Quality of compost and bedding issues

Compost Bedded Loose Housing Dairy Barn

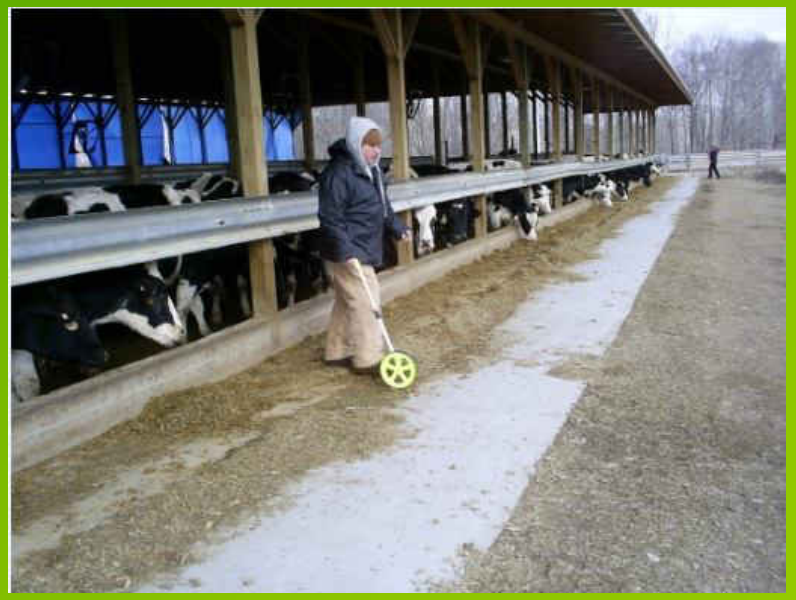
Compost Bedded Pack Loose Housing Dairy Barn

Success for the dairyman is based on both the management of the bed and the interaction of the bed and the surrounding managed environment within the structural envelope

Management of the Bedded Pack

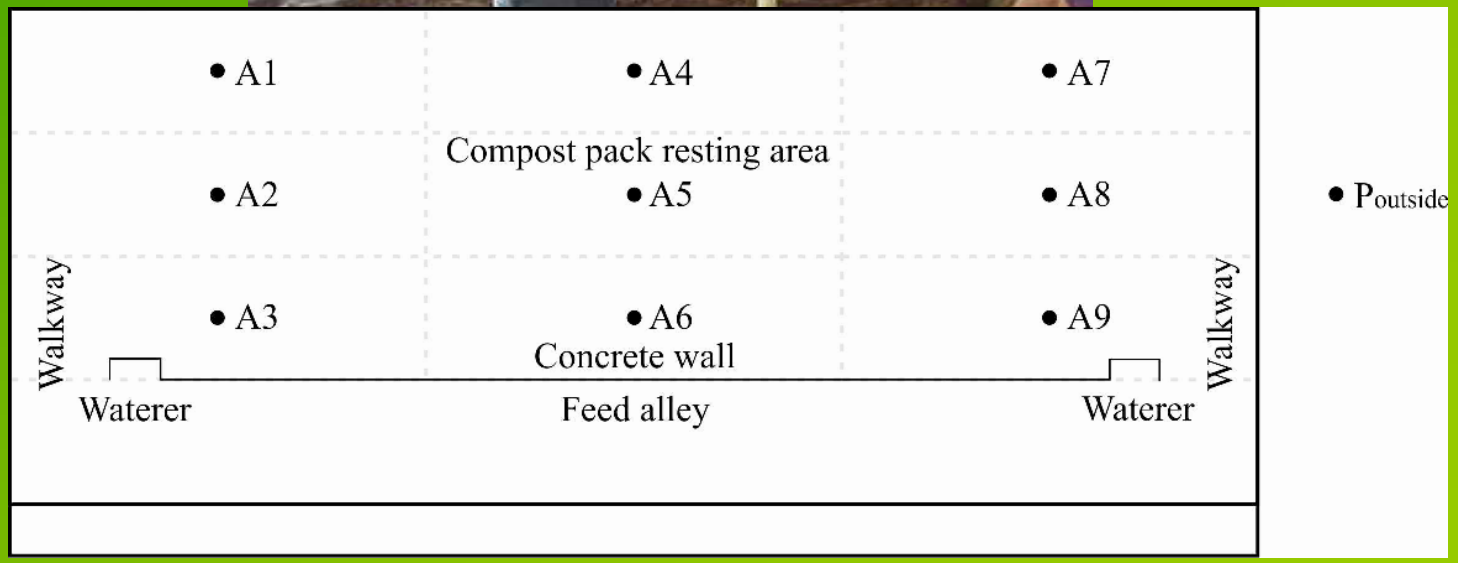
What we have learned from assessment of compost beds

Barn Facility Measurements



Environmental Measurements

- Air temperature, relative humidity, and air velocity and wind direction (0.05 and 1.2 m);



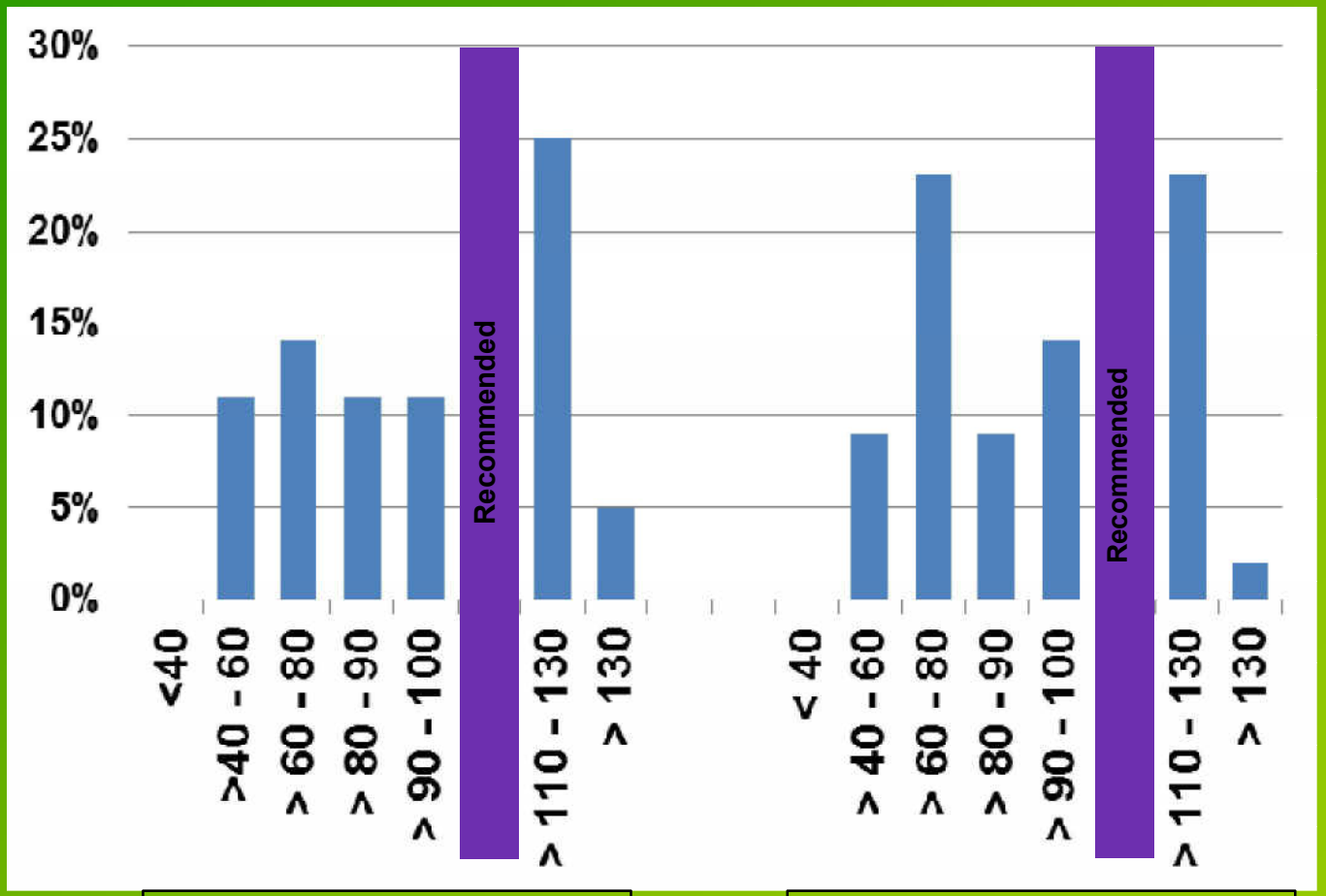
Bedding Temperature Measurement

Bedding temperature – surface and two different depths (0.10 and 0.20 m);

