# Measurements of Runoff, Sediment, and Phosphorus Losses From Several Discovery Farm Fields

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# Outline

- Background
- Study Objectives
- Sites
- Instrumentation
- Results from First Year
- Conclusions
- Future Work

# Background

- Water quality important
- Agricultural practices produce sediment and P loss to surface waters
- Midwest has lots of ag land
- Past erosion research focused on plot scale
- Difficult to scale plot research to entire fields

# Study Objectives

- Measure runoff, sediment loss, P loss from working farm fields in WI *
- Calibrate a precision-scale model to observations
- Calibrate (or translate) RUSLE2, P Index to observations by way of precision-scale model
- Use modeling tools to make management changes to mitigate sediment, P losses

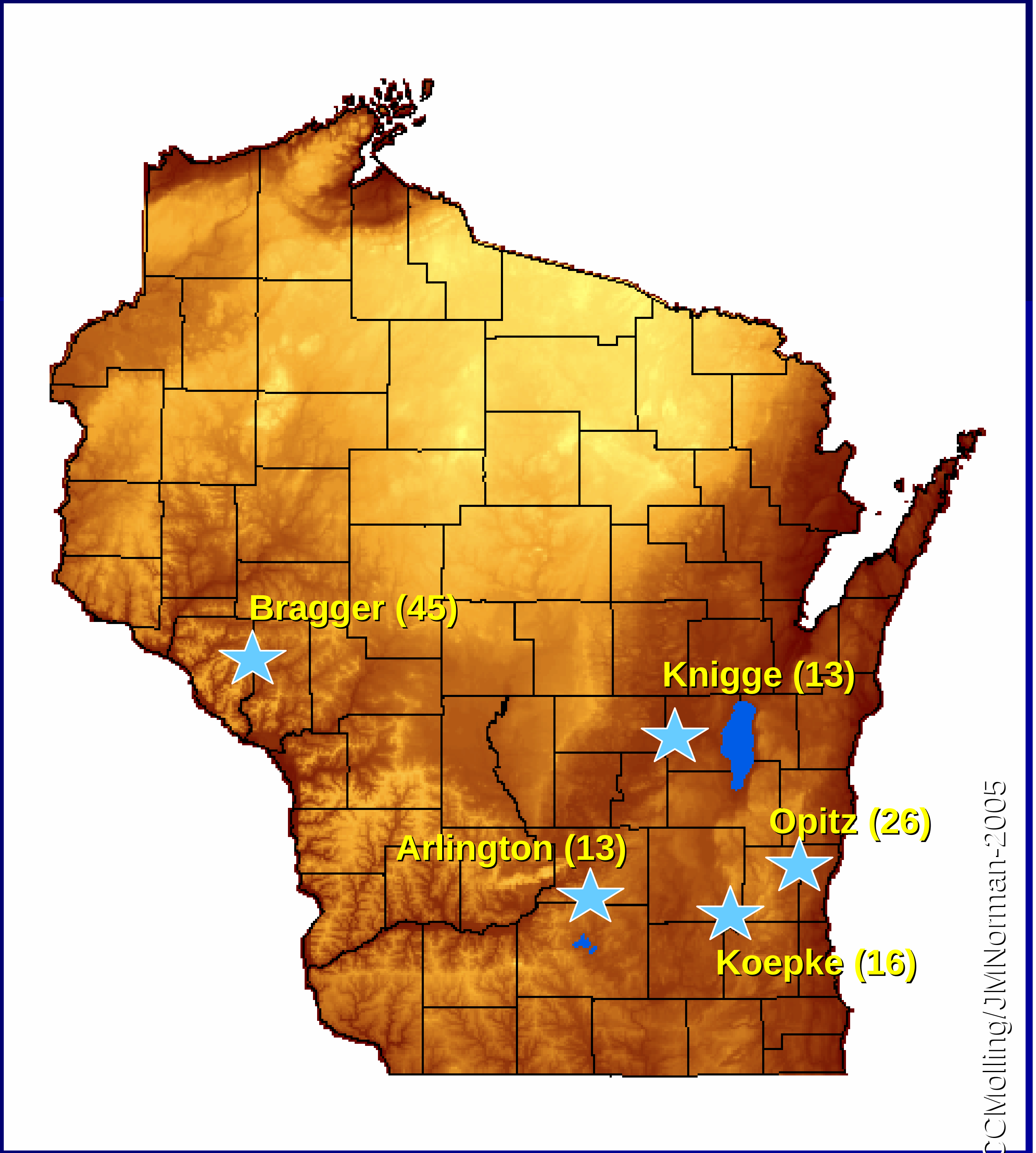
# Sites

Five Farms

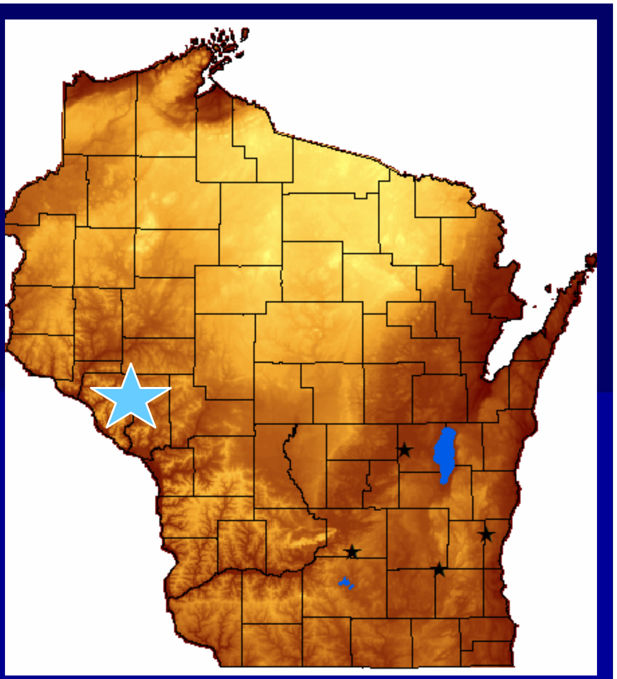
Wisconsin Discovery Farms Program:
Bragger
Knigge
Kopeke
Opitz

