Filtering the Facts: What Monitoring on Farm Fields Tells Us About Sediment and P Losses

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Comparing Runoff, Sediment and P-Losses from Snow-Melt and Storm Events

- Outline:
  - Objectives and Strategy of Monitoring & Modeling Subcommittee of WBI
  - Locations of Farms
  - Measurement instrumentation
  - Measurement sites & contributing areas
  - Runoff, sediment & P-loss from selected farm sites
  - Sediment trapping by an edge-of-field buffer
  - Where might this take us
  - Conclusion

The Wisconsin Buffer Initiative

- Objective:

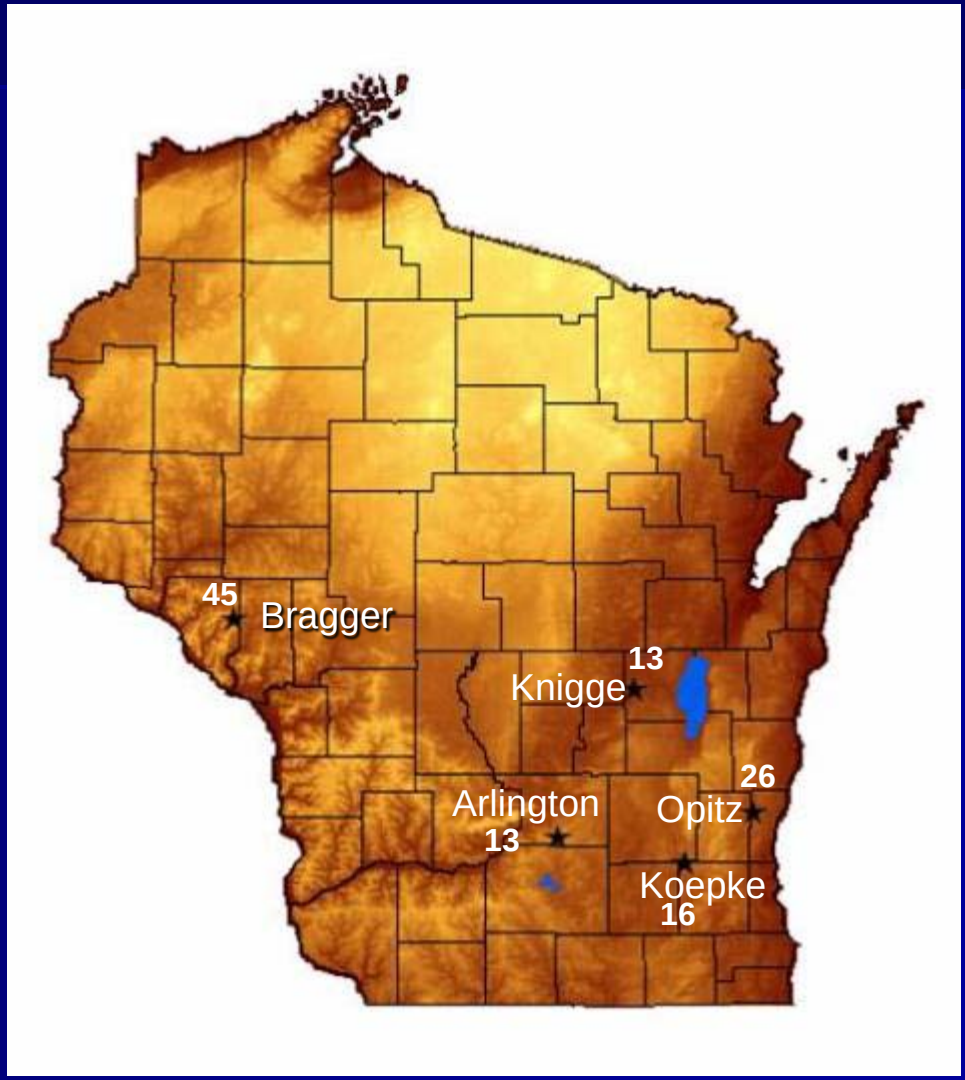
  The Monitoring and Modeling Subcommittee should establish a research program, in coordination with all interested organizations, to support an ADAPTIVE MANAGEMENT approach to implementing buffers to reduce contaminant transport from agricultural land to streams and lakes.

  - Establish field sites and measurement protocols to quantify the loss of P from several typical farm fields
  - Select or create a suitable model to generalize the results from the limited number of measurement sites to diverse landscapes
  - Use the combined results from the model and measurements to create a practical tool for practitioners to use to guide the implementation of buffers in Wisconsin.

