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Maryland's Nutrient, Animal Waste, and Technology Landscape

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Throughout 2023, researchers from the University of Maryland – College Park (UMD) and the University of Maryland Extension (UME) examined nutrient management in Maryland's (MD) agricultural sector, with a focus on animal manure and associated technologies. This study documented:

- Livestock populations across the state
- Annual manure production and associated nutrient content
- The volume and nutrient content of manure applied to agricultural fields
- The status of manure treatment technologies and their operational capacity

The research methodology drew from a range of data sources, including the U.S. Department of Agriculture (USDA), the Maryland Department of the Environment (MDE), and the Maryland Department of Agriculture (MDA). Additional data were obtained from:

- Maryland's Watershed Implementation Plans
- Annual Implementation Reports (AIR) submitted by MD producers
- Aerial photography and remote sensing data
- Composting programs and product registration records
- Laboratory test results from the Maryland State Chemist's Office
- 25 virtual interviews with agricultural industry stakeholders
- Public records from MDE's Animal Feeding Operations (AFO) Public Participation Process

Photo by Edwin Remsberg

Introduction

According to the 2022 USDA National Agricultural Statistics Service (NASS) Census, Maryland's agricultural sector generates over $3.378 billion in sales, with poultry and eggs contributing approximately 47.9% and cattle accounting for about 14.2%, collectively representing over 60% of the state's total agricultural market value (NASS, 2022). Managing manure and the associated nutrients is important for farmers, surrounding communities, and the protection of natural resources and the environment. Various animal waste technologies, such as anaerobic digestion, thermochemical processing, composting, and manure injection, offer strategies to process or utilize manure and other animal byproducts (University of Maryland Extension, 2025). These technologies can help reduce greenhouse gas (GHG) emissions, produce local renewable energy from existing resources, limit nutrient runoff into

the Chesapeake Bay, and enhance soil amendments compared to untreated manure. To help producers protect waterways from excess nutrients and remain profitable, the state of Maryland, via MDA funding mechanisms, such as the Animal Waste Technology Fund (see "Looking to the Future" below), invests in nutrient management technologies that support uses for animal waste (Maryland Department of Agriculture, 2024). Understanding Maryland's livestock industry enables researchers, producers, and decision-makers to develop strategies to allocate resources effectively, direct funding toward priority areas, and implement waste management practices that optimize nutrient management and environmental protection.

Livestock in Maryland

Broilers and cattle, including beef and dairy cattle, comprise the majority of *animal units* (AUs) — a standardized measure for comparing inputs and outputs across livestock species — and are the state's primary producers of manure and animal waste nutrients: nitrogen and phosphorus. In 2019, a representative year that accounts for abnormal data fluctuations caused by the COVID-19 pandemic, Maryland produced approximately 6 billion pounds of manure and a combined 60 million pounds of nitrogen and phosphorus derived from commercial animal waste. Disruptions in livestock production and processing were evident in 2020 and 2021, but the industry began to stabilize in subsequent years. By 2023, production data had normalized, facilitating a more dependable evaluation of current nutrient management strategies.

Broilers compose approximately 83% of all AUs in Maryland, with four Eastern Shore counties containing an estimated 80% of inventories: Worcester (22% of statewide total), Somerset (21%), Caroline (19%), and Wicomico (18%). See Figure 1 for a state county map of broiler AUs.

Dairy cow production is most significant in the Northwestern Maryland counties of Washington (26% of the statewide total), Frederick (25%), Carroll (11%), and Garrett (6%). See Figure 2 for a state county map of dairy cow AUs.

