

# Agriculture Land Use Loading Rate Ratios

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# Framing the discussion

The AMT is improving the representation of Agriculture for the Phase 7 CAST update.

AND



This led to the creation of two additional Land Uses to representing pasture and hay.

BUT



These new Land Uses require a ratio to define their Nitrogen load.

THEREFORE



The AMT reached a consensus decision on the Loading Rate Ratios for these new Land Uses.

# Phase 7 Improvements

## Reevaluation of Pasture and Hay representation

- Evaluation of manure spread algorithm-> motivation to assess current crop nutrient needs set for land use.

Pasture/Hay currently receive a small fraction of Land Grant University (LGU) recs for nutrient application.

- Result: more manure/nutrients allocated to cropland. Causing manure/nutrient excess allocated to cropland.

## Consensus creation of new Land Uses

- New Land Uses for Hay and Pasture
- Established application goals based on the low end of LGU recommendation,
- Created ratios for Non-Nutrient Management condition
- Remaining decision is how these Land Uses will load N to the water.

## Improved the application of manure nutrients to updated Land Uses

- Manure application consistent with perceived behavior and LGU recommendations

# What are the new Land Uses?

\* Already existed in  
CAST Phase 6

## \*Other Hay -

Hay crops that exclude species that fix nitrogen such as alfalfa and clover. Fertilizer and/or manure may be applied. Includes haylage, grass seed, and failed crops.

## Hay High-

Hay crops that exclude species that fix nitrogen such as alfalfa and clover. Fertilizer and/or manure are **applied to LGU recs**. In addition to the BMPs eligible on Other Hay, this load source is eligible for Core and Enhanced NM practices. Includes haylage and grass seed. (Excludes the failed crops)

## \*Pasture -

Land used for pasture or grazing animals. Fertilizer and/or manure may be applied in addition to directly excreted manure.

## Pasture High -

Land used for pasture or grazing animals. Fertilizer and/or manure are **applied to LGU recs** in addition to directly excreted manure. In addition to the BMPs eligible on Pasture, this load source is eligible for Core and Enhanced NM practices.



# Phase 7 CAST Ag Land Uses

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

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

# February decision to add Land Uses

Phase 6

## Group 1

Grain with manure

Silage

Small Grains

Double cropped

Other crops

Specialty (high and low)

## Group 2

Other Hay

Pasture

## Group 3

Soybeans

Legume Hay

Phase 7

## Group 1

Grain with manure

Silage with manure

Hay High

Pasture high

## Group 2

Small Grains

Double cropped

Other crops

Specialty (high and low)

## Group 3

Other Hay

Pasture

## Group 4

Soybeans

Legume Hay

# Things to consider:

- **IF we change Land Use (LU), we need to change the associated Loading Rate Ratio (LRR)**
  - If we create a new Land Use (Hay/Pasture), we need to develop the associated LRRs
- Loading Rate Ratio (LRR) = The LRR relates the estimated amount of nitrogen, phosphorus, or sediment exported from a land use to a “reference land use”



# We ran a test in CAST:

Application rates for hay and pasture are changed to:

- N=120 and P=40 for Hay High (all crops)
- N=60 and P=30 for Pasture High

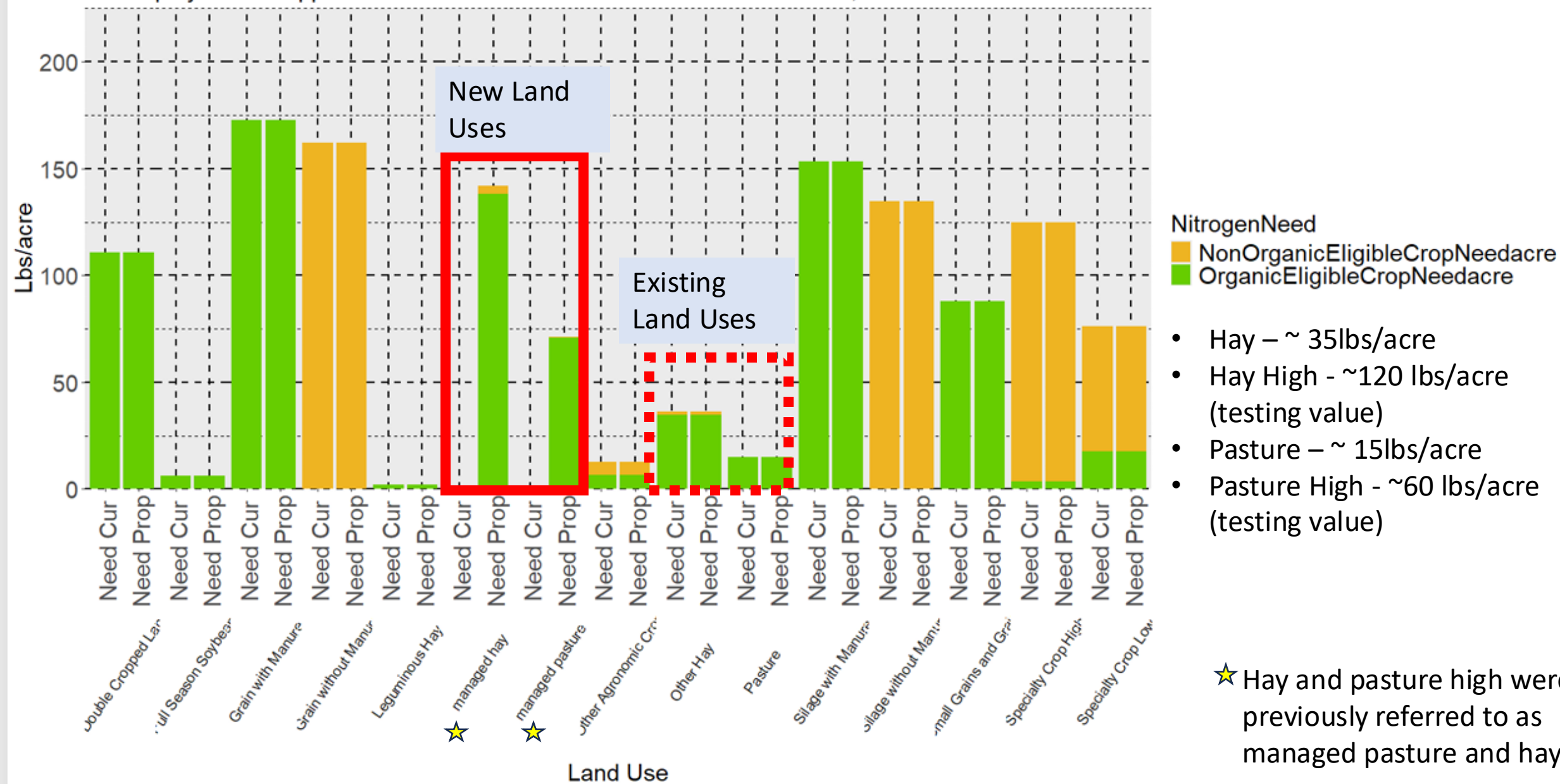
25% of hay acres = High application

10% of pasture acres = High application

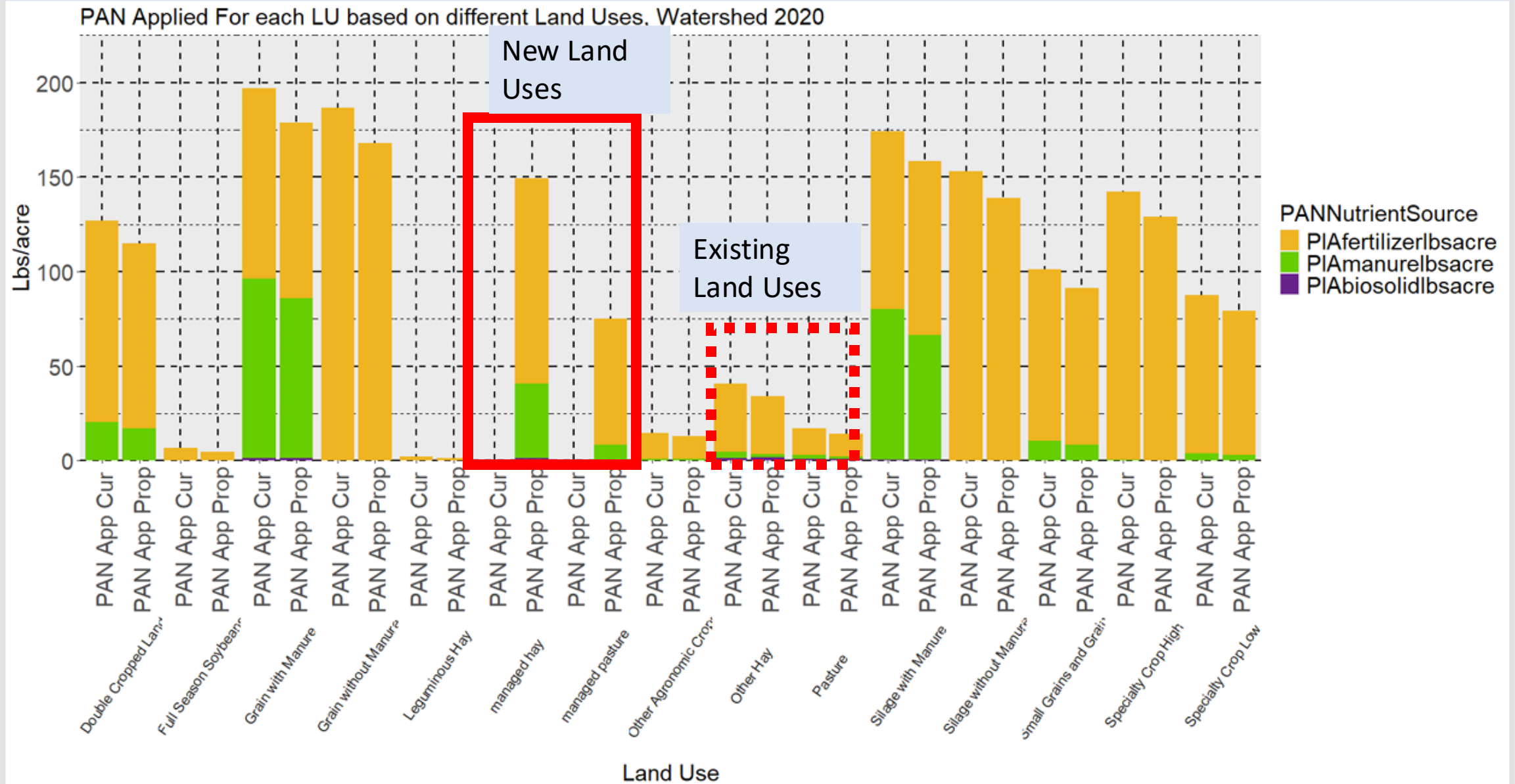
N NonNM factor for managed hay and pasture = 1.2

P NonNM factor for managed hay and pasture = 1.0

CAST projected N Application For each LU based on different Land Uses, Waterhsed 2020



- Plot denotes the expected N application goal for each CAST Land Use as per AMT testing guidelines



- Plot denotes the expected N application for each CAST Land Use resulting from AMT test run
- Application shifts across multiple land uses
- Important – application does NOT equal load

# New Land Uses Approved

- Next Action Item: 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: Hay High and Pasture High.

