

# **Extreme precipitation effects on sediment, nitrogen, phosphorus, and conservation practices in the Great Lakes Region**

**Steven R. Potter**

**Blackland Research Center  
Texas Agricultural Experiment  
Station  
Temple, Texas**

**Robert L. Kellogg**

**Resource and Assessment Division  
USDA-Natural Resource Conservation  
Service  
Beltsville, MD**

# Subject of Interest

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- Effects of Precipitation Volume & Intensity
  - Particulate N & P Transported w/ Sediment
  - Soluble N & P Transported w/ Runoff
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On Cultivated Cropland in  
Great Lakes Region

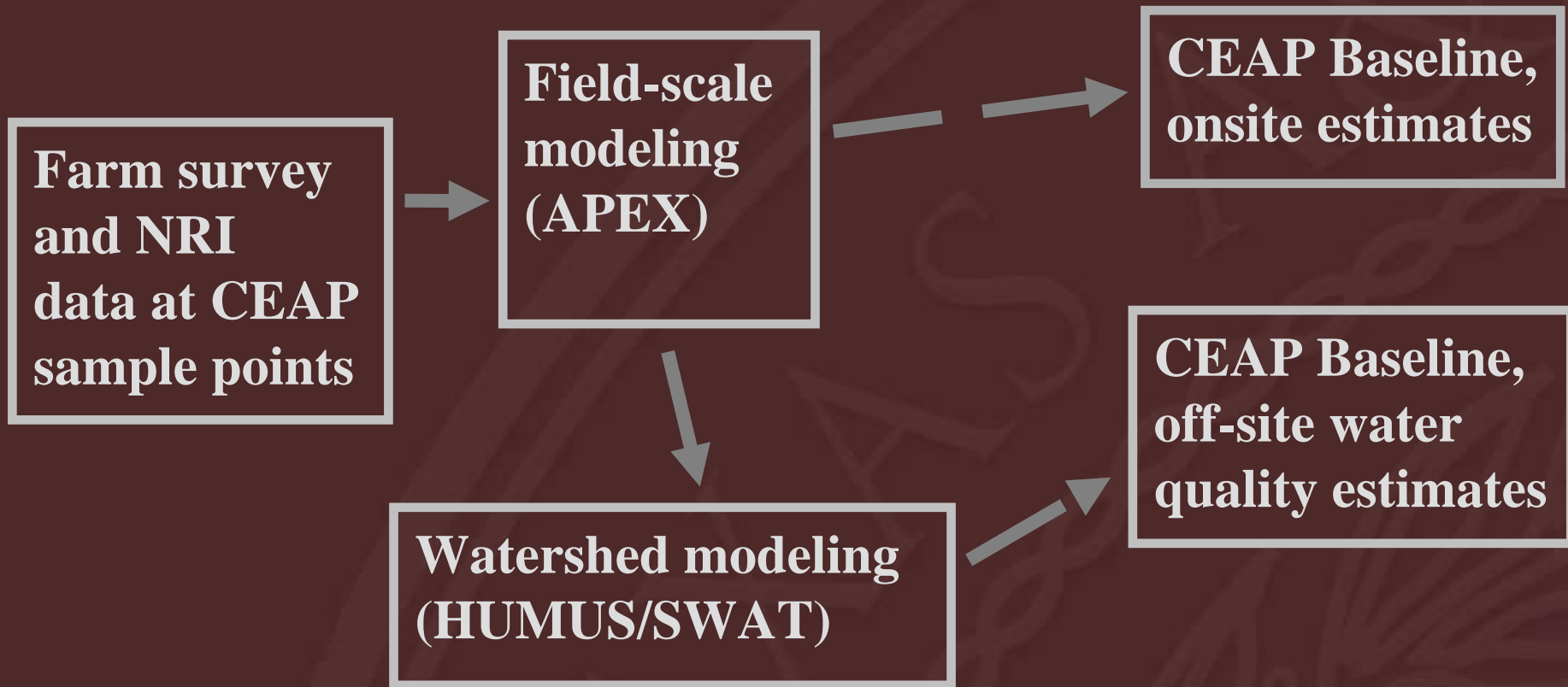
# Approach

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## CEAP National Assessment Simulation Model w/ Modifications

