

The Real Deal of Phosphorus, Agriculture and the Environment

**Don Flaten, Professor, Dept. of Soil Science
University of Manitoba
and many others ...**

**Saskatchewan Farm Stewardship Association
December 12, 2019**



2019 is the 350th anniversary of the discovery of phosphorus by Hennig Brandt in 1669



Public Concern About Agricultural Nutrient and Water Management 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 ARCHIVE

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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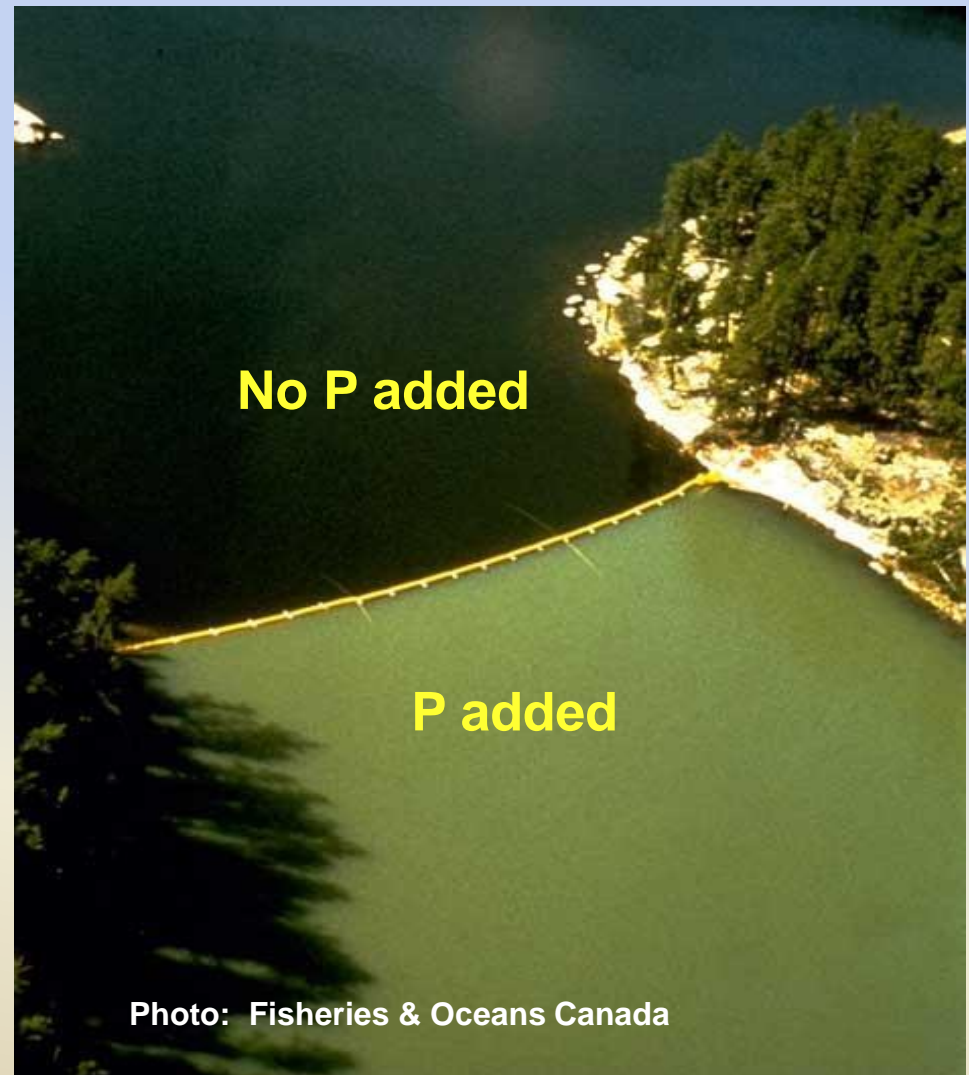
Increased frequency and severity of problems: eg. fouled swimming beaches



Main Problem: Excess P and “Algae”

“Eutrophication”
occurs at very
low conc’ns of P
(0.02-0.50 mg/L or
20-50 ppb)

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



Province-Wide Moratorium on New or Expanded Hog Farms introduced in 2011

- supported unanimously
by all gov't and
opposition MLAs

Winnipeg Free Press

February 19, 2013 SCHOOL DAY 1

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LOCAL

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Is it just pre-election hogwash?

Something stinks when Tories support NDP bill to clean up lake

By: Dan Lett
Posted: 06/18/2011 1:00 AM | Comments: 0

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The Manitoba legislature finished its current session this week with a rather unusual series of events.

Most notably, the session concluded with the opposition Progressive Conservatives voting unanimously for an NDP government bill aimed at cleaning up Lake Winnipeg.

The bill prescribes, among other things, an extension of the controversial hog moratorium and the construction of a \$350-million sewage-treatment plant in Winnipeg.

What is intriguing is it appears the Tories oppose those measures. Why the unanimous support?

The answer varies depending on your political stripe.

If you're a Tory, then your story is the Lake Winnipeg bill represents significant movement by the NDP on both hog and city sewage issues.

And that the Tories entered the session by promising to, on occasion and in the best interests of parliamentary



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Province wide ban on new or expanded hog farms removed by Bill 24, November 2017

Pallister running roughshod

Re: *"Change is never easy," Pallister says* (Nov. 13)

The Pallister government is running roughshod over the citizens of Manitoba, and in the end, our future generations will pay the price.

In particular, Bill 24. Giving royal assent to this bill will reduce the frequency of water testing and allow the expansion of the hog industry. The legislative committee hearings that were held last month were a sham. The government had no intention of listening to what the public has to say. Once again, industry has won over the health of the people, the environment and animal welfare.

And to add insult to injury, the federal government has appointed Terry Duguid to help save Lake Winnipeg. Looks like the left hand doesn't know what the right hand is doing.

LOIS TAYLOR
Winnipeg

(Wpg. Free Press Nov. 16, 2017)



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**More restrictions on
agricultural drainage
are probably coming ...**

LEGISLATION PROPOSED TO PROTECT WETLANDS

ANYONE who illegally drains wetlands or erects an illegal dike in Manitoba could soon face increased fines.

Sustainable Development Minister Rochelle Squires tabled legislation Thursday, promising it would bring enhanced protection to the province's wetlands.

The point of the bill is to move water more smoothly through rural Manitoba, but there will be big fines to back up the legislation, she said.

Fines against corporations increase to \$500,000 from \$25,000, and against individuals to \$50,000 from \$10,000.

— *staff*

Wpg Free Press Dec. 1, 2017



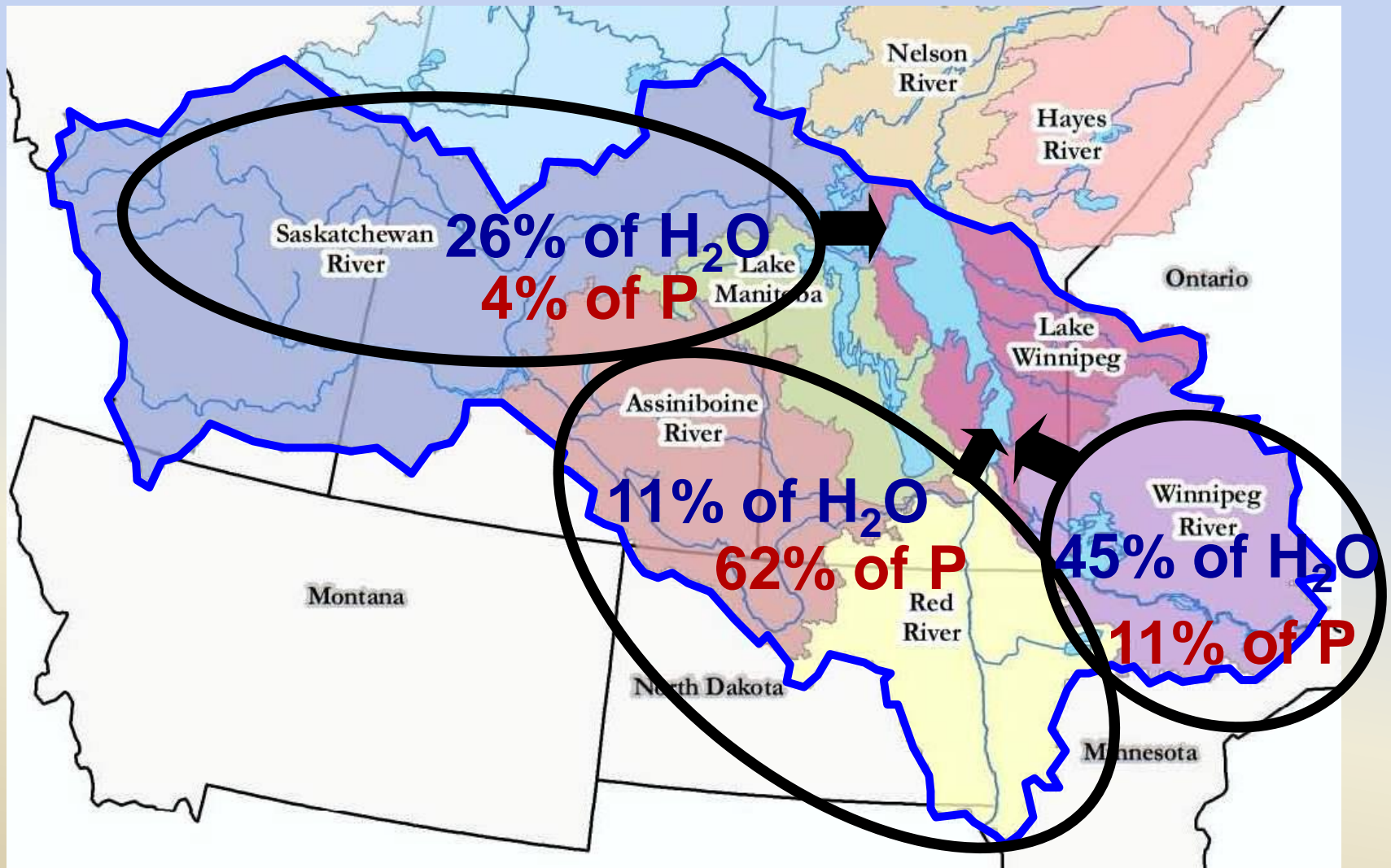
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Where does Lake Winnipeg's P come from?

- Water quality in Lake Winnipeg reflects many human and natural events in its watershed (eg. climate change) which is 40 times greater than the surface area of the lake.
- Some areas in the basin have more impact on Lake Winnipeg than others, eg. Red River Basin

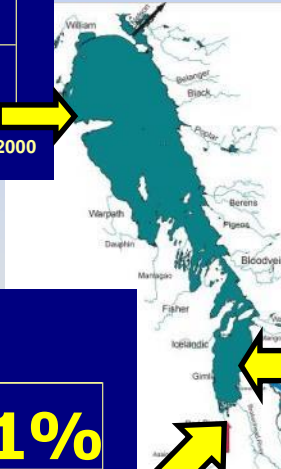
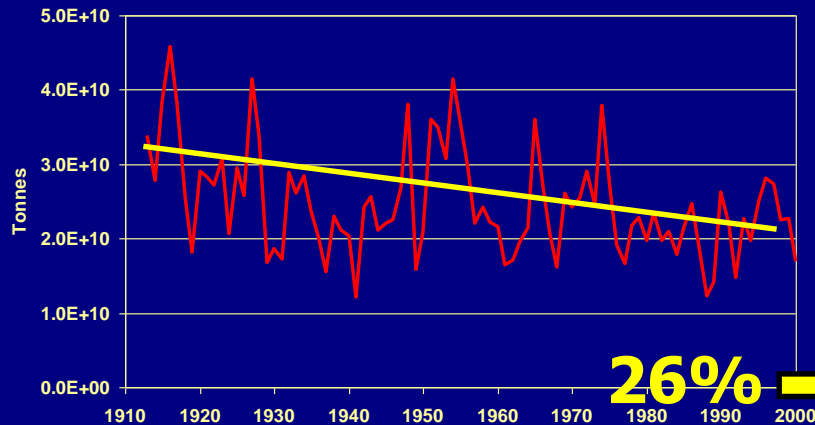


Contributions of Water and Phosphorus from Lake Winnipeg's Sub-Basins

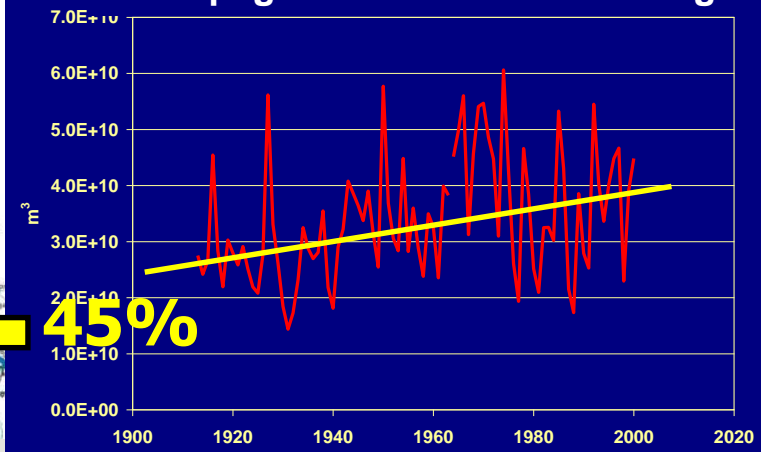


Long term water flows: 1910 – 2000 (Hesslein 2005)

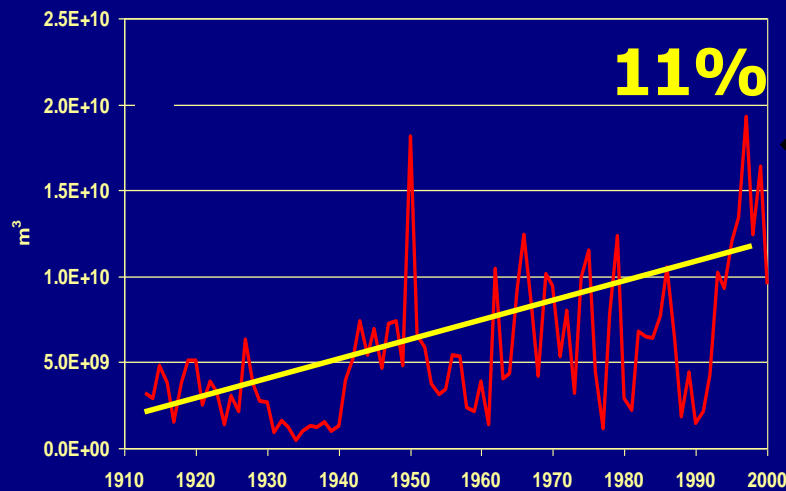
Sask'n River inflow – long term decline



Winnipeg River inflow - increasing

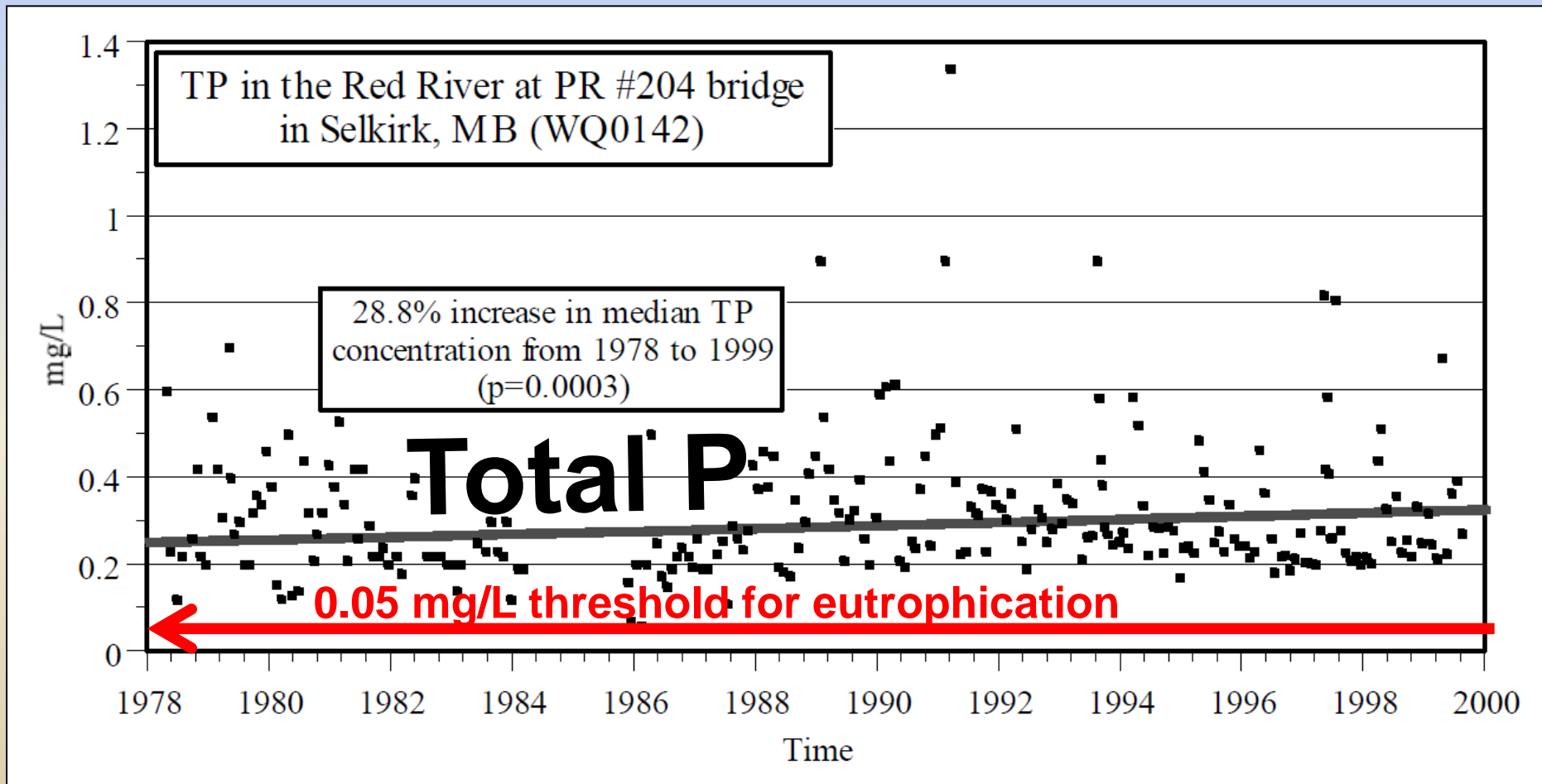


Red River – increasing



Ideally, P concentrations should be < 0.05 mg/L, but:

- Red River averages between 0.10-0.45 mg P/L;
Assiniboine R. 0.10-0.40 mg P/L



Jones, G. and Armstrong, N. 2001. Long term trends in total nitrogen and total phosphorus concentrations in Manitoba streams. Manitoba Conservation Report No. 2001-07.