Arlington Agricultural Research Farm

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

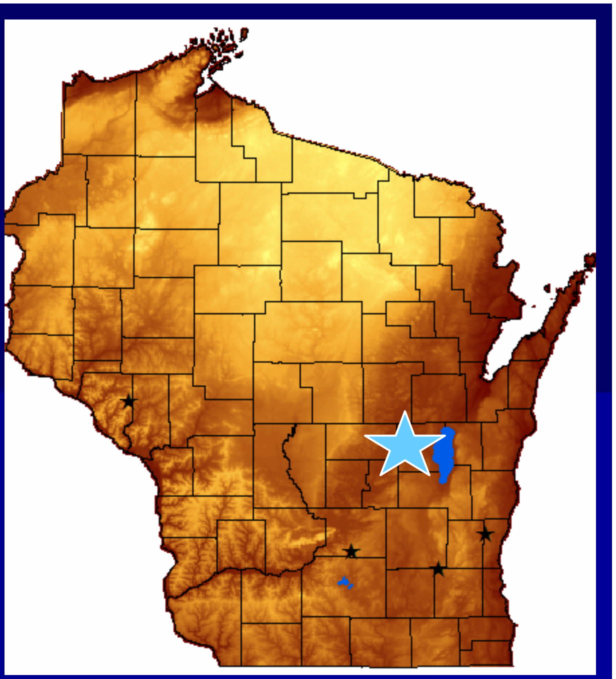


# Bragger



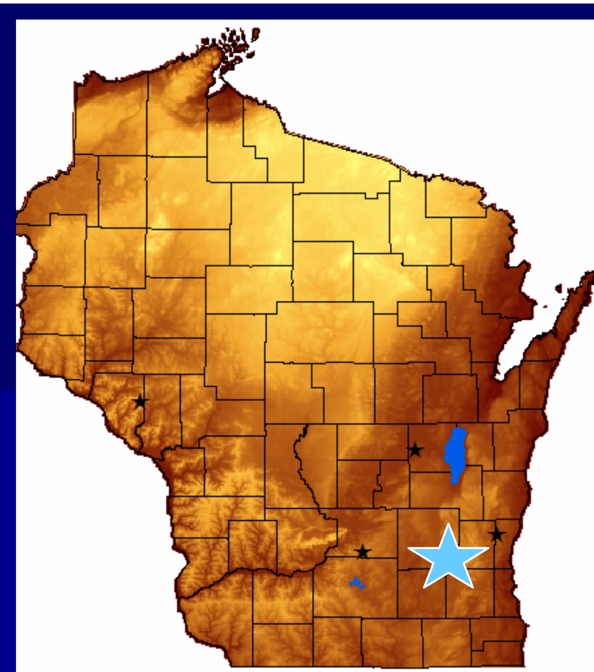
- Soil: silt loam
- Slope: 7%, 13%
- Bray P: 62, 97

# Knigge



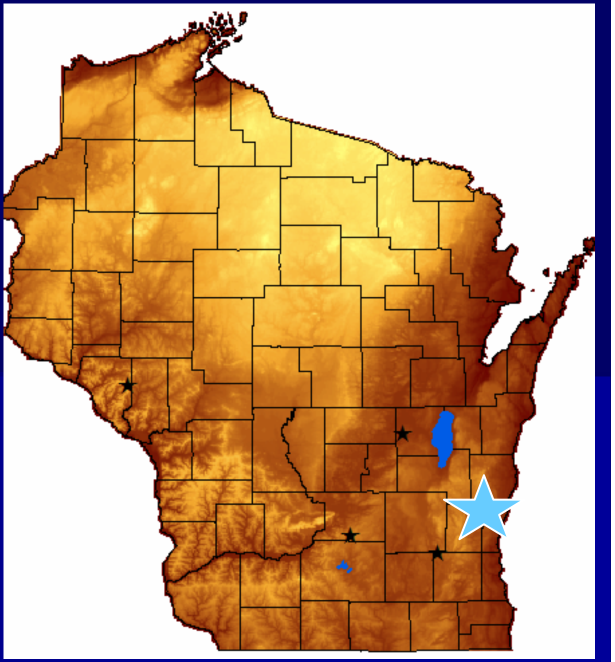
- Soil: clay loam
- Slope: 5%
- Bray P: 29, 19

