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Key Management Practices for Profitable Corn Production in the Northern Corn Belt

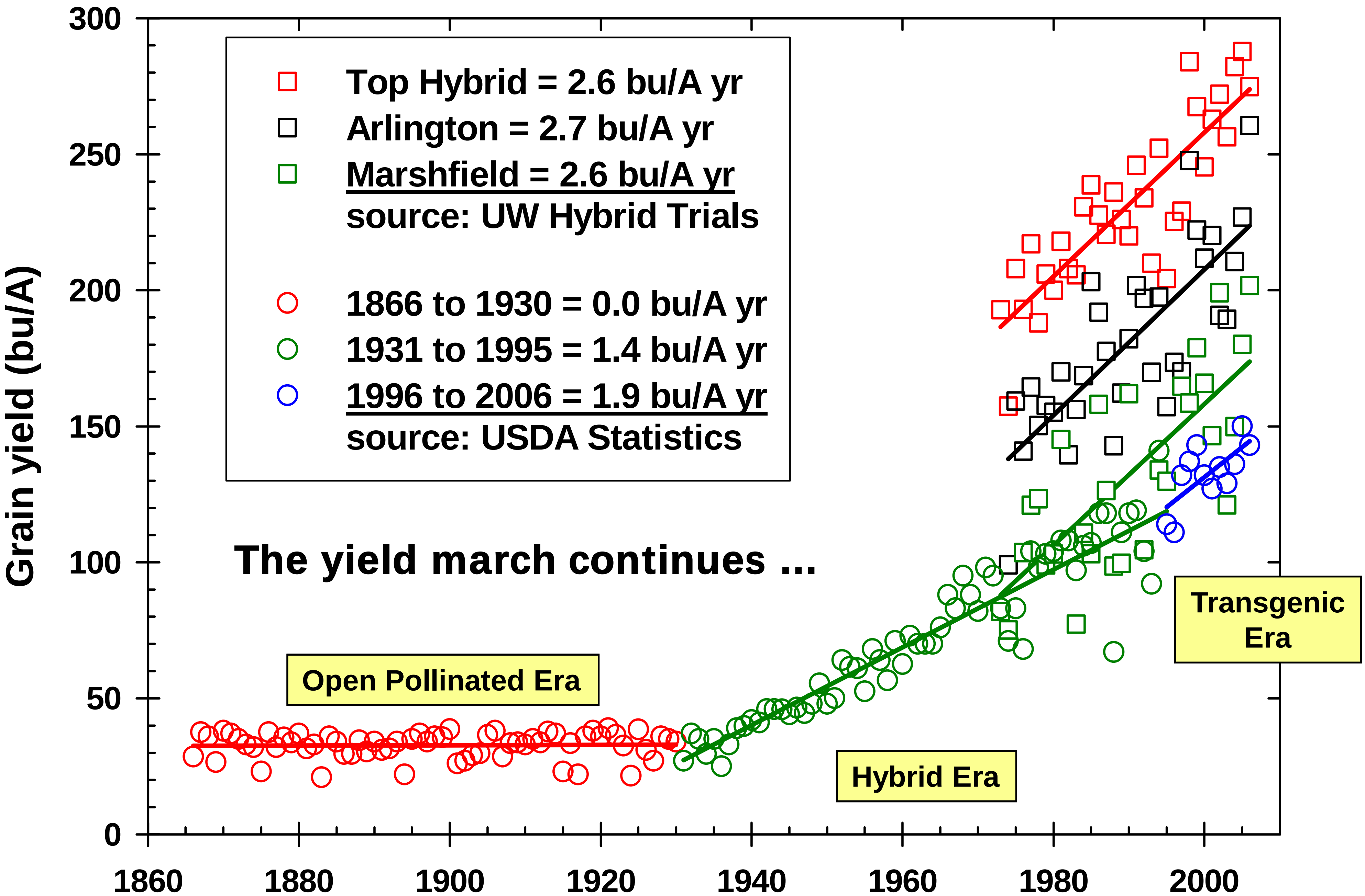
Joe Lauer
University of Wisconsin-Madison

2009 Wisconsin Corn Conferences
West Salem, Waupaca, and Kiel
January 20, 21 and 22

Overview

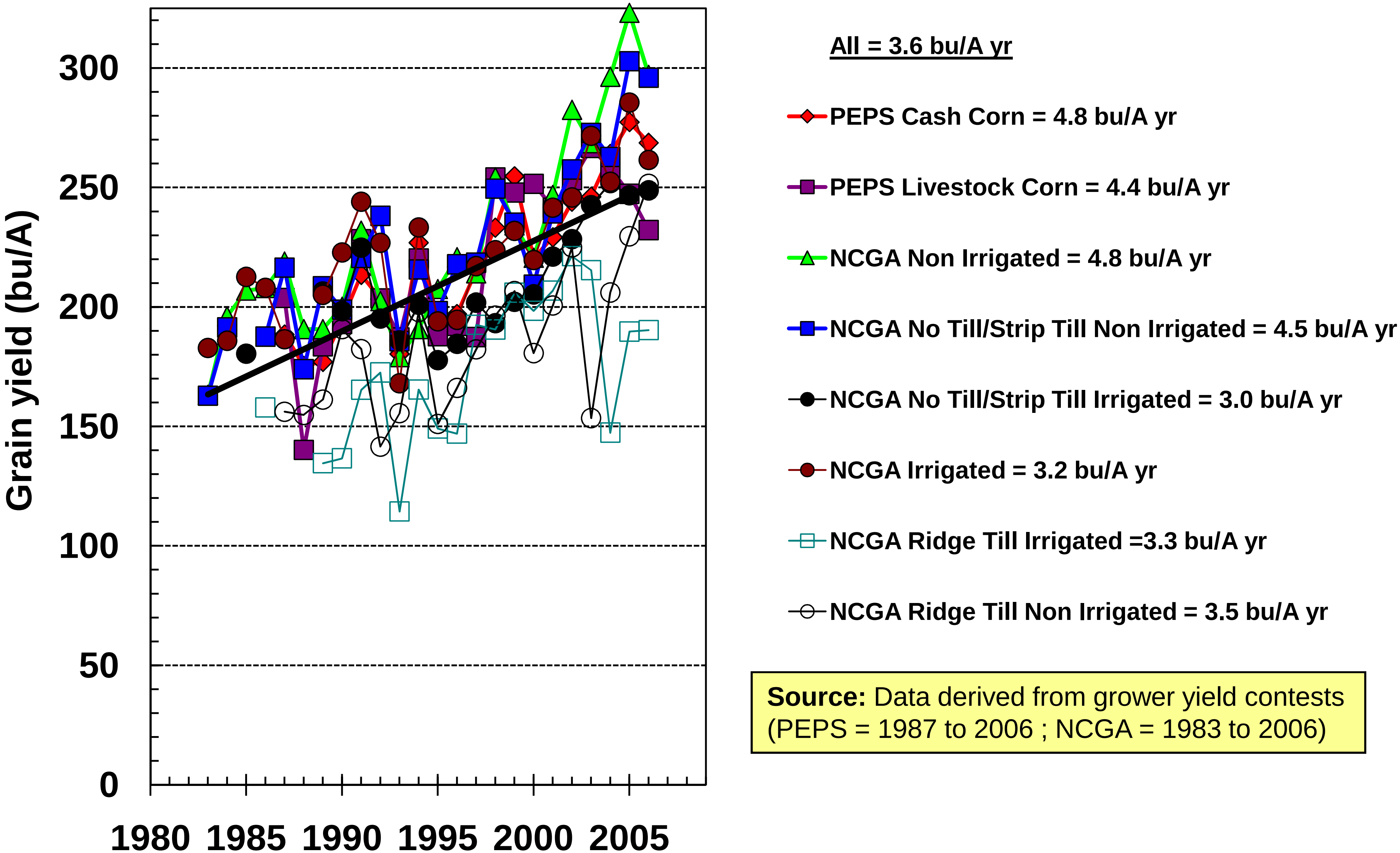
- Keys to high yields and profitability – Ten principles for successful corn production in the northern Corn Belt
- The impact of $300 per bag seed corn – What management adjustments are needed?
- What do we do with all these yield maps?

Corn yield in Wisconsin since 1866

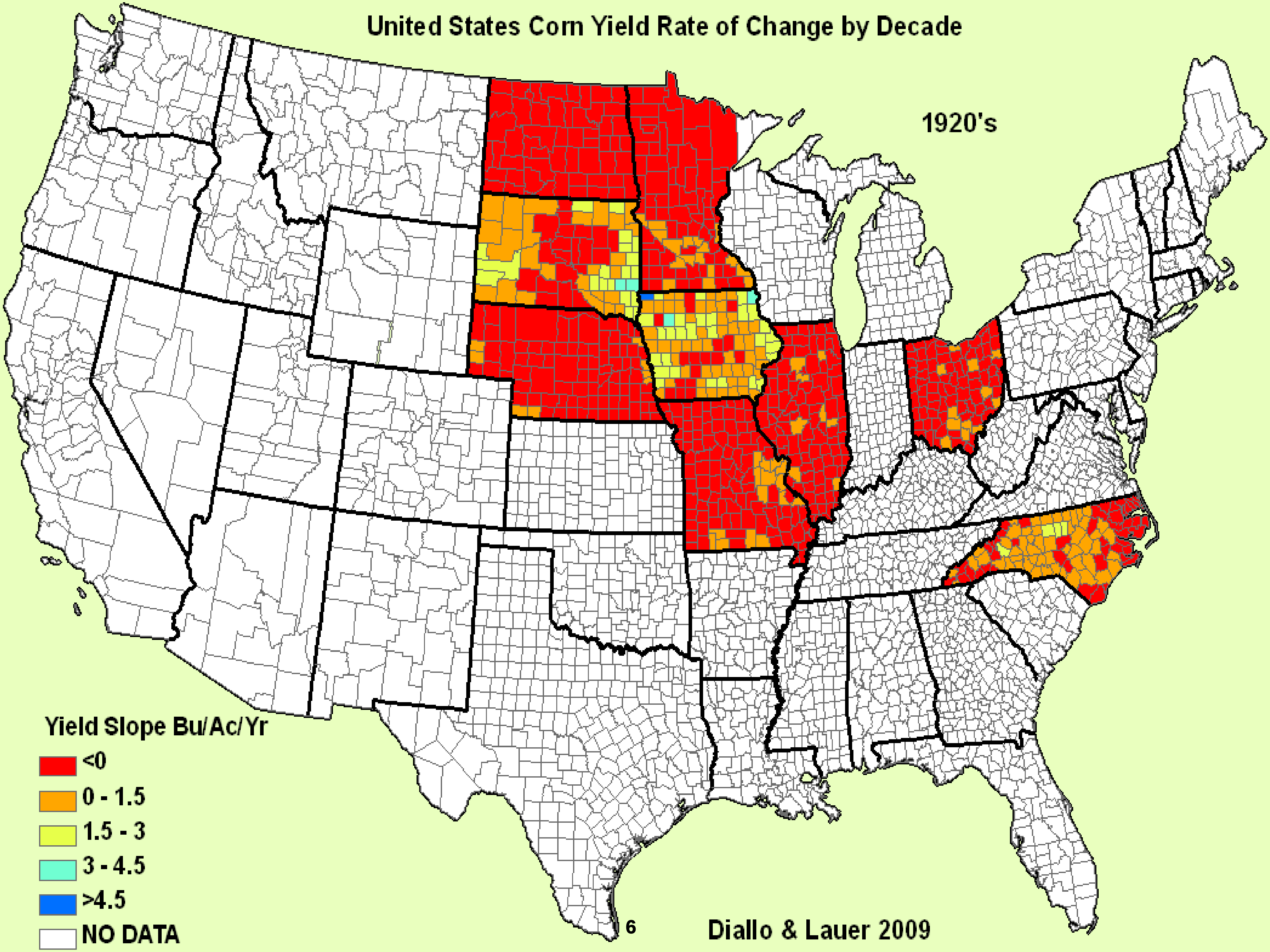


http://corn.agronomy.wisc.edu

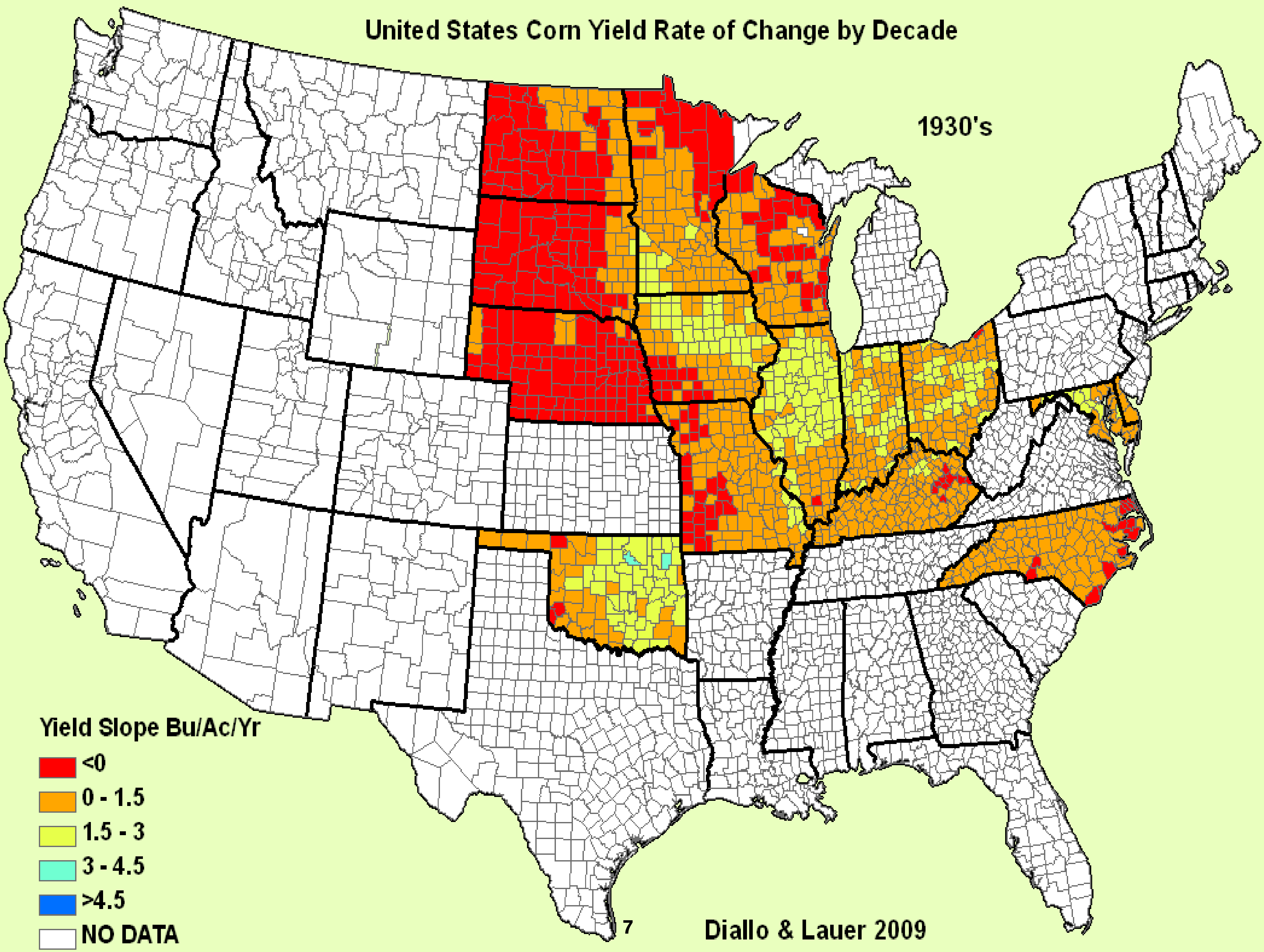
Corn Yield Progress in Wisconsin
(Top Producer in Category)

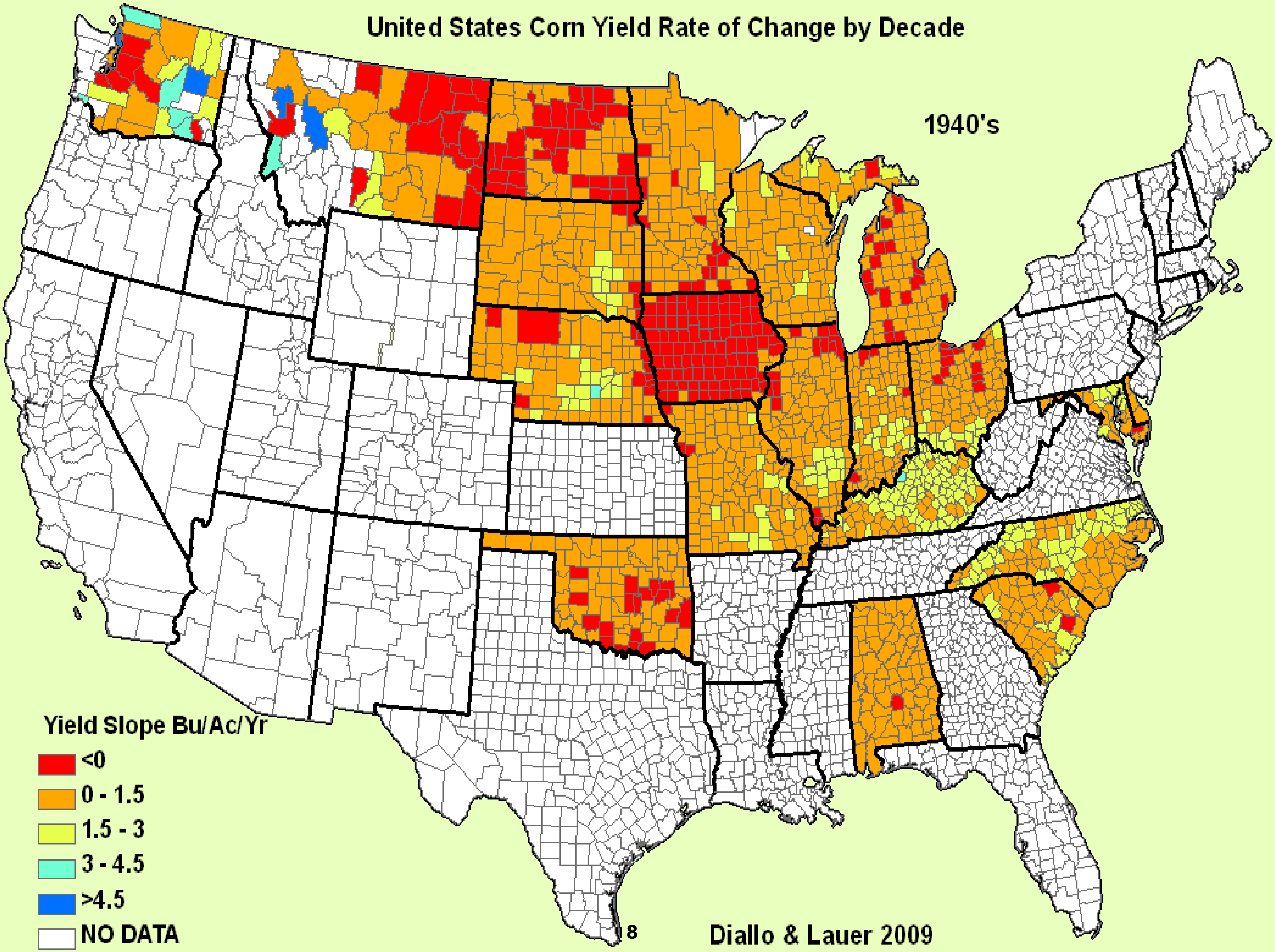


Source: Data derived from grower yield contests (PEPS = 1987 to 2006 ; NCGA = 1983 to 2006)



