The Need to Account for Site-Specific Information on Farming Activities in Assessing the Environmental Impact of Agriculture

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**Presented by Dr. Tom Gerik, Director, Blackland Research and Extension Center.

Overview of the Issue

- Agriculture impacts the environment?
  - Influence of government policies and programs?
- Ag Impacts are diverse and stochastic over time
  - Influence of weather, soils and market conditions
- Monitoring is expensive for widespread use
  - Difficult to assess impacts of alternative program rules and situation

- Impacts analysis must be based on simulation models
  - Two modeling approaches– differ in sampling and inference:
    - Aggregate or representative input data
    - Sample of site specific input data

Aggregate Input Data Approach

- Less expensive-- based on existing survey data
- Farm fields <u>grouped</u> by soil and landscape attributes
- Area-wide management practices assigned to the farm field groups
  - e.g., fertilizer rate method and timing estimated by state and crop from ARMS
- Group simulation results assigned to each group member
- Farm field level results summarized or displayed at various spatial scales using GIS software
- Does not precisely identify "hot spots", temporary threshold exceedence, and so forth, since group average input data is used
  - For many environmental factors, the principle concern of importance are the "hot spots"
- Hence: Aggregate approach may lead to misleading results
  - e.g., state's highest fertilizer rate (or the average for the group of high use farms) simulated on the poorest soil in a small area

Site Specific Sample Approach

- Data collection is expensive
- Exact soil, landscape attributes and management information are collected and simulated for a sample of farm fields
- Sample is a point-in-time “Snapshot”
  - May not be representative of longer period
  - Observed management activities may be very specific to that period’s weather and/or market conditions
- Farmers may be reluctant to reveal (e.g., fertilizer management)
- Area wide inference requires careful sample selection and probability weighting given the diverse nature of the individual farm fields
- The Site Specific Model approach typically involves greater extremes in soil and landscape characteristics since each individual sites is represented by it actual characteristics

Uses of Simulation Model Results

- Inference for entire population of farm fields in an area
  - e.g., average erosion rate for a watershed

- Inference for specific practice effects
  - e.g., erosion difference between Notill and Mulch till for corn-soybeans on 4% slope silt loam soil

Comparion of Aggregrate vs Site Specific for Two National Cropland Studies

- Aggregate Data Input Approach
  - National Soil Loss and Soil Carbon Study (NNLSQ)
  - Approximately 1,000,000 simulations
    - 35 management alternatives on average for each of about 28,000 aggregate **Unique Resource Units** (**URU**s – proxy for “farm fields”)
    - URU = collection of similar NRI points, “representative farm fields”
    - URU characterized by State, Climate, Soil, Crop, Irrigation type, and Conservation Practice system

- Site Specific Model Approach
  - Conservation Effects Assessment Project (CEAP)
    - National Cropland Assessment Component
    - 3 years of farm management data collected from each of approximately 20,000 farm fields, each field associated with a specific NRI point

The Study Area for the Comparison

- Small area in Minnesota

- Results from two NNLSQ URUs', one Corn and one Soybean

  - The URUs have similar climate, soil, and landscape attributes
  - NNLSQ URU's were each simulated up as mono-cropping for the crop reported in the 1997 NRI
  - Results from aggregate URU simulations were assigned back to member points in each URU for further analysis

- The CEAP NRI sub-sample includes a total of 32 NRI points for those NNLSQ URUs

  - Each CEAP NRI point was simulated with the crop rotation reported by the farmer, and for nearly all of this sub-set of points, the rotation was Corn - Soybeans

Characteristics of the Corn Resource Unit (URU)

NNLSQ Corn URU

- Weather Station - #443, Zumbrota MN
- NNLSC Soil Attributes (#437, MN0061, Lester, Clay Loam)
- 236,500 acres represented

The CEAP sample set for this URU

- included 4 soils (Loam and Silt Loam series) in addition to Lester
- Included CEAP farm field samples for 22 corn NRI points from the URU

	CEAP Corn Points			1997 NRI URU Average
	Min	**Average**	**Max**	**Average**
USLE	**0.2**	**5.9**	**44.9**	**6.8**
USLE_C	**0.00**	**0.26**	**0.50**	**0.25**
Slope %	**2.0**	**5.7**	**14.0**	**5.6**
Slope (ft)	**50.0**	**112.0**	**300.0**	**135.0**
RKLS	**5.5**	**22.9**	**118.9**	**27.6**

Characteristics of the NNLSQ Soybeans URU

- The same NNLSQ soils and weather as the corn URU
- Included CEAP Farm Field samples from 10 of the URU NRI points