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Concentrations of P are increasing in the Souris and Assiniboine Rivers

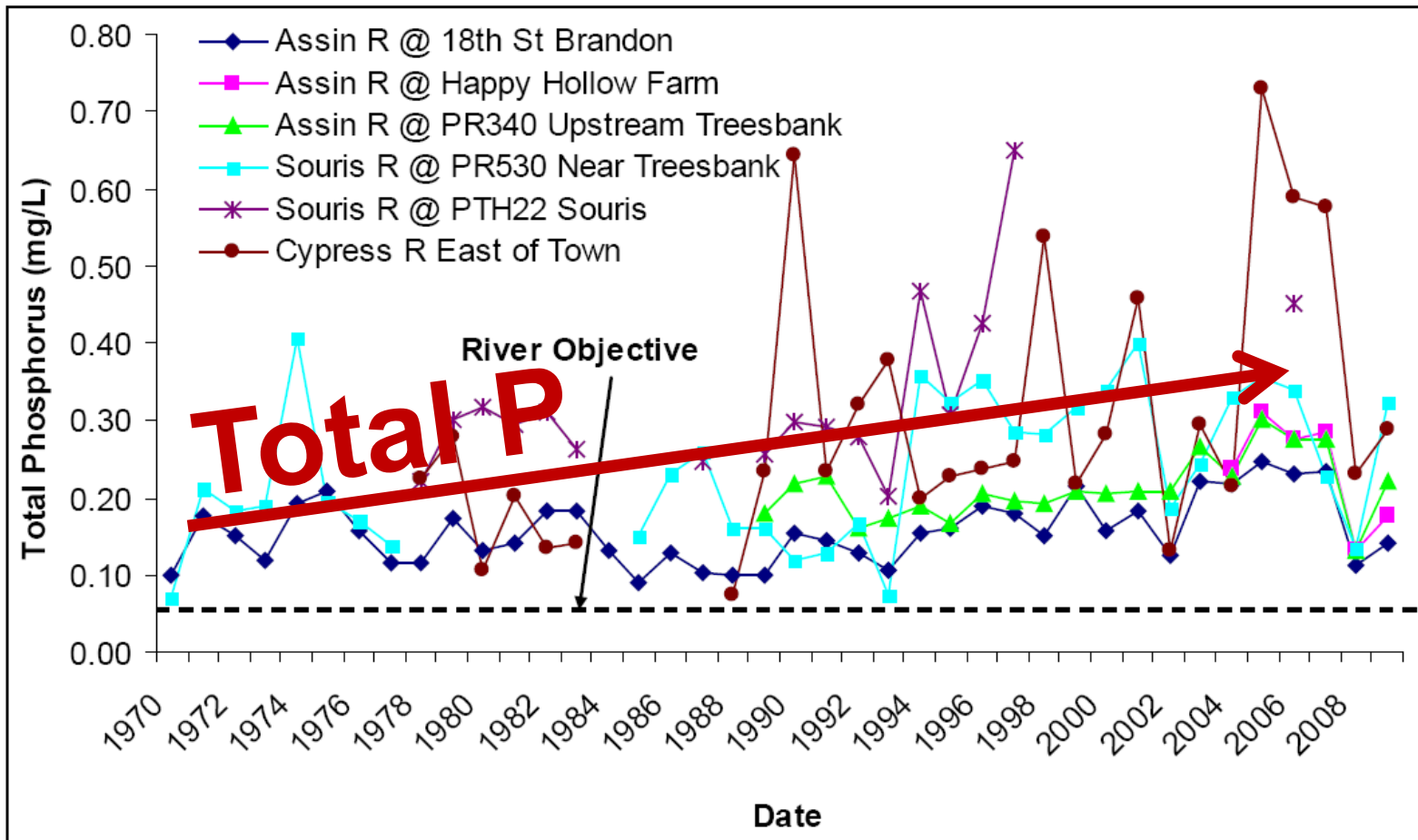


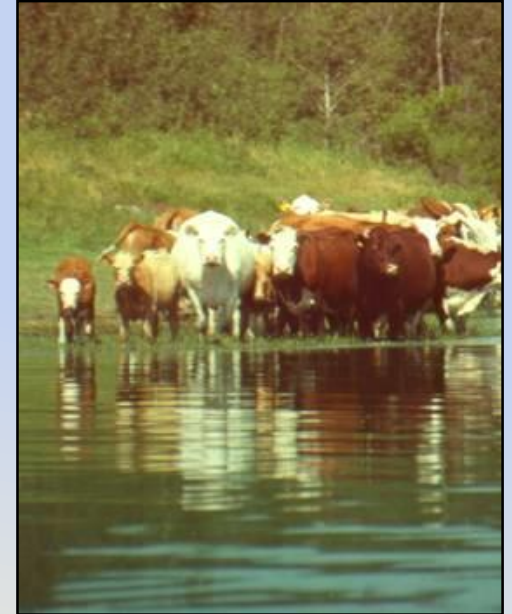
Figure 5: Total phosphorus (mg/L) concentrations from six long term water quality monitoring sites in the Central Assiniboine watershed between 1970 and 2009.



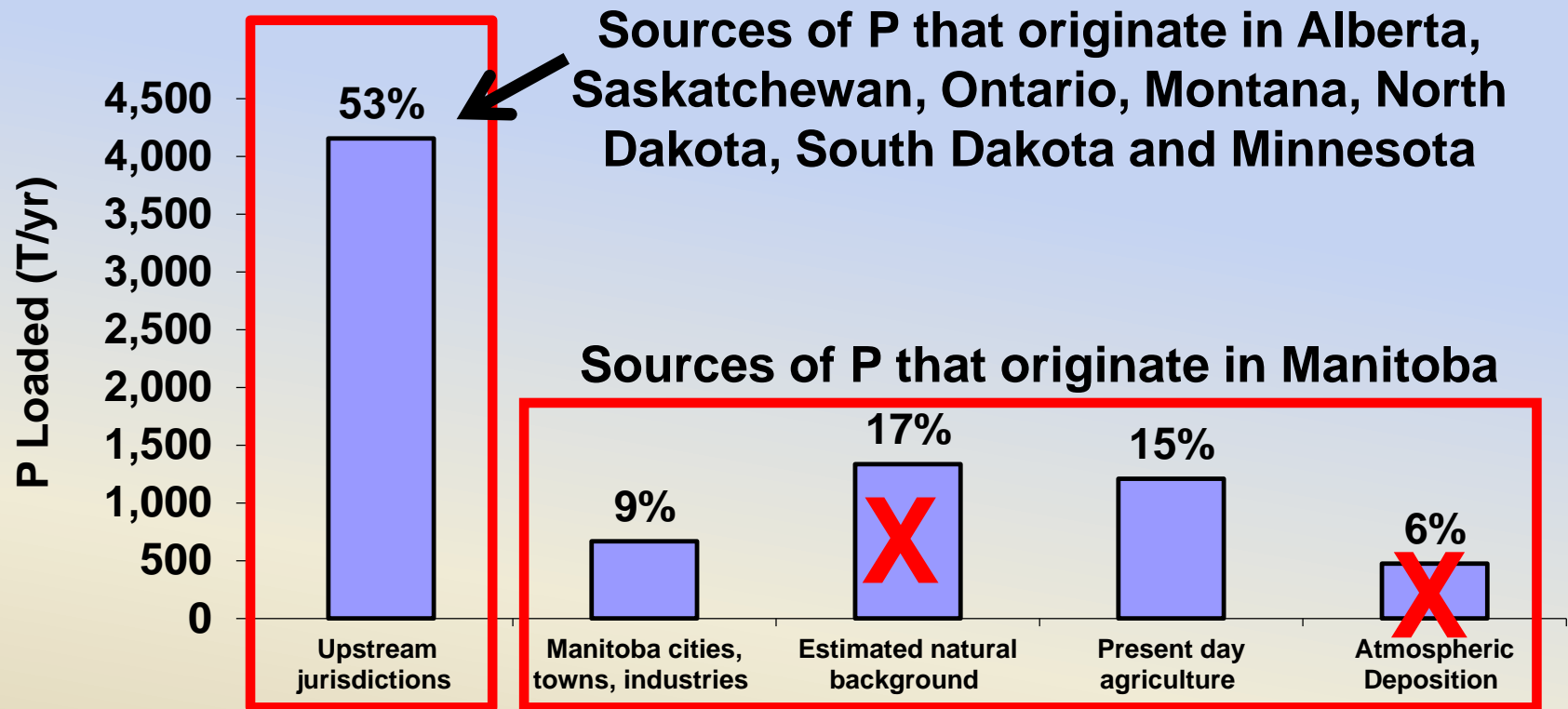
**Where does the P in the
rivers come from?**



P loading to Lake Winnipeg and other Prairie water bodies comes from many relatively small sources



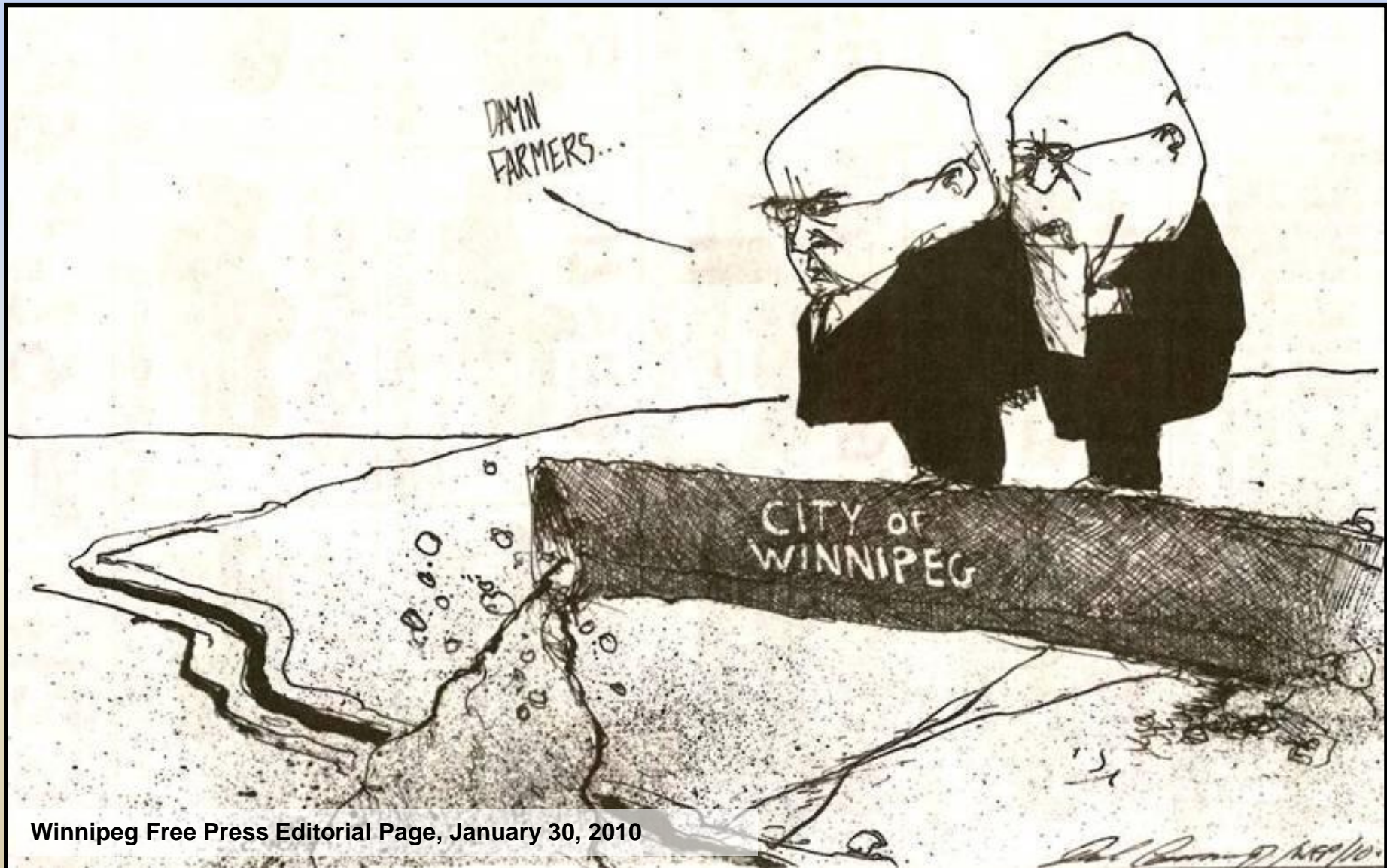
Lake Winnipeg's P comes from many relatively small sources



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



The “Blame Game” ...



Winnipeg Free Press Editorial Page, January 30, 2010



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SECTION B

Province tells city to have interim strategy in place by January

Phosphorus-reduction plan ordered

ALDO SANTIN AND LARRY KUSCH

THE Pallister government has denied Winnipeg City Hall's request for an extension to develop a solution to reduce phosphorus emissions at its north end sewage treatment plant.

Instead, it is compelling the city to produce an interim phosphorus reduction plan by the end of January, for implementation beginning Feb. 1.

The province is requiring Winnipeg to participate in a pair of committees, to be co-chaired by city and provincial representatives, to kick-start the process.

The North End plant is considered to be the largest, single-point contributor of phosphorus to Lake Winnipeg. The presence of phosphorus in the Red River has been identified as the culprit for the appearance of the slimy green algae in the lake.

"Manitobans expect action on Lake Winnipeg. Manitobans expect action on dealing with phosphorus coming

through the North End Water Pollution Control Centre," Municipal Relations Minister Rochelle Squires said Thursday.

Squires and Conservation and Climate Minister Sarah Guillemard, whose department issued the order, said the province will be a partner with the city and the federal government in financing upgrades to the plant. But they wouldn't commit to any specific funding levels until a plan is in place.

The City of Winnipeg was required to have upgrades to the north end sewage treatment plant completed by Dec. 31, to reduce phosphorus emissions to 1 mg/litre from the current rolling average of 3.54 mg/litre.

The city has approved a \$408-million project to upgrade the plant's power supply and headworks facilities, but two subsequent projects — biosolid and nutrient removal — have a combined price tag of \$1.38 billion, have not been approved and won't proceed without

financial support from the province and Ottawa.

In July, the water and waste department asked the provincial government for a two-year delay to allow it to determine what interim measures could be put in place ahead of the final two projects being completed.

On Thursday, the province said no to that request.

A project steering committee will oversee implementation of both the interim phosphorus reduction strategy to commence in February, as well implementation of the upgrades to meet the licence requirements. It will be assisted by an advisory committee that will include representatives from the city, multiple provincial government departments, as well as key stakeholders, such as the International Institute of Sustainable Development, Lake Winnipeg Foundation and Lake Winnipeg Indigenous Collective.

"We will depend on expert advice. We will be cautious, but I think all

Manitobans expect us to be moving forward on this particular project," Guillemard told reporters Thursday at the legislature.

Asked if the government was prepared to punish the city if it fails to meet its new deadlines, Guillemard said: "We haven't discussed any fines at this point. We have multiple options as a province to help the city come into compliance, and our choice is to work collaboratively with them."

She said the funding of any new initiatives is a separate issue. "Obviously, all three levels of government will be involved in this project. At this point, we're not discussing funding."

Alexis Kanu, executive director of Lake Winnipeg Foundation, said she was caught by surprise by the provincial announcement, but is pleased to see action.

"We're reassured this issue is being taken seriously, and we're glad to have a seat at the table to ensure it moves forward."

Kanu said she's unsure what interim measures the province has in mind, adding the water and waste department was considering an IISD/LWF proposal, as well as two others.

A spokesman for Mayor Brian Bowman's office said he only learned of the province's decision Thursday afternoon, and would withhold comment until today.

A spokesman for the city administration said civic officials will co-operate with the province.

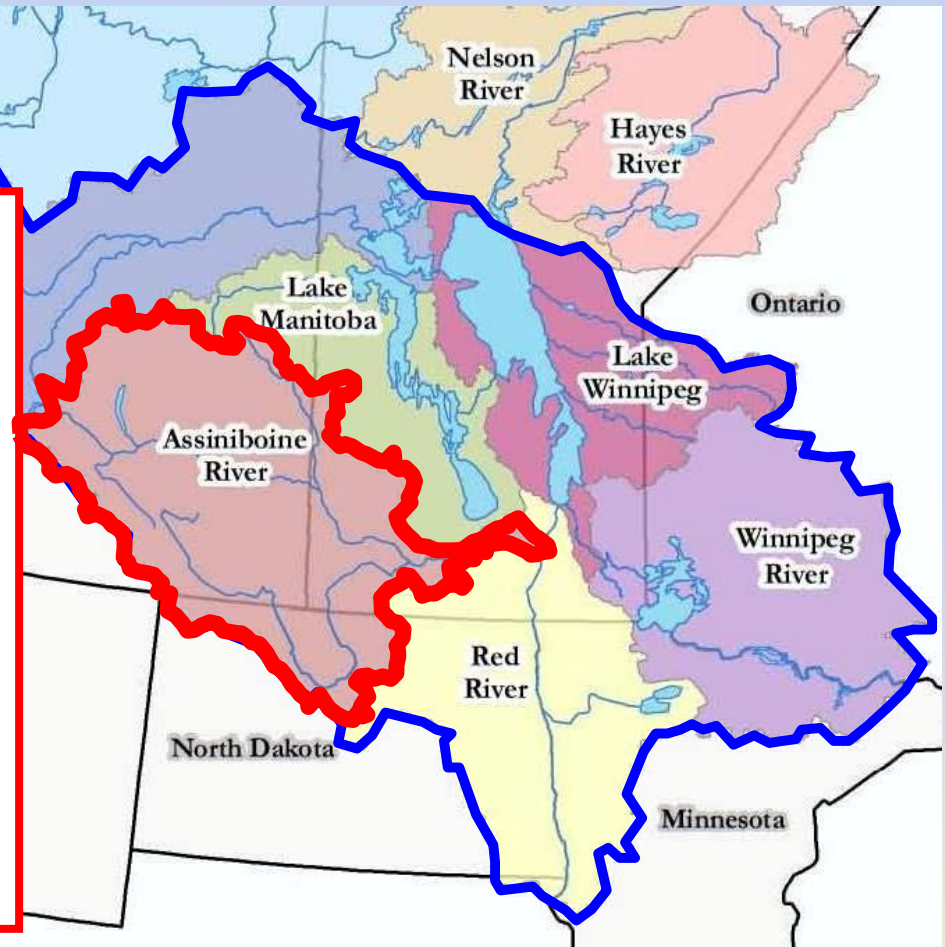
"We don't want to see any further delays on this project, and will work collaboratively with the province to move this project forward," said David Driedger, manager of communications. "We are hopeful that this collaboration will help ensure funding certainty on this project, as we are unable to provide timeline certainty until we have funding certainty."

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Average P losses from ag. land are small but significant

eg. Assiniboine R. watershed

- Total P load/year:
 - 600 T P or 3 M lb P_2O_5
- Watershed area:
 - 38 million ac
- P loss 0.08 lb P_2O_5 /ac/yr
- Crop removal ~ 25 lb/ac/yr
- Loading equivalent to < 0.3 % of crop removal



However, low runoff volumes result in high P conc'ns in water (200-1000 ppb) ... much higher than the threshold for algae growth (20-50 ppb) ... so small agricultural losses cause large water quality problems.

