Phosphorus Management: Questions of Balance

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AGVISE Soil Fertility Seminars
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P Balance Issues

1. Short term vs. long term P management strategies
2. Crop production vs. environmental protection
3. Environmental challenges for P vs. other environmental challenges

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Why is phosphorus balance important?

Food - P is a unique element that is essential for almost all life

Source: Christiansen/ Scientific American

Water - small amounts of excess P cause big problems with water quality


Photo: MB Conservation

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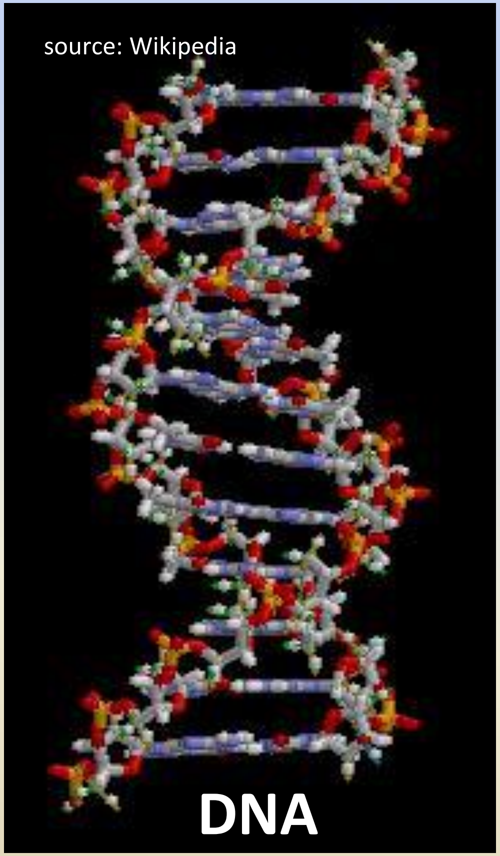
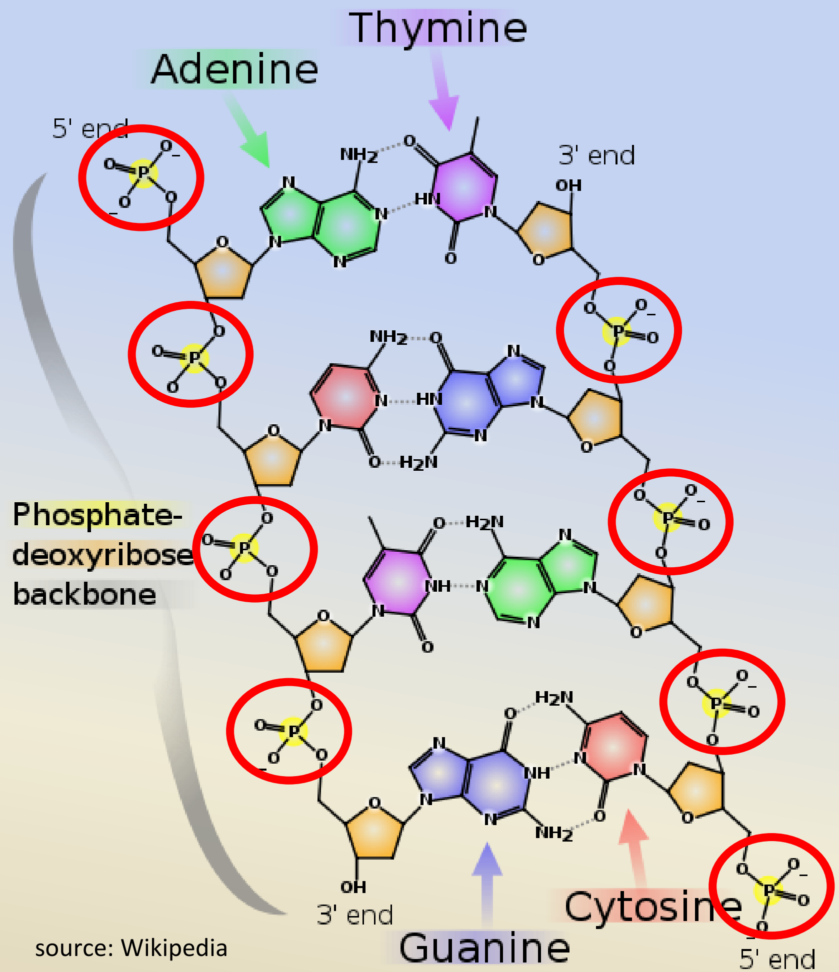
Examples of molecules that are vital for life and that require P



genetic coding & control



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P Management in Corn & Soybeans in Manitoba

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Corn Production in Manitoba

Photo: Pembina Valley On-Line

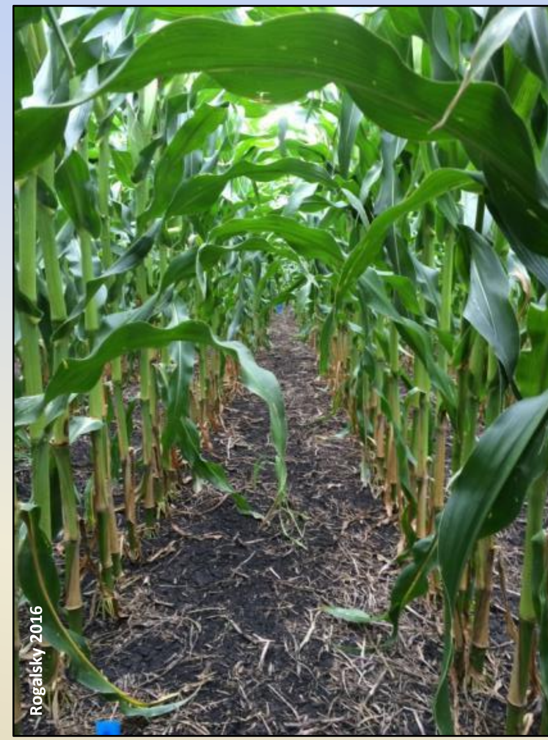
- Grain corn acreage is increasing in MB
- Short growing season and cold soils at planting
- Often planted on land with canola in rotation
- Conservation tillage an important BMP

Corn Rotation Study: Starter P & Zn

Fertilization strategies for corn grown after canola (non-mycorrhizal) vs. soybean

P?

Zn?



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Corn Rotation Study: Site Information

	Planting Date	Harvest Date	Olsen-P (ppm)	DTPA-Zn (ppm)
2015 Sites				
Carman, MB	May 25	Oct. 15	19	1.50
Stephenfield, MB	May 26	Oct. 14	6	0.82
2016 Site				
Carman, MB	May 12	Oct. 05*	9	1.91

* Carman 2016 site was hand harvested due to wind damage and green snap.

Corn Hybrid: DKC 26-28RIB (2150 CHU)

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Corn Rotation Study Treatments

Crop Treatments - Canola or Soybeans

Fertilizer Treatments (sidebanded 2” by 1” at planting)

<u>Control</u>

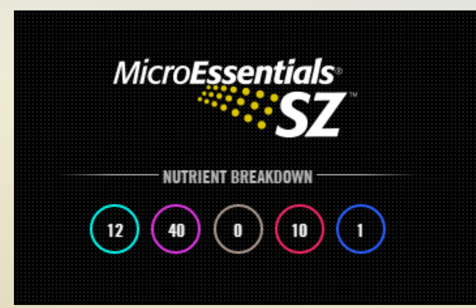
1. No P Check

<u>MAP (11-52-0) + AS (21-0-0-24)</u>

2.	27 P_2O_5	0 Zn	6.8 S lbs/ac
3.	54 P_2O_5	0 Zn	13.5 S lbs/ac

<u>MicroEssentials SZ (12-40-0-10S-1Zn)</u>

4.	27 P_2O_5	0.68 Zn	6.8 S lbs/ac
5.	54 P_2O_5	1.35 Zn	13.5 S lbs/ac



MicroEssentials (December 14, 2015) http://www.microessentials.com/#fusion-process

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Corn Rotation Study:
Early Season Response to Starter

MAP 27 lb P_2O_5/ac   No P Check   P deficiency symptoms at V3

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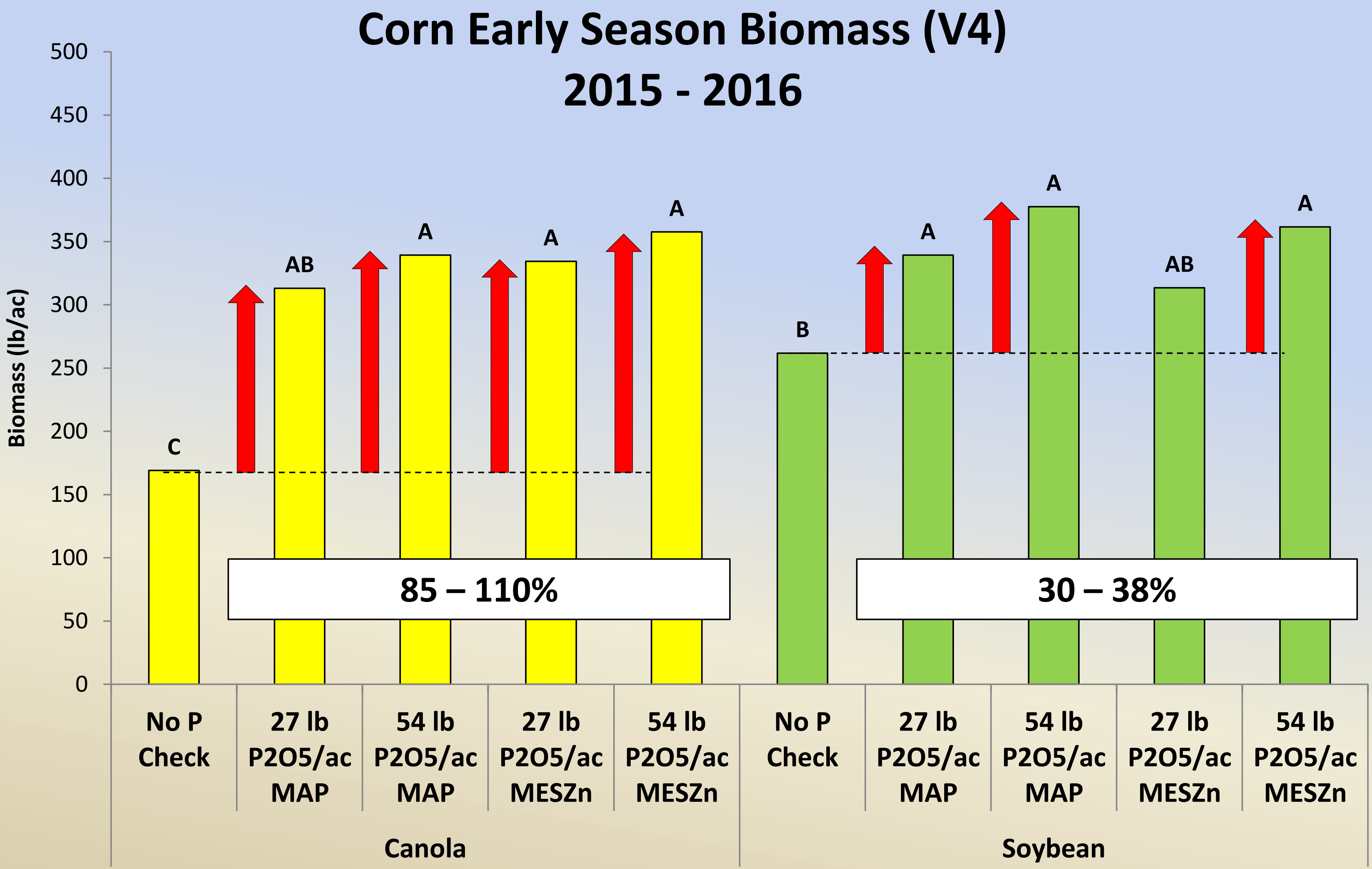
Corn Rotation Study



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Corn Rotation Study

Silking differences as compared to control plots

Site-year	Maturity Advance (days)	Fertilizer and Crop
Carman 2015	+2 to 3	All fertilizer treatments, corn on canola
Stephenfield 2015	ns	ns
Carman 2016	+2 to 7	All fertilizer treatments, regardless of crop

Earlier tasseling and taller corn plants with spring side-banded 27 lb P_2O_5/ac as MAP (L) and 27 lb P_2O_5/ac as MESZn (R) vs. control (M) at Carman following canola stubble

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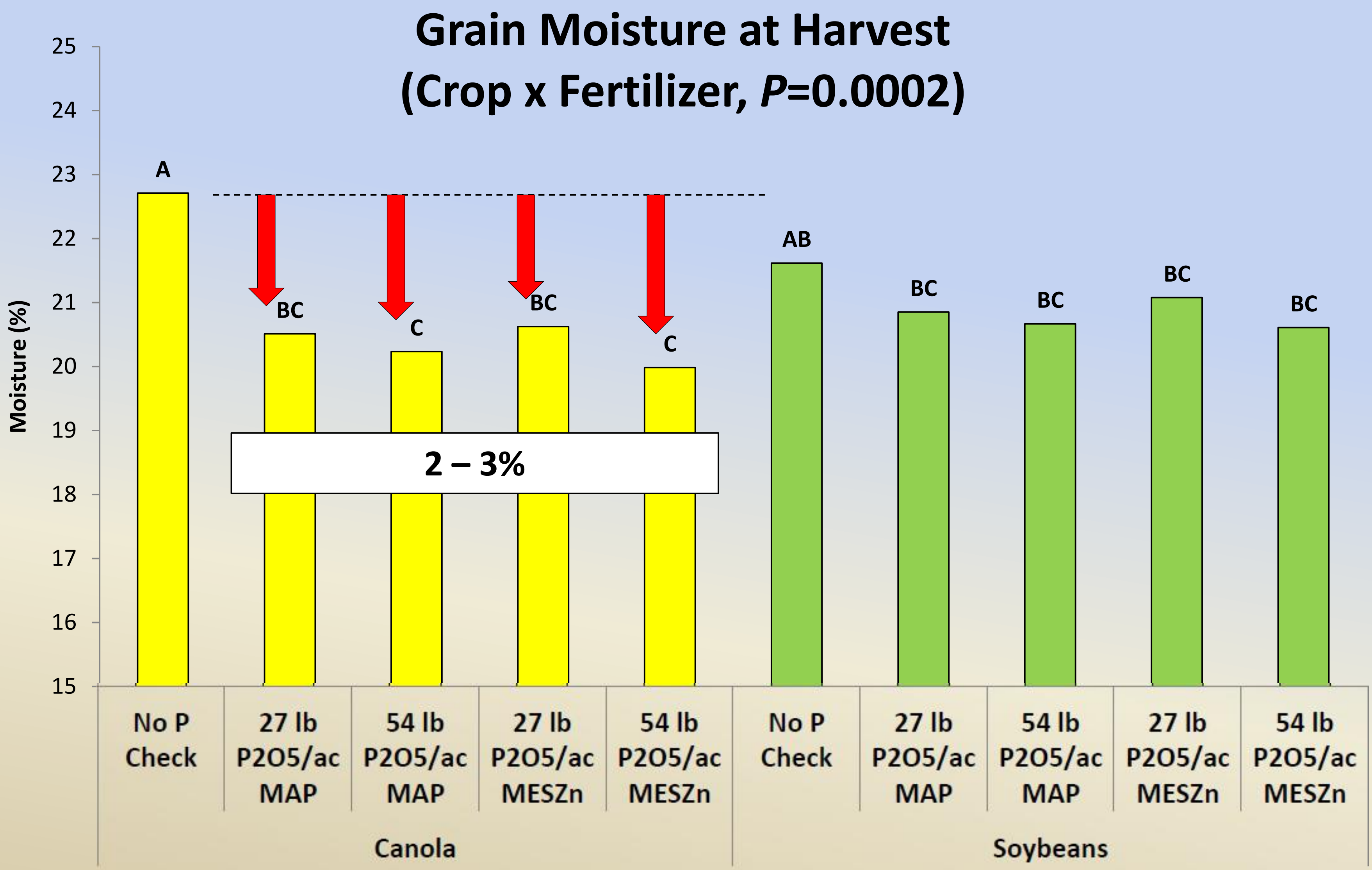
Corn Rotation Study



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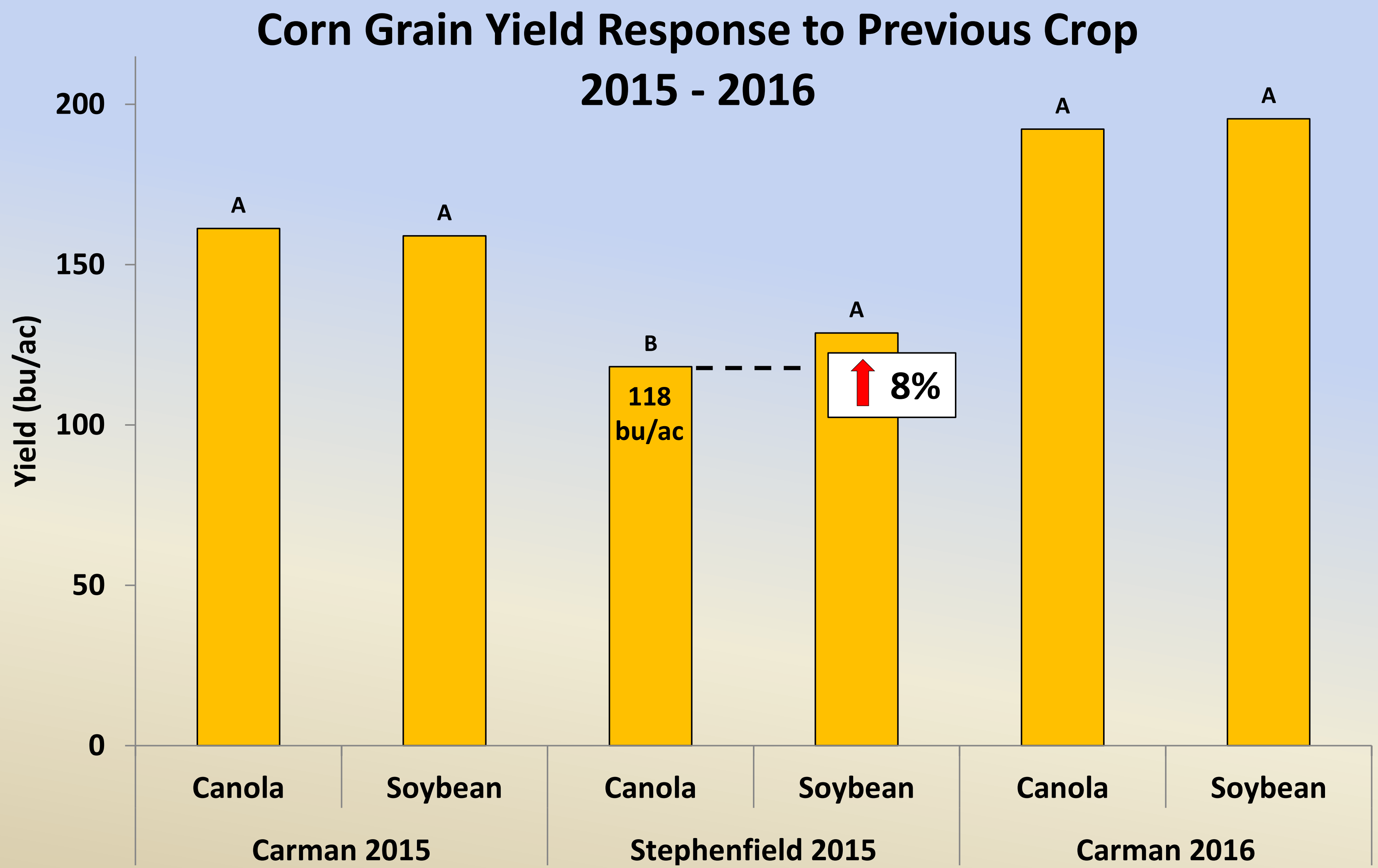
Corn Rotation Study



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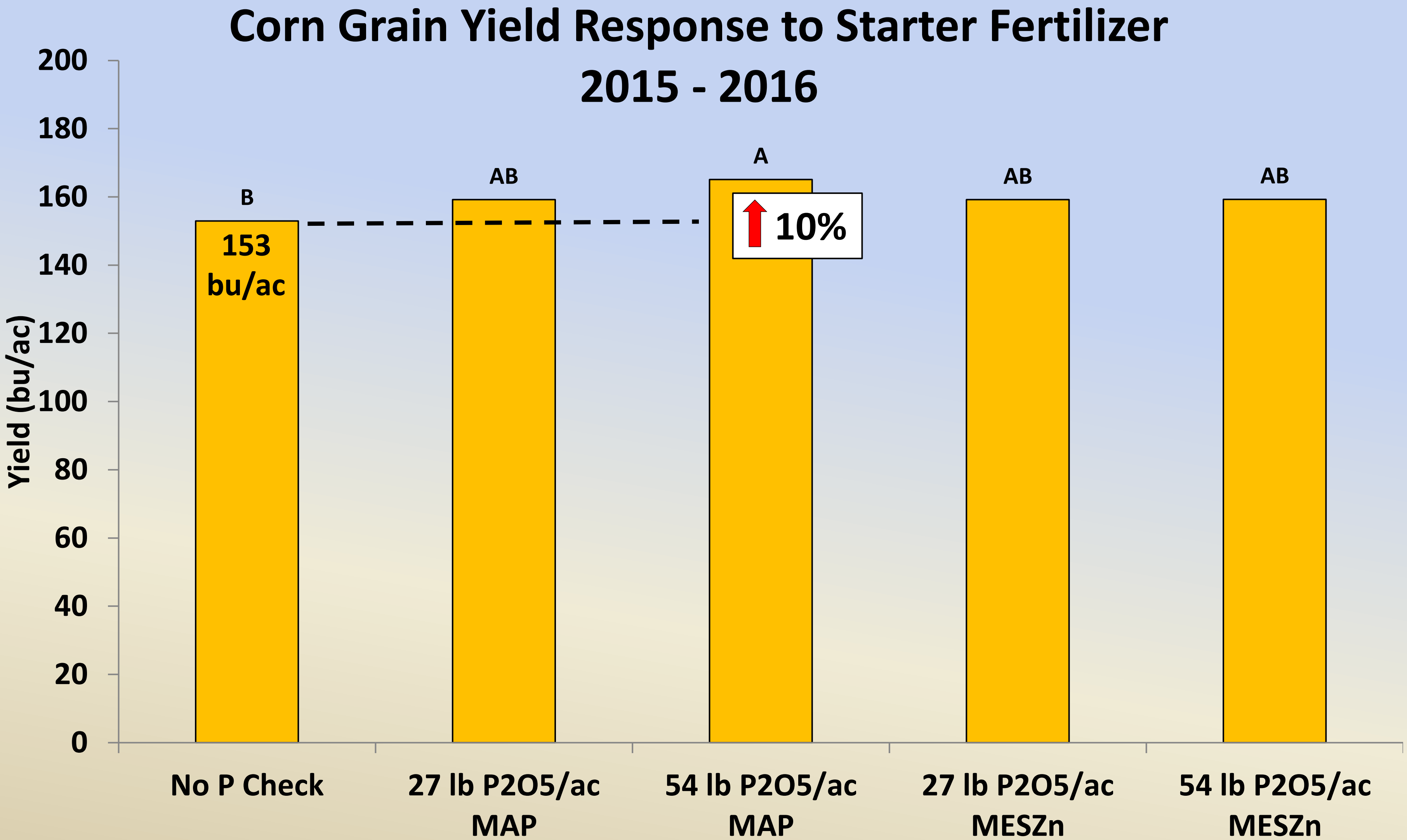
Corn Rotation Study



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Corn Strip Till Study – P Timing & Placement

P fertilization strategies for corn planted in strip tillage vs. conventional tillage

P?