United States Corn Yield Rate of Change by Decade
1920's
Yield Slope Bu/Ac/Yr
<0
0 - 1.5
1.5 - 3
3 - 4.5
>4.5
NO DATA
Diallo & Lauer 2009


United States Corn Yield Rate of Change by Decade
1930's
Yield Slope Bu/Ac/Yr
<0
0 - 1.5
1.5 - 3
3 - 4.5
>4.5
NO DATA
Diallo & Lauer 2009


United States Corn Yield Rate of Change by Decade
1940's
Yield Slope Bu/Ac/Yr
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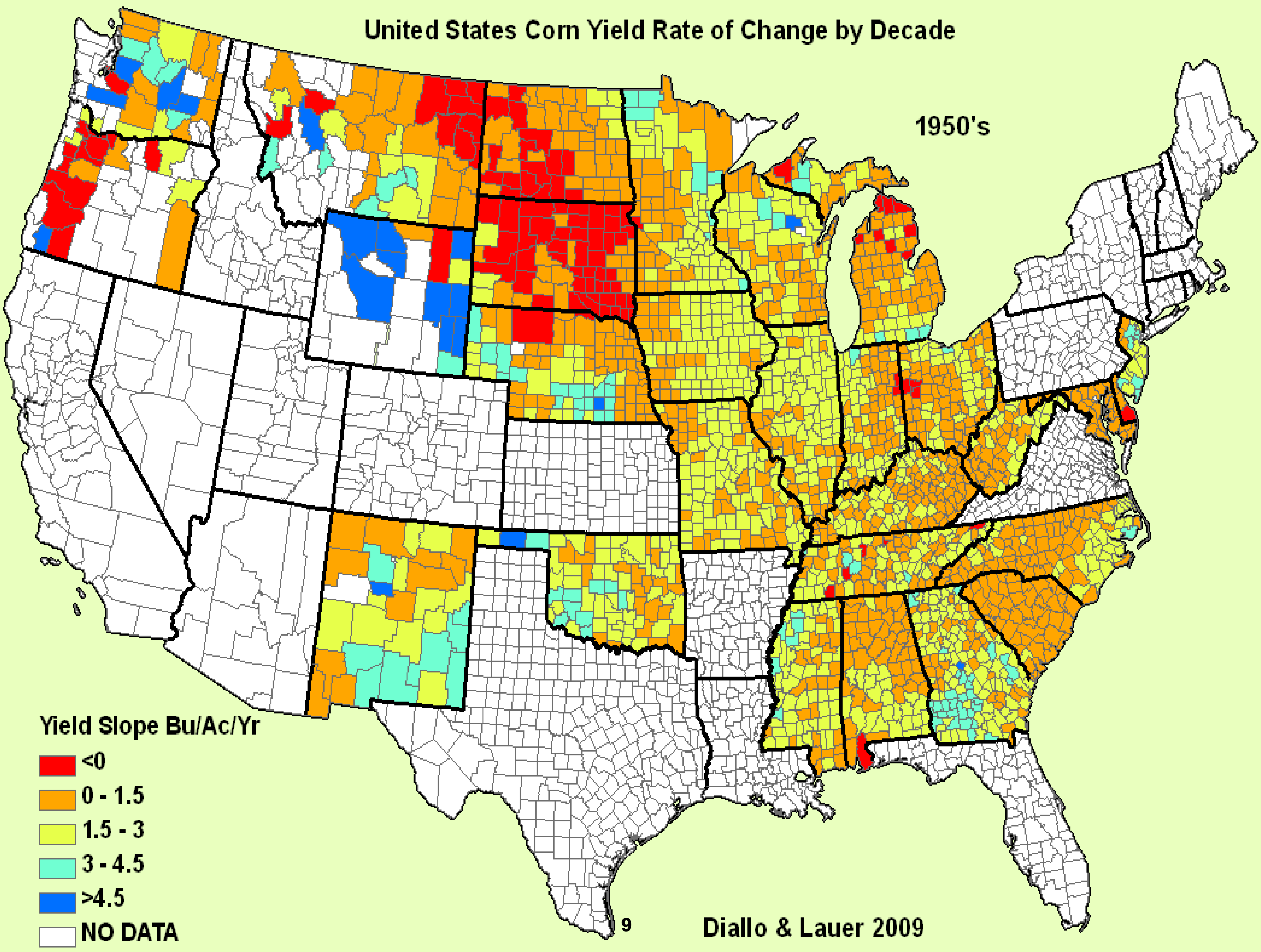
Diallo & Lauer 2009



United States Corn Yield Rate of Change by Decade
1950's
Yield Slope Bu/Ac/Yr
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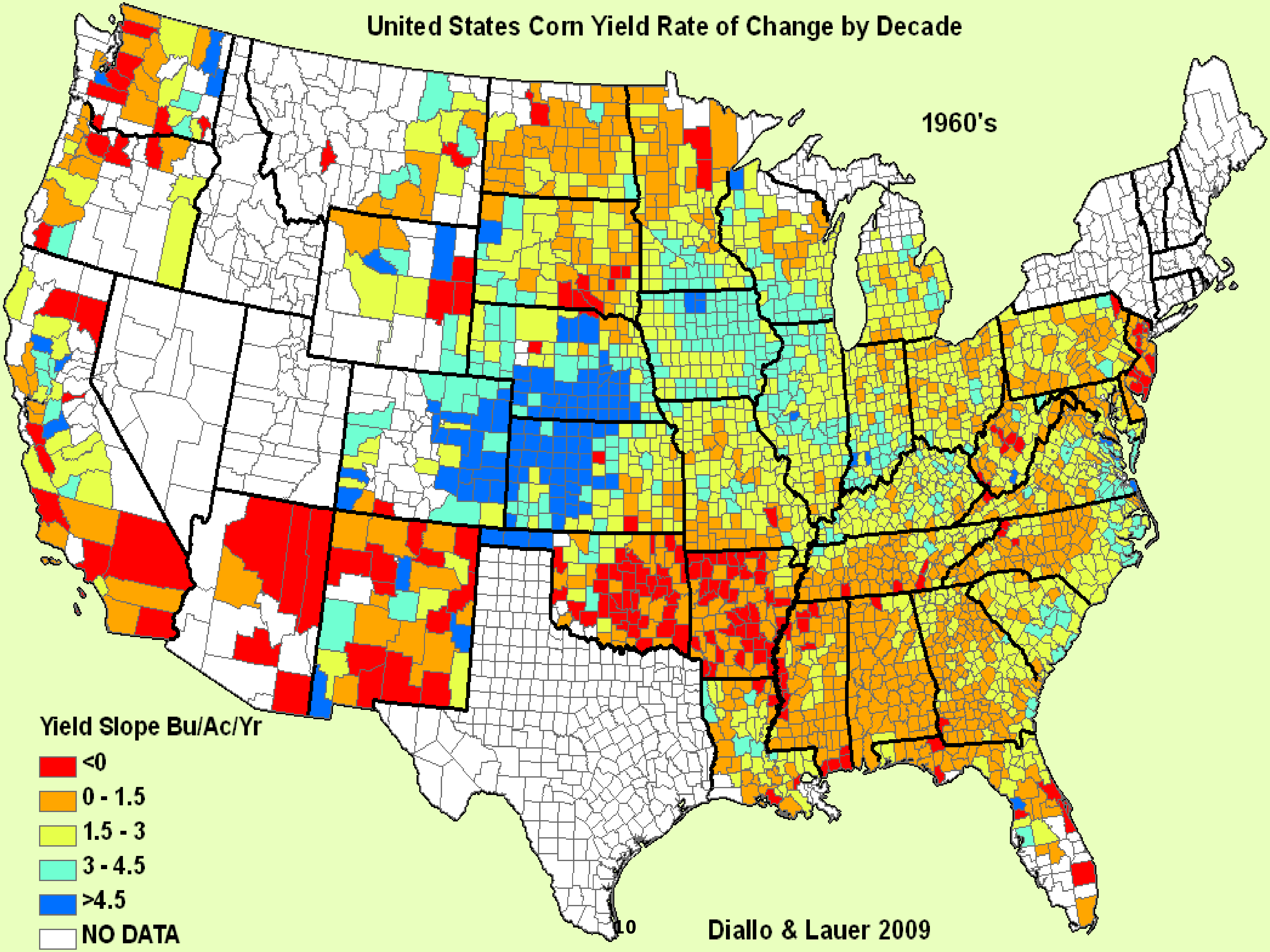
1.5 - 3
3 - 4.5
>4.5
NO DATA
Diallo & Lauer 2009


United States Corn Yield Rate of Change by Decade
1960's
Yield Slope Bu/Ac/Yr
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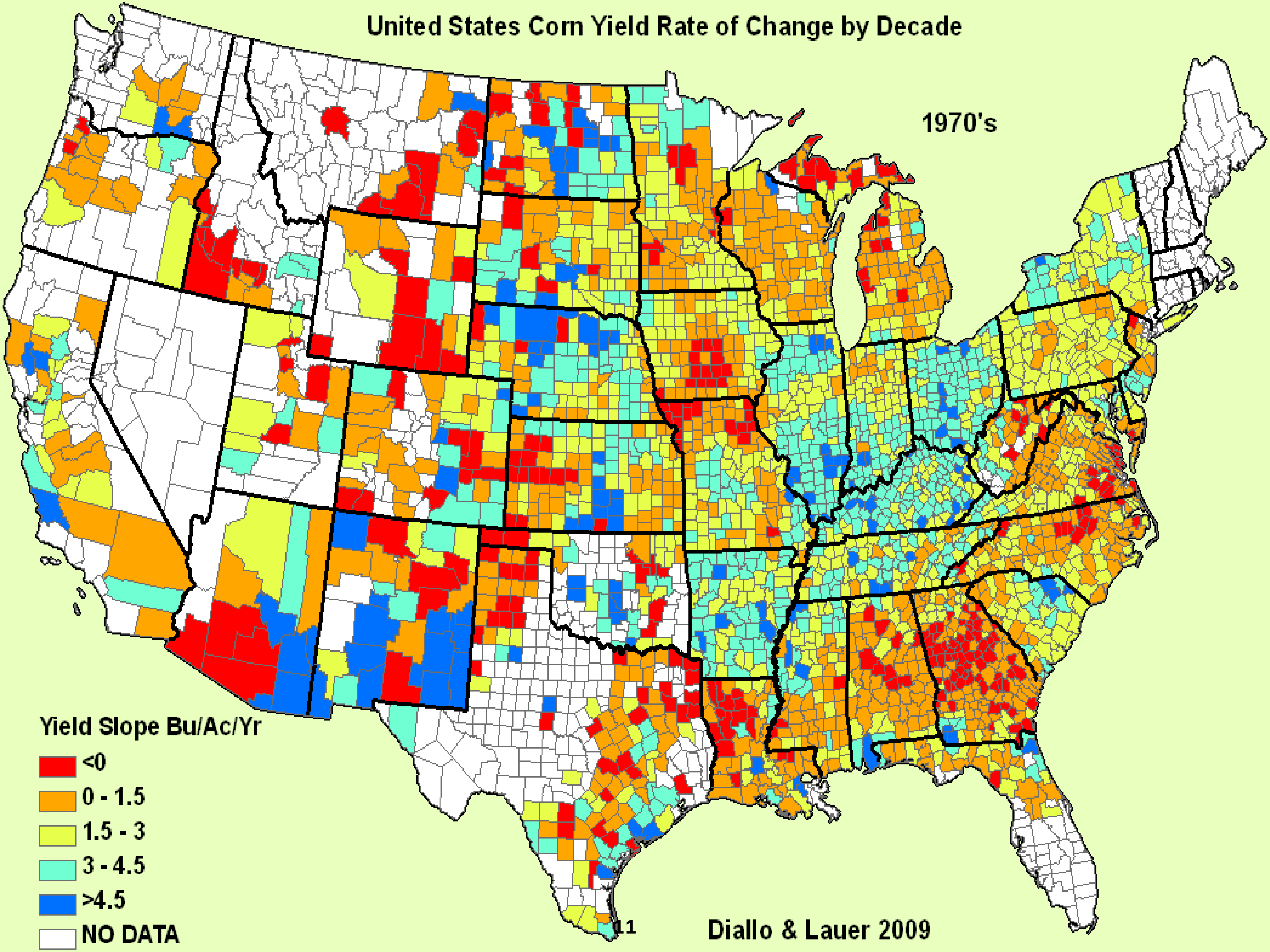
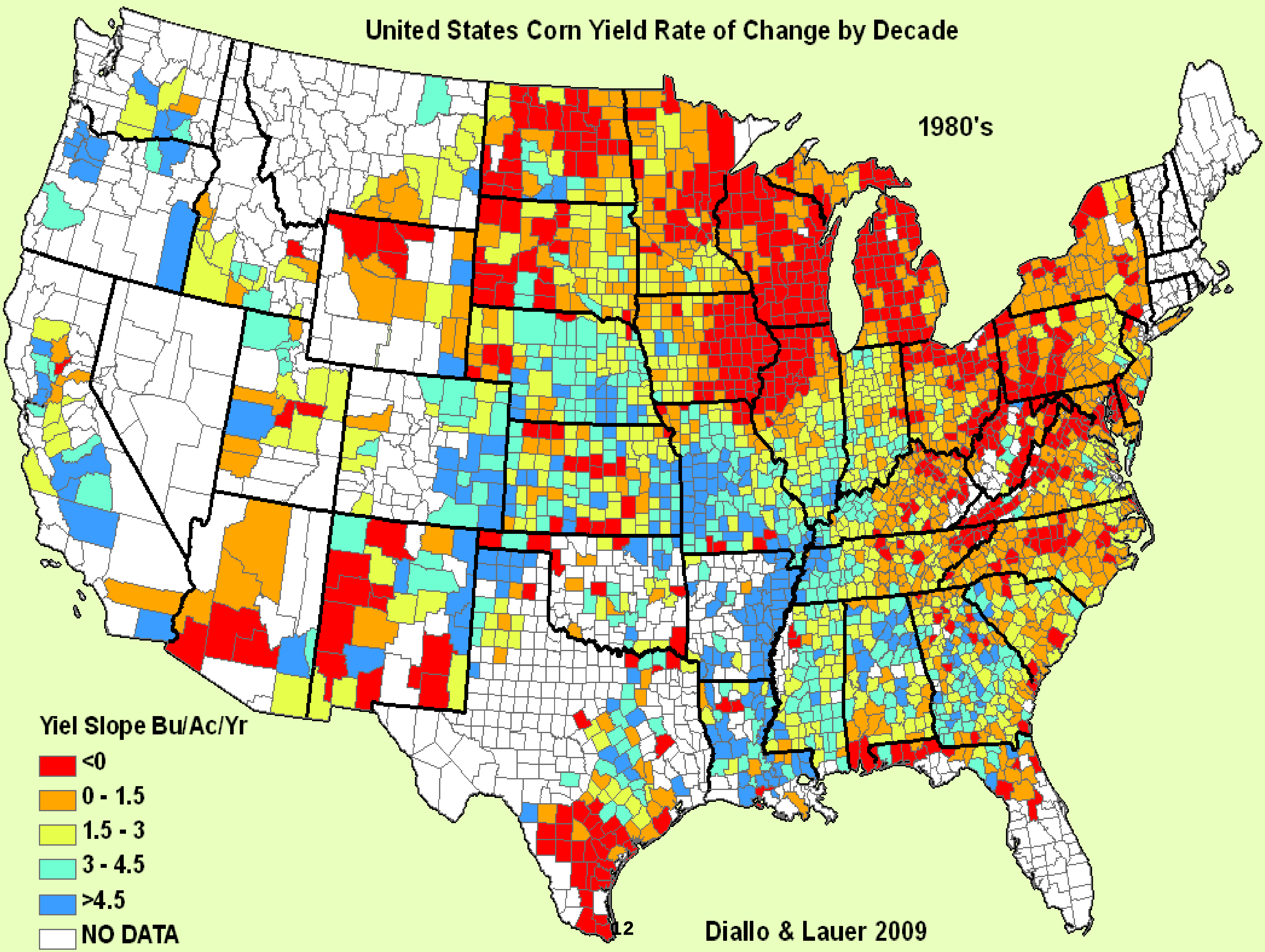
0 - 1.5
1.5 - 3
3 - 4.5
>4.5
NO DATA
Diallo & Lauer 2009

