Fertility Trends in 20 Years of Nutrient Drawdown Practices

at the Wisconsin Integrated Cropping Systems Trial

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Wisconsin Integrated Cropping Systems Trial (WICST)

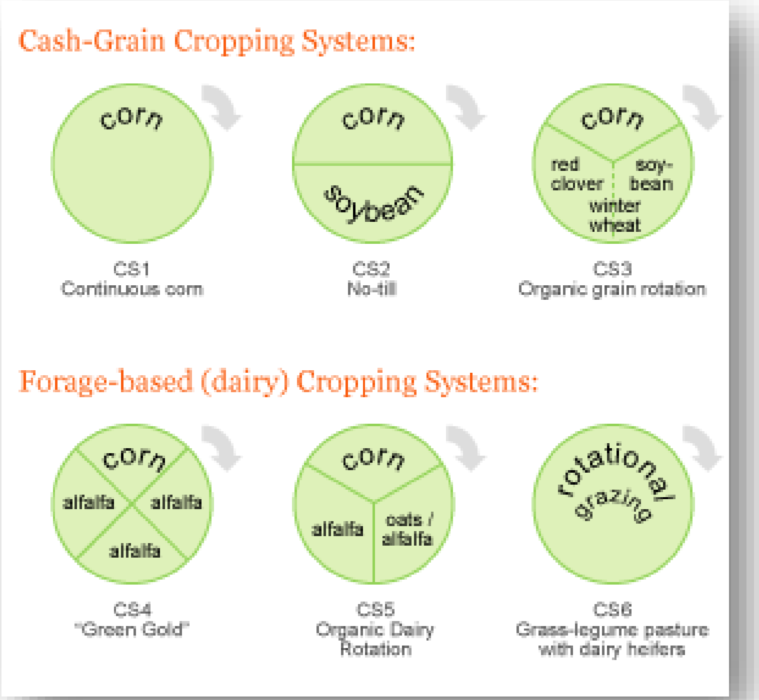
- Long Term Soil Experiment (LTSE)
- Established in two locations in 1989
  - Lakeland Agricultural Complex, southeast WI, used until 2002
  - Arlington Research Station, south-central WI, still active – Our focus
- Compares alternative production strategies that are common in Wisconsin
- Performance criteria
  - Productivity
  - Profitability
  - Environmental impact

Rock River Laboratory has been providing all analytical services for WICST since 2010

Posner, 13th Technical report

Six cropping systems

Defined as a combination of a crop rotation and management philosophy



Visual depiction of the cropping systems installed at WICST, recreated from WICST 13th annual report

Philosophies relate to level of external fertilizers, pesticides, tillage practices, and type of enterprise.

Systems range from a high-input, intensively tilled monoculture grain operation to zero input organic grazing

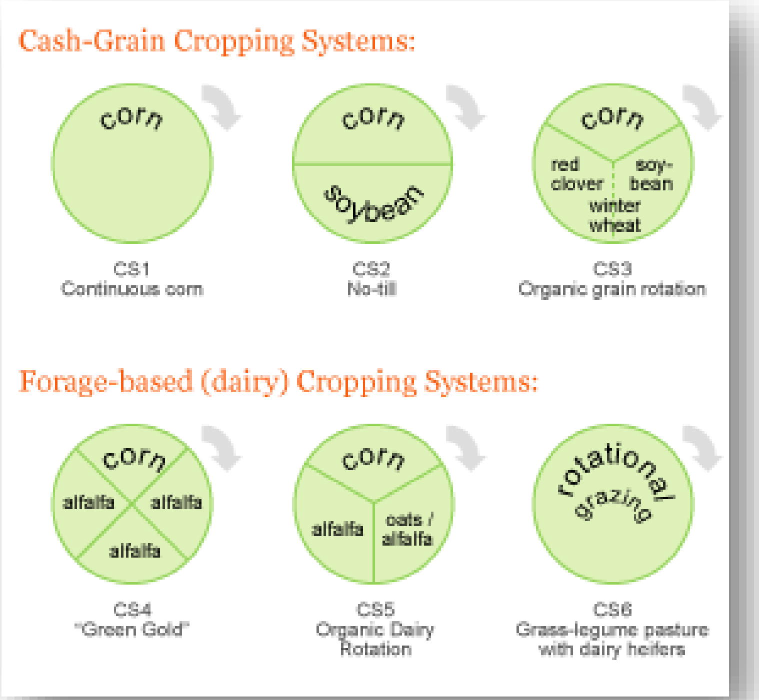
Divided into grain and forage enterprises

Rotational grazing data were not included due to the complex nature of the system

Posner, 2008

Six cropping systems

Acronyms, acronyms, acronyms, acronyms (AAAA)



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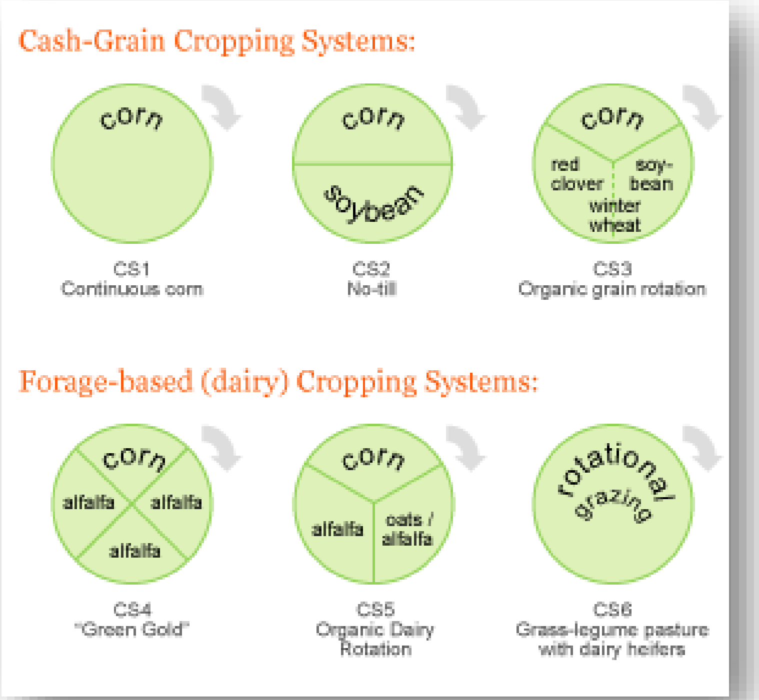


Visual depiction of the cropping systems installed at WICST, recreated from WICST 13th annual report

Cropping system = CS

CS1 = Continuous corn = CC

CS2 = Corn/Soybean = CB

CS3 = Corn/Soybean/Wheat = CBW

CS4 = Corn/Alfalfa/Alfalfa/Alfalfa = CAAA

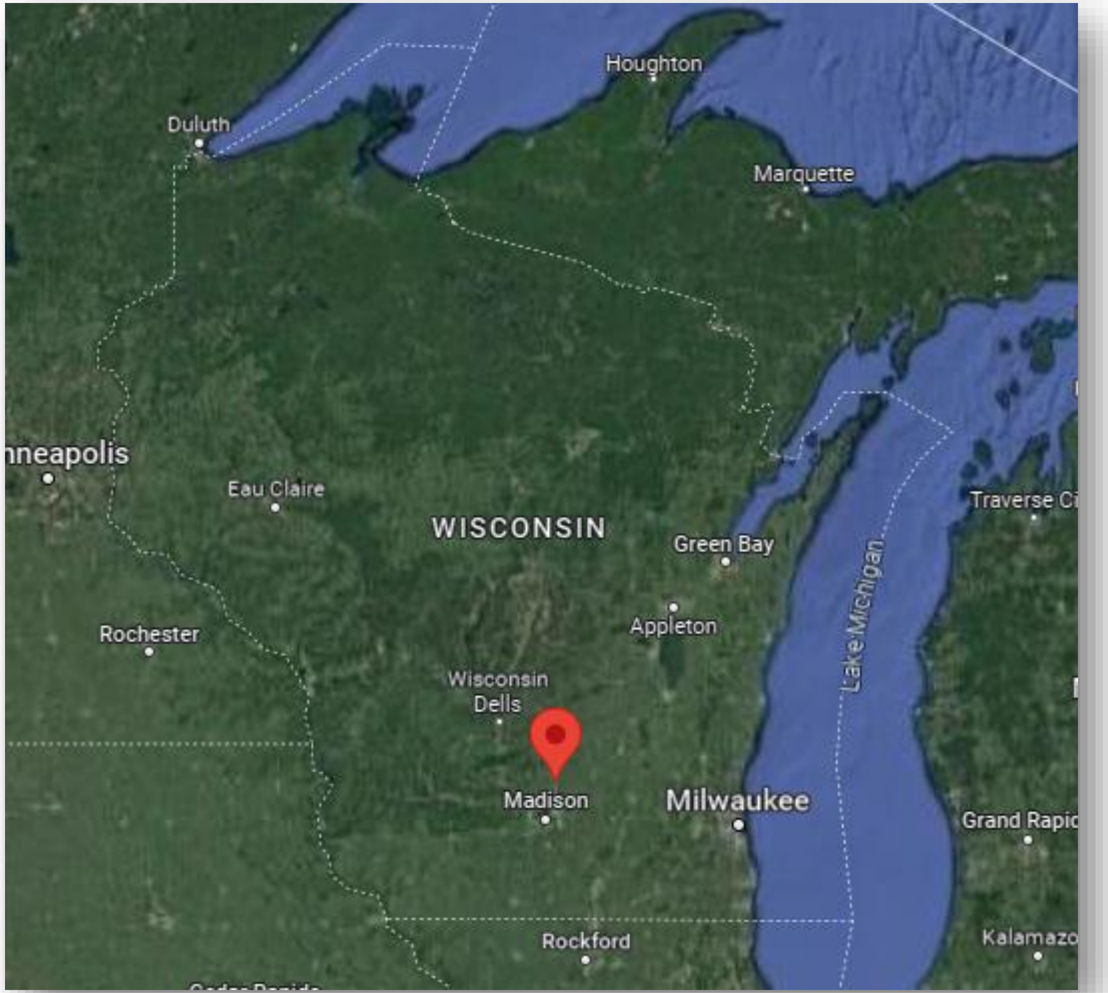
CS5 = Corn/Oats&Alfalfa/Alfalfa/Alfalfa = CoAA

CS6 = Rotational pasture = PAST

Posner, 2008

Site specifics – Arlington Research Station

- Located ~20 miles north of Madison
- Plano silt loam
  - Well drained
  - Fine-silty, mixed, mesic, Typic Argiudolls
- 24ha total size



Posner, 2008

Experimental design

- ~0.75ac plots allow farm-scale equipment to be used
- 4-block randomized complete block design
- One replication of each rotation phase in each block (spatial replication)
- Staggered start of rotations (temporal replication)

