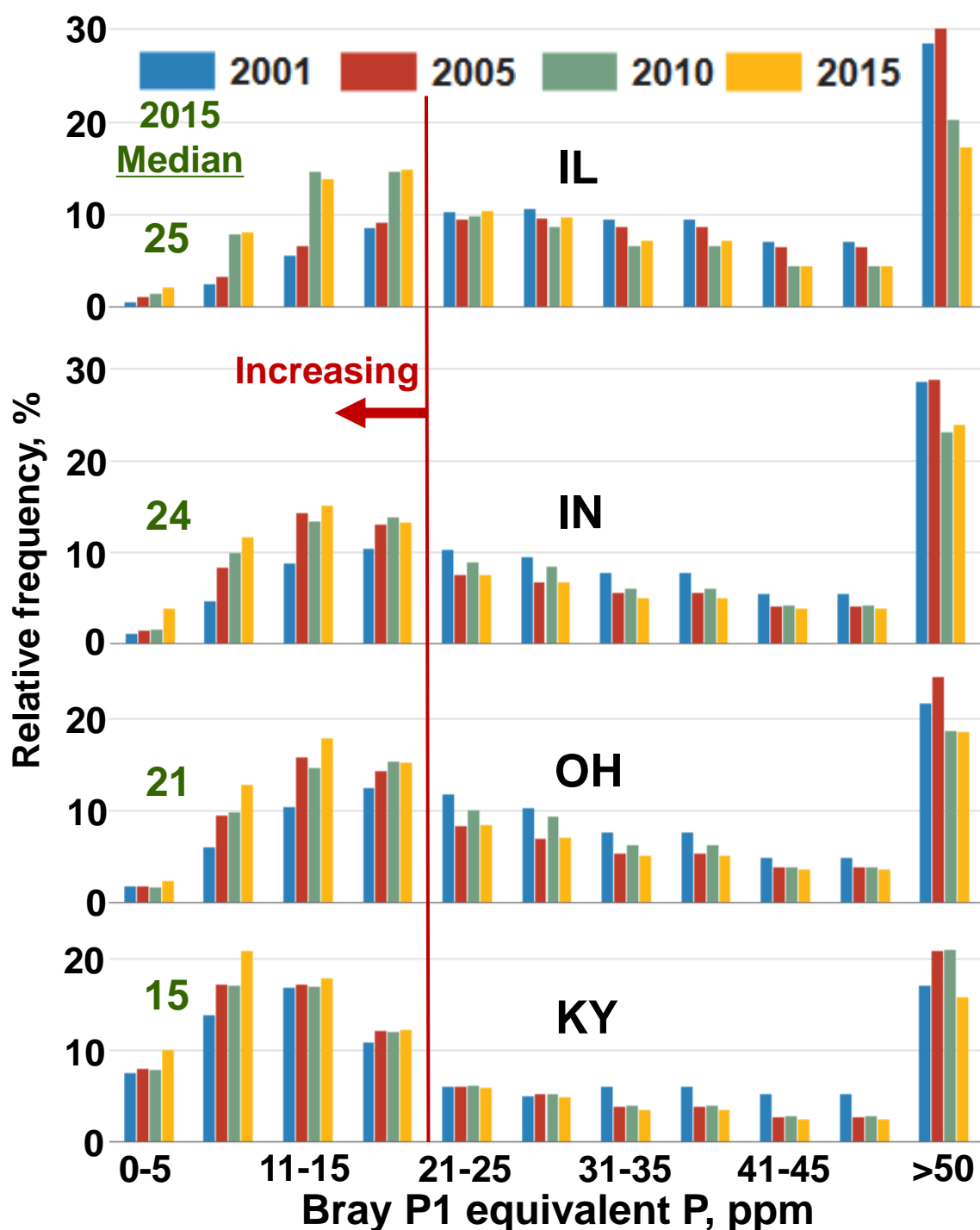
We need to be engaged in  
development of soil health  
objectives & metrics



