



How does Manure Application Timing Affect Phosphorus Loss in Runoff?

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The Issue

- ▶ Manure on soil surface has high P content and can be significant source of P loss in runoff
- ▶ Manure P content (and runoff risk) decreases in two ways
 - ▶ Leaching by rain or snowmelt into soil (fast)
 - ▶ Biological assimilation into soil (slow)
- ▶ Most manure P is lost when significant runoff occurs soon after application and manure P content is still high
- ▶ More time between manure application and when runoff occurs can decrease P loss, *but only if above mechanisms are active*

Research Questions

- ▶ Since winter and early spring runoff is consistent and significant in WI, northern states, is winter-applied manure more susceptible to P loss? How much more?
- ▶ Can delaying manure application to avoid storms that may produce runoff reduce P loss? By how much?
- ▶ Do we have good ways to assess these questions since they include many different scenarios?

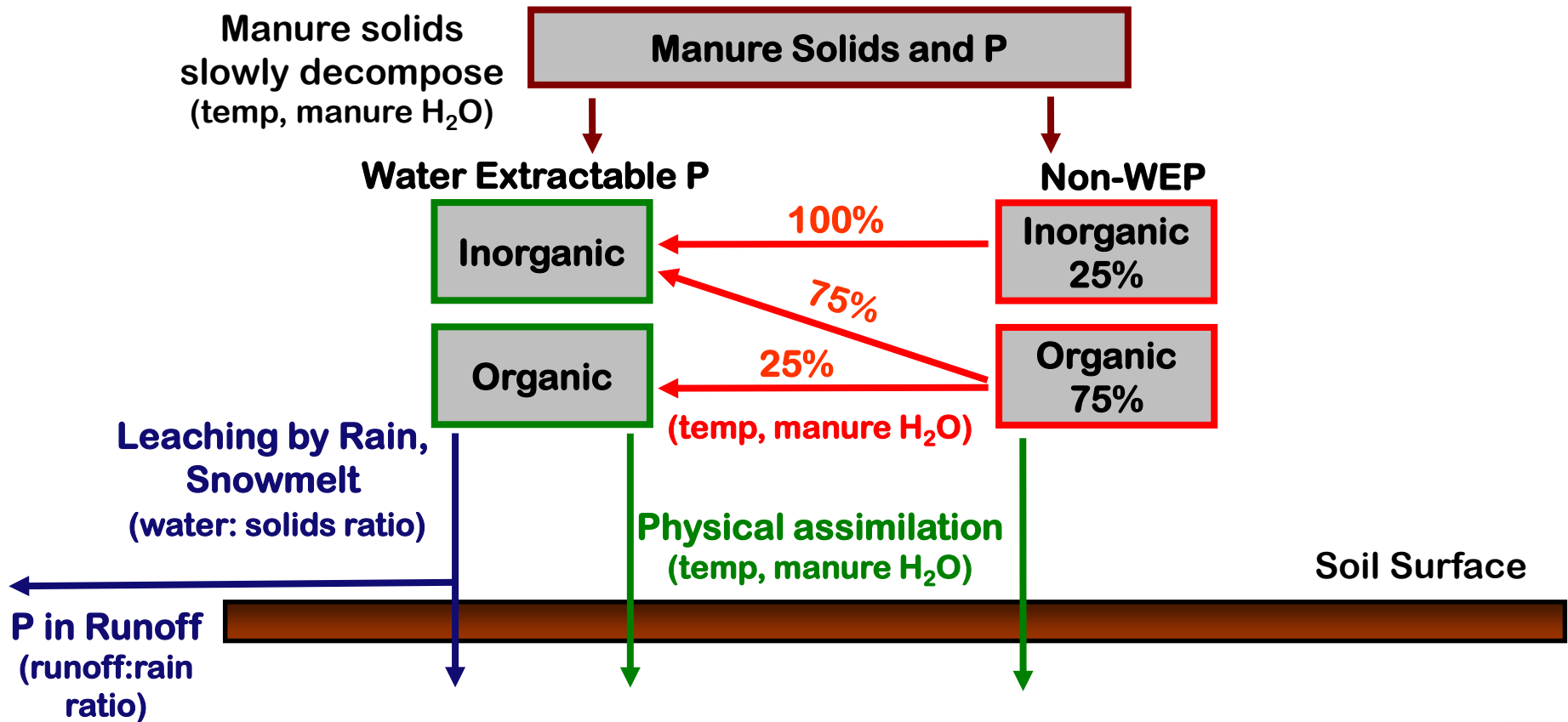
Research Project

- ▶ **Joint USDA/UW project to understand processes controlling manure P loss for winter conditions**
 - ▶ **Lab studies - Impact of:**
 - ▶ **Water temperature on P release from manure**
 - ▶ **Manure placement in snowpack and rate of manure on P release during snowmelt**
 - ▶ **Manure placement in snowpack and soil conditions on P loss in runoff**
 - ▶ **Field runoff study (Arlington): impact of tillage and winter manure application timing on P loss in runoff**
 - ▶ **Modeling: evaluate and improve predictions for manure P loss in runoff for winter conditions**

Modeling Objectives

- ▶ Assess ability of *SurPhos* model to simulate manure P loss in runoff for winter conditions
- ▶ Estimate impact of manure application decisions on runoff P loss
 - ▶ Seasonal: How does application day of year affect manure P loss?
 - ▶ Short-term: How does delaying application to avoid near-term runoff affect manure P loss?

