# A New Way Of Looking At Bunker Silage Density

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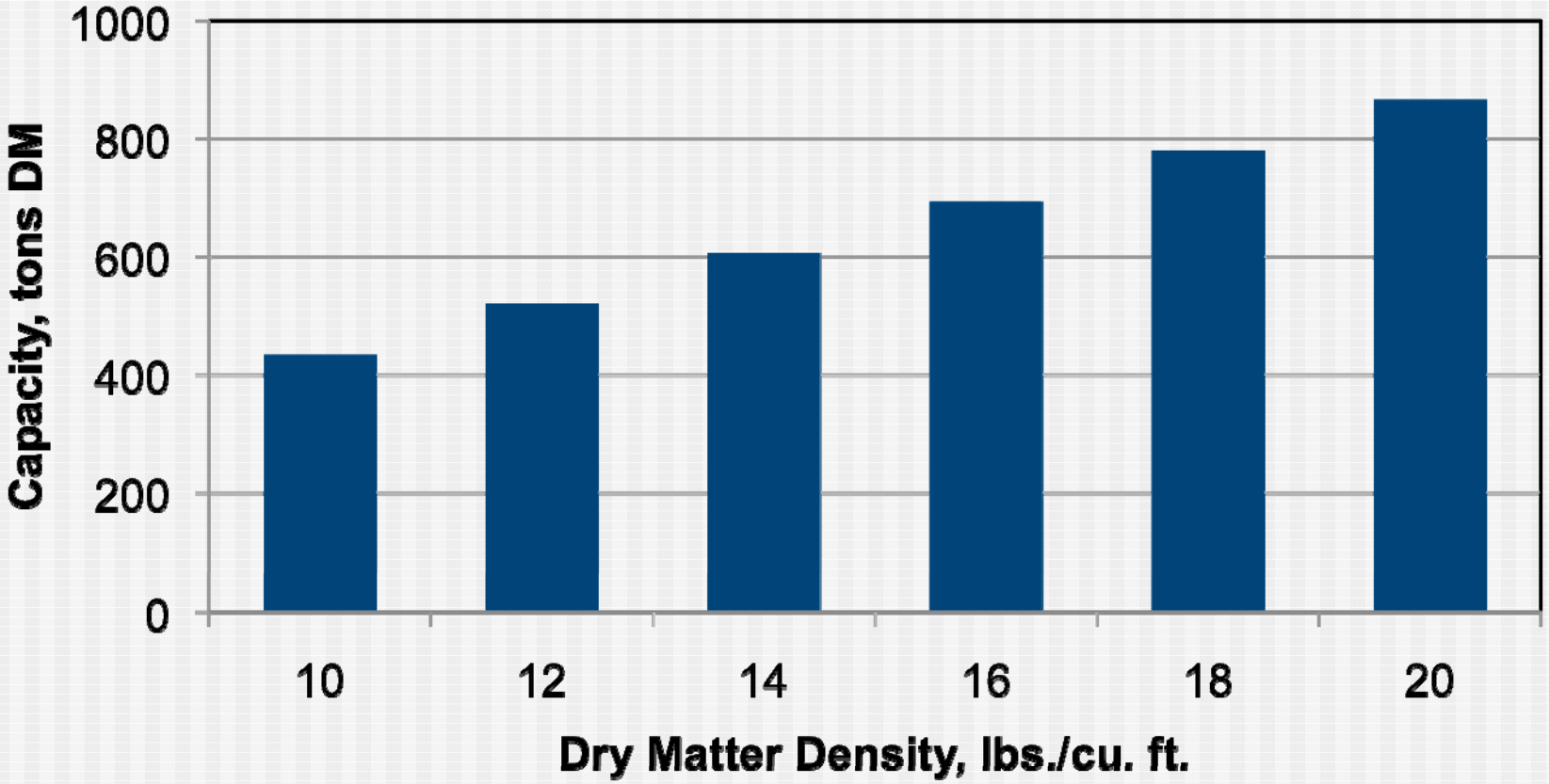
# Why Care About Bunker Silage Density?