# Koepke



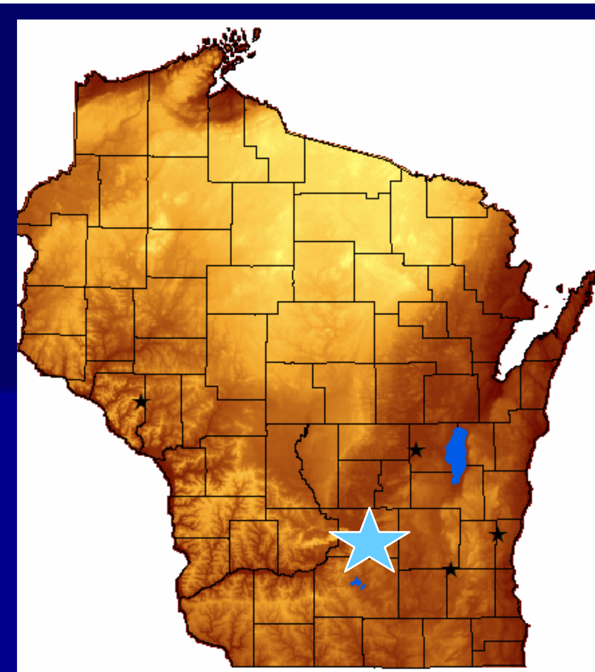
- Soil: loam
- Slope: 8%
- Bray P: 110, 128