Modeling Surface Manure P Loss (*SurPhos*)



How well does *SurPhos* work for winter conditions?

- ▶ **Komiskey et al. (2011), JSWC 66:303-312**
 - ▶ P loss in runoff monitored on WI dairy farm over 4 winters (2003-2007) from 3 fields(17 to 40 ac) in no-till corn/soy
 - ▶ Liquid dairy or solid beef manure surface-applied at different rates and times, but manure applied at least once in all months from September to March over 4 years.

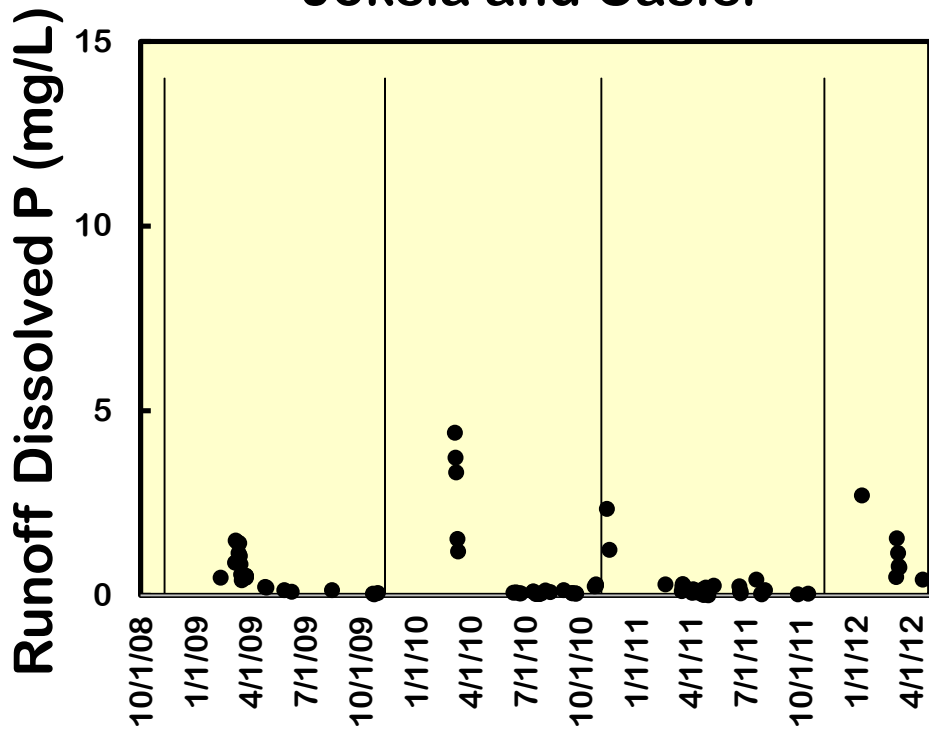
- ▶ **Jokela and Casler (2011), Can. J. Soil Sci. 91:479-491**
 - ▶ P loss monitored from WI field (4 ac) where liquid dairy manure (3-14% solids) surface-applied early November from 2008-2011