United States Corn Yield Rate of Change by Decade




United States Corn Yield Rate of Change by Decade
1980's
Yiel Slope Bu/Ac/Yr
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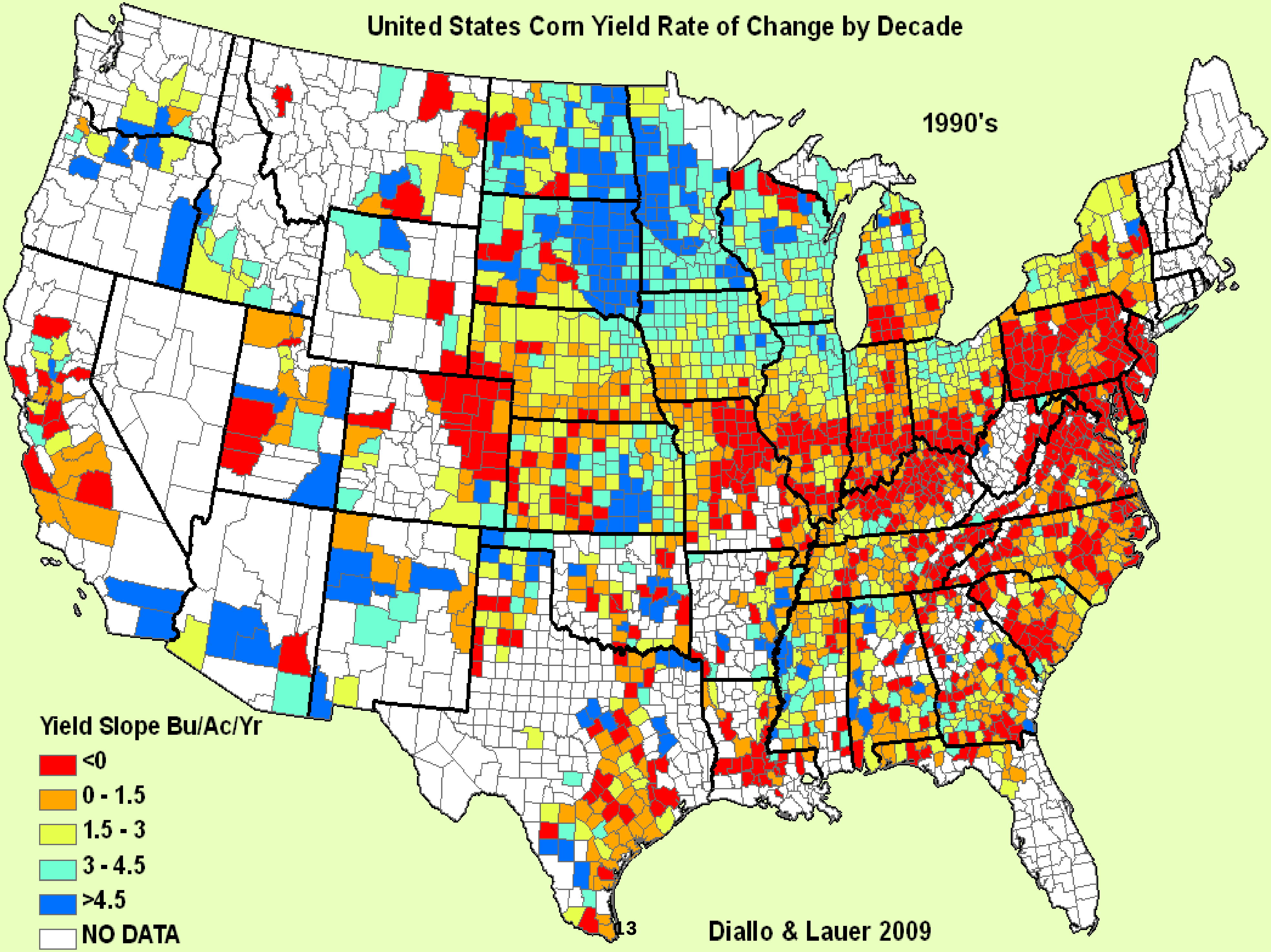
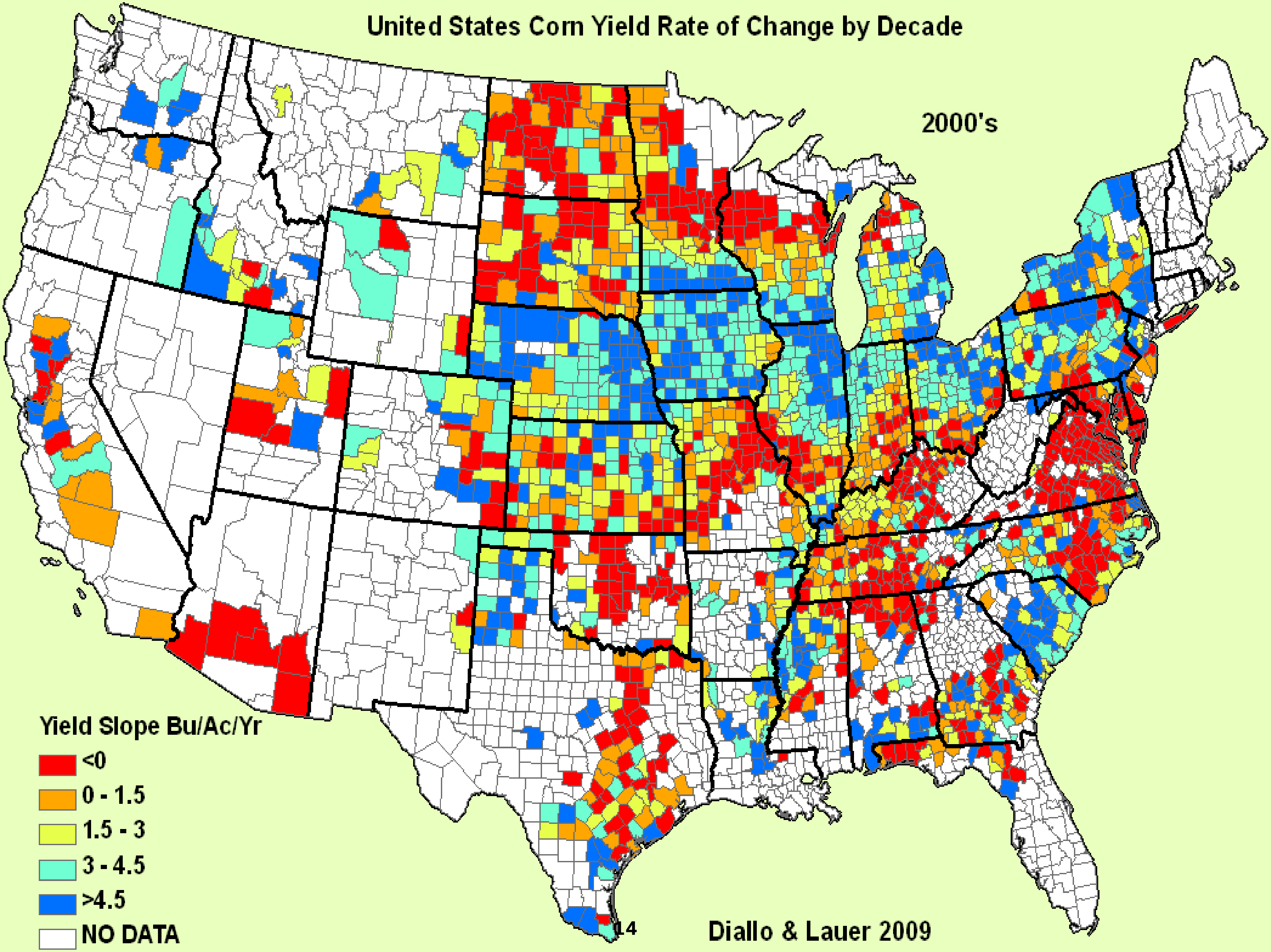
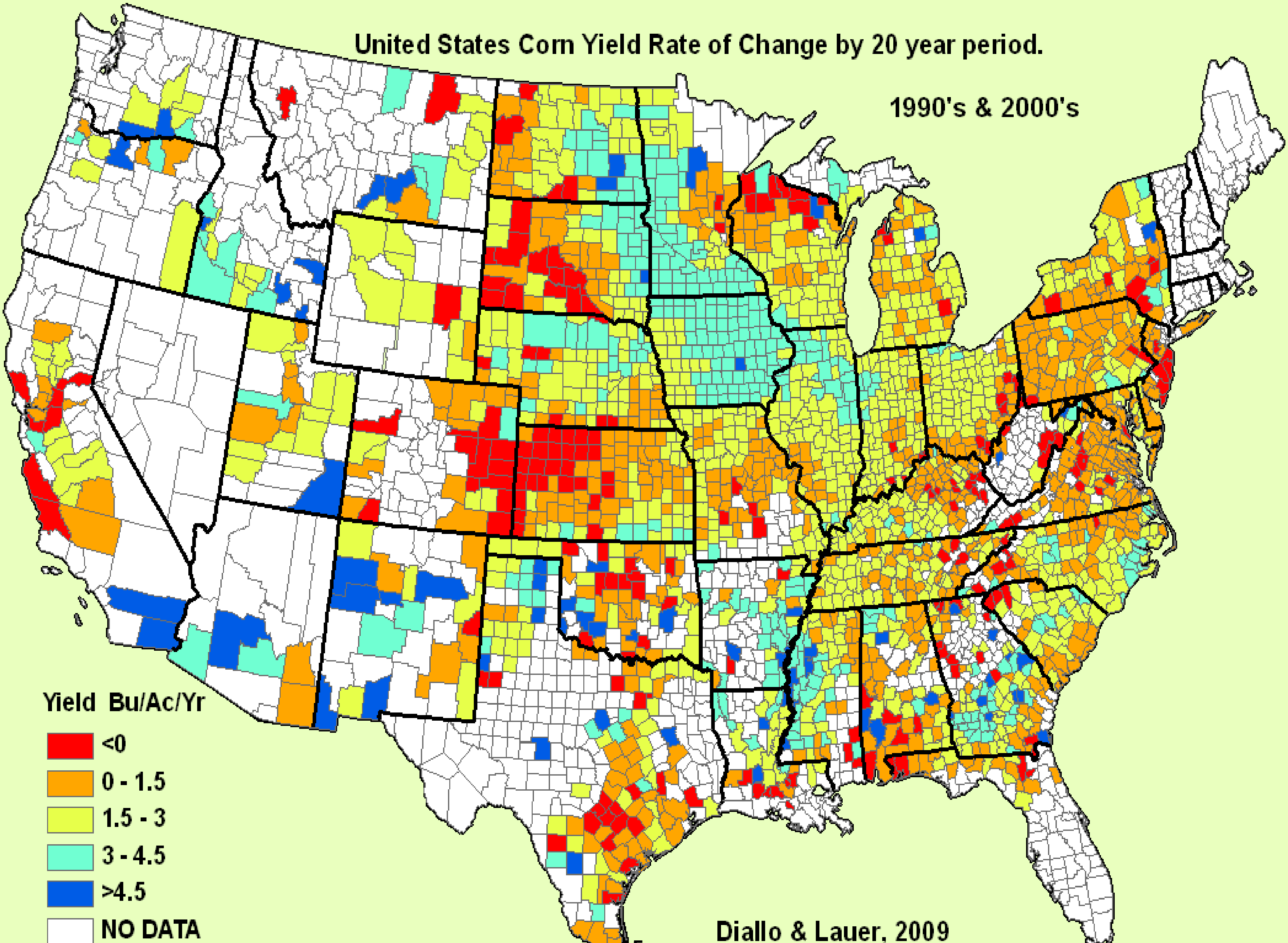
0 - 1.5
1.5 - 3
3 - 4.5
>4.5
NO DATA
Diallo & Lauer 2009


United States Corn Yield Rate of Change by Decade
1990's
Yield Slope Bu/Ac/Yr
<0
0 - 1.5
1.5 - 3
3 - 4.5
>4.5
NO DATA
Diallo & Lauer 2009

United States Corn Yield Rate of Change by Decade



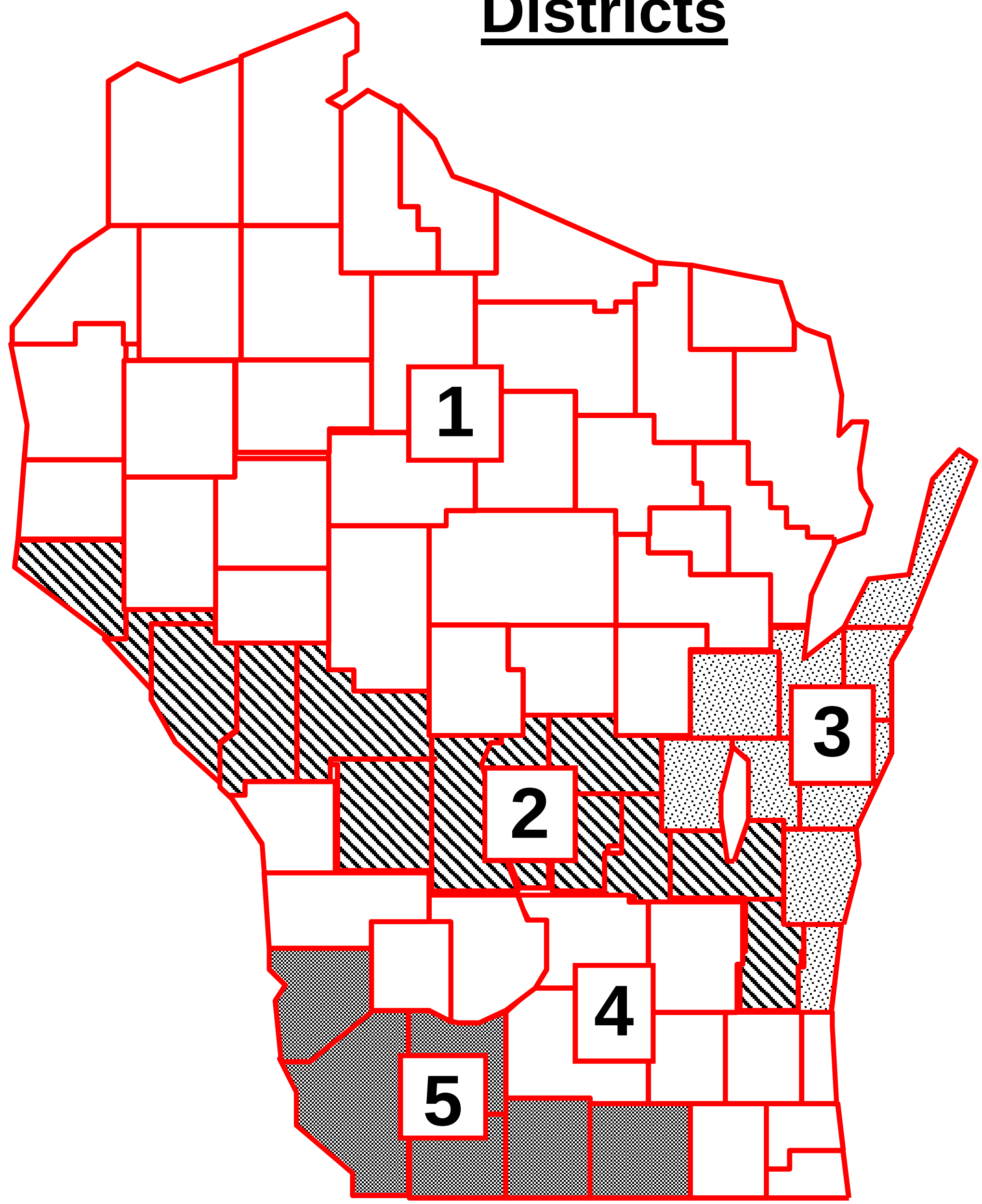

United States Corn Yield Rate of Change by 20 year period.
1990's & 2000's
Yield Bu/Ac/Yr
<0
0 - 1.5
1.5 - 3
3 - 4.5
>4.5
NO DATA
Diallo & Lauer, 2009

Profits through Efficient Production Systems

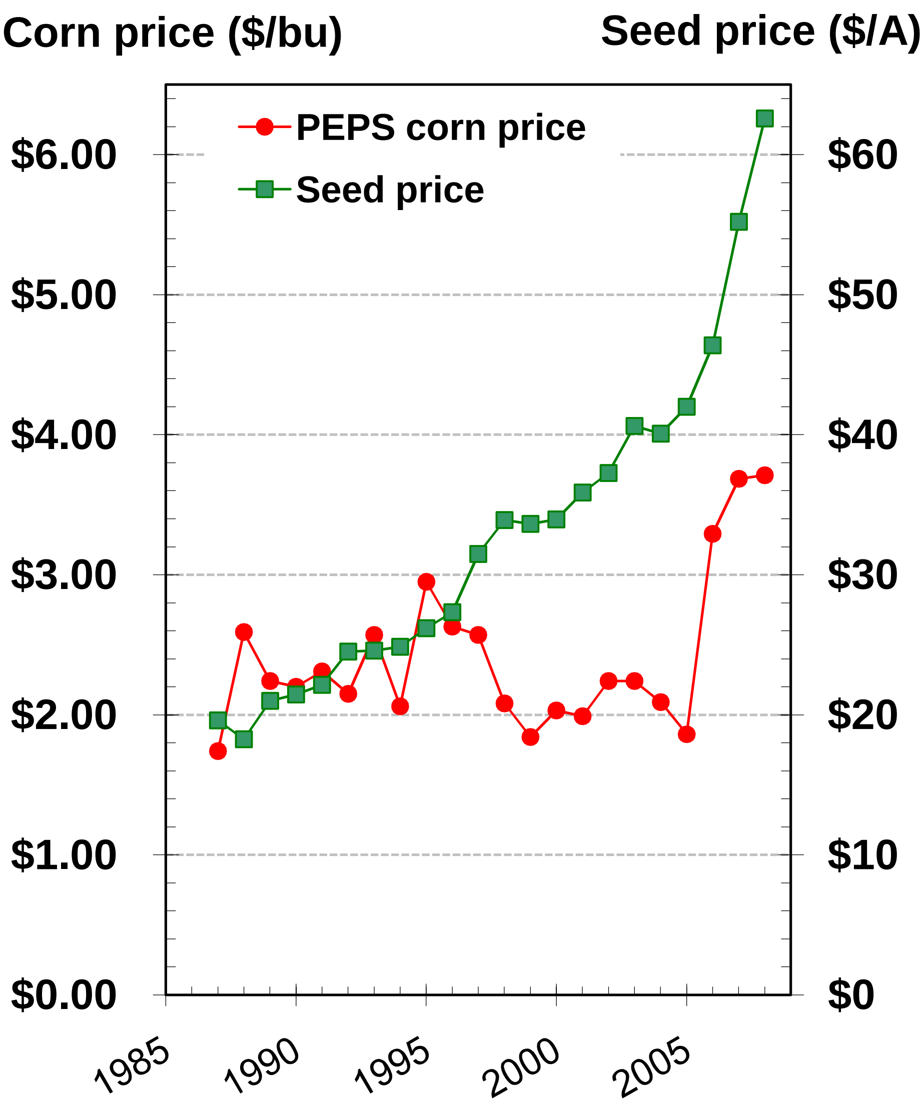
- **Objectives**
  - ✓Cost analysis of grain enterprises
  - ✓Emphasize soil and water conservation, efficiency, profitability, and competitiveness vs. productivity alone
  - ✓Recognize the way efficient growers integrate practices into a system

- **Divisions**
  - ✓Corn, Cash Crop
  - ✓Corn, Livestock
  - ✓Corn, Silage
  - ✓Soybean