# Opitz




- Soil: sandy clay loam
- Slope: 10%, 4%
- Bray P: 64, 89

# Arlington



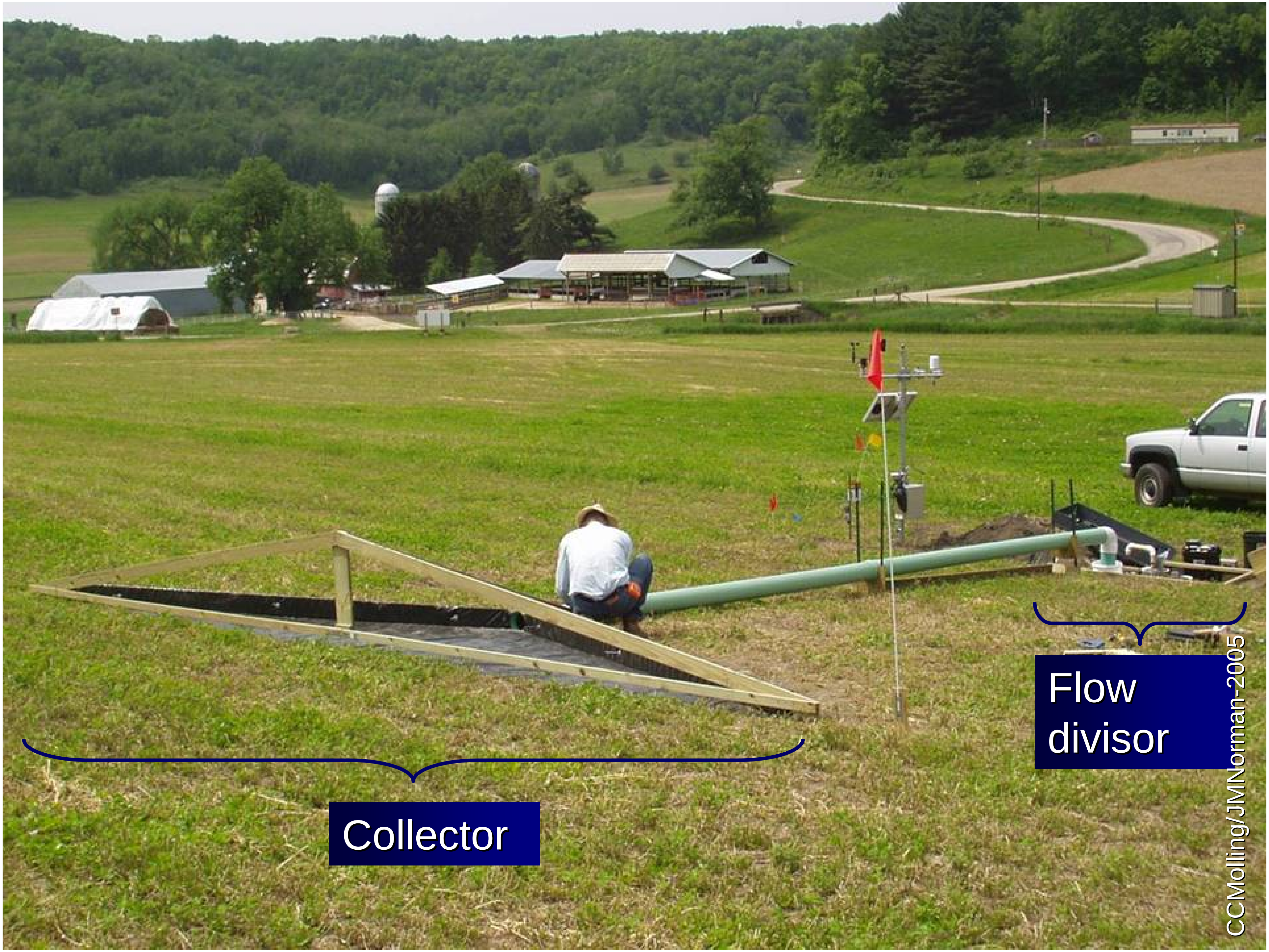


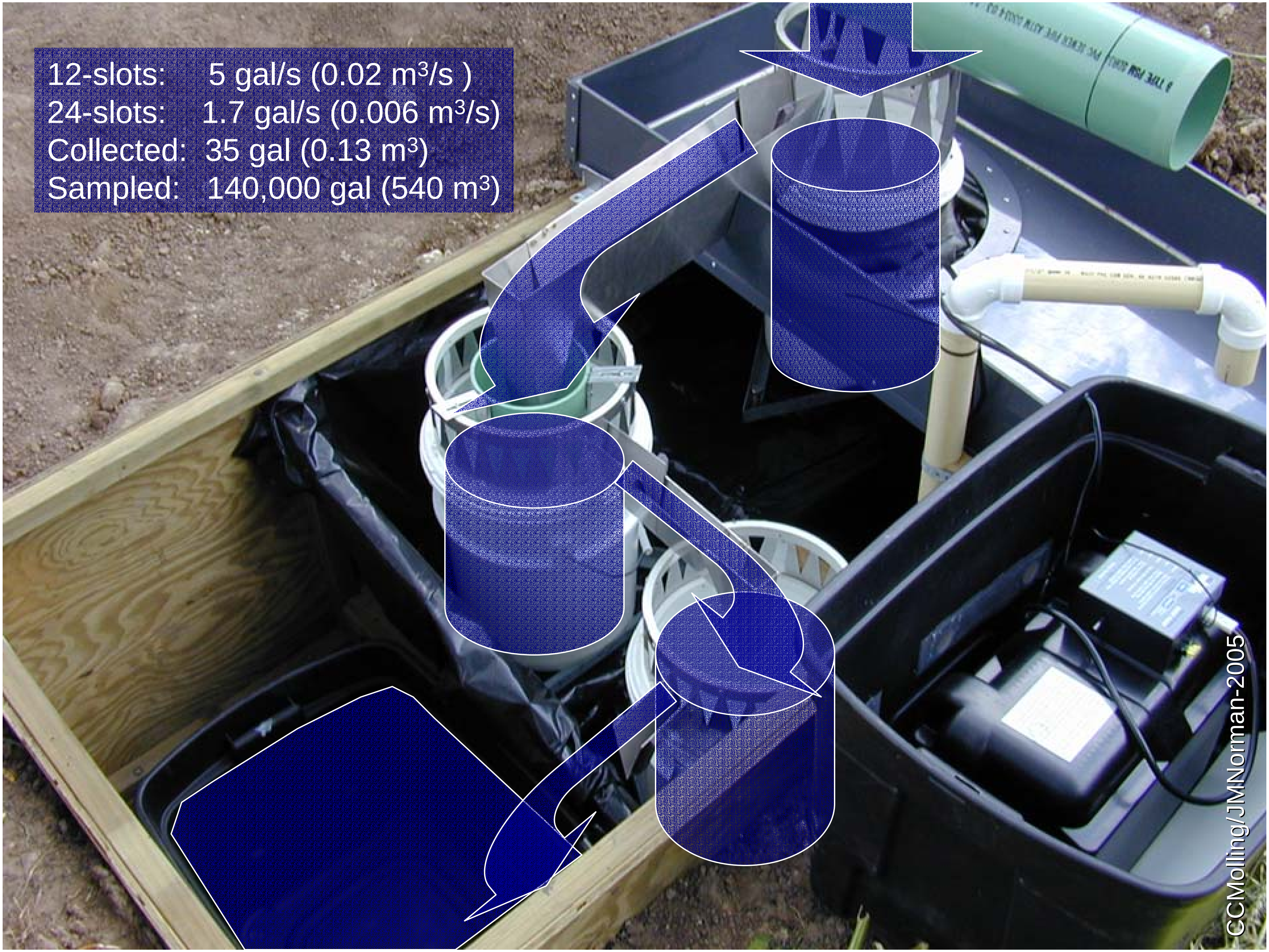
- Soil: silt loam
- Slope: 8%
- Bray P: 68

# Instrumentation

- 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 (0.2 ha)
  - Total runoff/chemical sediment losses per event

- Acknowledgment:
  - Daniel Yoder, University of Tennessee


Flow divisor
Collector
CCMolling/JMNorman-2005


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 $m^3$)
CCMolling/JMNorman-2005

