Maximizing Welfare and Performance Through Better Barn Design

Nigel B. Cook MRCVS
University of Wisconsin-Madison

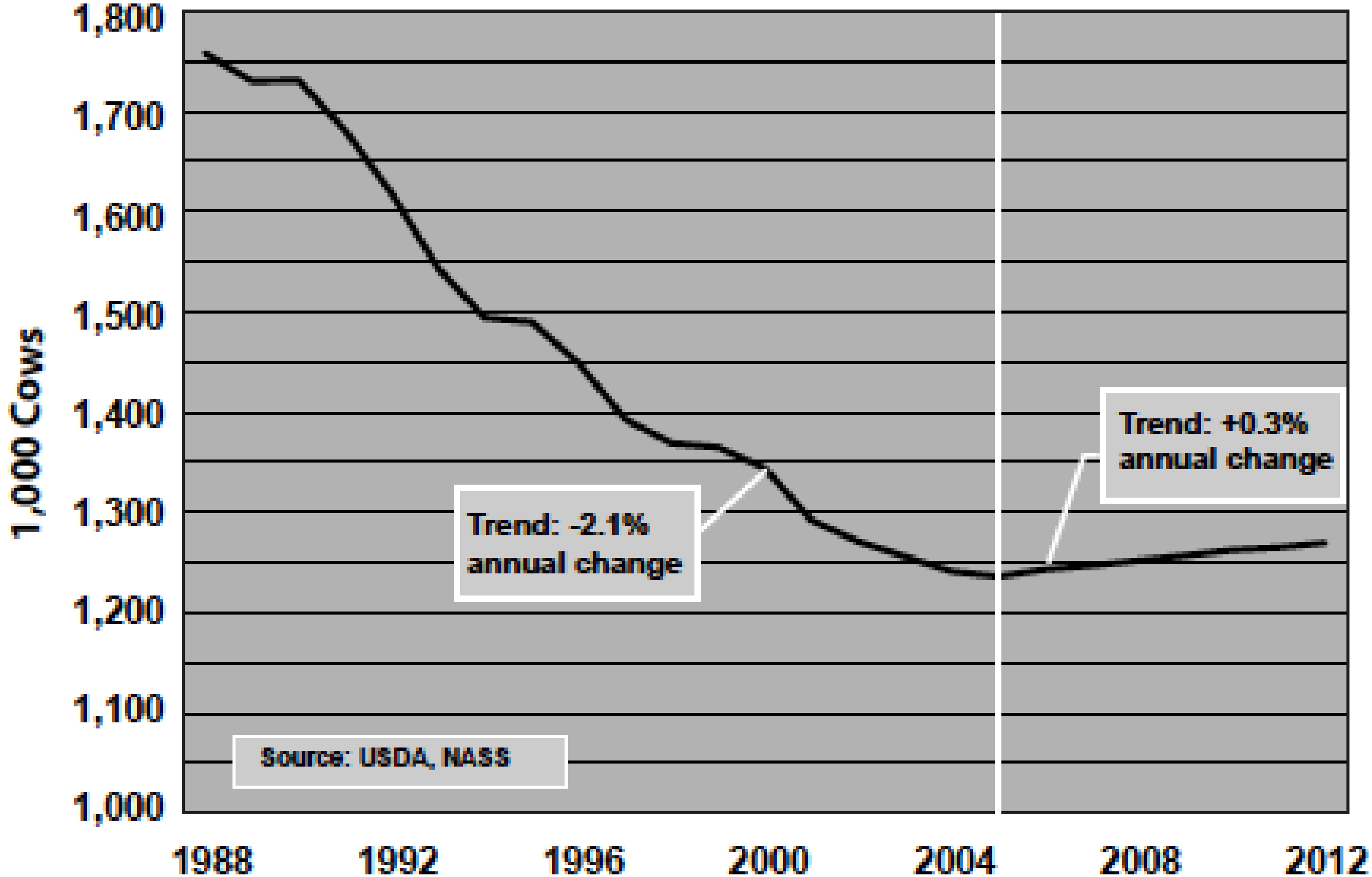
J. Dairy Sci. 99:1–9
http://dx.doi.org/10.3168/jds.2015-9925

Imagining the ideal dairy farm

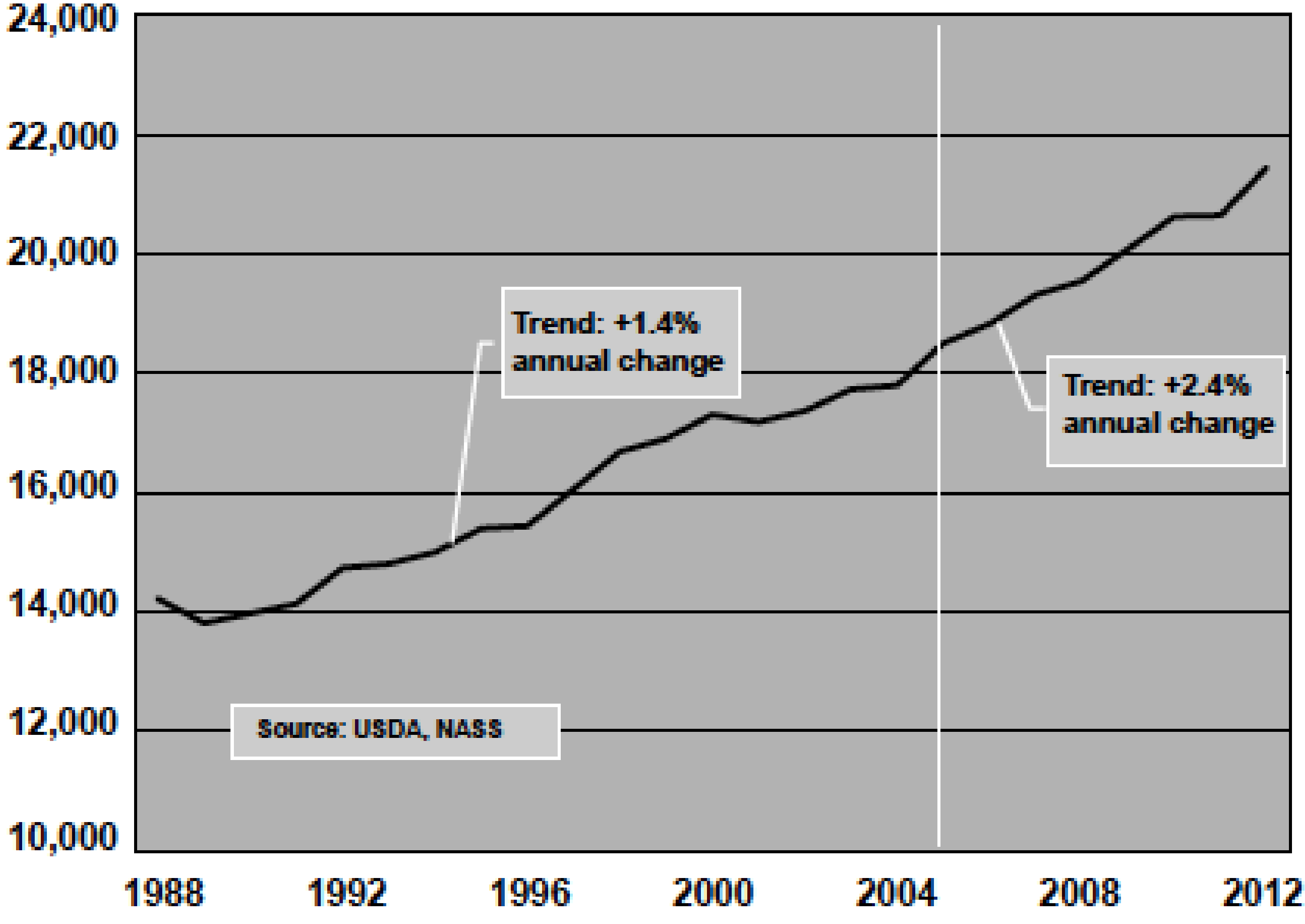
Clarissa S. Cardoso,*† Maria José Hötzel,† Daniel M. Weary,* Jesse A. Robbins,* and Marina A. G. von Keyserlingk*[1]
*Animal Welfare Program, Faculty of Land and Food Systems, The University of British Columbia, Vancouver, V6T 1Z4, Canada
†Laboratório de Etologia Aplicada e Bem-Estar Animal, Departamento de Zootecnia e Desenvolvimento Rural, Universidade Federal de Santa Catarina, Florianópolis, 88.034-001, Brazil

- Humane treatment of cows
- Space to roam – pasture based production
- Fed grass with no unnatural use of steroids, antibiotics or hormones
- Profitable, productive and efficient….and organic
- Eco-friendly and sustainable

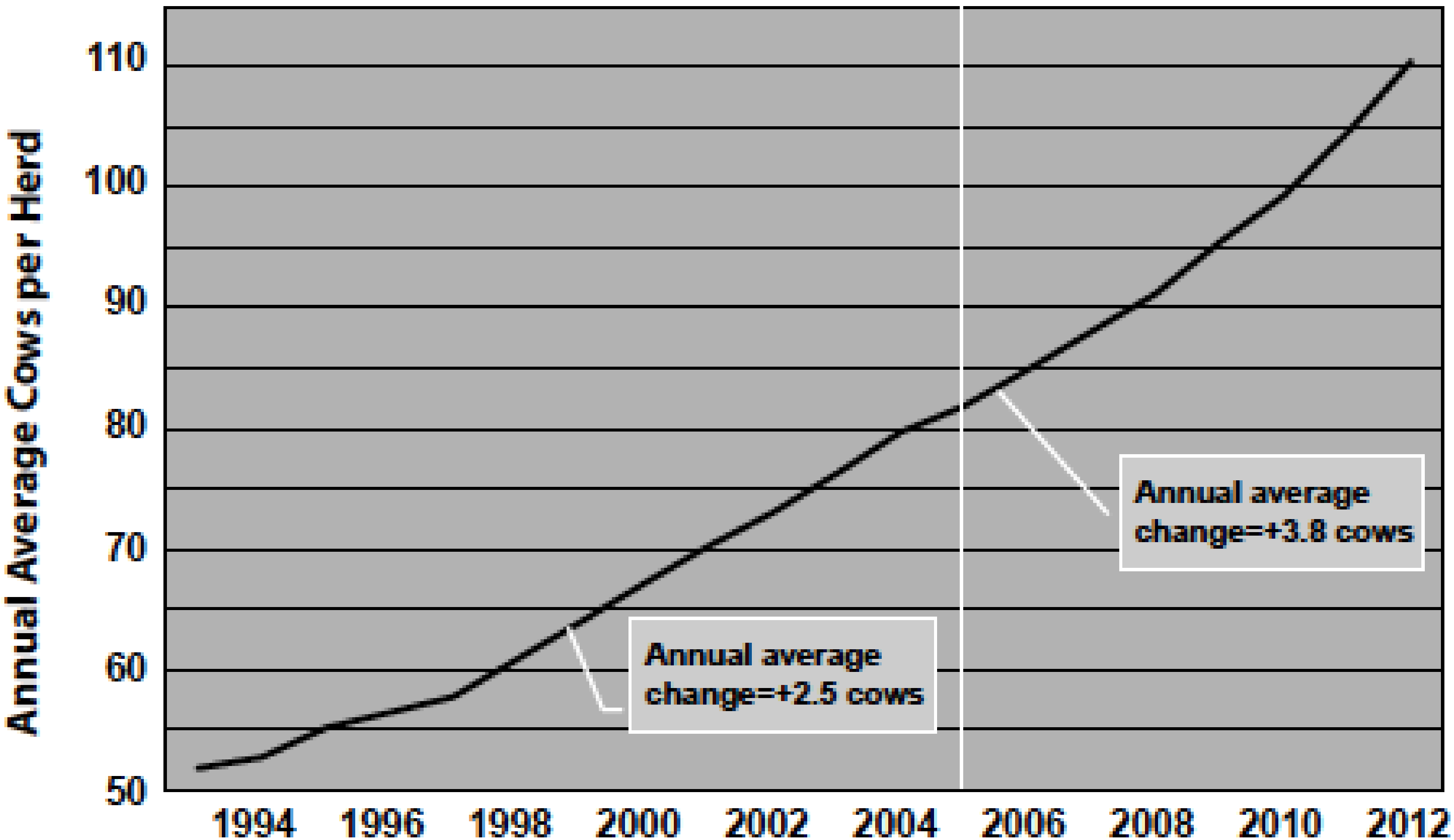
Wisconsin Milk Cows



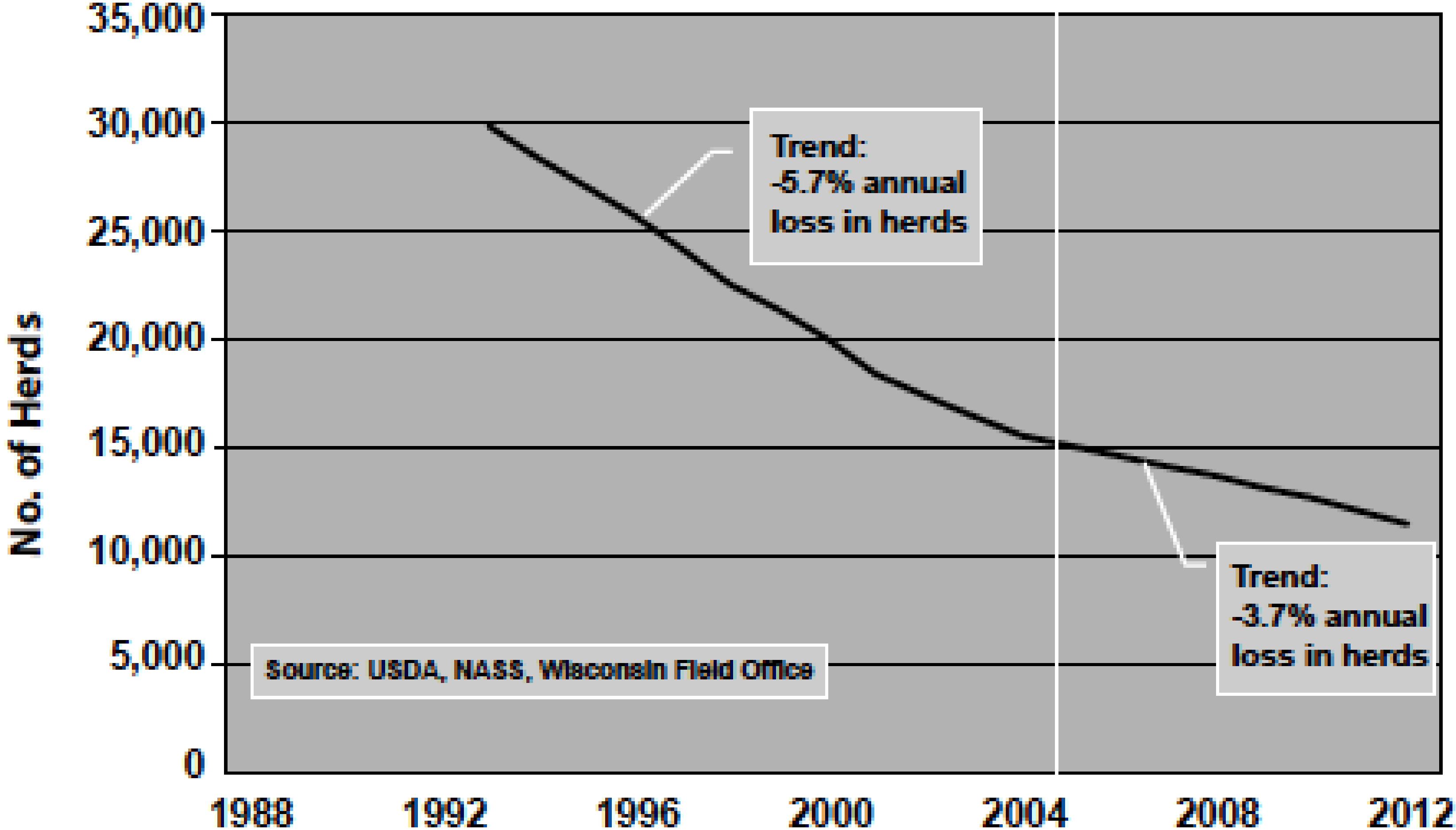
Wisconsin Milk (lb) Per Cow



Wisconsin Average Herd Size



Wisconsin # Dairy Herds



Note: Licensed herd data only available from 1993.
Data prior to August 2003 includes a small number of goat and sheep dairy herds.

The Wisconsin Dairy Industry

- 77% of WI dairy cows are housed in freestalls

Disconnect between consumer preferences and producer actions

FAPM | UW Veterinary Care | UW Home

SCHOOL OF VETERINARY MEDICINE
The Dairyland Initiative
UNIVERSITY OF WISCONSIN - MADISON

School of Veterinary Medicine

BLUEPRINT | VIRTUAL TOURS | TOOLS | PROFESSIONALS | SERVICES | NEWS AND PUBLICATIONS | SUPPORTERS

Welcome

To navigate the site, please click the tabs at the top of the page

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

In the News

Register today for The Dairyland Initiative Workshops Nov. 12, 13 & 14 in La Crosse, WI!

Summer Newsletter

UW–Madison News
Grant Generates Increased Access, Network Training to Dairyland Initiative

Hoard's Dairyman Series:
1. What Every Transition Cow Barn Needs
2. Solve your Transition Housing Puzzle
3. Worth the Investment

What's New?

- **The Dairyland Initiative Workshops** Nov. 12, 13 & 14 in La Crosse, WI. **Online registration**.
- **Robotic Milking Systems** page updated with new information.
- Footbath design **printable handout**.
- Revised **pasture access page**.
- Updated **Barn Improvement Partial Budget Calculator** that estimates feed costs associated with milk yield increases.
- New Blueprint page for **hoof-trimming area** design with a printable handout.
- **Printable handout** for brisket **page**.
- Adult cow freestall dimension
- **Printable handout** for heifer
- **Growing heifer barn** virtual t
- **Holding area positive pressu abatement** virtual tour.
- Virtual tour of a **new breedin**
- Virtual tours of "all-in, all-out **Dairy** and **Larson Acres**.
- **The Consultants page for Su Ventilation system design** in trainees.

In 2010, we made a commitment to improve the facilities we use to house dairy cattle

http://**thedairylandinitiative**.vetmed.wisc.edu

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

The Wisconsin Blueprint Guiding Principles

- Provide a comfortable place to rest that is designed to meet the space requirement of the animal, and not inhibit rising or lying movements.
- Provide enough feed and water space for each animal to optimize health.
- Wherever possible, provide exposure to natural light and ventilation, but utilize mechanical assistance when needed.
- Accommodate cows and calves in groups which are socially stable over time, and manage groups to minimize movements between them.
- Design barn layouts that do not result in undue time away from a place to eat and rest.
- Design facilities to reduce the risk for spread of disease between neighbors.

The Question.

Can we build and manage confinement housed freestall systems that achieve high performance and excellent well-being?

J. Dairy Sci. 98:3059–3070
http://dx.doi.org/10.3168/jds.2014-8369

Cluster analysis of Dairy Herd Improvement data to discover trends in performance characteristics in large Upper Midwest dairy herds

R. L. Brotzman, N. B. Cook, K. Nordlund, T. B. Bennett, A. Gomez Rivas, and D. Döpfer[1]
School of Veterinary Medicine, University of Wisconsin, 2015 Linden Drive, Madison 53706

- AgSource Cooperative Services DHIA served herds, from 3,078 herds in Upper Midwest with complete data, sorted 557 herds >200 cows likely to be freestall housed
- Principal component analysis found 16 DHIA variables that best explained differences between herds and performed cluster analysis
- Herds grouped into one of 6 clusters

Cluster Group DHIA Characteristics

Color variation *(generally)* represents "best" to "worst"

DHI Variable	Group 1 (n = 171)	Group 2 (n = 86)	Group 3 (n = 97)	Group 4 (n = 67)	Group 5 (n = 62)	Group 6 (n = 74)
Herd size, cows, lowest – highest	493^{b}	270^{e}	365^{cd}	270^{de}	403^{bc}	1097^{a}
Milking freq., lowest – highest	3.0^{a}	2.0^{d}	2.9^{a}	2.2^{c}	2.8^{b}	3.0^{a}
% 1st Lactation, lowest – highest	38.4^{b}	38.1^{b}	38.6^{b}	38.0^{b}	37.8^{b}	43.8^{a}
Energy Corrected Milk, kg	41.7^{a}	39.4^{b}	40.0^{ab}	33.9^{d}	36.9^{c}	40.2^{ab}
Days In Milk	182.9^{c}	179.7^{c}	195.5^{a}	189.1^{b}	192.5^{ab}	181.8^{c}
Days Dry	59.4^{ab}	59.4^{ab}	54.7^{c}	60.7^{a}	60.8^{a}	57.0^{bc}
Age at 1st Calving	24.1^{d}	24.5^{dc}	25.3^{ab}	25.6^{a}	24.9^{bc}	23.4^{e}
Transition Cow Index, kg	207.8^{a}	236.1^{a}	-10.9^{b}	-171.8^{c}	-212.9^{c}	-13.9^{b}
Milk Peak Ratio	74.4^{c}	74.1^{c}	77.8^{a}	77.6^{a}	76.4^{ab}	74.9^{bc}
Linear Somatic Cell Score	2.2^{d}	2.3^{d}	2.6^{c}	3.0^{a}	2.8^{b}	2.7^{c}
% New Udder Infections	8.7^{c}	8.9^{c}	11.9^{b}	14.7^{a}	13.9^{a}	12.6^{b}
% Udder Infections 1st test	11.0^{e}	13.7^{d}	15.7^{c}	19.9^{a}	17.8^{b}	14.5^{cd}
% Dry Period Infection Cures	75.5^{a}	66.4^{b}	63.9^{b}	56.5^{c}	63.7^{b}	71.5^{a}
% Culled, Non-dairy, lowest - highest	33.5^{b}	36.1^{b}	35.9^{b}	32.6^{b}	40.0^{a}	43.0^{a}
% Cows Died	5.7^{cd}	5.7^{cd}	6.3^{bc}	4.9^{d}	12.4^{a}	7.6^{b}
% Cows Died by 60 DIM	2.3^{bc}	2.7^{b}	2.4^{bc}	1.8^{c}	5.7^{a}	2.7^{b}

J. Dairy Sci. 98:8245–8261
http://dx.doi.org/10.3168/jds.2014-9264

Survey of facility and management characteristics of large, Upper Midwest dairy herds clustered by Dairy Herd Improvement records

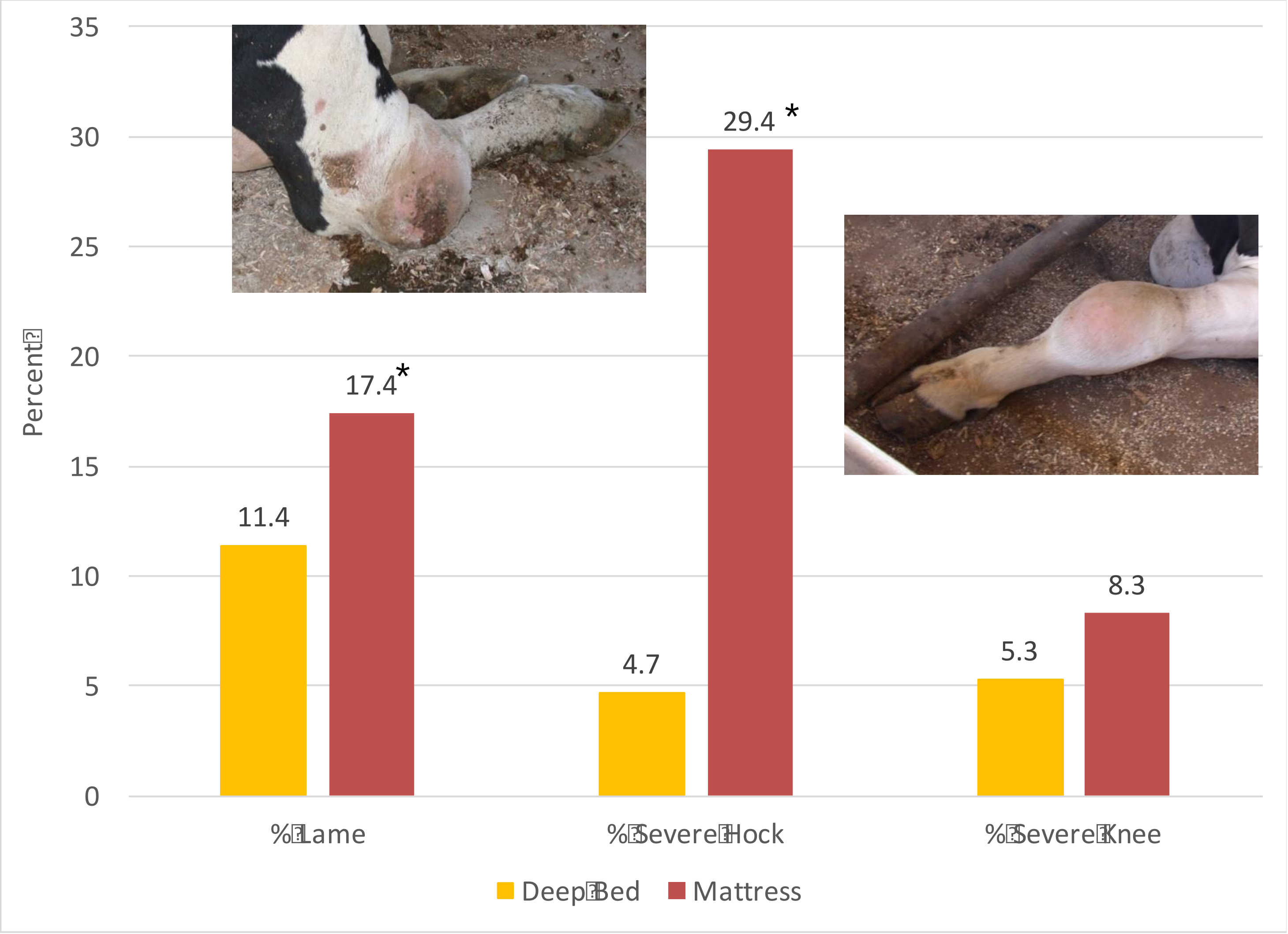
R. L. Brotzman, D. Döpfer, M. R. Foy, J. P. Hess, K. V. Nordlund, T. B. Bennett, and N. B. Cook[1]
School of Veterinary Medicine, University of Wisconsin, 2015 Linden Drive, Madison 53706

- Herds grouped into one of 6 clusters
- Telephone survey all 557 herds (201 responses) – facility and management
- Visited 22 herds in each of clusters 1, 2 and 6 (66 total) – physical well-being

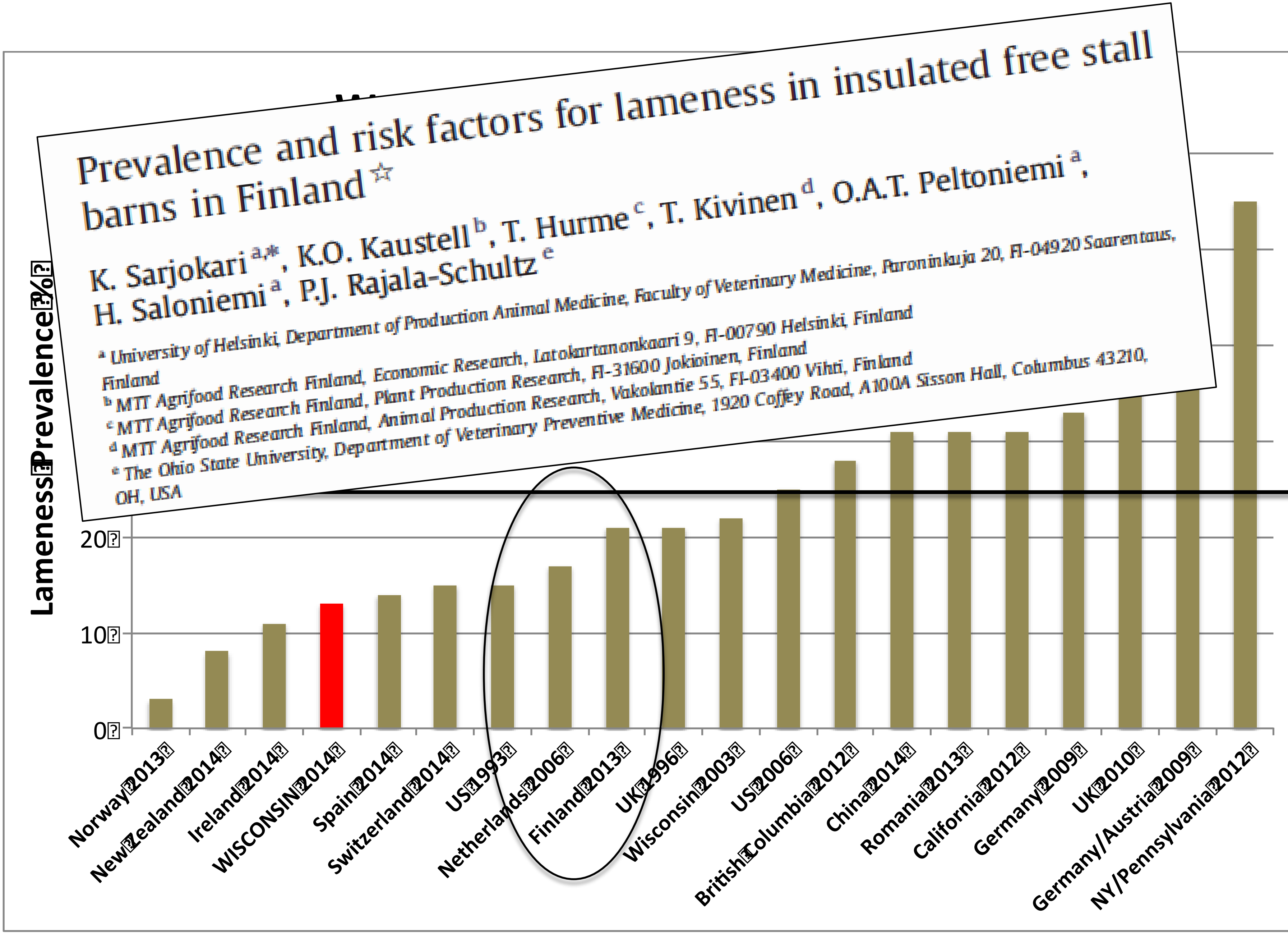
Cluster Group Survey Questions

Characteristic	*1*	*2*	*3*	*4*	*5*	*6*	*ALL*
Energy Corrected Milk (lb per cow)	*42*	*40*	*40*	*34*	*37*	*40*	
% sand	68	61	63	65	52	69	64
% mattress	29	36	37	35	39	22	32
% 2-row pens	48	70	56	26	45	38	48
% headlocks	73	67	74	70	56	75	70
% feeding 2 dry cow rations	70	55	52	48	61	78	63
% just-in-time calving	57	39	48	43	35	88	54
% dedicated 1st lactation heifer pen	84	48	74	61	70	97	75
% use custom heifer rearer	49	24	30	13	30	78	41
% trim cows at least 2 x per lactation	68	33	44	30	52	53	50
% trim heifers before calving	51	30	33	17	30	53	39
% using a synch program 1st breeding	87	61	59	39	69	94	73
% rBST	73	33	70	26	61	84	61
% Monensin	89	78	78	64	91	84	82
# cows per FTE	48	55	48	56	48	63	50
N=	63	33	27	23	23	32	201