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Corn Strip Till Study: Site Information

	Planting Date	Harvest Date	Olsen-P (ppm)	Residue
2015 Sites				
Carman, MB	May 25	Oct. 16	8	Wheat
Portage la Prairie, MB	May 26	Oct. 19	11	Barley
2016 Sites				
Carman, MB	May 12	Oct. 5*	5	Wheat
Portage la Prairie, MB	May 16	Oct. 6*	14	Wheat

*Carman 2016 site was hand harvested due to wind damage and green snap.
*Portage 2016 sites was hand harvested due to hail and black bird damage.

Corn Hybrid: DKC 26-28RIB (2150 CHU)

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Corn Strip Till Study:
2 Previous Tillage Treatments

Rogalsky 2015

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Corn Strip Till Study: 5 Fertilizer Treatments
(lbs/ac, spring (2” by 1”) and fall application (4-5”))

<u>CONTROL</u>

1. No P Check

<u>MAP (11-52-0) *Only*</u>

2. 27 P_2O_5 SPRING SB
3. 54 P_2O_5 SPRING SB

4. 27 P_2O_5 FALL DB
5. 54 P_2O_5 FALL DB

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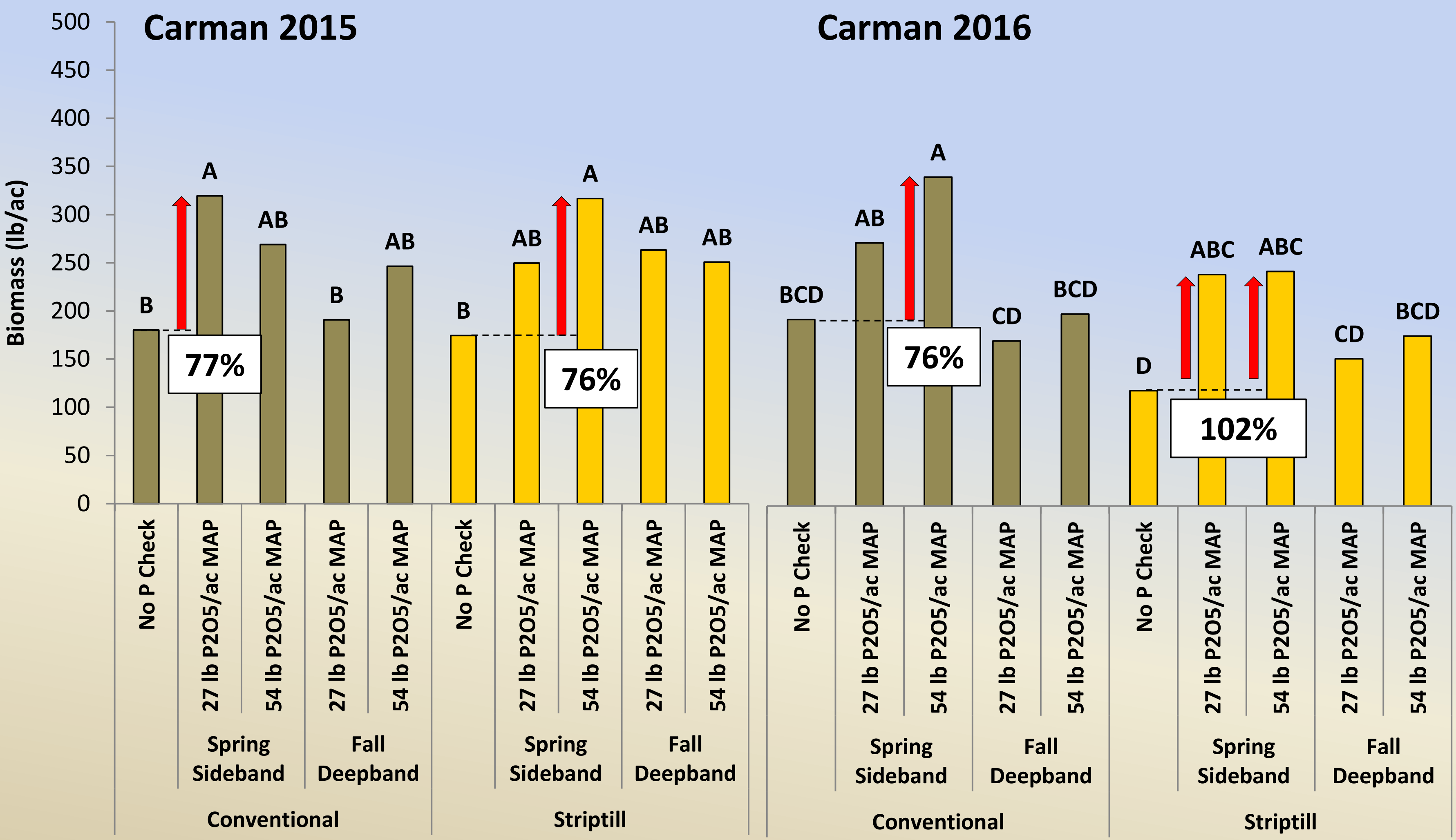
Corn Strip Till Study

Corn Early Season Biomass (V4) 2015 - 2016



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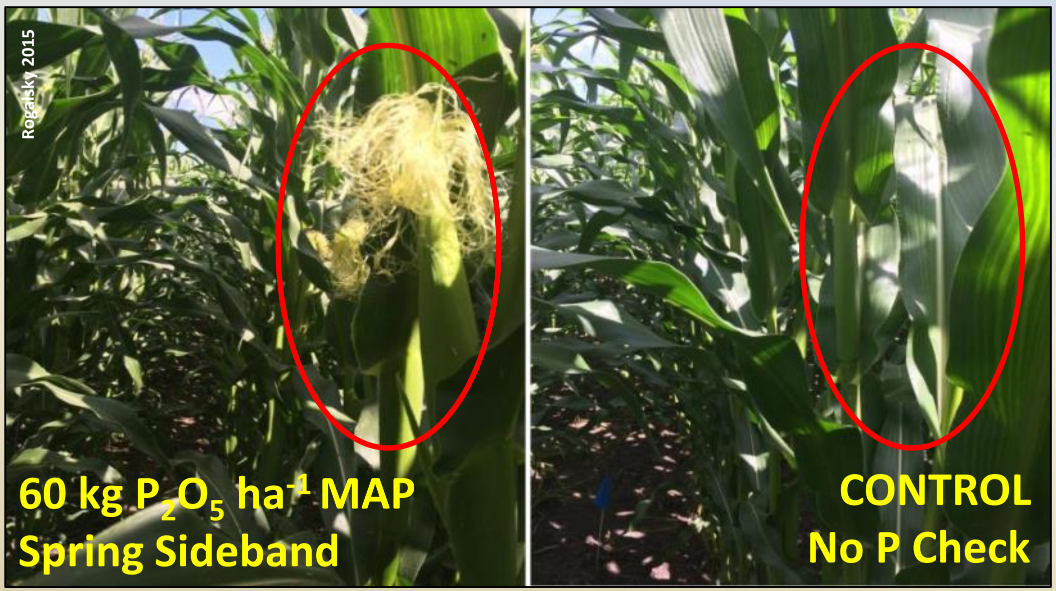
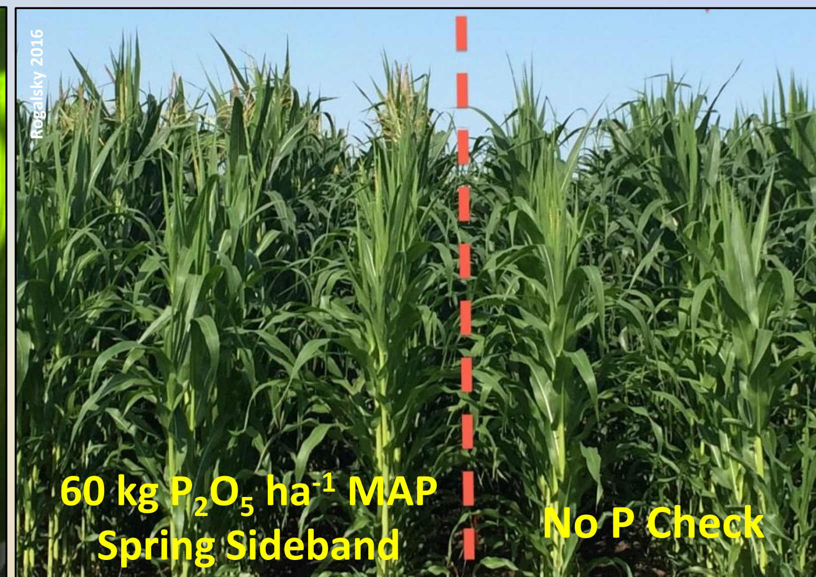
Corn Strip Till Study

Silking differences as compared to control plots

Site-year	Maturity Advance (days)	Fertilizer
Carman 2015	+2	All fertilizer treatments
Portage la Prairie 2015	ns	ns
Carman 2016	+3 to 4	Both rates of spring side-banded MAP
Portage la Prairie 2016	ns	ns





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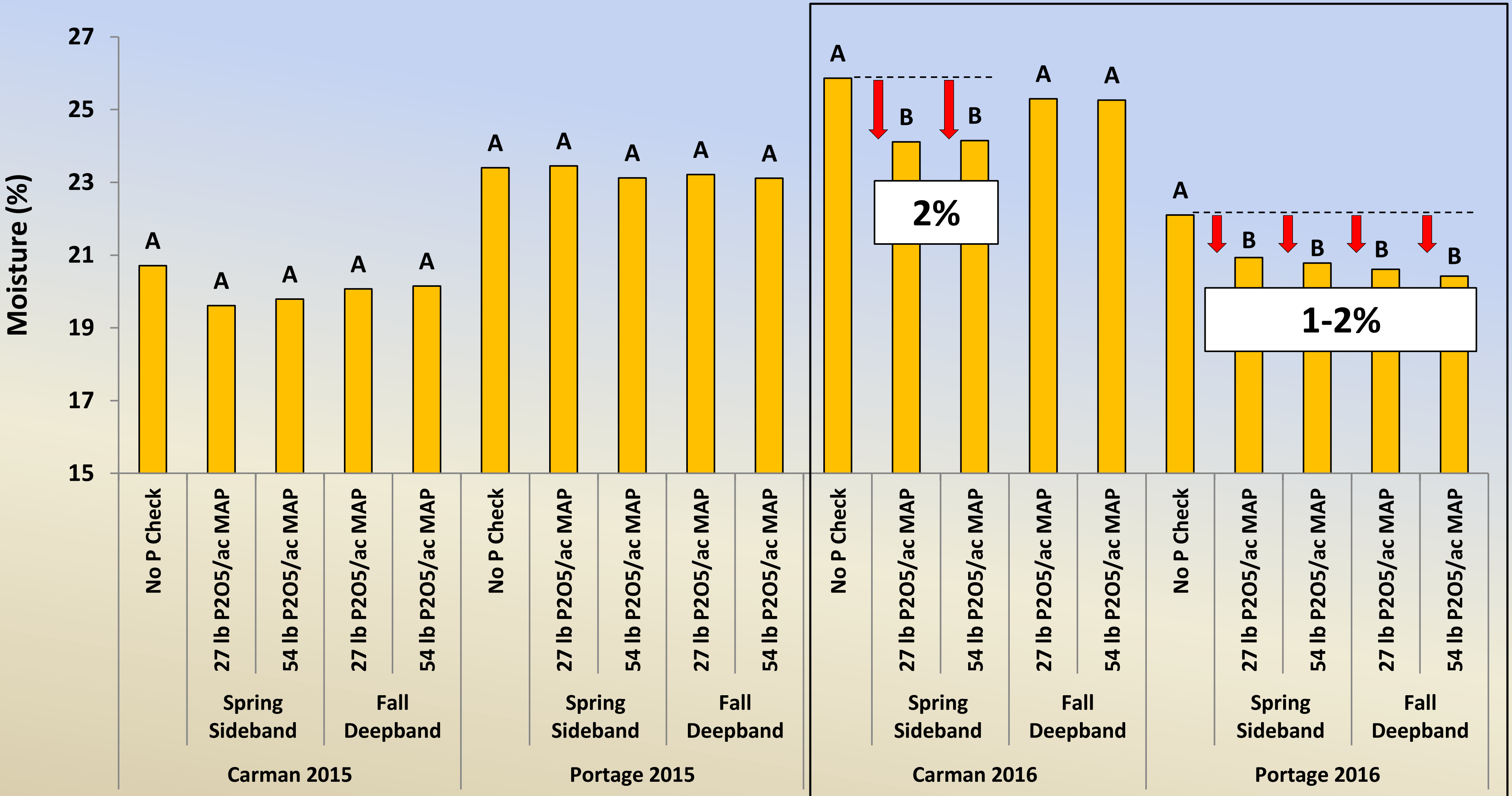
Corn Strip Till Study

Kernel Moisture at Harvest

2015 - 2016



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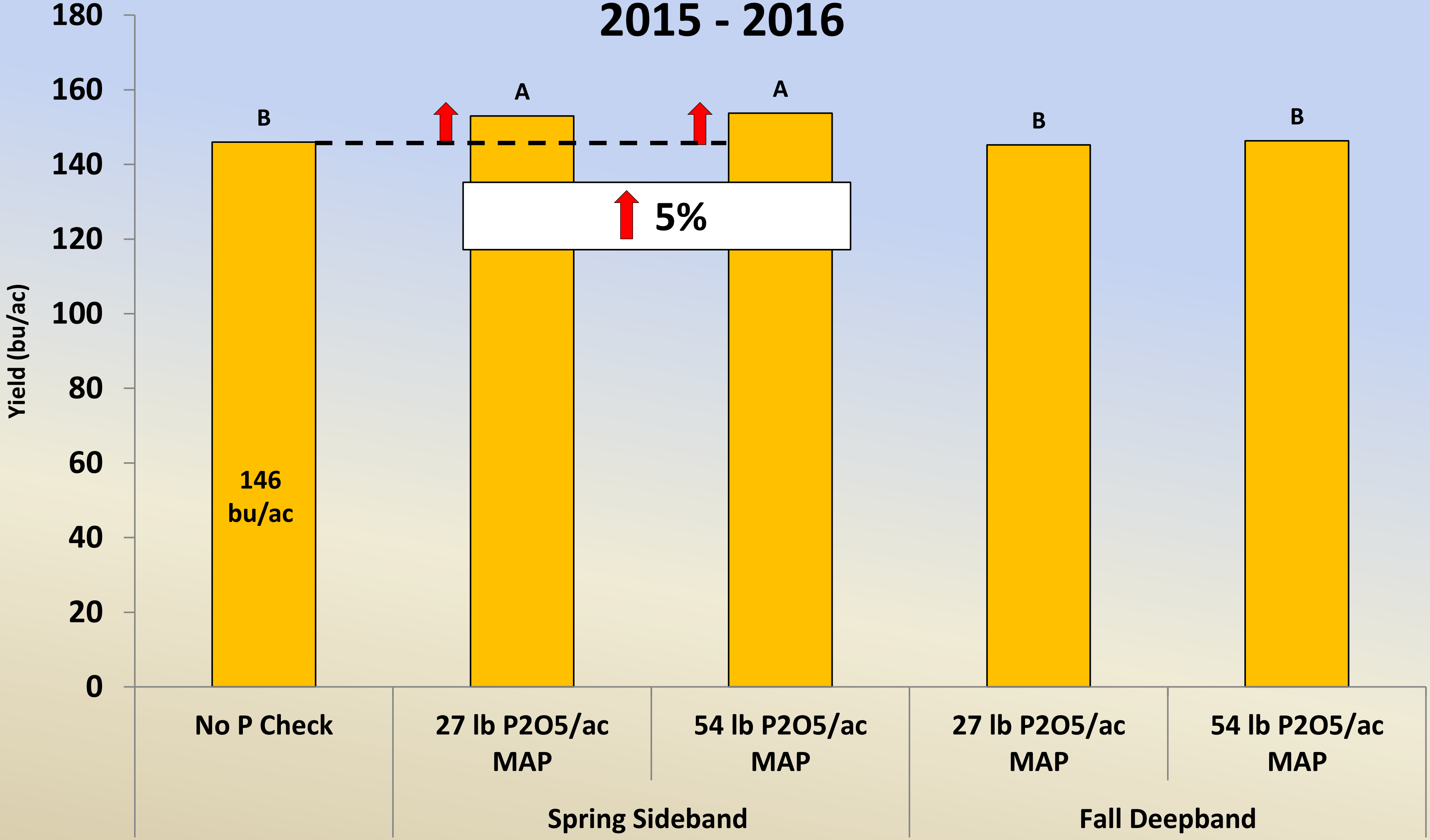
Corn Strip Till Study

Corn Grain Yield Response to P

2015 - 2016



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Corn Strip Till Study: Summary

Good News…

Corn planted in strip till yielded as well as corn planted in conventional till and had similar grain moisture.

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Manitoba Soybean P Study #1: Effects of P Fertilizer Rate & Placement on Plant Stand and Seed Yield

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Manitoba Soybean P Study #1:
Effects of P Fertilizer Rate & Placement

- Half of the sites tested 10 ppm or less for Olsen P (v. low-low)
- 3 rates of P_2O_5 (0, 40, 80) applied as MAP in SR, SB, or B'cast
- Opener type: knife or disc with row spacing from 7 to 12" (low SBU)

Site	Olsen P (ppm)			Soil Texture	Row Spacing	Seeder Opener
---	2013	2014	2015	----	Inches	Type
Roseisle	N/A	4 (VL)	4 (VL)	Sandy Loam	8	Knife
Melita	3 (VL)	5 (L)	7 (L)	Sandy Clay Loam	9.5	Knife
Brandon	5 (L)	6 (L)	5 (L)	Clay Loam	8	Knife
Carman	N/A	15 (H)	7 (L)	Sandy Clay Loam	8	Knife
Roblin	7 (L)	22 (VH)	8 (L)	Clay Loam	9	Knife
Beausejour	8 (L)	13 (M)	7 (L)	Heavy Clay	9	Disc
Arborg	14 (M)	22 (VH)	14 (M)	Silty Clay	9	Disc
St Adolphe	23 (VH)	25 (VH)	71 (VH)	Heavy Clay	7.3	Knife
Portage	34 (VH)	18 (H)	10 (L)	Clay Loam	12	Disc
Carberry	44 (VH)	11 (M)	15 (H)	Clay Loam	12	Disc

Effect of P rate and placement on soybean seed yield for 28 site years in Manitoba

	Year		
	2013	2014	2015
# Sites	8	10	10
Mean Seed Yield (bu/ac)	46	42	51
Control Seed Yield (bu/ac)	23 - 66	18 - 60	37 – 65
# Sites with Yield <u>Increase</u>	0	0	1*
# Sites with Yield <u>Decrease</u>	2**	0	0
Change in Yield	-29 to 36%	0	+15%