Assess *SurPhos* for winter conditions using measured data

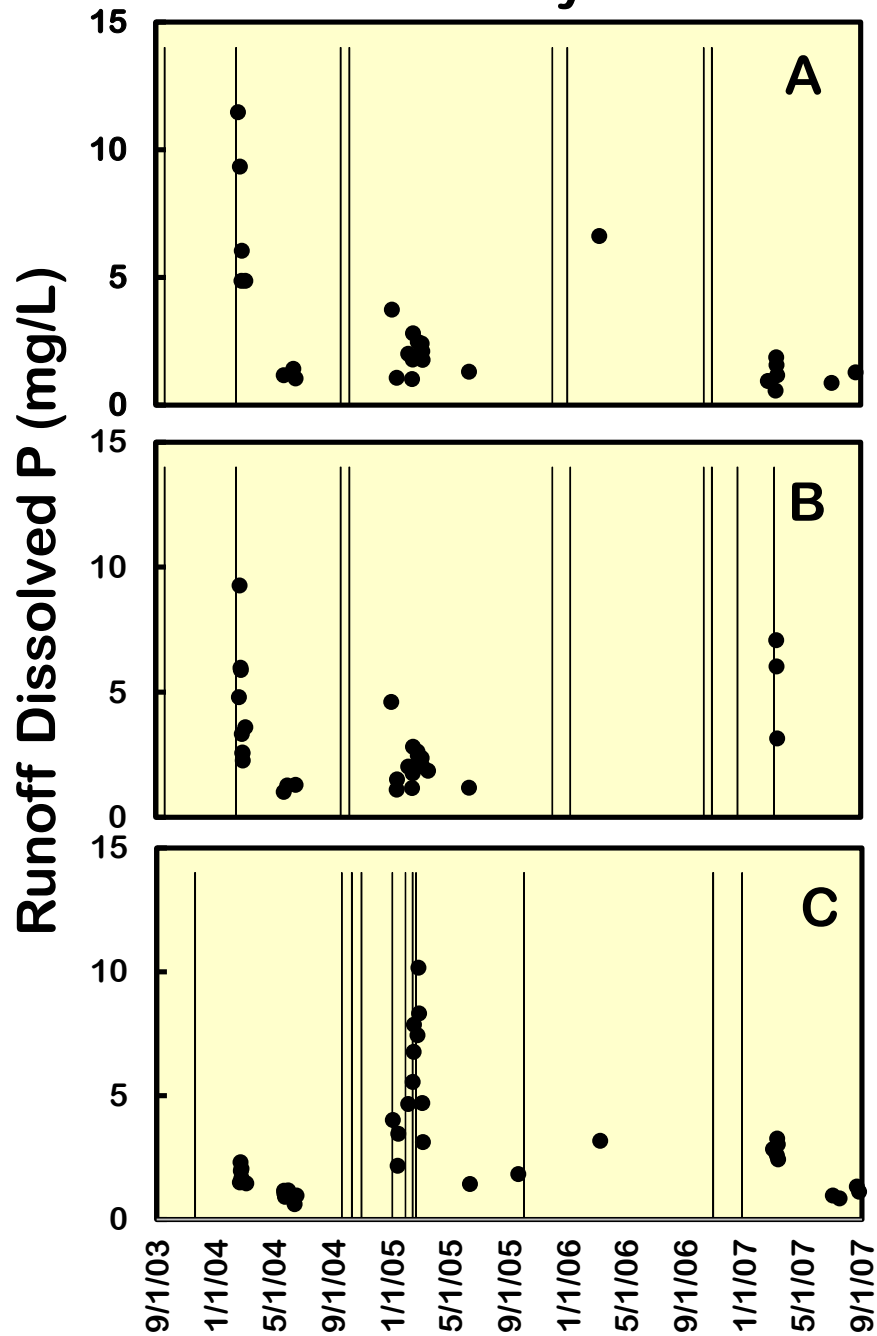
- ▶ Simulated study conditions with *SurPhos*
 - ▶ Used measured precipitation and runoff, reported manure application rates, times, P contents
- ▶ Compared measured and predicted dissolved P concentrations in runoff for all reported events
- ▶ Vadas et al., Journal of Environmental Quality (2017)