# Soil testing enhancements:

- Sampling
- Validation
- Refinement
- Recommendations

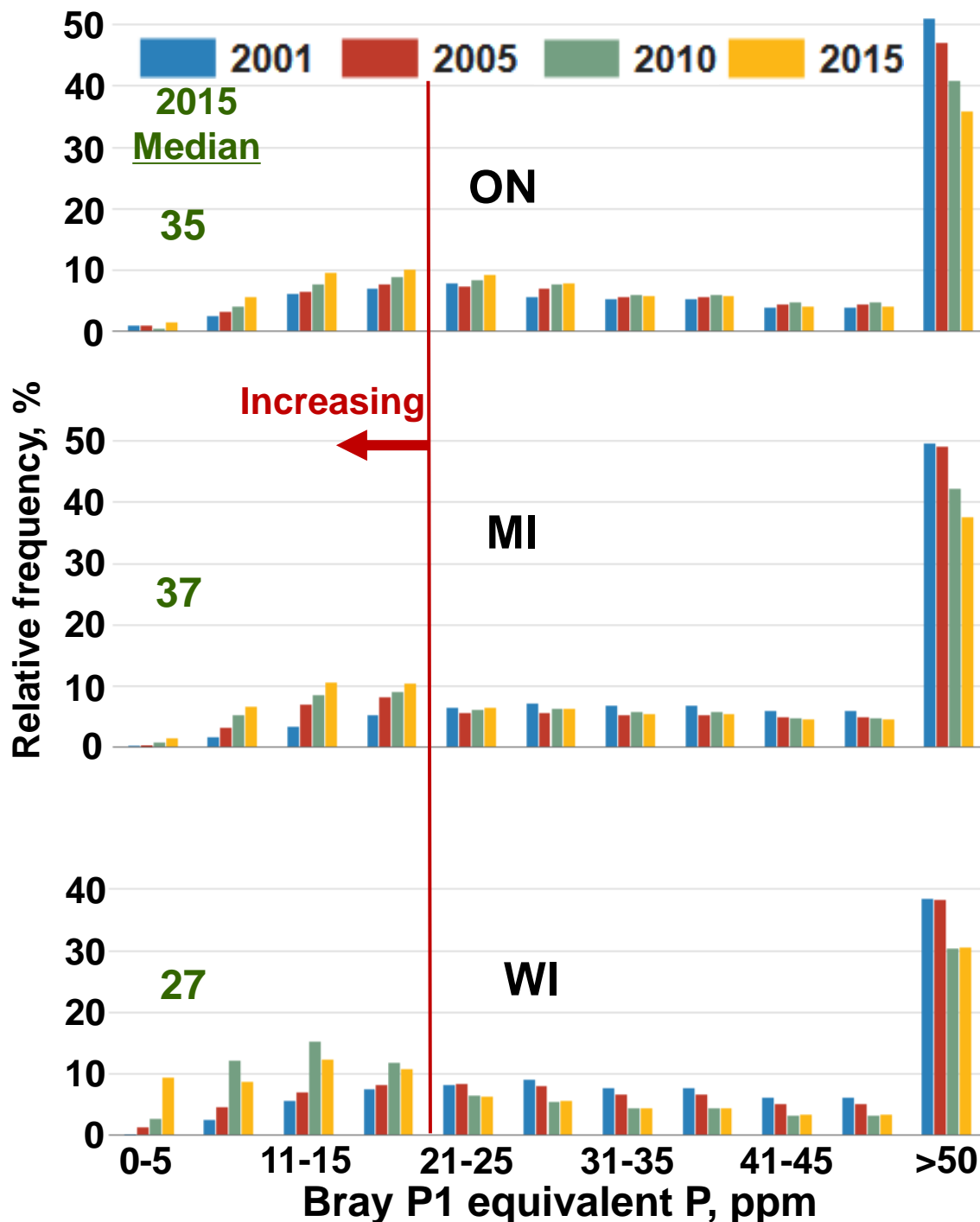




## Changes in soil test P levels in four states



- Samples testing in high & very high categories are declining
- Samples testing in responsive categories are increasing

