Phosphorus as a Resource
Sustainable Solutions for Infrastructure, Food Security and the Environment
Ryerson University, Toronto, Ontario
19 June 2014

Managing Phosphorus Cycling for Food Security

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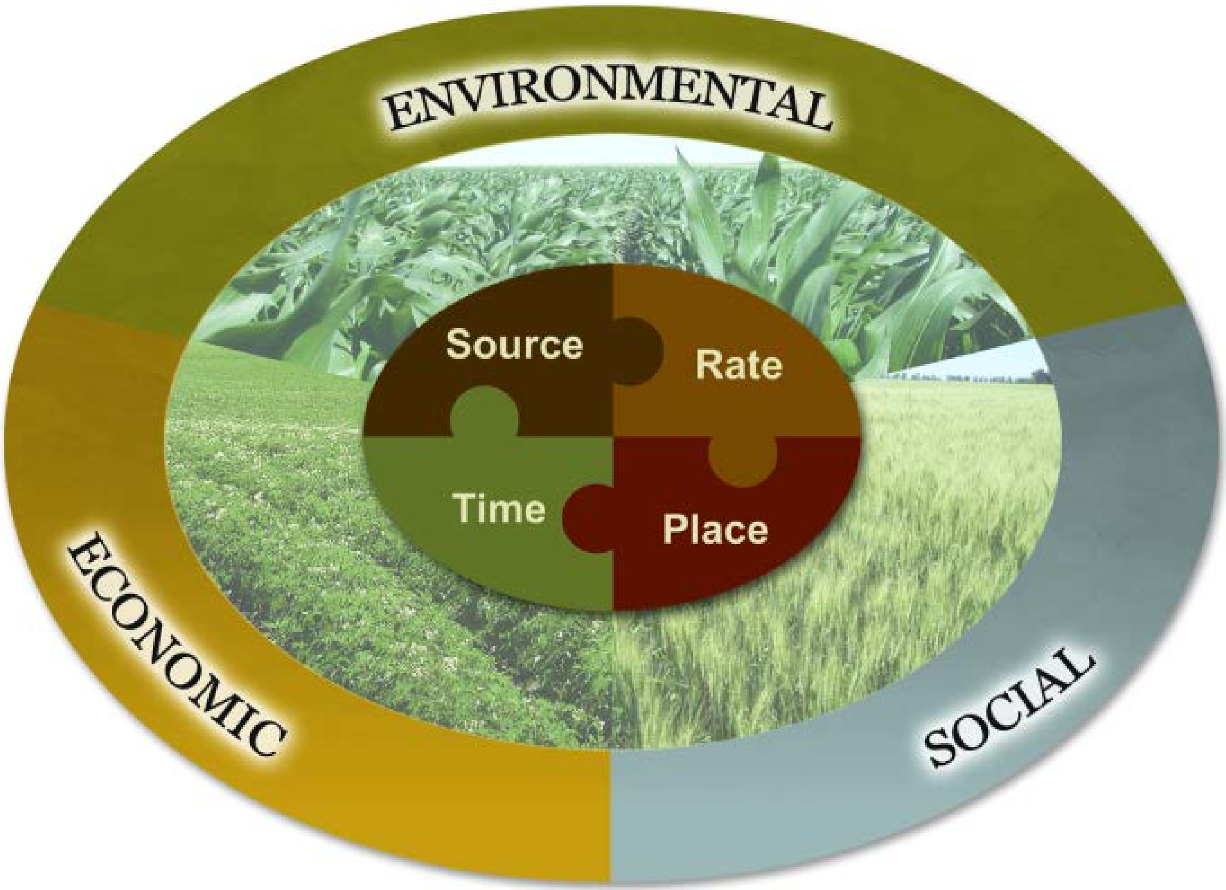
4R Nutrient Stewardship



