FIFTY YEARS OF CONTINUOUS CORN: EFFECTS ON SOIL FERTILITY

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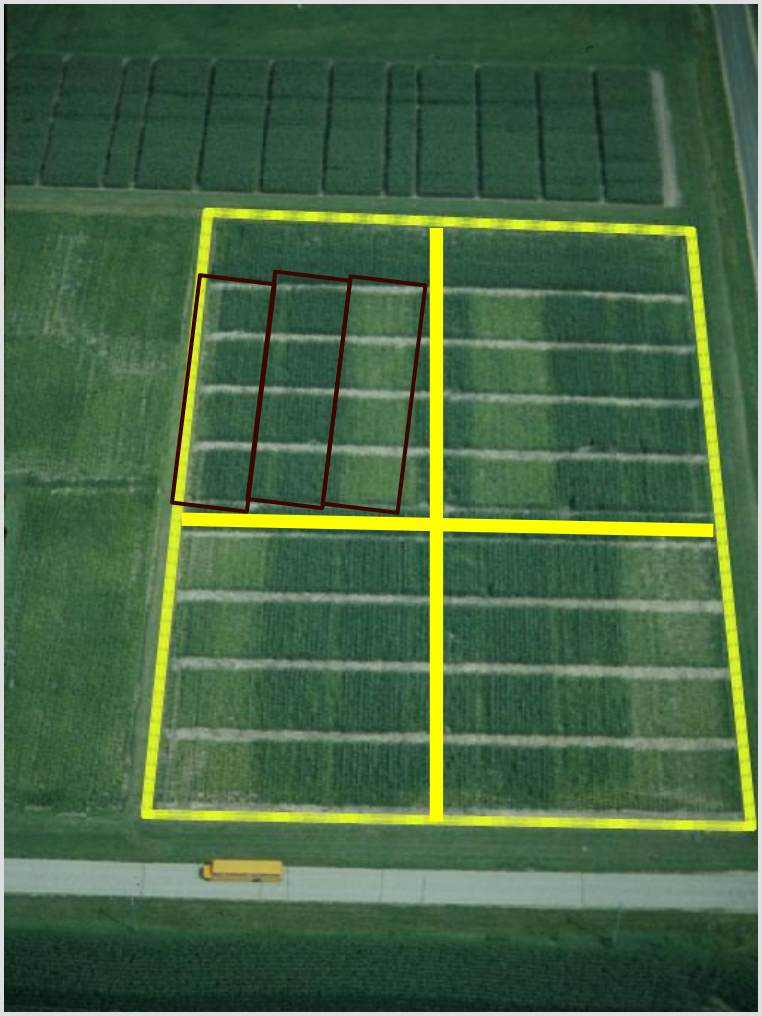
OUTLINE

- History of the Arlington Long-term Nitrogen Rate Trial
  - 50+ years of continuous corn
- What we've learned about:
  - Yields
  - Soil organic matter
  - Soil nitrogen
  - pH

WHAT IS THE ARLINGTON TRIAL?

- ~1933 farmed with "a minimum of good management"
- Established in 1958
- Art Peterson
- Three N rates
- None, medium, high
- Moldboard plow
- Continuous corn



HISTORIC CHANGES IN EXPERIMENTAL DESIGN

Early years (1958-1963)

- 0, 50, 100 lb ac^{-1} (ammonium nitrate)

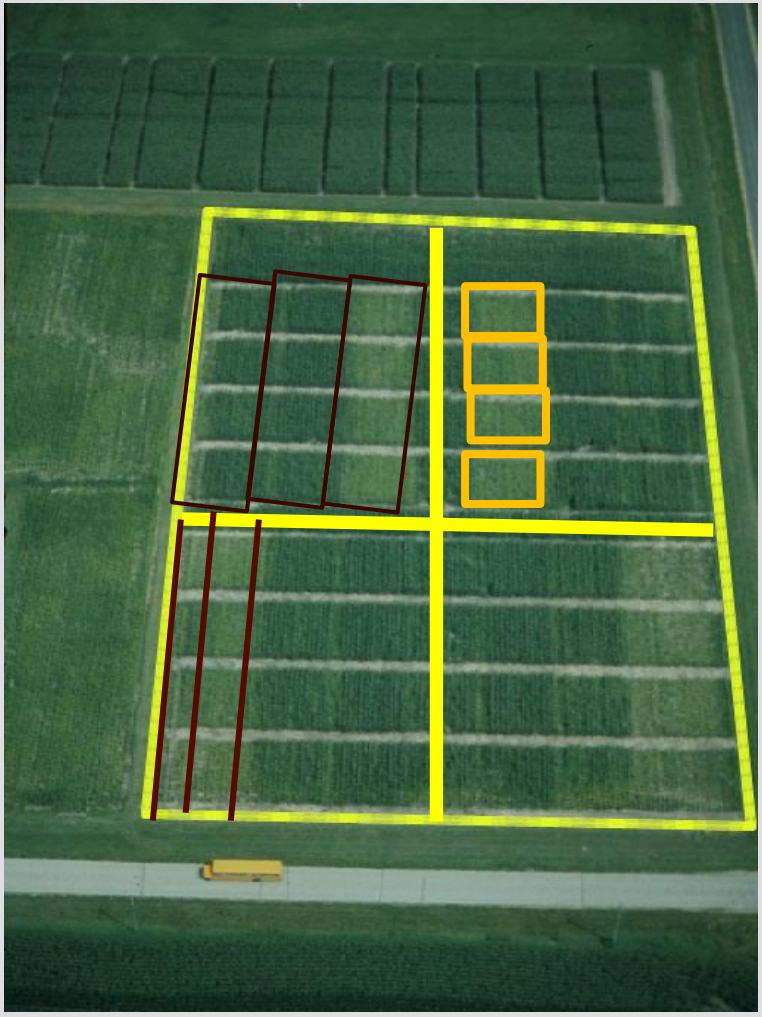
Improvement years (1963-1983)

- 0, 80-125, 160-250 lb ac^{-1} (anhydrous ammonia)

WHAT IS THE ARLINGTON TRIAL?

