Watershed P Balances as a Tool for TMDL Planning

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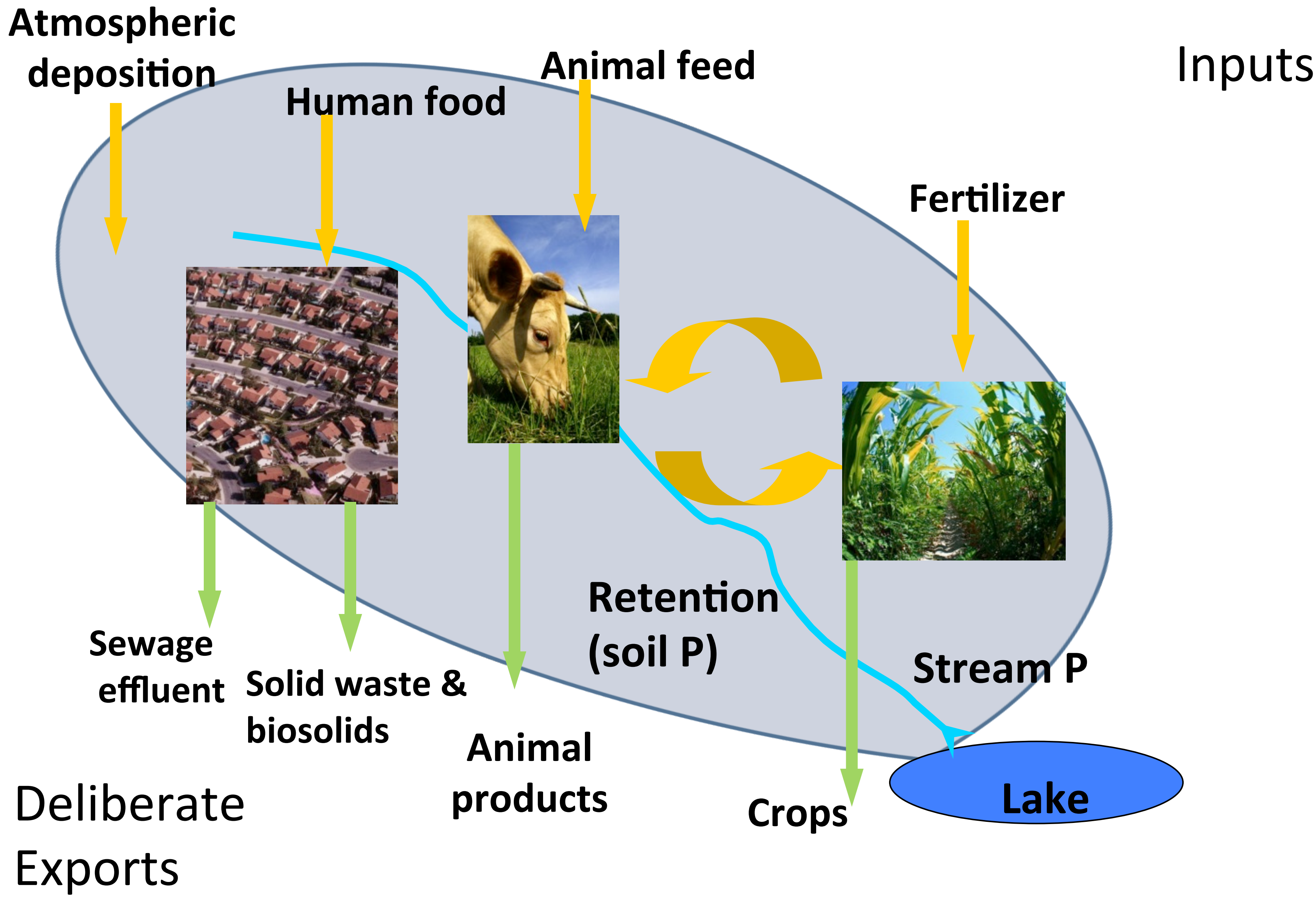
Sustainable Use of Renewable Resources – Enhancement of the Environmer



The Whole Watershed P Balance Concept

The promise of whole-watershed P balances

1. Current approaches, which often rely on trapping P at the end of the pipe/field, are not working on a large scale.
   A wealth of science suggests that creating a negative P balance would likely reduce stream P.