Physical Well-being



Visited 22 herds in each of clusters 1, 2 and 6 – 'Elite' group of 66 herds



Prevalence and risk factors for lameness in insulated free stall barns in Finland ☆
K. Sarjokari [a,*], K.O. Kaustell [b], T. Hurme [c], T. Kivinen [d], O.A.T. Peltoniemi [a], H. Saloniemi [a], P.J. Rajala-Schultz [e]
[a] University of Helsinki, Department of Production Animal Medicine, Faculty of Veterinary Medicine, Paroninkuja 20, FI-04920 Saarentaus, Finland
[b] MTT Agrifood Research Finland, Economic Research, Latokartanonkaari 9, FI-00790 Helsinki, Finland
[c] MTT Agrifood Research Finland, Plant Production Research, FI-31600 Jokioinen, Finland
[d] MTT Agrifood Research Finland, Animal Production Research, Vakolantie 55, FI-03400 Vihti, Finland
[e] The Ohio State University, Department of Veterinary Preventive Medicine, 1920 Coffey Road, A100A Sisson Hall, Columbus 43210, OH, USA
Lameness Prevalence %
0
10
20
Norway 2013
New Zealand 2014
Ireland 2014
WISCONSIN 2014
Spain 2014
Switzerland 2014
US 1993
Netherlands 2006
Finland 2013
UK 1996
Wisconsin 2003
US 2006
British Columbia 2012
China 2014
Romania 2013
California 2012
Germany 2009
UK 2010
Germany/Austria 2009
NY/Pennsylvania 2012

Lameness In 87 Finnish Dairy Herds

(Sarjokari et al., Livestock Science 156:44, 2013)

- Mean herd size 49 cows, production 8,984 kg
- Freestall housed, traditional milking parlors
- 23% herd lame on average, but lower if:
  - Divided feed barrier vs post and rail
  - Wider feed alleys
  - Alleys less slippery
  - Cleaner alleys
  - Softer stalls
  - Correctly located neck and front rails

Multi-variate Model: Lameness

- Mixed Model to explain clinical lameness using 27 variables after univariate screening at P>0.2, with group as a random effect
- Significant factors at P<0.05 in final model:
  - Stall Surface (deep bed 7.2% vs. mat 14.1%)
  - Pasture Access (yes 5.9% vs. no 15.4%)
  - Cows per FTE (benefit of fewer cows per FTE)

22 herds in each of clusters 1, 2 and 6 – 'Elite' group of 66 herds

Topics

- Stalls
- Floors
- Transition
- Cooling and Ventilation

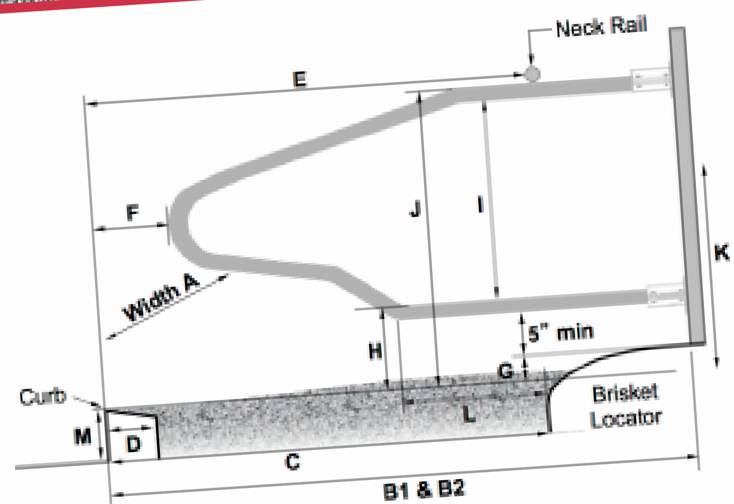
Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

Topics

- Stalls
- Floors
- Transition
- Cooling and Ventilation

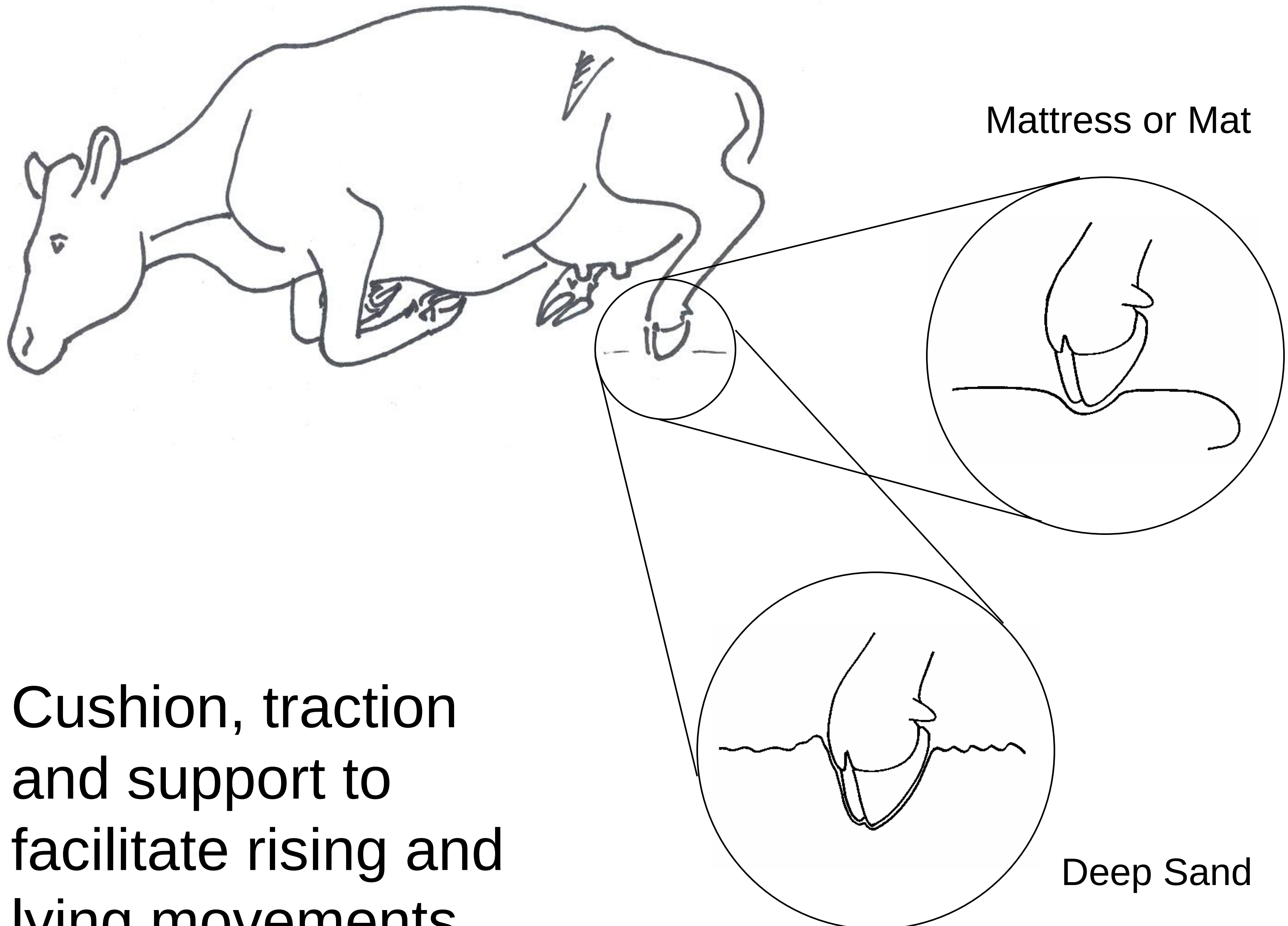
Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

Adult Cow Freestall Dimensions



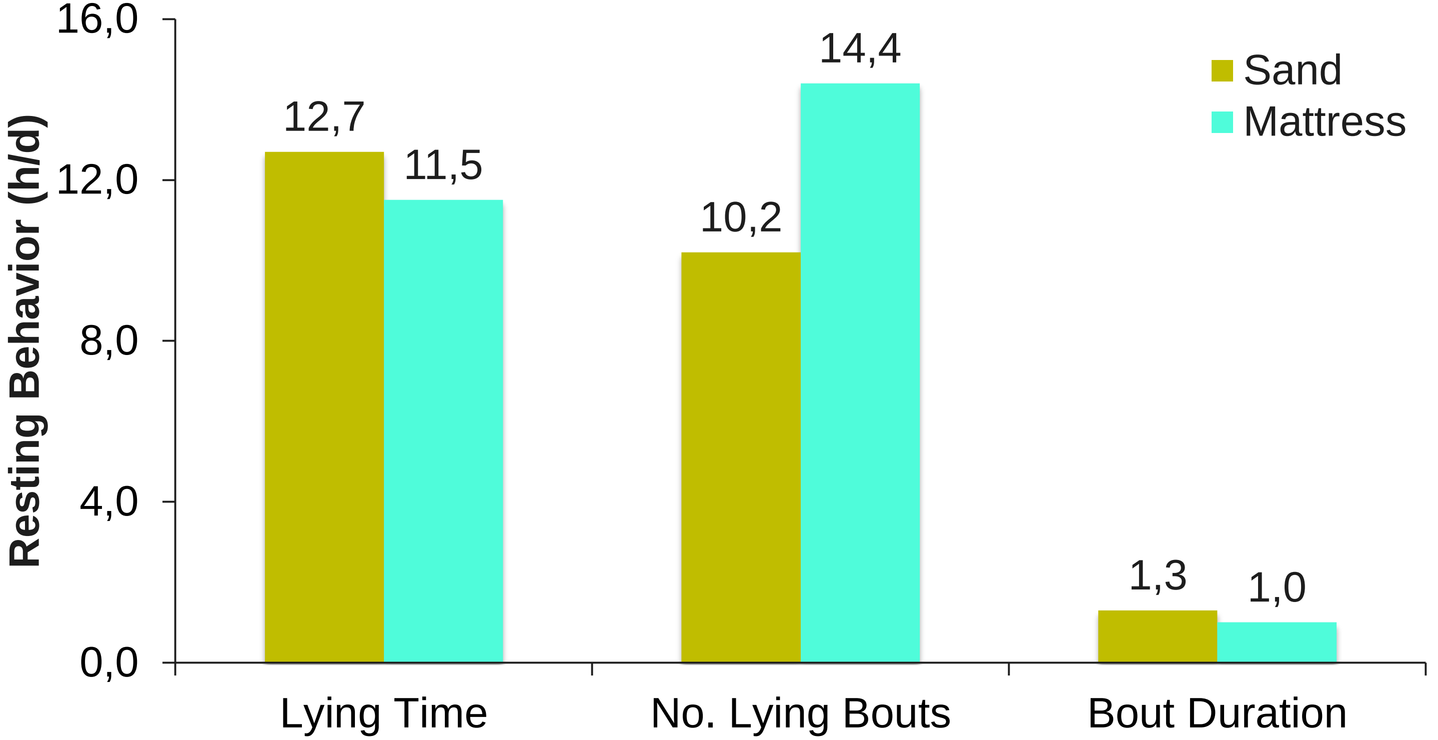
Stall Dimension (inches)	Body Weight Estimate (lbs)					
	1000	1200	1400	1600	1800	2000
Center-to-center stall divider placement (stall width) (A)	42	45	48	50	54	57
Total stall length facing a wall (B1)	96	108	108	120	120	126
Outside curb to outside curb distance for head-to-head platform (B2)	180	192	192	204	204	216
Distance from rear curb to rear of brisket locator (C)	64	66	68	70	72	75
Width of rear curb (D)	6-8	6-8	6-8	6-8	6-8	6-8
Horizontal distance between rear edge of neck rail and rear edge of curb for mattress stalls (E)	64	66	68	70	72	75
Horizontal distance between rear edge of neck rail and rear edge of curb for *deep bedded stalls* (E)*	58	60	62	64	66	69
Distance from rear edge of divider loop to point of curb (F)	9	9	9	9	9	9
Height of brisket locator above top of curb (loose bedded stall or mat/mattress surface) (G)	3	3	4	4	4	4
Height of upper edge of bottom stall divider rail above top of curb (loose bedded stall or mat/mattress surface) (H)	10	10	12	12	13	14
Interior diameter of the stall divider loop (I)	30	33	33	36	36	36
Height of neck rail above top of curb (loose bedded stall or mat/mattress surface) (J)	42	45	48	50	52	54
Obstruction height (K)	5-35	5-35	5-35	5-35	5-35	5-35
Horizontal distance from brisket locator to loop angle (L)	20-22	20-22	20-22	20-22	20-22	20-22
Rear curb height (M)	8	8	8	8	8	8

At http://thedairylandinitiative.vetmed.wisc.edu



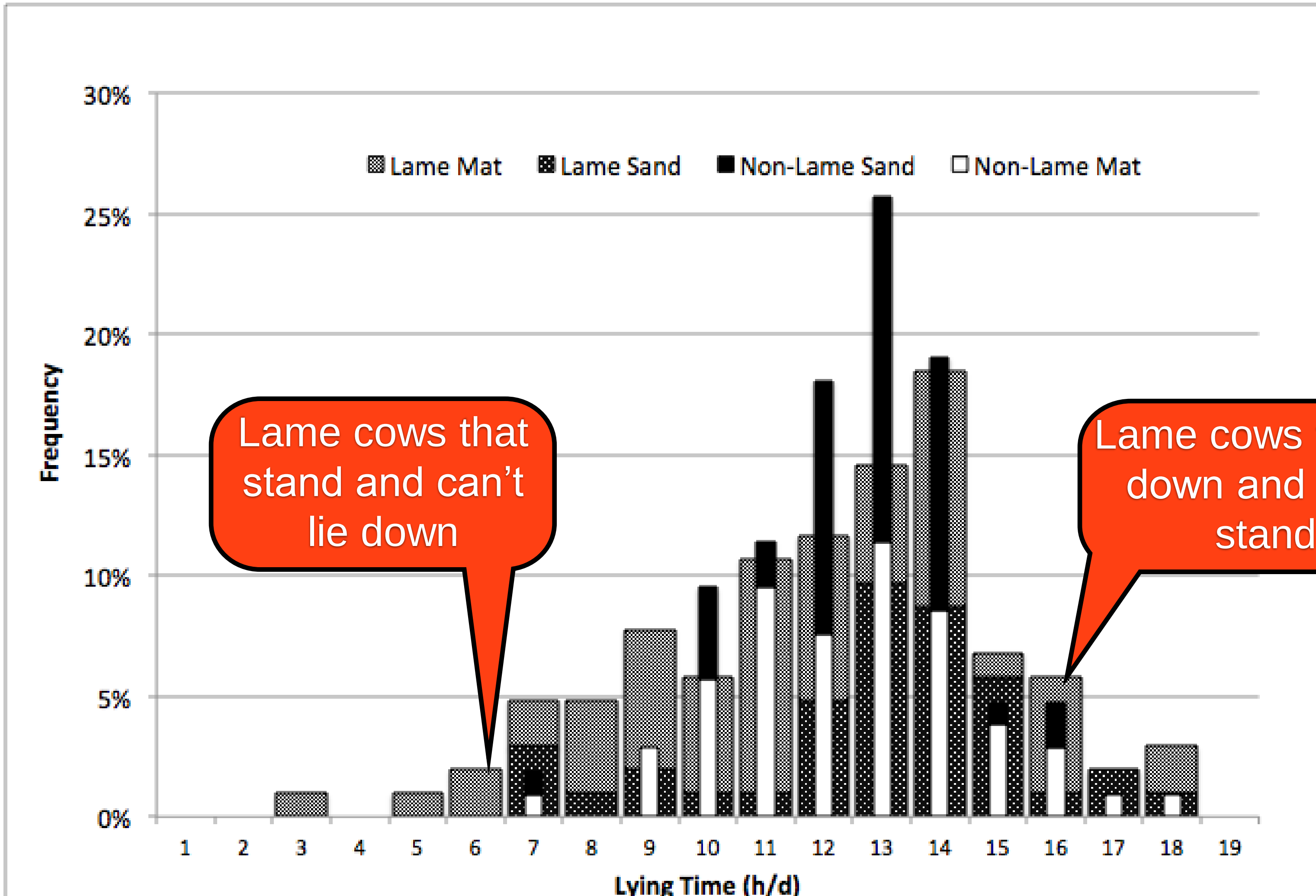
Cushion, traction and support to facilitate rising and lying movements

Sand promotes fewer, longer lying bouts



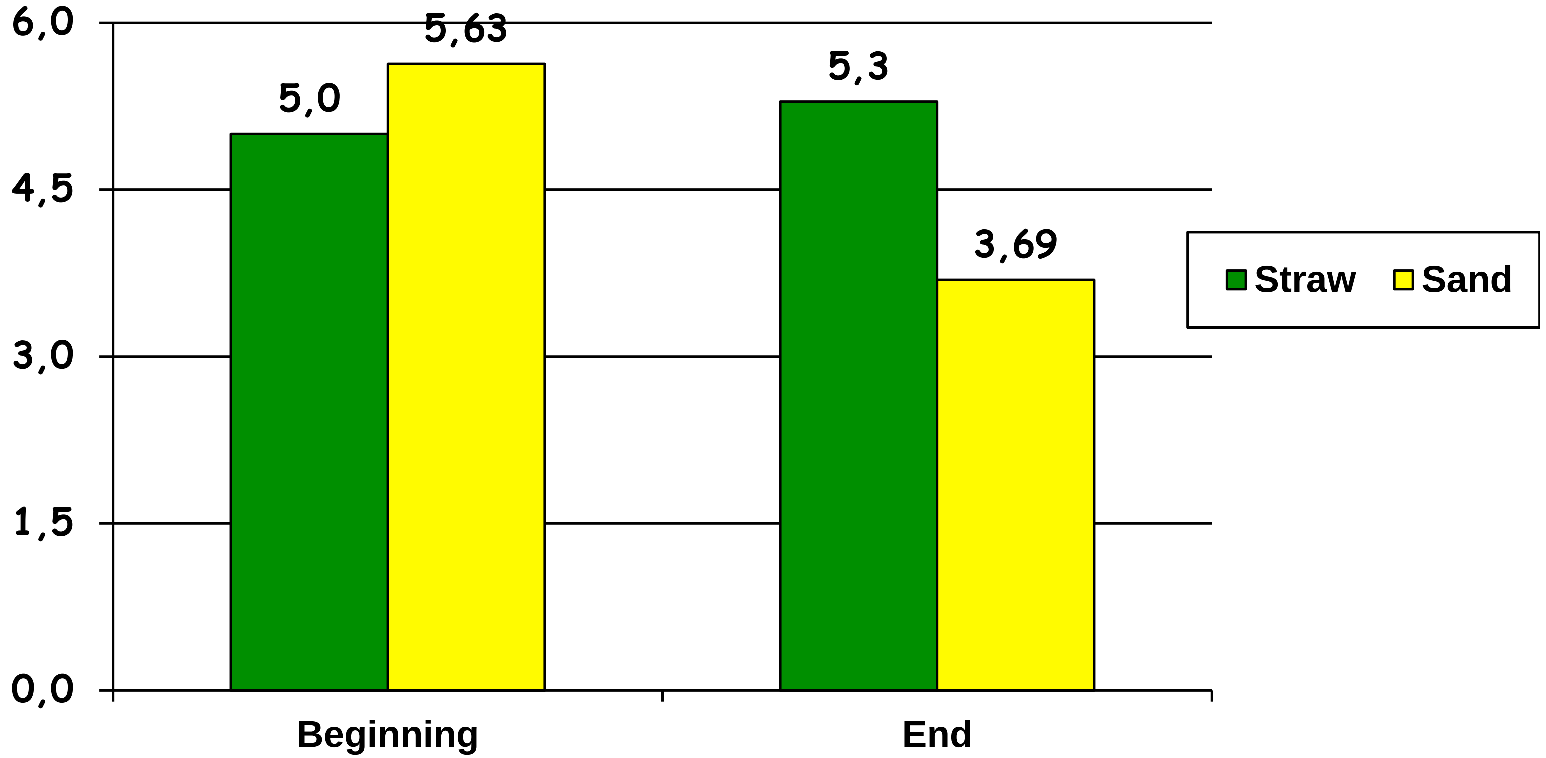
Data from 205 cows in 16 freestall barns from Gomez and Cook JDS 93:5772, 2010

Sand promotes normalized resting behavior



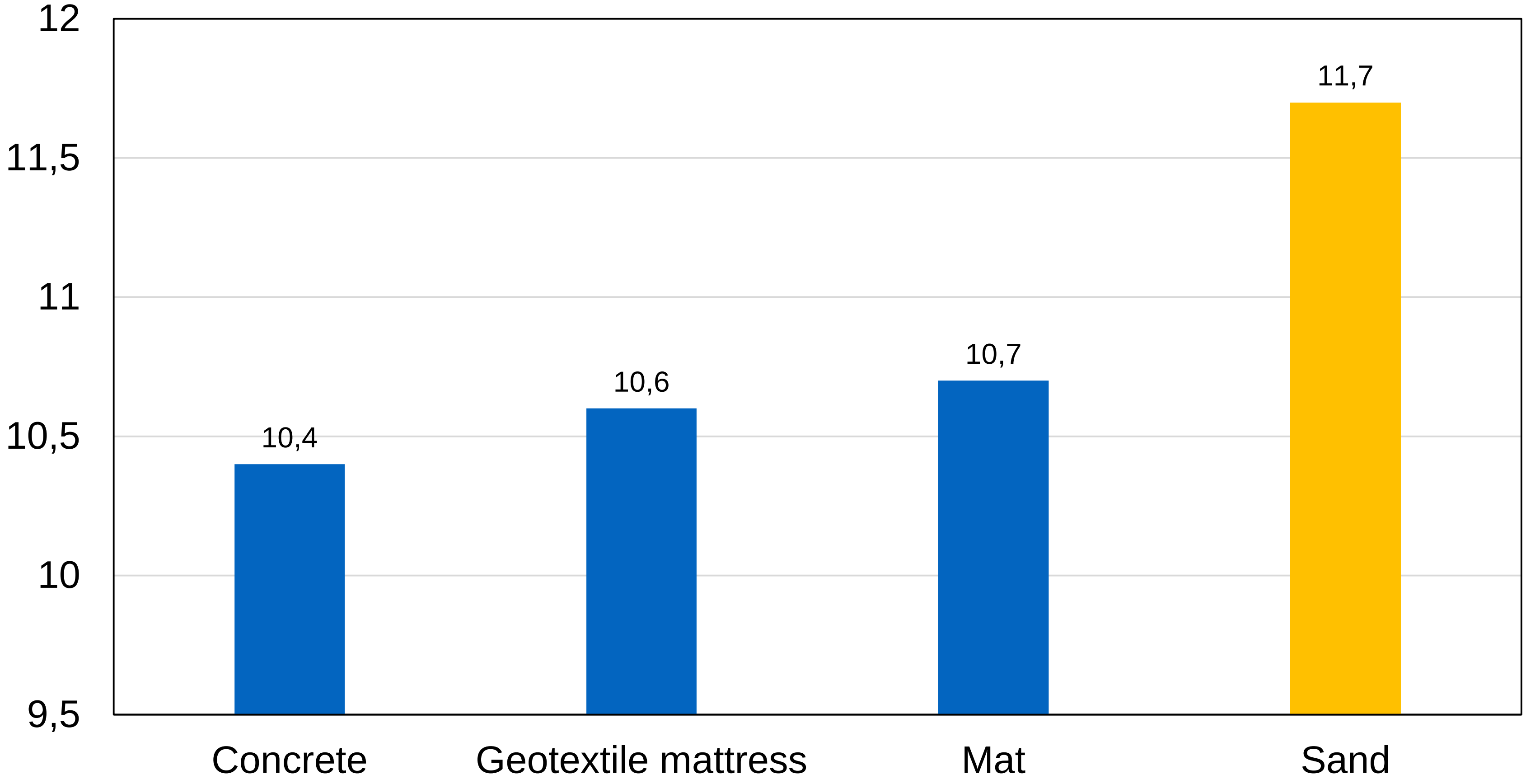
Change in Hoof Lesion Score (0-8) after 21 weeks on either sand or straw bedded freestalls

Norring et al., J Dairy Sci 91:570, 2008

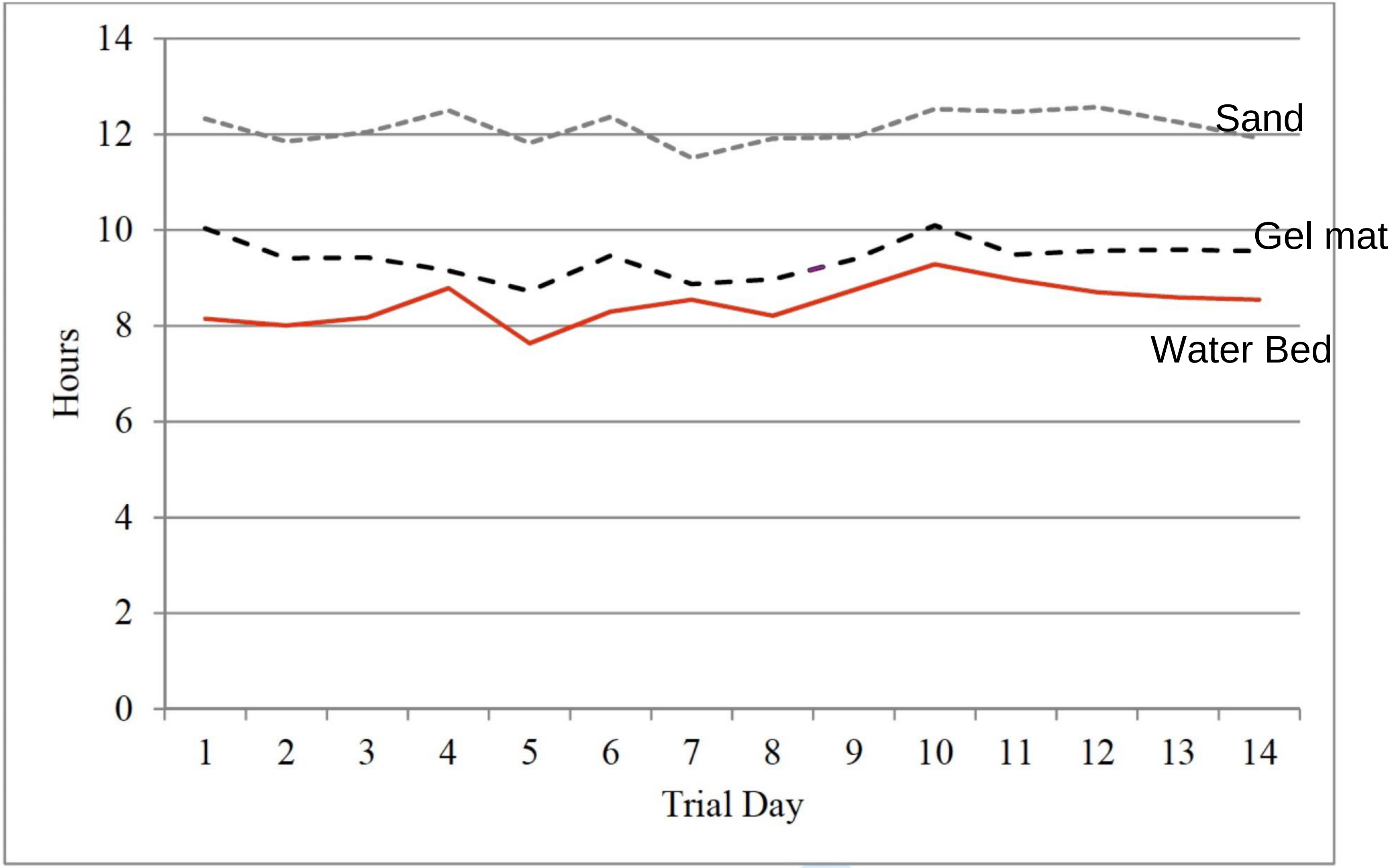


Bed Surfaces and Lying Time

(Solano et al., 2015 141 farms in Alberta, Ontario and Quebec)



Lying Times and Surface Types



Unpublished data University of Florida – 14d preference test

Wisconsin Dairy Industry – Bedding!

