Ag Land Use Loading Ratio Subgroup
(Ad hoc subgroup of Ag Modeling Subcommittee)

- **Task:** Estimate relative edge-of-field loading ratios of N, P, and sediment for 14 Ag land uses for the phase 6 Watershed Model.

- Edge of field is defined by the ground surface boundary and by the depth limit of the rooting zone.

- Loading ratios are relative to corn or sorghum grain without manure because this crop type is widespread and may supply much of the edge of field loads in the Chesapeake Watershed.

- Loading ratios are for ag land uses without BMPs.

Loading Ratios vs. Loading Rates

- Ratios are probably less variable than loading rates.
- Loading rates vary with local soil and hydro-geological conditions as well as with crop type.
- Therefore, loading ratios of crop types vary less across regions than do loading rates.
- Less literature values are needed to establish ratios but they must compare loads within similar conditions.

Initial Work, March-May 2015

- Examined literature reviews and databases compiled by Tetra Tech and Water Stewardship, Inc.
- Determined that expert reading and selection of sources for relevance was needed.
- Provided preliminary relative load ratios for nitrogen to the Ag Working Group in April.
- Obtained cooperative agreement with Virginia Tech for screening and analysis of the data by Gene Yagow.

Findings to Date: Nitrogen

- N loads are mainly from leaching of nitrate below rooting zone.
- Surface runoff of N probably has a negligible effect on total N load ratios.
- Crops with perennial cover have relatively low loads.

Effect of manure applications

- Manure applications increase load depending on application rate and crop N demand.

- As requested, we provide estimates of average N load ratio for crops receiving average manure applications, assuming that manure-eligible lands get manure.

- More accurate load ratios could be estimated with information on local manure N application rates and crop N demand.

Nitrogen Loading Ratios

Data summary of Relative NO3-N Loading Estimates for Phase 6.0 Land Uses J.J. Meisinger 9-8-15

	P6 Landuse	Wtd. Avg. (#obs.); Rel. to Corn, no Man.	Std Err. Mean; (# df) pooled across all obs.
1	**Corn or sorghum grain - elig. for manure** (1, 2, 3, 10, 11)	1.40 (12)	0.20 (7)
2	**Corn or sorghum silage - elig. for manure** (10)	1.62 (1)	NA
3	**Corn or sorghum grain - no manure**	1.00 (NA)	NA
4	**Corn or sorghum silage - no manure** [1]	1.16 (NA)	NA
5	**Sm gr w/ soybean dbl.cr. - no manure** (9)	0.79 (2)	0.09 (1)
6	**Full season soybean - no manure** (3, 10, 45)	0.71 (6)	0.11 (2)
7	**Sm gr w/ forage establ. - elig. for manure** [2]	0.84 (NA)	NA
8	**Other Agronomic Crops (cotton, tob., peanuts)** (15)	0.45 (1)	NA
9	**Pasture - direct dep; elig. for manure** (12, 13, 14)	0.23 (10)	0.06 (4)
10	**Legume (or legume-grass mix) Hay** (6, 7)	0.17 (4)	0.02 (2)
11	**Other Hay (perennial grasses, Or. Grass, T. fescue)** (12, 13)	0.24 (4)	0.06 (2)
12	**Ag open space (per. grasses, Or. Grass, T. fescue)** (8)	0.10 (2)	0.01 (1)
13	**Specialty- high input (potatoes, sweet corn, etc.)** (10)	1.34 (1)	NA
14	**Specialty - Low input (orchard, nursery st., peas)** [3]	0.31 (NA)	NA

Notes: [1] Est. from ratio (Corn/Sor. Silage w/ man.)/(Corn/Sor. Grain w/ man.) = 1.62/1.4 = 1.16

[2] Est. from Sm gr w/ sb dc w/o manure, adjusted to only Sm gr, plus a w/ manure factor. First estimate sb dc factor, with dc Sb = 50% of Full Sea. Sb, so Sm gr alone = 0.79 - (0.71/2) = 0.44. Then, Sm gr w/ manure factor = 0.44 + (corn w/ man. - corn gr w/o man.) = 0.44 + (1.40 -1.00) = 0.84

[3] Est. from Other Hay + 0.07 (due to greater loading w/ annuals) = 0.24 + 0.07 = 0.31