Bedding Moisture Measurement

Bedding moisture – surface to 0.20 m

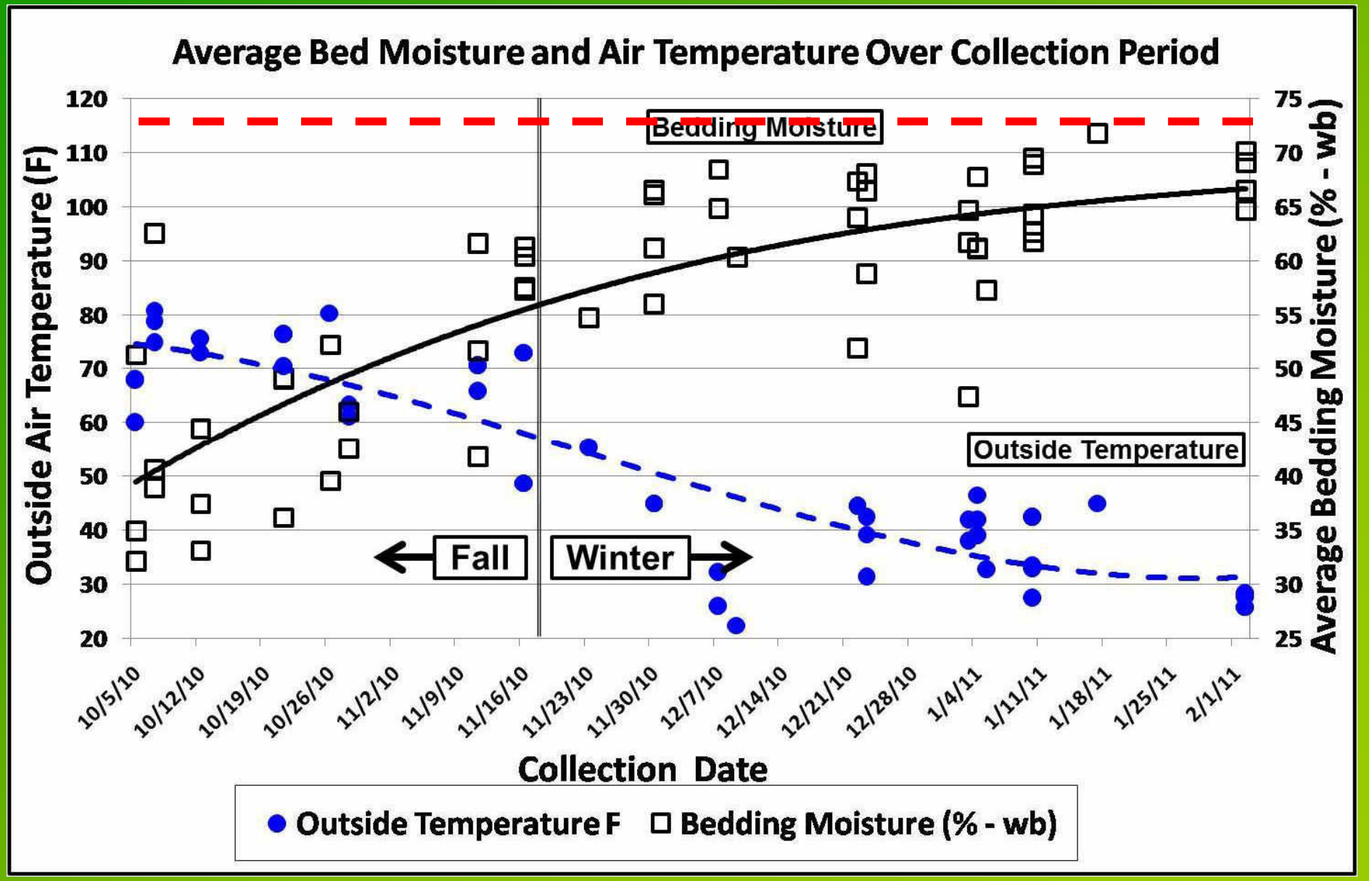
Stocking Density

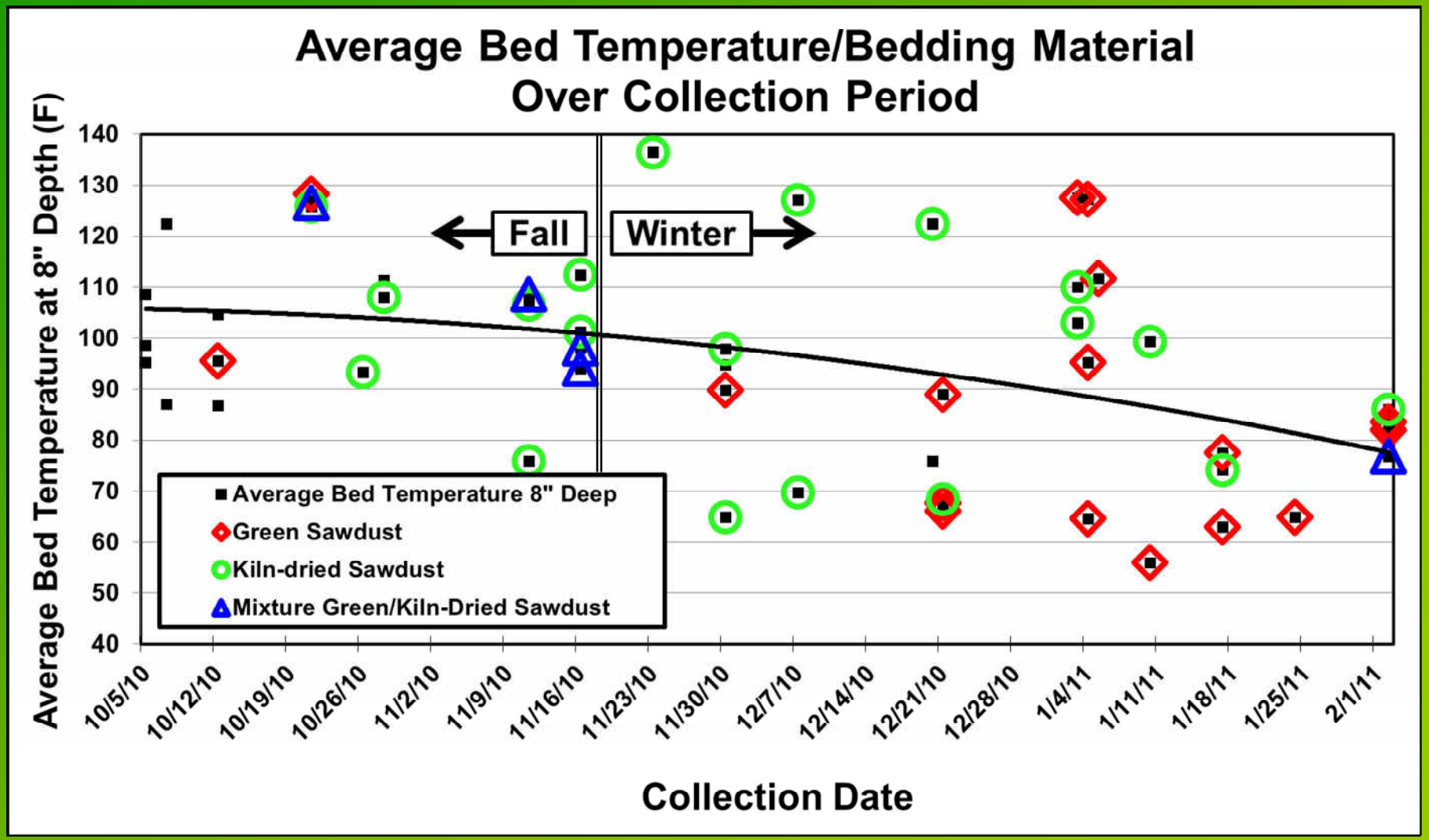


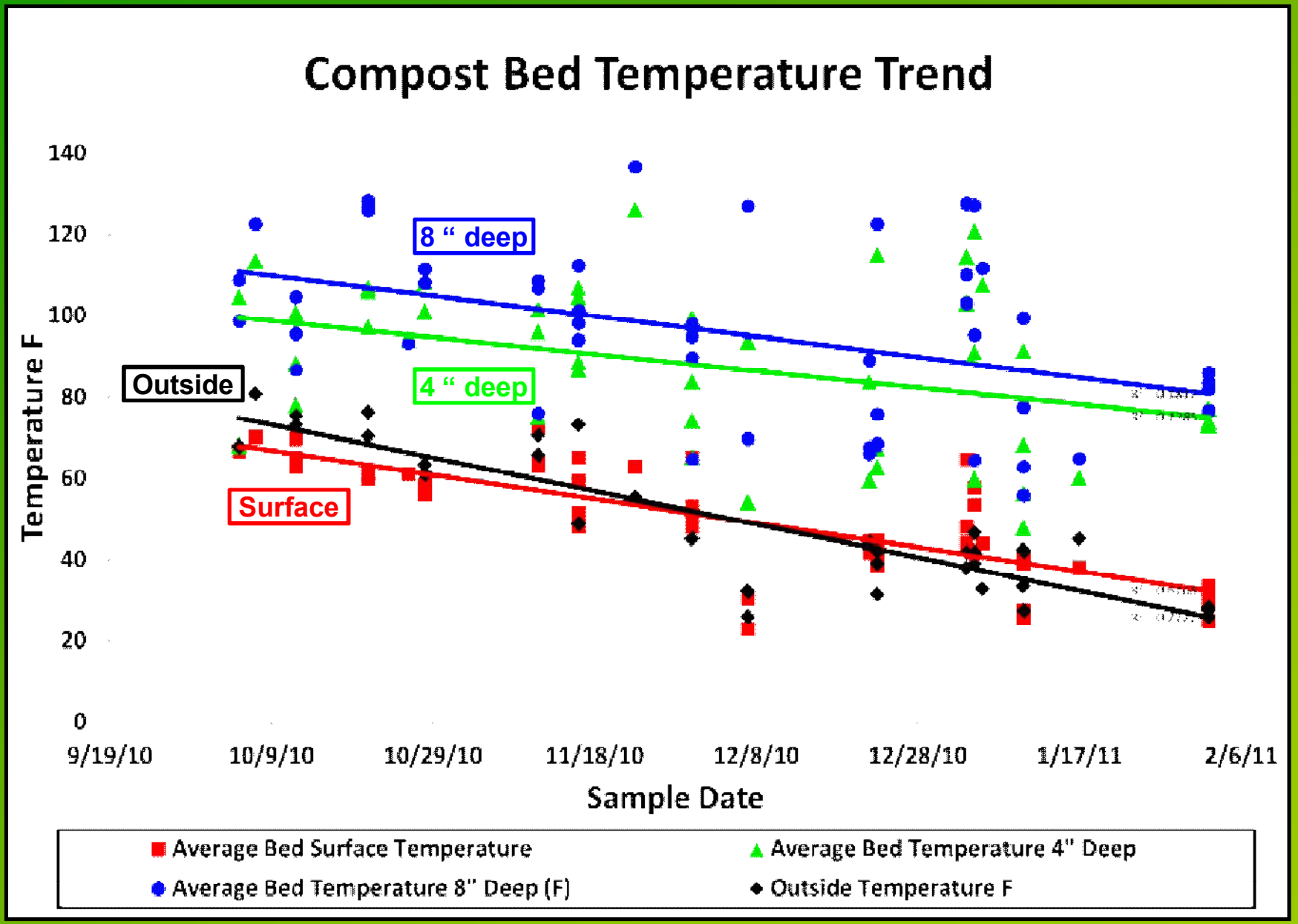
Stocking Density ft²/cow

Adjusted Stocking Density – ft²/cow

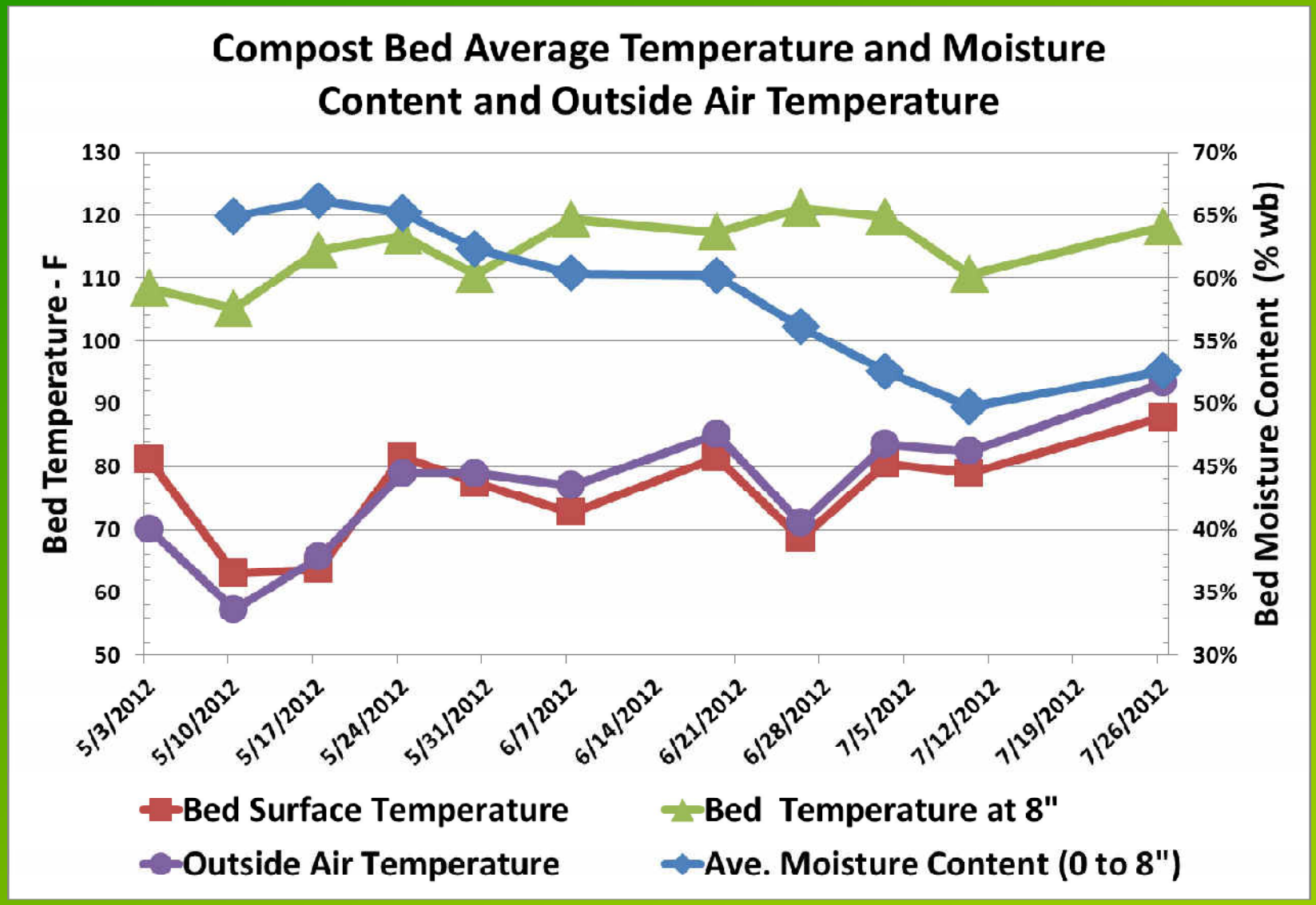
Average Water Holding Capacity = 72.7%

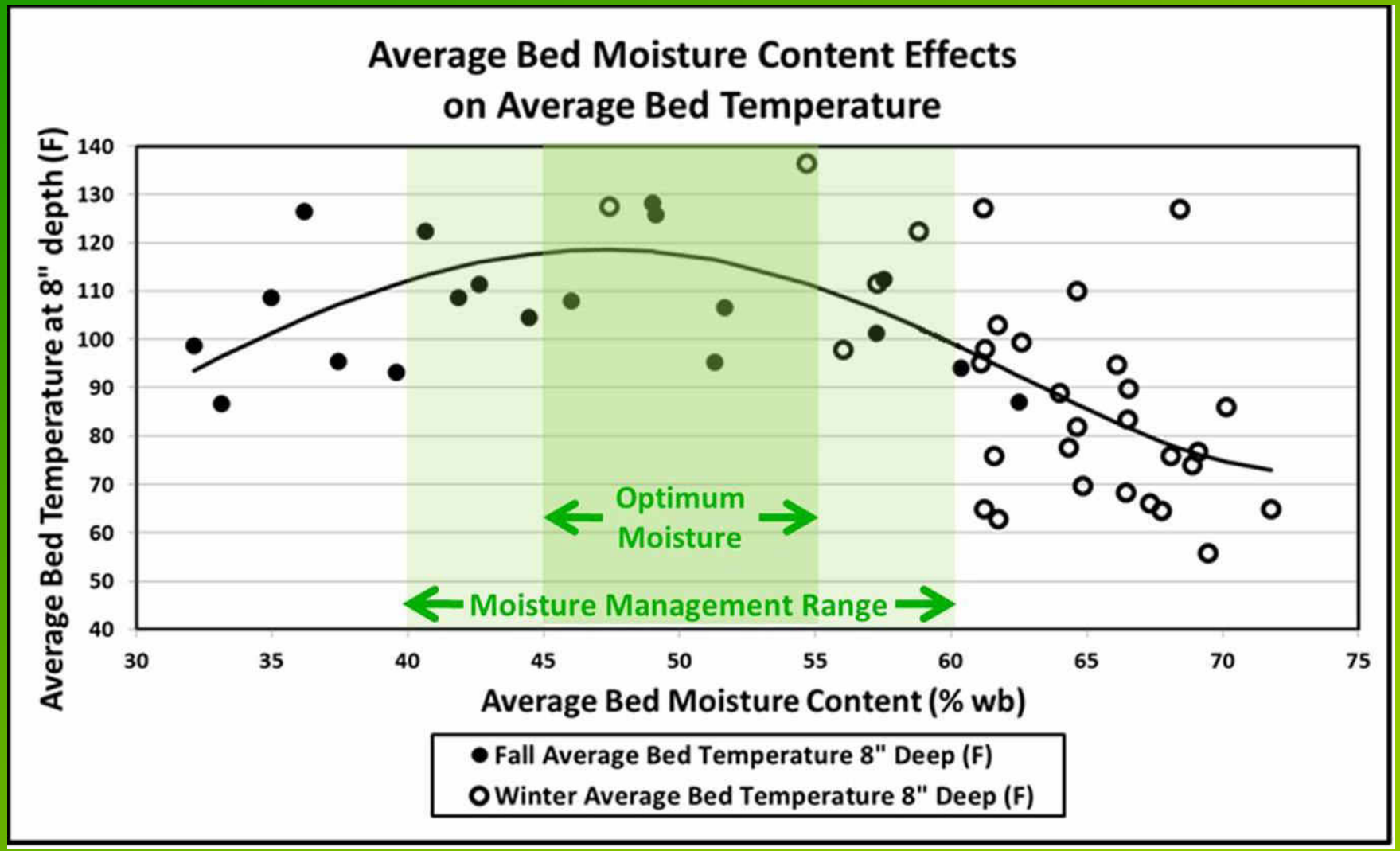


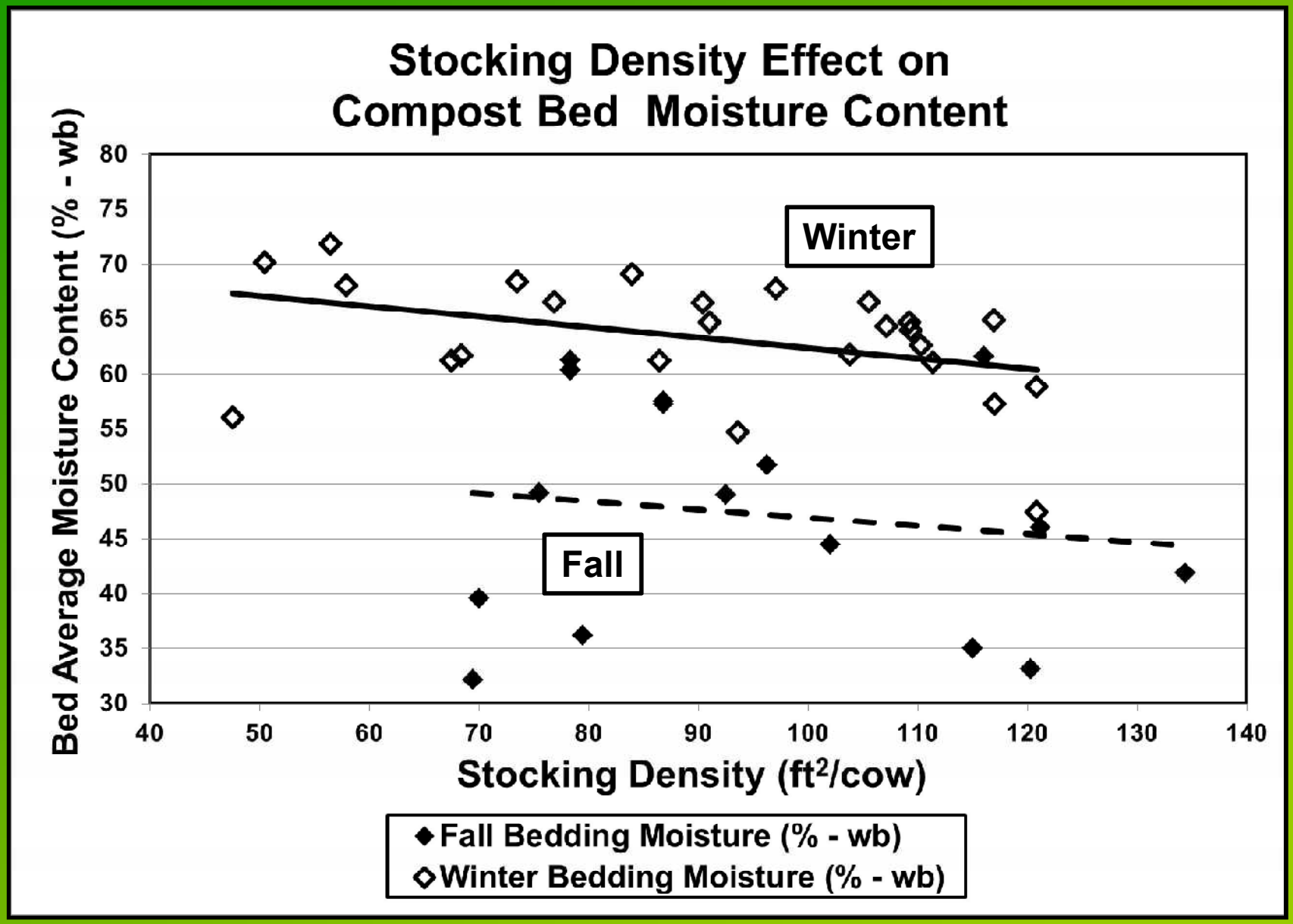

Average Bed Temperature/Bedding Material
Over Collection Period
Average Bed Temperature at 8" Depth (F)
140
130
120
110
100
90
80
70
60
50
40
Fall
Winter
Average Bed Temperature 8" Deep
Green Sawdust
Kiln-dried Sawdust
Mixture Green/Kiln-Dried Sawdust
10/5/10
10/12/10
10/19/10
10/26/10
11/2/10
11/9/10
11/16/10
11/23/10
11/30/10
12/7/10
12/14/10
12/21/10
12/28/10
1/4/11
1/11/11
1/18/11
1/25/11
2/1/11
Collection Date

