Uncertainty in Manure Utilization

Webinar

January 13, 2012

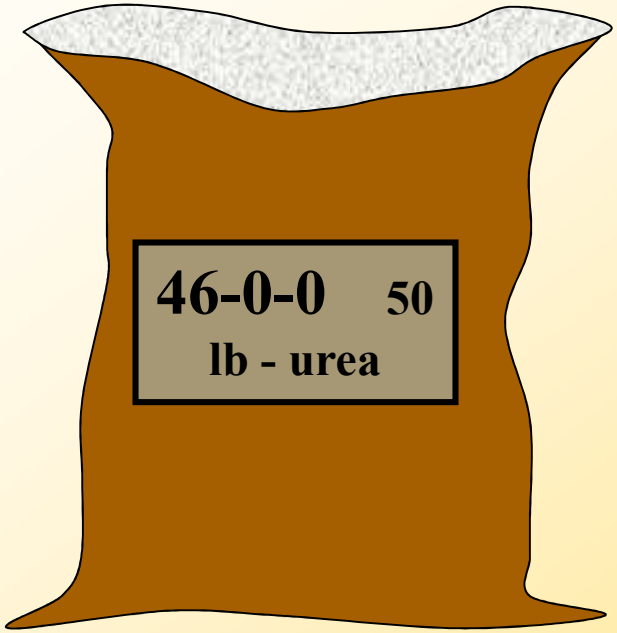
Department of Environmental Science and Technology

What Is “Uncertainty”?

- the inability to know facts or predict processes precisely

Where's the Uncertainty Here?

simple



complex

Manure: A Complex Nutrient Source

- a mixture of metabolic waste & solid waste from the digestive system
  - metabolic waste is soluble
    - urea (mammals), uric acid (birds)
  - feces is a mixed bag
    - undigested feed
    - microbe bodies
    - cell wall debris from animal gut

Manure: A Complex Nutrient Source (cont'd)

- manure is a complex mixture
  - soluble nutrient forms
    - urea and ammonium nitrogen
  - labile organic nutrient forms
    - break down quickly when added to soil
  - stable organic nutrient forms
    - break down slowly (month to years)
  - mineral forms of nutrients of varying stability

ABC AG LAB

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17 Farm Drive
Smithville, MD 20000

Manure Analysis Report

Analyte	% (as received basis)	lbs/ton
nitrogen (N) – total	0.65	13.07
ammonium nitrogen (NH_4-N)	0.17	3.49
P_2O_5	0.26	5.22
K_2O	0.56	11.20
moisture (%)	58.7	

Manure: A Variable Nutrient Source

	N	ammonium (NH_4^+)	phosphate (P_2O_5)	potash (K_2O)
average	0.78	0.13	0.41	1.04
minimum	0.04	0.01	0.04	0.12
maximum	2.67	1.77	2.92	6.09

solid dairy manure, % on an "as is" basis, 204 samples from FY 2008 to FY 2011

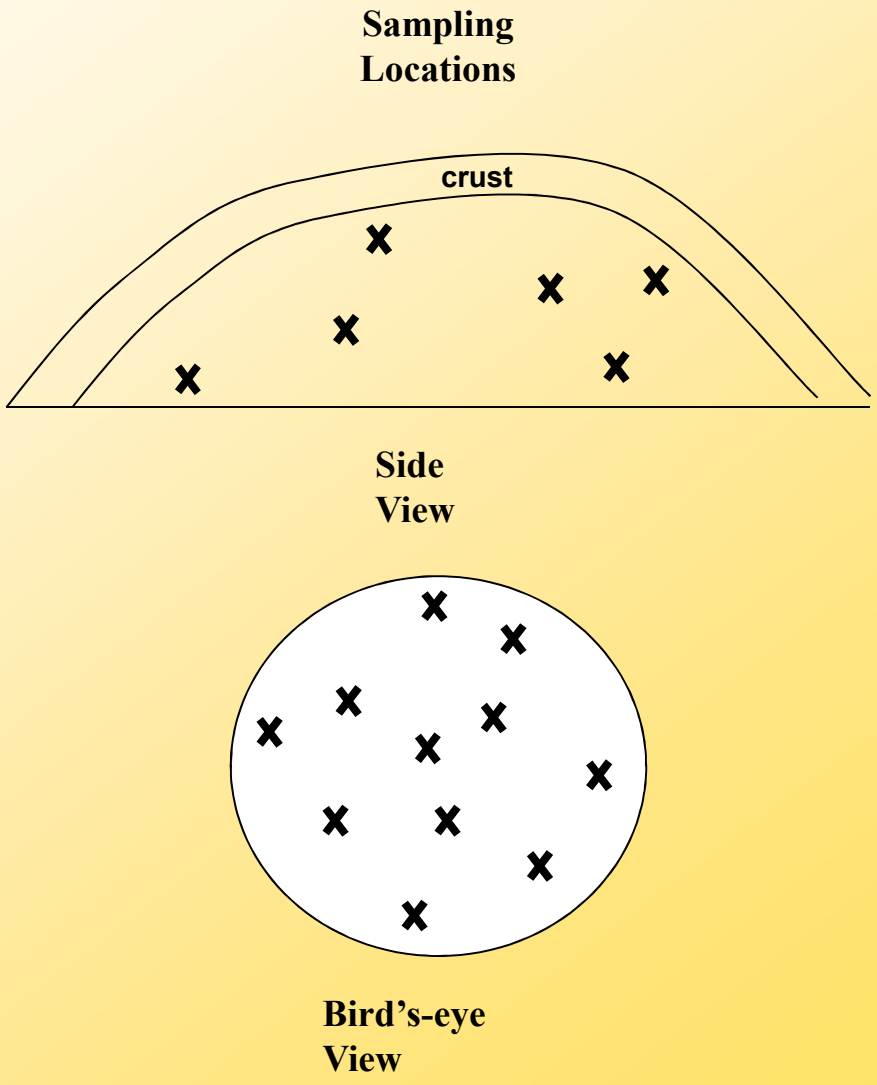
Why the Variability?

Goal of Manure Sampling

- collect a *representative* sample as close to time of utilization as is practical
  - minimize time and opportunity for further changes in composition
  - late fall to early winter for application the following spring (Thanksgiving and New Year)

Collecting a Representative Sample of a Solid Manure

1. Collect 10-15 samples.
   - before application
     - from various depths & locations in a pile
   - include bedding to the same extent as it is in the source
   - avoid untypical components
   - “composite sample”



Collecting a Representative Sample (cont.)