2. Constructed BMPs are expensive.
   The P balance approach leads to lower P use, potentially saving money.

3. The TMDL approach is expensive and confusing.
   The P balance approach is conceptually simple and intuitive.

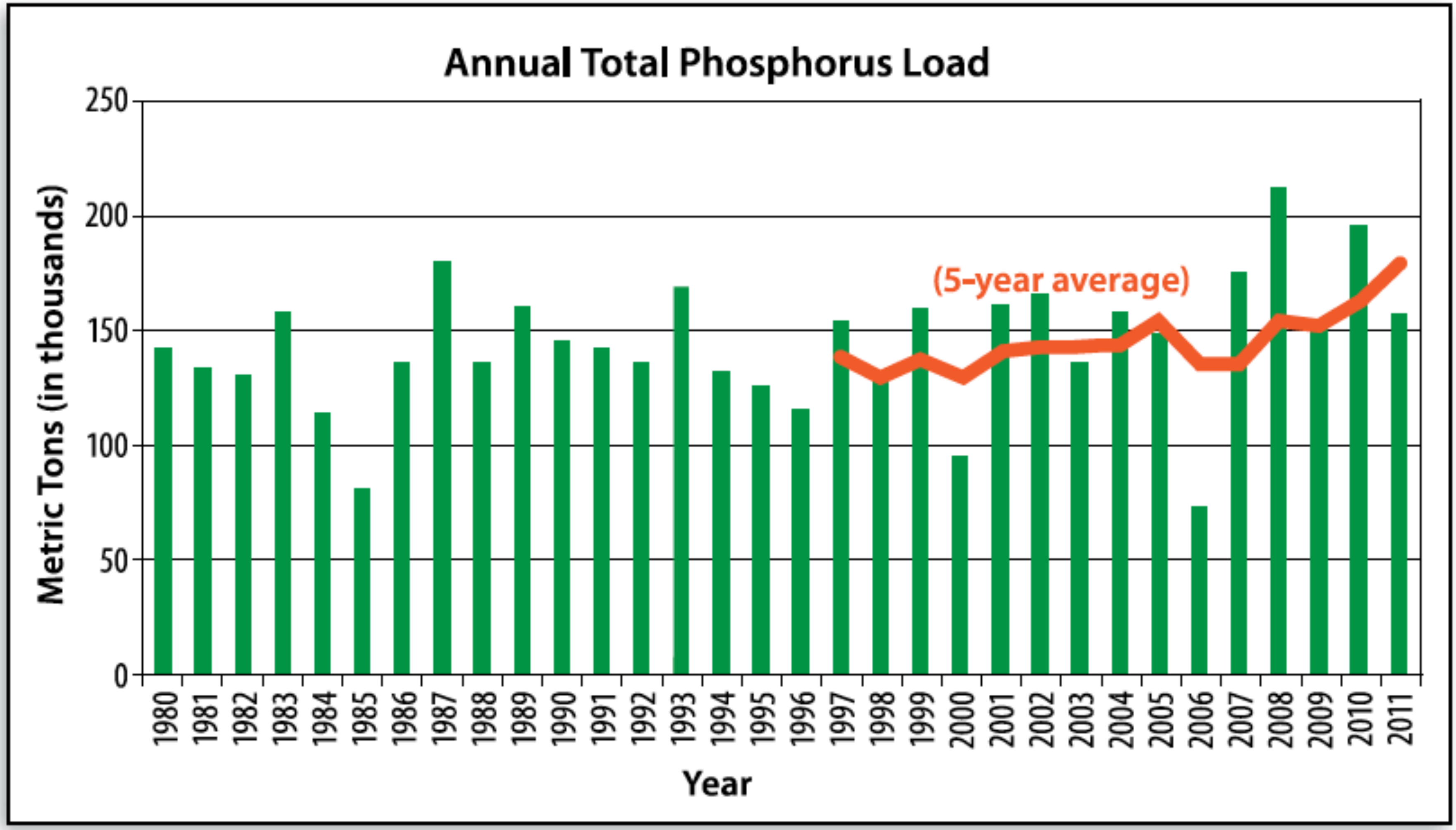
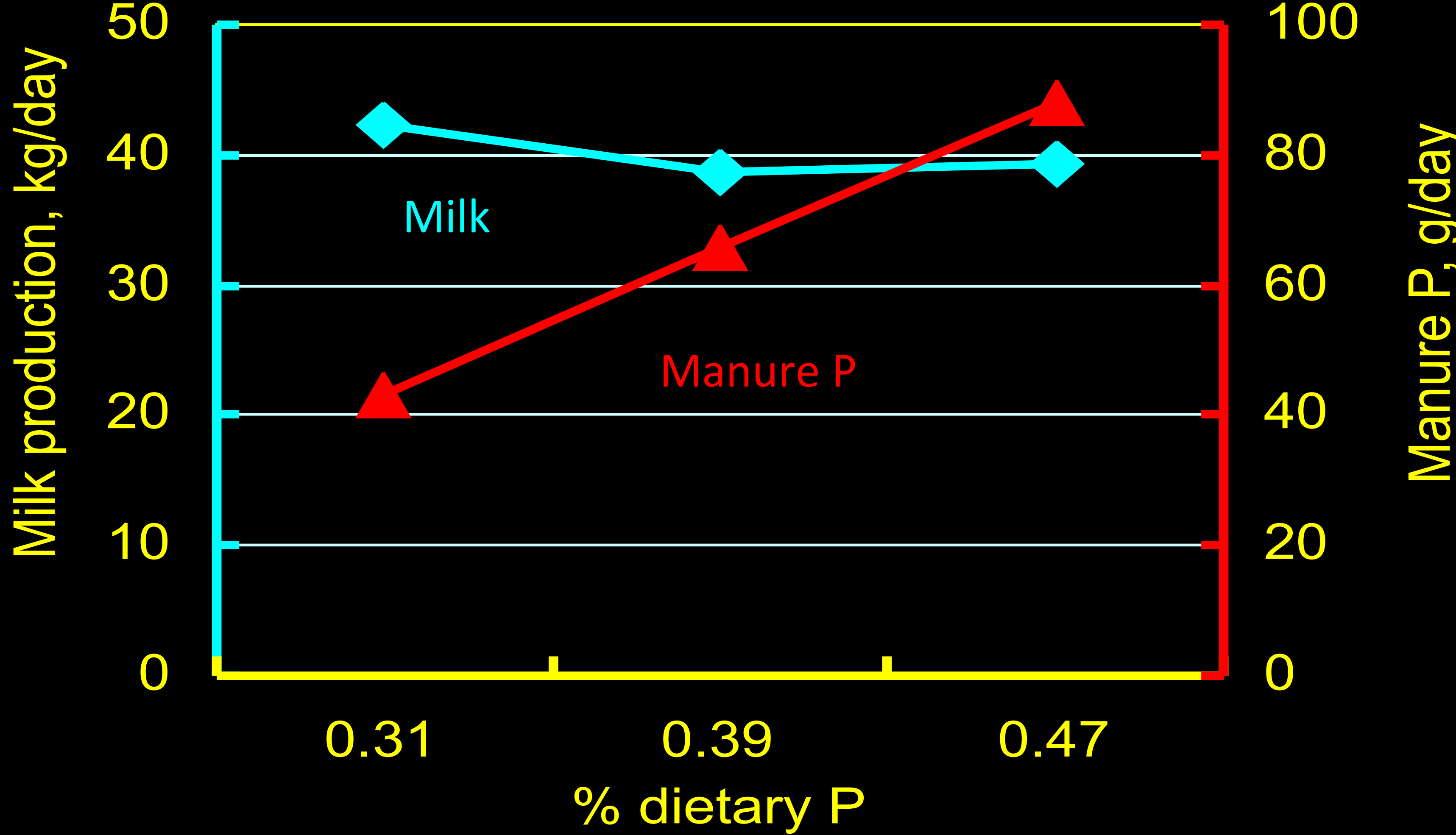


Figure 3. Annual TP loads to the Gulf of Mexico.

Point #1: Current approach for reducing NPS P pollution have not worked very well.



Point #2 (cost): Study of P supplements in dairies showed overuse of P supplements (Wu et al. 2001, J. Dairy Sci.)