	Inorganic (Sand)	Manure Solids	Organic
N =	156 (60%)	29 (9%)	62 (19%)
RHA Milk kg (lb)	12,870 (28,314)	11,779 (25,913)	12,025 (26,455)
SCC ('000/ml)	198	248	220

Rowbotham and Ruegg, JDS 98:1-21, 2015 WI herds shipping more than 25,000lb per day

The Sand/Mattress Difference

Data From 176 DHIA recorded Wisconsin Dairy Herds >200 cows

Mean (SD)	***Sand Herds n=117***	***Mattress Herds n=59***	***Sand Benefit***
Rolling Herd Average Milk (lb)	27,234 (2,777)	24,695 (2,855)	+2,539 (1,154 kg)
Energy Corrected Milk (lb per cow)	91 (9)	84 (9)	+7 (3.2 kg)
Transition Cow Index (lb)	+263 (843)	-58 (766)	321
Somatic Cell Count (‘000/ml)	214 (71)	227 (68)	-13
Turnover Rate (%)	36 (8)	38 (7)	-2

Sand Stall Options

- No recycle
  - Pack Mat™: saves 50% of sand (estimate ~ 20 lb (9 kg) sand per stall per day)
    - Concrete floor lagoon
    - Agitate and pump

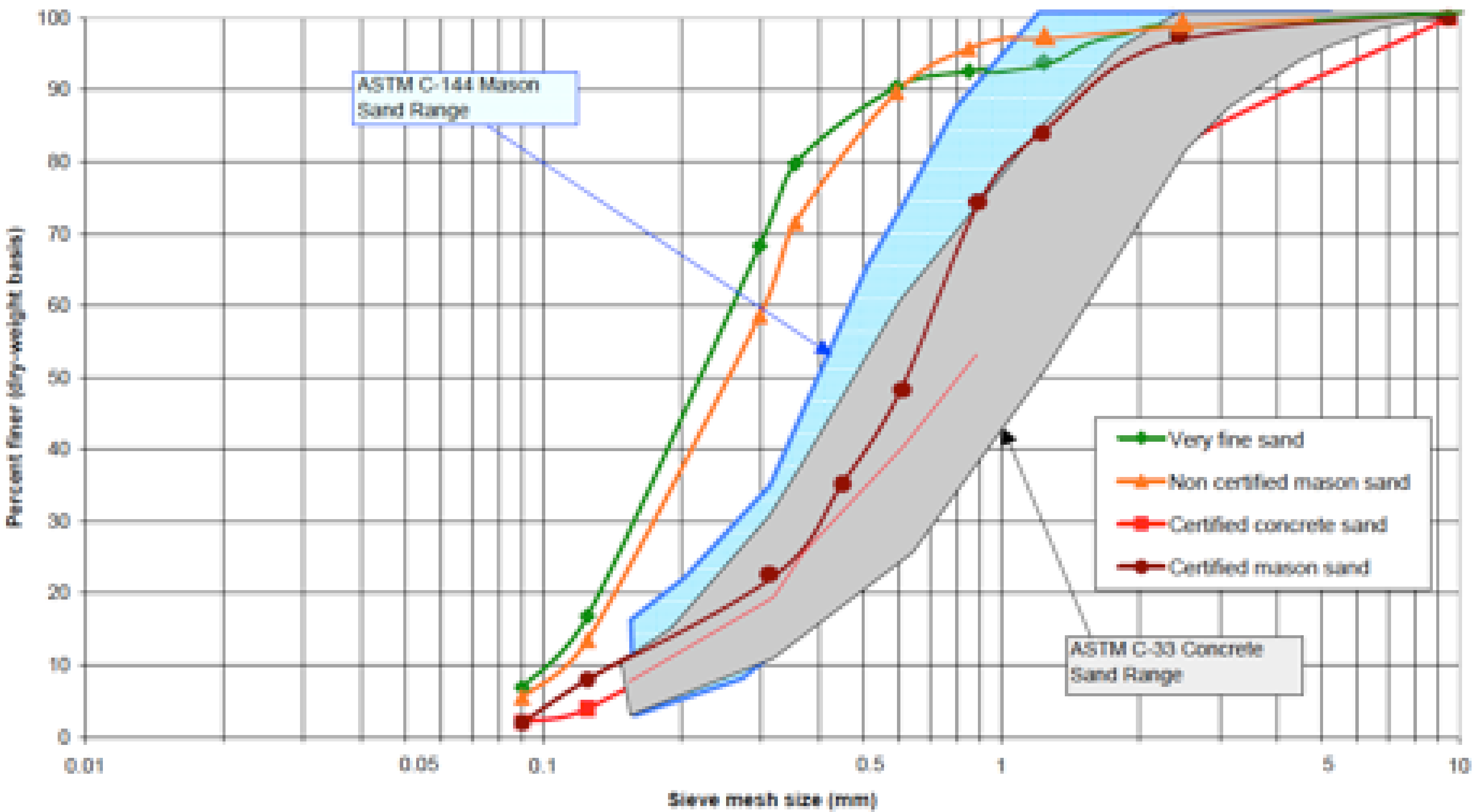
Sand Stall Options

- No recycle
  - Pack Mat™: saves 50% of sand (estimate ~ 20 lb sand per stall per day)
    - Concrete floor lagoon
    - Agitate and pump
- Recycle Sand
  - Settling lanes
  - Mechanical separation

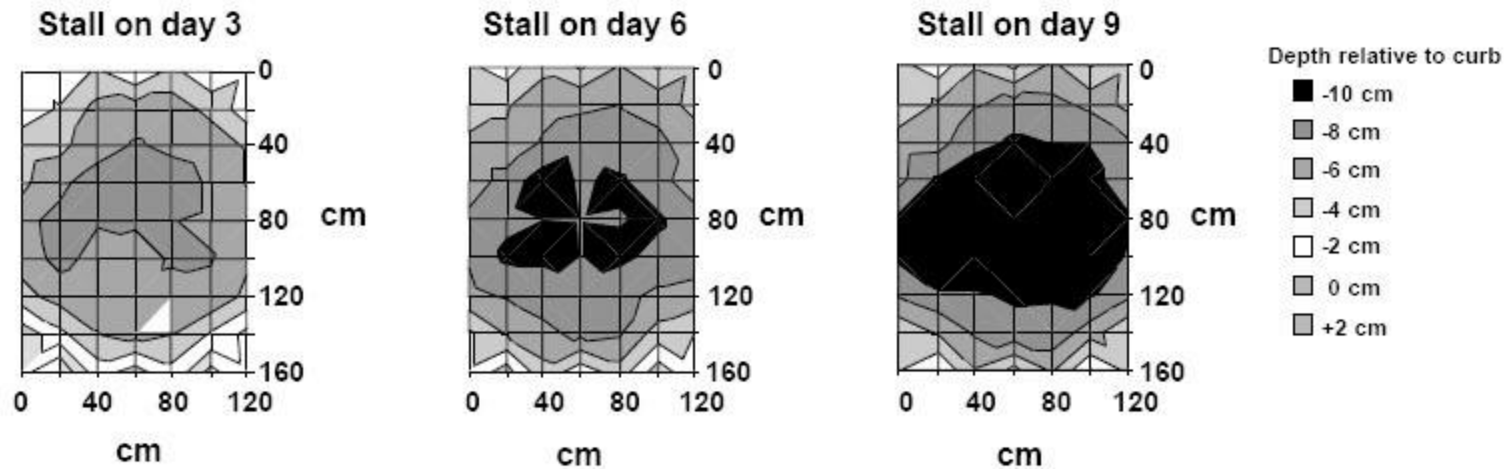
Settling Lanes


Mechanical Systems

Sieve Analysis

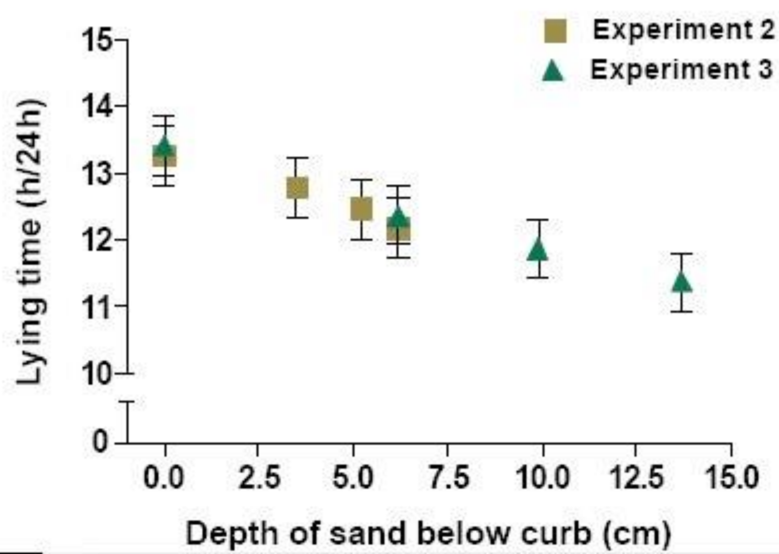


Experiment 1: Shape of stall surface changes in the days after new bedding is added



The distribution of the sand changed in the days after bedding was added and levelled. The stall surface became concave, with the maximum depths at the center of the freestall.

Experiments 2 and 3: Bedding level affects lying time



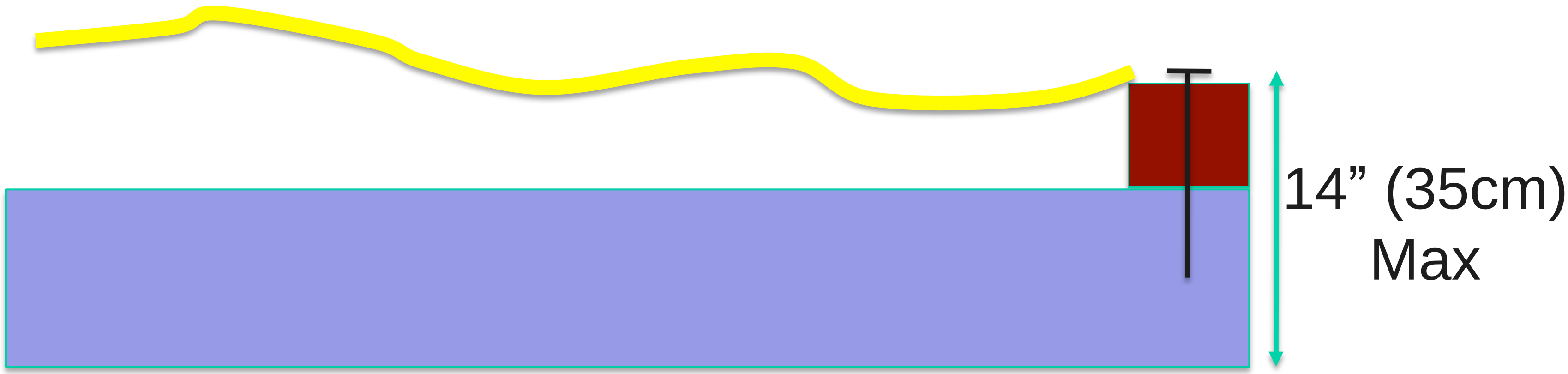
Lose 1 hour of lying for each 3 inches (8cm) of sand lost

(Drissler et al., 2006)

Sand Conversion Options

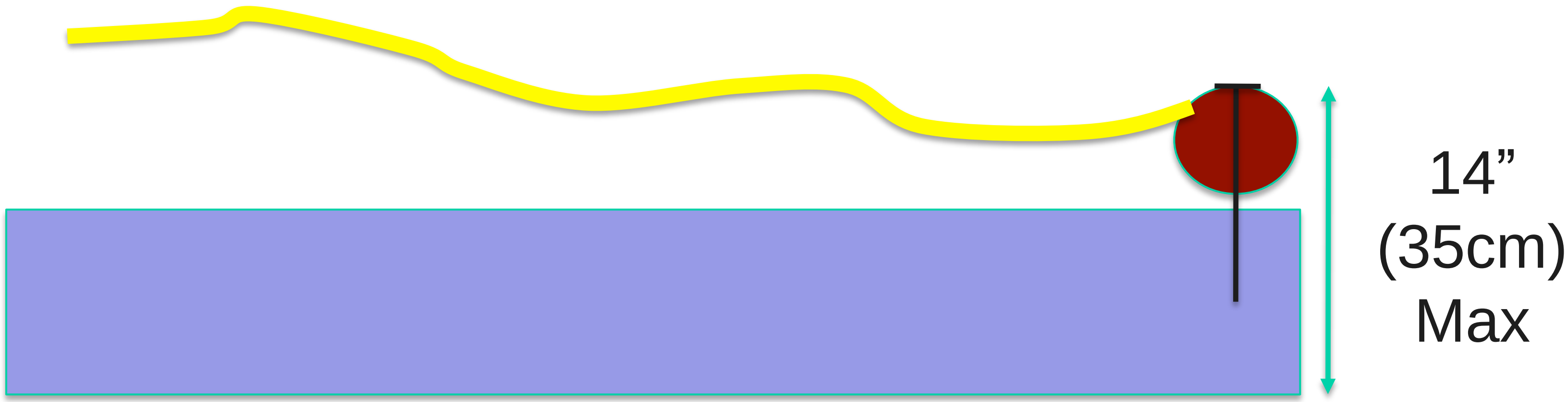
1. Completely remove the platform and re-pour the curb
2. Add a bedding retainer to the rear curb and put sand over concrete or a mat

Treated Landscape Timber

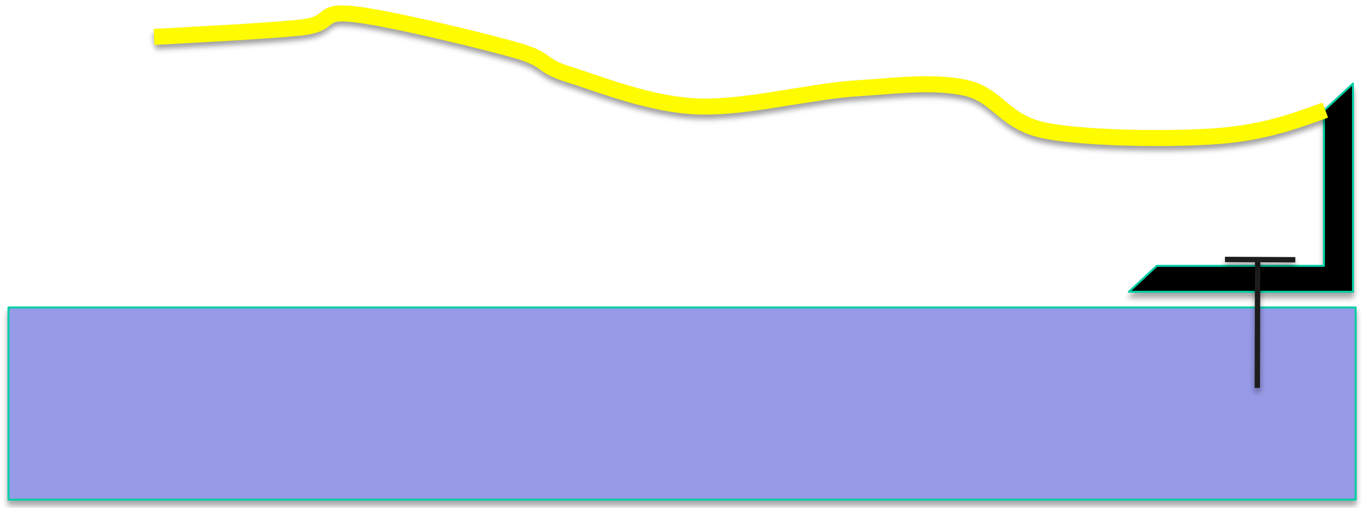


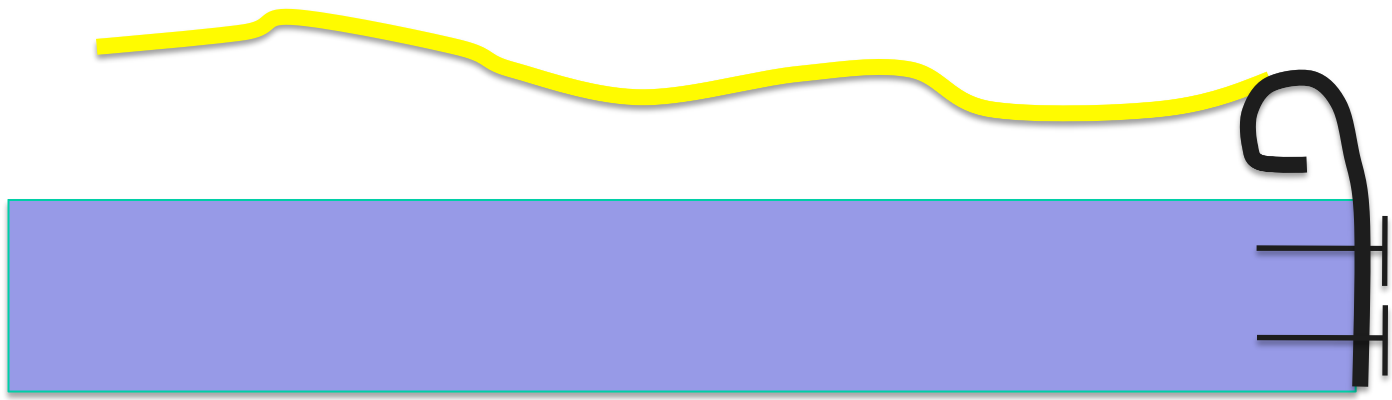
Landscape Timber comes in 8 foot (2.4m) long sections 1 stainless 81/2” (22cm) concrete lag bolts beneath each loop

Fiber Glass Pipe



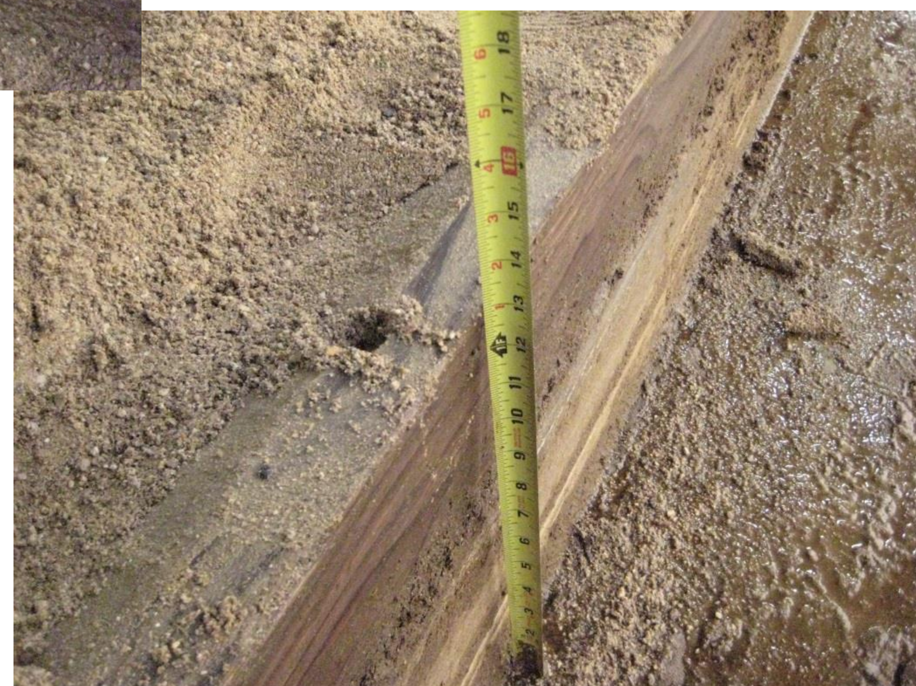
•3 3/16 inch O.D. 3/16” thick fiberglass pipe (comes in 30 foot lengths with beveled ends so that they slot together, cost is around $1.00 per foot)





4” x 4” timber – total curb height = 11” (28cm)

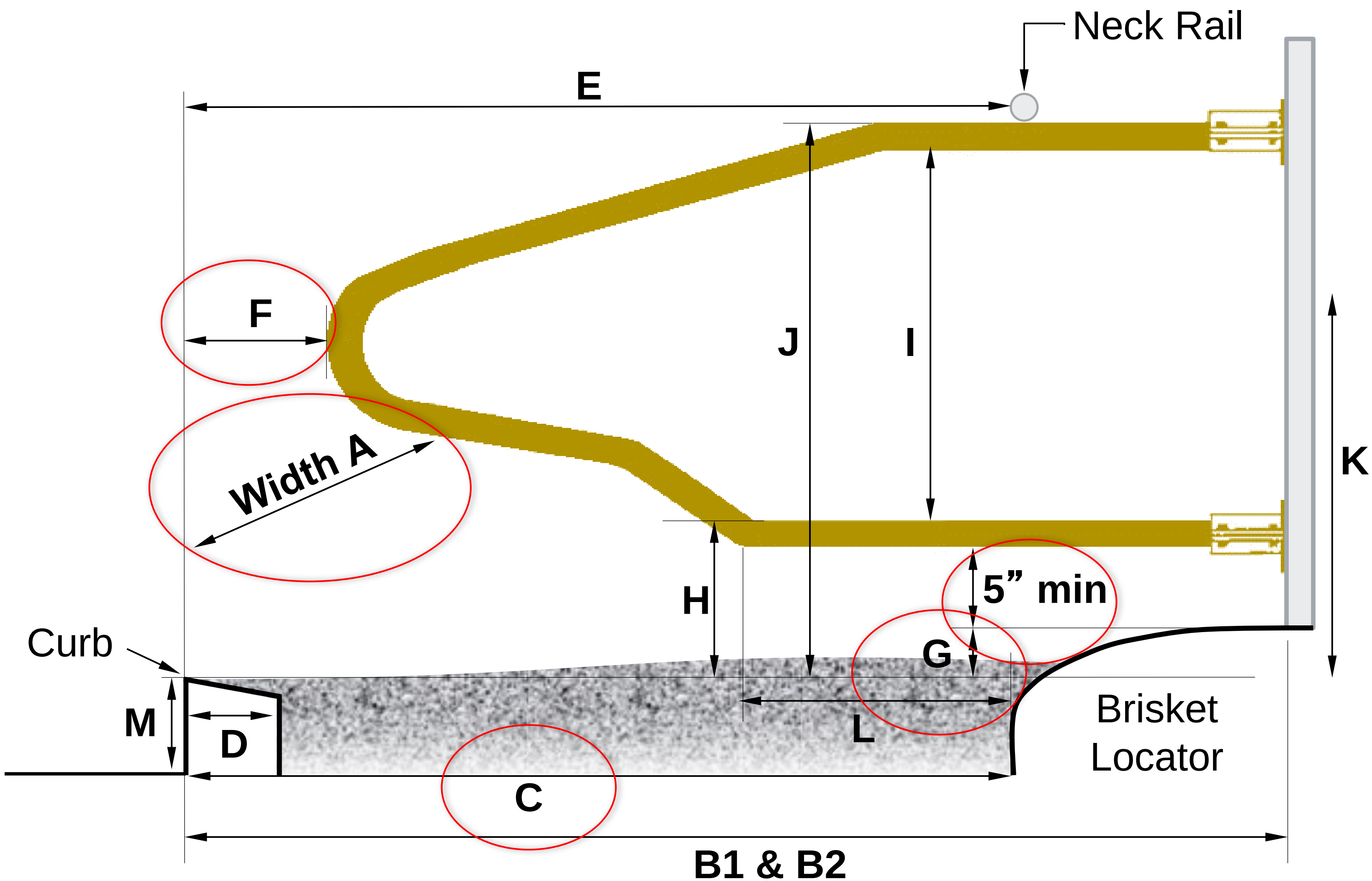
6” x 6” or 4” x 6” timber – total curb height = 13” (33cm)



Other Deep Loose Bedding Options

- Manure solids
- Sawdust, shavings
- Paper products
- Straw, lime mixture (Germany)
- Peatmoss (Finland)


Stalls appropriately sized to
provide sufficient resting space



Neck Rail
E
F
J
I
K
Width A
H
5” min
G
Curb
M
D
L
Brisket
Locator
C
B1 & B2

Resting Space Major Issues

- Insufficient resting space
- Poorly designed stall dividers causing injury
- Brisket locator obstructions

Indexing

By restraint …
or

By design …


Angle of lower divider rail should be 20-22” (51- 56 cm) behind brisket locator

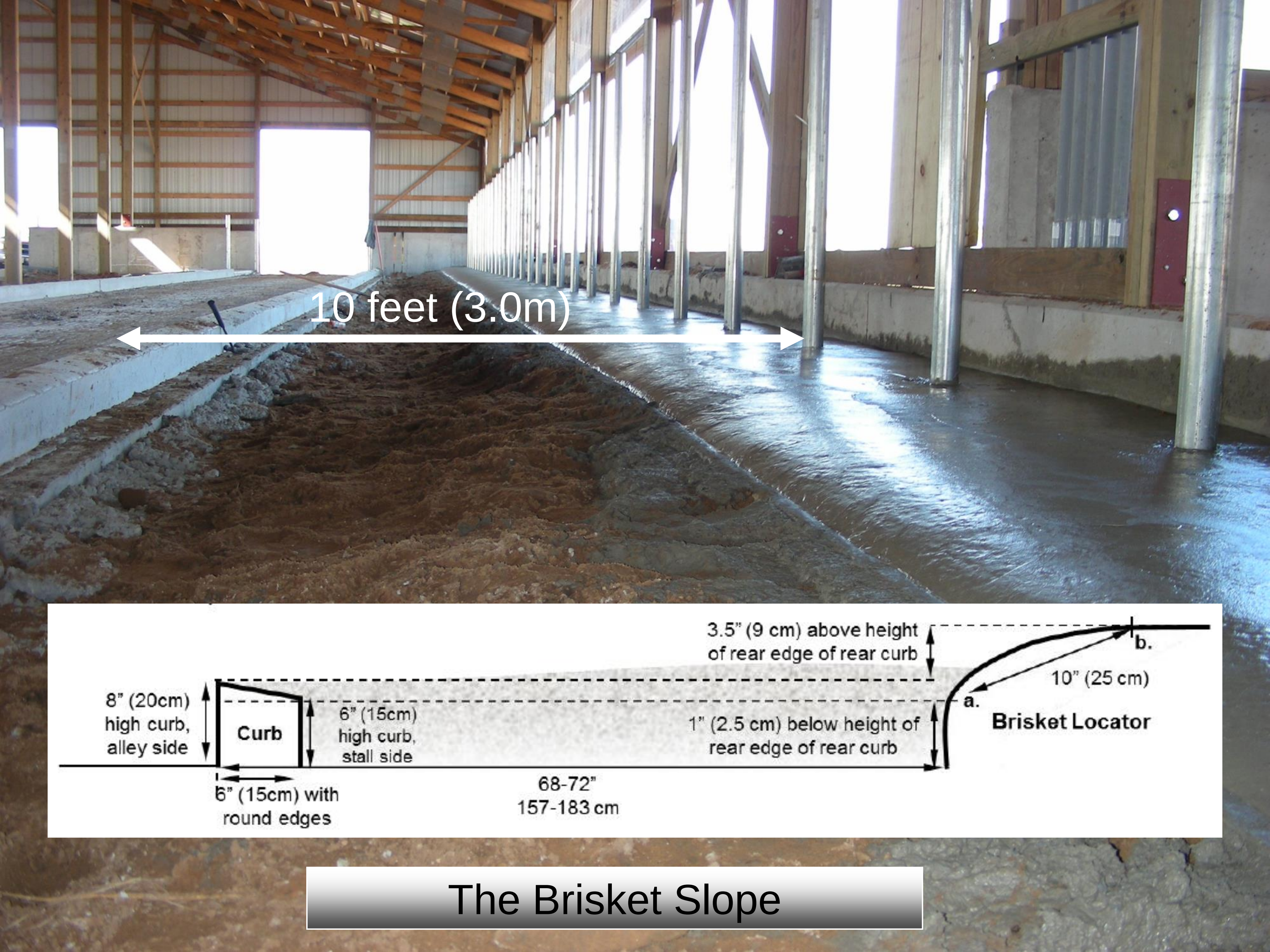
Cows need to be able to put their front foot over the brisket locator when rising

Let's be clear on this….

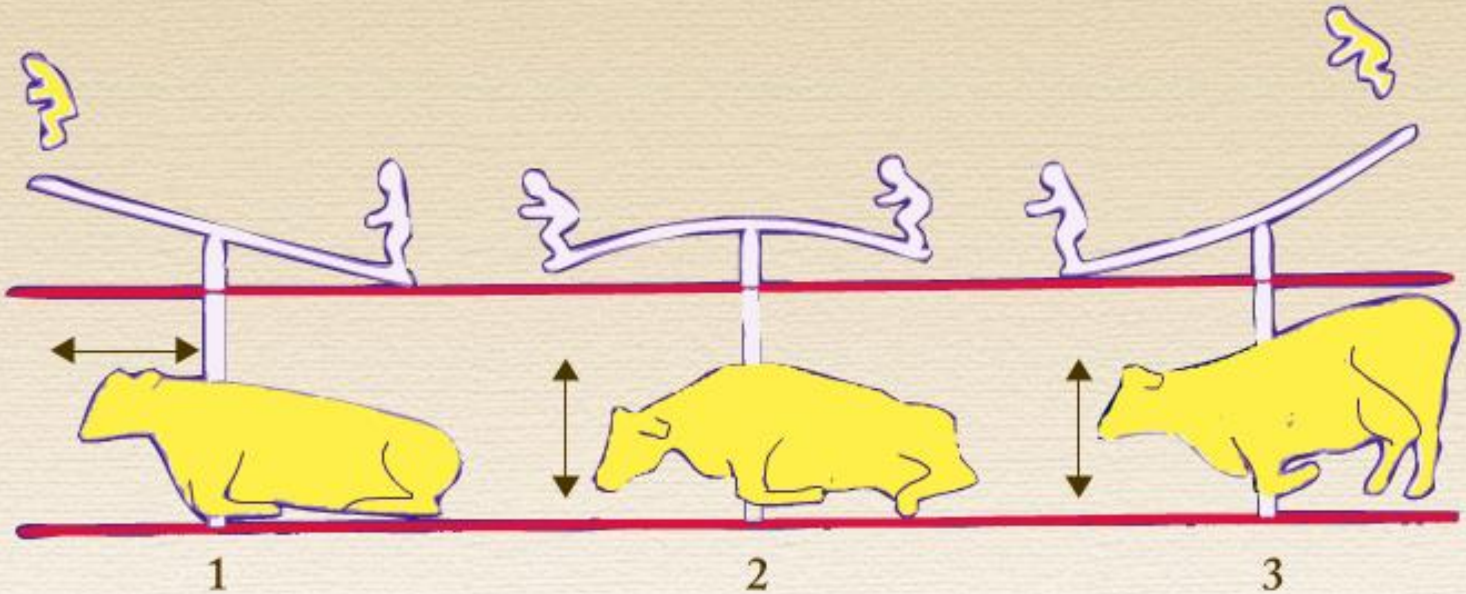
- Research says that cows prefer stalls without brisket locators over stalls with locators 8 inches (20cm) high (Tucker et al., 2006)
- Locators above 4 inches (10 cm) high obstruct the forward thrust of the forelimb as the cow rises
- Locators on stalls that are less than 8 feet (2.4m) long don't do very much but get in the way … especially if they are too high (mature cows are 8 feet (2.4m)!)
- Big stalls need well designed locators!