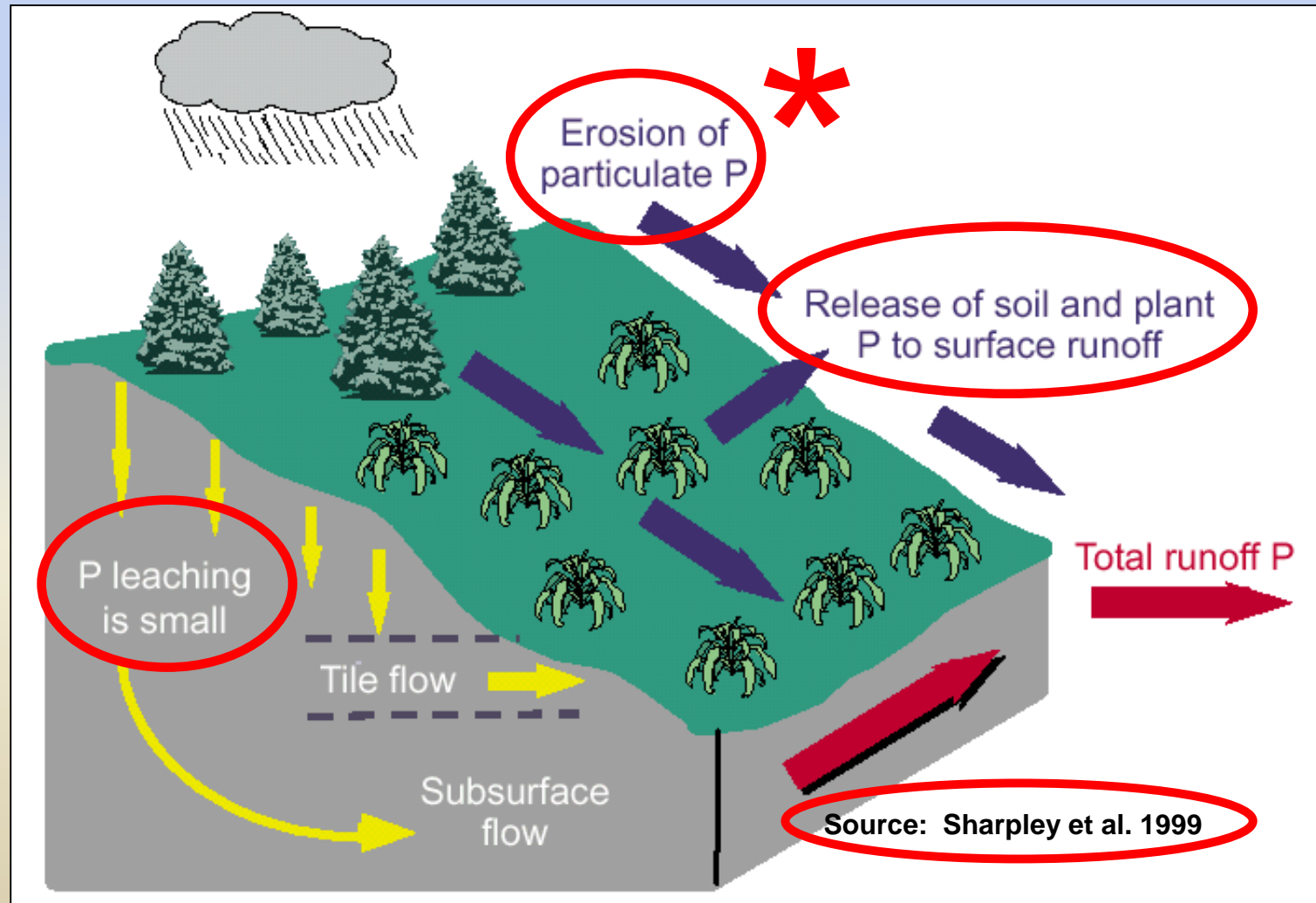




**How can agriculture
reduced its share of P
loading to surface water in
the Prairies?**



Sources and Transport Processes that Move Agricultural P to Surface Water



Dr. Andrew Sharpley's research site in Pennsylvania ... where most P is particulate P lost by erosion

Wet (1200 mm precipitation/year)

+ Warm (most of the runoff is from rainfall)

+ Steep slopes

= High risk of water erosion

Prairie watersheds produce 80% of their runoff during snowmelt ... with little erosion ... and most P loss is in dissolved forms

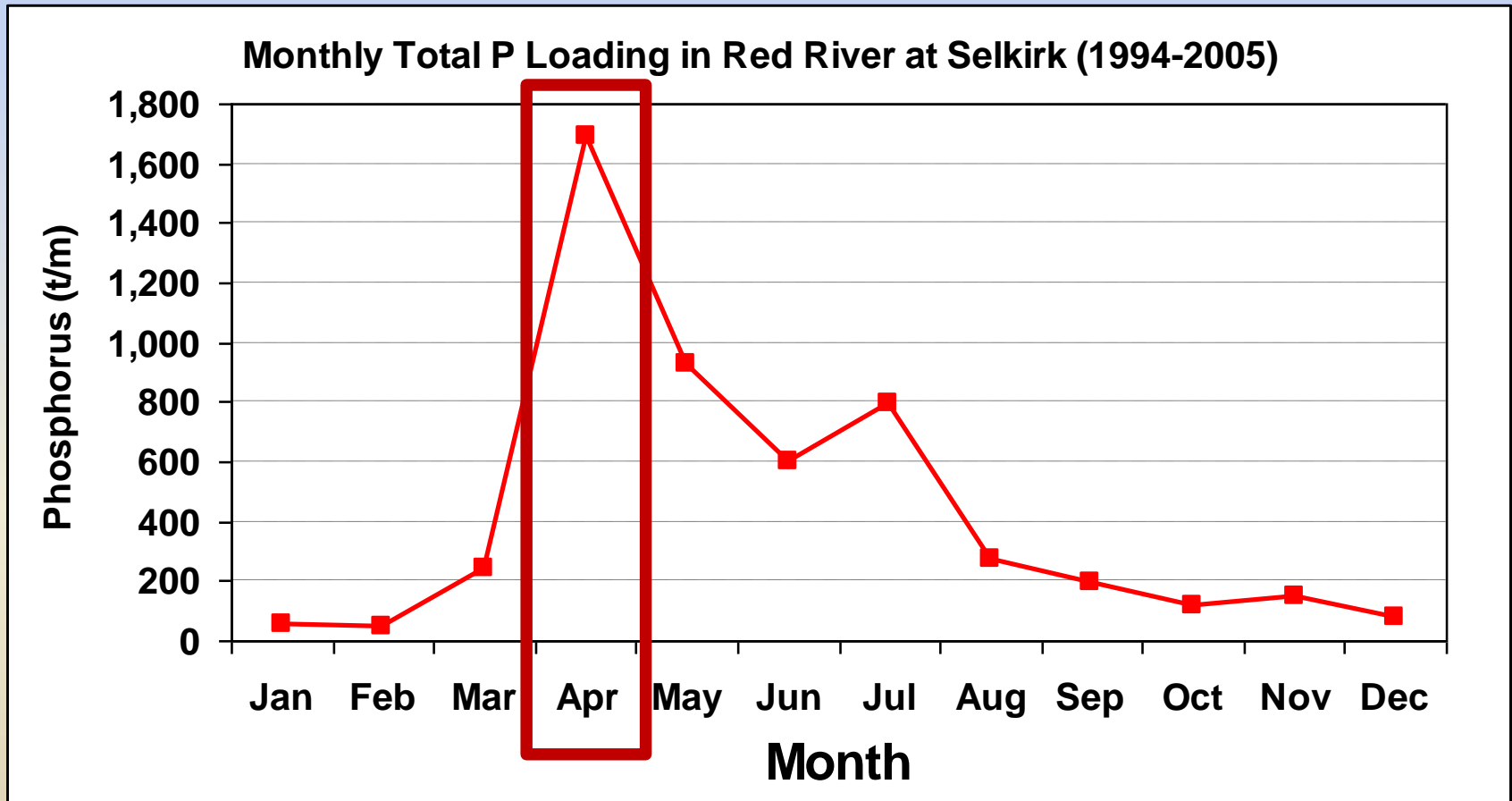
Dry (< 500 mm precipitation/year)

+ Cold (most runoff is from snowmelt, over thawing vegetative residues and frozen soil)

+ Flat topography

= Low risk of water erosion

Runoff and nutrient transport: Most P loading to Lake Winnipeg occurs during snowmelt



Lake Winnipeg Stewardship Board Report, December 2006



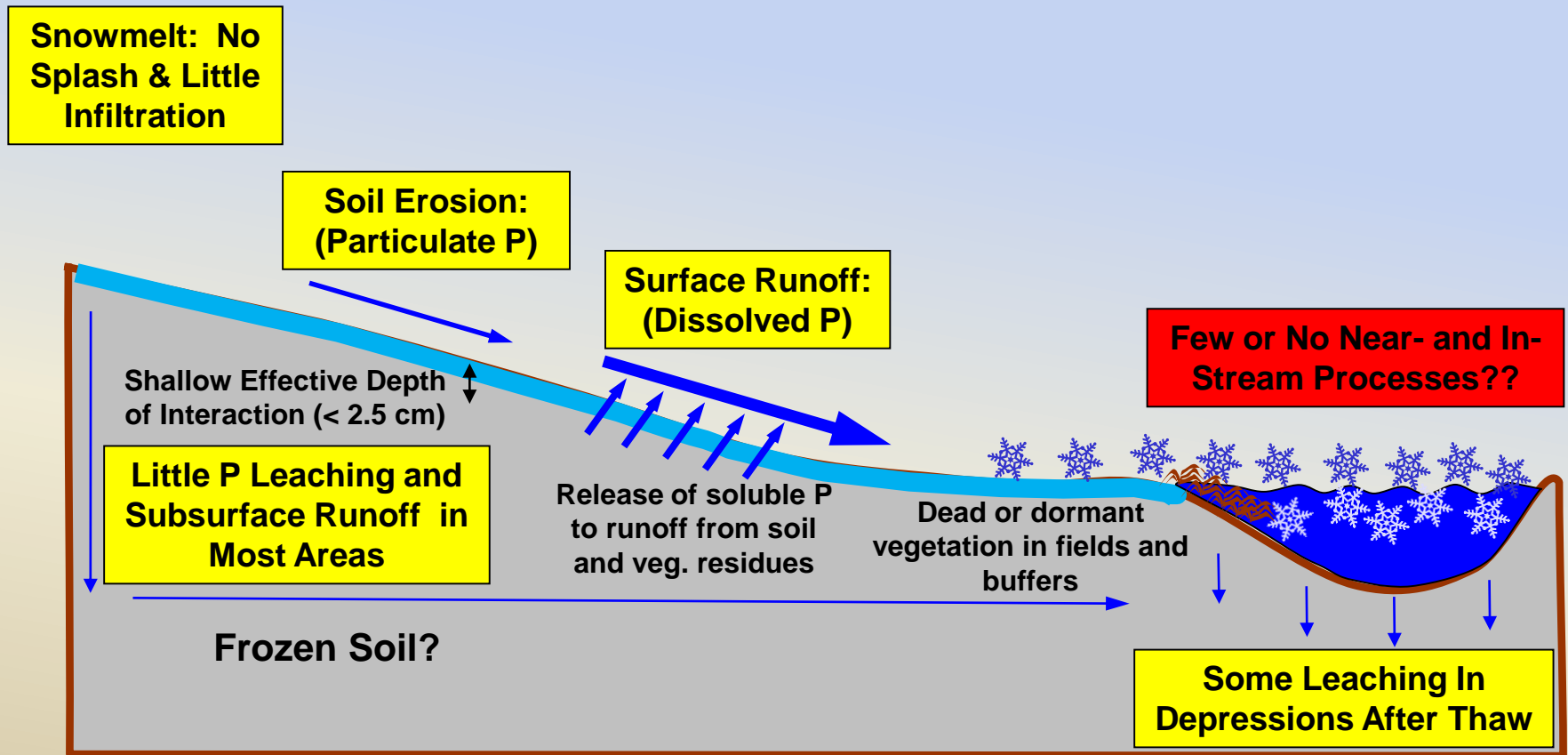
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**What are the differences
between rainfall runoff and
snowmelt runoff processes for
P loss in the Prairies?**



Snowmelt Runoff System for Nutrient Loss



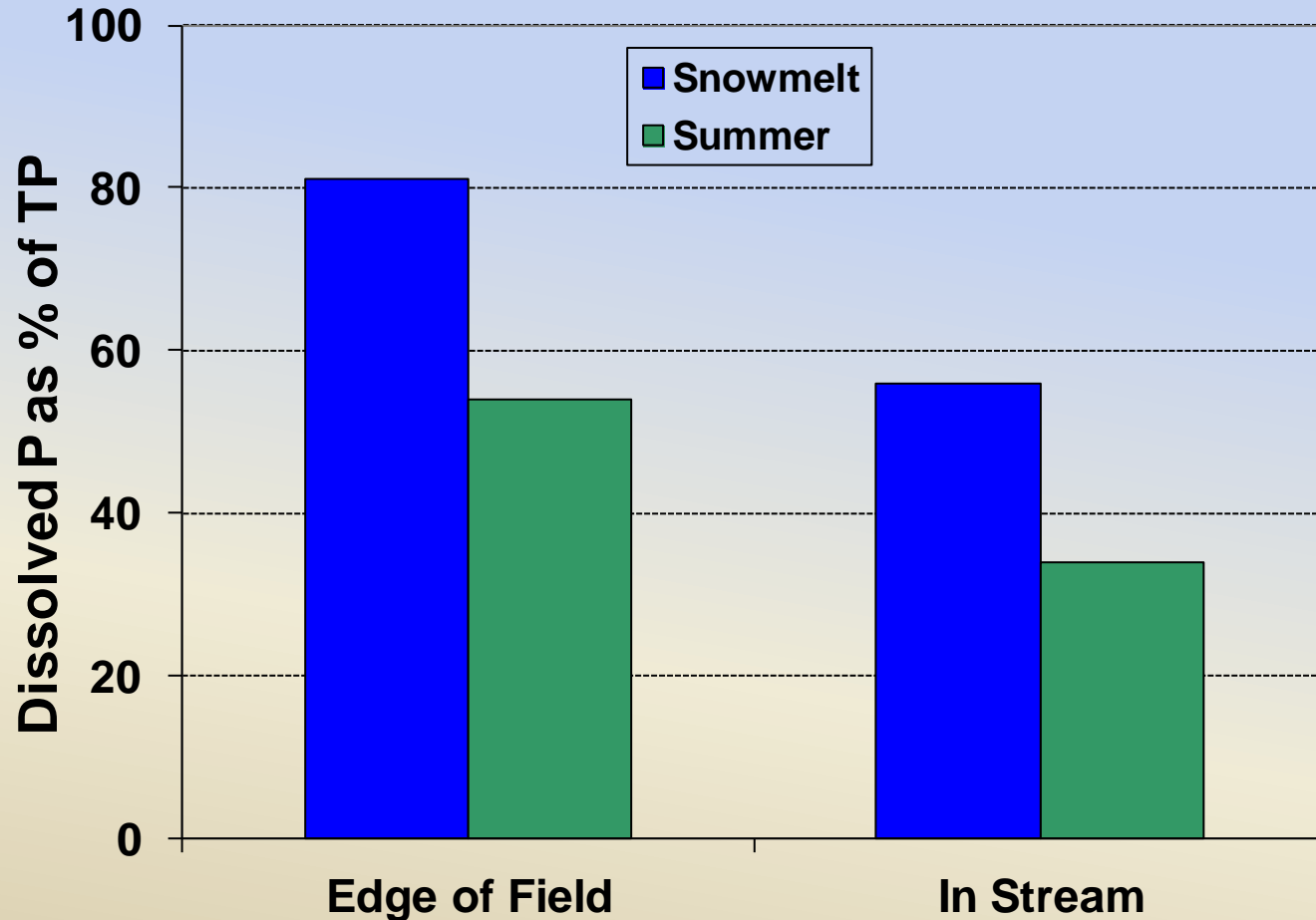
Depth of interaction between runoff and soil is shallow during snowmelt over frozen soil



Photos: David Lobb



Most of the phosphorus lost from Prairie fields is in dissolved, not particulate forms ... especially at edges of fields and especially during snowmelt

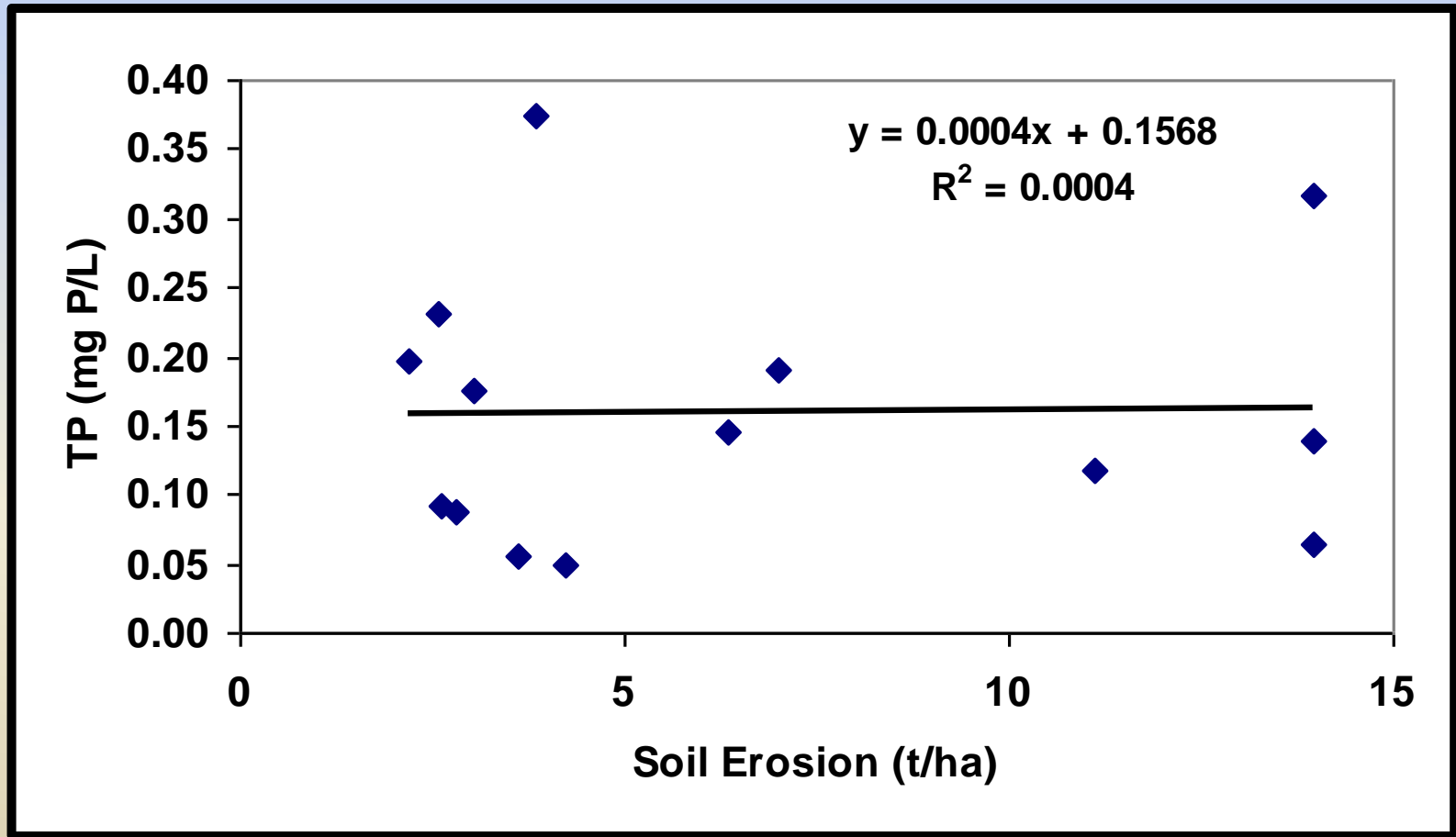


Elliott et al. 2007



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Erosion risk is not related to total P concentrations in rivers from 14 regional Manitoba watersheds



Salvano et al. JEQ 2009



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Eastern Manitoba landscape in late spring: Red River Valley's closed basins show little erosion



Photo: Cargill



Prairie "pothole" landscape in spring also reveals low rates of erosion in Western Manitoba



Photo: M. Conly, National Water Research Institute





How does the dominance of snowmelt runoff affect the performance of beneficial management practices (BMPs) that we generally use for controlling P loss in rainfall dominated runoff?