Experimental years (1984-1992)

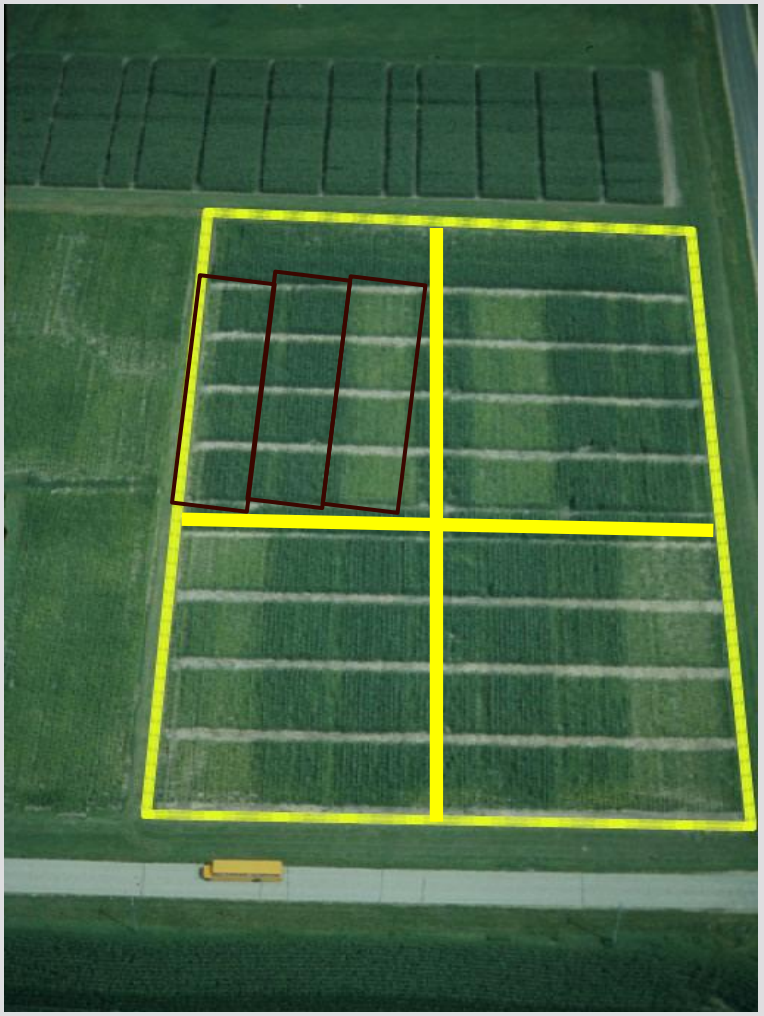
- Each historic N rate plot (none, medium, high) were split into four split plots
  - 0, 75, 150, and 225 lb ac^{-1} (urea)
- And two split plots
  - No lime or lime (applied in 1984 and 1988)



LONG-TERM CONTINUOUS CORN CROPPING SYSTEM

Modern years (1993-present)

- 0, 125, and 250 lb ac^{-1} of N



THE DATA

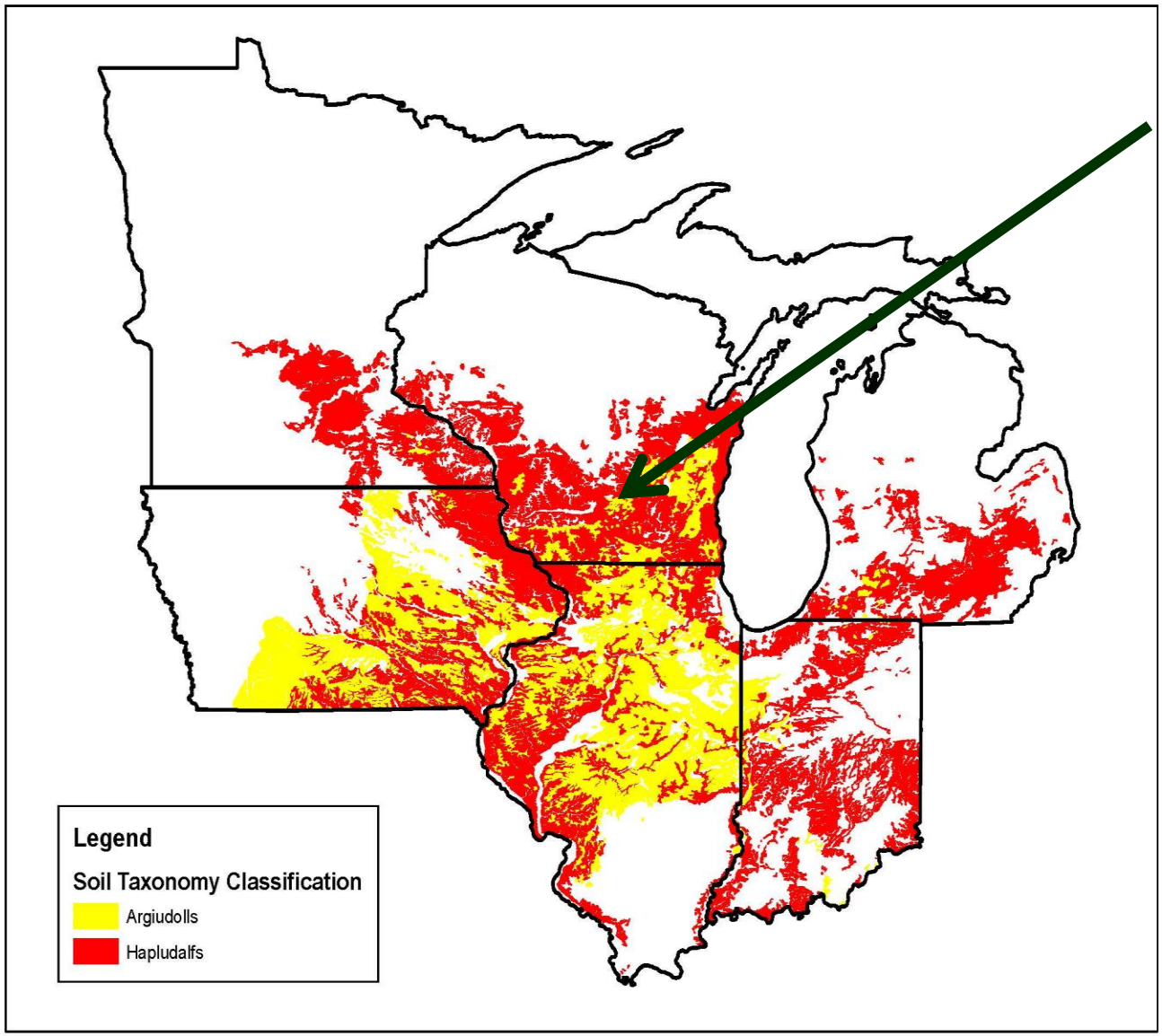
- Yield (since 1958)
- Routine soil analysis (0 to 8 in), which includes pH and OM (once every 5 to10 years)
- SOC and SON (0 to 8 in, 1984)
- Deep soil cores (3 ft) were collected in 2011 and analyzed for SOC and TN with depth

Table 2. Corn hybrid, genetically modified (GM) trait description, and soil insecticide applied at planting, 1986 to 2007.