Comparing Runoff and Sediment Losses from Snow-Melt and Storm Events

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

> 110 site-collector events of runoff from 5 farms during 6/03 – 7/04

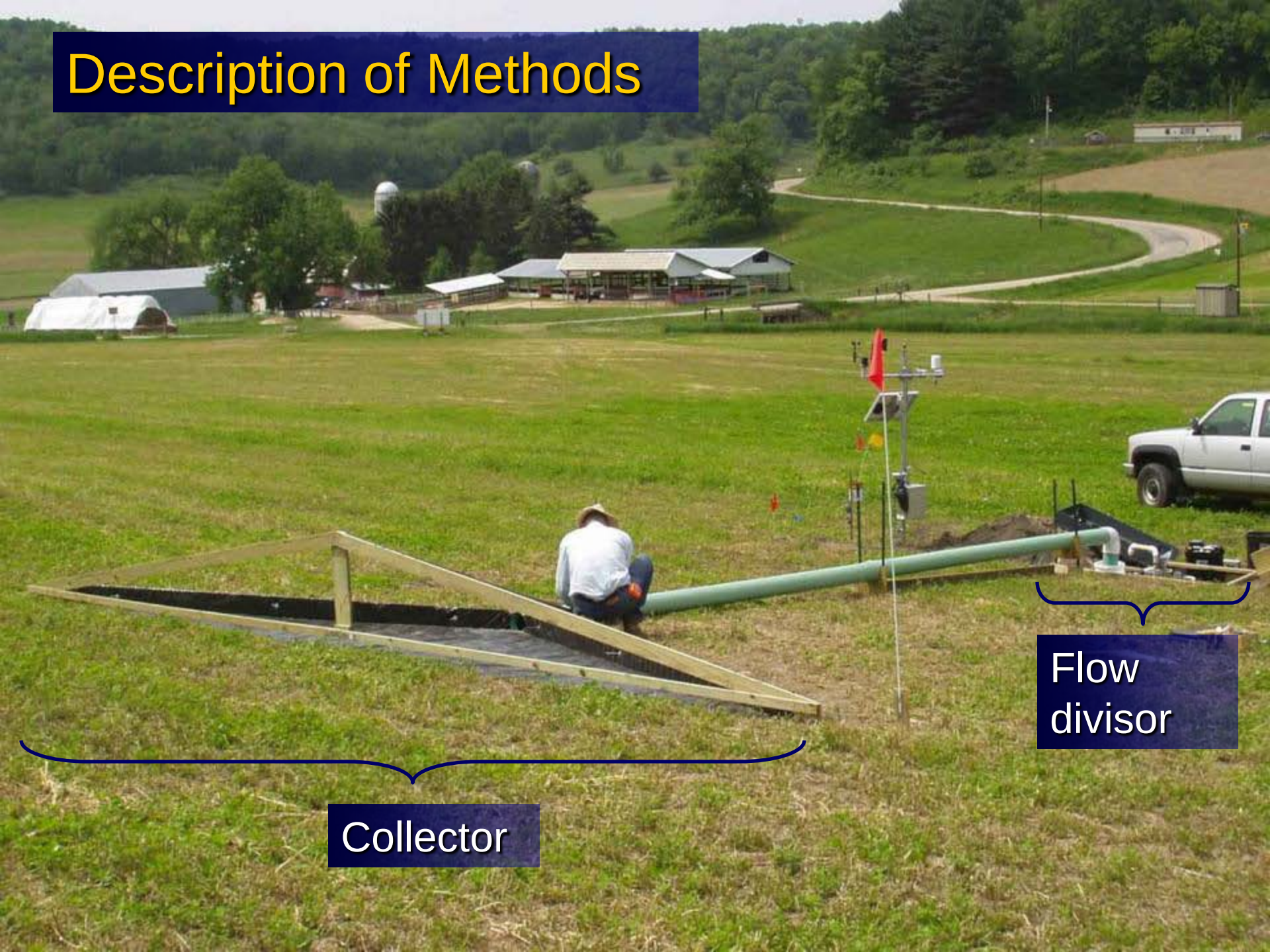


Instrumentation for Measuring Runoff, Sediment and Chemical Losses from Agricultural Fields

- 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 0.5 acre
  - Total runoff/chemical sediment losses per event

