Poultry Litter data update

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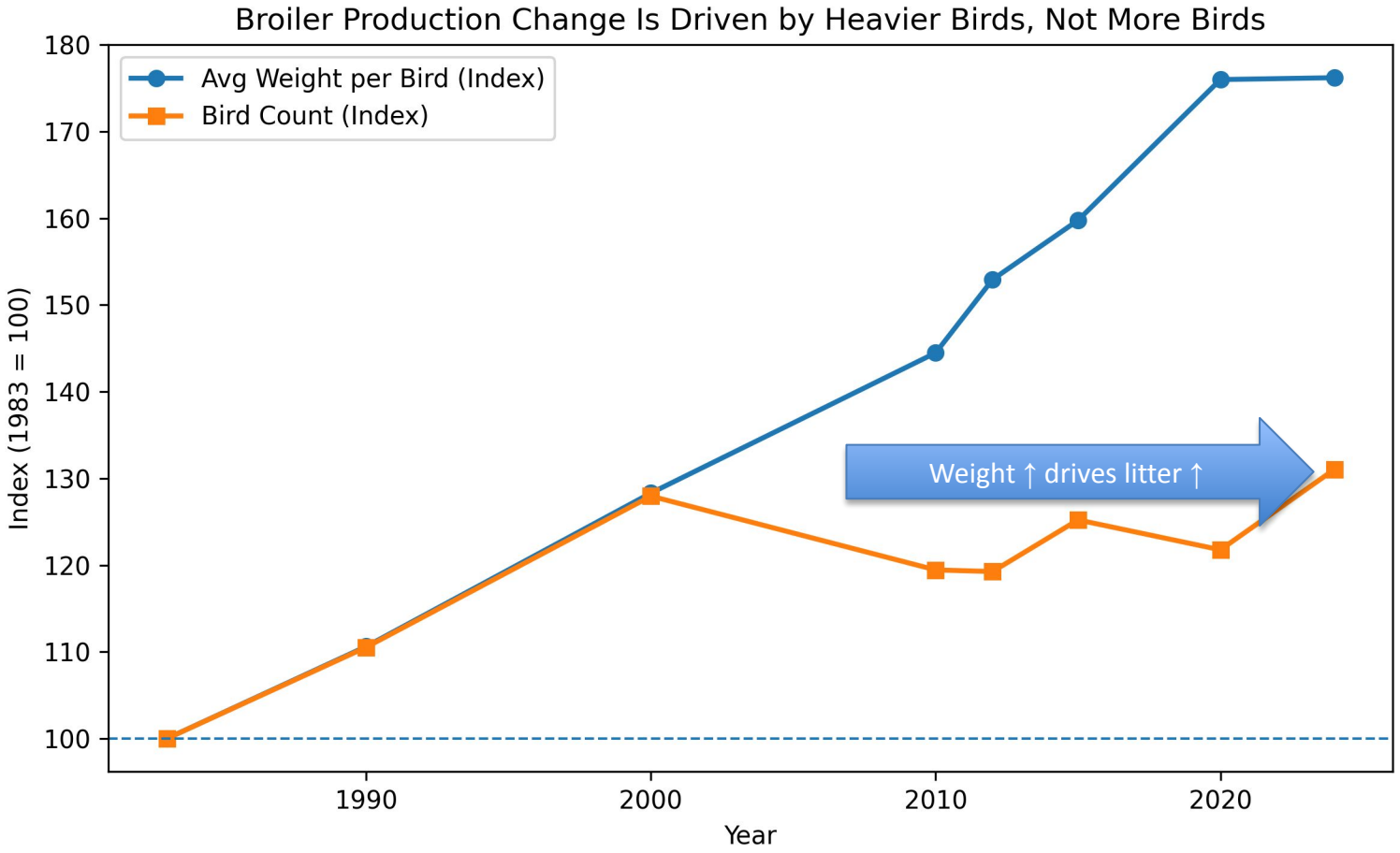
Why Phase 6 comparability matters

- Phase 6 Watershed Model coefficients are defined using *dry-basis nutrient concentrations* and elemental phosphorus (P) *on a per bird basis*.
  - This analysis processes post-2015 laboratory data using the same framework.
  - Ensures comparisons to Phase 6 benchmarks are technically valid and scientifically defensible.
  - BUT, some static constants appear to be trending through time
  - Report: https://tinyurl.com/52ake6xf

Why Phase 6 Modeled Litter Volume Using Bird



- Average broiler market weight increased ~76% since 1983.
- Bird counts remained relatively stable after the 1990s.
- Total poultry output increased primarily due to heavier birds.
- Phase 6 tied litter volume to bird weight,

(Eq. 4) - *Lbs of Litter/Bird Produced = 0.312971 X (Average Bird Market Weight) + 0.732730*.

Appendix B - Orientation

Appendix B. Nutrients Produced Per Bird

Broilers

DE	Average Lbs Market Weight/Bird	Wet Lbs Litter/Bird	Dry Lbs/Lb Wet Litter	Dry Lbs Litter/Bird	Lbs P/Dry Lb of Litter	Lbs P/Bird	Lbs N/Dry Lb Litter	Lbs N/Bird
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Average Lbs Market Weight/Bird

Wet Lbs Litter/Bird

Dry Lbs/Lb Wet Litter

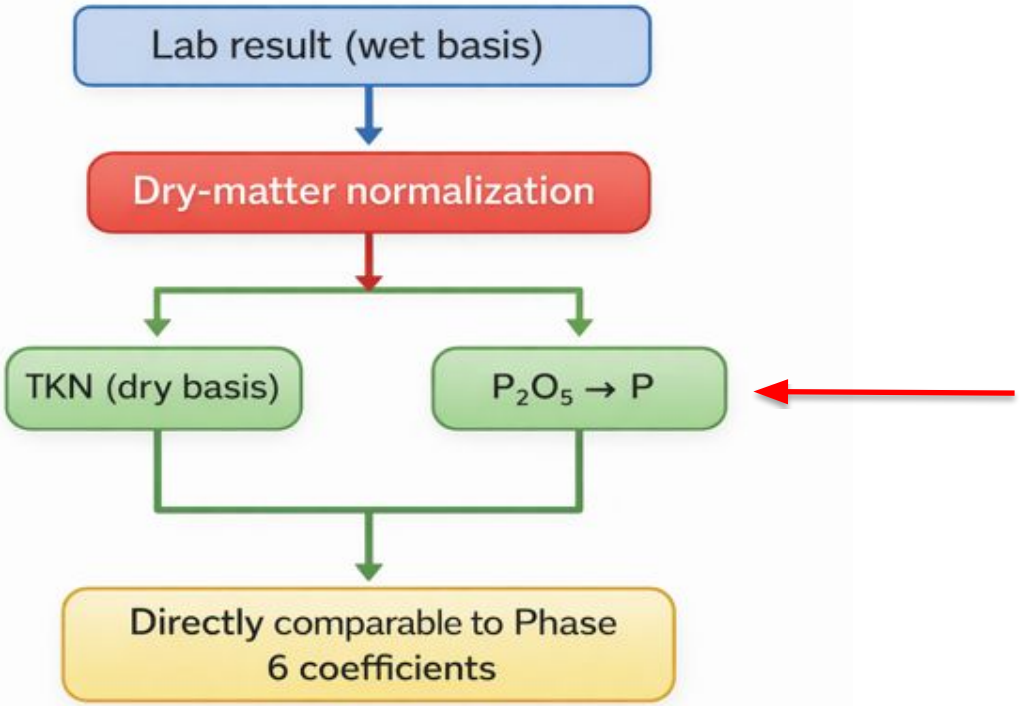
Dry Lbs Litter/Bird

Lbs P/Dry Lb of Litter
Lbs P/Bird
Lbs N/Dry Lb Litter
Lbs N/Bird

Phosphorus chemistry alignment (P2O5 → elemental P)

Phase 6 coefficients defined for elemental phosphorus (P).