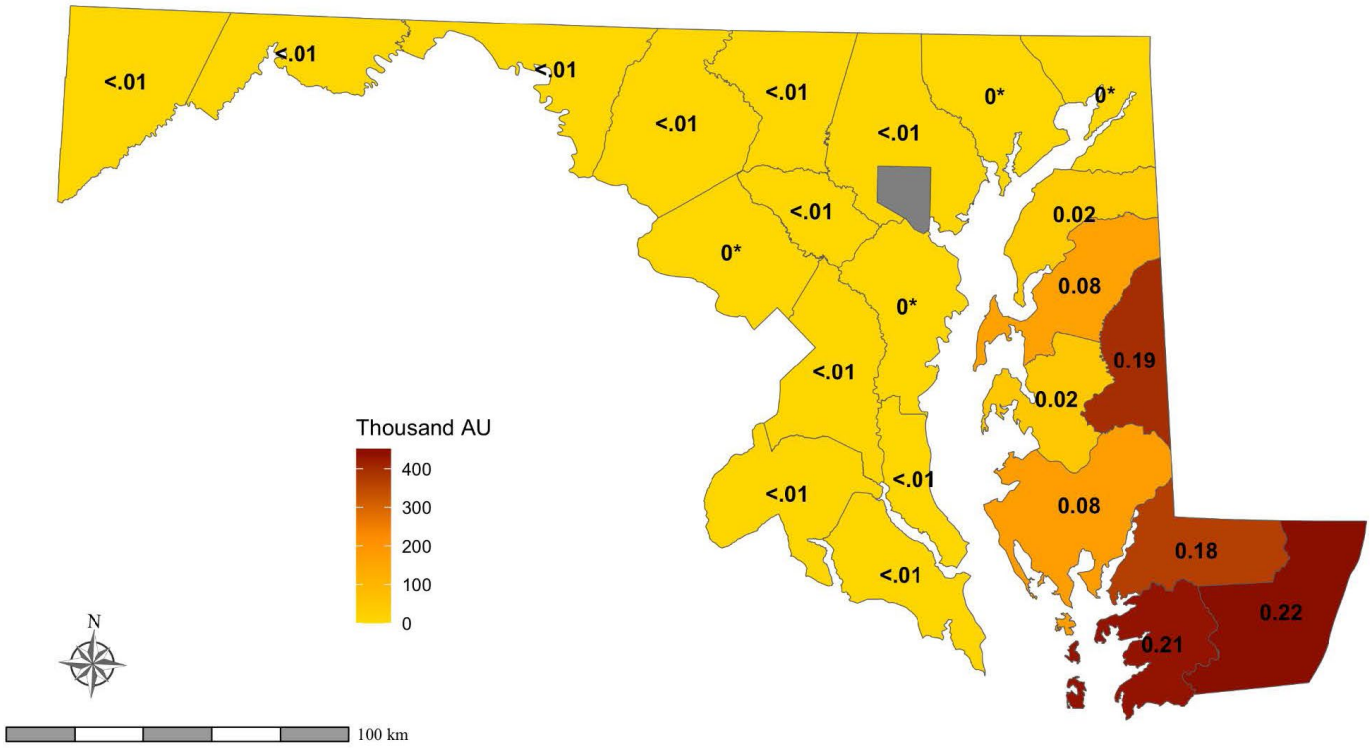

Figure 1. *Percent of broiler Animal Units (AUs) in each county, with shading showing the total count of AUs (in thousands) from the 2019 USDA the National Agricultural Statistics Service (NASS) survey data. AU conversion: approximately 125 chickens = 1 AU.*