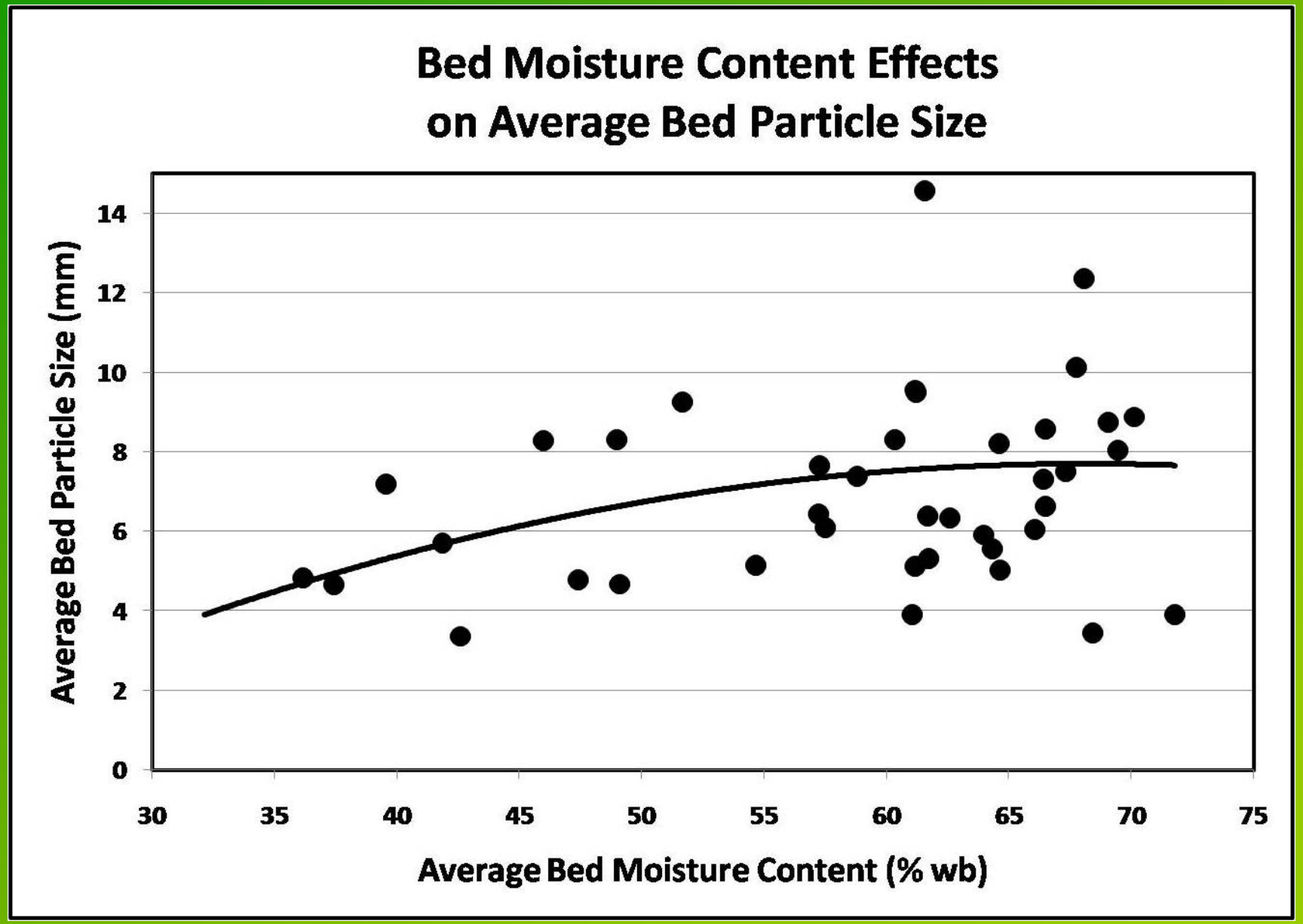

Compost Bed Temperature Trend
140
120
100
80
60
40
20
0
Temperature F
8 " deep
4 " deep
Outside
Surface
9/19/10
10/9/10
10/29/10
11/18/10
12/8/10
12/28/10
1/17/11
2/6/11
Sample Date
Average Bed Surface Temperature
Average Bed Temperature 4" Deep
Average Bed Temperature 8" Deep (F)
Outside Temperature F

Temporal Compost Bed Monitoring

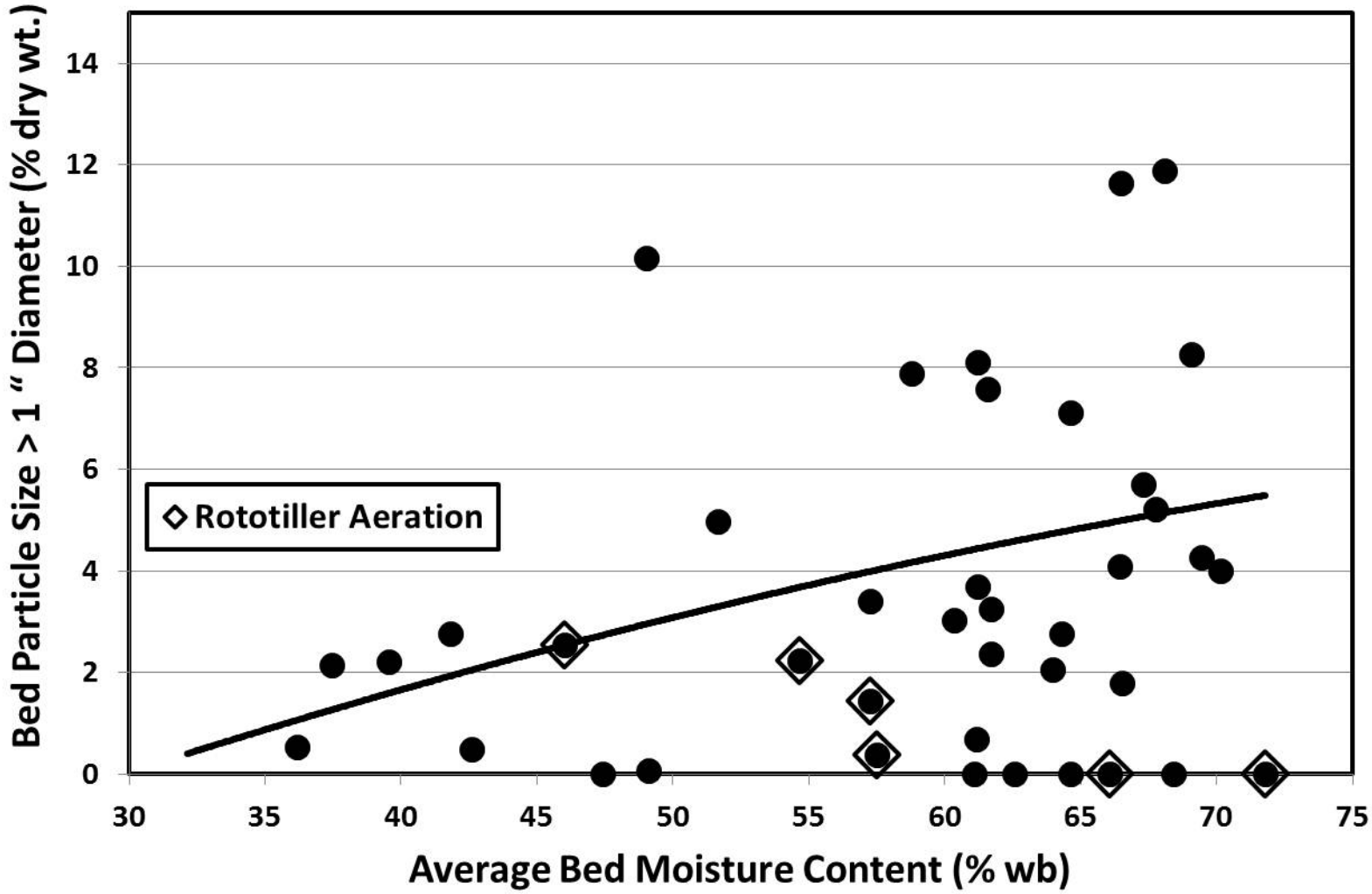



Average Bed Moisture Content Effects
on Average Bed Temperature
Average Bed Temperature at 8" depth (F)
140
130
120
110
100
90
80
70
60
50
40
30
35
40
45
50
55
60
65
70
75
Optimum
Moisture
Moisture Management Range
Average Bed Moisture Content (% wb)
Fall Average Bed Temperature 8" Deep (F)
Winter Average Bed Temperature 8" Deep (F)

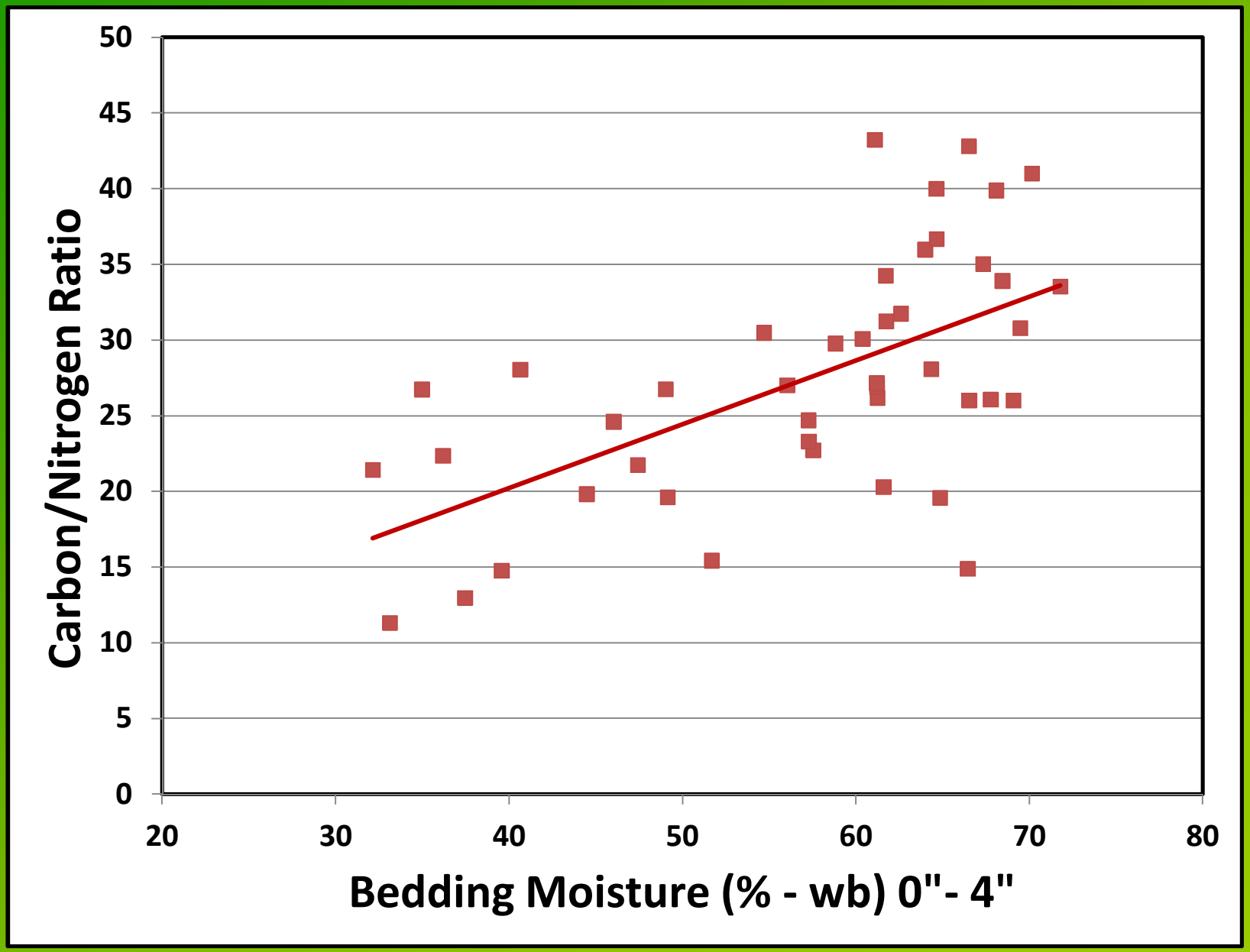

Stocking Density Effect on
Compost Bed Moisture Content
Bed Average Moisture Content (% - wb)
80
75
70
65
60
55
50
45
40
35
30
40
50
60
70
80
90
100
110
120
130
140
Stocking Density (ft²/cow)
Winter
Fall
Fall Bedding Moisture (% - wb)
Winter Bedding Moisture (% - wb)


Bed Moisture Content Effects
on Average Bed Particle Size
Average Bed Particle Size (mm)
0
2
4
6
8
10
12
14
30
35
40
45
50
55
60
65
70
75
Average Bed Moisture Content (% wb)

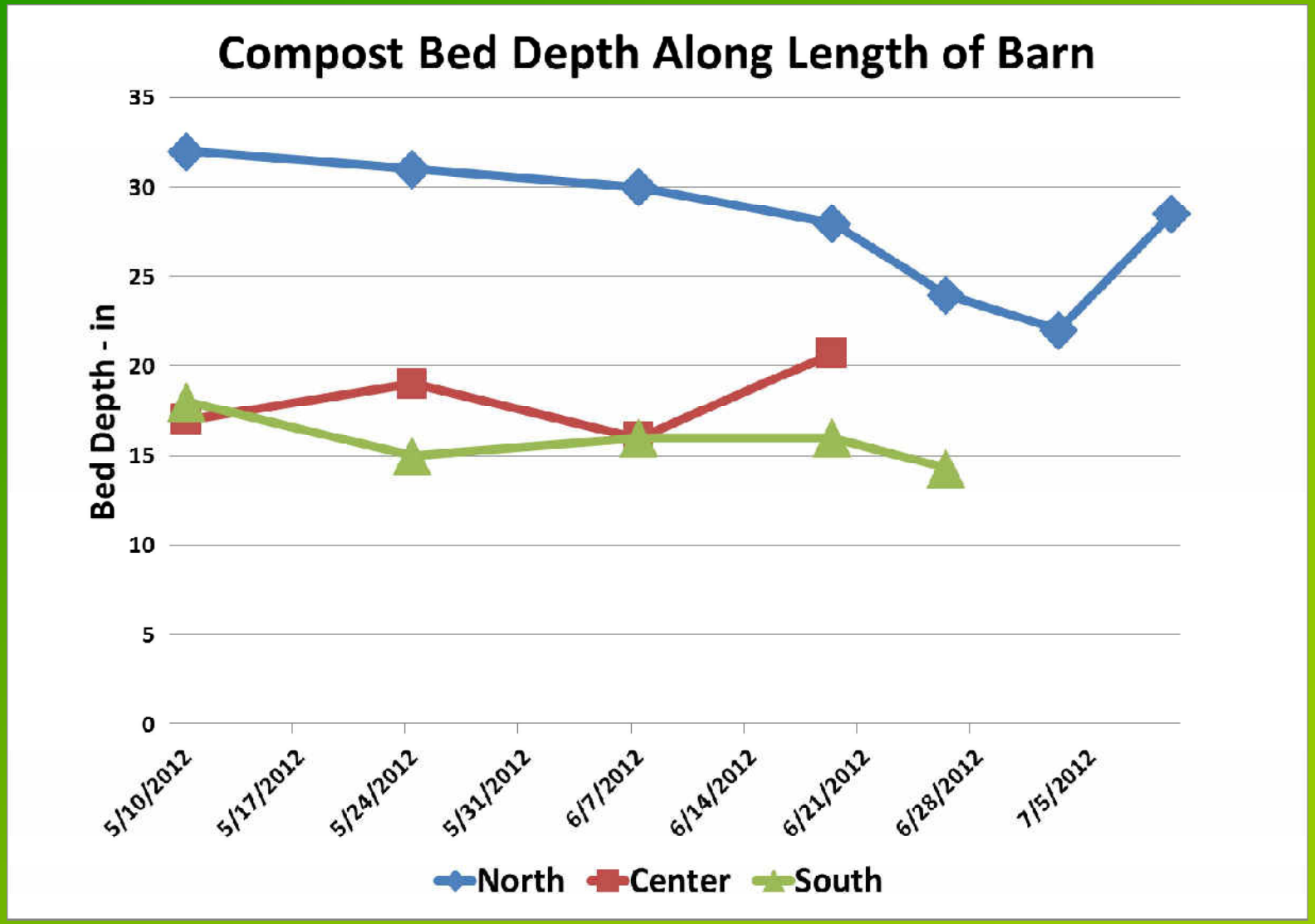
Bed Moisture Content Effects on Bed Particle Size