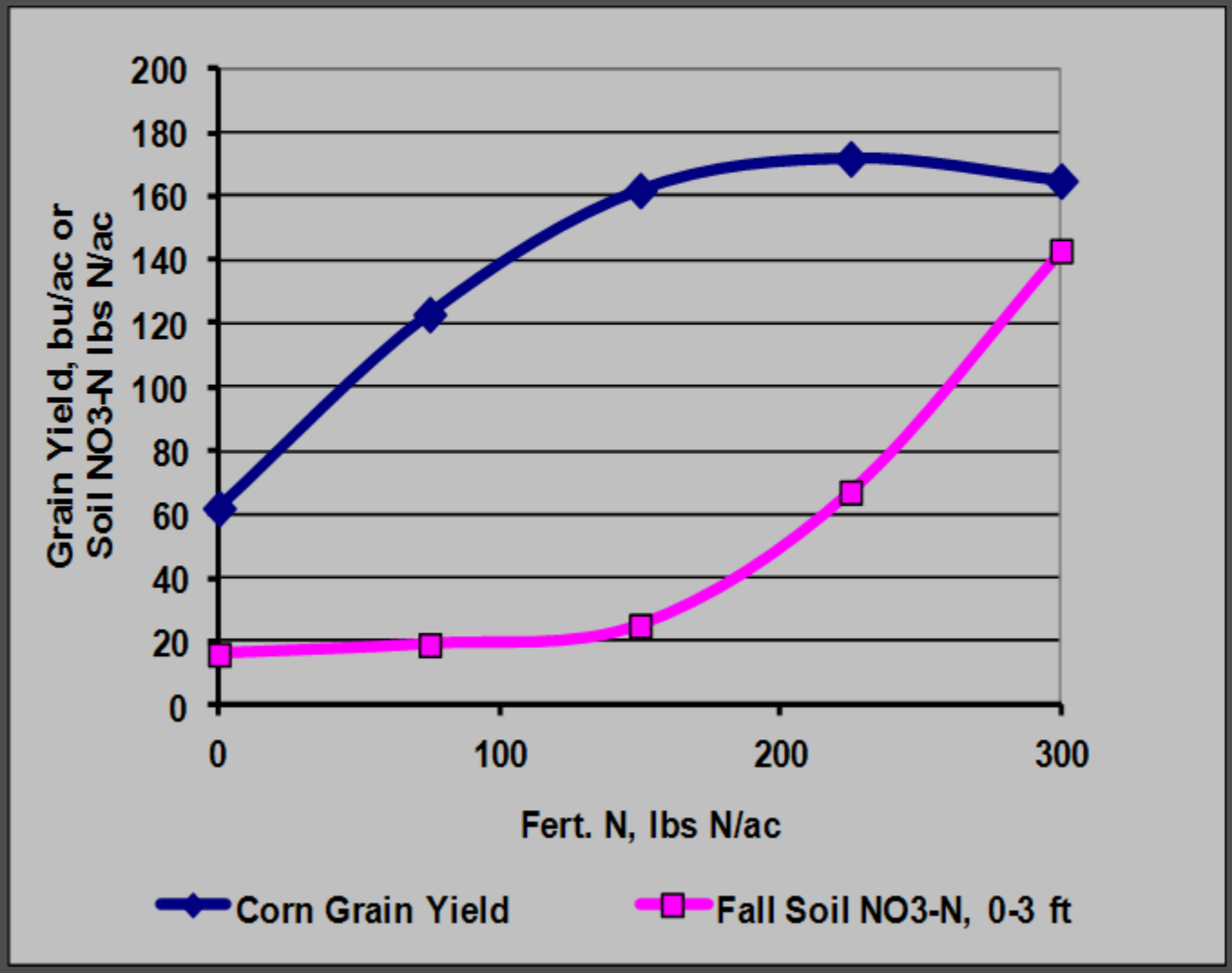
Relative NO3-N Data Sources

Source #	Citation
1:	Jemison & Fox, 1994, JEQ 23:337-343
2:	Roth & Fox, 1990, JEQ 19:243-248
3:	Ritter et al., 1990, J Irr & Drain Eng. 116:738-351
4:	Zhu & Fox, 2003, Agron. J. 95:1028-1033
5:	Parkin & Meisinger, 1989, JEQ 18:12-16 ; Meisinger Pers. Comm. (from deep soil cores)
6:	Toth & Fox, 1998, JEQ 27:1027-1033
7:	Owens, 1987, JEQ 34:34-38; Chichester, 1977, JEQ 6:211-217
8:	Angle, et al., 1989, Agr. Ecosys. & Environ. 25:279-286