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- Sampling and modeling approach based on a subset of CEAP-NRI sample points.
  - Farmer survey conducted to collect needed information at these NRI sample points.
  - Physical process model (APEX) used to estimate field-level benefits.
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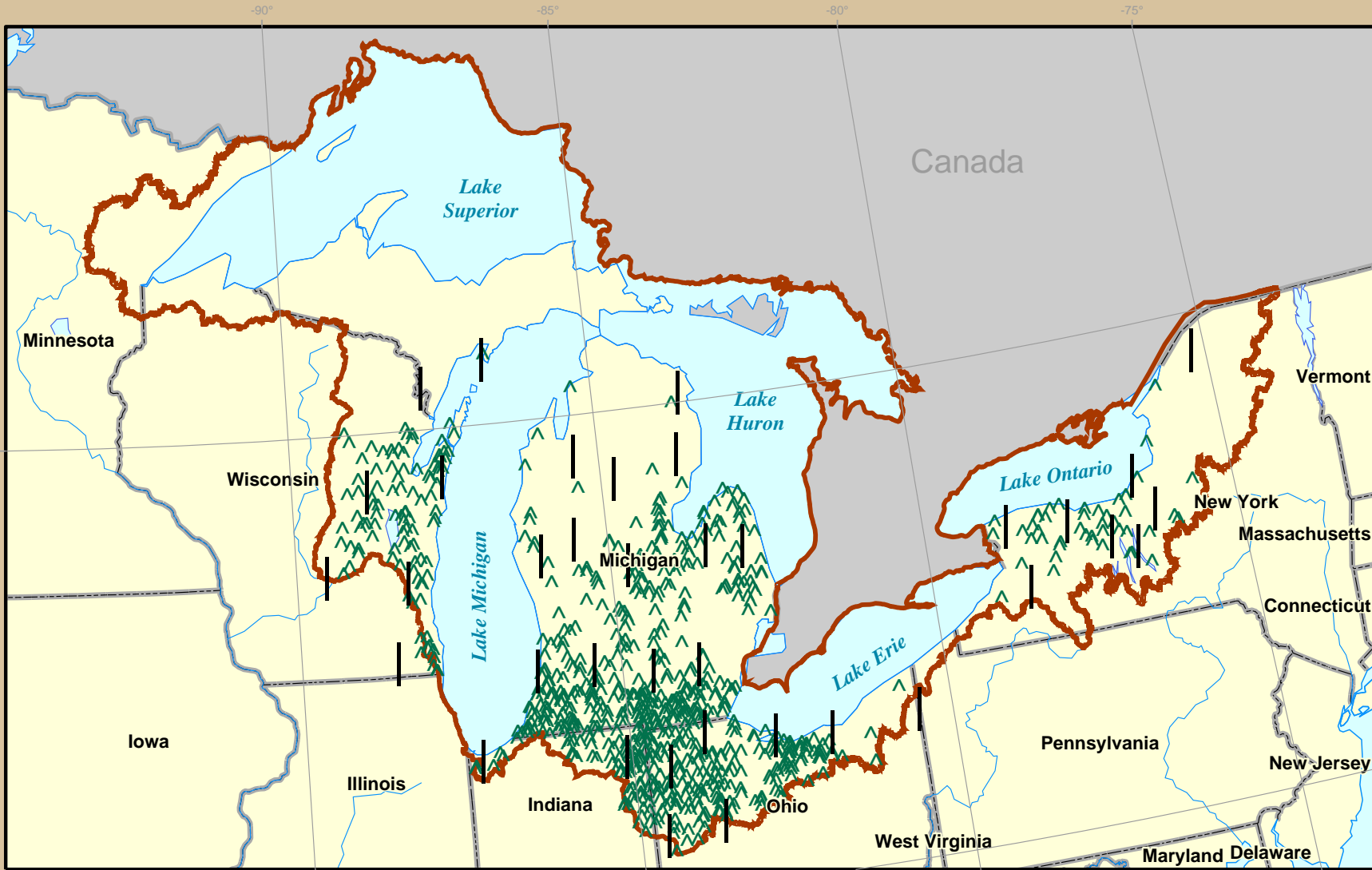
# **Schematic for Construction of CEAP Cropland Estimated Effects**

# Statistical Design Based on the NRI









# Simulation Domain

- 780 Cropland Points in “04” Basin (Hayland excluded)
- 4,926,600 Hectares (11,873,105 Acres)
- Management inputs from survey
- Structural Conservation Practices including contour farming, terraces, buffers, & grass waterways (tillage and nutrient management from survey)
- Location specific soils & topography from NRI
- Weather inputs derived from monthly statistics
- Daily rainfall is distributed exponentially to provide rainfall rates for Green & Ampt infiltration method