- If lab results are reported as P_2O_5, convert to elemental P
- for Phase 6 comparability:
  - $P = P_2O_5 \times (62/142) = P_2O_5 \times 0.4366$



Where the Phase 6 benchmark lines come from

Equation 1. Poultry Phosphorus Production Based on Litter (Used for Broilers)
Lbs of P/Year = (Lbs of Litter/Bird Produced) X (Lbs of Dry Matter/Lb of Litter) X (Lbs of P/Lb of Dry Matter) X (Birds Produced/Year)

- Phase 6 defines broiler litter nutrient concentrations on a dry-matter basis (lb nutrient / lb dry litter).
- Appendix B (Broilers): lb N / lb dry litter = 0.046215; lb P / lb dry litter = 0.018336.
- Convert to lb/ton dry matter: multiply by 2000 → N = 92.43 lb/ton DM; P = 36.67 lb/ton DM.

Appendix B. Nutrients Produced Per Bird

Broilers

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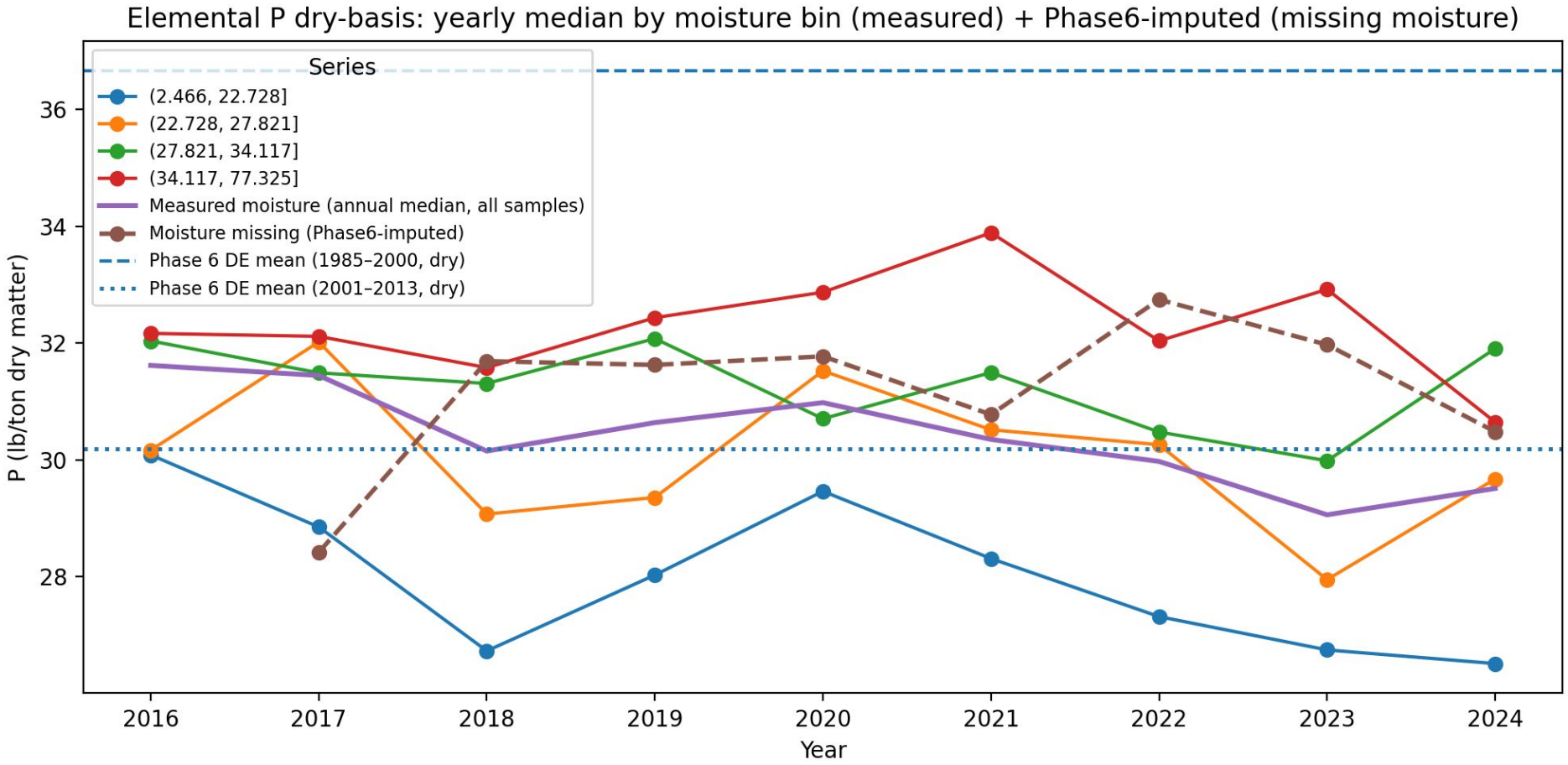
Manure Data