* Seed yield increased by 40 and 80 lb P_2O_5/ac at Roseisle 2015

** Seed yield reduced by 80 lb P_2O_5/ac seed-placed, at Melita and Carberry in 2013

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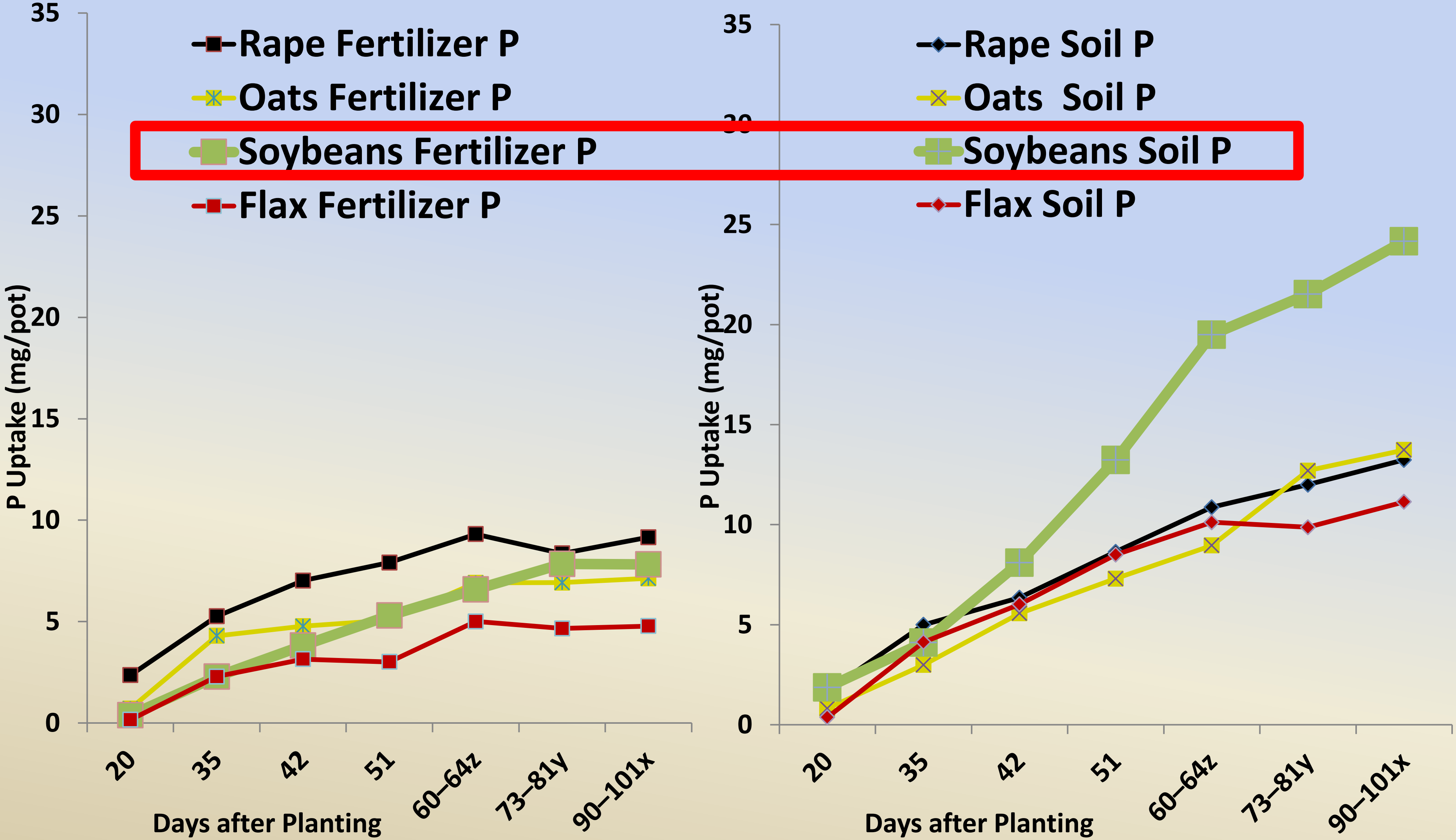
Why only 1 positive response to P in 28 site years?
Soybeans are efficient feeders for soil P in Manitoba soils



(Kalra and Soper 1968)

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Manitoba Soybean P Study #2: Soybean response to starter P fertilizer and soil P fertility from historic fertilization practices

- Located on three sites for a previous long term P fertilization trial that received 3 rates of MAP fertilizers applied each year, from 2002 until 2009, with total cumulative applications of 320, 640 and 1280 lbs P_2O_5/acre over the 8 year period
- No fertilizer P added from 2010-2012
- Soybean planted on the same sites in 2013, 2014, 2015

		Soil Test Olsen P (ppm)		
Historical P Applied (lb P/ac)	(lb P_2O_5/ac)	Brandon	Carman	Forrest
0	0	11	20	7
143	320	22	31	15
285	640	33	53	22
570	1280	54	91	40

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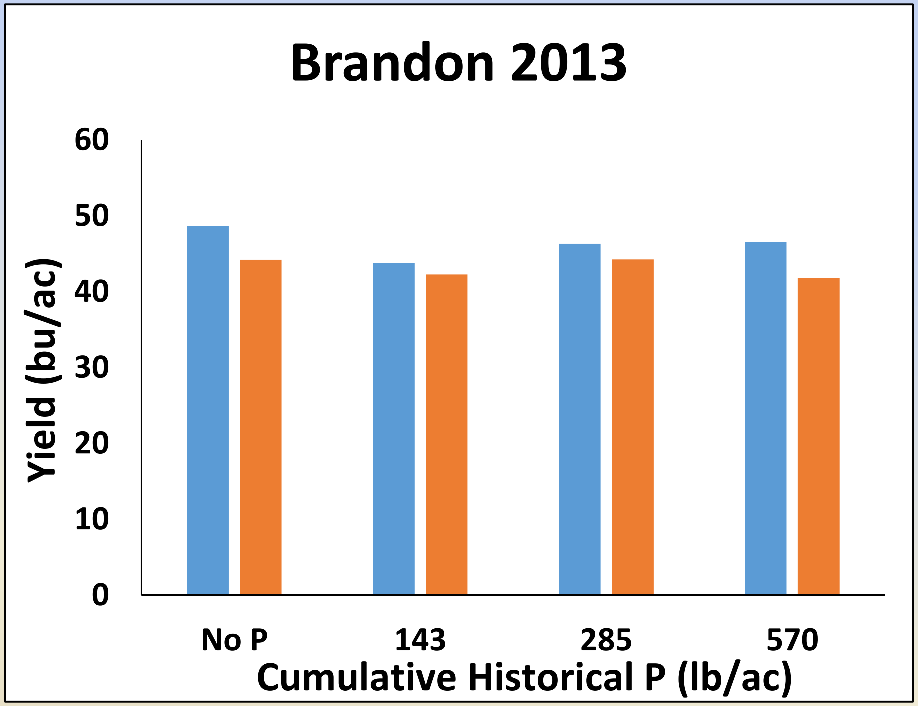
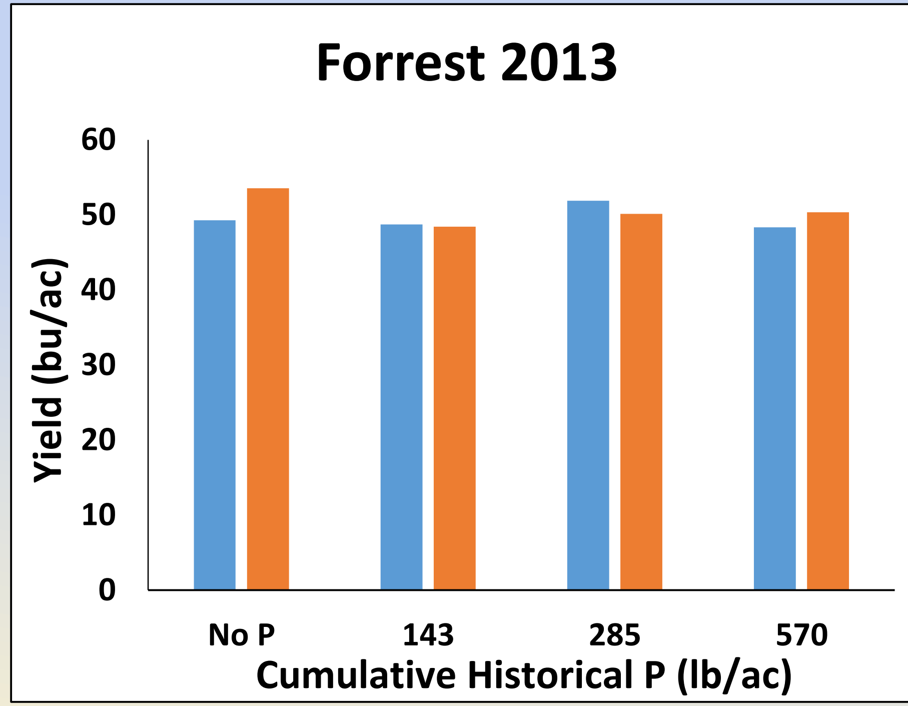
Soybean Seed Yield 2013

- no yield response to starter P or historic P fertility





With side-banded starter P (18 lb/ac)

Without starter P

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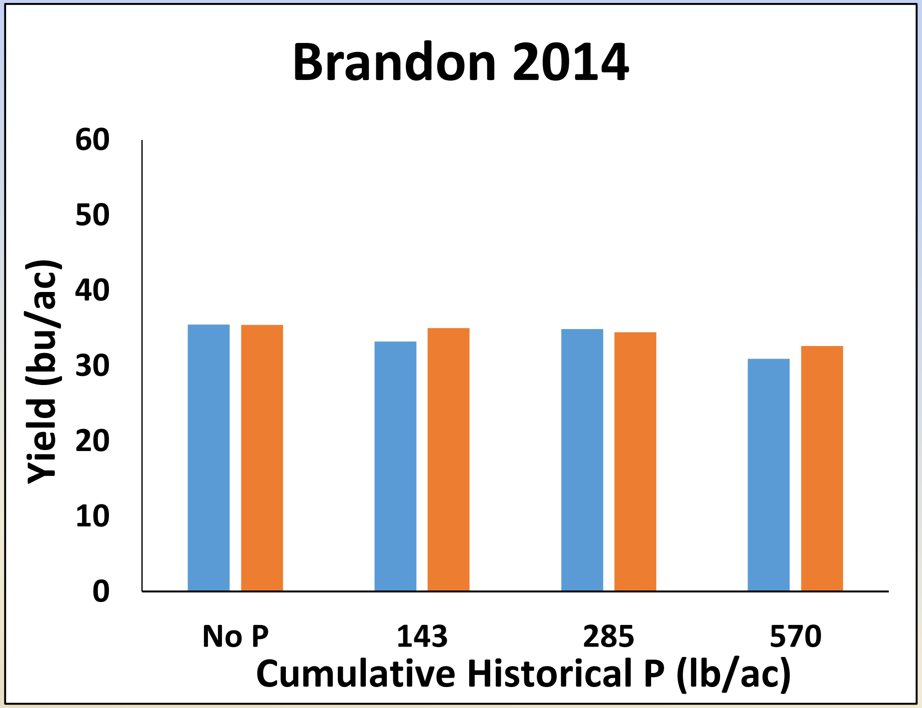
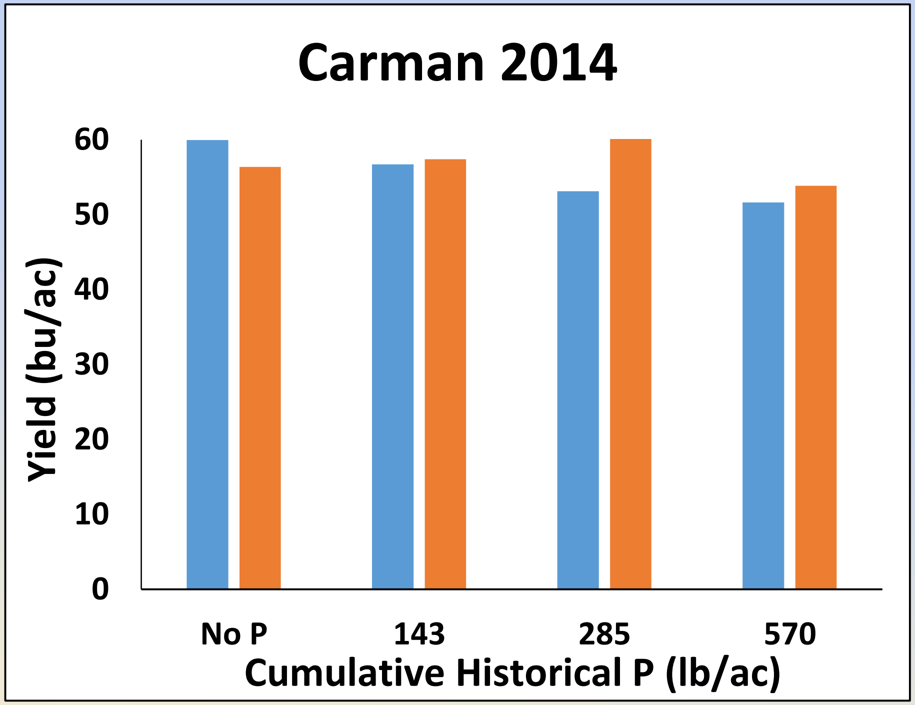
Soybean Seed Yield 2014

- no yield response to starter P or historic P fertility





With side-banded starter P (18 lb/ac, for 2nd year)

Without starter P

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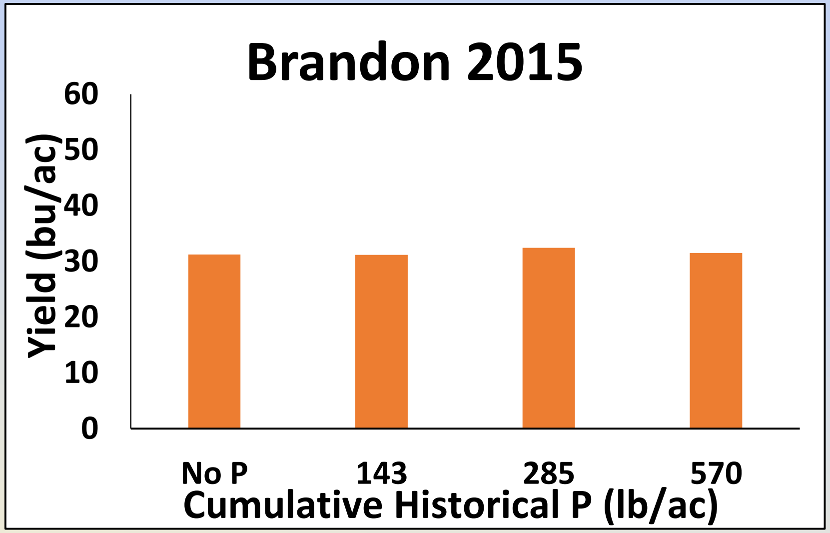
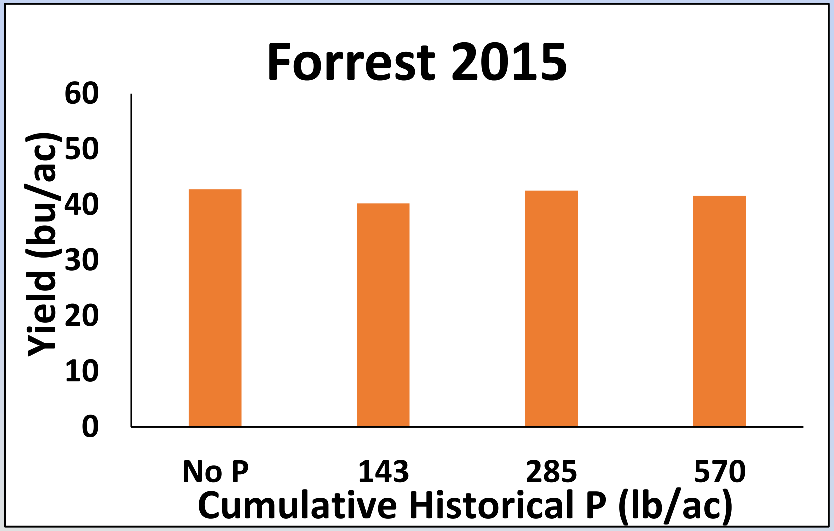
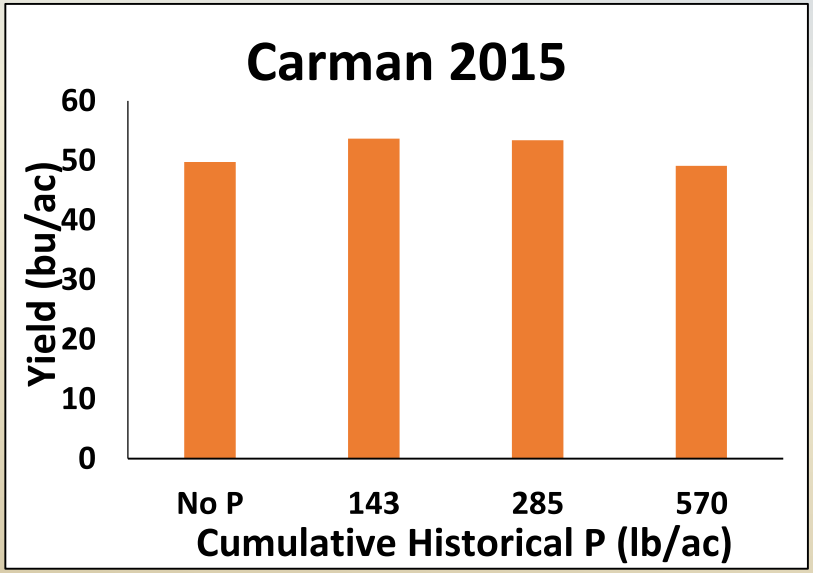
Soybean Seed Yield 2015

- no yield response to historic P fertility







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Summary and Conclusions for Manitoba Soybean P Study #2

- **The soil test threshold for soybean yield responses to long term soil P fertility and/or P fertilizer appears to be very low in Manitoba soils, lower than those in the soils tested so far (7, 11 & 20 ppm Olsen P)**
- **Observations of higher soybean yields on Manitoba soils with higher P fertility (e.g., manured soils) may be due to other factors**

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Soybeans may not "care" about P fertilizer, but what about the crop after soybeans?

The phosphorus deficit hangover ...

www.deviantart.com

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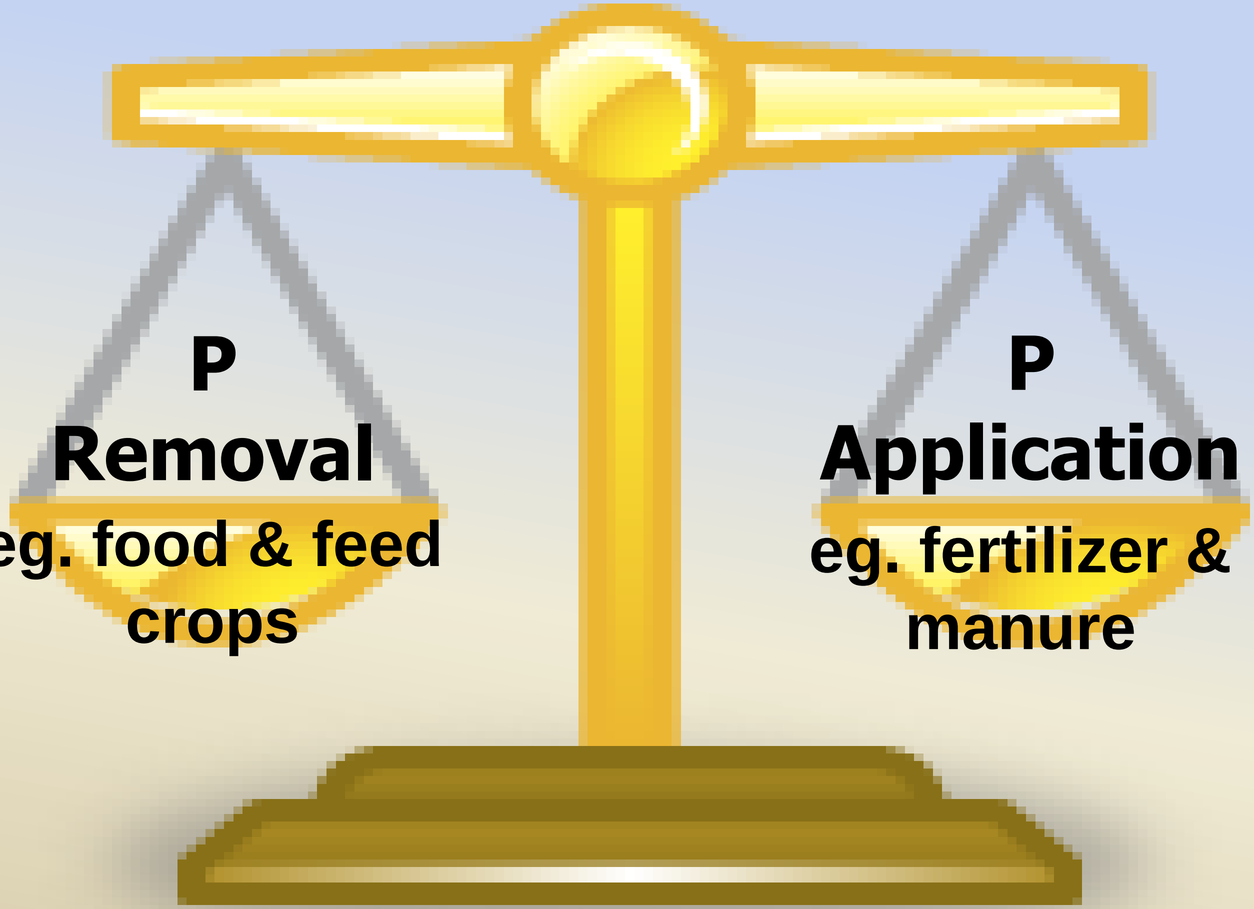
Balancing P application with crop removal is essential to avoid excessive accumulation or depletion of P in soil



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Effect of legume green manures on long term wheat yields in SK