Aerial image of Arlington location

Posner, 2008

Replication visualized

Phase	Plot ID	System	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	109	CS1	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
1	204	CS1	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
1	306	CS1	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
1	412	CS1	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
1	101	CS2	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB
1	214	CS2	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB
1	303	CS2	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB
1	401	CS2	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB
2	108	CS2		SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C
2	206	CS2		SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C
2	310	CS2		SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C
2	408	CS2		SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C	SB	C
1	106	CS3	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C
1	202	CS3	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C
1	307	CS3	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C
1	411	CS3	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C
2	102	CS3		SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG
2	212	CS3		SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG
2	313	CS3		SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG
2	407	CS3		SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG
3	104	CS3			SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB
3	201	CS3			SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB
3	301	CS3			SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB
3	402	CS3			SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB	WG	C	SB
1	111	CS4	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA
1	209	CS4	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA
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1	409	CS4	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA
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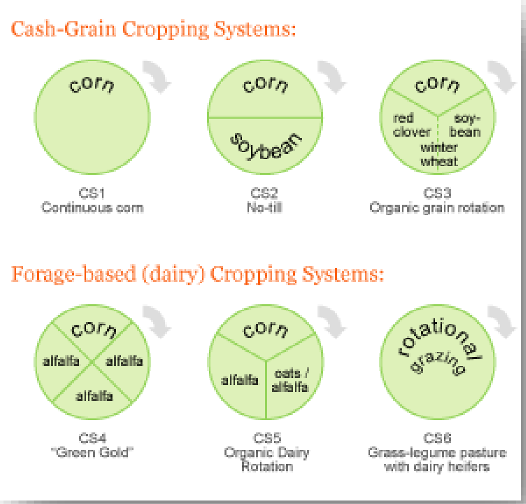
3	105	CS4			DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2
3	203	CS4			DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2
3	308	CS4			DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2
3	406	CS4			DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2
4	107	CS4				DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1
4	205	CS4				DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1
4	309	CS4				DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1
4	404	CS4				DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1	A2	C	DSA	A1
1	110	CS5	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C
1	208	CS5	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C
1	304	CS5	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C
1	413	CS5	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C
2	103	CS5		O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1
2	213	CS5		O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1
2	314	CS5		O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1
2	410	CS5		O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1
3	114	CS5			O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O
3	211	CS5			O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O
3	312	CS5			O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O
3	403	CS5			O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O	A1	C	O



Visual depiction of the cropping systems installed at WICST, recreated from WICST 13th annual report

Cropping System	Number of phases	Number of plots
CC	1	4
CS	2	8
CSW	3	12
CAAA	4	16
CoAA	3	12
Past	1	4

Fertilization strategy

- Soils were managed in a nutrient deficit per WI recs – intentional nutrient drawdown
- Manufactured P and K were added as starter in the corn phase of conventional systems and fall-applied as directed by soil tests when needed
- Manure applied in forage rotations during corn and alfalfa seeding years

Cropping system	Average soil test phosphorus (Bray 1)		Average soil test potassium (Bray 1)	
	mg kg^{-1}	Corn grain Interpretation	mg kg^{-1}	Corn grain Interpretation
CC	105	Ex high	257	Ex high
CS	93	Ex high	241	Ex high
CSW	87	Ex high	218	Ex high
CAAA	104	Ex high	267	Ex high
CoAA	61	Ex high	187	Ex High

Average initial soil test levels

Fertility study objectives

- Calculate long-term phosphorus and potassium nutrient balances (ΔNB)
  - Are systems being operated in nutrient deficit?
  - Quantify rate of nutrient removal (kg ha^{-1} yr^{-1}), is it different from zero?

- Regress soil test data against time (ΔST)
  - Are systems being operated in a nutrient deficit?
  - Quantify rate of soil test value change (kg ha^{-1} yr^{-1}), is it different from zero?

- Evaluate any potential correlations between nutrient balance and soil test
  - Does soil testing accurately depict the nutrient balance?
  - Does the cropping system impact the relationship?
  - How can we use this information to guide future decisions?

Hypothesis: ΔST will be well correlated to ΔNB in a relationship near 1:1

Data collection – nutrient budget

- Detailed nutrient budget records kept

  - Nutrient inputs (purchased fertilizer and manure)
    - Recorded as pounds of elemental input per acre (converted to kg/ha)
    - Manure analysis used when possible
      - Not discounted for first year availability

  - Yield data and nutrient removals recorded
    - Portions of harvested material analyzed for moisture, protein, P, and K
      - Analysis conducted at UW Soil and Forage Analysis Laboratory, Marshfield WI
    - Dry matter, P and K analyses combined with yield data to calculated P and K removal per acre as lbs/ac (converted to kg/ha)

Data collection – soil testing

- Soil fertility samples collected every year post harvest
  - 6 cores per sample, pulled to 15 cm depth, 3 samples per plot
  - Sampled more intensively than commercial recommendations
    - Spatially 20x
    - Temporally 4x
  - Samples analyzed at UW Soil and Plant Analysis Lab, Verona
    - Bray-1 (1:10) P & K, 1:1 Water pH, SMP Buffer, LOI organic matter

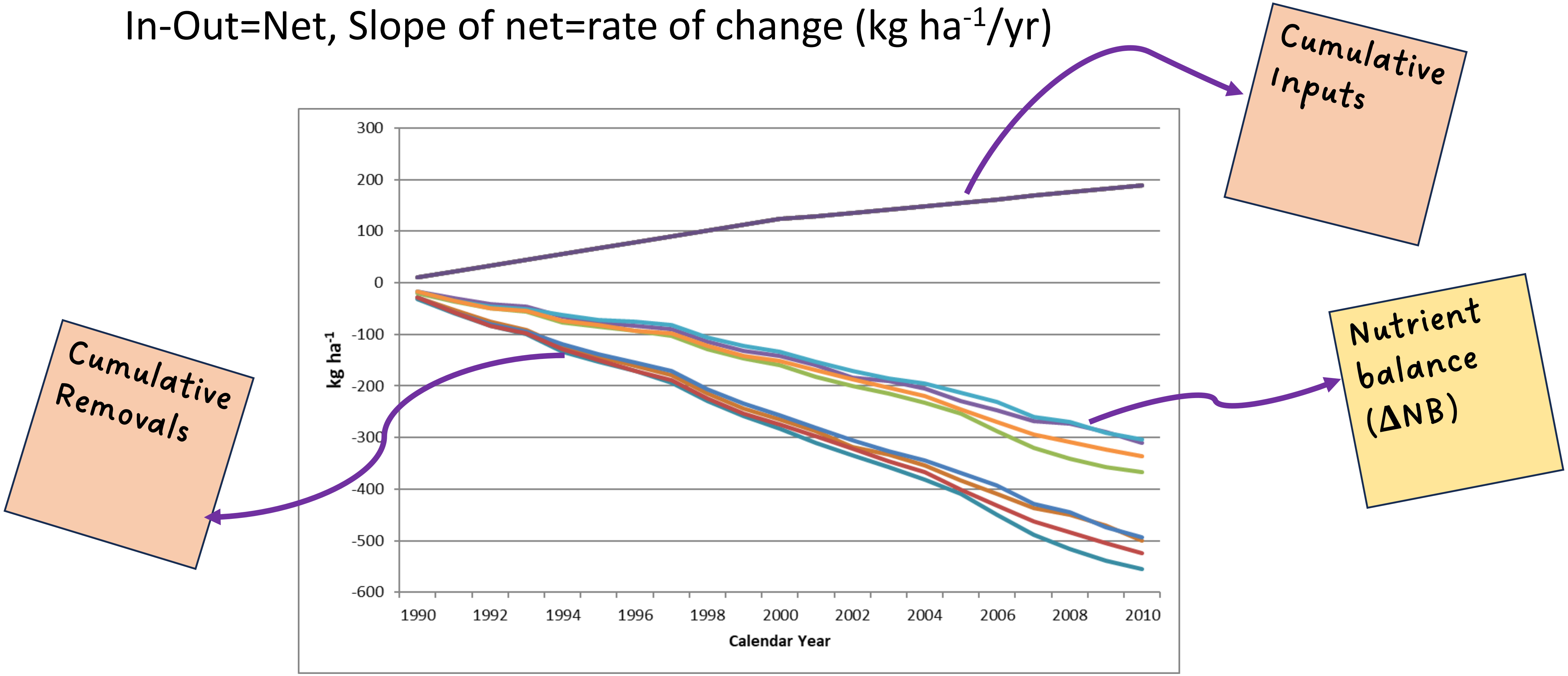
- Additional soil data collected intermittently
  - Nitrates
  - Deep fertility
    - 0-15 cm, 15-30 cm, 30-60 cm, 60-91 cm

Fertility Trends:
Nutrient Balance (ΔNB)

Wisconsin Integrated Cropping Systems Trial

Determining nutrient balance

In-Out=Net, Slope of net=rate of change (kg ha^{-1}/yr)



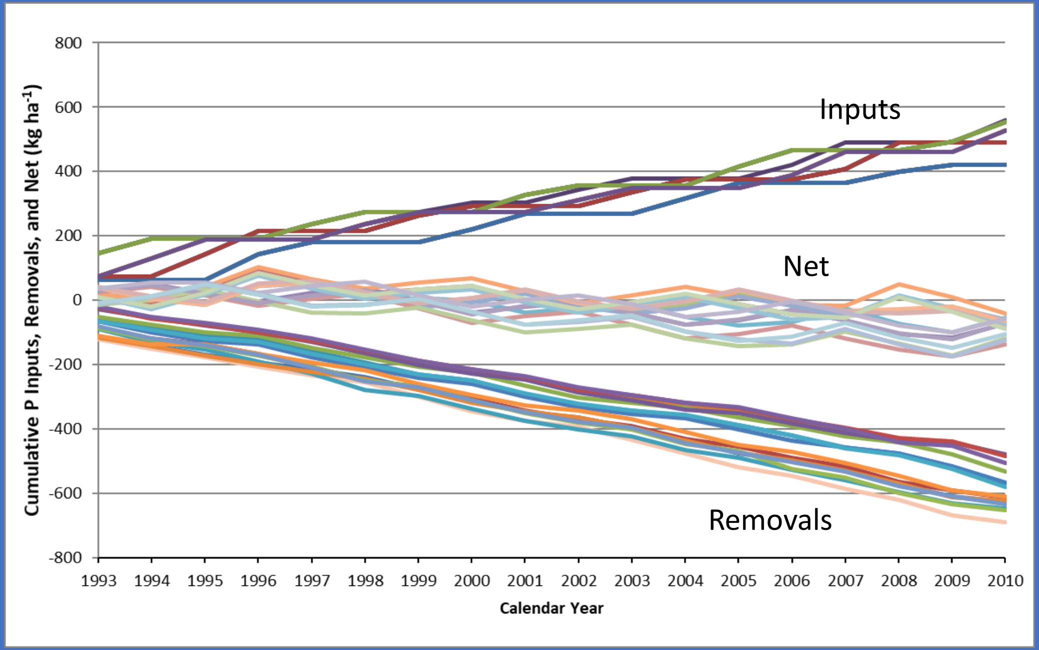
CC cumulative P inputs, removals, and net 1990-2010

