Manure Management

Fundamentals of Nutrient Management

June 18,2024

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Nutrient Management Advisor – Dorchester County

Fertilizer Options?

Manure

Legumes

Commercial Fertilizer

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AGRICULTURAL NUTRIENT MANAGEMENT PROGRAM

Bio-Solids

Benefits of Manure Application

Improves soil:

- Organic matter content
- CEC
- Water holding
- Structure
- Lowers bulk density
- Increases microbe activity

Spreading poultry manure (photo by Bob Nichols, USDA-NRCS)

Recycles nutrients between animals, soils and crops:

- Natural resource
- Reduces money spent on commercial fertilizer
- Reduces energy spent creating commercial fertilizer

Risks of Manure Application

Manure may contain:

- Pathogens
- Heavy metals
- Volatile organic compounds (VOC's)
- Pharmaceuticals/antibiotics

Spreading poultry manure (photo by Bob Nichols, USDA-NRCS)

Application of manure may cause:

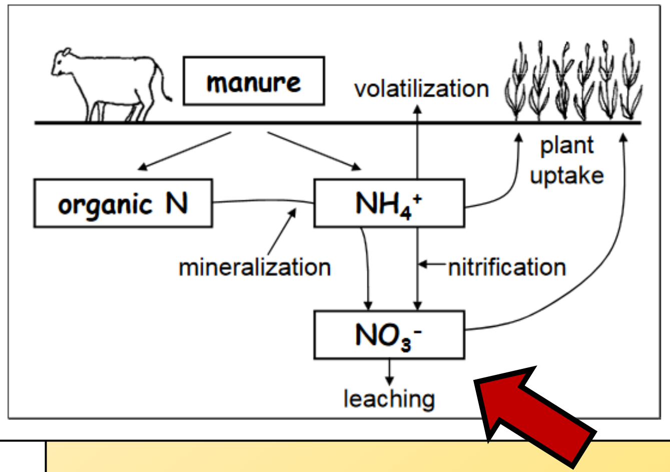
- Excess nutrients in our ground and surface water
- Lower air quality
    - Includes "smell" of ammonia, sulfur, methane
    - Greenhouse gases (N_2O, methane)

It's the Law!

- No manure applications from Dec. 15th to March 1st!
  - No spreading on frozen, saturated, or snow covered ground (>1")
  - Applications from Sept. 10th-Dec. 15th must be on an existing crop or one to be planted by Nov. 15th

✓Benefits and Risks of Using Manure as a Nutrient Source.

Figure 9.1. Partial N cycle showing the forms and transformations of nitrogen in manure.



- Manure and commercial fertilizer can both lose nutrients
- Speed of loss may be different depending on many factors

Land application of manure: Nutrient availability

- Manure is usually managed to provide the three major plant nutrients: N, P, and K.

- When properly managed, all of the risks can be minimized
  - Determining the availability of P and K is a relatively simple matter of determining the P and K content of the manure.
    - Plant availability of the P and K in manure is commonly assumed to be similar to the availability of these nutrients in commercial fertilizer because most of the P and K in land-applied manure are present in inorganic forms.
  - Determining the availability of N in manure is more complicated.

Types of Manure Storage

Temporary storage is necessary since we can't always immediately apply manure.

<u>Manure Storage Types:</u>

1. Directly deposited on pasture
2. Liquid lagoon
3. Dry stack barn
4. Compost bedded pack barn

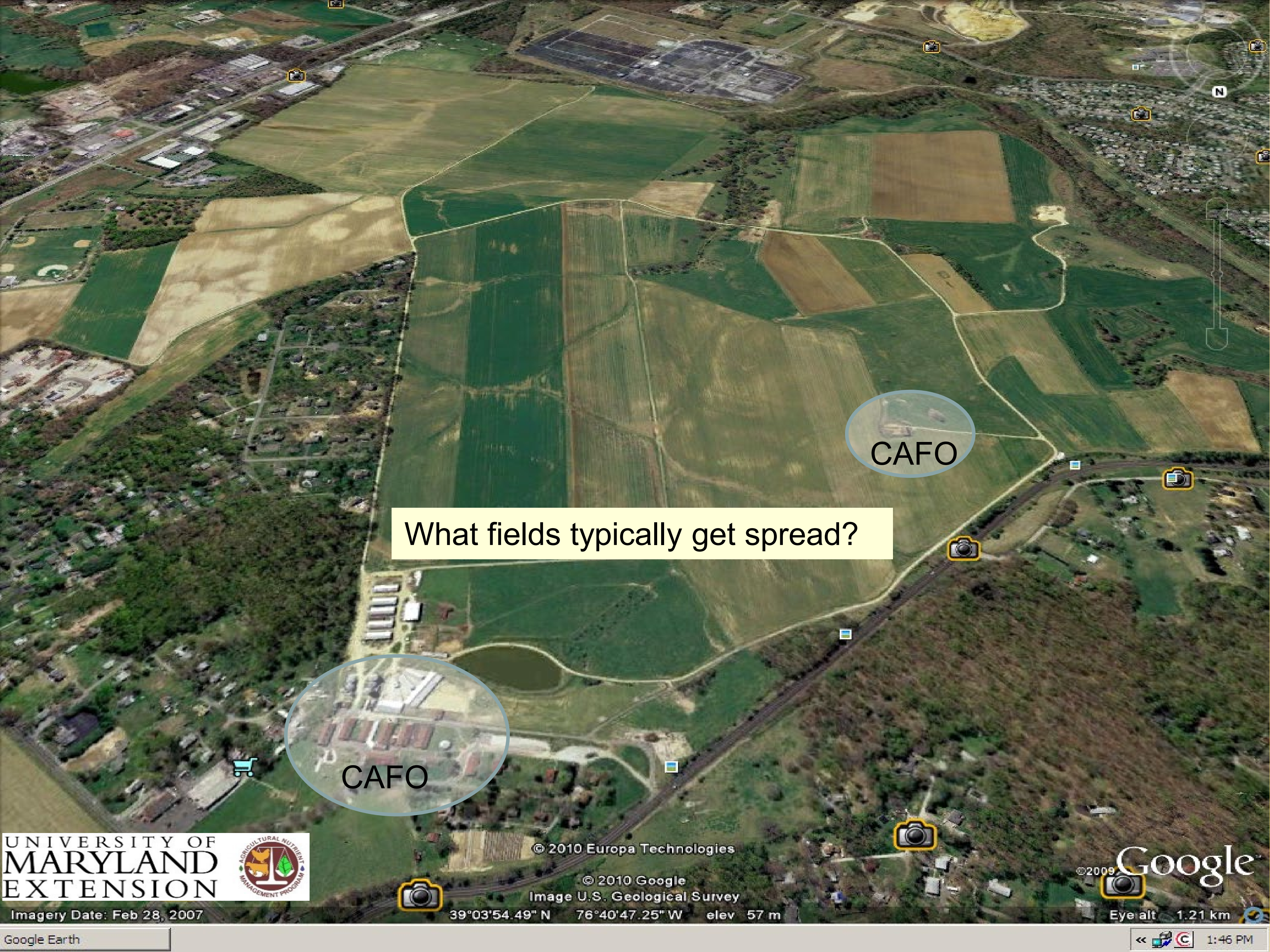
Deposited Directly on Pasture

Liquid Lagoon

Dry Stack Barn

Dairy Compost Bedded Pack Barn

Poultry *Compost* Bedded Pack Barn



What fields typically get spread?
CAFO
CAFO
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AGRICULTURAL NUTRIENT MANAGEMENT PROGRAM
© 2010 Europa Technologies
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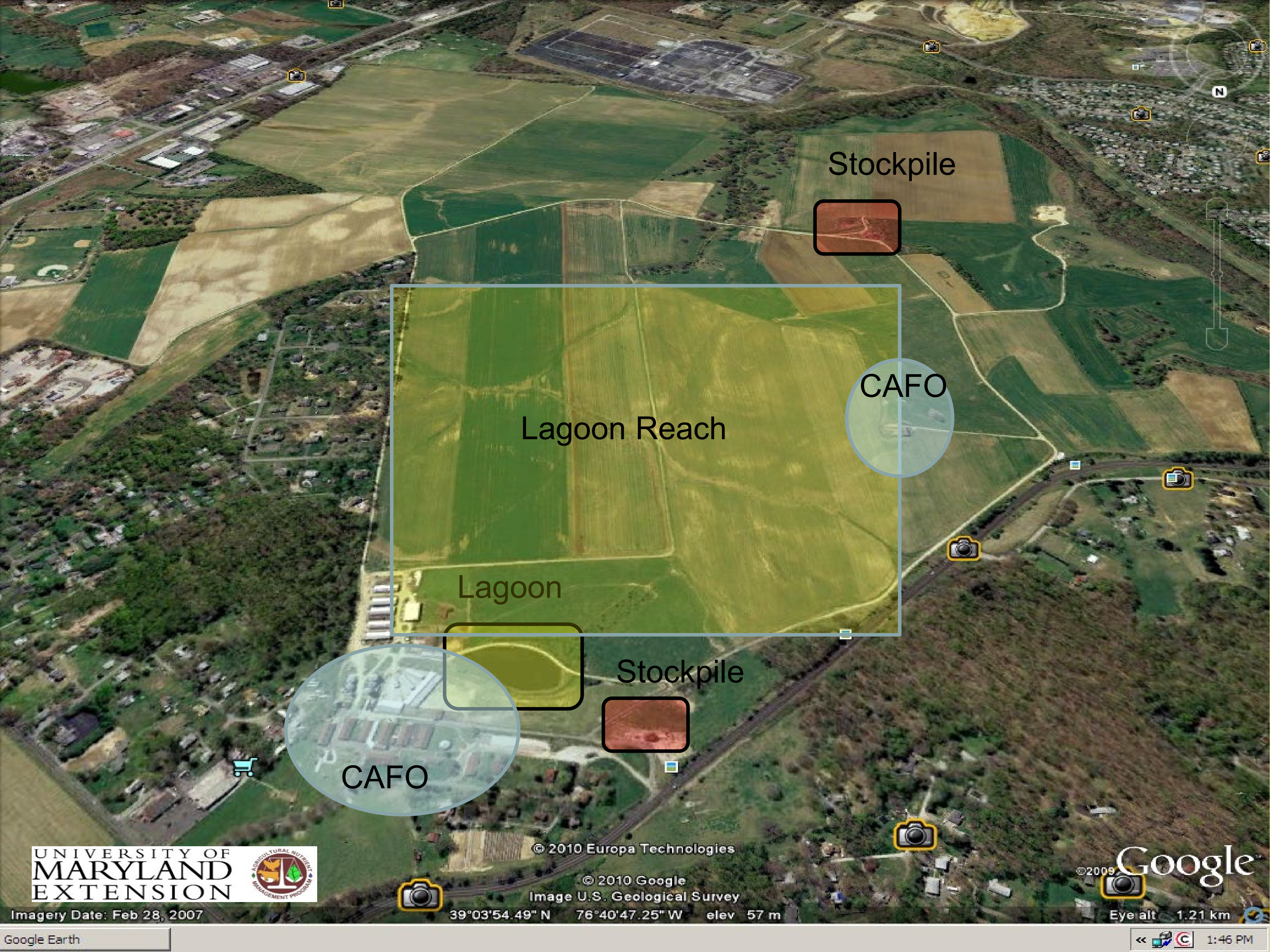
Image U.S. Geological Survey
©2009 Google
Imagery Date: Feb 28, 2007
39°03'54.49" N 76°40'47.25" W elev 57 m
Eye alt 1.21 km
Google Earth
1:46 PM



Stockpile
CAFO
Lagoon Reach
Lagoon
Stockpile
CAFO
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AGRICULTURAL NUTRIENT MANAGEMENT PROGRAM
© 2010 Europa Technologies
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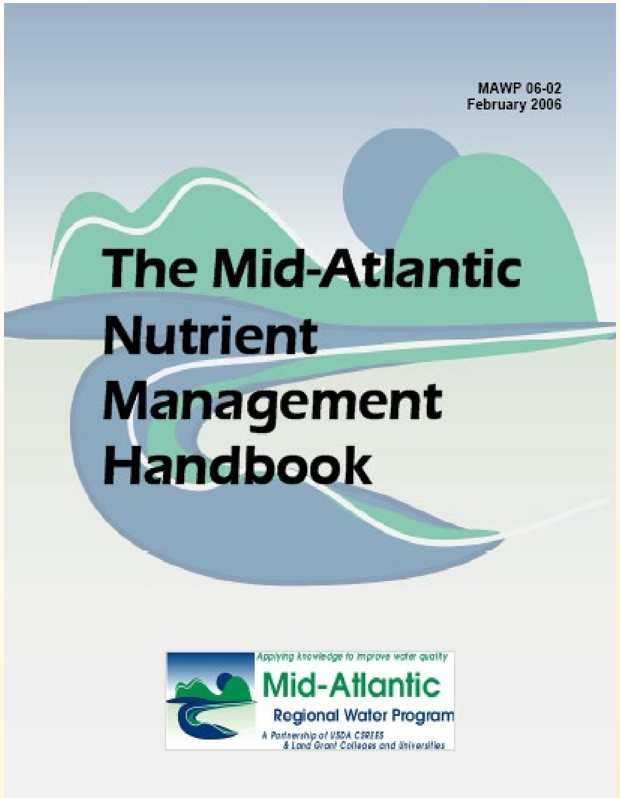
Image U.S. Geological Survey
©2009 Google
Imagery Date: Feb 28, 2007
39°03'54.49" N 76°40'47.25" W elev 57 m
Eye alt 1.21 km
Google Earth
1:46 PM

Factors affecting manure volume generated

Nutrient Management

https://extension.umd.edu/programs/agriculture-food-systems/program-areas/integrated-programs/agricultural-nutrient-management-program/additional-resources



The Mid-Atlantic Regional Water Program

Land Grant Universities in Delaware, Maryland, Pennsylvania, Virginia and West Virginia, and USDA's Cooperative State Research, Education and Extension Service (CSREES), working with EPA Region III, have formed a partnership to advance water quality protection and restoration efforts in the Mid-Atlantic by providing water quality science support, training and education. This regional program is anchored by, and complements, state water quality programs and existing Extension efforts.

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Chapter 9. Manure as a Nutrient Source

David J. Hansen
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✓*Calculating the Volume of Animal Manure Produced in an Agricultural Operation.*

Manure production by species

❖ **The quantity of manure produced varies considerably (pg 209):**

- ***Among species:*** **because of differences in animal diets and metabolism.**

- ***Within species:*** **due primarily to differences in management (bedding, feed source).**

✓Calculating the Volume of Animal Manure Produced in an Agricultural Operation.

Manure production by species

- **Variation in manure NPK content among species (pg 209):**

  - ***More than 50% of N, P, and K may pass through the animal into manure***
  - ***N can be lost to the atmosphere, P and K to runoff and leaching***

✓Calculating the Volume of Animal Manure Produced in an Agricultural Operation.