Right Source

Match fertilizer form to crop needs

Right Rate

Match amount to crop need

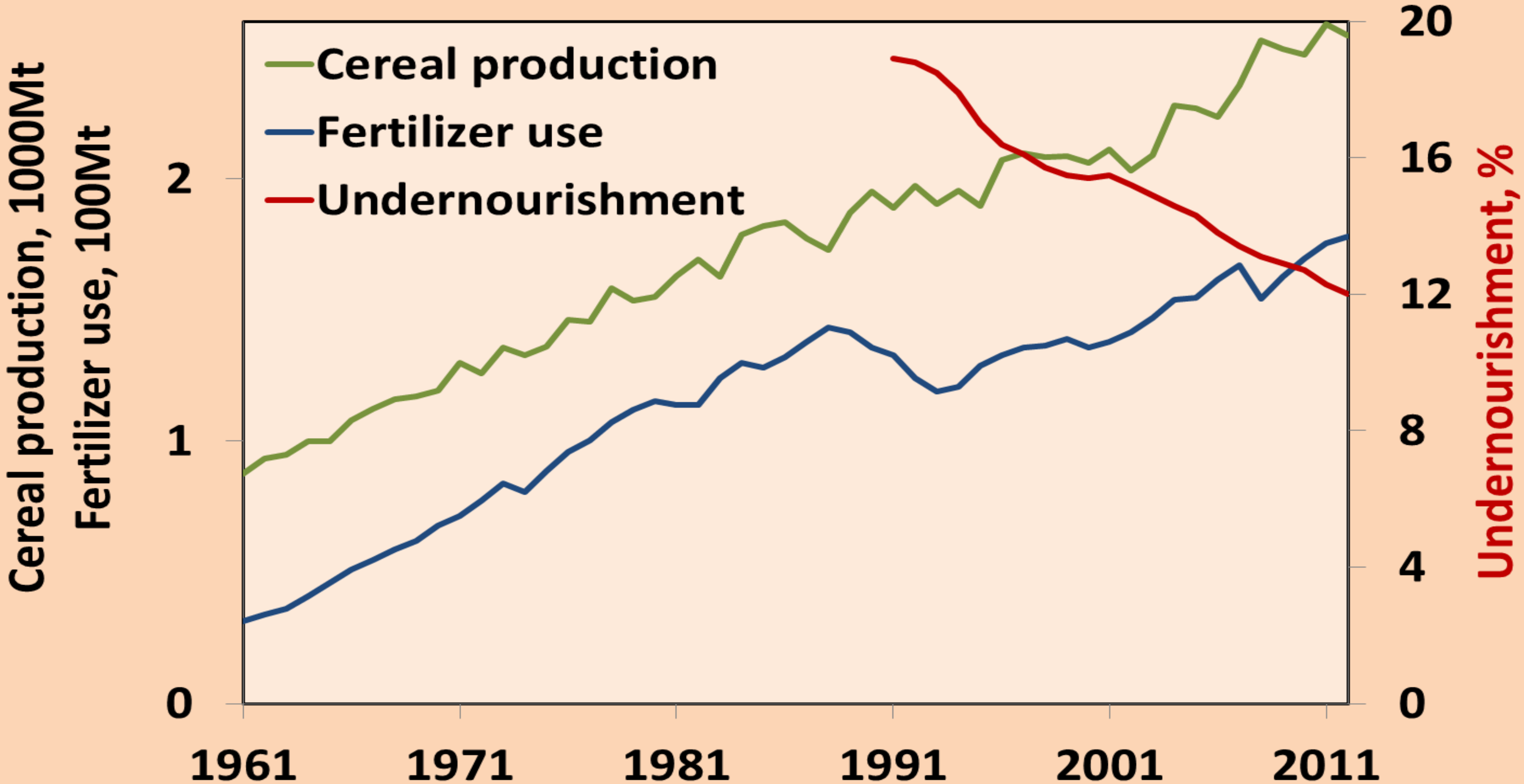
Right Time

Make nutrient available when crop needs them

Right Place

Keep nutrients where crops can use them

Increased fertilizer use has contributed to cereal production growth and reduced undernourishment



Data sources: United Nations Food and Agriculture Organization (FAO), International Fertilizer Industry Association (IFA)

World Phosphate Rock Reserves

P

Country	2011-12 Production	Reserves	Reserve Life	Resources (IFDC 2010)
	Mt		Years	Mt
Algeria	1.5	2,200	1470	--
China	85	3,700	43	16,800
South Africa	2.5	1,500	600	7,700
Jordan	6.5	1,500	230	1,800
Morocco	28	50,000	1790	170,000
Russia	11	1,300	115	4,300
USA	29	1,400	49	49,000
World Total	204	67,000	328	290,000