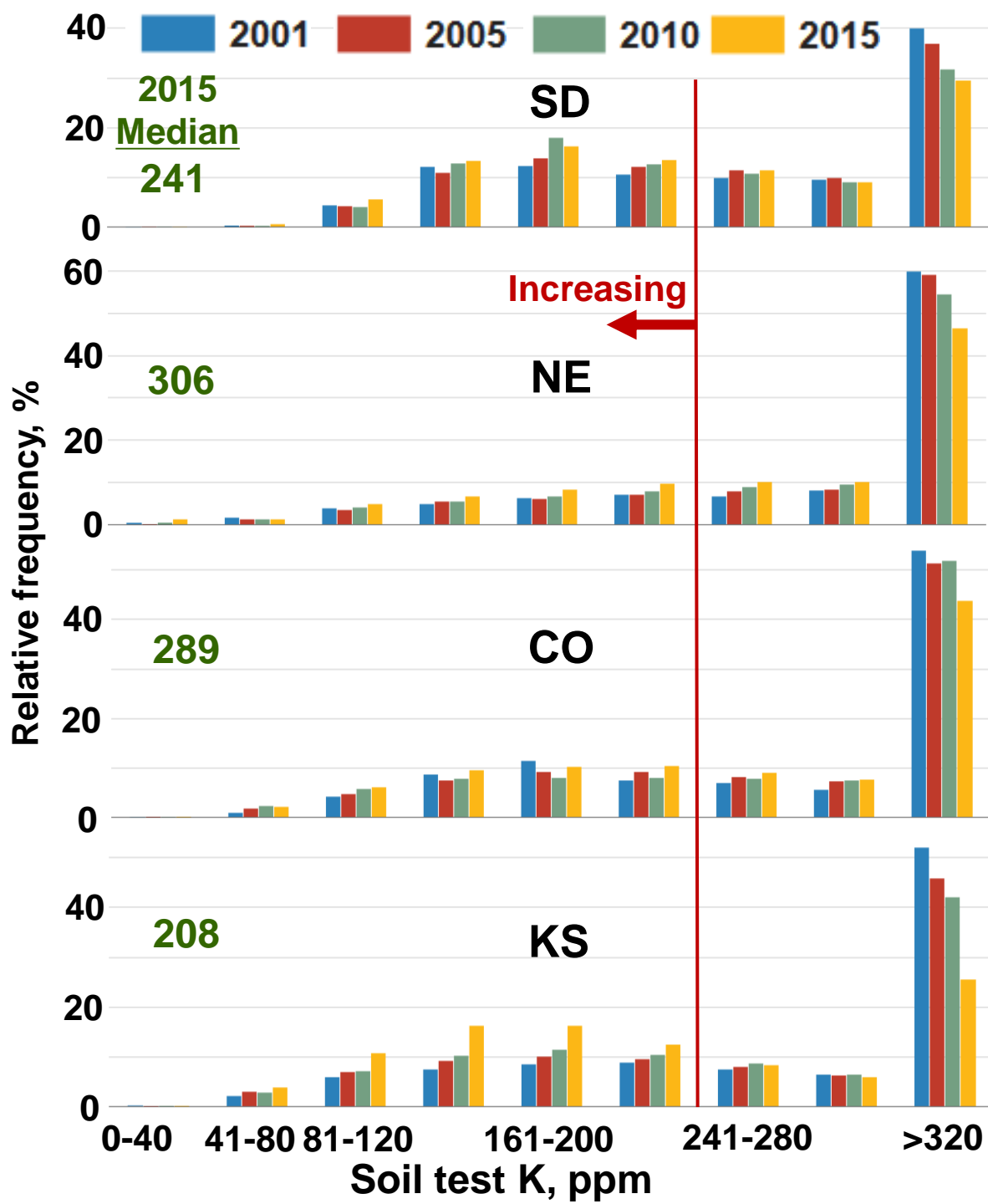


## Changes in soil test P levels further north

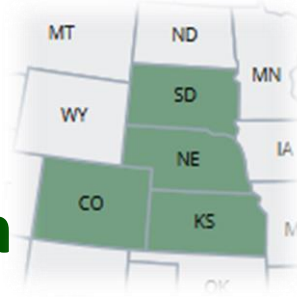


- Samples testing in high & very high categories are declining
- Samples testing in responsive categories are increasing