Dealing with the staggered start

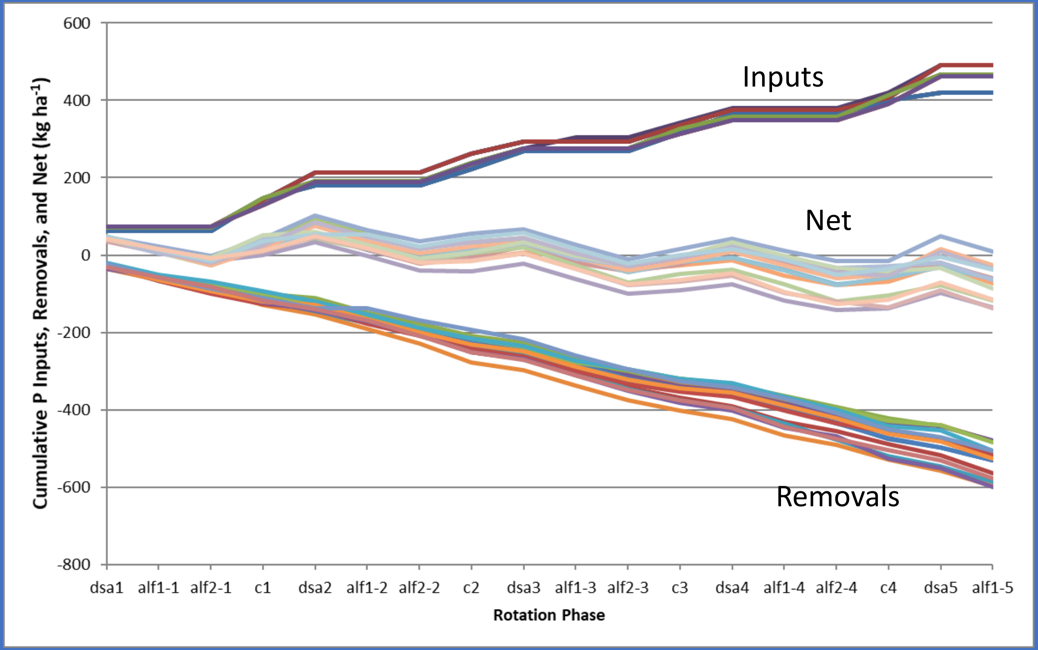
Plot ID	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
105			DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10
107				DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A4	C	DSA	A5	A4	C	DSA	A5
111	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	DSA
113		DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C
203			DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10
205				DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A4	C	DSA	A5	A4	C	DSA	A5
209	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	DSA
210		DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C
305	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	DSA
308			DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10
309				DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A4	C	DSA	A5	A4	C	DSA	A5
311		DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C
404				DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A4	C	DSA	A5	A4	C	DSA	A5
406			DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10
409	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	DSA
414		DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C

105	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10		
107	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A4	C	DSA	A5	A4	C	DSA	A5			
111	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	DSA
113	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	
203	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10		
205	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A4	C	DSA	A5	A4	C	DSA	A5			
209	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	DSA
210	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	
305	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	DSA
308	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10		
309	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A4	C	DSA	A5	A4	C	DSA	A5			
311	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	
404	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A4	C	DSA	A5	A4	C	DSA	A5			
406	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10		
409	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	DSA
414	DSA	A1	A2	C	DSA	A3	A4	C	DSA	A5	A6	C	DSA	A7	A8	C	DSA	A9	A10	C	

Phosphorus Balance Example

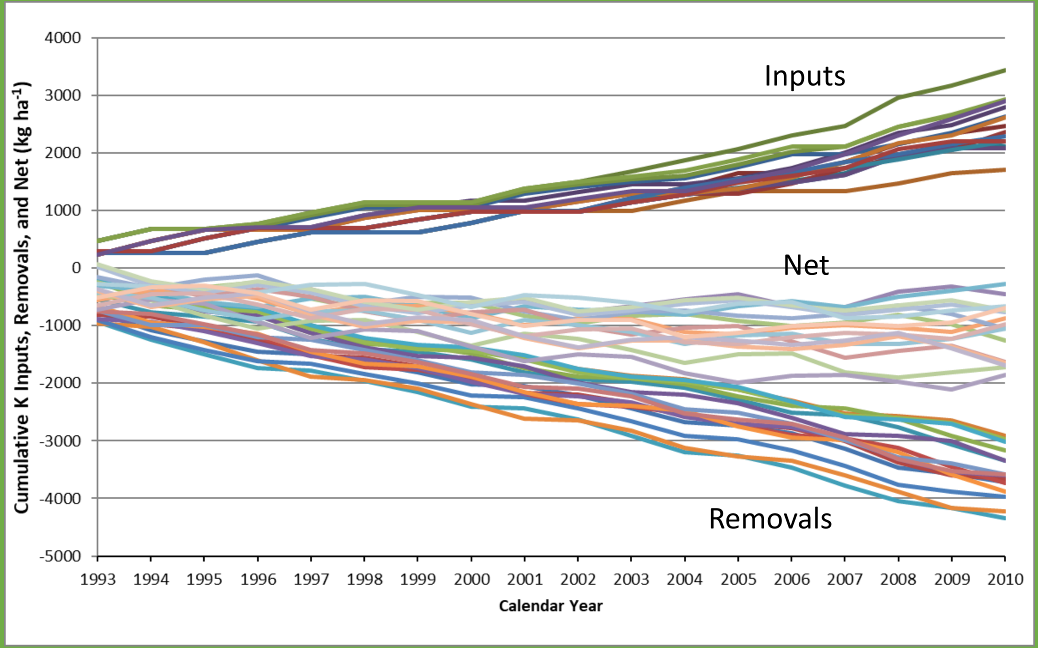


CAAA cumulative P inputs, removals, and net
by calendar year, 1993-2010

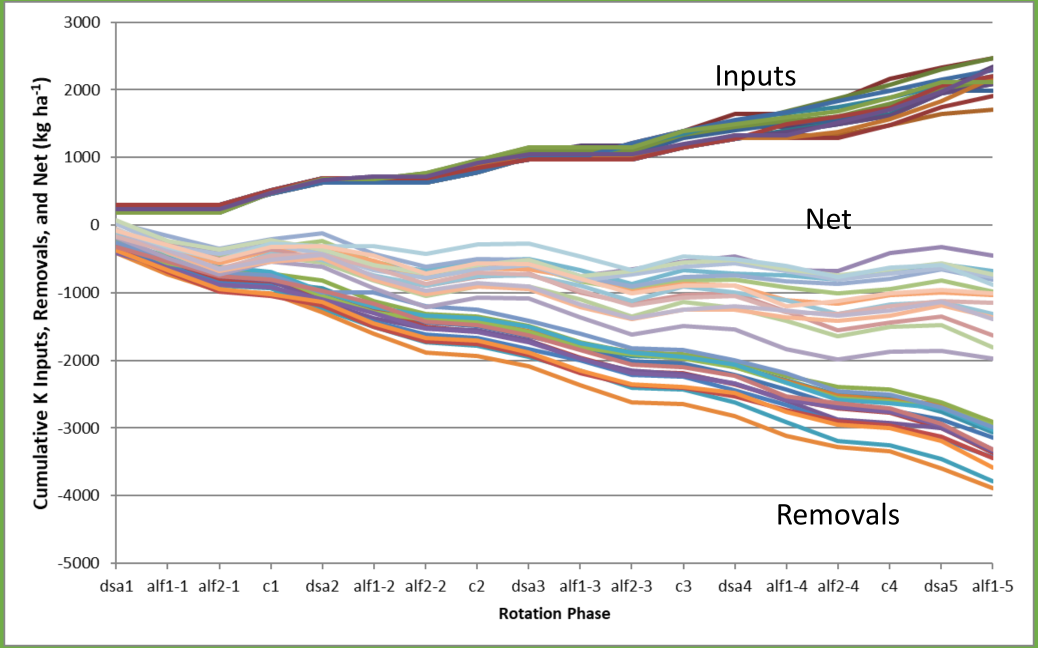


CAAA cumulative P inputs, removals, and net
by rotation phase, phases 1-18

Potassium Balance Example - CAAA



CAAA cumulative K inputs, removals, and net by calendar year, 1993-2010



CAAA cumulative K inputs, removals, and net by rotation phase, phases 1-18

Nutrient balance results

	Net P Balance (kg ha^{-1} yr^{-1})		Net K Balance (kg ha^{-1} yr^{-1})	
	CY	RP	CY	RP
CC	-16.8	-15.3	-8.1	-10.8
CS	-18.6	-18.2	-26.3	-32.7
CSW	-12.9	-15.1	-26.7	-32.6
CAAA	-6.7	-5.8	-46.2	-51.7
CoAA	-10.1	-9.8	-60.4	-75.8
Grain (1-3)	-15.4	-16.2	-23.5	-29.1
Forage (4-5)	-8.2	-7.5	-52.3	-61.9
All	-11.5	-11.7	-39.0	-46.5

CY: Calendar year

RP: Rotation phase

All slopes *p*-value <0.0001

Nutrient balance groupings – calendar year

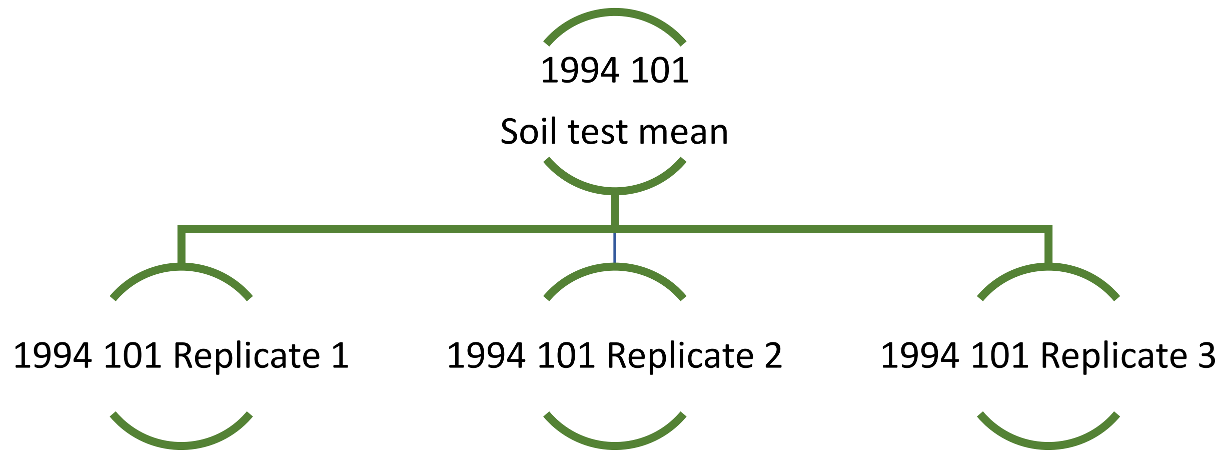
	Mean ΔNBP		Mean ΔNBK	
	($kg\ ha^{-1}\ yr^{-1}$)	Significance Group	($kg\ ha^{-1}\ yr^{-1}$)	Significance Group
CC	-16.8	D	-8.1	A
CS	-18.6	D	-26.3	AB
CSW	-12.9	C	-26.7	A
CAAA	-6.7	A	-46.2	BC
CoAA	-10.1	B	-60.4	C
Grain (1-3)	-15.4	E	-23.4	D
Forage (4-5)	-8.2	F	-52.3	E