Year	Company	Hybrid	GM traits†	Soil insecticide‡
1986	Pioneer	3475		
1987	Pioneer	3737		Counter 15G
1988	Kaltenberg	6400		Lorsban 15G
1989	Kaltenberg	6400		Counter 15G
1990	Kaltenberg	6400		Counter 15G
1991	Golden Harvest	2532		Lorsban 15G
1992	Pioneer	3417		Counter 15G
1993	Pioneer	3578		Counter 15G
1994	Pioneer	3578		Force 1.5G
1995	Pioneer	3578		Force 1.5G
1996	Northrup King	5220		Force 3G
1997	Golden Harvest	2441		Force 1.5G
1998	Pioneer	3563		Force 3G
1999	Pioneer	35N05	CB	Force 3G
2000	Pioneer	35R57	RR	Force 3G
2001	Pioneer	35R57	RR	Force 3G
2002	DeKalb	5551	RR	Force 3G
2003	DeKalb	DKC53–34	RR, CB	Force 3G
2004	DeKalb	DKC53–34	RR, CB	Force 3G
2005	Dairyland	Stealth-1105	RR	Force 3G
2006	Kaltenberg	5244	RR2, CB	Force 3G
2007	DeKalb	DKC51–39	RR2, CB, CR	Force 3G

† CB, corn borer resistant gene; CR, corn rootworm resistant gene; RR, Roundup Ready; RR2, Roundup Ready 2.