# Subgroup Process

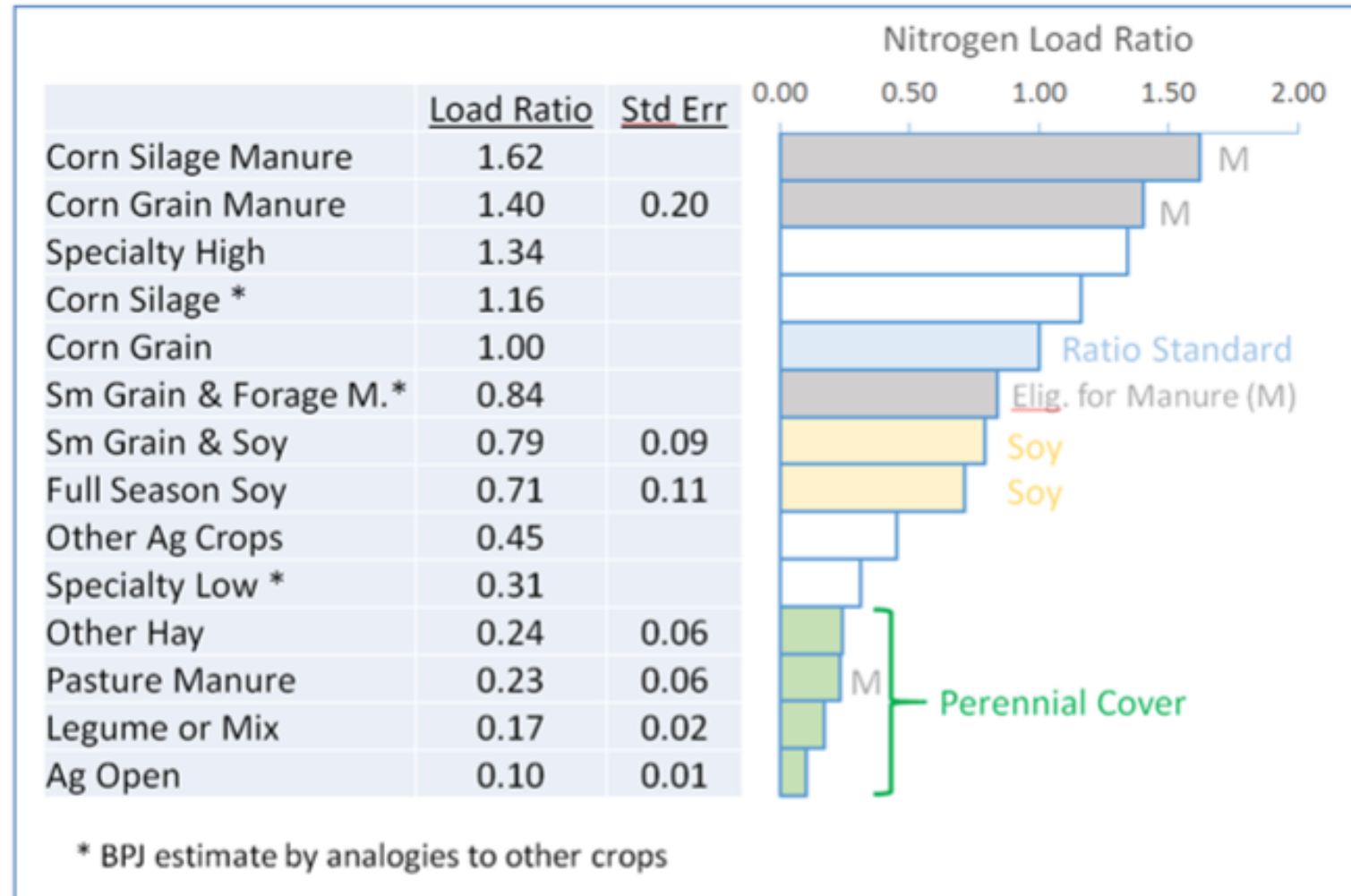
Initiated Feb 2025

- Pennsylvania
- Virginia
- UMD
- VT
- USGS

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).

# Subgroup concern: Perennial Grass ratio



Additional rates from Chapter 2 table 2.7:

- **Ag**
- Full Season Soybean 27.7
- Other Agronomic 17.6
- Specialty Low 12.1
- Other Hay 12.3
- Pasture 11.8
- **Non - Ag**
- MS4 Construction 26.80
- MS4 Tree Canopy over Turfgrass 8.53
- Non-Regulated Turf Grass 11.19
- Harvested Forest 11.88

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



# Land Grant University Recommendations for Pasture and Hay

Current LGU Recommendation for N:

- Fescue Hay 120-200 lbs.
- Pasture 60-75 lbs.
  - AMT approved Crop need:
    - Hay High = 120 lbs. N
    - Pasture High = 60 lbs. N
- Adjustment of Literature high application loading values
  - Hay High:  $120/200 = 60\%$
  - Pasture High:  $60/75 = 80\%$
  - 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)