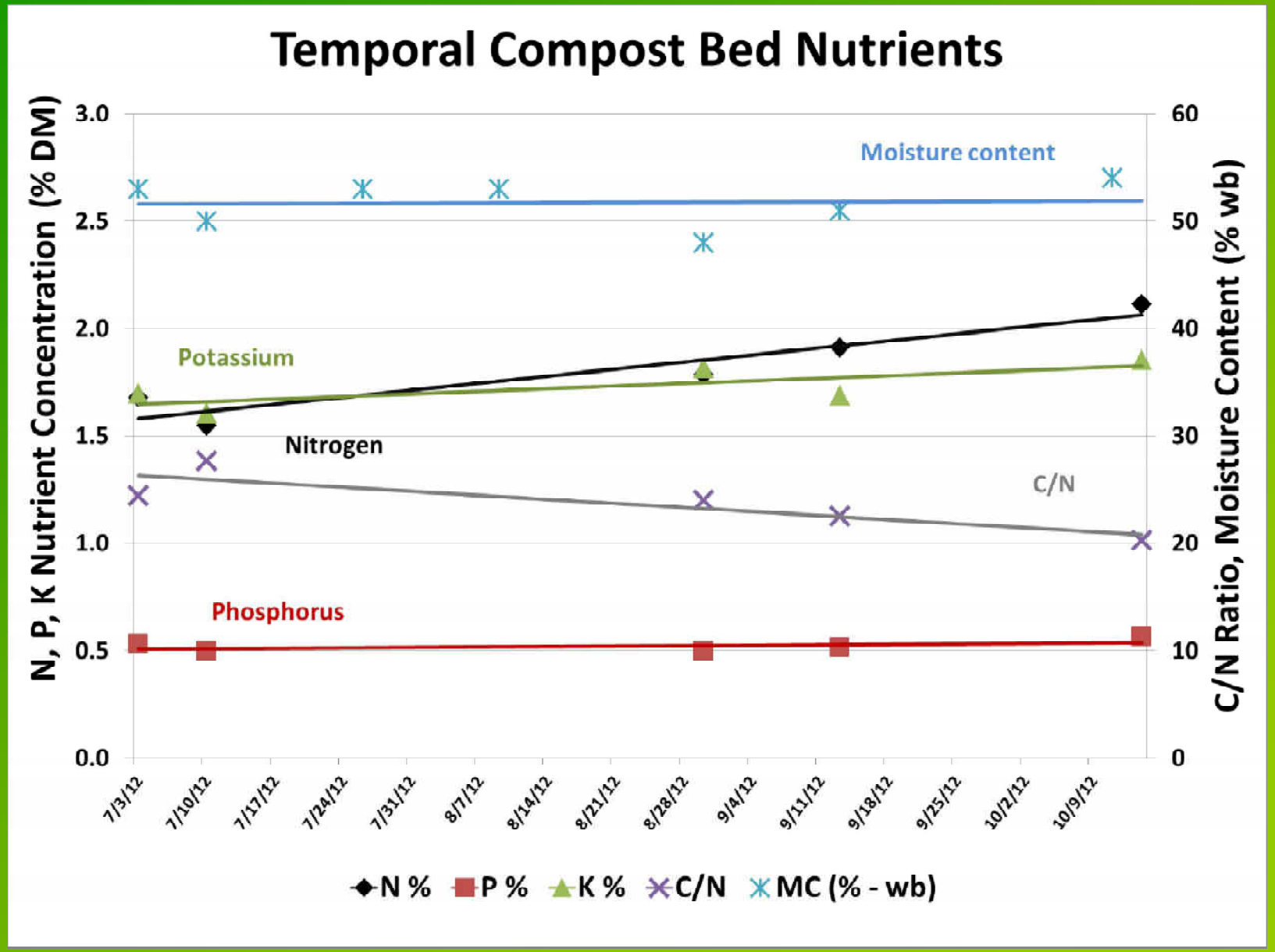


Bed Carbon/Nitrogen Ratio



Temporal Compost Bed Monitoring



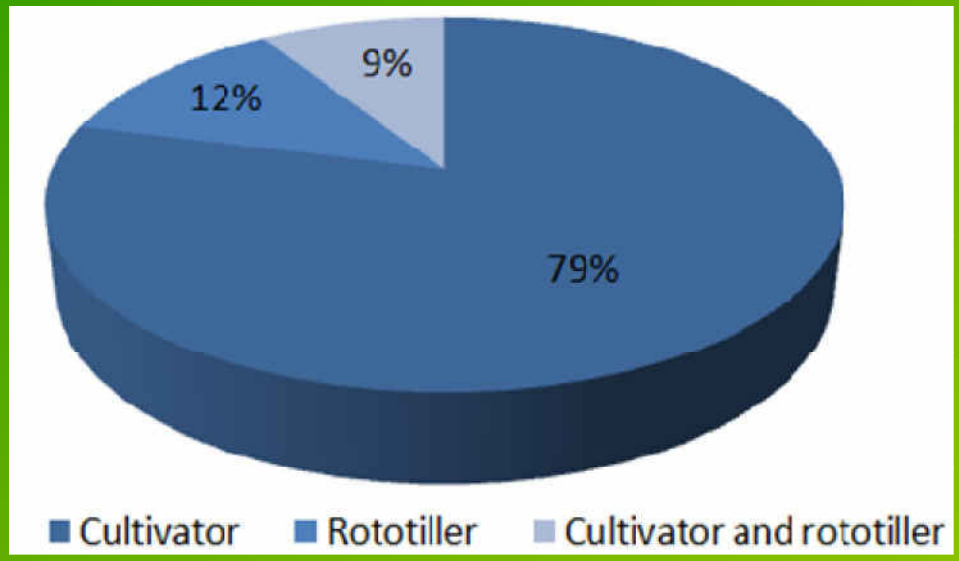

Temporal Compost Bed Nutrients
N, P, K Nutrient Concentration (% DM)
C/N Ratio, Moisture Content (% wb)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
60
50
40
30
20
10
0
Moisture content
Potassium
Nitrogen
C/N
Phosphorus
7/3/12
7/10/12
7/17/12
7/24/12
7/31/12
8/7/12
8/14/12
8/21/12
8/28/12
9/4/12
9/11/12
9/18/12
9/25/12
10/2/12
10/9/12
N %
P %
K %
C/N
MC (% - wb)

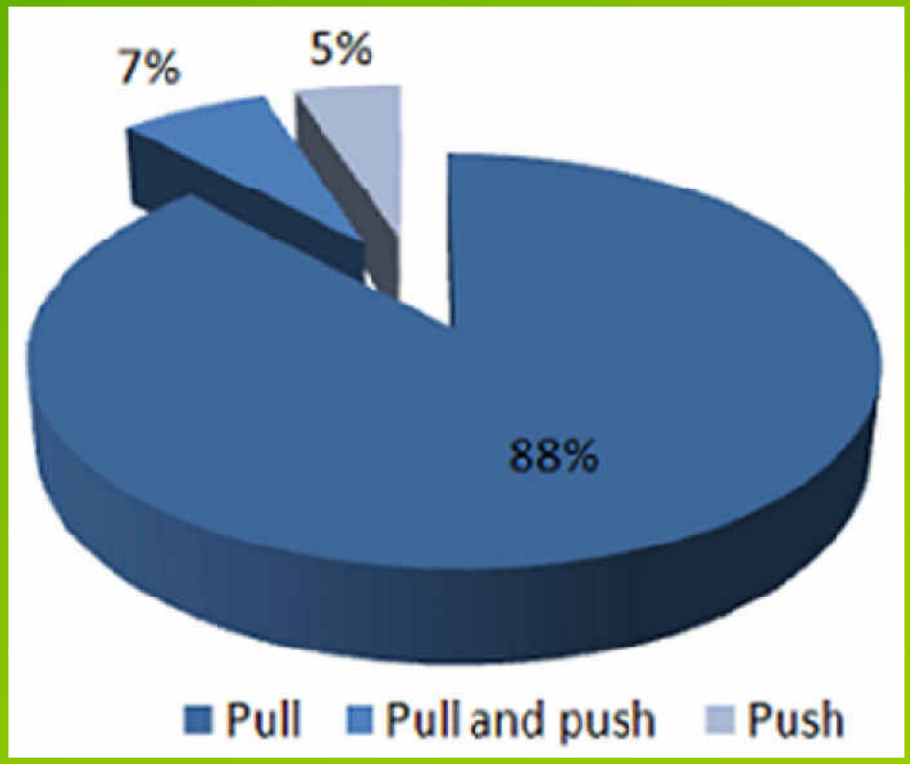
Stirring the Bed

2 x per day **religiously**

10-12" Stirring Depth

Tillage


9%
12%
79%
Cultivator
Rototiller
Cultivator and rototiller


7%
5%
88%
Pull
Pull and push
Push

How Can You Reduce Bedding Use In Winter

- Allow cow access to pasture in good weather
- Increase air circulation in barn when cows are milking or in pasture
  - But not to point of losing too much bed temperature
- Use kiln dry sawdust in winter, green sawdust during warmer weather
- Stockpile and/or store kiln dry sawdust under roof or tarp

Why Don't All Packs Work?

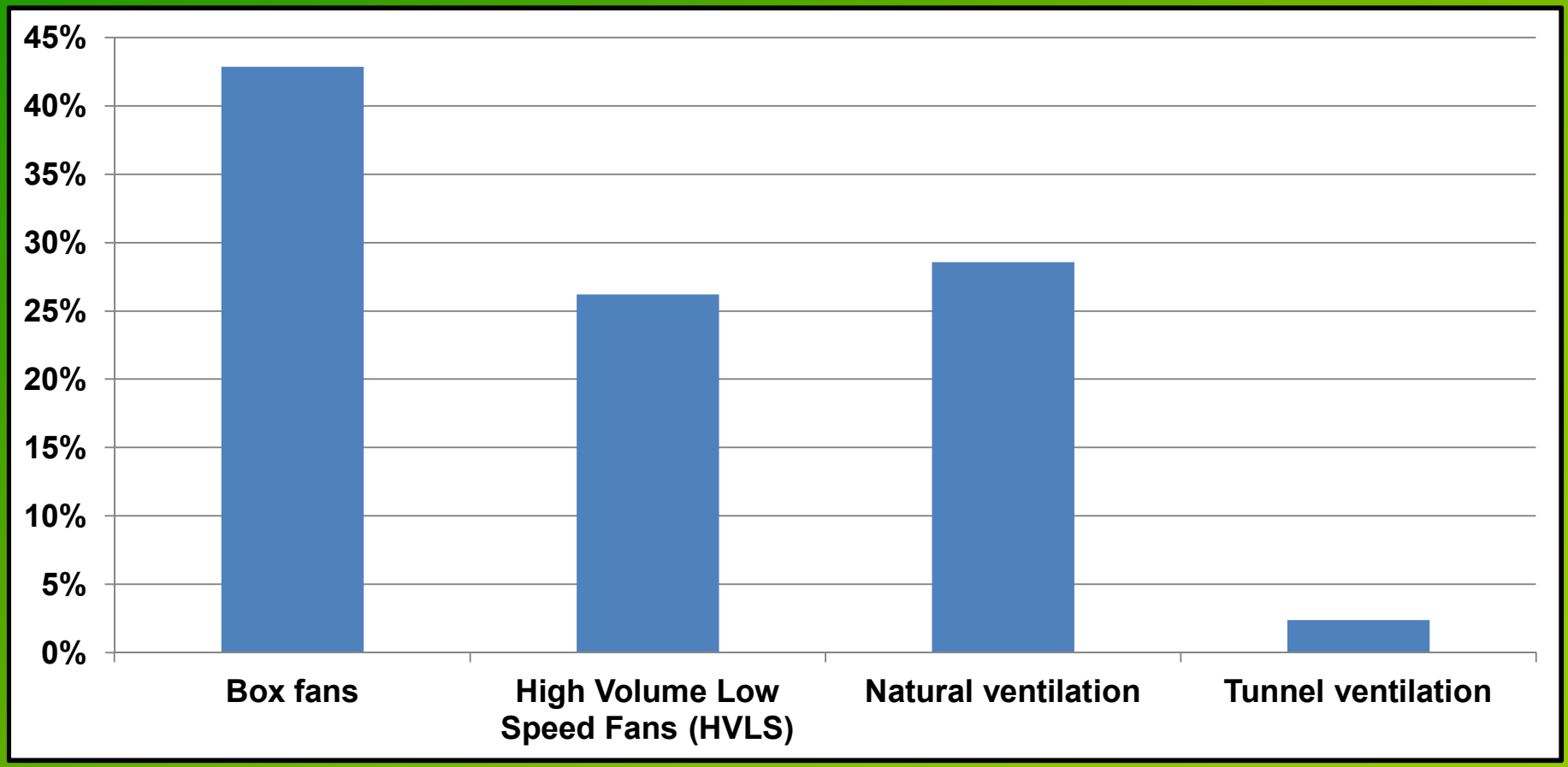
- Stocking density
  - too many cows! Poor distribution of cows
- Bed material used
  - straw, cedar
- Insufficient bedding volumes
- Inadequate/ineffective stirring
  - Stirring frequency (less than 2x/day)
  - Depth of stirring (<10-12")
  - Compaction from tractors
- Starting pack in the late fall/winter
- Too much ventilation in winter
  - no curtains
- Barn design flaws

What we have learned from assessment of barn structural details

Potential Design Flaws

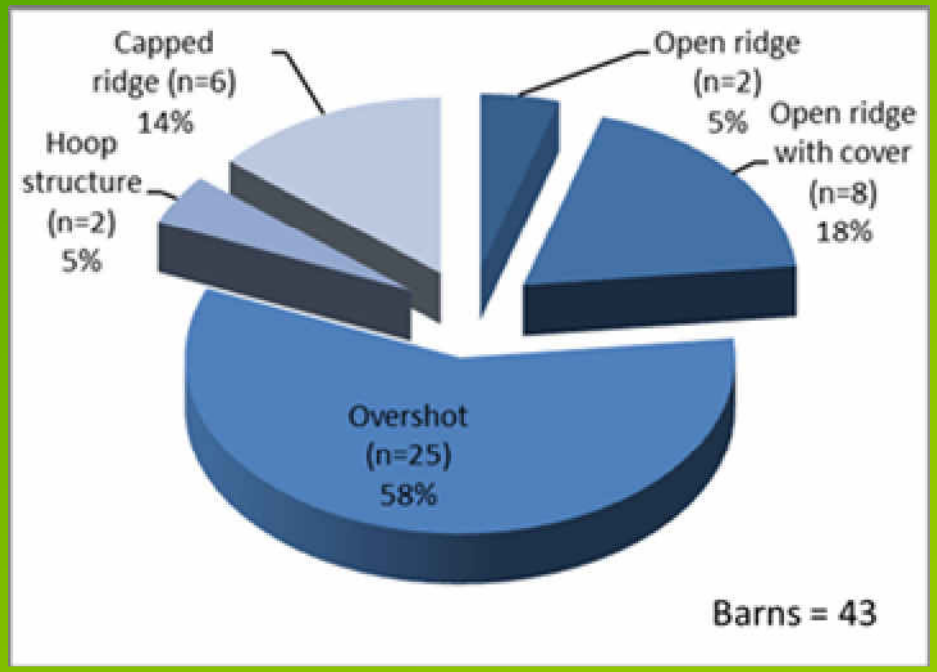
- Not enough space per cow
- Inadequate ventilation
  - Sidewalls too low (<16')
  - Too close to other buildings
  - Too small ridge opening
  - Poor ridge opening design
  - Fan availability/placement
- Lack of eave overhangs or curtains to block rain and cold wind
- Building orientation
- Walls along pack?
- Proximity to feed
- Not enough feed bunk space (24 to 30" per cow)
- Not enough water space (2 feet of tank perimeter per 15 to 20 cows
- Cow flow/traffic bottlenecks
- Waterers in pack
- Concrete base?