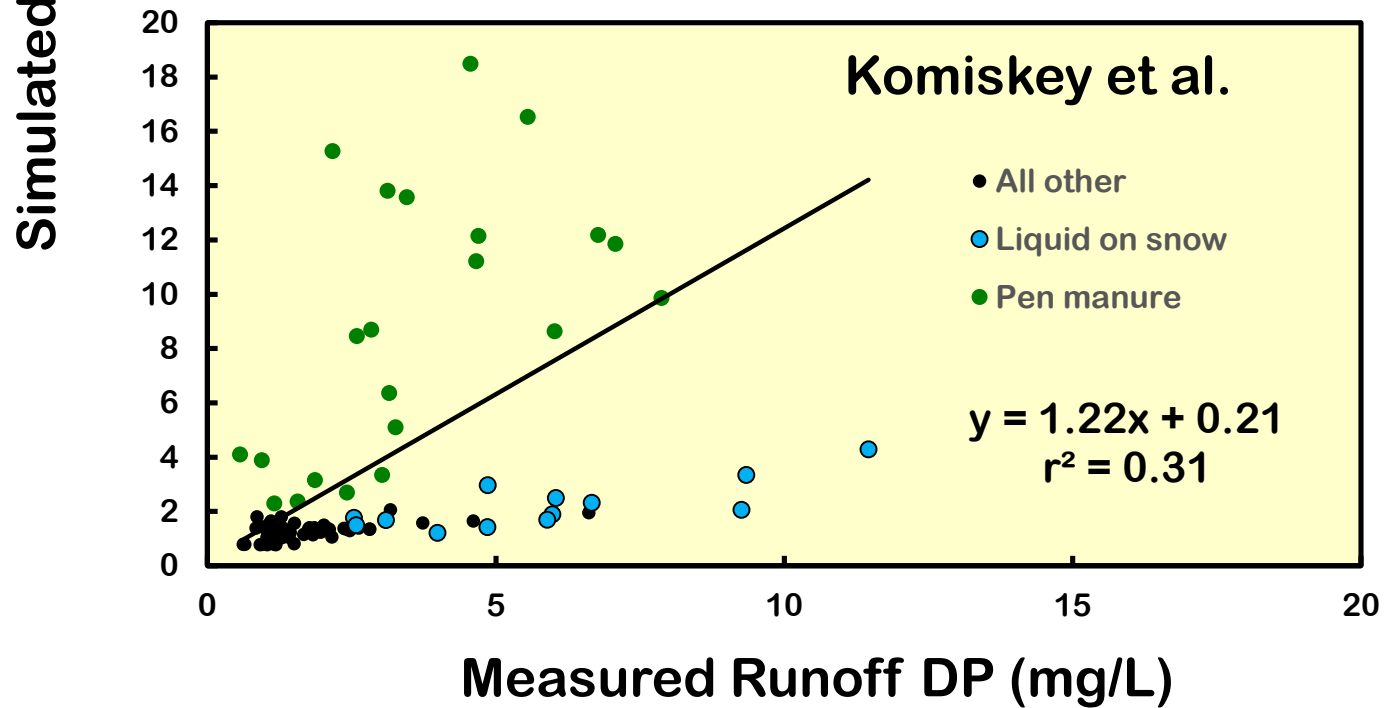
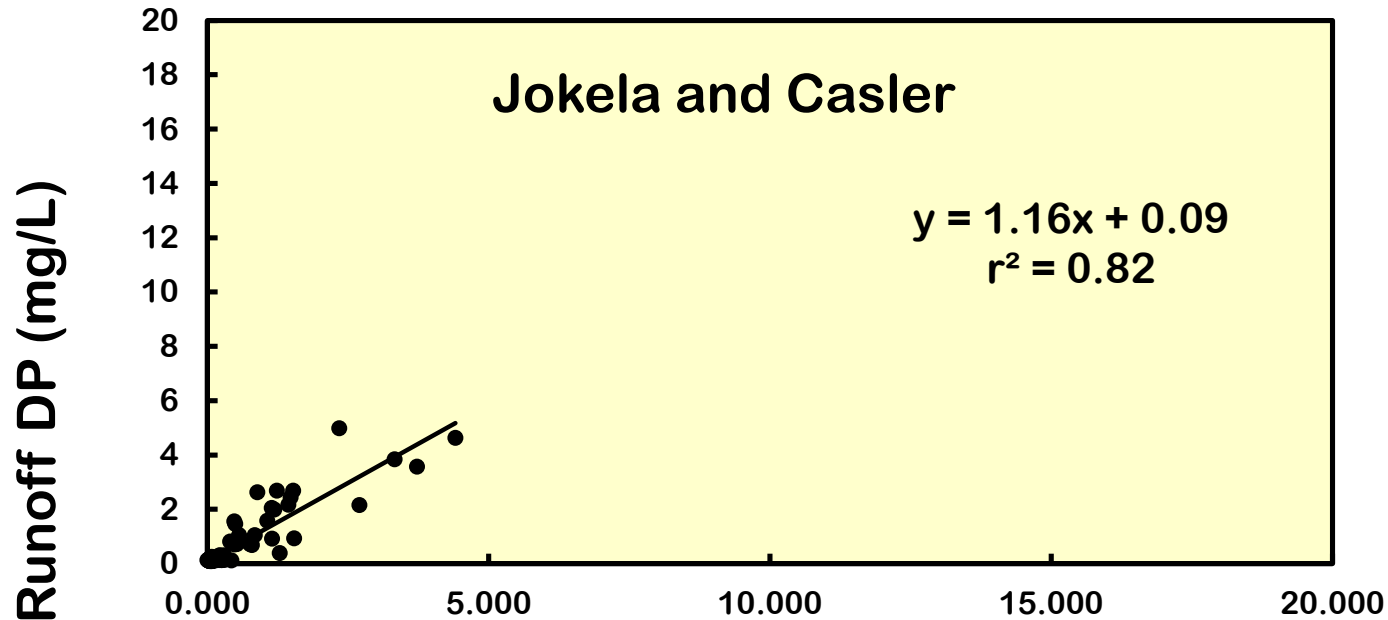
Measured runoff dissolved P