- Acknowledgment:
  - Daniel Yoder, University of Tennessee

Description of Methods




Residue/rodent screen
Bragger

Collector

Flow divisor


5
3
1
2
4


knigge


Knigge


12-slots: 5 gal/s
24-slots: 1.7 gal/s
Collected: 35 gal
Sampled: 140,000 gal


Knigge


Knigge


ECHO
Dielectric Anemometer
Decagon Devices, Inc. Pullman WA USA
509-332-2756 www.decagon.com/vaisala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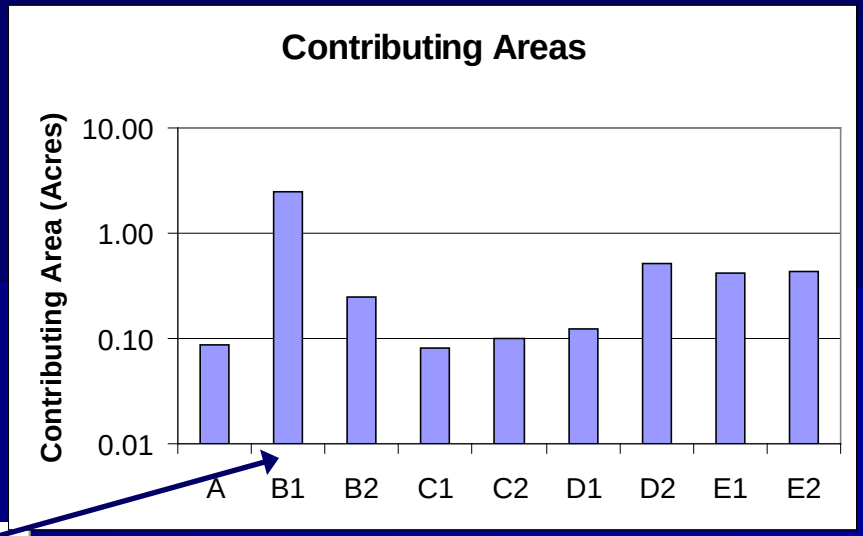
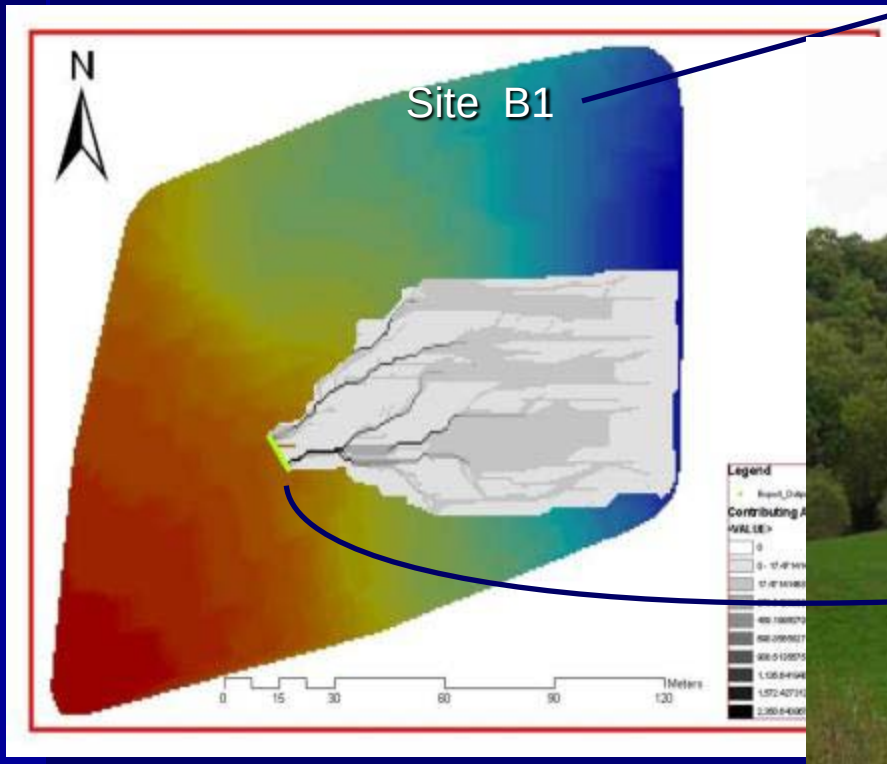
Bragger

Created from accurate DEM using 4 different algorithms.

Contributing area

5 Sites: 0.1 to 2.5 acres





Data collection and analysis

- Total runoff volume:

$$RO = V_1 + 12 \cdot V_2 + 12 \cdot 24 \cdot V_3 + 12 \cdot 24 \cdot 24 \cdot V_4$$

RO: Total runoff volume (m^3)

V1 to V4 (m^3): Volume of water collected in buckets 1 to 4, respectively.

- Sediment and chemical mass:

$$SS = V_1 \cdot C_1 + 12 \cdot V_2 \cdot C_2 + 12 \cdot 24 \cdot V_3 \cdot C_3 + 12 \cdot 24 \cdot 24 \cdot V_4 \cdot C_4$$

SS: Total suspended solid (kg)

C1 to C4 ($kg\ m^{-3}$): Concentration of solid/chemical measured in buckets 1 to 4, respectively.