Source: USGS, 2013

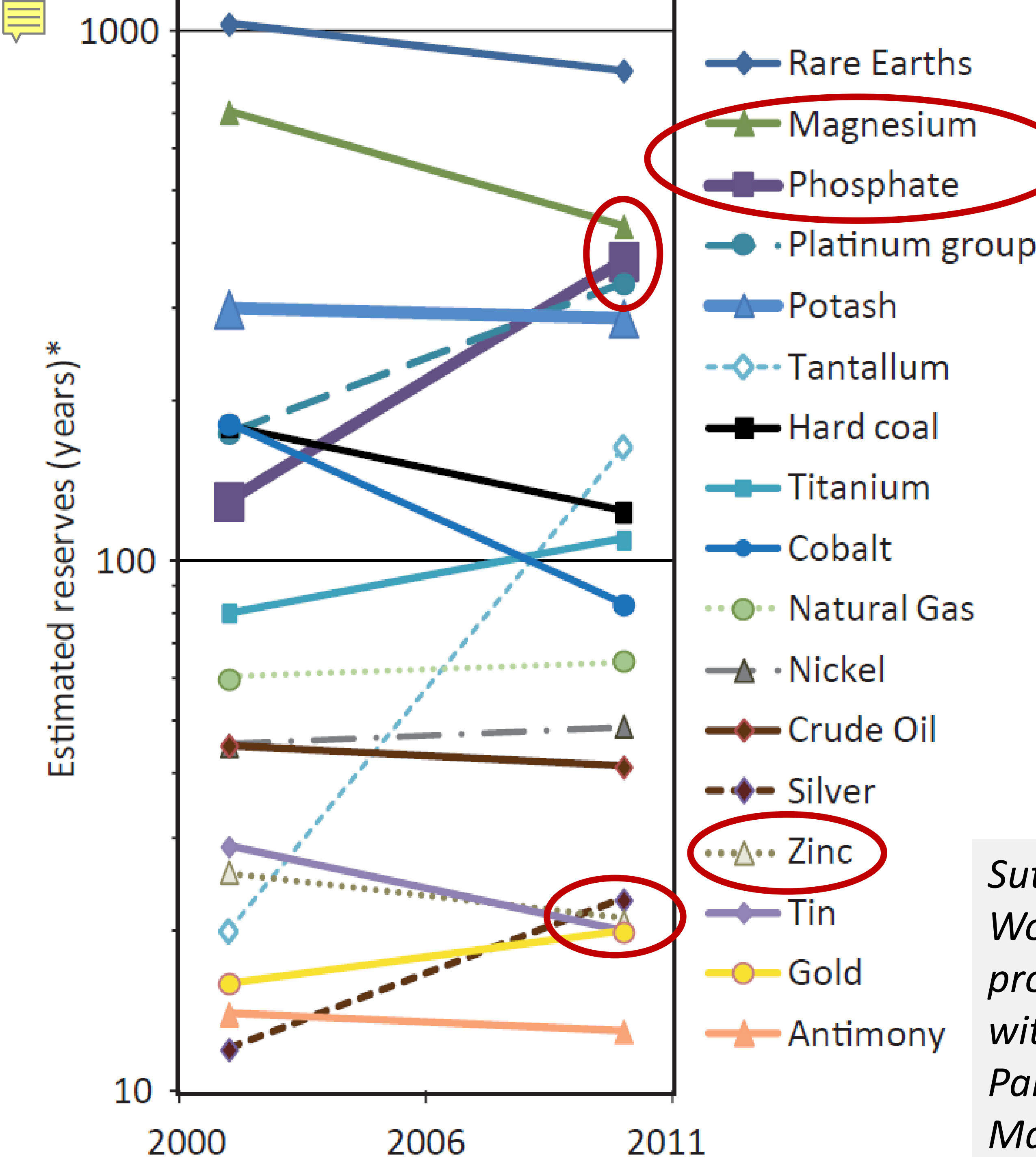