# 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:

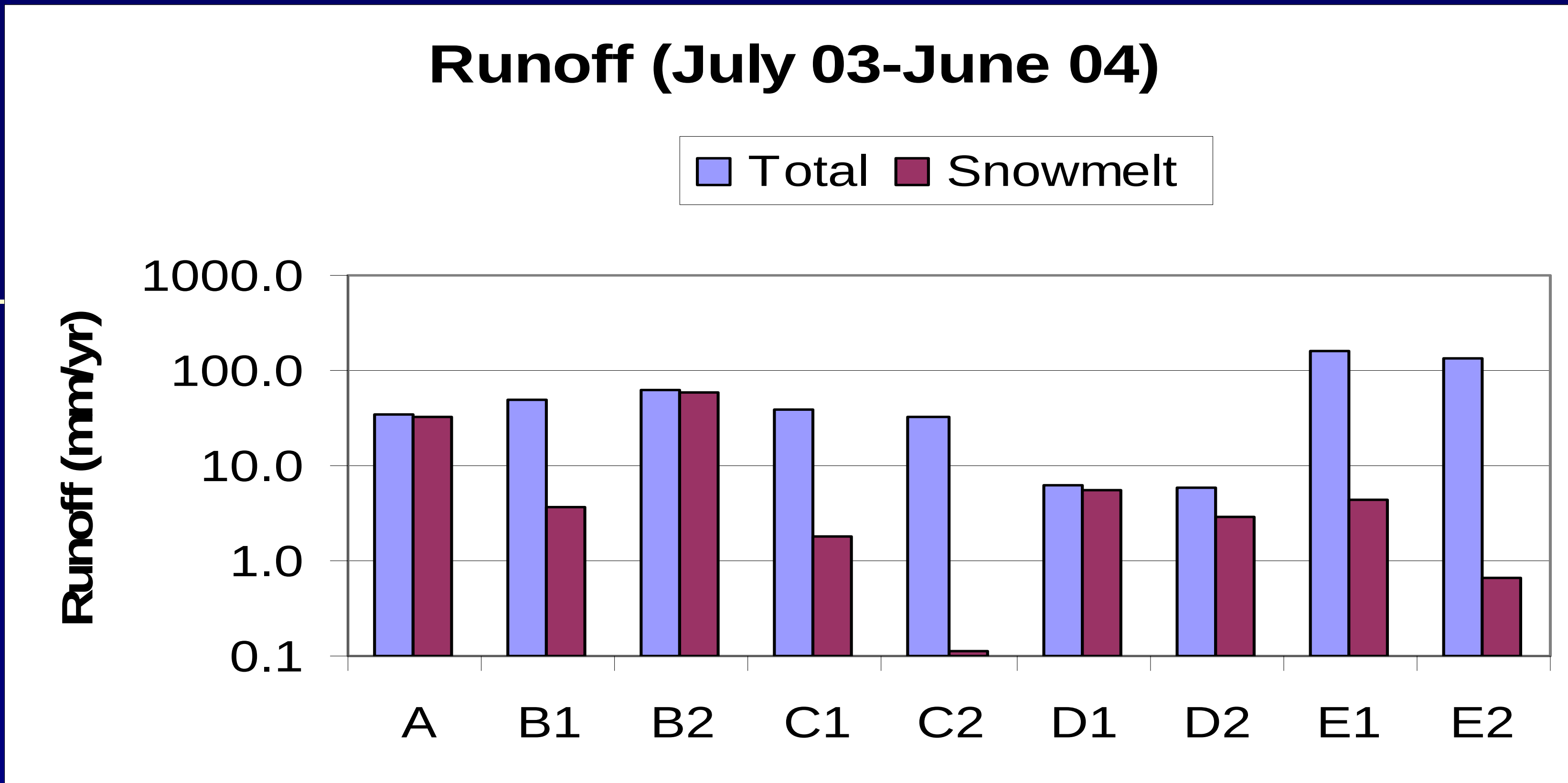
$$SS = V_1 \cdot C_1 + 12 \cdot V_2 \cdot C_2 + 12 \cdot 24 \cdot V_3 \cdot C_3 + 12 \cdot 24 \cdot 24 \cdot V_4 \cdot C_4$$

SS: Total suspended solid (kg)