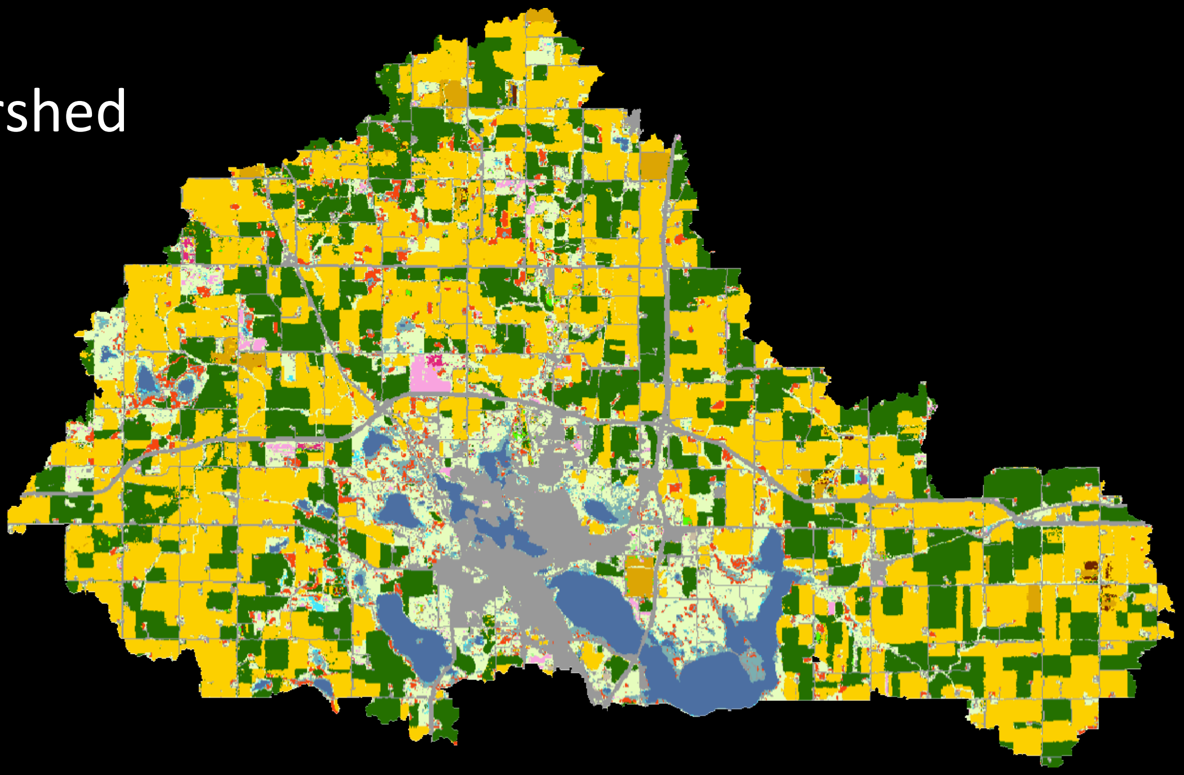
BMP		

Add this slide on BMP costs – from CRWSD

Goal: Develop a Watershed P Balance Tool To Inform Nutrient Reduction Plans

1. Develop watershed-specific P balance with sufficient detail to be *actionable*.
2. Develop spreadsheet tool to support general use.

Albert Lea Lake Watershed
- 164 square miles
- 64% cropland
- City of Albert Lea



Relationship between watershed P balance and stream P

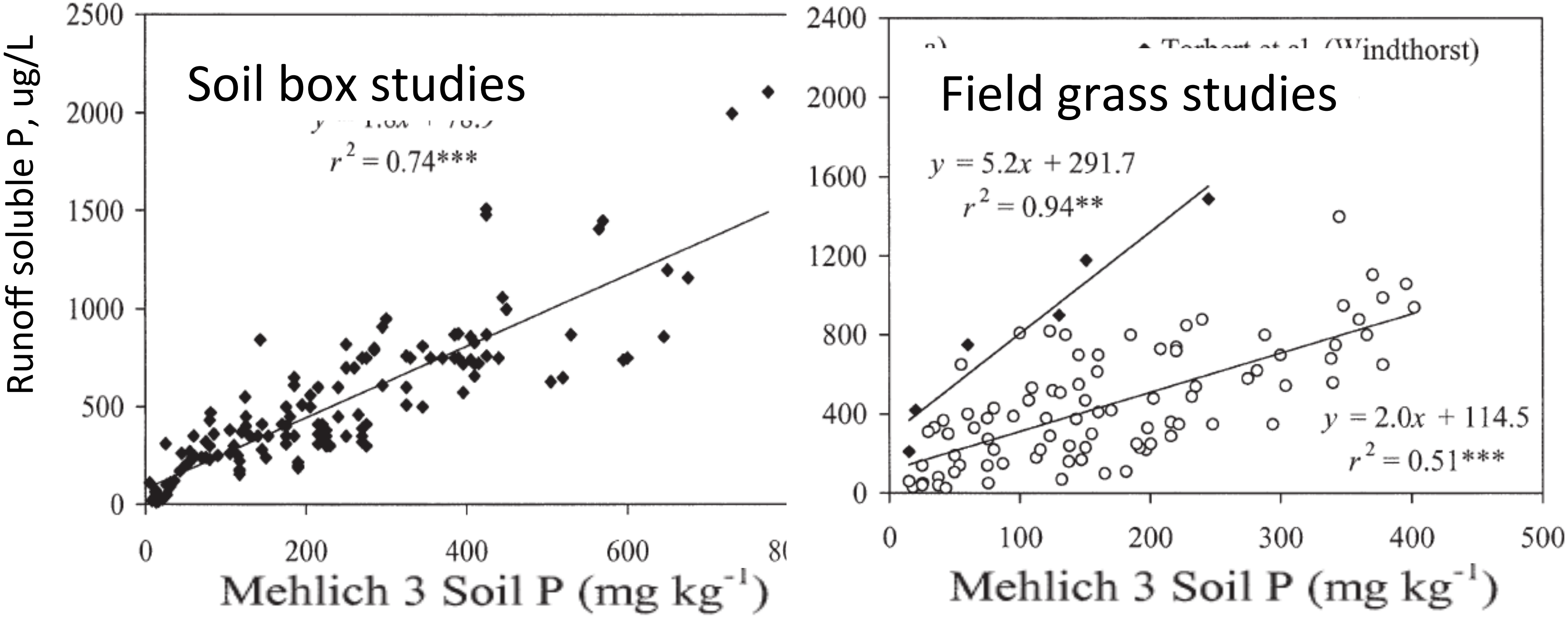
P inputs > Deliberate P export:

- Soil test P (STP) increases
- Stream P increases

P inputs < Deliberate P export:

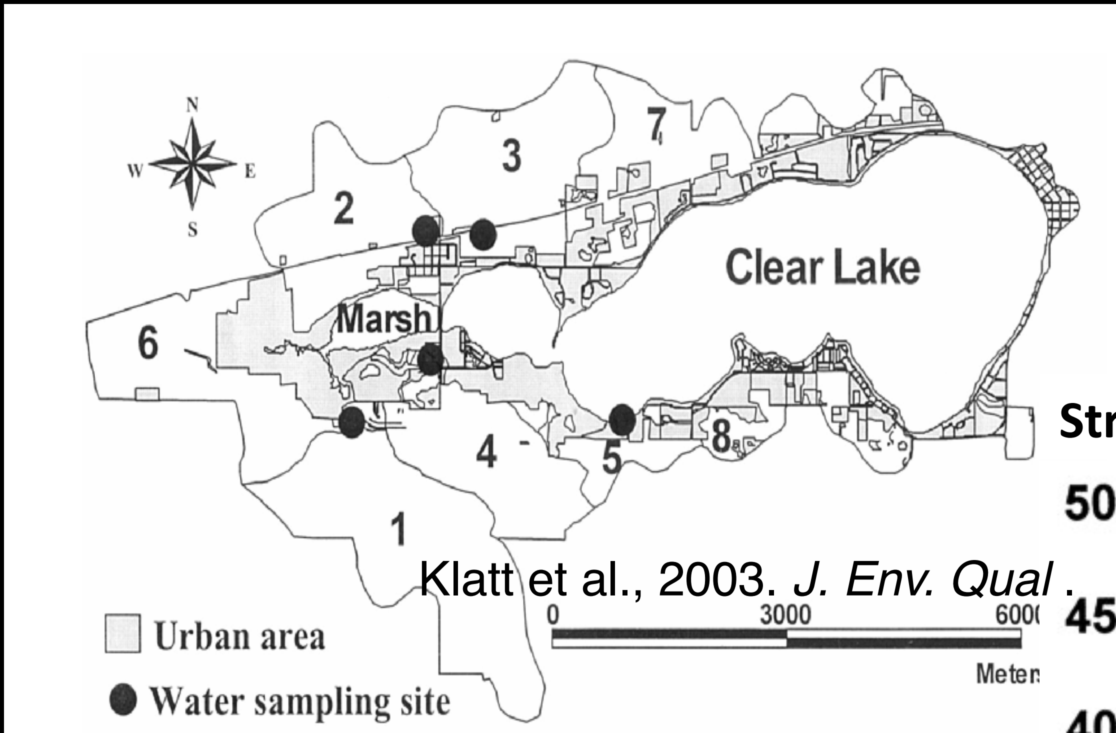
- STP decreases
- Stream P decreases

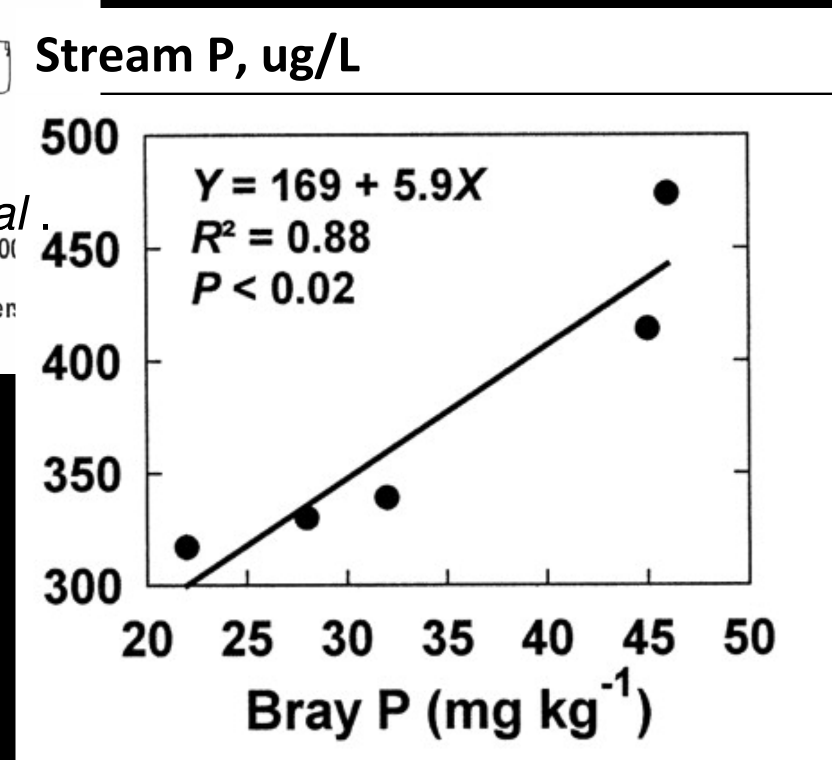
Is this true?



Runoff P is predicted from STP (Mehlich 3 P) in lab "soil box" studies (left) and in field grass studies (right).

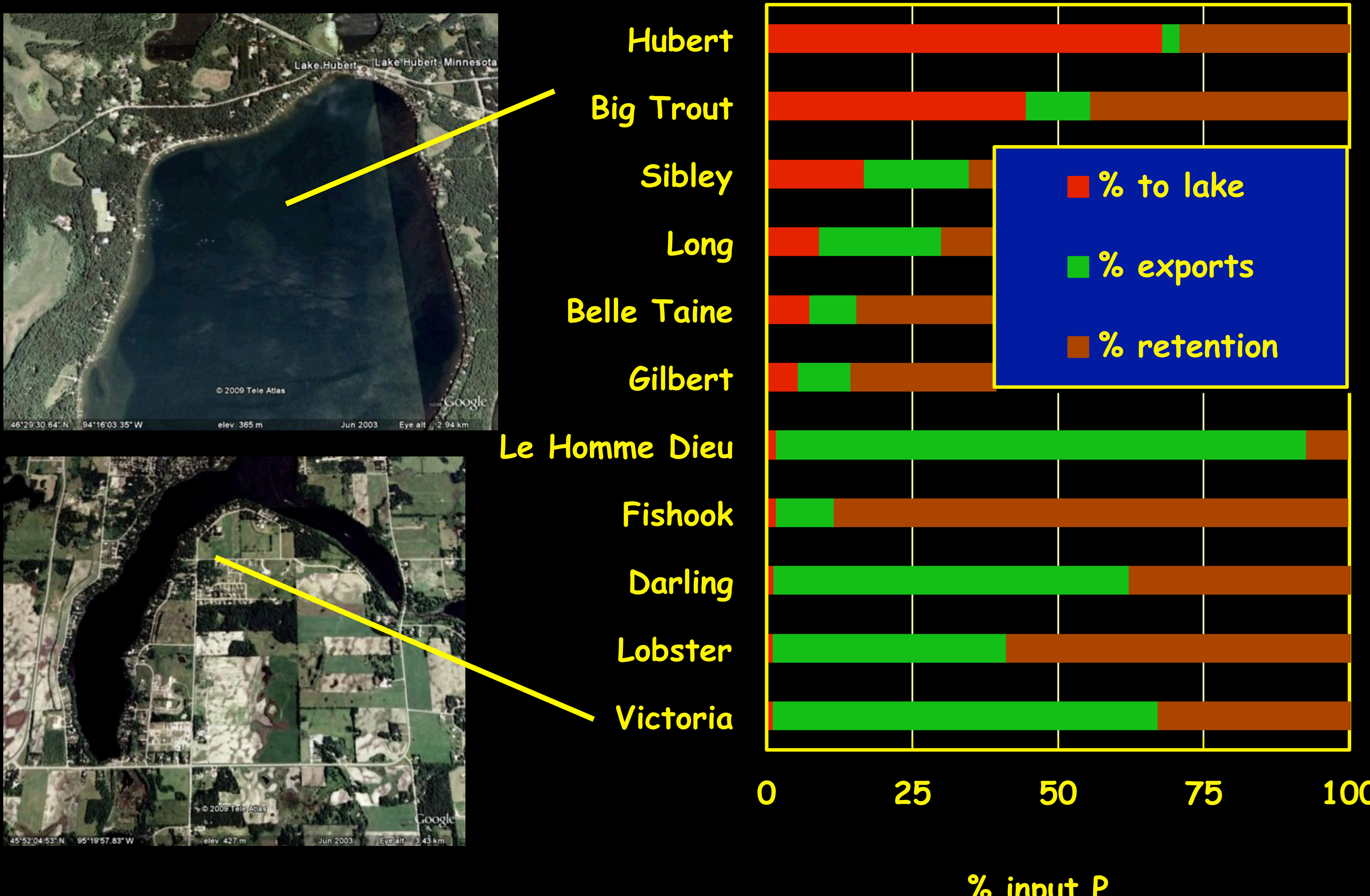
(Vadas et a., 2005, J. Env. Qual.)