Cost

Instruments	Buckets with dividor heads	$700
Pump system	Solar panel, sump pump, marine battery	$800
Data collection system	Logger, ech2o probes, transmiter, rain gage, Ipaq	$1,700
Materials	Pipes, elbows, metal stakes, boards, tarp, etc.	$400
Labor	Box, installation	$1,200
Total		$4,800


Bragger Family Dairy
Hildegard, Joe & Noel, and Dan & Kathy
* Wisconsin Discovery Farm Research Site
* 2001 State Conservation Farmer of the Year
* Middle Trempealeau River Watershed
1991 Demonstration Project–Manure Storage System
Sponsored by the Buffalo County Land Conservation Department in partnership with:

Rainfall/runoff event

- 2.7 in, West-Central Wisconsin 6/8/04

	Water volume		Sediment	DRP	TP
	(m^3)	(gal)	(g/L)	(mg/L)	(mg/L)
Bucket 1	0.02	5.0	15	0.6	19.6
Bucket 2	0.02	5.0	10	0.5	8.9
Bucket 3	0.02	5.0	9	0.4	7.4
Bucket 4	0.07	17.7	4	0.3	3.8

Runoff: 124,200 gal
Sediment: 0.83 ton/acre
DRP: 0.14 lb/acre
TP: 1.61 lb/acre


11.07.2003 13:04
Opitz


11 20 2003 09:54
Opitz


11.07.2003 12:36
Opitz

Background Information on Farms

Site	Texture	Slope	OM	Bray P	Total P	Cont. area
		(%)	(%)	(mg/kg)	(mg/kg)	(acre)
Arlington	silt loam	8	4.6	68	647	0.09
Bragger East (alfalfa)	silt loam	13	3.8	62	646	2.49
Bragger West (corn)	silt loam	7	3.9	97	608	0.25
Knigge 1 (before buffer)	clay loam	5	2.9	29	442	0.08
Knigge 2 (buffer)	loam	5	2.8	19	391	0.10
Keopke East (alfalfa)	loam	8	4.3	128	864	0.12
Keopke West (alfalfa)	loam	8	4.3	110	846	0.52
Opitz 1 (before buffer)	sandy clay loam	10	2.8	64	566	0.41
Opitz 2 (buffer)	sandy clay loam	4	3.8	89	608	0.43

Background Information on Farms

	Snowmelt		Rainfall		Total	Cont. area
Site	Events	Volume (gal)	Events	Volume (gal)	Events	(acre)
Arlington	4	3,032	9	92	13	0.09
Bragger East (alfalfa)	9	9,735	11	124,845	20	2.49
Bragger West (corn)	12	15,395	13	1,451	25	0.25
Knigge 1 (before buffer)	1	156	5	3,250	6	0.08
Knigge 2 (buffer)	1	6	6	3,342	7	0.10
Keopke East (alfalfa)	4	731	2	71	6	0.12
Keopke West (alfalfa)	4	1,578	6	1,677	10	0.52
Opitz 1 (before buffer)	2	1,967	11	68,035	13	0.41
Opitz 2 (buffer)	2	301	11	63,478	13	0.43
Total	39	32,901	74	266,241	113	

Comparing Runoff and Sediment Losses from Snow-Melt and Storm Events

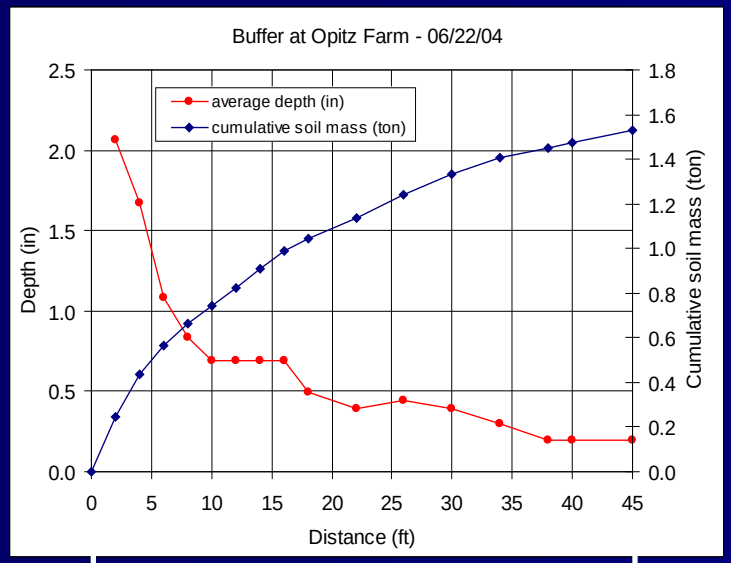
- Comparison of Measurements with RUSLE2:
  - "T" for Opitz soil is 5 tons/ac/yr
  - Measured soil loss is 5.5 tons/ac/yr
  - RUSLE2 estimate of erosion is 13 tons/ac/yr
  - Annual average erosivity (R-value) for E1 is 120
  - Annual erosivity for runoff year is 116 (average erosive year)
  - Worst case scenario for measurements because ½ of annual R-value came in 1 month after tilling the soil for planting
  - For bare soil through the year, RUSLE2 ~ 22 tons/ac/yr