LOCATION: NORTHERN PRAIRIE SOIL



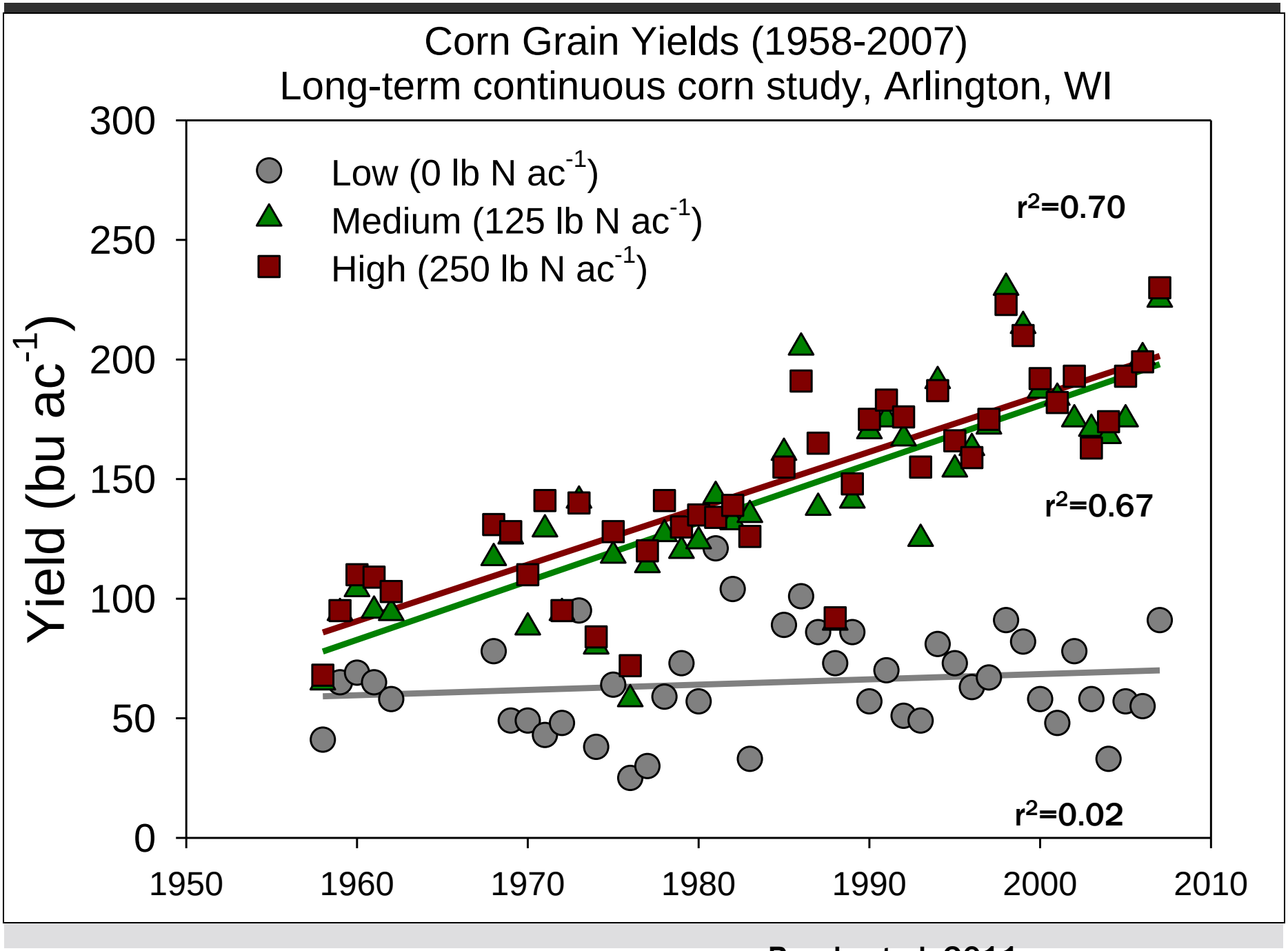
35 in A horizon

0-2% Slope

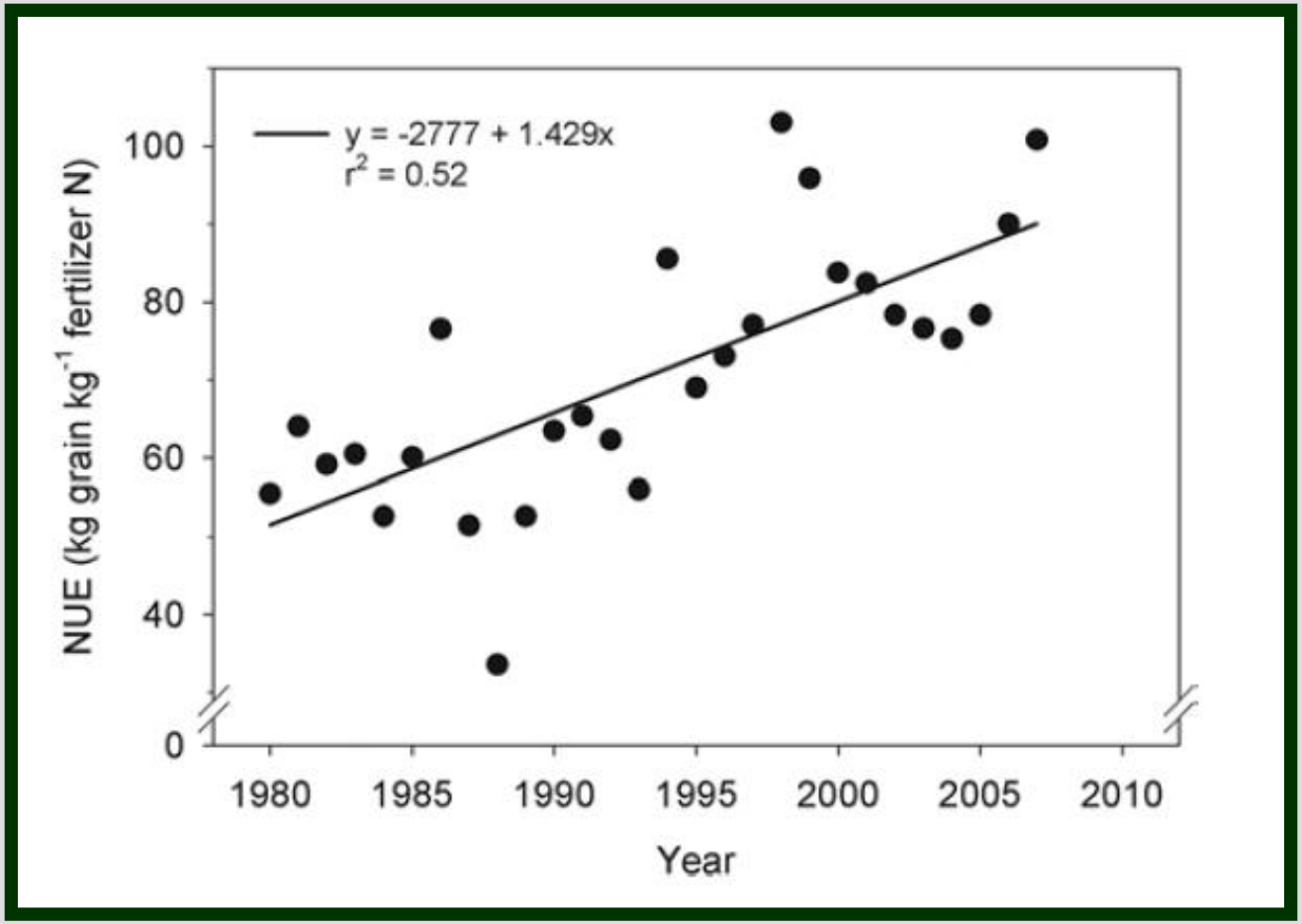
Internally drained landscape, no natural drainage ways, ponded conditions are common