**Legend**

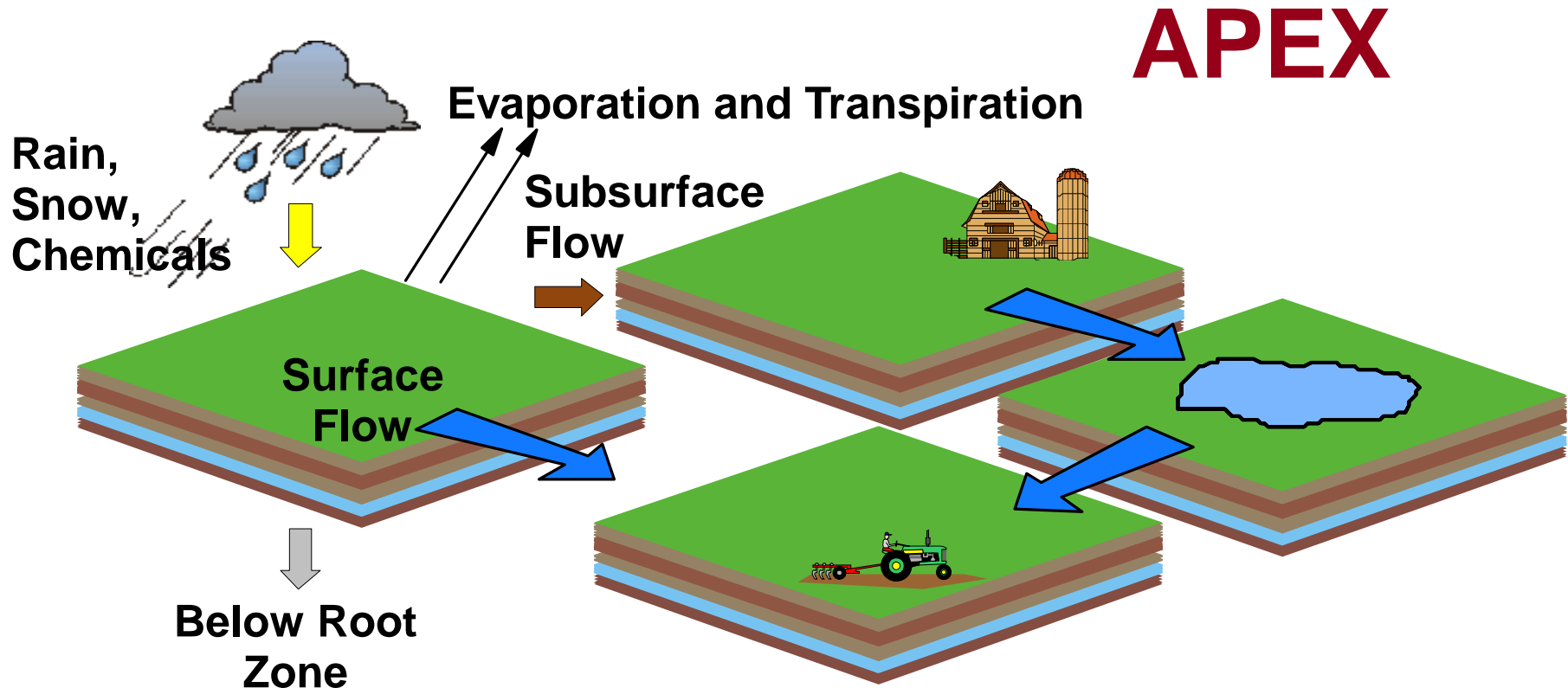
-  CEAP Points
-  Weather Stations
-  HUC Region 04
-  Rivers
-  Lakes
-  State Boundaries

# Great Lakes Region

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# Agricultural Policy Environmental eXtender



# Precipitation Volume

Daily rainfall methods based on skewed distribution  
developed by Nicks (1974,1989)

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- mean rainfall by month
  - standard deviation of monthly rainfall
  - skew coefficient
  - number of wet days in month
  - probability of wet-wet and dry-wet
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# Storm Intensity

## Max Half Hour Rainfall

$$\alpha_{0.5mon} = adj_{0.5\alpha} \cdot \left[ 1 - \exp \left( \frac{R_{0.5sm(mon)}}{\mu_{mon} \cdot \ln \left( \frac{0.5}{yrs \cdot days_{wet}} \right)} \right) \right]$$

Rainfall Rate Assumed  
Exponentially Distributed

# Green & Ampt Infiltration Method

Rainfall Intensity <  
Infiltration Rate =  
Rainfall Into Soil

$$f = SATK \cdot \left( \frac{s}{FT + 1.} \right)$$

Rainfall Intensity >  
Infiltration Rate =  
Rainfall Runoff

$$Q = \sum (dt \cdot (r - f))$$

Infiltration  $f$  (Ksat, Curve  
Number, Cumulative  
Infiltration)

