Agriculture Land Use Loading Rate Ratios

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Background:

- Pasture and Other Hay are the two largest Load Sources of agricultural acres across the Bay Watershed
  - They are significant in NY, PA, VA, and WV
- Phase 6 manure application could be improved
  - Pasture and Hay application goals were well below Land grant University Recommendations

Sum of AcresP6	DE	MD	NY	PA	VA	WV	Baywide
Ag Open Space	0.0%	1.3%	5.2%	2.8%	2.8%	2.5%	2.9%
Cropland	94.6%	78.0%	41.5%	54.3%	37.4%	12.7%	50.5%
Double Cropped Land	23.5%	18.2%	6.5%	8.8%	6.5%	1.8%	9.3%
Full Season Soybeans	21.4%	21.2%	4.9%	9.2%	11.5%	1.9%	10.7%
Grain with Manure	25.6%	12.3%	3.9%	8.4%	3.6%	1.4%	7.2%
Grain without Manure	11.6%	12.3%	6.0%	8.3%	5.9%	1.8%	7.7%
Other Agronomic Crops	4.8%	6.9%	8.6%	9.0%	6.0%	3.9%	7.5%
Silage with Manure	0.2%	1.1%	5.5%	4.5%	1.0%	0.5%	3.0%
Silage without Manure	0.0%	0.2%	1.0%	0.8%	0.2%	0.1%	0.5%
Small Grains and Grains	3.0%	3.8%	2.8%	2.9%	1.7%	0.5%	2.6%
Specialty Crop High	1.5%	0.7%	0.5%	0.5%	0.3%	0.1%	0.5%
Specialty Crop Low	2.9%	1.3%	1.8%	1.7%	0.7%	0.6%	1.4%
Leguminous Hay	0.6%	2.4%	15.7%	11.8%	1.8%	1.0%	7.9%
Other Hay	2.1%	8.4%	22.7%	17.1%	20.1%	31.3%	17.8%
Pasture	2.6%	9.8%	14.9%	14.0%	38.0%	52.4%	20.8%
Grand Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

New Land Uses Approved

- Two new Land Uses
  - Managed Hay
  - Managed Pasture
- Need to think about differences between new Land Uses and existing ones.
- *NOTE
  - Managed means higher application (aligned with Land Grant recommendations)
  - Naming being revisited

Chesapeake Bay Average	
Land class	Land Use
Pasture	Ag Open Space
	Legume Hay
	Other Hay
	Managed Hay*
	Pasture: **Reference Land Use**
	Managed Pasture *

Next Action Item:

- Need to create associated Loading Rate Ratio (LRR).
  - Basis to help distribute monitored loads to various modeled Land Uses during calibration and scenario runs.
- Follow the Phase 6 protocol:
  - "Ag Loading Rate Steering Committee" (2016).
    - Charge: work from literature review conducted by Tetra Tech and Water Stewardship Inc. to develop relative Land Use Loading Ratios for each Ag Land Use.
- AMT (2025) developed a subgroup to follow similar protocol to develop LRR for New Land Use: Managed Hay and Managed Pasture.