## Fescue, Tall - Perennial (*Festuca arundinacea*)

Description	Long-lived, tufted, deep-rooted; noted for early spring and late fall growth; leaves are dark green, shiny, and barbed along the edges, making them feel rough; leaves rolled in bud; very short ligule; sheath reddish pink belowground. Most existing tall fescue stands are infected with a fungal endophyte that induces fescue toxicosis in cattle.
Varieties	Endophyte-free varieties are somewhat less hardy than endophyte-infected tall fescue, requiring more careful management. Modern endophyte-free varieties are stronger than earlier varieties. Endophyte-enhanced varieties have potential for greater adoption.
Uses	Pasture, hay, and turf. Excellent when seeded at high rates for turf. Widely used for winter grazing.
Weight per bushel	24 lbs
Seeds per pound	220,000
Germinating time	14 days
Fertilizer	Establishment: 40 lbs N, 120-140 lbs $P_2O_5$ , and 120-140 lbs $K_2O$ at medium soil test levels. Pasture topdressing 30 lbs $P_2O_5$ and 30-60 lbs $K_2O$ annually, or 40-125 lbs $P_2O_5$ and $K_2O$ every 3-4 years. (For winter grazing, apply 60-75 lbs N in mid-August.) Hay topdressing: 120-200 lbs N, 40-90 lbs $P_2O_5$ , and 85-185 lbs $K_2O$ . For turf, see Turf section.
pH range	5.6-6.2
Soil adaptation	Adapted to practically all tillable soils. Tolerant to both dry and wet soils.
Time of planting	Early fall or spring at 15-25 lbs when seeded alone, and 6-12 lbs in mixtures for pasture; 4-6 lbs per 1,000 sq ft for turf.
Harvesting (hay)	First cut when heads begin to emerge. <b>Stems and seedheads of endophyte-infected fescue are highly toxic.</b> Approximate yields 2-6 tons hay/A.
Harvesting (seed)	When the field takes on a yellowish-brown cast and heads droop.
Harvesting (pasture)	Tolerant of continuous stocking. With rotational stocking, turn in at 8 inches; remove cattle at 2-3 inches. Keep vegetative to reduce potential problems with endophyte. <b>Remove pregnant mares from endophyte-infected fescue during last 3 months of gestation.</b>

# Reprocessing: 80% of LGU application

- 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 **Pasture High** Land Use Loading Rate Ratio = **1.52**

Proposed **Hay High** 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	high application state	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:

- Pasture High example math:
- $11.8 \text{ lbs./acre/yr} * 1.52^* = 17.9 \text{ lbs./acre/yr}$
- Proposed LRR place Hay High and Pasture High 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
	Hay High	1.56	18.4
	Pasture: Reference Land Use	1	11.8
	Pasture High	1.52	17.9

Pennsylvania expressed concerns:

Small literature pool

Lack of real-world information

# Subgroup Process

Initiated Feb 2025

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Extensive Lit Review and analysis discussion

- Less research available for grassland vs cropland.
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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 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 =  $[(\% \text{ Crude Protein} / \text{Crude Protein Conversion}) * (\text{Lbs. Dry matter} / \# \text{ acres})]$