# Water Erosion Model

Use MUST  
Theoretical  
Equation

Similar to USLE

Energy Component:  
Runoff Volume and  
Peak Flow

$Y = \chi(K)(CE)(PE)(LS)(ROKf)$	
$\chi = EI$	<i>for USLE</i>
$\chi = 1.586(Q \cdot q_p)^{0.56} A^{0.12}$	<i>for MUSLE</i>
$\chi = 2.5(Q \cdot q_p)^{0.5}$	<i>for MUST</i>
$\chi = 0.79(Q \cdot q_p)^{0.65} A^{0.009}$	<i>for MUSS</i>
$\chi = by_1 Q^{by_2} q_p^{by_3} A^{by_4}$	<i>for MUSI</i>

# Modeling Strategy

1. Estimate baseline using existing weather statistics to represent current conditions (presented data are preliminary results only).
2. Develop alternative scenarios having increased precipitation volume and/or storm intensity.
3. Compare and contrast simulation outcomes to estimate extreme precipitation effects relative to the baseline.

# Results

Caveat:

Results are not predictive; rather the scenarios are intended to illustrate effects by altering one part of a complex system.

The intention is to enlighten, expand thinking, and bring forth further questioning.

# Precipitation Scenarios

<b>Scenario</b>	<b>Monthly Precipitation Means</b>	<b>Max Half Hour Precipitation</b>
<b>Baseline</b>	No Change	No Change
<b>Extreme 10 15</b>	<b>+10%</b>	<b>+15%</b>
<b>Extreme 25</b>	No Change	<b>+25%</b>

Other Climate Parameters Unchanged

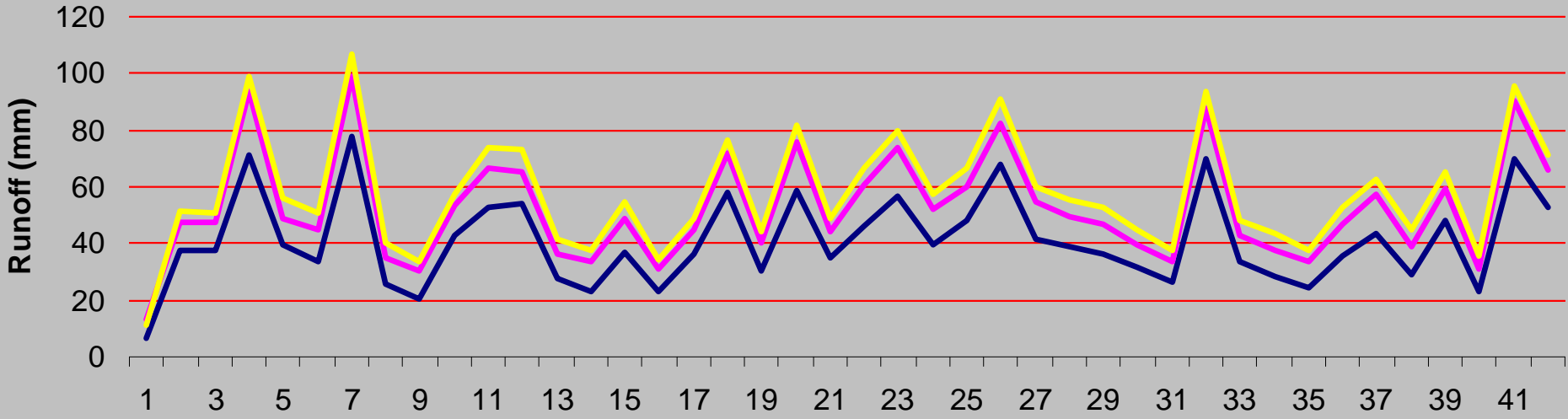
# Regional Results

Output	Average Annual Per Hectare Over Simulation			Percent Change from Baseline	
	Baseline	Extreme 10 15	Extreme 25	Extreme 10 15	Extreme 25
Precipitation (mm)	833.3	916.6	833.3	10.0	0.0
Runoff (mm)	41.0	52.7	58.0	28.7	41.5
Sediment (mtons/ha)	1.2	1.6	2.0	36.3	66.8
N w/ Sediment (kg/ha)	5.0	6.6	7.9	33.0	58.4
P w/ Sediment (kg/ha)	1.0	1.4	1.7	34.6	64.2
N in Runoff (kg/ha)	2.9	3.4	2.9	18.3	-0.7
P in Runoff (kg/ha)	0.15	0.19	0.20	26.2	37.7

