Quantifying Phosphorus Loses From Agricultural Fields

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Quantifying Phosphorus Loses From Agricultural Fields

- Overall objective:
  - To estimate runoff, soil loss and phosphorus loss from agricultural fields with complex topography and use the results to inform farmers and policy makers
- Outline:
  - Introduction
  - Research
  - Extension
  - Education
  - Conclusions

Introduction

Research

Extension

Education

Introduction

Research

- Monitoring
  - 5 farms
  - 3 crop types
  - 3 tillage types
  - 4-13% slopes
  - storms/snowmelt
  - 2 filter strips
  - Runoff, sediment, P
- Modeling
  - PALMS
  - Runoff, sediment, P
  - Drainage

Extension

- Wisc. Buffer Initiative
  - WBI Advisory Board
    - 15, 1-day mtgs. in 3 yrs.
  - Address non-pt. pollution in Wisconsin
- Validation of RUSLE2 & Wisconsin P-Index
- Discovery Farms
- Filter strip recs. to NRCS
- Economic analysis of filter strips vs upland practices to meet PI
- Preliminary drain-tile results

Education

- Graduate Educ.
  - Graduate module for watersheds course – PALMS hands-on work
- 2 Ph.D. students
- Student tours of facilities
- Lectures on non-point pollution in 3 undergraduate courses

Funding: CSREES ……..$548,000
WDNR, NRCS, UW …$877,000

RESEARCH

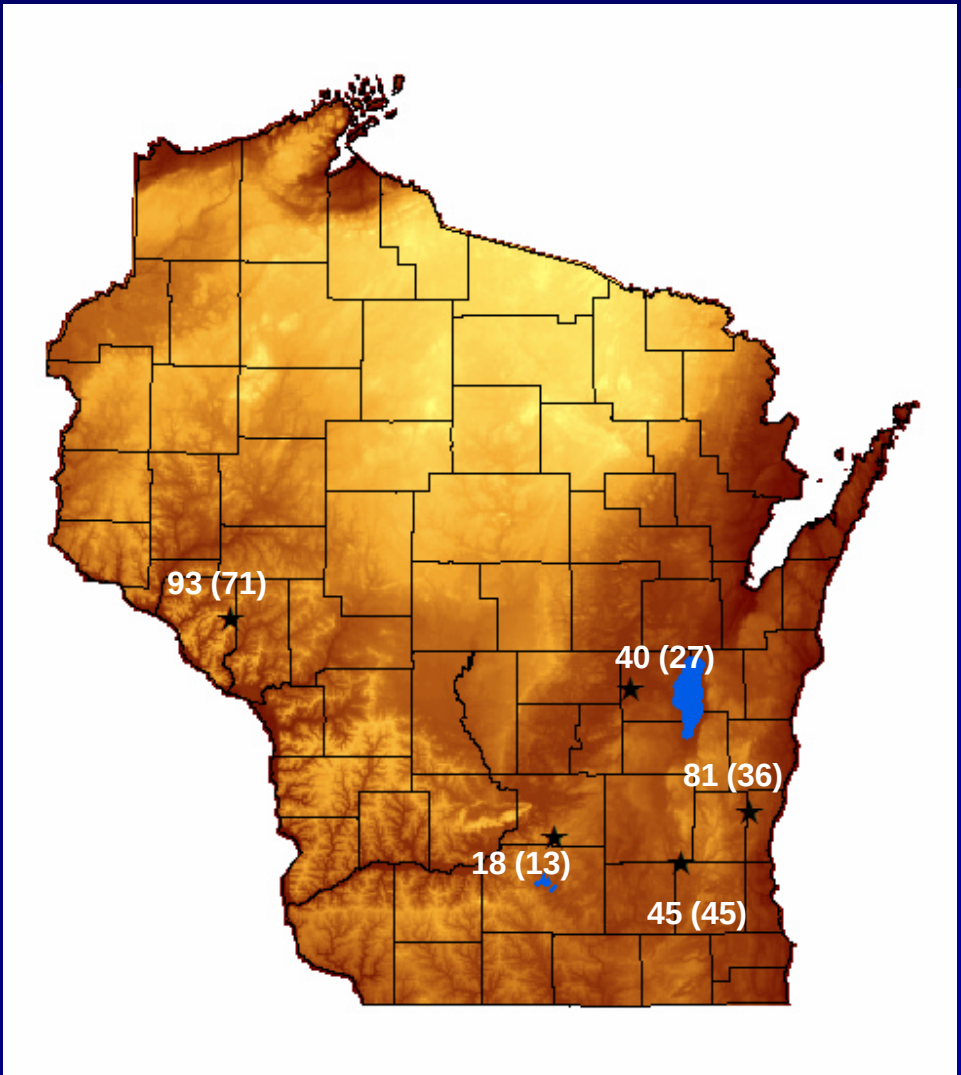
Background Information on Farms

Site	Crop	Texture	Slope	OM	Bray P	Total P	Cont. Area
			(%)	(%)	(mg/kg)	(mg/kg)	(acre)
AR6	corn, corn, soybeans	silt loam	8	4.6	68	647	0.08
BRE	alfalfa, corn, alfalfa	silt loam	13	3.8	62	646	2.00
BRW	corn, alfalfa, alfalfa	silt loam	7	3.9	97	608	0.32
KN1	corn, soy, corn	clay loam	5	2.9	29	442	0.08
KN2	tall grass buffer	loam	5	2.8	19	391	0.10
KP1	alfalfa, alfalfa, corn	loam	8	4.3	128	864	0.12
KP2	alfalfa, alfalfa, corn	loam	8	4.3	110	846	0.20
OP1	corn, alfalfa, alfalfa	sandy clay loam	10	2.8	64	566	0.25
OP2	tall grass buffer	sandy clay loam	4	3.8	89	608	0.27

RESEARCH

Five farms throughout Wisconsin used in this study (Wisconsin Discovery Farms Program)

> 469 site-collector events of runoff from 5 farms during 6/03 – 11/06 (see map)



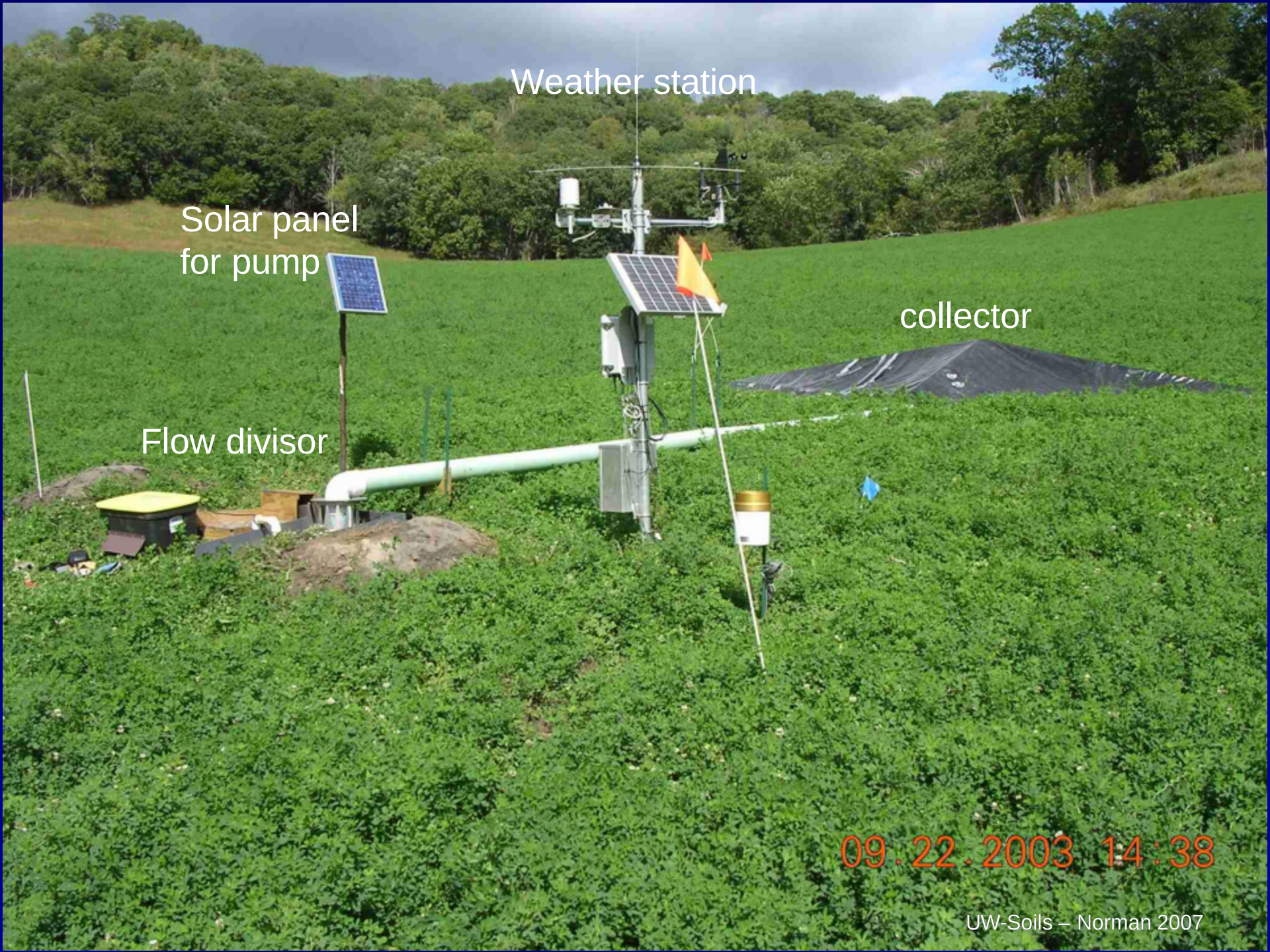
UW-Soils – Norman 2007

RESEARCH

Instrumentation for Measuring Runoff, Sediment and Chemical Losses from Agricultural Fields