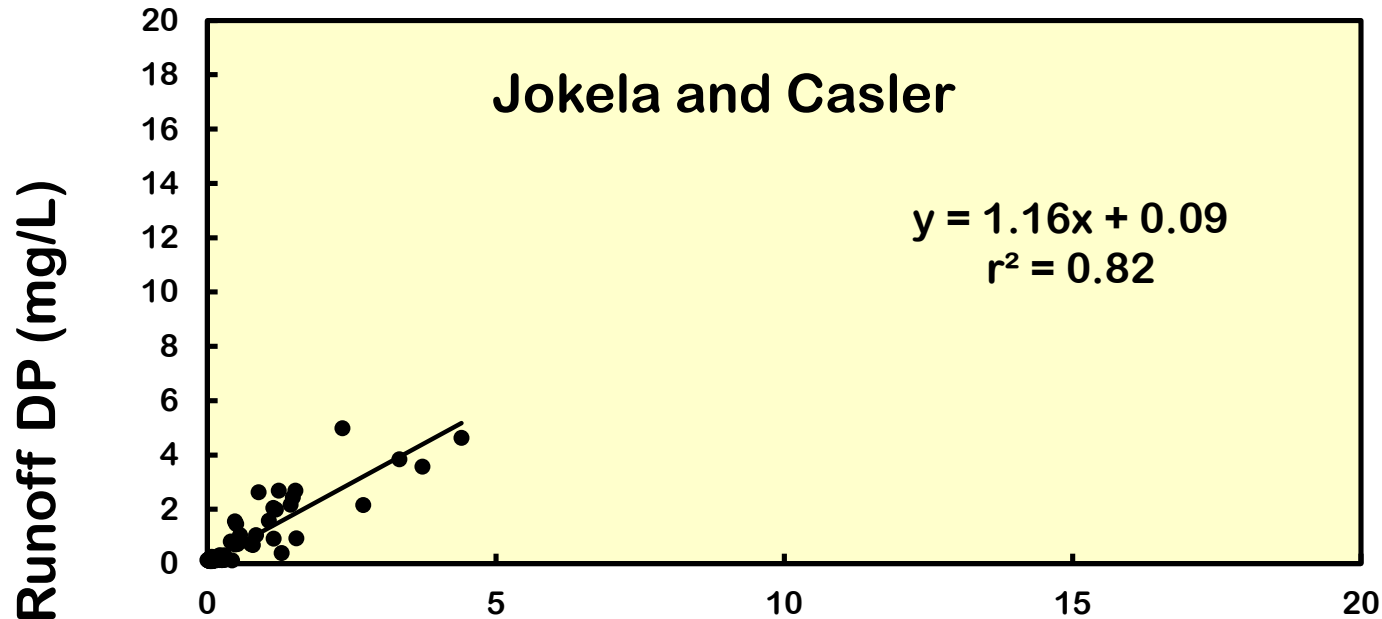
Jokela and Casler



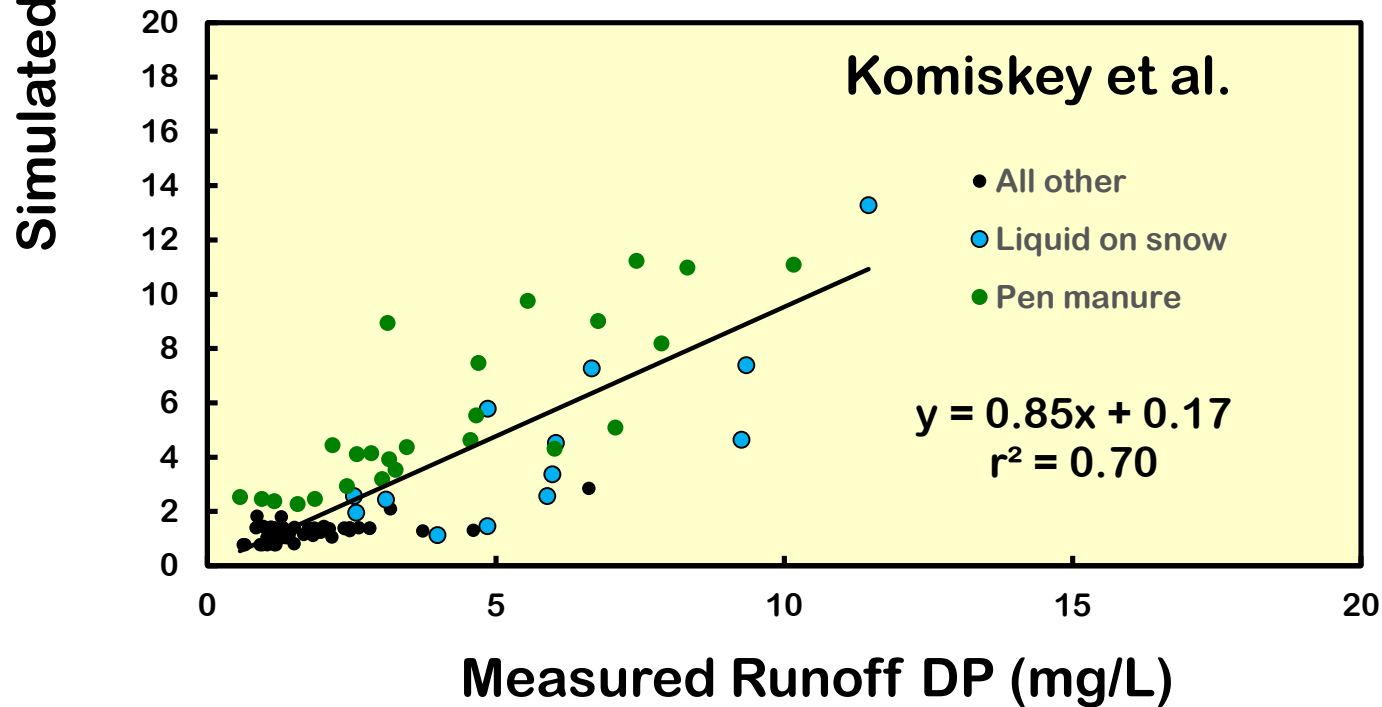
Komiskey et al.