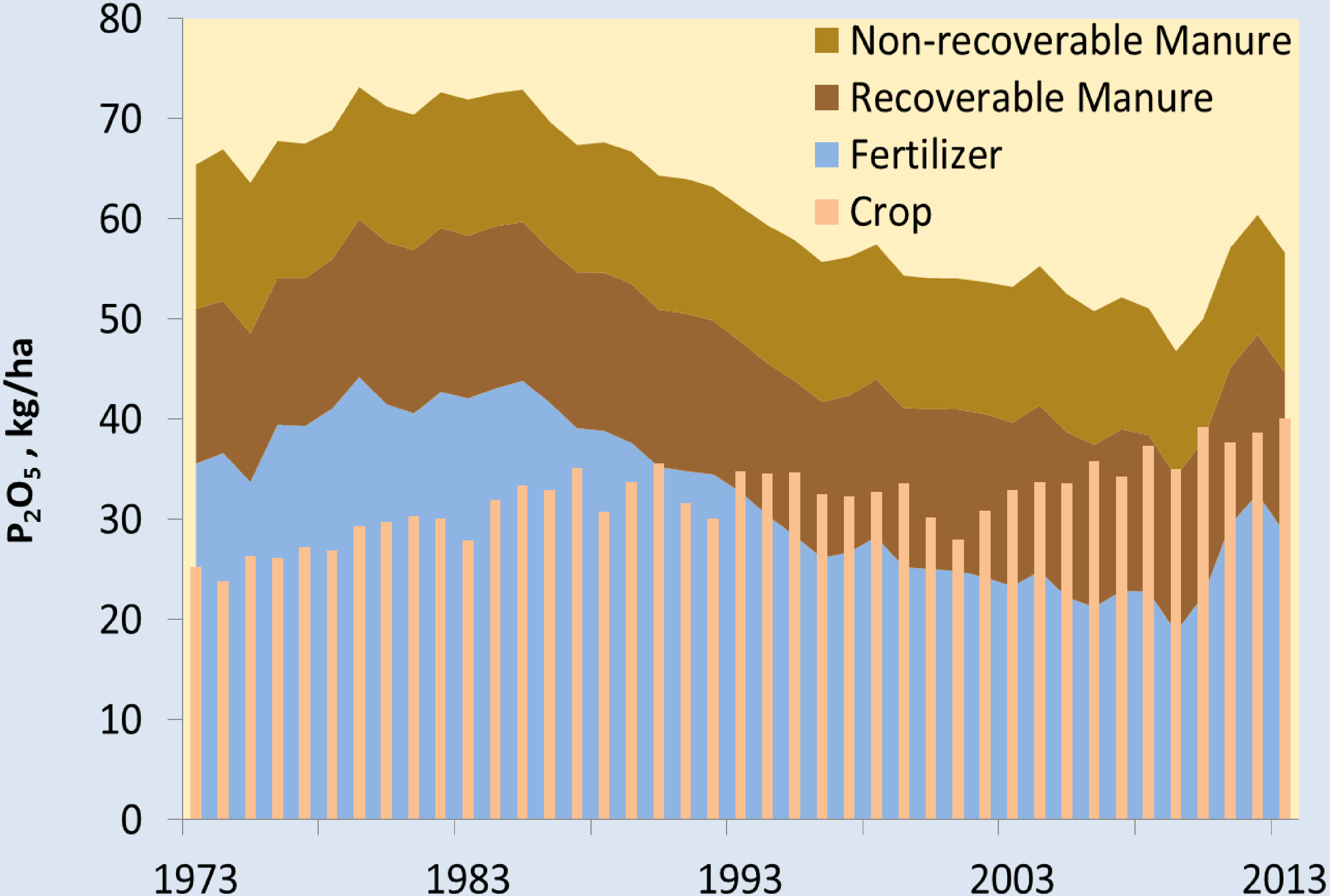
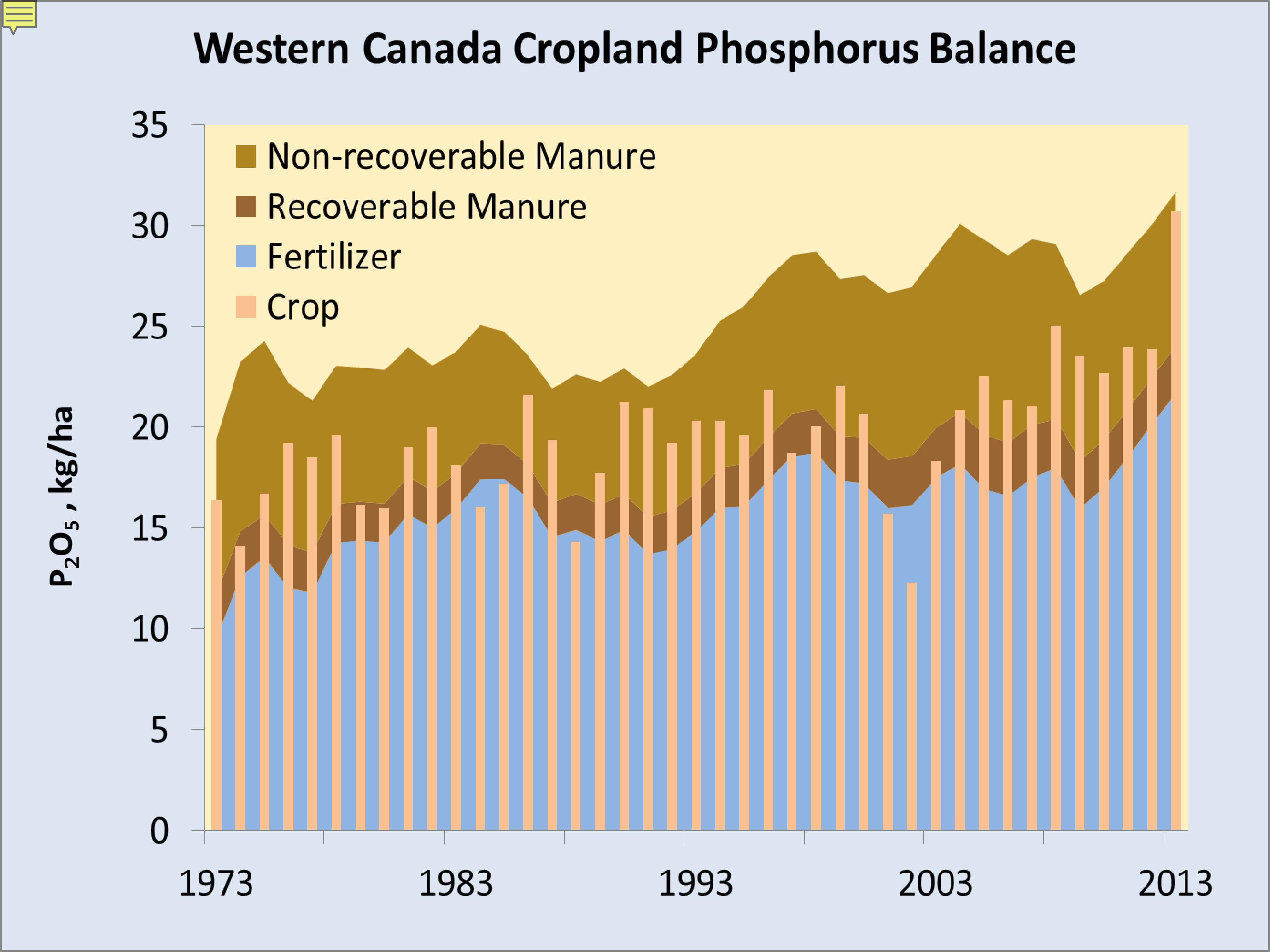