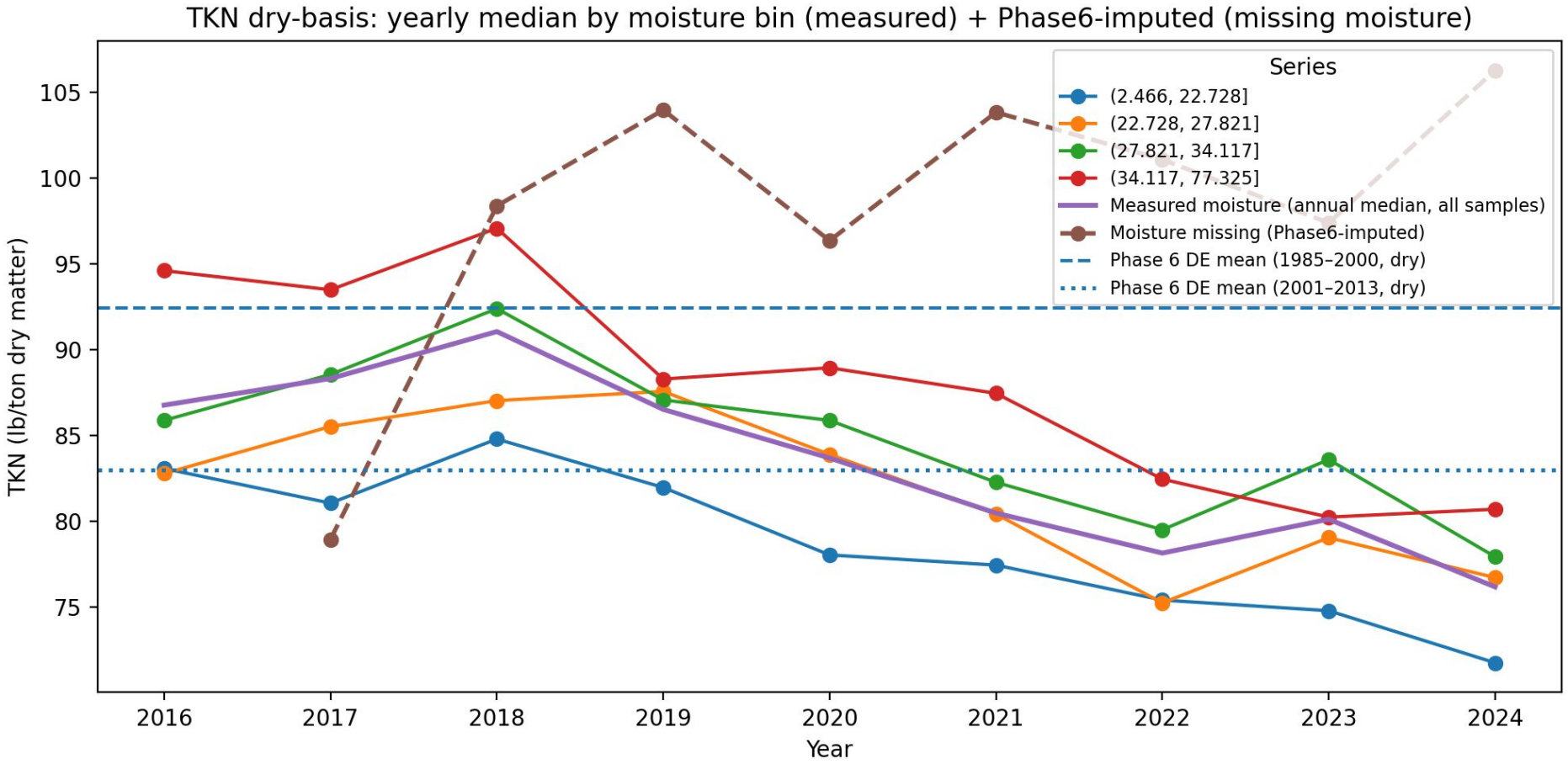
Poultry Phosphate and Potash

2024: P2O5 48.73 lbs./ton K2O 62.30 lbs./ton



Elemental P results, dry basis

- Elemental P converted from lab-reported P2O5.
- Normalized to dry-matter basis.
- Median dry-basis P consistently below Phase 6 benchmark.



Example: Total Nitrogen (TKN), dry basis

- Solid lines use measured moisture or dry matter.
- Purple Dashed line uses Phase 6 dry-matter assumption.
- Horizontal dashed line (Blue) shows Phase 6 benchmark (~92.4 lb/ton DM).

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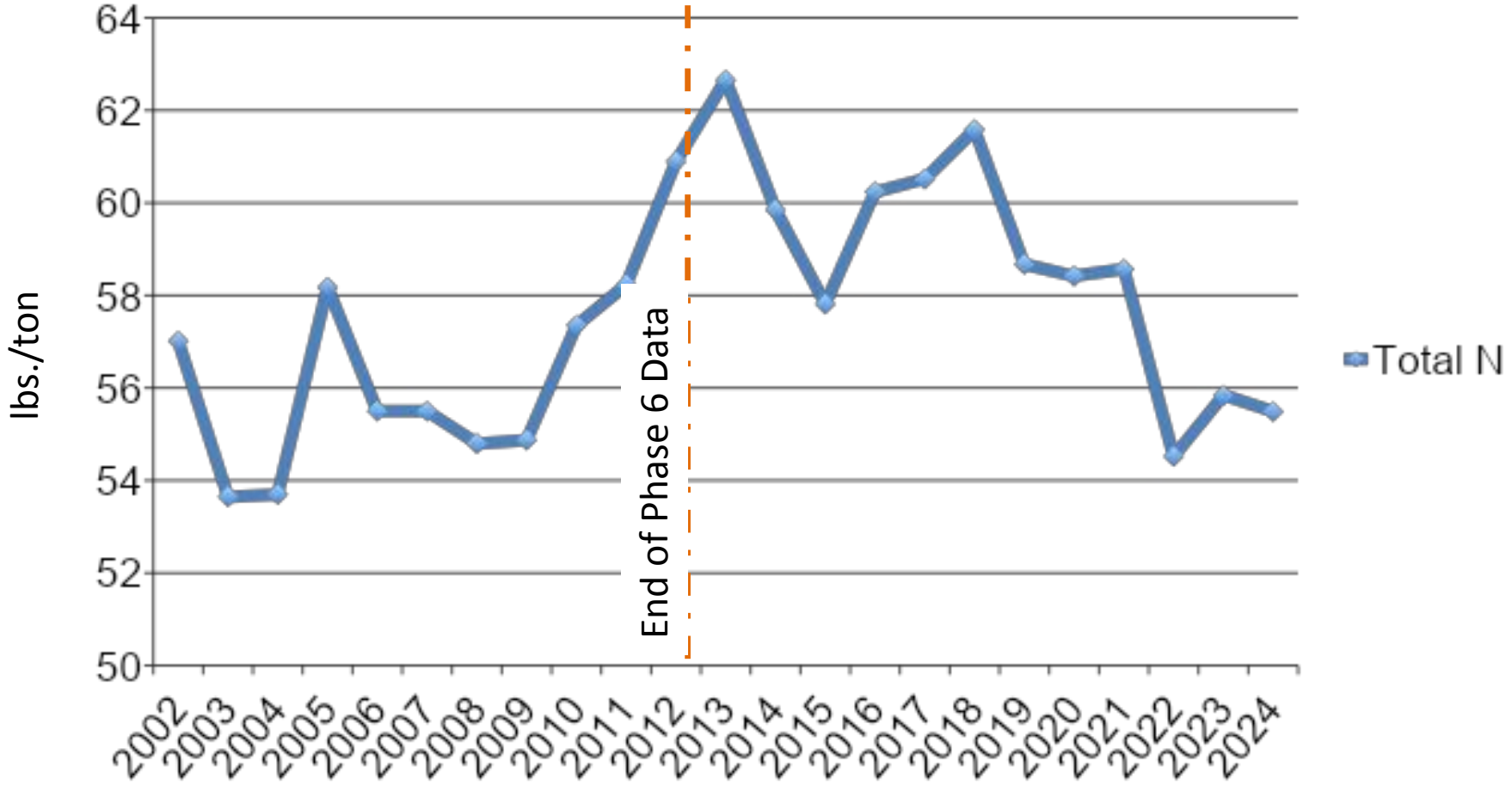
Manure Data