Needed change in P use will require **evidence** of a benefit



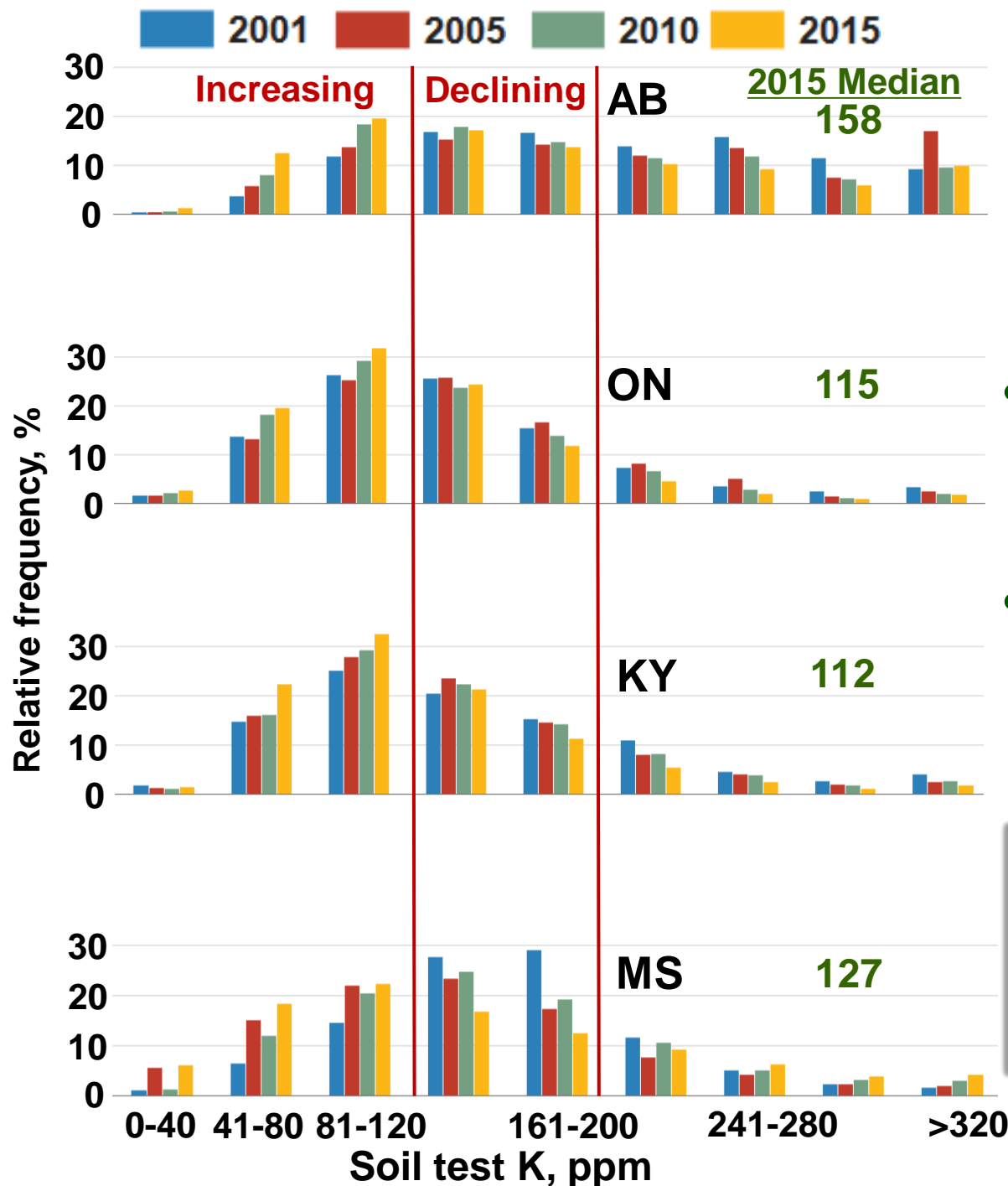
## Changes in soil K levels in 4 western states