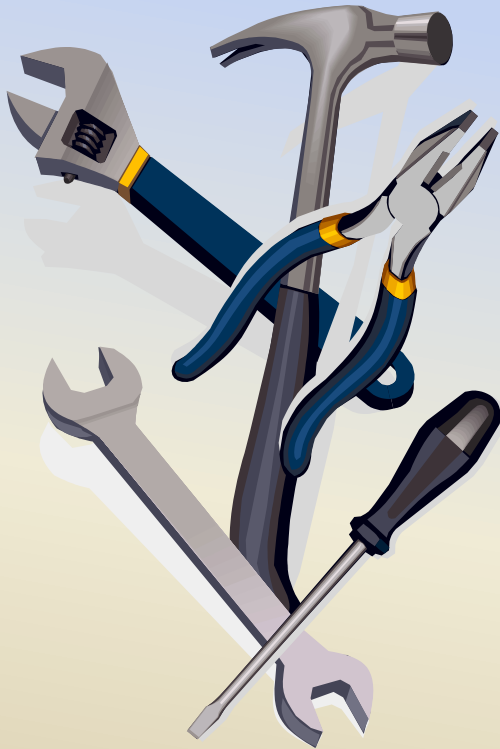
What beneficial management practices (BMPs) do we expect farmers to use?

Source BMPs (nutrient mgmt. in field)

- Rate, placement, timing of manure and synthetic fertilizer application

Transport BMPs (soil & water mgmt.)

- Conservation tillage
- Vegetated buffers
- Cover crops and perennial forage
- Wetland conservation, constructed wetlands and small reservoirs ... to manage water

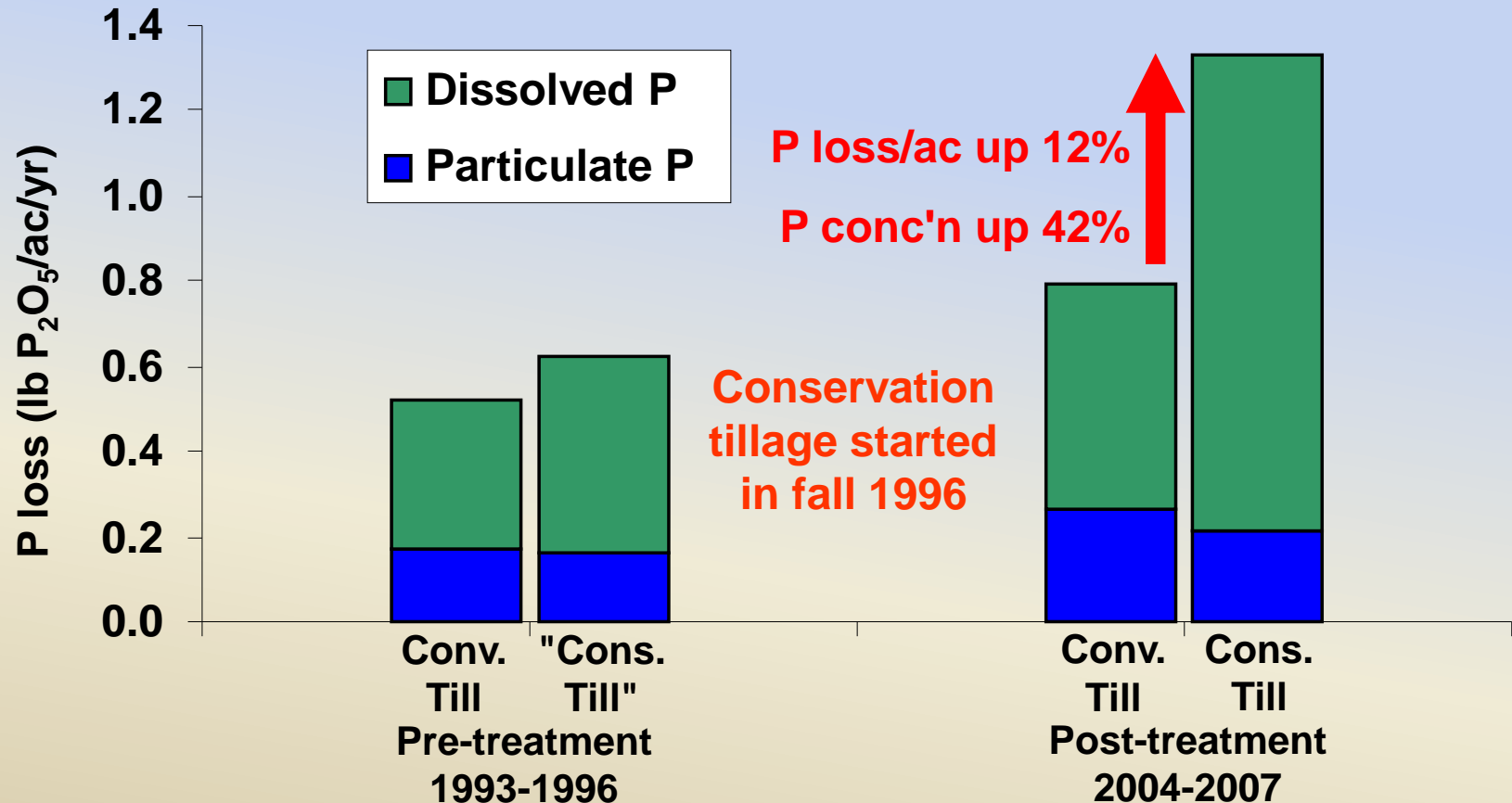




Effects of conservation tillage on water quality in South Tobacco Creek watershed:

- ✓ 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 greater than from conventional tillage ... because erosion of soil particles was a minor contributor to P loss in both systems

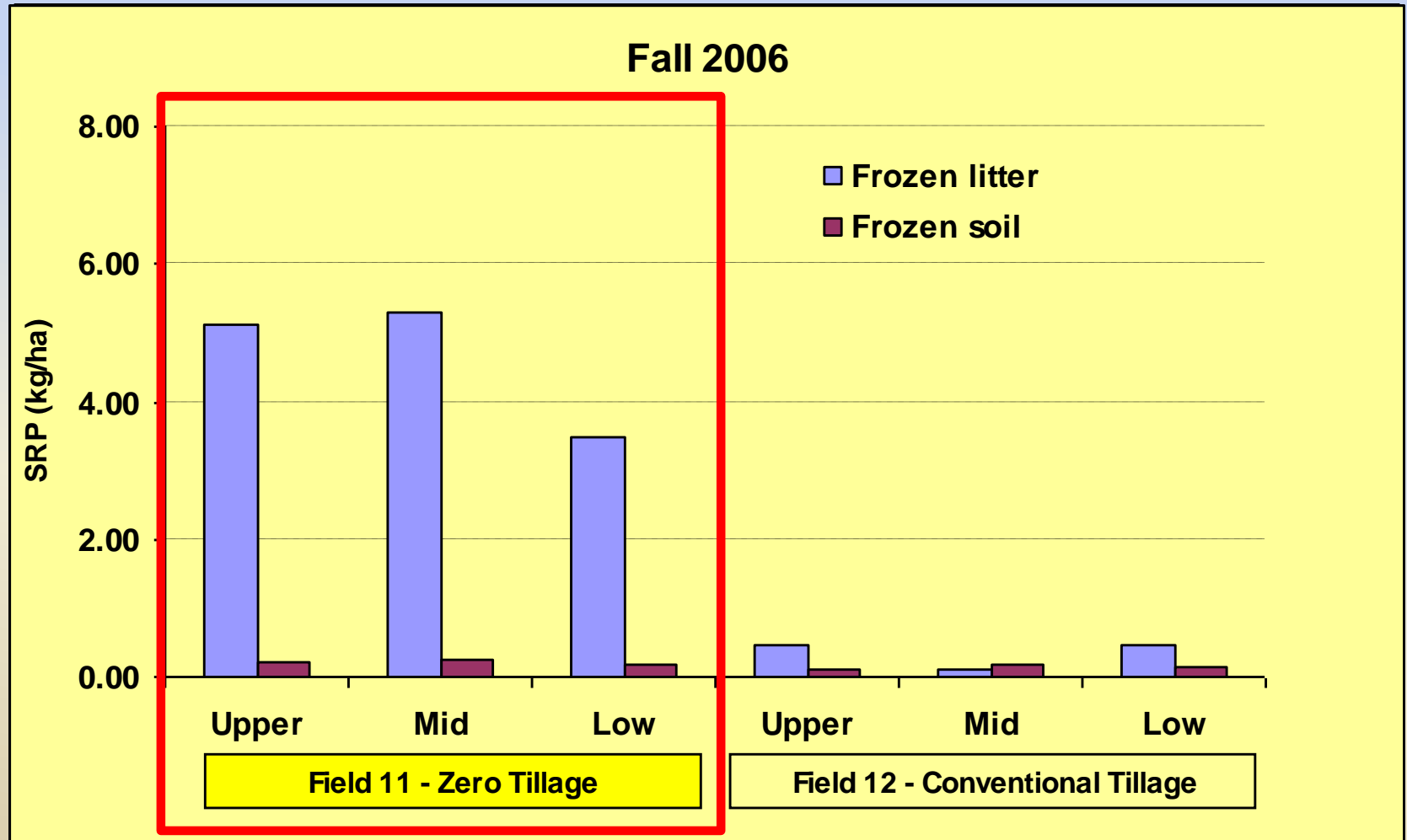


(Tiessen et al. JEQ 2010)



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Dissolved Phosphorus Released from Frozen & Thawed Vegetative Residues & Soil Collected in Late Fall at South Tobacco Creek, MB



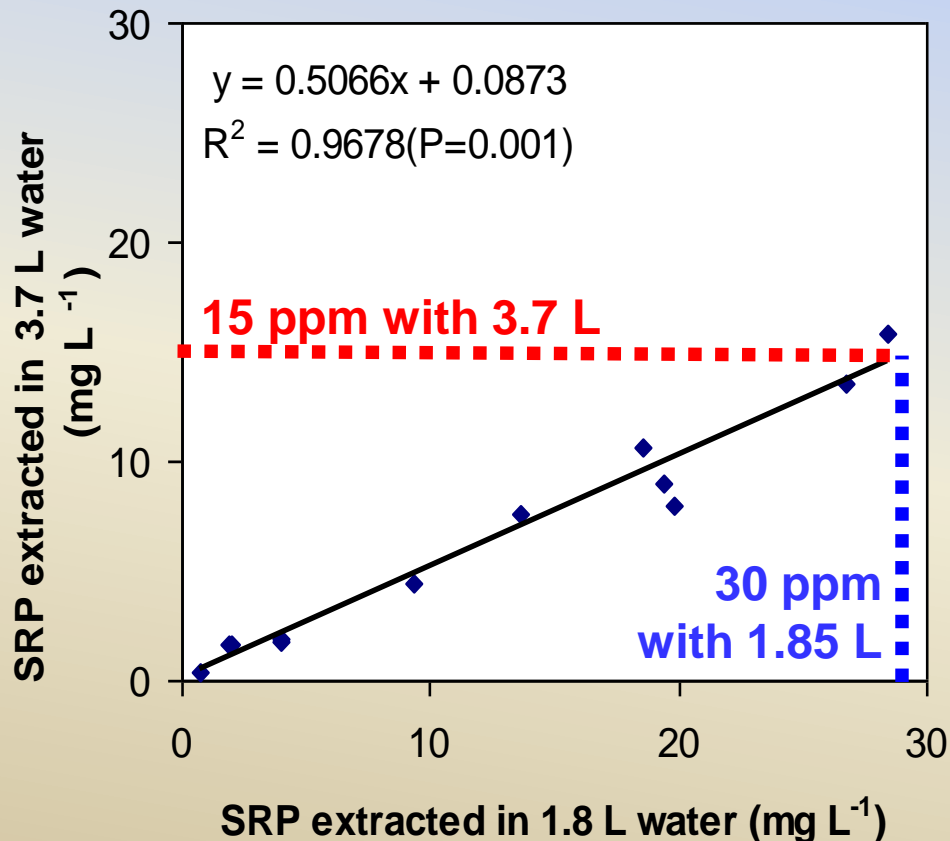
- South Tobacco Creek watershed project, Kumaragamage et al. 2007



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Effect of Water Volume or Flow on Dilution of Dissolved P from Frozen/Thawed Vegetative Residues

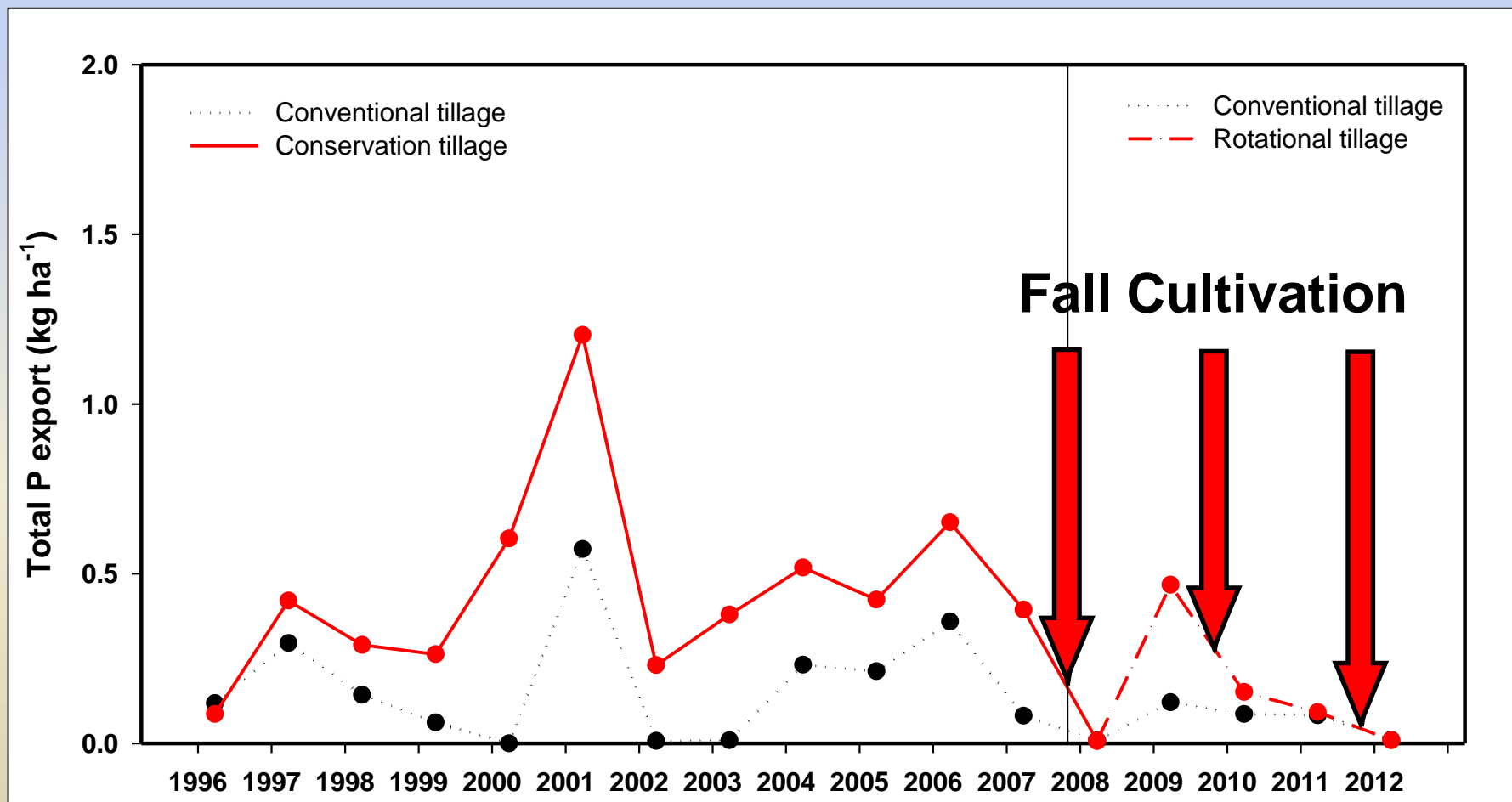
- The concentration of P from frozen/thawed vegetative residues extracted in 3.7 L water was approximately one half the concentration of P from residues extracted by using 1.85 L water



(Saleh MSc thesis 2008)



Rotational tillage ... intermittent tillage reduces P export during snowmelt during the tilled year