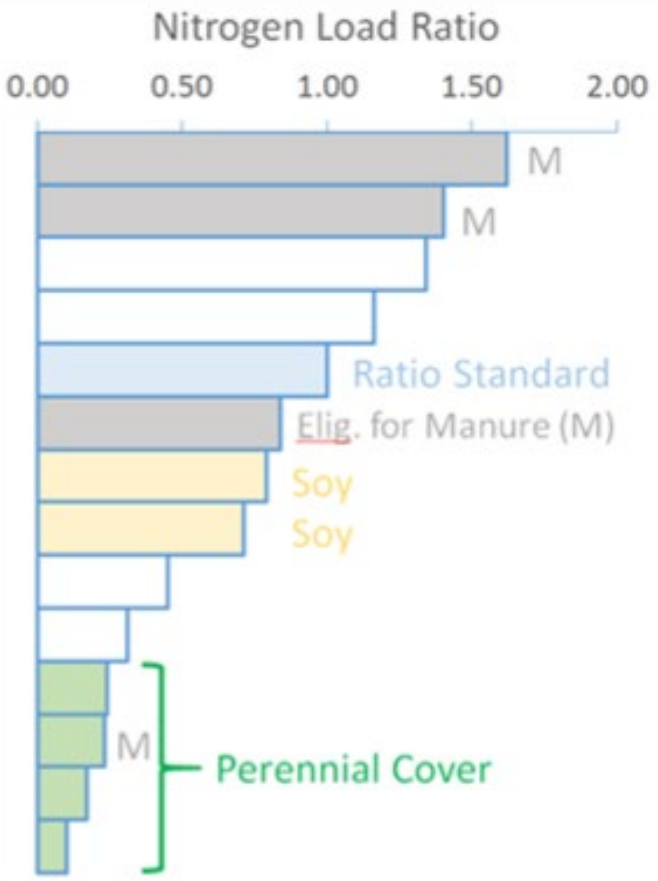
Subgroup Process

Initiated Feb 2025

- Pennsylvania
- Virginia
- UMD
- VT
- USGS

Perennial Grass ratio

	Load Ratio	Std Err
Corn Silage Manure	1.62	
Corn Grain Manure	1.40	0.20
Specialty High	1.34	
Corn Silage *	1.16	
Corn Grain	1.00	
Sm Grain & Forage M.*	0.84	
Sm Grain & Soy	0.79	0.09
Full Season Soy	0.71	0.11
Other Ag Crops	0.45	
Specialty Low *	0.31	
Other Hay	0.24	0.06
Pasture Manure	0.23	0.06
Legume or Mix	0.17	0.02
Ag Open	0.10	0.01



* BPJ estimate by analogies to other crops

Figure 2. Nitrogen Load Ratio Relative to Corn (or Sorghum) Grain Without Manure

Subgroup Process

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Extensive Lit Review and analysis discussion

- Less research available for grassland vs cropland.
- Little applicable research in the watershed found.
- Similar precedent for earlier development phases (phase 6).

Aligning with real world applications

- Current LGU Recommendation for N:
  - Fescue Hay 120-200 lbs.
  - Pasture 60-75 lbs.
- Adjustment of Literature high application loading values:
  - Managed Hay: 120/200 = 60%
  - Managed Pasture: 60/75 = 80%
- 80% used as a reduction factor, applied to literature data high values
- NOTE* AMT established N crop need for new Land Use (states have provided values based on LGU recommendations)

Literature data processing

- *Data from literature for pasture NO3 loss.*
- *"high" rates in literature were above high end of LGU recommendation.*
- ***Applied 80% reduction, as crop needs were set at 80% of LGU high,***

Proposed **Managed Pasture** Land Use Loading Rate Ratio = **1.52**

Proposed **Managed Hay** Land Use Loading Rate Ratio = **1.52 +0.04 = 1.56**

Difference between previous Hay and Pasture (.04) set by previous committee.

Loading Rate (Kg/ha/yr)	low application state (unmanaged)	high application state (managed)	80% high	Ratio (high/low)	z score
NO3	0.41	0.74	0.592	1.44	-0.46
NO3	29	49	39.2	1.35	-0.57
NO3	31	54	43.2	1.39	-0.52
NO3	42	65	52	1.24	-0.70
NO3	1.6	4.3	3.44	2.15	0.35

Example Calculations:

- Managed Pasture:
  - 11.8lbs./acre/yr * 1.52 = 17.9 lbs./acre/yr
- Managed Hay:
  - 11.8lbs./acre/yr * 1.56 = 18.4 lbs./acre/yr
- Proposed LRR place Managed Hay and Managed Pasture at top end of perennial grass systems Loading Rates.

Chesapeake Bay Average			
Land class	Land Use	Loading Rate Ratio	Loading Rate (pounds per acre per year)
Pasture	Ag Open Space	0.43	5.1
	Legume Hay	0.74	8.7
	Other Hay	1.04	12.3
	Managed Hay	1.56	18.4
	Pasture: **Reference Land Use**	1	11.8
	Managed Pasture	1.52	17.9

Pennsylvania expressed concerns:

- Small literature pool
- Lack of real world information

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- Similar precedent for earlier development phases (phase 6).

Additional Information sought

- Land Grant University Recommended application rates
- Nutrient Management Plans

New approach

- Target literature only if it focuses on areas like the Bay watershed
  - Nothing international
  - 80%, 85%, 90% ratios
- Collect new data from the watershed:
  - Land Grant recommended application and removal values
  - Nutrient management plans