- Samples testing in very high category are declining
- Samples testing in responsive categories are increasing

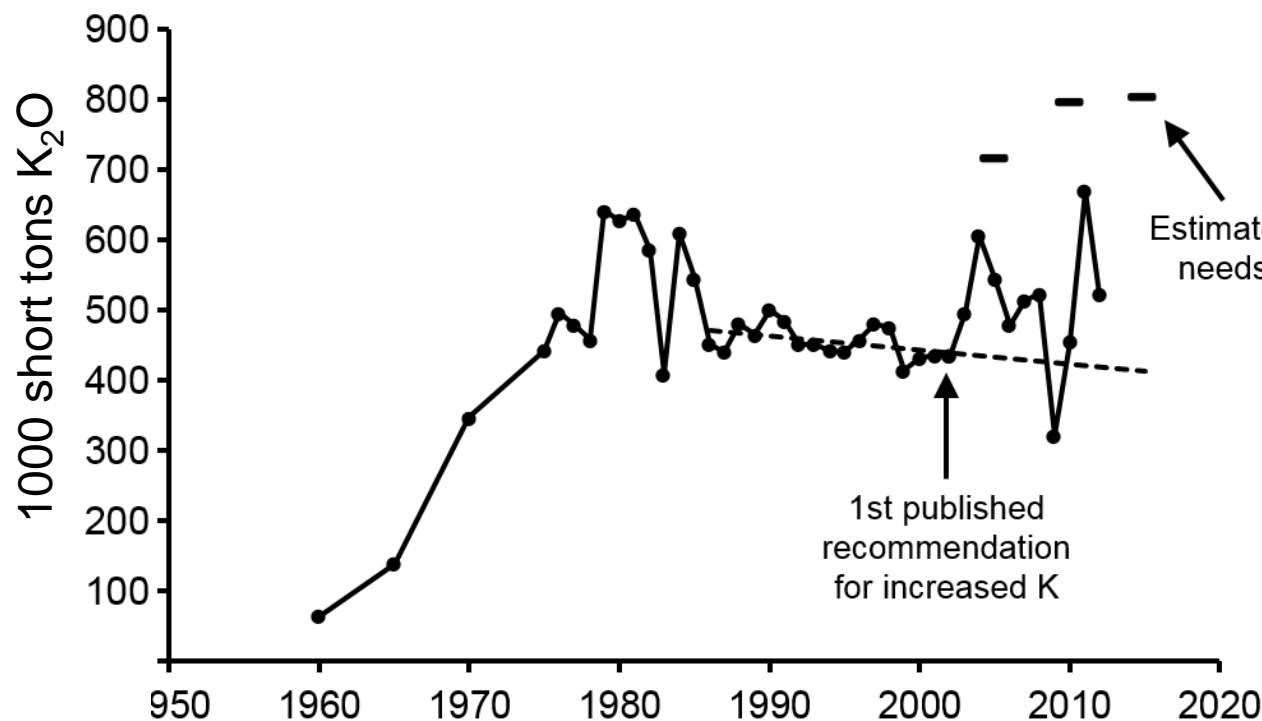


# Changes in soil K levels in 4 states & provinces



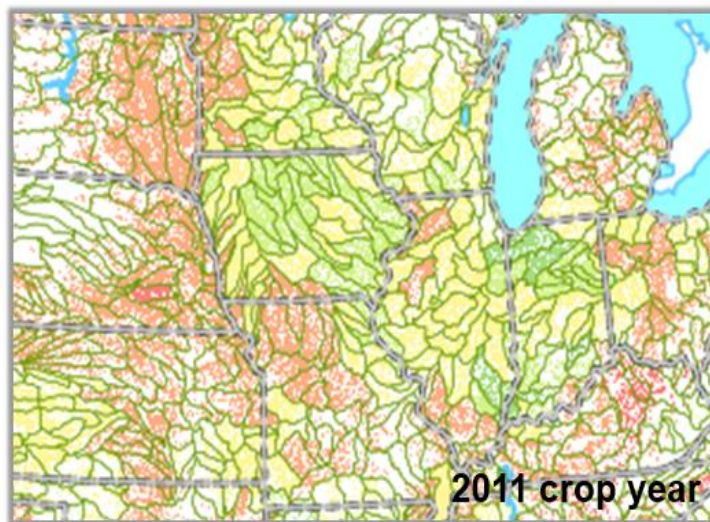
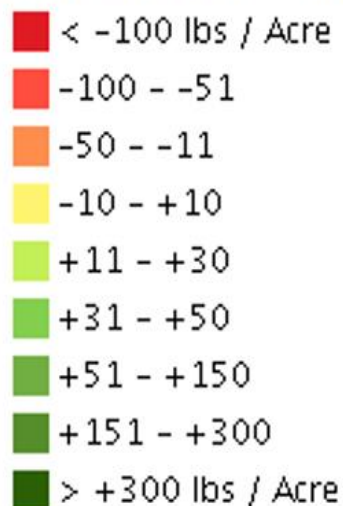
- Samples testing in intermediate categories are declining