- Requirements:
  - Measurements where there is no source of power
  - Remote locations on operation farms
  - Measures nearest to discharge outlet as possible where slopes are small
  - Contributing areas about 0.5 acre (0.2 ha)
  - Total runoff/chemical sediment losses per event

- Acknowledgment:
  - Daniel Yoder, University of Tennessee



UW-Soils – Norman 2007

Collector

Flow Divisor

12-slots: 5 gal/s (0.02 m^3/s)
24-slots: 1.7 gal/s (0.006 m^3/s)
Collected: 35 gal (0.13 m^3)
Sampled: 140,000 gal (540 m^3)

UW-Soils – Norman 2007

Measurement System

Bragger
UW-Soils – Norman 2004

10.14.2003 17:19
Bragger
UW-Soils – Norman 2004

Opitz

UW-Soils – Norman 2004

Knigge
UW-Soils – Norman 2004

Opitz
UW-Soils – Norman 2004

Winter conditions to catch snow-melt

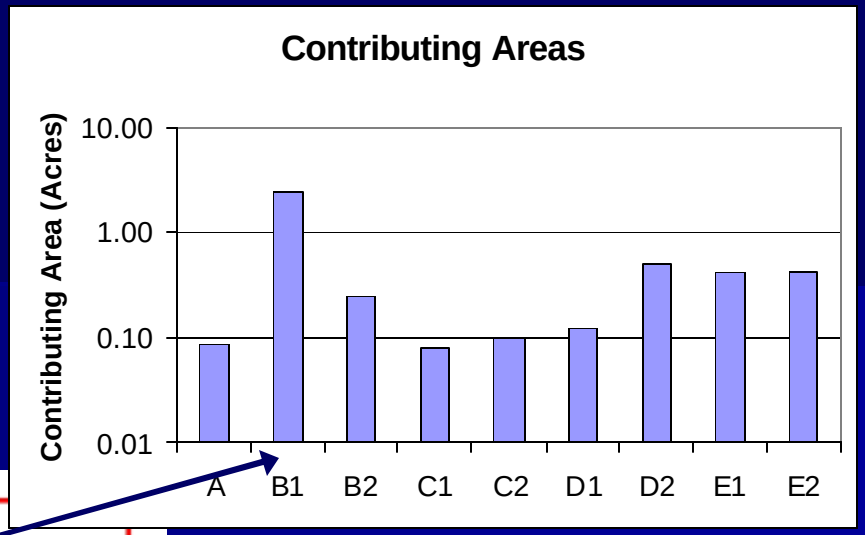
Alfalfa

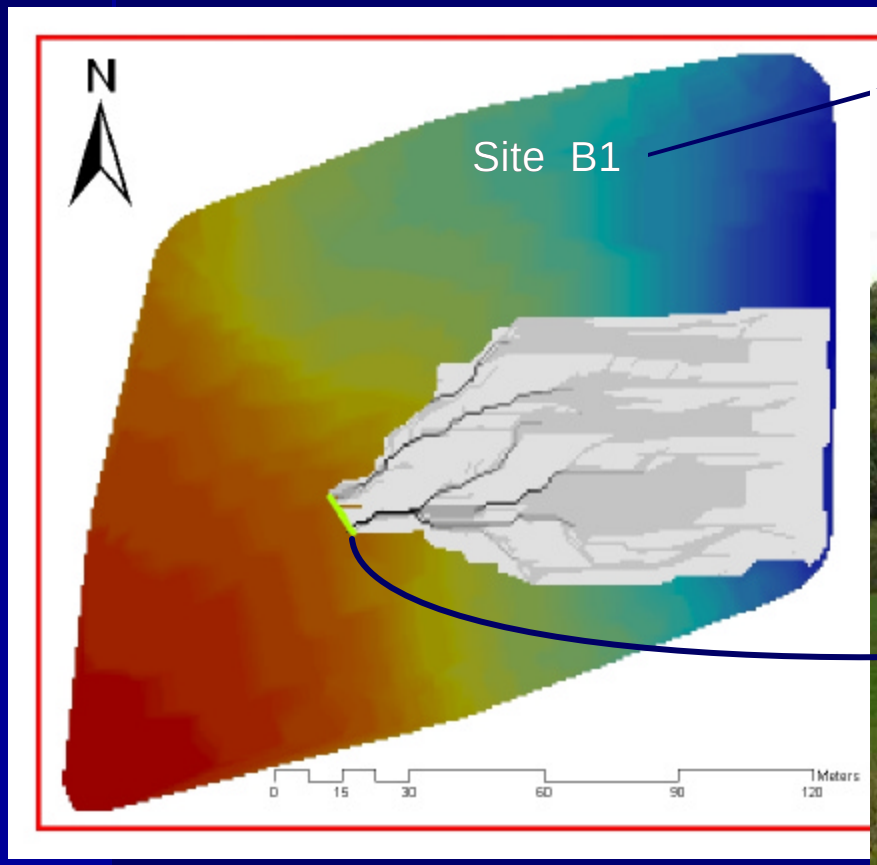
Corn

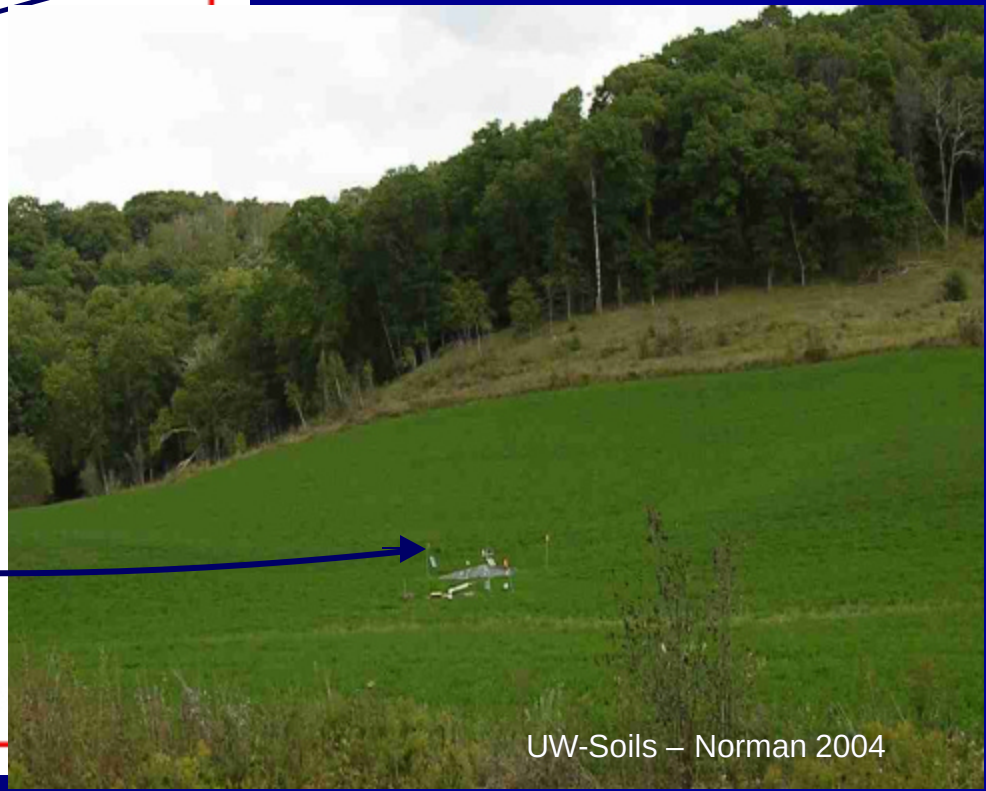
Contributing area

Created from accurate DEM using 4 different algorithms.