# With and Without Structural Conservation Practices

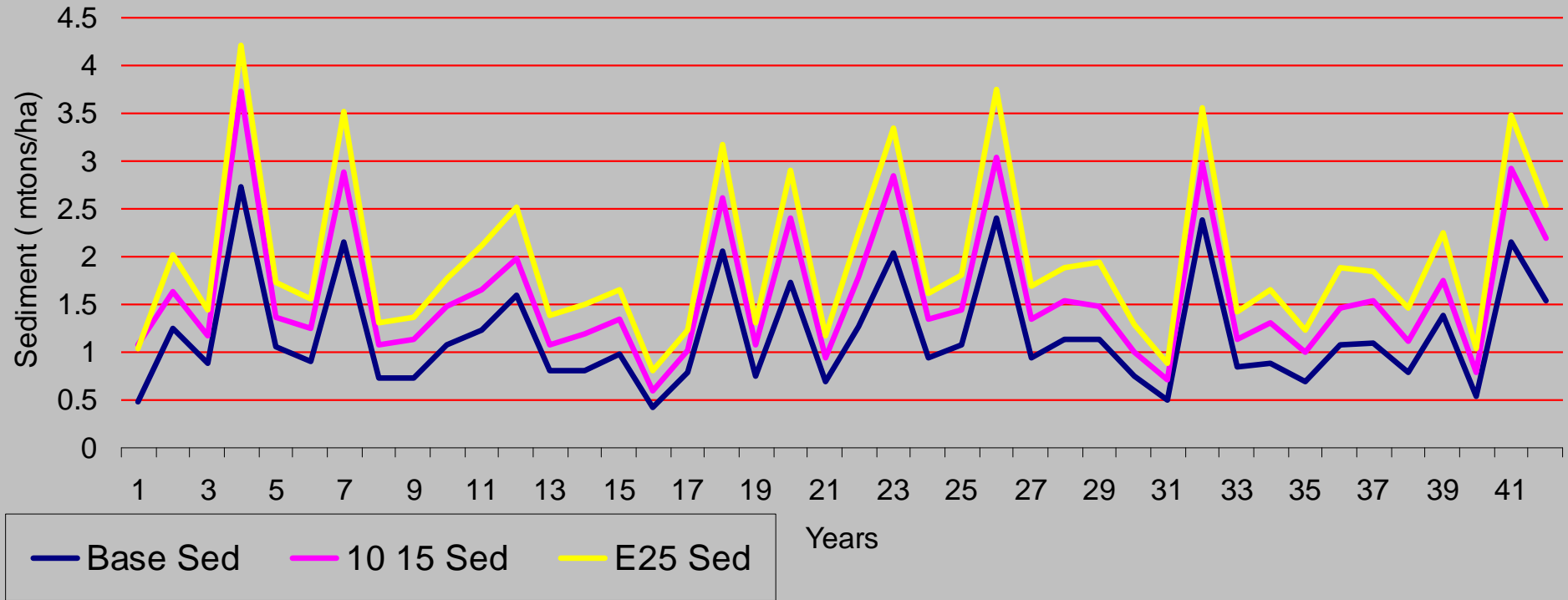
Scenario	Baseline		Extreme 10 15		Extreme 25	
	Without CP	With CP	Without CP	With CP	Without CP	With CP
System						
Area (ha)	8,836,251	2,930,866	Same		Same	
Precipitation (mm)	831.0	840.0	914.1	924.1	831.0	840.0
Runoff (mm)	41.6	39.2	53.3	50.9	58.7	55.7
Sediment (mtons/ha)	1.3	0.9	1.8	1.2	2.1	1.4
N w/ Sediment (kg/ha)	5.0	4.8	6.7	6.4	8.1	7.3
P w/ Sediment (kg/ha)	1.1	0.9	1.4	1.2	1.7	1.4
N w/Runoff (kg/ha)	2.8	3.0	3.3	3.7	2.8	3.1
P w/ Runoff (kg/ha)	0.1	0.2	0.2	0.2	0.2	0.3