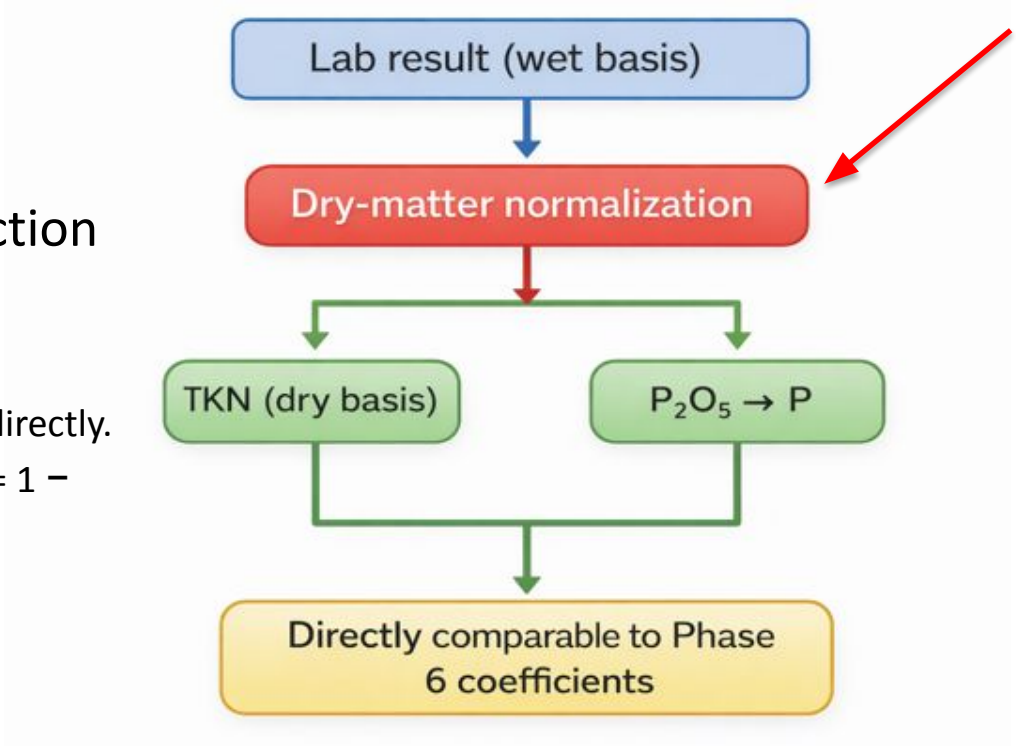
Poultry Total Nitrogen



Dry-basis conversion using measured moisture

X_dry = X_as-is / Dry Matter Fraction

- Dry Matter reported by lab is used directly.
- If moisture is reported: Dry Matter = 1 − Moisture.



Dry-basis conversion using Phase 6 imputation

When moisture is missing, Phase 6 dry-matter assumption is used.

- Dry Matter = 0.7135 (71.35%).

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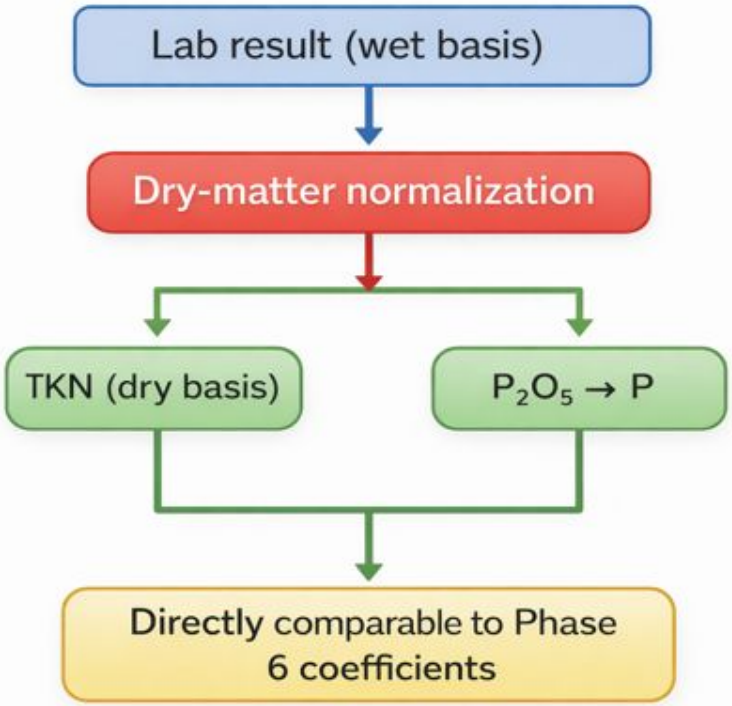
2008	6.500206	2.810911	0.713500	2.005585	0.014122	0.028324	0.040363	0.080952
2009	6.905832	2.940593	0.713500	2.098113	0.014346	0.030100	0.039897	0.083709
2010	6.939795	2.951452	0.713500	2.105861	0.014744	0.031048	0.040236	0.084731
2011	7.000000	2.970700	0.713500	2.119594	0.014830	0.031435	0.040236	0.085284
2012	7.100000	3.002671	0.713500	2.142406	0.015704	0.033643	0.041000	0.087839
2013	7.100186	3.002730	0.713500	2.142448	0.015826	0.033907	0.042545	0.091150