Manure production by species

Animal Unit (AU)

- **1000 lb live weight = 1 animal unit (AU)**
  - ***(e.g. Table 9.1, 209 – 1 AU = 1000 lbs. beef cattle)***
- **It's an assumption/average**
  - ***1 beef cow may weigh more/less than 1000 lbs.***
- **2.67 breeder hogs = 1000 lbs.(@375 lbs./hog)**

Manure production by species (Table 9.1, pg 209)

	Animals per AU[a]	Annual manure production per AU
	-1000 lbs-	---tons---
Beef cattle	1.00	11.50
Dairy cattle	0.74	15.24
Swine (breeders)	2.67	6.11
Swine (other)	9.09	14.69
Hens (laying)	250.00	11.45
Pullets (over 3 months)	250.00	8.32
Pullets (under 3 months)	455.00	8.32
Broilers	455.00	14.97
Turkey (slaughter)	67.00	8.18
[a]AU = animal unit		

From Tetra Tech, Inc., 2004.Technical fundamentals of CAFOs for permit writers and inspectors. Tetra Tech, Pasadena, CA.

How much manure on a 200 cow dairy?

	Column A	Column B
	Animals per AU[a]	Annual manure production per AU
	-1000 lbs-	---tons---
Beef cattle	1.00	11.50
Dairy cattle	0.74	15.24

200 cows

$$\frac{1\text{ AU}}{0.74\text{ dairy cows}}$$

$$\frac{1\text{ AU}}{15.24\text{ tons manure}}$$

- Determine units of your answer
- Write out the variables you know with the units as fractions

Answer =Total tons of manure

How much manure on a 200 cow dairy?

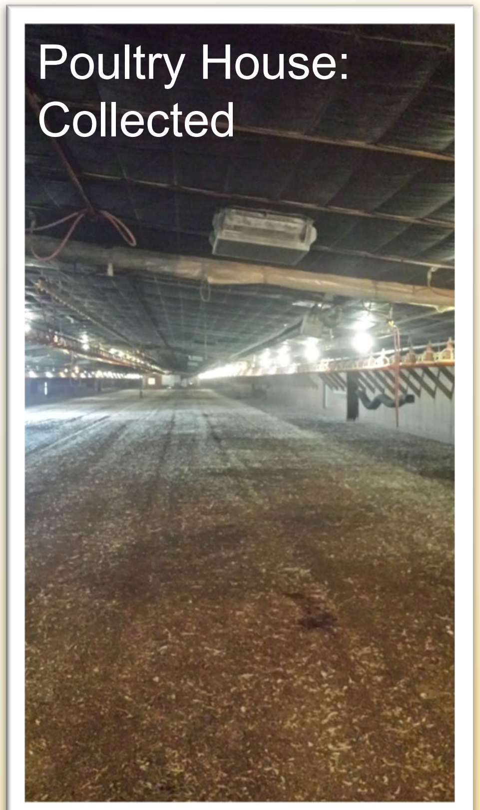
	Column A	Column B
	Animals per AU[a]	Annual manure production per AU
	-1000 lbs-	---tons---
Beef cattle	1.00	11.50
Dairy cattle	0.74	15.24
Broilers	455.00	14.97
Turkey (slaughter)	67.00	8.18

$$\frac{\text{15.24 tons manure}}{\text{1 AU dairy}} \times \frac{\text{1 AU dairy}}{\text{0.74 cows}} \times \text{200 cows}$$

= 4119 Total tons of manure

Manure Storage and Handling

Collection: Understand that some animals are confined under roof, while some may have access to pasture.



Pasture Considerations

- Manure on pasture *can* be considered not collected

- Manure under roof may be considered partial confinement
  - Ask how many hours a day confined (2, 6 ,12)
  - Calculate manure production based on those days

How much manure on a 200 cow dairy?

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MANURE QUANTITY ESTIMATION
(For Solid Manure)
You can only edit values highlighted in blue

Farm name:	Local Dairy			
Manure Production period:				
Starting date:	3/1/2020	Ending date:	2/28/2021	
A. Total days in manure production period:			365	
Livestock Information				
B. Livestock group	1	2	3	
	Dairy Cows	Heifers	Young Stock	
C. Average weight (lbs.)	1350	750	550	
D. # of animals	200	20	20	
E. Animal units (AU) [(**C** x **D**)/1000]	270	15	11	
F. Full days confined during manure production period	365	365	365	
G. Days partially confined during manure production period				
H. Hours per day confined				
I. Day equivalents partially confined (**G** * **H**/24)	0	0	0	
J. Total day equivalents confined (**F** + **I**)	365	365	365	
K. Total day equivalents unconfined on pasture (**A** - **J**)	0	0	0	
L. Weight of manure/AU/day (lbs.) (see **Table 1.**)	106	85	85	
Bedding Estimation	1	2	3	
M Bedding type (straw, sawdust, etc.)				
N. Volume of bedding this production period (cu.ft.). (If weight of bedding is known, proceed to **P** and enter it directly.)				
O. Density of bedding (lbs. per cu.ft.) (see **Table 2.**)				
P. Weight of bedding (tons) [(**N** x **O**)/2000]	0.0	0.0	0.0	
Uncollected Manure (Deposited on Pasture)	1	2	3	
Q. Weight of manure on pasture (tons) [(**E** x **L** x **K**)/2000]	0	0	0	
Collected Solid Waste (Manure And Bedding)	1	2	3	
R. Weight of collected manure (tons) [(**E** x **L** x **J**)/2000]	5,223	233	171	
S. Weight of collected manure & bedding (tons) (**P** + **R**)	5,223	233	171	

Updated: 5-12-18

	Animal Units?	Manure Generated per Year (tons)
Dairy Cows (200)	**270**	**5,223**
Bred Heifers (20)	**15**	**233**
Young Stock (20)	**11**	**171**
Bedding?		
Total	**296**	**5627**

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Table 1. MANURE PRODUCTION RATES*

ManureType	Description	Lbs manure/AU/day	Cu. ft. manure/AU/day
Dairy	lactating cow[4]		
	12,500 lbs milk/yr	81	1.3
	15,000 lbs milk/yr	88	1.4
	17,500 lbs milk/yr	94	1.5
	20,000 lbs milk/yr	100	1.6
	22,500 lbs milk/yr	106	1.7
	25,000 lbs milk/yr	113	1.8
	27,500 lbs milk/yr	119	1.9
	dry cow	82	1.3
	heifer	85	1.3
	bull[2]	70	1.1
	veal	60	0.96

How much manure on a 200 cow dairy?

Livestock Information	1	2	3
Livestock group	D.milkers,22.5k#/	D. heifer	D. heifer
Average weight, lbs	1350	750	550
Number of animals	200	20	20
Animal units	270.0	15.0	11.0
Starting date	03/01/2023	03/01/2023	03/01/2023
Ending date	02/28/2024	02/28/2024	02/28/2024
Total days	365	365	365
Full days confined	365	365	365
Days partially confined			
Hours per day confined		0	0
Total time confined, days	365.0	365.0	365.0
Total time on pasture, days	0	0	0
Weight of manure, lbs/AU/day	106.0	85.0	85.0
Bedding Estimation	**1**	**2**	**3**
Bedding type	None	None	None
Density of bedding, lbs/cu.ft.			
Volume of bedding, cu.ft.			
Weight of bedding, tons			
Uncollected Manure			
Manure left on pasture, tons	0.0	0.0	0.0
Collected solid waste	**1**	**2**	**3**
Manure, tons	5223.1	232.7	170.6
Solid manure & bedding, tons	5223.1	232.7	170.6
Total waste from all groups, tons	5626.5		
Link to Solid Manure Analysis	None		

✓Factors that Cause Variation in the Plant Nutrient Levels in Manure

Beef/Dairy/Poultry/Swine Manure

Factors which cause variation in manure nutrients

1. Animals are relatively inefficient in their utilization of nutrients, and 50% can end up in their manure.
2. Diet (type of feed) affects nutrient content of manure
3. There is also a lot of species variation (swine vs poultry vs cattle)
4. Additions like **phytase** can help chickens retain more P
5. The amount and type of bedding (if any) will also influence the nutrient content of the material.
6. Storage and handling can affect nutrient content
7. Sampling procedures

Manure nutrient content variation by species

Table 9.2, page 209

Manure Type	N (total)	P (P_2O_5)	K (K_2O)
	---------------lb / ton ---------------		
Broiler litter[b]	59	63	40
Turkey (fresh)[a]	27	25	12
Layer[a]	35	42	28
Horse[b]	9	6	11
	------------lb / 1000 gal ------------		
Swine[b]	40	37	23
Dairy[b]	28	19	25

[a] from Zublena, J.P., J.C. Barker, and T.A. Carter. 1990. Soil facts: Poultry manure as a fertilizer source. North Carolina Extension Service Pub. AG-439-5.
[b] from Bandel, V.A. 1990. Using manure to cut fertilizer costs. University of Maryland Cooperative Extension Service Fact Sheet 512.

Other nutrients in manure (poultry)

Typical concentrations of secondary and micro-nutrients in various poultry manures. Secondary and micro-nutrients enhance the value of manure as a balanced nutrient source.

Manure Type	Ca	Mg	S	Na	Fe	Mn	B	Mo	Zn	Cu
Layer	----------------------------lbs/ton----------------------------									
Undercage scraped	43.0	6.1	7.1	4.5	0.5	0.27	0.05	<0.01	0.32	0.04
Highrise stored	86.0	6.0	8.8	5.0	1.8	0.52	0.05	<0.01	0.37	0.04
Broiler litter	----------------------------lbs/ton----------------------------									
Broiler house	41.0	8.0	15.0	13.0	1.3	0.67	0.05	<0.01	0.63	0.45
Roaster house	43.0	8.5	14.0	13.0	1.6	0.74	0.05	<0.01	0.68	0.51
Breeder house	94.0	6.8	8.5	8.6	1.3	0.57	0.04	<0.01	0.52	0.21
Stockpiled	54.0	8.0	12.0	6.2	1.5	0.59	0.04	<0.01	0.55	0.27
Turkey litter	----------------------------lbs/ton----------------------------									
Brooder house	28.0	5.7	7.6	5.9	1.4	0.52	0.05	<0.01	0.46	0.36
Grower house	42.0	7.0	10.0	8.4	1.3	0.65	0.05	<0.01	0.64	0.51
Stockpiled	42.0	6.8	9.5	6.4	1.5	0.62	0.05	<0.01	0.56	0.34
Layer	------------------------lbs/1000 gallons------------------------									
Liquid slurry	35.0	6.8	8.2	5.3	2.9	0.42	0.04	0.02	0.43	0.08
Lagoon sludge	71.0	7.2	12.0	4.2	2.2	2.30	0.08	0.01	0.80	0.14
Layer	-------------------------lbs/acre-inch-------------------------									
Lagoon liquid	25.0	7.4	52.0	51.0	2.0	0.24	0.4	0.02	0.70	0.19

From Zublena, J.P., J.C. Barker, and T.A. Carter. 1990. Soil facts: Poultry manure as a fertilizer source. North Carolina Extension Service Pub. AG-439-5.

Other nutrients in manure (poultry)

Typical concentrations of secondary and micro-nutrients in various poultry manures. Secondary and micro-nutrients enhance the value of manure as a balanced nutrient source.

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Layer			-------------------------lbs/1000 gallons-------------------------							
Liquid slurry	35.0	6.8	8.2	5.3	2.9	0.42	0.04	0.02	0.43	0.08
Lagoon sludge	71.0	7.2	12.0	4.2	2.2	2.30	0.08	0.01	0.80	0.14
Layer			---------------------------lbs/acre-inch---------------------------							
Lagoon liquid	25.0	7.4	52.0	51.0	2.0	0.24	0.4	0.02	0.70	0.19

From Zublena, J.P., J.C. Barker, and T.A. Carter. 1990. Soil facts: Poultry manure as a fertilizer source. North Carolina Extension Service Pub. AG-439-5.

Factors which cause variation in manure nutrients

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2. Diet (type of feed) affects nutrient content of manure

3. There is also a lot of species variation (swine vs bird vs cattle)

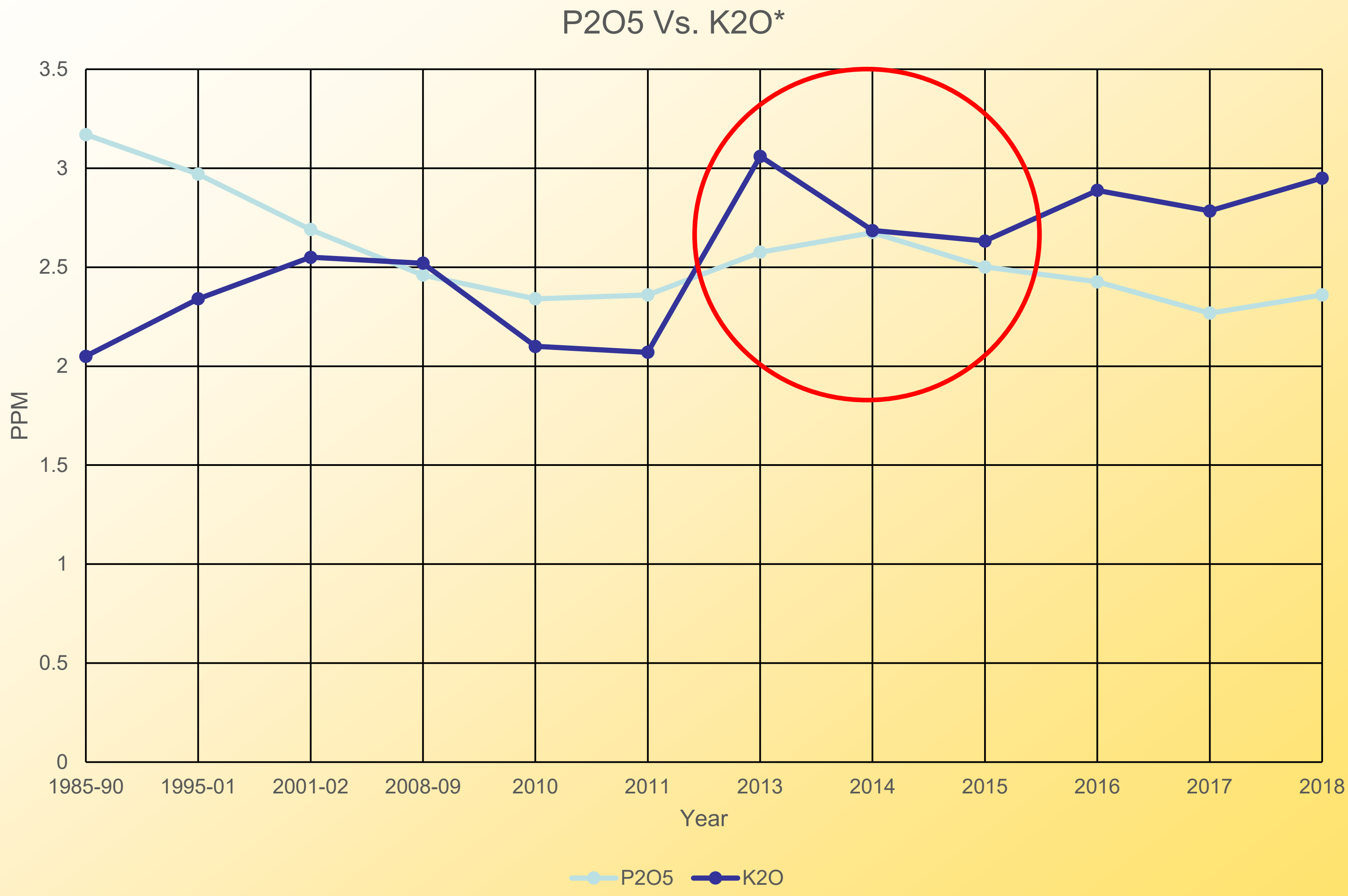
4. **Additions like phytase can help chickens retain more P**

5. The amount and type of bedding (if any) will also influence the nutrient content of the material.

6. Storage and handling can affect nutrient content

7. Sampling procedures

Changes in Poultry Manure Content



* Summary of Poultry Broiler Manure Analysis from University of Maryland Nutrient Management Program

Crop Removal Relative to Manure Content*

Table 1.2-8. Typical crop nutrient removal for phosphorus and potassium.