	CEAP Soybean Points			1997 NRI URU Average
	Min	**Average**	**Max**	**Average**
USLE	**1.8**	**8.1**	**22**	**8.7**
USLE_C	**0.12**	**0.27**	**0.42**	**0.27**
Slope %	**1.0**	**6.1**	**11.0**	**5.7**
Slope (ft)	**75.0**	**117.0**	**200.0**	**122.0**
RKLS	**5.4**	**30.0**	**75.9**	**32.6**

Other Management Attributes

- All CEAP samples had Corn-Soybeans rotations except for one each of continuous corn and Corn-Spring Wheat-Soybeans

- Tillage system prevalence (% of samples)*:

	Conventional	Mulch	Notill
CEAP	30	67	3
NNLSQ Corn	81	17	2
NNLSQ Soybean	50	45	5

*CEAP sample tillage type classification based on rotation average STIR value calculation.
NNLSQ tillage type based on CTIC survey, 2002.

Sampling and Inference for the NNLSQ

- URU soil, climate, and landscape attributes were computed as average of member NRI points

- multiple management treatments were simulate
    - Combinations--fertilizer rate, timing, and method and tillage systems

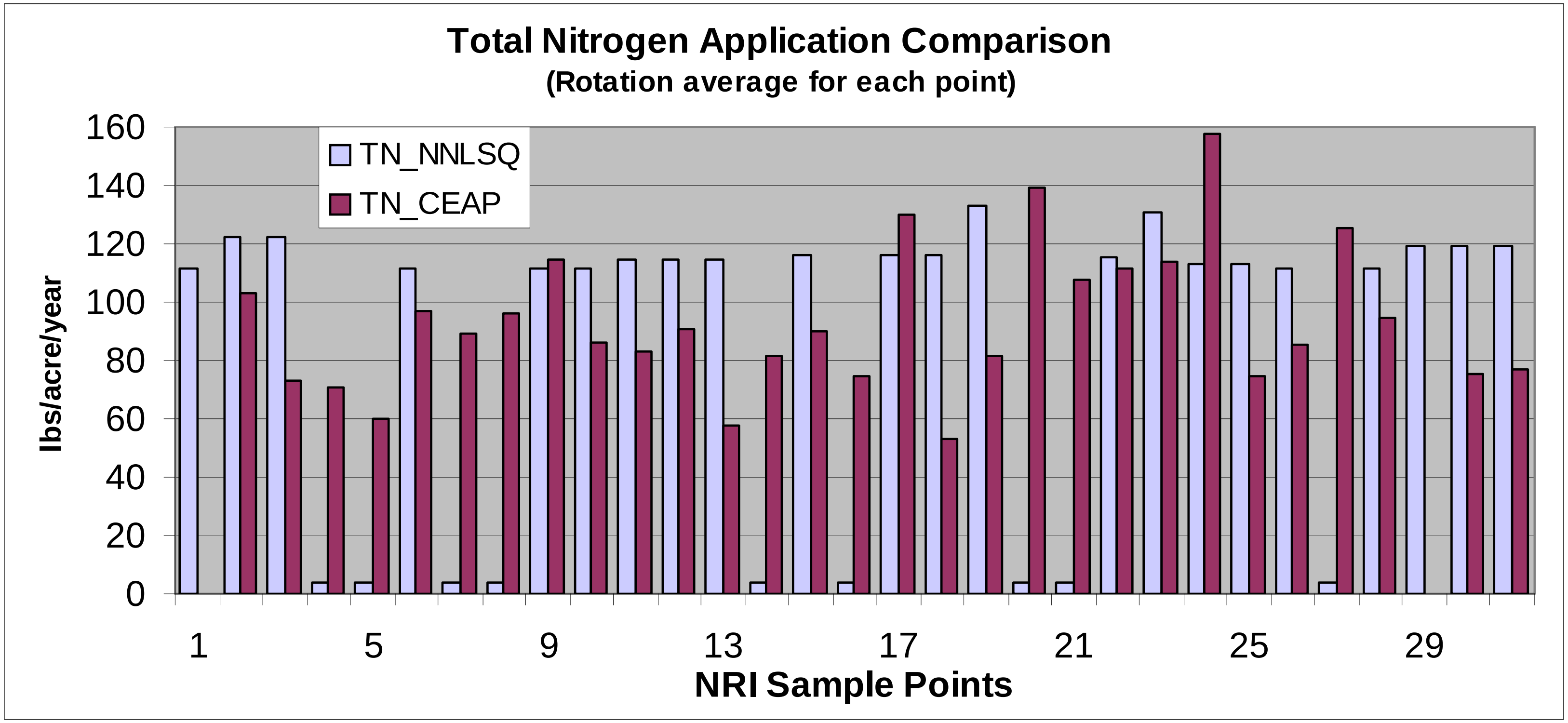
- since a URU was not necessarily a contiguous area, different member NRI points of the URU may have had different mixed of tillage systems and other aspects of management
    - e.g., tillage system mix data from county level surveys