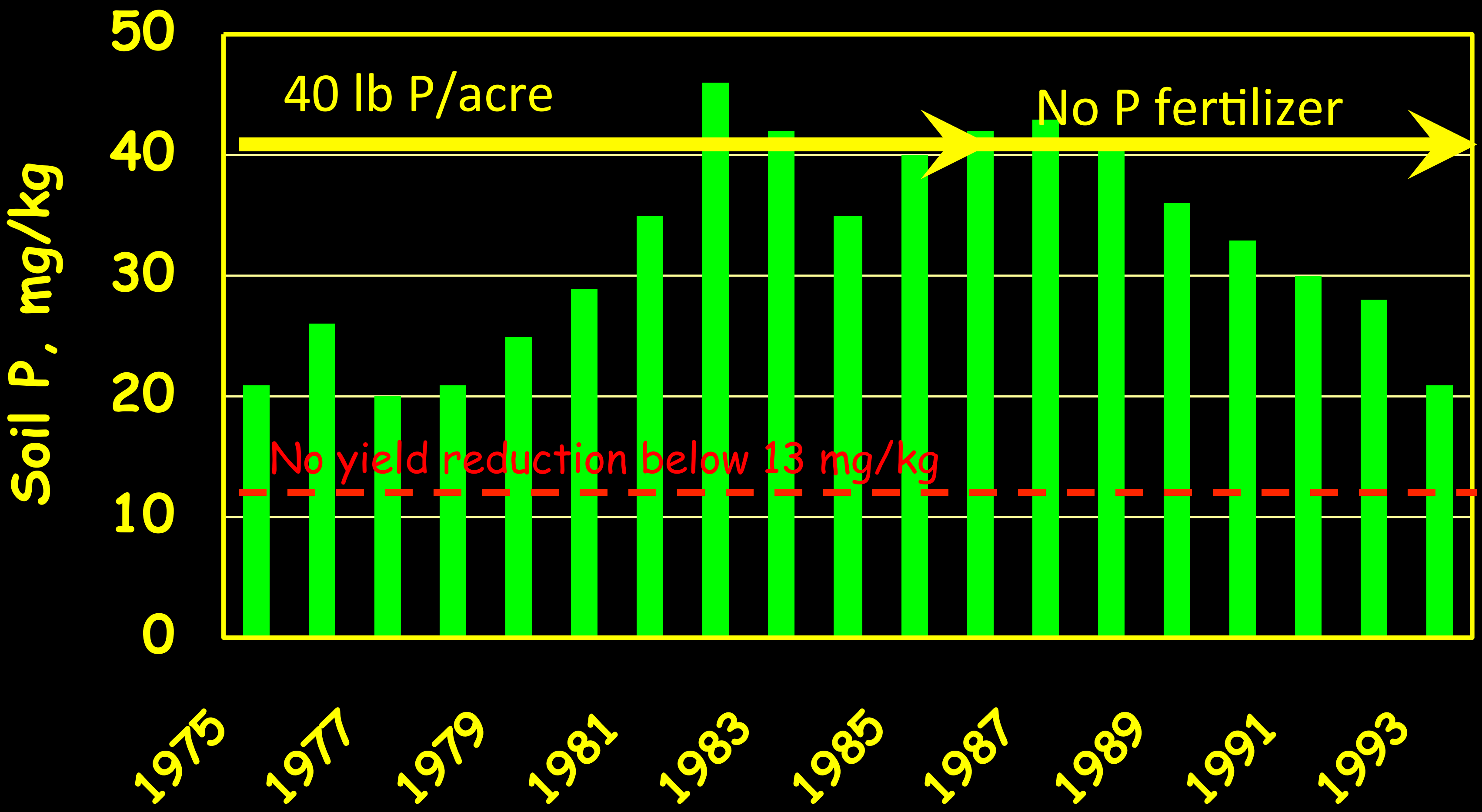
2. For watersheds, stream P concentrations is related to average STP

(Klatt et al., 2003*, J. Env. Qual.*)



2. Understand the fate of input P to watersheds

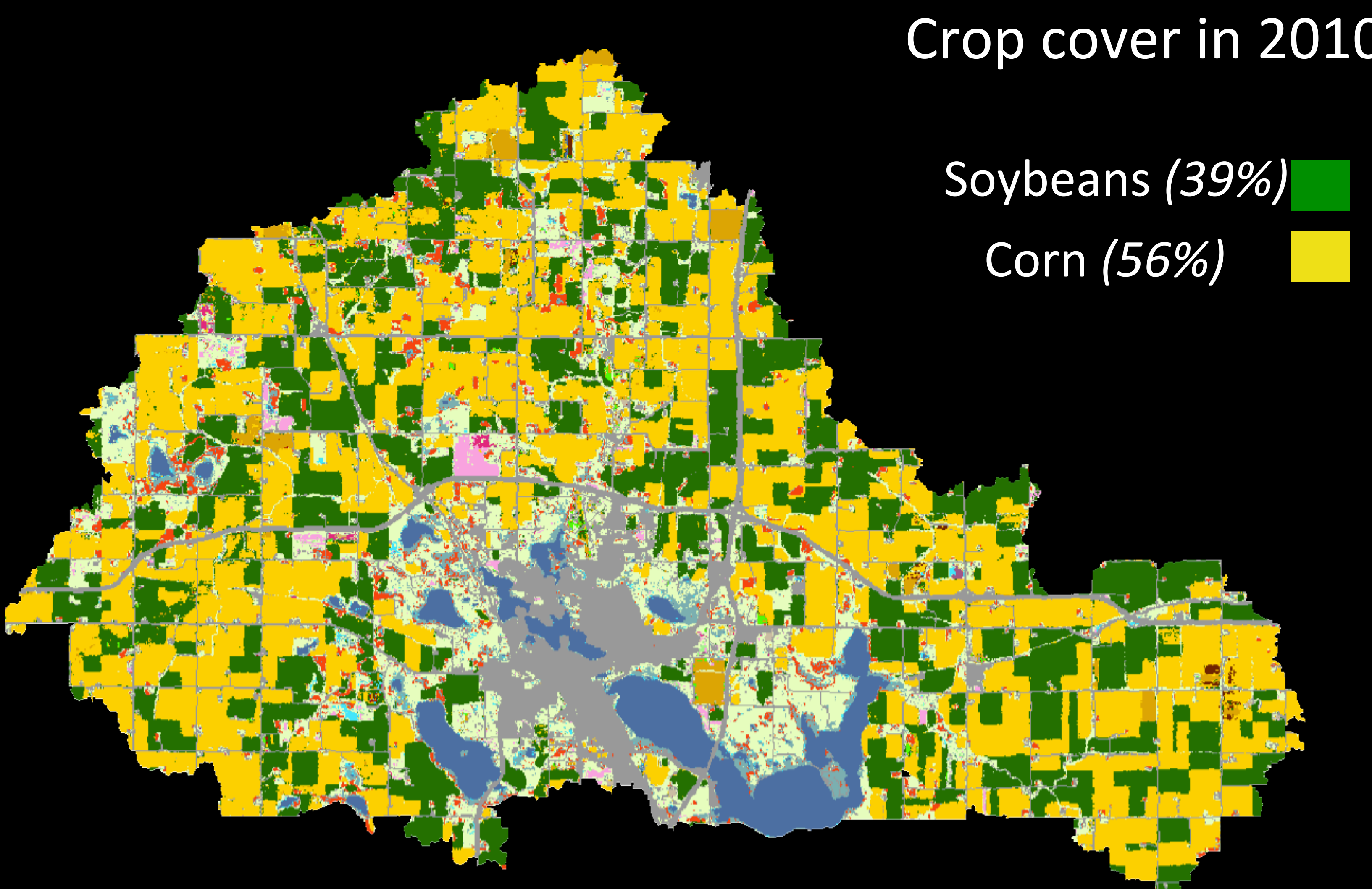
(Schussler et al. 2007).