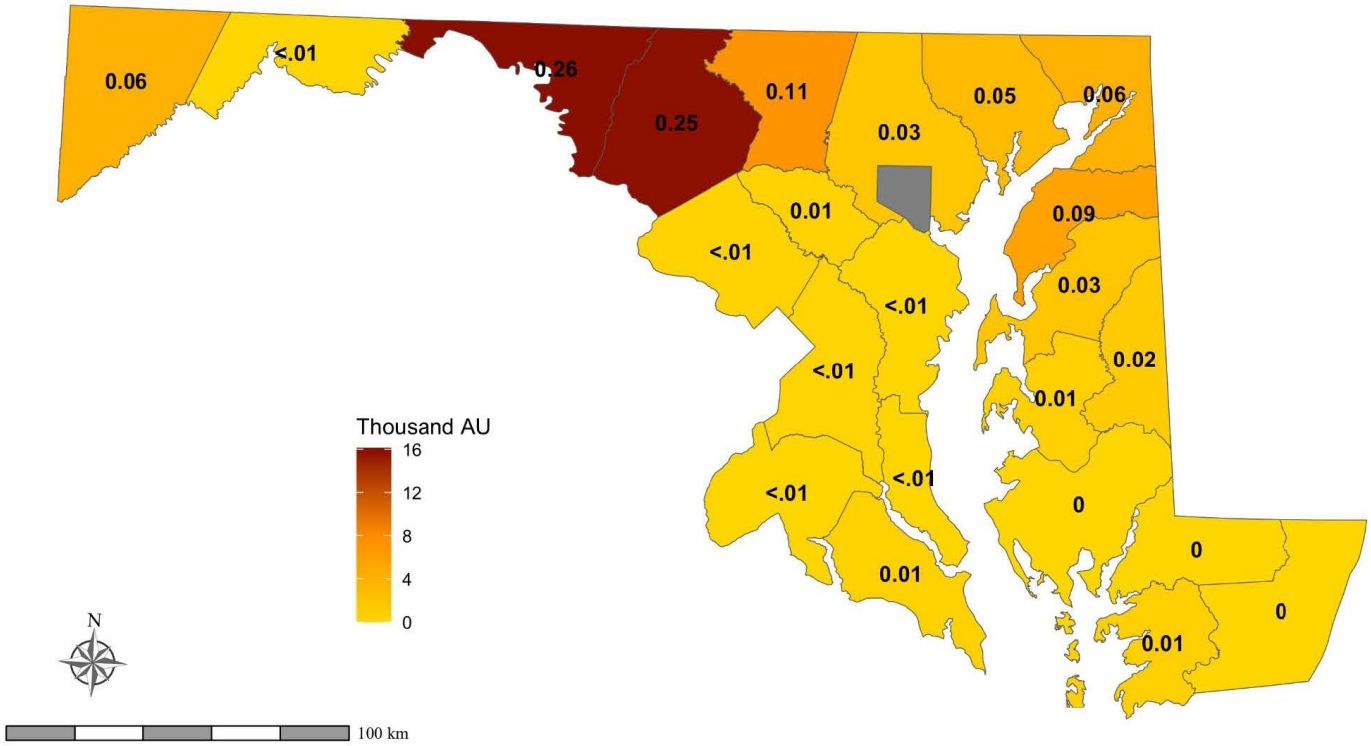

Figure 2. *Percent of dairy cow Animal Units (AUs) per Maryland county, with shading showing a total count of AUs (in thousands) from 2019 Annual Implementation Reports. AUs conversion: 1,000lb cow = 1 AU.*

Manure production and nutrients derived from animal waste are closely related to animal inventories. The volume of animal waste is highest in Washington (18.6%), Frederick (18.2%), and Carroll (9.7%) counties. However, total nitrogen and phosphorus derived from animal waste are highest in Worcester (12.3%), Somerset (11.5%), and Frederick (11.4%) counties. See Figure 4 for a state county map of animal waste nutrients.

Animal Waste

Effective nutrient management in Maryland should address the three animal waste products with the most significant volume: *cattle manure, poultry litter, and Dissolved Air Flotation (DAF) sludge*, a type of food processing residual.

Cattle manure from beef and dairy cattle accounts for the state's largest share of manure volume (78%). Despite more significant broiler inventories, cattle produce the most manure volume statewide due to their relatively large size, which results in higher manure production per animal.

In other words, the high liquid content of cattle manure inflates the volume of cattle waste; however, cattle manure still provides 36% of the state's animal waste nutrients. Cattle manure in Maryland is commonly stored in uncovered lagoons, resulting in GHG emissions.

Poultry litter, the manure produced by chickens, is a dry product relative to cattle manure and has a higher nutrient density. Broilers are Maryland's most significant contributor to nitrogen and phosphorus production, with their litter producing 51% of statewide animal nutrients.