Fertility trends: Soil testing (ΔST)

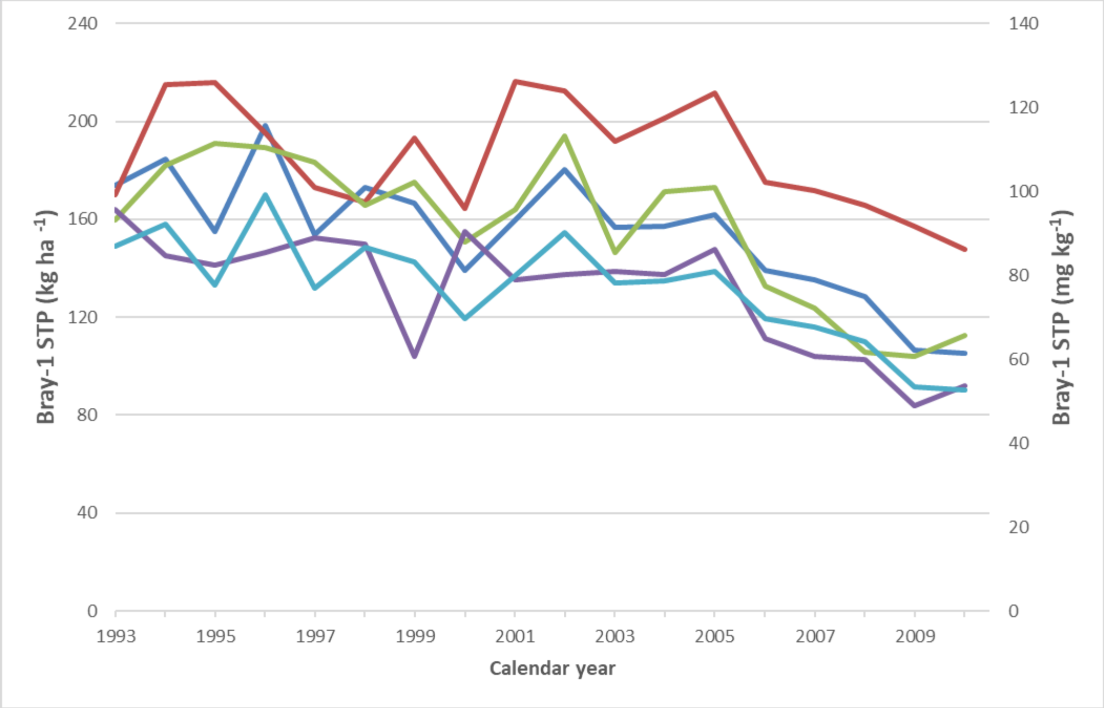
Wisconsin Integrated Cropping Systems Trial

Summarizing soil test data

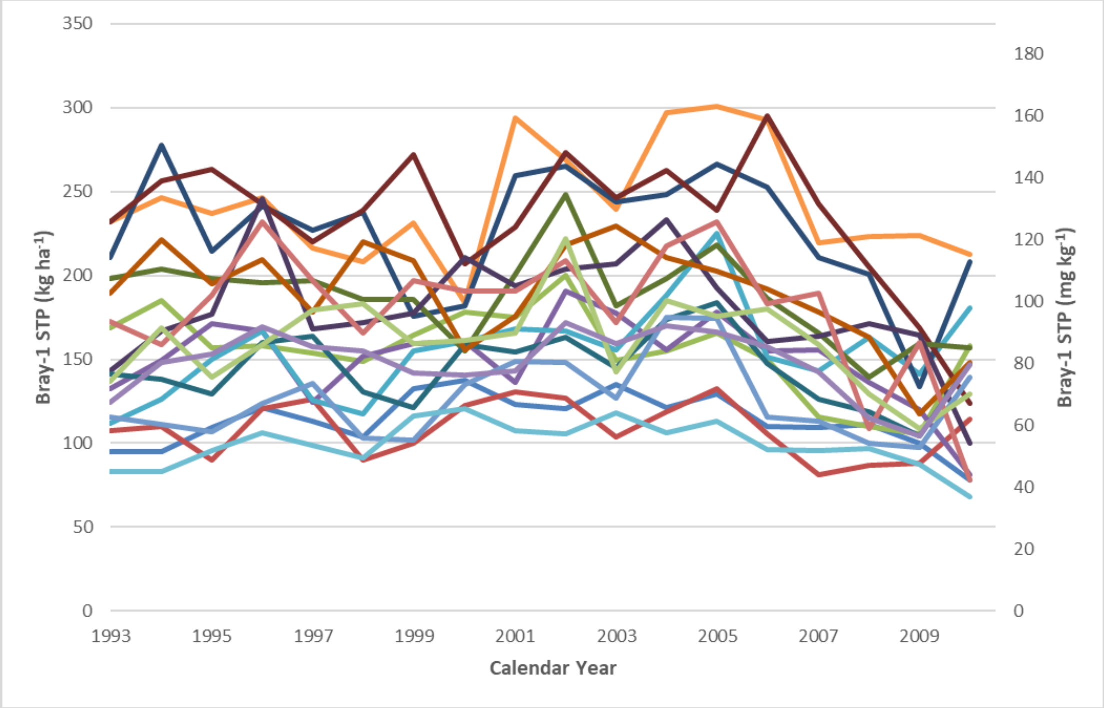
- Subplots tested in triplicate each year
- Triplicates combined by arithmetic mean
- Several methods of central-tendency summary were tested for bias, none was found