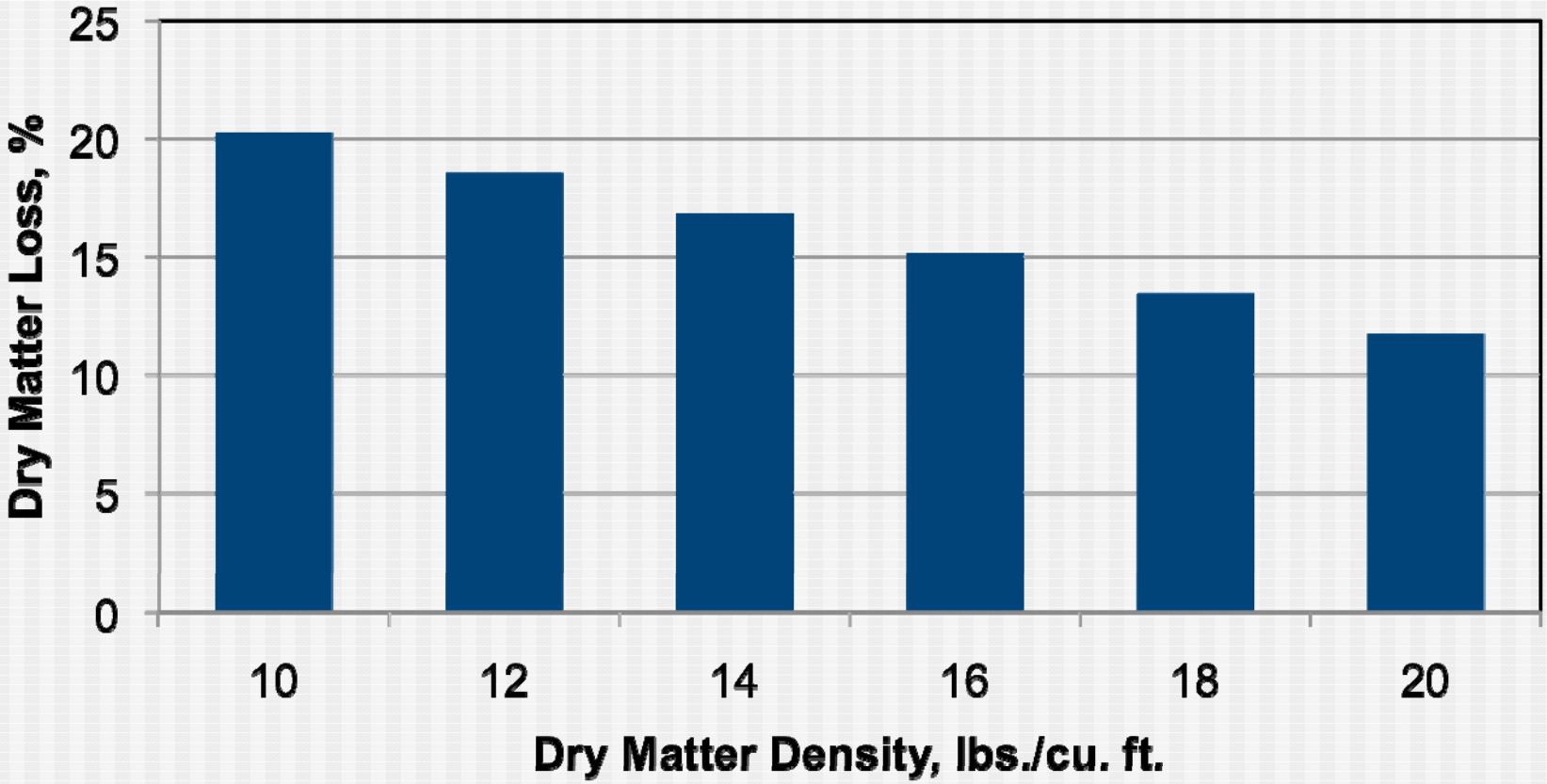
Density affects:

- How much you can get in your bunker
- How much loss during storage
- Profitability

# Bunker Capacity:
# 180’ x 40’ x 12’



# Bunker DM Losses As Affected By Density – 180 days storage




Based on Ruppel, 1992

# Benefits of Improved Bunker/Pile Silo Packing

**Assume:**

50% Corn Silage
5% Opportunity Cost
Layer Thickness 6”
Extra Storage Pad=$0.75/sq ft

500 Cow Herd
Harvest Rate 80 T AF/Hr
Feed Value= $0.042/lb DM

| **Achieved Density** (lbs DM/cu ft) | **16** | **14** | **12** |
|---|---|---|---|
| Packing Tractor Weight (lbs) | 50,000 | 36,000 | 25,000 |
| Tractor Initial Cost ($) | 163,000 | 149,000 | 119,500 |
| Init. Cost Additional Storage ($) | 0 | 6,840 | 10,650 |
| Extra Storage Cost (20 yr)($/Yr) | 0 | 549 | 855 |
| Feed Value Lost Cost ($/Yr) | 14,061 | 15,924 | 17,788 |
| Tractor Annual Cost(10 yr)($/Yr) | 5,324 | 3,622 | 2,905 |
| Total Annual Cost ($/Yr) | 19,385 | 20,096 | 21,548 |
| Cost Reduction ($/Yr) | 2,163 | 1,452 | 0 |