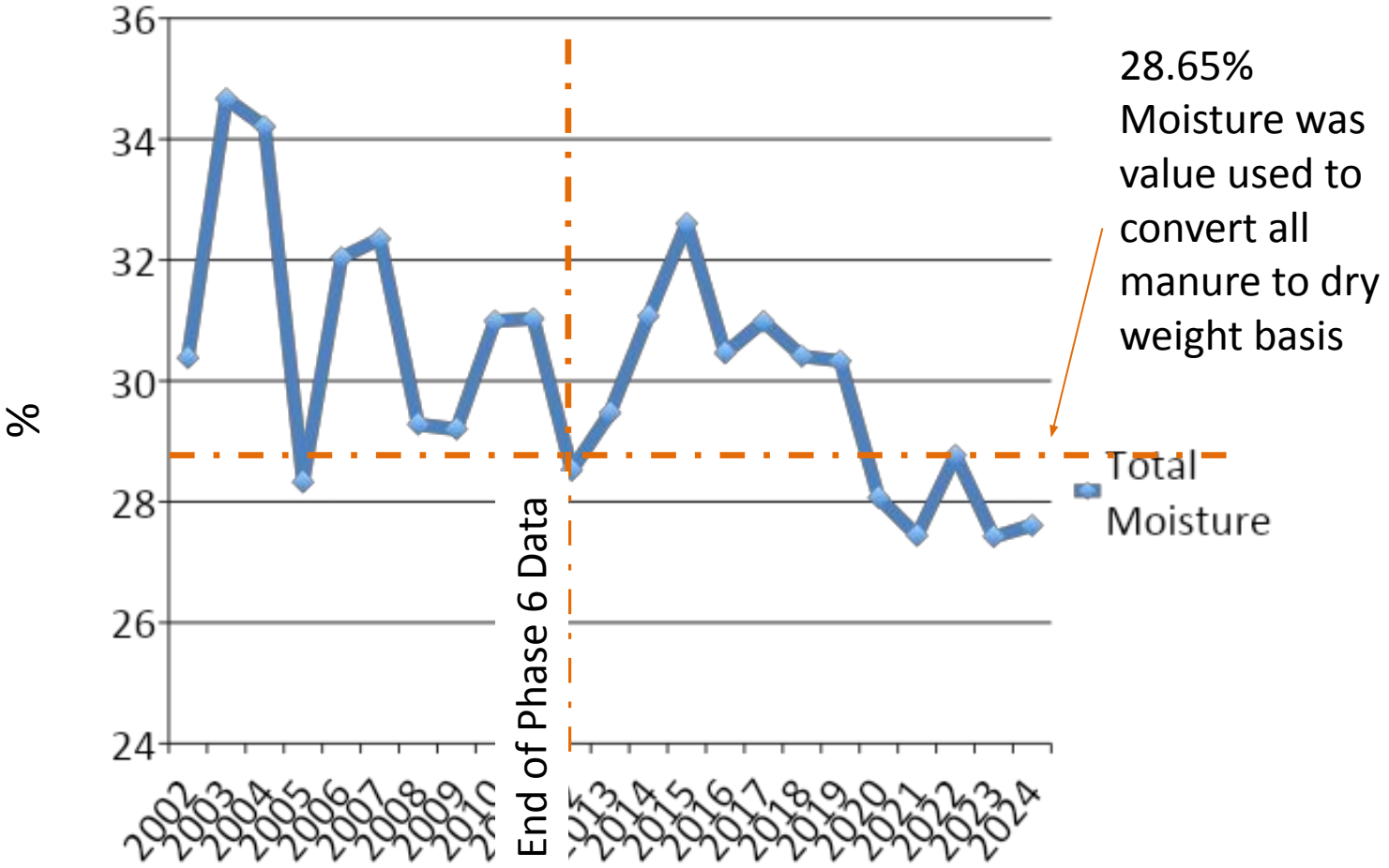


Phase 6 Moisture Normalization Method

- **Why a constant dry-matter value is used**
  - Phase 6 expresses poultry litter nutrient concentrations on a dry-matter basis to ensure consistency
  - Analysis of more than 9,800 broiler litter samples from DE, MD, VA, and WV was varied without a strong trend; standard deviation less than 5 percent
  - Average moisture content was 28.65%, corresponding to a dry-matter fraction of 0.7135.

Manure Data

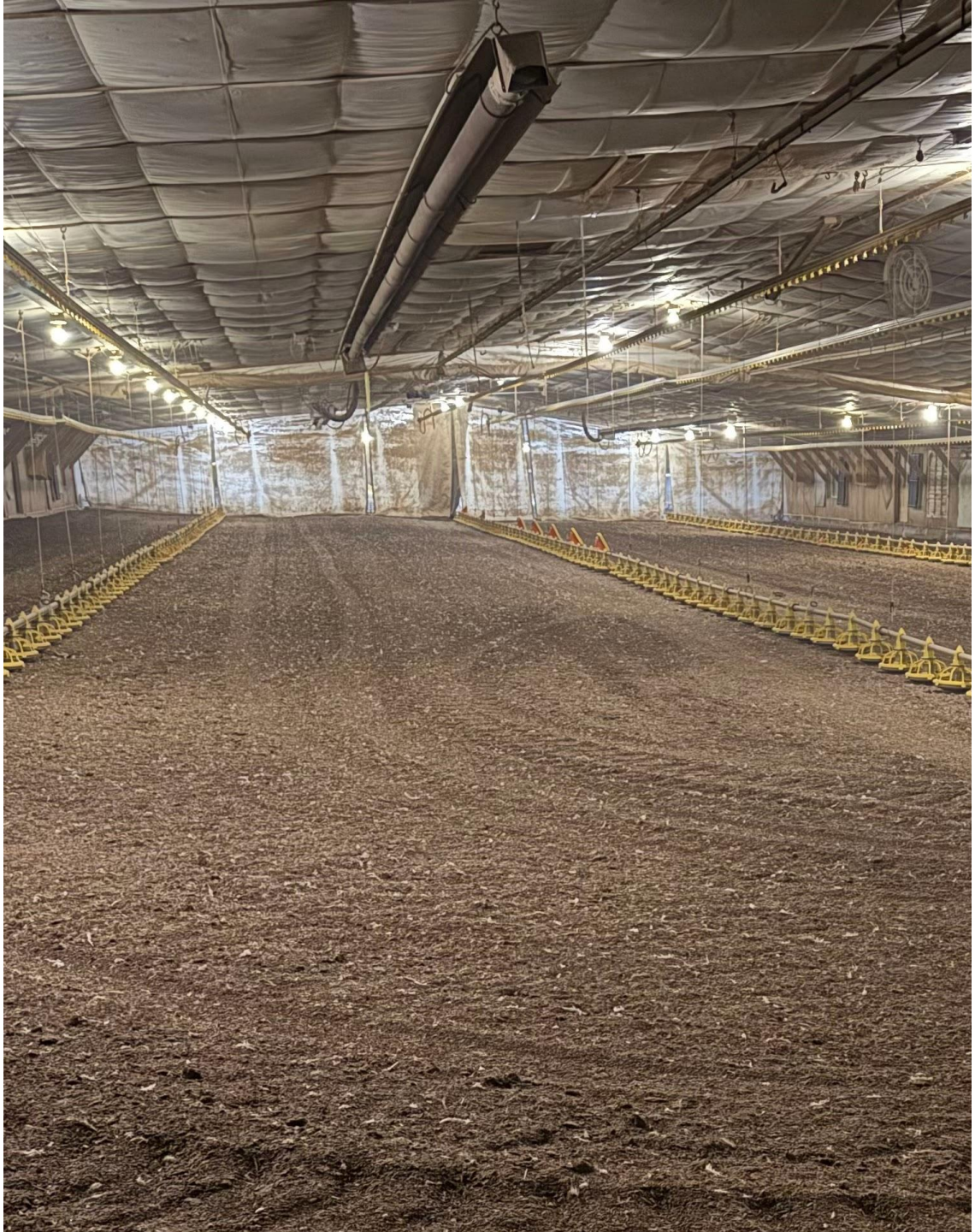
Poultry Total Moisture



28.65% Moisture was value used to convert all manure to dry weight basis

since 2012, an apparent strong decreasing trend appears in DDA data.

Windrowing & Conditioning



Litter Management has Multifaceted Impacts

Variable	Infrequent Clean-out + Cake-outs	Frequent Total Clean-outs
Moisture (%)	↓ Lower	↑ Higher
N per ton	↑ Higher	↓ Lower
P per ton	↑ Higher	↓ Lower
Annual volume	↓ Lower	↑ Higher
Annual nutrient mass	≈ Same or ↓	↑ Slightly
Variability	↑ More variable	↓ More uniform

adapted from

Dexter B. Watts, H. Allen Torbert and Eton E. Codling, 2019. Poultry Production Management on the Buildup of Nutrients in Litter. *International Journal of Poultry Science, 18: 445-453.*