Updated literature values

Removed as an outlier

Location	Source (Loss of NO3 kg/ha/yr)	low application state (unmanaged)	high application state (managed)	80%Ratio (high/low)	85%Ratio (high/low)	90%Ratio (high/low)
Georgia , USA	Field-Scale Nitrogen and Phosphorus Losses from Hayfields Receiving Fresh and Composted Broiler Litter R. W. Vervoort,* D. E. Radcliffe, M. L. Cabrera, and M. Latimore, Jr. 1998	1.6	4.3	2.15	2.28	2.42
North Carolina, USA	1Nutrient Losses from Fertilized Grassed Watersheds in Western North Carolina V. J. Kilmer,2 J. W. Gilliam,a J. F. Lutz,a R. T. Joyce,4 a4nd C. D. Eklund 1974	2.36	10.34	3.51	3.72	3.94
Georgia, USA	Flue Gas Desulfurization Gypsum: Implication for Runoff and Nutrient Losses Associated with Broiler Litter Use on Pastures on Ultisols Dinku M. Endale,* Harry H. Schomberg, Dwight S. Fisher, Dorcas H. Franklin, and Michael B. Jenkins 2014	0.25	0.18	0.58	0.61	0.65
Georgia, USA	Flue Gas Desulfurization Gypsum: Implication for Runoff and Nutrient Losses Associated with Broiler Litter Use on Pastures on Ultisols Dinku M. Endale,* Harry H. Schomberg, Dwight S. Fisher, Dorcas H. Franklin, and Michael B. Jenkins 2014	0.2	0.26	1.04	1.11	1.17
			AVERAGE RATIO:	1.26	1.33	1.41

Potential Literature Based Loading Rate Ratios:

- 80% ratio - 1.26
  - 1.26*11.8 = 14.9 lbs./acre/year
- 85% ratio - 1.33
  - 1.33*11.8 = 15.7 lbs./acre/year
- 90% ratio - 1.41
  - 1.41*11.8 = 16.6 lbs./acre/year

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Pasture	Ag Open Space	0.43	5.1
	Legume Hay	0.74	8.7
	Other Hay	1.04	12.3
	Managed Hay	1.30	???
	Pasture: **Reference Land Use**	1	11.8
	Managed Pasture	1.26	???

Example Calculations:

- Managed Pasture:
  - 11.8lbs./acre/yr * 1.26 = 14.9 lbs./acre/yr
- Managed Hay:
  - 11.8lbs./acre/yr * 1.30 = 15.3 lbs./acre/yr

Chesapeake Bay Average			
Land class	Land Use	Loading Rate Ratio	Loading Rate (pounds per acre per year)
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	Legume Hay	0.74	8.7
	Other Hay	1.04	12.3
	Managed Hay	1.30	15.3
	Pasture: **Reference Land Use**	1	11.8
	Managed Pasture	1.26	14.9

New state relevant information:

- N application recommendations for Hay:
  - MD = 50 lbs./acre per ton
  - PA = 50 lbs./acre per ton
  - WV = 35 lbs./are per ton
  - DE = 40-60 lbs./acre per ton
  - NY = 50 lbs./acre per ton
  - VA 40 lbs./acre per ton
    - Nutrient management plan information indicates closer to 50
- Nitrogen Removal = [(% Crude Protein/Crude Protein Conversion)*(Lbs. Dry matter/# acres)]

Calculating N removal from state information

- Nitrogen Removal = [(% Crude Protein/Crude Protein Conversion)*(Lbs. Dry matter/# acres)]
- Pa based values for Crude Protein and Moisture
  - Crude = 8-20%
  - Moisture = 11-16%
- Ball, et. al., 2001
  - *Fertilizing with nitrogen generally increases the crude protein level of grasses*
- Lets assume:
  - CP% = 15
  - DM % = 12

		1800 lbs. dry matter	1760 lbs. dry matter	1700 lbs. dry matter	1640 lbs. dry matter
CP%	N	DM 10%	DM 12%	DM 15%	DM 18%
10	0.015	27	26.4	25.5	24.6
12	0.019	34.2	33.44	32.3	31.16
15	0.024	43.2	42.24	40.8	39.36
18	0.028	50.4	49.28	47.6	45.92

Metadata analysis of MANAGE database

- Derived from the MANAGE database
- All studies from OK, TX, AK
- Difficult to separate hay and pasture without more in-depth reading of sources
- Some study sites include conservation practices that might be considered BMPs (reductions in load) in CAST
- Ratio of 1.56