Holmes, 2007

# The Old Target: Improving Dry Matter Density

# WI Study of Silage Densities in Bunker Silos

- 19 extension agents collecting samples
- 87 hay crop silages
- 81 corn silages
- Surveyed the packing practices

# Dry Matter Density in Bunkers Based on WI Survey

Affected by:

- Tractor weight
- Layer thickness
- Packing time
- Silage height
- DM content

# How to Improve Silage Density

- Spreadsheet tools:
  - Bunker Silo Density Calculator
  - Silage Pile Density Calculator
- http://www.uwex.edu/ces/crops/uwforage/storage.htm

# Bunker Silo Density Calculator

**Spreadsheet to Calculate Average Silage Density in a Bunker Silo(English Units)**

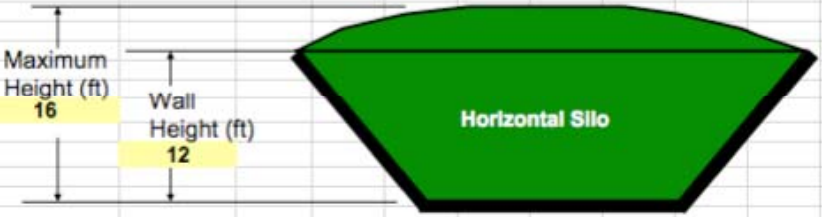
Brian Holmes(1) and Richard Muck(2)
(1) Biological Systems Engineering Dept. and
(2) US Dairy Forage Research Center
University of Wisconsin-Madison

23-Aug-07

| | | |
|---|---|---|
| Bunker Silo Wall Height (feet) = | 12 | |
| Bunker Silo Maximum Silage Height (feet) = | 16 | Values in yellow cells are user changeable |
| Silage Delivery Rate to Bunker (T AF/Hr) = | 160 | Typical values 15-200 T AF/hr |
| Silage Dry Matter Content (decimal ie 0.35) = | 0.35 | Recommended range of DM content = 0.3-0.4 |
| Silage Packing Layer Thickness (inches) = | 6 | Recommended value is 6 inches or less |

| Packing Tractor - Each Tractor | Tractor Weight (lbs) | Tractor Packing Time (% of Filling Time) |
|---|---|---|
| Tractor # 1 (Typical tractor weight is 10,000-60,000 lbs) | 40,000 | 100 |
| Tractor # 2 (Typical tractor weight is 10,000-60,000 lbs) | 40,000 | 100 |
| Tractor # 3 (Typical tractor weight is 10,000-60,000 lbs) | 0 | 0 |
| Tractor # 4 (Typical tractor weight is 10,000-60,000 lbs) | 0 | 0 |
| Proportioned Total Tractor Weight (lbs) = | 80,000 | |
| Average Silage Height (feet) = | 14.0 | Green cells are intermediate calculated values |

| | | |
|---|---|---|
| Packing Factor = | 441.0 | Values in pink cells are results of calculations |
| Est. Average Wet Density = Bulk Density (lbs AF/cu ft) = | 44.2 | Wet Density greater than 44 lbs AF/cu ft is recommended |
| Maximum Achievable Bulk Density (lbs AF/cu ft)= | 73.3 | Wet Density greater than Max. Wet Density is unrealistic |
| Gas Filled Porosity = | 0.40 | Gas Filled Porosity less than 0.40 is recommended |
| Est. Average Dry Matter Density (lbs DM/cu ft) = | 15.5 | Density greater than 15 lbs DM/cu ft is recommended |
| Maximum Achievable DM Density (lbs DM/cu ft)= | 25.7 | DM Density greater than Max. Achievable is unrealistic |




English Units | Metric Units | Espanol - (unidades métricas)