APR 8 2004

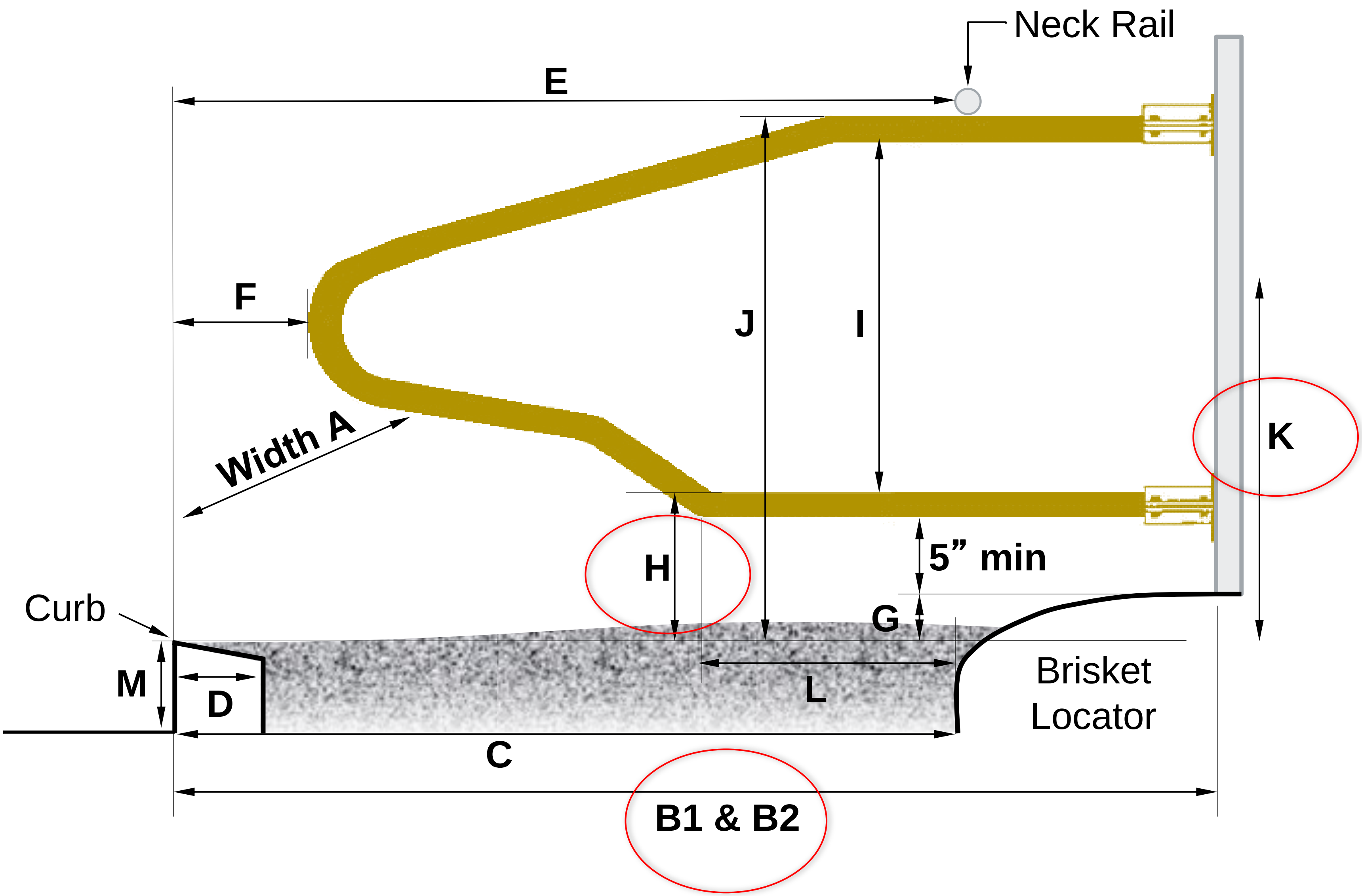


The Brisket Slope



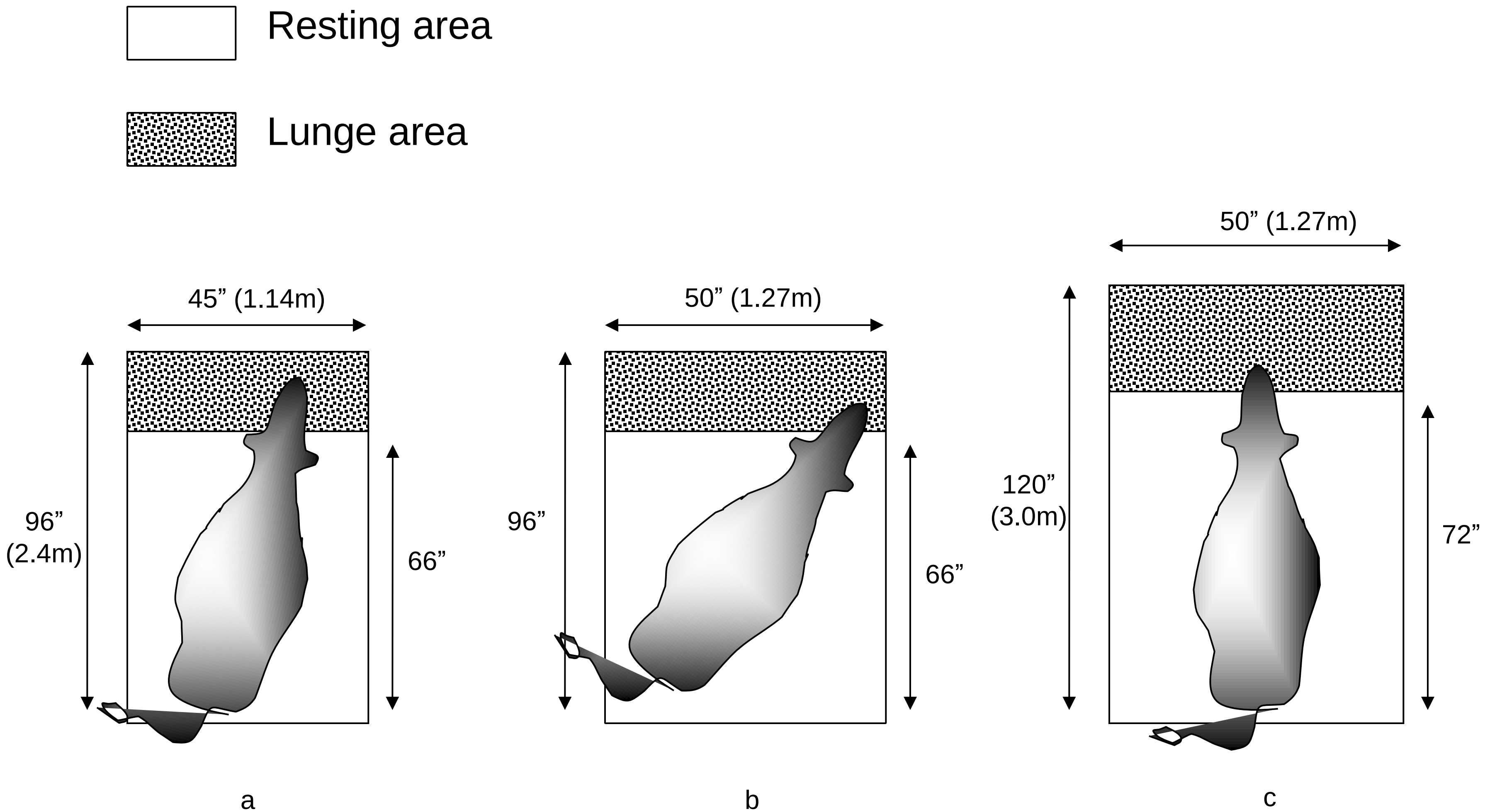
Lunge Space – in a horizontal plane

The Bob-Zone – in a vertical plane

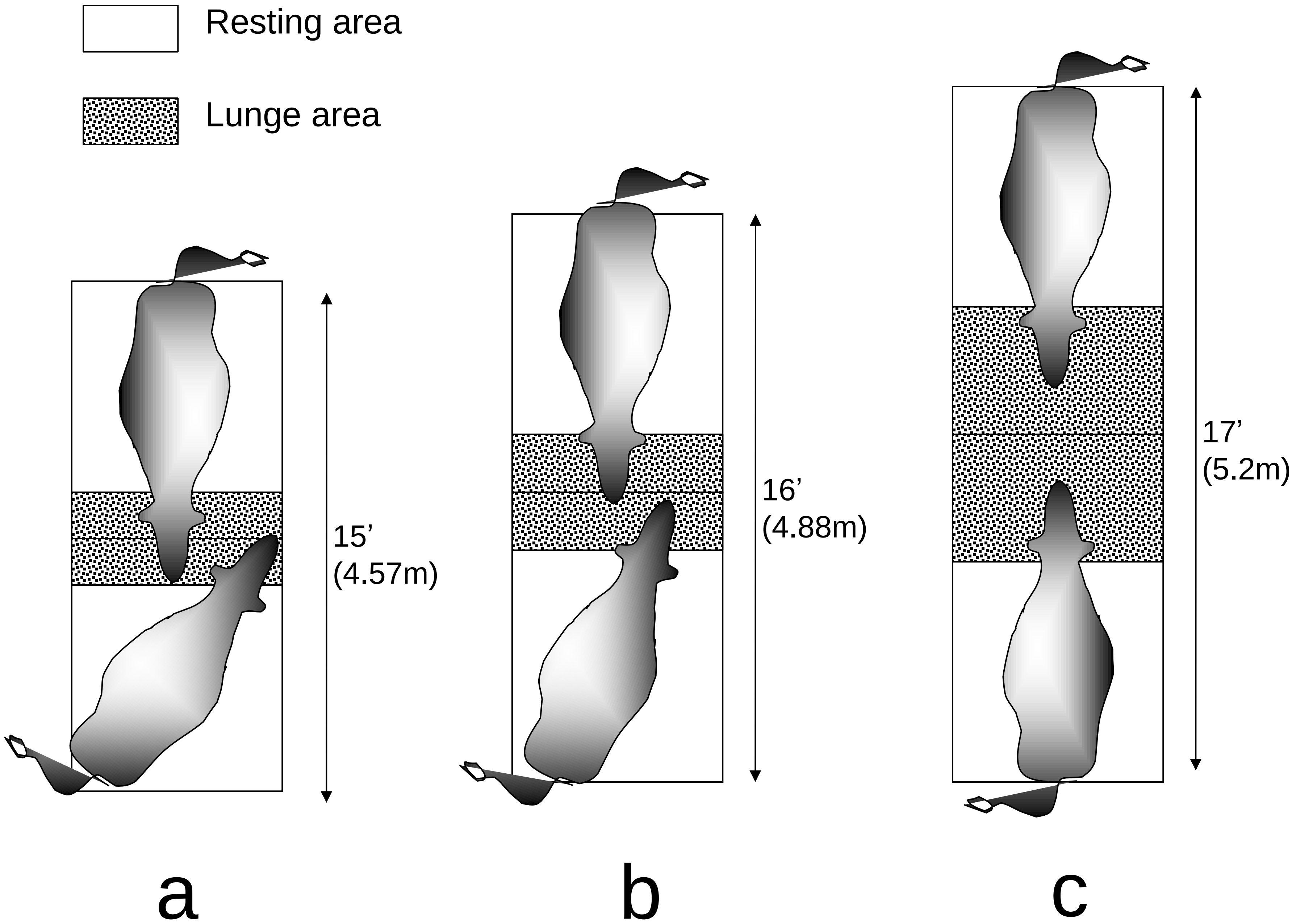

Neck Rail
E
F
J
I
Width A
K
H
5" min
Curb
G
M
D
L
Brisket
Locator
C
B1 & B2

Lunge and Bob Major Issues

- Insufficient stall length for front lunge
- Divider loop design that restricts side lunge in the absence of front lunge space
- Front lunge and bob obstructions
- Diagonal lying



The association between width and length



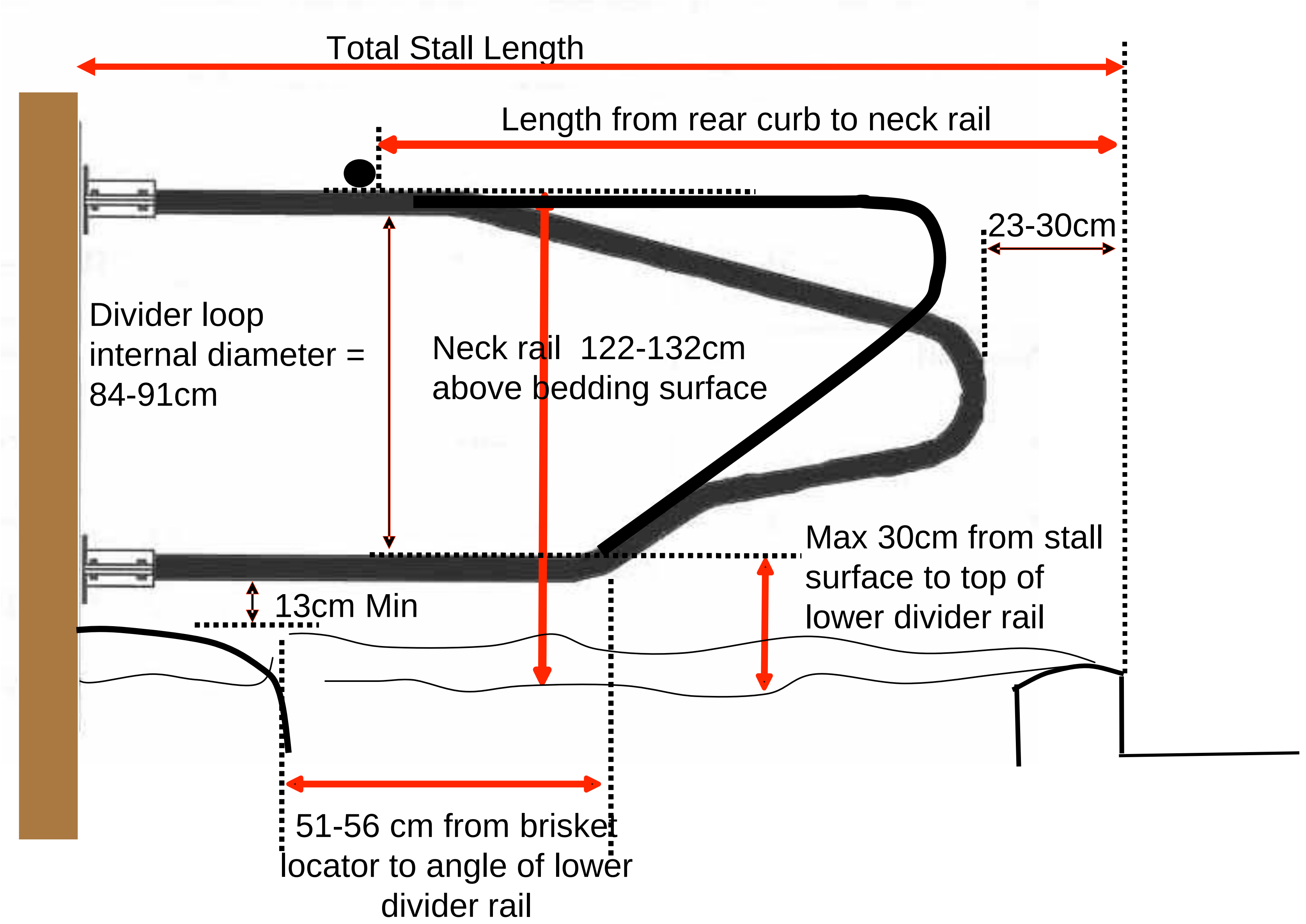
Resting area
Lunge area
15’
(4.57m)
16’
(4.88m)
17’
(5.2m)
a
b
c

Where can the cow lunge?

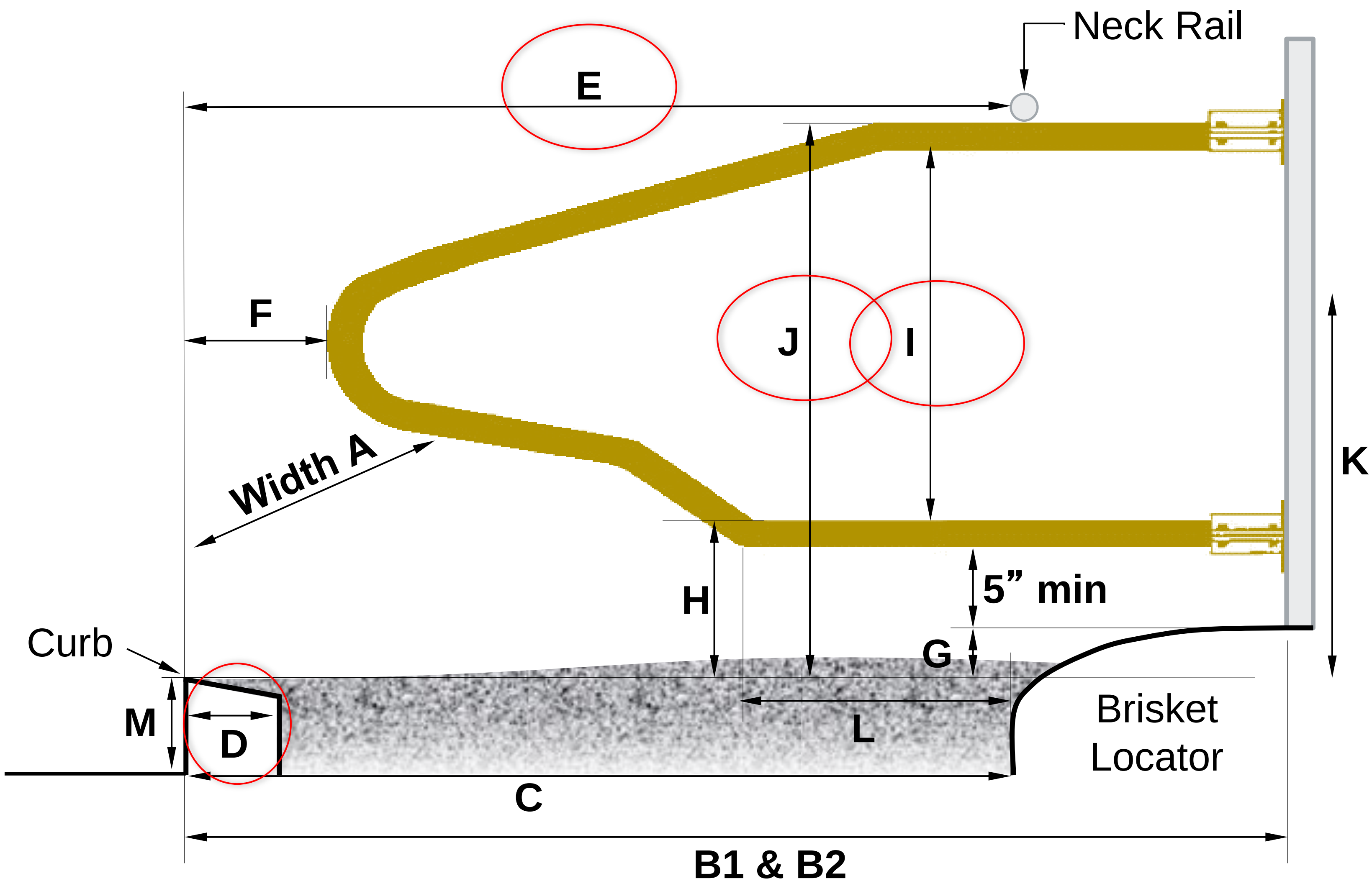
- To the front
- To the side


~36-38” or level with top of head at rest


Just right ....level with top of
the cows heads - 36-38”
above rear point of the curb ...


Total Stall Length
Length from rear curb to neck rail
23-30cm
Divider loop
internal diameter =
84-91cm
Neck rail 122-132cm
above bedding surface
Max 30cm from stall
surface to top of
lower divider rail
13cm Min
51-56 cm from brisket
locator to angle of lower
divider rail

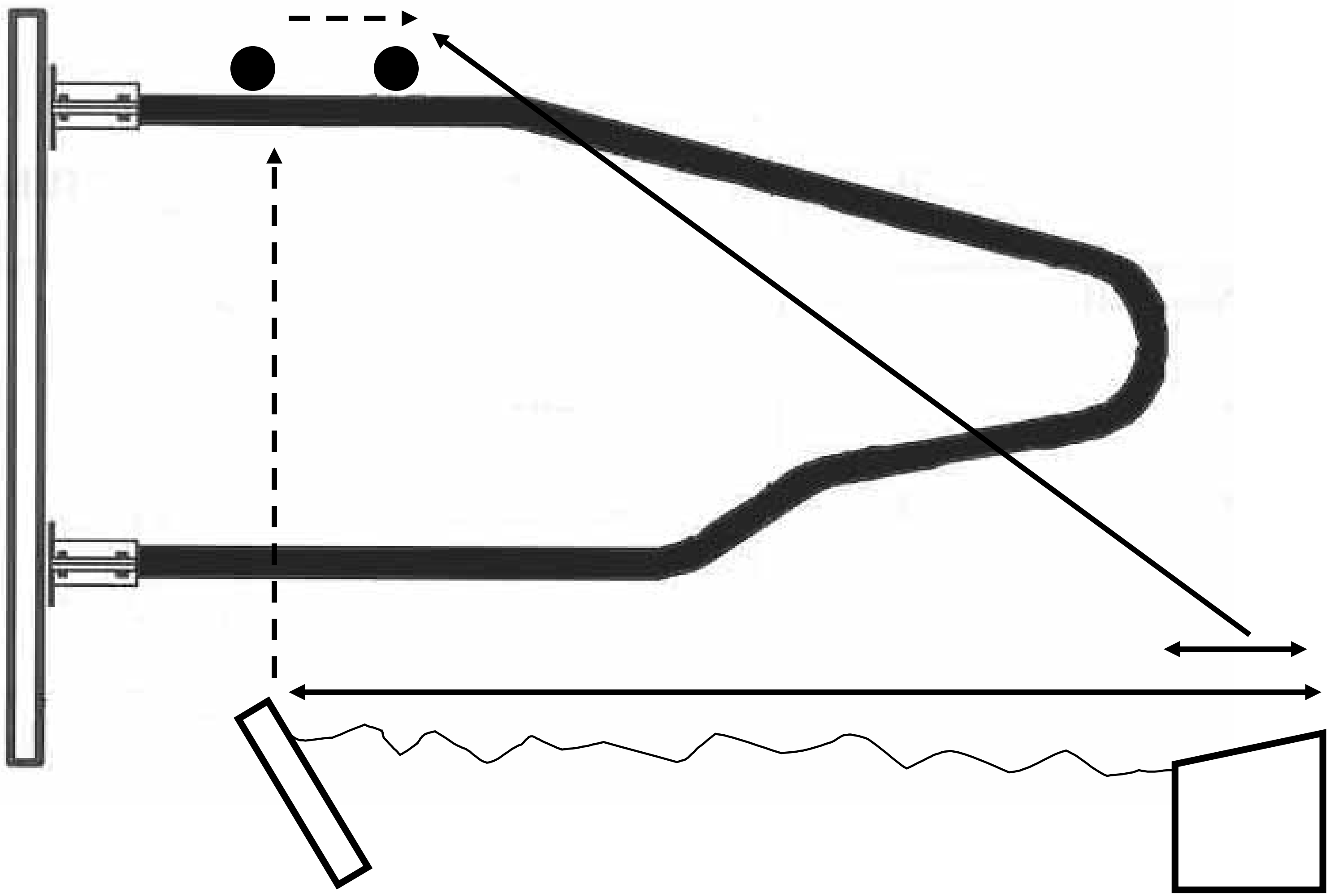

172cm
127cm
~700kg
50 cm
13cm
30cm


Neck Rail
E
F
J
I
Width A
K
H
5” min
G
Curb
M
D
L
Brisket
Locator
C
B1 & B2

Neck Rail Major Issues

- Neck rail located too low
- Incorrect horizontal location of the neck rail in mattress and deep loose bedded stalls
- Poor curb design

Neck rails in deep loose bedded stalls need to be ~6” closer to the rear curb than in mat stalls



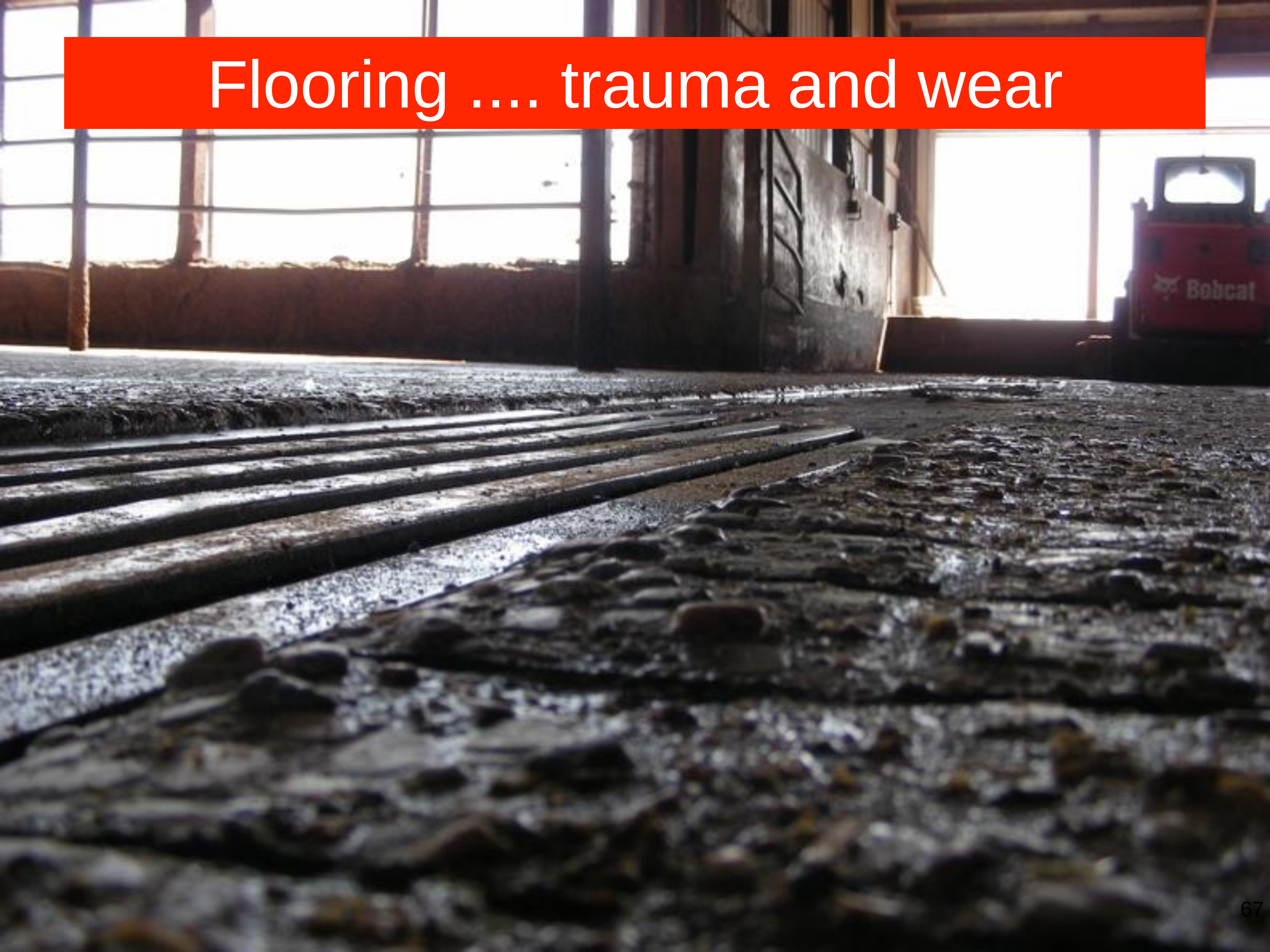
Topics

- Stalls
- Floors
- Transition
- Cooling and Ventilation

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

White Line Abscess = trauma + handling

Flooring .... trauma and wear

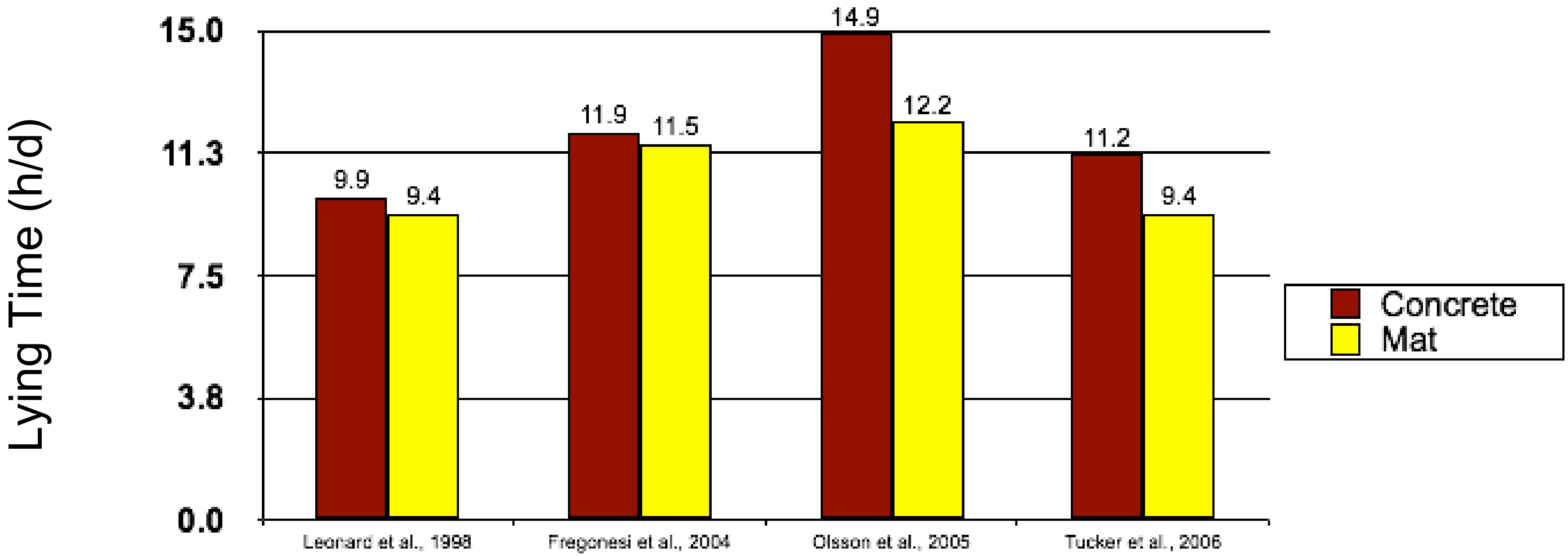


How Elite Herds Prevent Lameness – Strategic Use of Rubber Flooring

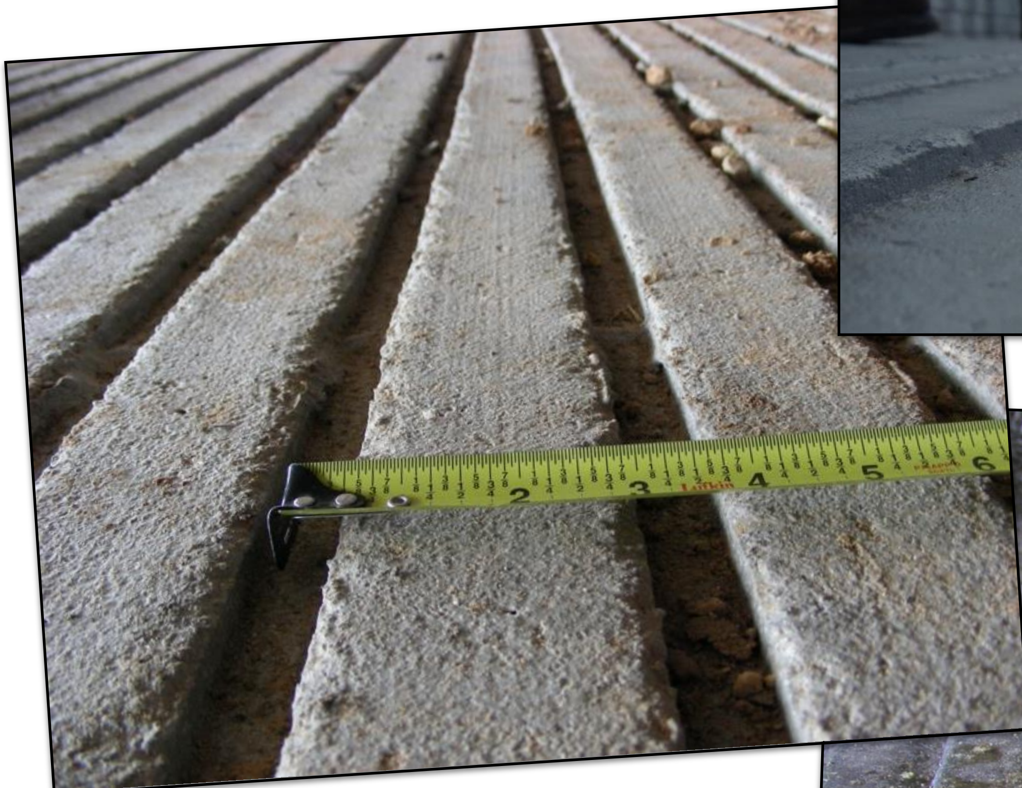
Characteristic	***66 Elite Herds***
% Rubber floors in pens	**5**
% Rubber floors in transfer lanes	**15**
% Rubber floors in holding areas	**41**
% Rubber floors in parlors	**68**