### Runoff by Year (regional average)



— Base RO    — 10 15 RO    — E25 RO

## Sediment by Year (regional average)



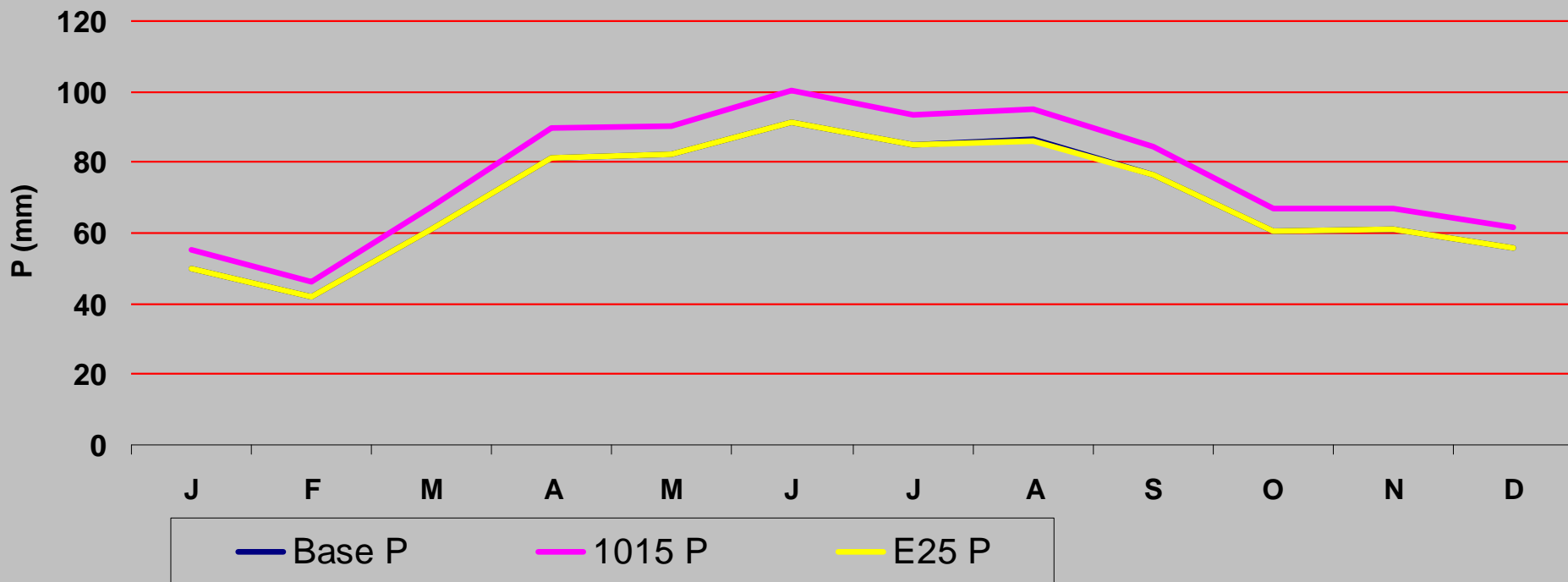
# Vulnerable Acres Total N (kg /ha)

<b>Cum % Area</b>	<b>Base</b>	<b>10 15</b>	<b>E25</b>
<b>1.0</b>	<b>52.9</b>	<b>68.2</b>	<b>81.5</b>
<b>5.0</b>	<b>23.8</b>	<b>29.3</b>	<b>32.6</b>
<b>10.0</b>	<b>15.3</b>	<b>18.2</b>	<b>20.6</b>
<b>15.0</b>	<b>10.5</b>	<b>13.5</b>	<b>15.5</b>
<b>20.0</b>	<b>9.1</b>	<b>11.0</b>	<b>12.3</b>
<b>25.0</b>	<b>7.8</b>	<b>9.8</b>	<b>10.4</b>
<b>50.0</b>	<b>4.6</b>	<b>5.7</b>	<b>5.8</b>

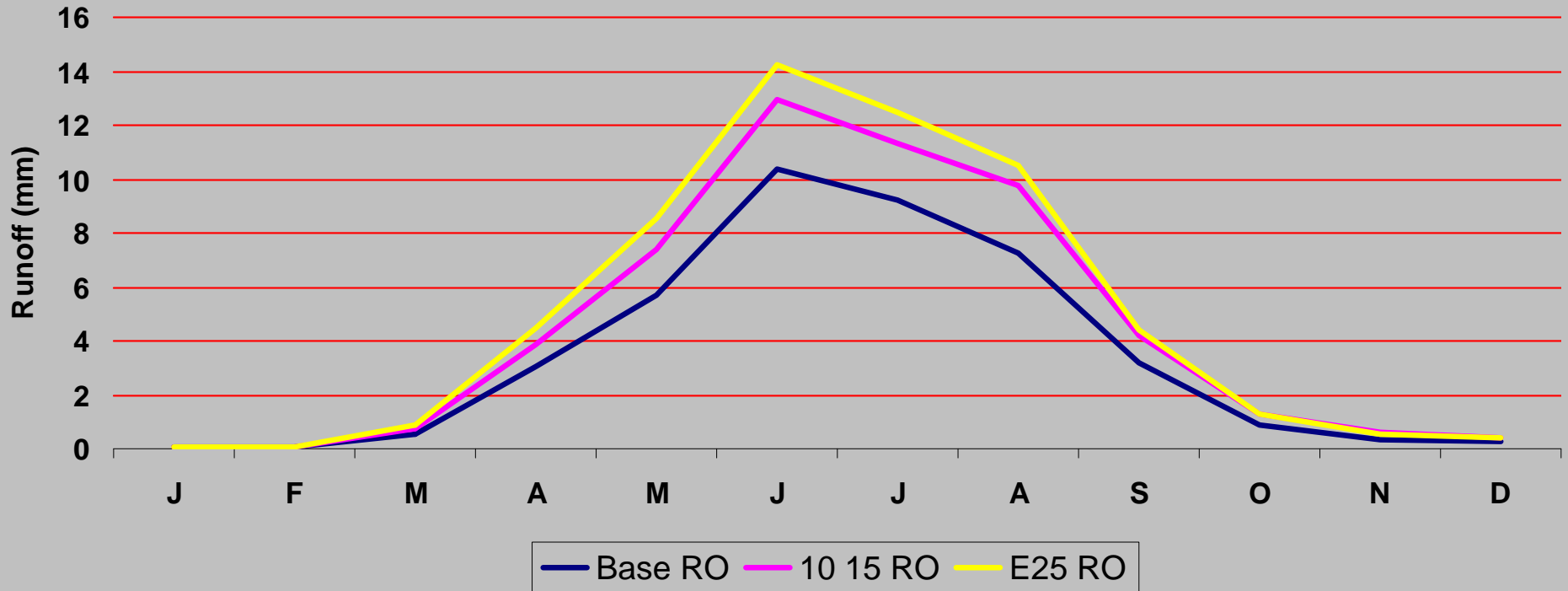
# Vulnerable Acres Total P (kg /ha)