	Per unit of yield			Removal for given yield	
Crop (units)	*P_2O_5*	*K_2O*	*Typical yield/A*	*P_2O_5*	*K_2O*
Corn (bu)	0.4	0.3	150 (bu)	60	45
Corn silage (T)[1]	4.0	8.0	25 (T)	125	275
Grain sorghum (bu)	0.6	0.8	125 (bu)	75	100
Forage sorghum (T)[1]	3.0	10.0	15 (T)	45	150
Sorghum/sudangrass[1]	7.0	7.0	15 (T)	105	105
Alfalfa (T)[2,3]	15.0	50.0	5 (T)	75	250
Red clover (T)[2,3]	15.0	40.0	3.5 (T)	55	140
Trefoil (T)[2,3]	15.0	40.0	3.5 (T)	55	140
Cool-season grass (T)[2,3]	15.0	50.0	4 (T)	60	200
Bluegrass (T)[2,3]	10.0	30.0	2.5 (T)	25	75
Wheat/rye (bu)[4]	1.0	1.8	60 (bu)	60	110
Oats (bu)[4]	0.9	1.5	80 (bu)	70	120
Barley (bu)[4]	0.6	1.5	75 (bu)	45	110
Soybeans (bu)	1.0	1.4	50 (bu)	50	70
Small grain silage (T)[1]	7.0	26.0	6 (T)	40	160

1. 65 percent moisture.
2. For legume-grass mixtures, use the predominant species in the mixture.
3. Dry hay equivalent, 10 percent moisture.
4. Includes straw.

*** 2019 – 2020 Penn State Agronomy Guide**

Crop Removal Relative to Manure Content*

extension.umd.edu

Manure Summary Report (2022 update)

Poultry, solid w/litter (broilers) – 2019 through 2021 — **404** Samples

	N (total)	NH_4-N	P_2O_5	K_2O	Moisture
			%		
Mean	2.71	0.34	2.52	2.95	27.97
Minimum	0.82	0.001	0.16	0.11	7.42
Maximum	4.82	1.83	5.43	6.98	70.70
Median	2.79	0.23	2.49	2.97	26.21

Poultry wo/litter (layers) – 2017 through 2021 — **48** Samples

	N (total)	NH_4-N	P_2O_5	K_2O	Moisture
			%		
Mean	2.92	0.64	2.47	1.77	43.67
Minimum	0.92	0.03	0.97	0.69	6.83
Maximum	5.95	1.46	4.88	3.36	71.48
Median	2.87	0.70	2.09	1.65	44.55

Beef Cattle, solid – 2017 through 2021 — **475** Samples

	N (total)	NH_4-N	P_2O_5	K_2O	Moisture
			%		
Mean	0.74	0.10	0.43	0.85	64.61
Minimum	0.12	0.001	0.004	0.03	6.76
Maximum	2.75	0.98	2.96	4.35	79.91
Median	0.64	0.07	0.35	0.68	69.81

Beef Cattle, semisolid – 2017 through 2021 — **133** Samples

	N (total)	NH_4-N	P_2O_5	K_2O	Moisture
			%		
Mean	0.38	0.06	0.21	0.39	83.07
Minimum	0.16	0.004	0.06	0.06	80.02
Maximum	0.96	0.35	0.77	1.34	89.40
Median	0.35	0.05	0.18	0.34	82.95

*** 2022 ANMP Manure Summary Report**

Crop Removal Relative to Manure Content

Corn (175 bushel per acre @ Medium FIV Soil Test)

Nutrients Needed/ Nutrients Supplied	Nitrogen (lbs. per acre)	P2O5 (lbs. per acre)	K2O (lbs. per acre)
Corn nutrient requirements	175	89	135
Poultry: 2.0 tons/ acre	57	101	118
Semi Solid Cattle: 10 tons/ acre	52	86	170
Liquid Cattle: 10,000 gal/acre	56	67	175

✓Storage and Handling May Cause Significant Nutrient Loss Especially Nitrogen

Manure Storage and Handling (pg 213)

- Sampling should be done as close to application time as possible because nutrient content can change

Changes in nutrient content occur due to

- **Dilution** – from rainwater
- **Settling** – Phosphorus precipitation (into a solid)
- **Gaseous loses** – nitrogen volatilization

Proper Manure Sampling Procedure

Solid

- Sample right before spreading
- Take 5 samples of manure during loading
- Avoid large chunks of bedding
- Mix each sample together in a bucket to get a representative sample

Liquid

- Sample right before spreading
- Agitate pit thoroughly before sampling (2-4 hours minimum)
- Take 5 samples of manure during loading
- Mix each sample together in a bucket to get a representative sample

Send off that day if possible!

AgroLab

Account No. : 96

Poultry Manure Analysis Report

Invoice No. : 1125363
Date Received : 03/22/2021
Date Analyzed: 03/23/2021

Lab No. : 12921

Results For : Joe Progressive
Sample ID : 1 HOME FARM

	Analysis Dry Basis	Analysis As Is Basis	Lbs / Ton Dry Basis	Lbs / Ton As Is Basis	Lbs / Ton Available First Year
Organic N, % N	3.49	2.33	69.9	46.6	24.7
Ammonium, % N	0.306	0.2040	6.1	4.1	3.9
Nitrate, % N	0.010	0.0070	0.2	0.1	0.1
Total N, % N	3.81	2.54	76.2	50.8	28.7
Phosphorus, % P_2O_5	3.35	2.23	67.0	44.7	40.2
Potassium, % K_2O	4.78	3.19	95.6	63.7	60.6
Sulfur, % S	1.18	0.79	23.6	15.8	6.3
Calcium, % Ca	2.09	1.39	41.9	27.9	19.6
Magnesium, % Mg	0.83	0.55	16.7	11.1	7.8
Sodium, % Na	0.97	0.65	19.4	13.0	13.0
Sodium Adsorption Ratio (SAR)	14.31				
Zinc, ppm Zn	575.2	383.5	1.2	0.8	0.5
Iron, ppm Fe	911.1	607.4	1.8	1.2	0.9
Manganese, ppm Mn	776.4	517.6	1.6	1.0	0.7
Copper, ppm Cu	441.7	294.5	0.9	0.4	0.6
Aluminum, ppm Al	915.6	610.4	1.8	1.2	0.9
Boron, ppm B	64.3	42.9	0.1	0.1	0.1
pH		8.2			
Moisture, %	33.33				
Dry Matter (TS), %	66.67				

Note: The available first year Ammonium-N is calculated based on maximum availability, or incorporation within 24 hours. Advise a nutrient consultant for adjustments beyond 24 hr incorporation.

Reviewed By : L.D. Severson - AgroLab Inc 3/24/2021 Copy : 1 Page 1 of 1

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Harrington, DE 19952

Proper Manure Sampling Procedure

Variation in Analysis:
Poultry Manure (As is)

Date of Sample	Total N (ppm)	Total P2O5 (ppm)	Total K2O (ppm)	Moisture (%)
1/7/20	1.14	1.00	.82	72.6
2/24/20	3.13	2.92	2.92	22.46

Proper Manure Sampling Procedure

Variation in Analysis:
Poultry Manure (As is)

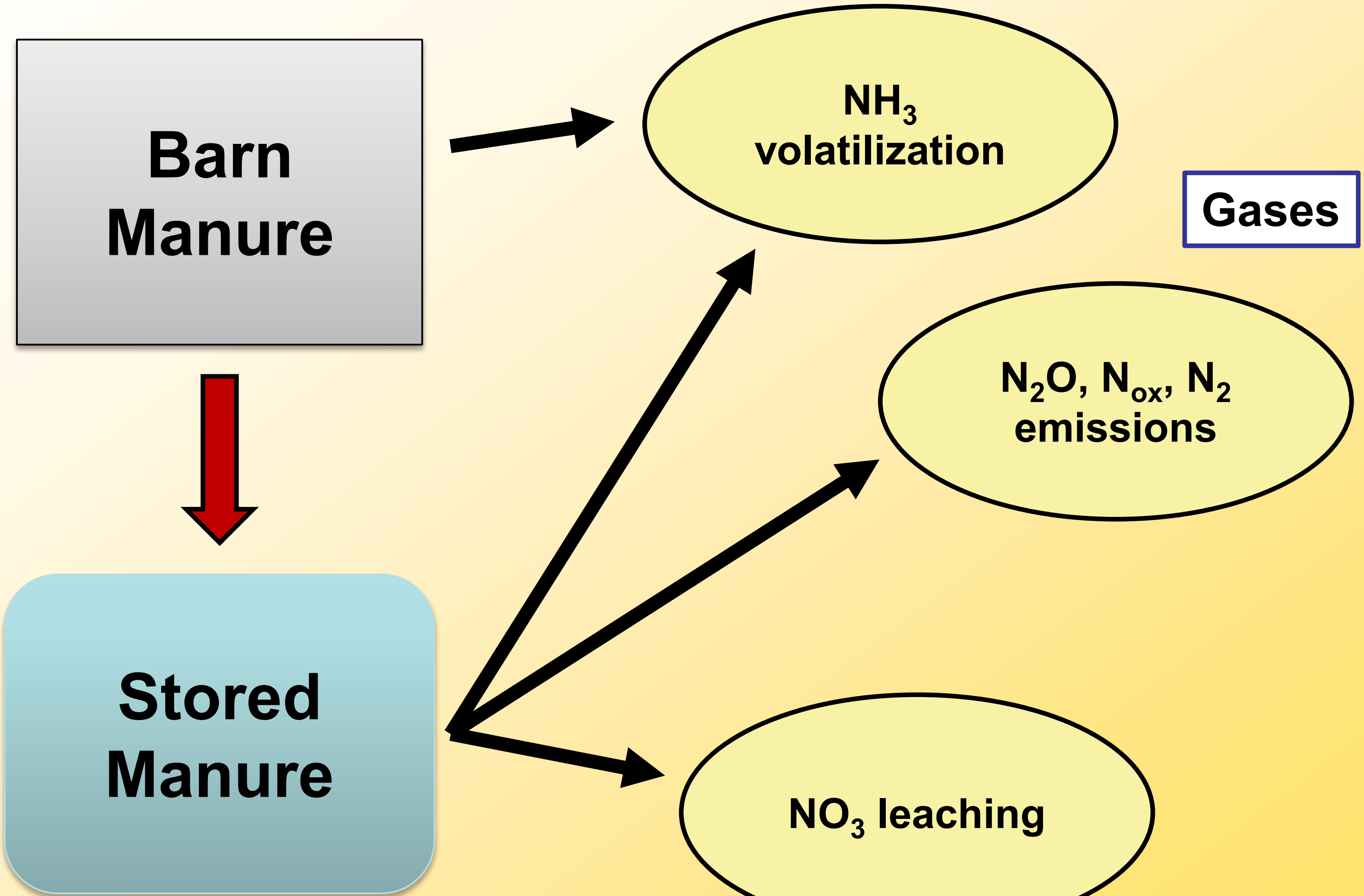
Date of Sample	Lbs. of N @ 2 Tons per acre	Total P2O5 2 Tons per acre	Total K2O 2 Tons per acre
1/7/20	24	40	33
2/24/20	65	117	117

Loss of P and K in manure storage

- P and K lost during storage are relatively low
- Most losses are due to handling
  - P and K do not become gases
  - They must be lost as liquid or solid runoff, windblown dust, ect
- Losses of P in lagoons is due to settling of solids (so its still technically there)

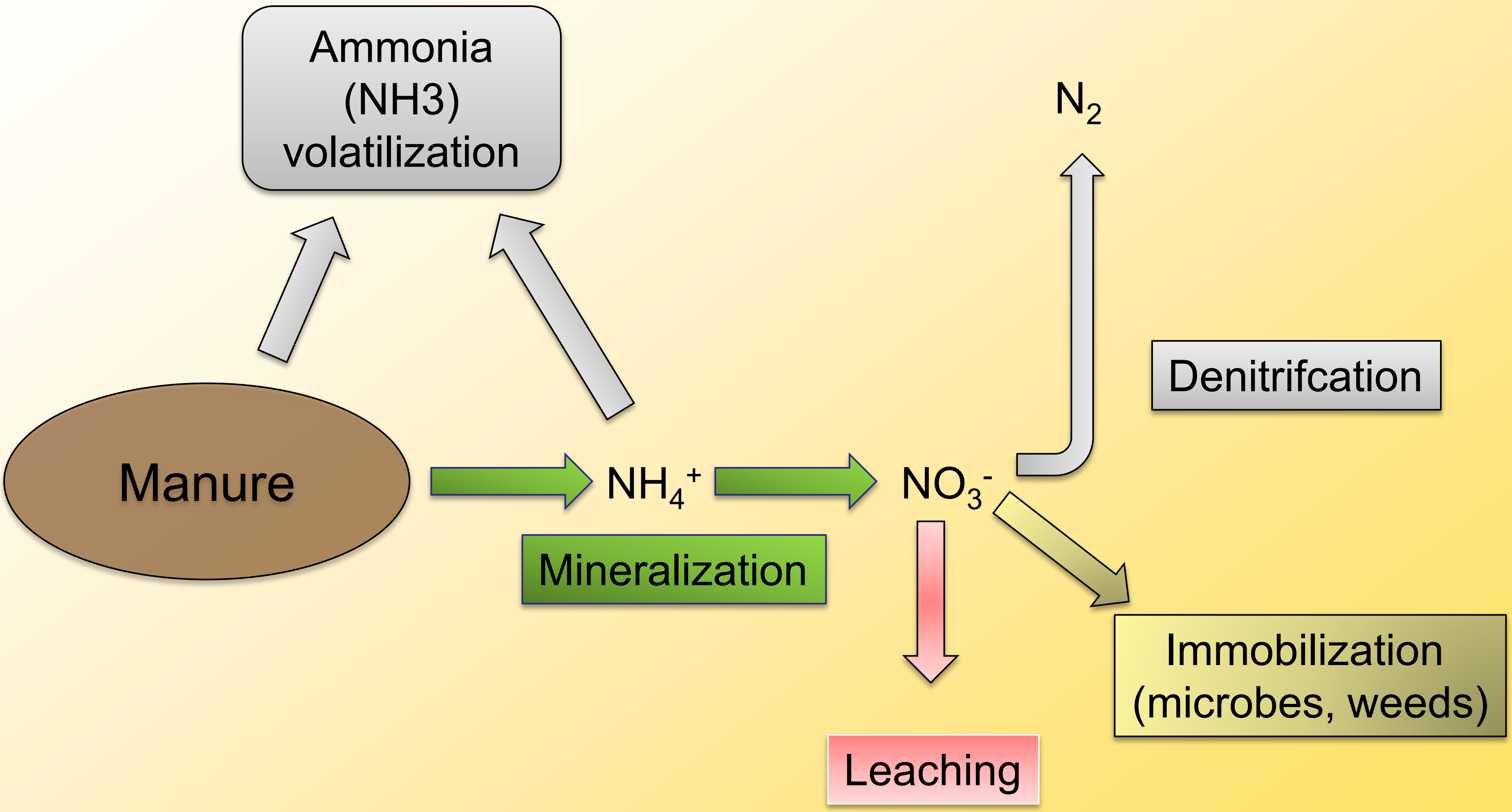
Loss of Nitrogen

N losses during storage can range from 15 to 90%



Loss of Nitrogen

N losses during storage can range from 15 to 90%



Nitrogen forms in manure

- **Nitrogen in manures is found in:**
  - ***Organic N*: the fraction in dead plant and animal material and is found primarily in amine groups ($-NH_2$) and uric acid.**
  - ***Inorganic N*:**
    - ***ammonium* (NH_4^+)**
    - ***nitrate* (NO_3^-)**

  The most common form of inorganic N in manure is ammonium.