Not tile-drained

Yield



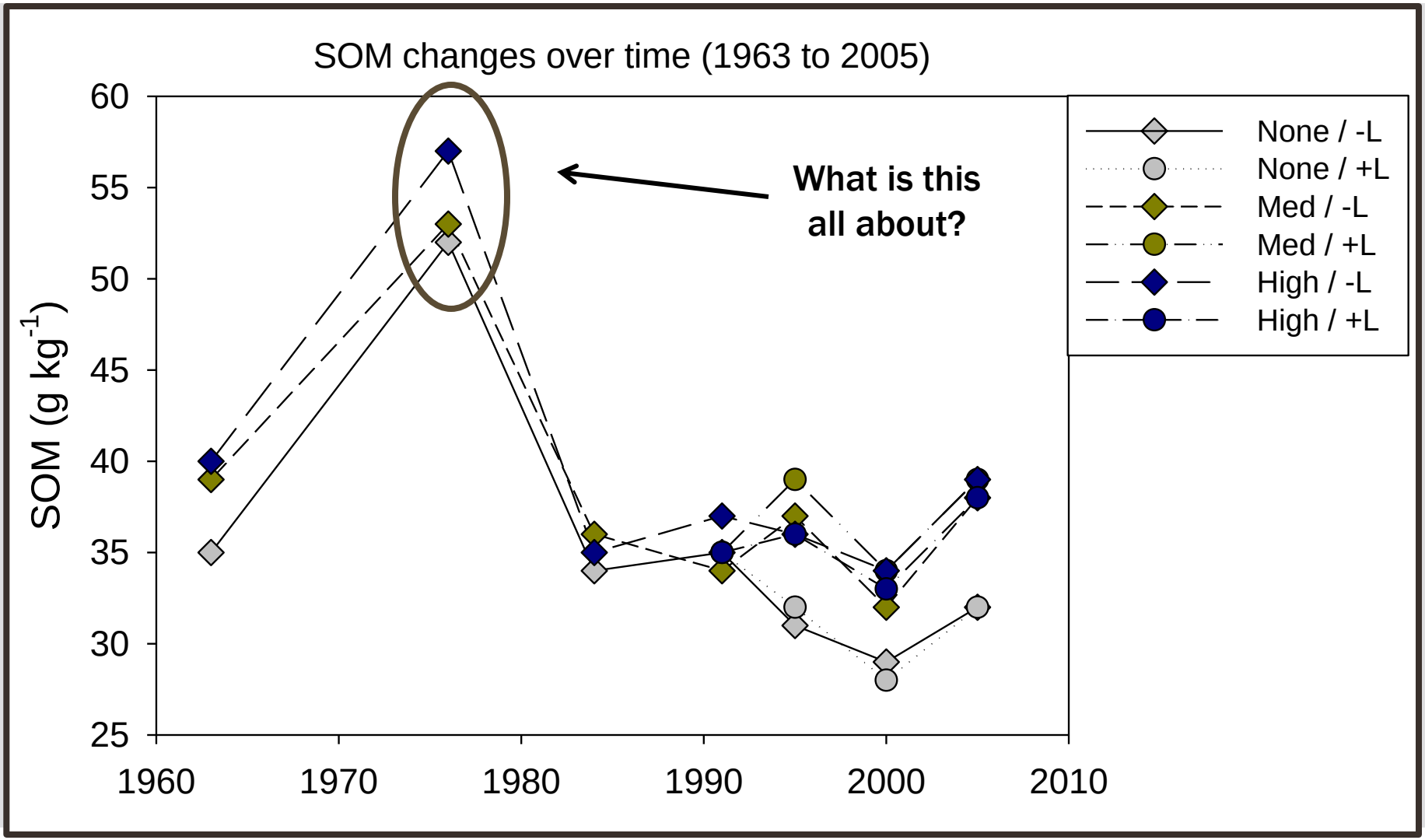
Bundy et al. 2011



Nitrogen use efficiency has increased over time…with the same nitrogen management practice.

Soil organic matter & soil organic carbon

LONG-TERM CONTINUOUS CORN CROPPING SYSTEM



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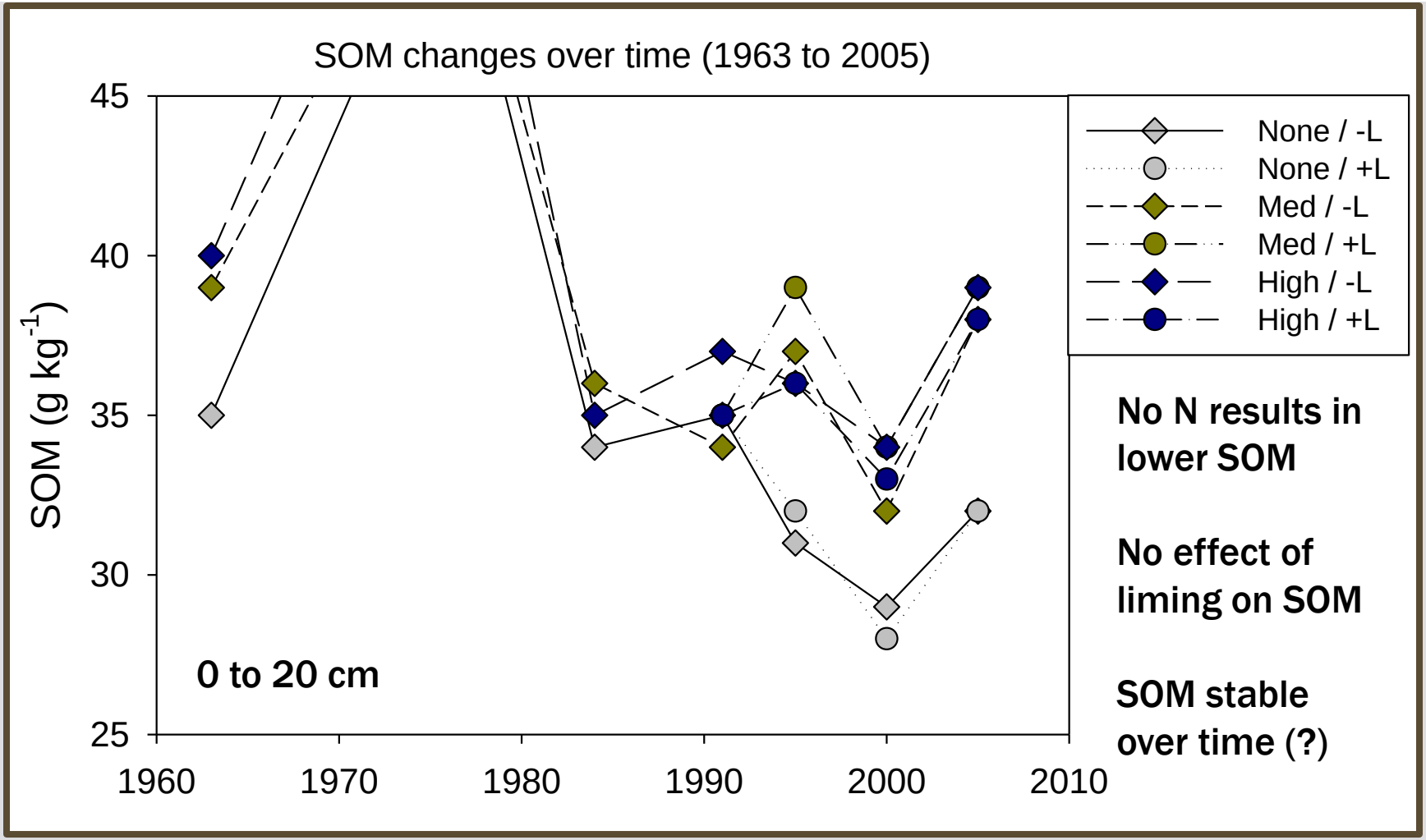


SOIL ORGANIC CARBON (0-20 CM) (g kg^{-1})