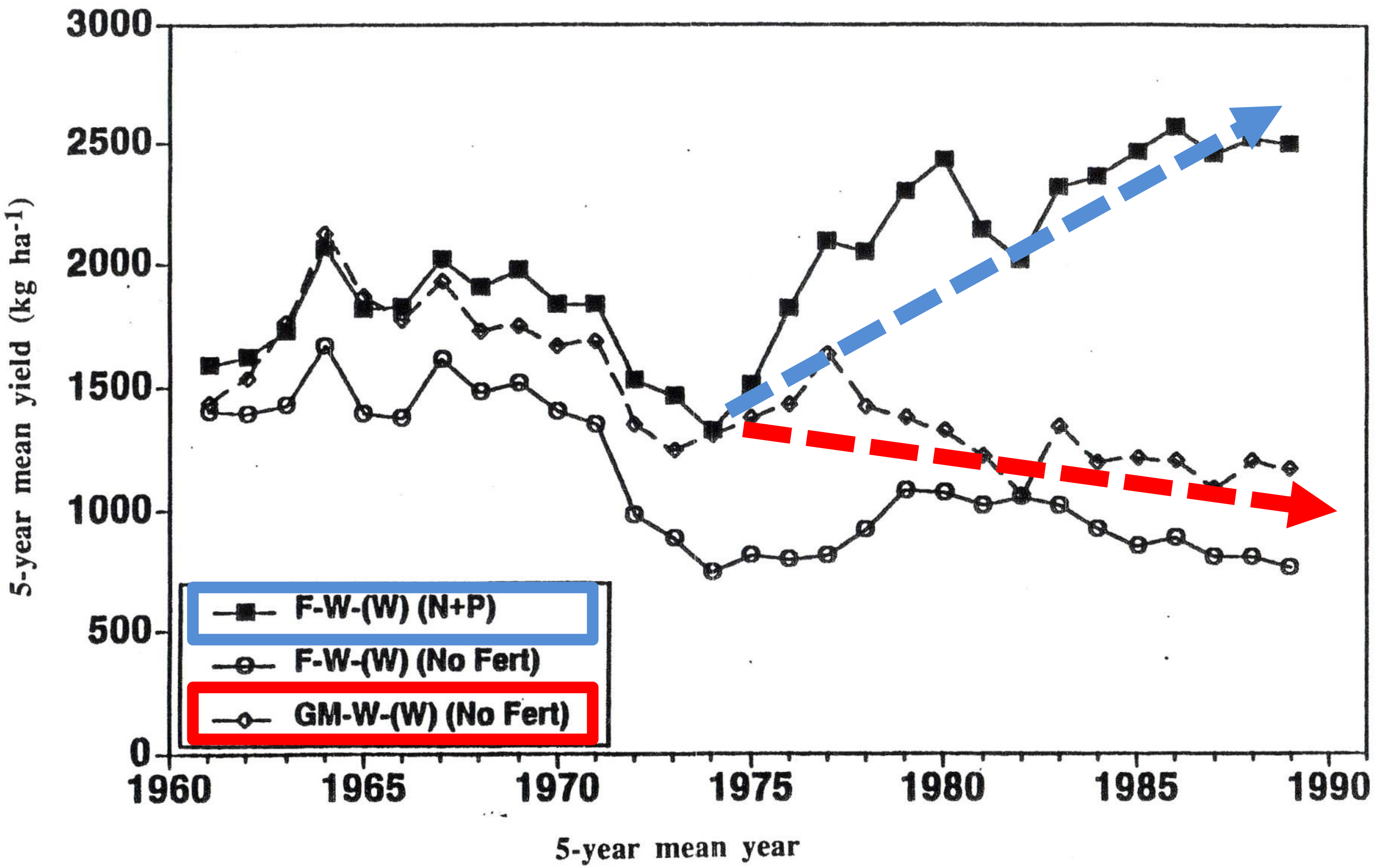
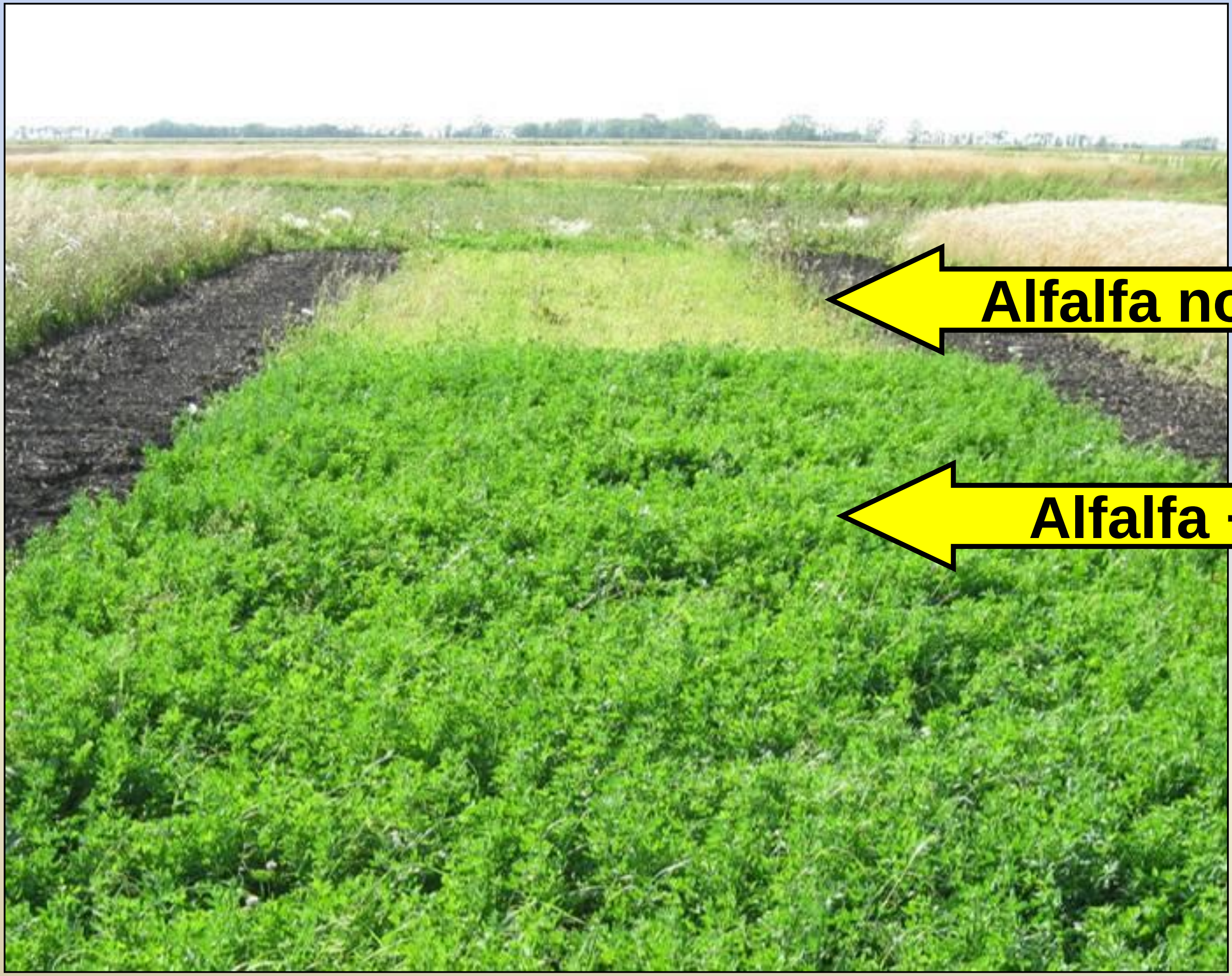


Figure 1. Yields of stubble wheat crops in fallow-wheat-wheat (F-W-W), fallow-wheat-wheat plus fertilizer (F-W-W (N+P)) and green manure-wheat-wheat (GM-W-W) rotations at Indian Head (Black soil zone) (C.A. Campbell, unpublished data).

Cowell & Doyle 1993

Dr. Martin Entz's long term organic rotation at U of MB demonstrates the importance of P replacement



Alfalfa no compost (P)

Alfalfa + compost (P)

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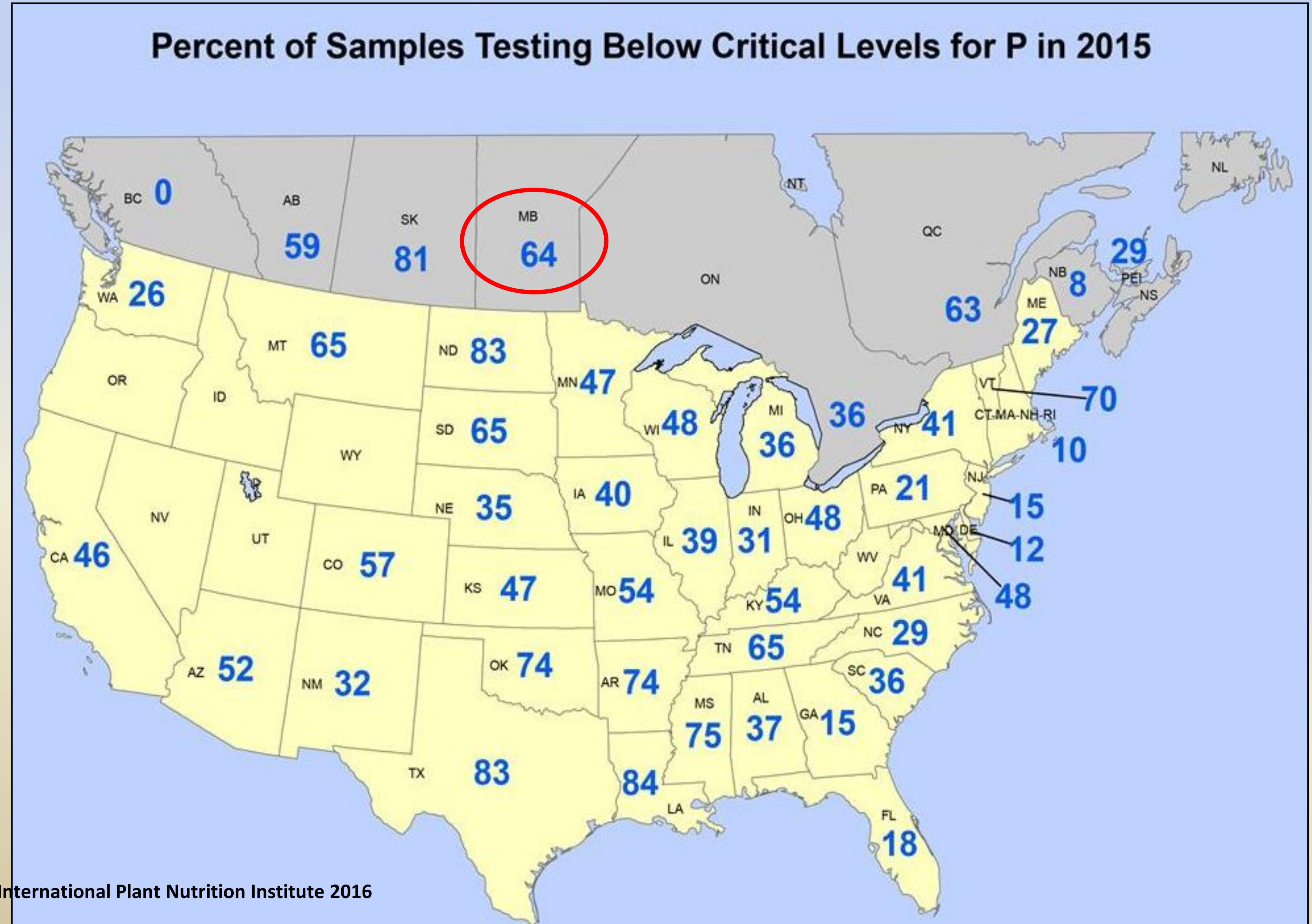
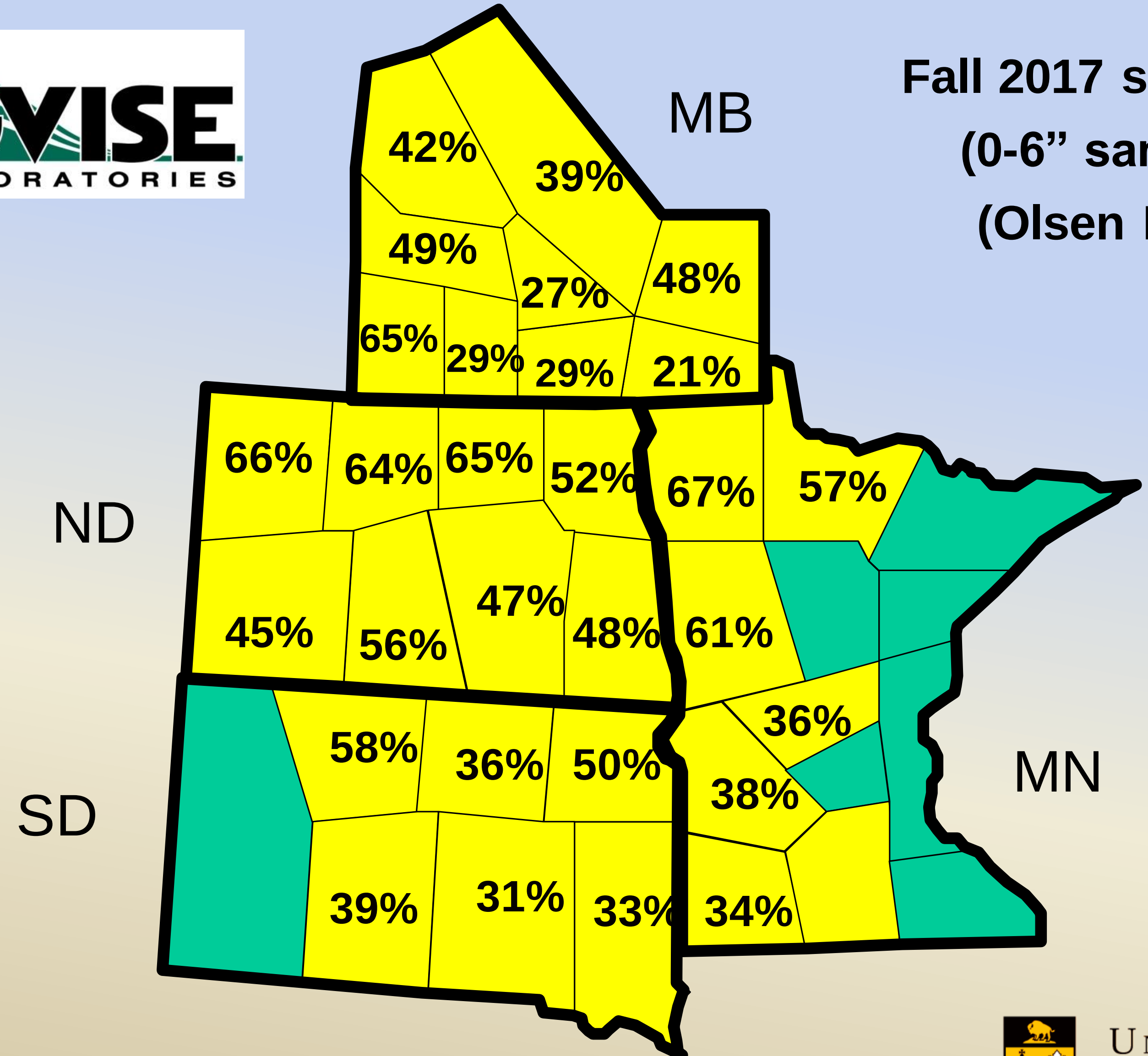
Majority of Manitoba Soils Are Deficient in P According to % Less Than Critical Level



International Plant Nutrition Institute 2016

% Soil Samples with Phosphorus less than 10 ppm



Fall 2017 samples
(0-6" samples)
(Olsen P test)

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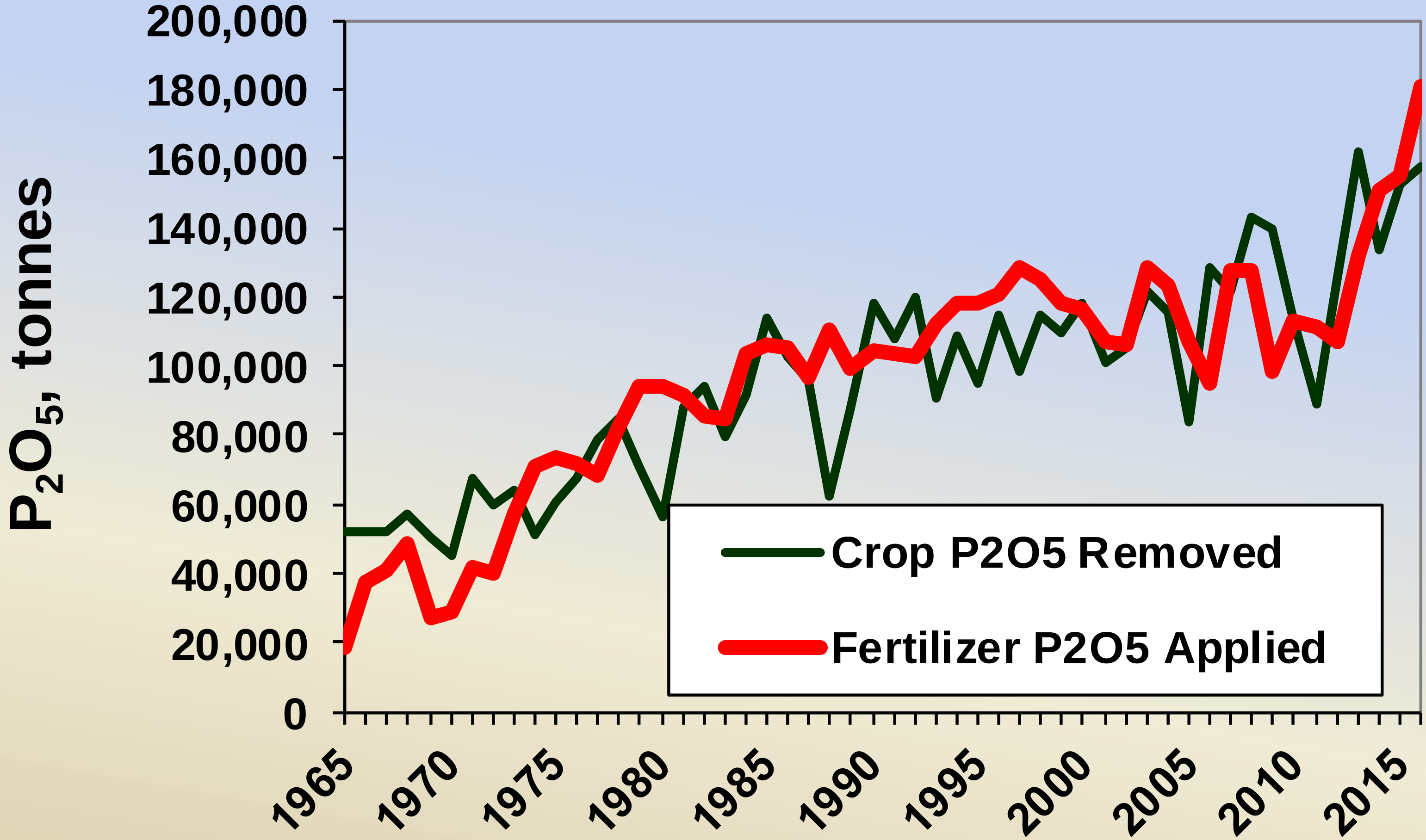
Crop Removal and Replacement of P in Manitoba (1965-2016)*



*John Heard (Manitoba Agriculture) with data from Statistics Canada data, does not include additions of manure or removal of straw P

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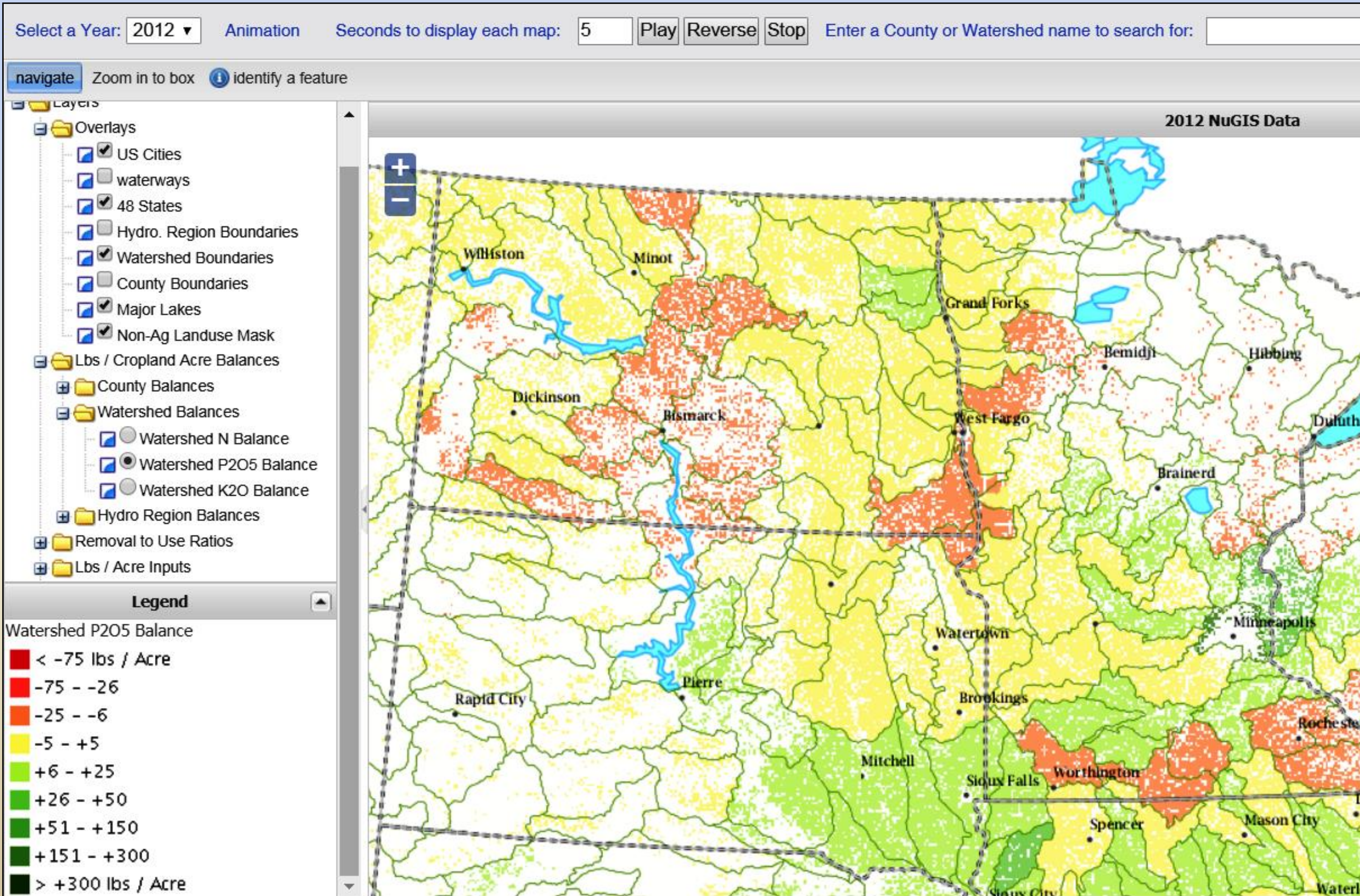
Phosphorus Balance in ND, SD, MN