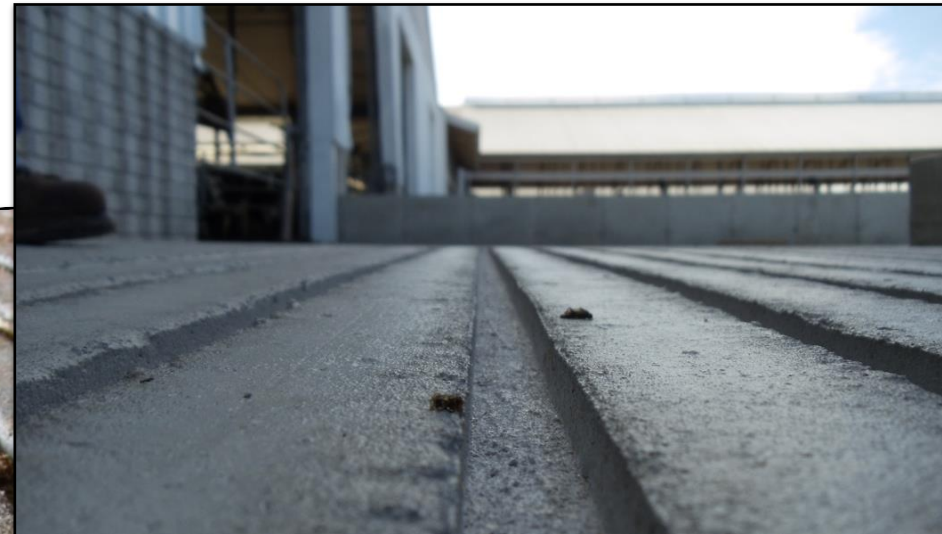

195

Effect of Rubber Flooring Surfaces in Freestall Pens



All four studies show a reduction in lying time in the stall (mattress stalls)





¾” wide (2cm)
½” deep (1.3 cm)
3 1/4” OC (8.3 cm)

Texture Old Floors

Topics

- Stalls
- Floors
- Transition
- Cooling and Ventilation

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

The Wisconsin Blueprint: Transition Cows

- 30 inches (0.75 m) of bunk space 21 days before and after calving – to ensure that all cows can eat at the same time
- Deep loose bedded freestalls sized to accommodate the size of the cows using them or a comfortable, dry bedded pack
- At least one stall per cow (or at least 100 square feet (10 sq m) of bedded pack per cow)
- Minimize regrouping stress within the critical period 2-7 days before calving
- A quiet place to calve, with limited disturbance from humans and other cows – to ensure as natural a birth as possible with a lowered risk for dystocia and stillbirth

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

Wisconsin Herd Transition Management - 2015

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

- 44 herds
- Herd size 894 cows
- 20 day average prefresh stay
- 62% freestall prefresh (29% bedded pack)
- 78% deep loose bedding (60% sand)
- 40” (101 cm) bunk space per cow prefresh
- 80% group maternity pen, 20% individual pens

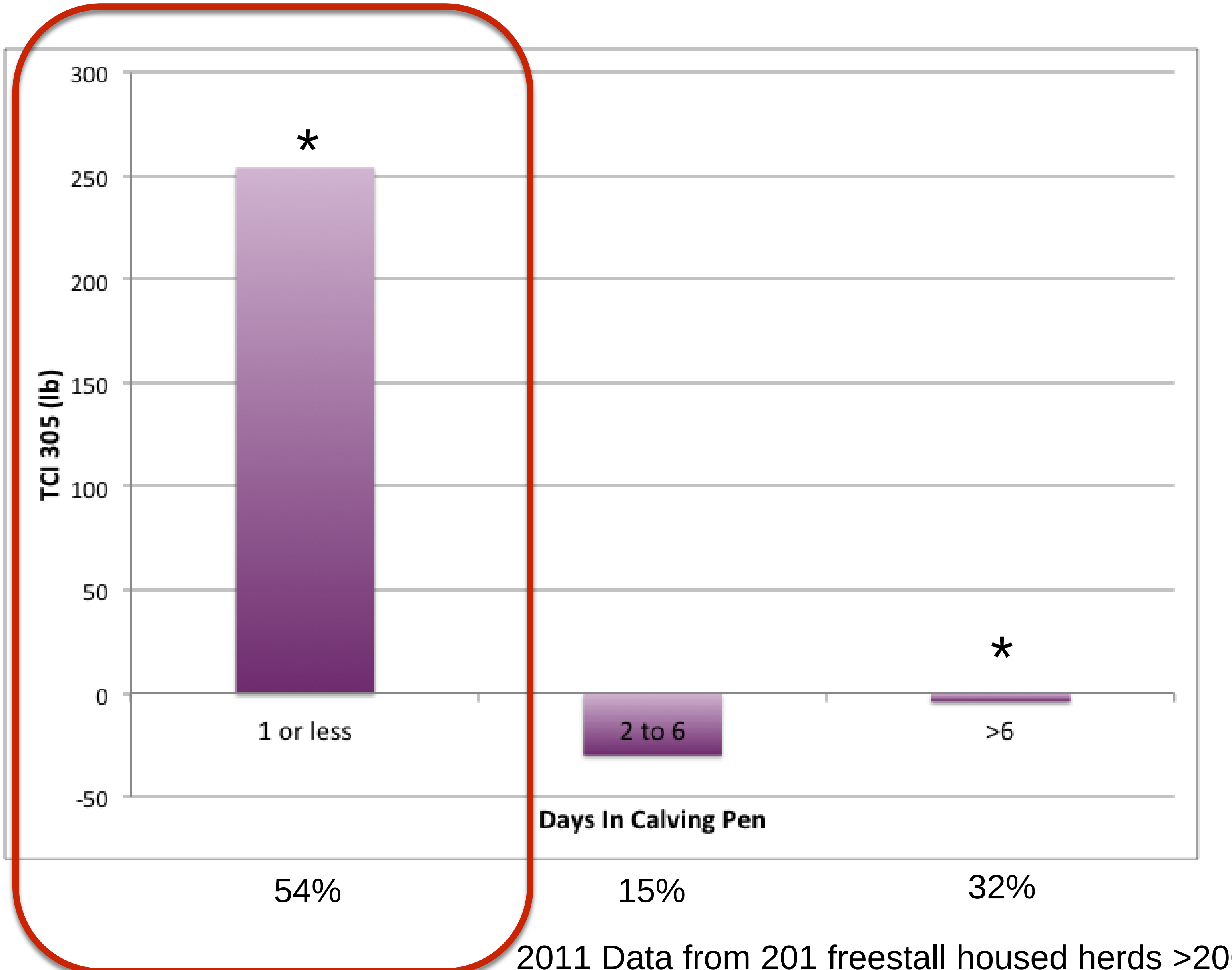
Maternity Pen Options

1. Just-in-time calving – where cows are moved to the maternity pen (the pen in which the cow calves) within hours of birth
2. Short-stay maternity pen – where cows are moved to the maternity pen less than 2 days before they calve
3. Long-stay maternity pen – where cows are moved into the maternity pen more than 7 days before they calve

‘Just-in-Time’ Calving

- Move cows from a freestall to a calving pen at the point of calving
- Commonly practiced by more than half of larger freestall herds

TCI® and Days in Calving Pen



54% 15% 32%

2011 Data from 201 freestall housed herds >200 cows

- Risk of stillbirth is reduced by moving cows with waterbag or feet showing to maternity pen vs cows with only mucus showing (Carrier et al., 2006)
- Moving cows in late stage I of labor have the longest labor (mucus showing) and 50% reduction in lying time 1 h before calving (Proudfoot et al., 2013 JDS 96:1638)

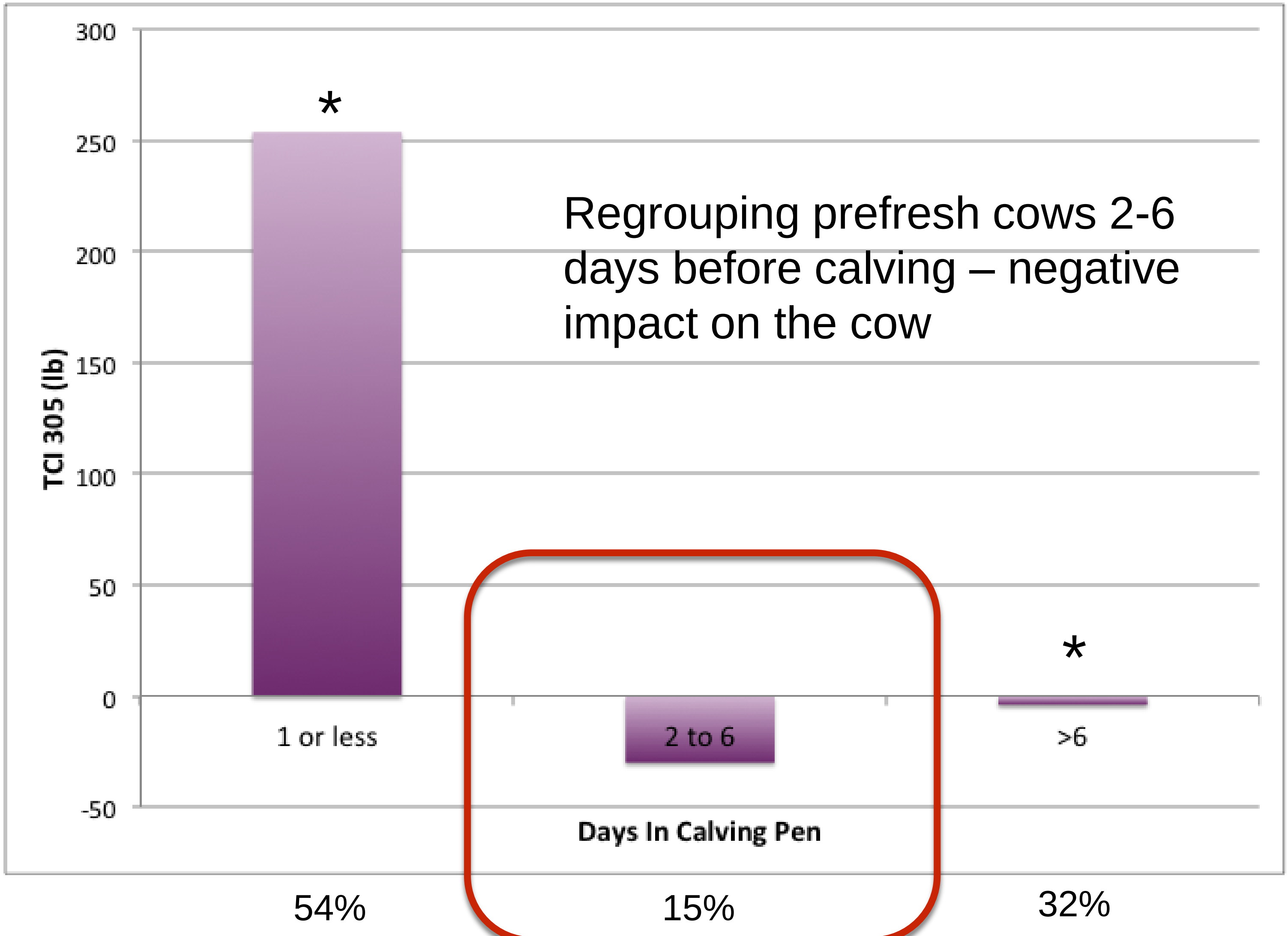
- This requires around the clock supervision of the pre-fresh group 24/7 every hour…….

- Larger, 3X milking dairy herds

A quiet private place to calve ...

Proudfoot et al., 2014. *J. Dairy Sci. 97:2731-2739*

TCI ® and Days in Calving Pen

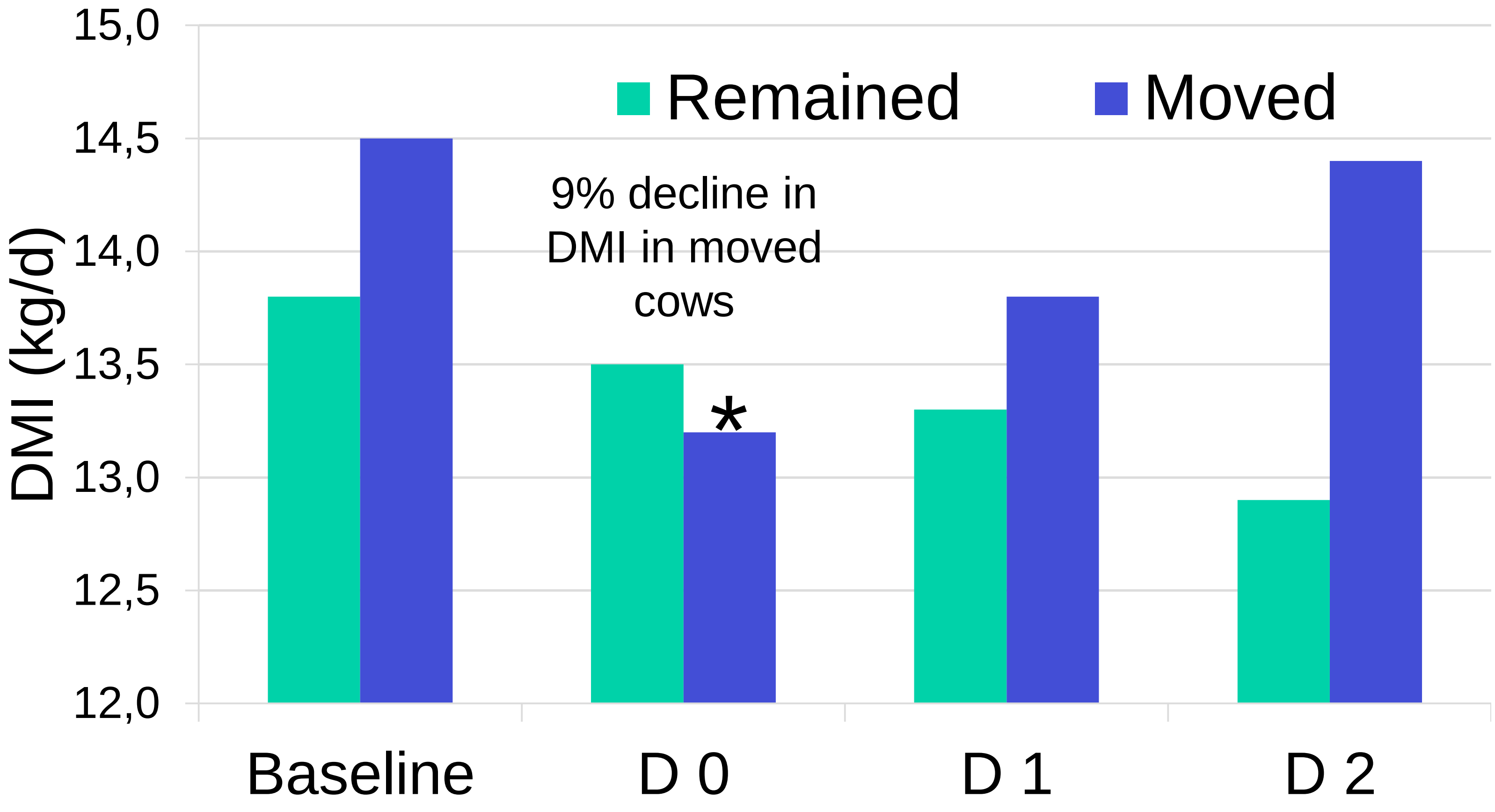


54% 15% 32%

2011 Data from 201 freestall housed herds >200 cows

DMI (kg/d) comparing cows that remained vs. moved between groups

Schirman et al., JDS 94:2312, 2011



48 cows in 6 cow groups regrouped in groups of 3 starting 40 days before expected calving

Maternity Pen Options

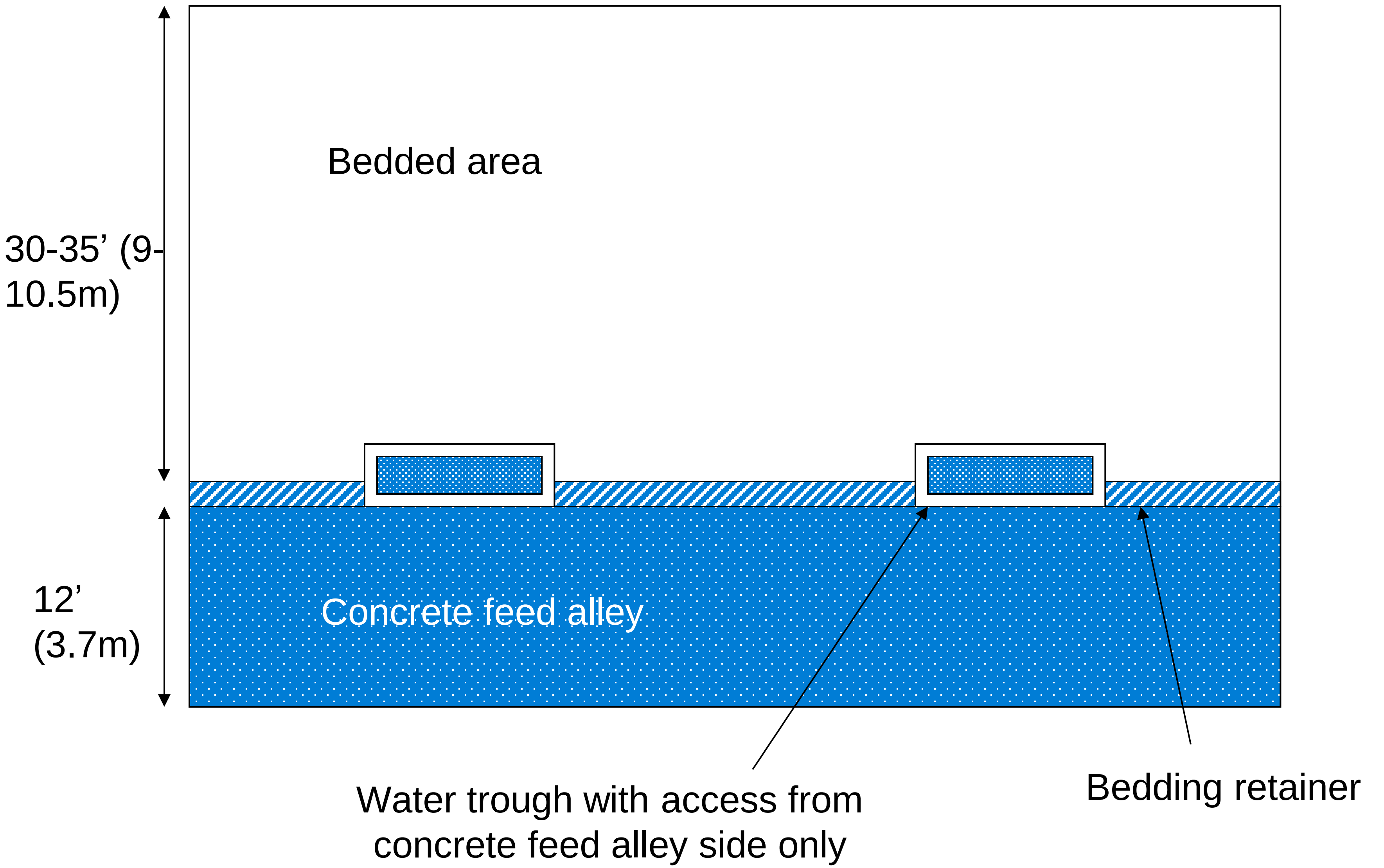
1. Just-in-time calving – where cows are moved to the maternity pen (the pen in which the cow calves) within hours of birth
2. Short-stay maternity pen – where cows are moved to the maternity pen less than 2 days before they calve
3. Long-stay maternity pen – where cows are moved into the maternity pen more than 7 days before they calve

Short-Stay Maternity Pen

- Cows within 2 days of calving avoid social contact and do not appear to be as affected by regrouping stress as cows 2-7 days before calving
- The success of this approach depends on the ability of workers to predict calving 2 days prior to the event
- This approach is therefore more applicable to smaller herds, typically less than ~ 250 cows, where dry cow groups are small and social stresses less than in larger herds.
- The elements critical to the success of short-stay maternity pens are:
  - Excellent stockmanship and timing of calving
  - A group maternity pen – to avoid prolonged isolation of individual cows

Most common approach in smaller herds

Bedded Pack Guidelines



Maternity Pen Options

1. Just-in-time calving – where cows are moved to the maternity pen (the pen in which the cow calves) within hours of birth
2. Short-stay maternity pen – where cows are moved to the maternity pen less than 2 days before they calve
3. Long-stay maternity pen – where cows are moved into the maternity pen more than 7 days before they calve

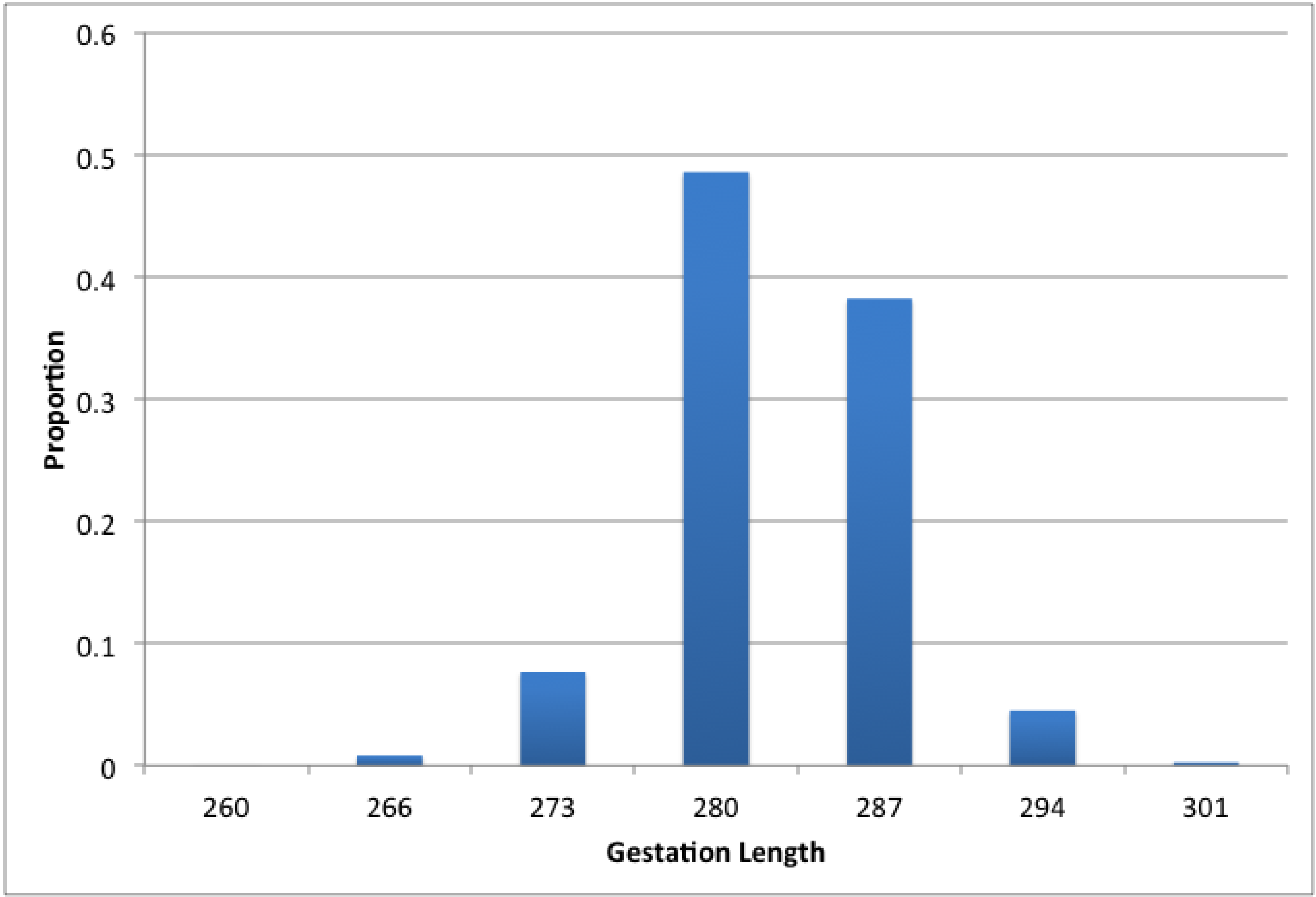
Long-Stay Maternity Pen

- With this strategy, we try to move cows into the maternity pen more than 7 days before calving.

- It is virtually impossible to predict that an an individual cow will calve in 7 days – but a group approach can be taken in herds more than ~350 cows

- The concept is to move a group of cows from the dry cow group to a maternity pen each week – with a group pen of sufficient capacity to accommodate a week of calving cows, and sufficient separate maternity pens to accommodate each group until they all calve, with the minimum of regrouping.

94% term calvings within 14 days



2419 calvings, stable group plus JIT system

Long-Stay Maternity Pen

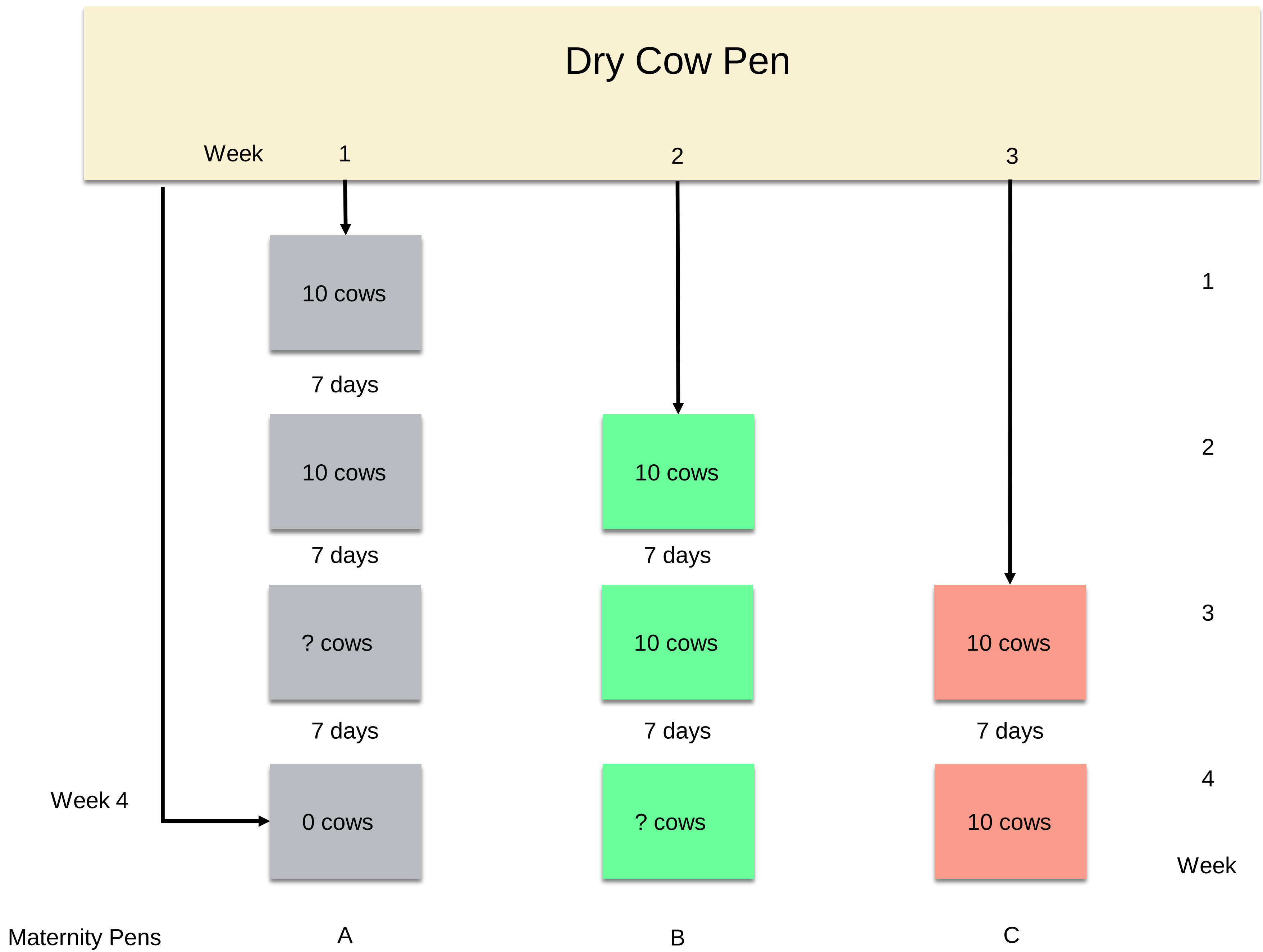
- Typically, 85-95% of cows calve over a 14-day period around 280 days carried calf (DCC). This spread should be examined in the individual herd and the appropriate DCC selected to optimize the 14-day period chosen to accommodate the majority of the cows, while ensuring that most cows spend more than 7 days in the maternity pen.