Pre-cultivation†: 25.0 g kg^{-1}

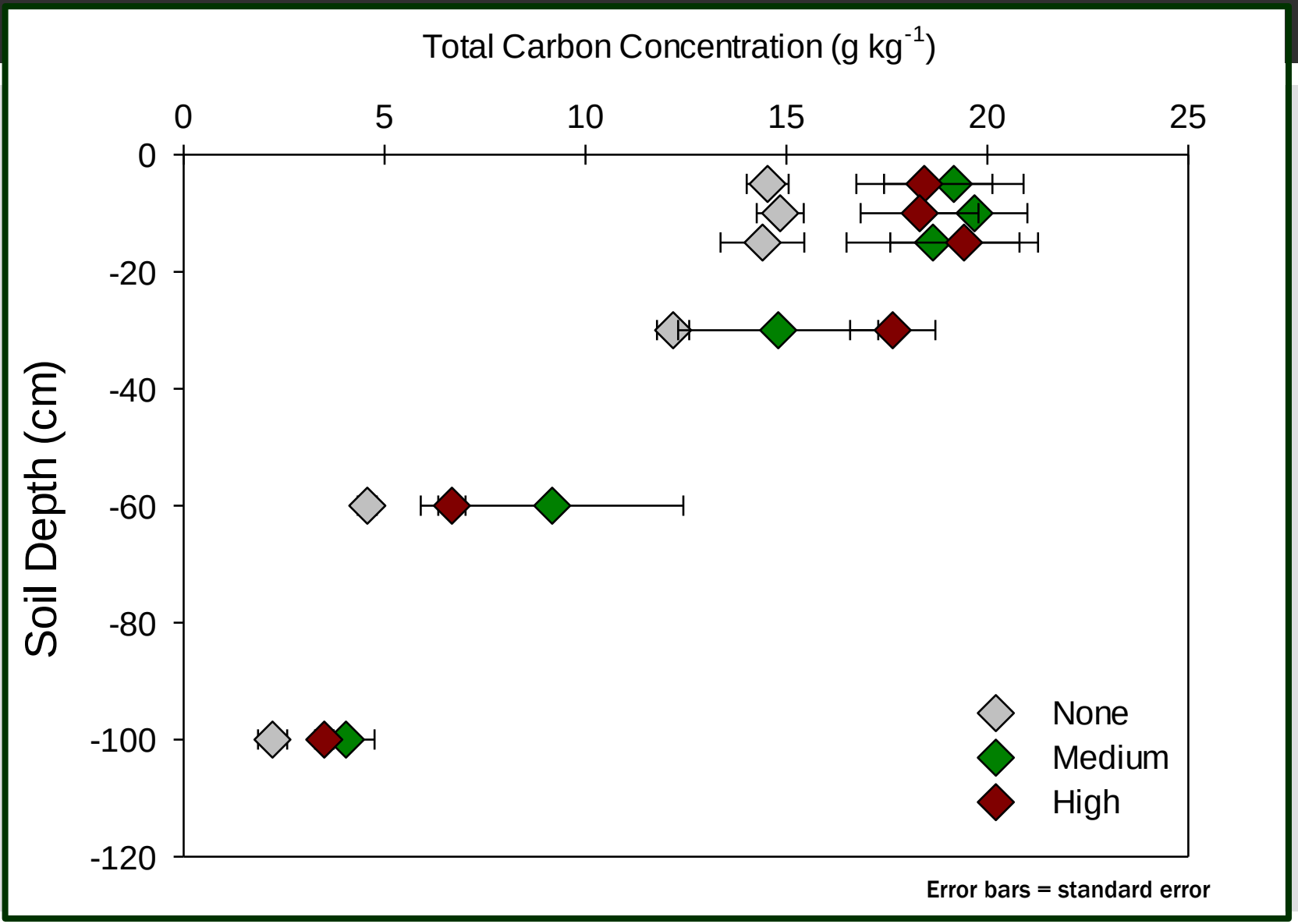
1958 (field): 18.8 g kg^{-1}

1984

- Low: 19.6 g kg^{-1}
- Medium: 22.0 g kg^{-1}
- High: 22.2 g kg^{-1}

† Collected from uncultivated prairie (Vandotti et al., 1997)

TOTAL CARBON WITH DEPTH



Soil organic nitrogen & total soil nitrogen

NITROGEN DYNAMICS 1954-1983

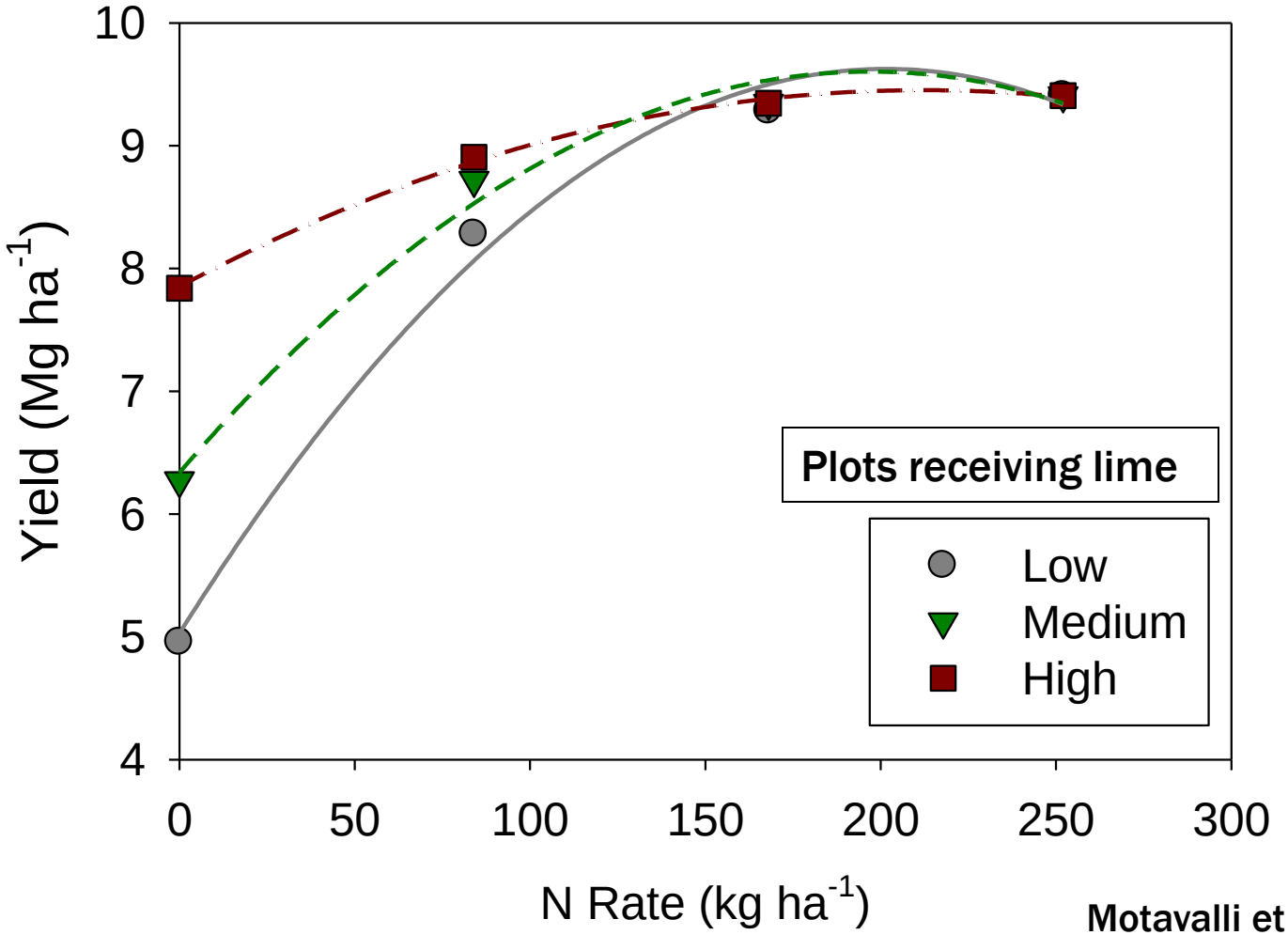
	Net N	SON	C/N
	kg ha^{-1} yr^{-1}	g kg^{-1}	
Low	-28	1.56 b	12.6
Med.	40	1.74 a	12.7
High	140	1.81 a	12.3