3. Understand temporal watershed P dynamics

(Randall et al., 1997, *J. Ag. Production)*

Approach for Albert Lea Watershed P Balance



USDA Cropland Data Layer *(2010)*

Albert Lea Lake watershed crop data

	Fertilizer application per acre		Land area fertilized	Land area†	Calculated total P crop uptake‡	Calculated total P applied
	lbs P_2O_5	lbs	%	(acre)	(tons)	(tons)
Alfalfa	11	5	20	687	9	0.3
Corn	66	29	89	33,123	543	426
Corn-Sweet	62	27	62	1,256	28	10
Soybeans	46	20	5	23,164	223	12

†Area calculated using the USDA, 2010 Cropland data layer.
‡Based on %P dry-matter values from Ketterings and Czymmek (2007).

Crop data were determined from 88 on-farm interviews (Denton Bruening) + NASS data.

Adjusted Number of Animal Units

(Denton Bruening and Colin Whitmer)

Livestock System	Permitted	Actual	% of Permitted
Beef	2,223	829	37%
Dairy	218	218	100%
Horses	245	43	18%
Sheep	398	95	24%
Swine	12,824	6,157	48%
Turkey	445	440	99%
Multi-Animal	434	98	23%
Watershed Total	**16,787**	**7,880**	**47%**

Visual inspection showed that actual animal counts were lower than permit values.

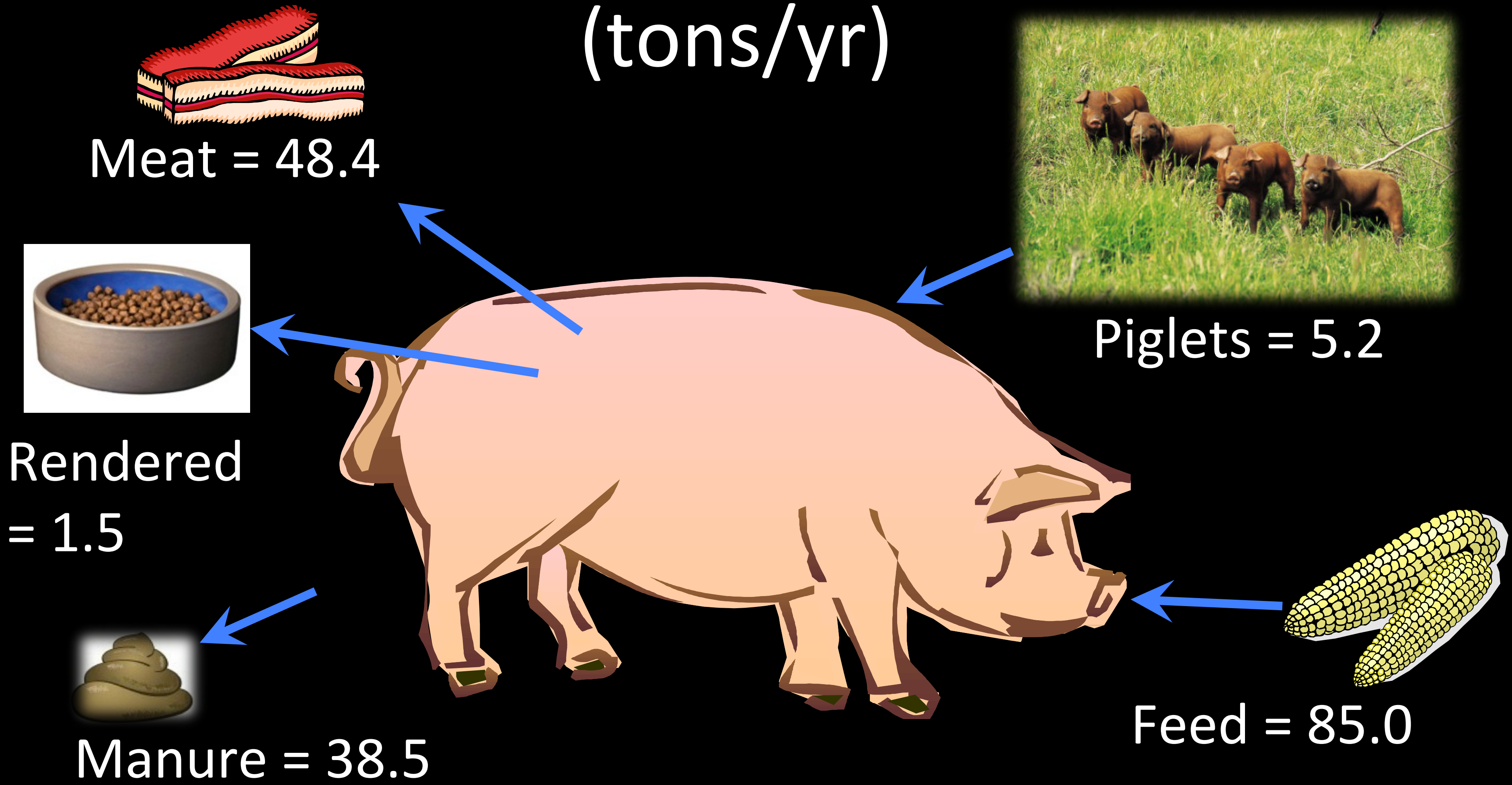
P Flow through MN Swine System

Stage	Count	Feed P	Manure P
		---Gg/Yr---	
Piglet	10,800,000	3.2	1.4
Feeder	10,800,000	12.2	5.6
Sow	306,000	1.6	1.3
Gilt	291,000	1.4	0.6
Boar	2,150	.008	.007

<u>Output P (Gg/Yr)</u>

- 8.1 Pork Produced
- 0.3 Rendered
- 0.2 Composted

Swine P Balance (tons/yr)



Output: 88.4 ton P / yr

Input: 90.2 ton P / yr

We developed P balances for each animal system.