\- Consequently, variation in assigned weighted average simulation results across member NRI points within each URU

Fertilizer Application Comparison (lbs/acre/year)

	Nitrogen				Phosphorus			
	Corn CEAP	Corn NNLSQ	Soybeans CEAP	Soybeans NNLSQ	Corn CEAP	Corn NNLSQ	Soybeans CEAP	Soybeans NNLSQ
Count	39	72	11	39				
(with manure)	3	6	0	6				
Fertilizer								
Min	11	0	0	0	0	0	6	0
Avg	***135***	***94***	***12***	***3***	***37***	***19***	***44***	***2***
Max	191	158	21	181	75	34	100	33
S.D.	38	50	9	47	18	12	32	10
Manure								
Min	0	0	0	0	0	0	0	0
Avg	*4*	*17*	*0*	*1*	*1*	*7*	*0*	*1*
Max	72	283	0	426	20	106	0	182
S.D.	14	64	0	131	3	26	0	60
Total								
Min	11	0	0	0	0	0	6	0
Avg	*139*	*111*	*12*	*4*	*38*	*26*	*44*	*3*
Max	210	283	21	426	75	106	100	182
S.D.	36	58	9	131	17	24	32	56

* CEAP count is the number of sample point and crop years combinations surveyed.
NNLSQ count is the number of fertilizer treatments simulated for the state/crop group combination (treatments defined by rate, timing, method, and manured/or not.)