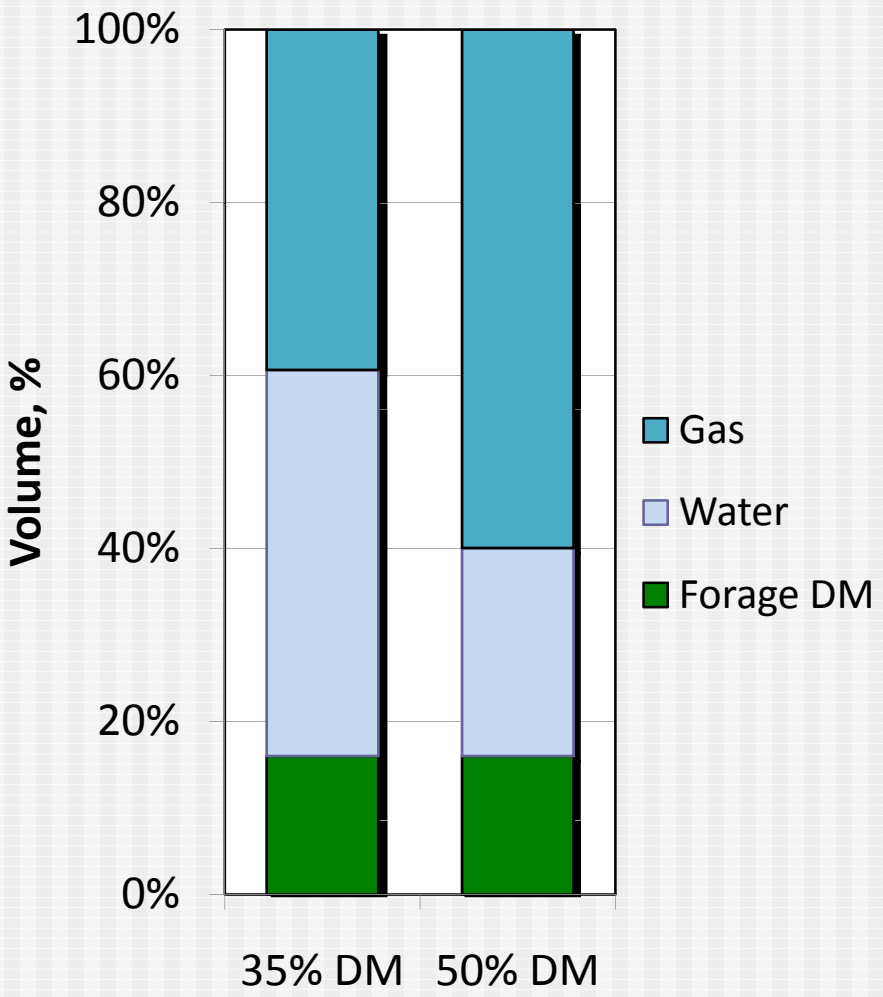
# So, What Is The Problem With Dry Matter Density?

# Problem 1 With DM Density

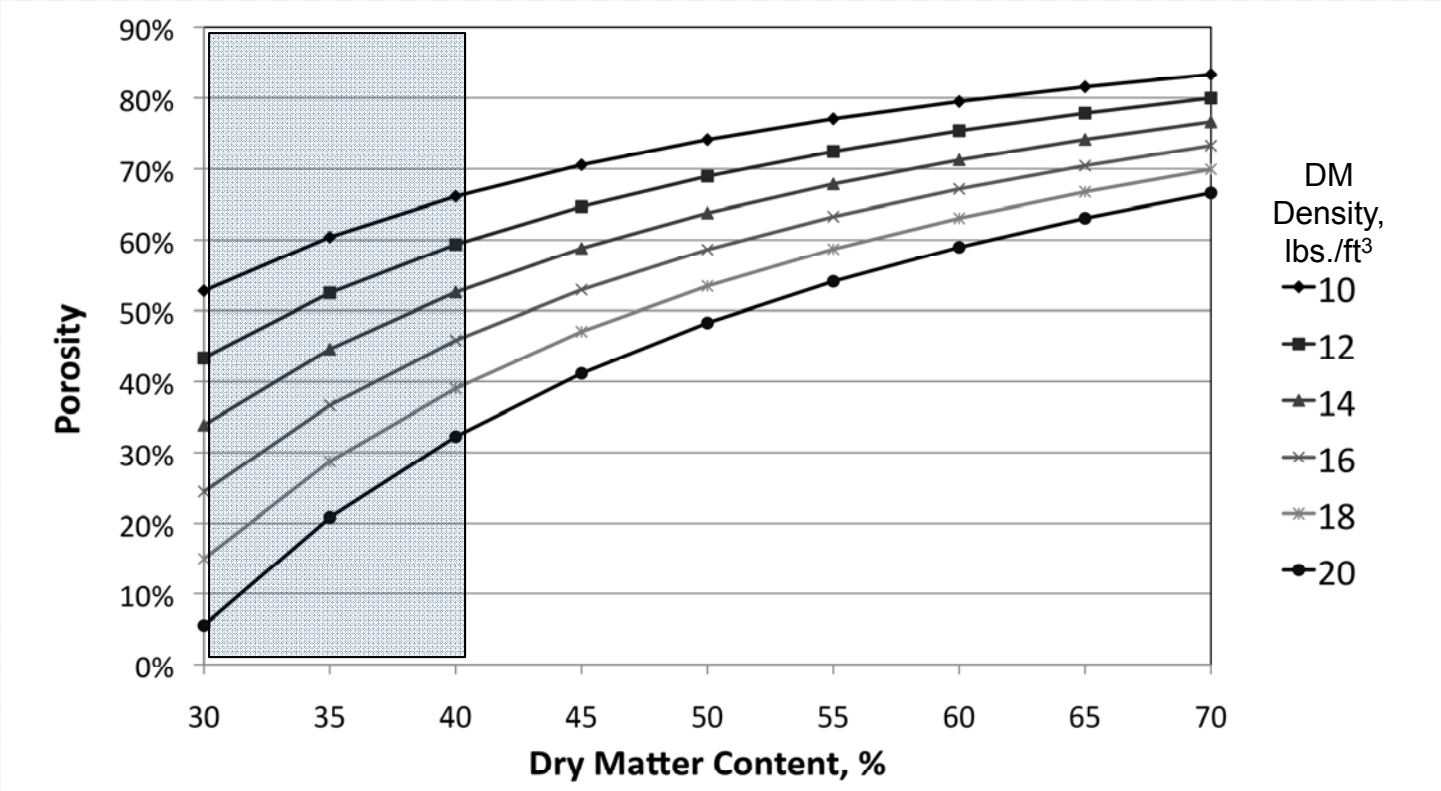
- How do you estimate how you are doing during the packing process?