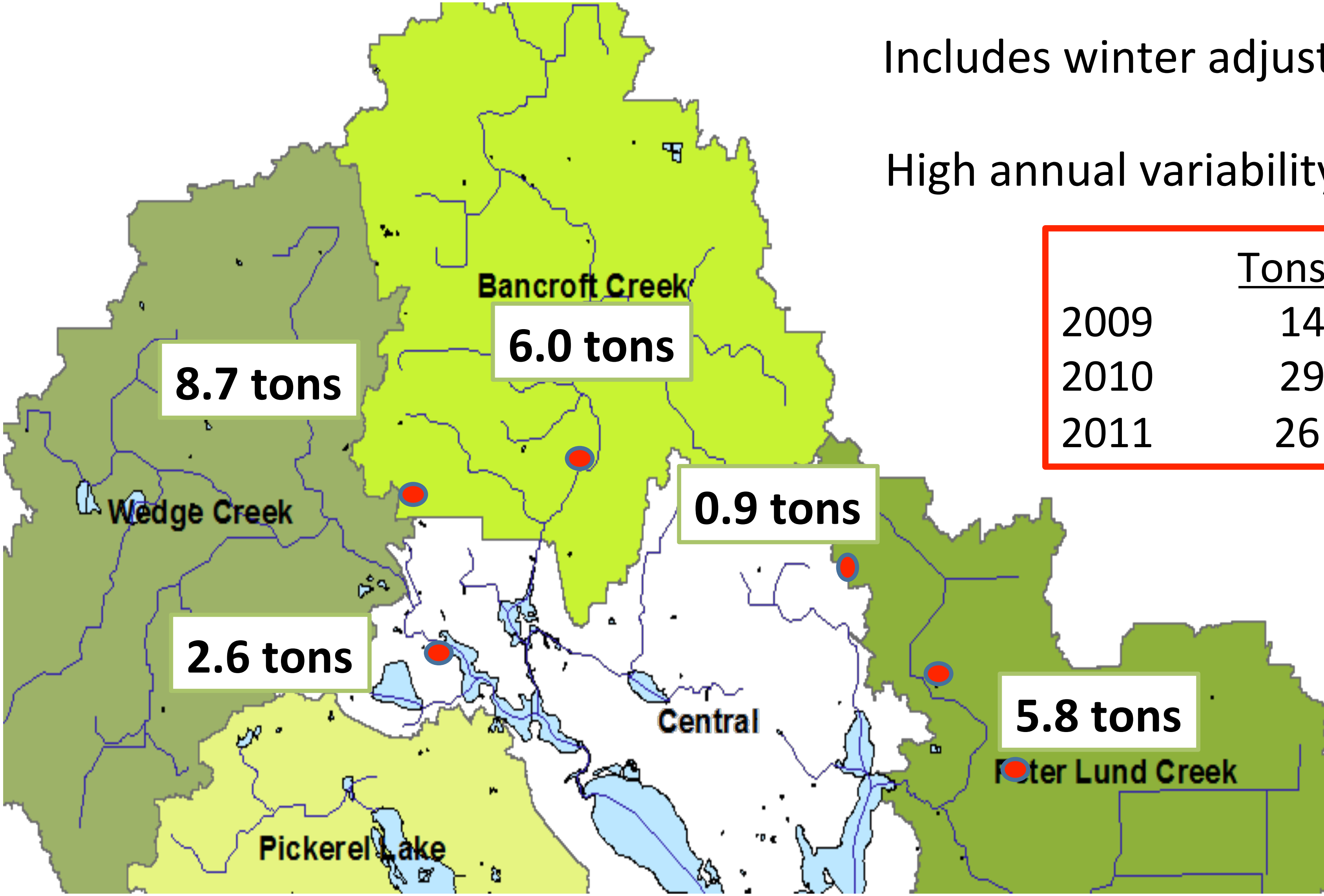
Summary of Calculated Livestock Efficiencies

System	Input	Manure	Product Export	Efficiency
		(tons/yr)		
Beef	18.1*	14.3	5.0	28%
Pork	90.2	38.5	49.9	55%
Dairy	3.6*	2.4	1.3	37%
Turkey	22.7*	11	12.4	54%

** Includes calves / piglets / poults imported into herd*

We developed a spreadsheet calculator for each major animal system.