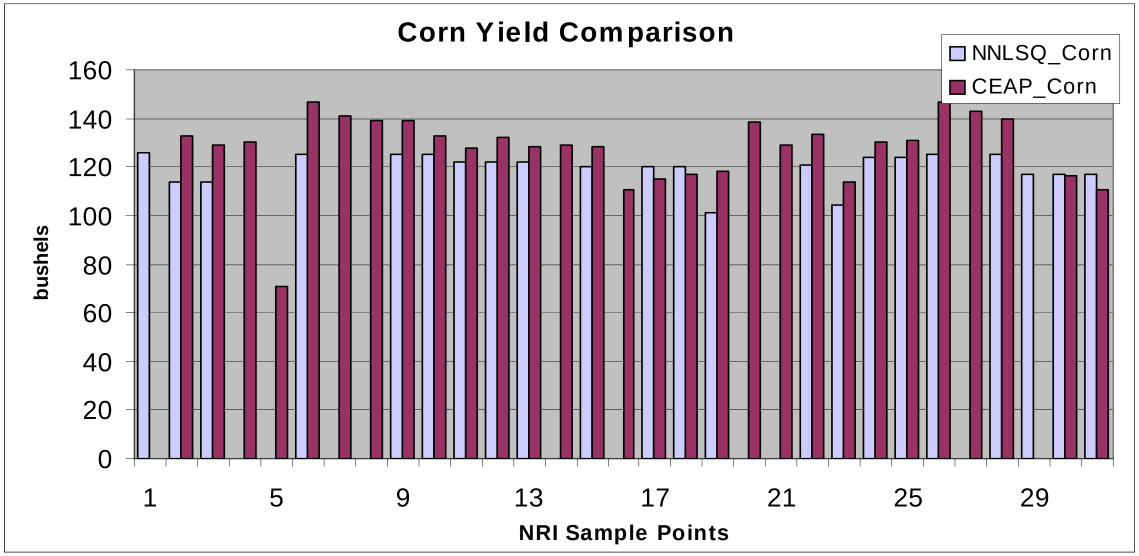


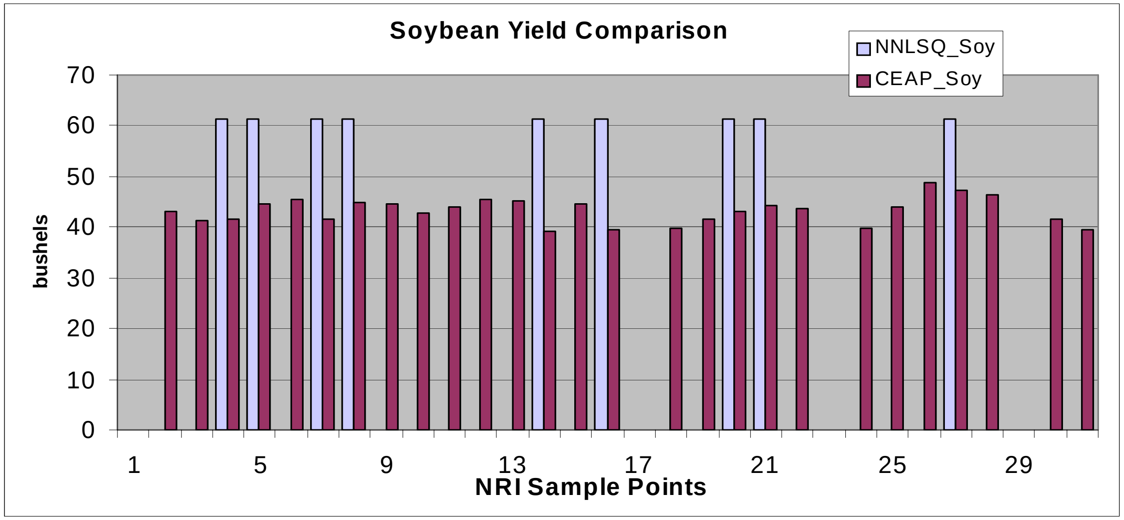
Total Nitrogen Application Comparison
(Rotation average for each point)
TN_NNLSQ
TN_CEAP
lbs/acre/year
0
20
40
60
80
100
120
140
160
1
5
9
13
17
21
25
29
NRI Sample Points

Table x. NNLSQ and CEAP model output comparison[a].

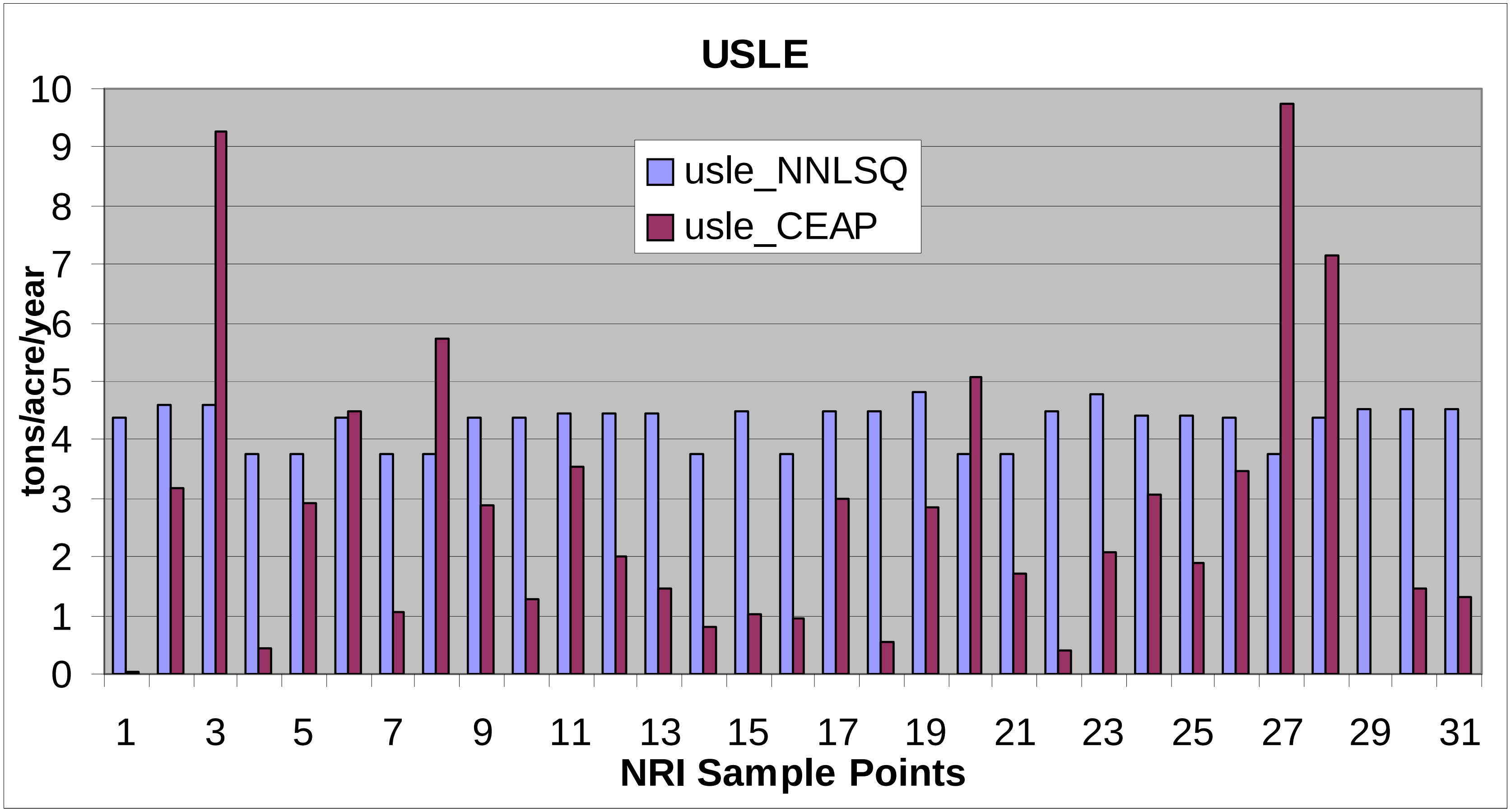
		NNLSQ	CEAP	Diff.	%
Runoff	inches	3.5	3.1	-0.4	-11.6
Percolation	inches	1.8	1.9	0.2	9.6
Crop Yields					
Corn	bushels	117.1	123.4	6.3	5.3
Soybeans	bushels	61.2	42.7	-18.5	-30.2
USLE	tons	4.4	2.0	-2.4	-53.8
N with sediment	lbs	15.66	16.84	1.18	7.5
NO3 in runoff	lbs	1.40	0.04	-1.36	-96.9
N03 in percolation	lbs	0.77	3.88	3.11	400.9
Total N	lbs	17.84	19.02	1.18	6.6
P with sediment	lbs	3.34	2.97	-0.37	-11.1
P in runoff	lbs	0.34	0.16	-0.19	-54.2
Total P	lbs	3.68	3.12	-0.56	-15.1