Manure storage and handling: Nutrient loss

Table 9.6
pg 214

Manure System	N	P (P_2O_5)	K (K_2O)
	-------------percent lost-------------		
Solid			
Daily scrape and haul	20-35	5-15	5-15
Manure pack	20-40	10-20	10-20
Poultry, deep pit or litter	25-50	5-15	5-15
Solids on open lot			
Scrape once/year	40-55	20-40	30-50
Daily scrape and haul	20-35	10-20	15-25
Separated solids, 90 days storage	30	10-20	10-20
Liquid (slurry)			
Anaerobic pit	15-30	5-20	5-20
Aboveground storage	10-30	5-15	5-15
Manure basin or runoff pond, 120-180 days storage	20-40	5-50	5-50
Liquid lagoon	70-85	50-80	30-80
Lagoon, 365 days	90	50-80	30-80

From Fulhage, C.D., and D.L. Pfost. 2002. Fertilizer nutrients in livestock and poultry manure. University of Missouri Cooperative Extension Bulletin EQ351.

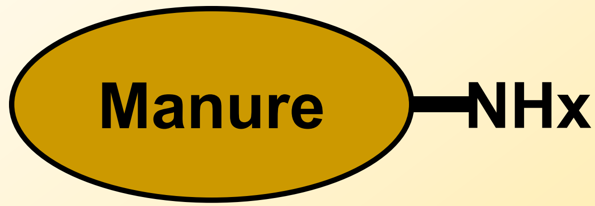
Manure storage and handling: Nutrient loss

Part 1 of table for estimating annual nutrient availability after losses from different kinds of storage.

Manure Storage/ Treatment System	Nitrogen			Phosphorus (P_2O_5)			Potassium (K_2O)		
	N Pro-duced	Factor	Available N	P Pro-duced	Factor	Available P	K Pro-duced	Factor	Available K
Example: poultry manure on sawdust; per ton	*60*	** 0.50*	*30*	*58*	** 1.0*	*58*	*52*	** 1.0*	*52*
Open lot or feedlot		* 0.50			* 0.95			* 0.70	
Storage (slurry manure, bottom loaded storage)		* 0.85			* 1.0			* 1.0	
Storage (liquid manure, top loaded storage)		* 0.70			* 1.0			* 1.0	
Storage (pit beneath slatted floor)		* 0.75			* 1.0			* 1.0	

Nitrogen forms in manure

- ***Organic N (bonded to organic molecule)*:**



- ***Inorganic N (MINERAL)*:**
    - ***ammonium*** **(NH_4^+)**
    - ***nitrate*** **(NO_3^-)**

The most common form of inorganic N in manure is ammonium.

Availability of N in manure, Table 9.8, pg 218

- ❖ The inorganic N fraction (approximately 20 to 65% of total N in manure) is considered immediately available to plants.

- ❖ The organic N fraction must be converted to inorganic N (through *mineralization)* to become plant-available.

- ❖ Mineralization rate of organic N is highly variable and influenced by factors such as temperature, moisture, and C:N ratio of the manure.

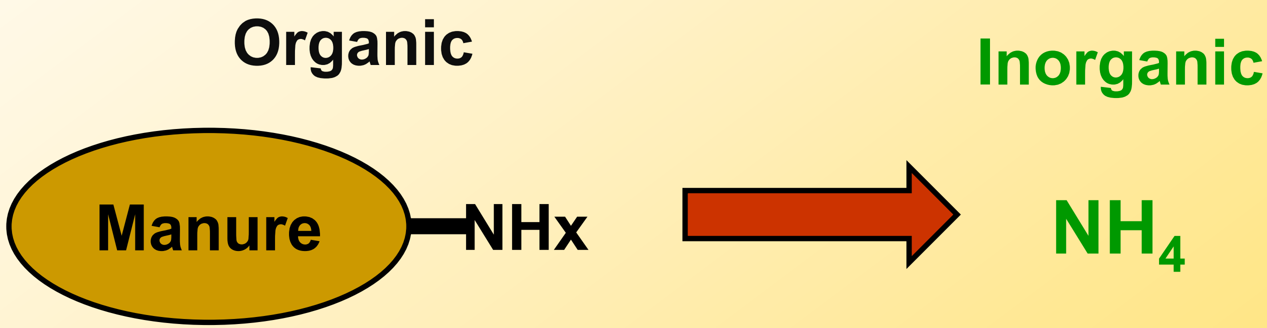
Manure type	Organic N	Inorganic N (NH_4^+)
	------------------ %	------------------
Dry poultry	77	23
Liquid poultry	36	64
Semi-solid dairy	70	30
Liquid dairy	58	42
Semi-solid beef	80	20
Swine lagoon	47	53
Mixed swine	35	65

Average percentage of forms of nitrogen in different types of manure

From Virginia Department of Conservation and Recreation. 1993. Nutrient management handbook. 2nd edition. VA DCR, Richmond, VA.

Mineralization

Release of organic N from manure by microbial breakdown



Mineralization Rates (% mineralized)

How do you calculate the Nitrogen released over time? Pg 218, table 9.9

Animal type	Year of application	Year after application	Second year after application
Cattle	0.35	0.18	0.09
Layers	0.60	0.15	0.08
Horses	0.20	0.10	0.05

Mineralization of organic N

Questions:

What type of manure? Storage?

How much organic N does it contain?

What is mineralization rate?

Multiply organic N by mineralization rate

Mineralization of organic N

How much N is released from sawdust + poultry (layer) after 0, 1 and 2 years in the soil?

- Amount of total N in layers (Table 9.2, pg 209): **59 lb/ton**
- Storage factor for poultry and sawdust (Table 9.7, pg 215): **0.50**
- Amount of organic N in dry poultry (Table 9.8, pg 218): **77% (0.77.)**

Mineralization rates from previous slide (amount remaining)

- 0 Yr: **= 0.60**
- 1 Yr **= 0.15**
- 2 yr **= 0.08**

Mineralization of organic N

How much N is released from sawdust + poultry (layer) after 0, 1 and 2 years in the soil?

Year	Total N	Organic N	Storage Factor	Mineralization rate	N released
0	59	0.77	0.5	0.6	13.6
1	59	0.77	0.5	0.15	3.4
2	59	0.77	0.5	0.08	1.8

Manure will provide less Nitrogen over time

Determining remaining organic N

If test question says you have 20 lb/ton organic N, multiply by mineralization rate.

Year	Organic N		Mineralization rate	N released
0	20		0.6	12
1	20		0.15	3
2	20		0.08	1.6

N volatilization in manure

- *Volatilization* is the loss of N as ammonia gas (NH_3).
- There are two major pathways for this loss in agriculture:
  - Conversion of ammonium-N (NH_4^+-N) to ammonia-$NH_{3.}$
  - Conversion of urea ($CO(NH_2)_2$) to ammonia-$NH_{3.}$
- Urea is a nitrogen-containing compound that is readily converted to ammonia upon catalysis by the ubiquitous enzyme urease:
  - $CO(NH_2)_2 + H_2O + \text{urease} \longrightarrow 2NH_3 + CO_2$

Ammonium Conservation Factors
for solid manures (<90% moisture)

Time to incorporation	Conventional tillage	Conservation tillage	No-till or tillage >3 days
<1 hr	.96	.66	
1-3	.93	.64	
3-6	.78	.57	
6-12	.71	.53	
12-24	.63	.49	
1-2 days	.58	.47	
2-3 days	.53	.44	
>3 days (no-till)			.35

Advantages/ Disadvantages of Incorporation

Advantages

- Ammonium conservation
- Incorporation of manure throughout the root zone
- Odor reduction
- Short term organic matter incorporation
- Reduced planting issues

Disadvantages

- Increased risk of soil loss
- Destruction of soil structure
- Long term reduction of organic matter

Tools to Monitor Adequate Nitrogen

- Pre-Side-dress Nitrogen Test(PSNT)
- Fall Soil Nitrogen Test (FSNT)
- Tissue Sampling (Ear Leaf @ Silking)
- Corn Stalk Test (between ¼ milk line, which is just before silage harvest, to about 3 weeks after black layer formation.)

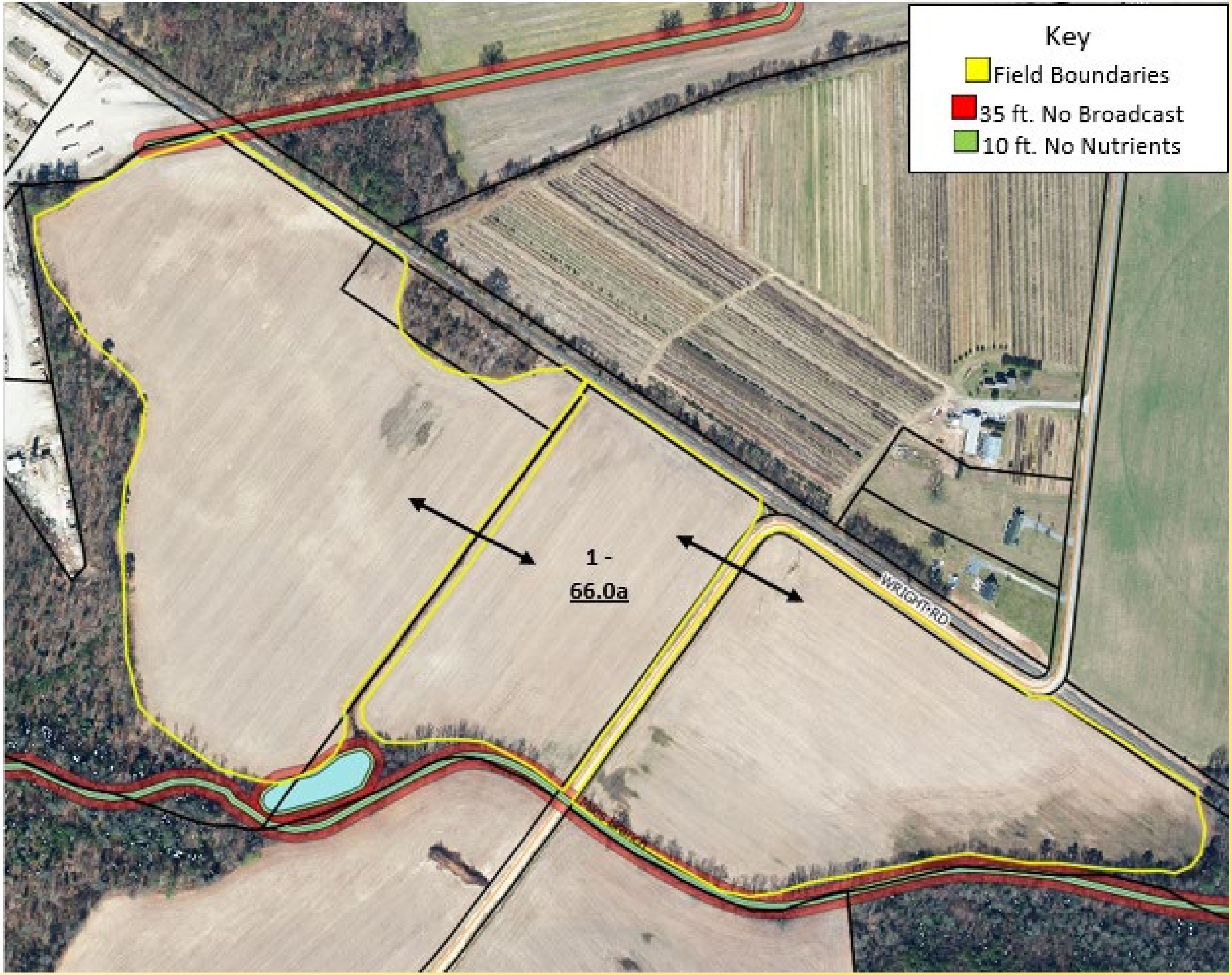
Soil Factors Affecting Liquid Applications

- Slope, stream and pond setbacks, ditches, sinkholes, etc.
- Never spread on saturated soils to prevent denitrification
- Spreading on karst soils allows manure to reach groundwater extremely fast

To spread or not to spread?

To spread or not to spread?

To spread or not to spread?


Key
Field Boundaries
35 ft. No Broadcast
10 ft. No Nutrients
1 -
66.0a
WRIGHT RD

Spreading Equipment

- Broadcast Applications of Fertilizer, Manure Lime & Seed
- Even Distribution of Crop Inputs
- Accuracy Via: Ground Driven Conveyors
- Width of Spread Via: Visual Reference, Strips, Crop Rows, etc.

When should an application of manure or fertilizer be applied?
Do I need a Nutrient Management Plan?

Calibration & Adjustment

- **Pay Close Attention to the Operators Manual**
- **Set Machine for Field Conditions**
- **Stop! – If Outcome is Not Desirable and Readjust**
- **Machinery May Require Added Attachments for Proper Application (gates)**

Calibrating manure application equipment

❖ Proper calibration of manure application equipment is a critical part of manure and nutrient management.

❖ Manure application equipment can be calibrated in one of three basic ways:

- The *tarp* method: Place a tarp flat on the field, spread manure on the tarp, weigh the manure, and calculate the application rate. Repeat measurement at least 3 times.
- The *swath and distance* method: Determine the swath width and distance traveled to empty the spreader and calculate the rate based on area covered and the weight of the load. Repeat measurement at least three times.
- The *loads-per-field* method: Simply count the number of loads of manure applied and divide by the numbers of acres.

❖ For each of the calibration methods, it is critical that all of the controllable variables (i.e., equipment speed, gate settings, type and consistency of manure) remain constant!

Calibrating manure application equipment

https://extension.umd.edu/resource/manure-spreader-calibration

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Manure Spreader Calibration

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Updated: February 18, 2021

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Manure Spreader Calibration

Calibration is a way of checking and/or making adjustments to manure application equipment to ensure that a nutrient source is being applied uniformly and at the desired rate. It is important to properly calibrate manure application equipment to minimize the potential for over or under applying nutrients to a crop.