Average Annual Agricultural Stream P Loads, 2009-2011 = 24 tons/yr



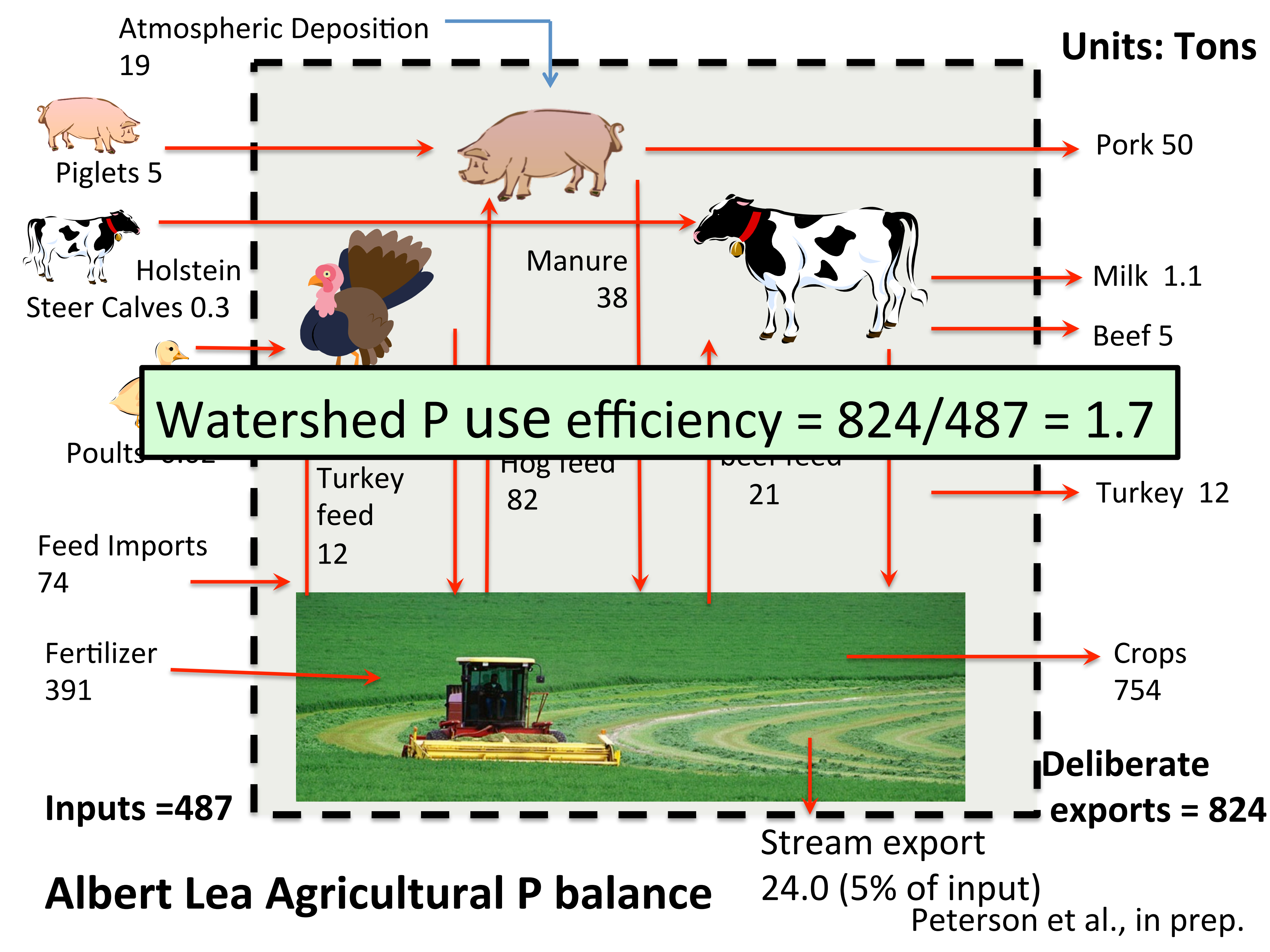
Includes winter adjustment

High annual variability

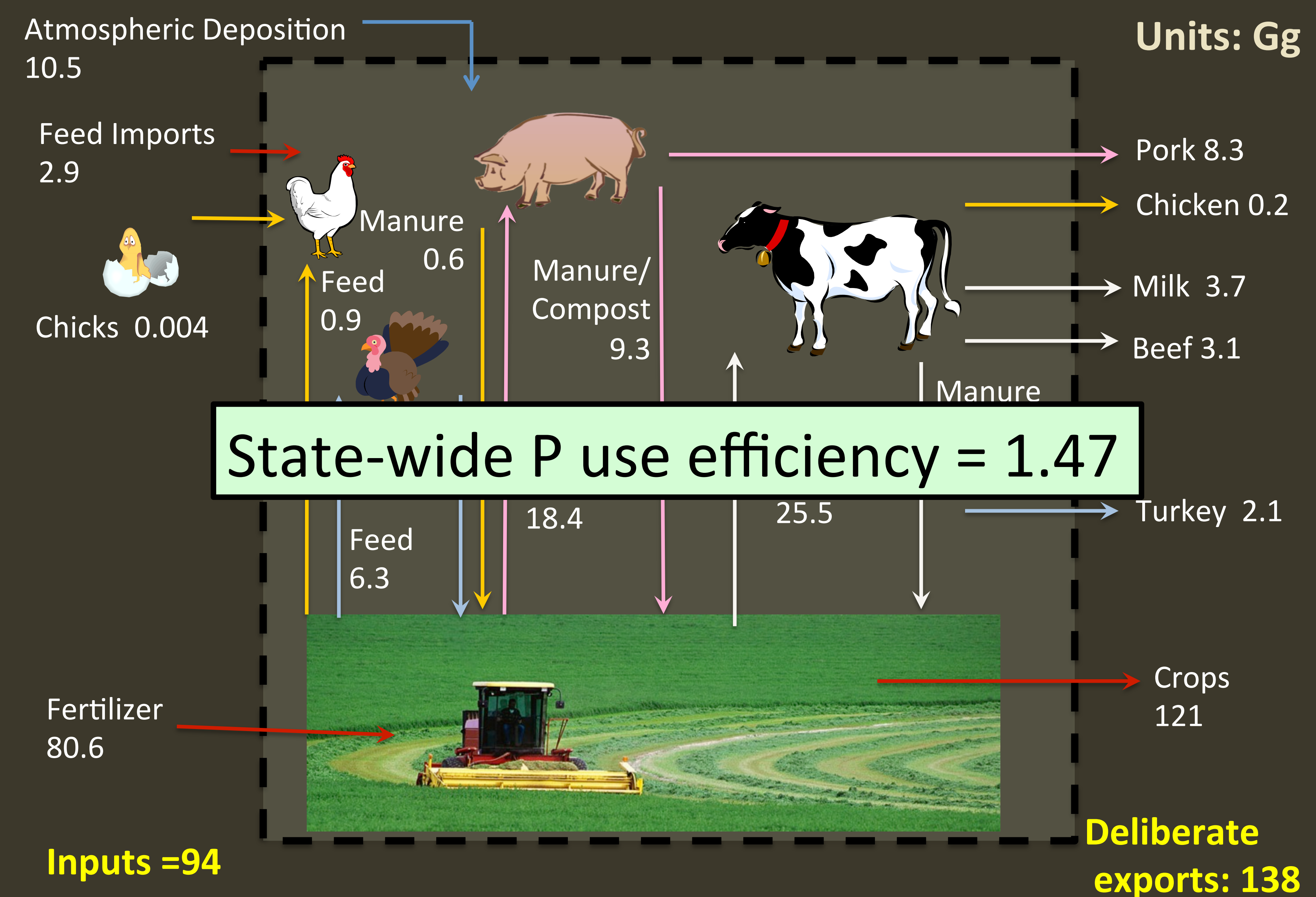
	Tons TP
2009	14
2010	29
2011	26

Stream	TP flux, kg/yr	TP yield, kg/ha-yr	Part. P, %	Soluble P, %	Water yield, cm/yr
Bancroft Ct.	5411	0.62	26	**74**	30
Wedge Cr.	7904	0.88	39	**61**	33
Peter Lund Cr.	5250	0.69	36	**64**	24

Watersheds are similar with respect to TP yields, dominance of soluble P, and water yields.



Atmospheric Deposition
19
Units: Tons
Piglets 5
Pork 50
Holstein
Steer Calves 0.3
Manure
38
Milk 1.1
Beef 5
Watershed P use efficiency = 824/487 = 1.7
Poults
Turkey
feed
12
Hog feed
82
beef feed
21
Turkey 12
Feed Imports
74
Fertilizer
391
Crops
754
Inputs =487
Deliberate
exports = 824
Stream export
24.0 (5% of input)
Albert Lea Agricultural P balance
Peterson et al., in prep.



State-wide Ag P balance

Peterson in prep b

P balances for urban and agricultural components of Albert Lea watershed

	P input, Gg/yr	Stream export, Gg/yr	% to stream
Wastewater	44	28	64%
Urban landscape	2.0	0.8	40%
Agriculture	463	24	5%

Highest P inputs to agriculture, but agricultural runoff and urban wastewater contribute about the same to stream export.

Integration into Watershed Restoration and Protection (WRAP)?

Summary

1. Watershed P balances can be a useful tool for nutrient management, especially to improve P use efficiency.
2. For the Albert Lea ag region, P use efficiency was > 100% for 2010.
3. Spreadsheet calculator facilitates development of other whole-watershed P balances.
4. *Whole watershed P balance tool could be integrated into WRAP and TMDL processes*.

Next step: Identify opportunities to shift current P flow through system toward a circular P economy

(NSF proposal in review).