Districts



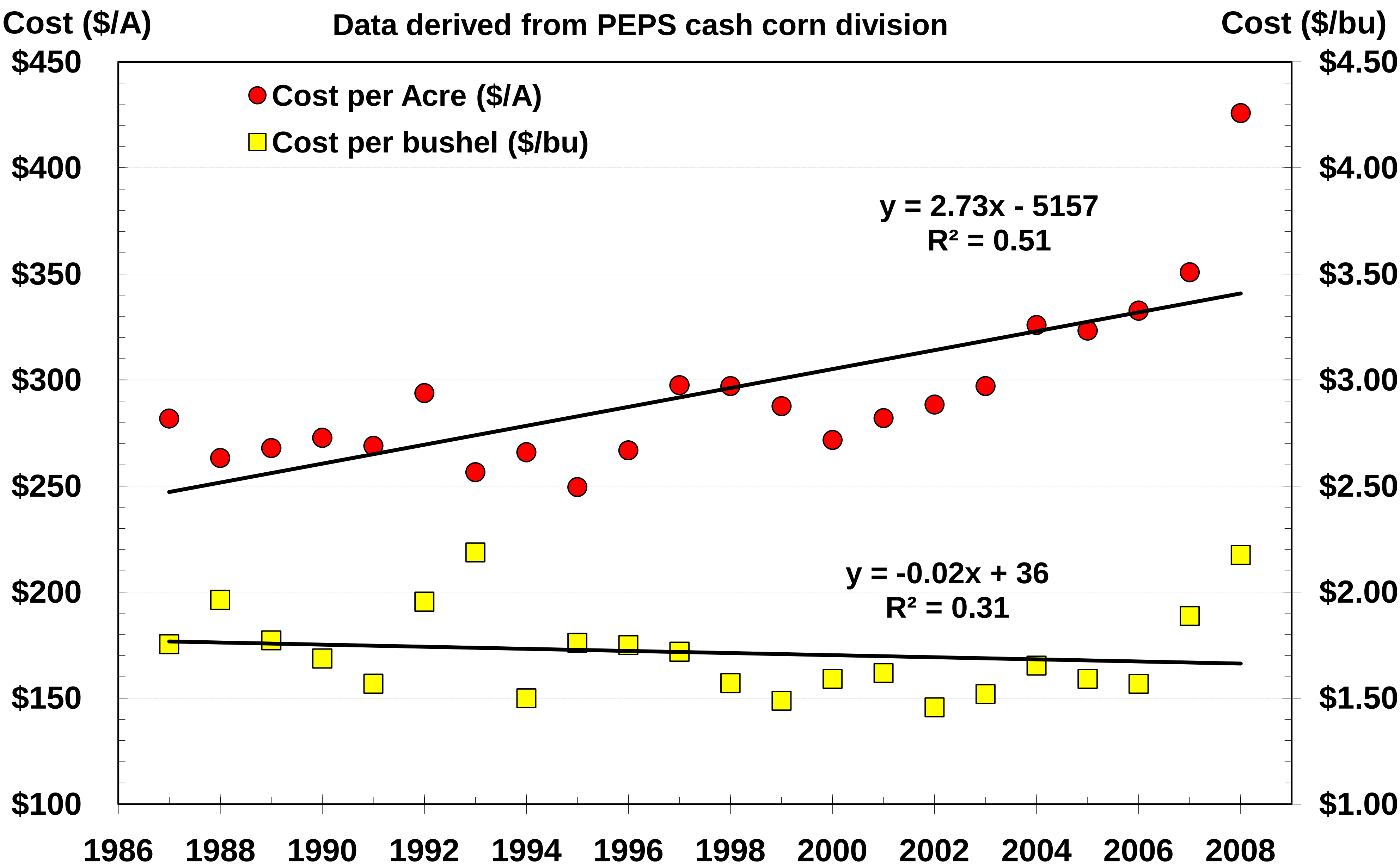
Calculating Grower Return



Partial Budget Analysis

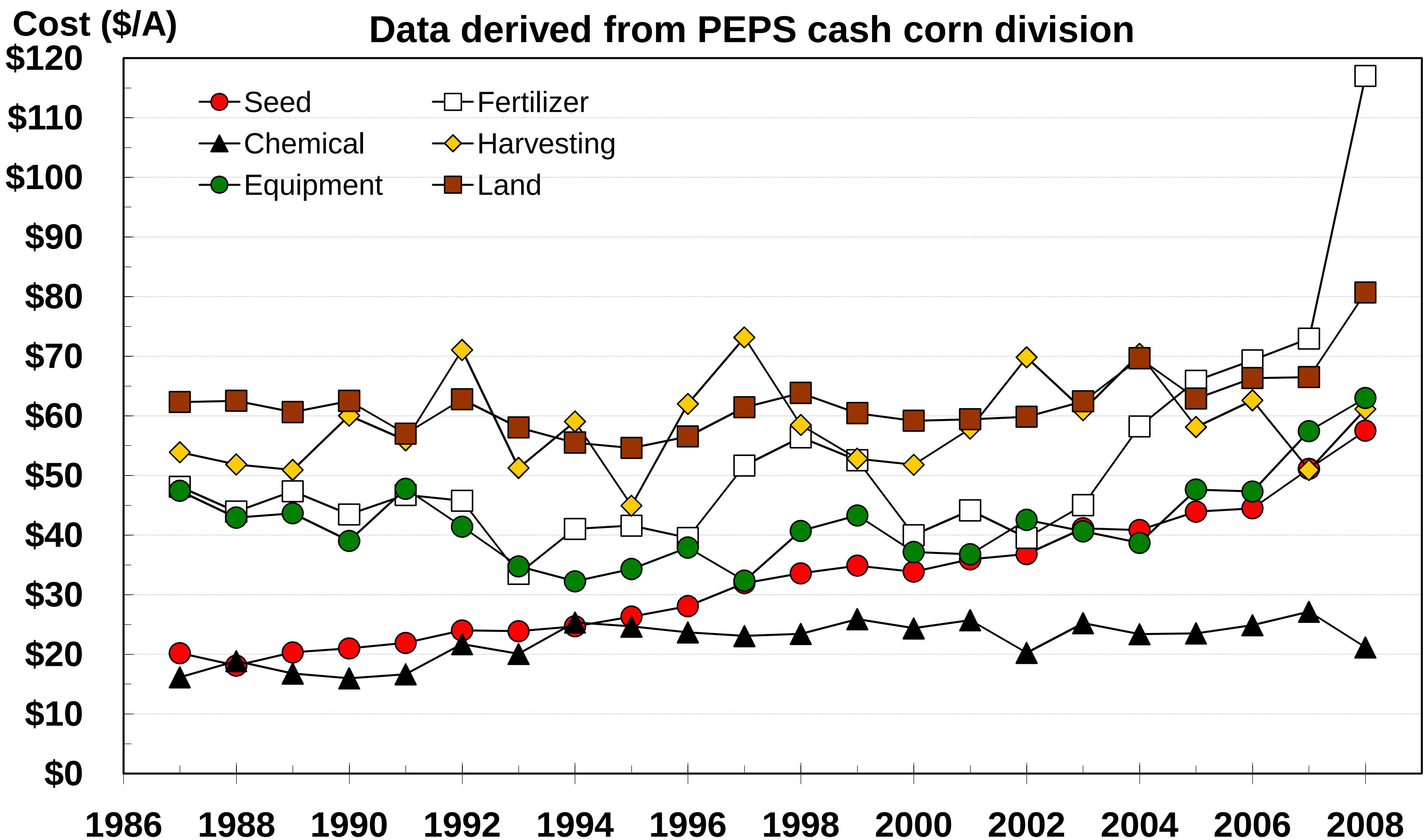
- **Corn Price per bushel**
  - ✓ Price matrix: $2.00, $4.00, $6.00
  - ✓ grPEPS: Weighted Price per bushel =
    50% November Average Cash price
    \+ 25% March CBOT Futures ($0.15 basis)
    \+ 25% July CBOT Futures ($0.10 basis)
    - ❑ November Average Cash price derived from WI Ag Statistics; CBOT Futures prices derived from closing price on first business day in December.
- **Grower return = (Yield x Price) - Input costs**
  - Handling ($0.02 per bushel)
  - Hauling ($0.04 per bushel)
  - Trucking (system rate)
  - Drying (system rate per bushel-point > 15.5%)
  - Storage (system rate per 30 day)
  - ✓ Marketing plan: 50% sold at harvest, 25% at 4 months, and 25% at 8 months.
- **Corn Production Systems**
  - ✓ Livestock: drying=$0.00, trucking=$0.00, storage=$0.01
  - ✓ On-farm: drying=$0.02, trucking=$0.11, storage=$0.02
  - ✓ Commercial: drying=$0.04, trucking=$0.11, storage=$0.03

How much does it cost to produce corn in WI?



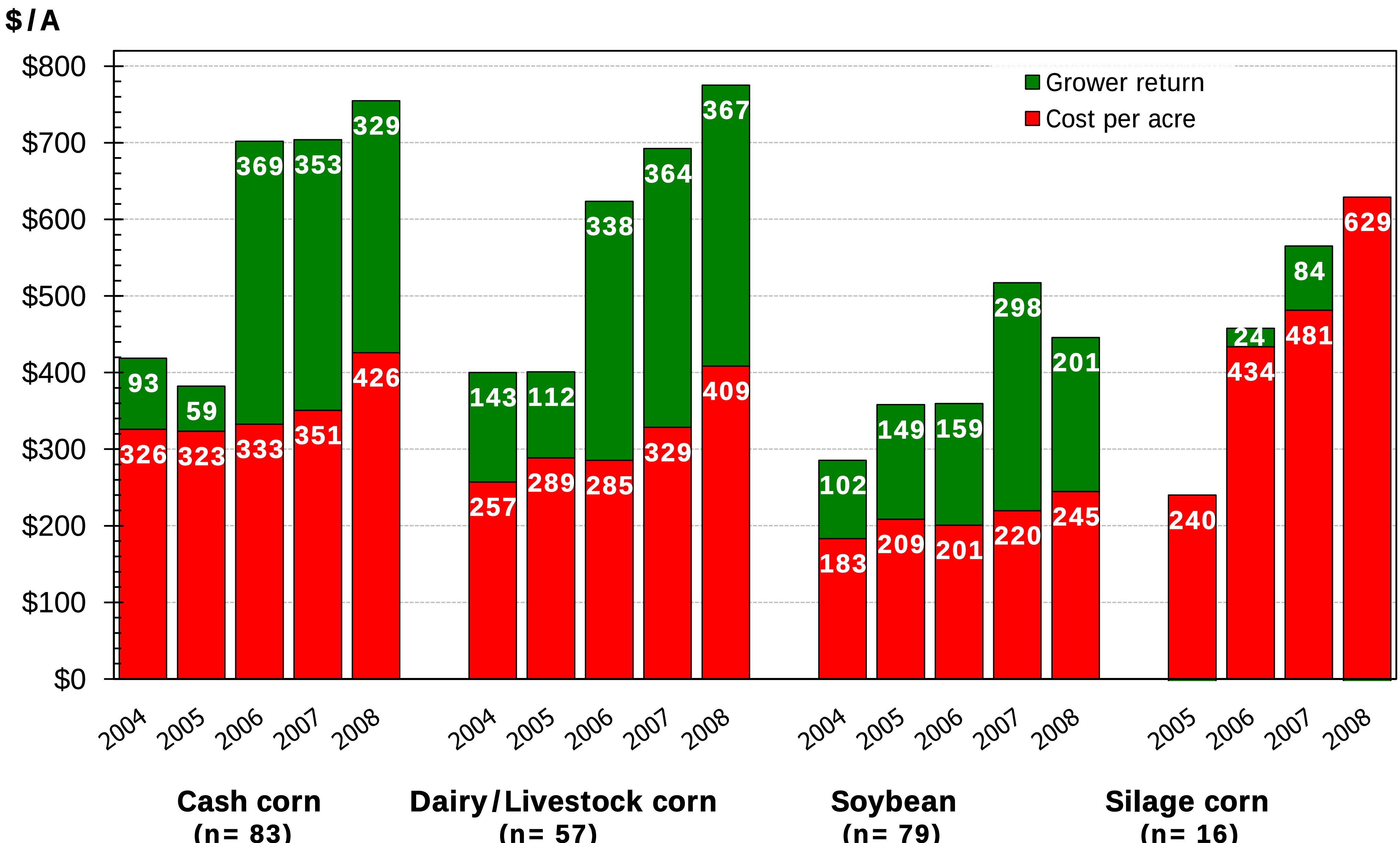
Source: Lauer

Average corn production costs for major inputs



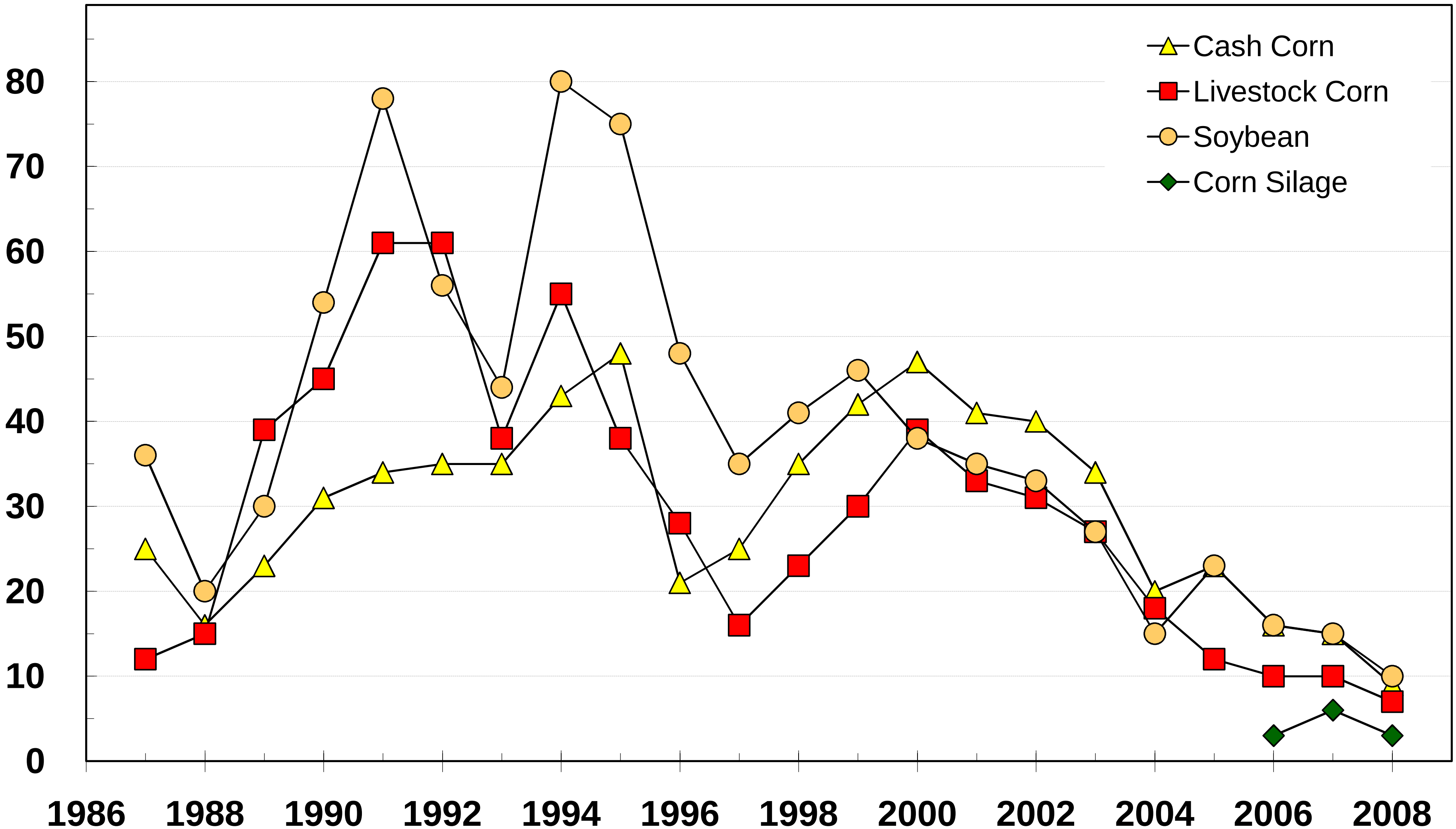
Source: Lauer

Corn and Soybean Cost of Production and Grower Return



Source: Lauer

Number of Participants in PEPS (n= 2173)



How can you get involved in PEPS?

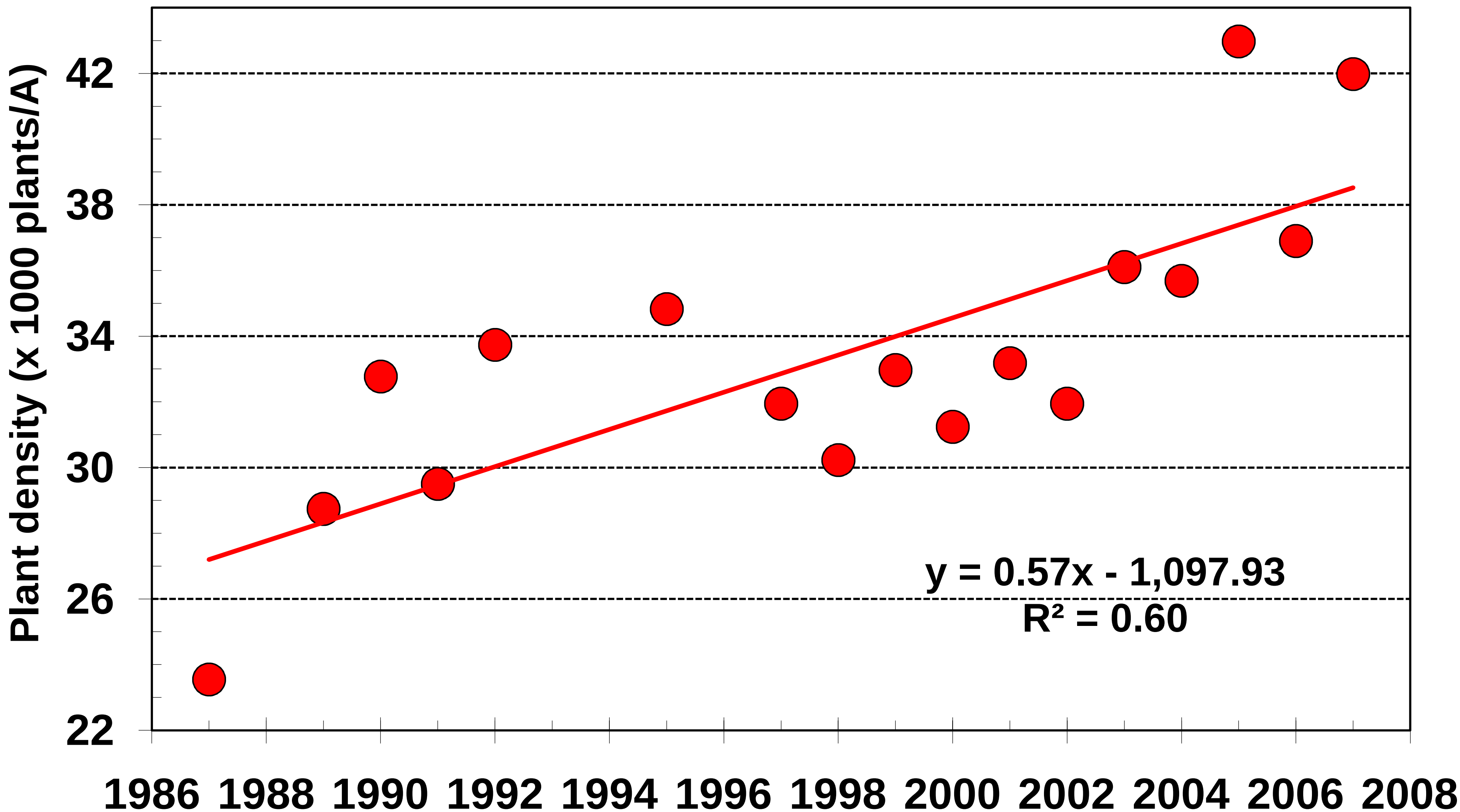
- **Contest versus Verification options**
- **Does it pay to grow corn on my farm?**
  - ✓Do I know my production costs?
  - ✓If I do, how do I compare?
  - ✓How efficient is my operation?
  - ✓Am I a good steward?
  - ✓If I make changes, how does that affect my bottom-line?
- **What role can agents/dealers/consultants play in PEPS?**
  - ✓Promote among producers who would benefit (helping with forms, soil loss and yield checks)
  - ✓Encourage National Corn Growers Association yield contestants to enter
  - ✓Provide input to PEPS committee from "real world"
  - ✓Financial sponsorship

Agronomic and economic consequences of corn management decisions in WI

1. **Weather / Environment**
2. **Hybrid**
   - ✓ Top to bottom ranking = 0 to 30% change
   - ✓ Presence or absence of genetic traits = 0 to 100% change
3. **Date of Planting**
   - ✓ May 1 to June 1 = 0 to 30% change
   - ✓ Also need to add moisture penalty
4. **Pest Control**
   - ✓ Timeliness
   - ✓ Weeds > Insects > Diseases
   - ✓ Good v. Bad = 0 to 100% change
5. **Plant Density**
   - ✓ 32,000 to 15,000 plants/A = 0 to 22% change
6. **Rotation**
   - ✓ Continuous v. Rotation = 0 to 30% change
   - ✓ Greater consequence in 'stress' environments
7. **Soil Fertility**
   - ✓ 160 v. 0 lb N/A = 20 to 50% change
8. **Harvest Timing**
   - ✓ Oct. 15 to Dec. 1 = 0 to 20% change
9. **Tillage**
   - ✓ Chisel v. No-till = -5 to 10% change
   - ✓ No-till = energy savings
   - ✓ Cultivation: Yes v. No = 0 to 10% change
10. **Row Spacing**
    - ✓ 30-inches to 15-inches = 0 to 5% change

Is Plant Density at Maximum Yield Changing?