<b>Cum % Area</b>	<b>Base</b>	<b>10 15</b>	<b>E25</b>
<b>1.0</b>	<b>9.1</b>	<b>13.8</b>	<b>16.0</b>
<b>5.0</b>	<b>4.5</b>	<b>5.5</b>	<b>6.9</b>
<b>10.0</b>	<b>2.6</b>	<b>3.4</b>	<b>4.2</b>
<b>15.0</b>	<b>1.8</b>	<b>2.5</b>	<b>2.9</b>
<b>20.0</b>	<b>1.4</b>	<b>1.8</b>	<b>2.2</b>
<b>25.0</b>	<b>1.1</b>	<b>1.5</b>	<b>1.8</b>
<b>50.0</b>	<b>0.5</b>	<b>0.7</b>	<b>0.9</b>

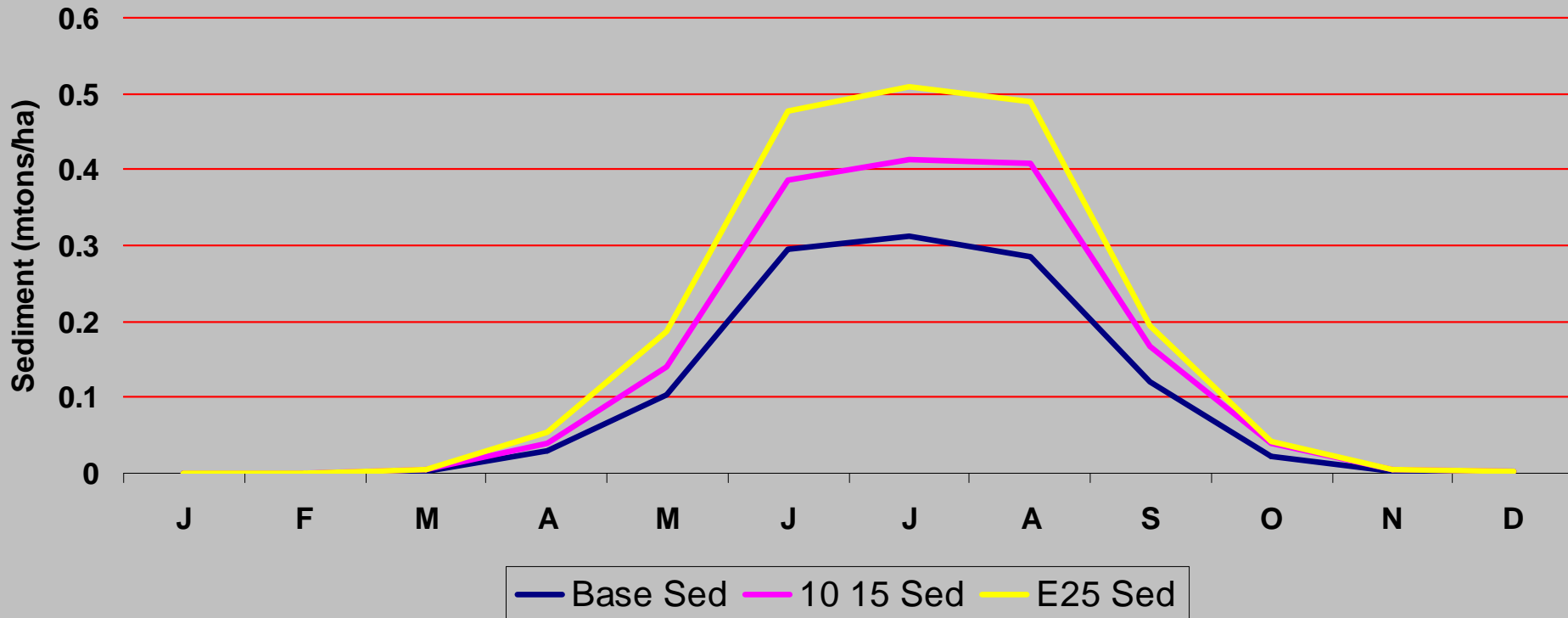
### Precipitation by Month (regional average)