IPNI. 2012. A Nutrient Use Information System (NuGIS) for the U.S. Norcross, GA. January 12, 2012. Available on line >www.ipni.net/nugis<



Manitoba's new recommendation for P fertil'n strategy: Phosphorus balance should be managed through the rotation … not just on a single crop basis

- What is the current soil P level?
  - If excess, can draw down by using only starter P
  - If near optimum, can balance input and removal
  - If low, may want to build by applying fertilizer or manure P in excess of crop removal

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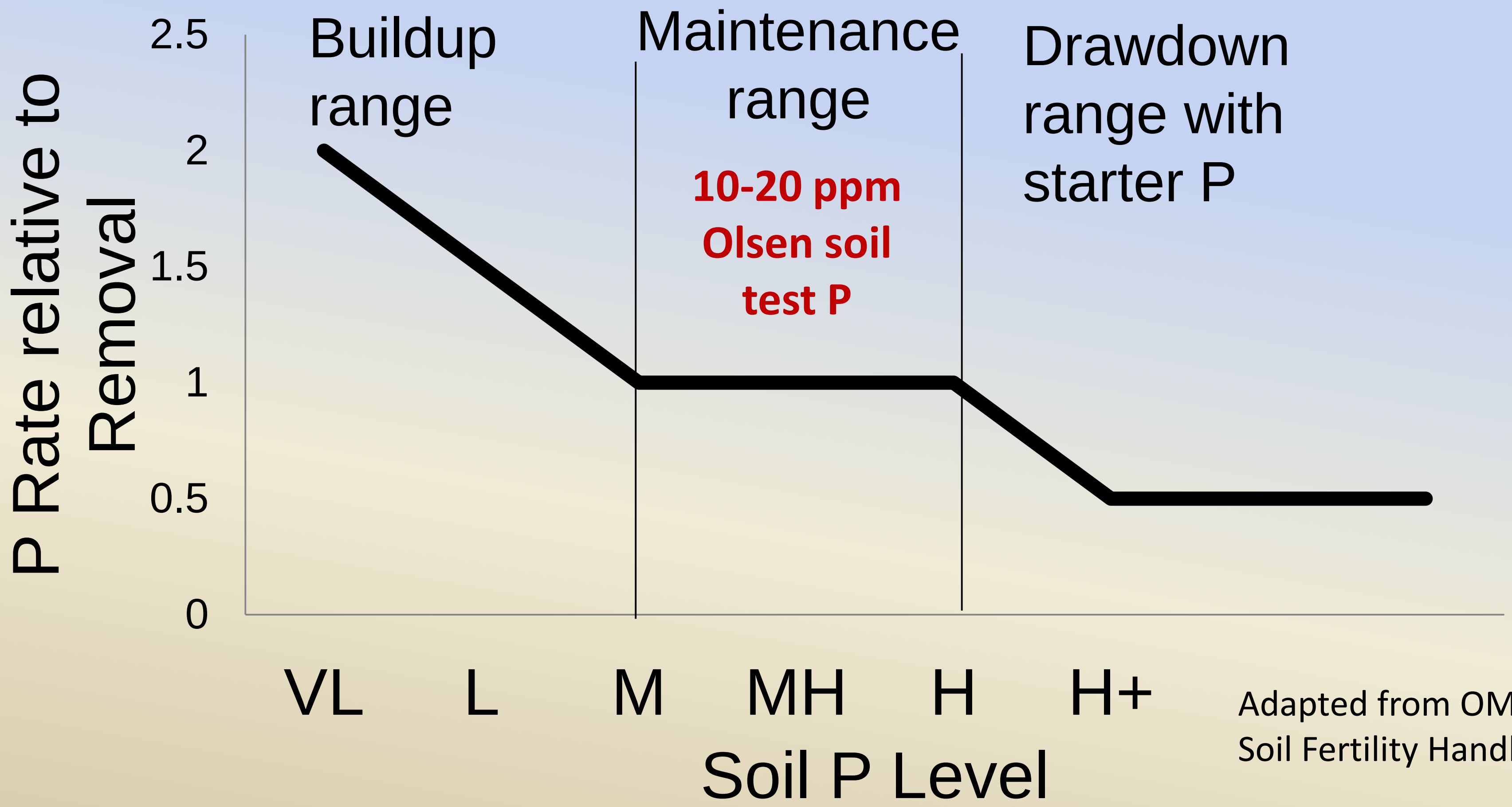
A fertilization concept to move soil P levels into an optimum range over time



Adapted from OMAFRA Soil Fertility Handbook

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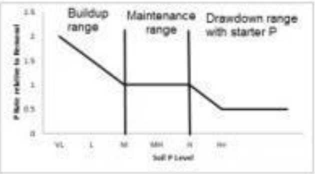
MANITOBA Pulse Soybean GROWERS

Phosphorus Fertilization Strategies



Did you know? Soybeans remove 0.84 lbs P per bushel, which means a 40 bu/ac soybean crop removes 34 lbs P/ac. Attention must be paid to ensure a proper fertilization strategy is adopted to ensure application rates are meeting removal rates through the entire crop rotation – learn more below.

Manitoba fertilizer phosphorus (P) guidelines have not been updated since 1992 and some troubling trends have been identified:

- In several of the past years the crop removal of P has surpassed the application rate of fertilizer P
- More soil test values are declining into the LOW range in some areas of Manitoba

This decline in soil test P levels (STP) may arise for a number of reasons:

- Changing crop acreages– from relatively low P removal crops of cereals and flax to canola, soybeans and corn
- Move to low disturbance seeders and planters with narrow openers and wide row spacings (low seedbed utilization) which limit the safe rate of seed row applied fertilizer, especially with sensitive crops such as canola and soybeans
- Promotion and adoption of low P rate starter fertilizers that do not replace P that is removed by crops
- Increase in grain yields since development of original MAFRD recommendations in the early 1990s due to breeding (ie introduction of hybrid canola, general purpose spring wheats etc.) and technology (ie fungicide use)
- Provincial recommendation tables do not include yield adjustment factors, so rates have been inadequate to meet current yield levels, let alone match rates of P removal

Thinking about your cropping system, or that your client, does P applied equal P removed? Or are crop removal rates exceeding P applied, leading to a negative soil P balance? Use the Interactive Phosphorus Balance Calculator to determine your annual P balance:

Interactive Phosphorus Fertilization Calculator

Phosphorus Recommendation Strategies for Manitoba

Manitoba Soil Fertility experts have collaborated to develop "Phosphorus Fertilization Strategies for Long Term Agronomic and Environmental Sustainability" which outlines

Phosphorus Balance Calculation for a Rotation (Version 4 - October 1, 2014)

Crop	Typical Yield	Yield Units	P Applied	P Removed* per unit	P Removed* per acre	Annual Balance
			------------ (lb P_2O_5/ac) ------------			
HR Spring wheat	60	bu/ac	30	0.59	35	-5
Winter wheat	75	bu/ac	30	0.51	38	-8
Barley		bu/ac		0.42	0	0
Oats		bu/ac		0.26	0	0
Canola	40	bu/ac	20	1.04	42	-22
Soybeans	40	bu/ac	10	0.84	34	-24
Peas		bu/ac		0.69	0	0
Flax		bu/ac		0.65	0	0
Corn (grain)		bu/ac		0.44	0	0
Other**				0.00	0	0
Total for Rotation			90		149	-59

Notes: Does not account for nutrients removed when straw or chaff is removed or burned

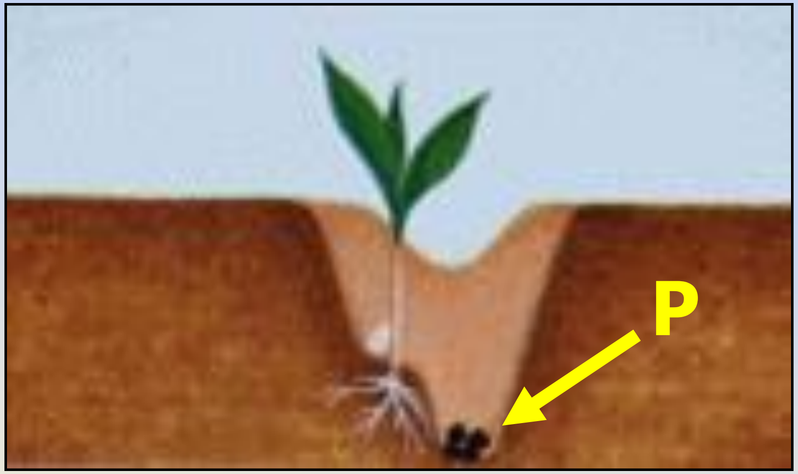
Fill in any of the blue cells for typical rotation, yields, and P appl'n

*P removal figures are estimates from the Manitoba Soil Fertility Guide.

**For nutrient removal in other crops see table in next worksheet.

Almost all fertilizer P in the Canadian Prairies is banded under soil surface, in or near seed, at planting

- Agronomically beneficial, especially in cold soils in areas with short growing season
- Environmentally beneficial because P placed under soil surface after spring snowmelt runoff



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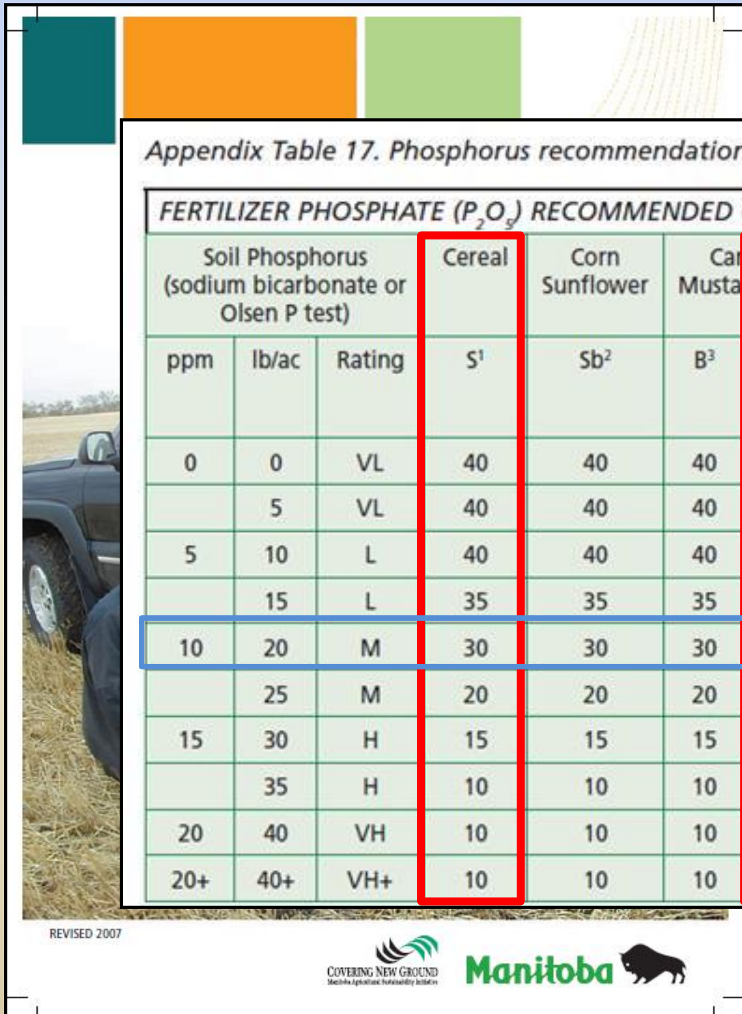
P sufficiency strategy for short term (fertilizing for optimum economic responses in first year after application) often decreases P fertility for long term



Appendix Table 17. Phosphorus recommendations for field crops based on soil test levels and placement[76].

FERTILIZER PHOSPHATE (P_2O_5) RECOMMENDED (lb/ac)																
Soil Phosphorus (sodium bicarbonate or Olsen P test)			Cereal	Corn Sunflower	Canola Mustard Flax		Buckwheat Fababeans		Potatoes		Peas Lentils Field beans[1] Soybeans[1]		Legume forages		Perennial grass forages	
ppm	lb/ac	Rating	S[1]	Sb[2]	B[3]	S[1]	B[3]	S[1]	B[3]	PPI[4]	B[3]	S[1]	seeding PPI[5]	Est. stand BT[6]	seeding PPI[5]	Est. stand BT[6]
0	0	VL	40	40	40	20	40	20	55	110	40	20	75	55	45	30
	5	VL	40	40	40	20	40	20	55	110	40	20	75	55	45	30
5	10	L	40	40	40	20	40	20	50	100	40	15	75	55	45	30
	15	L	35	35	35	20	35	20	45	90	35	15	65	50	35	20
10	20	M	30	30	30	20	30	20	45	90	30	10	60	40	30	20
	25	M	20	20	20	20	20	20	40	80	20	10	50	35	20	15
15	30	H	15	15	15	0	15	20	35	70	15	0	45	30	15	10
	35	H	10	10	10	0	10	20	30	60	10	0	30	20	0	0
20	40	VH	10	10	10	0	10	20	30	60	10	0	30	20	0	0
20+	40+	VH+	10	10	10	0	10	20	30	60	10	0	25	20	0	0

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Following short term "P sufficiency" strategy for seed-row P from MB Soil Fertility Guide leads to P deficits

P balance for 4 year rotation: Following MB Soil Fertility Guide Rec. for 10 ppm Olsen P				
Crop	Yield (bu/ac)	P Applied ----------	P Removed* (lb P_2O_5/ac)	Annual Balance ----------
GP spring wheat	60	30	35	-5
Canola	40	20	40	-20
Winter wheat	75	30	38	-8
Soybeans	35	10	30	-20
4 Year Total		90	143	-53

* Using 0.59, 1.0, 0.51, 0.85 lb P_2O_5/bu respectively for grain only

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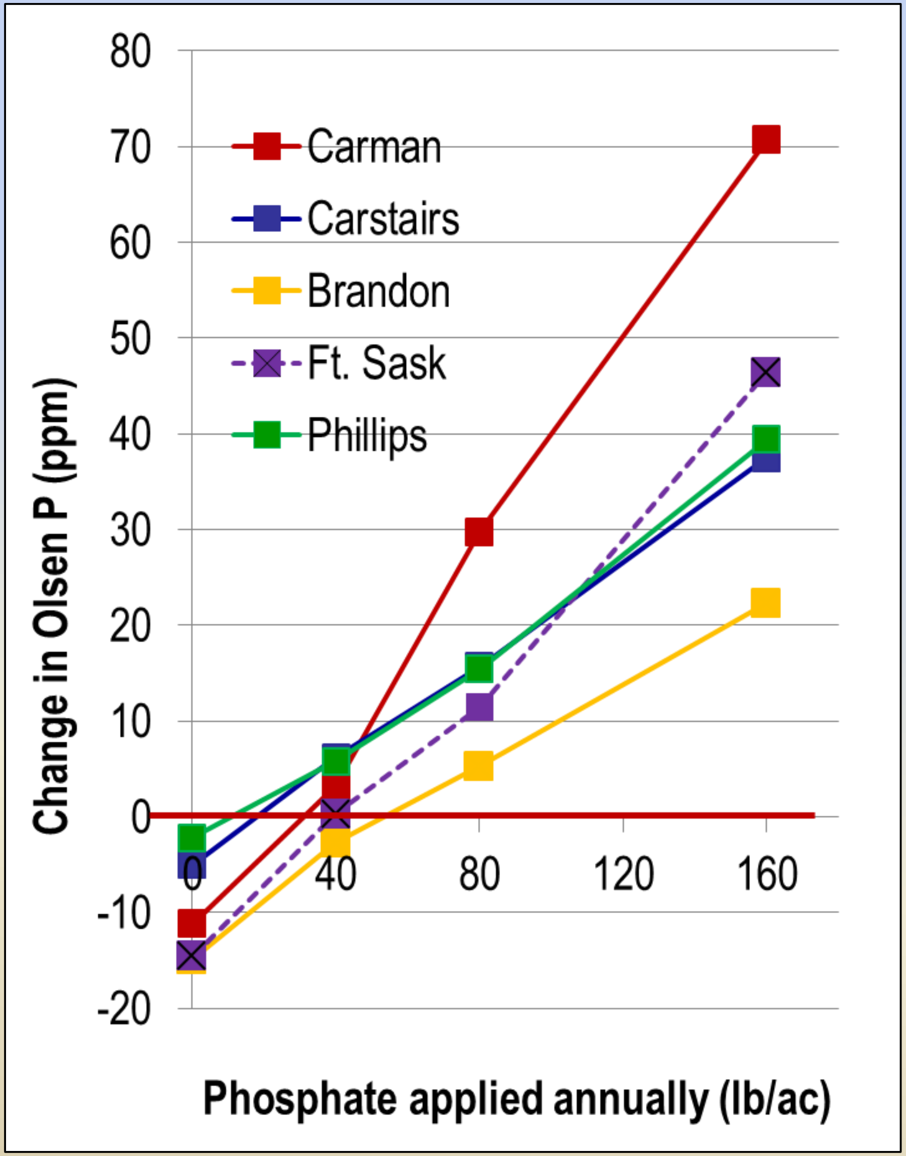
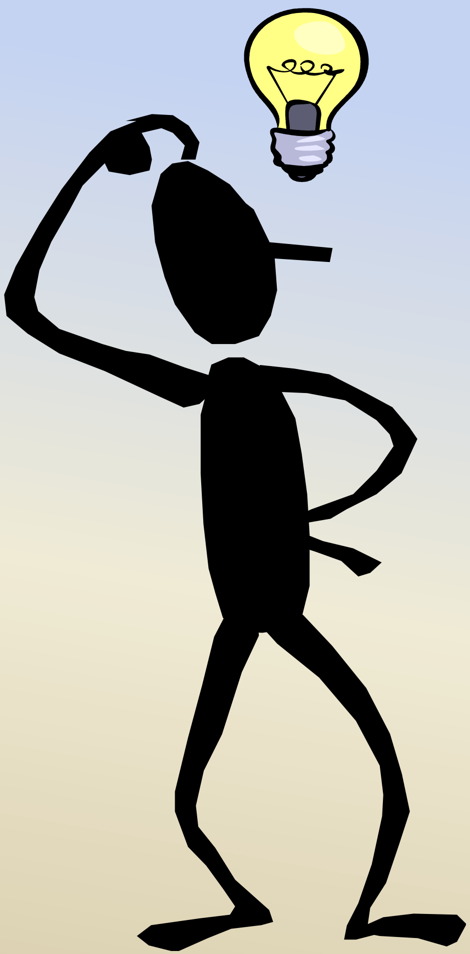
Olsen P also followed P balance in Alberta and Manitoba soils after 8 years of P applications in a durum-flax rotation

- **Large increases in Olsen P occurred with high P rates**
- **Olsen P declined when no P applied**
- **At 40 lb phosphate/acre/year, Olsen P was maintained at most sites (but flax P removal is low)**
- **Surplus P to raise Olsen P by 1 ppm:**
  - **16-23 lb P_2O_5/ac at Carman**
  - **29-32 lb P_2O_5/ac at Carstairs**
  - **27-35 lb P_2O_5/ac at Brandon**
  - **21-25 lb P_2O_5/ac at Ft. Sask.**
  - **32-41 lb P_2O_5/ac at Phillips**



Grant et al. unpublished

Recommended Strategies for Maintaining P Fertility in Soybean Fields



- **Apply sufficient P in sidebands or midrow bands to match crop removal on annual basis**
- **Use a rotational fertilization strategy over several years :**
  - **Add extra P to crops in rotation that tolerate high rates of seed-placed P**
  - **Periodically band P into soil during fall tillage ... eg. MAP with AS prior to canola, which responds to fert. P & N**
  - **Build soil P to target level, but avoid excess accumulation, eg. manure applied at rate to meet crop N requirements will provide P benefit for several years**

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Rotational Fertilization Strategies for P Balance

Annual & Overall P Balance for P Strategies in 4 Year Rotation					
Crop	Yield	MB SFG	Max Seed Row P	N-Based Manure in 1st yr	P Maint. with Sideband
	(bu/ac)	------------- (lb P_2O_5/ac) -------------			
GP spring wheat	60	-5			
Canola	40	-20			
Winter wheat	75	-8			
Soybeans	35	-20			
4 Year Total		-53			

* Using values of 0.59, 1.0, 0.51, 0.85 lb P_2O_5/bu respectively for grain only

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Why not simply broadcast P?

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Broadcasting P fertilizer, especially in conservation tillage systems leaves water soluble P on the soil surface ... prone to runoff ... especially if applied in fall

An invitation to regulation ...

Why is phosphorus balance important?