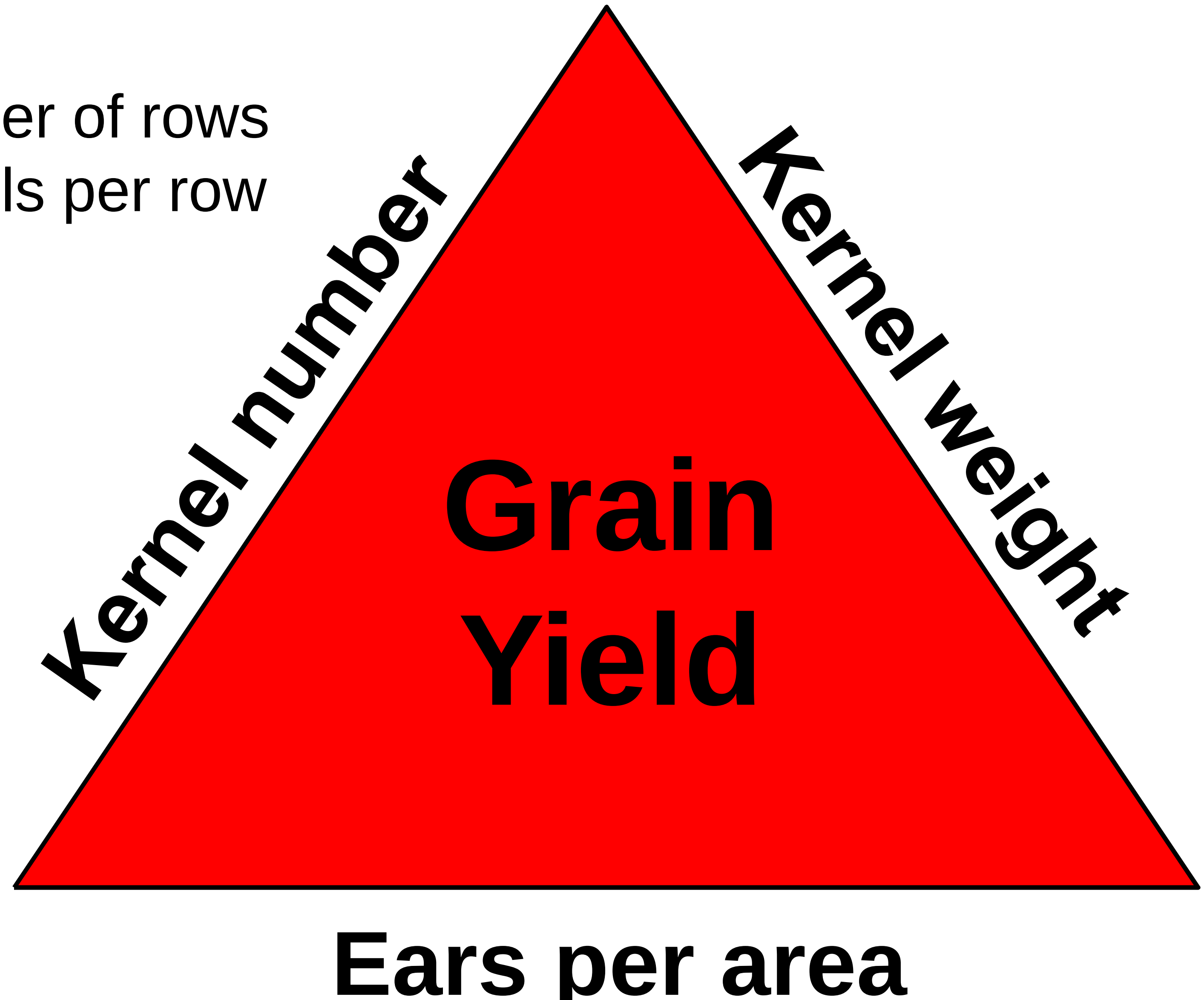
Annual grain yield increase at optimum plant density = 2.8 bu/A



Source: Lauer
Arlington, 1987-2003 02PD, n= 867 plots

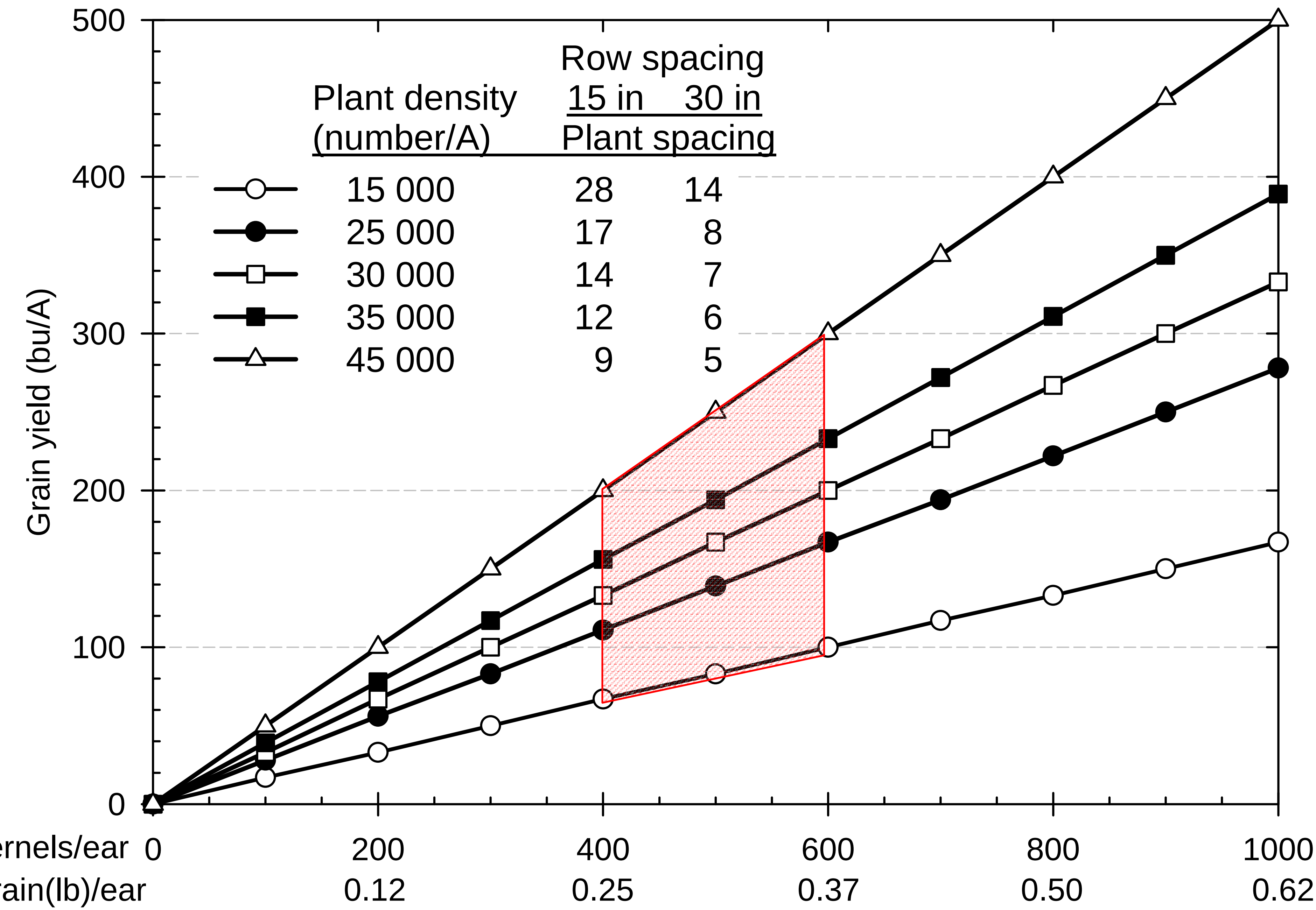
Yield Components of Corn

Number of rows
Kernels per row



Potential Grain Yield Using Calculated Components

Assume 90,000 kernels/bu and 56 lb/bu; kernel mass = 282 mg



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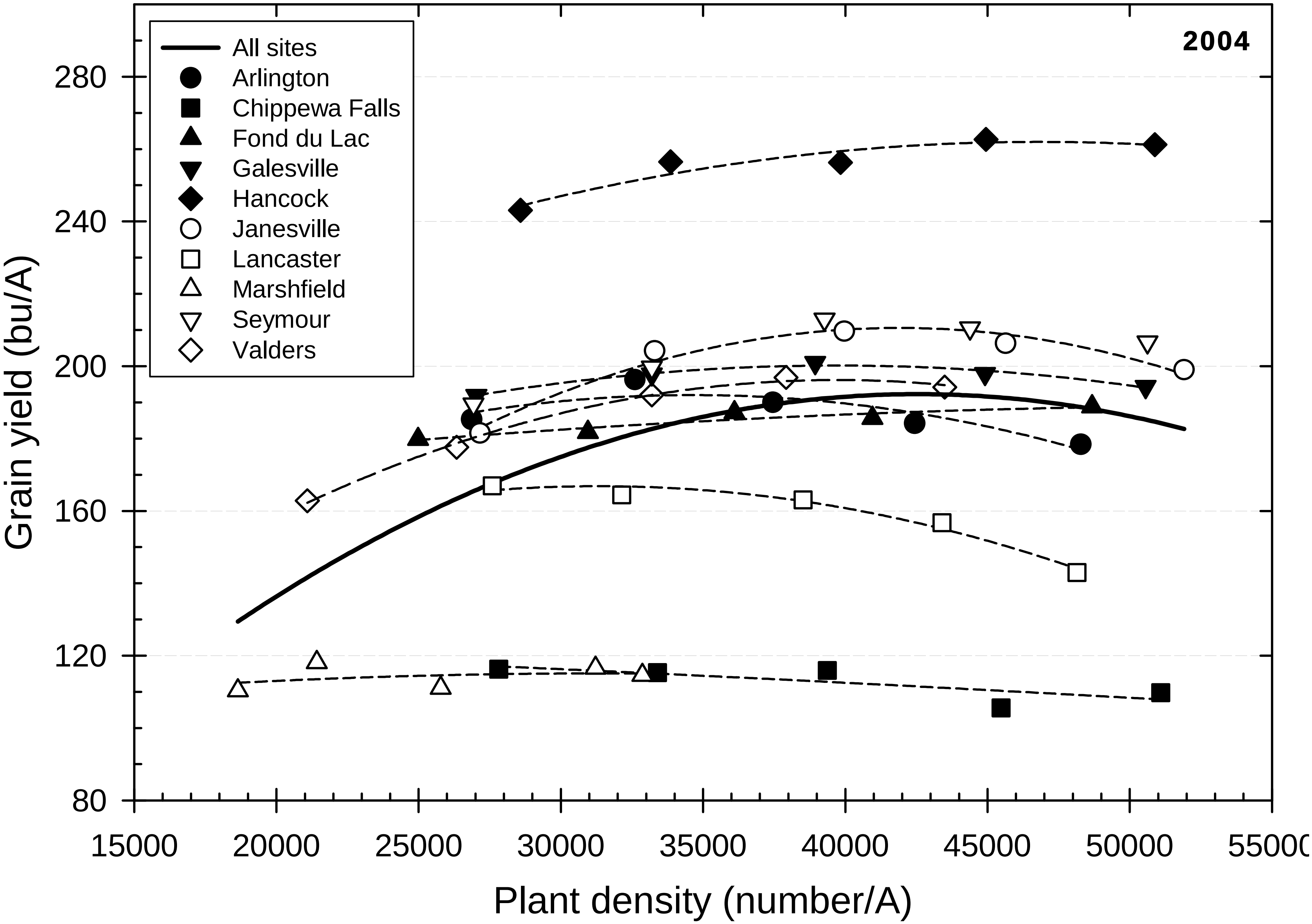
Corn response to plant density in Wisconsin

Varies by location and hybrid (GxE)

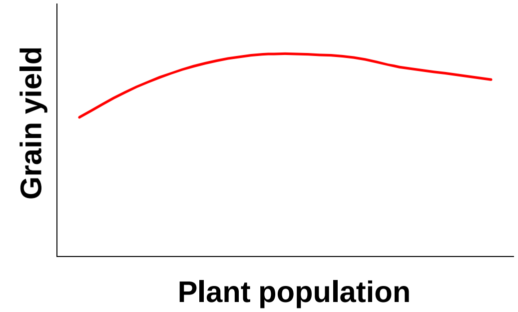
Concerns: Lodging and Drought

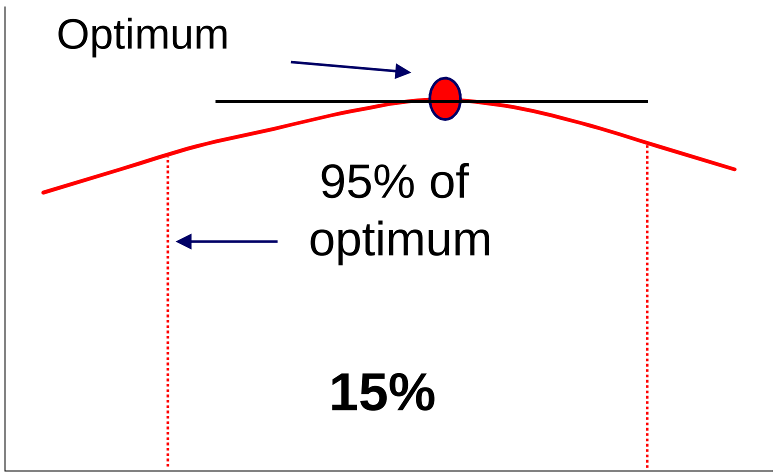


http://corn.agronomy.wisc.edu

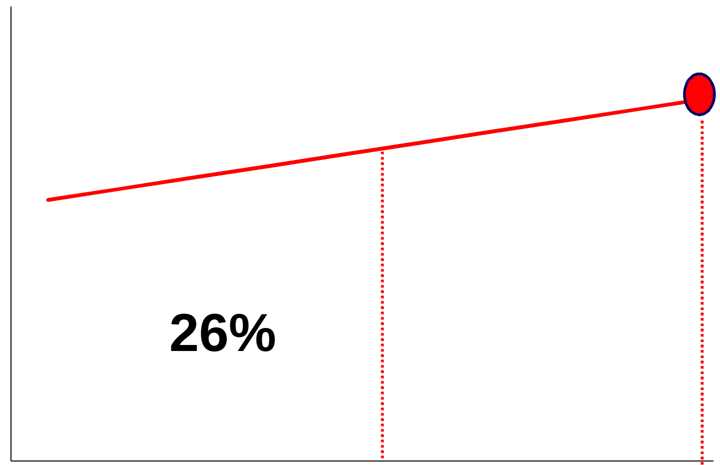
What Does the Relationship Between Grain Yield And Plant Density Look Like?

Total forms = 8; GxE n= 5571 cases (123 locations; 631 hybrids; 80,822 plots)
Trials with min PD≤ 28,000 and max PD≥ 34,000