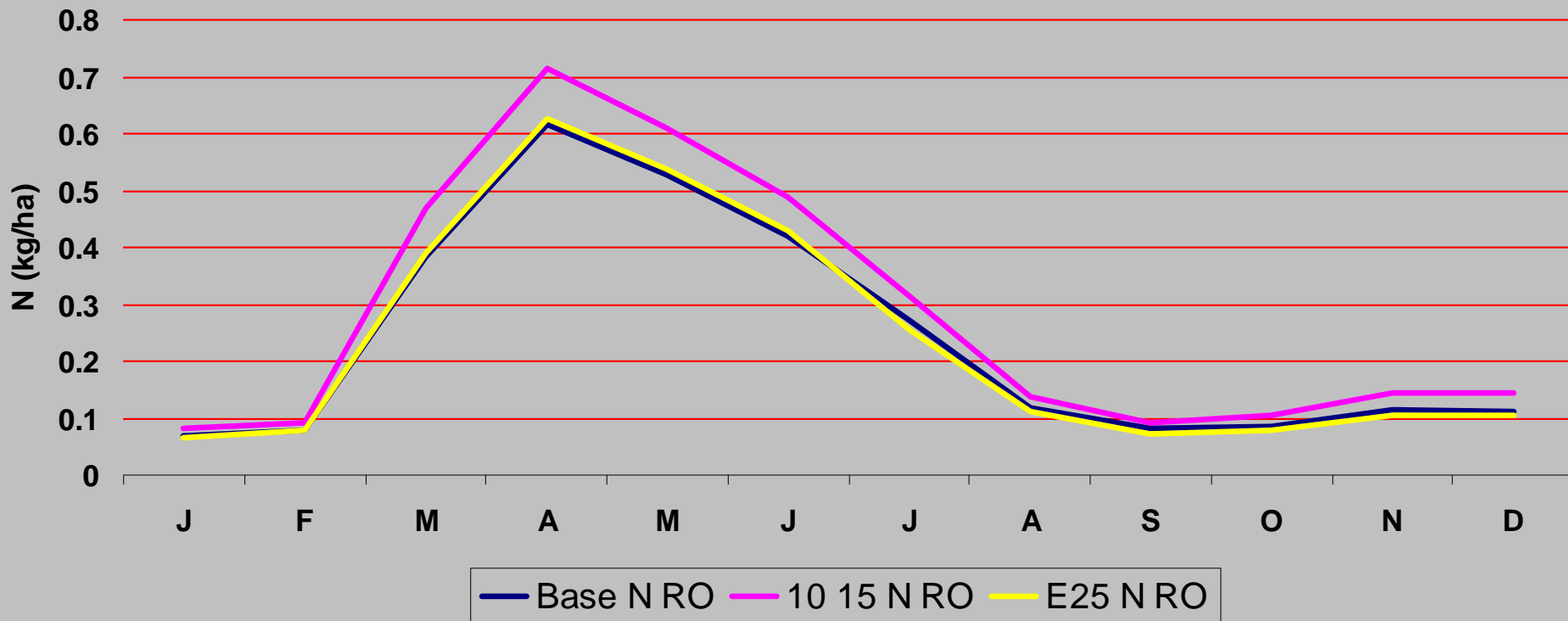
## Runoff by Month (regional average)



## Sediment by Month (regional average)



### N in Runoff by Month (regional average)



# Some Lessons Learned

- Green & Ampt highly sensitive to Ksat, soil water
- Depending on specific questions, there are a number of strategies for implementing other extreme P scenarios including design storms and return periods.
- Continue ...

# Thank You

For more information:

Steve Potter

254-774-6111

[spotter@brc.tamus.edu](mailto:spotter@brc.tamus.edu)