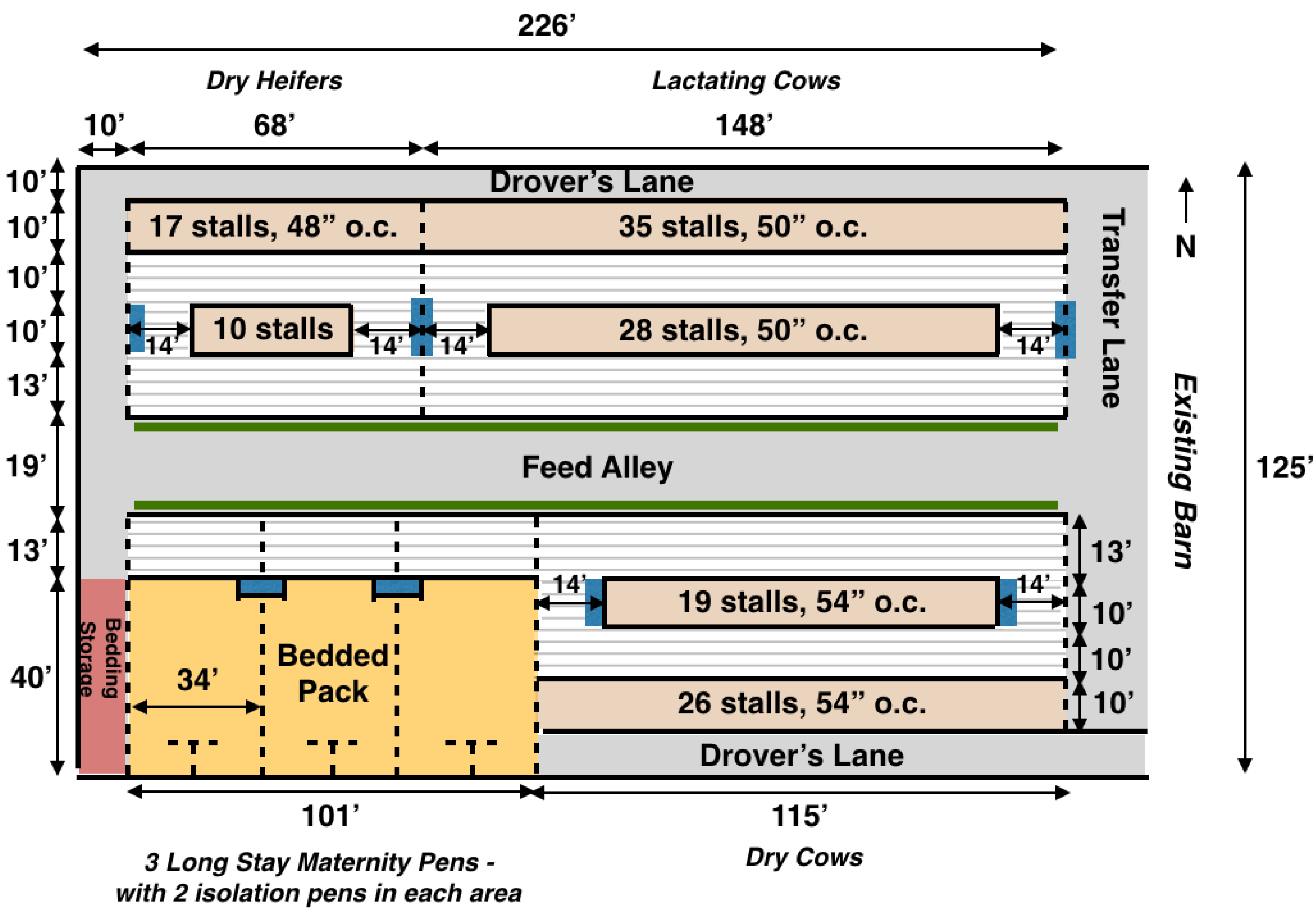
Long-Stay Maternity Pen

- 500 cow dairy freshening 1.04*500=520 calvings per year
- Calvings per day @ avge = 1.5
- On average, herd will dry off 1.5*7 = 10 cows per week,

- Required capacity to freshen 150% of weekly average calving rate with space for cows to remain in pen for 14 days
  – 150% x 1.5 calvings per day x 14 days = 31 cows

- We need 31/10 = ~3 x 10 cow maternity pens to avoid regrouping
- Size at ~ 150 sq ft per cow

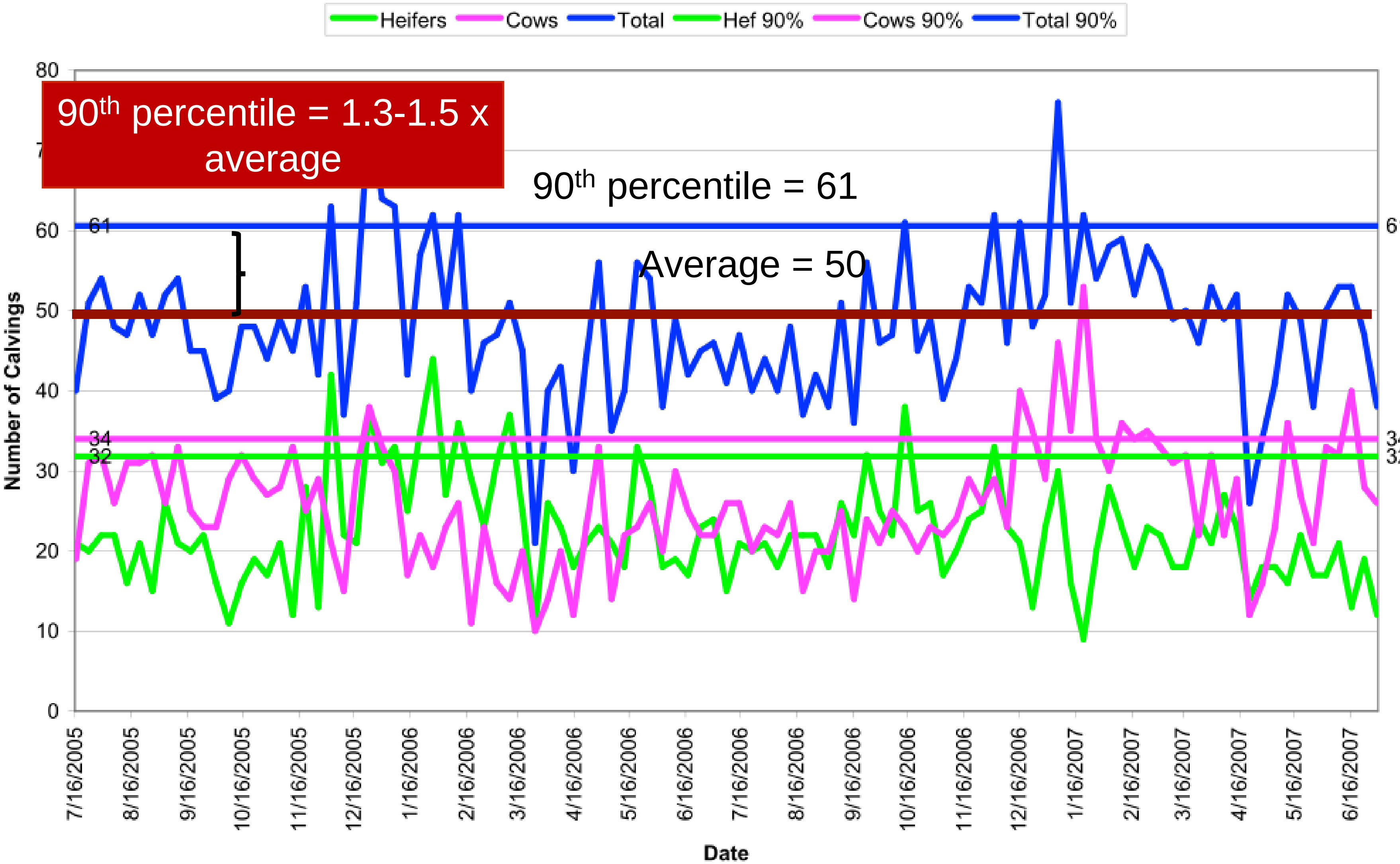

Dry Cow Pen
Week 1
2
3
10 cows
7 days
10 cows
10 cows
7 days
7 days
? cows
10 cows
10 cows
7 days
7 days
7 days
Week 4
0 cows
? cows
10 cows
1
2
3
4
Week
Maternity Pens
A
B
C


226’
Dry Heifers
Lactating Cows
10’
68’
148’
Drover’s Lane
17 stalls, 48” o.c.
35 stalls, 50” o.c.
10 stalls
28 stalls, 50” o.c.
14’
14’
14’
14’
Transfer Lane
N
Existing Barn
125’
10’
10’
10’
10’
13’
19’
13’
40’
Feed Alley
13’
10’
10’
10’
14’
14’
19 stalls, 54” o.c.
26 stalls, 54” o.c.
Bedding Storage
Bedded Pack
34’
Drover’s Lane
101’
115’
3 Long Stay Maternity Pens - with 2 isolation pens in each area
Dry Cows

How do we size the pre-fresh/dry cow pen?

- The only pen on the farm that the cows get to decide when they leave!
- Every cow on the farm occupies this pen during the course of a year
- Have to overbuild to accommodate calving surges and distribute the cost over all of the cows in the herd

Average vs 90th Percentile



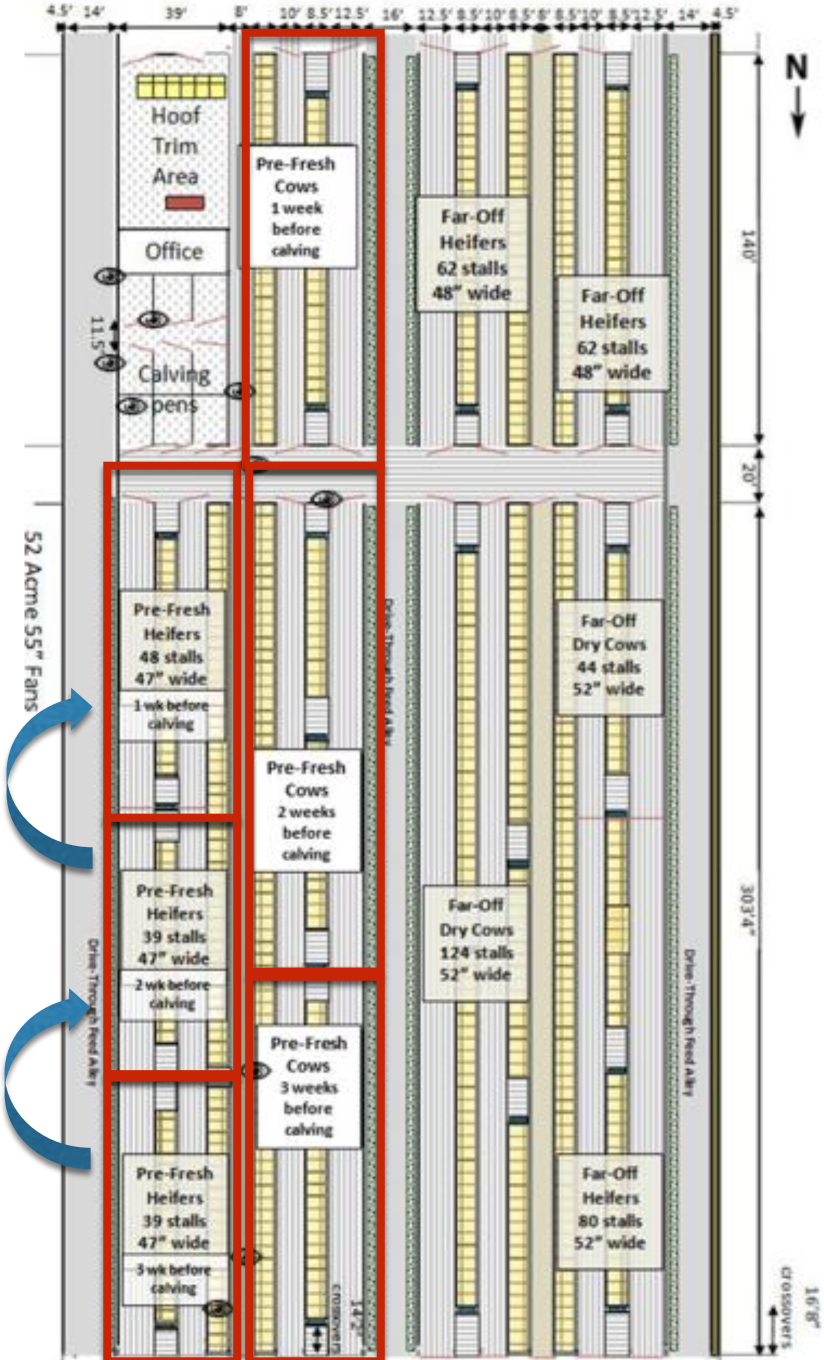
Prefresh/Dry Pen Options

- Traditional Prefresh
- Sequential Fill Prefresh
- All-in, All-out Prefresh/Maternity

Prefresh/Dry Pen Options

- Traditional Prefresh
- Sequential Fill Prefresh
- All-in, All-out Prefresh/Maternity

Sequential Fill Prefresh

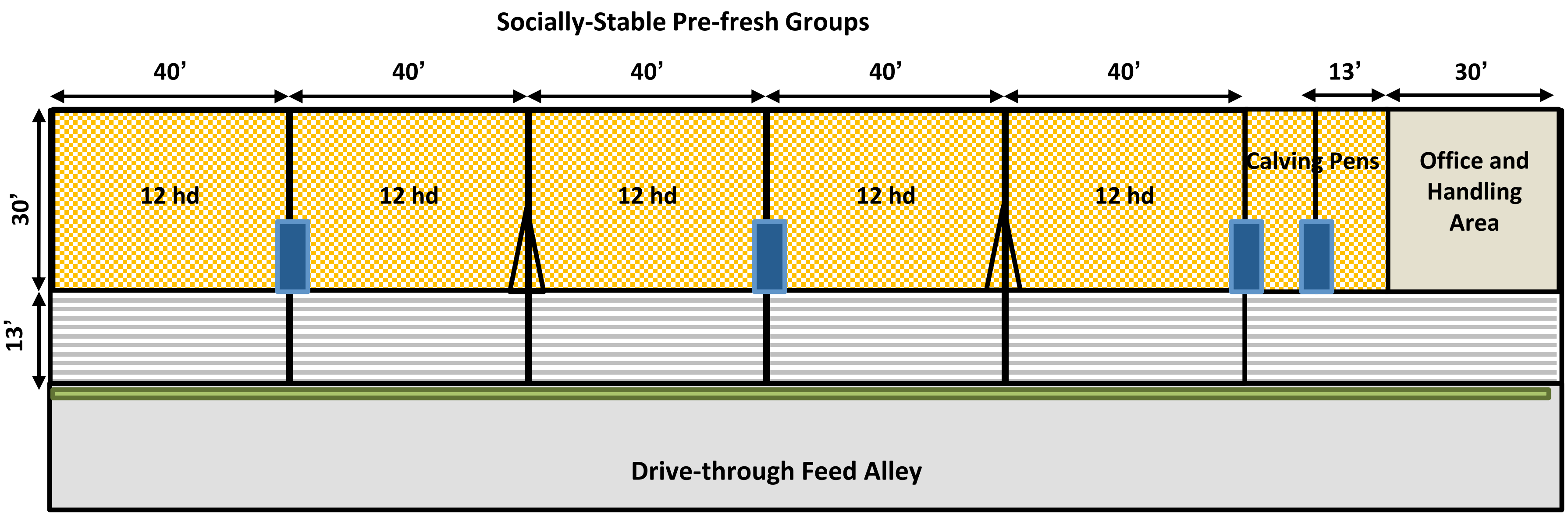


- 21 day transition split into 3 x 7 day pens
- Fill at the far end, move toward the calving area once a week
- Absorb 'straggler' cows that have yet to calve in pen nearest maternity area

Prefresh/Dry Pen Options

- Traditional Prefresh
- Sequential Fill Prefresh
- All-in, All-out Prefresh/Maternity

All-in, all-out Pre-fresh/Maternity



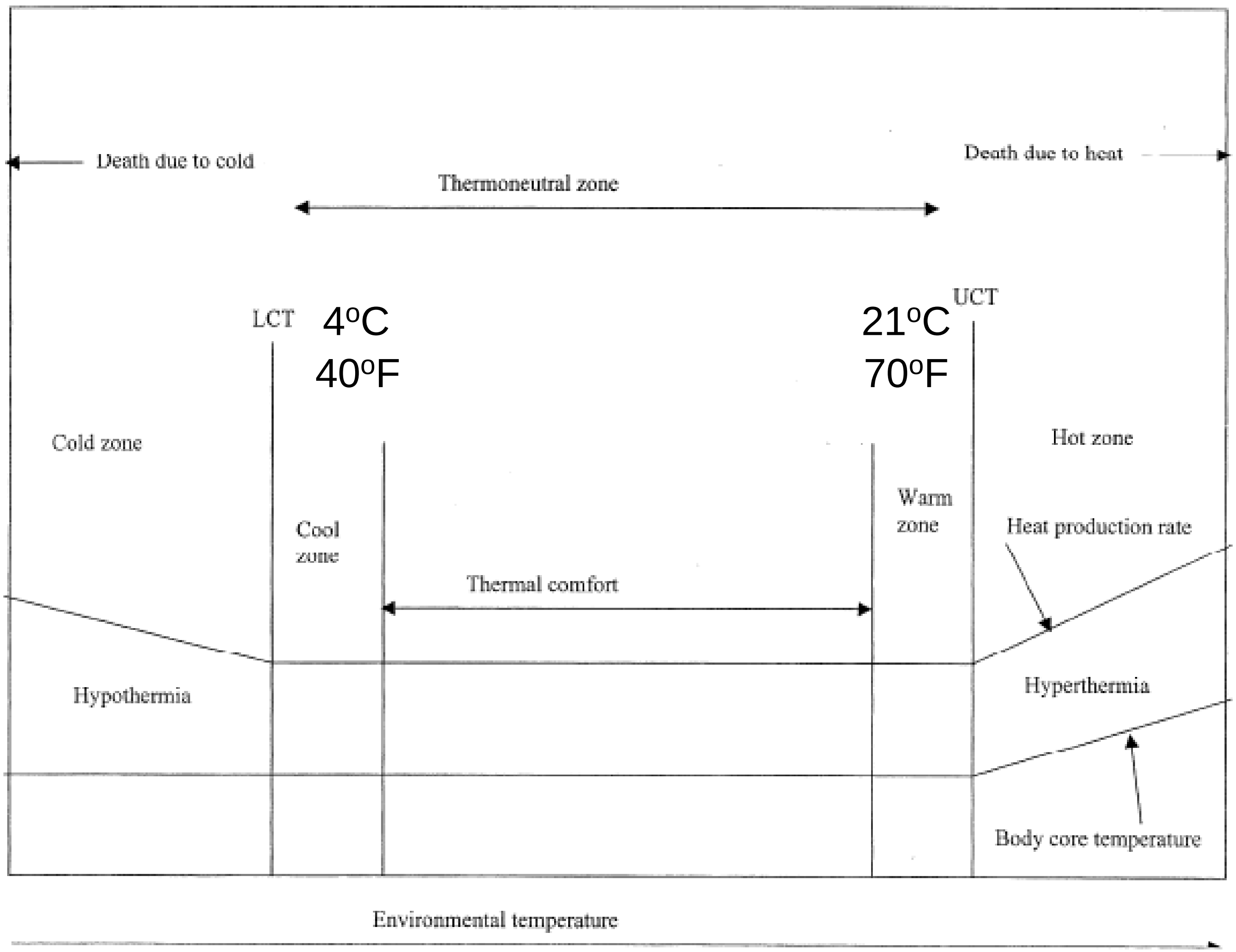
UW Emmons Blaine Arlington Dairy Facility

Topics

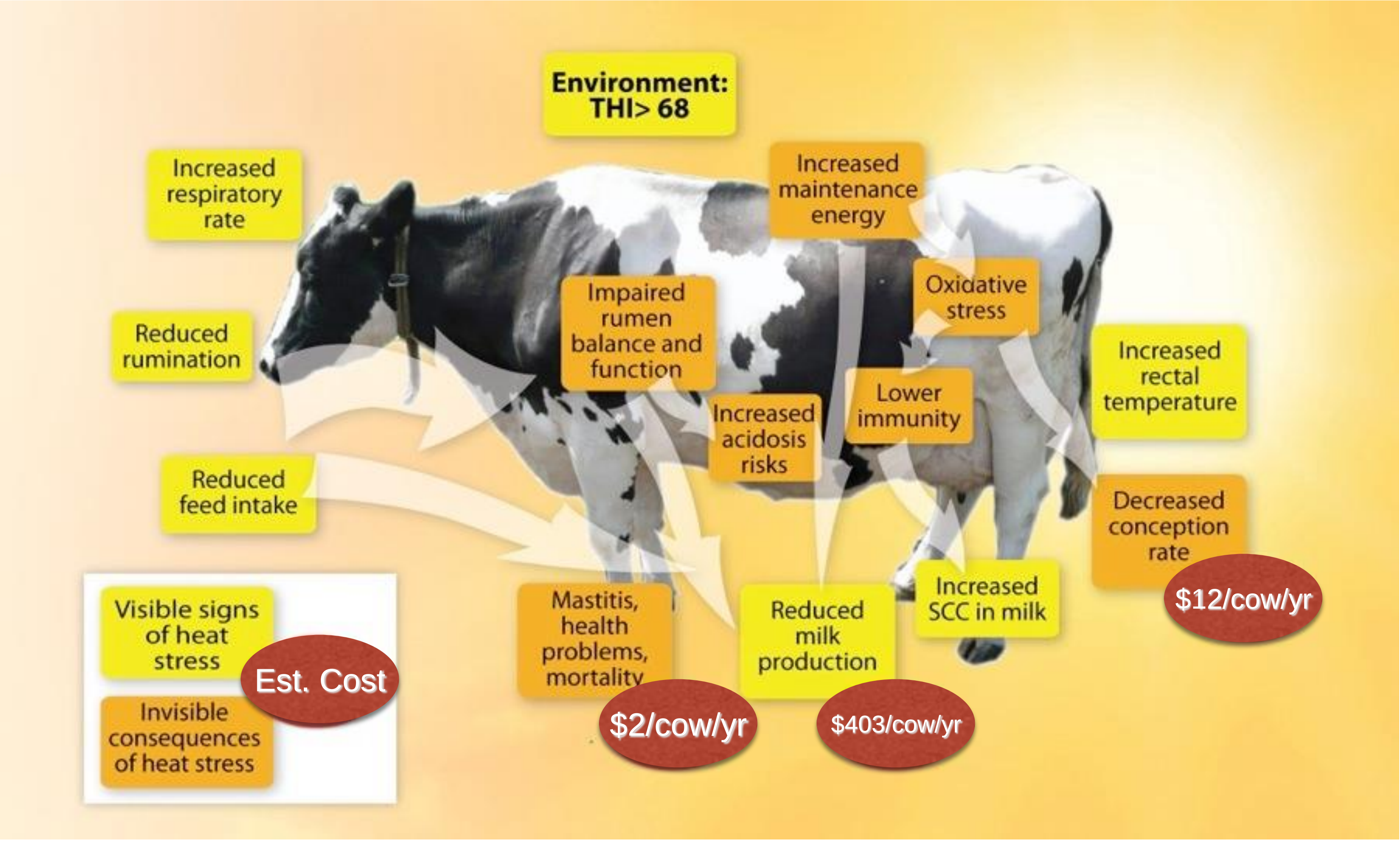
- Stalls
- Floors
- Transition
- Cooling and Ventilation

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

The Thermoneutral Zone



Effects of Heat Stress: Physiological and Behavioral



Temperature		% Relative Humidity																				
°F	°C	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
72	22.0	64	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71	72	72
73	23.0	65	65	66	66	66	67	67	68	68	68	69	69	70	70	71	71	71	72	72	73	73
74	23.5	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73	74	74
75	24.0	66	66	67	67	68	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
76	24.5	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
77	25.0	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76	77
78	25.5	67	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	76	77	77	78
79	26.0	67	68	69	69	70	70	71	71	72	73	73	74	74	75	76	76	77	77	78	78	79
80	26.5	68	69	69	70	70	71	72	72	73	73	74	75	75	76	76	77	78	78	79	79	80
81	27.0	68	69	70	70	71	72	72	73	73	74	75	75	76	77	77	78	78	79	80	80	81
82	28.0	69	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81	81	82
83	28.5	69	70	71	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	82	83
84	29.0	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83	83	84
85	29.5	70	71	72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84	84	85
86	30.0	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84	85	86
87	30.5	71	72	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	85	85	86	87
88	31.0	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86	87	88
89	31.5	72	73	74	75	75	76	77	78	79	80	80	81	82	83	84	85	86	86	87	88	89
90	32.0	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
91	33.0	73	74	75	76	76	77	78	79	80	81	82	83	84	85	86	86	87	88	89	90	91
92	33.5	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
93	34.0	74	75	76	77	78	79	80	80	81	82	83	85	85	86	87	88	89	90	91	92	93
94	34.5	74	75	76	77	78	79	80	81	82	83	84	86	86	87	88	89	90	91	92	93	94
95	35.0	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	35.5	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96
97	36.0	76	77	78	79	80	81	82	83	84	85	86	87	88	89	91	92	93	94	95	96	97
98	36.5	76	77	78	80	80	82	83	83	85	86	87	88	89	90	91	92	93	94	95	96	98
99	37.0	76	78	79	80	81	82	83	84	85	87	88	89	90	91	92	93	94	95	96	98	99
100	38.0	77	78	79	81	82	83	84	85	86	87	88	90	91	92	93	94	95	96	98	99	100
101	38.5	77	79	80	81	82	83	84	86	87	88	89	90	92	93	94	95	96	98	99	100	101
102	39.0	78	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100	101	102
103	39.5	78	79	81	82	83	84	86	87	88	89	91	92	93	94	96	97	98	99	101	102	103
104	40.0	79	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101	103	104
105	40.5	79	80	82	83	84	86	87	88	89	91	92	93	95	96	97	99	100	101	102	103	105
106	41.0	80	81	82	84	85	87	88	89	90	91	93	94	95	97	98	99	101	102	103	104	106
107	41.5	80	81	83	84	85	87	88	89	91	92	94	95	96	98	99	100	102	103	104	106	107
108	42.0	81	82	83	85	86	88	89	90	92	93	94	96	97	98	100	101	103	104	105	107	108
109	43.0	81	82	84	85	87	89	89	91	92	94	95	96	98	99	101	102	103	105	106	108	109
110	43.5	81	83	84	86	87	89	90	91	93	94	96	97	99	100	101	103	104	106	107	109	110
111	44.0	82	83	85	86	88	90	91	92	94	95	96	98	99	101	102	104	105	107	108	110	111
112	44.5	82	84	85	87	88	90	91	93	94	96	97	99	100	102	103	105	106	108	109	111	112
113	45.0	83	84	86	87	89	91	92	93	95	96	98	99	101	102	104	105	107	108	110	111	113
114	45.5	83	85	86	88	89	92	92	94	96	97	99	100	102	103	105	106	108	109	111	112	114
115	46.0	84	85	87	88	90	92	93	95	96	98	99	101	102	104	106	107	109	110	112	113	115
116	46.5	84	86	87	89	90	93	94	95	97	98	100	102	103	105	106	108	110	111	113	114	116
117	47.0	85	86	88	89	91	93	94	96	98	99	101	102	104	106	107	109	111	112	114	115	117
118	48.0	85	87	88	90	92	94	95	97	98	100	102	103	105	106	108	110	111	113	115	116	118
119	48.5	85	87	89	90	92	94	96	87	99	101	102	104	106	107	109	111	112	114	116	117	119
120	49.0	86	88	89	91	93	95	96	98	100	101	103	105	106	108	110	111	113	115	117	118	120