# Problem 2 With DM Density

- Porosity – gas filled voids around the silage particles
- Losses increase proportionally as porosity increases
- What happens to porosity at fixed DM density when DM content changes?

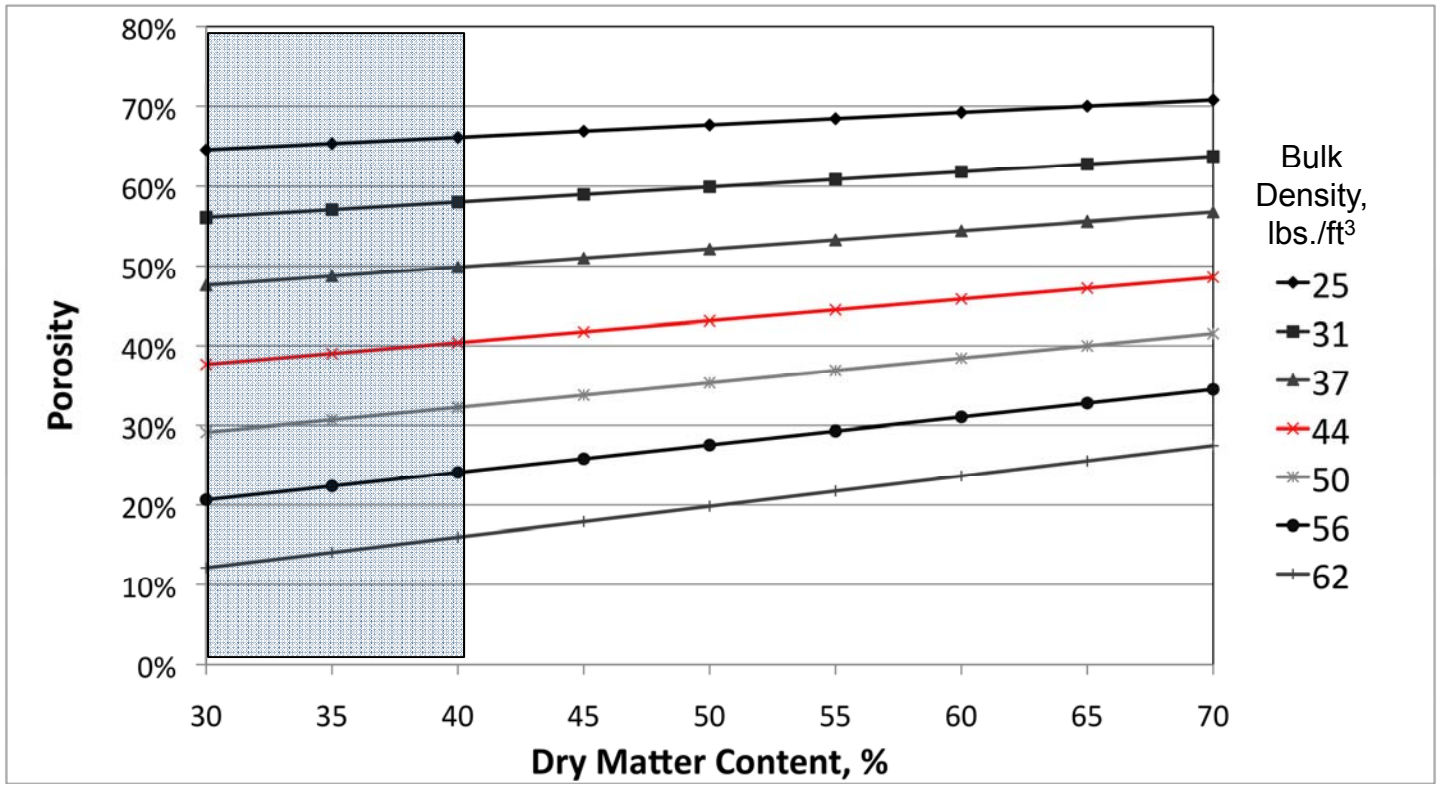


# Porosity as a Function of DM Content and DM Density



# The New Target: Improving Bulk Density

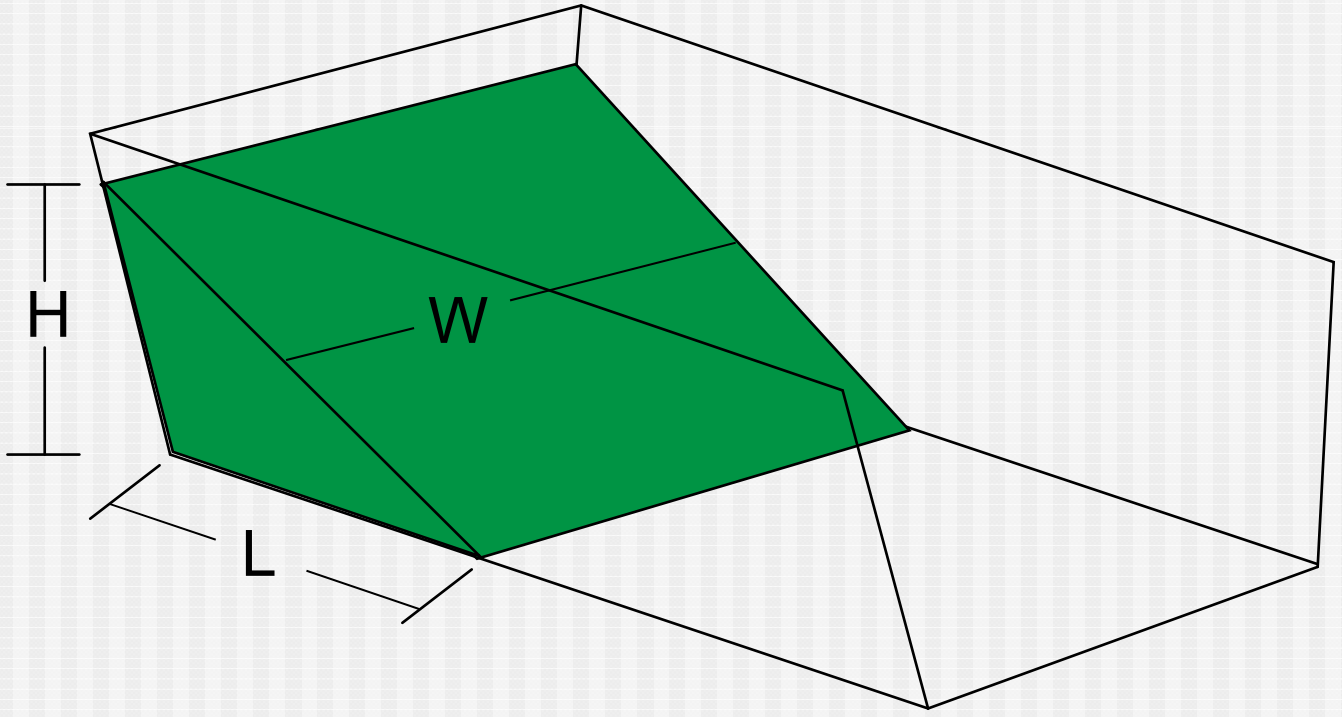
# Porosity as a Function of DM Content and Bulk Density