9:	Spargo, 2009, Agron Abst. Poster & Pers. Comm.
10:	Staver, 2009, Pers. Comm. (from deep soil cores)
11:	Angle, et al., 1993, JEQ 22:141-147
12:	Stout et al., 2000, Agr. Ecosys. & Environ. 77:203-210
13:	Jabro et al., 1997, JEQ 26:89-94
14:	Owens et al., 2012, JEQ 41:106-113
15:	Wilson et al., 1995, Am. Soc. Agr. Eng. Spec. Pub. Clean Water, Clean Environ.- 21st Cent. vII pp 251-254.

What's the Link between Potential N Losses & N Application Rate?

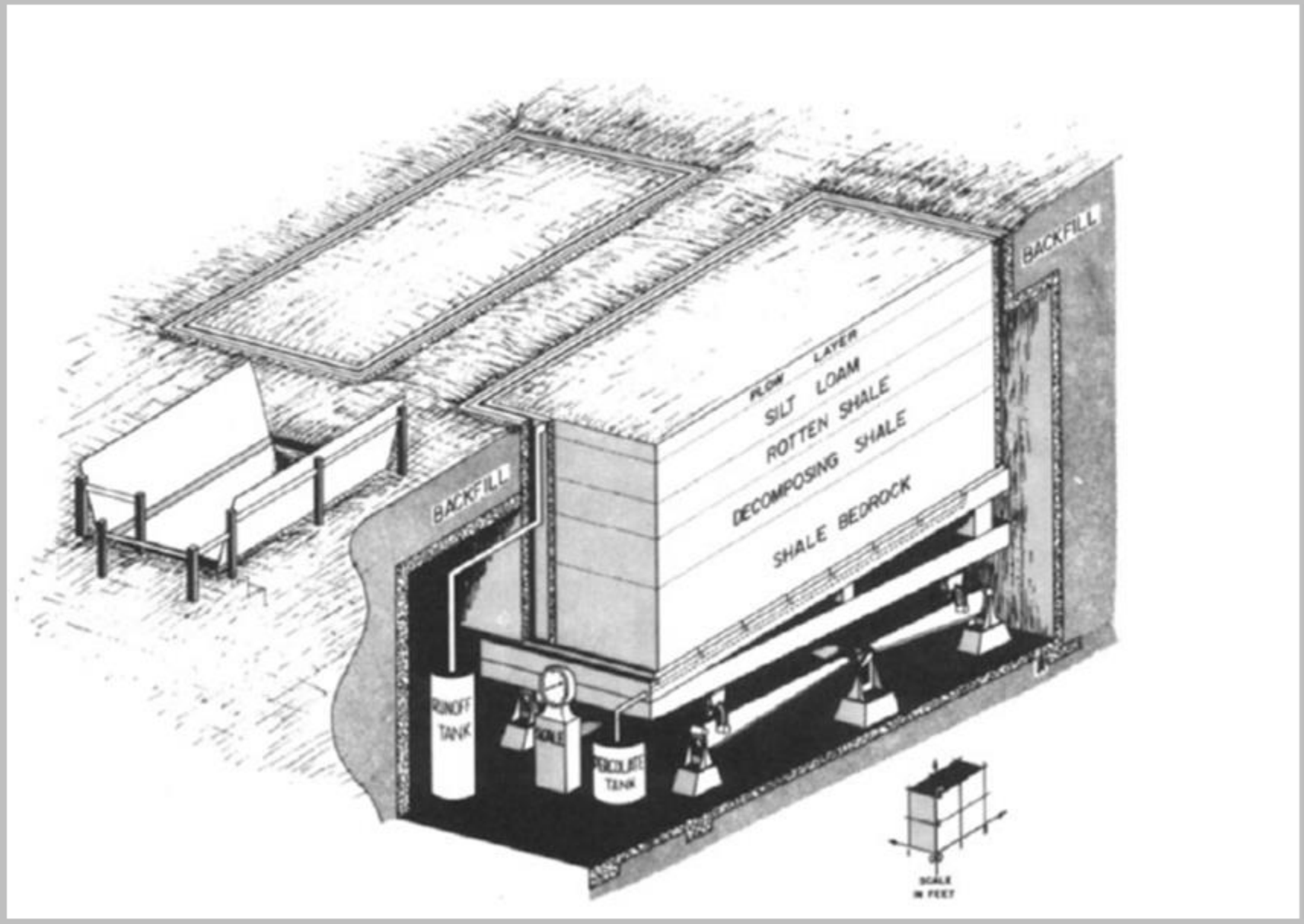
(adapted from Coale et al., 2000)