DAF sludge is an animal waste byproduct from animal mortality and food processing facilities, composed of flocculated solids, proteins, and fats extracted from wastewater. Under Maryland law, DAF is categorized as a food processing residual, which includes materials that may undergo varying treatments like anaerobic digestion or composting (COMAR 15.20.13, 2024). DAF in Maryland is commonly applied to land as a soil amendment, supplying 2 million pounds of nitrogen annually.

Figure 3. *Manure tanker being filled before injection (Photo by Edwin Remsberg)*

However, poorly managed DAF land applications can cause odor and insect problems in nearby communities.

Overly frequent land applications of raw DAF can overwhelm the soil's absorption capacity, increasing the risk of runoff and nuisances before crops can utilize the nutrients. Further, DAF sludge is rich in organic nitrogen, which requires a conversion process to transform into plant-available forms. Therefore, pre-treatment methods, like anaerobic digestion and composting, can be beneficial to mineralize nitrogen in a controlled environment. Despite this, the majority of land-applied DAF in Maryland does not undergo any prior treatment.

How Manure is Managed and Used in Maryland

Animal waste is often stored before transportation to treatment facilities or disposal. Storage can also be required due to state policies that designate when it is permissible for manure to be field-applied. Animal waste storage types in Maryland rank as follows: waste storage facilities have the highest capacity (2,970,000 AU), followed by waste storage ponds (11,000 AU) and treatment lagoons (8,070 AU).

On-farm manure injection, a field-application technology that stores nutrients below the soil surface to reduce runoff potential, is currently practiced on over 2,500 acres in Maryland (University of Maryland Extension, 2025). The adoption of manure injection is increasing, a trend expected to continue due to the accessibility of nutrient management equipment and low barriers to entry. The number of operators utilizing manure injection is growing in the North Central region and the northern area of Maryland's Eastern Shore, where cattle (dairy and beef) concentrated animal feeding operations (CAFOs) are prevalent.

Cattle production in these areas produces manure that is more suitable for injection than the drier poultry waste commonly found on the Eastern Shore. The following map, Figure 4, illustrates the locations of current and non-operational animal waste technology sites, including anaerobic digesters, industrial composting sites, pyrolysis sites, and manure injection sites. Additionally, Figure 4 highlights the geographic distribution of animal waste processing facilities and the concentration of livestock and poultry operations in Maryland. In addition, the map features an ellipse capturing approximately two-thirds (66.2%) of CAFOs for cattle (in blue) and poultry (in brown). Total animal waste nutrients (nitrogen and phosphorus, or N + P) produced in 2019 by all livestock operations are represented by gradient orange shading, with darker shades indicating