Barn Ventilation



Ridge Design

Type		Name
		
		
	→	Overshot
	→	Hoop structure
	→	Capped ridge

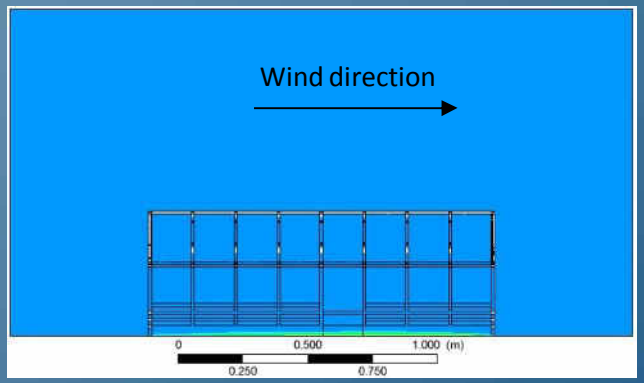


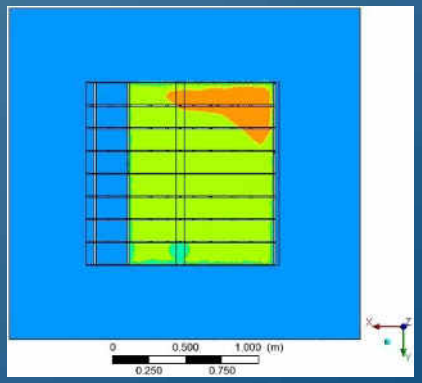
Airflow Patterns

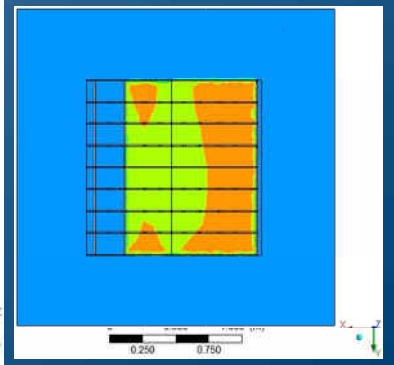
The smoke was visually observed when it was passed through and over the ridge opening

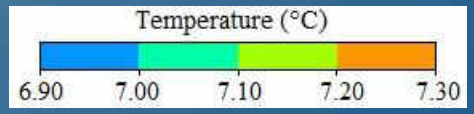

0.27
0.23
1.35
0.19
0.22
0.95
1.20

Develop CFD model of compost barn





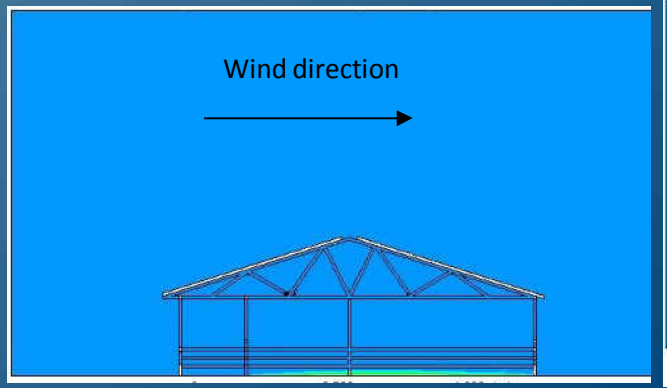


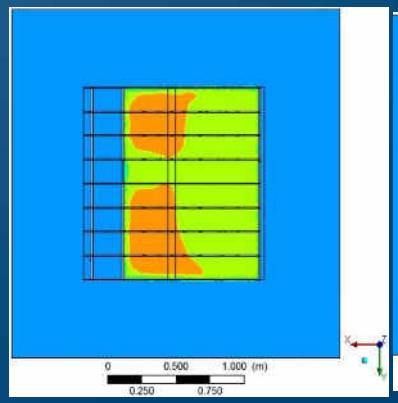


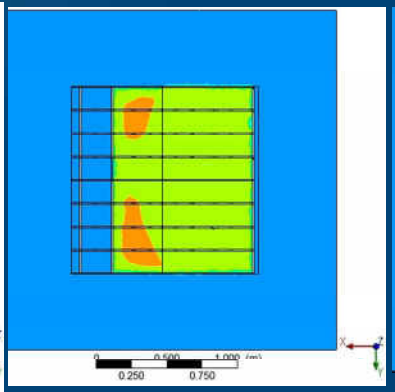
open ridge (OR)

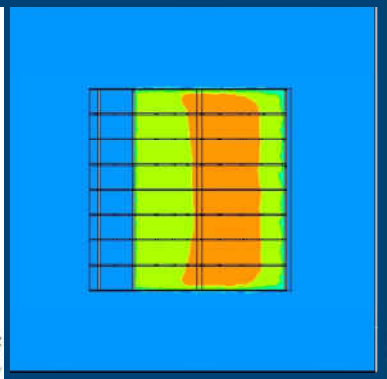
Closed ridge

Overshot

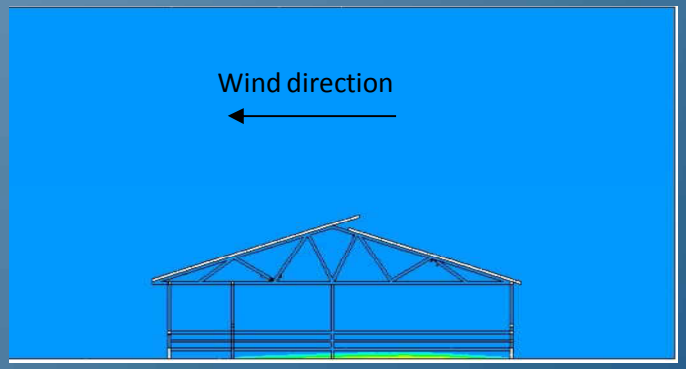


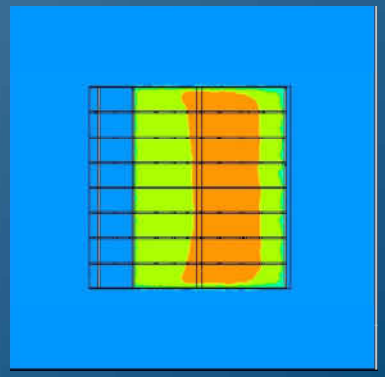




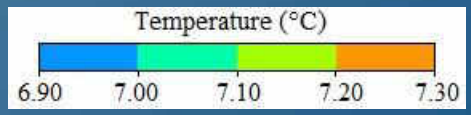


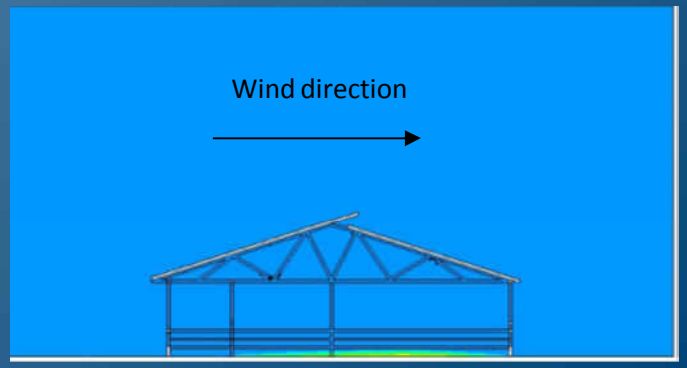
Develop CFD model of compost barn

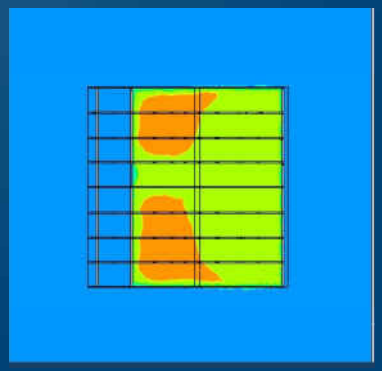




Overshot







Position in the Landscape

HIGH GROUND:

-To reduce the effects of local obstructions such as trees and other buildings

-Takes advantage of upslope air currents

HILLSIDE CUTS:

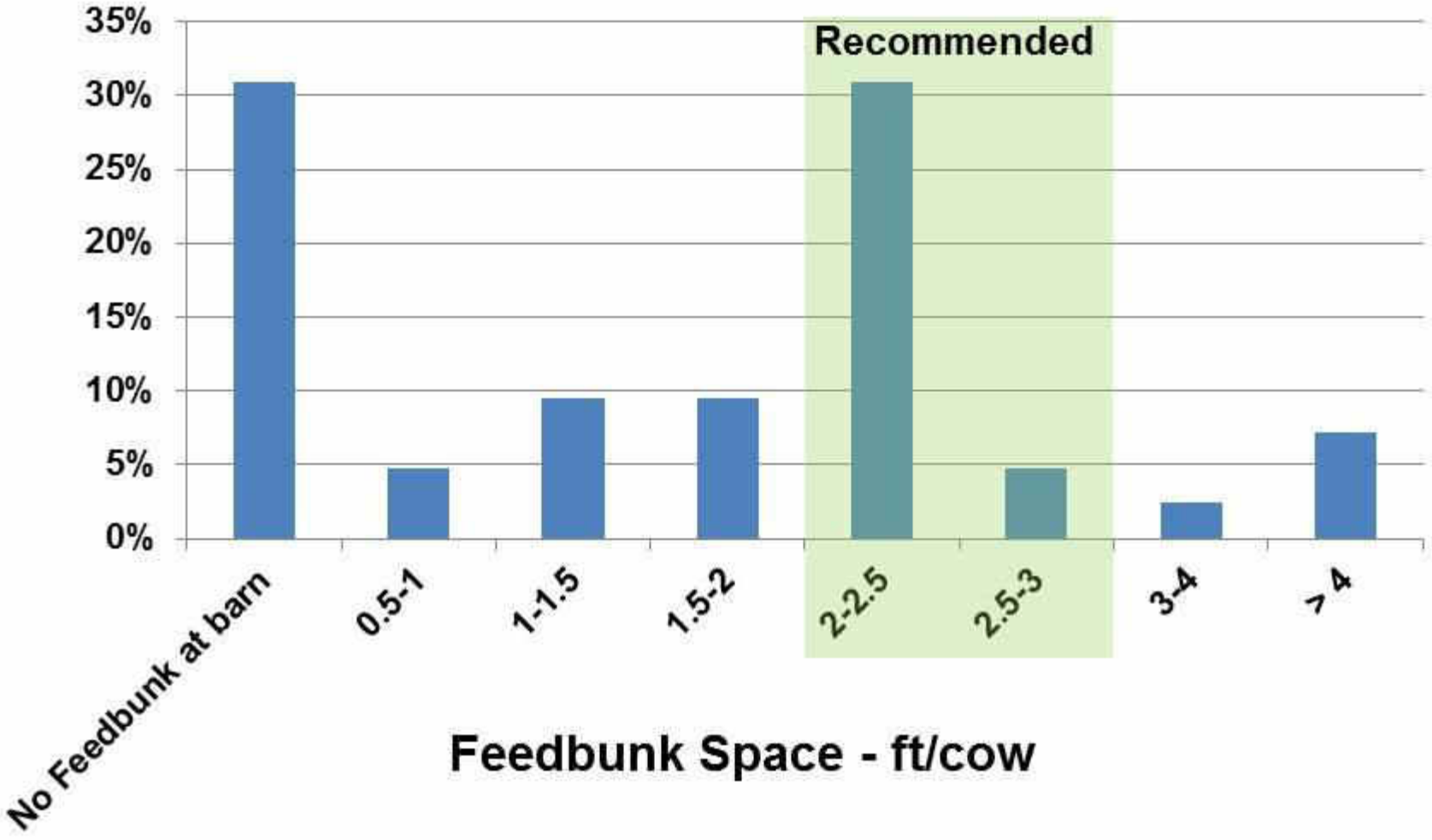
DEPRESSIONS:

-In upland wind shadow

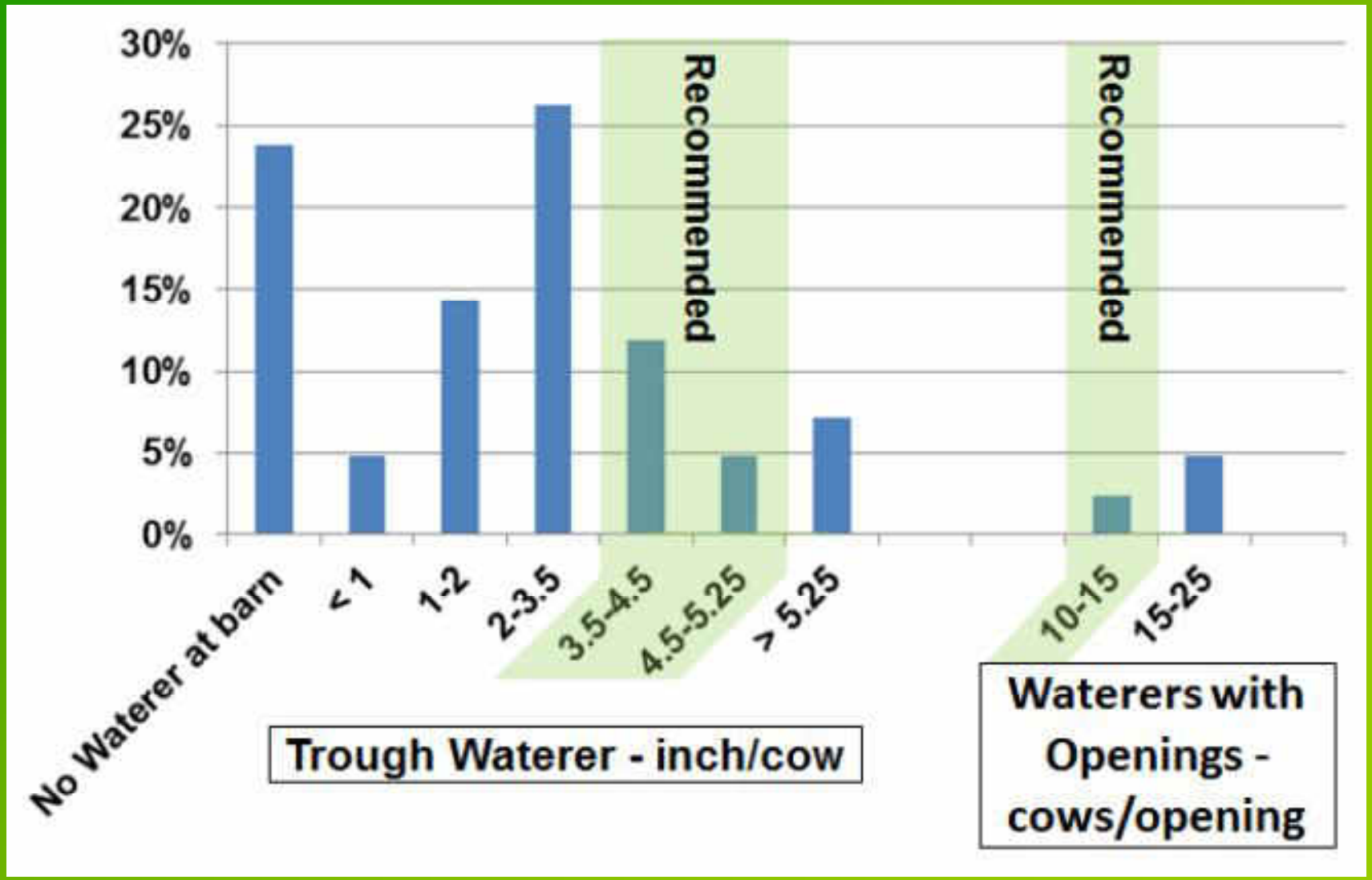
-Bowl depression subject to temperature inversions

-Does reduce winter radiation losses to sky

Feedbunk Space



Waterer Space



Compost Bedded Pack Success

- **Maintain bed temperature for:**

  - destruction of pathogens
  - increased moisture vaporization

To generate enough heat --

Need to have a high porosity bed for a level of oxygen to sustain the compost process. (But not too high or too low)