n = 102
NSE = 0.64
RMSE = 0.46 mg/L



n = 93
NSE = 0.65
RMSE = 1.42 mg/L

Estimate impact of manure application timing on runoff P loss

Used measured, field-scale precipitation and runoff data from WI (108 site years from 6 locations, 2003-2012)

3 data groups based on ratio of runoff:precip during winter period: Low (0-10%), Med. (10-25%), High (25-50%)

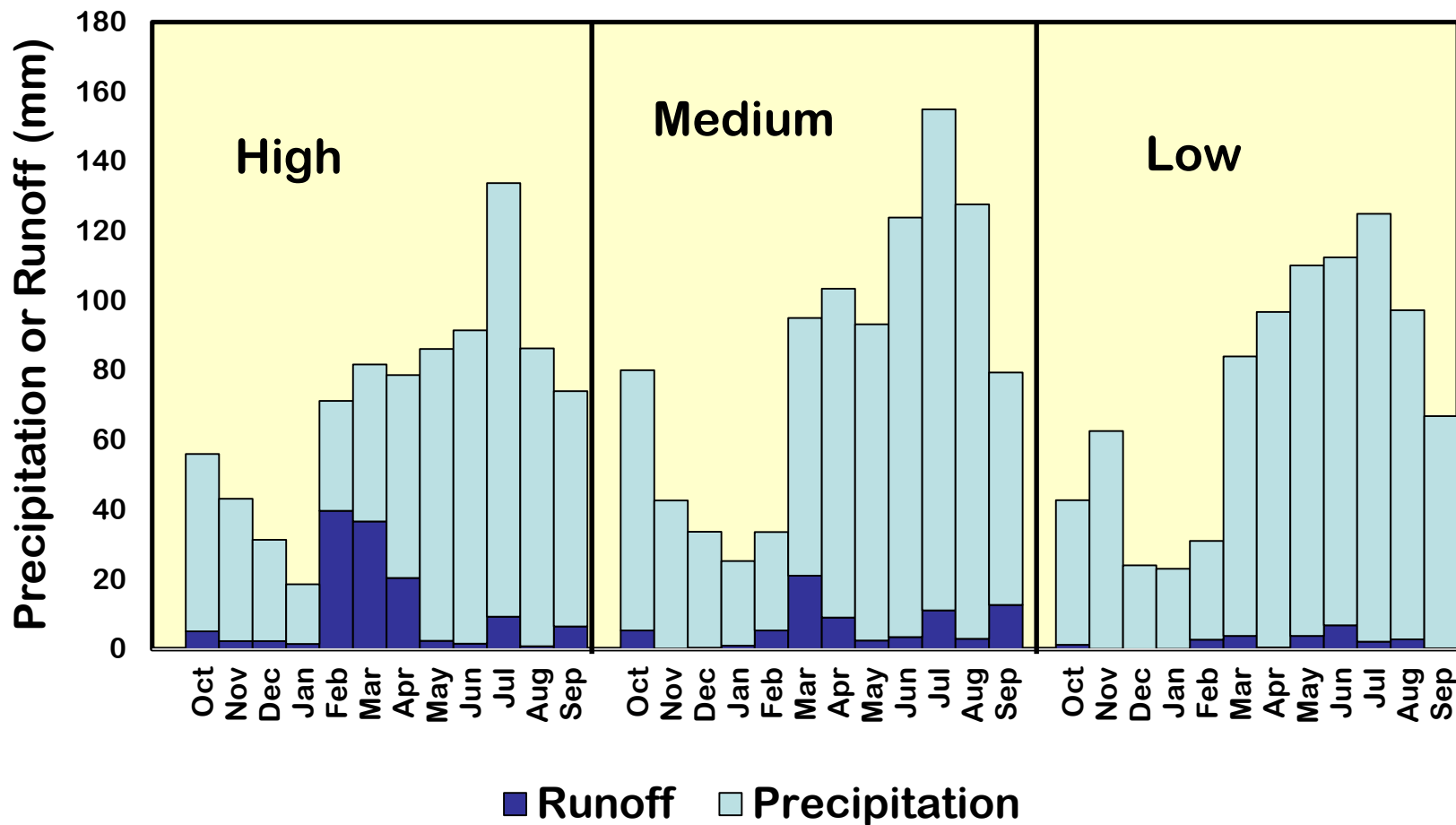
Used *SurPhos* to predict P loss in runoff, varying which day of year manure is applied

Manure applied in single application at 10,000 gallons/ac and 35 lb P/ac, 6% solids

Repeated simulations, delaying application if runoff occurred within 2, 4, 6 days (need this number of runoff-free days)