Food - P is a unique element that is essential for almost all life

Source: Christiansen/ Scientific American

Water - small amounts of excess P cause big problems with water quality

Photo: MB Conservation

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Main Problem: Excess P and "Algae"

"Eutrophication" occurs at very low conc'ns of P (20-50 ppb):

- Blue-green "algae" (cyanobacteria)
- Oxygen Depletion
  - Fish kills
- Nerve and Liver Toxins
  - Livestock & wildlife mainly at risk

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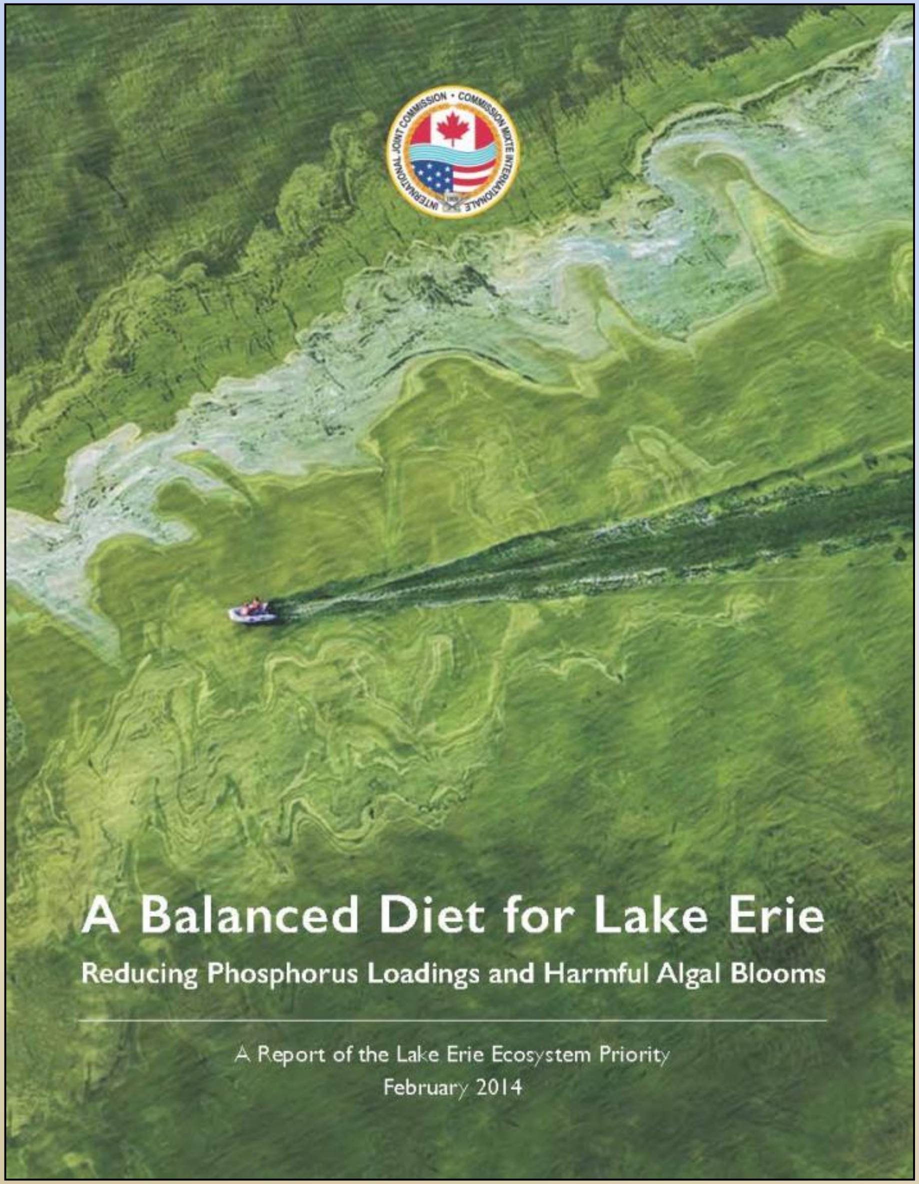
International Joint Commission Report on Improving Water Quality in Lake Erie – February 2014



"The control of phosphorus in agricultural operations must focus on changes in agricultural practices that have been implemented in recent decades, such as <u>increased prevalence of fall application of nutrients, applying two years' worth of fertilizer in a single application, and broadcast application</u>."

page 7 of International Joint Commission (2014). A Balanced Diet for Lake Erie: Reducing Phosphorus Loadings and Harmful Algal Blooms. Report of the Lake Erie Ecosystem Priority.

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Excess P & toxic blue-green algae in Lake Erie shuts down water supply to Toledo, Ohio – August 2014

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THE WALL STREET JOURNAL. U.S.

U.S. NEWS

Ohio Regulators Aim to Help Water Problem With Fertilizer Licenses

Farmers in Ohio to Be Required to Get New Certification to Use Fertilizers

Email Print 22 Comments

By MARK PETERS and MATTHEW DOLAN CONNECT

Updated Aug. 5, 2014 7:47 p.m. ET

Algae floats in Lake Erie on Monday at Maumee Bay State Park in Oregon, Ohio. *Getty Images*

The drinking-water crisis in one of Ohio's largest cities is drawing attention to a new requirement for farmers in the state: a license to fertilize.

Popular Now What's This?

ARTICLES

1 The $140,000-a-Year Welding Job

2 Search for Paris Attack Suspects Intensifies

3 Opinion: How to

Y
A

Public Concern About Agricultural Nutrients and Water Quality is Increasing

WINNIPEG FREE PRESS, TUESDAY, DECEMBER 10, 2002 LOCAL A11

Lake Winnipeg pollution blamed on farm runoff

By Helen Fallding

FARM runoff may be the biggest source of pollution in Lake Winnipeg and the province's southern rivers, according to a new study by Manitoba Conservation.

About three-quarters of the phosphorus added to the Assiniboine and Red rivers as they passed through Manitoba from 1994 to 2001 had washed off the land. The figures are almost as bad for nitrogen, which combines with phosphorus to promote the growth of algae blooms.

The blooms are bad for fish and wildlife and can produce dangerous toxins.

University of Winnipeg biologist Eva Pip, who has read the report, said many people assumed municipal sewage was the biggest culprit behind the deteriorating health of Lake Winnipeg.

"There's always been finger-pointing... but now that we have some actual numbers, this gives us a starting point which we can use to start addressing the problem."

In a previous study completed last year, Manitoba Conservation staff concluded that nitrogen and phosphorus loads in Lake Winnipeg increased 13 and 10 per cent respectively over the last three decades as a result of changes in the Red River basin.

"Those are very significant values in a short time," Pip said.

A Lake Winnipeg snail recently declared endangered is an early warning sign that the lake is in trouble, she said.

Lake Winnipeg has had very bad algae blooms for the last five years, including some this summer at Victoria Beach and on the western shore as far north as the Jackhead reserve, Pip said.

She is calling for more regulation of the nutrients farmers apply to their land.

The latest Manitoba Conservation study, led by Alex Bourne, did not separate the effects of chemicals from manure or natural sources.

Manitoba's livestock farmers are required to monitor the amount of nitrogen they apply in manure, but phosphorus is regulated only in Quebec.

Livestock farmers have long complained they are subject to much greater scrutiny than the majority of their neighbours who use chemical fertilizer — soon to be regulated in Ontario after the Walkerton contaminated water scandal.

Keystone Agricultural Producers vice-president David Rolfe said quality assurance programs that require farmers to better manage their fertilizer if they want to be certified might be a better approach than more regulation.

Manitoba's water quality manager Dwight Williamson said a discussion paper should be out within six months on setting water quality objectives in the Assiniboine, Souris and Qu'Appelle rivers.

Manitoba Agriculture staff already have extension programs encouraging farmers to invest in soil testing so they don't waste fertilizer and to use low-till agriculture to keep water on the land. "We do this all the time," John Heard said.

When fertilizer prices are high, farmers have more incentive to keep their fertilizer use to a minimum, he said.

Pip said the move to drain more farmland — supported by increased government dollars — is also contributing to runoff problems.

Manitoba has no control over pollutants in the rivers before they cross the U.S. and Saskatchewan borders.

Winnipeg's wastewater treatment plants and sewers added more than 4,000 tonnes of nitrogen to the Red River a year, according to the Manitoba Conservation study — 11 per cent of the total load in the river at Selkirk.

Pip said the nutrient load will be worse now that the city has added orthophosphate to drinking water to deal with elevated lead levels from old pipes.

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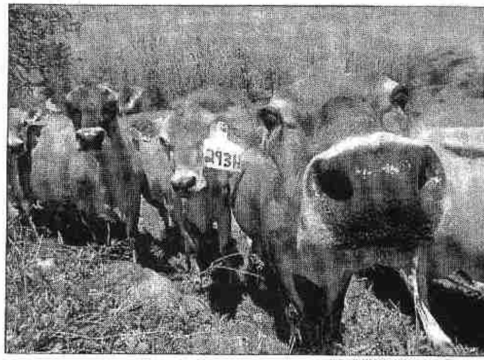

MICHAEL MOORE / ASSOCIATED PRESS ARCHIVES

Over-fertilizing of fields is common in livestock-abundant areas.

Over-fertilizing polluting province's water bodies

By Helen Fallding

FARMERS in livestock-intensive areas of Manitoba are over-fertilizing their land, potentially contributing to water pollution as far away as Lake Winnipeg.

In an $81,000 study for the Manitoba Livestock Manure Management Initiative, DGH Engineering found the nutrients nitrogen and phosphorus building up in soils in the rural municipalities of Hanover and La Broquerie near Steinbach.

In two other municipalities where there is less livestock production — Roland, south of Carman, and Sifton in western Manitoba — there was less buildup.

Excess nutrients not taken up by crops wash off fields into streams and rivers, with Red River nutrients eventually working their way to Lake Winnipeg. The lake has been plagued with bad algae blooms in recent years that are toxic to fish and wildlife and interfere with the enjoyment of summer beaches.

DGH senior engineer Doug Small said farmers applying manure to their fields from livestock barns are also applying some chemical fertilizer.

In Roland, fertilizer inputs average 85 kilograms per hectare of nitrogen and 14 kilograms per hectare of phosphorus, but the numbers in Hanover are 98 for nitrogen and 32 for phosphorus.

"We're not saying it's an immediate serious crisis," Small said. "There's an issue here that needs to be addressed for long-term sustainability."

Only about five per cent of Manitoba farmland receives animal manure.

Small said the obvious solution is for farmers using manure to cut back more on expensive chemical fertilizers — something that would save them money and conserve the natural gas used to make fertilizer.

The owners of large livestock operations are required by the province to test the soil where their manure is applied to monitor levels of nitrogen, but phosphorus is not yet regulated.

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Importance of Water Quality

StarTribune DANGER DOWNSTREAM

MINNESOTA'S
THREATENED RIVERS

Story by Josephine Marcotty • Photo and video by Aaron Lavinsky • Star Tribune

SUNDAY, OCTOBER 2, 2016

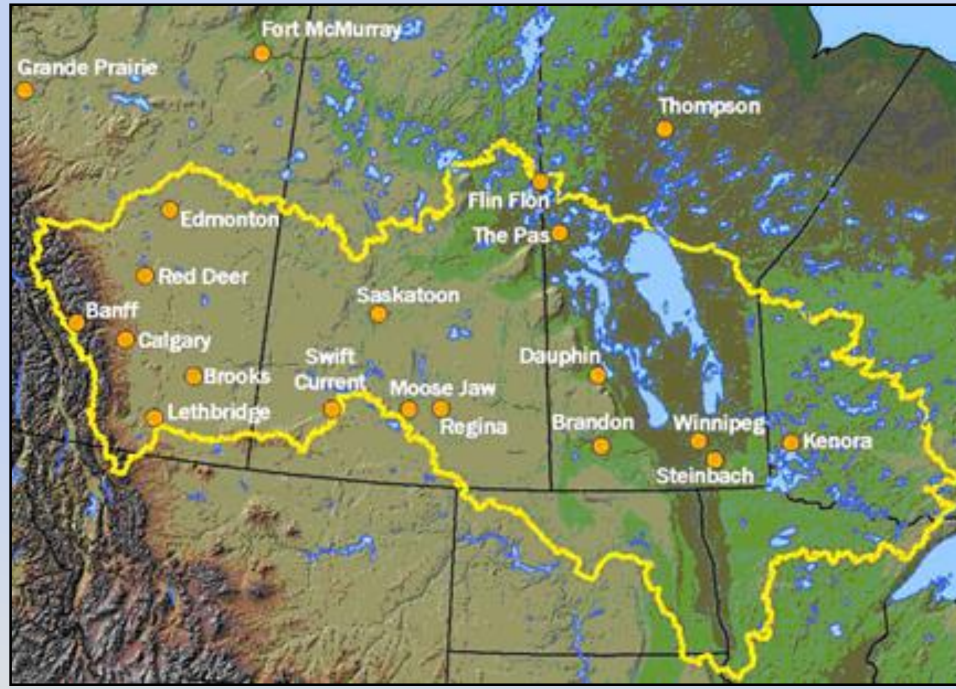
StarTribune DANGER DOWNSTREAM

PART 2: THE RED RIVER POLLUTED RIVER'S TOLL

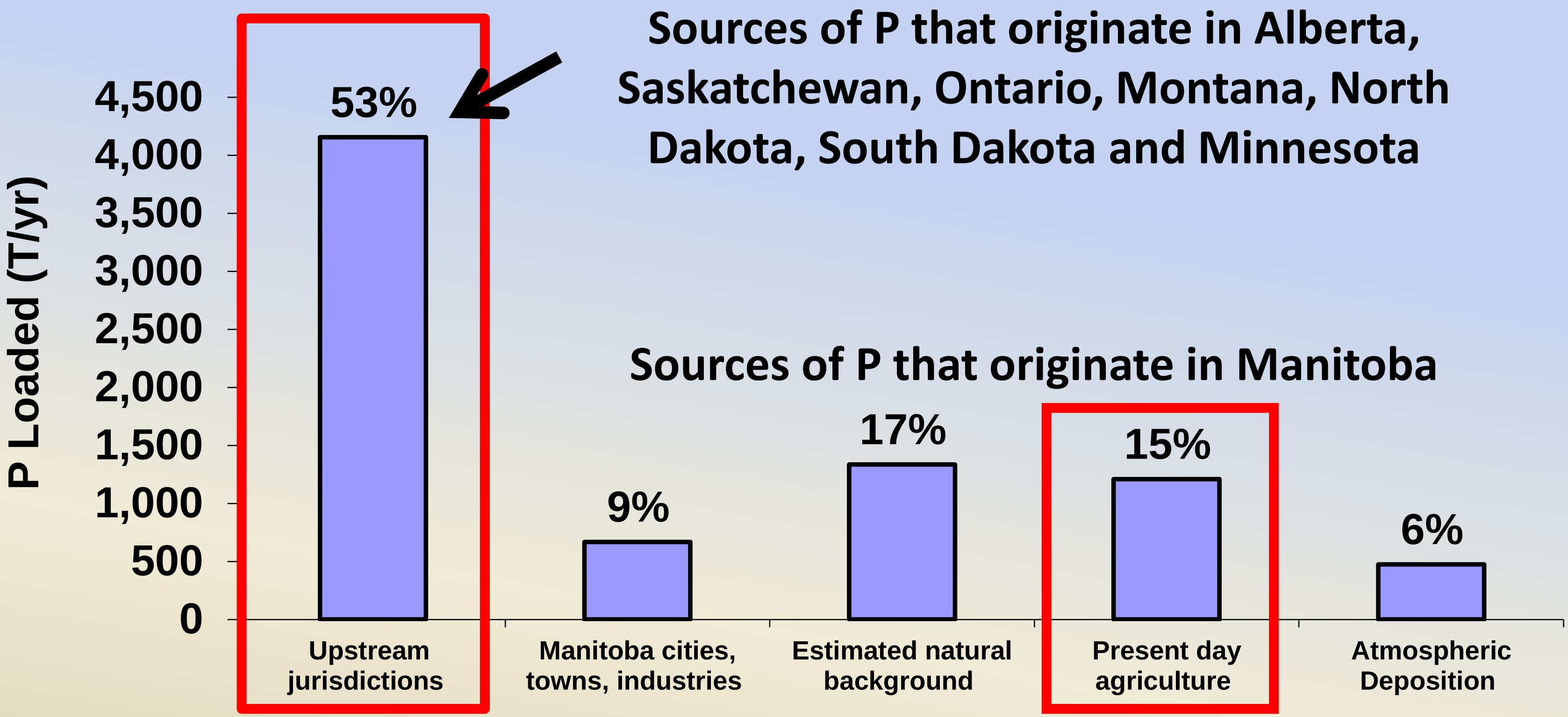
The Red River winds through a sweeping landscape of farms, carrying chemicals downriver that are poisoning Lake Winnipeg – a fate that Minnesota's other rivers could face.

Lake Winnipeg Basin

- 2nd largest watershed in Canada (380,000 square miles)
- over 50% of the watershed is used for agriculture
- relatively dry climate, where runoff dominated by snow-melt over relatively level landscape
- home to 6.6 million people in 4 provinces and 4 states

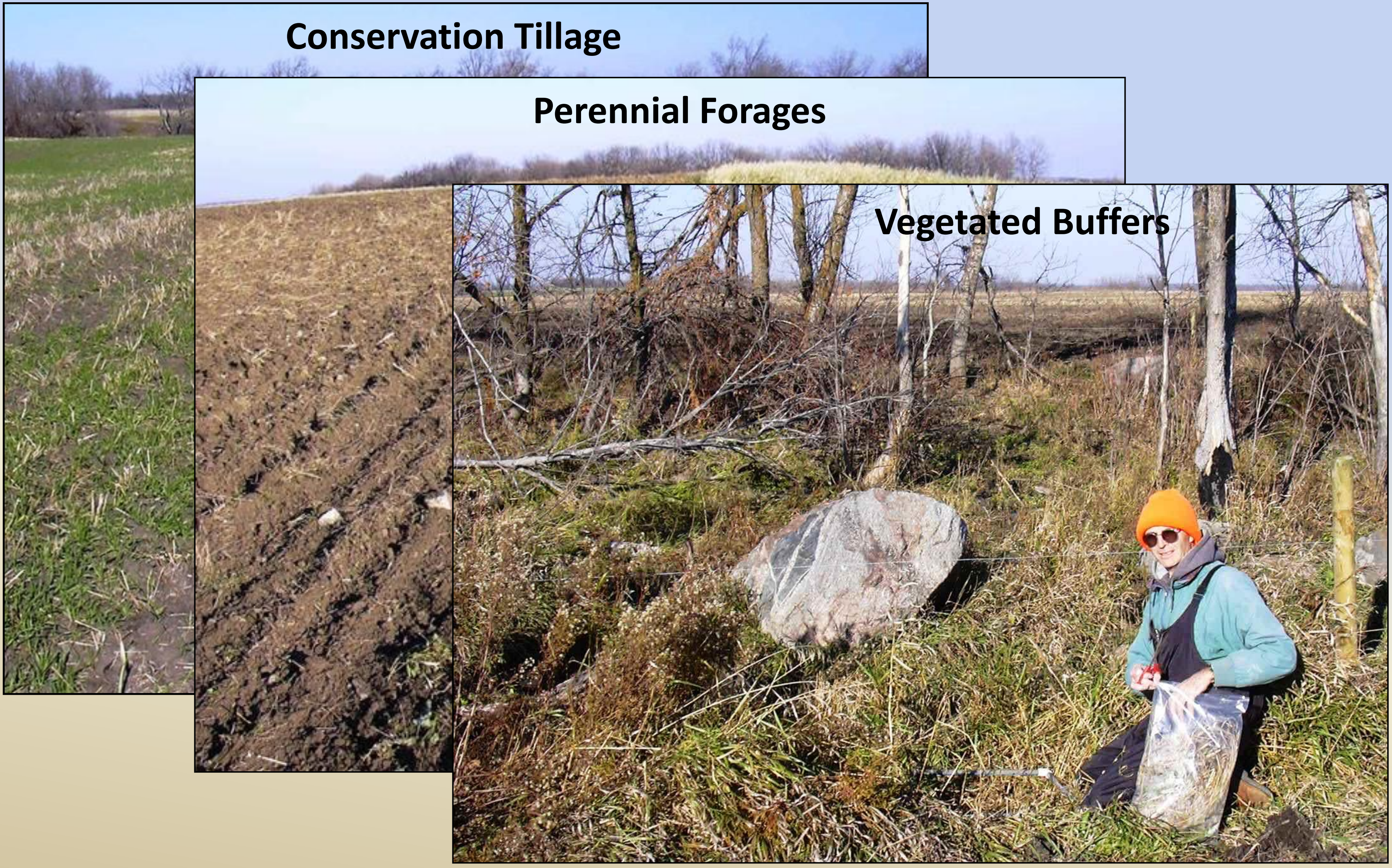


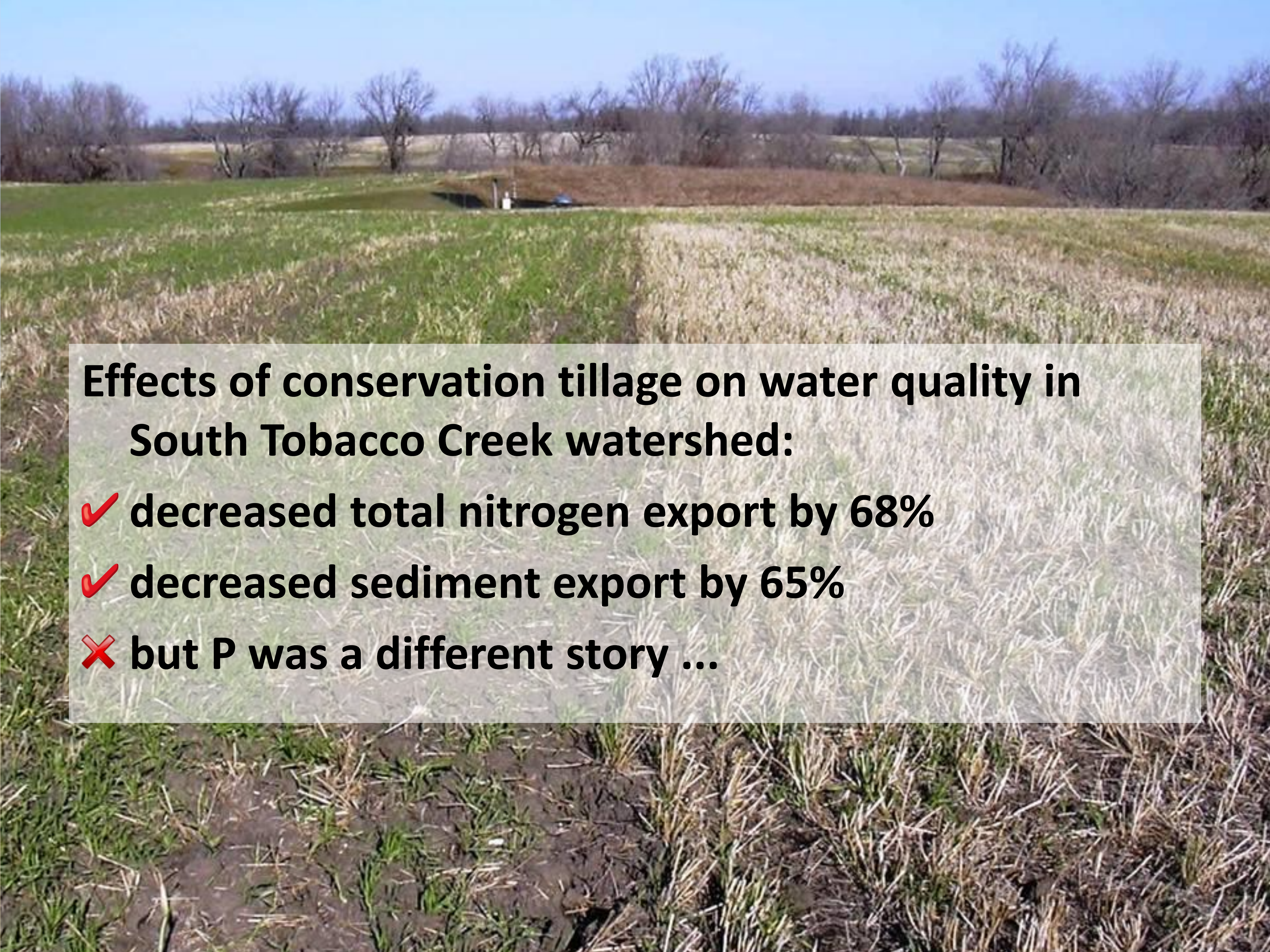
Lake Winnipeg's P comes from many relatively small sources