- Bed stirring
- Bedding type
- Bedding particle size

Stirring the Bed

Wheels following tillage tool leads to compaction and lower temperatures

Moisture Levels

Just right leads to clean, comfortable conditions for cow

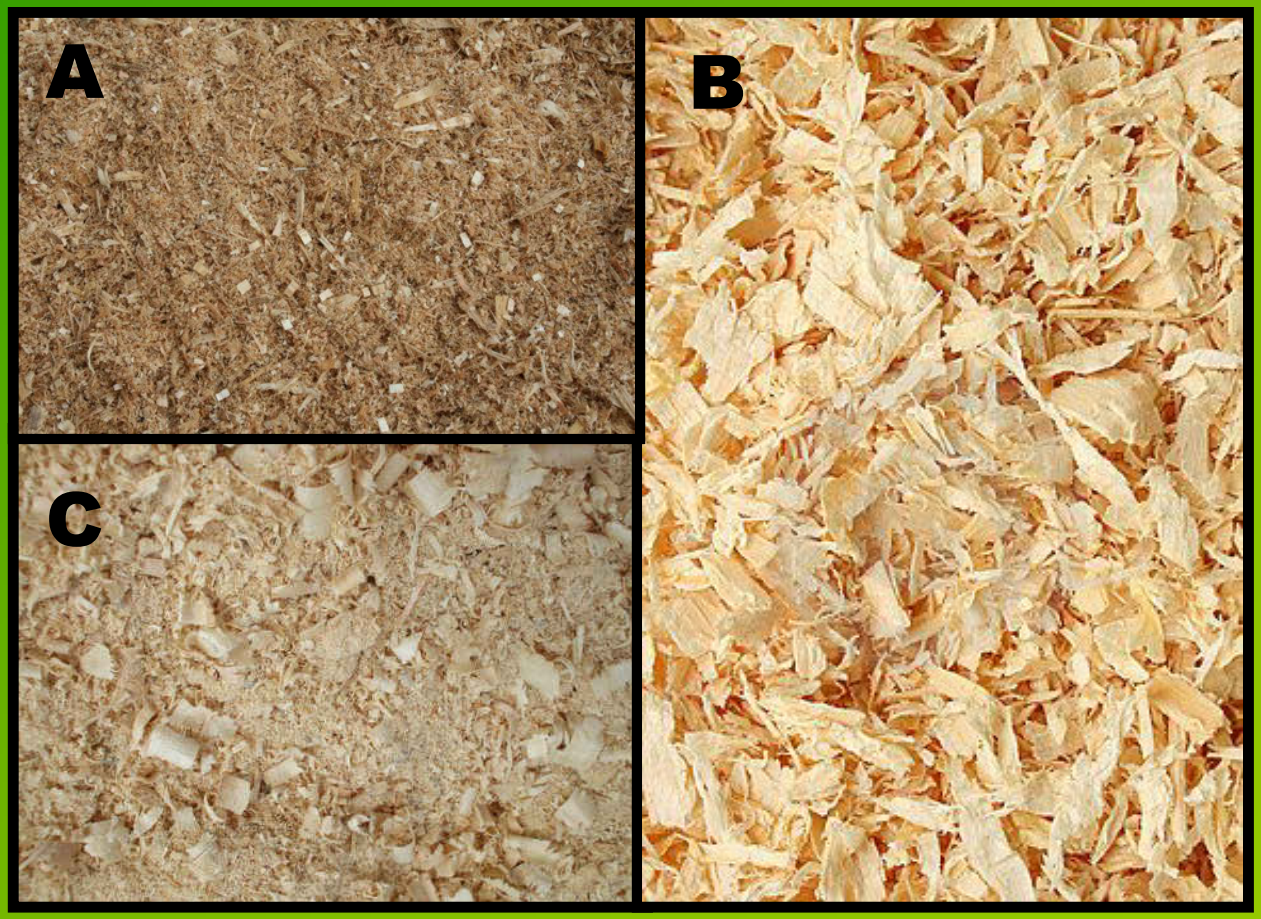
Too wet leads to poor conditions and a dirty potentially cold stressed cow

Waterers in bed area can create a too wet condition

Type Bedding Materials

Type Bedding Materials

Sawdust



Shavings

Sawdust/ Shavings

Type Bedding Materials

Not Recommended

Wood chips **Hammer milled**

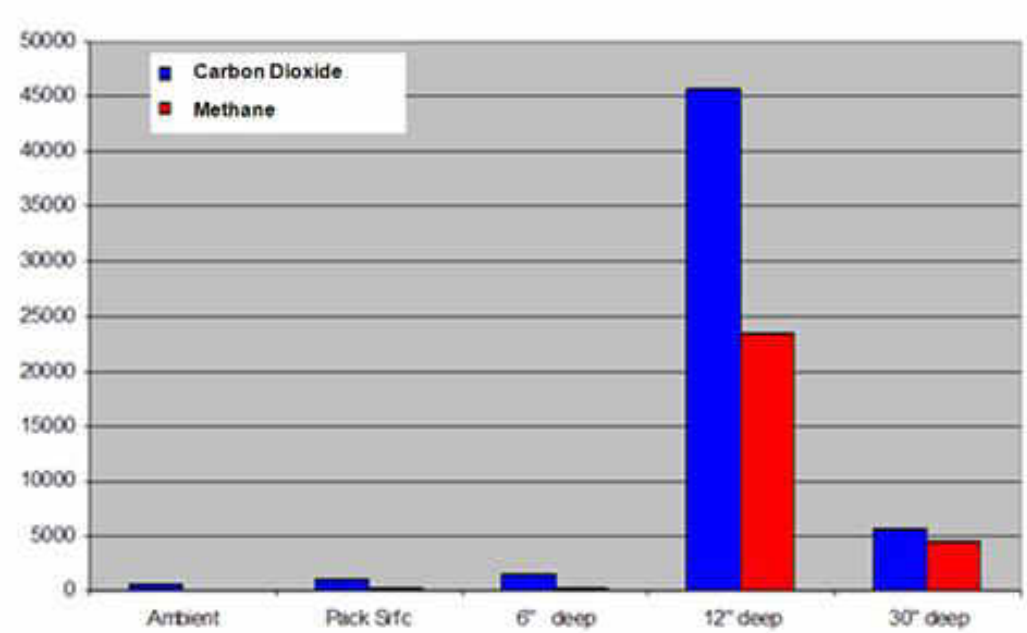
What are Alternative Bedding Sources

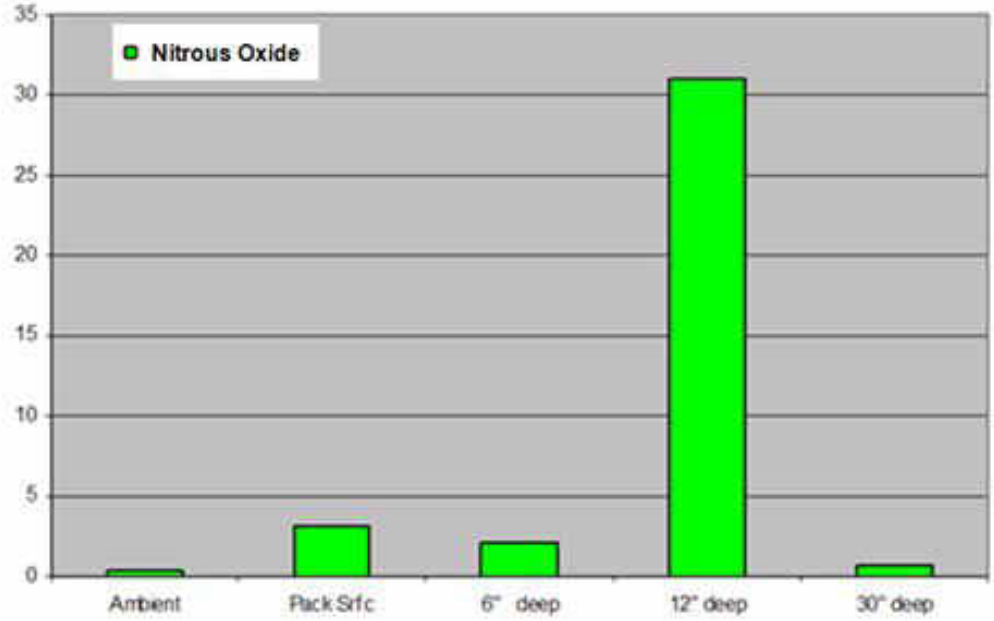
- Efforts underway to increase sawdust supply
- Green vs kiln dried sawdust
- Ground corn cobs
- **Finely chopped** soy straw/stubble
- Kenaf?
- Peanut shells?
- Other ideas?
- Need more definitive research and producer ideas and cooperation to answer these questions


1:1 Chopped Straw:sawdust


Ground Straw

Some Concerns for Greenhouse Gas Generation

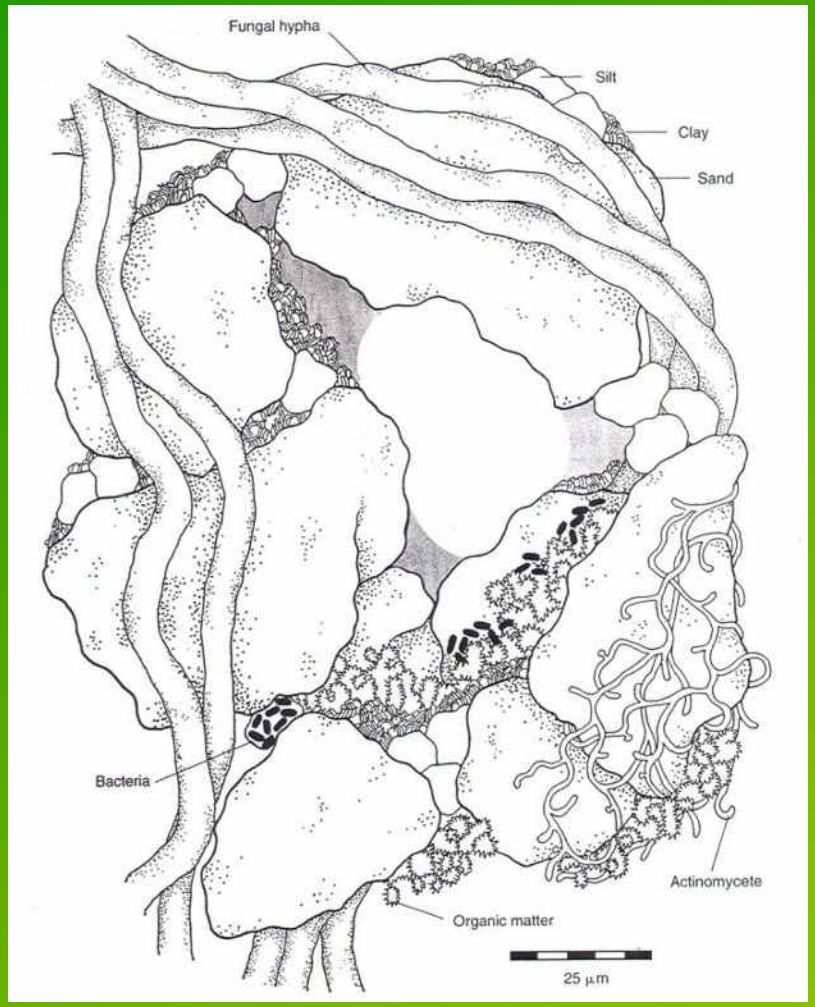




Air Space Concentrations (ppm) of GHGs in Compost Bed Profile

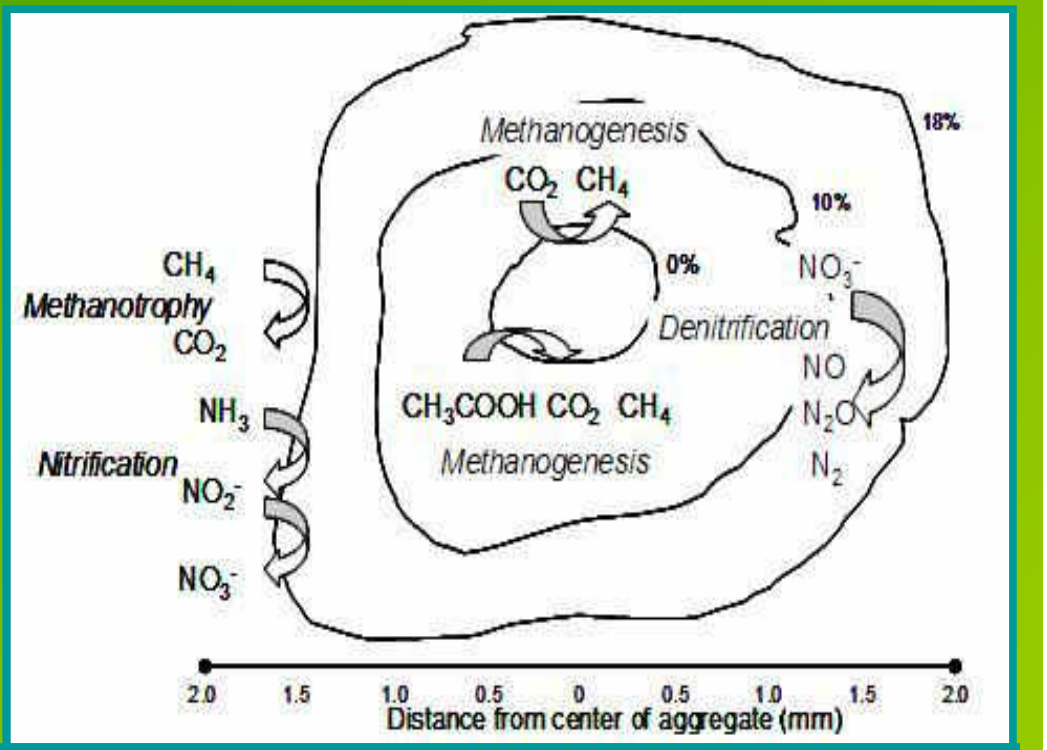
Questions?

Soil Aggregate Microenvironment Model



Typical Soil Aggregate

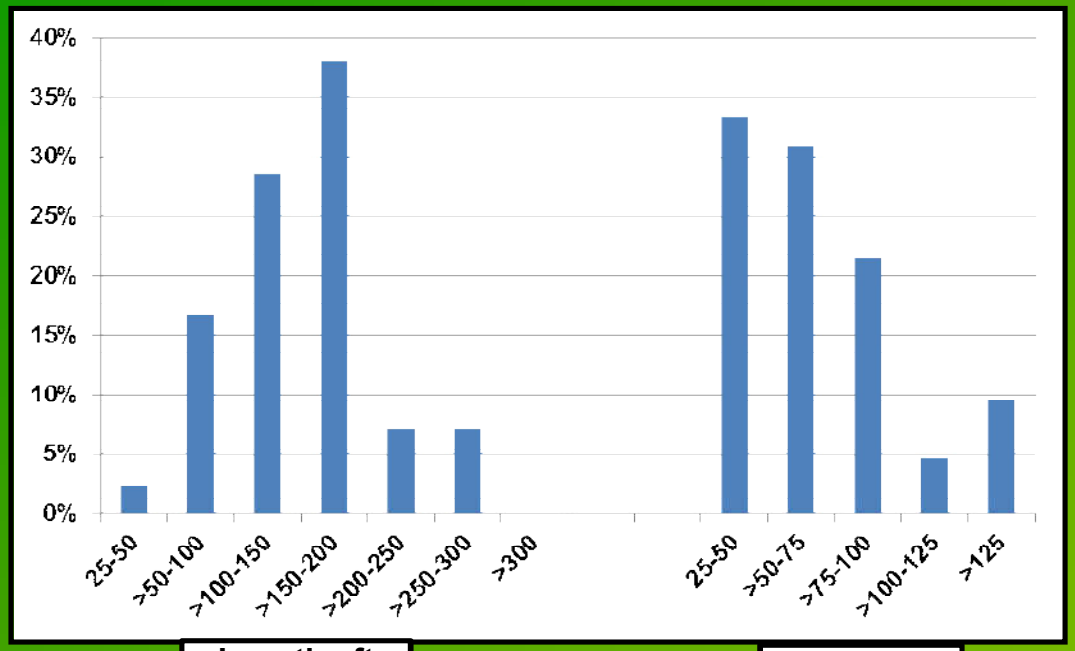
Sylvia, et al. 2005. Prin. & Appl. Of Soil Micro. Pearson. Upper Saddle, NJ.