Net N = Applied N – N removed with grain

(0-20 cm) (Vanotti et al., 1997)

LONG-TERM CONTINUOUS CORN CROPPING SYSTEM

Effects of long-term N fertilization on grain yield response to new N fertilizer rates
(Average yield from 1984 to 1990)



Motavalli et al., 1992

Historic N rate did not effect optimum N rate

Historic over-application of N increased yields with no N inputs

Not a carry-over effect

Historic over-application changed something

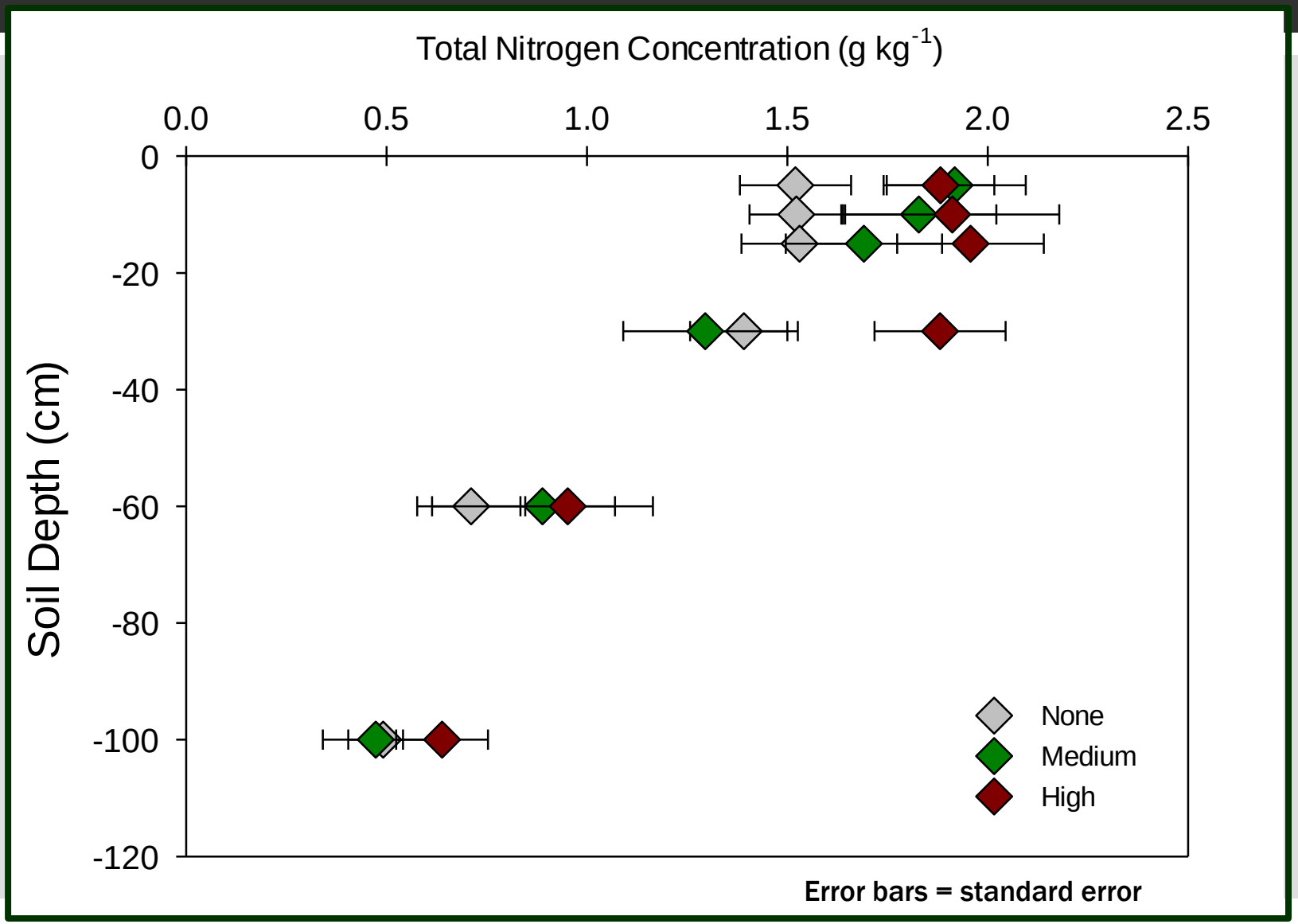
SOIL ORGANIC NITROGEN

Soil organic N concentrations (%) in 0-8 in 1984 and 1990. The 1990 results are after no N inputs and with or w/out lime

N rate	1984	1990 with lime	1990 w/out lime
None	1.56		
Medium	1.74	1.53	1.63
High	1.81	1.66	1.71