Metadata analysis of MANAGE database

Sources

- Edwards, D.R., T.C. Daniel, J.F. Murdoch, and P.A. Moore, Jr. 1996. Quality of Runoff From Four Northwest Arkansas Pasture Fields Treated with Organic and Inorganic Fertilizer. Trans. ASAE 39(5): 1689-1696.
- Harmel, R.D., H.A. Torbert, B.E. Haggard, R. Haney, and M. Dozier. 2004. Water Quality Impacts of Converting to a Poultry Litter Fertilization Strategy. J. Environ. Qual. 33:2229-2242.
- Menzel, R.G., E.D. Rhoades, A.E. Olness, and S.J. Smith. 1978. Variablility of Annual Nutrient and Sediment Discharges in Runoff from Oklahoma Cropland and Rangeland. J. Environ. Qual. 7(3): 401-406.
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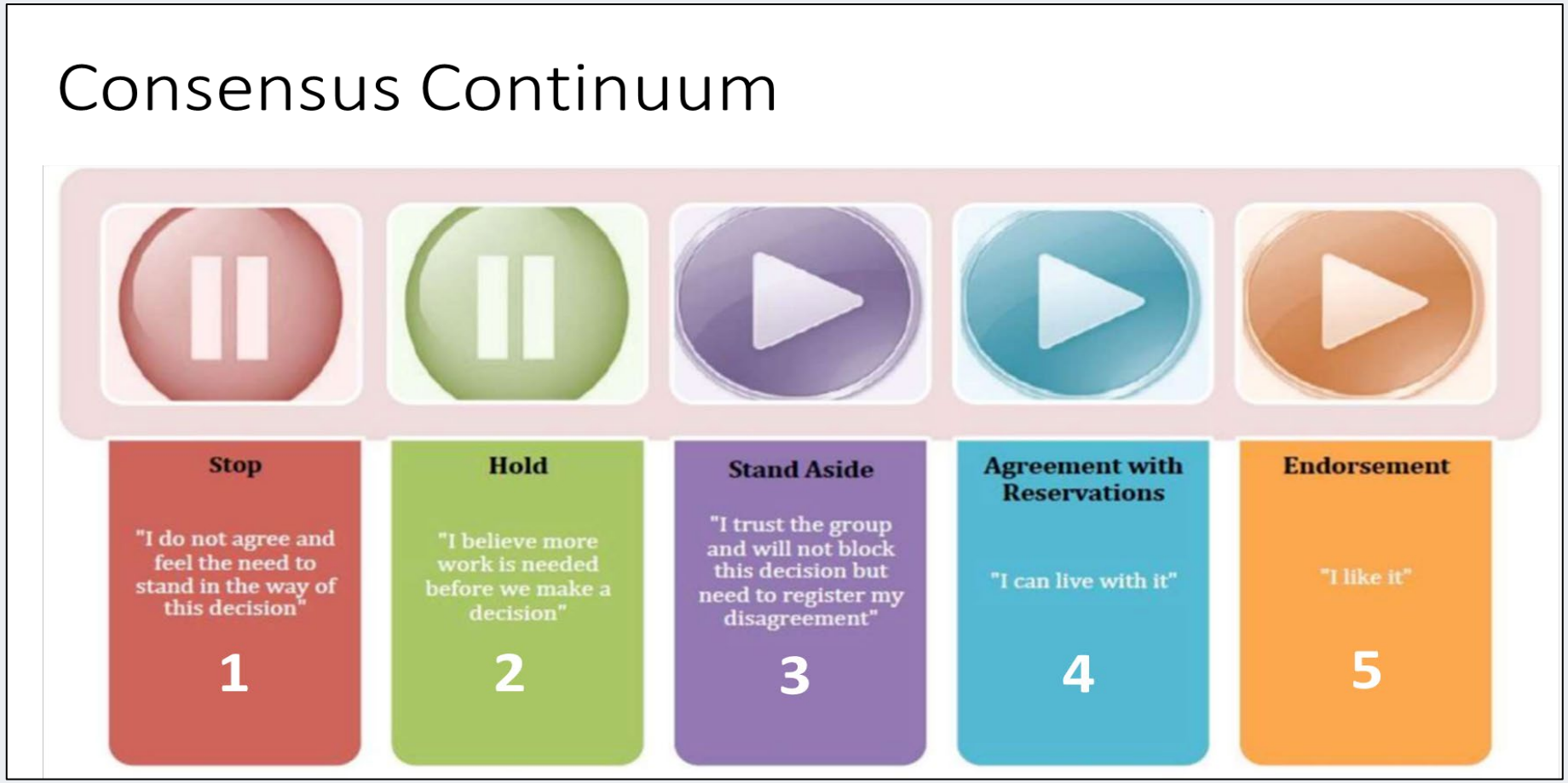
- Smith, S.J., A.N. Sharpley, J.W. Naney, W.A. Berg, and O.R. Jones. 1991. Water Quality Impacts Associated with Wheat Culture in the Southern Plains. J. Environ. Qual. 20:244-249.
- Smith, S.J., A.N. Sharpley, W.A. Berg, J.W. Naney, and G.A. Coleman. 1992. Water Quality Characteristics Associated with Southern Plains Grasslands. J. Environ. Qual. 21:595-601.

Questions?

Decision:

- We should adopt the following Land Use Loading Rate Ratios:
  - Managed Pasture (High Application) = 1.26
  - Managed Hay (High Application) =1.30



Decision:

- We should alter the names of the following Land Uses as follows:
  - Managed Pasture => Pasture High
  - Managed Hay => Hay High