Soil test P example

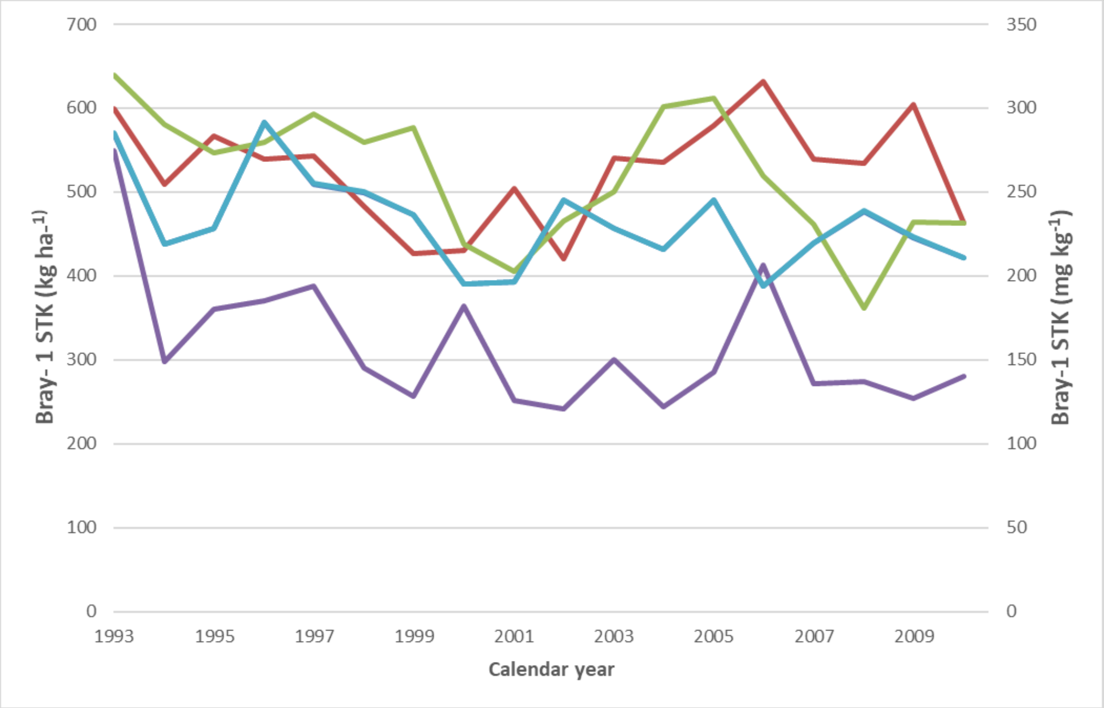


CC Soil test P values by calendar year

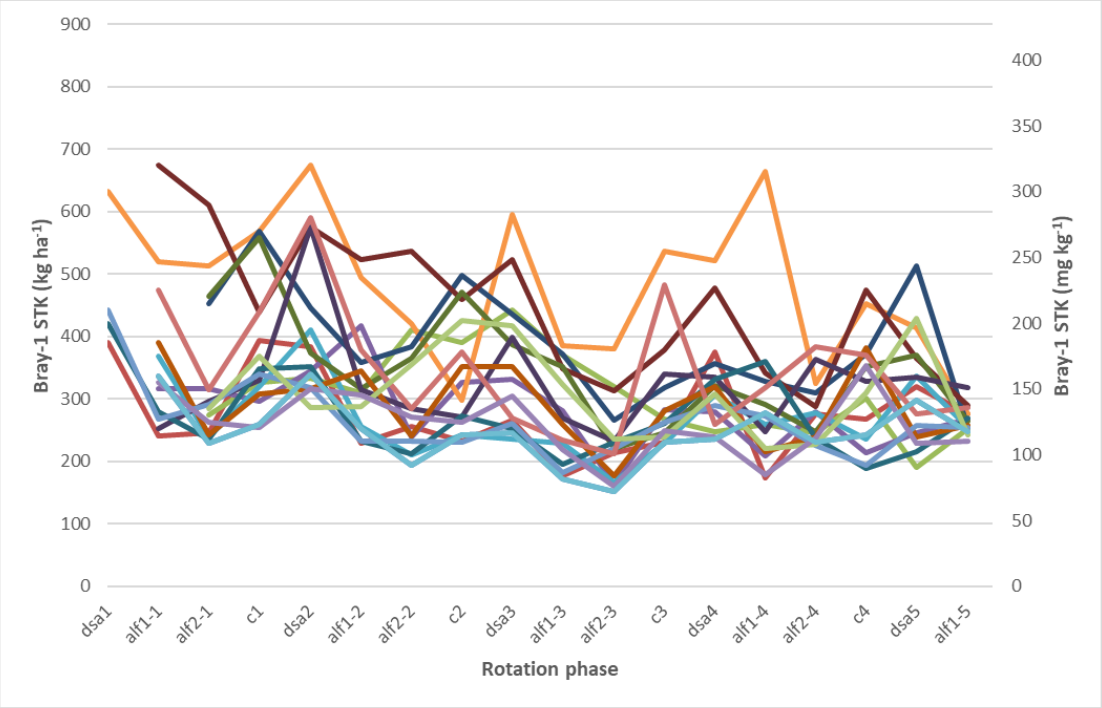


CAAA Soil test P values by calendar year

Soil test K example



CC Soil test K values by calendar year



CAAA Soil test K values by crop rotation

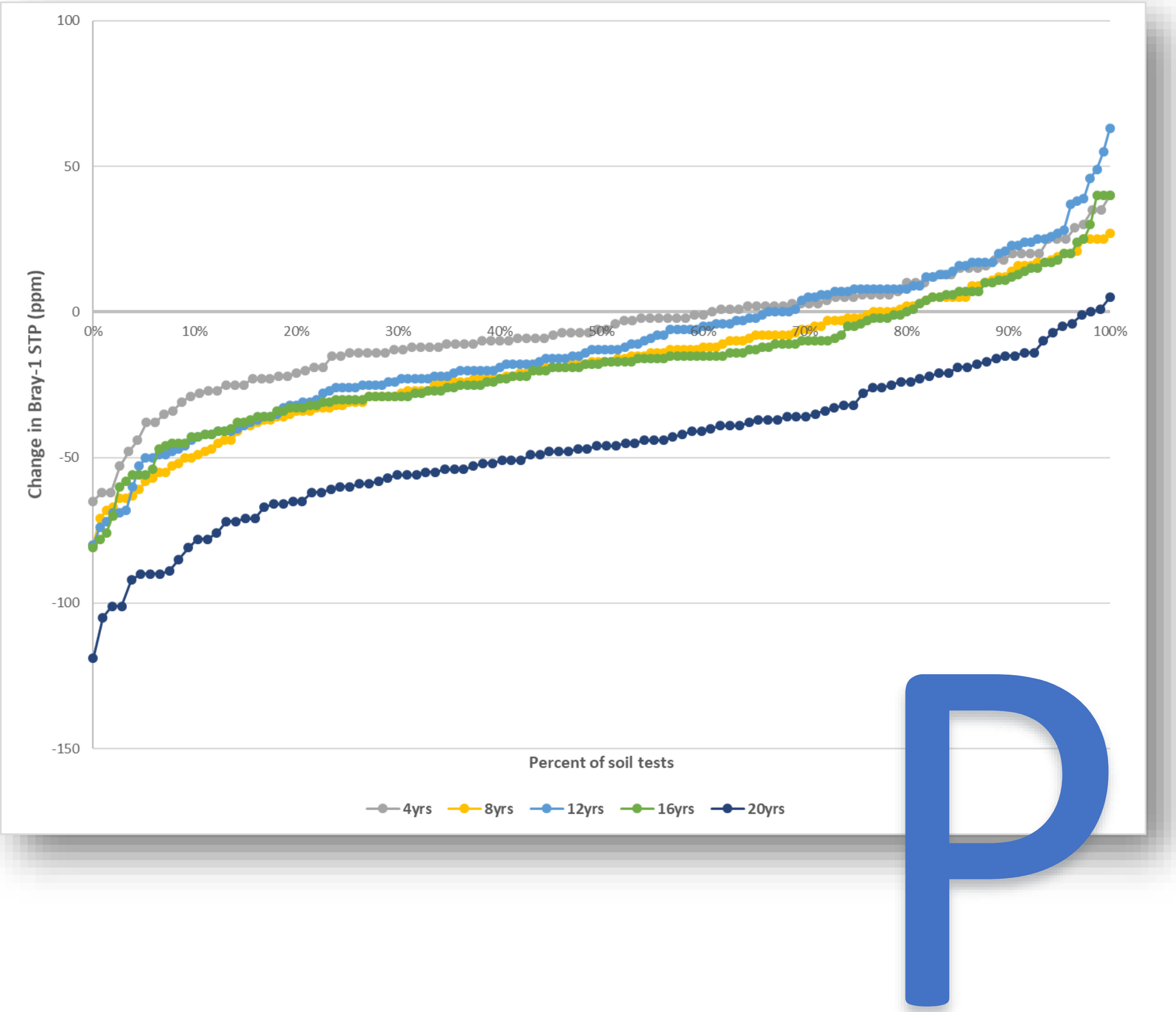
Soil test results

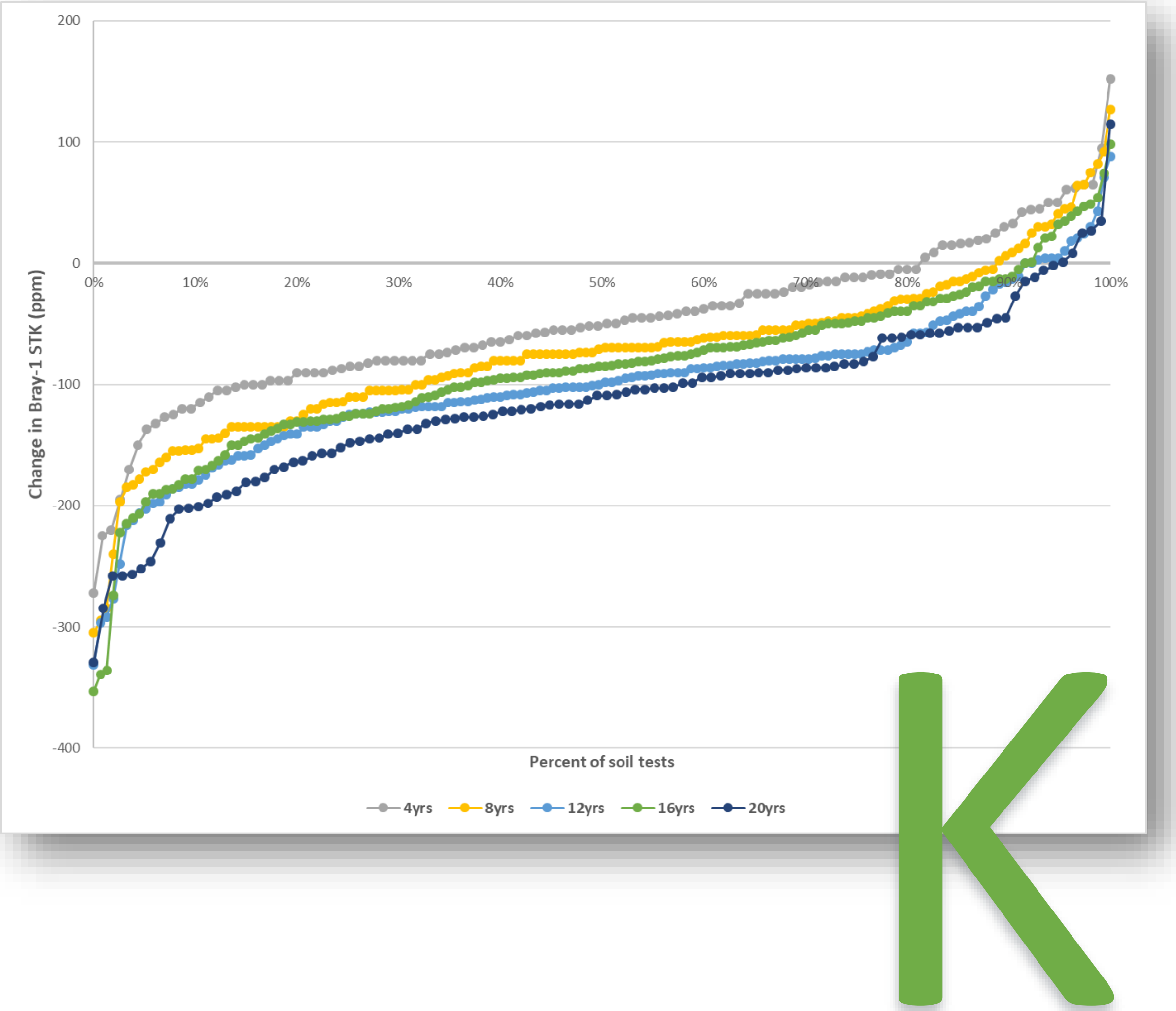
	ΔSTP (kg ha^{-1} yr^{-1})				ΔSTK (kg ha^{-1} yr^{-1})			
	CY		RP		CY		RP	
Cropping System	Slope	*p*	Slope	*p*	Slope	*p*	Slope	*p*
CC	-3.3	0.0001	-2.6	0.0001	-5.0	0.0402	-4.1	0.1131
CS	-3.8	0.0001	-3.8	0.0001	-10.3	0.0001	-10.2	0.0001
CSW	-2.6	0.0001	-2.9	0.0001	-9.3	0.0001	-9.9	0.0001
CAAA	-1.1	0.0438	-0.2	0.7126	-6.7	0.0001	-7.3	0.0001
CoAA	-1.9	0.0001	-0.6	0.2868	-9.5	0.0001	-11.2	0.0001
Grain (1-3)	-3.1	0.0001	-3.2	0.0001	-9.0	0.0001	-9.2	0.0001
Forage (4-5)	-1.4	0.0002	-0.4	0.3500	-7.9	0.0001	-9.0	0.0001
All	-2.2	0.0001	-1.7	0.0001	-8.4	0.0001	-9.0	0.0001