There are two methods for calibrating manure application equipment:

1. **Weight-area method** - This method, which is appropriate when dealing with heavier solid manure, involves spreading manure on a collection surface of known dimensions, weighing the manure on the collection surface, and calculating the application rate. The application rate is then converted to a per-acre basis.
2. **Load-area method** - This method, which is appropriate for liquid and solid manures and poultry litter, involves spreading several loads of manure on the field, measuring the area, and then calculating the manure application rate for that area. The application rate is then converted to a per-acre basis.

For more information on calibration, including uniformity of spread pattern and examples of worksheets, refer to the following University of Maryland Extension Soil Fertility Guide publications:

- EC-1 "Calibration of Manure Spreaders: Uniformity, Spread Patterns and Effective Swath Width"
- EC-2 "Calibration of a Manure Spreader Using the Weight-area Method"
- EC-3 "Calibration of a Liquid Manure Spreader Using the Load-area Method"
- EC-4 "Calibration of a Manure Spreader Using the Load-area Method (with Drive-on Scales)"
- EC-5 "Calibration of a Manure Spreader Using the Load-area Method (with Estimation of Density and Load Weight)"

For more information about operating and calibrating many types of nutrient application equipment, consult the NRAES-57 "Fertilizer and Manure Application Equipment" publication.

Nutrient Management Advisors in University of Maryland Extension offices can provide instruction and assistance with manure spreader calibrations. Please visit our **Nutrient Management Advisors** web page to find your local Extension advisor.

Calibrating with the swath and distance method

❖ Determining Effective Swath Width

Swath is the width of the strip of land upon which manure is spread by one pass of a spreader. Some spreaders, like many box spreaders, have swaths that mirror the width of the spreader itself (see Figure 2a below). Other spreaders, like spinner spreaders, deposit material on both sides of the spreader as well as directly behind the spreader (see Figure 2b below). This type of spreader has a wider swath.

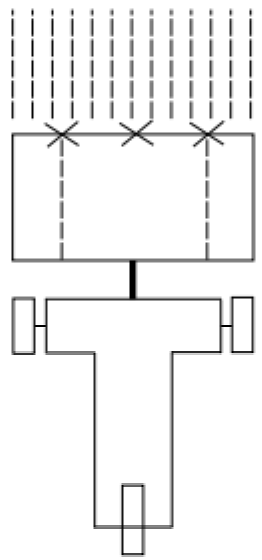


Figure 2a. Bird's eye view of a box spreader swath

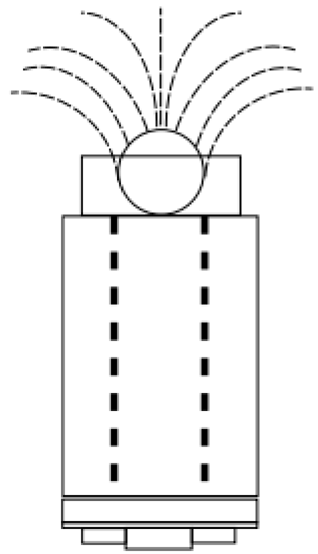


Figure 2b. Bird's eye view of a spinner spreader swath

Calibrating with the swath and distance method

❖ **Determining Effective Swath Width**

If one investigates the application rate across a swath, also known as the spread pattern, the application rate for all types of spreaders is highest directly behind the spreader and decreases with distance from the spreader. Figure 3 below shows a spread pattern from one pass of a rear-discharge box spreader. The swath is 18 feet and the highest application rate (about 15 tons per acre) is directly behind the spreader. Application rates drop quickly with distance from the spreader.

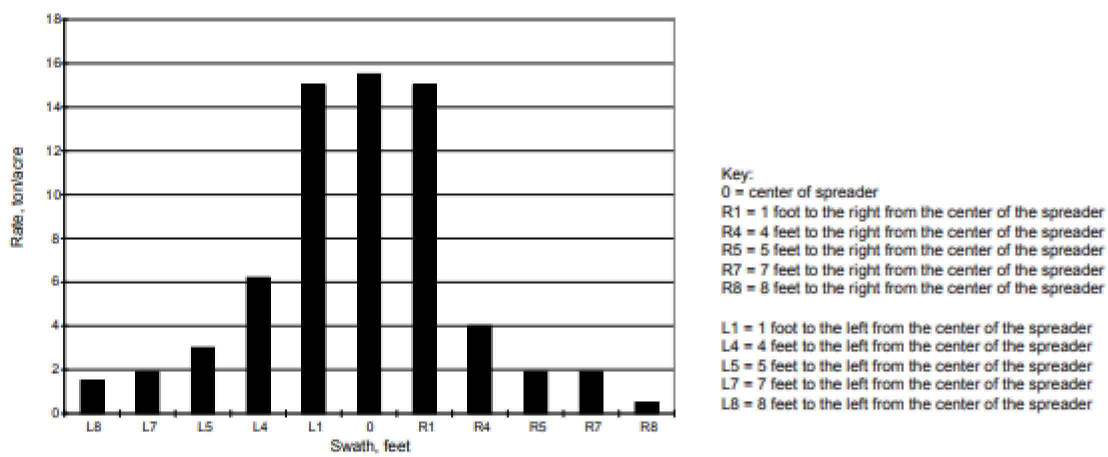


Figure 3. Spread pattern from a rear-discharge box spreader after one pass (© 2000 Iowa State University; *Manure Application with Dry Spreaders*; J. Lorimor)

Calibrating with the swath and distance method

❖ Determining Effective Swath Width

Figure 4 below shows a spread pattern for three passes of the same rear-discharge, box spreader. The swath width (i.e., the distance from the center of one pass to the center of the next pass) was 12 feet. While swaths were overlapped, the application rate across the field was extremely non-uniform.

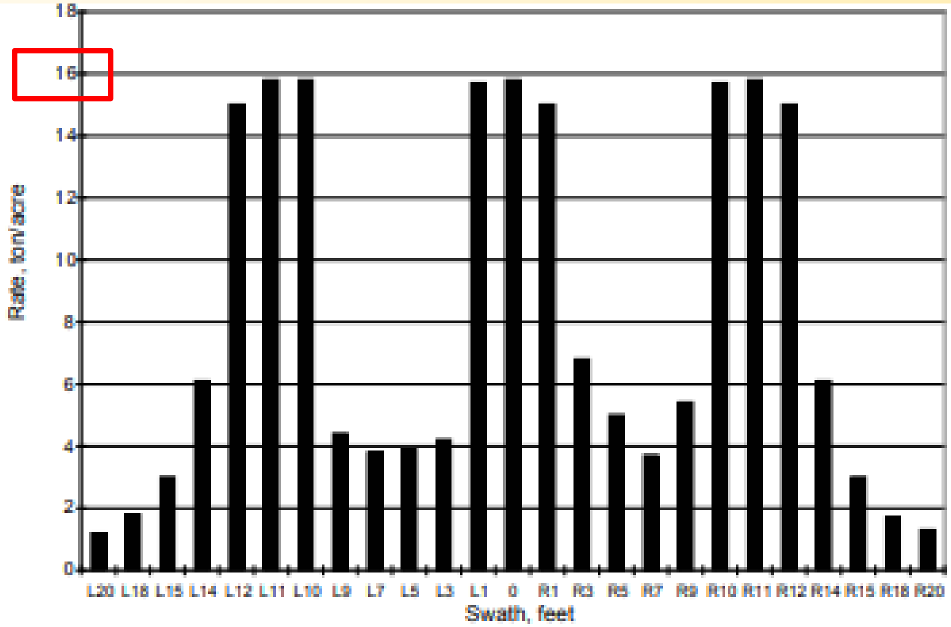


Figure 4. Spread pattern from a rear-discharge, box spreader using a 12-foot swath width (© 2000 Iowa State University; *Manure Application with Dry Spreaders*; J. Lorimor)

Calibrating with the swath and distance method

- **Determining Effective Swath Width**

  If one uses a 6-foot swath width for the same set of circumstances, the application rate across the field would be much more uniform (see Figure 5 below).

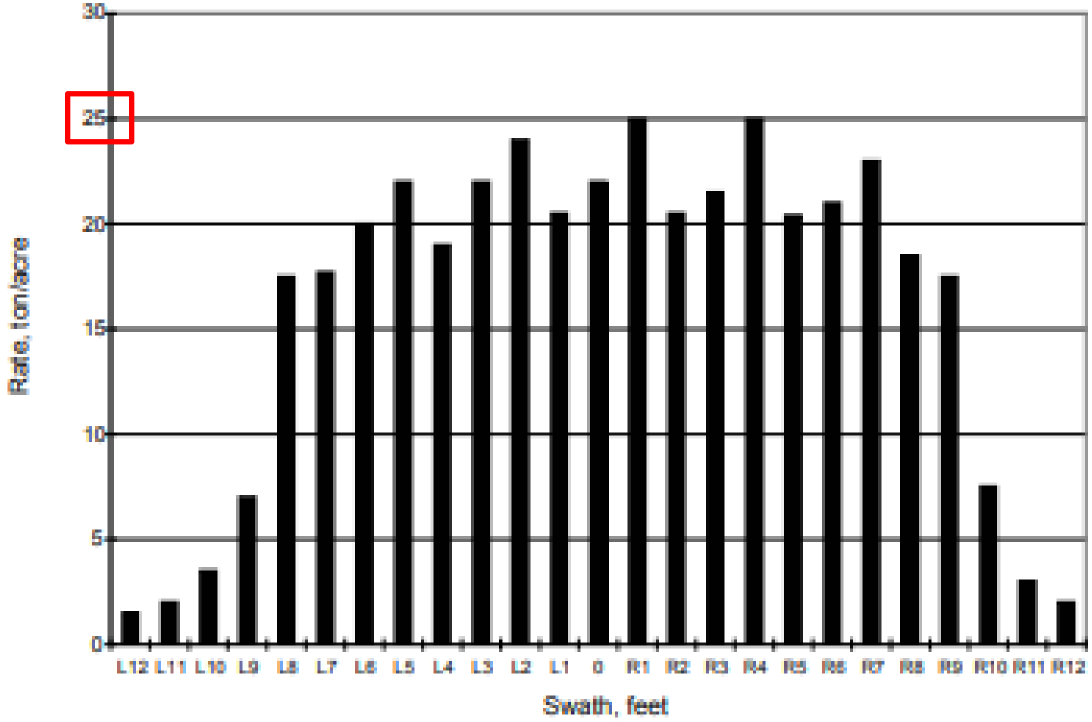


Figure 5. Spread pattern from a rear-discharge, box spreader using a 6-foot swath width (© 2000 Iowa State University; *Manure Application with Dry Spreaders*; J. Lorimor)

Calibrating with the swath and distance method

❖ **Determining Effective Swath Width**

Effective swath width can be thought of in several ways.

• It is the distance between the center point of one pass of a spreader and the center point of the next pass. This overlap of manure application will lead to a more uniform nutrient application.

• It is the sum of the distance on each side of the center of the spreader where the application rate is 50% of the maximum application rate (typically directly behind the spreader).

Figure 6 below illustrates the concept of effective swath width.

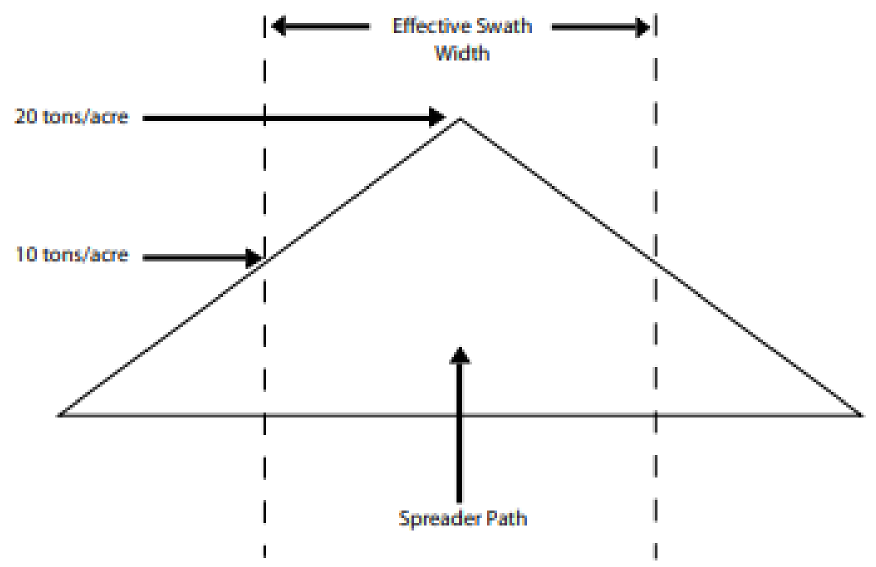


Figure 6. Effective swath width (© 2008 University of Georgia Cooperative Extension; modified from *Calibration of Manure Spreaders*; J. Worley et al.)

Calibrating with the swath and distance method

❖ **Determining Effective Swath Width**

Scenario: A spinner spreader, with typical settings and speed, spreads poultry manure while traveling over the center of a line 3 feet by 3 feet collection surfaces.

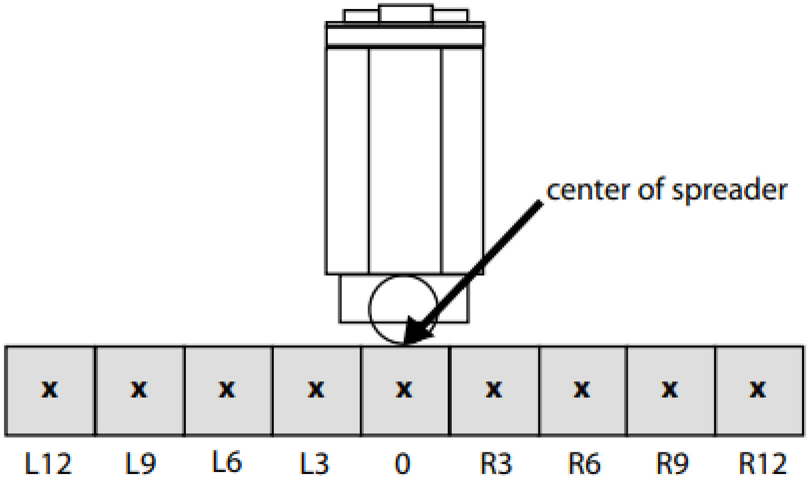


Figure 8. Location of collection surfaces relative to the center of the spreader in feet

Calibrating with the swath and distance method

❖ **Determining Effective Swath Width**

The sheets are collected and manure weighed.

Table 1. Weight of poultry litter on each collection surface

Location of collection surfaces in feet relative to center of spreader	Weight of litter in pounds per collection surface
L12	6
L9	15
L6	30
L3	36.8
0	40.8
R3	37
R6	28
R9	14.5
R12	5.6

Calibrating with the swath and distance method

❖ **Determining Effective Swath Width**

A plot of the results determining an effective swath width.