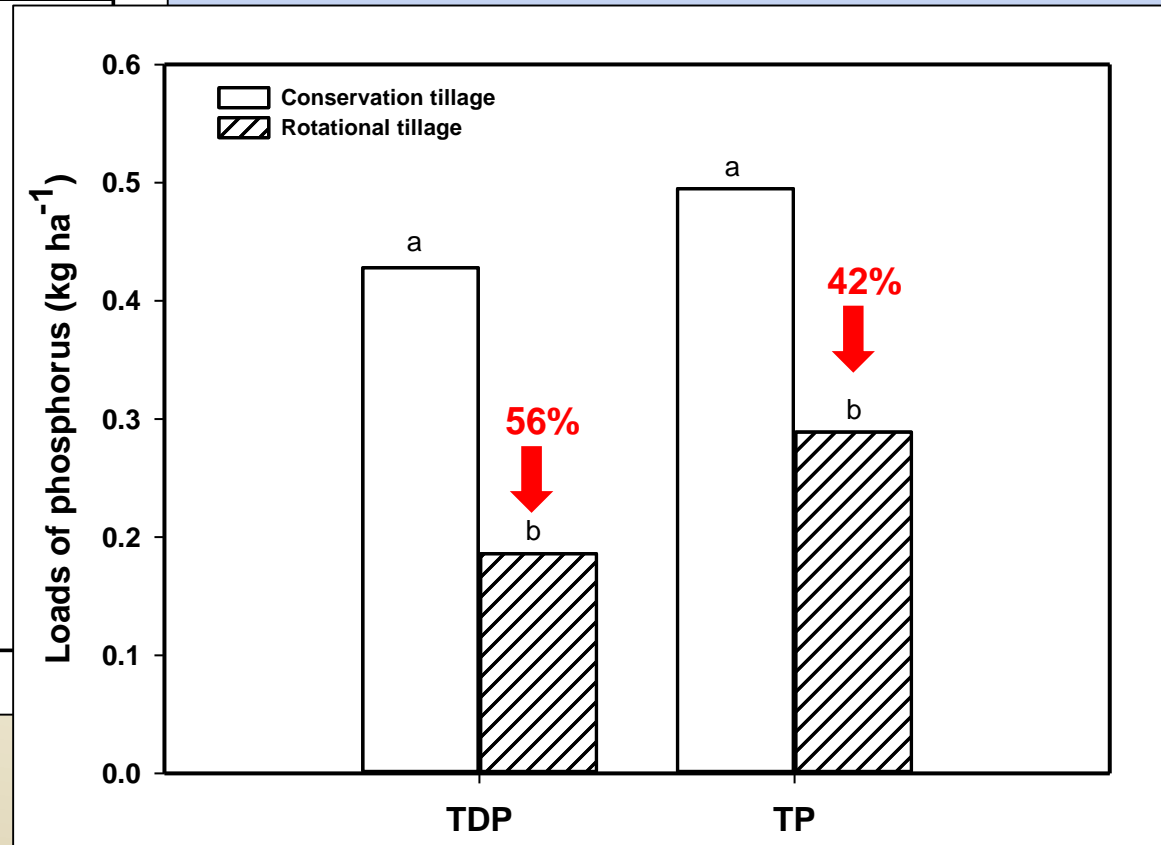
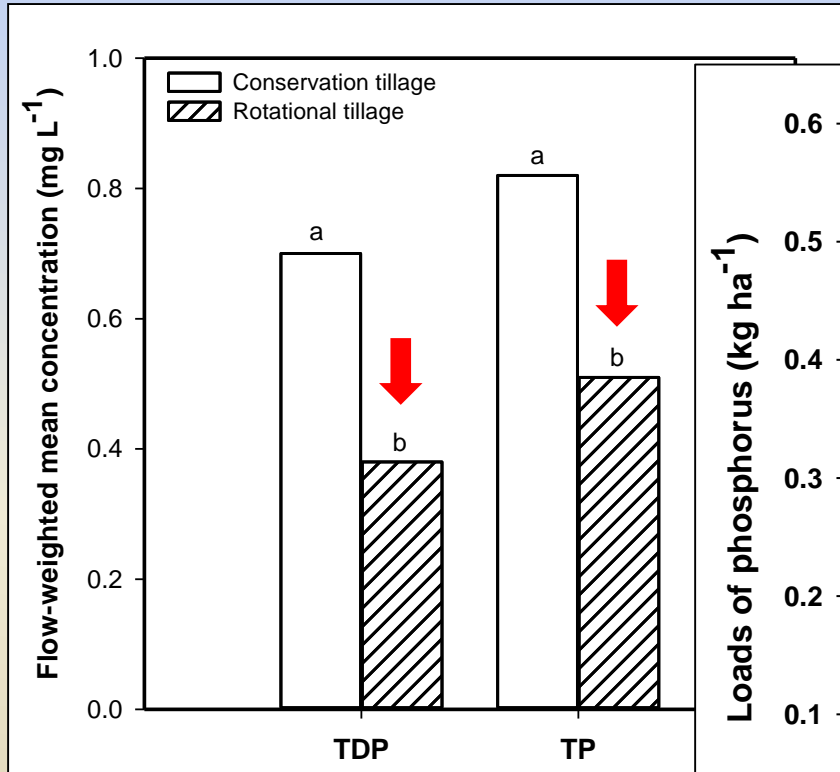


South Tobacco Creek Model Watershed – Liu et al. J. Environ. Qual. 43:1679–1689 (2014)



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According to analysis of covariance, total dissolved and total P concentrations and loads in snowmelt runoff were reduced by 40-60% after fall cultivation

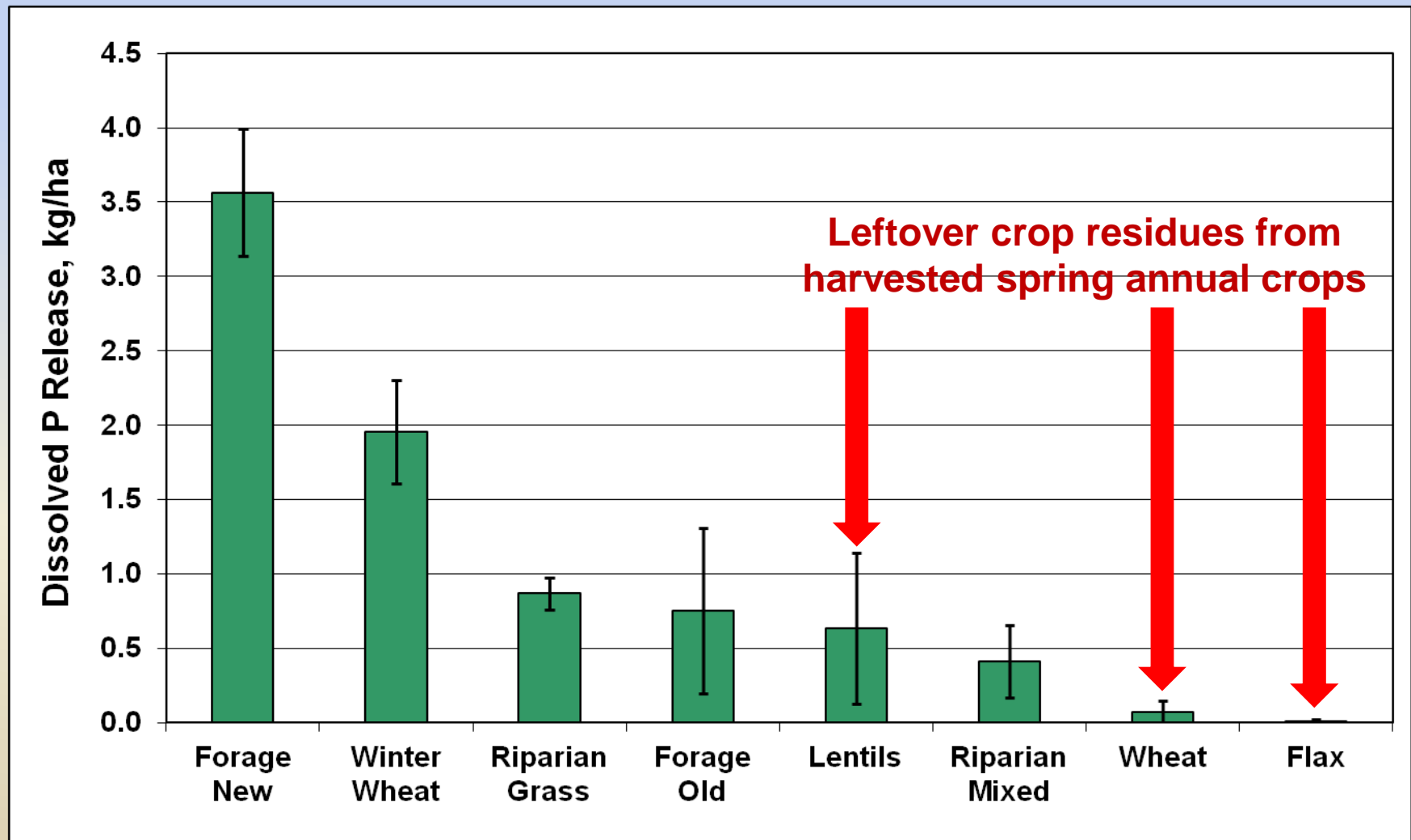


South Tobacco Creek Model Watershed - Liu et al. J. Environ. Qual. 43:1679–1689 (2014)



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

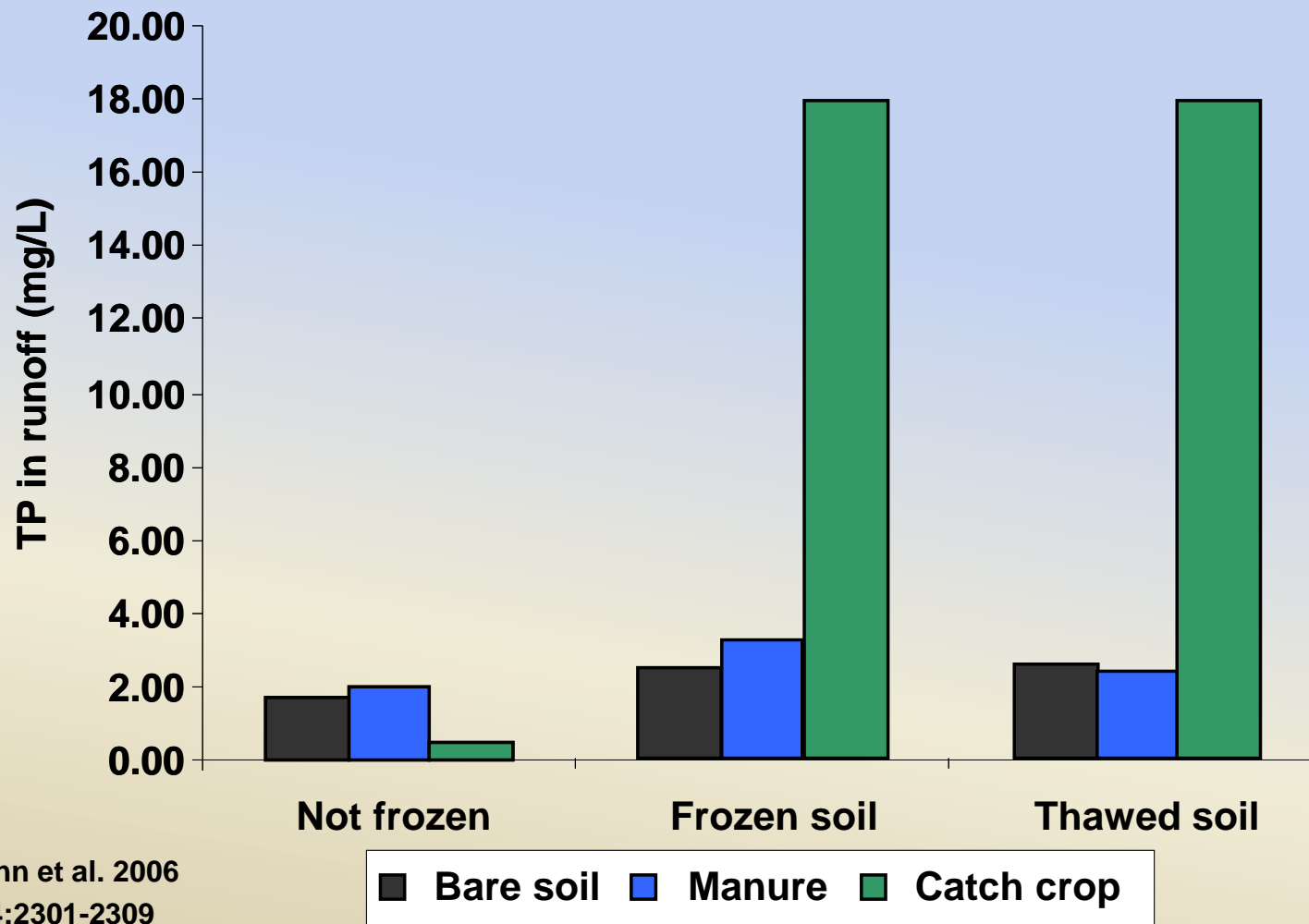


Elliott, J. 2013. Evaluating the potential contribution of vegetation as a nutrient source in snowmelt runoff. Can. J. Soil Sci. 93:435-443.



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

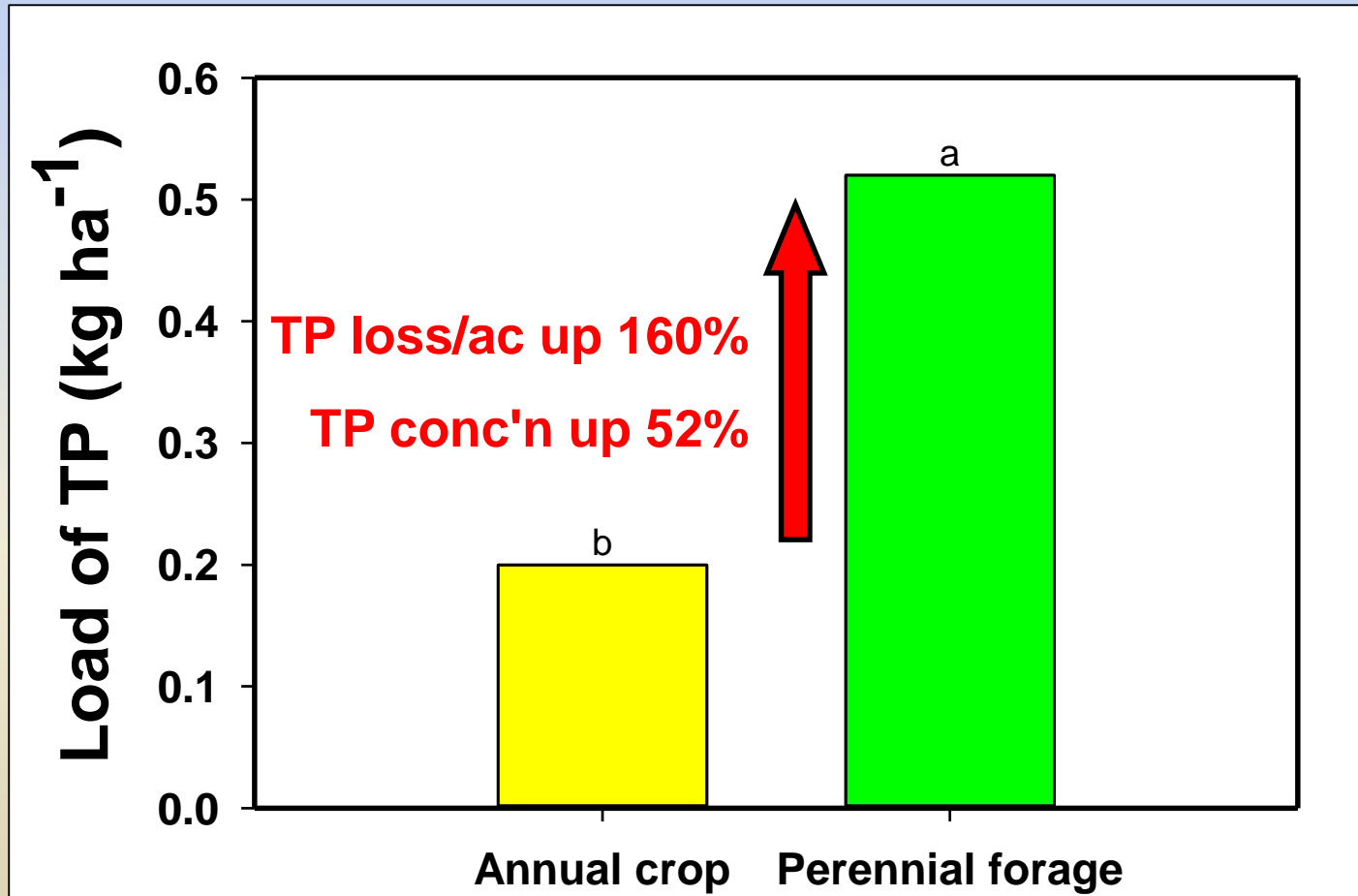


Bechmann et al. 2006
JEQ 34:2301-2309



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Perennial alfalfa forage (unfertilized) lost more than 2.5 times as much total P in snowmelt runoff than fertilized, 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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Vegetated buffer strips in Manitoba not as effective as expected

Sheppard et al. CJSS 2006 (SE MB)

- **VBS reduced runoff [TP] in 50% of cases,**
- **increased P in 18%, had no effect 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**



Photo: Steve Sheppard



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



Photo: David Lobb



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



RESEARCH ARTICLE

Uncertainties in vegetated buffer strip function in controlling phosphorus export from agricultural land in the Canadian prairies

Reza Habibi
Philip N. Owens

Published online September 6, 2018

Journal of Environmental Quality

SPECIAL SECTION

RIPARIAN BUFFER MANAGEMENT

Received: 30
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Abstract Vegetated buffer strips are used as a control for non-point pollution and sediment transport. There is a lack of long-term data on the effectiveness of vegetated buffer strips for controlling phosphorus exports from agricultural land. This study aimed to investigate the effectiveness of vegetated buffer strips in controlling phosphorus exports from agricultural land in the Canadian prairies.

Effectiveness of Vegetated Buffer Strips in Controlling Legacy Phosphorus Exports from Agricultural Land

Reza Habibiandehkordi,* David A. Lobb, Philip N. Owens, and Don N. Flaten

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Abstract

The continued phosphorus (P) loading to aquatic ecosystems and the associated risk of eutrophication have led to a loss of the efficiency of current management practices for improving water quality. Best management practices (BMPs) are widely encouraged by governments and agricultural producers. However, there is a lack of long-term data on the effectiveness of vegetated buffer strips (VBS) for controlling phosphorus exports from agricultural land. This study aimed to investigate the effectiveness of vegetated buffer strips in controlling phosphorus exports from agricultural land in the Canadian prairies.