2. Mix composite sample **very well**.

3. Sub-sample composite.

4. Package and ship to lab.
   – plastic re-sealable bags (double bagging recommended)

From Manure Analysis to Available Nutrients

- not all N is plant-available
  - various protocols to estimate plant-available N (PAN)
- P and K in raw manures are plant-available

Estimating PAN of Manures

- PAN = available ammonium N + available organic N (N_{org})
  - available ammonium N
    - ammonium N x conservation factor
    - NH_4-N x f_{con}
  - available organic N
    - organic N x mineralization factor
    - N_{org} x f_{min}

Estimating PAN of Manure

- PAN = $(NH_4\text{-}N \times f_{con}) + (N_{org} \times f_{min})$
- mineralization factor
  - published average values from research
    - depends upon animal type
- ammonia conservation factor
  - research-based
    - depending upon typical incorporation practices

Mineralization Rates (portion of original organic N)

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

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

There's Uncertainty?

- published mineralization rates are averages
  - actual mineralization rate may vary due to composition of manure, soil, or weather conditions
- ammonia conservation factors assume no rainfall
  - may be more than predicted if rainfall occurs soon after application

Within an Animal Type

- Delaware study of 20 litters from commercial broiler houses incubated with same soil
  - average mineralization was 66%
  - range was 21% to 100%
- USDA study of 107 dairy manures in Northeast
  - mineralization ranged from 0% to 55%

Soil Differences?

- in a Georgia study with one broiler litter and 9 soils under controlled conditions
  - average mineralization rate was 62%
  - ranged from 41% to 80%
  - loamy sands > sandy loams > clays

Relevant Question

- What soil characteristics might be responsible for a higher mineralization rate of a particular manure in a loamy sand soil than a clay soil?

The Weather?

- mineralization is a microbial-driven process
  - cooler than usual?
  - wetter than usual?
  - drier than usual?

Slower breakdown of labile organic materials!

In-season Monitoring of N Availability on Manured Fields

- use in-season tests to determine actual N status whenever available

- in Maryland, Pre-Sidedress Nitrate Test (PSNT) is such a test

What Rate of Manure Is Applied Across the Field?

- calibration is essential!

- assumptions about calibration
  - producers want to know the application rate of their spreader
  - producers want as uniform rate of application as is possible

Today's Emphasis

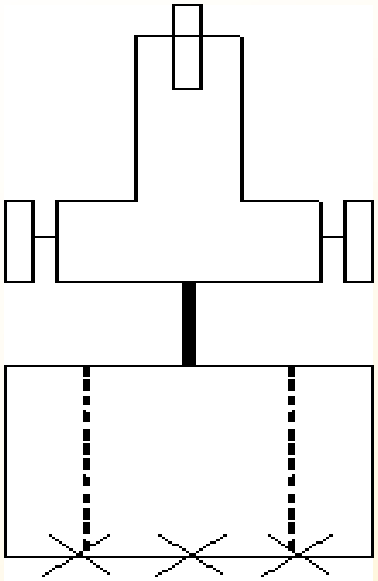
- rear-discharge spreaders
- use weight-area method in example

Weight-area Method

- Collect manure on a small portion of a field and project the rate of application on this area to a per-acre basis
  - tarps, plastic sheets or other collection surfaces
- It is a useful method for many types of manure application equipment

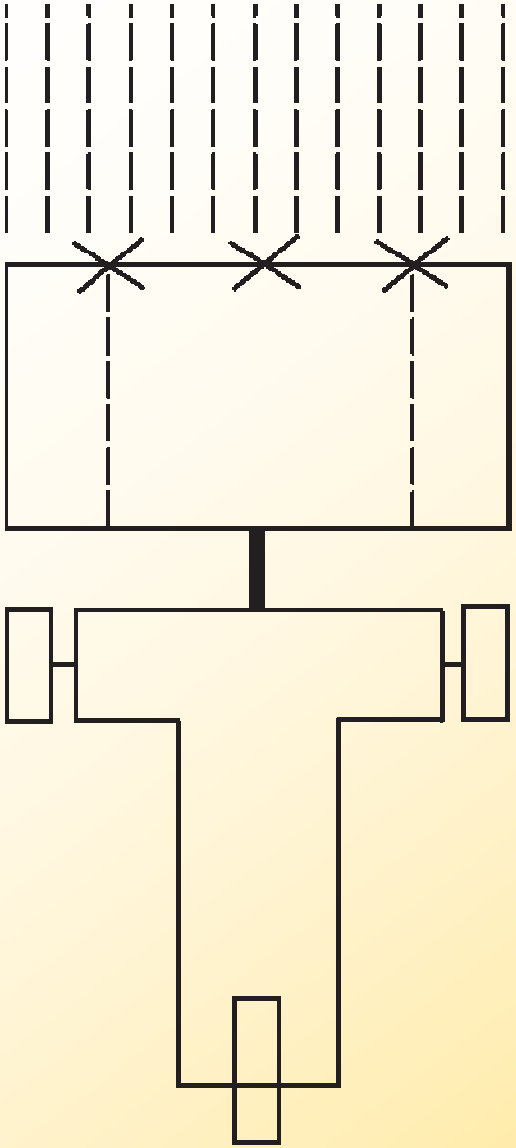
Uniformity Across the Spread Width

- What do you know about the application uniformity across the spread width of your application equipment?
- Does any material get spread to the side?