Sediment and P Trapped by an Edge-of-Field Buffer

Farm	**Rainfall**	**Runoff**	**Sediment**		**DRP**		**TP**	
	(in)	(gal)	Input (lb)	Captured (%)	Input (lb)	Captured (%)	Input (lb)	Captured (%)
Opitz								
Rainfall (10 events)								
total	**17**	**67,989**	**4,534**	**57**	**0.35**	**48**	**9.74**	**54**
average	2	6,799	453	74	0.04	34	0.97	72
maximum	3	23,292	2,162	100	0.14	100	3.90	100
minimum	1	7	0	2	0.00	-179	0.00	2
Snowmelt (2 events)								
total		**1,965**	**4**	**94**	**0.02**	**90**	**0.01**	**85**
average		983	2	97	0.01	95	0.01	92
maximum		1,885	3	100	0.02	100	0.01	100
minimum		80	0	94	0.00	90	0.00	84

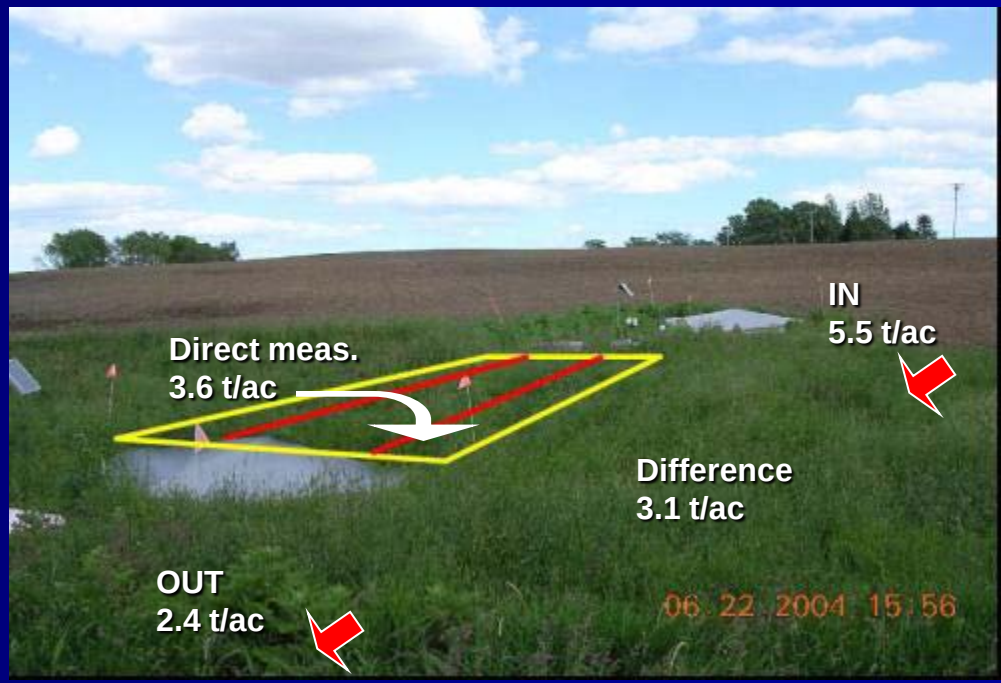
Comparing Runoff and Sediment Losses from Snow-Melt and Storm Events

- Sediment trapping by edge-of-field buffers on Field E (55% sand)
  - Checked measurement system by comparing trapped sediment with measurements before and after buffer



Buffer start

Buffer end



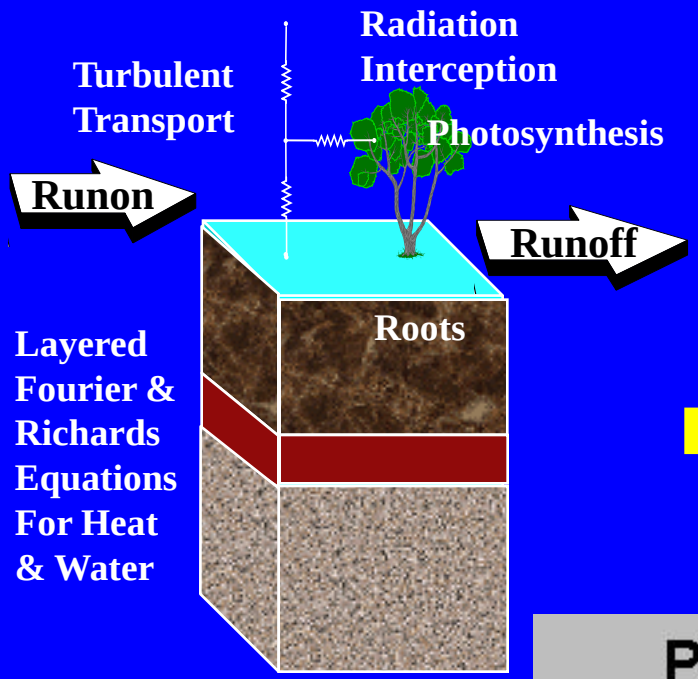
Comparing Runoff and Sediment Losses from Snow-Melt and Storm Events - Summary