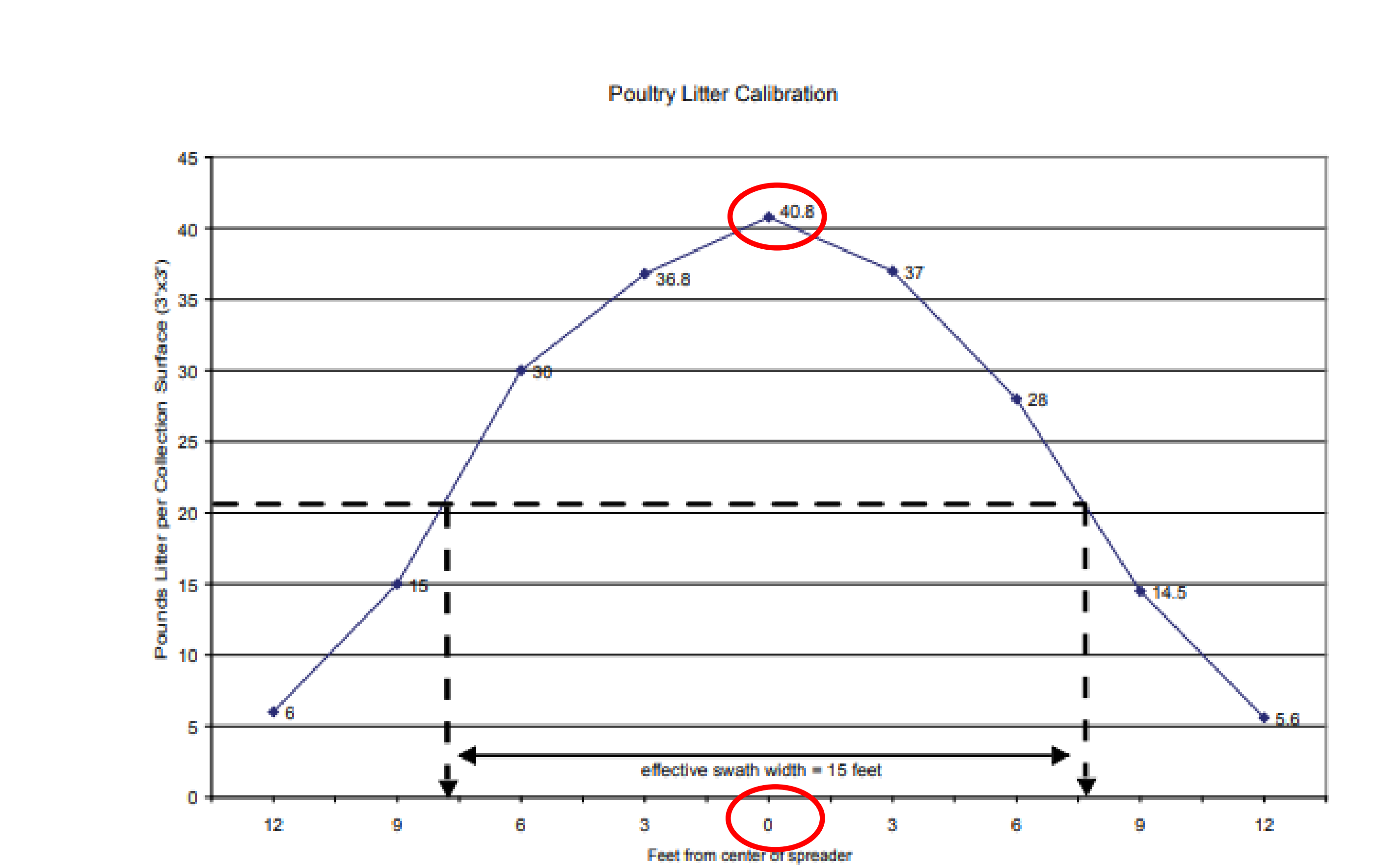


Figure 9. Graph of data for effective swath width scenario

Maximum Rate: 40.8 lbs. @ 0 feet.

Calibrating with the swath and distance method

❖ **Determining Effective Swath Width**

A plot of the results determining an effective swath width.

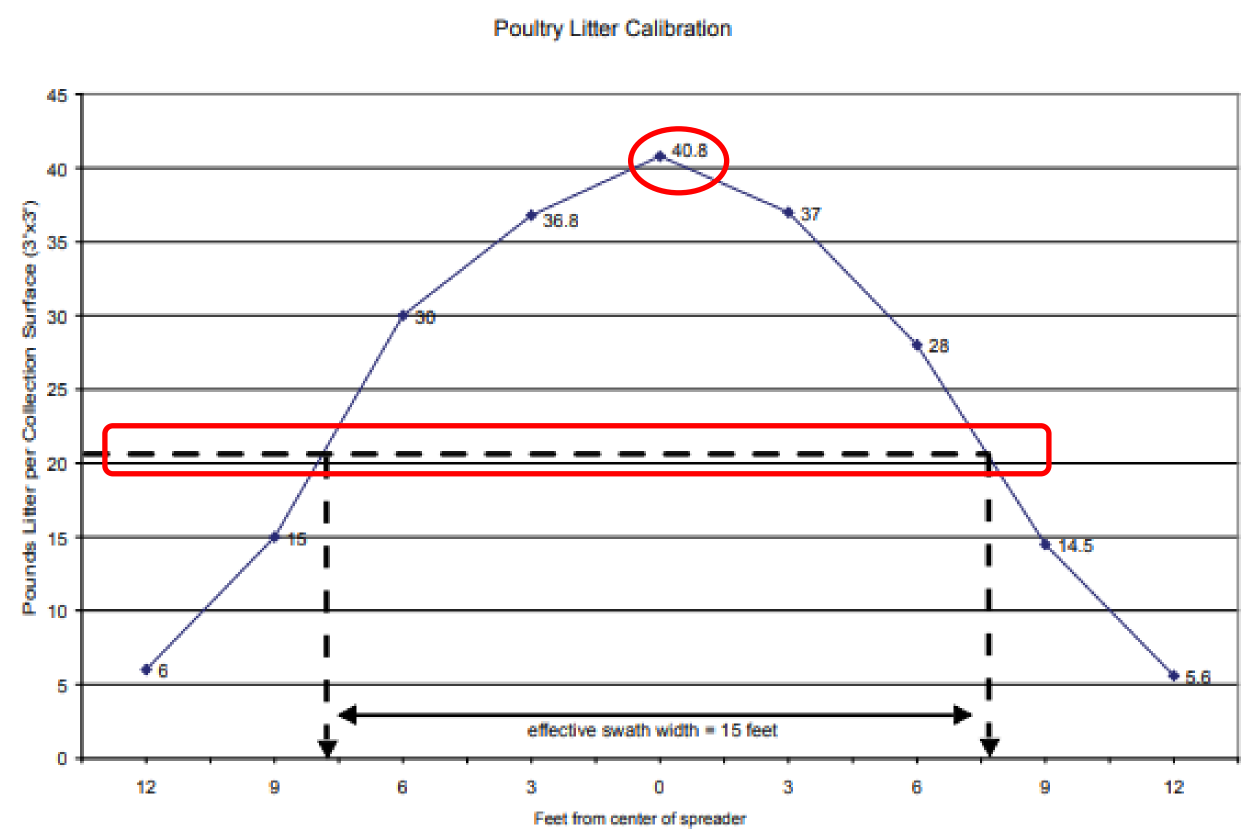


Figure 9. Graph of data for effective swath width scenario

Maximum Rate: 40.8 lbs./ 2 = 20.4 lbs..

Calibrating with the swath and distance method

- **Determining Effective Swath Width**

  A plot of the results determining an effective swath width.

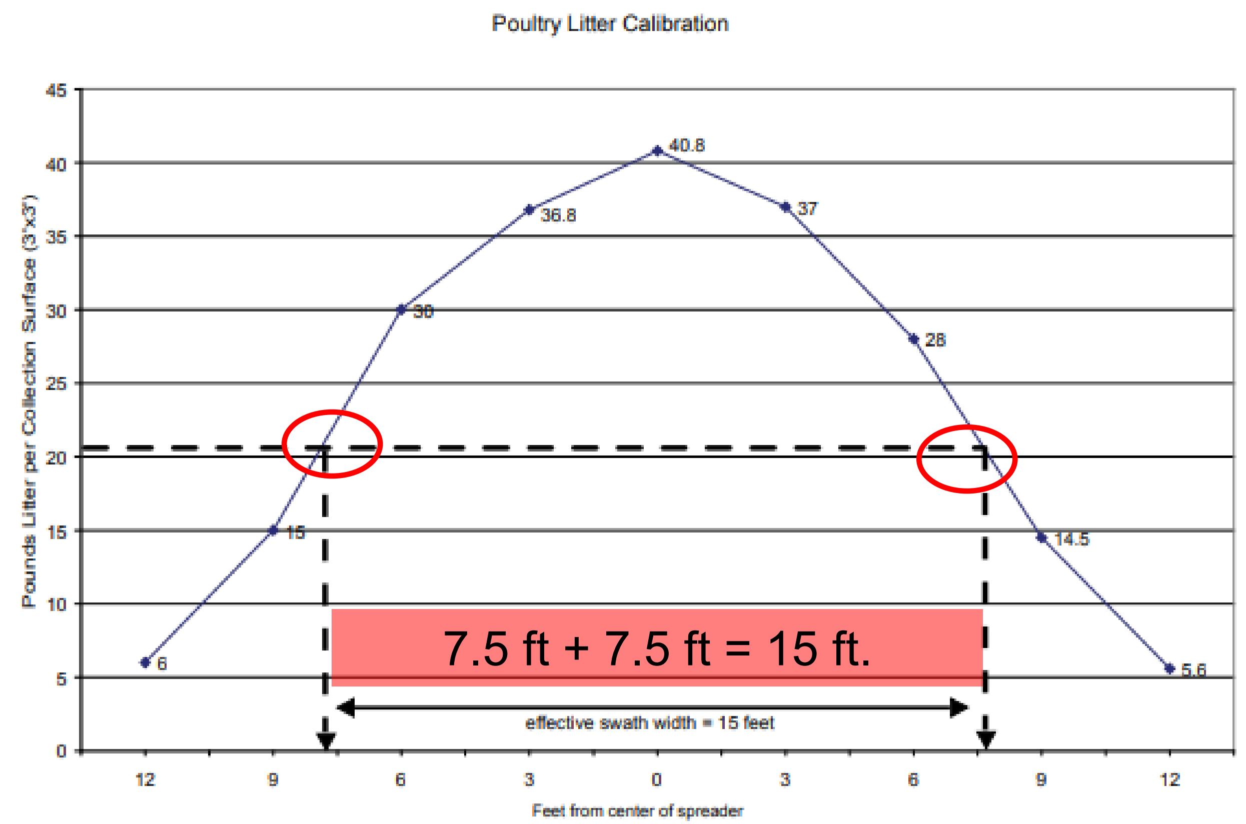
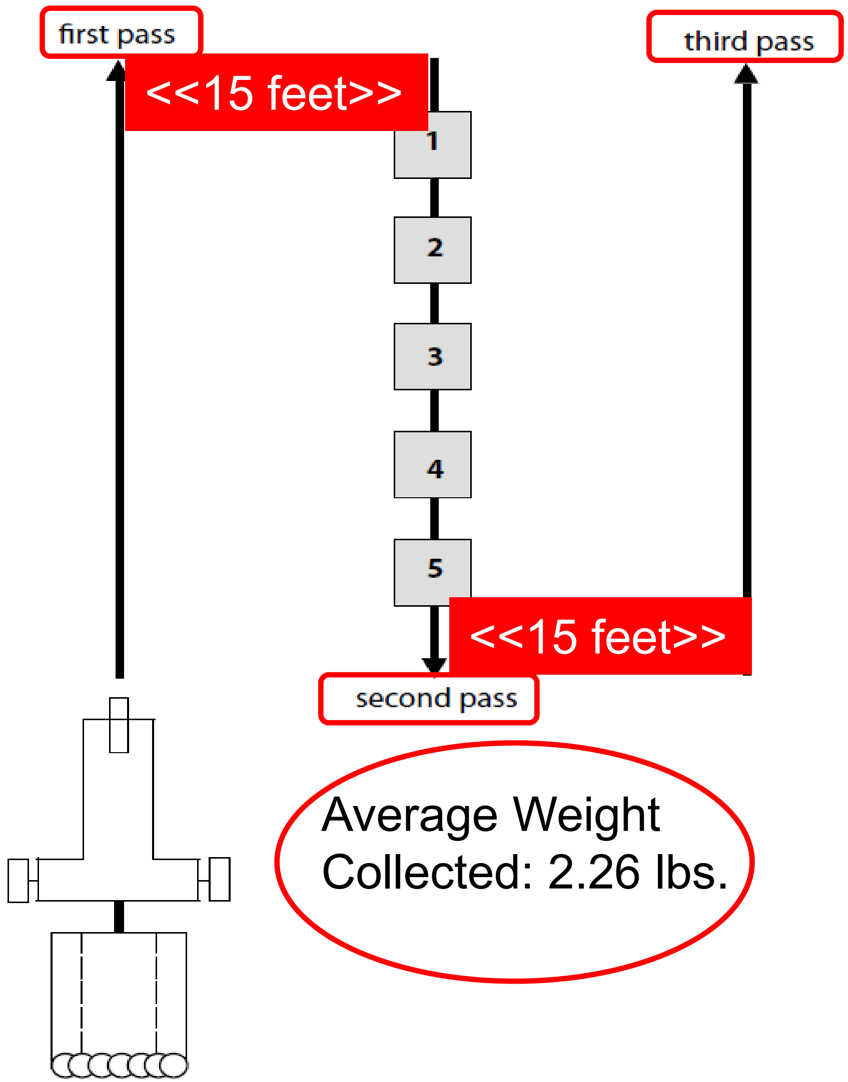


Figure 9. Graph of data for effective swath width scenario

Effective Swath Width of 15 feet.

Calibrating with the tarp method



Calculation:

5’ x 5’ = 25 square feet

(2.26 lbs. x 43,560)

/ (25 x 2,000)

98,445.6 / 50,000 =

1.97 tons per acre

Calibrating with the swath and distance method

- Calculations for determining application rate for the swath and distance method are similar to those used for the tarp method above.
  1. Determine the weight of a "load" of manure either
     - by direct measurement (i.e., weighing).
     - by converting from volume measurement (many applicators are rated by bushel (1.25 cu. ft.) or cubic foot capacity).
     - measure weight of manure in 5 gallon bucket (.67 cu. ft.)
  2. Determine the width of the application swath and the distance required to apply the load. From this point, the calculations are identical to those for the tarp method.
- Example:
  - You have a spreader that holds 215 cu. ft. of manure (~6.45 tons or 12,900 lbs.).
  - Your application width is 10 feet and the equipment travels 3000 feet along a field to empty the load.
  - The calculation would be:

12,900 lbs. / 30,000 sq. ft. (10 ft. * 3000 ft. = 30,000 sq. ft.) = .43 lbs./sq. ft.