REVIEW

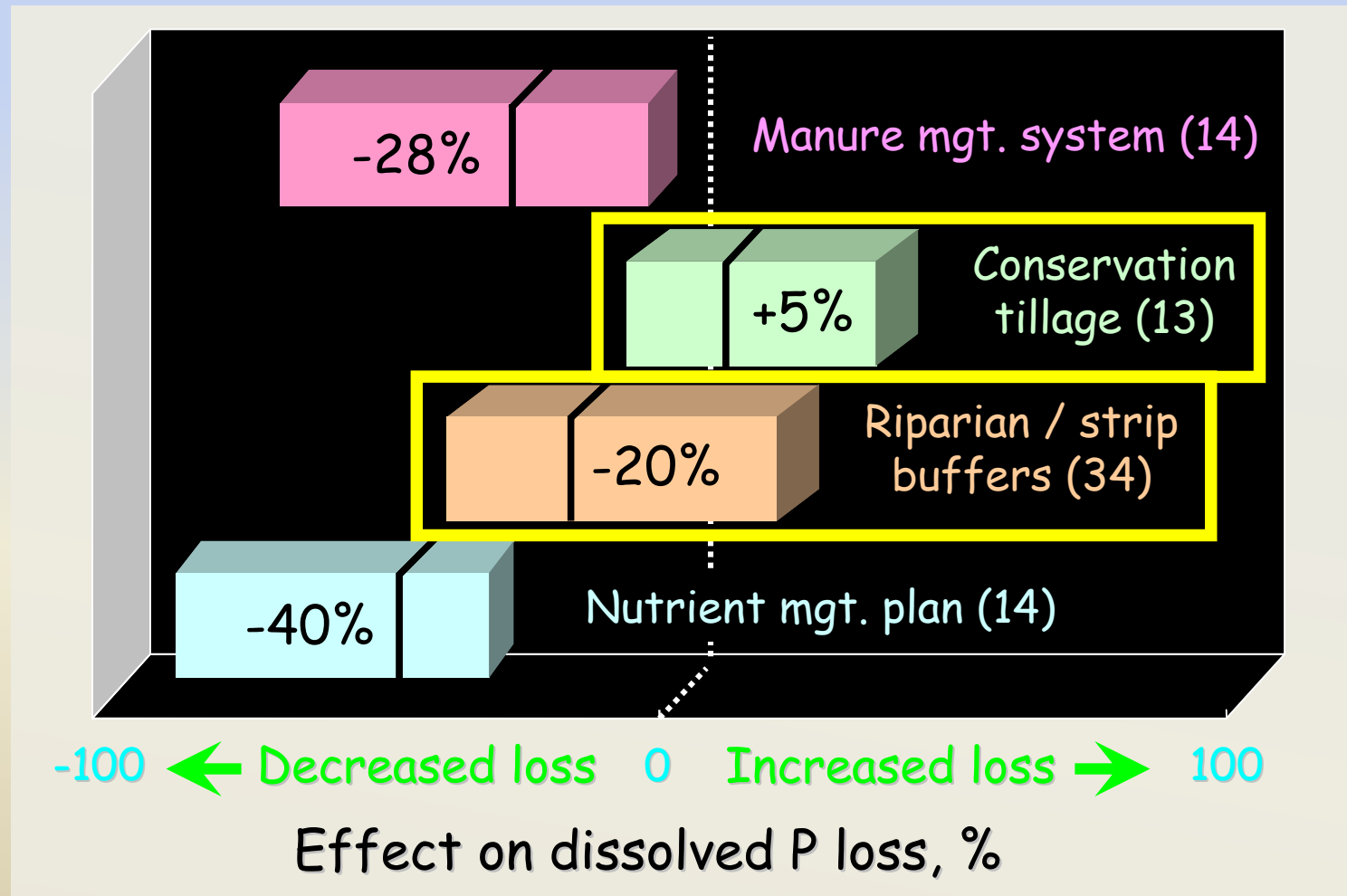
Phosphorus dynamics in vegetated buffer strips in cold climates: a review

Kristen A. Kieta, Philip N. Owens, David A. Lobb, Jason A. Vanrobaeys, and Don N. Flaten

Abstract: The movement of excess phosphorus (P) into streams, rivers, and lakes poses a significant threat to water quality and the health of aquatic ecosystems and thus, P has been targeted for reduction. In landscapes dominated by agriculture, P is primarily transported through non-point sources, which a number of best management practices aim to target. One such practice is vegetated buffer strips (VBS), which are designed to use dense vegetation above the surface and extensive root systems below the surface to reduce runoff velocity, trap sediments, increase infiltration, and increase plant uptake of nutrients. The effectiveness of VBS for controlling phosphorus exports from agricultural land is uncertain. This review aims to synthesize the current knowledge on the effectiveness of VBS for controlling phosphorus exports from agricultural land in cold climates.

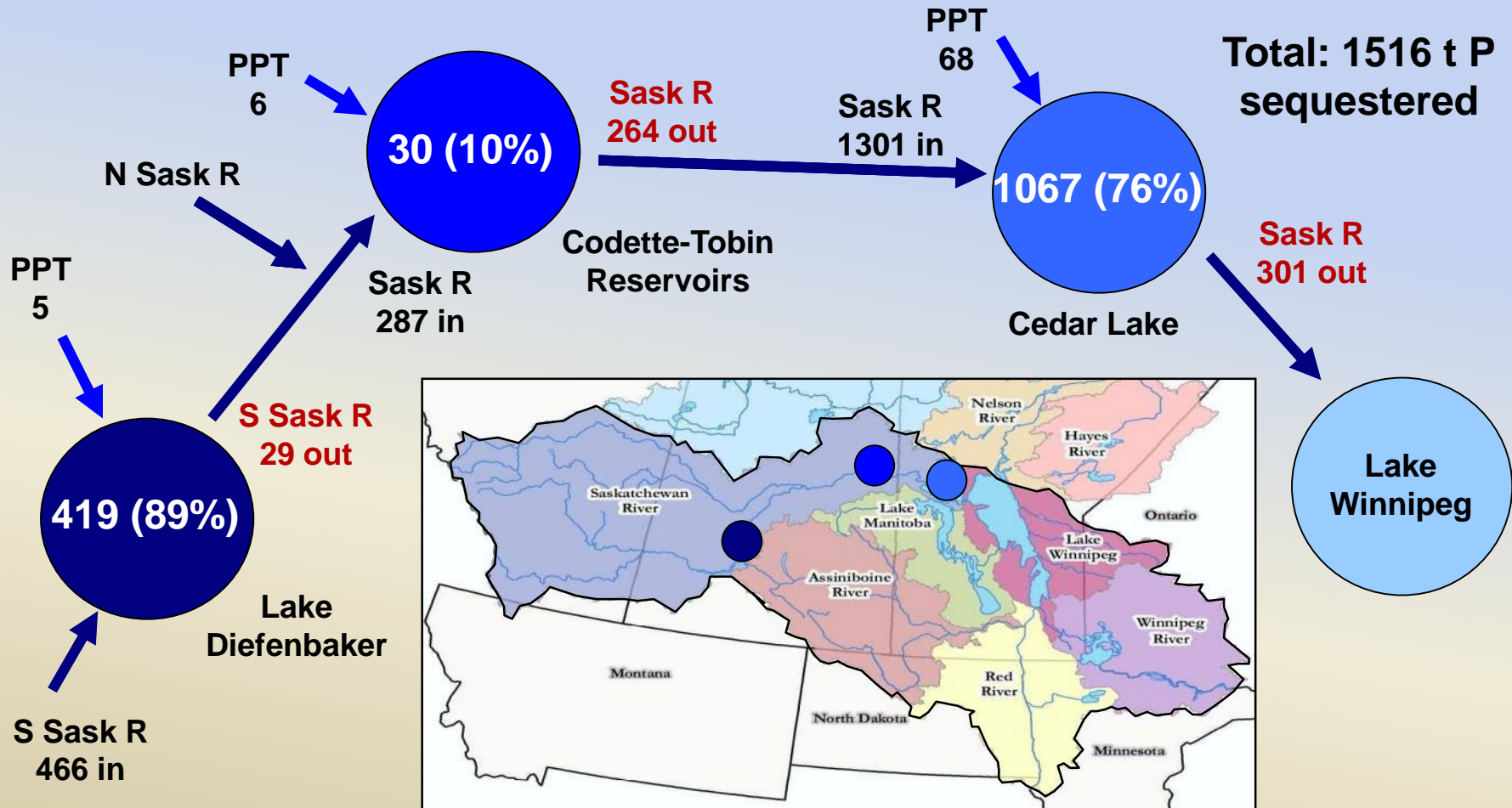
BMP effectiveness for reducing losses of dissolved P

(Sharpley, adapted from Gitau et al. JSWC, 2005)



Large dams and reservoirs: Saskatchewan River Tonnes P in/out/retained, Sept. 2008–Sept. 2009

Brian Parker (formerly with Environment Canada)



Small dams & reservoirs reduce sediment and nutrient loading in Manitoba



eg. small reservoirs in South Tobacco Creek WEBS project reduced loads of:

- sediment (77%)**
- TN (15%), TDN (14%)**
- TP (12%), TDP (10%)**
- mechanisms?**
- relevance to natural or restored wetlands?**

Source: Tiessen et al. 2011 JSWC 66:158-171



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Targeted capturing of runoff ... eg. from confined cattle overwintering areas can reduce farm watershed P loading substantially



Li et al. J. Environ. Qual. 2011

On the Stepler farm in MB, BMPs reduced P export in runoff by 38% and P concentration by 32% ...

1/3 to 2/3 of the reduction due to holding pond ... from 1% of area & 4% of runoff



Integrated Water Management: Offstream Drainage/Irrigation Reservoirs



**Carl Classen 's farm reservoir near Elm Creek, MB
for collecting surface & tile drain water for
subsequent irrigation**

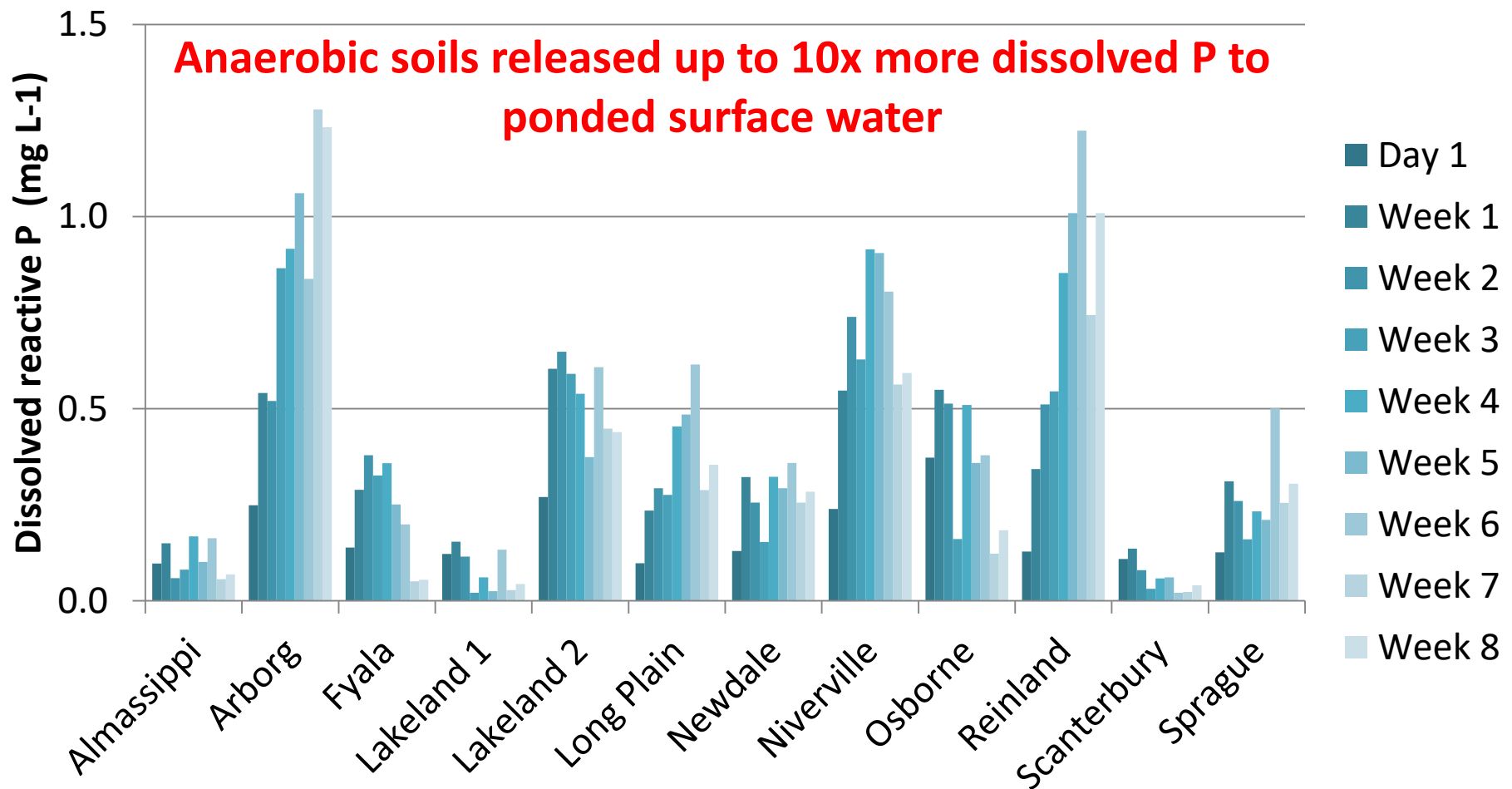


Phosphorus Release from Submerged Agricultural Soils

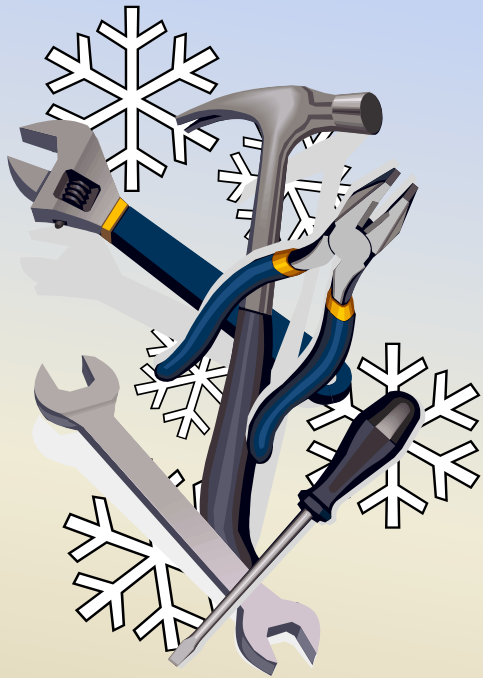
- Many flooded agricultural soils release large amounts of P to ponded surface water if the soil becomes anaerobic
- Major implications for BMPs that “slow the flow” of water off ag land ... eg. restricted drainage, constructed or restored wetlands



Dissolved P Released from Flooded Soil to Ponded Surface Water: Amarawansha et al. JEQ 44:1252



What beneficial management practices (BMPs) do we expect farmers to use?



Source BMPs (nutrient mgmt. in field)

- Rate, placement, timing of manure & synthetic fertilizer application

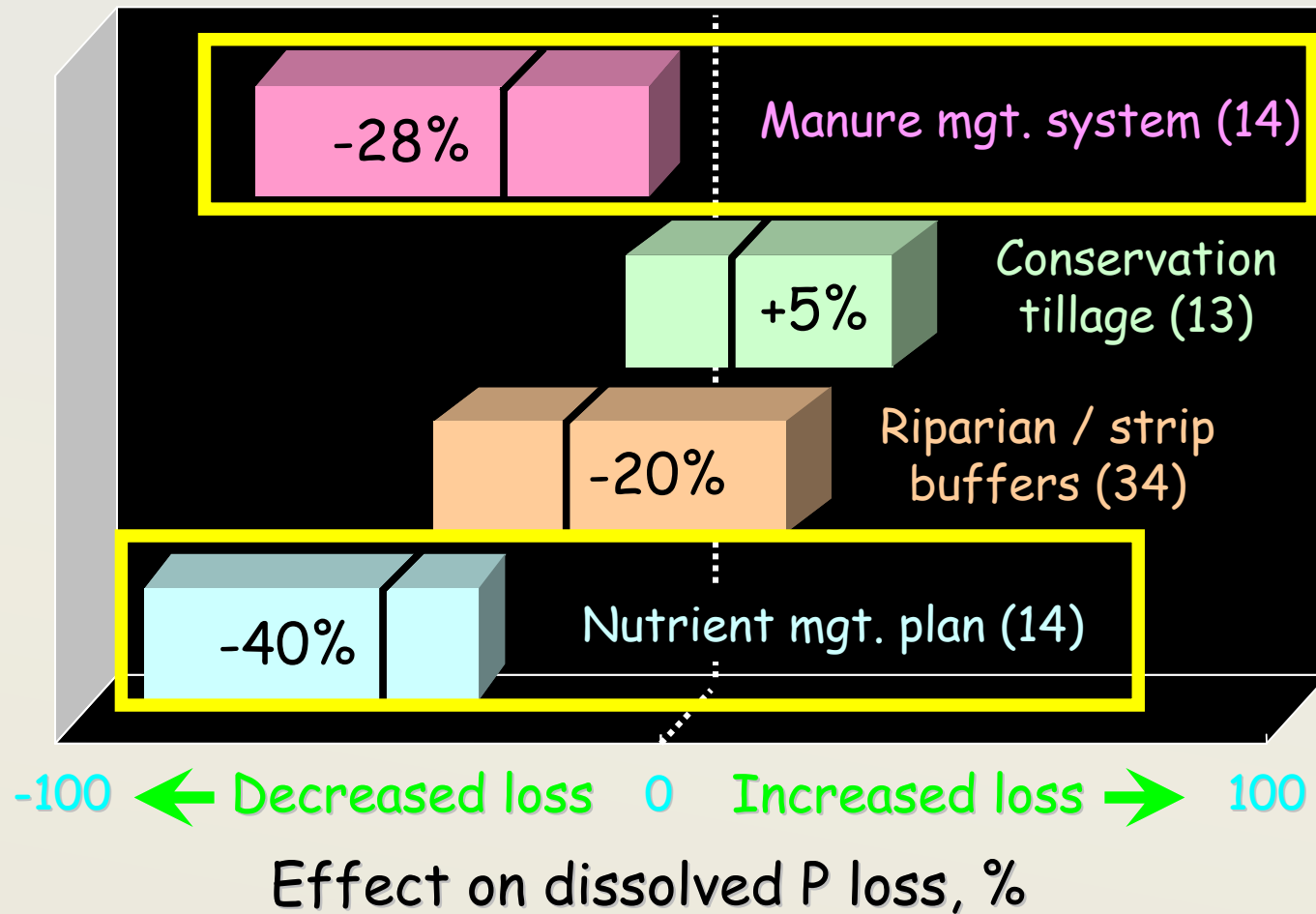
Transport BMPs (soil & water mgmt.)