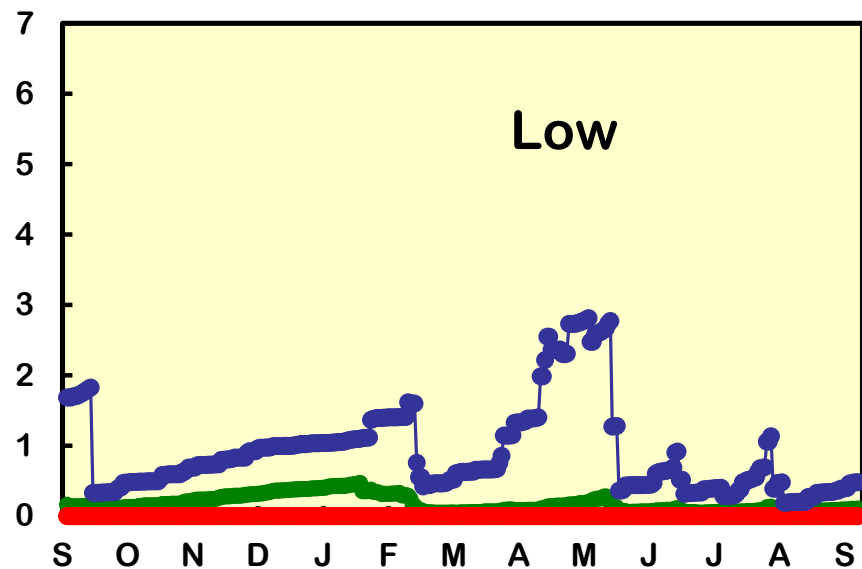
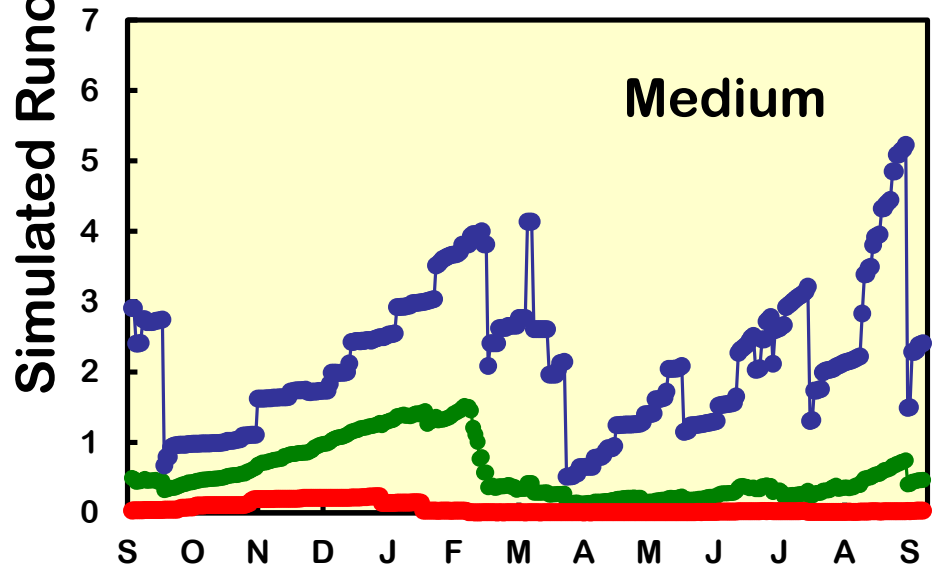
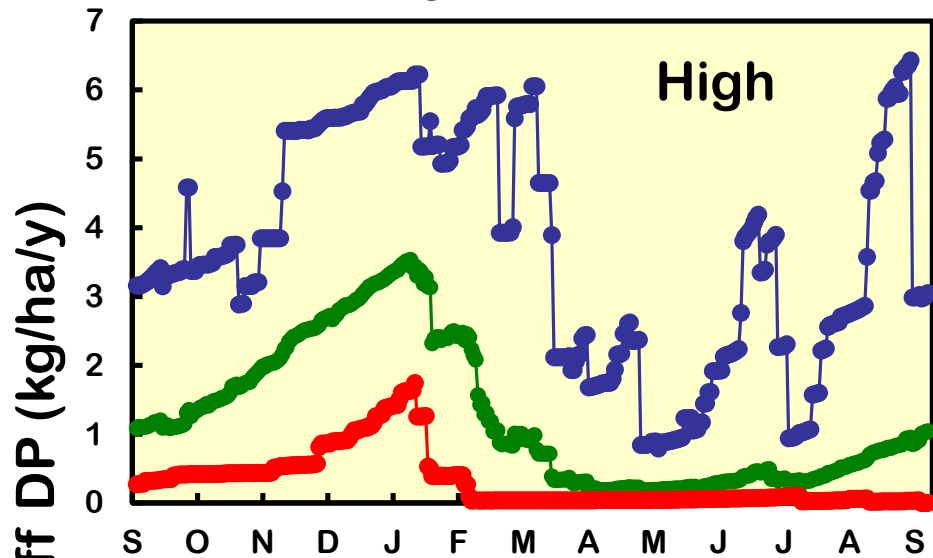