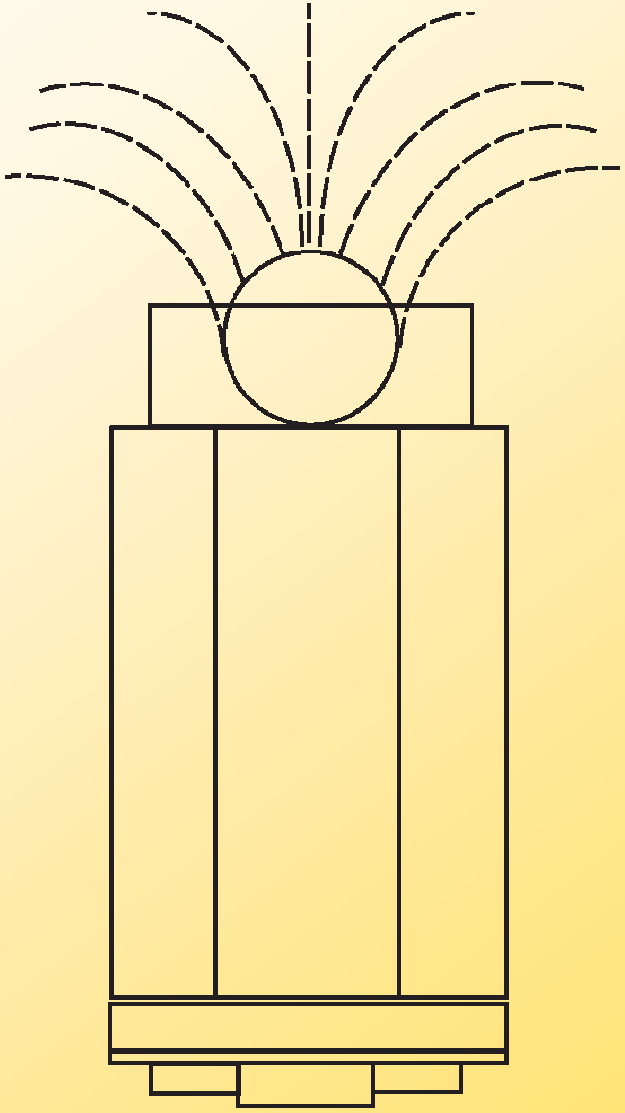


15	21	18
16	19	17.5
24	26	25

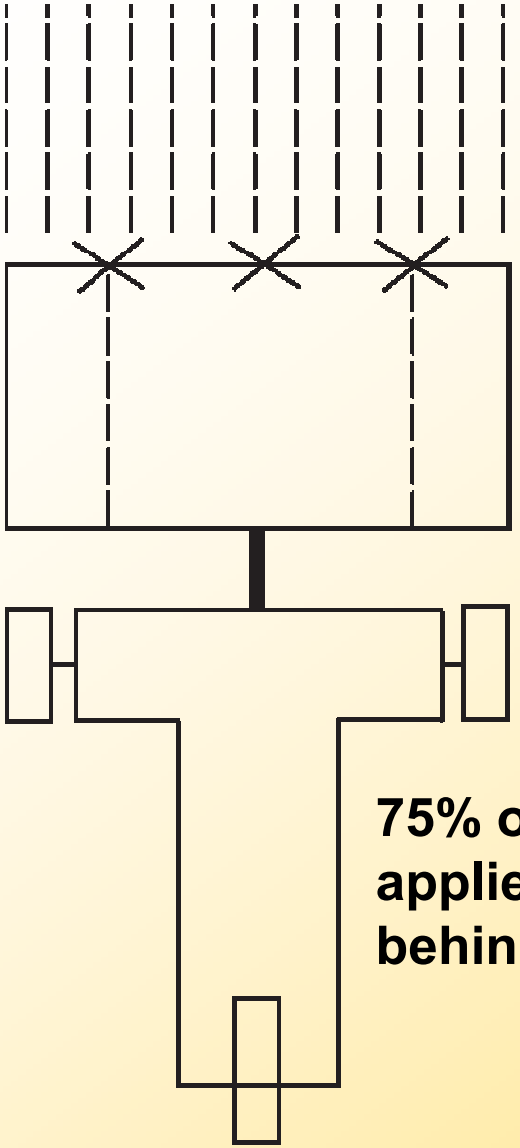
average=20 tons/acre
+/- 25% to 30%



Spread pattern of a box spreader

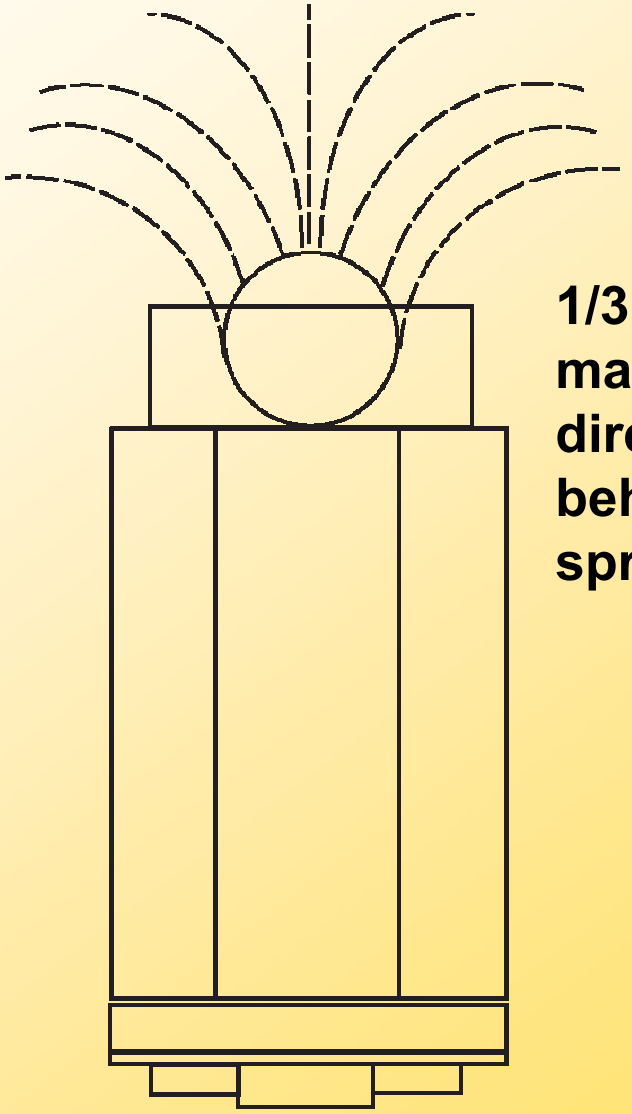