[a]Weighted with 1997 NRI point acreage expansion factors.





*Varied NNLSQ weights assigned to treatments for each point depending on location and other attributes.



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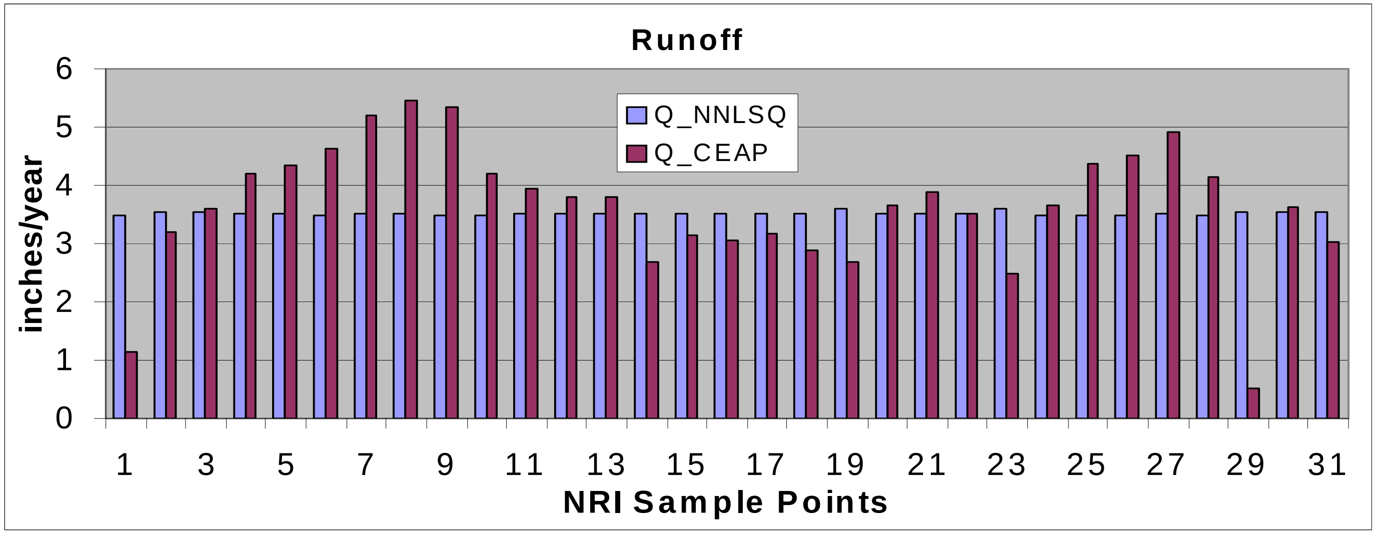