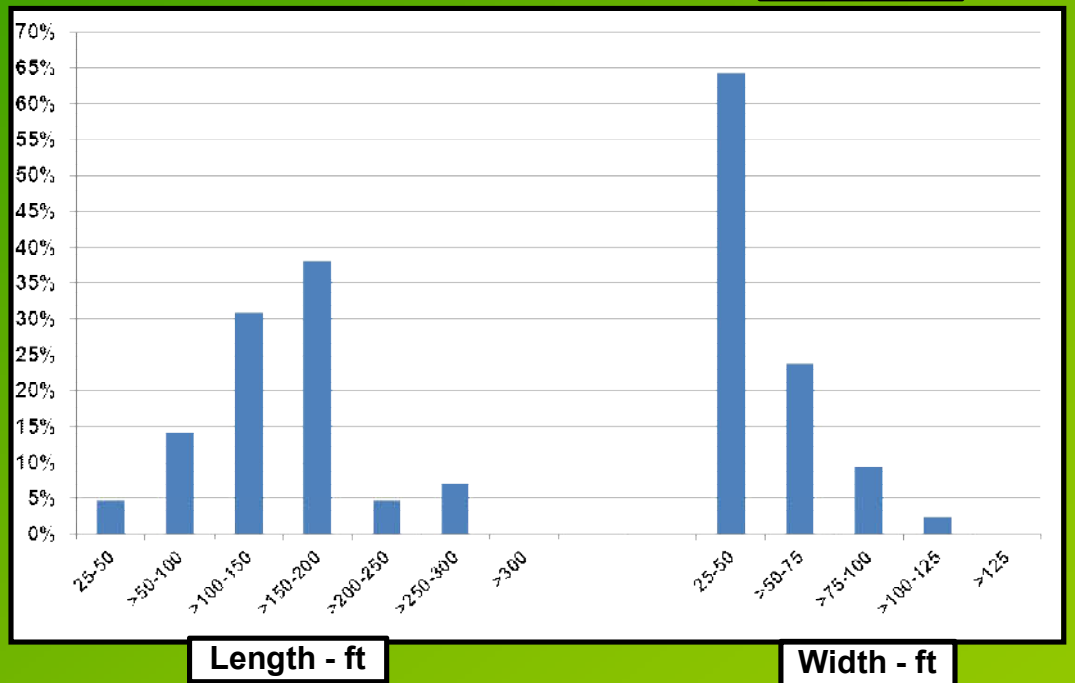
Distribution of physiological properties within an aggregate/particle. Lines represent isobars of O_2 concentration (%). Coyne, 2010.

Structure Dimensions

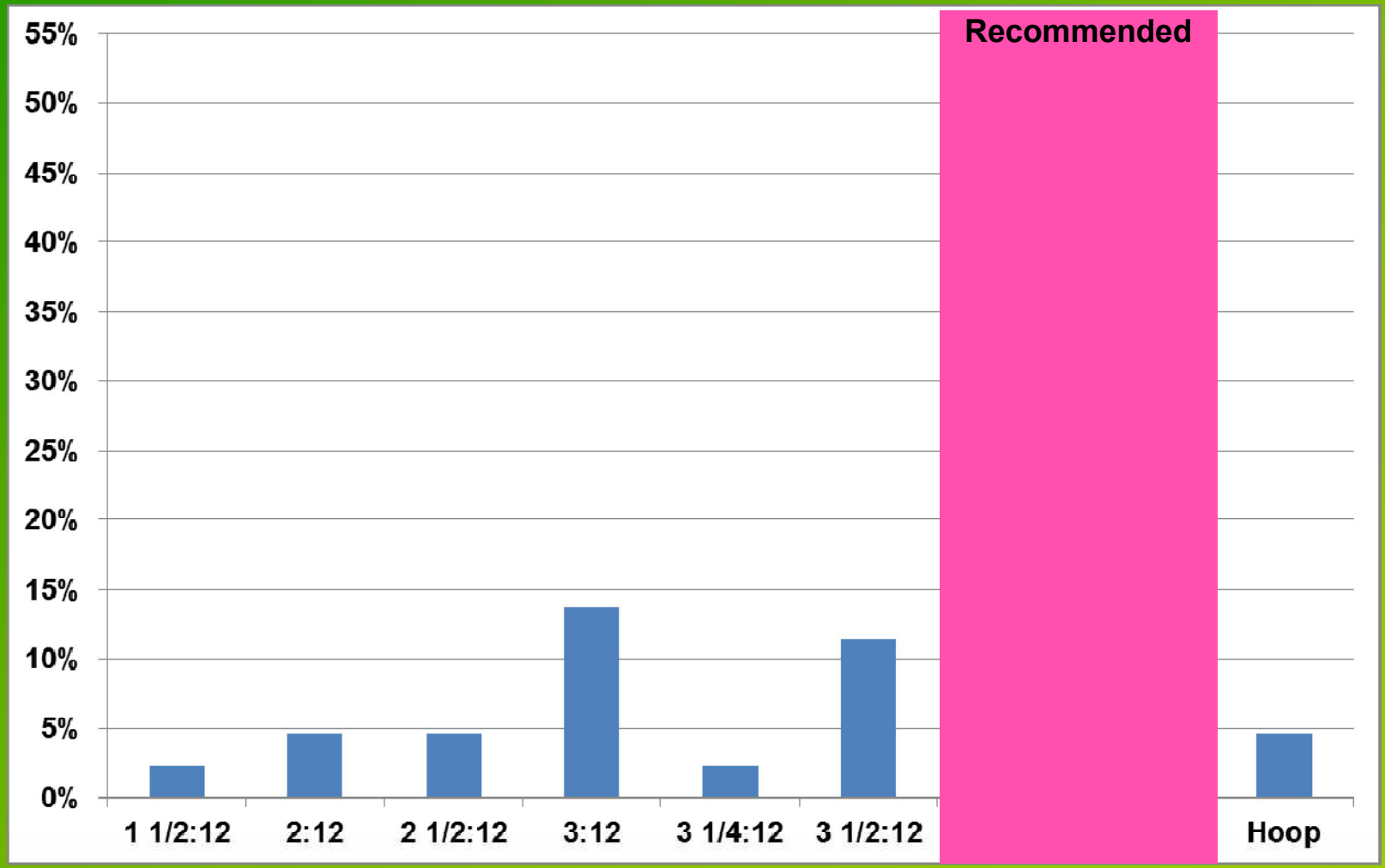
Barn



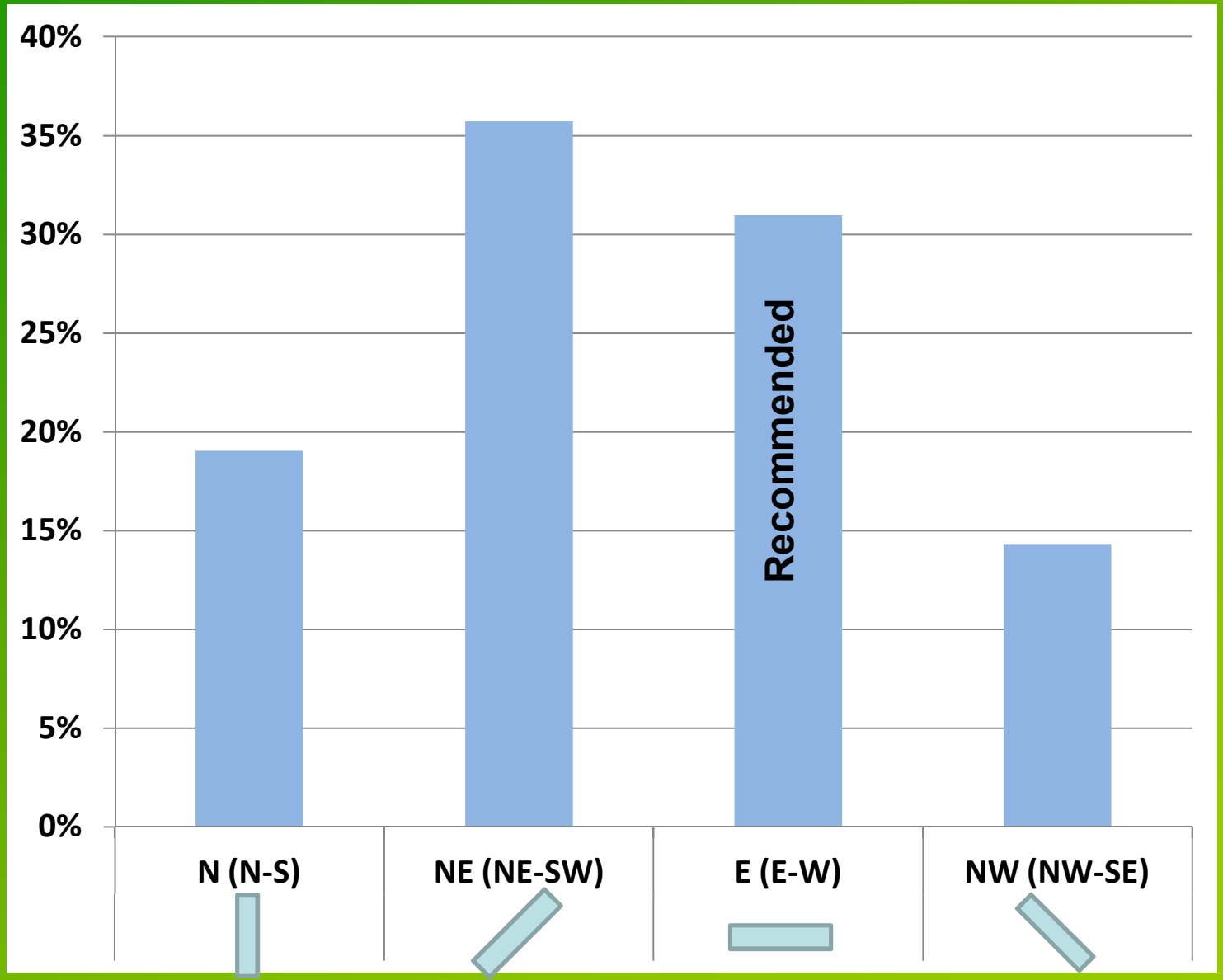
Bedded Area



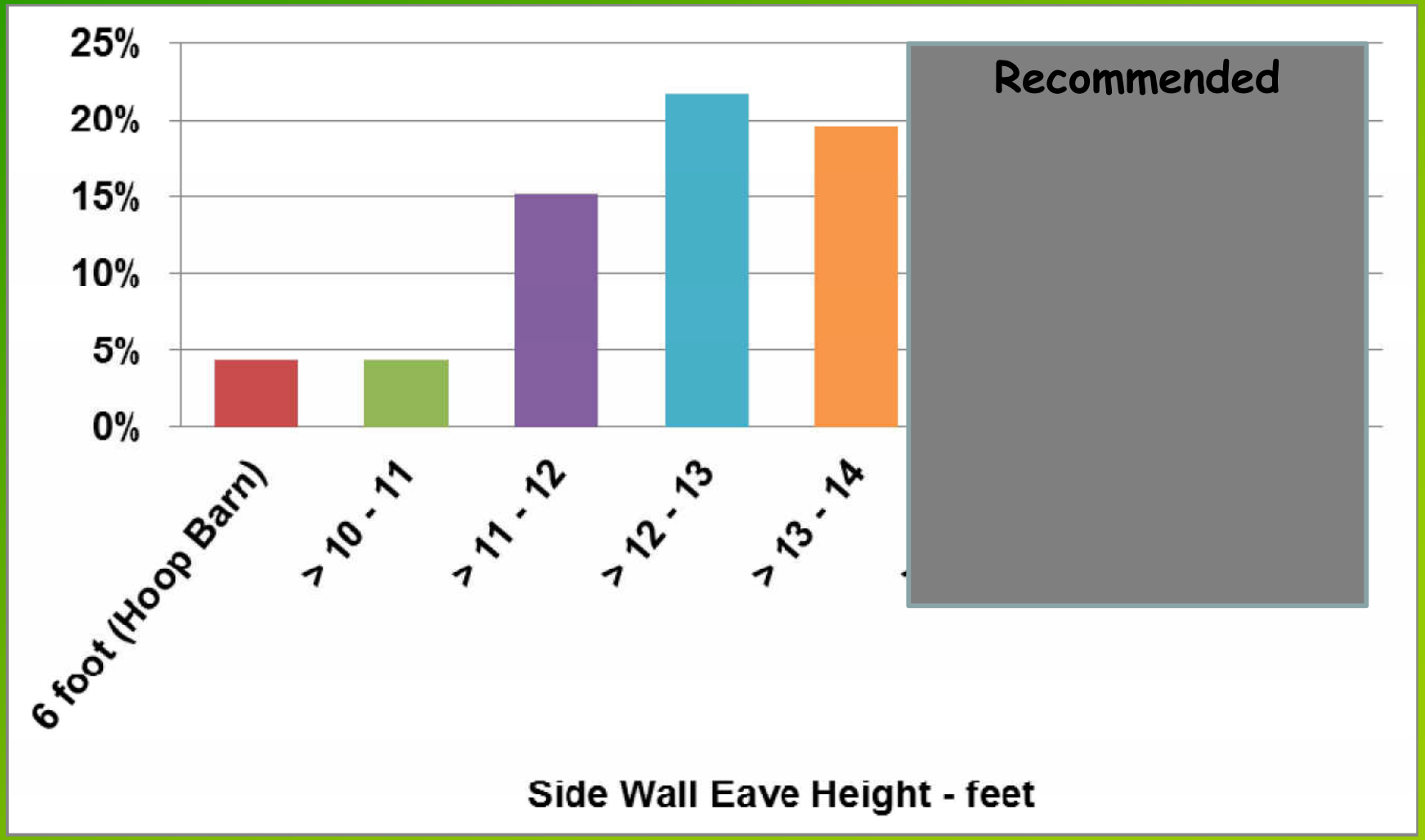
Roof Pitch


55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Recommended
1 1/2:12
2:12
2 1/2:12
3:12
3 1/4:12
3 1/2:12
Hoop