0.43 lbs./sq. ft. * 21.78 (43,560/2000) = 9.37 tons/acre applied

Calibrating with the loads-per-field method

- The loads-per-field method is the easiest to calculate:
  1. Determine the ***weight in tons or gallons in 1,000's*** of a load of manure.
  2. Determine the ***size of the field*** in acres.
  3. Count the ***number of loads*** applied to the field.
  4. Multiply that number by the ***weight in tons or 1,000's of gallons of a single load***.
  5. Divide that number by the ***acreage of the field.***

- Example:
  - You have a spreader that holds 5,000 gallons of manure.
  - Your field is 55 acres and you apply 60 loads to the field.
  - The calculation would be:

60 loads * 5,000 gallons/load = 300,000 gallons
300,000 / 55 acres = 5,455 gallons/acre applied

Calibrating with the loads-per-field method

❖**Major drawback of the loads-per-field method is that it is an "after the fact" calculation so that the applicator does not have the opportunity to make adjustments in the application rate for the particular field.**

❖**May best be used as a method of monitoring application rates during the clean-out of a storage facility, using the first two methods described to actually calibrate the spreader before the full scale application of manure begins.**

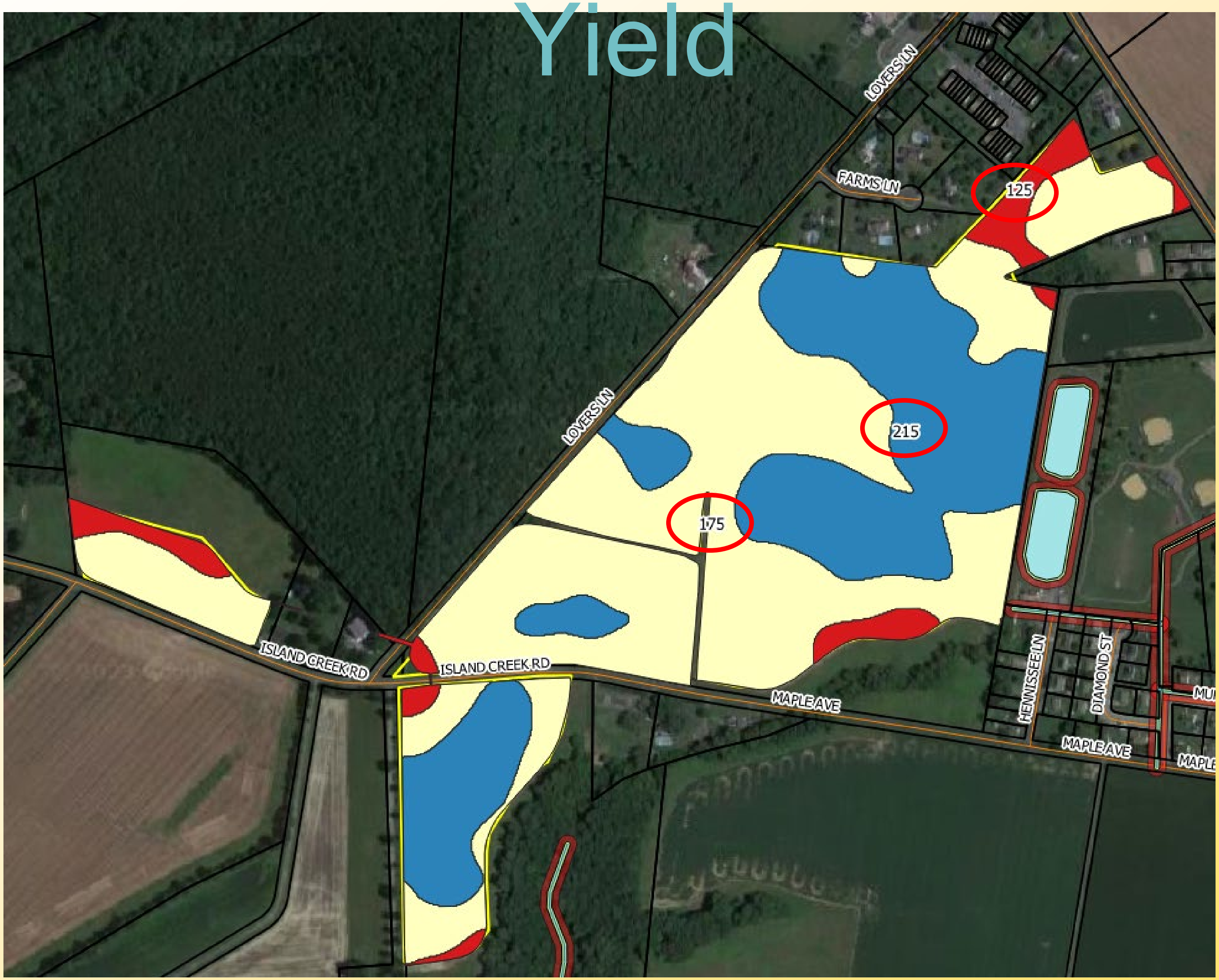
Loading manure into spreader (photo by Bob Nichols, USDA-NRCS)

Applicator Technology

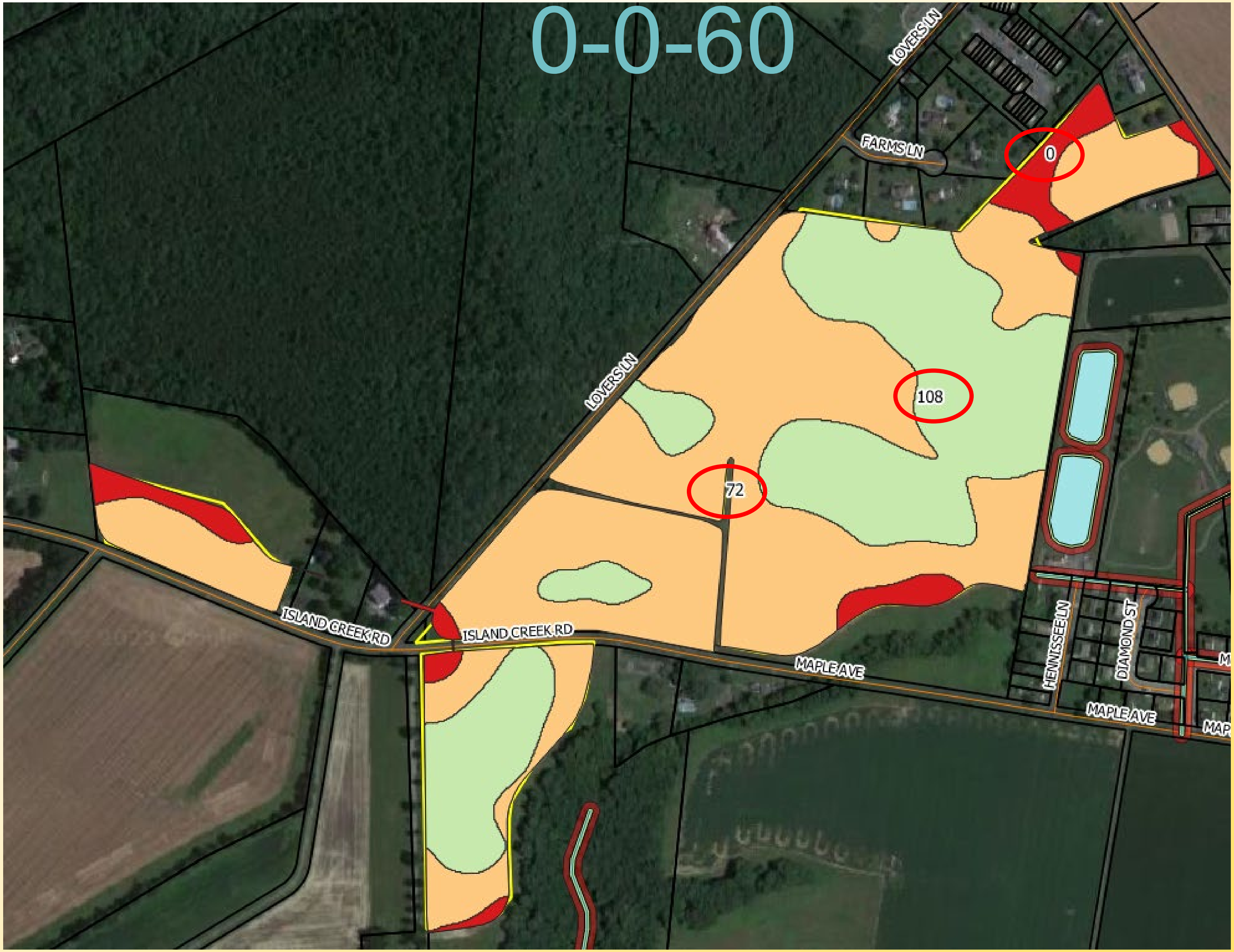
igure 4 Commercial Applicator with Variable Rate Controls