5 Sites: 0.1 to 2 acres

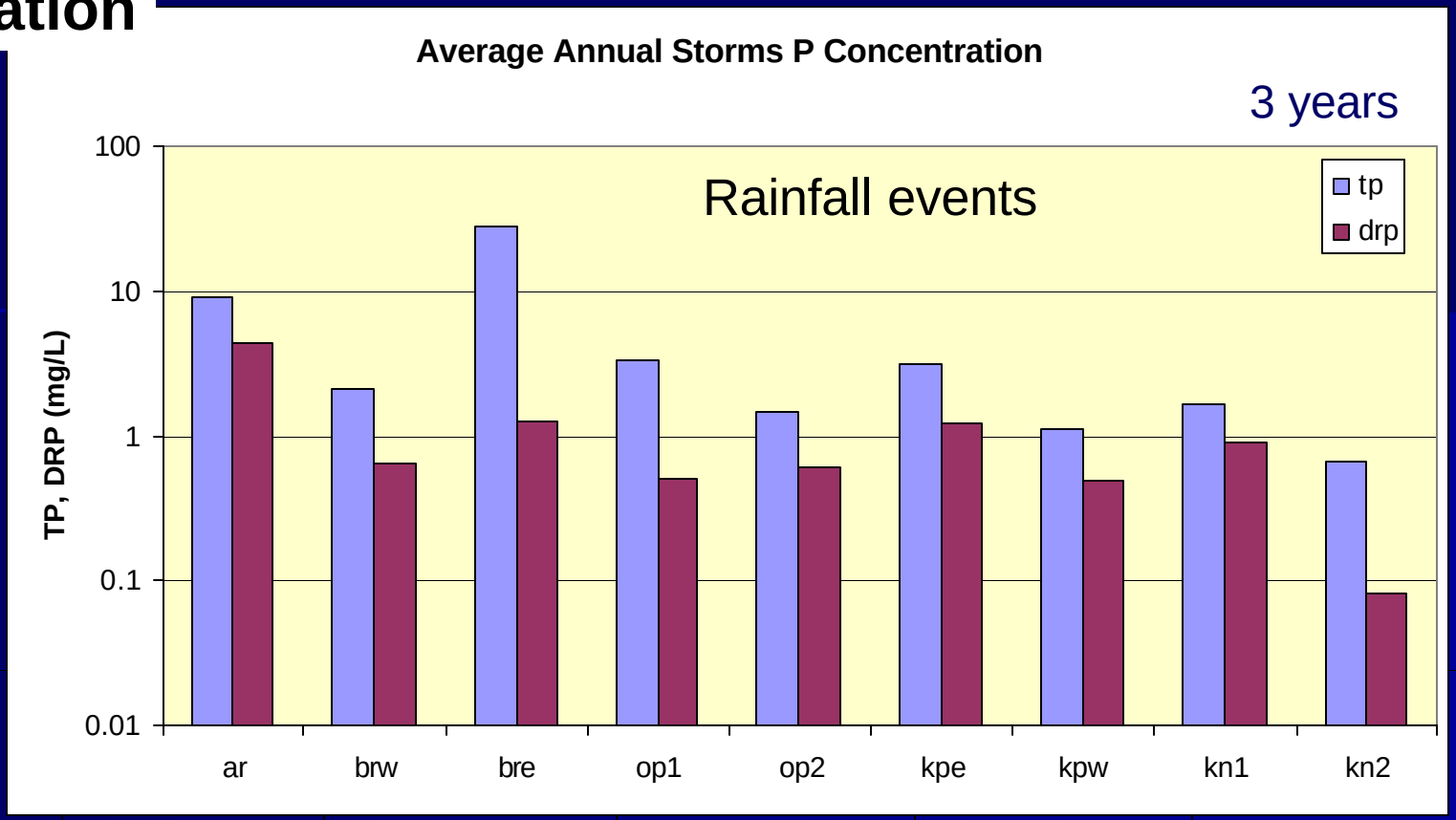






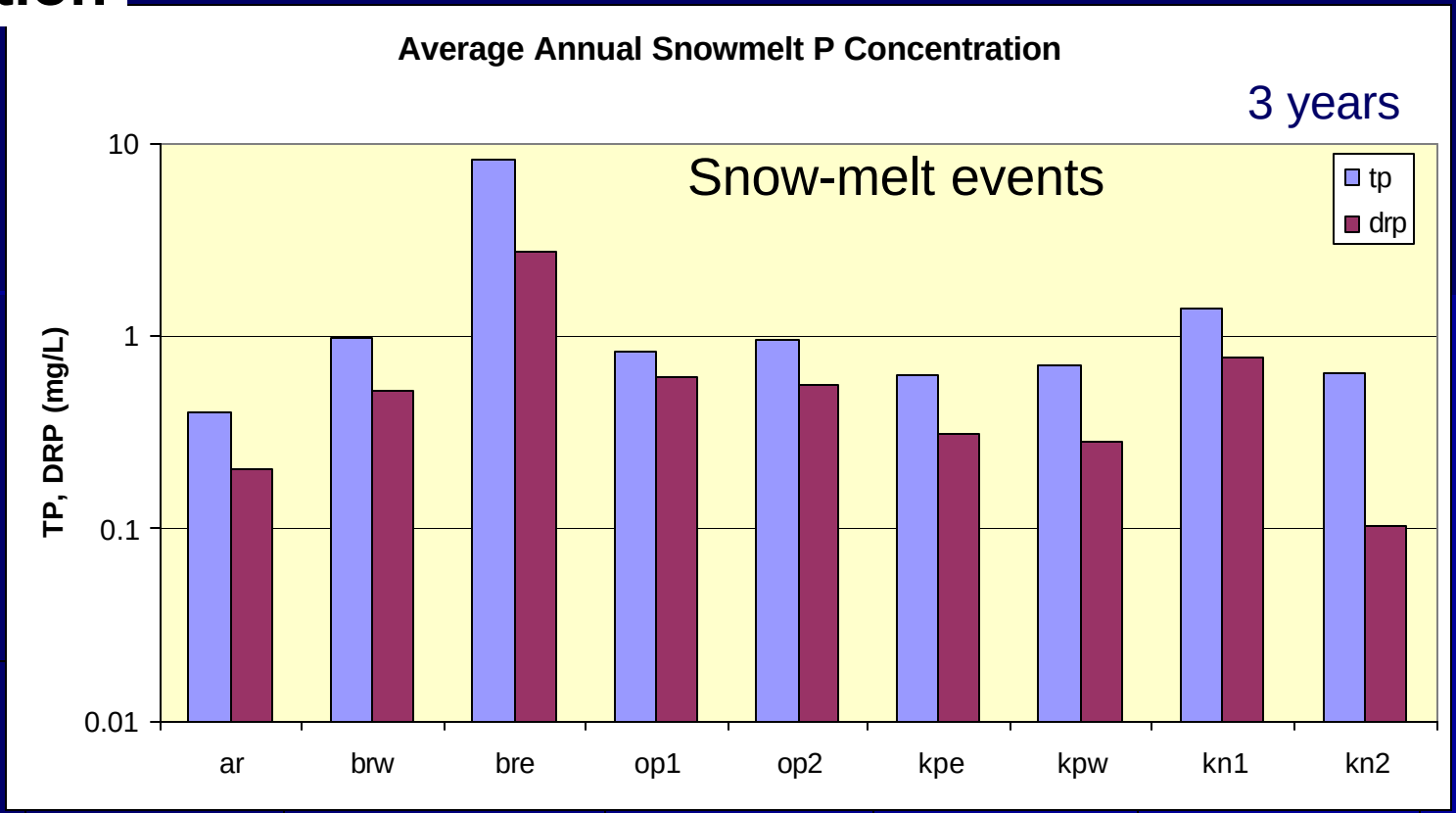
UW-Soils – Norman 2004

P Concentration



Rain (mm)	810	860		811		857		778	
Slope	8	13	7	10		8	8	5	
Texture	SiL	Silt Loam		SaCl		Loam		Clay Loam	
Bray P	68	97	62	64		111	128	29	
Runoff	8	38	126	119	79	14	188	6	17

P Concentration



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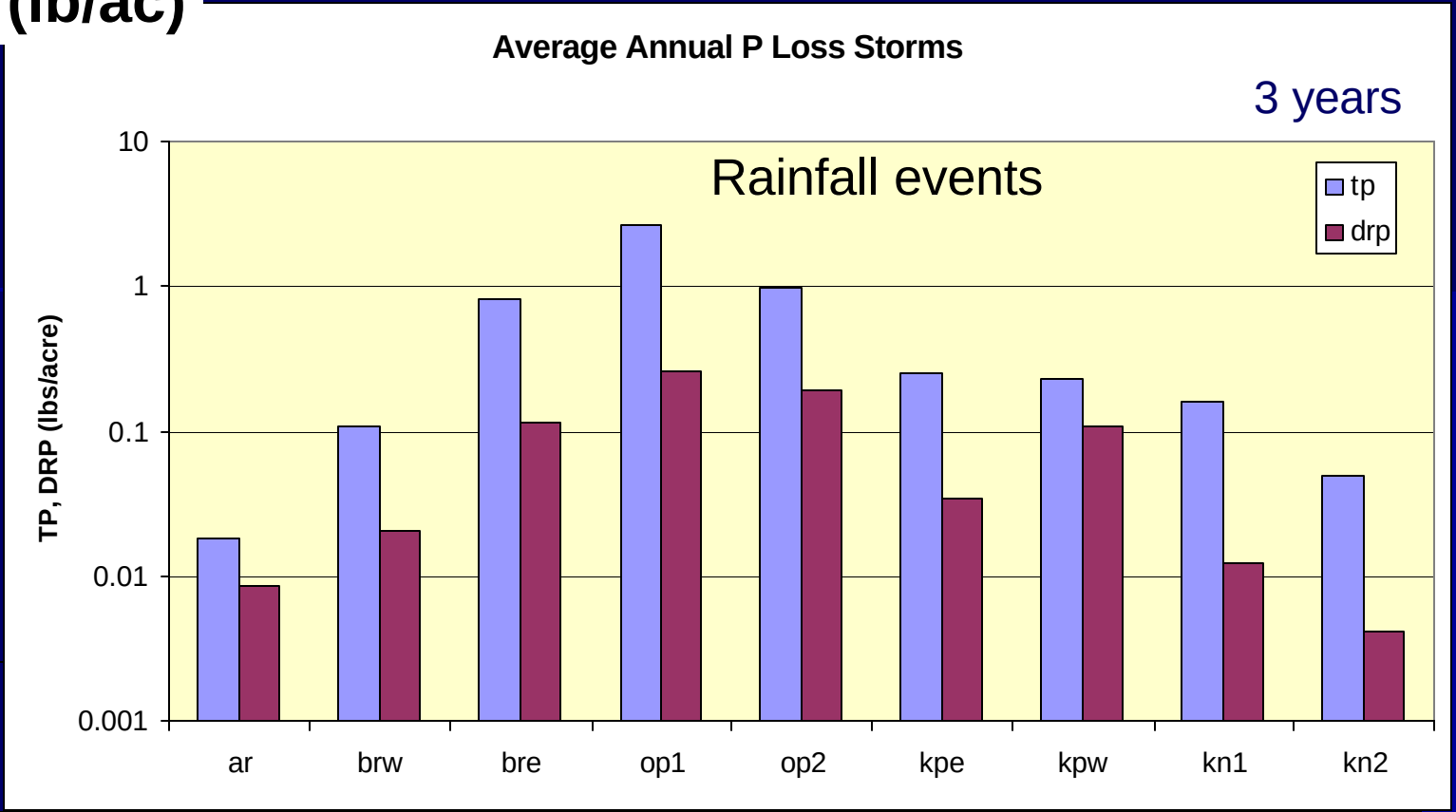
P Loads (lb/ac)