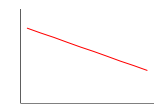


+ Linear and - Quadratic

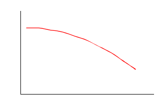


+ Linear

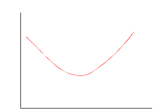
-L= 1%

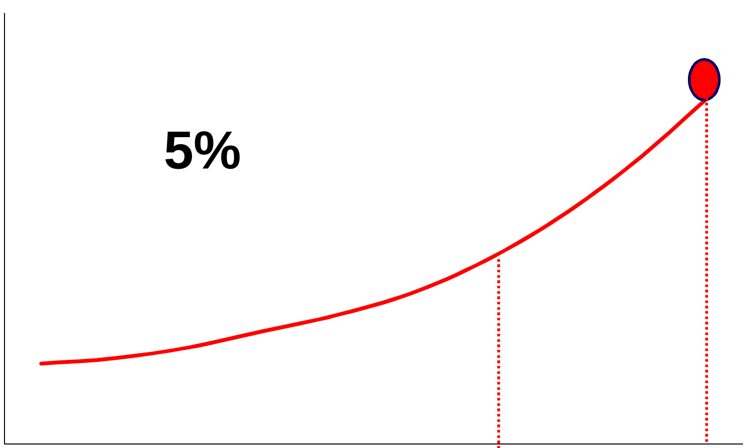


-Q= 2%

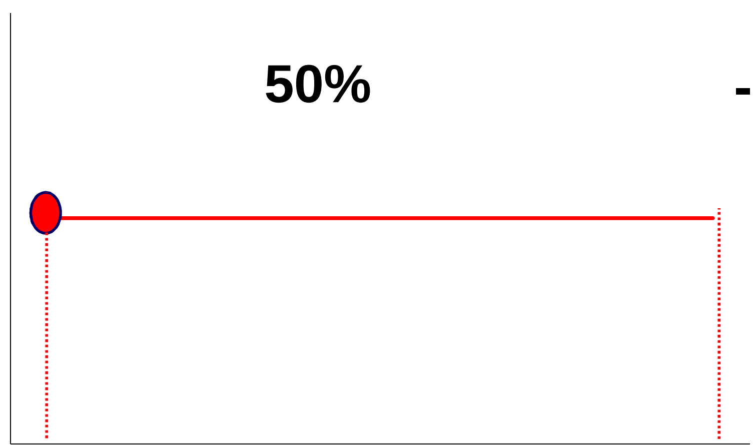


-L+Q= 1%



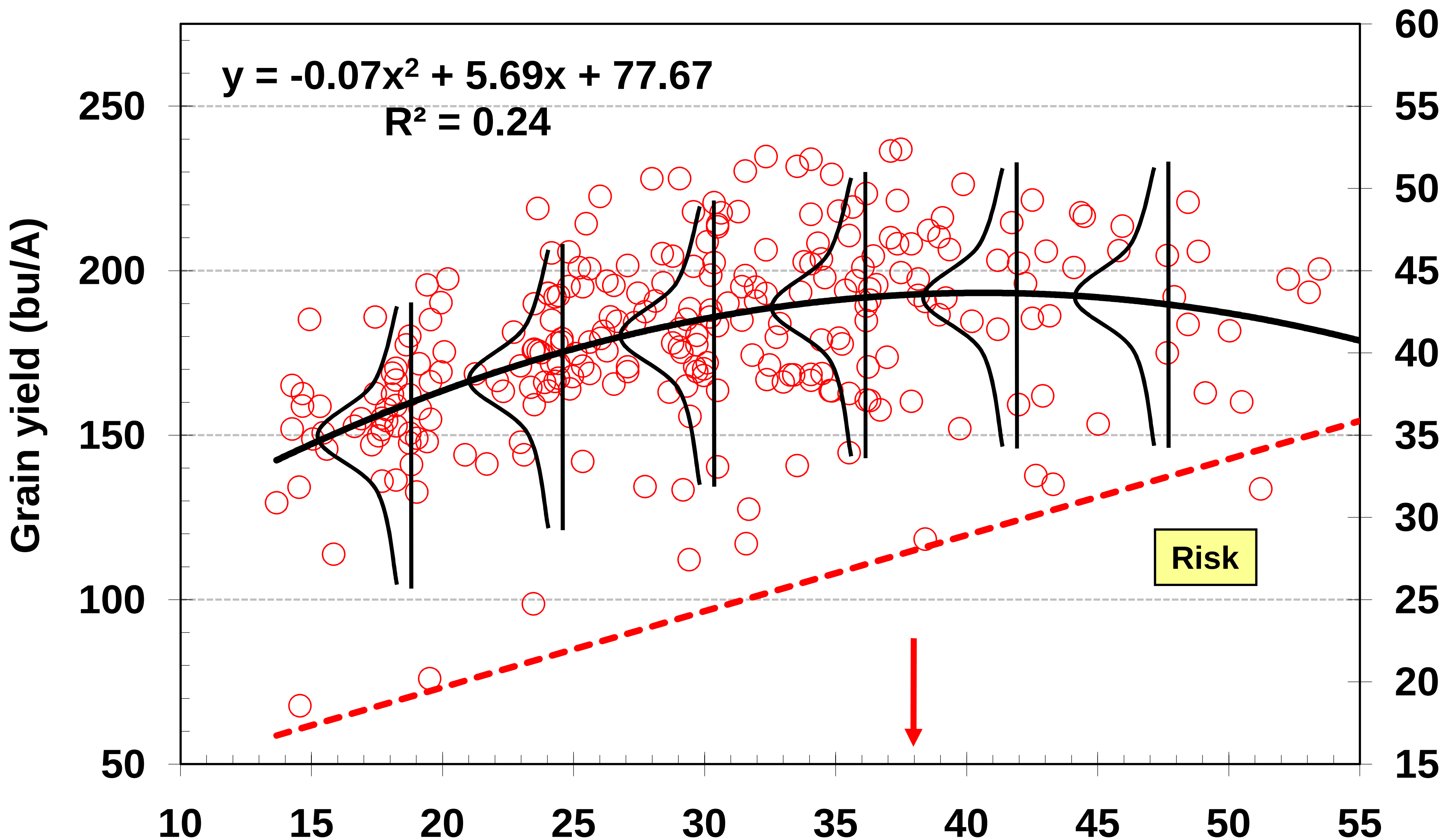


+ Quadratic



None

Increasing plant density increases grain yield … but there is a risk



Source: Lauer
Arlington, 1987-2005, n= 867 plots

UW Extension

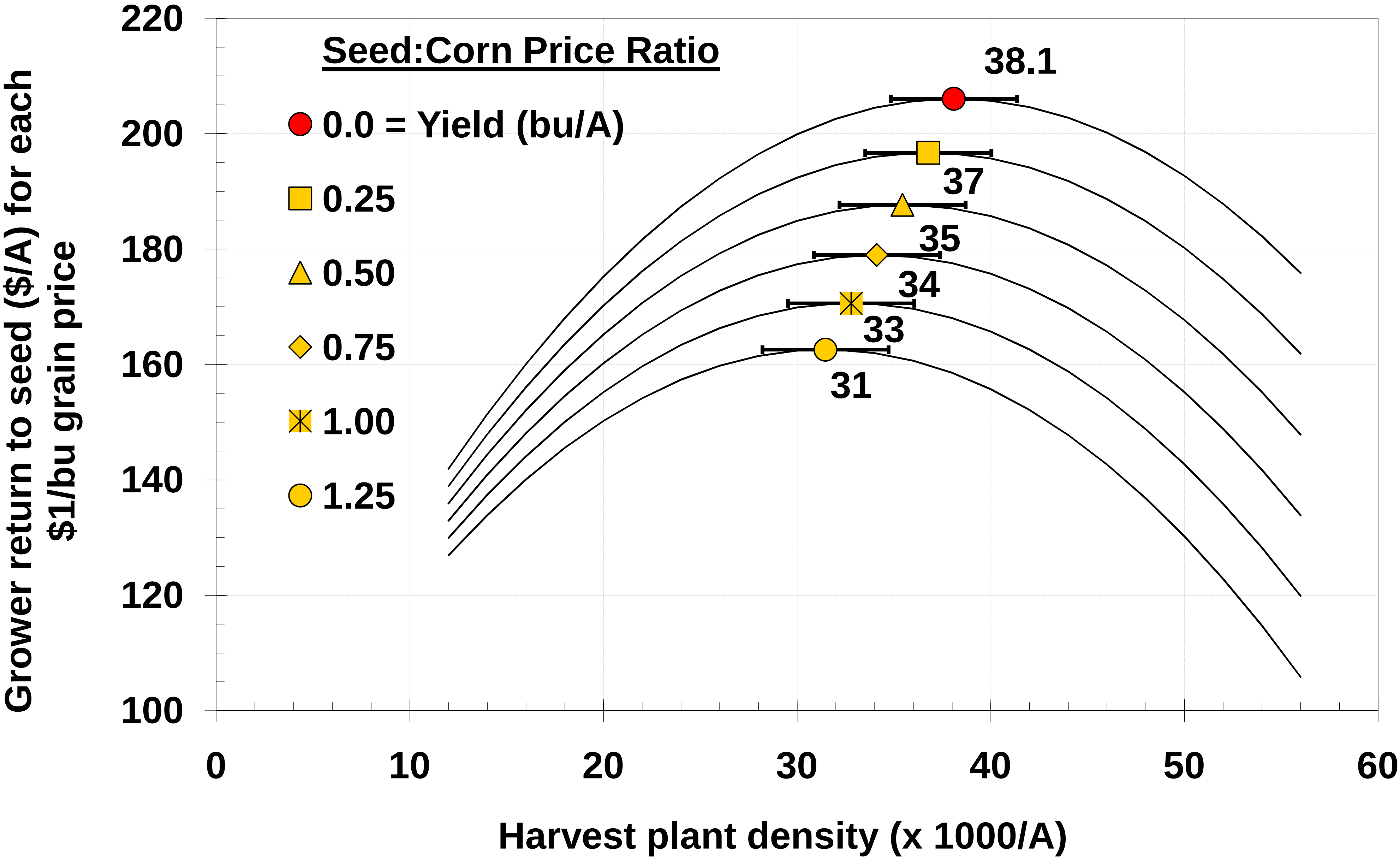
Should We Be Concerned About Seed Costs?

- **Seed costs have dramatically increased over the last few years.**
  - ✓ Transgenic hybrids and technology fees has driven the cost of seed
    - ❑ In the early 1990s, premium seed would run about \$80 - \$100 per bag.
    - ❑ Premium hybrids cost \$150 - \$250 per bag.
- **The plant density that maximizes corn yield is increasing over time.**
- **When grower returns are low, farmers are concerned about the cost of all inputs for corn production**
- **Ultimately, optimum plant density is affected by both seed cost and corn price.**

The Maximum Return to Seed (MRTS) Strategy
Price ratio of seed:corn (i.e. $/1000 seeds÷ $/bu corn).

Price of seed		Price of corn ($/bu)								
$/80 K bag	$/1000 seeds	$1.00	$1.75	$2.50	$3.25	$4.00	$4.75	$5.50	$6.25	$7.00
$0	$0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$40	$0.50	0.50	0.29	0.20	0.15	0.13	0.11	0.09	0.08	0.07
$80	$1.00	1.00	0.57	0.40	0.31	0.25	0.21	0.18	0.16	0.14
$120	$1.50	1.50	0.86	0.60	0.46	0.38	0.32	0.27	0.24	0.21
$160	$2.00	2.00	1.14	0.80	0.62	0.50	0.42	0.36	0.32	0.29
$200	$2.50	2.50	1.43	1.00	0.77	0.63	0.53	0.45	0.40	0.36
$240	$3.00	3.00	1.71	1.20	0.92	0.75	0.63	0.55	0.48	0.43
$280	$3.50	3.50	2.00	1.40	1.08	0.88	0.74	0.64	0.56	0.50
$320	$4.00	4.00	2.29	1.60	1.23	1.00	0.84	0.73	0.64	0.57
$360	$4.50	4.50	2.57	1.80	1.38	1.13	0.95	0.82	0.72	0.64
$400	$5.00	5.00	2.86	2.00	1.54	1.25	1.05	0.91	0.80	0.71

Maximum return to seed at Arlington, WI



Spreadsheet for Calculating Seed Costs

CropSeedPriceCalculator_v1.2.xls [Compatibility Mode] - Microsoft Excel

Crop Seed Price Calculator v1.2 written by Joe Lauer, University of Wisconsin (September 2008)

	Hybrid A	Hybrid B	difference
Predicted Field Yield (bu/A)	150		
Hybrid / Variety	Hybrid A	Hybrid B	difference
Seed Price ($/bag)	$150.00	$150.00	$0.00
Kernels/Seeds per bag (no./bag)	80,000	80,000	$0.00
Seed Population (number/acre)	32,000	32,000	0
Potential plant death (%)	10	10	0
Acres per bag (acres/bag)	2.27	2.27	0.00
Seed Cost ($/acre)	$66.00	$66.00	$0.00
Herbicide Cost ($/acre)	$0.00	$0.00	$0.00
Insecticide Cost ($/acre)	$0.00	$0.00	$0.00
Fungicide Cost ($/acre)	$0.00	$0.00	$0.00
Insurance Cost ($/acre)	$0.00	$0.00	$0.00
Harvest Moisture (%)	20.0	20.0	0.0
Drying ($/point*bushel)	$0.06	$0.06	$0.00
Drying Cost ($/bushel)	$0.27	$0.27	$0.00
Handling Cost ($/bushel)	$0.02	$0.02	$0.00
Hauling Cost ($/bushel)	$0.04	$0.04	$0.00
Trucking Cost ($/bushel)	$0.11	$0.11	$0.00
Storage Cost ($/bushel)	$0.12	$0.12	$0.00
Yield adjustment ($/bushel)	$0.56	$0.56	$0.00
Yield adjustment ($/acre)	$84.00	$84.00	$0.00
Total Input Cost ($/acre)	$150.00	$150.00	$0.00

Economic advantage ($/acre) of Hybrid A or Hybrid B. Seed price difference = $0 per bag: A = $150, Hybrid B = $150.

Yield advantage bushel/acre		Crop Price ($/bushel) $1.00	$2.00	$3.00	$4.00	$5.00	$6.00	$7.00
	14	$14	$28	$42	$56	$70	$84	$98
	12	$12	$24	$36	$48	$60	$72	$84
Hybrid A	10	$10	$20	$30	$40	$50	$60	$70
yields less than	8	$8	$16	$24	$32	$40	$48	$56
Hybrid B	6	$6	$12	$18	$24	$30	$36	$42
	4	$4	$8	$12	$16	$20	$24	$28
	2	$2	$4	$6	$8	$10	$12	$14
Hybrid A = (Hybrid B)	0	$0	$0	$0	$0	$0	$0	$0
	2	$2	$4	$6	$8	$10	$12	$14
	4	$4	$8	$12	$16	$20	$24	$28
Hybrid A	6	$6	$12	$18	$24	$30	$36	$42
yields more than	8	$8	$16	$24	$32	$40	$48	$56
Hybrid B	10	$10	$20	$30	$40	$50	$60	$70
	12	$12	$24	$36	$48	$60	$72	$84
	14	$14	$28	$42	$56	$70	$84	$98

Crop Seed Price Calculator v1.2

Conclusions

- **Optimum plant populations for grain yield are higher than currently recommended levels.**
  - ✓At Arlington, optimum plant density has been annually increasing 420 plants/A
- **About half of the environments (50%) do not respond to plant population. But,**
  - ✓High plant populations rarely reduce grain yield (<4%)
  - ✓Need to manage for the opportunities in a responsive environment.

Guidelines for Choosing an Appropriate Plant Density for Corn

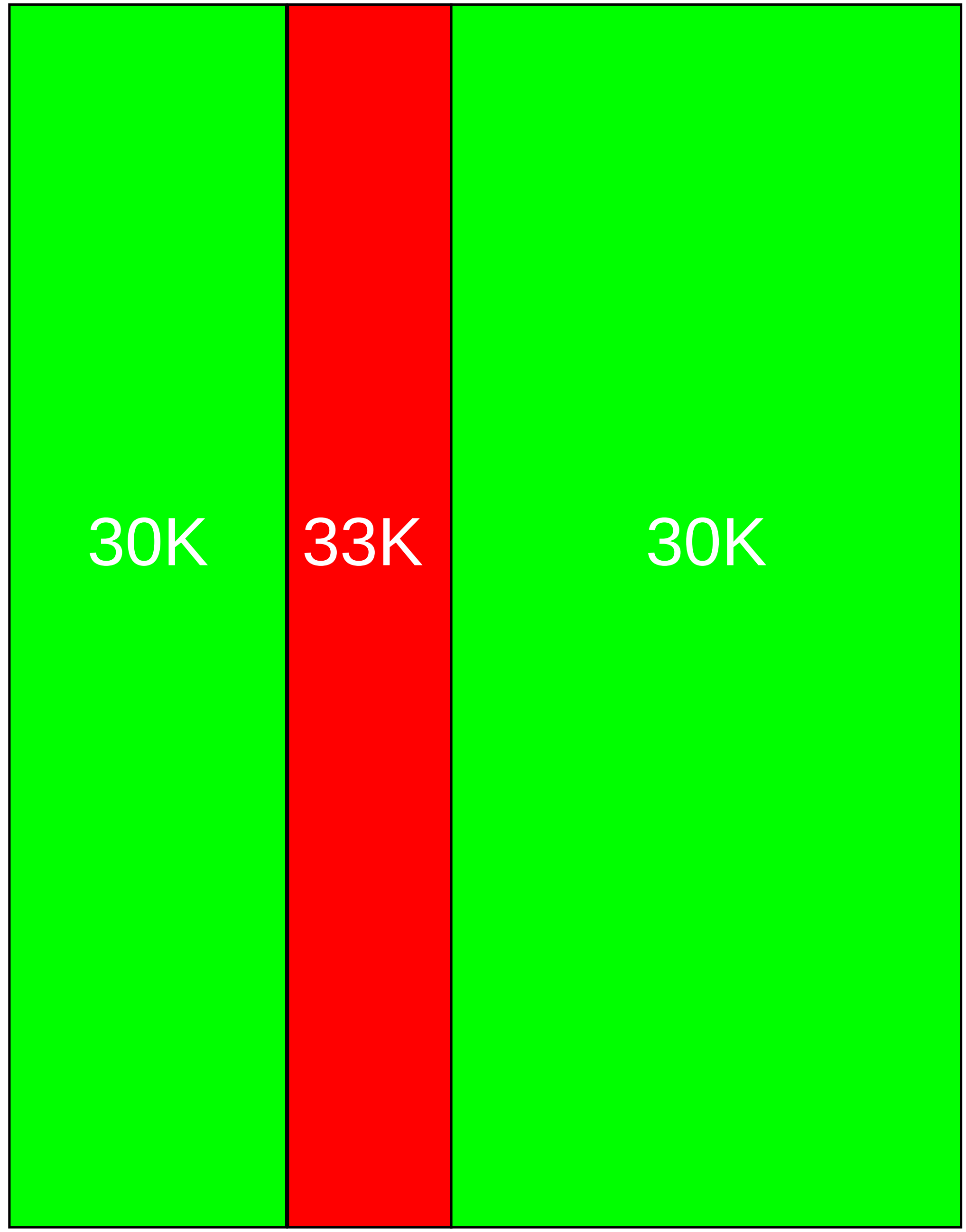
- **May have the most potential to move a farmer from current yield levels.**
  - ✓Might be the place to start for moving off the “yield plateau.”
  - ✓Optimum plant densities seem to be increasing as newer hybrids are commercialized.
    - ❑Grain yield increases to plant densities of 38,100 plants/A.
- **The EOPD for seed:corn price ratios between 0.5 and 1.5 is 29,800 to 36,200 plants/A.**
  - ✓The plant density of 32,700 plants/A is within $1.00 of the EOPD for ratios between 0.5 and 1.5.
- **In general, silage yield increases as plant density increases.**
  - ✓But, a trade-off exists where quality decreases with increasing population.
  - ✓Thus, the EOPD is the same for corn grown for silage or grain.