*Figure 2.9 Putting phosphorus and potassium (potash) reserves into context: Changes in estimated reserves of different commodities as estimated in 2002/2003 and 2010 (Based on Scholz & Wellmer, 2013; U.S. Geological Survey, 2012a; U.S. Geological Survey, 2012c). * Ratio of estimated reserve to annual mine production.*

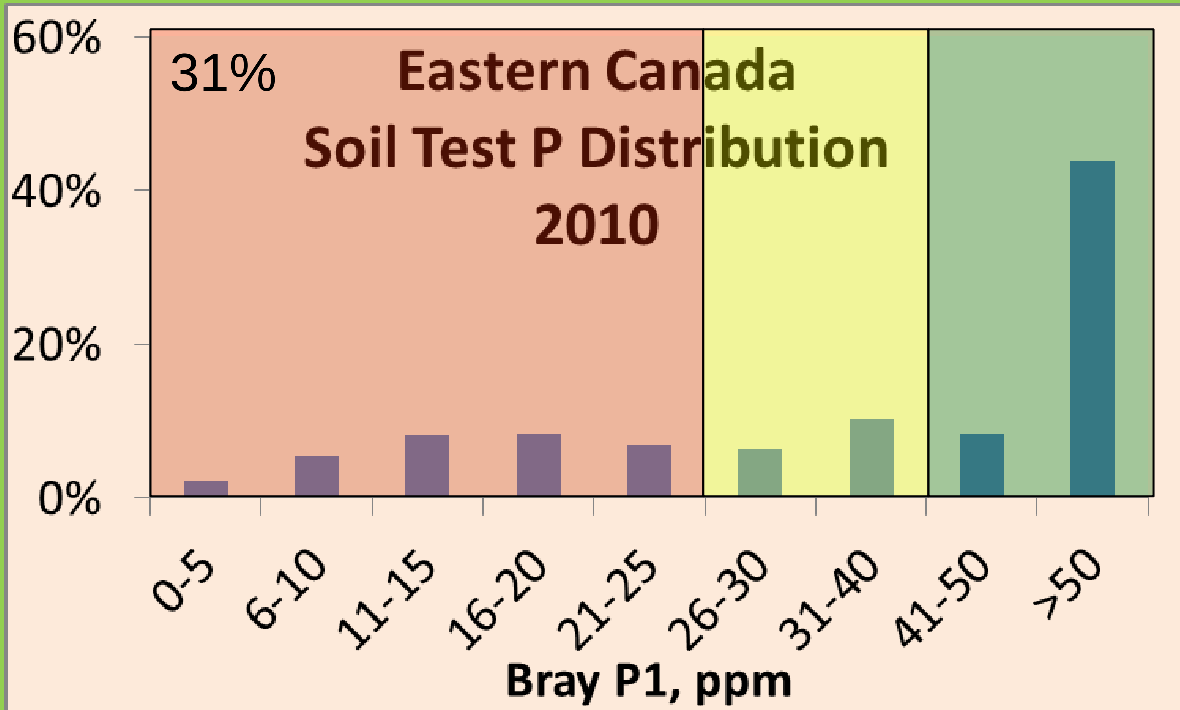
Sutton et al. 2013. Our Nutrient World: The challenge to produce more food and energy with less pollution. Global Partnership on Nutrient Management.

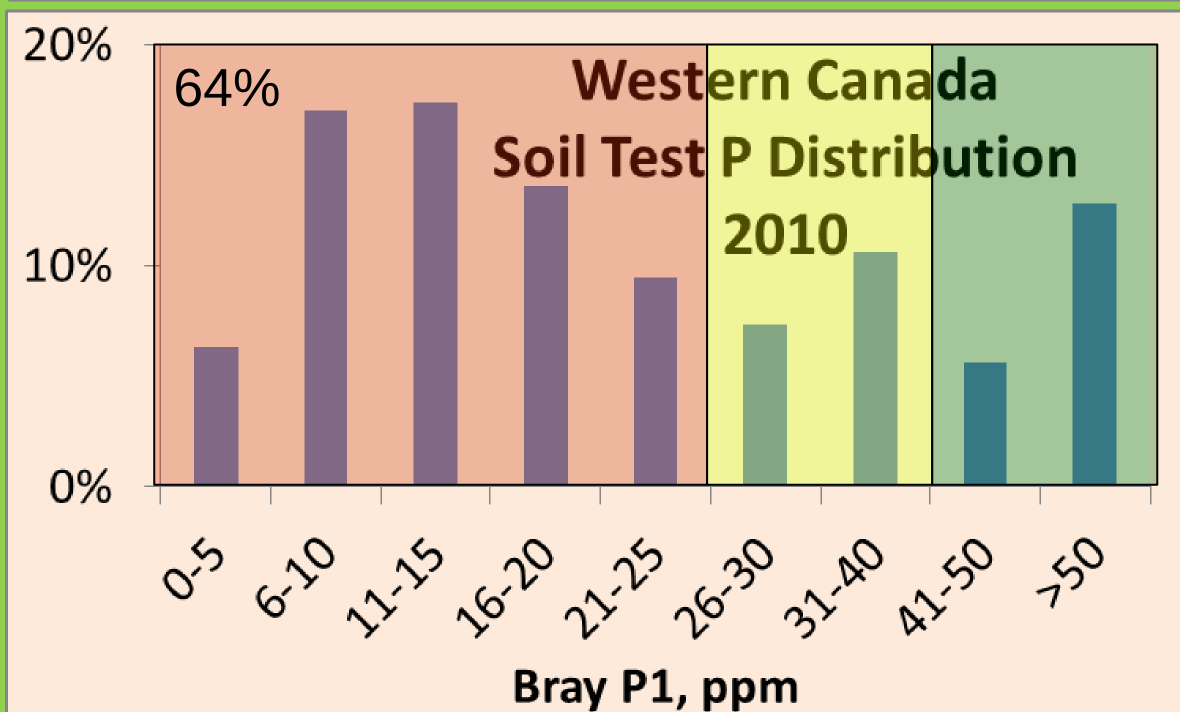
Eastern Canada Cropland Phosphorus Balance