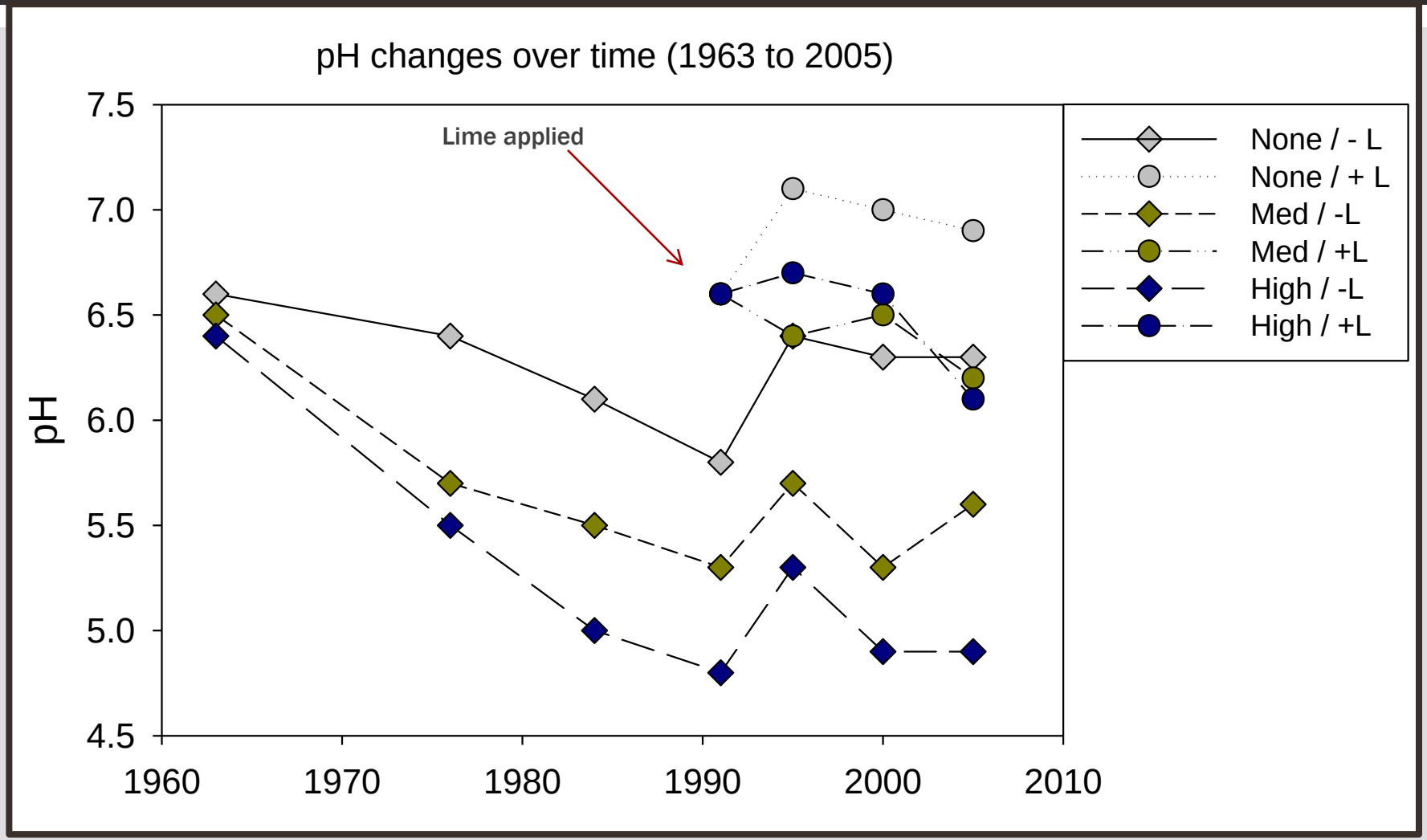
- Application of lime decreased soil organic N – made more N available for crop
- No application of N also resulted in decrease in SON
- No fertilizer reduces SON – corn steals the N
- Lime reduces SON – increases mineralization

TOTAL N WITH DEPTH



pH

LONG-TERM CONTINUOUS CORN CROPPING SYSTEM



Over-application of N does not only doesn't get you greater yields, it costs you more in lime!

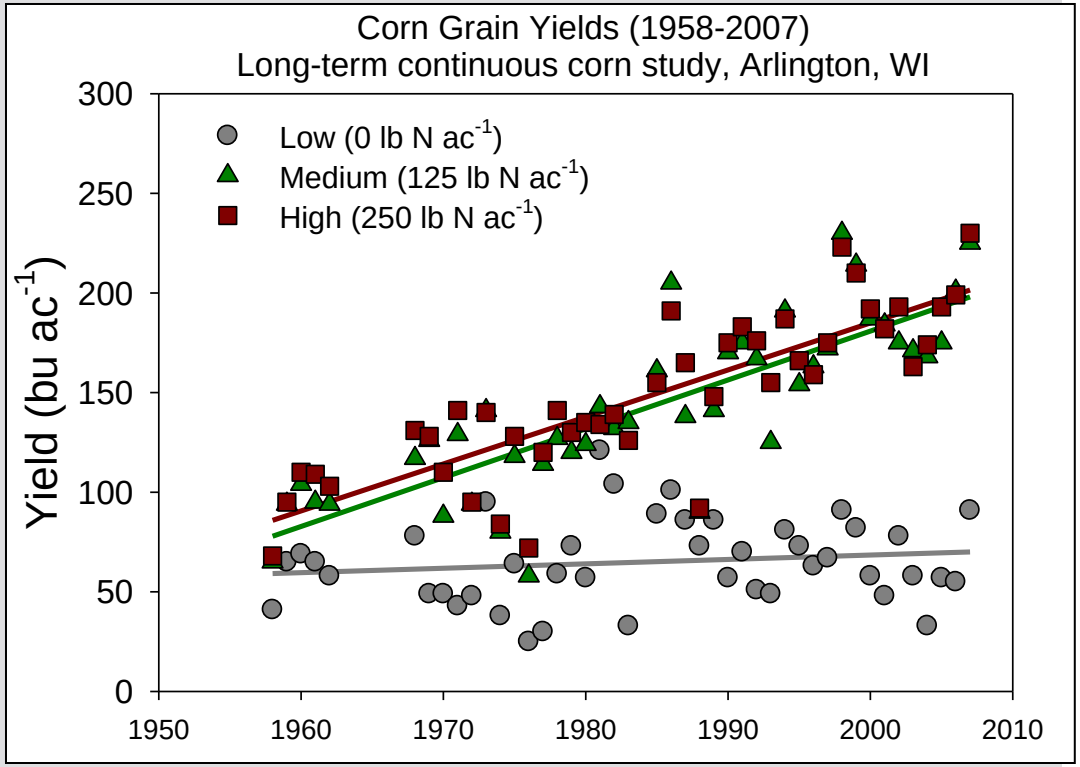
Review

BENEFITS AND CONSEQUENCES

- Application of N: In conjunction with utilization of improved corn hybrids and pest management practices, application of N led to a steady yield increase over time.
- Over-application of N: reduces NUE, but did not reduce SOC compared to optimum N rate, also increased TN

QUESTION:

- Is maintenance of SOC dependent on the steady increase in stover returned over time?
- What will happen if yields plateau?



SUSTAINABLE SYSTEM?

- Application of N: Yes
- Application of lime: YES
- Continuous corn: ?
  - Yes, at least in terms of fertility and on this soil type.
  - Other factors that can compromise the sustainability of continuous corn.
- Moldboard plow: In this 2 acre parcel