Measured Runoff Groups



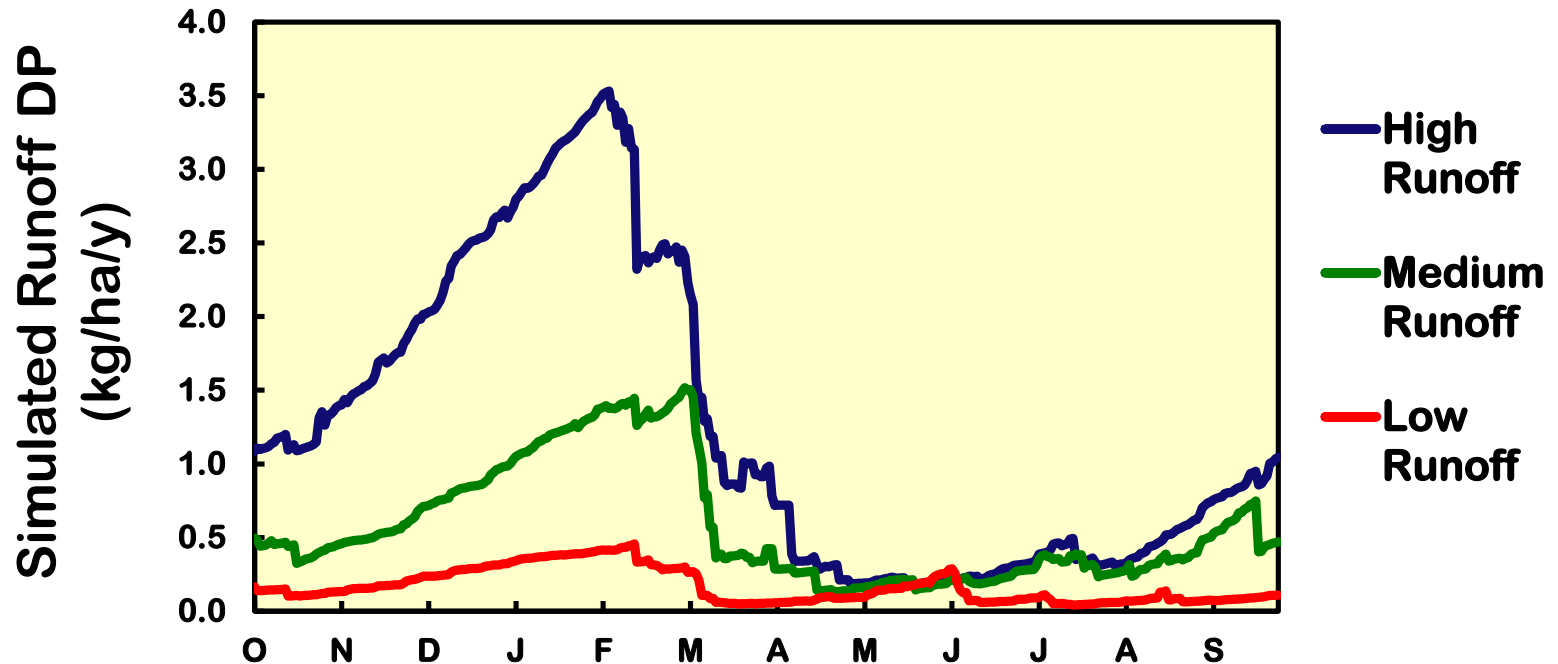
Simulated Manure Dissolved P Loss

—●— Average —●— Min —●— Max



Manure P Loss for Different Seasons and Fields

Runoff Group	Winter P Loss (kg/ha/y)	Non-Winter P Loss (kg/ha/y)	Season Difference	Runoff Difference over Low
Low	0.28	0.11	2.5x	--
Medium	1.01	0.35	2.9x	3.4x
High	2.40	0.67	3.6x	7.5x



High runoff group: Effect of manure application delay on P loss

Category	Number of Runoff-free days after Application			
	0	2	4	6
Average Full-year P Loss (kg/ha) for 35 y	1.25	1.20	1.14	1.11
Average Winter P Loss (kg/ha) for 35 y	2.40	2.29	2.16	2.06
Average Non-winter P Loss (kg/ha) for 35 y	0.67	0.65	0.63	0.63
% of days (n=12,275) when delay reduced P loss	--	3.6	6.9	9.1
Average decrease in P loss (kg/ha), max in parentheses, when delay decreased P loss	--	1.48 (5.97)	1.69 (5.97)	1.73 (5.97)
% of days when delay increased P loss	--	1.2	2.2	3.3
Average increase in P loss (kg/ha), max in parentheses, when delay increased P loss	--	0.35 (2.13)	0.45 (2.34)	0.47 (2.35)

Summary

- We have reliable tools to estimate impact of manure application timing and placement on P loss in runoff.
- In general, winter manure application increases risk of P loss, but winter can be from mid-Nov. to mid-March.
- Delaying application when runoff is likely can reduce P loss; but number of opportunities for producers to actively use delays to reduce P loss may be limited.
- Manure application to fields or seasons with lower runoff has more consistent potential to reduce P loss than avoiding near-term runoff.
- Impact of when and where manure is spread on P loss appears less critical from April-September than October-March.