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

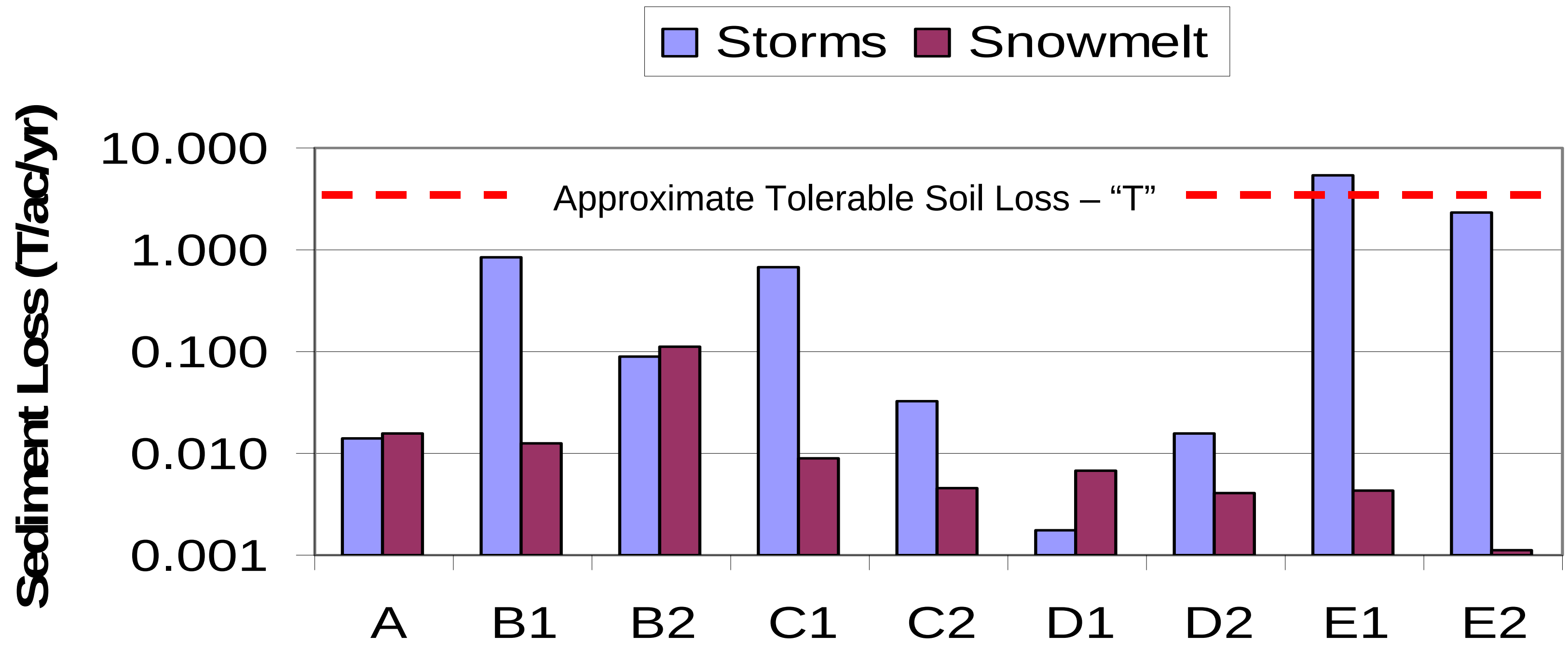
# Results

- Runoff
- Sediment Loss
- Phosphorus Loss




| | | | | | Buffer | | | | Buffer |
|---|---|---|---|---|---|---|---|---|---|
| Rain (mm) | 564 | 907 | | 1034 | | 988 | | 970 | |
| Slope | 8 | 13 | 7 | 5 | | 8 | 8 | 10 | |
| Texture | SiL | Silt Loam | | Clay Loam | | Loam | | SaCL | |
| Tillage | No Till | No Till | | MB Plow | | No Till | | Chisel | |
| Runoff | 34 | 51 | 64 | 40 | 32 | 6 | 6 | 158 | 138 |

# Sediment Loss (July 03-June 04)




| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Buffer | | | | Buffer |
| Rain (mm) | 564 | 907 | | 1034 | | 988 | | 970 | |
| Slope | 8 | 13 | 7 | 5 | | 8 | 8 | 10 | |
| Texture | SiL | Silt Loam | | Clay Loam | | Loam | | SaCL | |
| Tillage | No Till | No Till | | MB Plow | | No Till | | Chisel | |
| Runoff | 34 | 51 | 64 | 40 | 32 | 6 | 6 | 158 | 138 |