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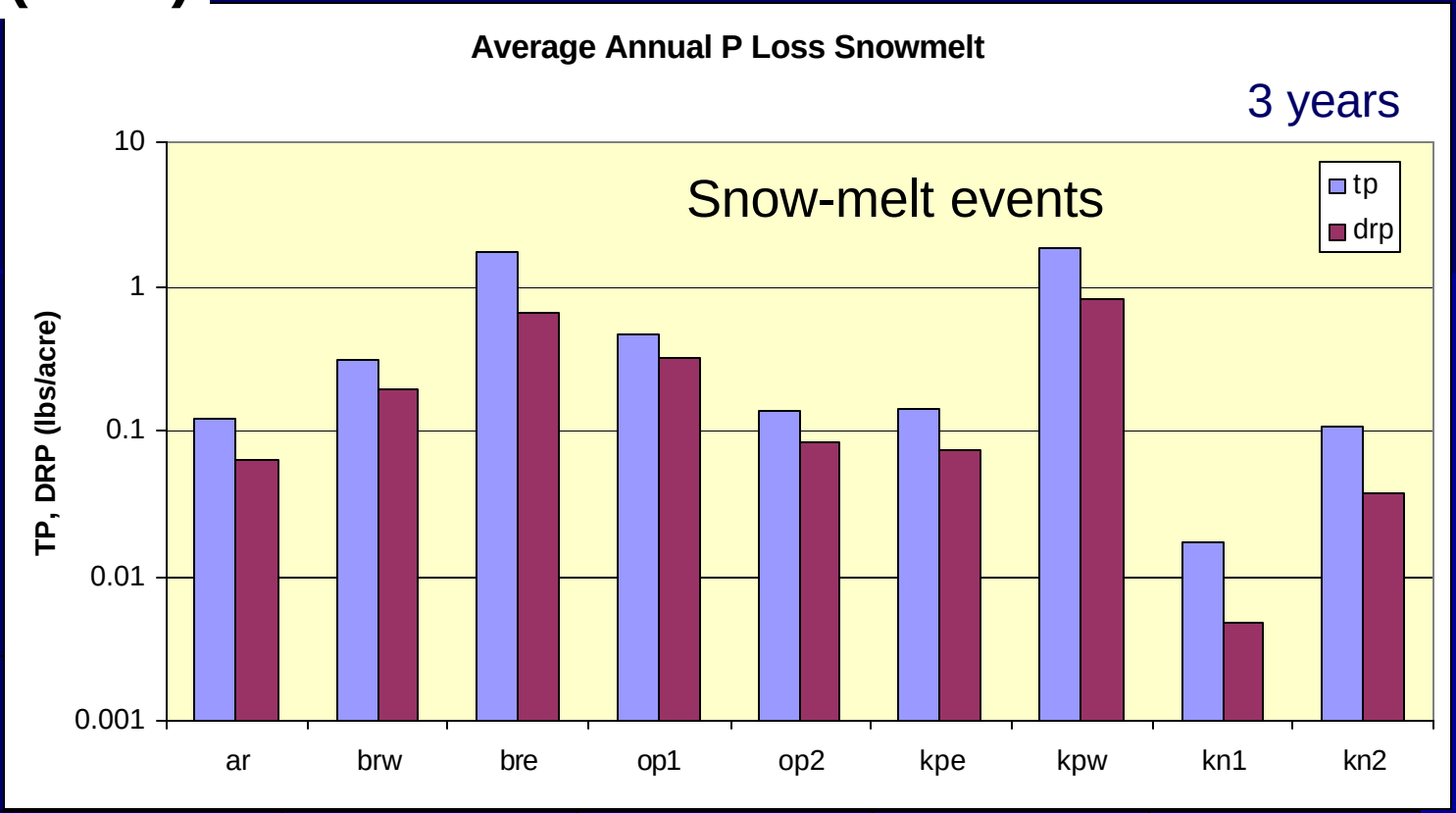

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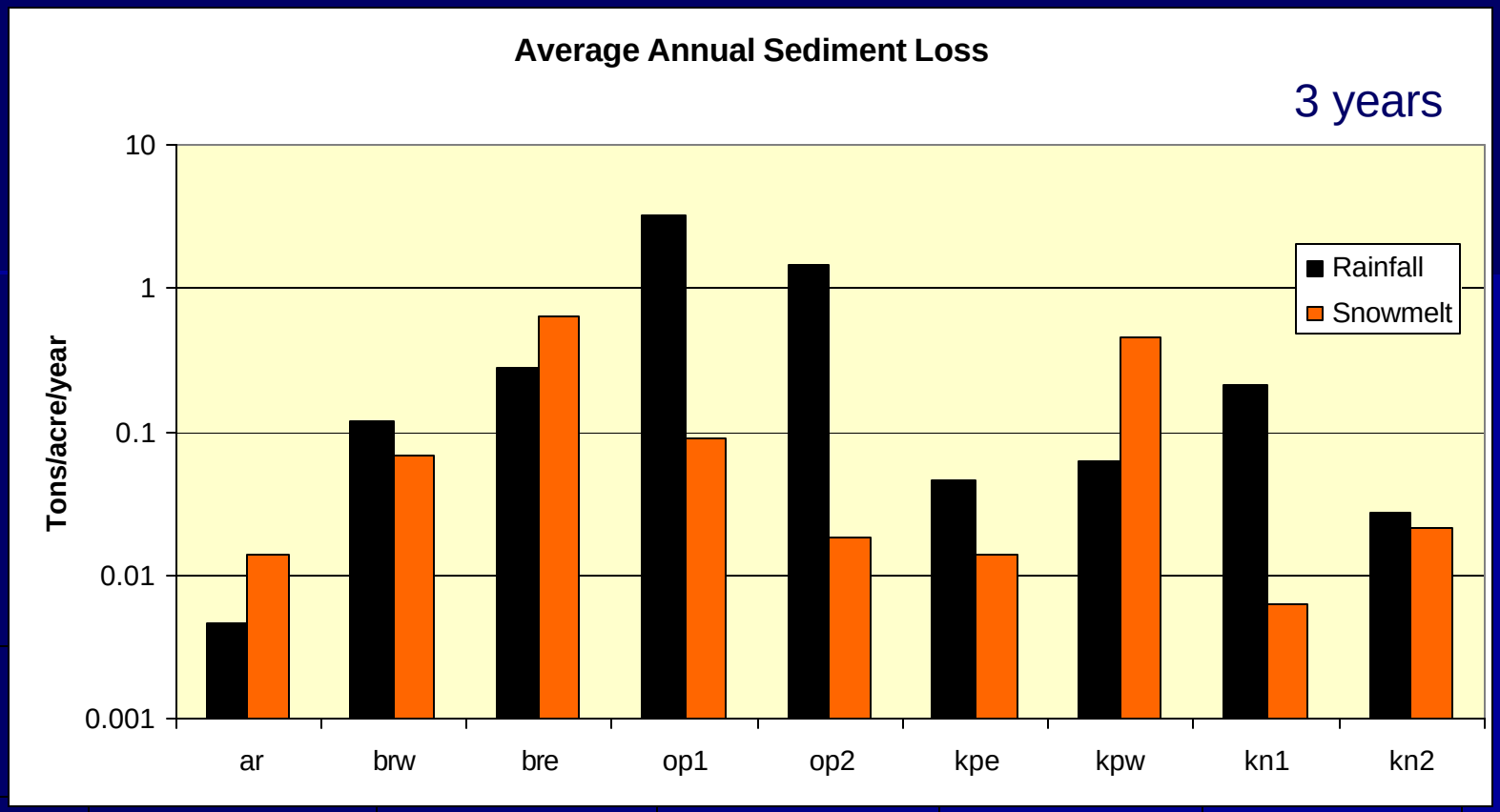