Cont. Corn, no CC, 3-yr study, Matapex silt loam, Lower Eastern Shore



Example Relative to Corn Ratio Estimate, Alfalfa, Monolith Lysimeters

Owens et al, 1987, JEQ 34:34-38



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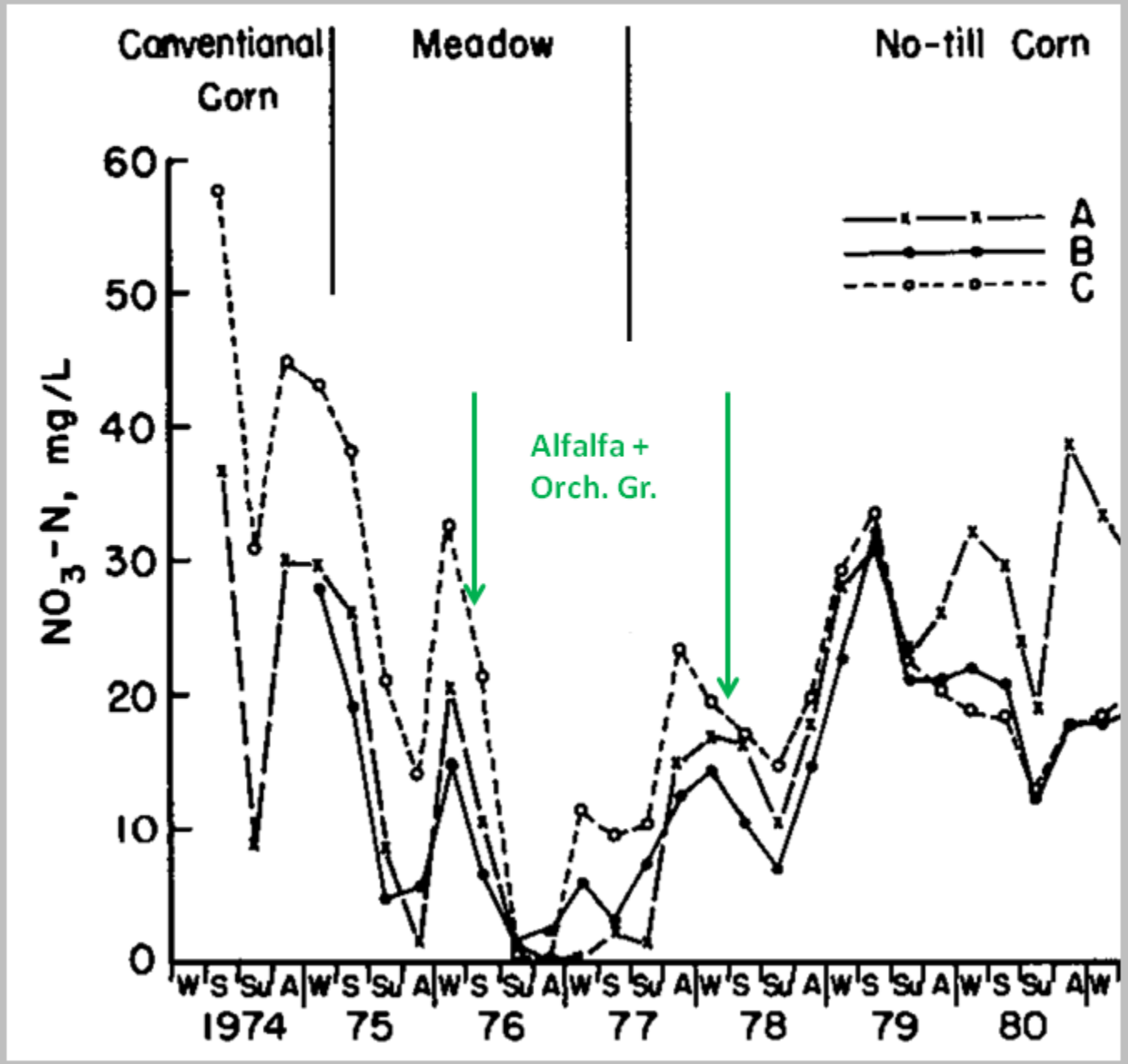