Guidelines: How do you know if an environment is responsive? Let the plants tell you how your field is doing …

- Tillered v. Runt plants
- Prolific v. Barren shoots
- Big v. Small ears
- Full ear tips v. Nose-back
- Lodging

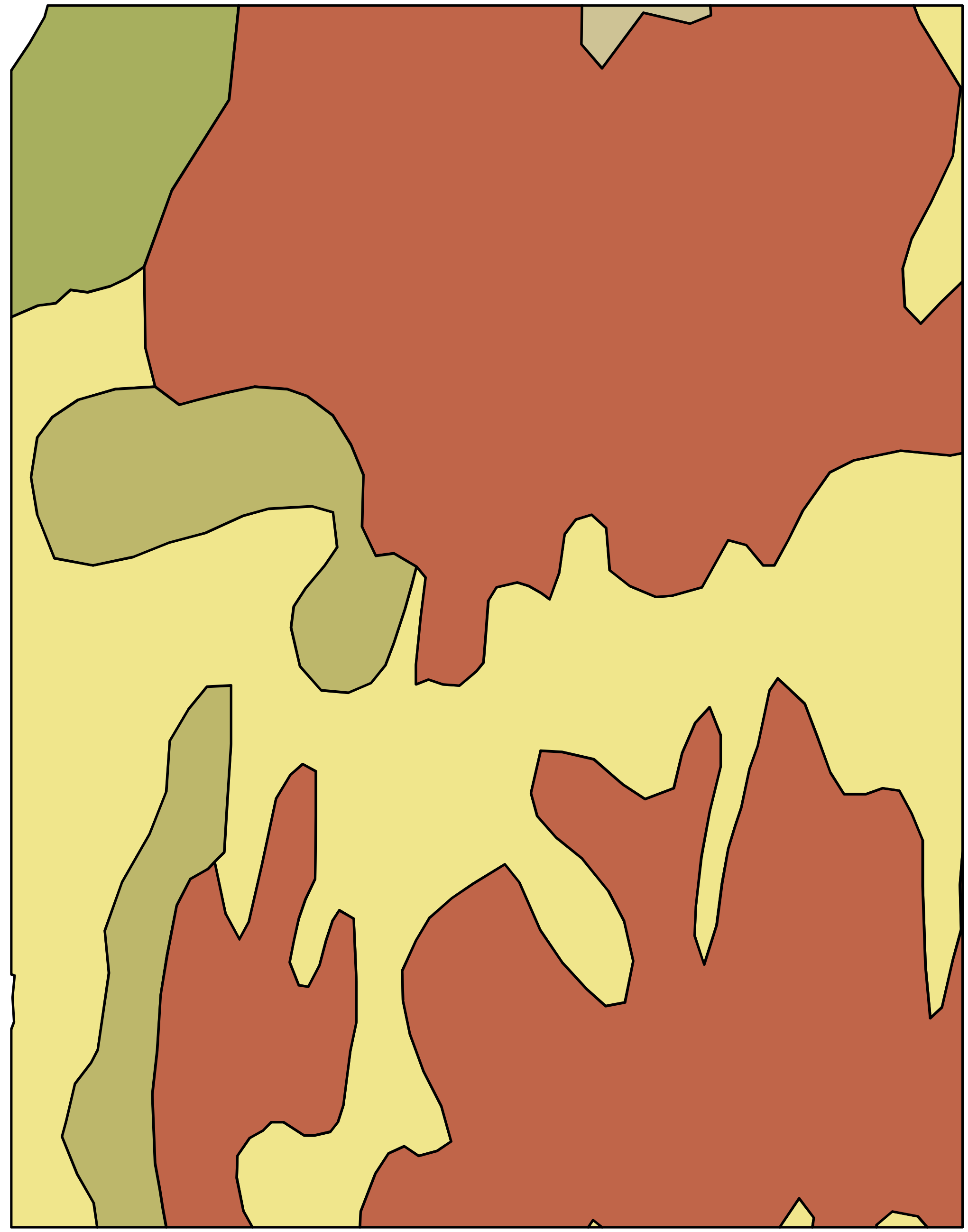
Guidelines: One place to begin is evaluate your plant density for each field ...

- **Reference Strips for On-Farm Testing Plant Density**
- **Field specific**
- **At least one strip per field. Total of 3-4 strips per farm.**
- **Increase plant population 10% in one-strip.**
  - ✓ Plant majority of field to normal plant density
  - ✓ Ideally 2-3 strips per field



What do we do with all these yield maps?

- **Precision farming and yield maps are ~15 years old.**
  - ✓ Crop yields typically vary over space and time. This in-field variability is the focus of precision agriculture – how to manage it, diminish it, or overcome it (Lamb, 1997).
  - ✓ Tremendous costs
    - ❑ Infrastructure / Equipment / Data
    - ❑ People / Time
  - ✓ Generated lots of data
- **To successfully implement variable rate technology, we need <u>predictable</u> patterns of grain yield variability.**
- **<u>Bottom line:</u> Time is required before yield maps are useful.**
  - ✓ "Farming for your sons and daughters."



So far little economic benefit seen with yield maps ...

Equipment

- **Sensitive**
  - Requires frequent calibration ("GIGO")
- **Sophisticated**
  - ✓ Requires time to learn electronic skills in order to operate equipment and software.
- **Requires both yield monitor AND GPS data.**

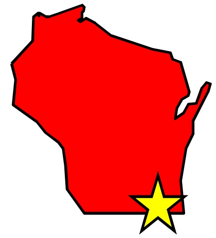
Data

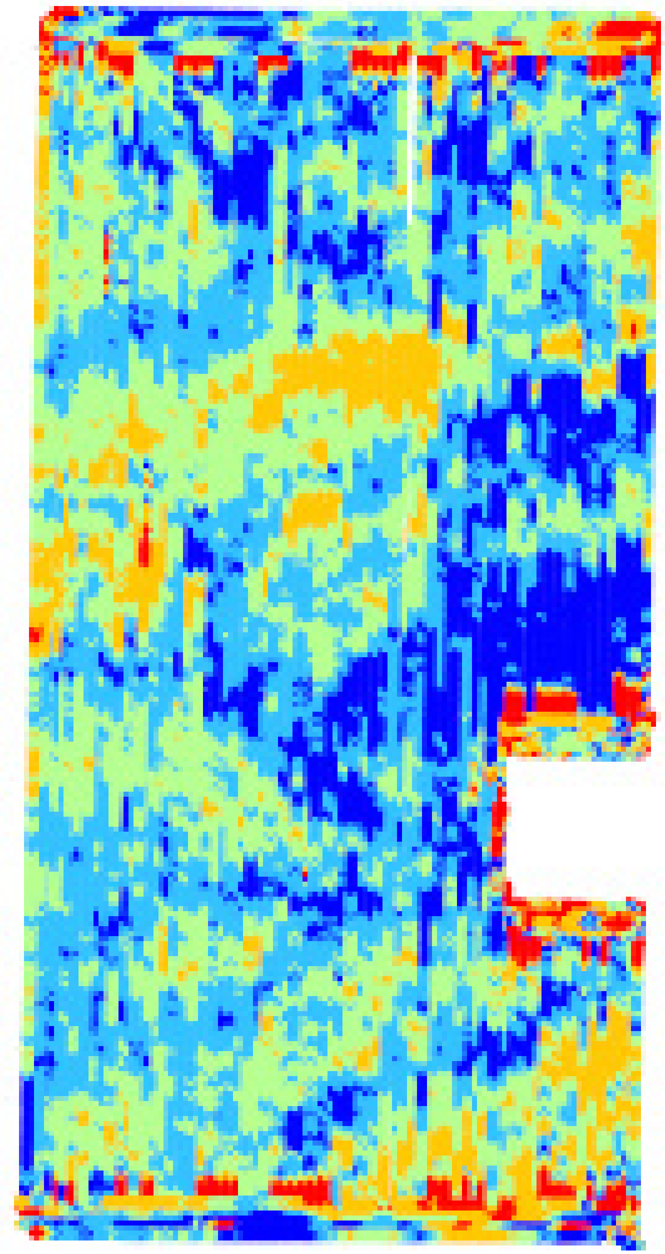
- **Computer resources**
- **Management**
- **Software for Analysis**
  - ✓ Sophisticated and complicated

People

- **Lack of local technical assistance**
- **Decision making**
  - ✓ Uncertainty for recommendations
- **Most benefit is to people in the field rather than absentee owner operators who do little or no field work.**
  - ✓ Data requires interpretation (notes)

Assessing Variable Rate Technology Implemented on Management Zones determined by Multiyear Yield Data





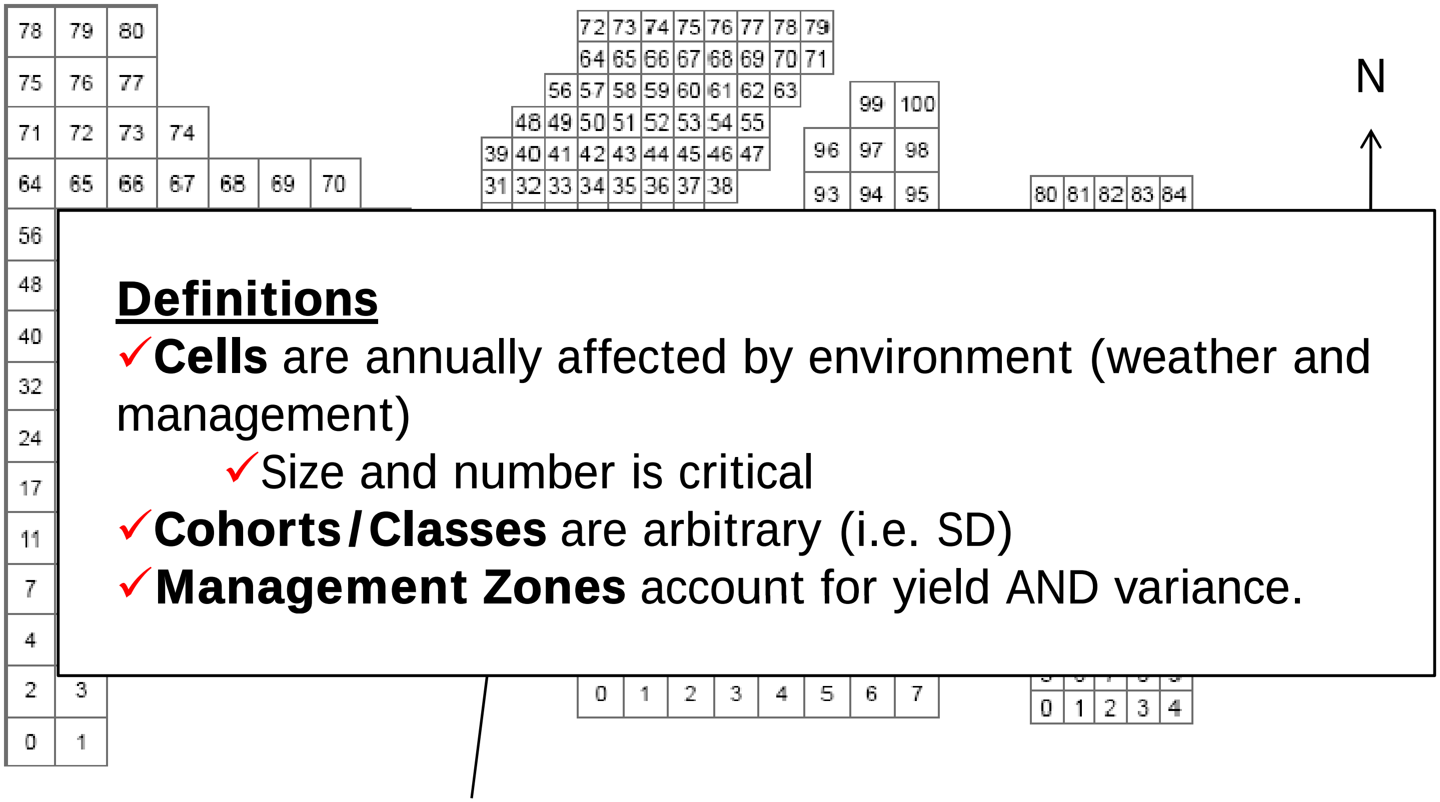
- **Objectives:**
  - ✓ Determine if geo-referenced cells within a field vary with respect to grain yield cohort from year to year.
    - ❑ How much?
    - ❑ Biologically significant?
    - ❑ Economically significant?
  - ✓ Determine if multi-year grain yield data can be used to predict a management zone classification.
  - ✓ If grain yield prediction is achievable, can variable rate starter fertilizer prescriptions, based on management zone grain yield cohorts, be beneficial (agronomic and/or economic).

Source: Hopf, 2008

Materials and Methods - from the Grower

- **Yield maps were collected over a 13 year period on five fields in Walworth County, WI.**
  - ✓ The crop rotation for all fields was an alternating corn-soybean rotation.
  - ✓ These fields represent a unique dataset due to the high-quality spatially referenced grain yield and grain moisture data.
- **Fields were divided into spatially-referenced cells, which remained consistent within a field across years.**
  - ✓ The size of a cell depended on field size (~100 cells per field).
- **During the last growing season in which corn was grown, either 2005 or 2006, the producer implemented variable rate starter fertilizer applications.**
  - ✓ The N-P-K fertilizer analysis was either 10-34-0, or 16-22.5-0.
  - ✓ Starter fertilizer application for these fields was split between three rates of low, medium, and high.
- **“Post-mortem” analysis**

Materials and Methods –Layout of Fields (~400 A)



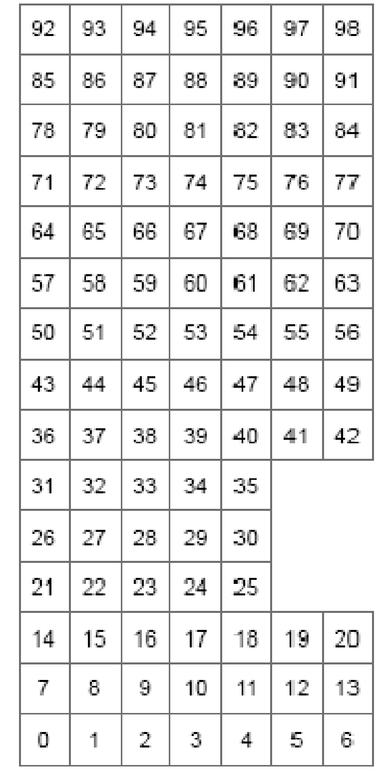
Definitions

✓**Cells** are annually affected by environment (weather and management)

✓Size and number is critical

✓**Cohorts/Classes** are arbitrary (i.e. SD)

✓**Management Zones** account for yield AND variance.



Field E
0.62 A
2500 m^2

Field D
0.25 A
1000 m^2

Field C
0.49 A
2000 m^2

Field B
0.25 A
1000 m^2

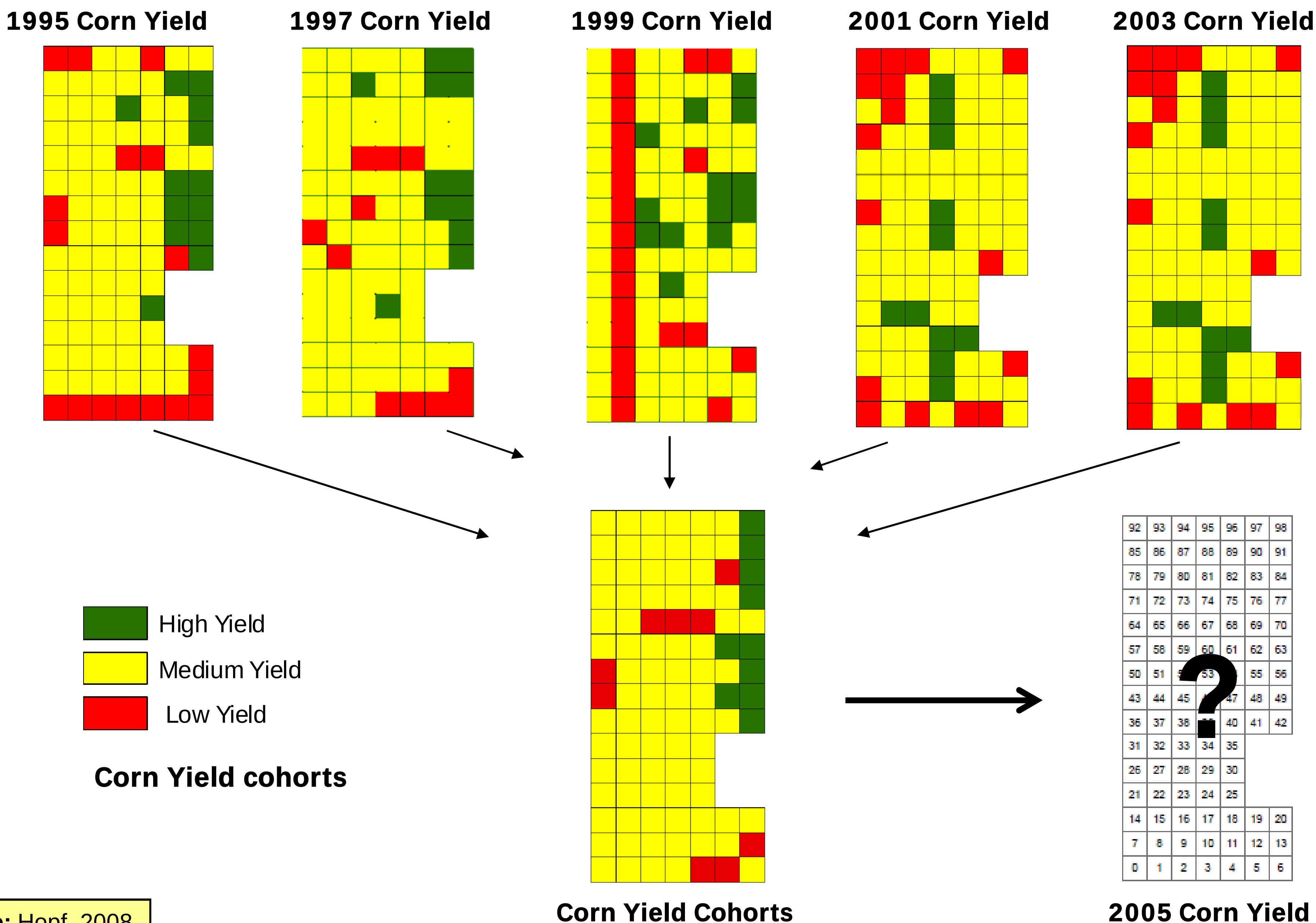
Field A
0.62 A
2500 m^2

Source: Hopf, 2008

Materials and Methods – Data Cleaning

- **Combines equipped with commercially available yield sensing systems were used to collect data from 1994-2007.**
- **Individual points were determined unreliable based on several criterions.**
  - ✓All negative values for grain yield and grain moisture were deleted.
  - ✓Points with GPS positional errors were deleted.
  - ✓Outside headlands were deleted, to avoid significant changes in grain flow while entering and exiting the field.
  - ✓Grain moisture points that were abnormally high, and were not associated with normal grain harvest practices were deleted.
  - ✓Grain yield points that were deemed higher than the agronomical potential for a field under a set of management practices (>300 bu/A) were deleted.