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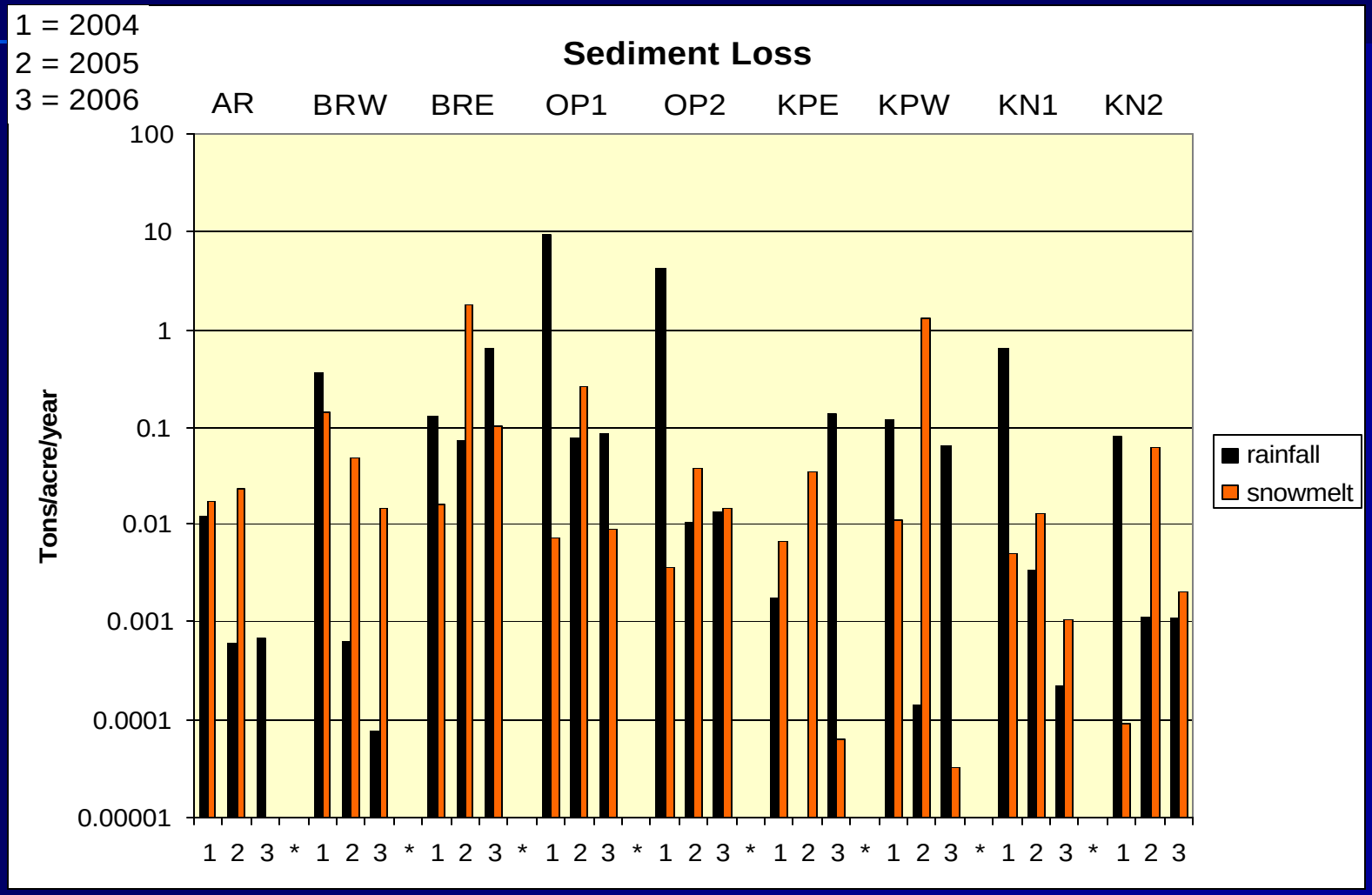
Slope	8	13	7	10		8	8	5	
Texture	SiL	Silt Loam		SaCl		Loam		Clay Loam	
Tillage	No-Till	No-till		Chisel Plow		No-Till		MB/Chisel	
Runoff	8	38	126	119	79	14	188	6	17

Comparing Sediment Losses from Snow-Melt and Storm Events



Filter Strip Effectiveness at Edge of Field

- Filter strip on Field OP1/OP2 (55% sand)

- Filter strip on Field KN1/KN2 (32% clay)

Filter Strip Effectiveness

	Sediment Input (lb/ac)	% captured	TP Input (lb/ac)	% captured	DRP Input (lb/ac)	% captured
Rainfall KN1/KN2	1,041	84	0.040	63	0.03	58
Rainfall OP1/OP2	18,000	52	7.4	60	0.70	20
Snowmelt KN1/KN2	31	-960	0.04	-650	0.01	-820
Snowmelt OP1/OP2	500	79	1.3	68	0.90	72

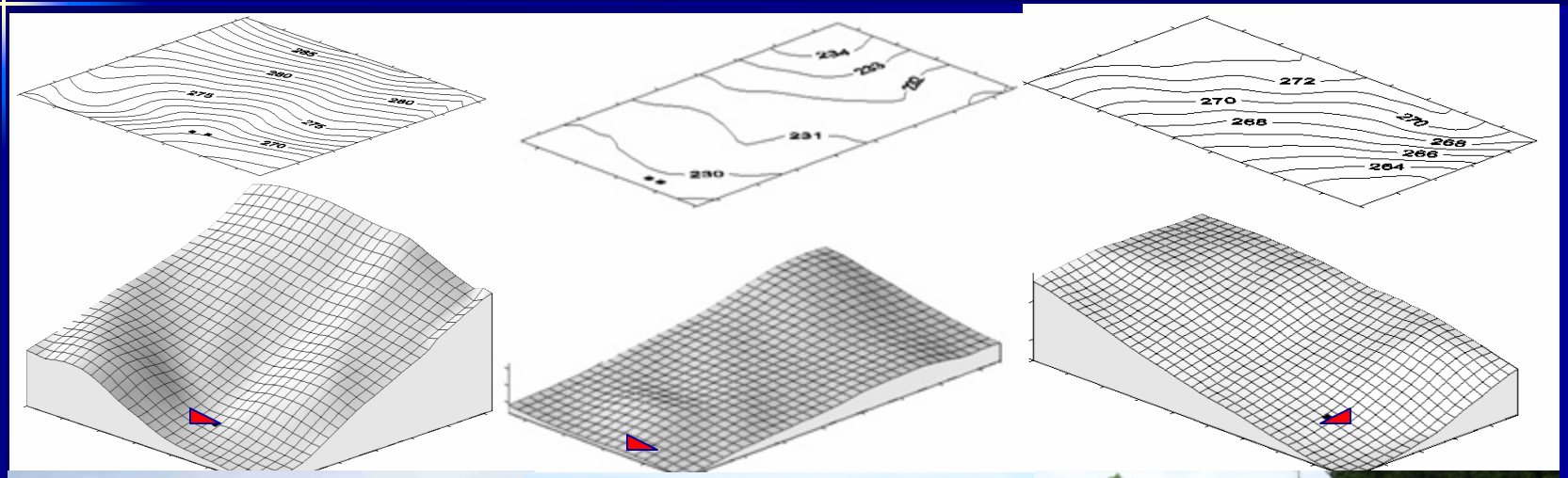
Remove the largest event (8000 lb/ac) and becomes 76%

Research

Modeling

- PALMS
  - Runoff, sediment loss & erosion predictions
  - Phosphorus loss predictions
    - Particulate
    - Dissolved
  - Buffer effectiveness
- Phosphorus leaching sub-model
  - Currently no P leaching models
  - We have begun work on P leaching sub-model based on water soluble P measurements in soil and manure

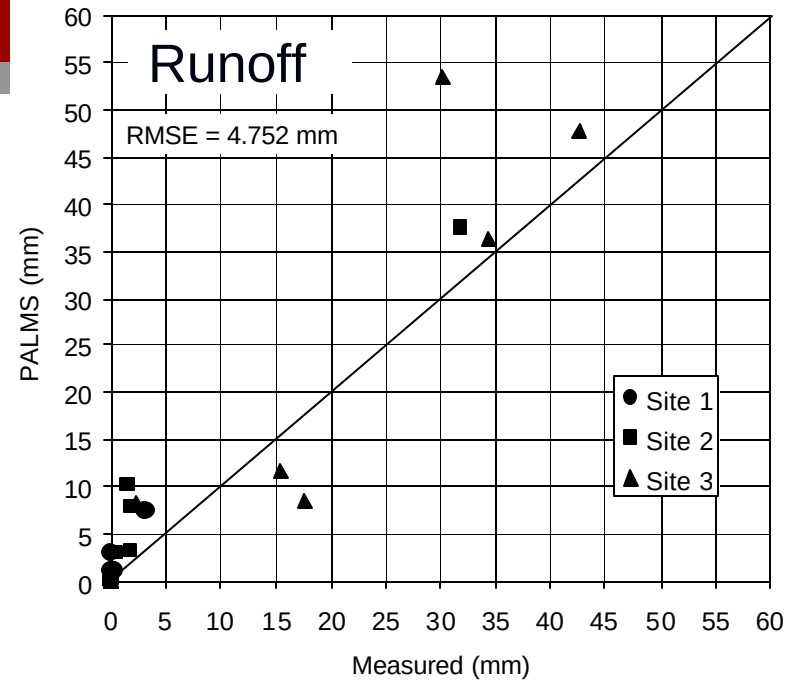
Comparing Measured Runoff and Sediment losses With Model Estimates From PALMS

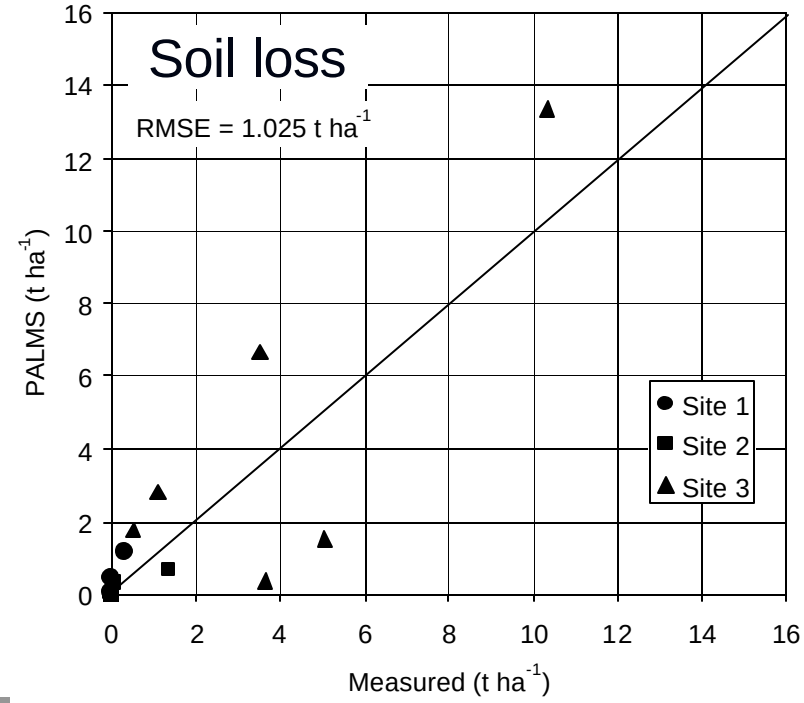


- 46 site events (year 2004)
- Runoff sampled = 183 m^3 (48,300 gal)
- Sediment sampled = 2,447 kg (2.7 tons)