Spread pattern of a spinner spreader



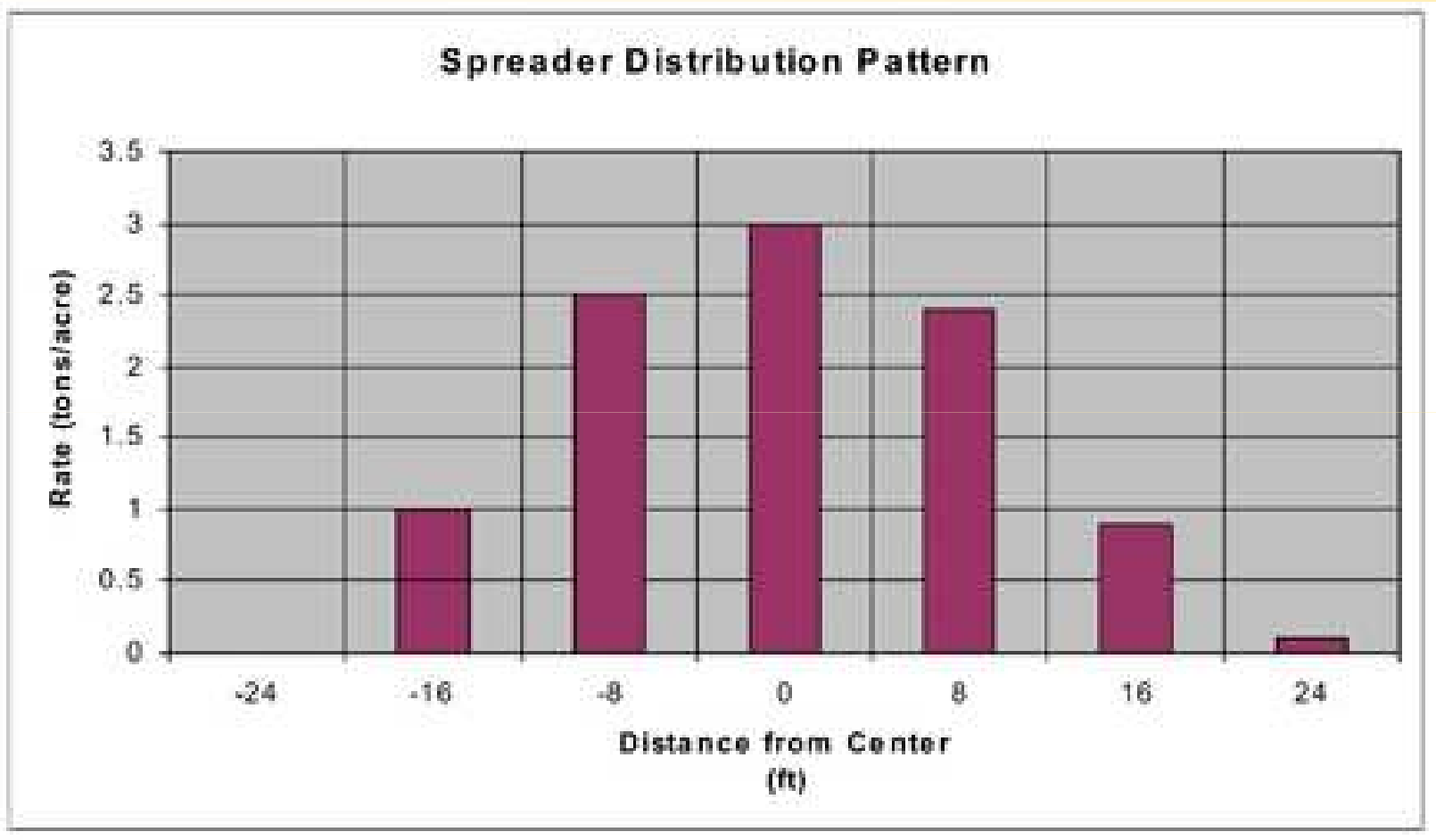
75% of material applied directly behind spreader

Spread pattern of a box spreader



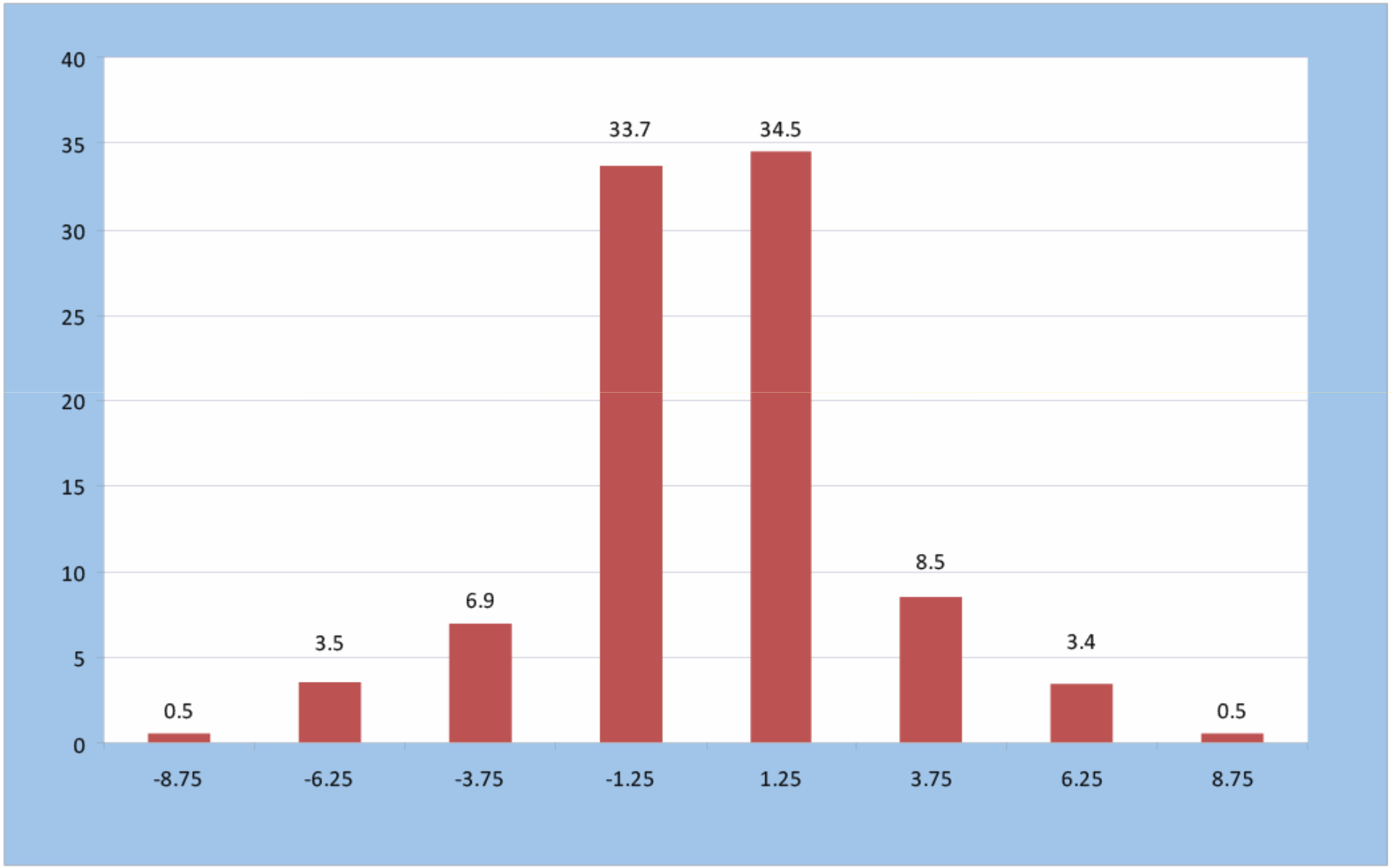
1/3 of material directly behind spreader