- Samples testing in responsive categories are increasing

Needed change in K use will require **evidence** of a benefit



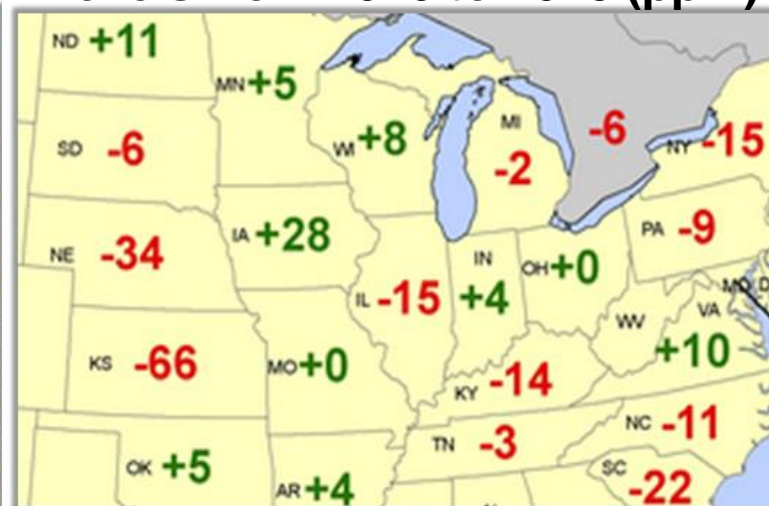
Research provided evidence of a benefit to changing K use in IA

Watershed  $K_2O$  Balance



NuGIS (5/16/2016)

Change in median soil test K levels from 2010 to 2015 (ppm)