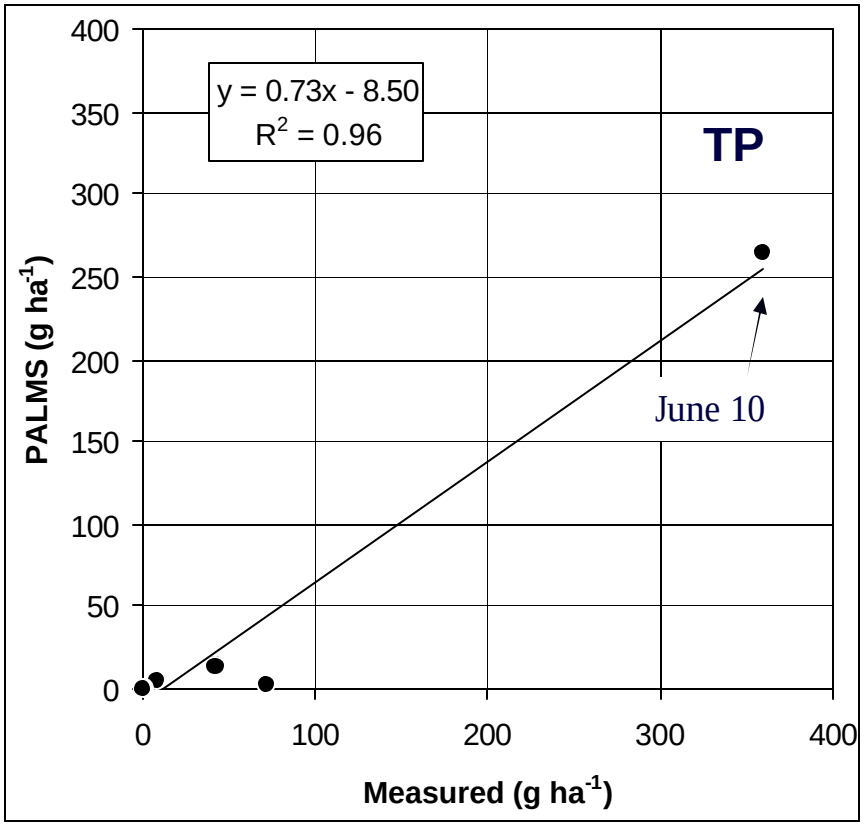
Continuous simulation

	Runoff (mm)	Soil loss (t ha^{-1})
	Site 1	
RMSE	1.11	0.20
R^2	0.83	0.86
	Site 2	
RMSE	4.14	0.24
R^2	0.94	0.84
	Site 3	
RMSE	7.63	1.98
R^2	0.87	0.74
	Entire data set	
RMSE	4.75	1.03
R^2	0.88	0.79

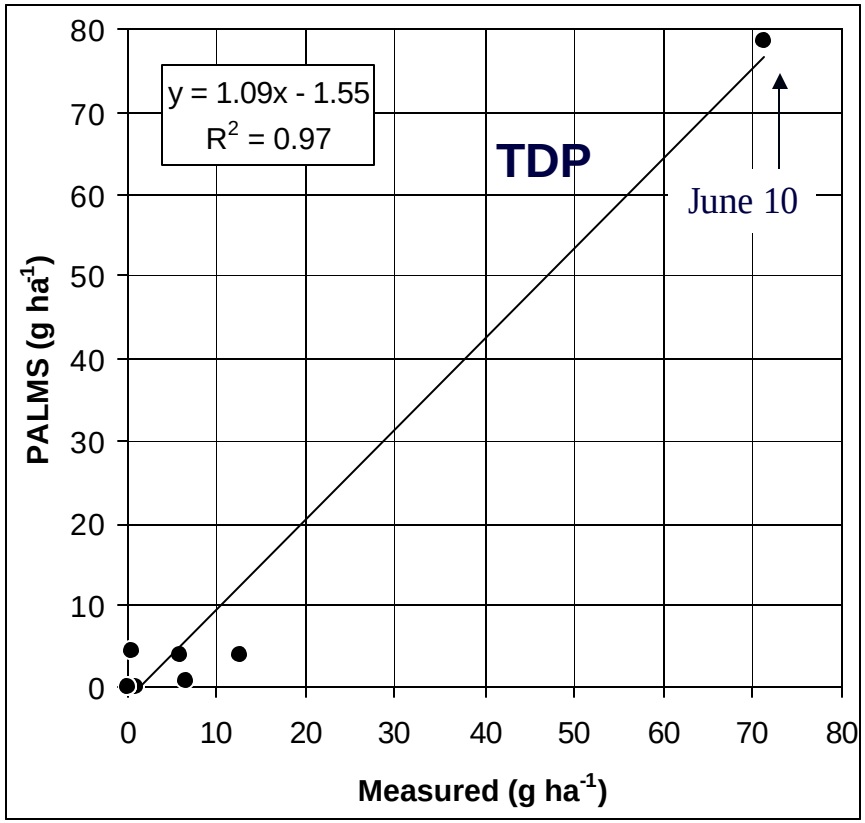




Measured and estimated total phosphorus loss for KN1



Measured and estimated total dissolved phosphorus loss for KN1



Statistics for the total and total dissolved phosphorus losses measured and predicted with PALMS

	TP (g ha^{-1})		TDP (g ha^{-1})	
	RMSE	R^2	RMSE	R^2
Entire set	39.5	0.96	4.2	0.97
w/o June 10 event	26.9	0.31	3.8	0.34

Comparing Measured Sediment and P-Capture of Filter Strip with PALMS Model Estimates

- Preliminary comparison between PALMS predictions of buffer effectiveness and measurements

	% Captured			
	OP Farm		KN Farm	
	PALMS	Measured	PALMS	Measured
Sediment	33	52	58	84
Dissolved P	0	20	72	58
Total P	32	60	41	63

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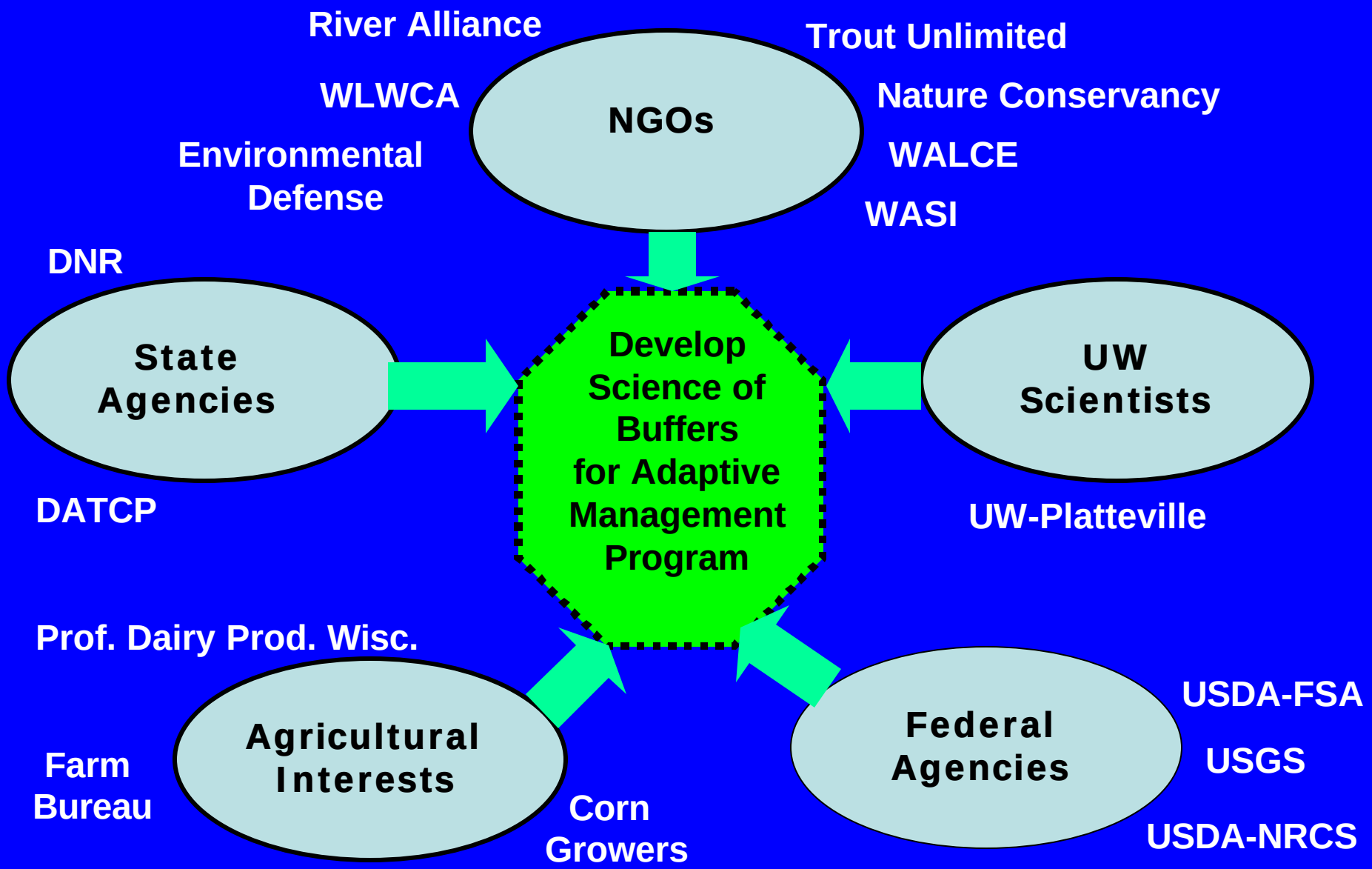
The Wisconsin Buffer Initiative