- Conservation tillage
- Vegetated buffers
- Cover crops and perennial forage
- Wetland conservation, constructed wetlands and small reservoirs ... to manage water

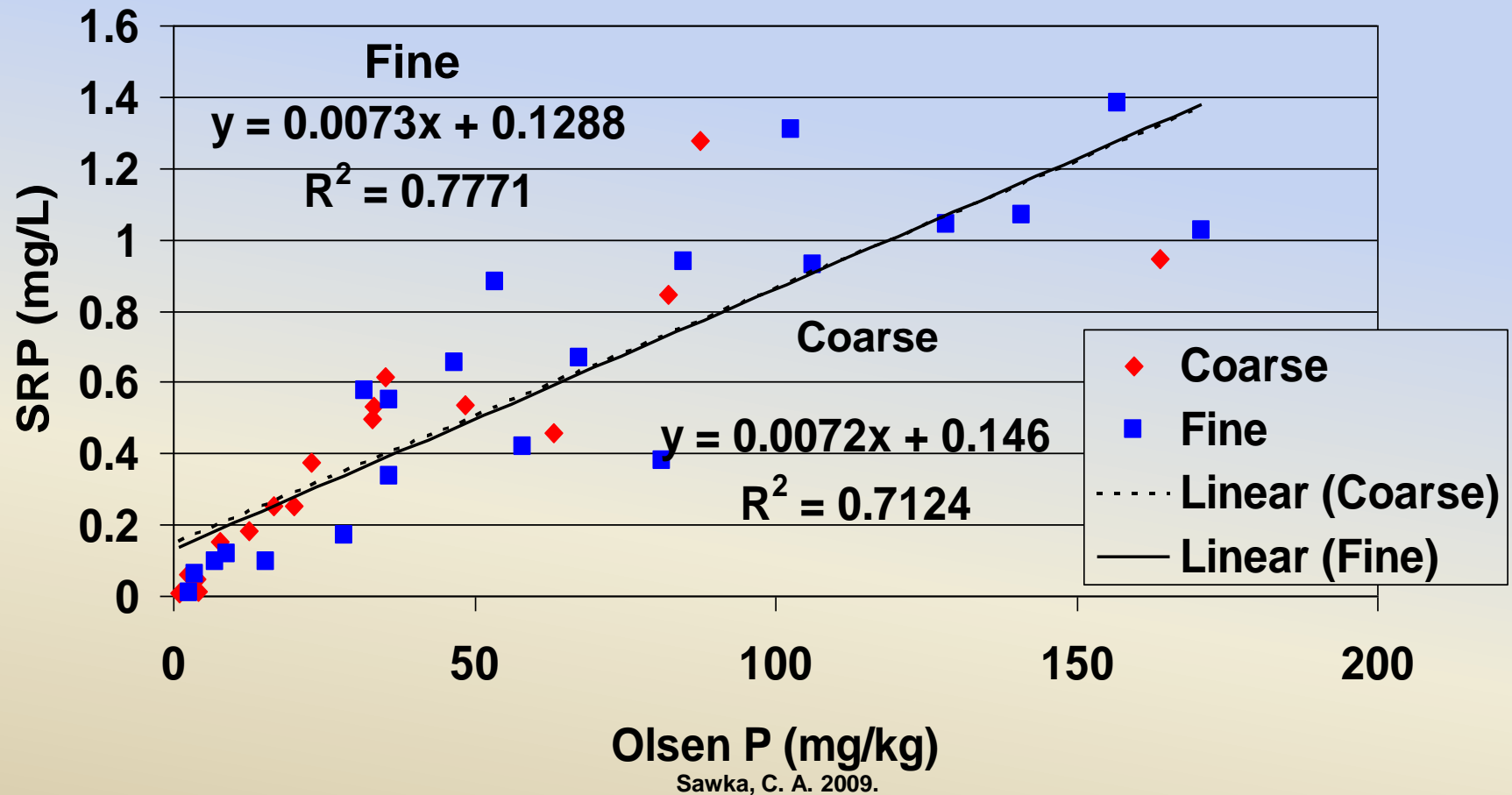


BMP effectiveness for reducing losses of dissolved P

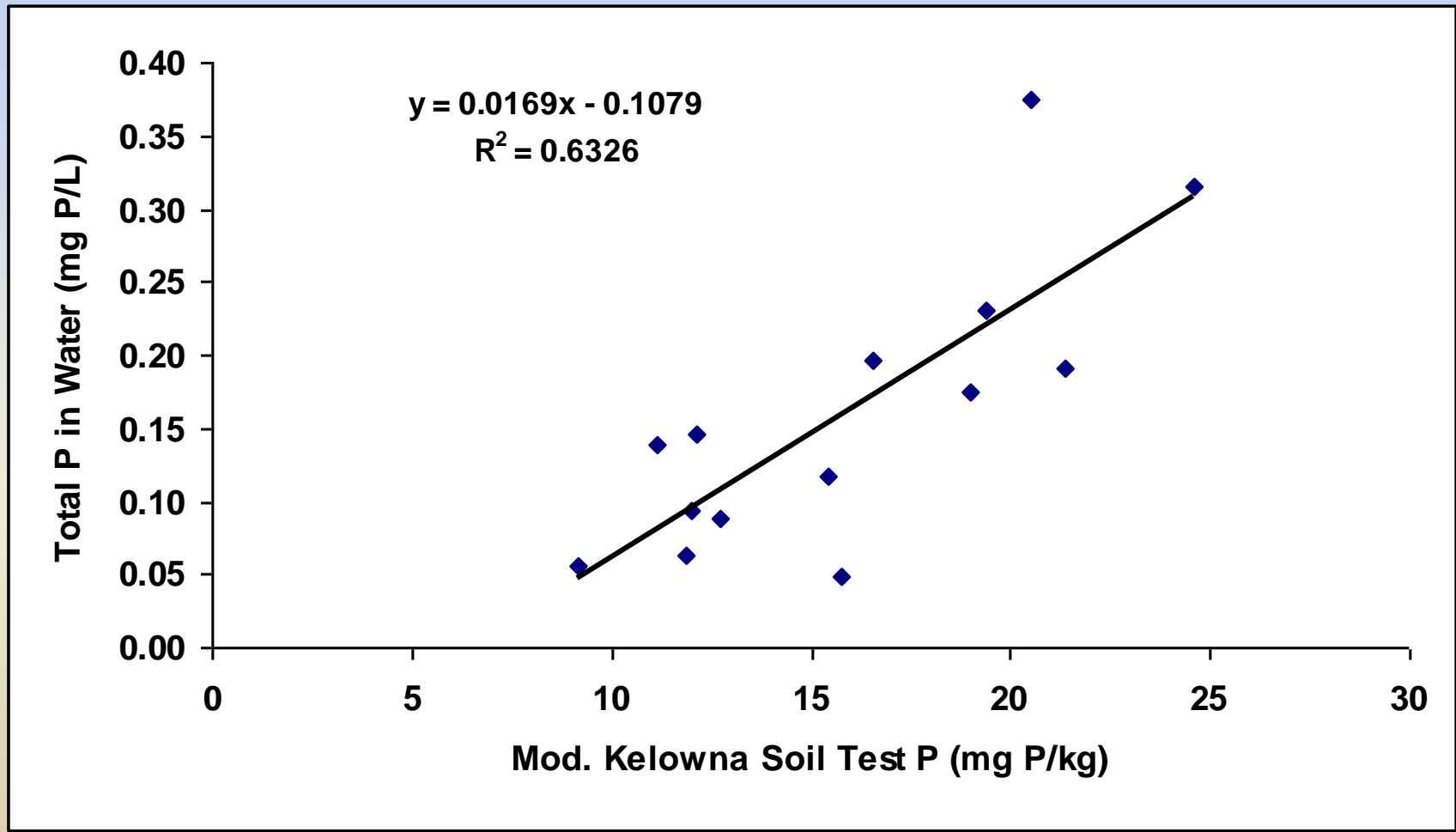
(Sharpley, adapted from Gitau et al. JSWC, 2005)



Olsen soil test P is strongly related to soluble P concentrations in simulated runoff from coarse and fine-textured Manitoba soils



Soil test P is related to river P concentrations in 14 regional Manitoba watersheds

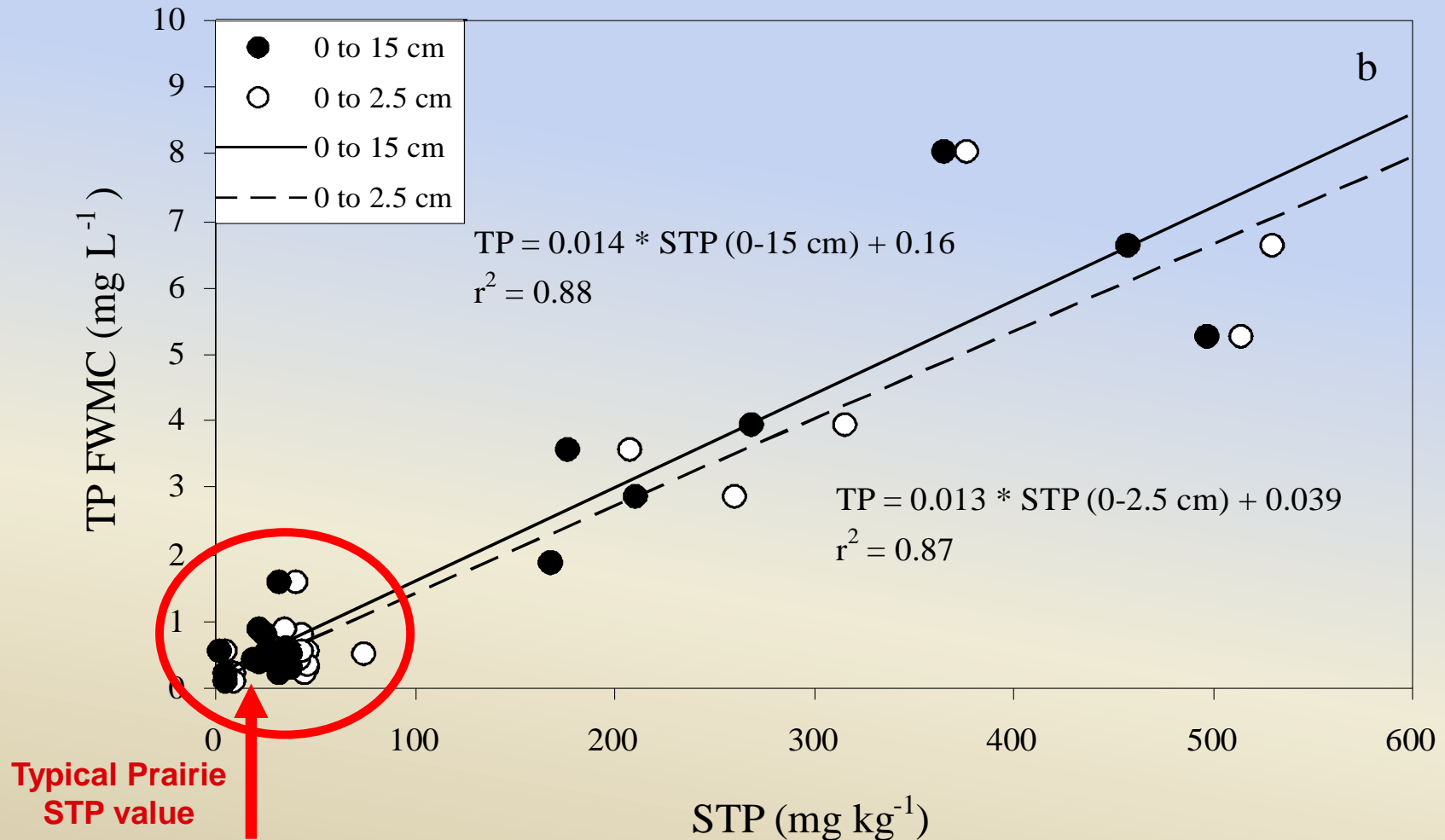


Adapted from Salvano and Flaten. 2006. Phosphorus risk indicators: Correlation with water quality in Manitoba. JEQ

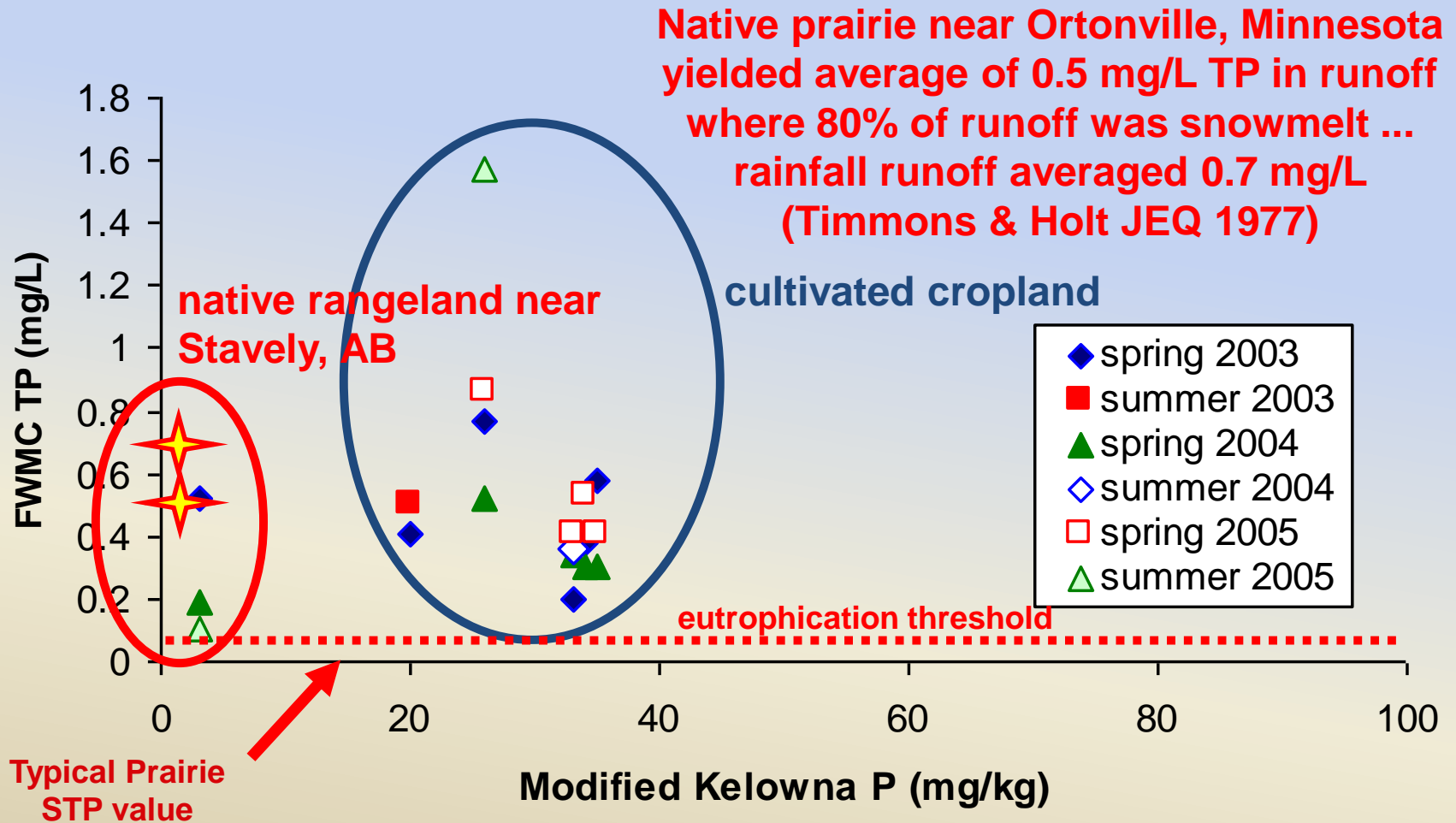


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At high levels of STP, STP is strongly related to total P concentrations in runoff in Alberta

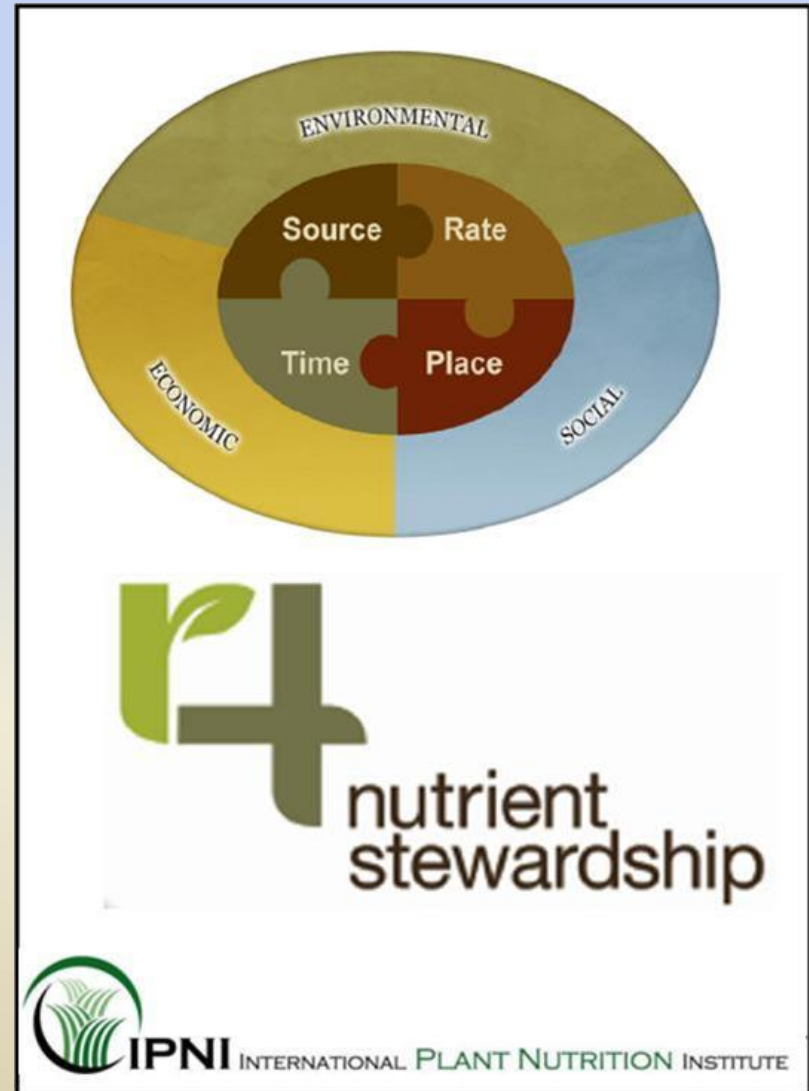


At low levels of STP, STP is not related to total P concentrations in runoff in Alberta

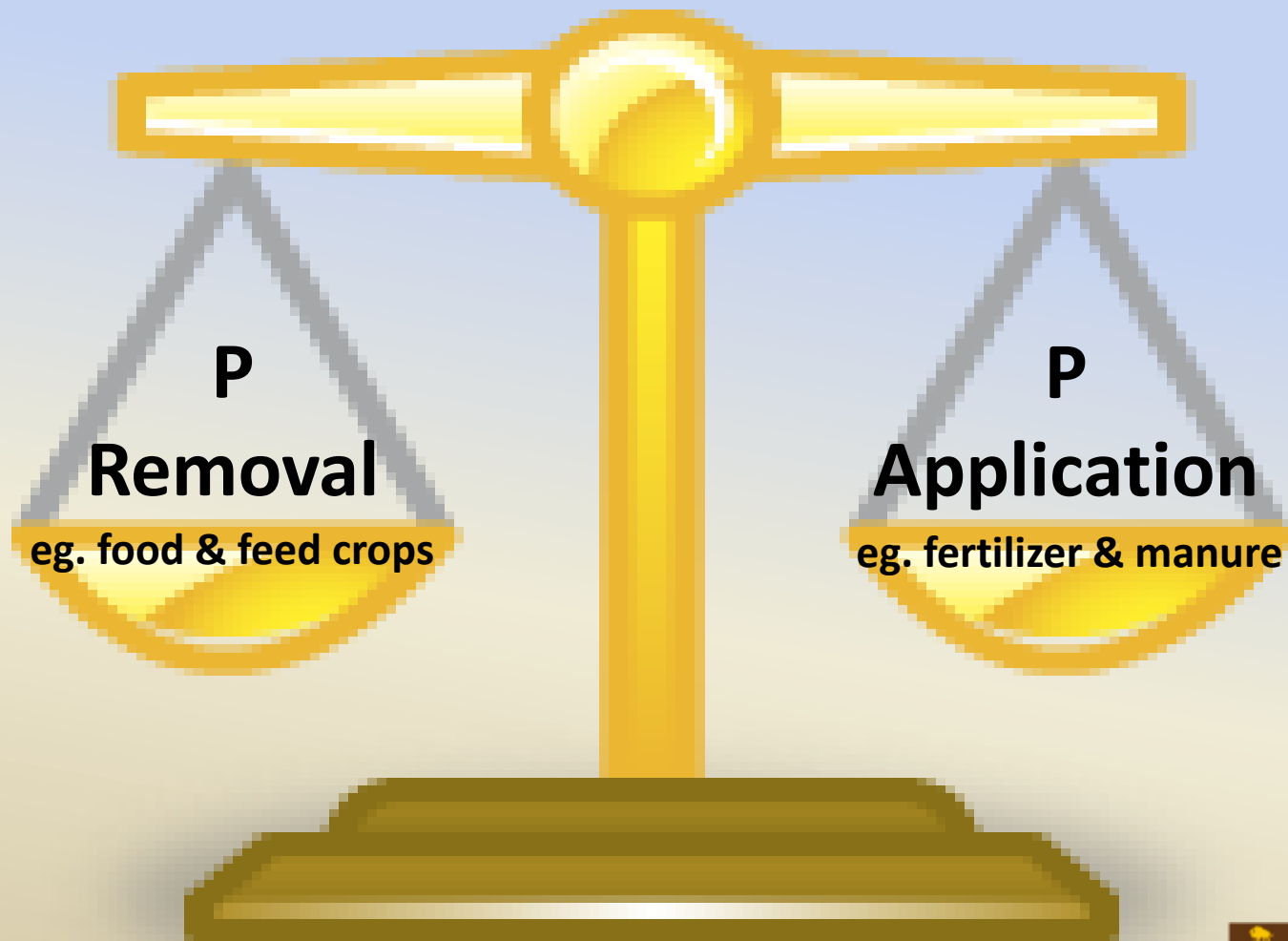


4R Nutrient Stewardship as a Strategy for Sustainable Agricultural Production

- ✓ **Right rate**
- ✓ **Right source**
- ✓ **Right placement**
- ✓ **Right timing**