Manitoba Water Stewardship. 2006. Questions and Answers: Water Quality Management Zones for Nutrients (data are estimated for 1994-2001)

Managing P loss with traditional soil and water conservation BMPs

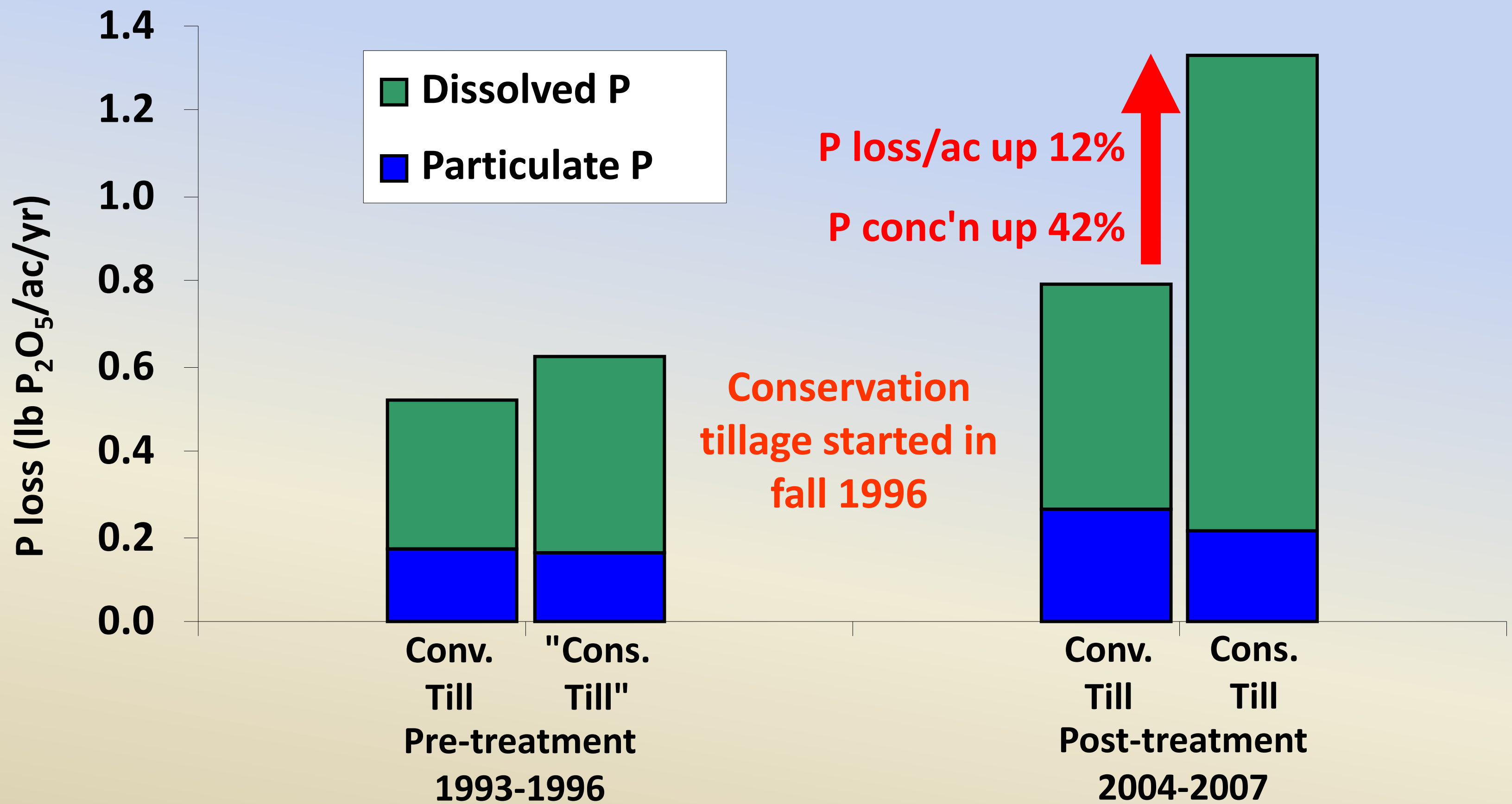




Effects of conservation tillage on water quality in South Tobacco Creek watershed:

- ✔ decreased total nitrogen export by 68%
- ✔ decreased sediment export by 65%
- ✘ but P was a different story ...

South Tobacco Creek twin watershed study: P loss from conservation tillage was <u>greater</u> than from conventional tillage ... because erosion of soil particles was a minor contributor to P loss in both systems



(Tiessen et al. JEQ 2010)

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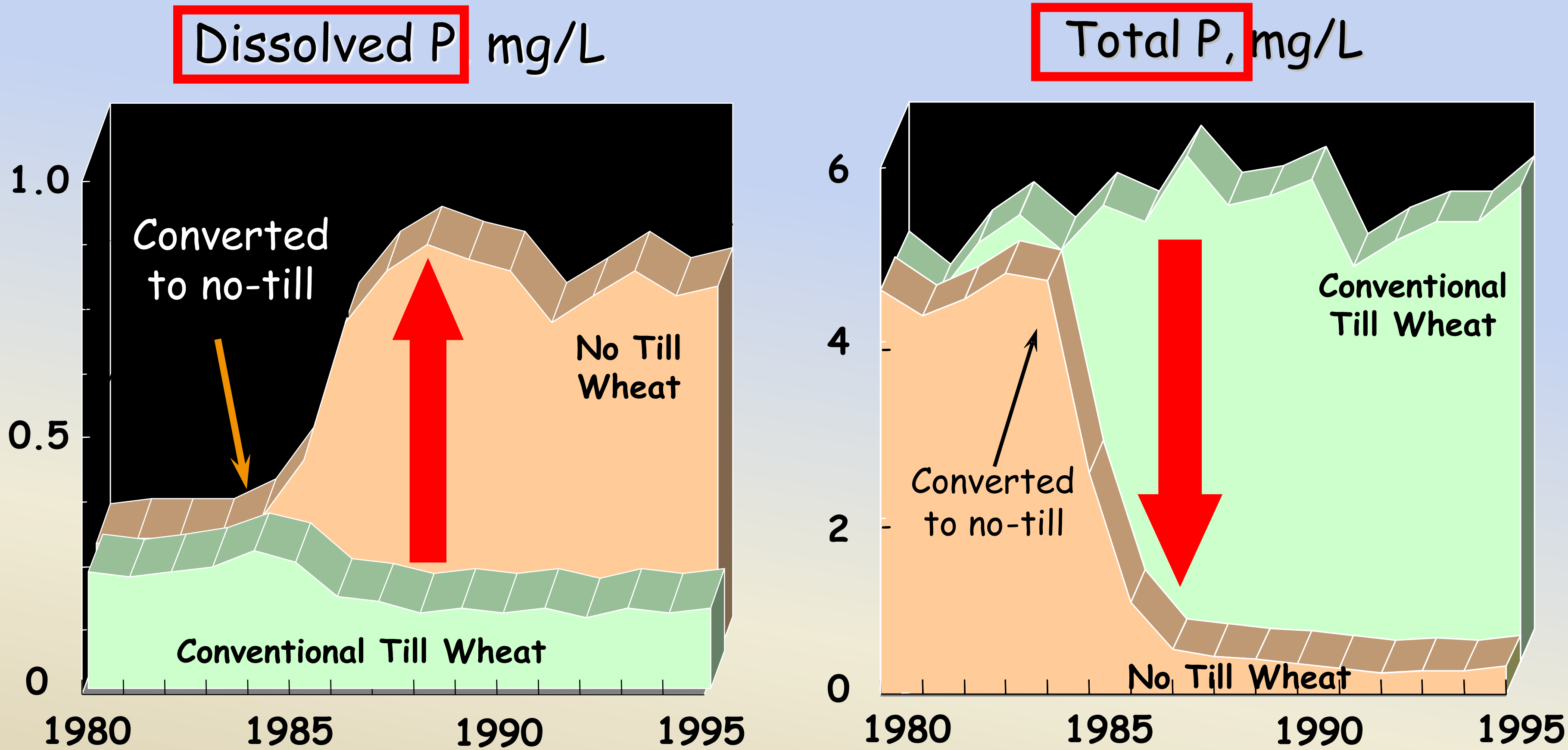
In Oklahoma, conservation tillage increased losses of dissolved P, but reduced total P loss from wheat by 95% ... where most of the P loss was by erosion



El Reno, OK - Sharpley and Smith, 1994

University of Manitoba

Published January 12, 2017

Journal of Environmental Quality

TECHNICAL REPORTS

SURFACE WATER QUALITY

Increased Soluble Phosphorus Loads to Lake Erie: Unintended Consequences of Conservation Practices?

Helen P. Jarvie,* Laura T. Johnson, Andrew N. Sharpley, Douglas R. Smith, David B. Baker, Tom W. Bruulsema, and Remegio Confesor

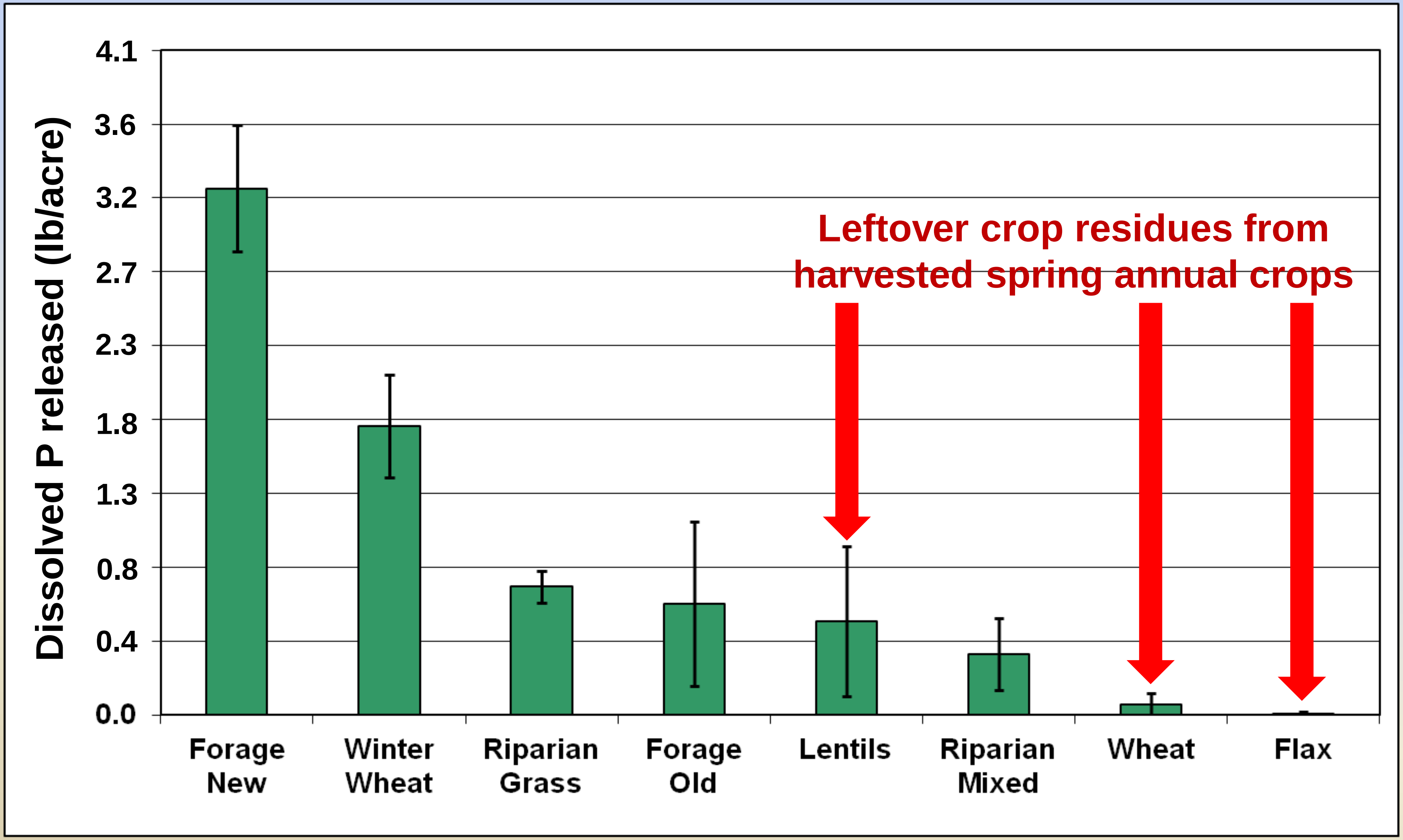
"Our findings suggest that changes in agricultural practices, including some conservation practices designed to reduce erosion and particulate P transport, may have had unintended, cumulative, and converging impacts contributing to the increased SRP loads, reaching a critical threshold around 2002."

Abstract

Cumulative daily load time seri
marked a step-change increase
phosphorus (SRP) loads entering
from three major tributaries: the
Rivers. These elevated SRP loads
last 12 yr. Empirical regression r
the contributions from (i) incr
weather and precipitation pat
delivery (the combined effects c
and/or increased transport effici
fractions). Approximately 65% o
2002 was attributable to increa
runoff volumes accounting for t
SRP delivery occurred concomita
P budgets. However, within these
long-term, largescale changes i
tillage to minimize erosion and particulate P loss, and increased tile drainage to improve field operations and profitability. These practices can inadvertently increase labile P fractions at the soil surface and transmission of soluble P via subsurface drainage. Our

Priority was established in response to growing challenges relating to phosphorus (P) enrichment, compounded by climate change, and aquatic invasive species (IJC, 2014); in February 2016, the governments of Canada and the United States announced new P

Fresh frozen green plant residues at greatest risk for simulated snowmelt runoff P losses



Elliott, J. 2013. Evaluating the potential contribution of vegetation as a nutrient source in snowmelt runoff. Can. J. Soil Sci. 93:435-443.

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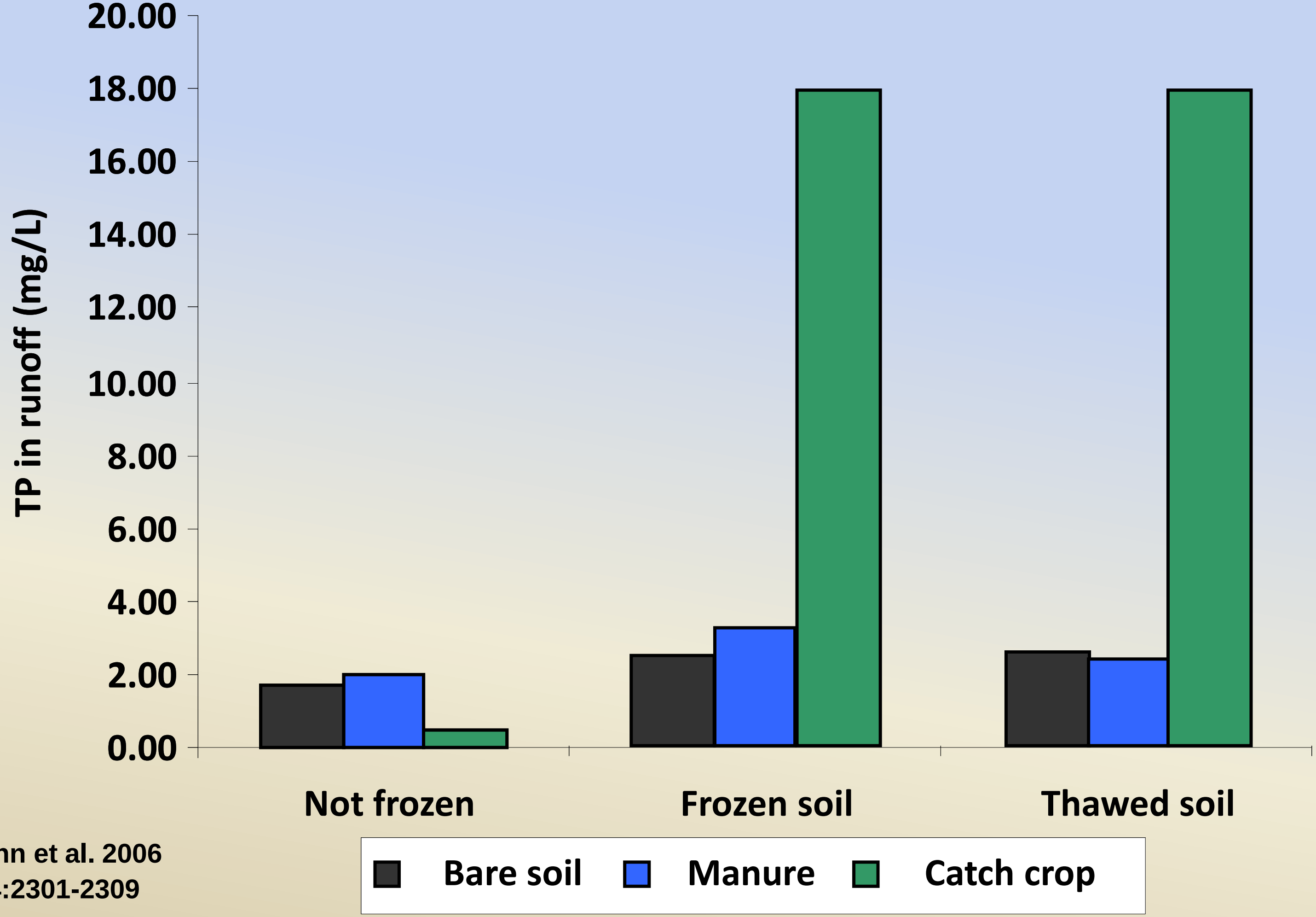
Freezing, thawing increases P loss from cover crops on manured soil: USDA research in PA



Bechmann et al. 2006
JEQ 34:2301-2309

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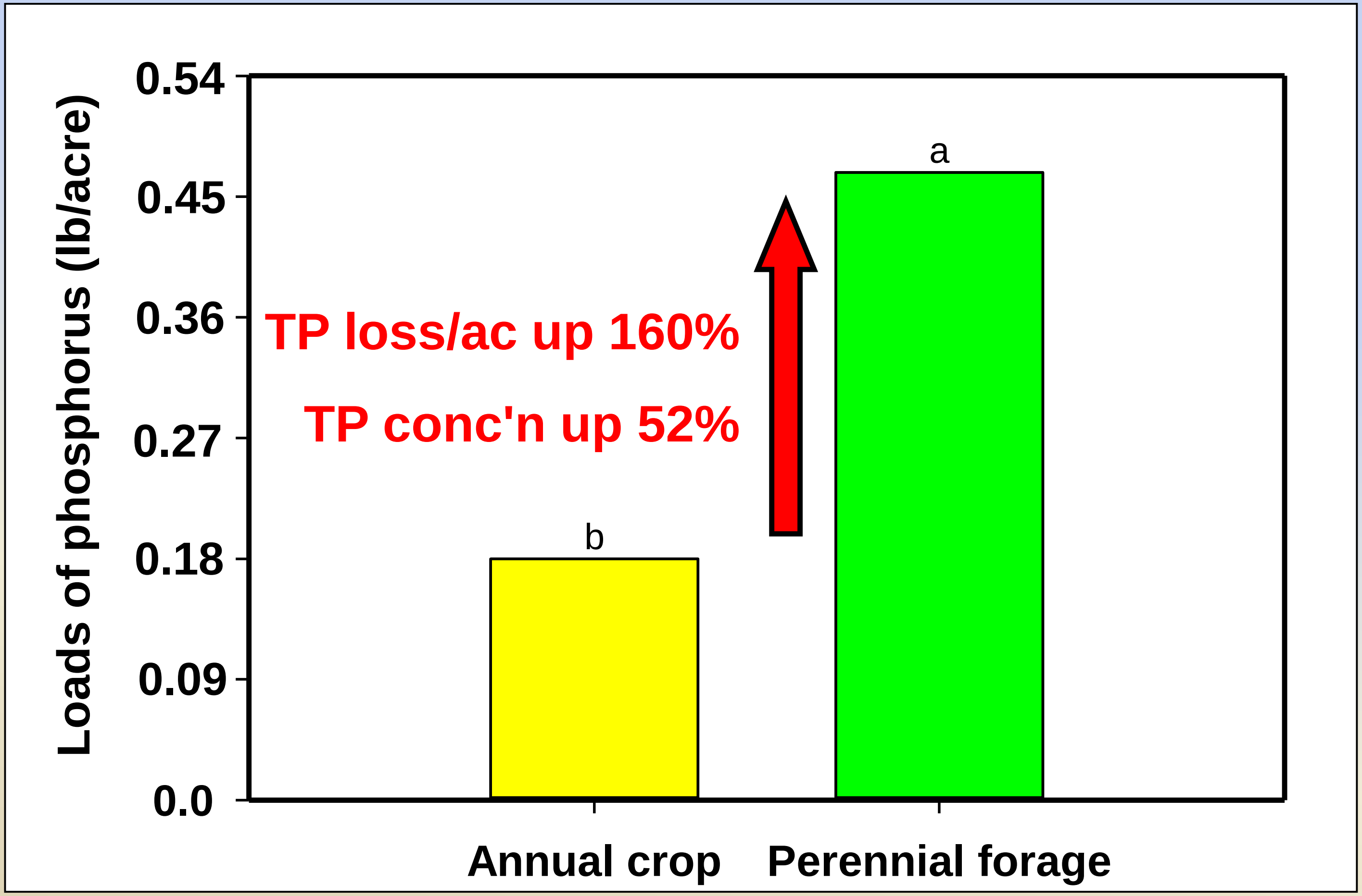
Perennial alfalfa forage loses 2.6 x as much P in snowmelt runoff as conventionally tilled annual crops (8 site years)



South Tobacco Creek Model Watershed – Liu et al. J. Environ. Qual. 43:1644–1655 (2014)

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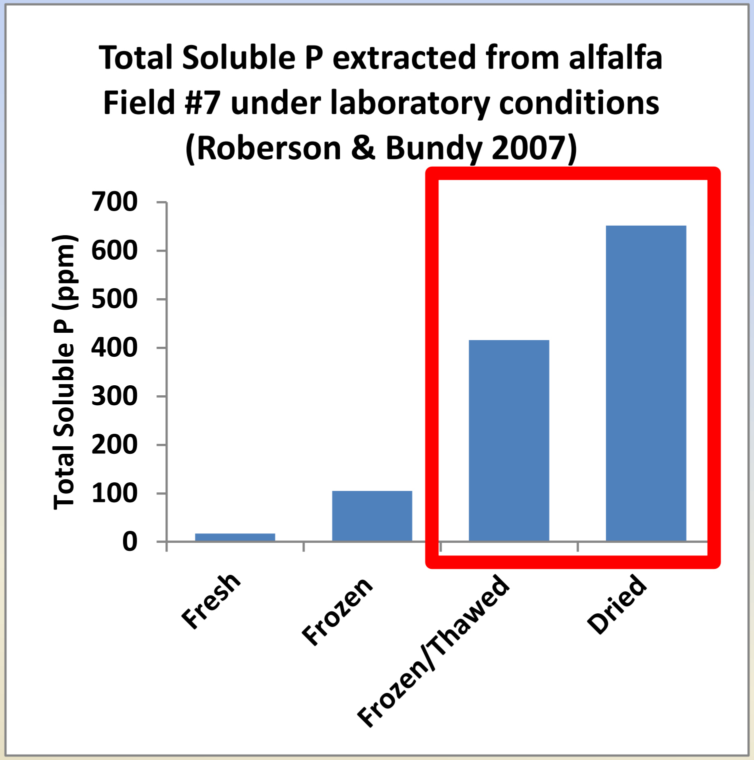
WI studies show that P losses from frozen or dried alfalfa under laboratory conditions did not match losses under field conditions

Lab Study



"Actual P losses likely depend on the timing and extent of plant freezing and drying and of precipitation events after freezing."