Soil test groupings – Calendar year

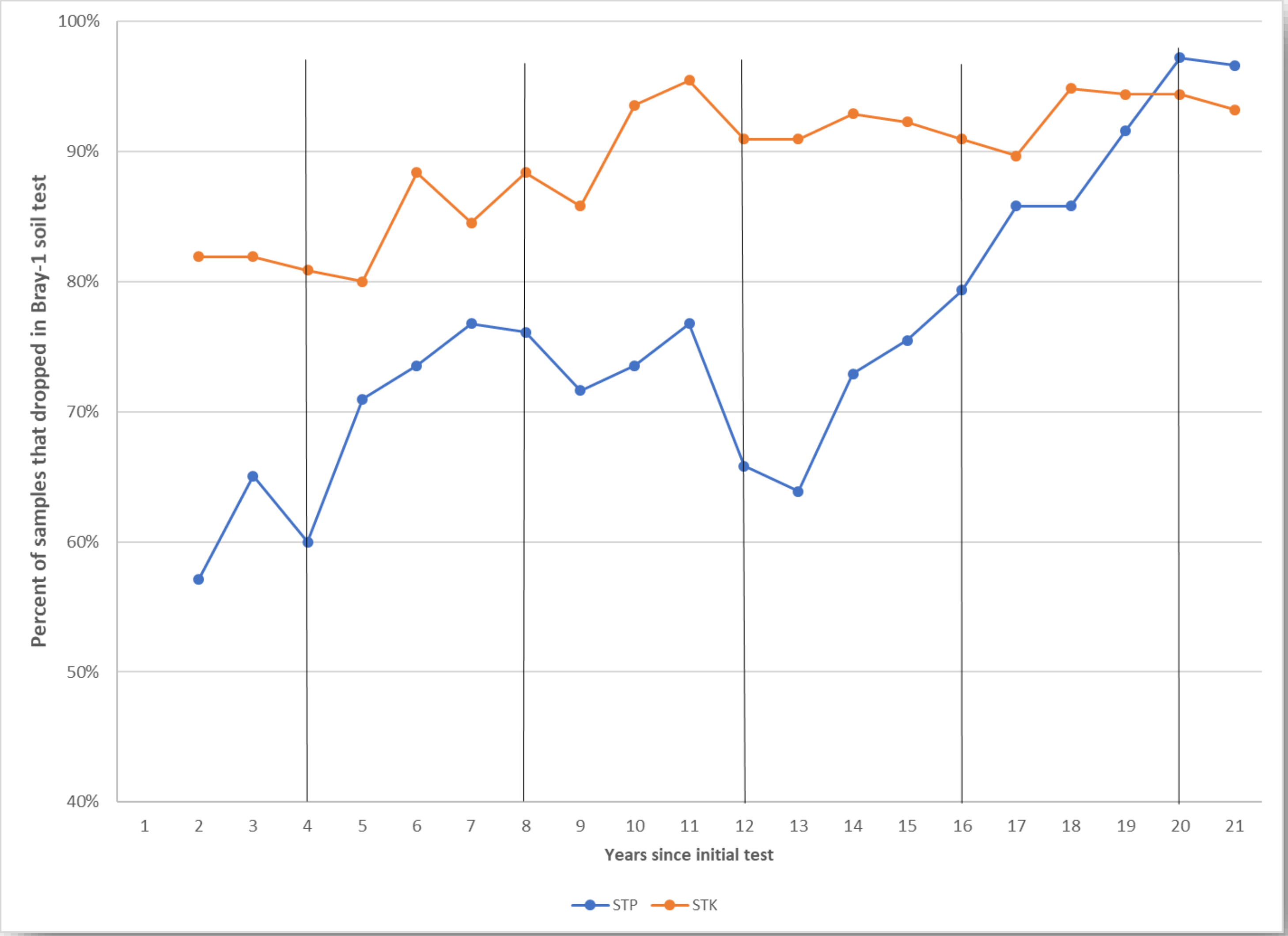
	ΔSTP		ΔSTK	
Cropping System	(kg ha^{-1} yr^{-1})	Significance Group	Slope	p
CC	-3.3	BC	-5.0	A
CS	-3.8	C	-10.3	A
CSW	-2.6	BC	-9.3	A
CAAA	-1.1	A	-6.7	A
CoAA	-1.9	AB	-9.5	A
Grain (1-3)	-3.1	D	-9.0	B
Forage (4-5)	-1.4	E	-7.9	B

Alternative perspectives – cumulative frequency





Alternative perspectives –Sampling intervals



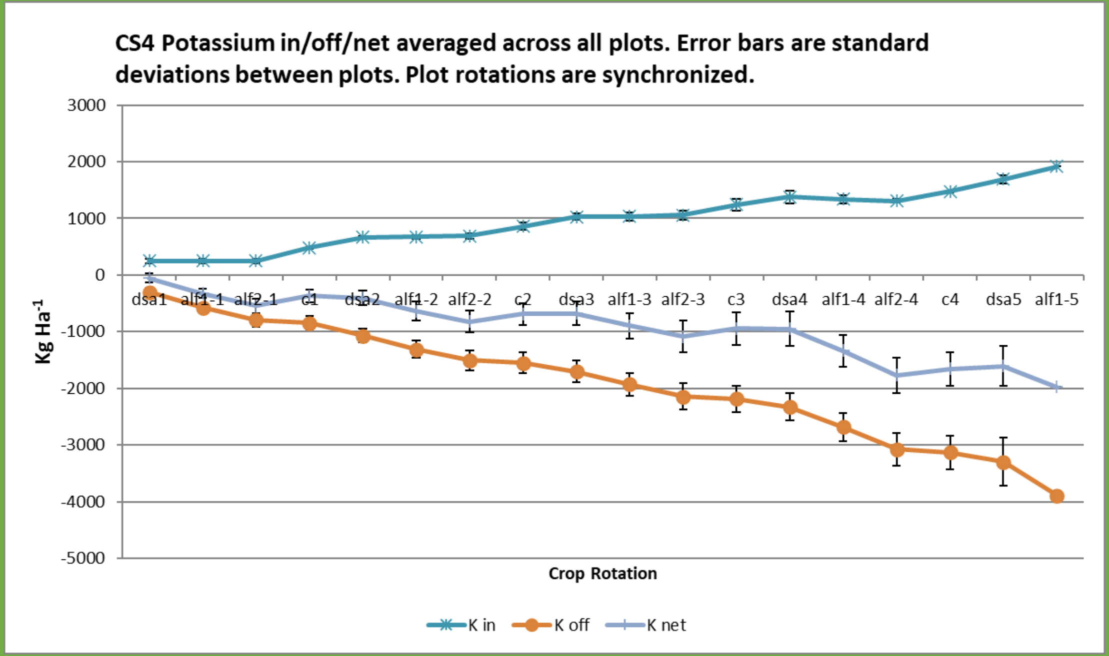
- 4yrs:
  - 60% STP
  - 82% STK
- 8yrs:
  - 76% STP
  - 88% STK
- 12yrs:
  - 66% STP
  - 91% STK
- 16yrs:
  - 79% STP
  - 91% STK
- 20yrs:
  - 97% STP
  - 94% STK

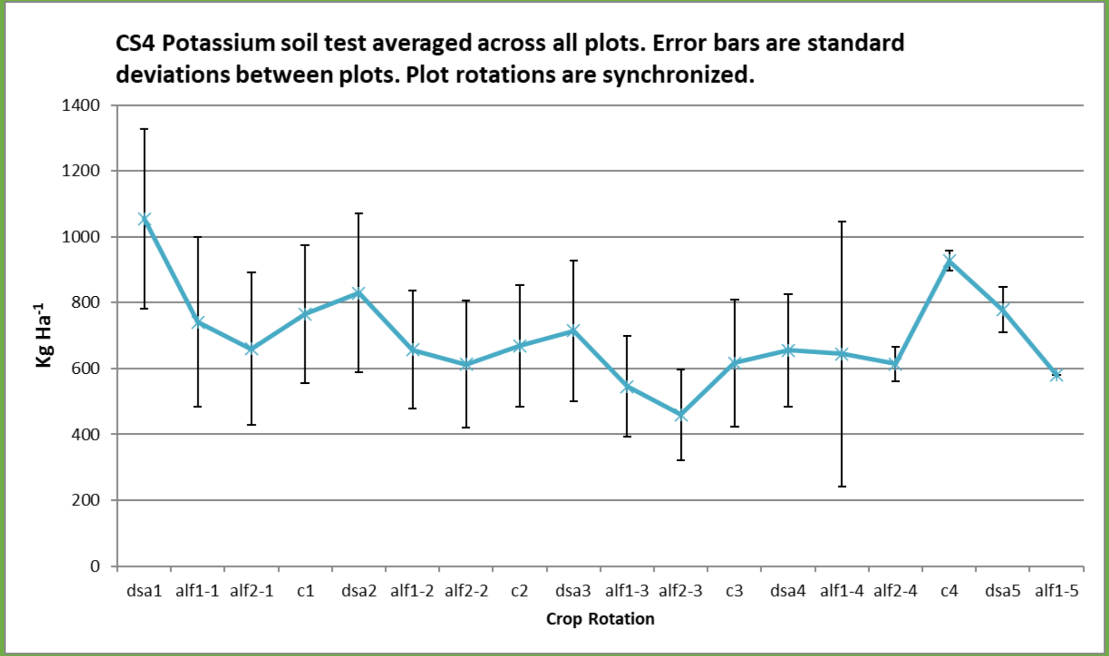
Percent of samples that saw a drop in soil test at a given sampling interval