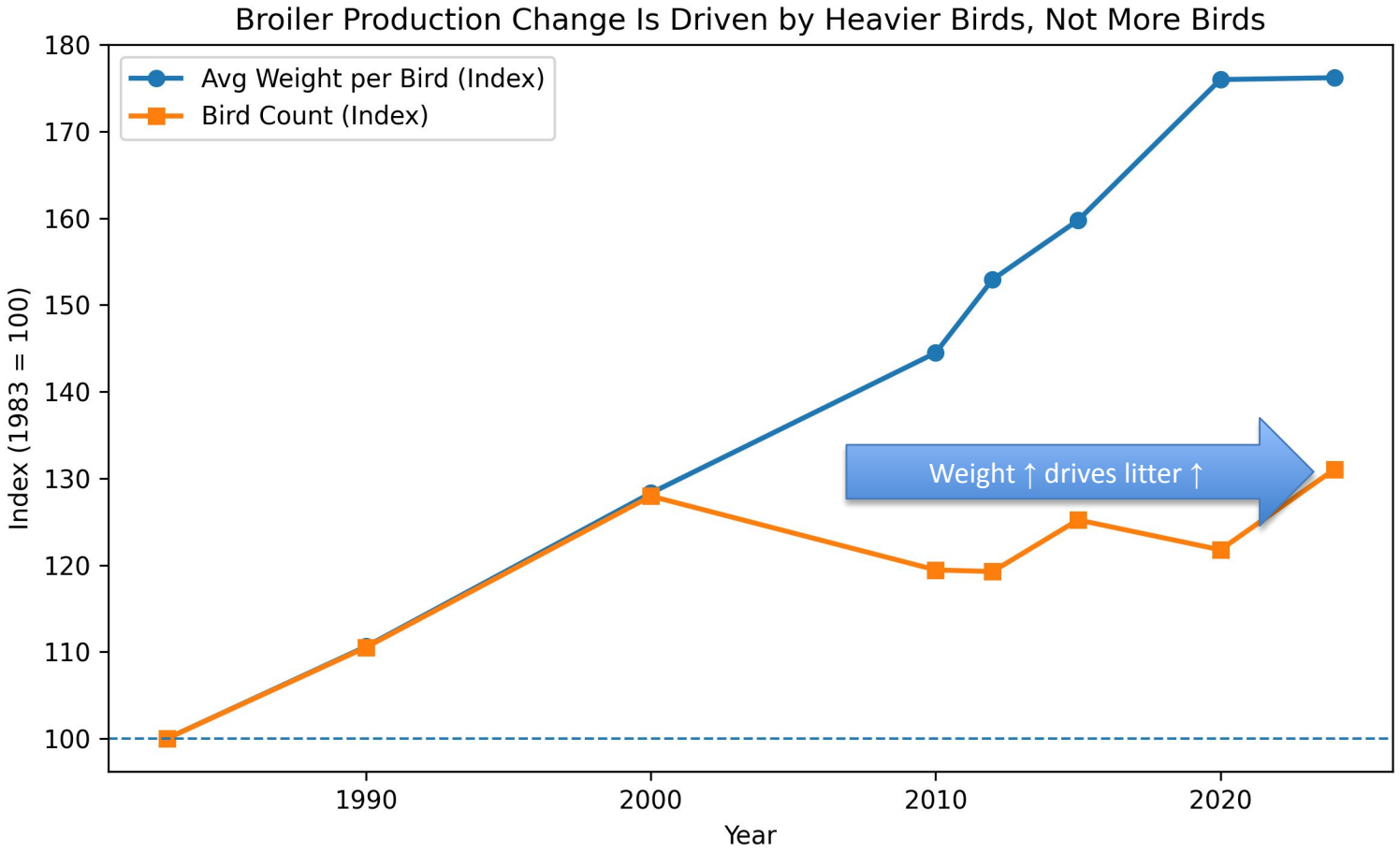
Phase 7 Proposed Moisture Method

- **Use annual average with some smoothing function**
  - Litter moisture is lower with improving ventilation and husbandry practices
  - Moisture decreases with litter composting
  - Decreased in TKN conc and sustained P concentration suggest composting has measurable effect

Industry Trends - Not explicitly captured

- Capacity to grow and process birds
  - finite plants and lines
  - increasing avg weights
  - future automation?
- Consumer preference for larger birds and the other marketed types (ABF, Cornish, organic, etc.)
- Feed conversion
- New bedding materials?
  - miscanthus, false floor
- Husbandry/ Litter management – examples include stocking density, litter treatment, ~~and windrowing~~.