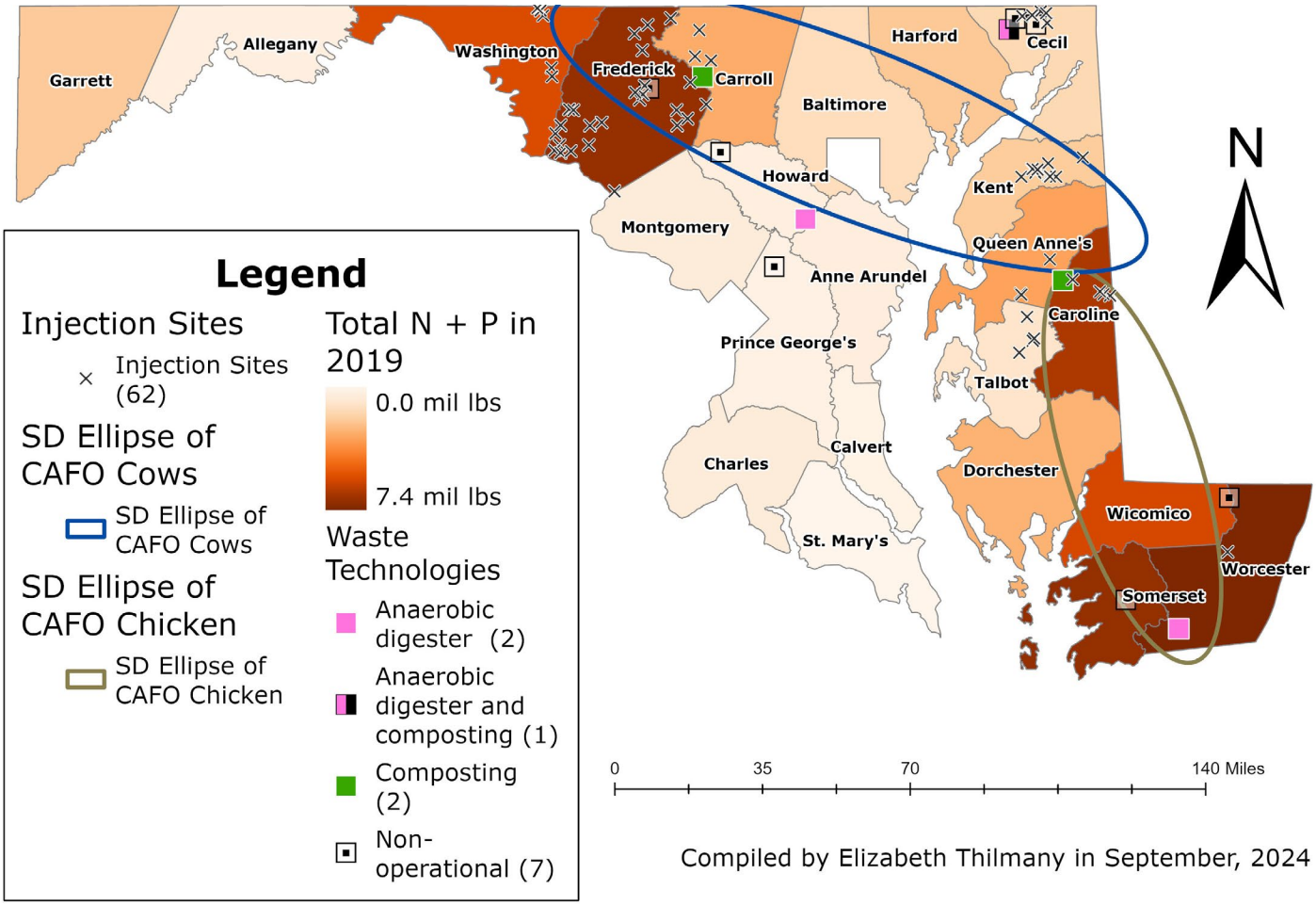

Figure 4. *Map of Maryland's animal waste technology sites, showing a standard deviation (SD) ellipse of concentrated animal feeding operations (CAFOs) for cattle and broilers, and animal waste nutrients by county. The SD ellipse captures the geographic concentration of CAFOs, encompassing approximately two-thirds (66.2%) of cattle and dairy cow (blue) and poultry (brown) operations.*

counties with higher N + P volumes from animal waste produced in those counties.

Animal waste management sites are limited relative to the states' animal waste production and are not necessarily co-located with concentrations of nutrients in manure. Currently, at least three operational anaerobic digesters and three permitted industrial composting sites in Maryland have been documented to receive manure or DAF.

Figure 4 includes seven animal waste management sites as "non-operational." Table 1 provides more specific information about these facilities by distinguishing between inactive facilities and facilities in development.

- *Inactive facilities* are defined as inactive but not decommissioned, intermittently active, or having a history of managing animal waste but the status of which has become unclear. Three industrial composting sites and one anaerobic digester are designated as inactive under this definition in Maryland.
- *Facilities in development* are defined as those under construction or in planning that have received grants from MDA's AWT Fund. There are two anaerobic digesters and one pyrolysis facility designated for development in Maryland.

An additional four industrial composting sites, not included in Table 1 or Figure 4, have permits with MDE to process manure, but their activity regarding

animal waste is unconfirmed. The absence of a current, central database documenting on-farm and commercial animal waste treatment facilities presents a barrier to determining these technologies' employment and operational status. Despite strong interest from most farmers, widespread adoption of animal waste technologies is not likely to occur without increased incentives, permit assistance, and educational support.