Field Study

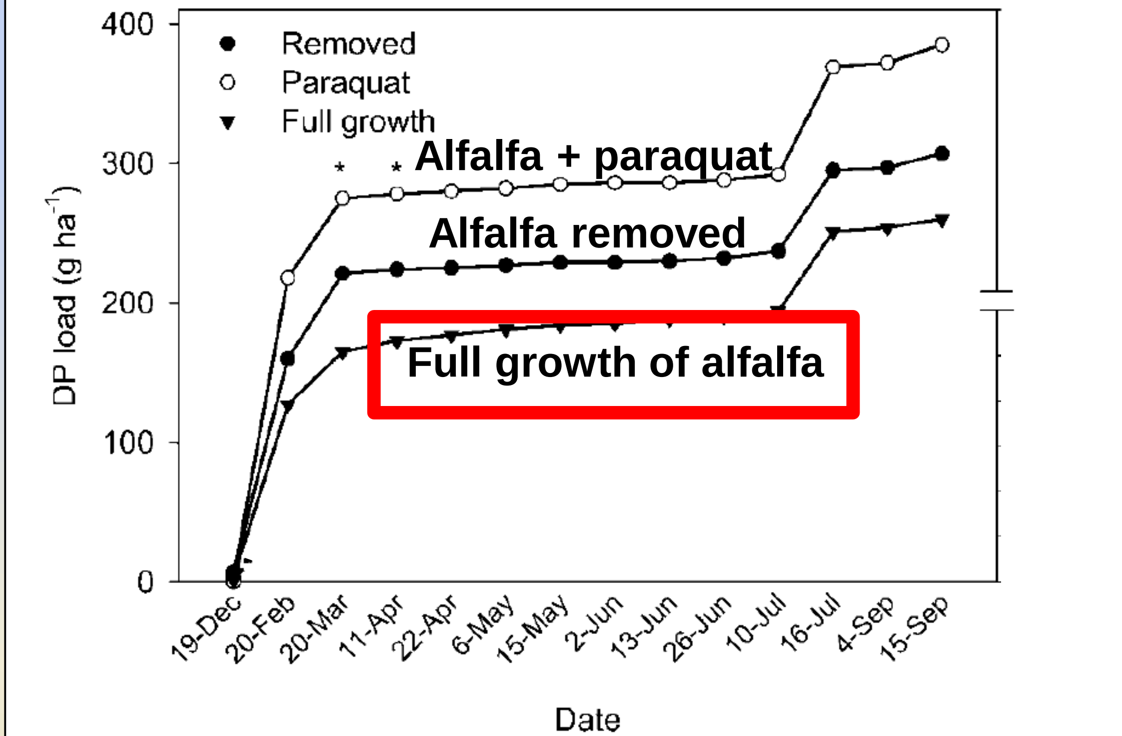


Fig. 4. Effect of fall cutting height and paraquat application to alfalfa (15 Oct. 2002) on cumulative dissolved reactive P (DP) (solid line) and natural runoff (dashed line) load at site 7, Oct. 2002 through Sept. 2003. (*) Orthogonal comparison of full growth and paraquat treatment on cumulative DP load was significant at the 0.20 probability level. **(Roberson and Bundy. JEQ 36:532–539 (2007))**

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Vegetated buffer strips in Manitoba not as effective as expected

Sheppard et al. CJSS 2006 (SE MB)

- VBS <u>reduced</u> runoff [TP] in 50% of cases,
- <u>increased</u> P in 18%, had <u>no effect</u> in 32%
- overall average … only 4% reduction in runoff [TP]

Sheppard et al. 2011 &

Habibiandehkordi et al. 2017

- No significant reduction in P with VBS in 45 of 54 seasonal measurements in Eastern-Interlake CD, Pembina Valley CD, and Little Sask. CD trials

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In-stream and near-stream processes (eg. vegetated buffers and biological uptake) are minimal during snowmelt

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Flow is often concentrated in only a small area of the buffer, overwhelming the nutrient retention system

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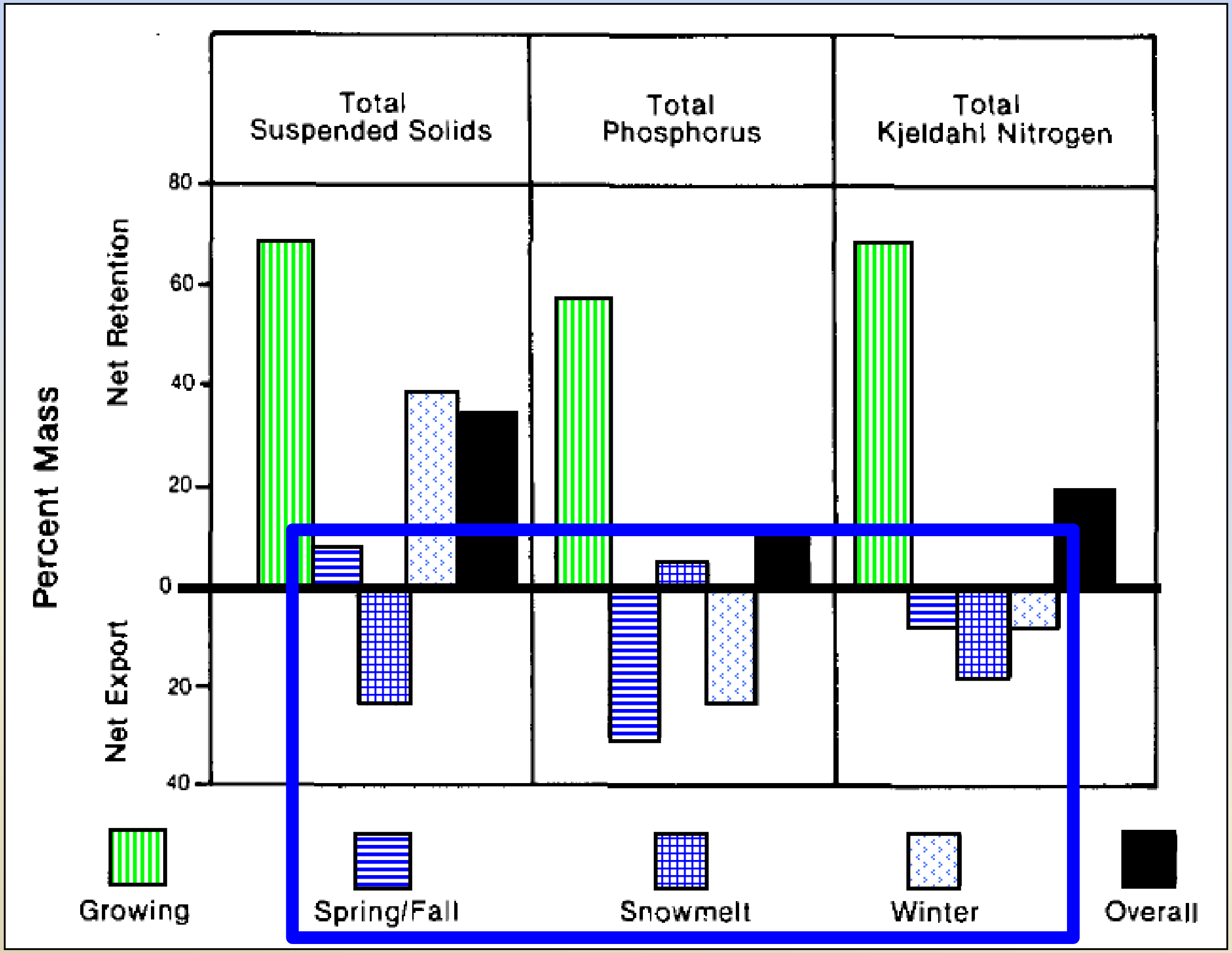
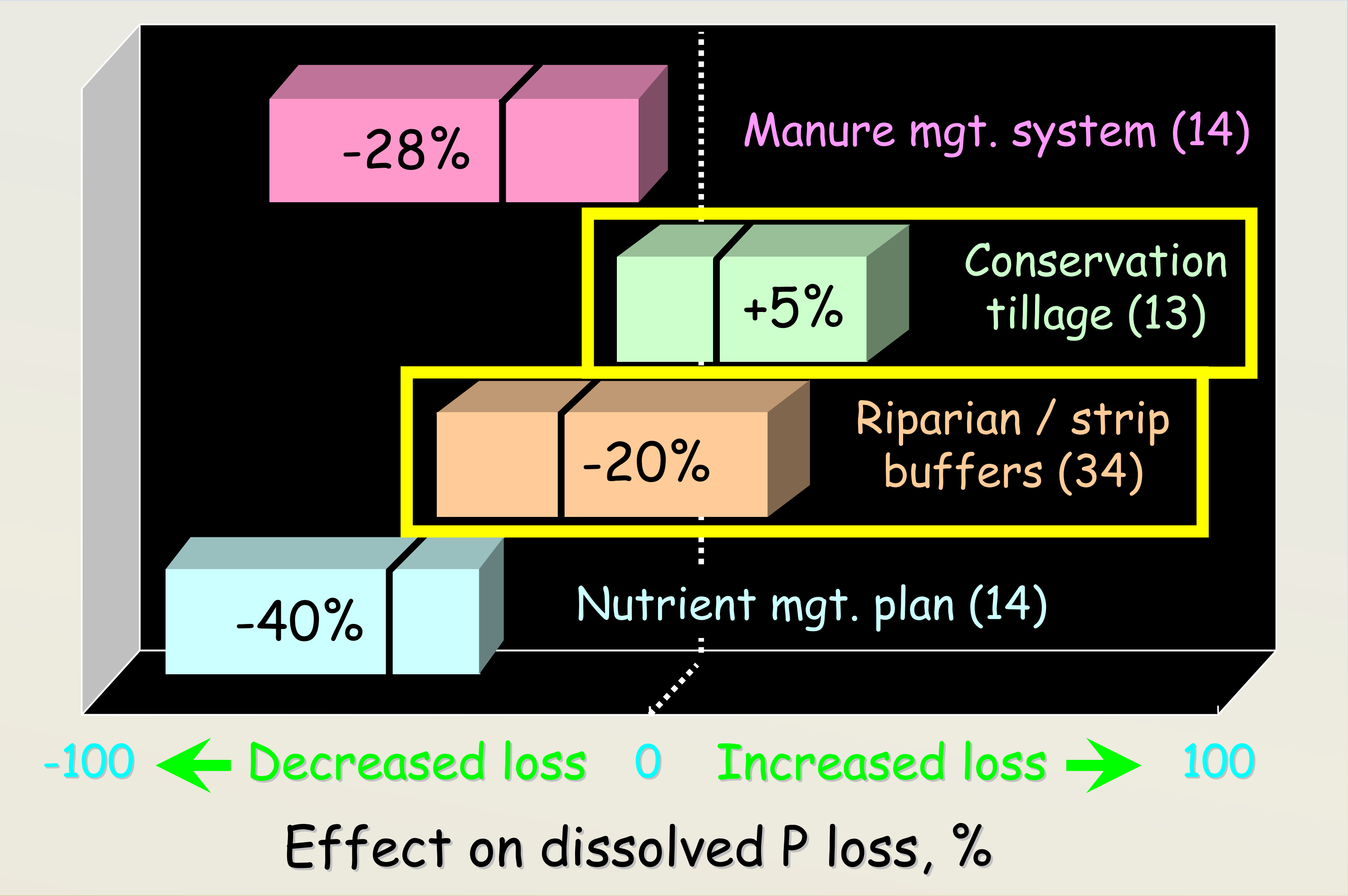
Barnyard vegetative filter strips: Ineffective outside growing season in Vermont



Schellinger & Clausen JEQ 1992

BMP effectiveness for reducing losses of dissolved P (Sharpley, adapted from Gitau et al. JSWC, 2005)



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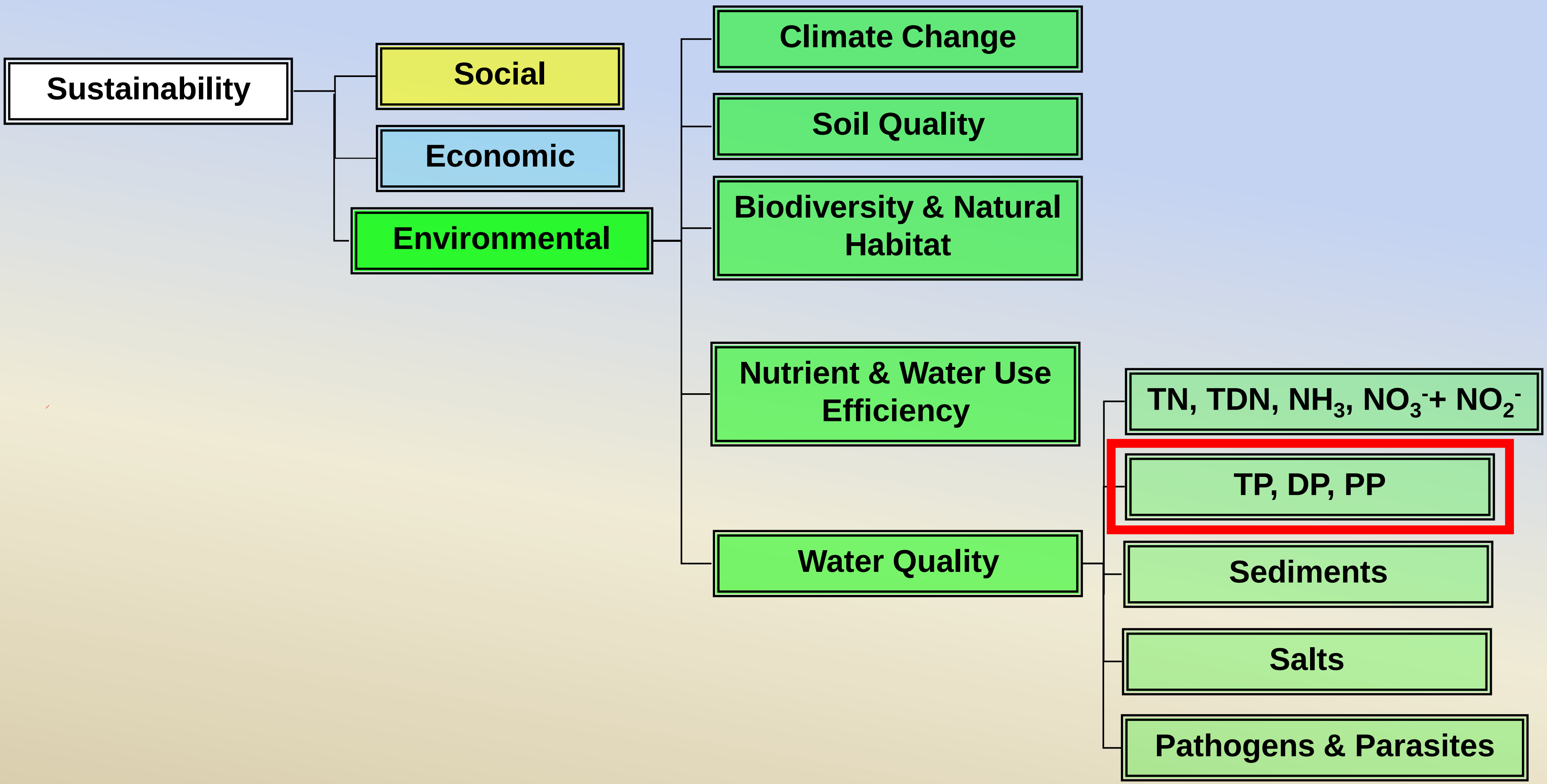
Balancing Benefits, Co-Benefits, and Trade-Offs

- **Also, remember that P loss is only one of many objectives that agricultural practices must address to be sustainable**



Balancing Benefits, Co-Benefits, and Trade-Offs

- **No BMP, including conservation tillage, perennial forage or vegetated buffers is a cure-all, for all environmental issues and situations**

- **BMPs have different effects on different issues (eg. N vs P) in different environments (eg. rainfall on sloping land vs. snowmelt runoff on plains)**
- **Co-benefits are variable, but trade-offs are inevitable … let's use knowledge to maximize co-benefits & minimize trade-offs**

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Balancing Benefits, Co-Benefits, and Trade-Offs

- **Perhaps it's time to treat <u>environmental</u> health like <u>human</u> health ... with more effort to aim for improved overall health:**

  - **Diagnose the correct <u>cause</u>**
    - **assess each case individually and comprehensively**
    - **identify the real cause of the most important problem(s)**
  - **Prescribe the right <u>cure</u>**
    - **make sure the "cure" works**
    - **treat with precision**
    - **consider all the benefits**
    - **consider all the "side effects"**
    - **continuously monitor, adapt & fine tune the treatment**

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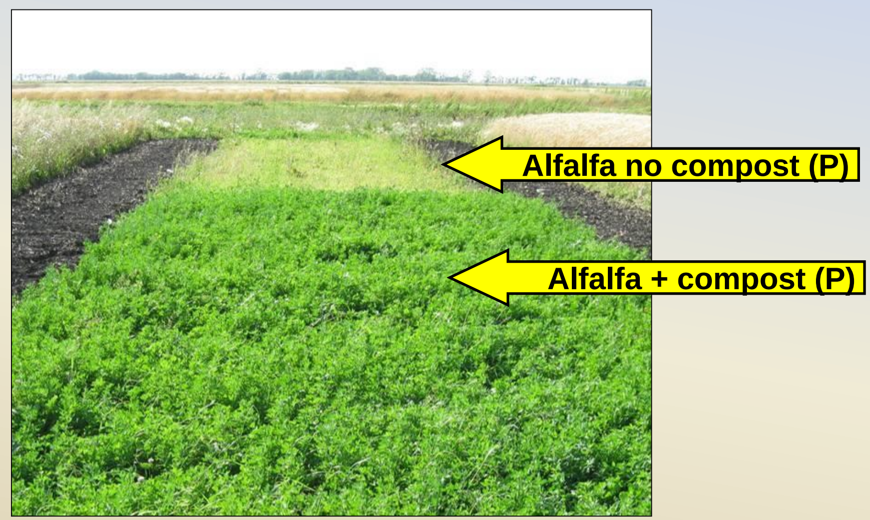
Overall Summary and Conclusions

1. **Starter P improves early season growth, advances maturity, and increases yield in corn, but has little benefit for soybean.**

   However, we need to add enough P to balance removal to maintain long term productivity for the whole crop rotation.

MAP 27 lb P_2O_5/ac **No P Check**



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Overall Summary and Conclusions, cont'd.

2. **Careful management of P rate, placement & timing is critical for reducing the risk of P loss to surface water ...**

   especially considering that very <u>small</u> concentrations of P cause <u>big</u> problems with water quality ...

   and some traditional soil and water conservation practices that <u>reduce</u> water erosion may <u>increase</u> the loss of dissolved P in Northern Great Plains watersheds

Photo: Fisheries & Oceans Canada

Overall Summary and Conclusions, cont'd.

3. We should be make sure that "beneficial management practices" are truly beneficial under local conditions ...

   and aim for improving overall environmental health, being careful to consider all the co-benefits and trade-offs of beneficial management practices

Acknowledgements

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