Why Phase 6 Modeled Litter Volume Using Bird



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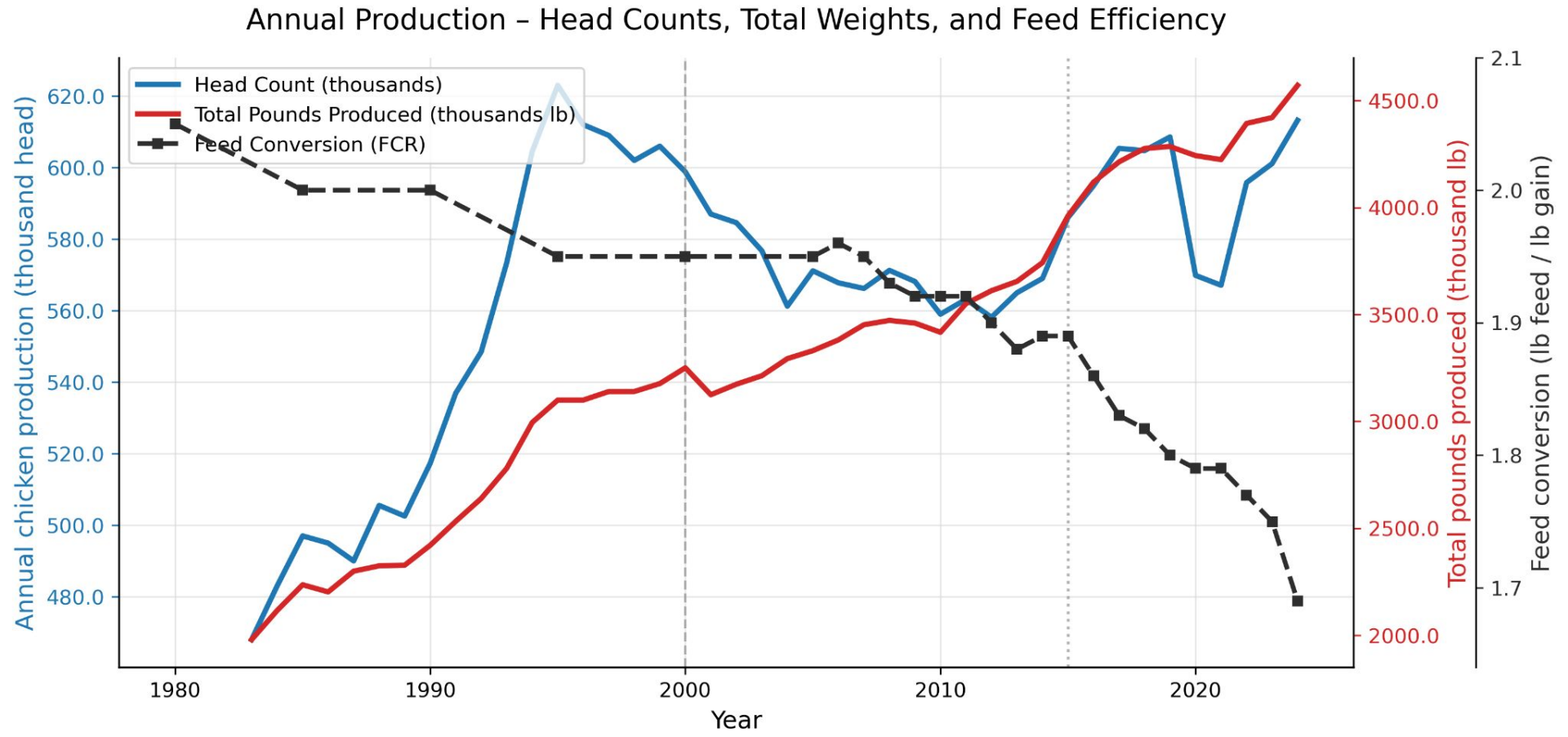
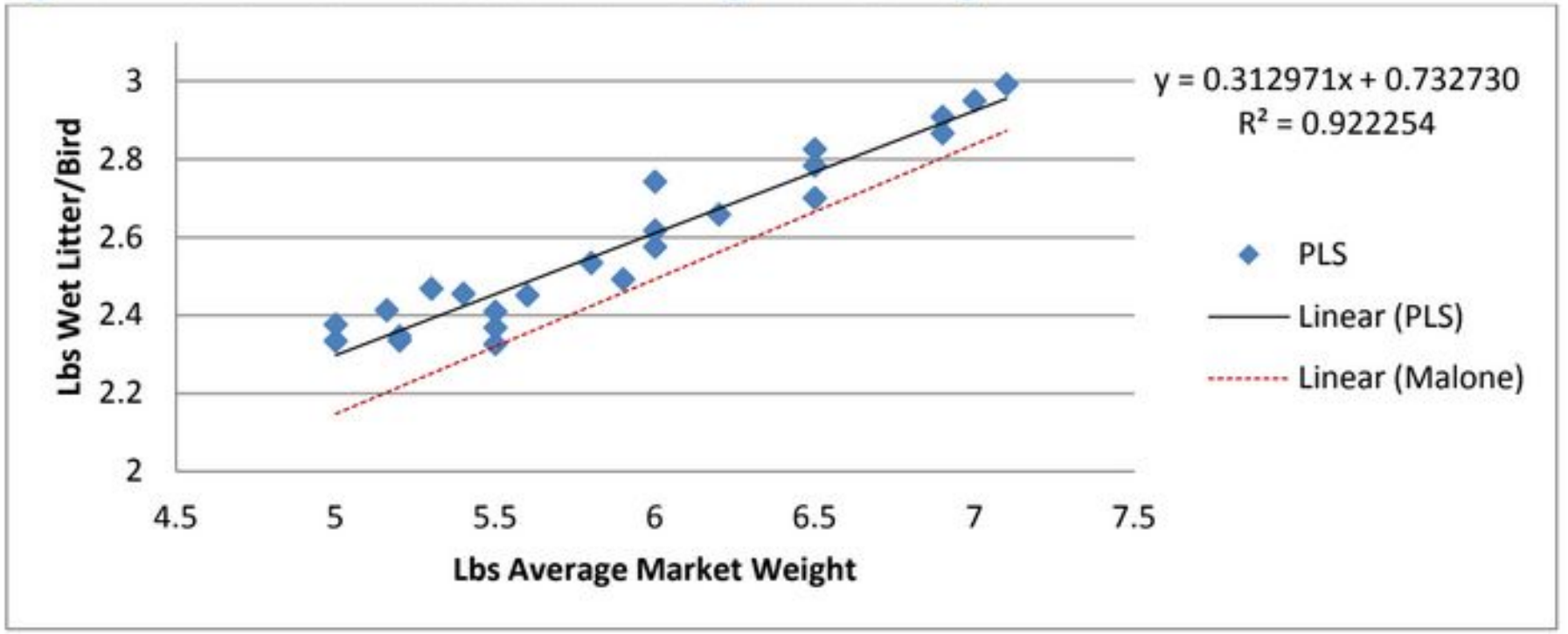
DCA Production Data



FCR source: National Chicken Council, U.S. Broiler Performance (Feed-to-Gain).

Phase 6 manure generation

Figure 1. Broiler Litter Production and Average Market Weight



Feed Conversion Efficiency & Manure/Nitrogen Reduction

- Improved digestive/feed efficiency reduces excreta and N output — birds selected for higher digestive efficiency excreted ~49–60% less fresh and dry excreta and lower nitrogen mass (de Verdal et al., 2011)
- Selection for improved feed efficiency reduces manure production and associated nutrient emissions (Willems et al., 2013)