Spread pattern of a spinner spreader

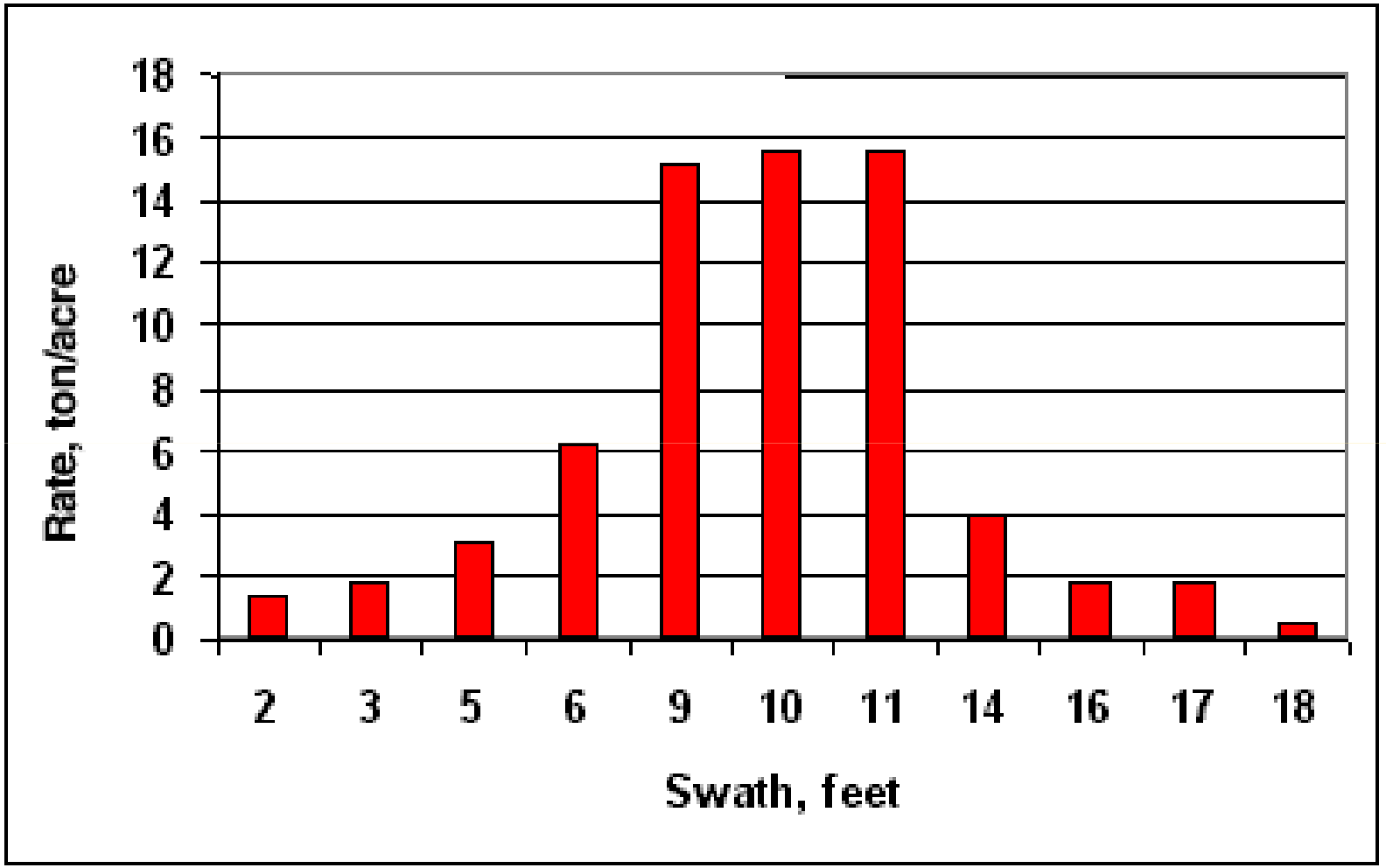

Spreader Distribution Pattern
Rate (tons/acre)
3.5
3
2.5
2
1.5
1
0.5
0
-24
-16
-8
0
8
16
24
Distance from Center (ft)