Applicator Technology

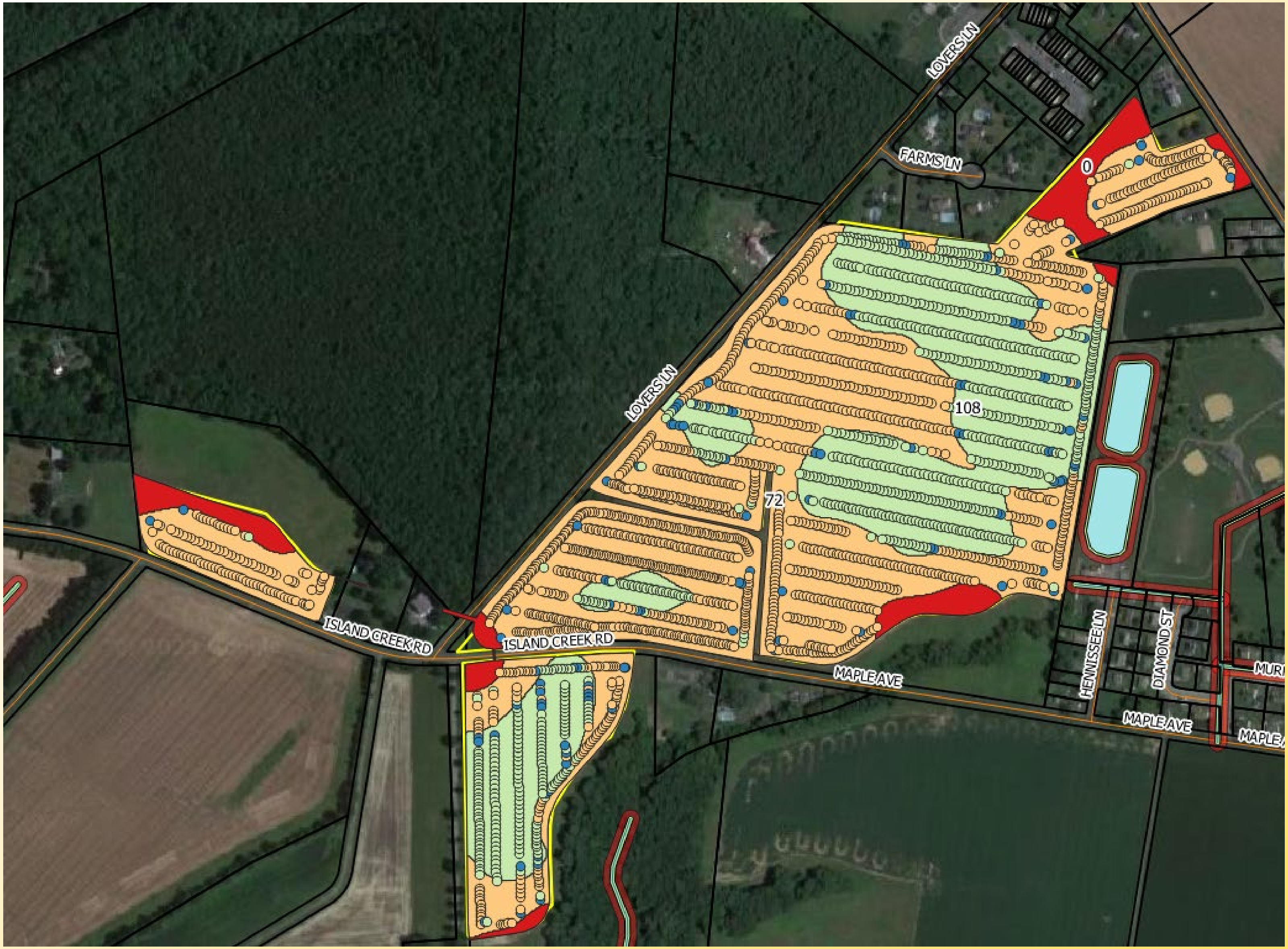
Yield



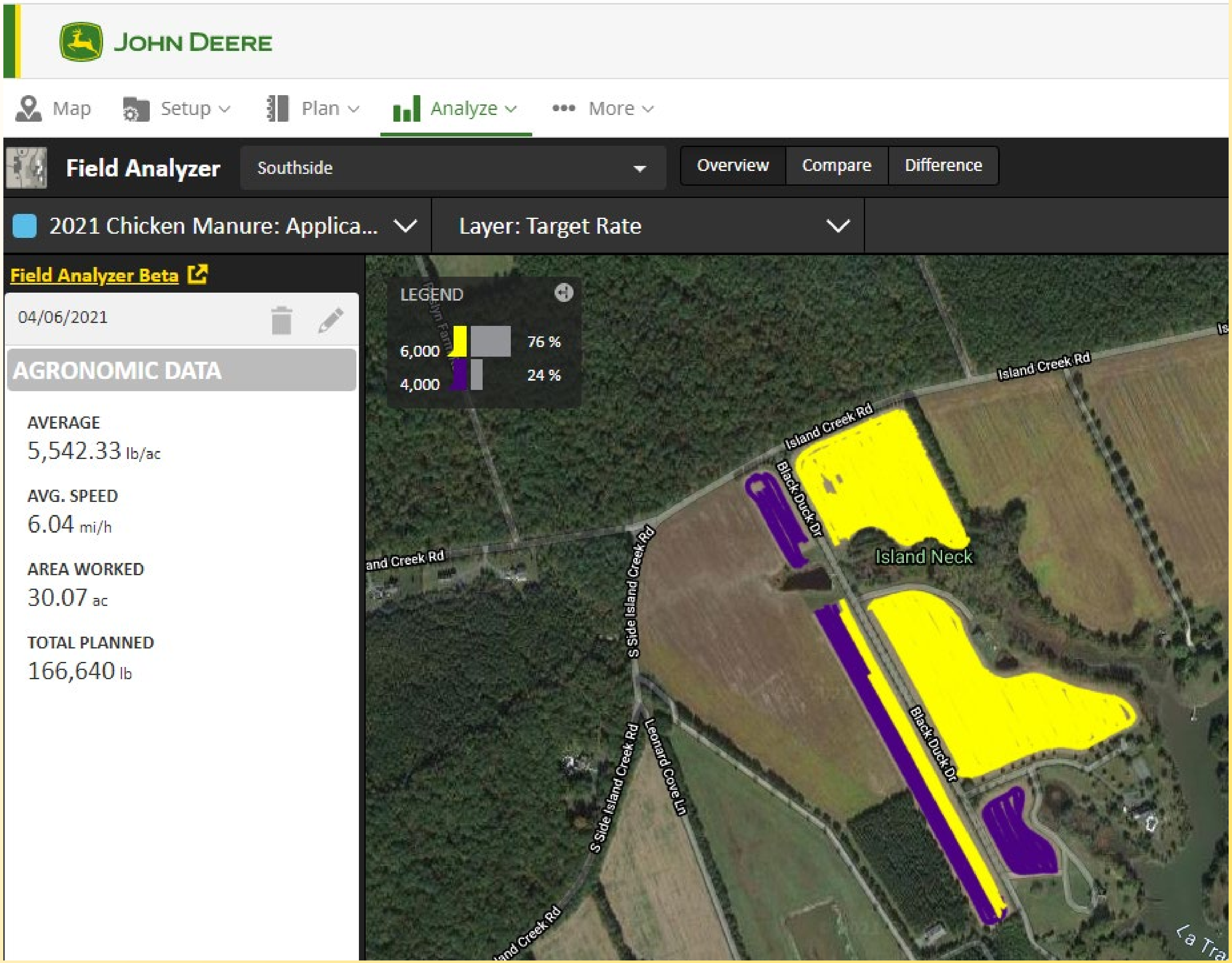
Applicator Technology



Applicator Technology



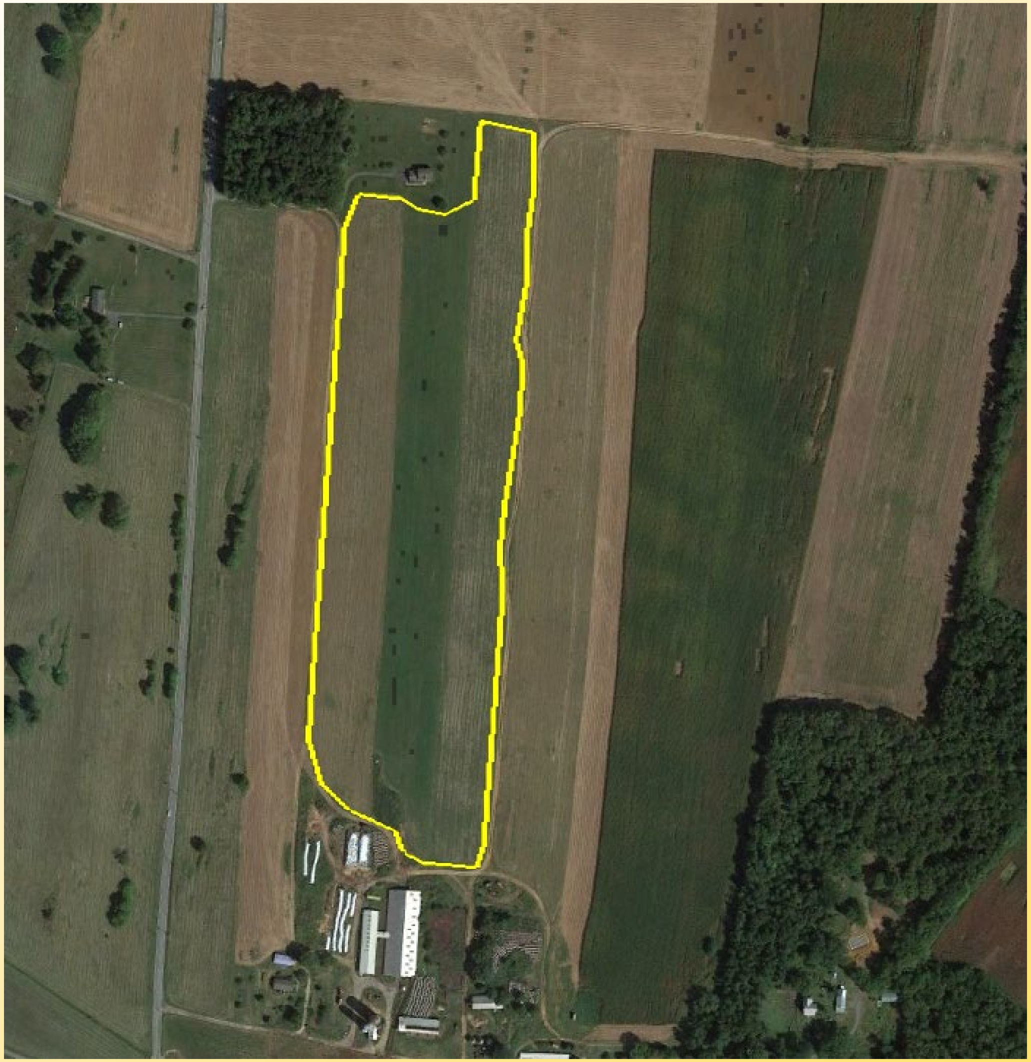
Manure Application Mapping



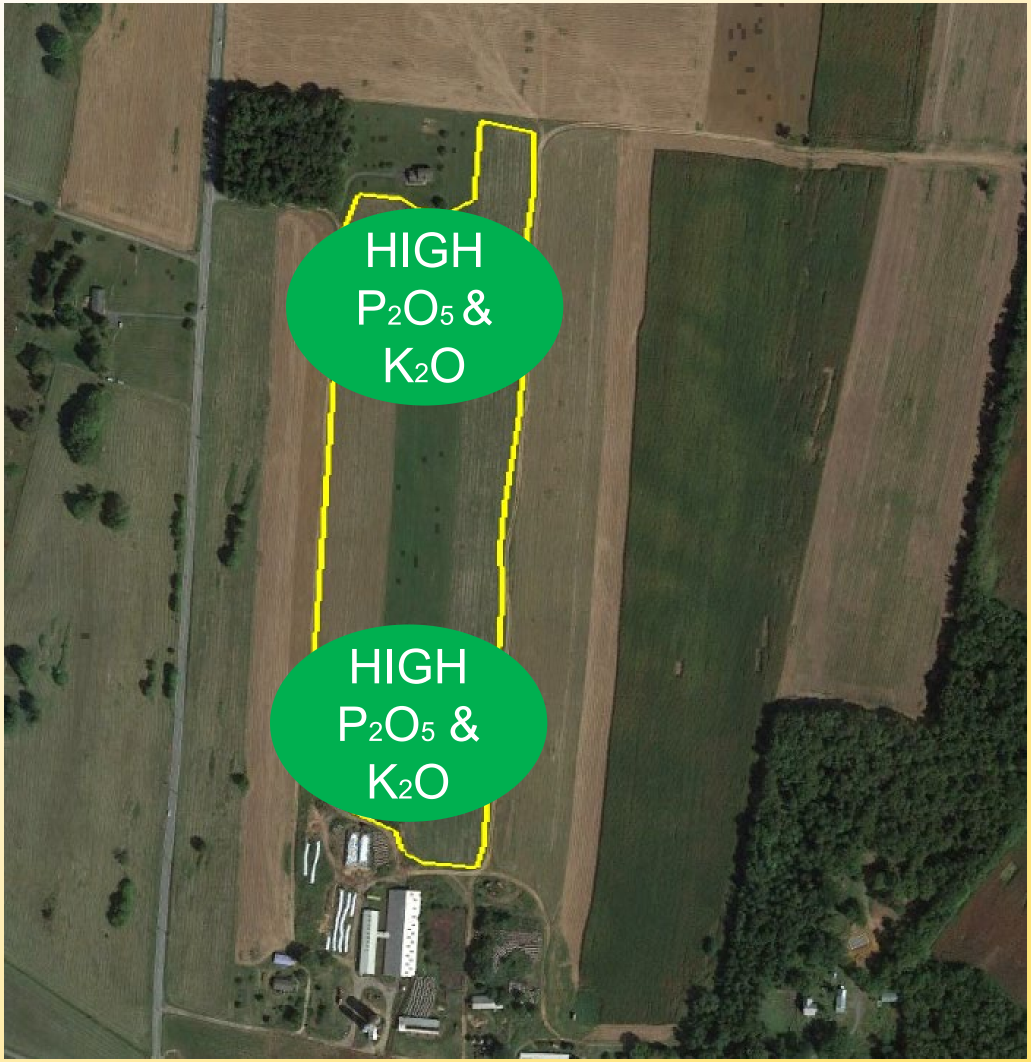
Always Remember:

- When you can’t cover an entire field, make a note of where you left off!
- Finish that field the next time you spread
  - Over time, the whole field will have been covered

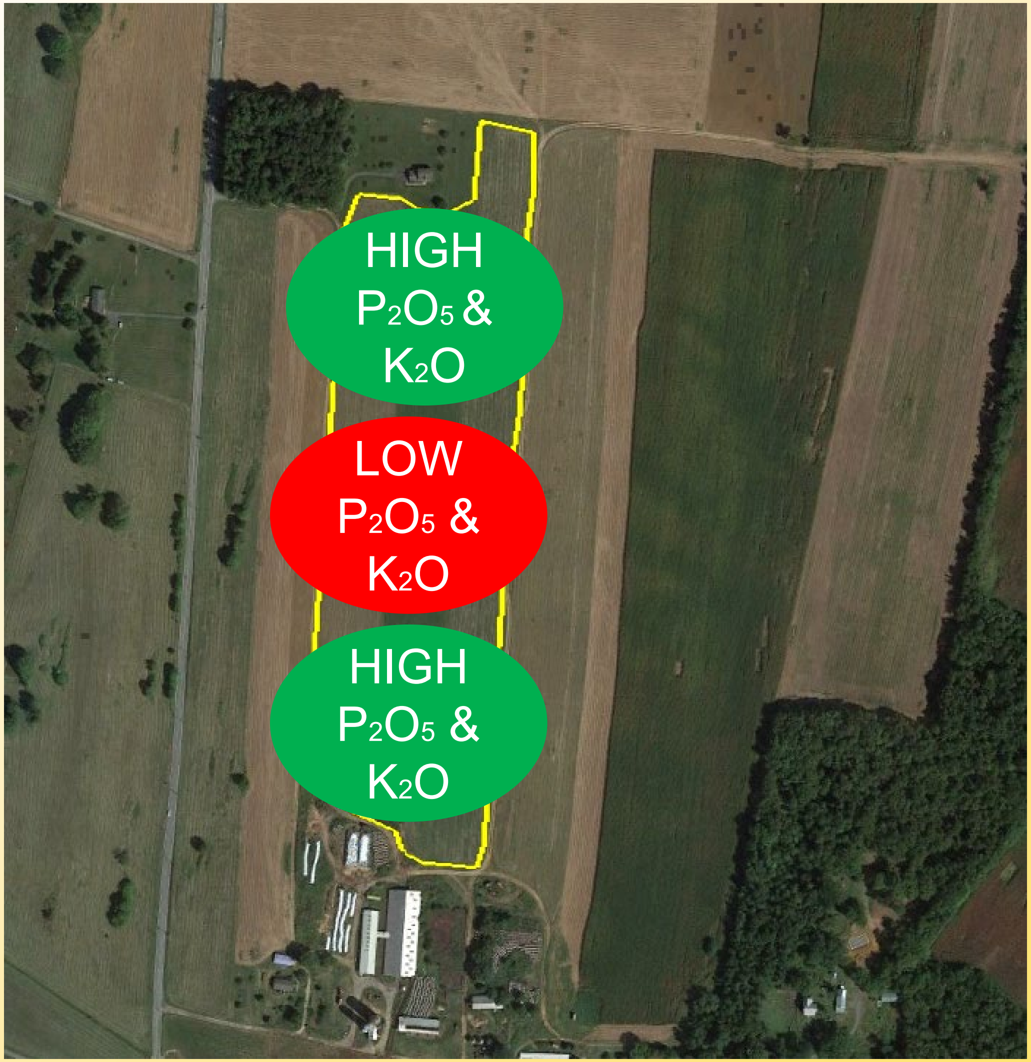
Precision Sampled Manured Field



Precision Sampled Manured Field



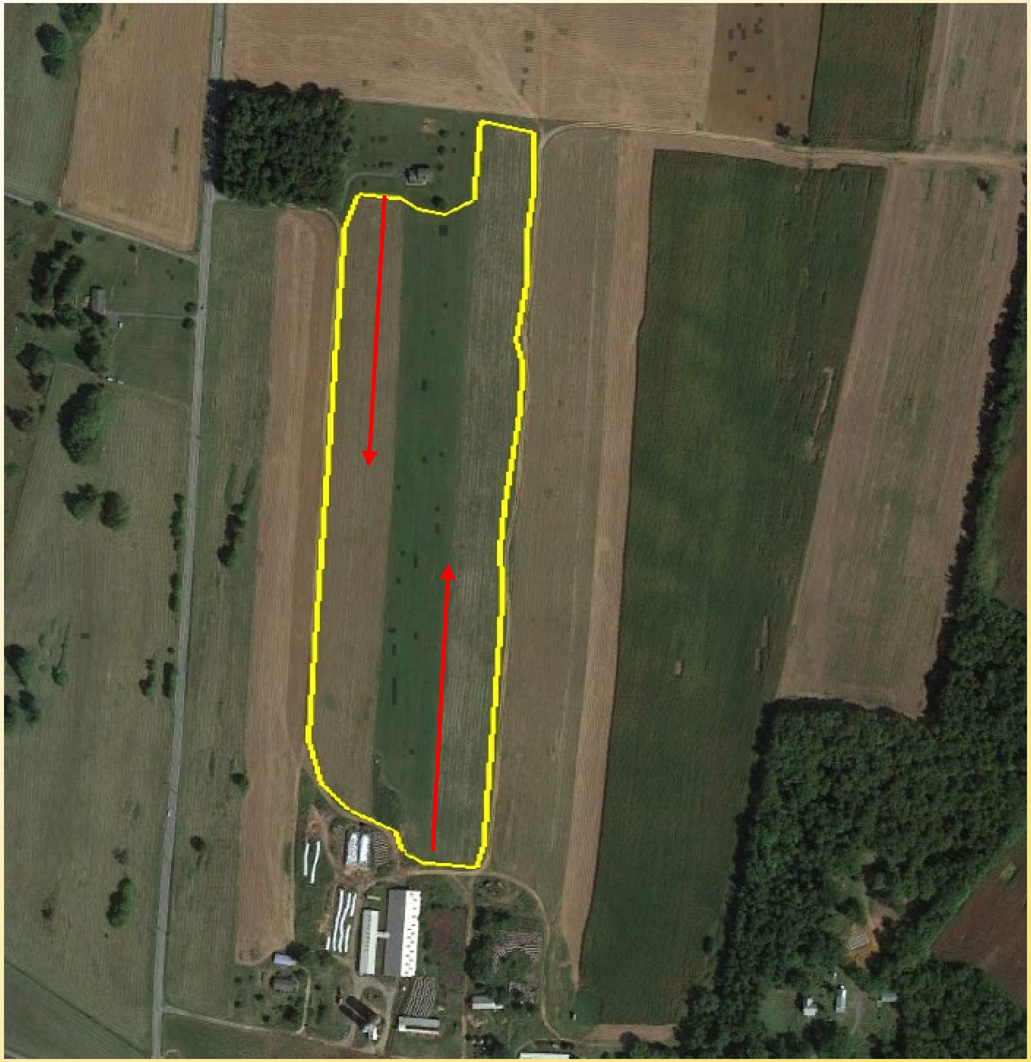
Precision Sampled Manured Field



Why were levels so low in the middle of the field?

Precision Sampled Manured Field

Why were levels so low in the middle of the field?



Limitations of Spreaders

- Box spreaders can’t spread 0.5 tons/acre
- Liquid spreaders can’t spread 800 gallons/acre
- Be realistic about organic nutrient recommendations

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Thank You!
Any Questions?

UNIVERSITY OF MARYLAND EXTENSION