- Sediment trapping by edge-of-field buffers on Field E (55% sand)
  - Sediment trapping measured over 45 ft. of buffer of tall grasses
  - 13% of runoff water infiltrated into buffer
  - 57% of storm sediment and 97% of snowmelt sediment trapped by buffer
  - 50% of storm P & 90% of snowmelt P trapped by buffer

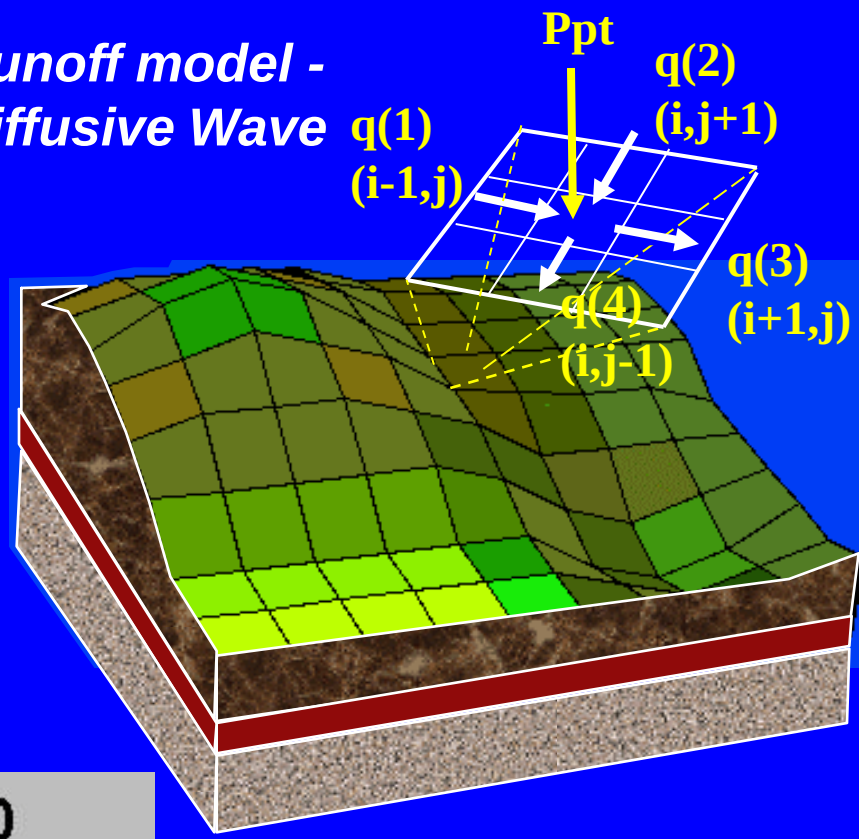
PALMS (Precision Agricultural-Landscape Modeling System)

Combine models of vertical transport in soil and canopy with overland flow models