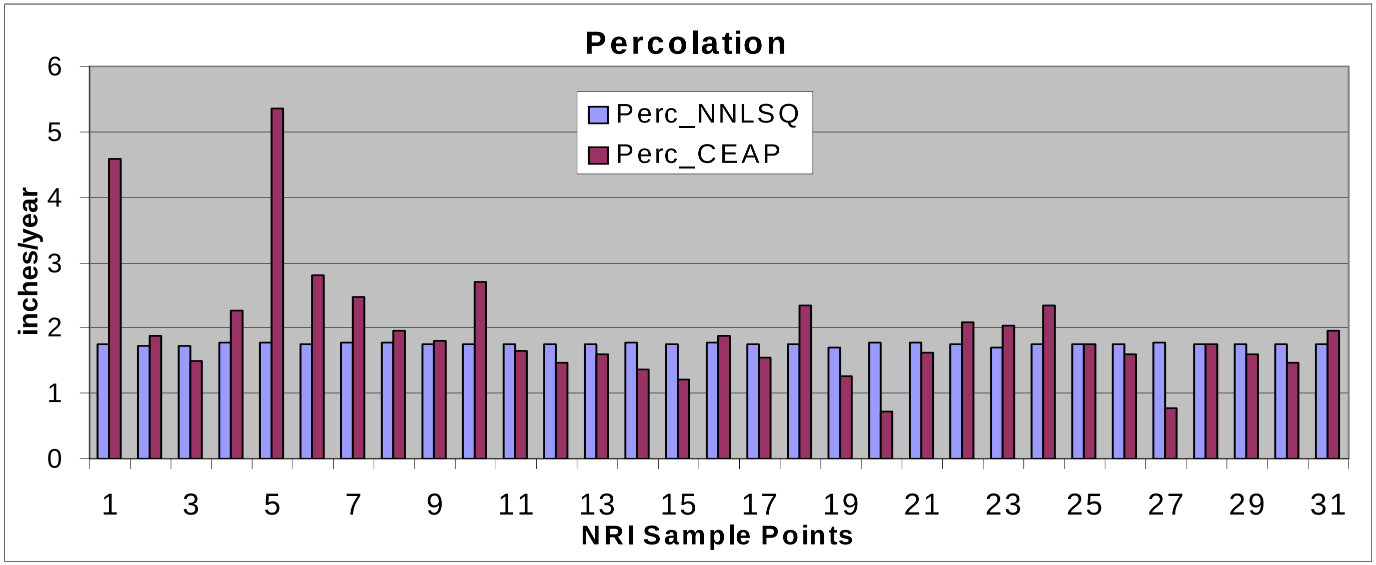

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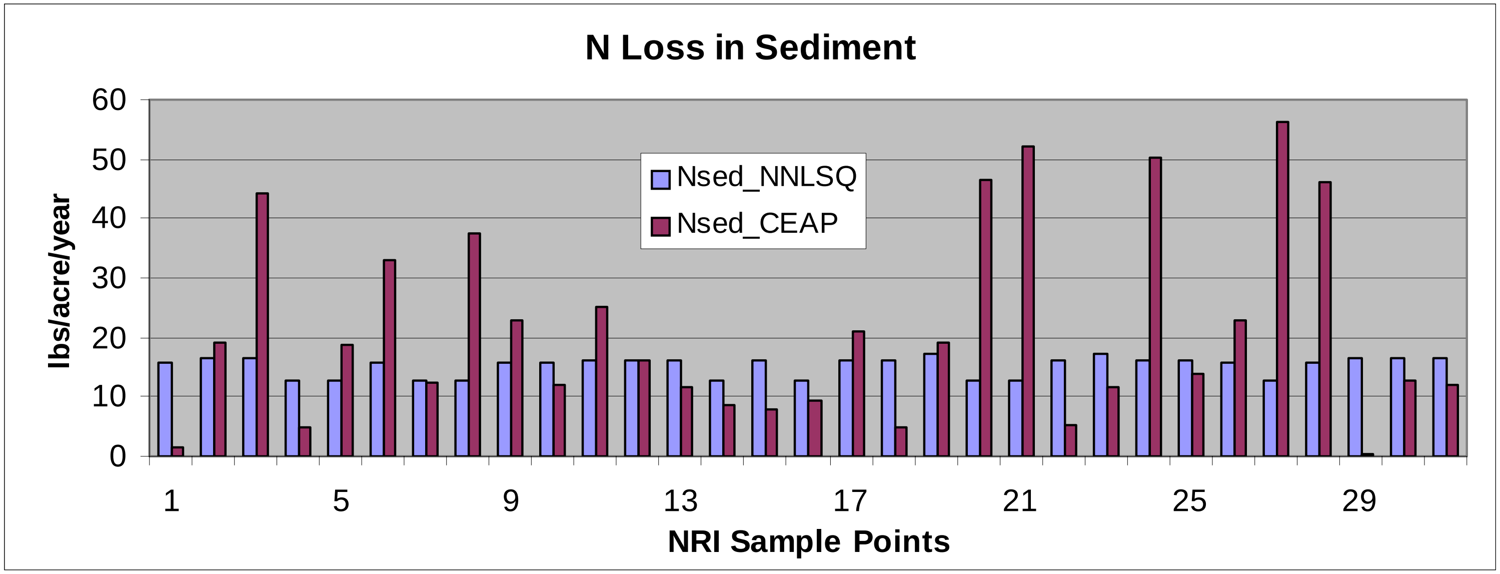