Lysimeter ID	Alfalfa Relative to Corn Ratio
Y102 A	0.181
Y102 B	0.137
Y102 C	0.211
2-year Avg.:	0.18 (0.02)

Nitrogen Loading Ratios

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7	**Sm gr w/ forage establ. - elig. for manure** [2]	0.84 (NA)	NA
8	**Other Agronomic Crops (cotton, tob., peanuts)** (15)	0.45 (1)	NA
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Notes: [1] Est. from ratio (Corn/Sor. Silage w/ man.)/(Corn/Sor. Grain w/ man.) = 1.62/1.4 = 1.16

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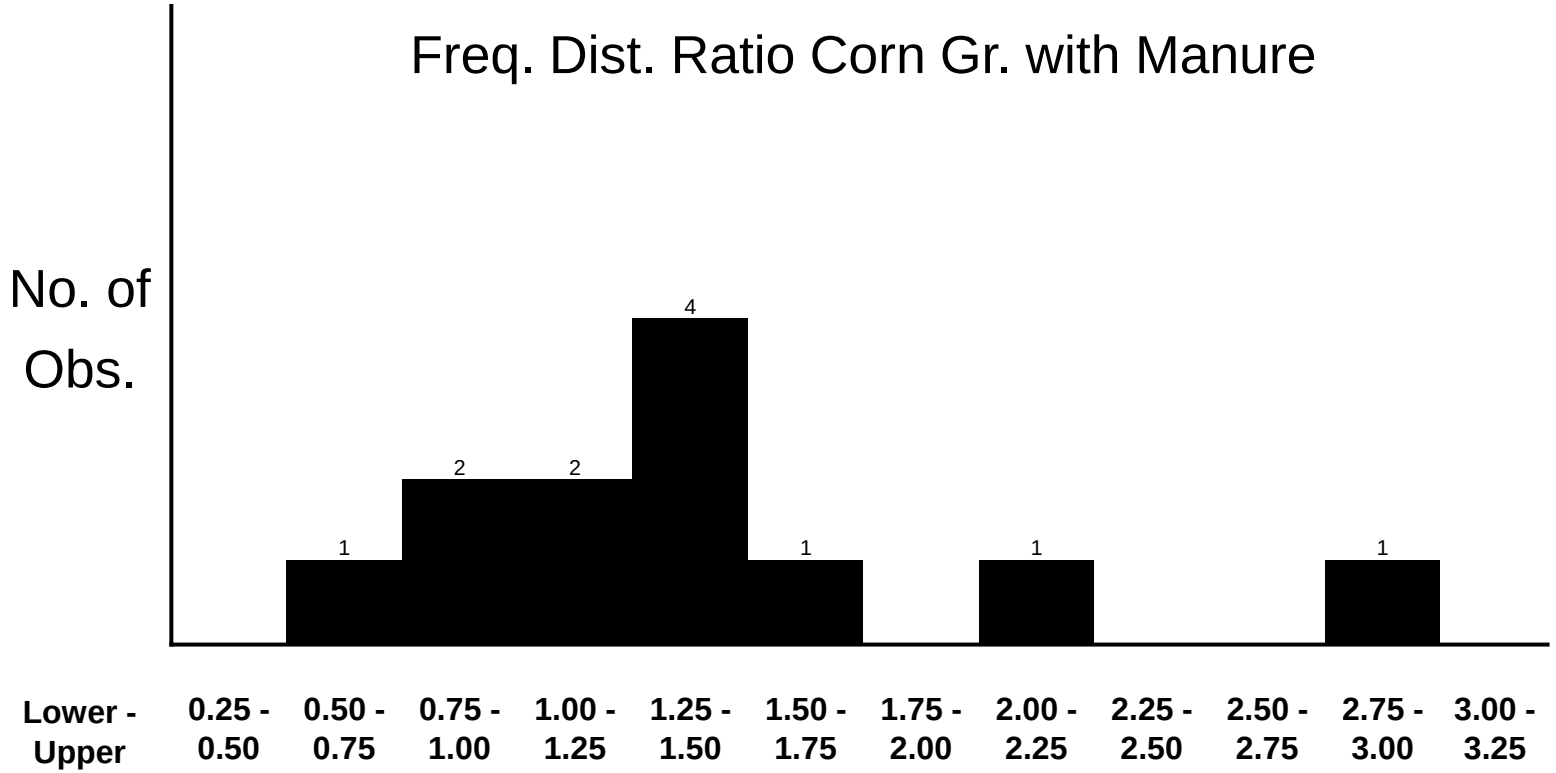
A Word of Caution for using Relative NO3-N Ratios