Wisconsin Buffer Initiative

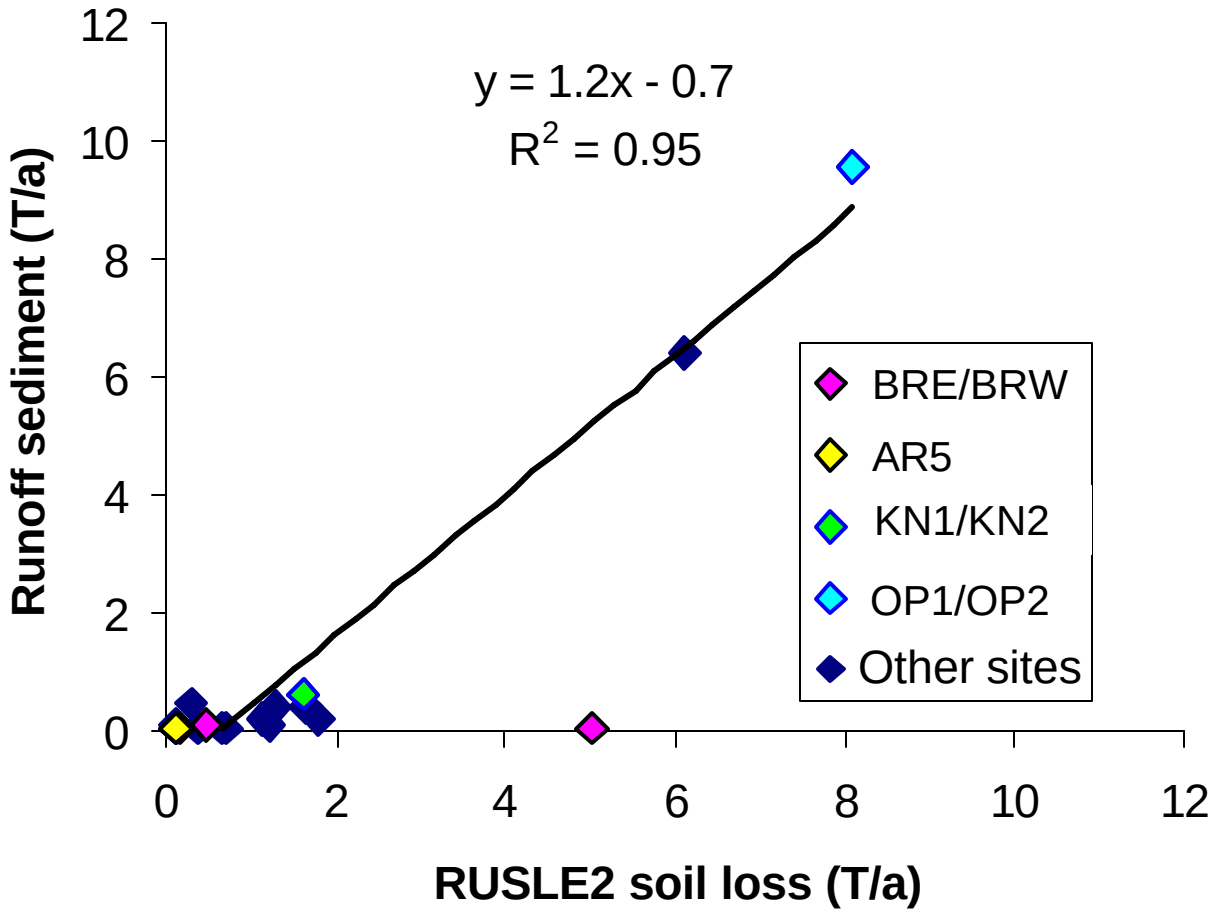
FINDINGS
AND
RECOMMENDATIONS

Made to the
Wisconsin Natural Resources Board
Febuary 22, 2006

CHARGE: **Based on "the best and most complete available science" where are riparian buffers most needed across the diverse Wisconsin landscape in order to enhance or protect water quality in the most effective and efficient manner?**