FATAL CONDITIONS

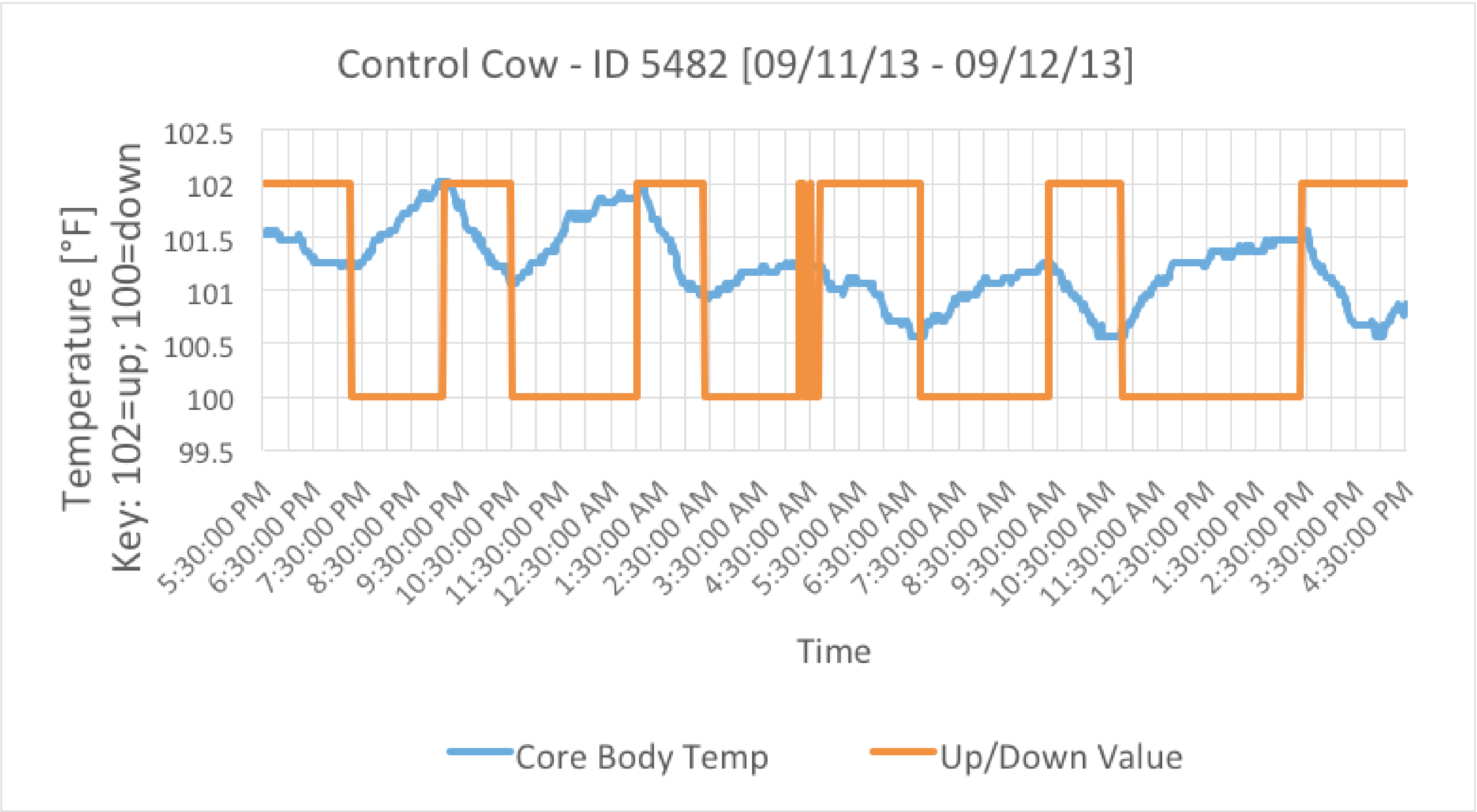
- **Stress Threshold** Respiration rate exceeds 60 BPM. Milk yield losses begin. Repro losses detectable. Rectal temperature exceeds 38.5 °C (101.3°F)
- **Mild-Moderate Stress** Respiration rate exceeds 75 BPM. Rectal temperature exceeds 38°C (102.2°F)
- **Moderate-Severe Stress** Respiration rate exceeds 85 BPM. Rectal temperature exceeds 40 °C (104°F)
- **Severe Stress** Respiration rate 120-140 BPM. Rectal temperature exceeds 41 °C (106°F)

Impact of heat stress at THI 68 ~ 22°C

Adoption of Heat Abatement Measures

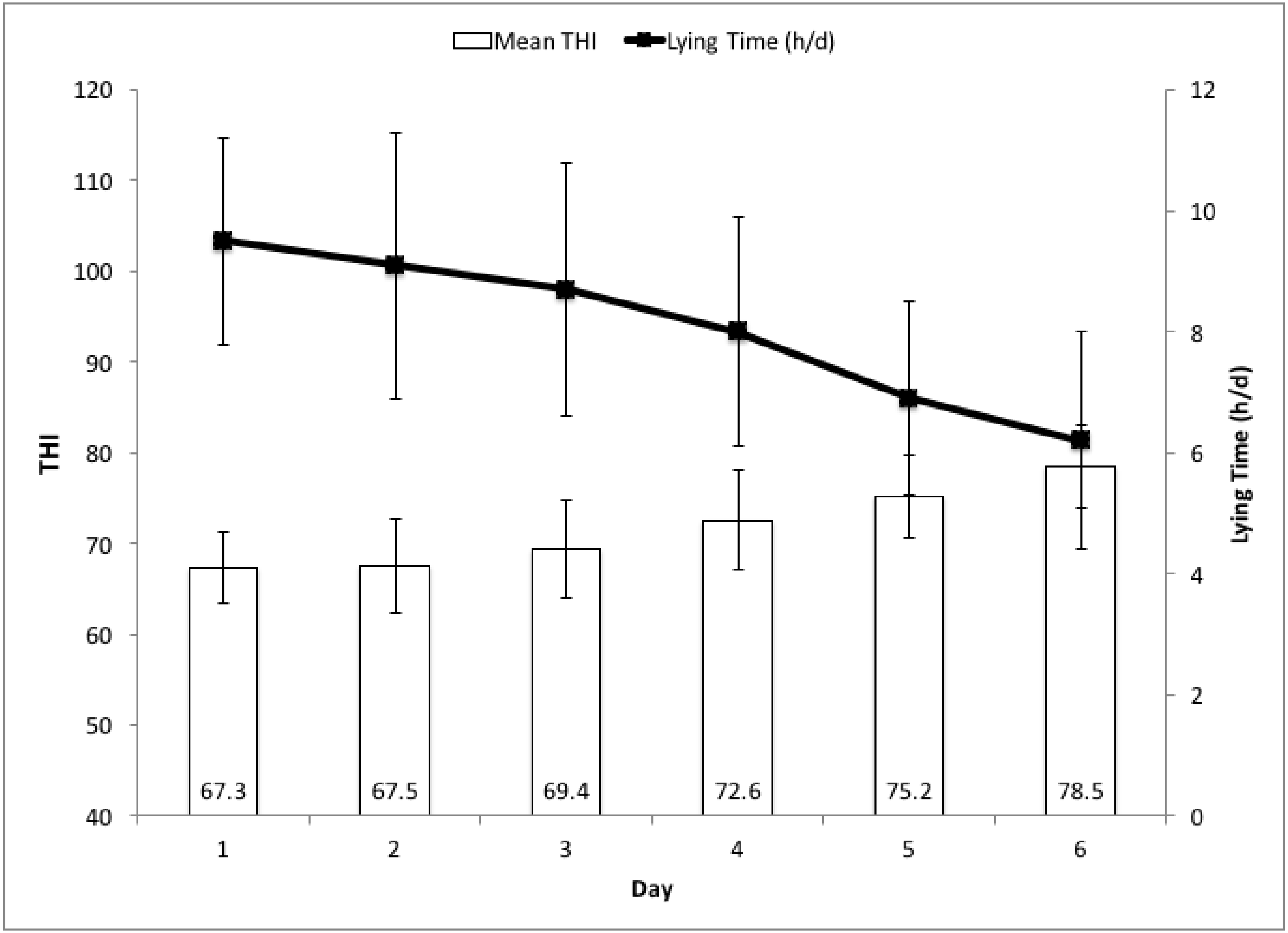
Characteristic	***66 Elite Herds***
Natural Ventilation	86
Fans in holding area	98
Soaking in holding area	62
Fans in pen	84
Soaking in pen	79

Too Hot to Lie Down!

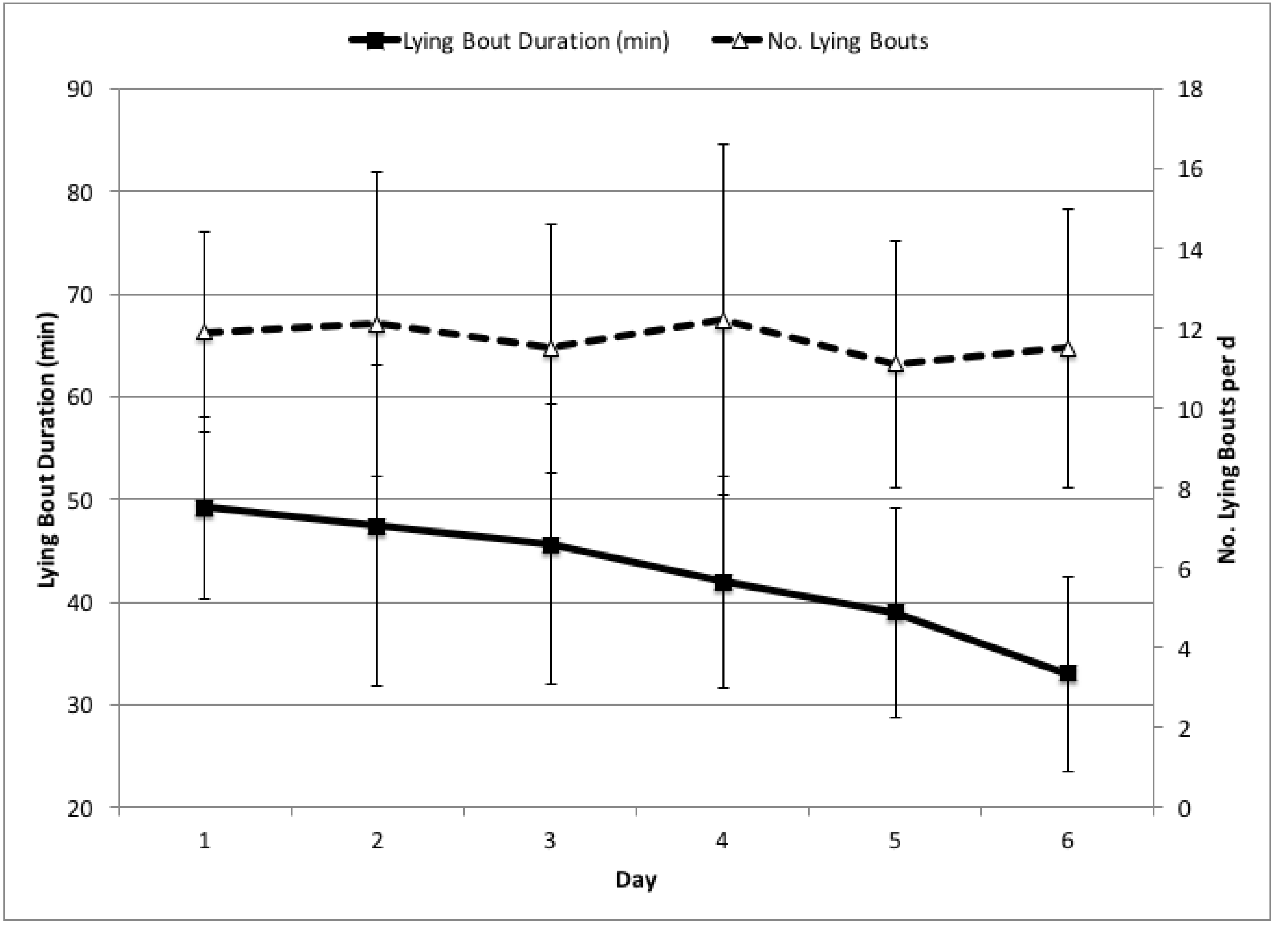


Body temperature increases 0.5ºC per hour when heat stressed cows lie down and decreases by 0.26ºC per hour when they stand

Heat Stress and Resting Behavior



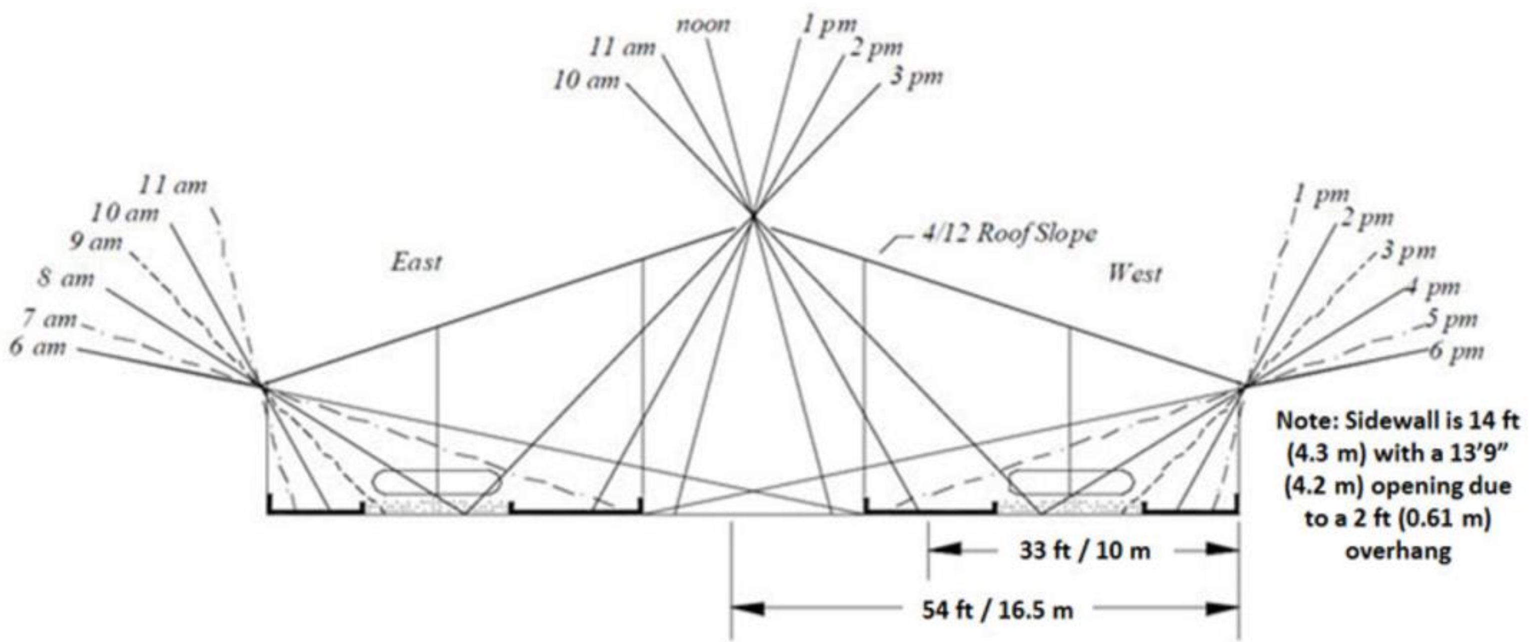
Heat Stress and Resting Behavior



Bunching!

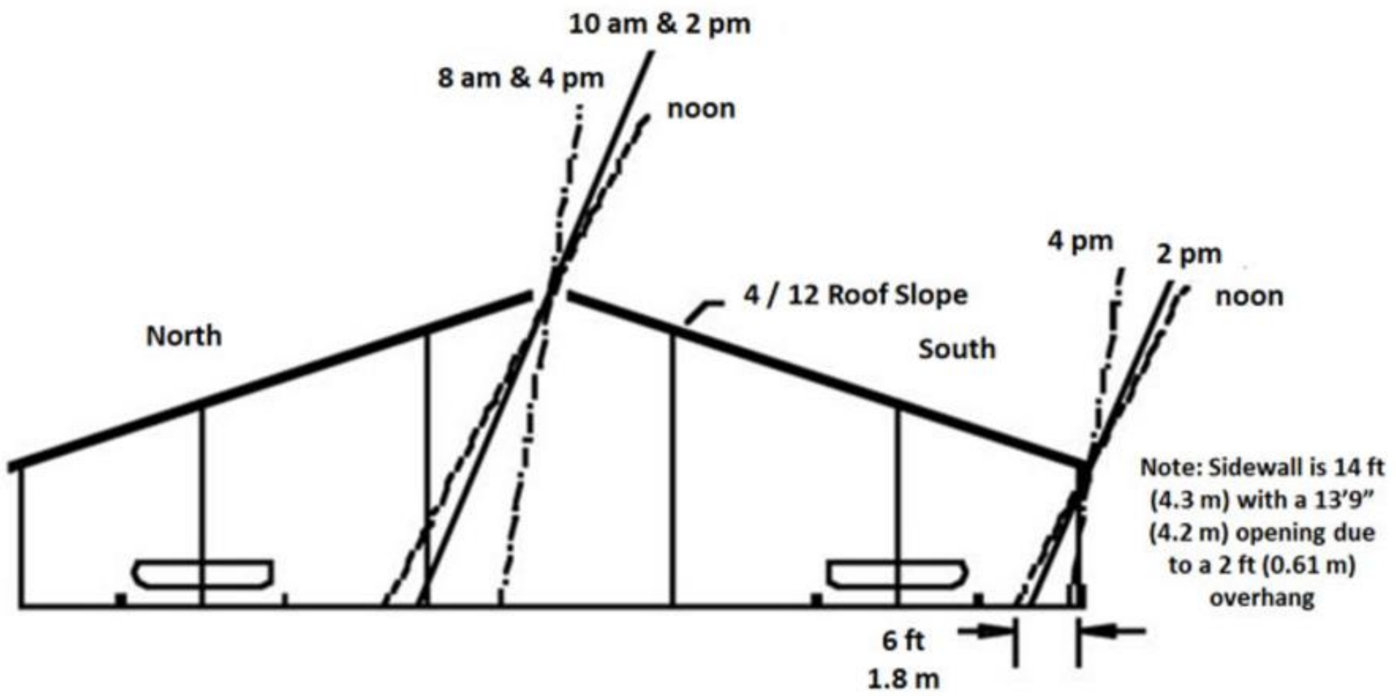
Barn Orientation and the Sun

Sun angles of a north–south oriented freestall barn for August 21, 40 degrees north latitude (Omaha–Springfield).



Barn Orientation and the Sun

Sun angles of an east–west oriented freestall barn for August 21, 40 degrees north latitude (Omaha–Springfield).

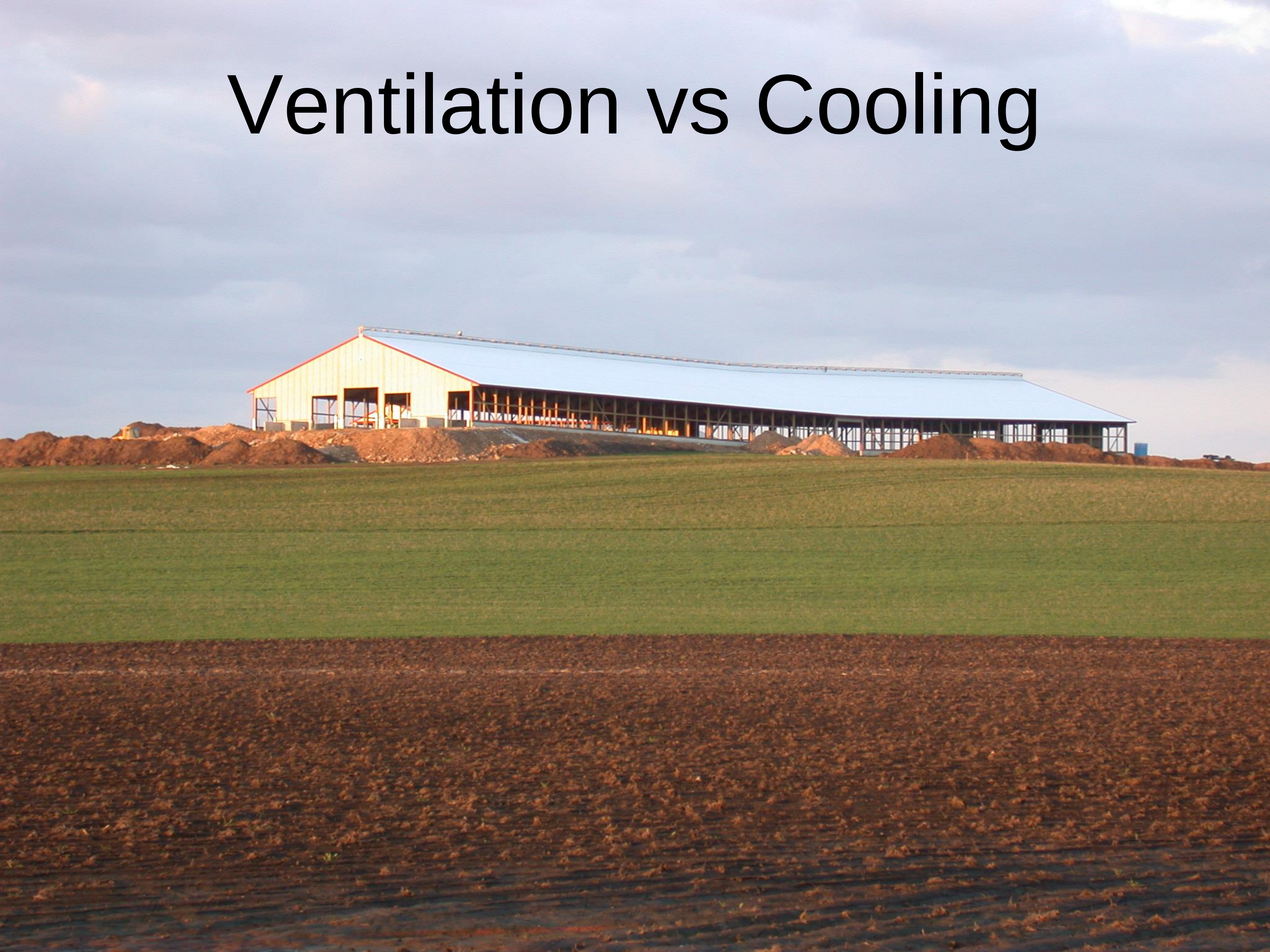


Bunching

- Caused by heat stress and fly worry
- Cows equate ‘hot’ with ‘light’ - grazing animals
- Cows seek darker areas of the barn .... even though it may be hotter!

- Improve heat abatement and darken the barn
- Fly control

Ventilation vs Cooling



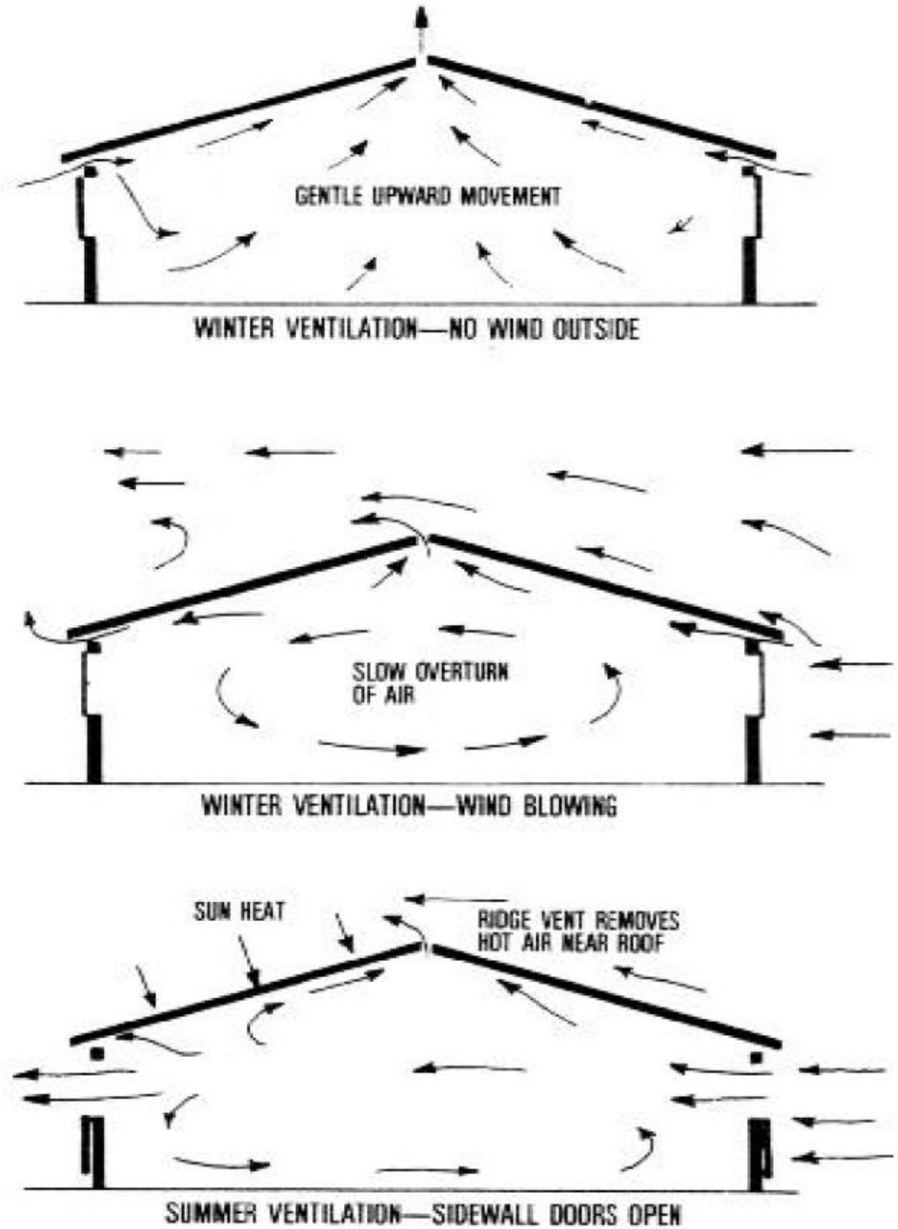
Ventilation = “Out with the old, in with the new”

Natural Ventilation

- Thermal buoyancy (Chimney Effect)
- Warm air rises, cold air falls
- Wind
- Vector force into building openings
- Air passing over the roof creates a lifting force over the ridge

Natural Ventilation Principles

1. Open ridge
2. Open eaves
3. Adequate interior roof slope (1:4 minimum, smooth)
4. Free from wind shadows

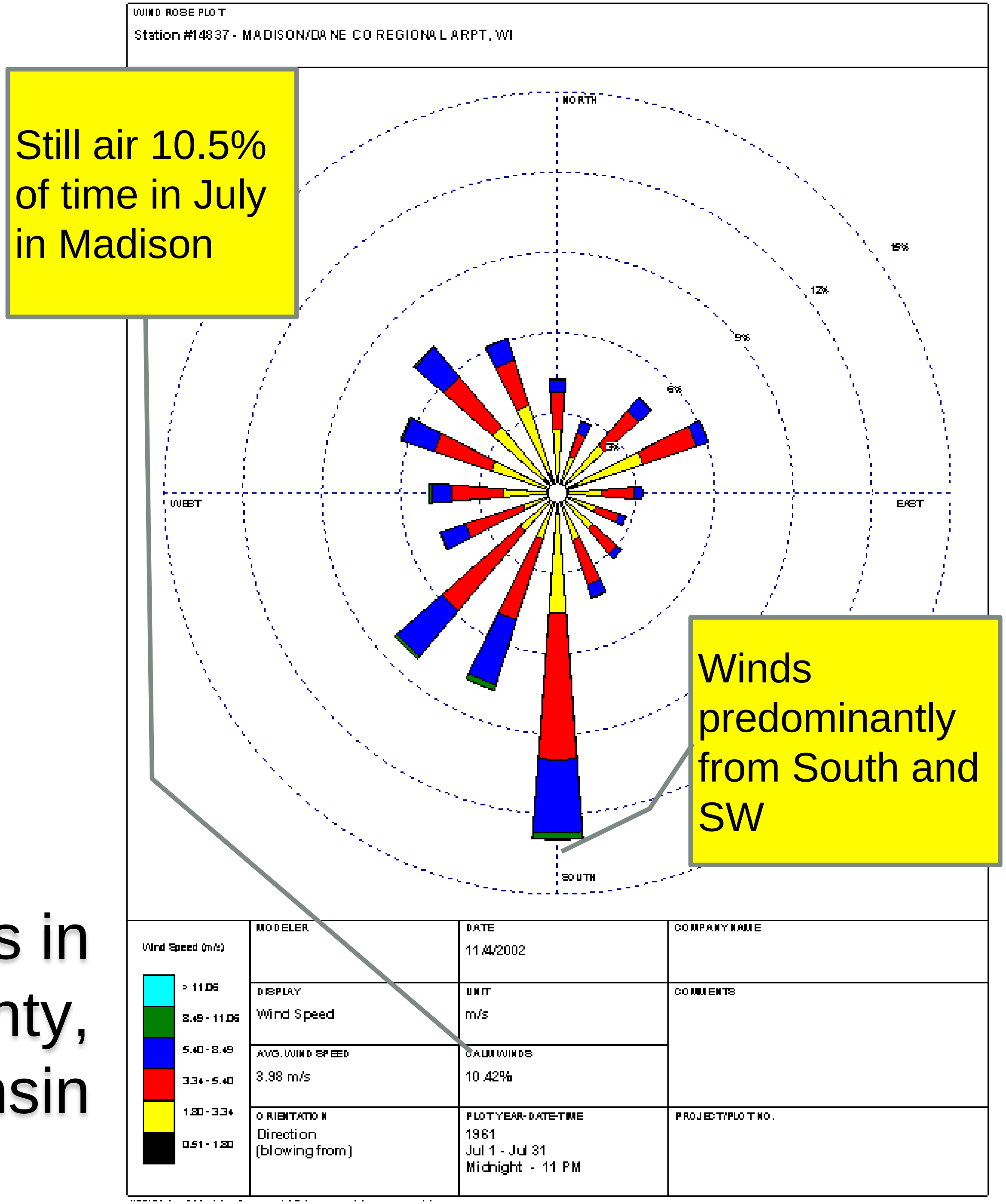


Wind Shadows

Obstructing Height (feet)	Windward building or obstruction, Length (feet)					
	50	75	100	150	200	250
10	50	50	50	50	57	63
12	50	50	50	59	68	76
14	50	50	56	69	79	89
16	50	55	64	78	91	101
18	51	62	72	88	102	114
20	57	69	80	98	113	126
22	62	76	88	108	124	139
24	68	83	96	118	136	152
26	74	90	104	127	147	164
28	79	97	112	137	158	177
30	85	104	120	147	170	190