Sediment Loading Ratios

- Literature highly variable and incomplete for assessing geographical variability as well as variability among agricultural land uses.
- Traditional agricultural models for EOF erosion rates have been well vetted and relied on for farm conservation planning.
- RUSLE2 was already being used as a Scenario Builder input and incorporates factors that account for variability in geography as well as land use.
- RUSLE2 – best option for assessing relative sediment loading rates.
- Recommendation: Use common adjustment to all P6 agricultural land uses.

Phosphorus Loading Ratios

- Preliminary loads being generated by APLE.
- Sediment-attached P
  - Function of RUSLE2 relative erosion rates
  - Recommendation: use common adjustment factor.
- Dissolved P (manure, fertilizer, and soil P)
  - Manure and fertilizer are inputs specified from county-level and ag census data
  - Soil P is represented by county average soil P contents from annual soil test summaries (also incorporates geographic variability as well as land use)
  - Recommendation: use common adjustment factor.

Issues Identified with Application of RUSLE2 and APLE

Review of RUSLE2 Factors Assessed by TT for use in Scenario Builder

- Our Sub-group had reservations about the old RUSLE rates for pasture and hay relative to cropland (too high).
- Our review showed that RUSLE2 overall produced more reasonable erosion rates and relative rates, but
- There were inconsistencies in the evaluation of sub-factors for RUSLE2 factors between states and CMZs.
- Recommendation: use RUSLE2 as suggested previously, but sub-factors, particularly “crop canopy %” and “crop residue %” need improved scrutiny.

RUSLE2 Example 1: c-factor

State/CMZ Combinations

RUSLE2 Crop Type	DE	MD				NY	PA		VA			WV	c-factors by crop	
	59	4.1	59	65	66	4.1	4.1	65	64	66	67	62	average	median
Alfalfa Hay Harvested Area	0.09	0.05	0.17	0.12	0.01	0.04	0.04	0.10	0.01	0.01	0.01	0.08	0.06	0.05
Broccoli, spring												0.34	0.34	
Cabbage						0.40							0.40	
Corn & Wheat			0.06	0.21	0.06		0.07	0.07	0.27	0.06	0.07		0.11	0.07
Corn for Grain	0.21	0.15	0.21	0.17	0.19	0.14	0.15	0.15	0.19	0.20	0.21	0.16	0.18	0.18
Corn for Silage	0.43	0.32	0.40	0.35	0.37	0.33	0.34	0.34	0.41	0.43	0.46	0.38	0.38	0.37
Cucumber	0.53	0.34	0.53	0.66	0.21		0.13	0.35					0.39	0.35
Other managed hay Harvested Area	0.06	0.01	0.15	0.01	0.15	0.10	0.01	0.01	0.00	0.00	0.00	0.08	0.05	0.01
Pasture / Range	0.15	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.03	0.02	0.01
Potato	0.63	0.64	0.63	0.82	0.83	0.63			0.55	0.59	0.61	0.68	0.66	0.63
Snap Beans	0.58												0.58	
Soybean	0.30		0.30	0.21	0.24	0.17	0.19	0.19	0.21	0.22	0.24	0.23	0.23	0.22
Soybean & Wheat	0.03		0.15	0.13	0.15			0.12	0.18	0.20	0.20	0.13	0.14	0.15
Soybean Wheat - Relay							0.07						0.07	
Tomato									0.35	0.37	0.40		0.37	
Watermelon		0.18	0.24	0.23	0.24		0.22	0.22					0.22	0.23
Wheat for Grain	0.08		0.25	0.22	0.24	0.28	0.29	0.21	0.17	0.19	0.20	0.20	0.21	0.21
Average C-factors by state/CMZ	**0.28**	**0.21**	**0.26**	**0.26**	**0.22**	**0.22**	**0.14**	**0.16**	**0.21**	**0.21**	**0.22**	**0.23**	**0.22**	
Specialty - low and high inputs	0.58	0.39	0.46	0.57	0.43	0.51	0.18	0.29	0.45	0.48	0.50	0.51	0.45	0.47