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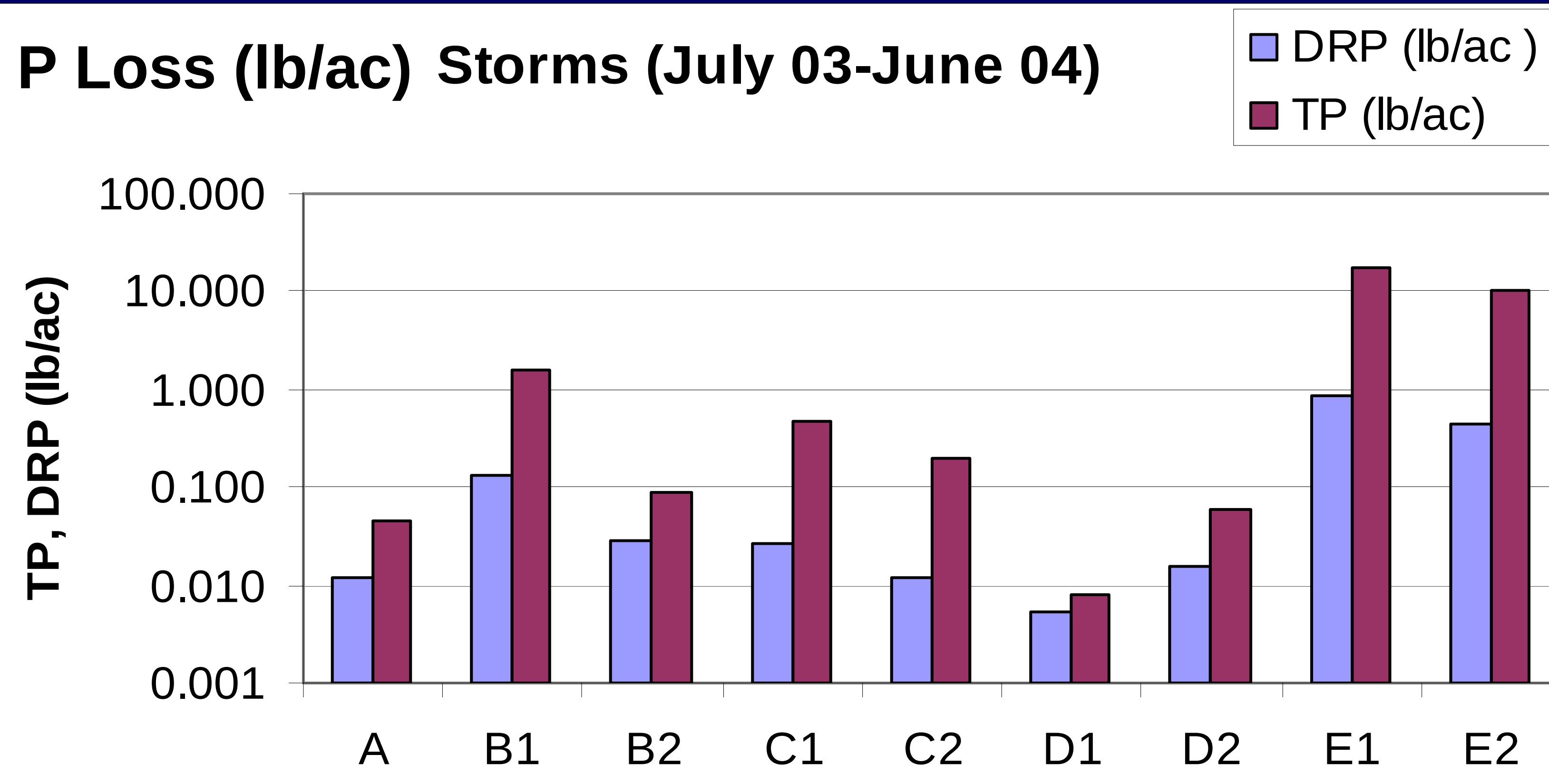
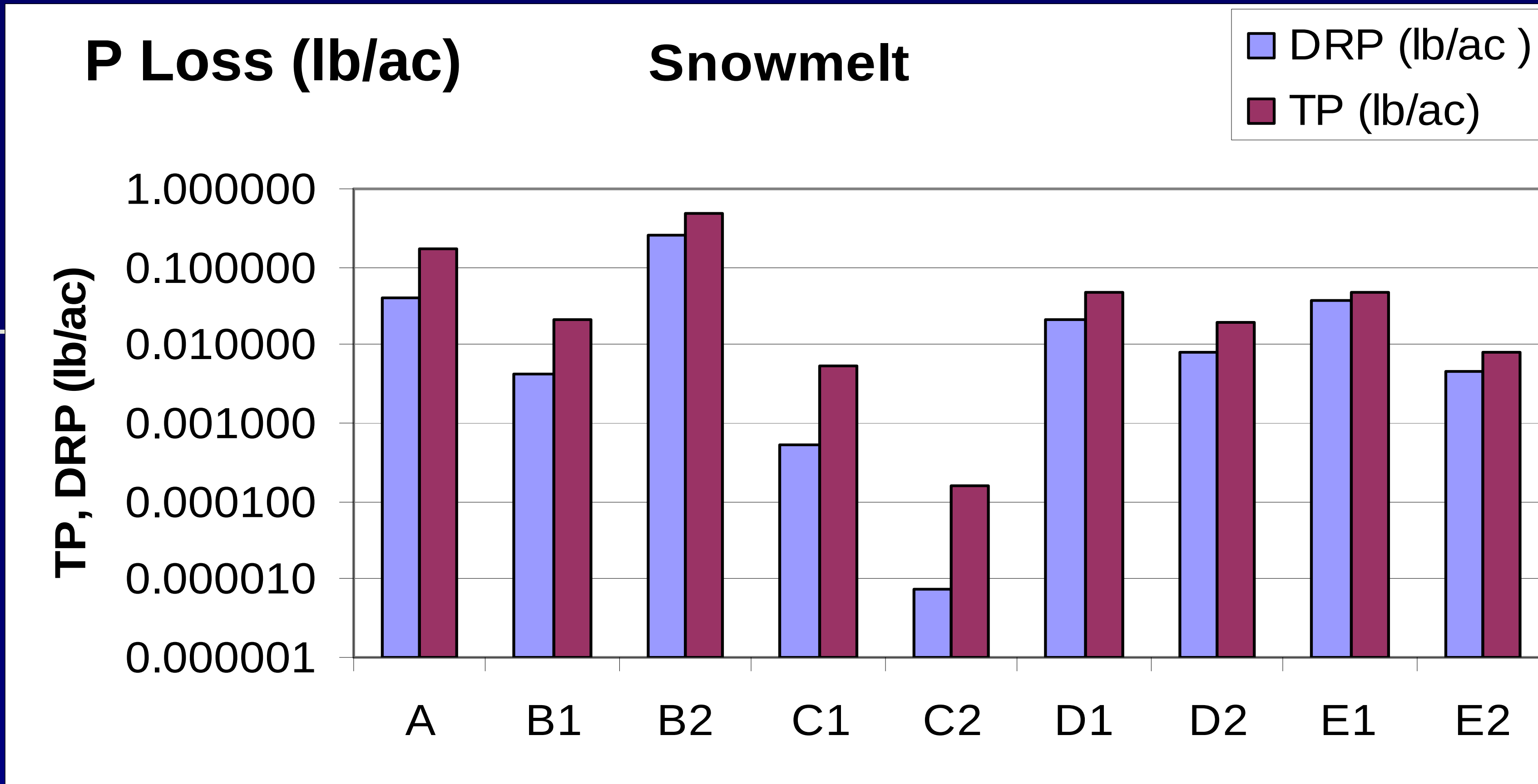
# P Loss (lb/ac) Storms (July 03-June 04)




| | A | B1 | B2 | C1 | C2 | D1 | D2 | E1 | E2 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Buffer | | | | Buffer | |
| Rain (mm) | 900 | 907 | | 1034 | | 988 | | 970 | |
| Slope | 8 | 13 | 7 | 5 | | 8 | 8 | 10 | |
| Texture | SiL | Silt Loam | | Clay Loam | | Loam | | SaCL | |
| Bray P | 68 | 62 | 97 | 29 | | 128 | 111 | 64 | |
| Runoff | 34 | 51 | 64 | 40 | 32 | 6 | 6 | 158 | 138 |