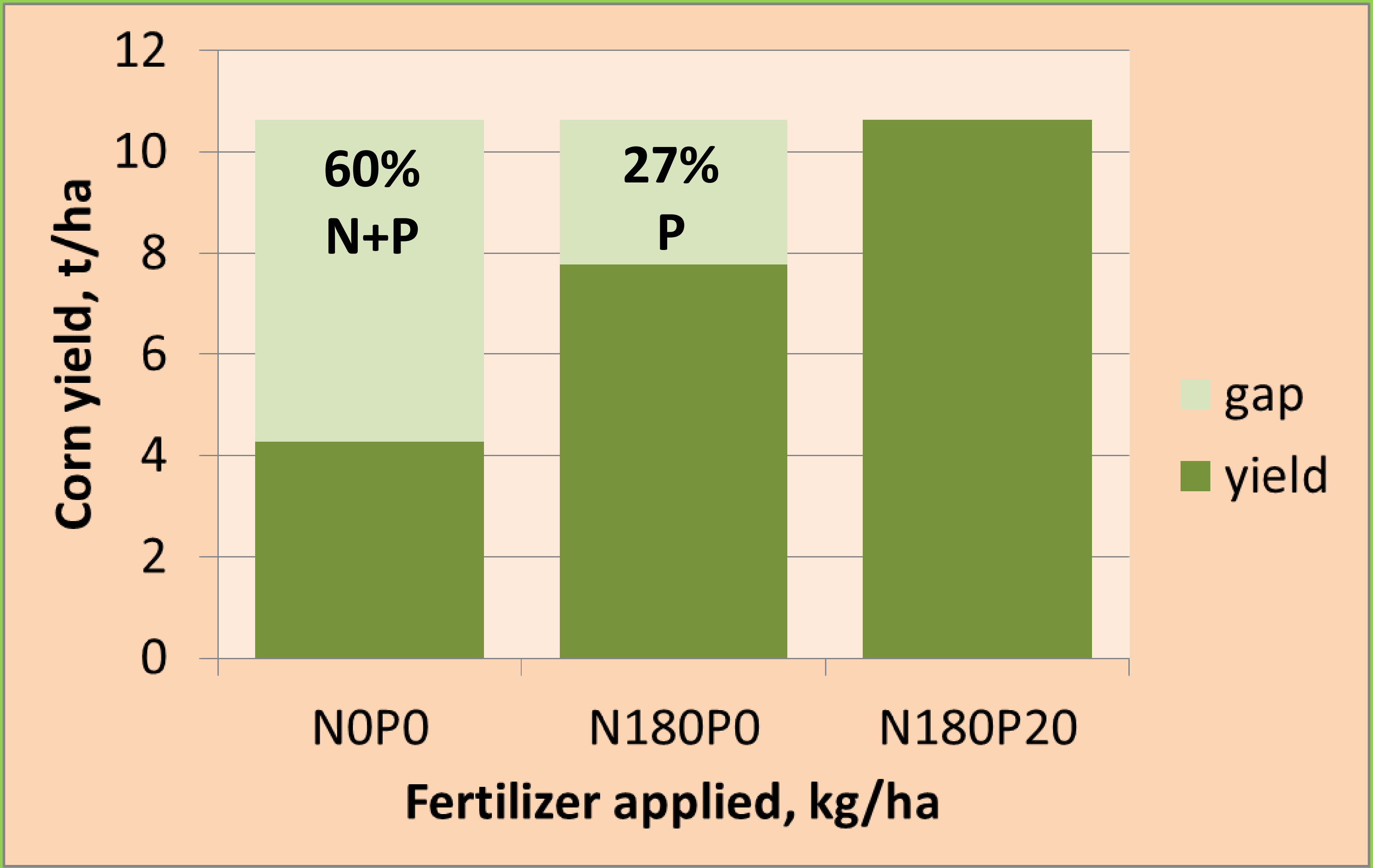

Western Canada Cropland Phosphorus Balance
Non-recoverable Manure
Recoverable Manure
Fertilizer
Crop
P_2O_5 , kg/ha
0
5
10
15
20
25
30
35
1973
1983
1993
2003
2013