Fertility trends: Nutrient Balance vs Soil Tests

Wisconsin Integrated Cropping Systems Trial

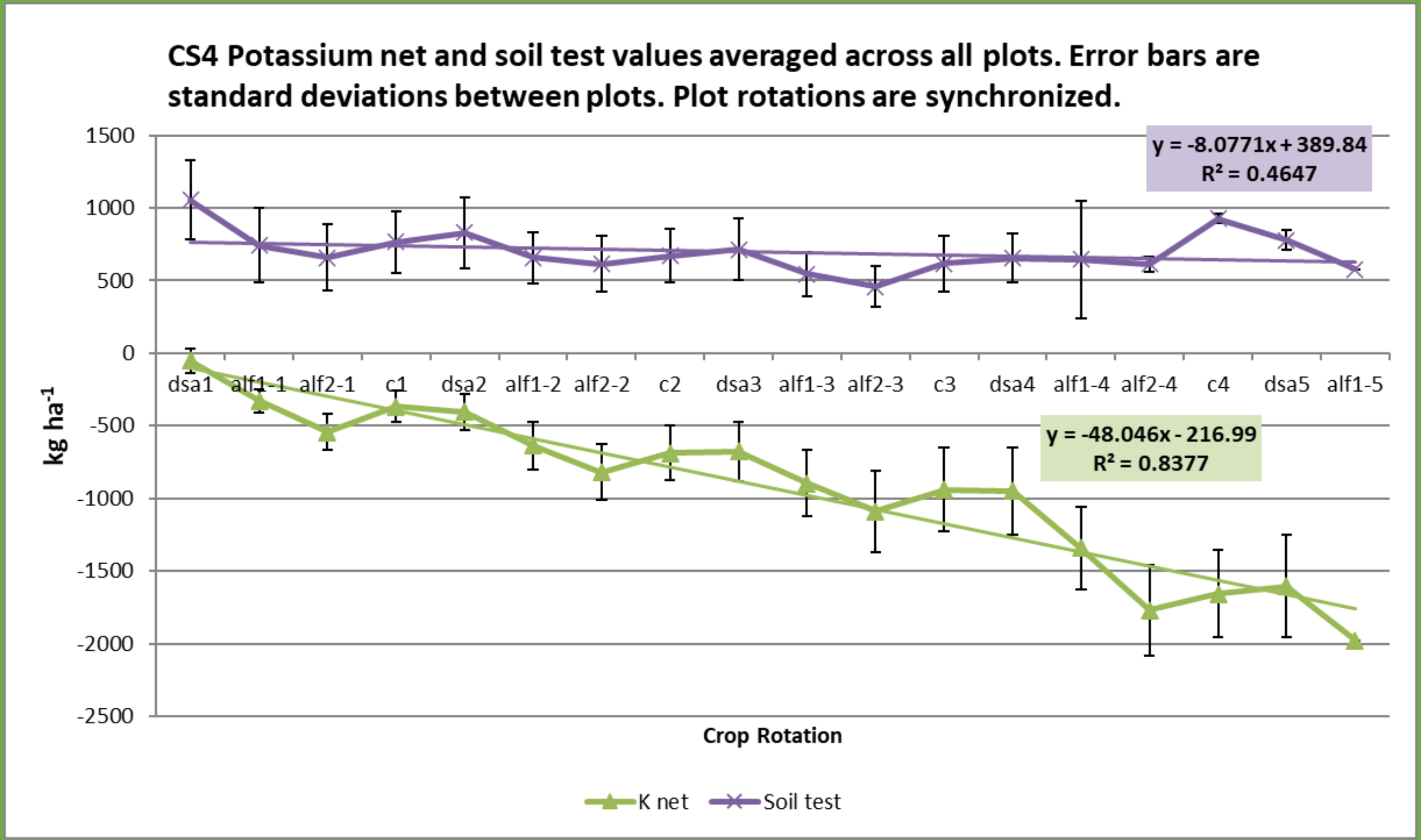
Potassium example





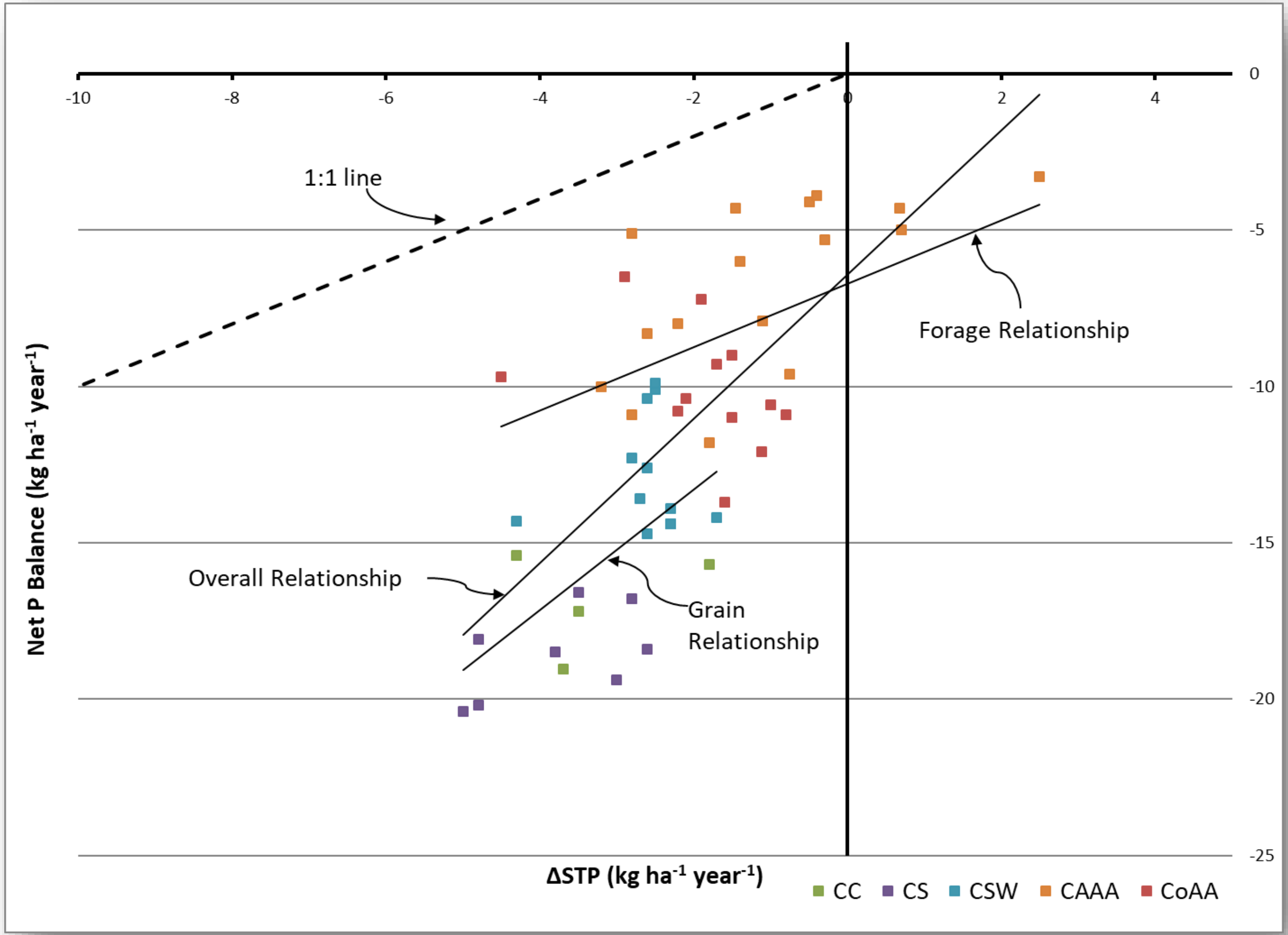
Combine all plots into a single average rate, one for nutrient balance, and one for soil tests, with standard deviation among plots indicated at each point

Potassium example



Remove nutrient inputs and removals, then plot nutrient budget and soil test rates together on a single graph

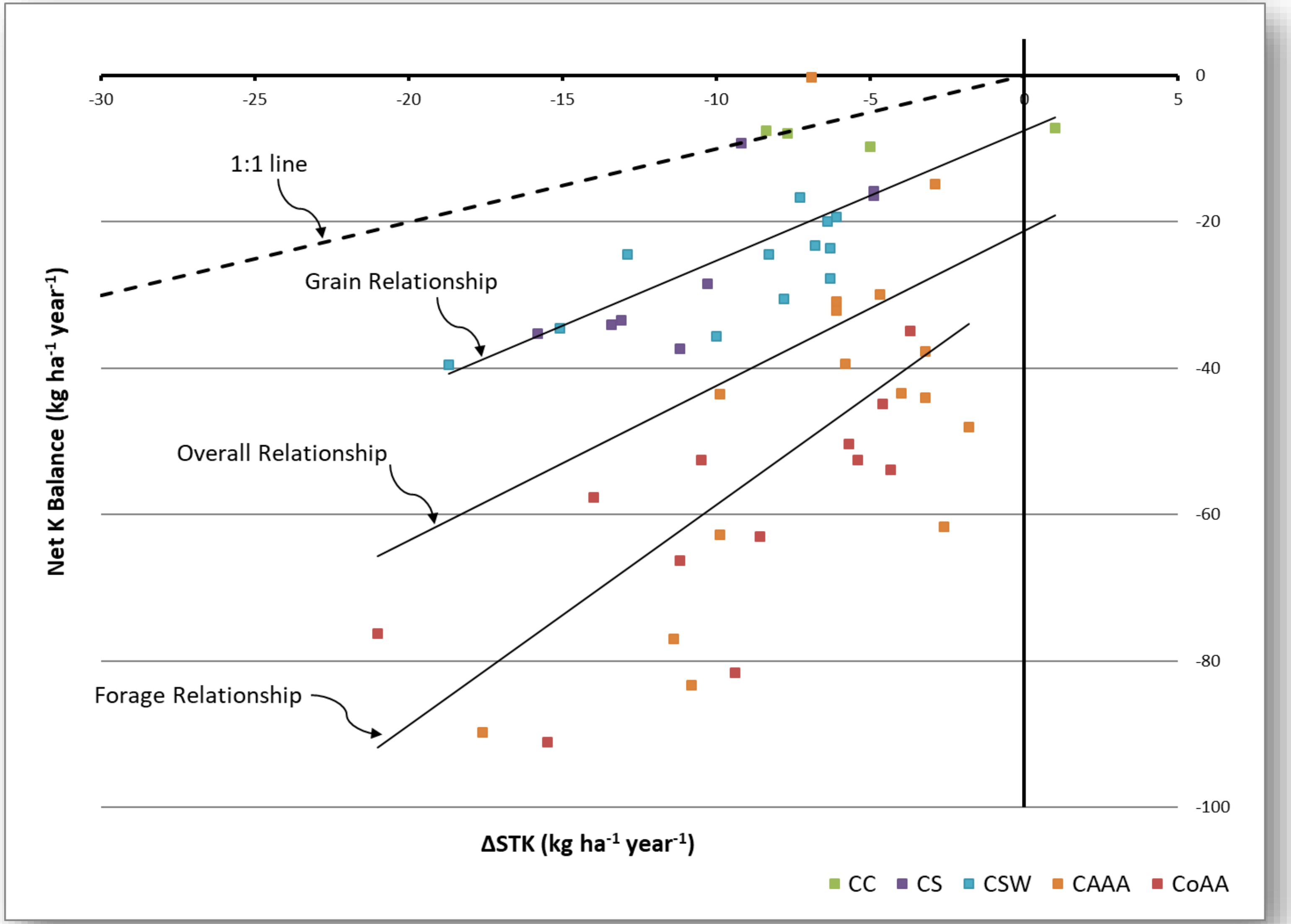
Bringing it all together - Phosphorus



Phosphorus Relationship Data

	Slope	p-value	r^2
CC	0.35	0.7721	0.05
CS	0.80	0.1605	0.30
CSW	0.13	0.8907	0.00
CAAA	1.16	0.0071	0.41
CoAA	-0.73	0.2302	0.14
Grain	1.93	0.0022	0.35
Forage	1.01	0.0112	0.22
All	2.30	0.0001	0.51

Bringing it all together – Potassium



Potassium Relationship Data

	Slope	p-value	r^2
CC	0.06	0.7865	0.05
CS	2.15	0.0218	0.61
CSW	1.28	0.0054	0.55
CAAA	3.53	0.0098	0.39
CoAA	2.20	0.0077	0.52
Grain	1.78	0.0001	0.54
Forage	3.01	0.0001	0.45
All	2.11	0.0015	0.18

Fertility study objectives

- <u>Calculate long-term phosphorus and potassium nutrient balances (ΔNB)</u>
  - Quantify nutrient balance as a rate (kg ha^{-1} yr^{-1}) [yup]
  - Are systems being operated in nutrient deficit? [uh-huh]

- <u>Regress soil test data against time (ΔST)</u>
  - Quantify rate of change in soil test values (kg ha^{-1} yr^{-1}) [check]
  - Are systems being operated in a nutrient deficit? [ehh… yes(ish)?]

- <u>Evaluate any potential correlations between nutrient balance and soil test</u>
  - Does soil testing accurately depict the nutrient balance? [no comment]
  - Does the cropping system impact the relationship? [probably?]
  - How can we use this information to guide future decisions?