Source: UGA

Spreader Distribution Pattern

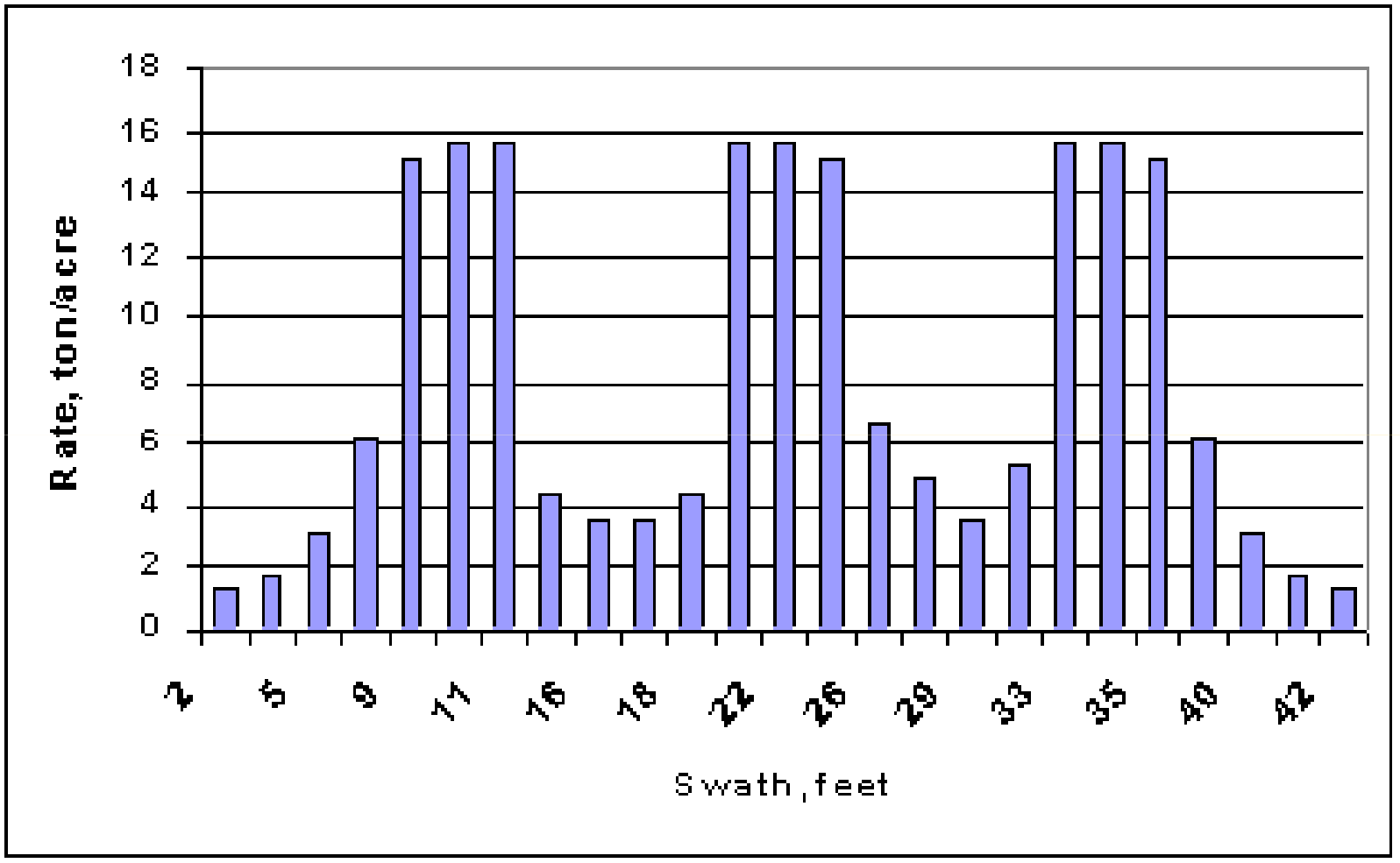


one pass of a spreader



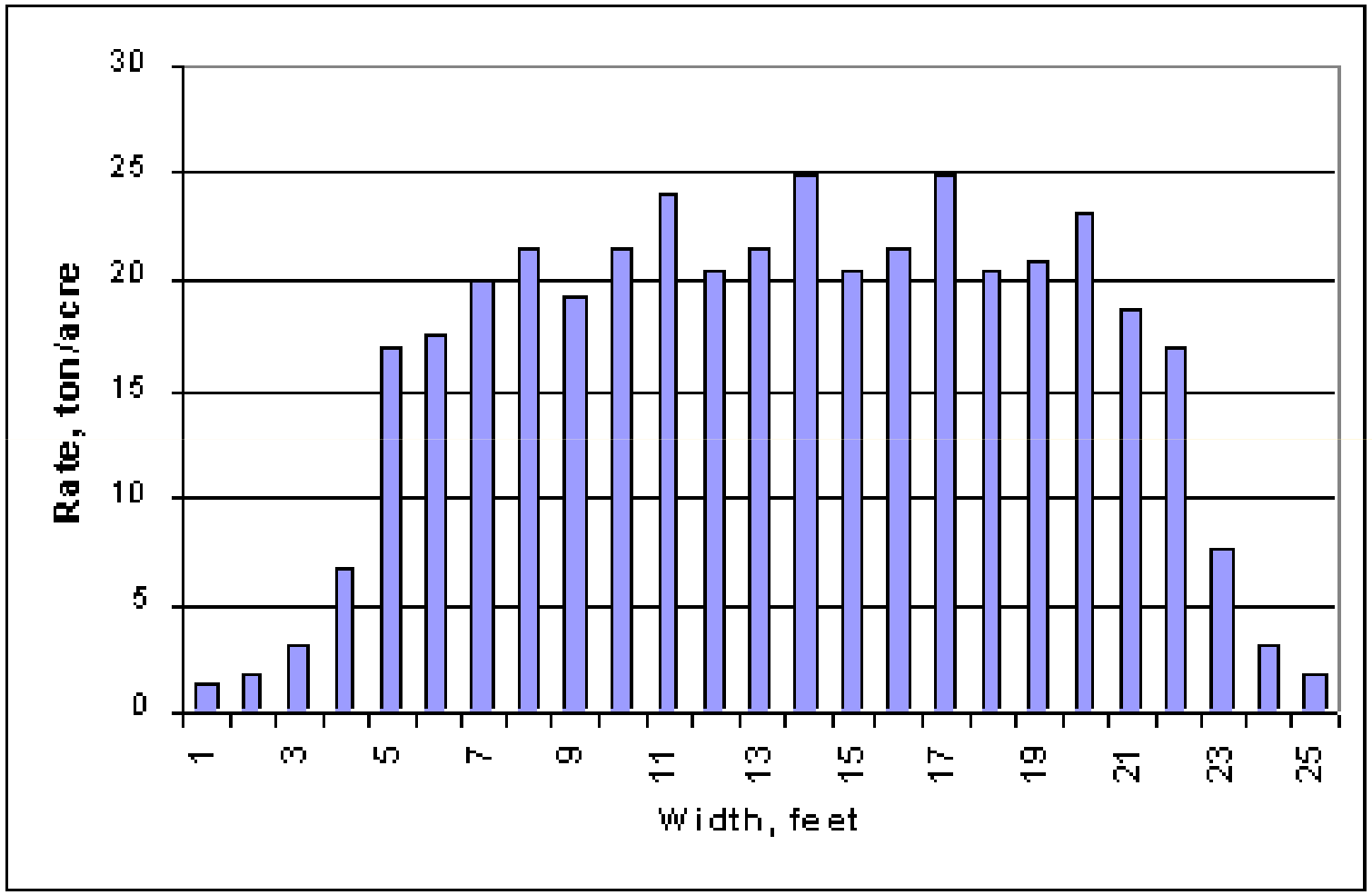
Source: Iowa State University

3 passes of a spreader; 12 feet apart



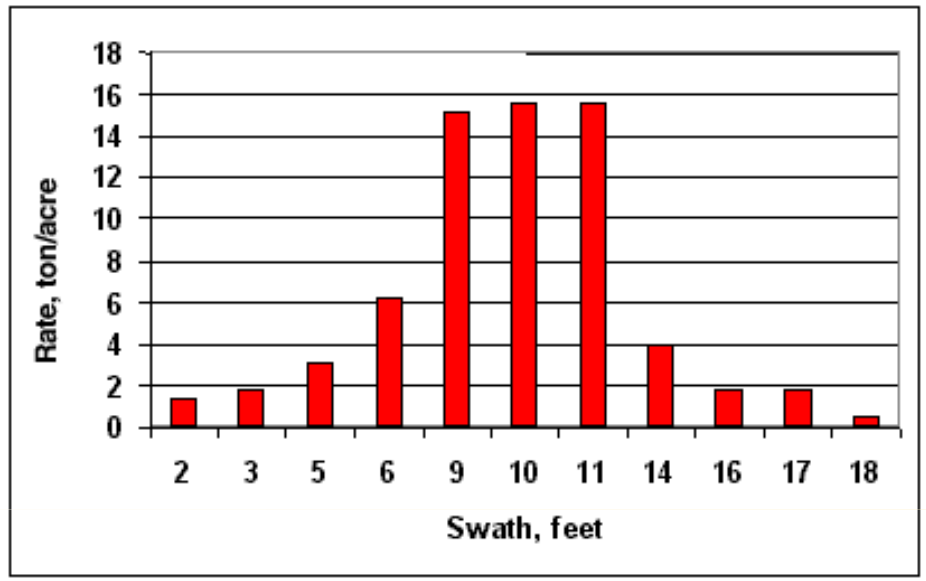
Source: Iowa State University

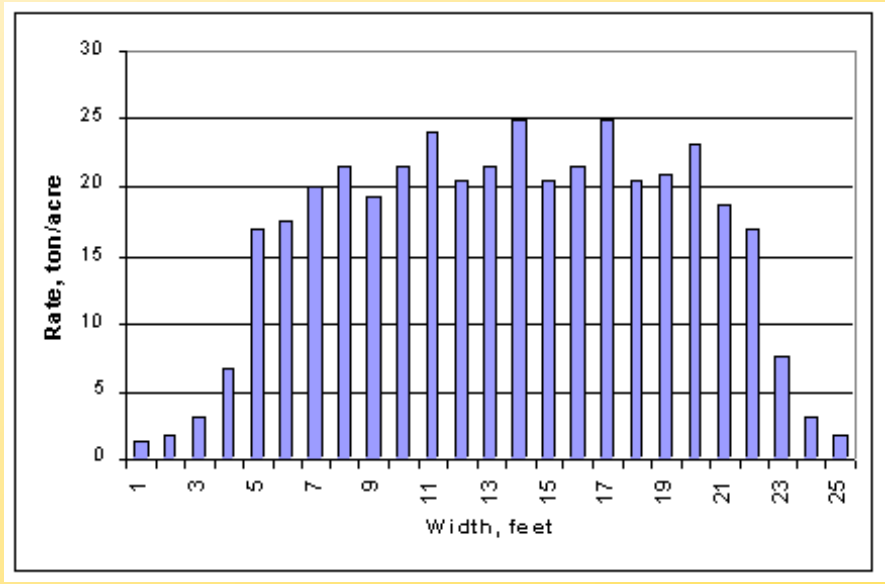
3 passes of a spreader; 6 feet apart



Source: Iowa State University

Maximum Rate?





Effective Swath Width (ESW)

- conceptually, the distance between the center point of one pass of a spreader and the center point of the next pass