IPNI Soil Test P Levels in Canada

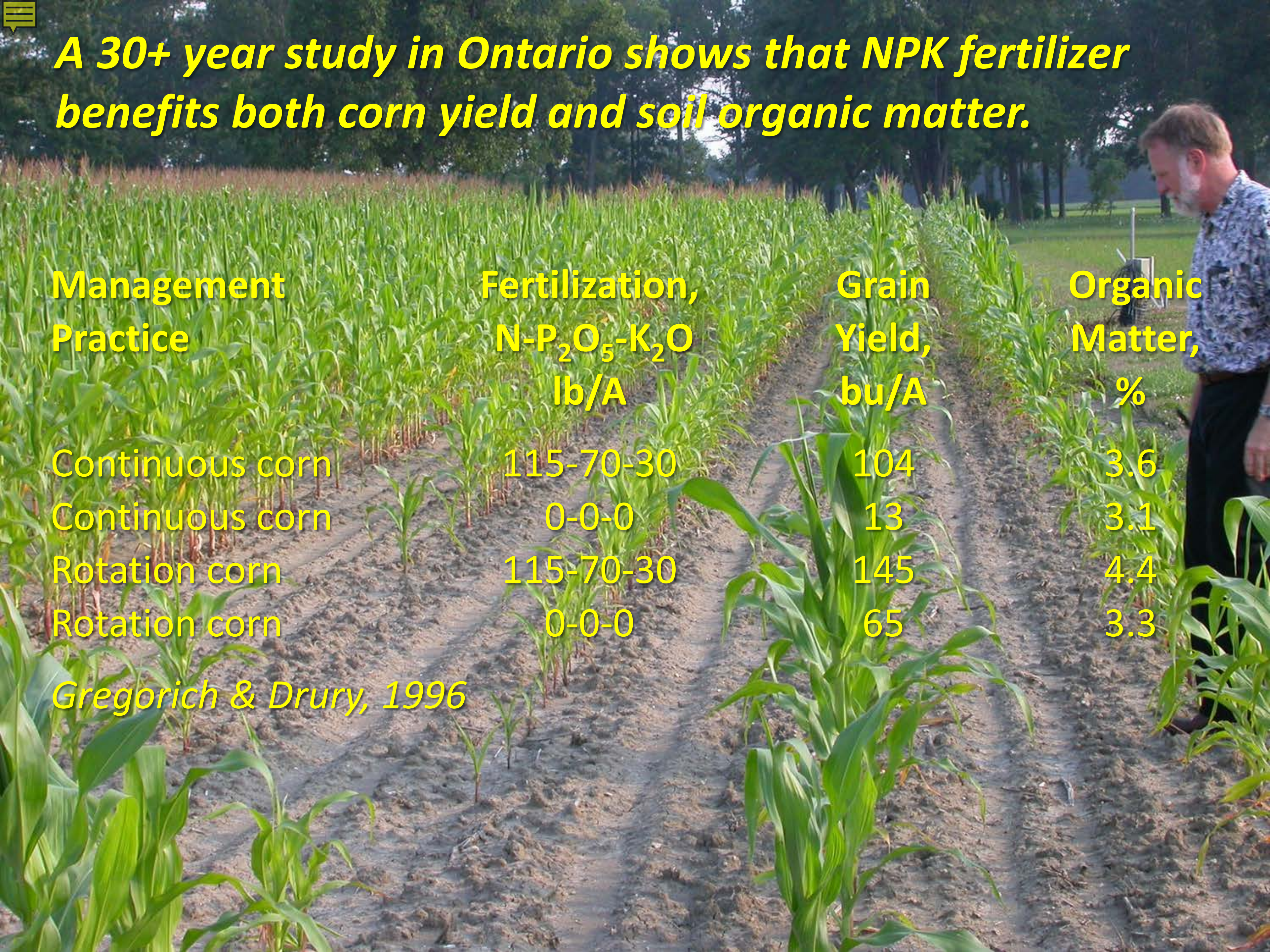




How much of crop yield can be attributed to P?



One example: Long-term contribution of P to yield of irrigated corn in Kansas – 40-year average, 1961-2000 (Stewart et al., 2005, Agron. J. 97:1–6)



A 30+ year study in Ontario shows that NPK fertilizer benefits both corn yield and soil organic matter.

Management Practice	Fertilization, $N\text{-}P_2O_5\text{-}K_2O$ lb/A	Grain Yield, bu/A	Organic Matter, %
Continuous corn	115-70-30	104	3.6
Continuous corn	0-0-0	13	3.1
Rotation corn	115-70-30	145	4.4
Rotation corn	0-0-0	65	3.3

Gregorich & Drury, 1996

How much of crop yield can be attributed to P?