# Benefits Of Bulk Density

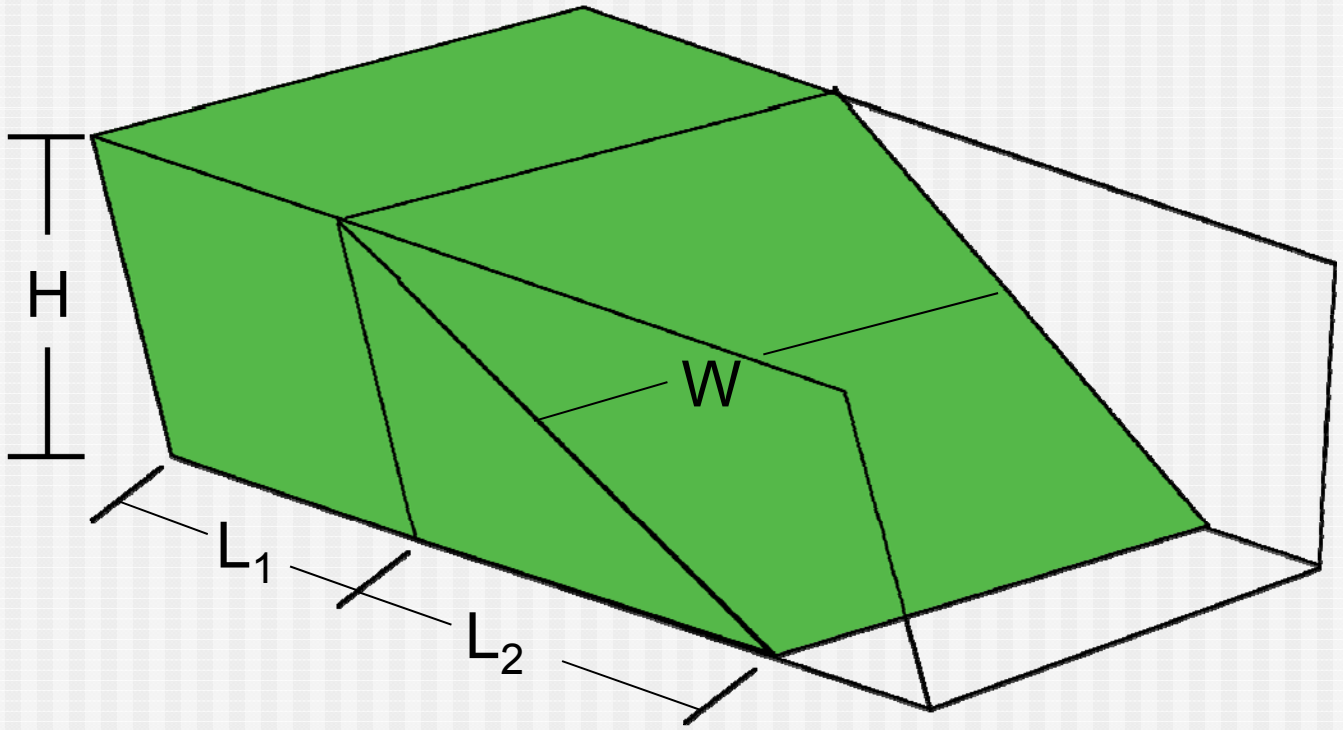
- Porosity is relatively insensitive to the DM content of the crop
- Easier to estimate density on the fly while filling
  - Weight of forage put in the silo divided by the volume filled

# Estimating Volume




Volume ≈ ½ L·W·H

# Estimating Volume




Volume ≈ $L_1 \cdot H \cdot W + \frac{1}{2} L_2 \cdot W \cdot H$

# Minimum Bulk Density Target

- 44 lbs./cu. ft.
- 700 kg/cu. m

# How to Improve Silage Bulk Density

- Same spreadsheet tools as for DM density:
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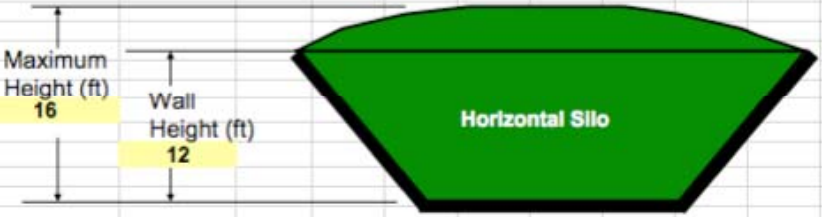