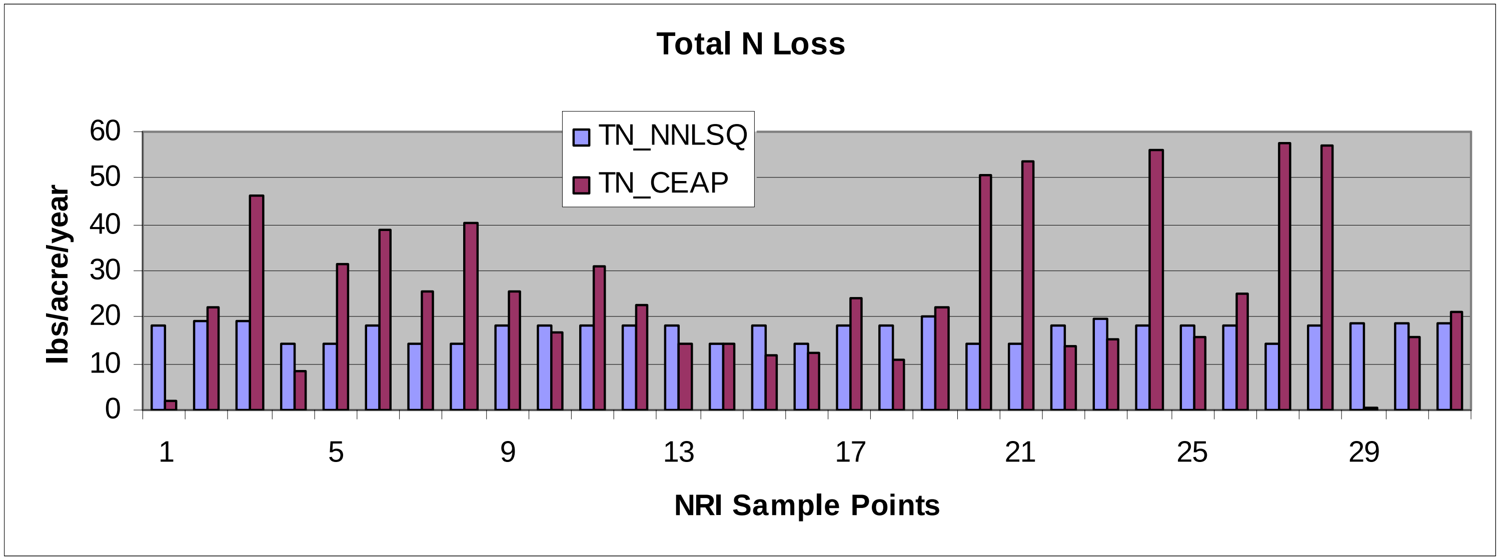

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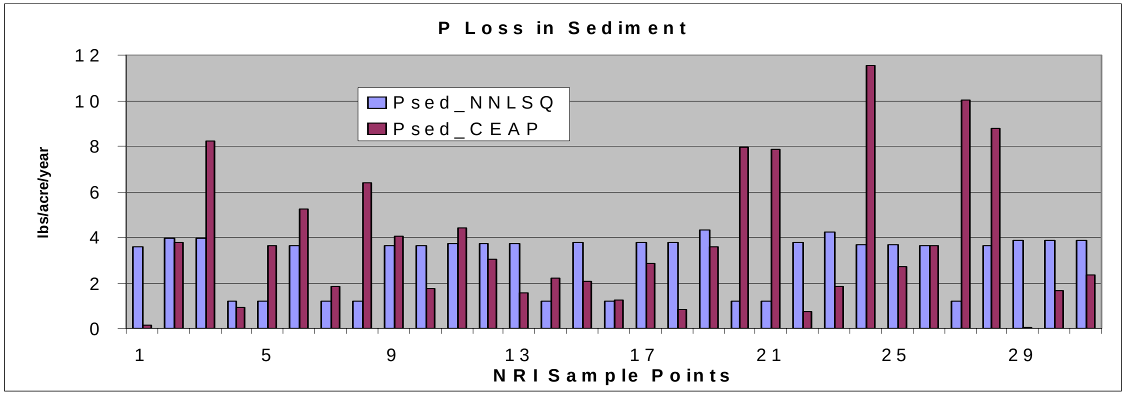

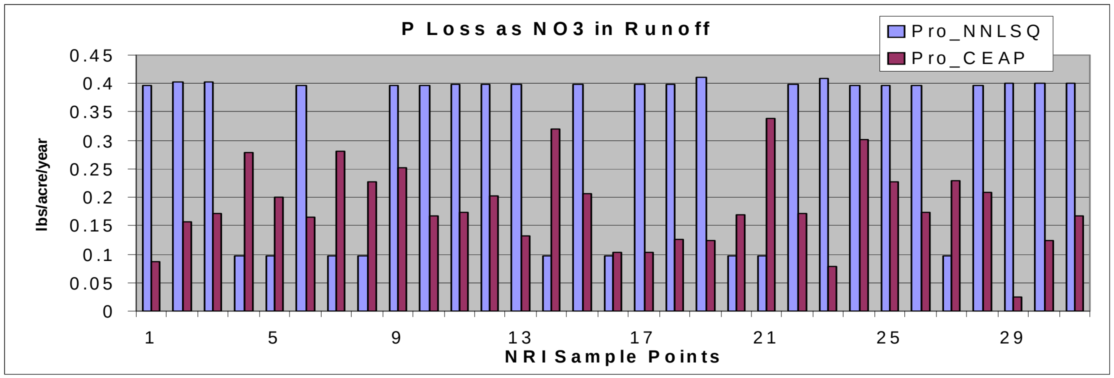

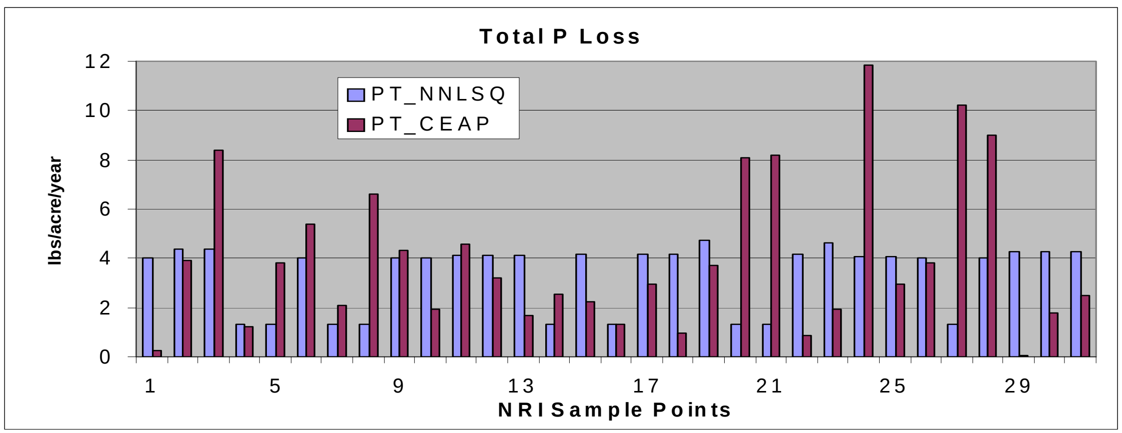

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Conclusions

- For evaluation of average or total effects both approaches give similar answers

- The site specific simulation approach is much better in evaluating
  - Treatment needs
  - Hot spots
  - Bad actors
  - Technology impacts
  - Etc.

- Is the improved analysis with the site specific approach worth the cost?
  - Depends on the answers that are needed
  - In many situations, the choice is not between using the Aggregate Input Data Approach or the Site Specific approach, but rather to do the Site Specific Approach or not (Is the site-specific data available?)