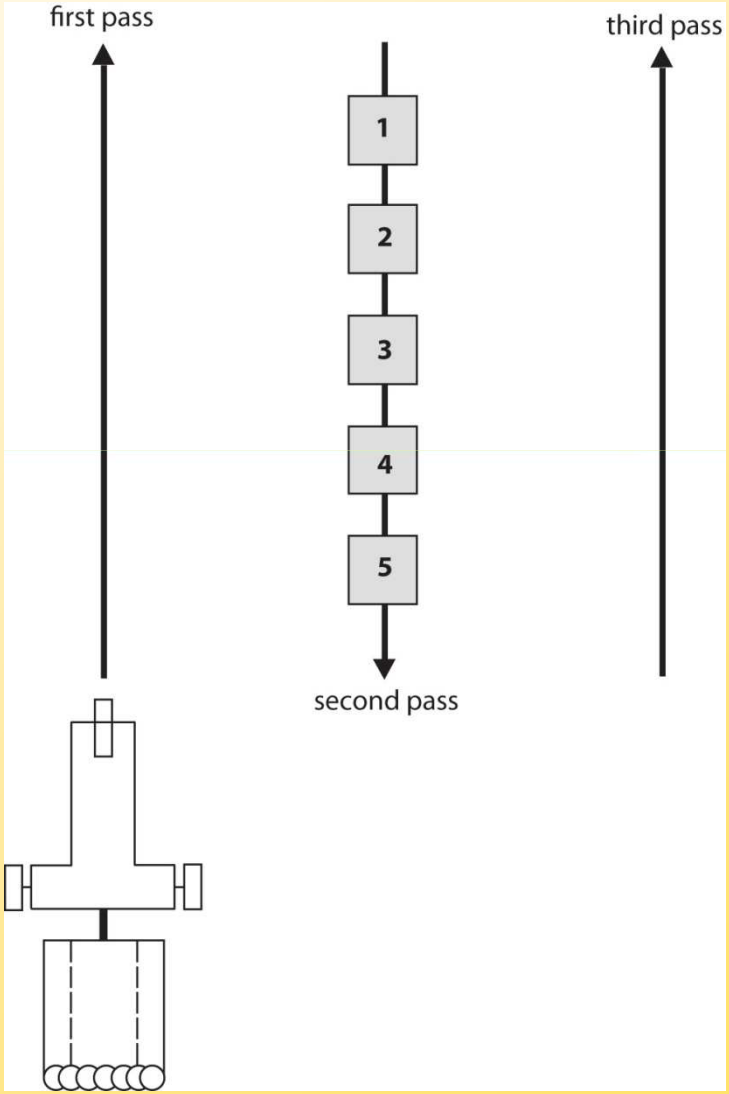
- arithmetically, the sum of the distance on each side of the center line of the tractor and spreader path where the application rate is 50% of the maximum application rate

Dealing with Lateral Application

- box spreader
  - spread pattern is tight
  - ESW is width of spreader
  - placement of collections surfaces is critical
- spinner spreader
  - spread pattern is wide
  - ESW must be determined

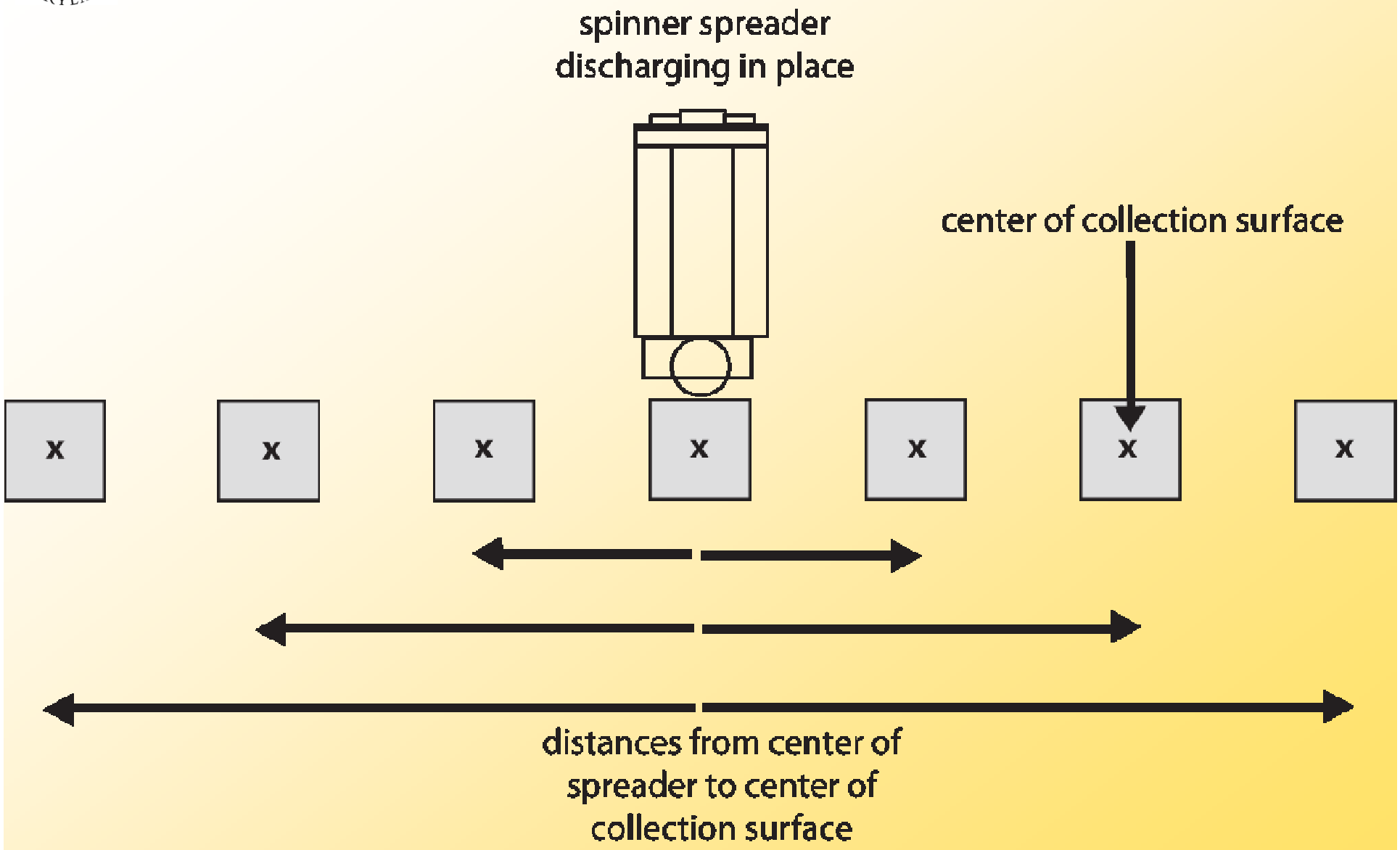
Weight-area Method
(Box Spreaders)