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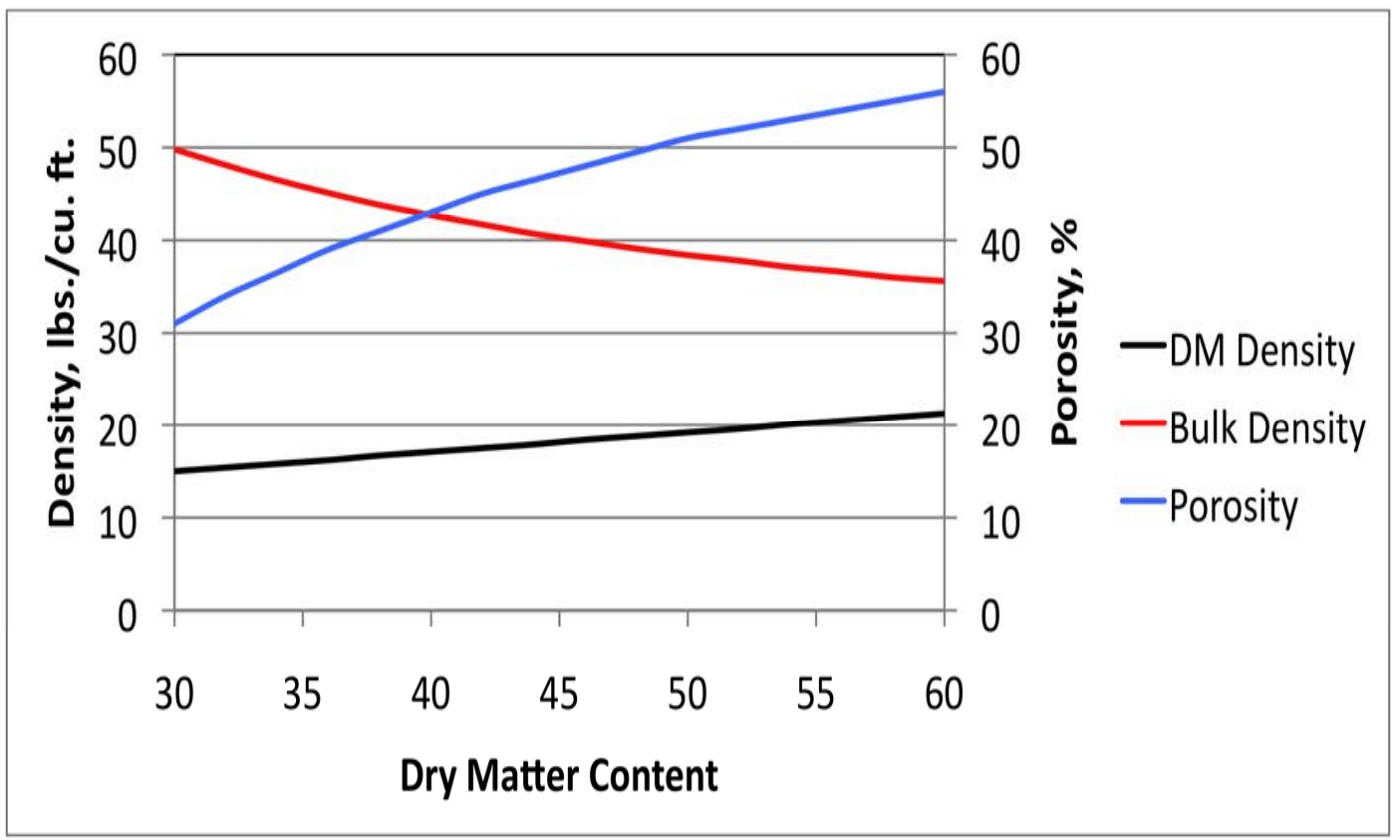
# How Density Changes With DM Content For Identical Packing




Bottom line: The drier the crop, the more you have to do to get above the target bulk density.

# Packing Operation

- Progressive wedge
- Thin layers (6 in.)
- Uniform coverage: two directions, multiple passes
- Continuous
- Drive slowly, avoiding wheel slip

# Packing Vehicle

- Heavy tractor(s), weighted within specs
- Robust transmission with shuttle shift
- Blade or bucket
- Roll over protection with seat belts
- 4-Wheel drive or assist
- Wheels: well-lugged, high tire pressure
- Experienced operator(s)

# Packing Operation

With multiple packing tractors, have a plan to work together, avoiding accidents

# Summary

- High bunker density is a profitable goal that minimizes losses, reduces storage costs
- New target of increasing bulk density
- Minimum bulk density of 44 lbs./cu. ft.
- Still use a combination of heavy packing tractors, thin layers and packing time per ton to achieve high density

# Questions?

Presentation will be posted on the
U.S. Dairy Forage Research Center web site

www.ars.usda.gov/mwa/madison/dfrc

Or “google” dairy forage research

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