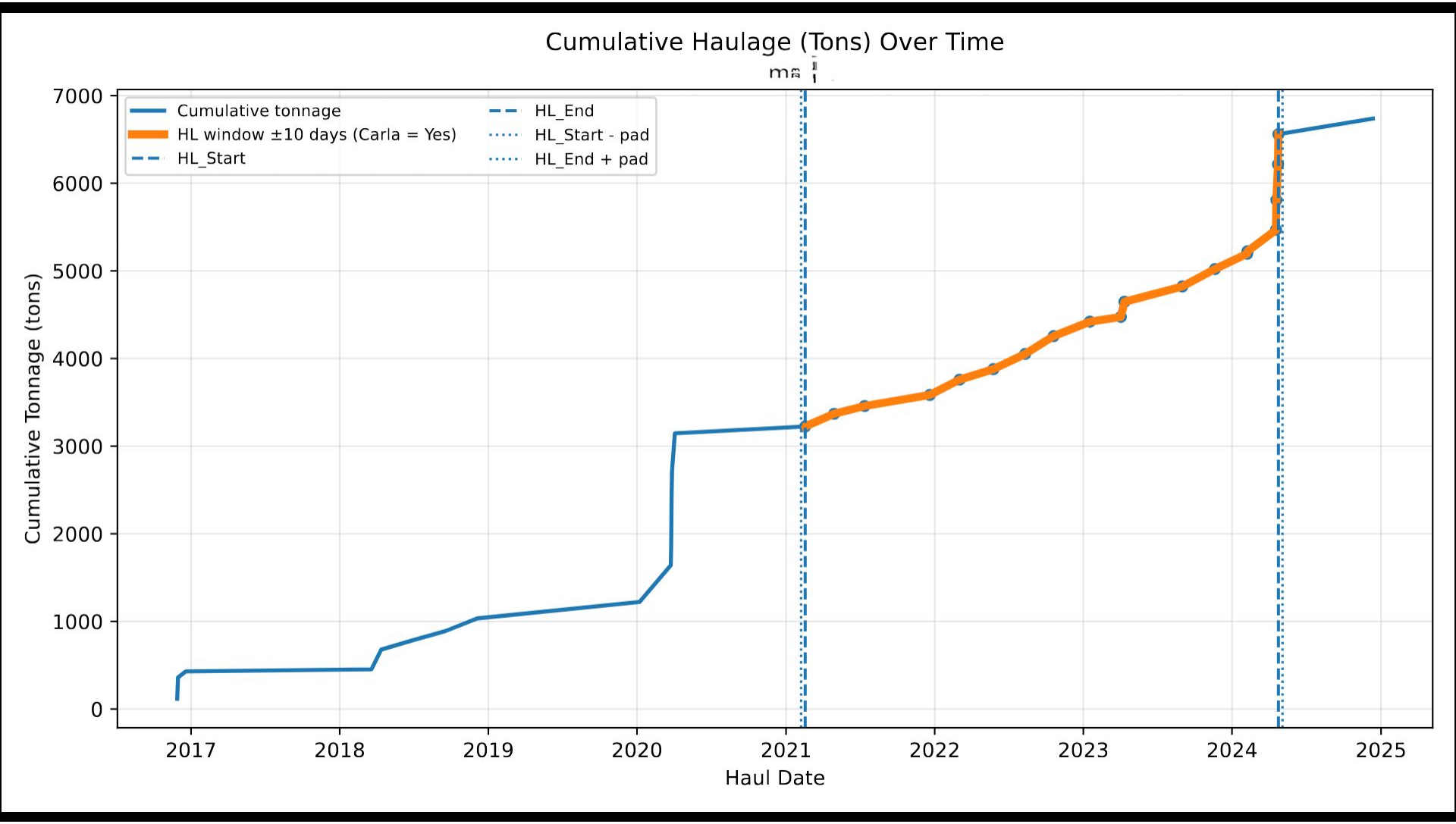
Other variables impacting analytes

- Cleanout Frequency
  - Crust and cake removal percentage
  - Conditioning methods, litter mixing depth
- Other nutrient technologies – litter amendments and N phase inhibitors.
- Broiler types
  - Cornish hens, friers
  - Organic

Litter Management has Multifaceted Impacts

Variable	Infrequent Clean-out + Cake-outs	Frequent Total Clean-outs
Moisture (%)	↓ Lower	↑ Higher
N per ton	↑ Higher	↓ Lower
P per ton	↑ Higher	↓ Lower
Annual volume	↓ Lower	↑ Higher
Annual nutrient mass	≈ Same or ↓	↑ Slightly
Variability	↑ More variable	↓ More uniform

Clean out detection



Proposed next steps

- Collect integrator data for bird counts, weights and flocks for farms with detailed manure history
- Estimate changes in volume through time
- Look for possible covariables beyond feed conversion
  - in bird types,
  - cleanout frequency &
  - moisture

Smoothing unresolved

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2008	6.500206	2.810911	0.713500	2.005585	0.014122	0.028324	0.040363	0.080952
2009	6.905832	2.940593	0.713500	2.098113	0.014346	0.030100	0.039897	0.083709
2010	6.939795	2.951452	0.713500	2.105861	0.014744	0.031048	0.040236	0.084731

What about smoothing or moving averages?

Glancey report approved 3 yr moving average for the investigated period

projecting in both time directions

Detect Manure Volume Production Using Company Provided Bird Counts, Manure Haulage Data Across Cleanout Cycles

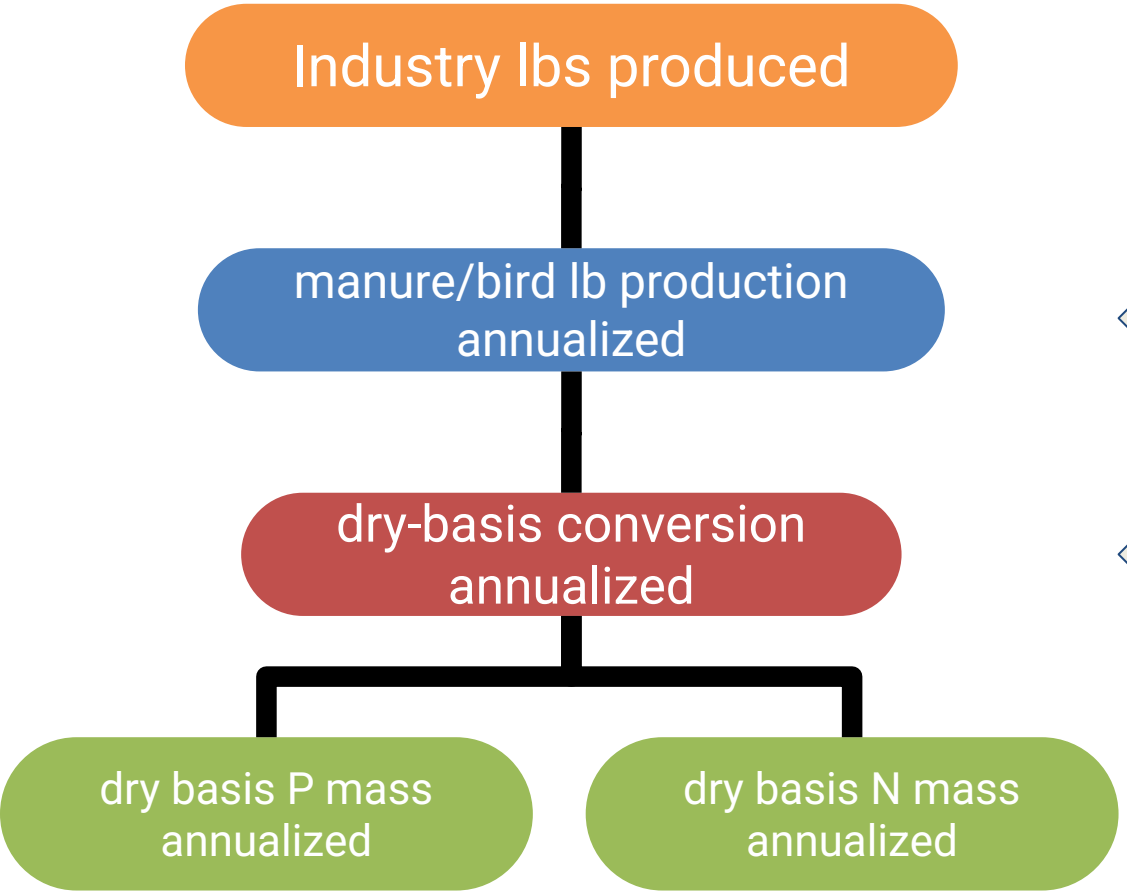
- Working with manure hauler, identified dozens of farms for which clean out to cleanout manure tonnage data are available.
- Working poultry integrators to enumerate bird mass across the manure hauler temporal record (on a farm-by-farm basis)
- Combining this information, how much manure was produced by a known bird mass, allows analysis to capture the effects of industry trends and management practices (2015-2024).
- This differs from the Phase 6 report because that report integrated various management practices into a single equation (Wet Lbs/Lb)

Phase 7: Capturing new variables

- **Update** broiler litter nutrient concentrations on a dry-matter basis with **annual average moisture.**
  - Also add new actual annual averages
- **Continue to use nutrient concentration** values vary by year to reflect changes in production practices, feed formulations, or expert judgment, but
  - **investigate effects of cleanout** intervals for effects on manure property trends
- Challenge AMT regarding with change to **smoothing method**.
- Replace projected annual bird weights and counts with **recent data from industry (2014-2024)**
  - reflecting ~22% increase in weights
  - ~8% increase in counts

Phase 7 nutrient framework

(conceptual)



data update

proposed new methods

data update

Capture a Signal that Relates Manure Moisture and NPK Concentrations

- Hypothesis – “Long interval manure management practices will show a relationship between crust-outs and moisture and nutrient concentrations.”
- Create a statistical relationship between manure moisture and NPK concentrations for known manure management practices.
- If this hypothesis is correct, it may be possible to an annual basis with a year’s worth of standard manure analysis, to normalize per bird manure by sample moisture content when applied on a regional basis.