P Rate: Balancing P application with crop removal is essential for sustainable crop production and environmental protection



Percent of Samples Testing Below Critical Levels for P in 2015



**Clayton Harder's canola field, north of Wpg.
With and Without 40 lbs P_2O_5 + 12 lbs S/acre**



Photo: Clayton Harder

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

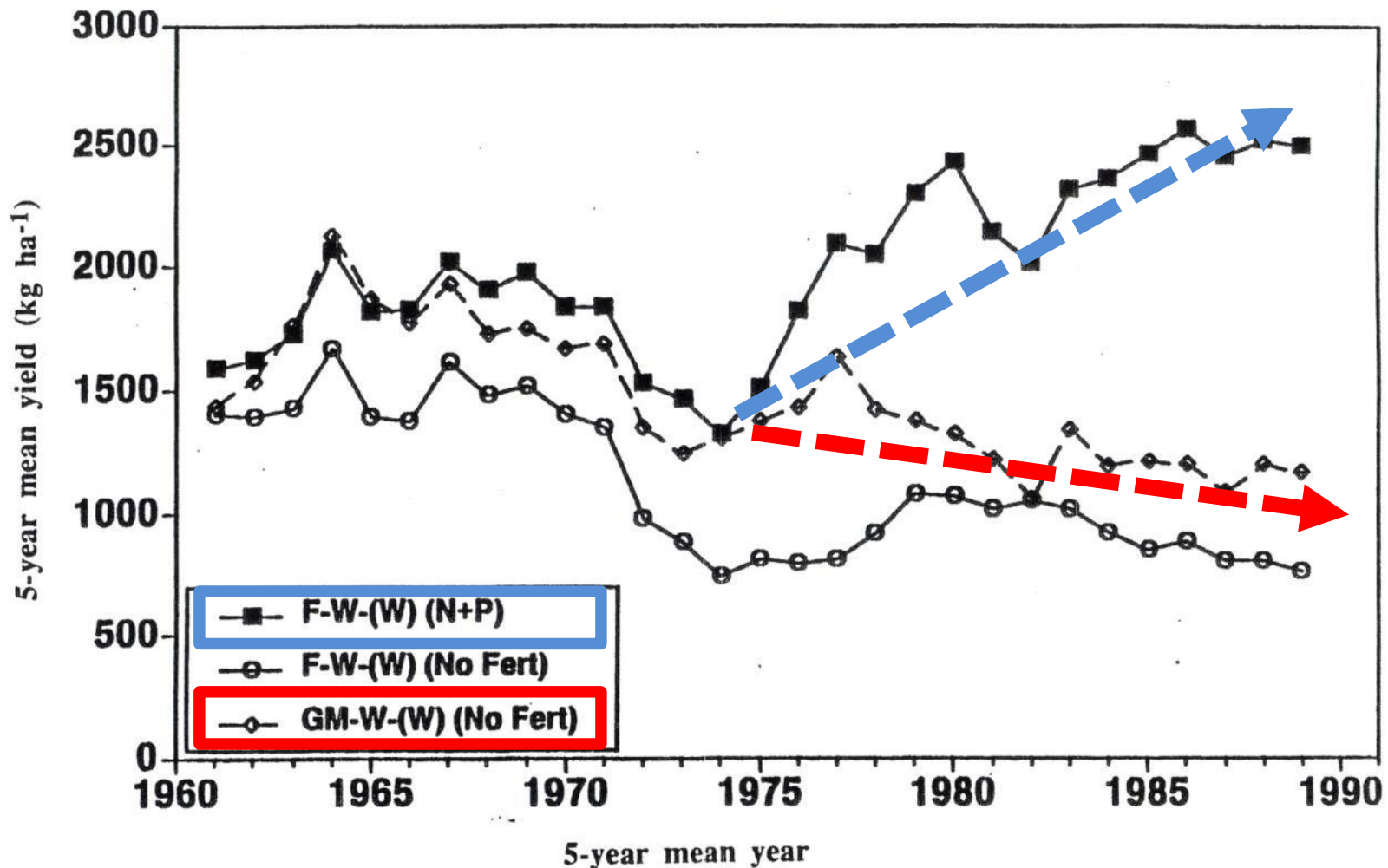
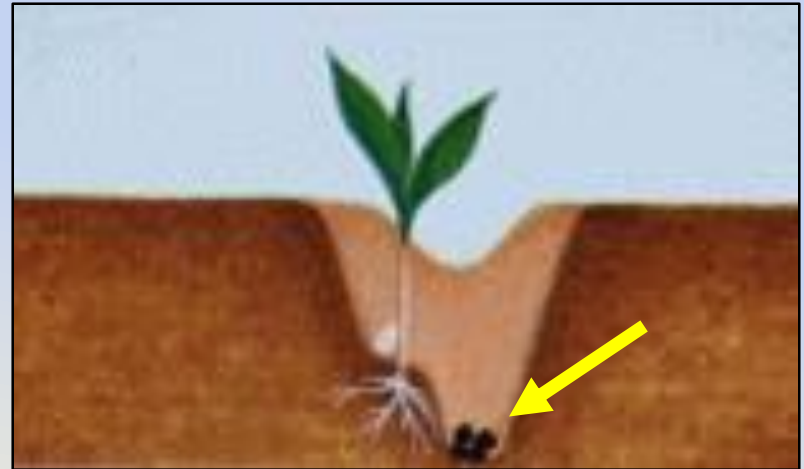


Figure 1. Yields of stubble wheat crops in fallow-wheat-wheat (F-W-W), fallow-wheat-wheat plus fertilizer (F-W-W (N+P)) and green manure-wheat-wheat (GM-W-W) rotations at Indian Head (Black soil zone) (C.A. Campbell, unpublished data).

P Placement: Almost all fertilizer P in MB is banded under soil surface, in or near seedrow, at planting

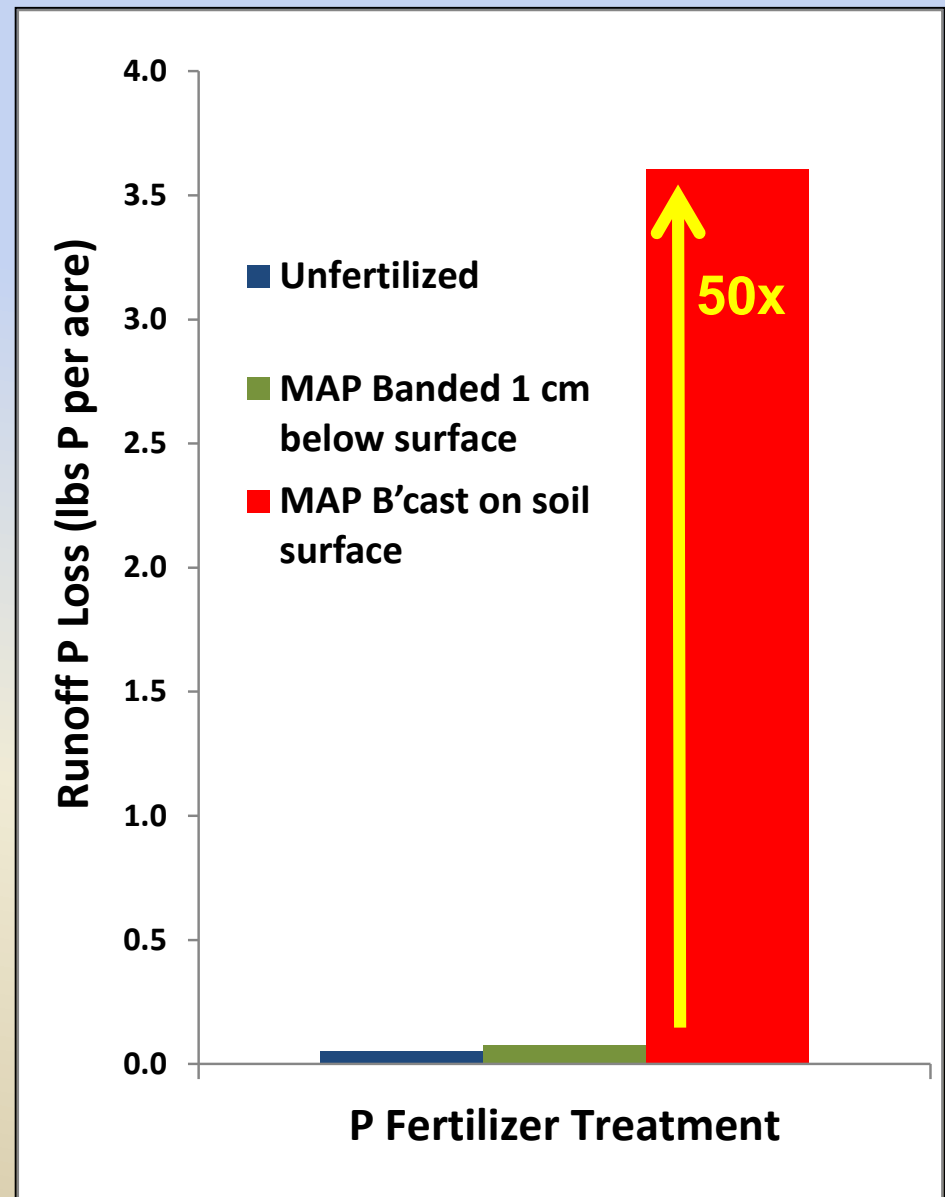
Agronomically beneficial
Environmentally beneficial
because P placed under
soil surface after spring
runoff



Broadcasting P decreases agronomic efficiency and increases environmental risk

Runoff losses for banded vs. broadcast P applied at 100 lbs MAP (11-52-0) per acre in laboratory studies were 50 times greater for broadcast P than for P banded 1 cm below the soil surface

(Smith et al. 2016)



What's the right placement for manure?

- Manure should be injected or incorporated, wherever possible ... especially if applied in fall
- In MB, approx. 60% of solid manures and 83% of liquid manures are injected or incorporated (Stats Canada 2006)
 - better agronomically
 - less odour and risk of nutrient loss



Photo: Rahman et al. 2005. Cdn. Biosys. Eng. 47: 6.9-6.16.



Timing of nutrient application

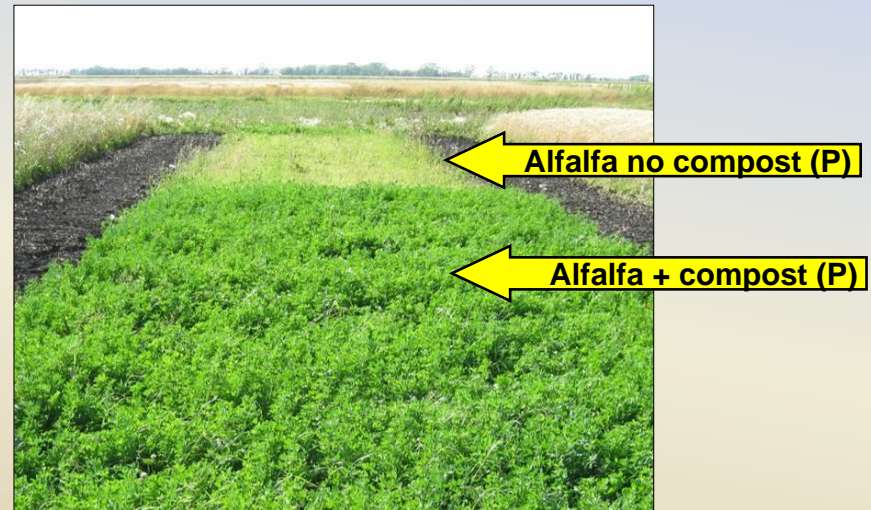
- Manure or fertilizer broadcast on frozen soil or snow is bad agronomically and environmentally (eg. Srinivisan et al. 2006, Klausner 1976, Young & Mutchler 1976)
- In MB, winter application of manure prohibited for large livestock operations in 1999 and universally for manure and fertilizer in 2013



Summary and Conclusions



- Phosphorus is essential for all forms of life
- Over the short and long term, we need to add P to cropland to maintain long term productivity



Summary and Conclusions, cont'd.



September 3, 2006. The largest area of algal blooms ever seen on Lake Winnipeg (G. McCullough, U of MB)

- Small amounts of excess P in runoff cause big problems with water quality
- Many small sources of P contribute to the problem
- Agriculture needs to find ways to reduce its share of the P load to surface water



Summary and Conclusions, cont'd.

- **Snowmelt runoff is the dominant form of runoff in many parts of the Northern Great Plains**
- **Processes and BMPs that control P loss in snowmelt runoff are not well known ... but they are different from those that control P loss in rainfall runoff**



Photo: David Lobb

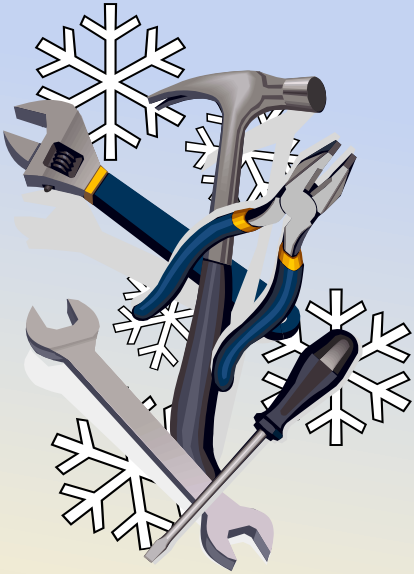


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Summary and Conclusions, cont'd.

Source BMPs

- Many nutrient management BMPs are available and widely used (e.g., 4Rs - right source, rate, placement, timing of P fertilizer and livestock manure)
- Aim for P balance, avoid high soil test P, avoid winter application of fertilizer and manure, avoid fall broadcast P fertilizer without incorporation



Summary and Conclusions, cont'd.



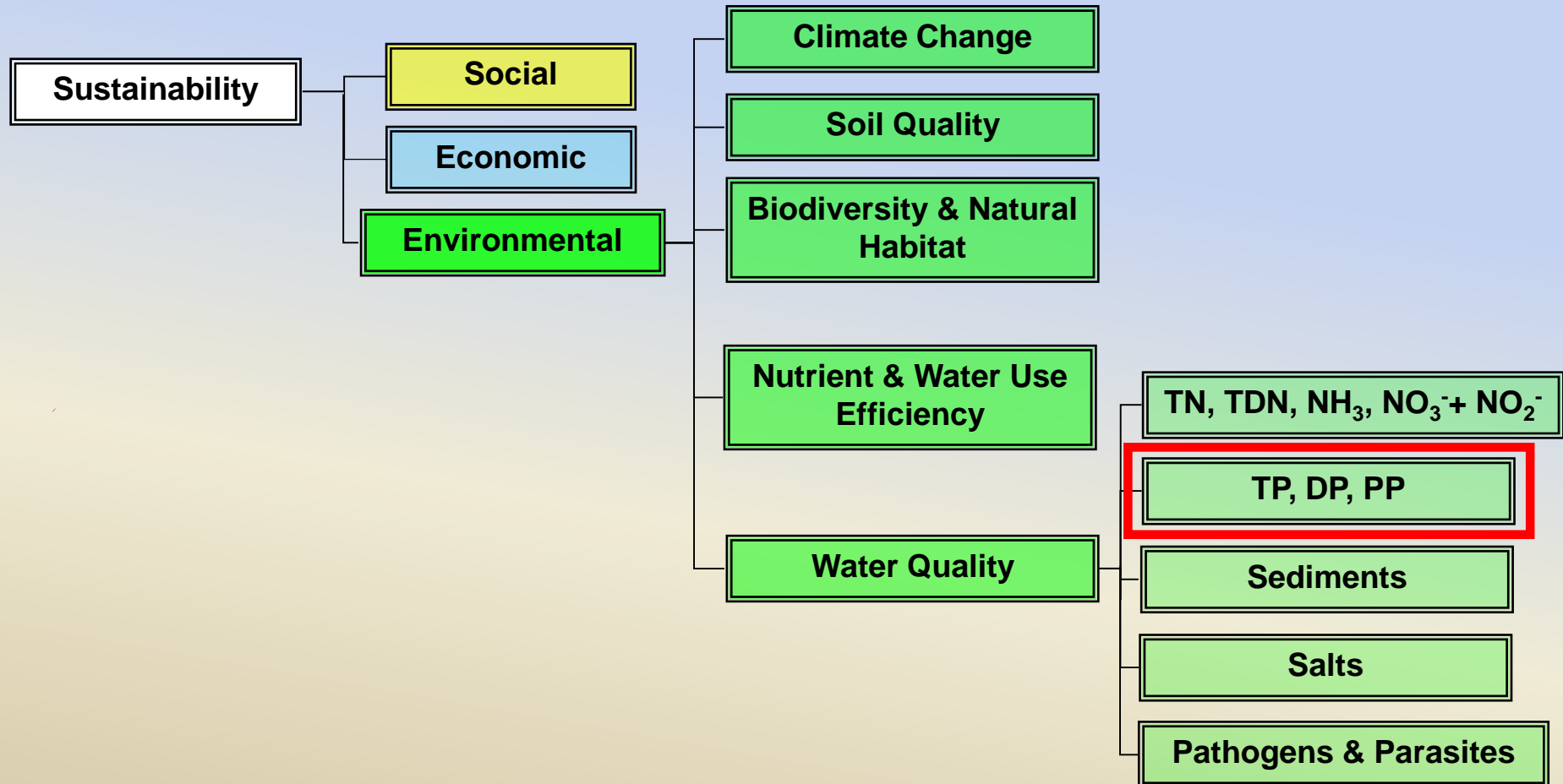
Transport BMPs

- **Practical BMPs for intercepting nutrients in Northern Great Plains soils, landscapes and climate need more development**
- **If erosion is not the main cause of P loss, erosion control measures such as conservation tillage, perennial forage or vegetated buffers will do little to reduce P loss**
- **Careful selection and management of transport BMPs is required to avoid increasing P losses, partly because vegetation can be a P source, instead of a P sink, especially during snowmelt**



Summary and Conclusions, cont'd.

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



Acknowledgements

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*** main sponsors for South Tobacco Creek Model Watershed**