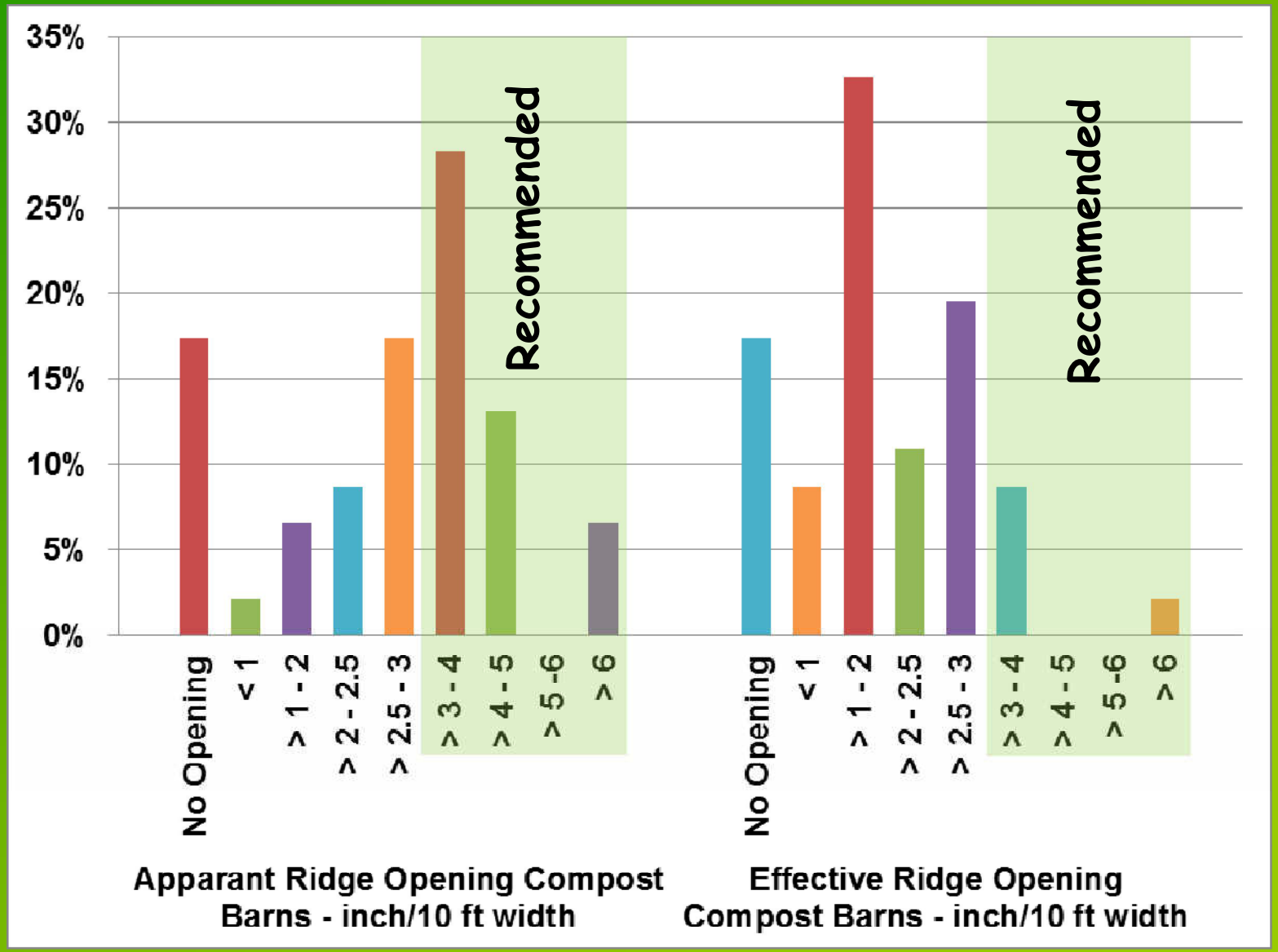
Barn Orientation



Side Wall Eave Height

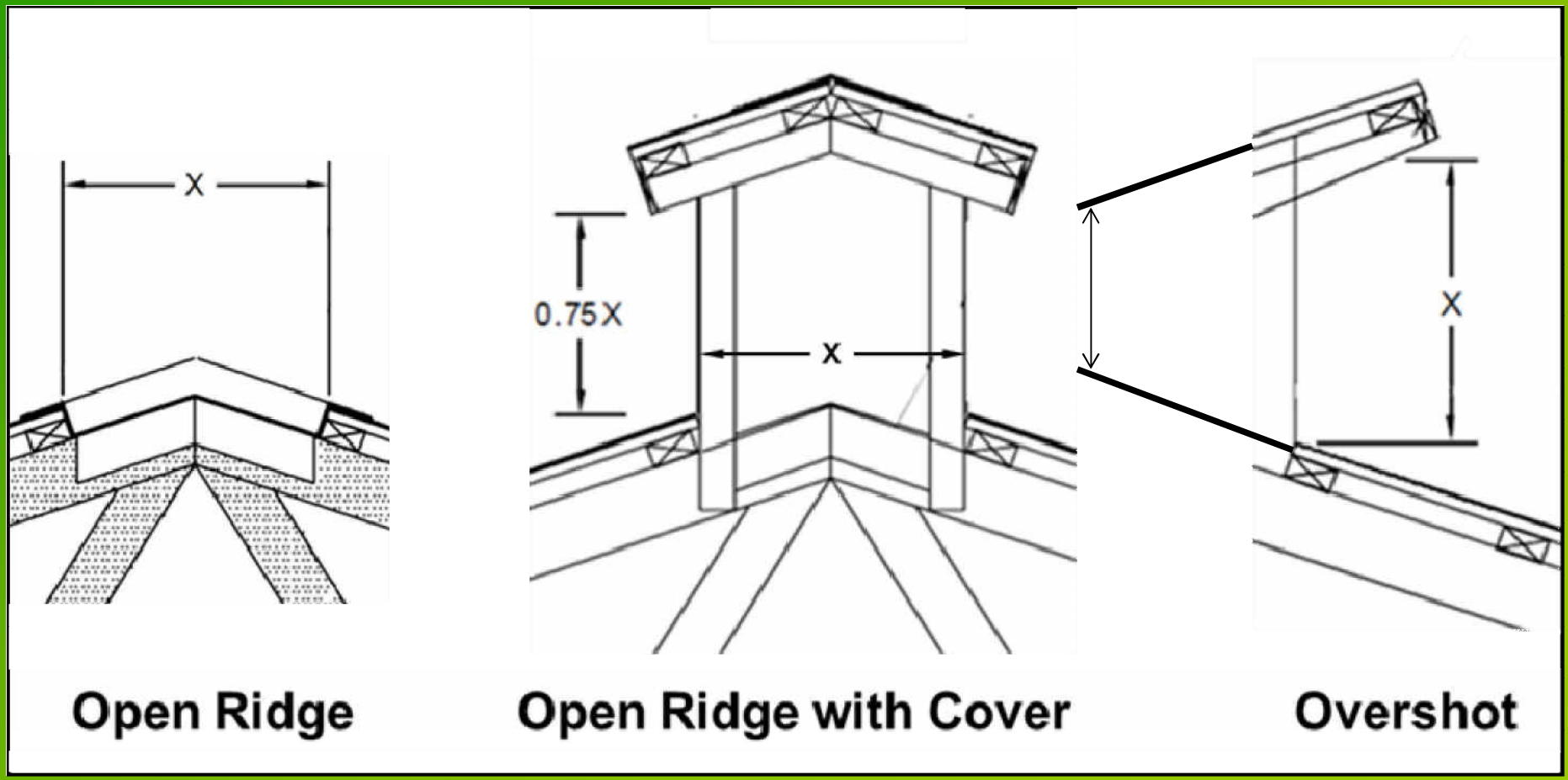


Ridge Opening to Barn Width Ratio



Ridge Opening Detail

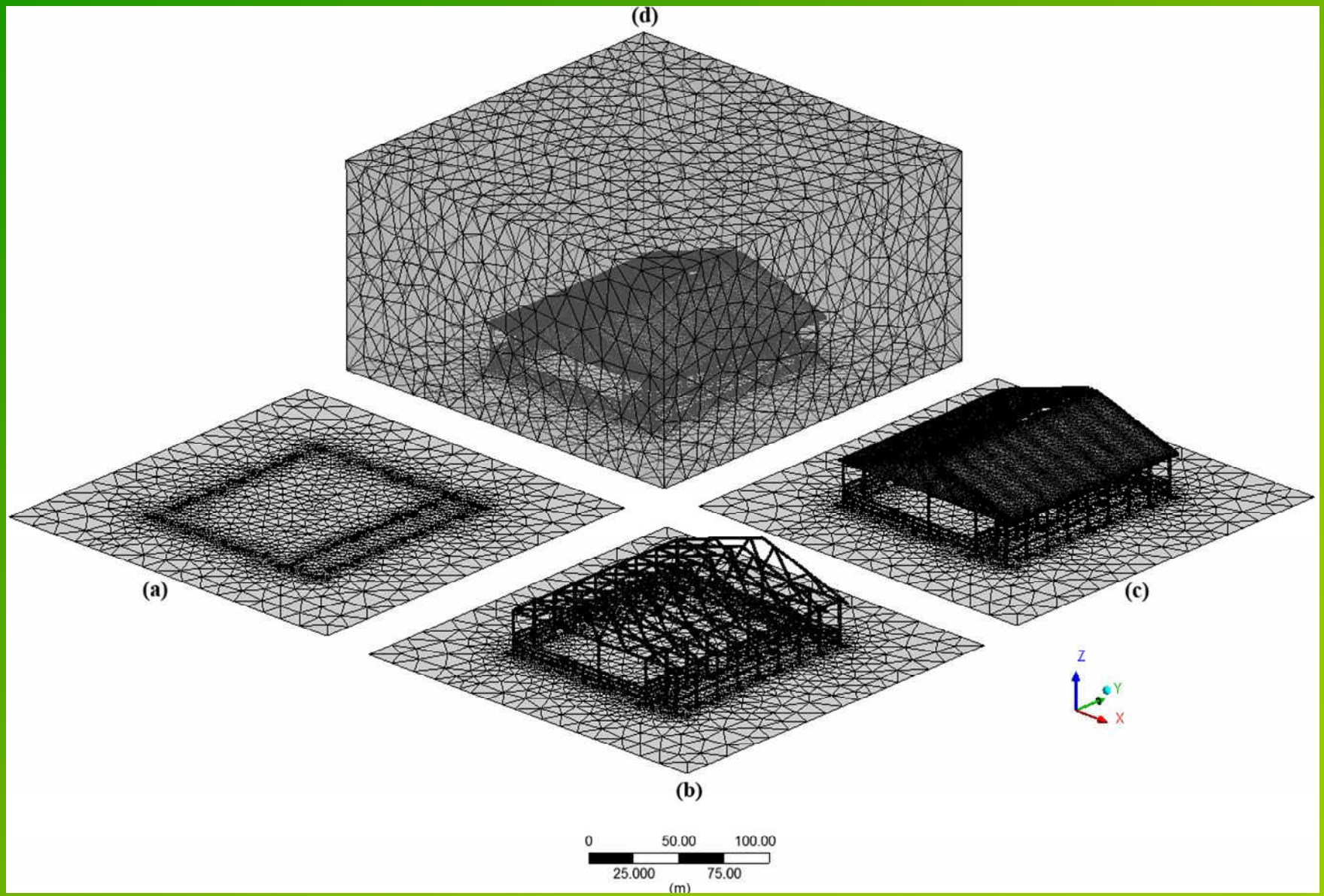
- Apparent vs Effective -



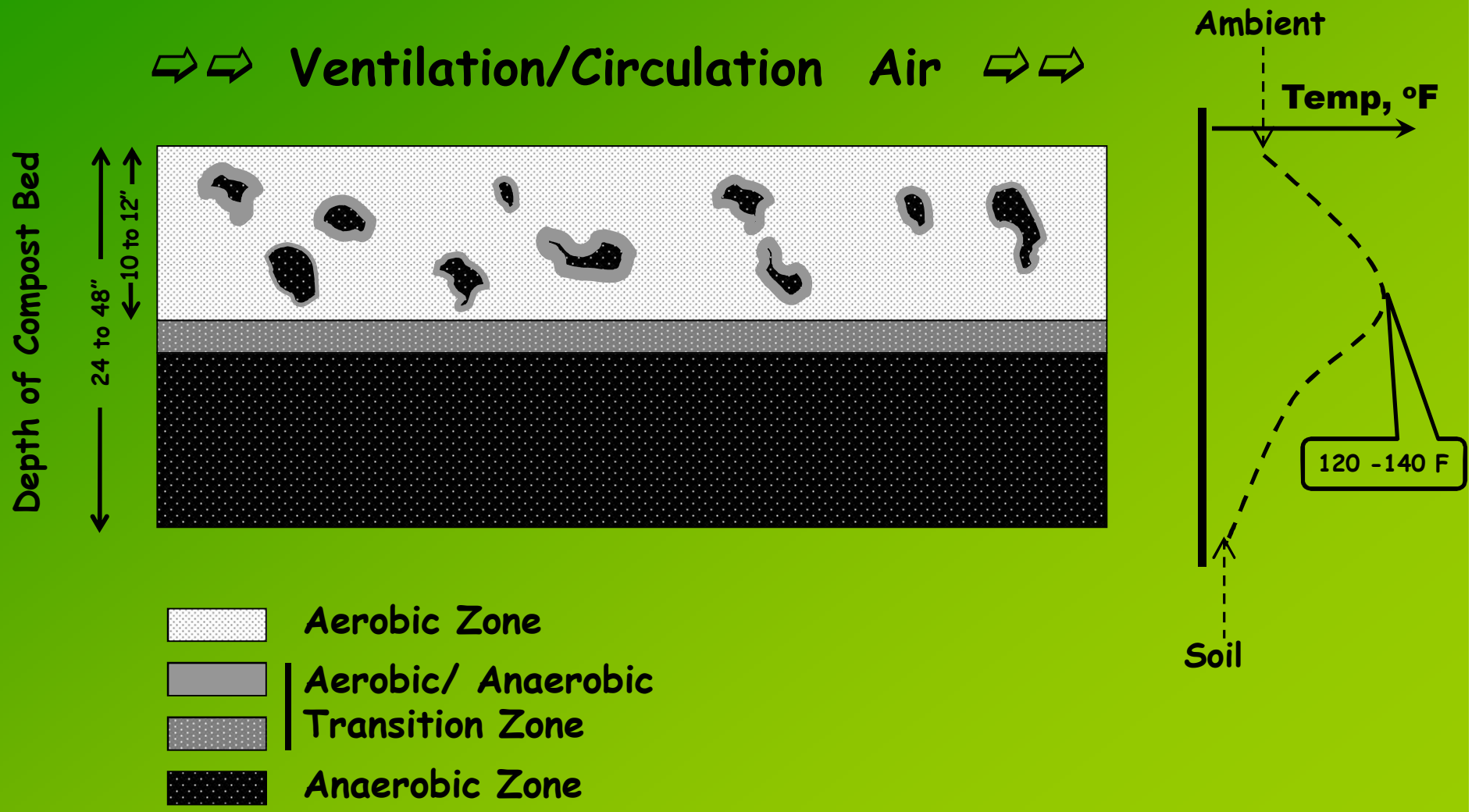
Open Ridge

Open Ridge with Cover

Overshot

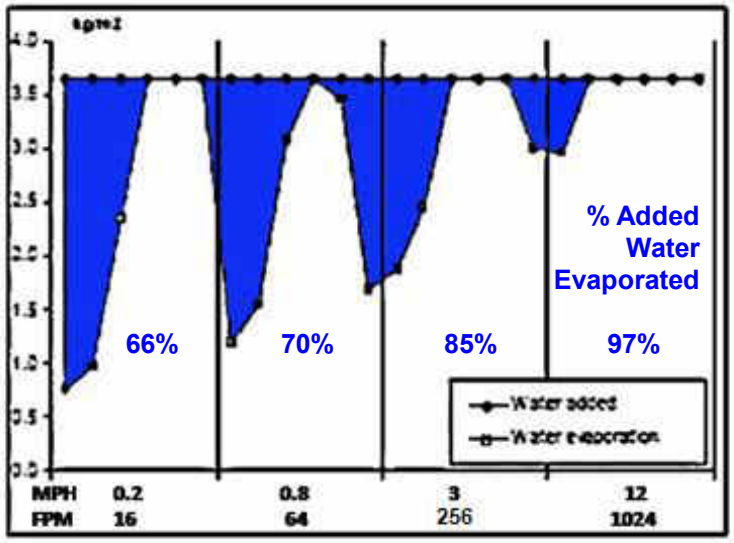

(d)
(a)
(c)
(b)
Z
Y
X
0
50.00
100.00
25.000
75.00
(m)

Compost Bedded Pack



Pack Moisture Control

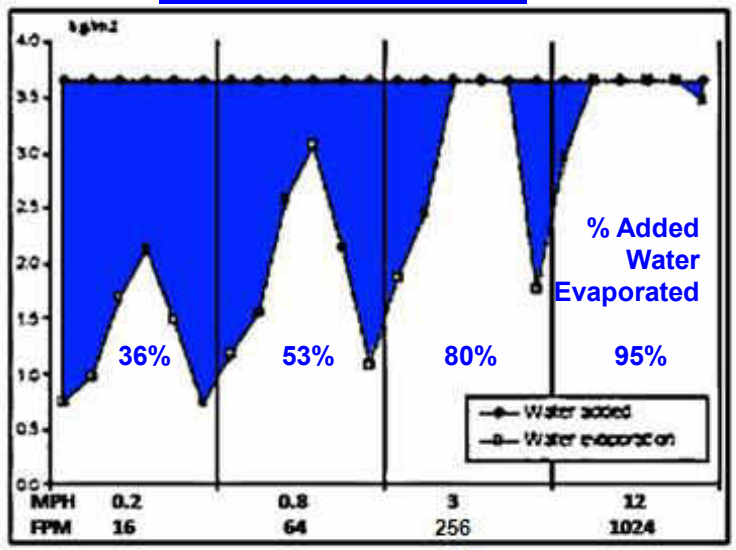
- Biological activity generates heat which helps to dry the bedding material
- Bedding cannot absorb all the water from urine and manure without evaporation of water
- Too wet of a bedded pack reduces aeration, slows biological activity, slow heat generation and water evaporation



Modeled water evaporation (kg/m^2)

Composted Bedded Pack

Water in Bedding



Modeled water evaporation (kg/m^2)

Bedded Pack

COMPOSTING BED MATERIAL INCREASES WATER EVAPORATION

INCREASING AIR VELOCITY OVER BED MATERIAL INCREASES WATER EVAPORATION