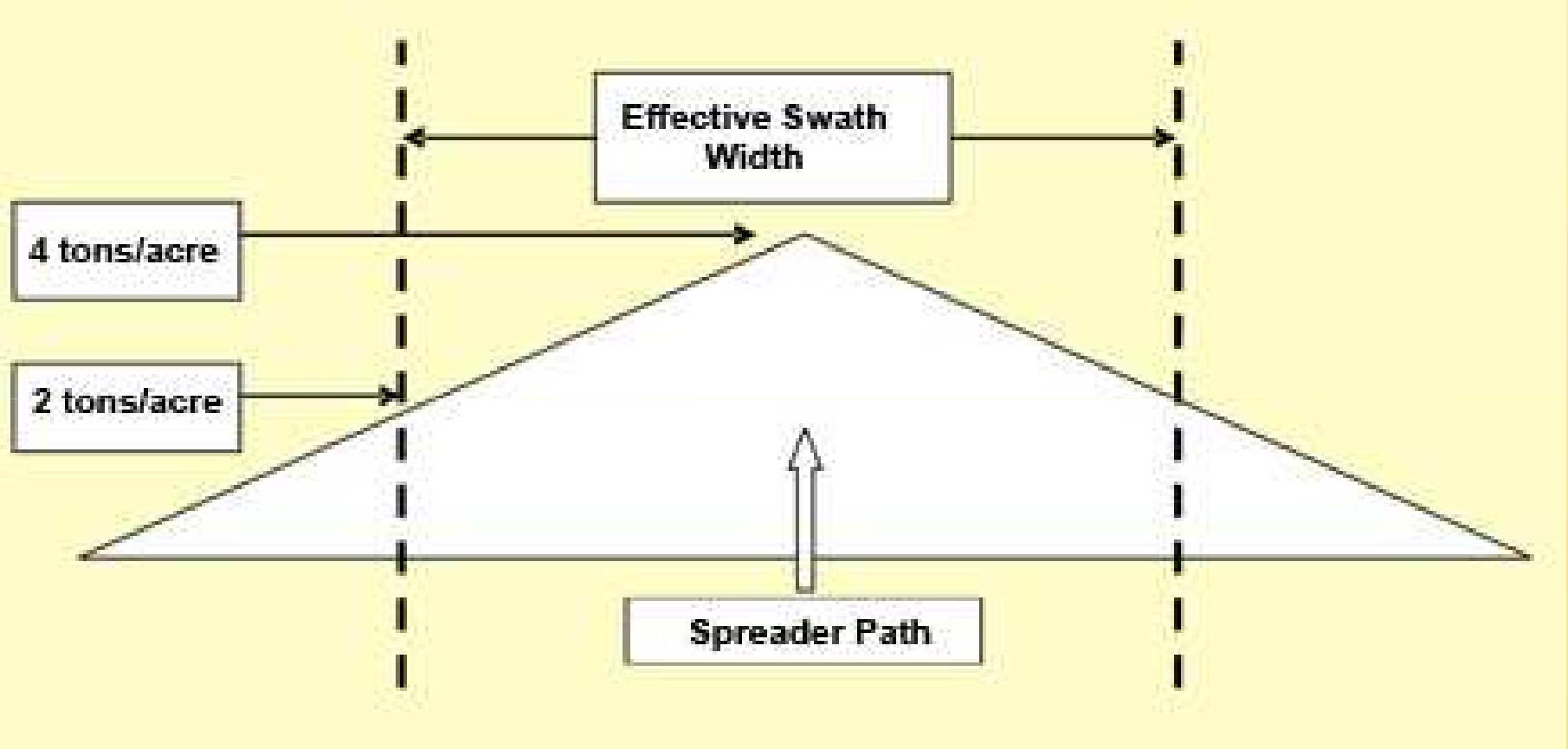
1. Stake 5 plastic sheets in the field parellel to the direction of spreading.
2. Position those sheets on the second pass and weigh them after the third pass.



Weight-area Method (cont.)

3. Spread manure observing the effective swath width between passes to optimize uniformity.
4. Collect and weigh the manure on each sheet.
5. Average the quantity applied to the sheets and project to tons-per-acre.


spinner spreader
discharging in place
center of collection surface
x
x
x
x
x
x
x
distances from center of
spreader to center of
collection surface



Source: UGA, C825

Effective Swath Width (ESW)

- arithmetically, the sum of the distance on each side of the center line of the tractor and spreader path where the application rate is 50% of the maximum application rate

How large should the tarp be?

- not so heavy it damages your back to lift it
- not so light you can't weigh the material accurately
- 56" x 56" is 1/2000th of an acre
  - weight in #/tarp = ton/acre

Consult Calibration Publications for More Information

- 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)”

*http://anmp.umd.edu/Pubs/Pubs_Equip.cfm

Determining ESW and calibration take time and effort. They are worth doing if you want a relatively uniform specific application rate!

Credit: Hutchinson, UME

Uncertainty

- What is the actual nutrient content of the manure?
- How much of the nitrogen will be released this year of application?
- Is the recommended rate actually applied in a uniform manner?

Dealing with Uncertainty

Source of Uncertainty	"Dealing with" Uncertainty
variable nature of manure	obtain an analysis of a representative sample
variable release rate of nitrogen from manure	confirm nitrogen status with in-season tech-niques when available
application rate	determine and observe ESW and calibrate the spreader

Any questions or comments?