Calculating corn yield cohorts to predict next year's yield

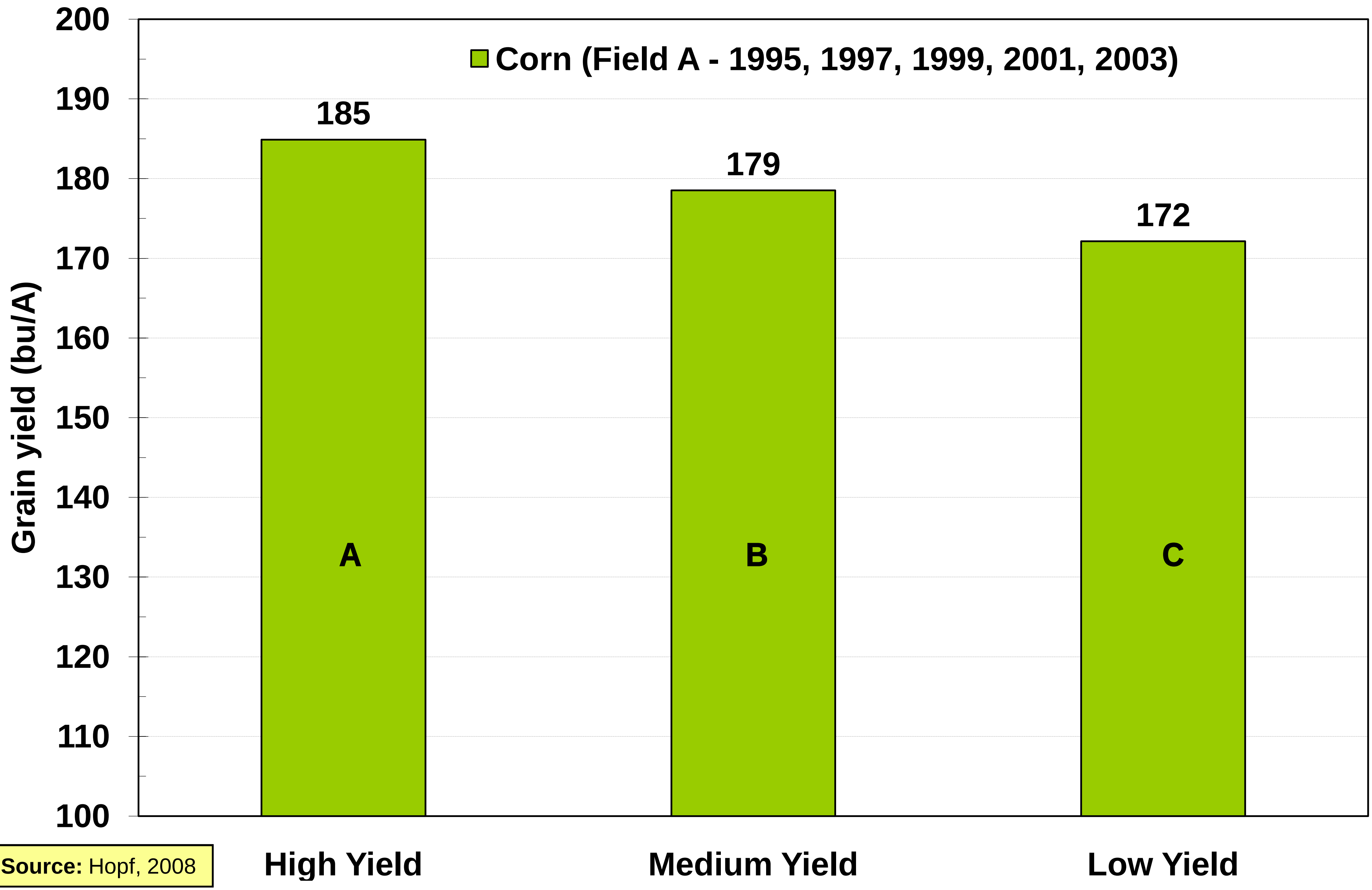


Source: Hopf, 2008

Methods of Analysis – Field Management Zones

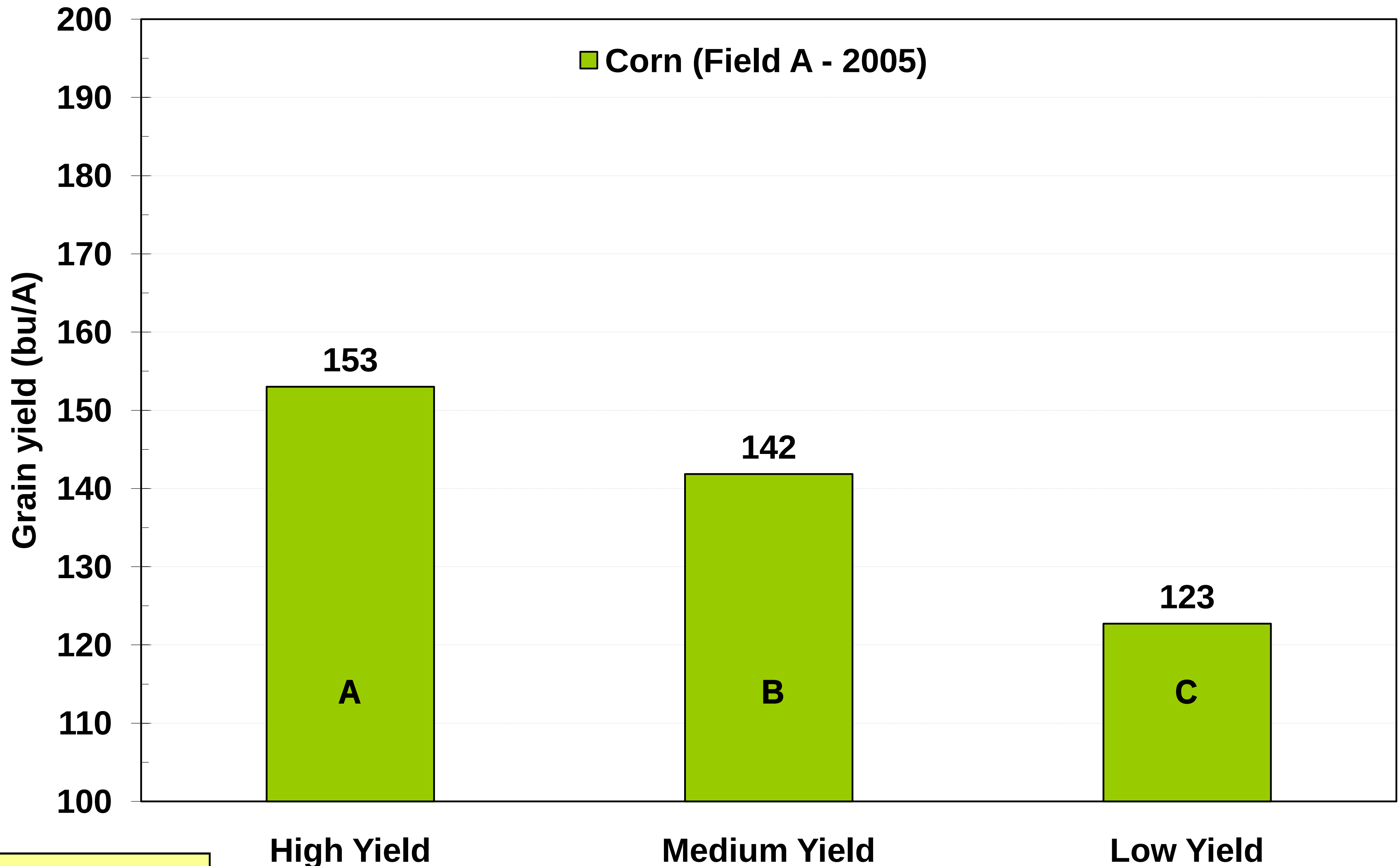
Yield cohort	Cells
High	17%
Medium	66%
Low	17%

What is the yield range between yield cohorts?



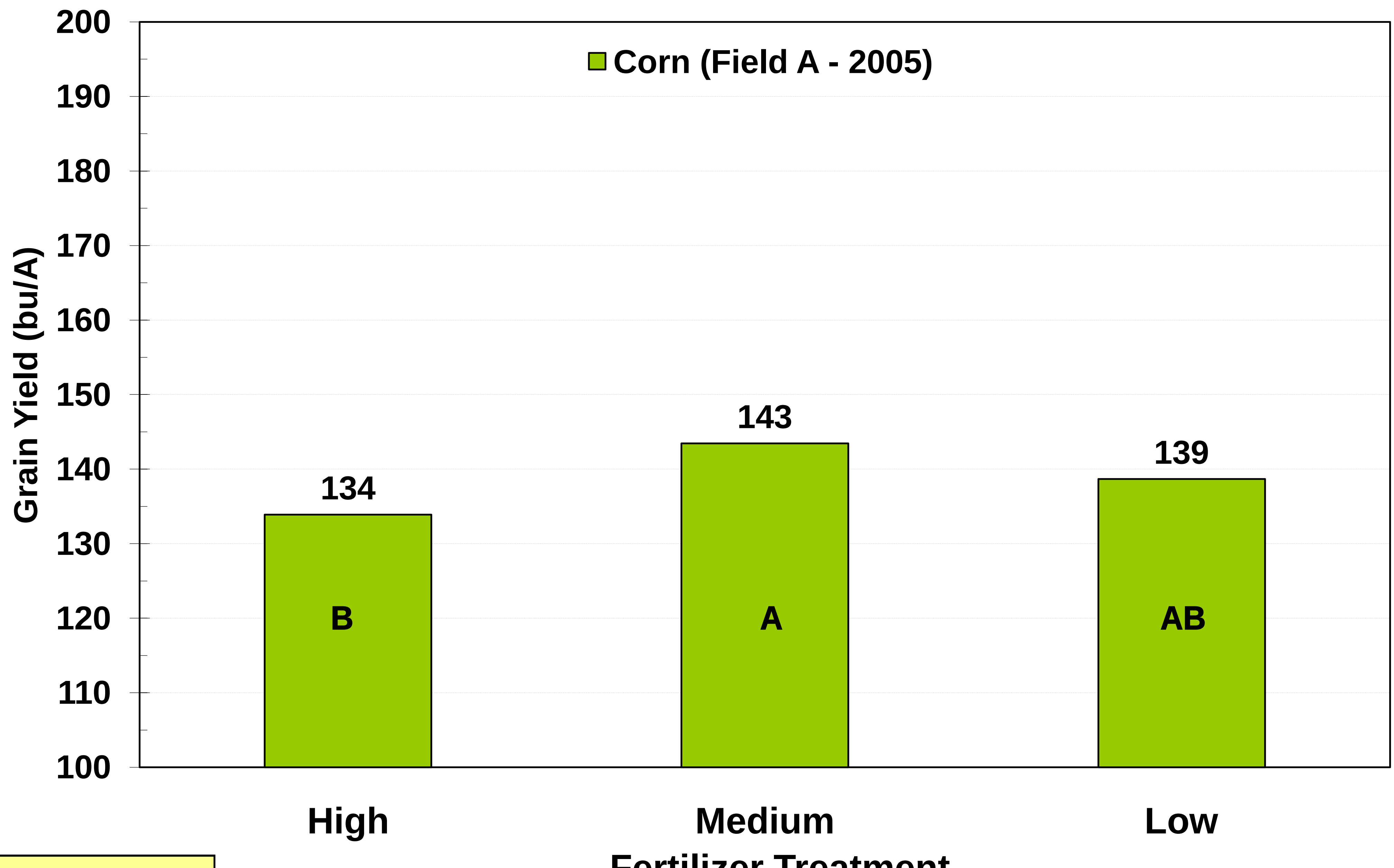
Source: Hopf, 2008

Following cell classification and variable rate application of starter fertilizer, what was the range between yield cohorts?



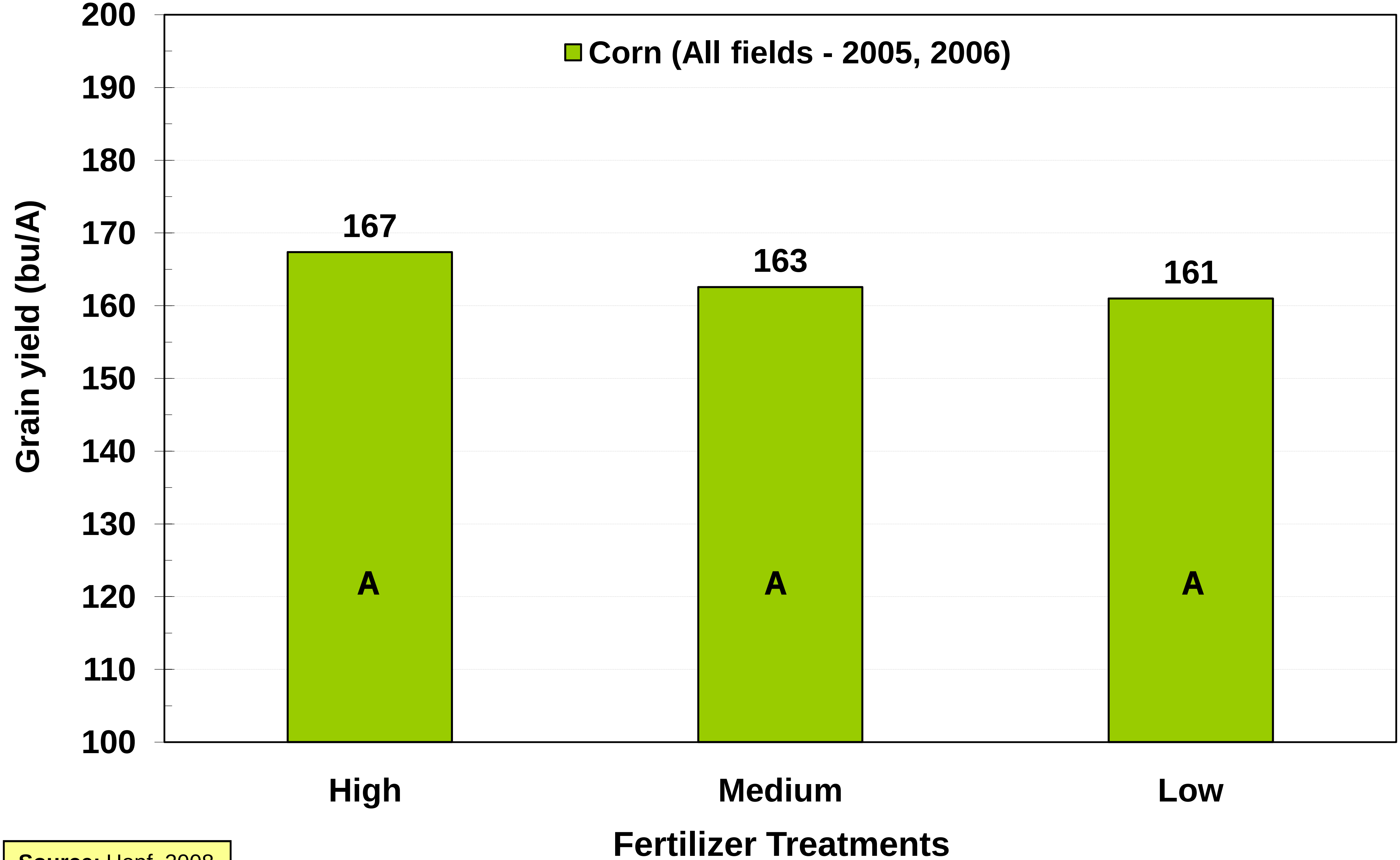
Source: Hopf, 2008

Did variable rate fertilizer application have any effect on yield?



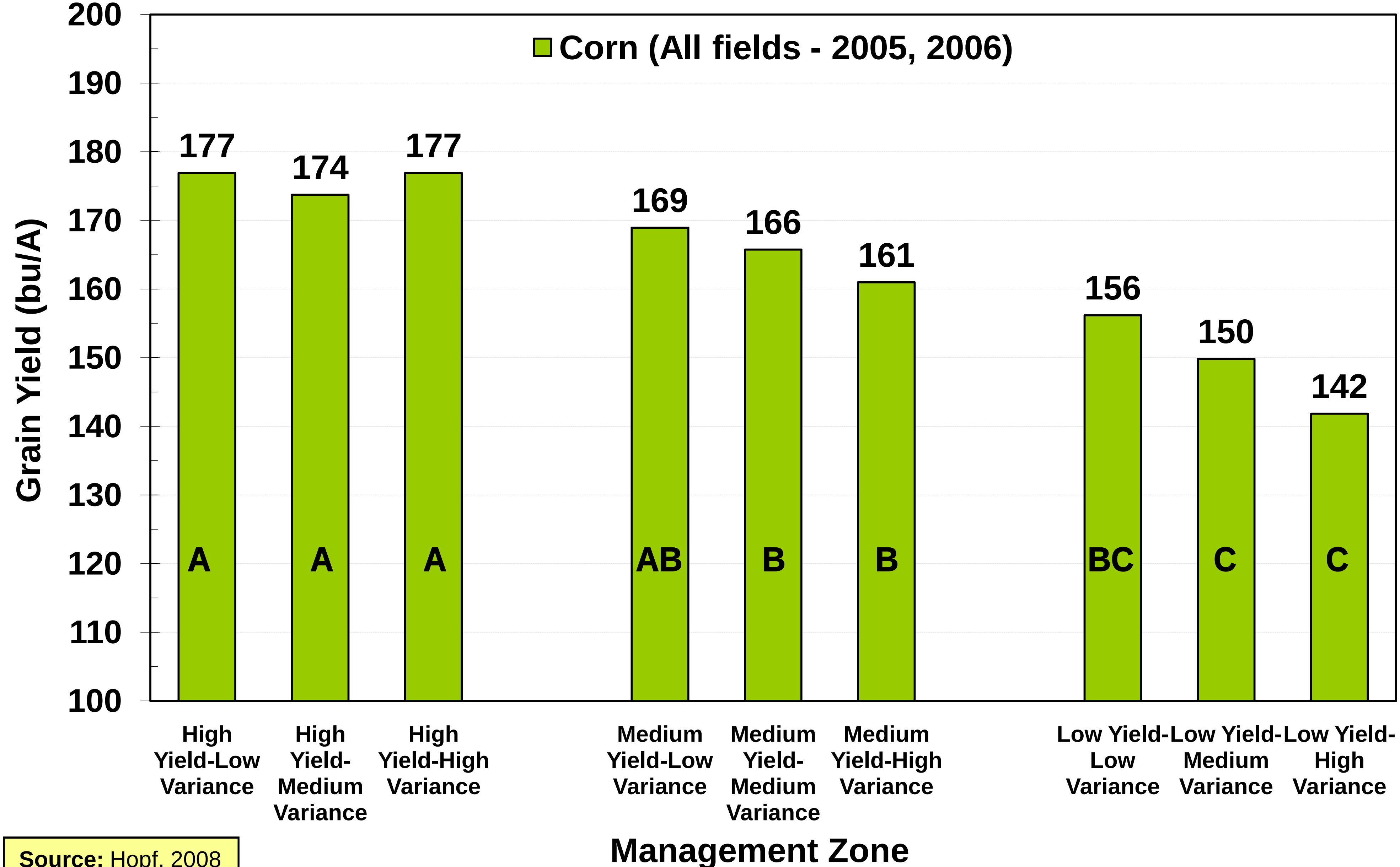
Source: Hopf, 2008

Did variable rate fertilizer application have any effect on yield?



Source: Hopf, 2008

Did variable rate fertilizer application have any effect on yield within a management zone?



Source: Hopf, 2008

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Conclusions

- **Annual weather conditions affected classification of cells into cohorts.**
- **The range between the highest and lowest yielding MZ within a field averaged 26 bu/A across all fields.**
- **Predicting grain yield of MZs across all fields during the year of variable rate fertilizer application was successful.**
  - ✓ Corn grain yield of MZs based on corn grain yield produced 174, 166, and 150 bu/A in the high, medium and low yield classes.
- **Averaged across all fields, variable starter fertilizer treatment did not impact corn grain yield**

What crop management decisions can be managed in responsive environments?

<u>Maybe</u>

- **Hybrid**
- **Plant density**
- **Fertilizer: N, P, K, micro, starter, lime**
- **Pesticide**
  - ✓Fungicide
  - ✓Herbicide

Summary

- **Grain yield increases are occurring faster in Corn Belt counties outside of Wisconsin.**
- **The most expensive corn crop ever planted occurred in 2008. The most risky corn crop ever planted will be in 2009.**
- **Optimum plant populations for grain yield are higher than currently recommended levels.**
- **Predicting grain yield of MZs across all fields during the year of variable rate fertilizer application was successful.**
  - ✓Averaged across all fields, variable fertilizer treatment did not impact corn grain yield

Thanks for your attention!
Questions?

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