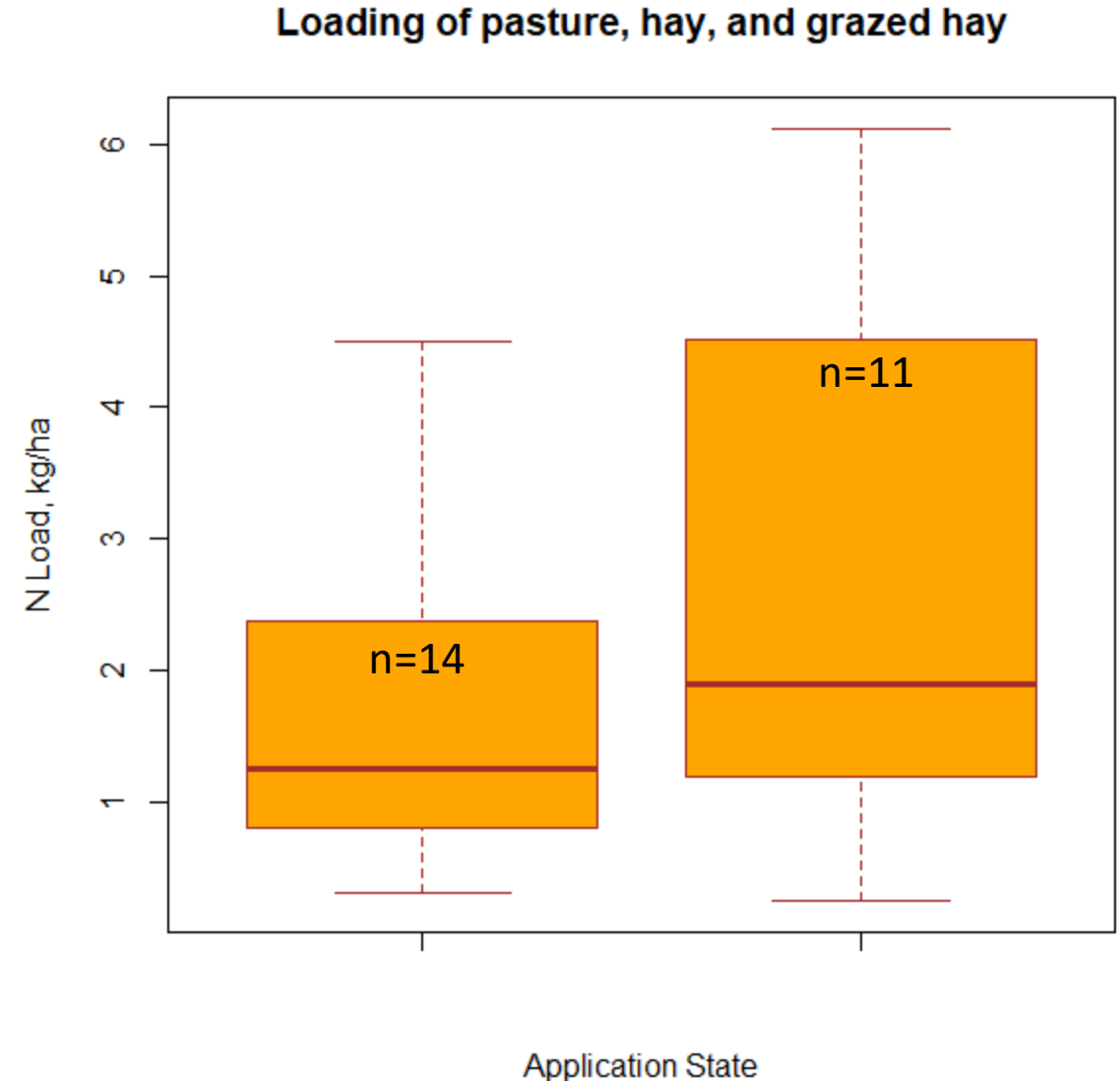
# Calculating N removal from state information

- Nitrogen Removal =  $[(\% \text{ Crude Protein} / \text{Crude Protein Conversion}) * (\text{Lbs. Dry matter} / \# \text{ acres})]$
- [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
- Roughly 15-20 % of N remains on field

		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



# Proposed Ratios:

- Pasture High:
  - 1.26
- Hay High:
  - 1.30

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
	Hay High	1.30	??
	Pasture: Reference Land Use	1	11.8
	Pasture High	1.26	??

# Example Calculations:

- Pasture High:
  - $11.8 \text{ lbs./acre/yr} * 1.26 = 14.9 \text{ lbs./acre/yr}$
- Hay High:
  - $11.8 \text{ lbs./acre/yr} * 1.30 = 15.3 \text{ lbs./acre/yr}$

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
	Hay High	1.30	15.3
	Pasture: Reference Land Use	1	11.8
	Pasture High	1.26	14.9



# Decision:

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

## Consensus Continuum



Questions?