Soil/canopy model



Runoff model - Diffusive Wave

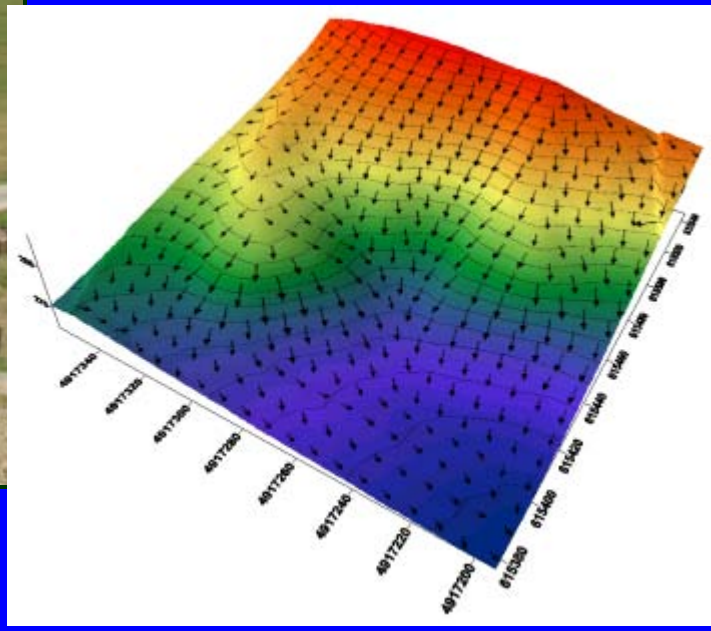


IBIS

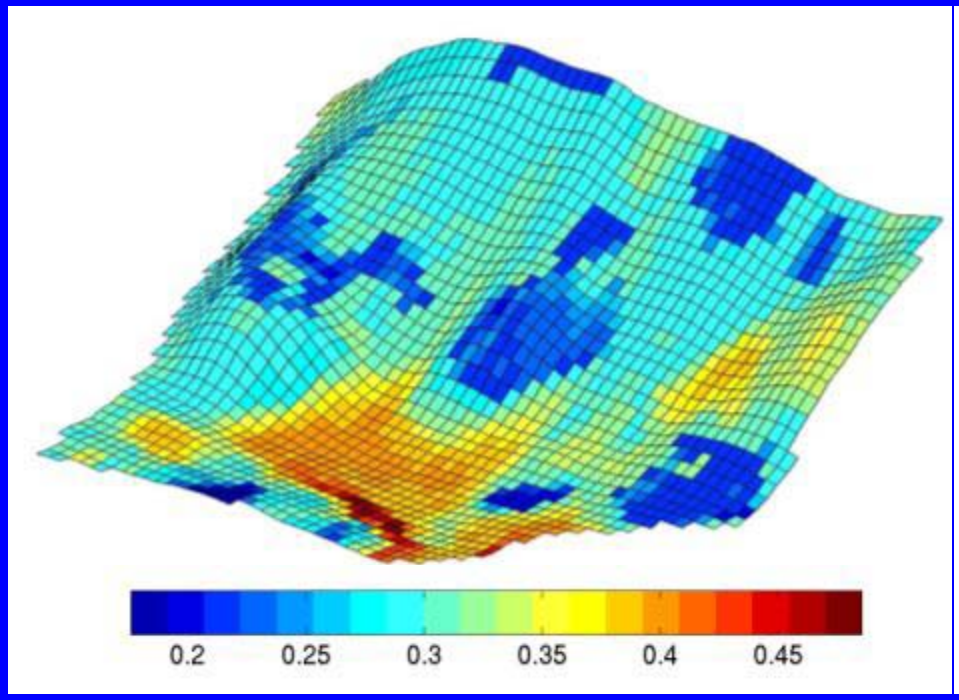
User Interface

Application to the Bragger Farm

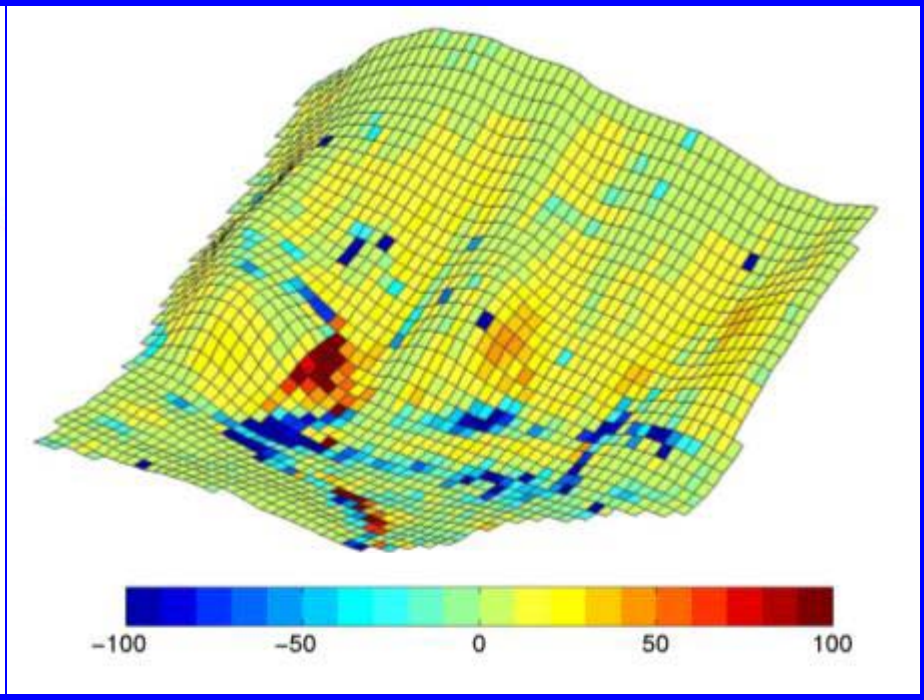
6.8 acre
14% slope
Silt loam
3.5 in
(Actual rain event)