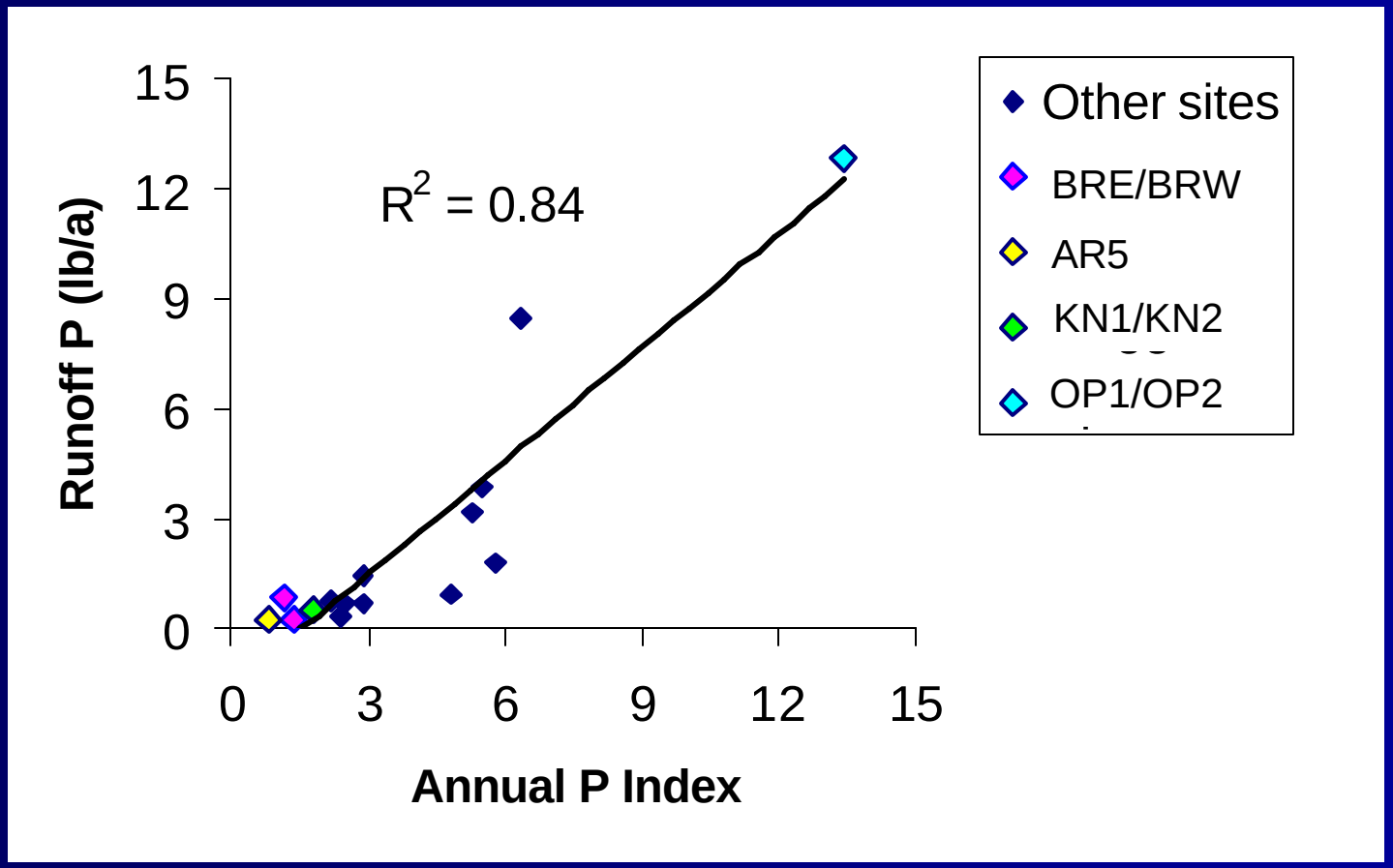
Validation of RUSLE2

Annual Sediment Yields, 2004



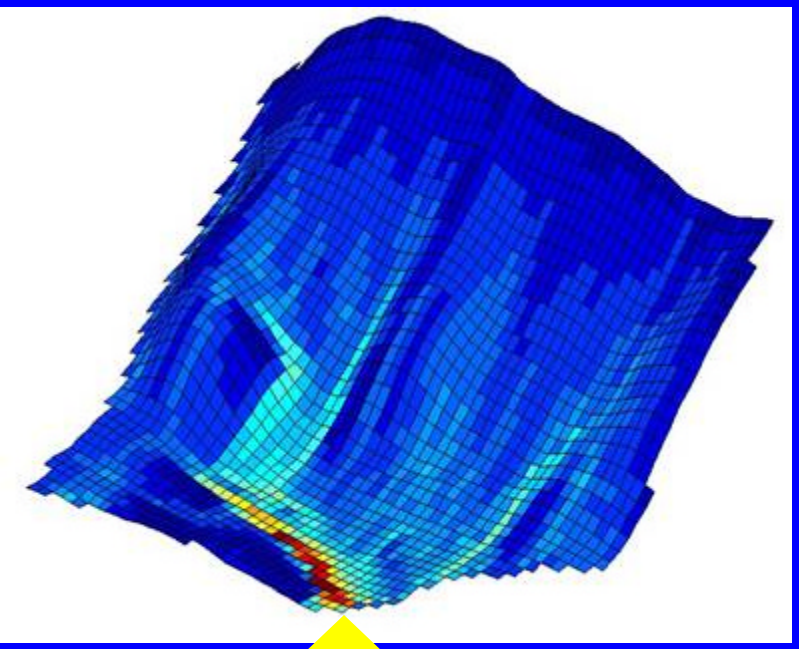
Validation of Wisc. P-Index

P Index and Measured P Yields, 2004



Recommendations to NRCS

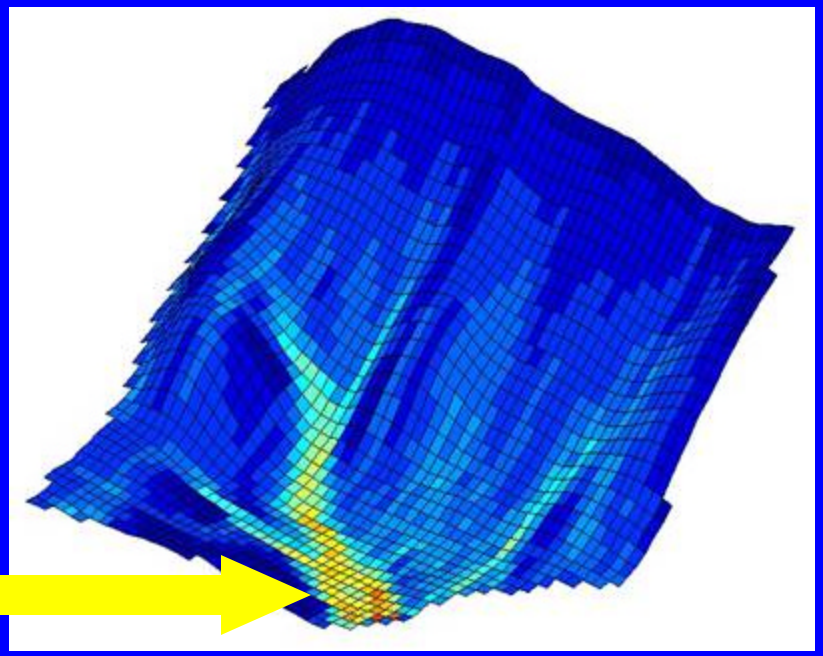
Placement and Configuration of Conservation System Including Buffer



Situations where upland treatments are not sufficient to solve runoff problems

Bare soil runoff is concentrated

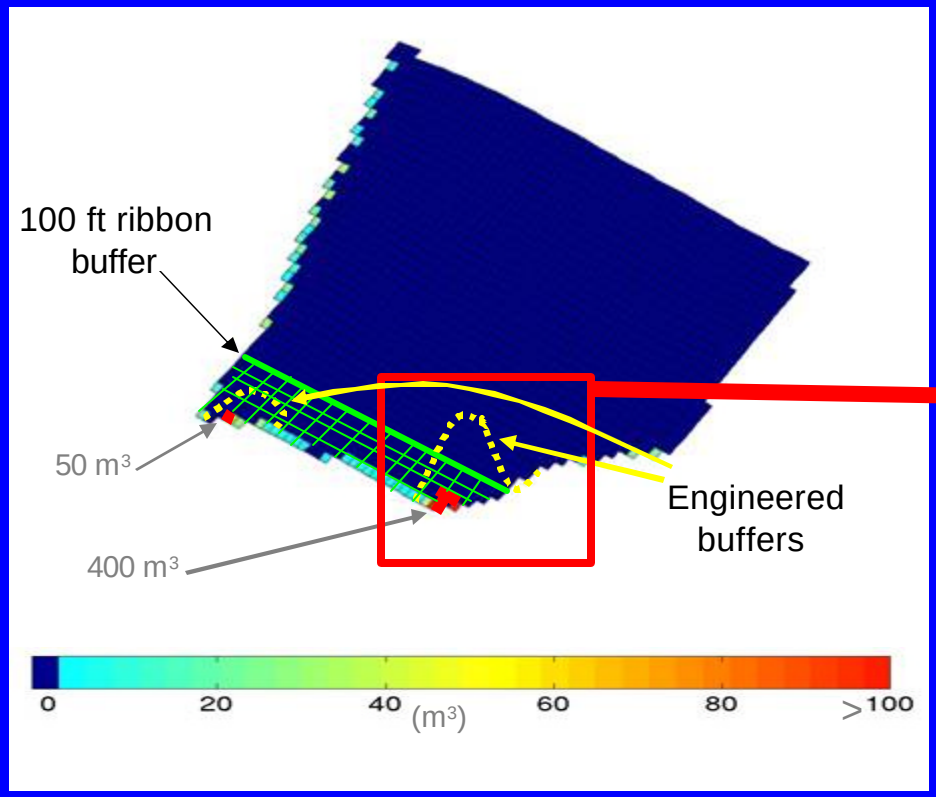
Grassed waterway runoff is more diffuse, but still not sufficient

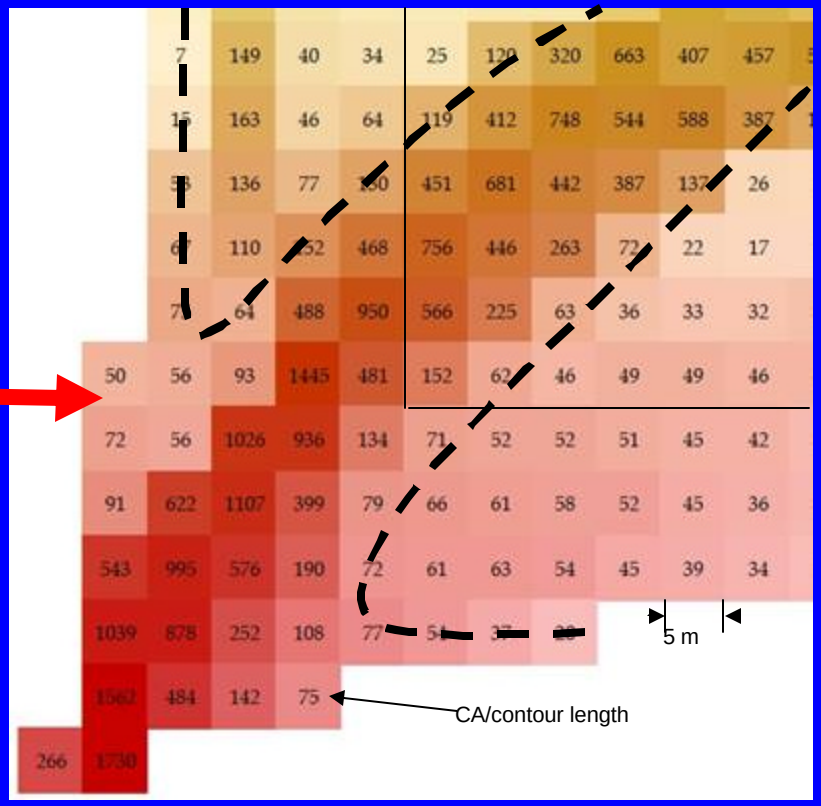


Recommendations to the NRCS

Placement and Configuration of Buffers

- Simple “ribbon” buffers may not capture sediments
- Modify existing design criteria to incorporate **contributing area** into buffer design

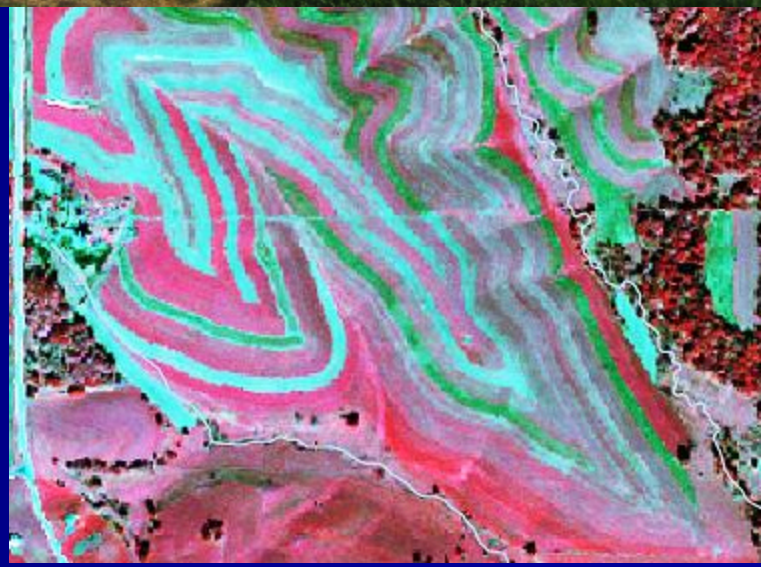




Economics of Using Tillage vs Filter Strips to meet “T” and P-Index

	Farm As is	w/Filter strips	With No-till
Acres Over “T”	88	9	0
Acres in Filter	0	13.5	0
P-Index	10 (>6)	4 (<6)	2
Surplus manure	0	220 (tons)	0

Upland practices more economical



Preliminary Results on P Loss in **Drain Tiles** Compared to P Loss With Runoff

- Drain tiles monitored in 2006 on no-till field of corn
- Approximate TP loss from drain tiles during growing season
  - ~ 2 – 3 lb P/ac/yr
- Measured loss with runoff
  - 0.2 lb P/ac/yr
- **Ten times as much total phosphorus exits by way of the drain tile than with runoff.**

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Major Conclusions

- Leveraging original $548k grant with additional $877k meant working on 5 farms instead of 1 farm, & adding 2 filter strip experiments (469 site-events).
- Fundamental model development (PALMS) was successful and extended results for runoff, sediment and P losses.
- Adding WBI to objectives expanded outreach so results are influencing how Wisconsin regulates P and sediment.
  - Validation of RUSLE2/P-Index helps provide tool for farmers & policy makers.
  - Upland practices more effective than filter strips at reducing P & sediment losses.
  - Recommended method to customize filter strips to reduce area
- Teaching module developed for hands-on experience for graduate students at the power of process models.