(average of: broccoli, cabbage, cucumber, potato, snap beans, tomato, watermelon)

- low C-factor value relative to other state/CMZ average values for the same crop

- high C-factor value relative to other state/CMZ average values for the same crop

cmz = Crop Management Zones

RUSLE2 Example 2: crop residue %

Average of Monthly Crop Residue % for *Pasture/Range* Land Use

state	cmz	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
DE	**59**	31	30	24	18	16	21	27	22	16	25	29	33	**24**
MD	**4.1**	55	54	53	46	39	32	30	29	28	40	50	55	**43**
	59	20	19	33	47	36	38	50	47	38	26	22	21	**33**
	65	43	44	41	42	32	34	49	48	40	37	40	42	**41**
	66	44	44	41	40	30	33	48	47	38	36	40	43	**40**
NY	**4.1**	56	57	56	18	1	1	1	0	0	11	25	47	**23**
PA	**4.1**	7	7	6	5	4	3	6	9	9	6	6	7	**6**
	65	27	27	32	36	29	27	32	29	24	22	25	26	**28**
VA	**64**	32	39	36	34	33	32	30	27	26	24	24	24	**30**
	66	30	37	33	31	30	28	27	25	24	22	22	22	**27**
	67	29	36	33	31	29	28	26	24	23	21	21	22	**27**
WV	**62**	73	72	70	58	40	42	52	63	72	76	75	74	**64**

Review of Preliminary APLE Results

- Overall pasture P loading rates are too high.
- Recommendation: Verify that the latest version, APLE2.4 (2013), is being used, and that the ability to differentiate between manure from grazing animals and spread manure is being utilized.
- We expect lower rates once revised RUSLE2 inputs and updated Mehlich-3 soil P inputs are used, but would appreciate the opportunity to review when revisions are complete.

Final P6 Land Use Relative Loading Ratios

P6 Landuse		Relative N Loadings	Relative P Loadings		Relative Sediment Loadings
		(leaching + runoff)	(sediment-attached P)[4]	(dissolved P)[5]	(runoff)[6]
1	**Corn or sorghum grain - elig. for manure** (1, 2, 3, 10, 11)	1.40	**1.00**	**1.00**	**1.00**
2	**Corn or sorghum silage - elig. for manure** (10)	1.62			
3	**Corn or sorghum grain - no manure**	**1.00**			
4	**Corn or sorghum silage - no manure** [1]	1.16			
5	**Sm gr w/ soybean dbl.cr. - no manure** (9)	0.79			
6	**Full season soybean - no manure** (3, 10, 45)	0.71			
7	**Sm gr w/ forage establ. - elig. for manure** [2]	0.84			
8	**Other Agronomic Crops (cotton, tob., peanuts)** (15)	0.45			
9	**Pasture - direct dep; elig. for manure** (12, 13, 14)	0.23			
10	**Legume (or legume-grass mix) Hay** (6, 7)	0.17			
11	**Other Hay (perennial grasses, Or. Grass, T. fescue)** (12, 13)	0.24			
12	**Ag open space (per. grasses, Or. Grass, T. fescue)** (8)	0.10			
13	**Specialty- high input (potatoes, sweet corn, etc.)** (10)	1.34			
14	**Specialty - Low input (orchard, nursery st., peas)** [3]	0.31			

Notes: [1] Est. from ratio (Corn/Sor. Silage w/ man.)/(Corn/Sor. Grain w/ man.) = 1.62/1.4 = 1.16

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[3] Est. from Other Hay + 0.07 (due to greater loading w/ annuals) = 0.24 + 0.07 = 0.31

[4] Common factor adjustment to LRseg-based RUSLE2 erosion estimates.

[5] Common factor adjustment to LRseg-based APLE dissolved P estimates based on county soil test data.

[6] Common factor adjustment to LRseg-based RUSLE2 erosion estimates.