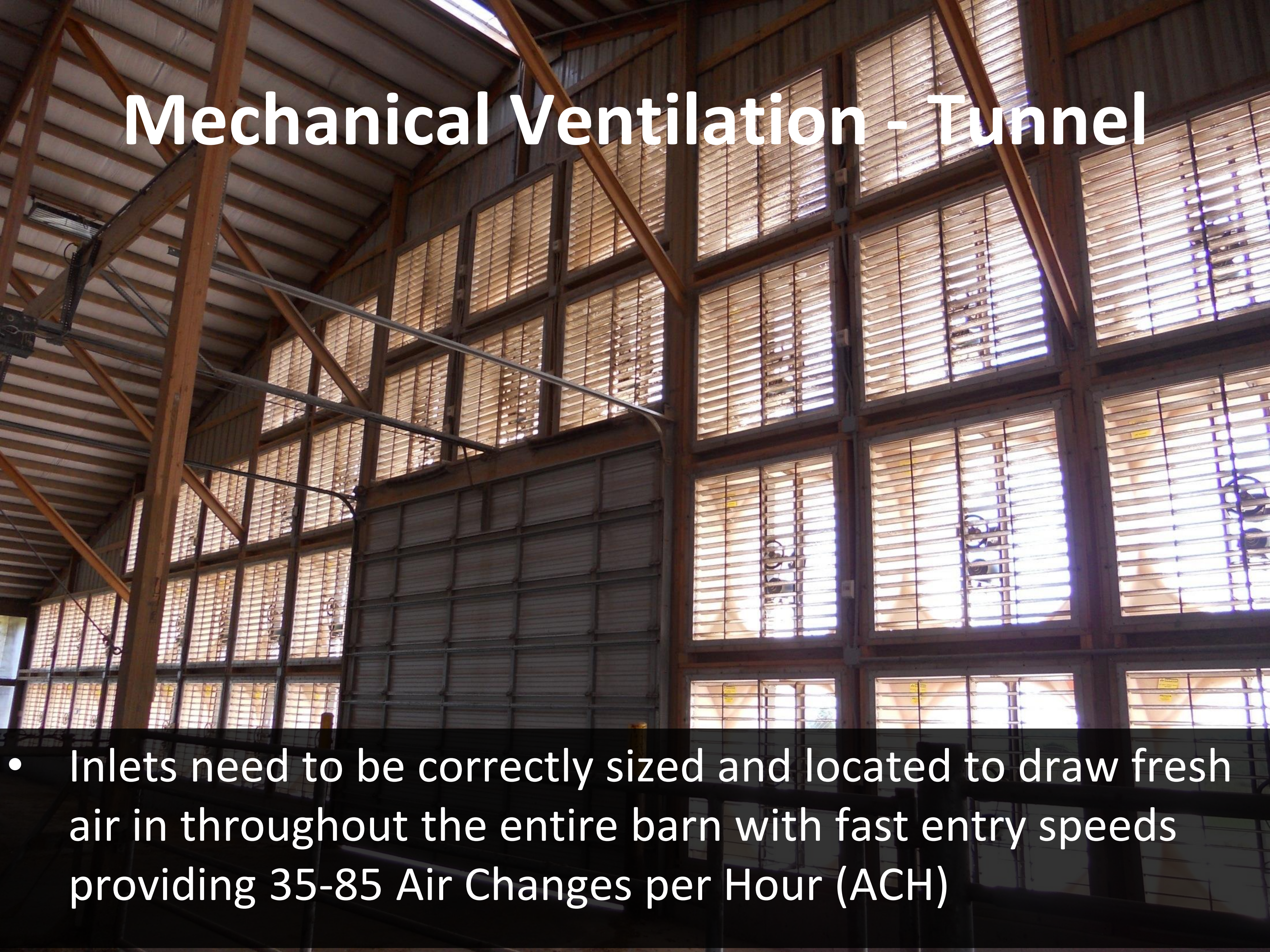
Obstructing Height (meters)	Windward building or obstruction, Length (meters)					
	15.2	22.9	30.5	45.7	61.0	76.2
3.0	15.2	15.2	15.2	15.2	17.4	19.2
3.7	15.2	15.2	15.2	18.0	20.7	23.2
4.3	15.2	15.2	17.1	21.0	24.1	27.1
4.9	15.2	16.8	19.5	23.8	27.7	30.8
5.5	15.5	18.9	21.9	26.8	31.1	34.7
6.1	17.4	21.0	24.4	29.9	34.4	38.4
6.7	18.9	23.2	26.8	32.9	37.8	42.4
7.3	20.7	25.3	29.3	36.0	41.5	46.3
7.9	22.6	27.4	31.7	38.7	44.8	50.0
8.5	24.1	29.6	34.1	41.8	48.2	53.9
9.1	25.9	31.7	36.6	44.8	51.8	57.9

Wind Direction in Wisconsin



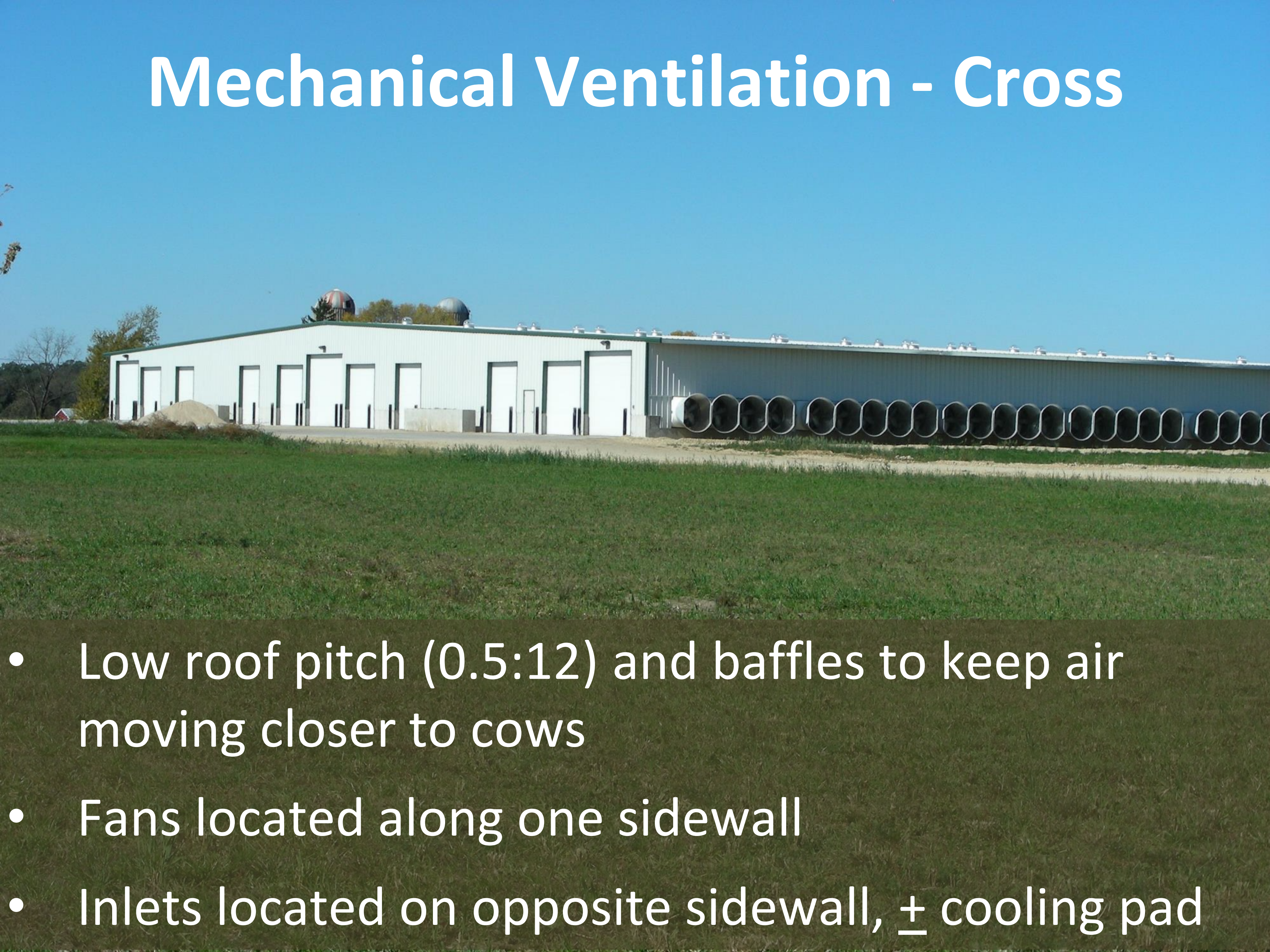
July Winds in Dane County, Wisconsin

Mechanical Ventilation - Tunnel



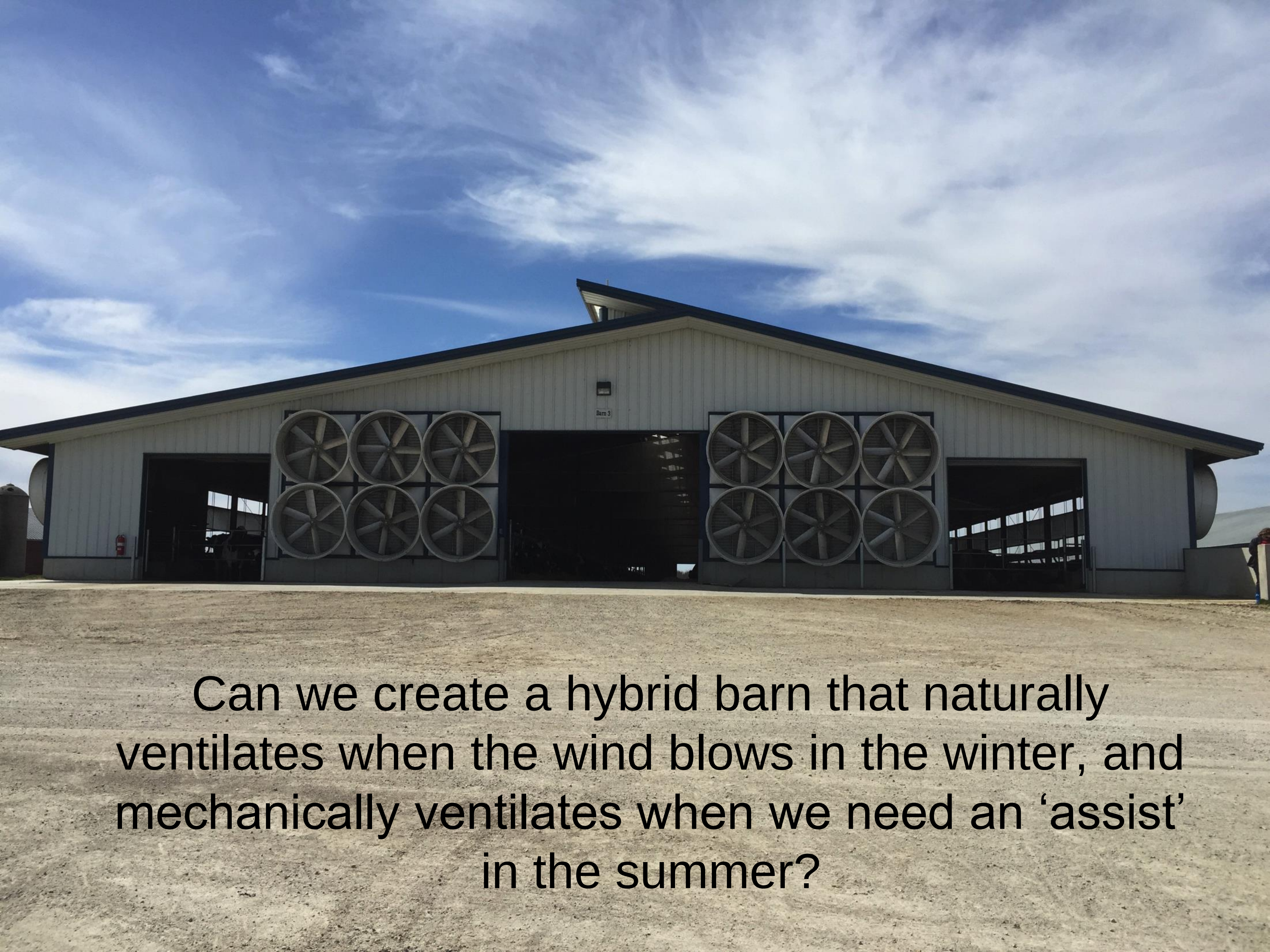
- Inlets need to be correctly sized and located to draw fresh air in throughout the entire barn with fast entry speeds providing 35-85 Air Changes per Hour (ACH)

Mechanical Ventilation - Cross



- Low roof pitch (0.5:12) and baffles to keep air moving closer to cows
- Fans located along one sidewall
- Inlets located on opposite sidewall, ± cooling pad

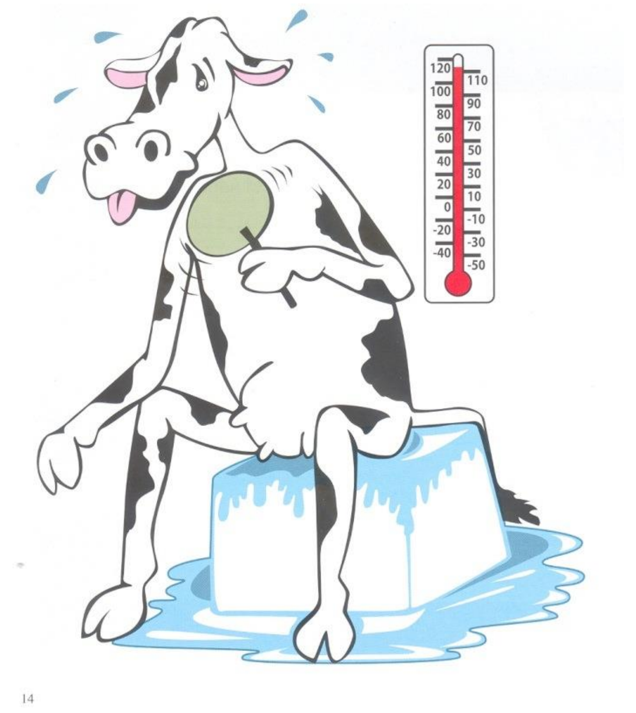
Tunnel	Ventilation System	Cross
Along the length of the barn	***Air flow direction***	Across the width of the barn
Usually 4 or 6 rows	***Rows of stalls***	Can be designed with 4-16 rows, with 8-12 most common
South end of a NS oriented barn or East end of an EW oriented barn	***Usual fan location (to avoid fans working against prevailing winds)***	East side of a NS oriented barn or North of an EW oriented barn
Usually longer than a cross	***Air flow distance***	Usually shorter than a tunnel
At the end wall or along the side walls at one end of the barn, providing less even air entry distribution	***Inlet location***	Along the entire length of the barn, providing evenly distributed air entry over a greater distance
Problems with air flow along the feed and stall alleys once the air enters the barn – path of least resistance	***Air distribution***	Air travels perpendicular to the alleys, with potentially better distribution of air in the cow pen
Influence air flow over very few stalls	***Use of baffles to redirect the air toward the cow***	Function well to distribute air at high speed over a row of stalls along the length of the barn
More restricted space to provide necessary surface area	***Use of Evaporative Cooling Pads***	Better designed along the inlet for even distribution
Roof pitch and openings often suitable for natural ventilation in winter/spring/fall	***Natural ventilation option***	Wide-body barns usually have low roof pitch and side wall location of fans precludes use as an inlet
Potential for natural ventilation and improved air flow with lower risk for freezing	***Winter ventilation***	Air distribution problematic at low ACH – freezing alleys along inlet side of barn common
Largely independent of barn – but transfer lane must be managed as a potential inlet	***Location of the milking center***	Problematic as frequently located at the air discharge side of the barn. Transfer lane may also serve as an inlet.
Optional natural ventilation in an emergency	***Energy dependence***	24/7 requiring back-up generator and emergency plan
Compatible	***Compatibility with organic bedding***	Air speeds may create problems with moving bedding – dust and air hygiene problems
Poorer control of light intensity in barns with a natural ventilation option	***Photoperiod***	Potential for better control of light intensity
Generally barns are traditional width, but they may be spaced closer together vs naturally ventilated barns	***Footprint***	Potential to increase #cows housed in available space in wide-bodies barns



Can we create a hybrid barn that naturally ventilates when the wind blows in the winter, and mechanically ventilates when we need an ‘assist’ in the summer?

How Cows Cool

- Conduction
- Convection
- Radiation
- Evaporation



- When ambient temperature approaches body temperature, the only viable route of heat loss is evaporation - sweating and thermal panting

Methods of Cooling

Cool the Cow

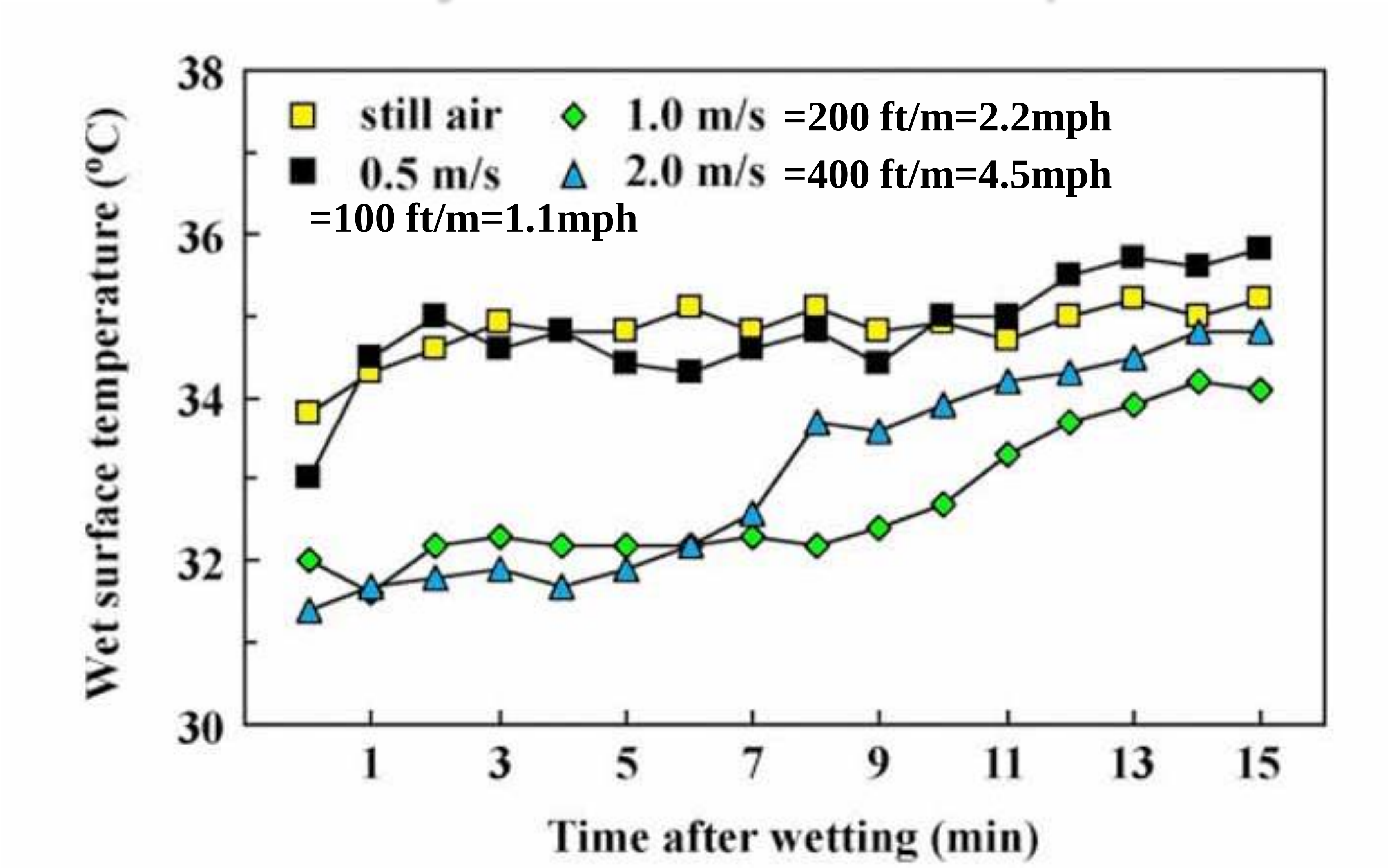
- Air
- Soak
- Air and Soak

Cool the Air

- Misting
- Evaporative Pads
- (Air Conditioning)

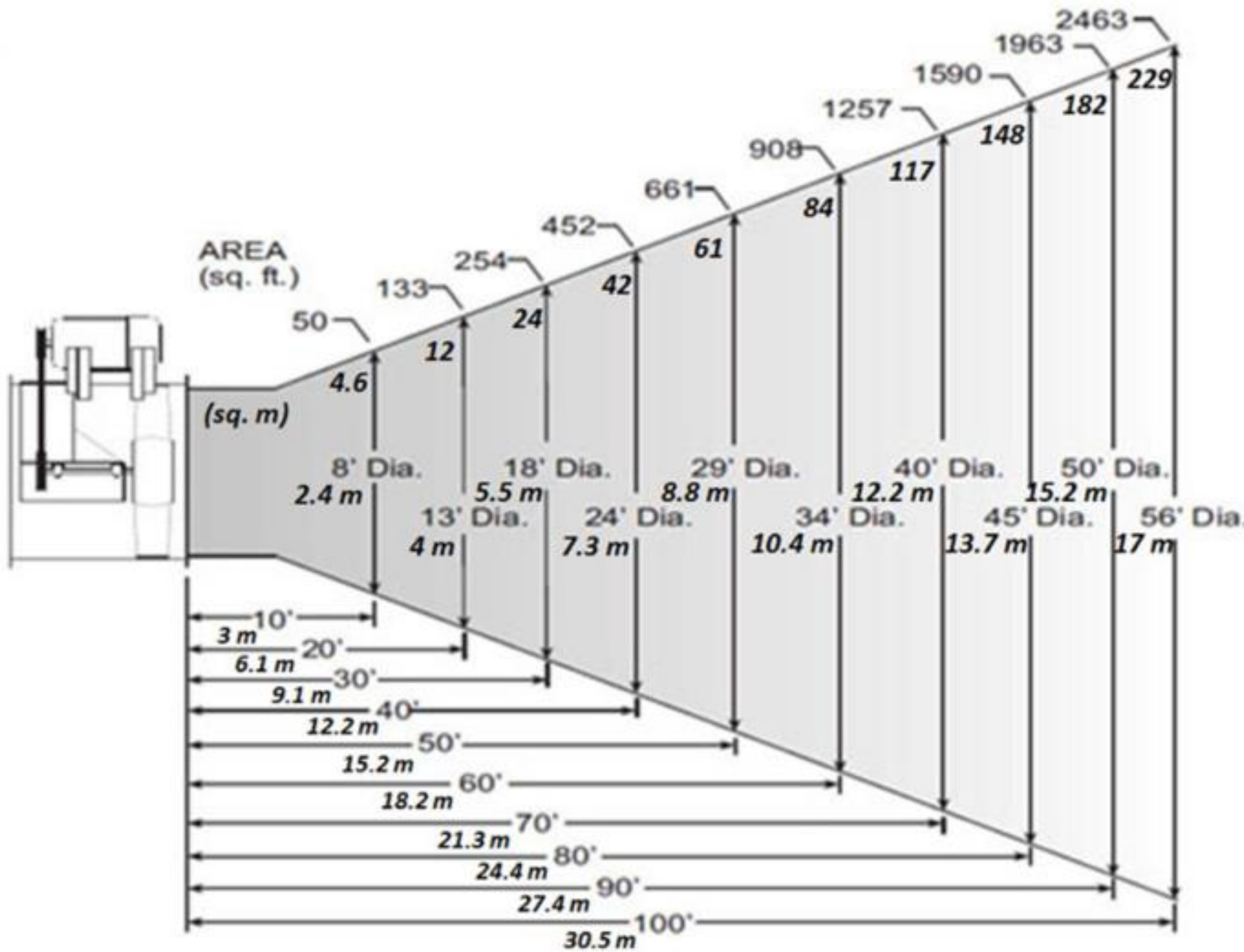
Air Movement and Soaking

Air velocity & wet skin temperature



Berman, JDS 91:4571, 2008

Fan discharge & throw distance



Fan Diameter	0.9 meters	1.2 meters
	5191 Liters/sec	9439 Liters/sec
Distance from Fan, m	**Air Speed, m/s**	**Air Speed, m/s**
1.5	4.2	7.7
3	1.3	2.3
4.6	0.64	1.2
6.1	0.39	0.71
7.6	0.27	0.48
9.1	0.19	0.36
10.7	0.15	0.27
12.1	0.11	0.22
13.7	0.10	0.18
15.2	0.08	0.15

Fan Diameter	3 ft	4 ft
	11,000 cfm	20,000 cfm
Distance from Fan, ft	**Air Speed, ft/min**	**Air Speed, ft/min**
5	834	1516
10	253	461
15	126	230
20	77	140
25	53	95
30	38	70
35	29	54
40	23	43
45	19	35
50	16	29

- With 3-ft fan, optimal air speed of 200-400 ft / minute is 7-11 feet from fan
- With 4-ft fan, optimal zone is 10-15 ft from fan
- Optimal speeds delivered over ~50-75 square feet of area


Is this an efficient
use of water and the
best location for
soaking cows?

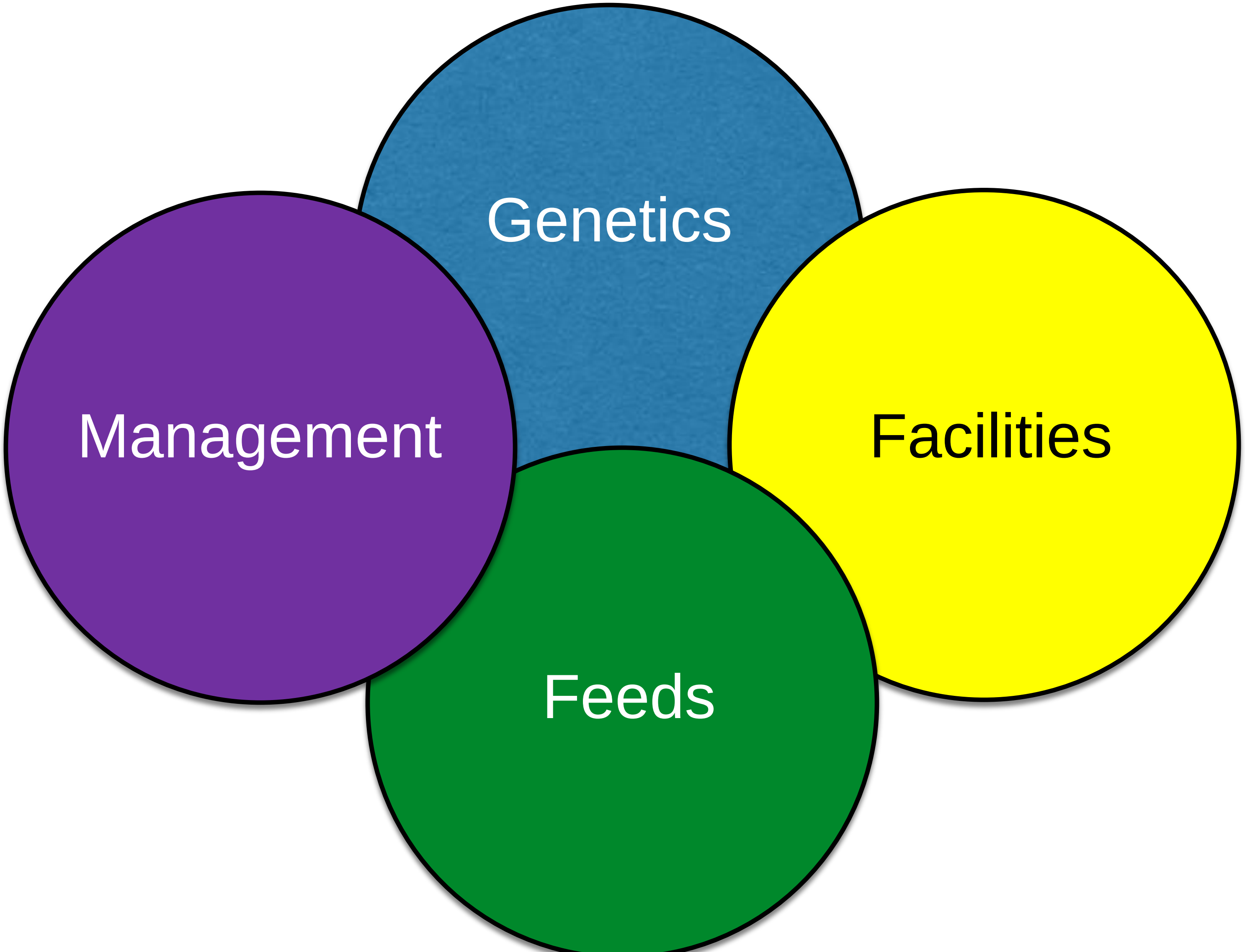
SMART targeted soaking systems - parlor exit lanes, soaker pens?

Topics

- Stalls
- Floors
- Transition
- Cooling and Ventilation

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

Identify the rate limiting step



AMS: A small but rapidly growing segment of our industry

AMS Challenges in North America

(529 herds)

Numeric Variables	Mean	Standard Deviation
Cows_per_Robot	50.5	9.54
Average_DIM	178	27.87
Kg_Concentrate_per_100kg_Milk	15.86	5.38
Rest_Feed_%	7.72	7.38
Number_of_Refusals (per cow per day)	1.86	1.38
Number_of_Failures (per robot per day)	5.49	3.46
Production_per_Cow_per_Day kg	32	4.91
Production_per_Robot_per_Day kg	1627	397
Number_of_Milkings (per cow per day)	2.91	0.36
Milk_Speed (kg per minutes)	2.59	0.31
Average_Boxtime (minutes)	6.84	0.70
Number of Connection Attempts (per cow per day)	1.41	0.23

Temblay et al, submitted

AMS: Poor Decisions

- Slatted floors
- Mattress beds
- 3-row pens

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

The Dairyland Initiative is Sponsored by:

zoetis · Dean Foods Foundation · Saputo · ZINPRO Performance Minerals · PDPW
AgSource Cooperative Services · Save Cows Symposium · DeLaval · Shur-Gain · Landmark Feeds · nutreco · ABS · cowhomes.com

Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

www.thedairylandinitiative.vetmed.wisc.edu

Thank you!