PALMS Simulation on Bragger Farm with 90 mm of Rain



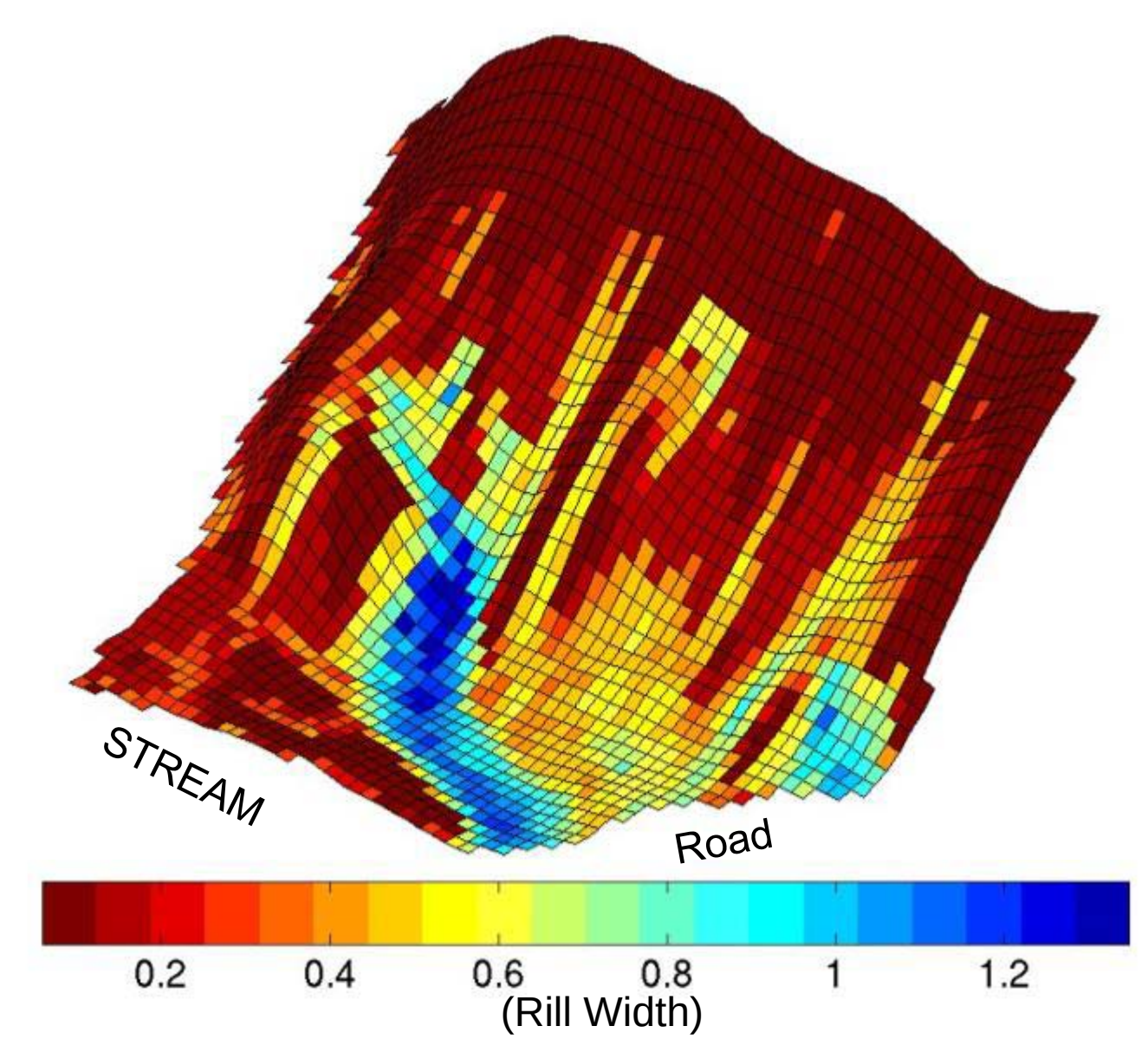
Interrill erosion
(kg/m^2)



Net total erosion
(kg/m^2)

10 kg/m^2 = 40 t/ac

Where Would You Put the Buffer?



Conclusions from Measurements

- Sediment loss is much more variable than runoff over the 5 farm fields
- Estimates of erosion from RUSLE2 are higher than measured soil losses (2 to 10 times)
  - Reason may be the difference between real fields and a model based on measurements from small unit plots
- Buffer effectiveness depends on many factors and varied from 50 90% for sediment, DRP and TP
- Sediment concentrations (mg/kg) and P losses (lb/ac) in snowmelt were an order of magnitude smaller that storm runoff
- P loss from 0.01 to 10 lb/ac/yr were measured