Table 1. *By county, the aggregated estimated weight of nitrogen and phosphorus (N + P) in manure across species (in US tons) produced in the representative year 2019 alongside the percent share of the state total; the aggregated yearly estimated Animal Units (AU, 1000 lbs.) of broilers, layers, and all cattle reported by USDA National Agricultural Statistics Service Survey in the representative year 2019; and animal waste management sites delineated by type in September 2024.*

County	Total N + P in US tons (Percent of Statewide share)	Broilers, layers, and all cattle in Animal Units	Number of Processing Facilities	Facility Types (Number in County)
Allegany	176.5 (1%)	3,710		
Anne Arundel	195 (1%)	1,520		
Baltimore	631.5 (2%)	7,320		
Calvert	72 (<1%)	1,140		
Caroline	3,166 (11%)	400,580	1	Composting (1)
Carroll	1,399.5 (5%)	21,800	1	Composting (1)
Cecil	738 (2%)	8,110	4	Digestion (1); Digestion in development (1); Composting (1); Inactive composting (1)
Charles	274.5 (1%)	3,130		
Dorchester	1,313.5 (4%)	174,350		
Frederick	3,398.5 (11%)	42,150	1	Inactive composting (1)
Garrett	981.5 (3%)	15,880		
Harford	1,016.5 (3%)	12,330		
Howard	192.5 (1%)	2,430	2	Digestion (1); Inactive composting (1)
Kent	974 (3%)	44,740		
Montgomery	273 (1%)	3,370		
Prince George's	127 (<1%)	1,560	1	Inactive digestion (1)
Queen Anne's	1,534 (5%)	165,470		
Saint Mary's	286.5 (1%)	4,010		
Somerset	3,443 (12%)	437,500	1	Digestion in development (1)
Talbot	476.5 (2%)	46,680		
Washington	2,701 (9%)	40,340		
Wicomico	2,782 (9%)	369,520	1	Pyrolysis in development (1)
Worcester	3,682 (12%)	453,640	1	Digestion (1)
Total	**29,834.5 (100%)**	**2,261,280**	**13**	**Digestion in development (2); Pyrolysis in development (1); Digestion (3); Composting (3); Inactive digestion (1); Inactive composting (3)**

Maryland's Regional Role in Animal Waste

Maryland plays a key role in the regional management of food processing residuals, including DAF sludge. In recent years, Maryland has received shipments of DAF from neighboring states, in part due to differences in regulatory approaches to storage and land application. However, evolving regulations and market conditions may influence where and how these materials are transported and applied in the future. It is important to note that reducing land applications of DAF in Maryland does not necessarily reduce nutrient loads to the Chesapeake Bay, as nutrients applied elsewhere in the watershed may still contribute to leaching and runoff.

Changes in the Landscape

Dairy production and the cattle population in Maryland have been experiencing a steady decline in recent years, with cattle inventory projections forecasting an approximate 25% decline from the 2022 baseline by 2032. Despite declining cattle inventories and stable poultry inventories, animal waste nutrients produced in Maryland are expected to increase in quantity. While the population of broilers is expected to remain constant, trends predict the average broiler weight will increase by approximately 10% by 2032, which will result in a rise in broiler AUs and animal waste nutrients. Consequently, developing and implementing animal waste technologies will remain critical to Maryland.

Looking Towards the Future

The Maryland Department of Agriculture oversees the Animal Waste Technology Fund, which provides grants to individuals and organizations pursuing animal waste management strategies. These efforts are crucial for enhancing environmental sustainability, protecting public health, and improving farm operations across the state. Maintaining current and accurate data on the functioning of farms throughout Maryland is vital to supporting farmers, allocating resources effectively, and developing targeted support programs for the state's most pressing needs. Farmers are strongly encouraged to participate in data collection efforts, such as USDA NASS surveys and census, as well as the MDA Nutrient Management AIR, to facilitate this process.

Contact

For more information on the Animal Waste Technology Fact Sheet series and the Maryland Animal Waste Technology Assessment submitted to MDA, see https://go.umd.edu/AWTF.

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