IPNI, 2015

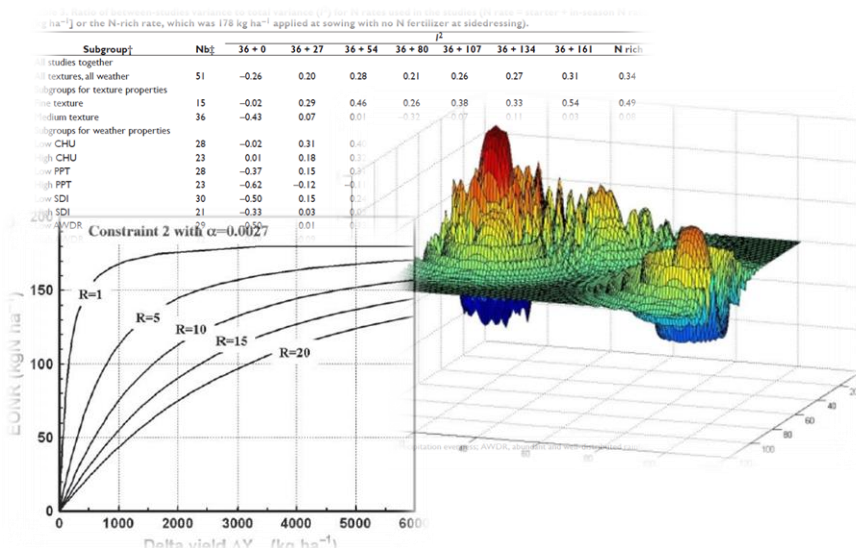
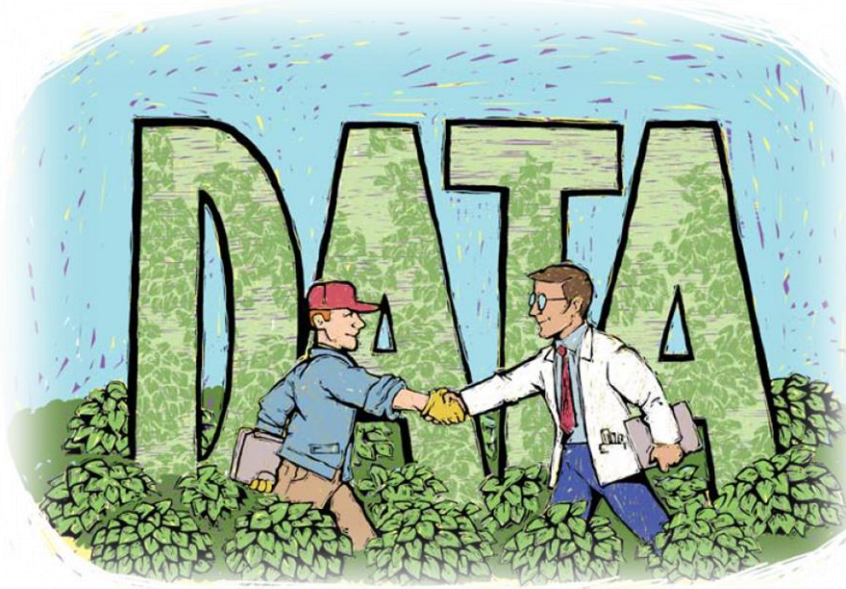
# Evidence-based agronomy

## On the farm

- Data as a valued product of the farm ... part of its legacy
- Using data/metrics for learning, selling, and communicating

## In ag research

- Publishing and curating high quality, open-access data sets
- Systematic reviews of literature and meta-analyses



# What's next? A communication challenge ...

- Great **progress** in agronomy in the last 35 years
- But **challenges** remain ... to continue efforts to:
  - Increase **productivity & profitability** for producers
  - Reduce **nutrient loss** to surface & ground **water**
  - Reduce **loss** of nitrous oxide, ammonia, & other N forms to **air**
  - **Capture more nutrients** in the crop rather than risk loss to **environment**
- **Biggest challenge is to tell our story**
  - Help the public appreciate:
    - The **remarkable progress** of the last 35 years
    - Our **dedication** to accelerating that progress in the future
    - Progress based on **science-based** technologies & hard facts
- **Focus on credible education** rather than questioning motives



## An example of our challenge ...



Recent letter to the Director General of FAO, Pope Francis criticized modern agriculture for its:

- “production at any cost”
- “improperly modifying various animal and plant species”
- model that “despite all its science, allows around 800 million people to continue to go hungry.”

One cannot question the motives of such a man, but we can use these statements to inspire us to better communicate our own motives and dedication to future progress.

**We have an evidence-rich story worth telling**

# What's next?

**The future that  
we create**