Hypothesis: ΔST will be well correlated to ΔNB in a relationship near 1:1

REJECTED

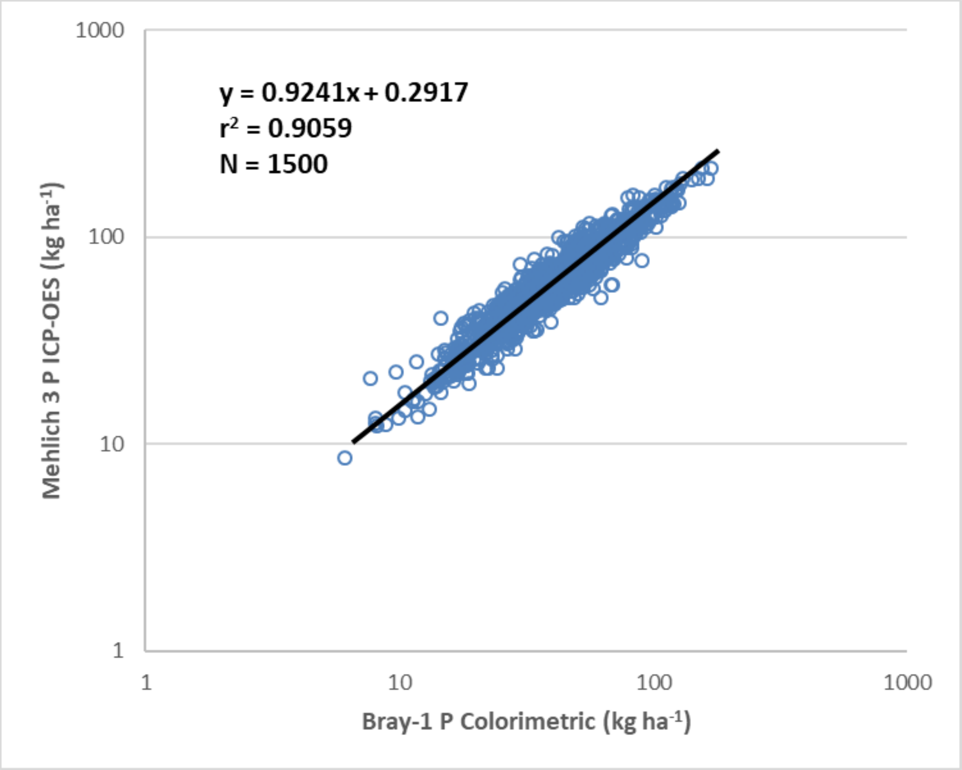
Did soil testing work?

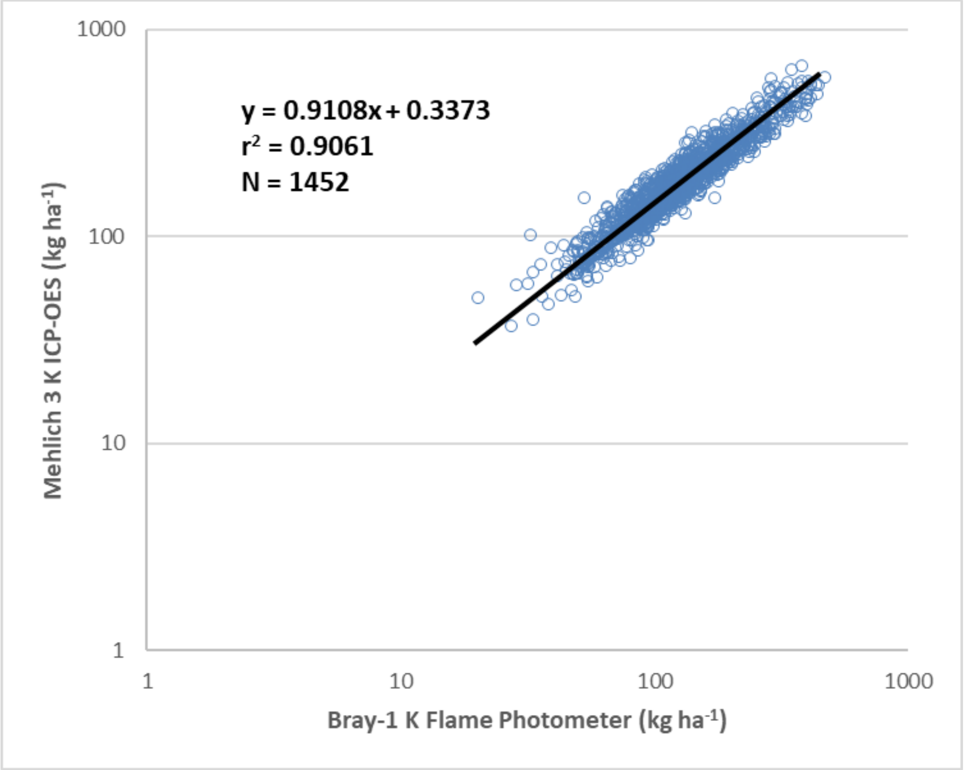
What is soil testing supposed to do?

- Predict the probability of a yield response to fertilizer additions

Did soil testing work? – impact of methods

- Wisconsin has settled on Bray-1 for P and K, but others exist
- Could a stronger/more complex extractant better match ΔNB?





Conversion formulas created by analyzing WICST soils by both methods, 2012-2017 at Rock River Laboratory, Inc

Did soil testing work? Mehlich III data

	Phosphorus relationship Data			Potassium relationship Data		
System	Slope	p-value	r^2	Slope	p-value	r^2
CC	0.27	0.7721	0.05	0.04	0.8060	0.04
CS	0.63	0.1772	0.28	1.84	0.0280	0.58
CSW	0.03	0.9694	0.00	1.13	0.0062	0.54
CAAA	0.95	0.0070	0.42	3.01	0.0114	0.38
CoAA	-0.64	0.2106	0.15	1.90	0.0074	0.53
Grain	1.53	0.0028	0.34	1.56	0.0001	0.54
Forage	0.84	0.0101	0.23	2.57	0.0001	0.44
All	1.88	0.0001	0.52	1.83	0.0015	0.18

Slopes approach 1, but variation is unchanged

Did soil testing work?
Hidden additions & nutrient cycling

Looking at deep soil tests

System	Depth (cm)	ΔSTP	p-value	R^2	ΔSTK	p-value	R^2	N
CC	15-30	-3.70	0.001	0.56	-6.99	0.003	0.48	16
	30-61	-7.28	0.148	0.14	-6.84	0.039	0.27	16
	61-91	-8.05	0.230	0.14	-5.14	0.022	0.42	12
CS	15-30	-0.71	0.528	0.01	-5.01	0.017	0.18	32
	30-61	-1.11	0.769	0.00	-8.90	0.002	0.28	32
	61-91	-2.20	0.678	0.01	-8.74	0.001	0.40	24
CSW	15-30	-1.82	0.004	0.17	-4.82	0.002	0.26	48
	30-61	1.69	0.060	0.08	-4.46	0.008	0.15	48
	61-91	-0.20	0.810	0.00	-5.79	0.002	0.23	40
CAAA	15-30	0.16	0.844	0.00	-6.19	0.000	0.35	64
	30-61	0.04	0.986	0.00	-7.05	0.000	0.27	64
	61-91	-0.93	0.753	0.00	-5.57	0.000	0.21	56
CoAA	15-30	0.73	0.160	0.04	-4.49	0.000	0.43	48
	30-61	2.99	0.007	0.15	-5.01	0.001	0.21	48
	61-91	3.97	0.028	0.12	-3.82	0.001	0.26	40

What did we learn today?

Evidence that cropping system can impact ΔST vs. ΔNB in a drawdown period

- Good relationship between ΔSTK and ΔNB-K at enterprise level
  - Degree of agreement appears to be influenced by cropping system
    - ΔNB-K = 1.78 x ΔSTK for grain ($p<0.0001$, $r^2=0.54$)
    - ΔNB-K = 3.01 x ΔSTK for forage ($p<0.0001$, $r^2=0.45$)
  - Potassium cycling from subsoil contributes to K additions

- Good relationship between ΔSTP and ΔNB-P at highest level
  - ΔNB-P = 2.30 x ΔSTP overall ($p<0.0001$, $r^2=0.51$)
  - Relationships deteriorate at enterprise and cropping system levels
  - No evidence of phosphorus cycling from subsoil

Questions raised & further work

Is it valid to look at soil testing in this context?

- Not what soil testing is intended to do
- Outside of the responsive range
- Implications for nutrient management

Is the current soil test procedure adequate?

- Sampling depth/nutrient cycling
- Sampling intensity
- Extraction method
- Do current interpretations incorporate cropping system adequately?

What influences nutrient cycling?

- No evidence of P depletion or cycling
- Subsoil K depletion, but no evidence of cycling

Thank you!!

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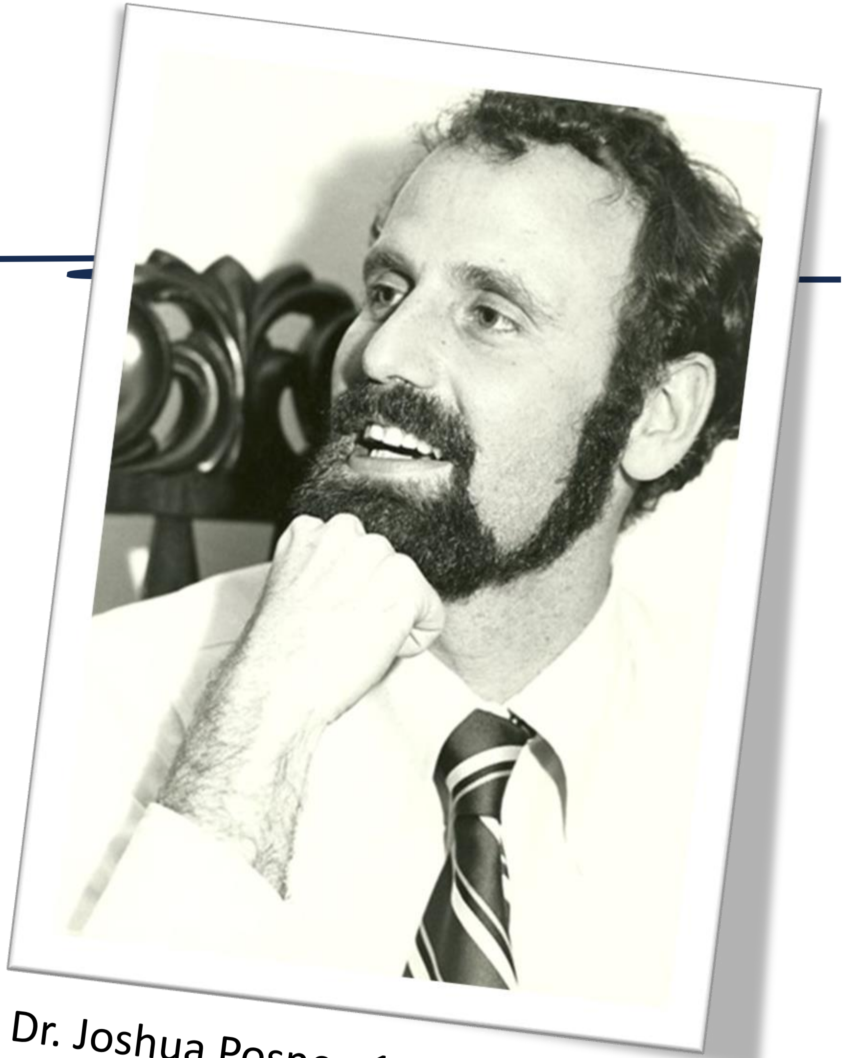
ROCK RIVER LABORATORY, INC.
AGRICULTURAL ANALYSIS

Support LTSEs however you can!



Dr. Joshua Posner, 1947 - 2012

Collaborators:
Janet L. Hedtcke, Gregg Sanford, Matt Ruark, Phillip Barak, Laura Ward-Good, Joshua Posner