CCMolling/JMNorman-2005




| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Buffer | | | | Buffer |
| Rain (mm) | 900 | 907 | | 1034 | | 988 | | 970 | |
| Slope | 8 | 13 | 7 | 5 | | 8 | 8 | 10 | |
| Texture | SiL | Silt Loam | | Clay Loam | | Loam | | SaCL | |
| Bray P | 68 | 62 | 97 | 29 | | 128 | 111 | 64 | |
| Runoff | 34 | 51 | 64 | 40 | 32 | 6 | 6 | 158 | 138 |

# Buffer Effectiveness: Field E

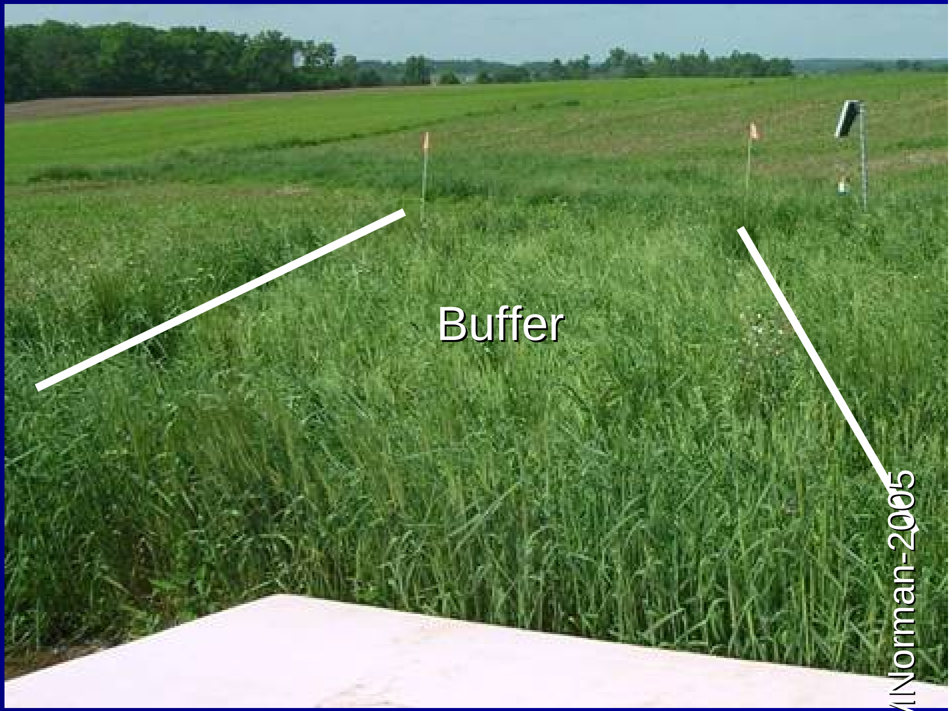
- Sediment trapping by edge-of-field buffers on Field E (55% sand)
  - 14 m buffer of tall grasses
  - 13% of runoff water infiltrated into buffer
  - 57% of storm sediment and 97% of snowmelt sediment trapped by buffer
  - 50% of storm P & 90% of snowmelt P trapped by buffer


Buffer Field E

CCMolling/JMNorman-2005

# Buffer Effectiveness: Field C

- Sediment trapping by edge-of-field buffers on Field C (35% clay)
  - 14 m buffer of tall grasses
  - 20% of runoff water infiltrated into buffer
  - 94% of storm sediment and 97% of snowmelt sediment trapped by buffer
  - 50% of storm P and 95% of snowmelt P trapped by buffer




Buffer Field C

CCMolling/JMNorman-2005

# Buffer Effectiveness

- Sediment trapping by edge-of-field buffers on Field C (35% clay)
  - 94% of sediment trapped by buffer
  - Greater trapping efficiency than Field E
    - Lower buffer slope (2% at field C vs 4% at field E)
    - Slope of field is less (5% in field C vs 10% in field E)
    - Contributing area is ¼ as large in field C as field E
  - Even though field C has more clay and thus might be expected to have lower buffer efficiency, it is higher because of other factors
  - DRP and TP trapping efficiencies are similar between fields C and E even though field E captured 12.7 lb TP/ac/yr and Field C captured 0.24 lb TP/ac/yr

# Comparison with RUSLE2

- Field E1:
  - soil is 53% sand
  - “T” for this farm 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 for E1 is 120 (English units)
  - 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

# Comparison with RUSLE2

- Field C1:
  - soil is 35% clay
  - "T" for this farm is 3 tons/ac/yr
  - Measured soil loss is 0.67 tons/ac/yr
  - RUSLE2 estimate of erosion is 7.1 tons/ac/yr
  - Annual average erosivity (R-value) for E1 is 110 (English units)
  - Annual erosivity for runoff year is 230 (ultra, extremely erosive year)
  - RUSLE2 predicts 3.4 tons/ac/yr for average year

# Conclusions

- Sediment loss is 30 times more variable over the 5 farm fields than runoff is
- 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 (0.03 ac)
- Edge-of-field buffer efficiency measured; 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 runoff were an order of magnitude smaller that storm runoff in this study
- P loss from 0.01 to 10 lb/ac/yr were measured

# Future Work

**PALMS**

- produces site- and event-specific maps of runoff, erosion, sedimentation
- extensive data needs, runs slowly
- can be validated against observations of runoff events

**SNAP+**

- produces average sedimentation, erosion, P loss over field and rotation
- uses readily-available data, runs quickly
- can't be compared directly to runoff events

will use PALMS to calibrate SNAP+ (RUSLE2 and P Index)

# Questions?