- Short-term (one year):
  - Very small on soils with adequate P levels
  - Average ~7% (0-34%) for Ontario soils testing below critical level
- Long-term (within 40 years): up to 27%

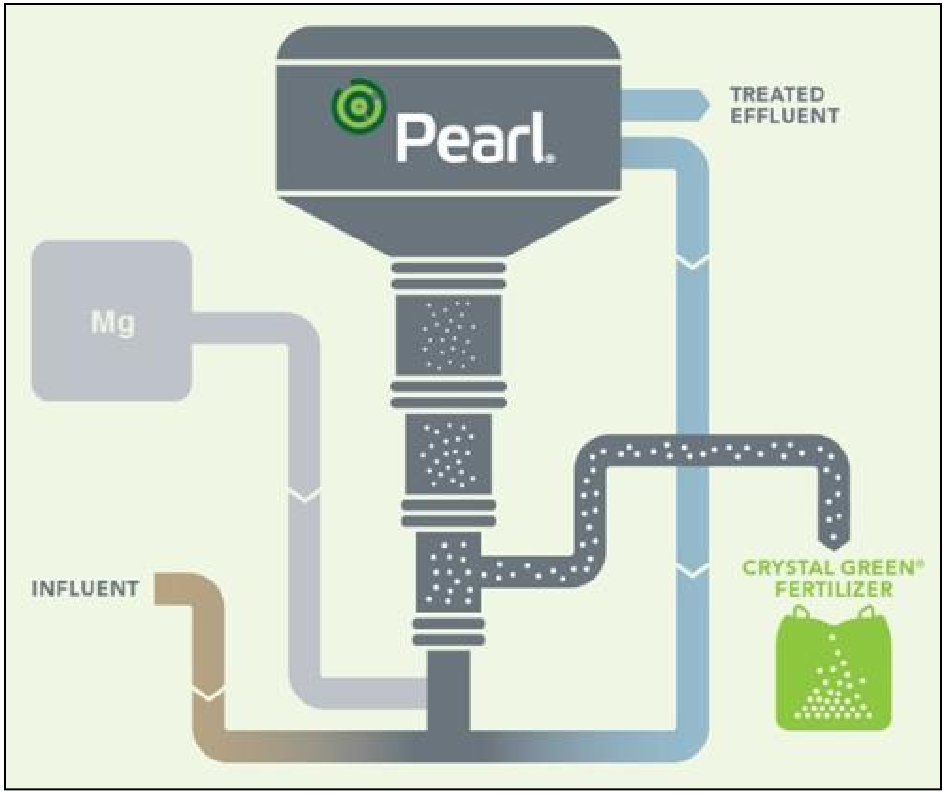
Biosolids

1. Amount of P in biosolids is roughly equal to dietary P supply.
2. Total biosolids from sewage treatment in North America contains an equivalent of 8% of crop P removal.
3. Currently, half the biosolids are land applied, to less than 1% of the cropland.
4. Good source of zinc.
5. Low analysis sources:
    1. Issues with bulk and transportability.
    2. Accuracy of reported nutrient analysis – “guaranteed minimum” does not apply well to bulk materials

Struvite crystallization is promising technology … nutrient rich streams mixed with MgCl in a controlled chemical precipitation

- Precipitation reaction: Mg^{+2} NH_4^{+} PO_4^{-3}
  - Removes up to 90% P and 20% N
  - Low salt index and low heavy metal content
- Produces a slow-release N, P and Mg fertilizer

Ostara Technology



Struvite from manure: potential?

1. Large potential source in eastern Canada
2. Amount of Mg to add – more costly as fertilizer than P, similar limits as a non-renewable resource?
3. Facilitated by anaerobic digestion for swine manure (Moody et al., 2009) – increases soluble Mg
4. Of 30+ anaerobic digesters in Ontario, only one for swine manure, most for dairy manure (DeBruyn, Hilborn, pers. comm. 2014)
5. Role of phytase in swine diet? Increased solubility of P and Mg but likely lower concentrations of P
6. Can NH_4^+ be retained?
7. Could have a big impact if Mg requirement and N losses could be reduced.

Is struvite less susceptible to loss in runoff when applied surface broadcast?

- Water solubility:
  - Three orders of magnitude lower than common fertilizer forms, MAP and DAP (0.2 g/L versus 370 to 580 g/L)
  - But still considerably higher than critical P concentration for algae (25 versus 0.03 mg/L)
- Runoff comparisons not available
  - No titles in Agricola contain both the word “struvite” and “runoff”

Protecting water quality with 4R

- Placement most critical
- Timing also significant
- Source needs to be a form that can be applied in the right place at the right time

Version 2.0
October 2013

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Summary – P for Food Security

1. Phosphorus inputs to crops are essential to food security.
2. In terms of world reserves and resources, zinc is more limited than P.
3. Opportunity exists to enhance recovery and recycling of P
4. 4R Nutrient Stewardship requires P sources that can be applied at the right rate, the right time and the right place for best crop performance as well as minimizing losses to water.

nutrient stewardship

http://nane.ipni.net