Hay Storage & Feeding Management

by
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Questions to Consider

- Are you cutting hay for quality or quantity?
- Do you know what your bales weigh?
- Are you forage testing to confirm protein, energy and fiber levels?
- Are you tracking hay consumption or hay disappearance?
- What kind of hay feeders are you using?

The goal is to get the most high-quality forage into the animal.

Typical Forage Harvesting Losses

Field curing
-26%

Harvesting
-14%

Storage
-35%

Feeding
-30%

30% Left

Optimum Forage Harvesting Losses

Field curing
-12%

Harvesting
-8%

Storage
-5%

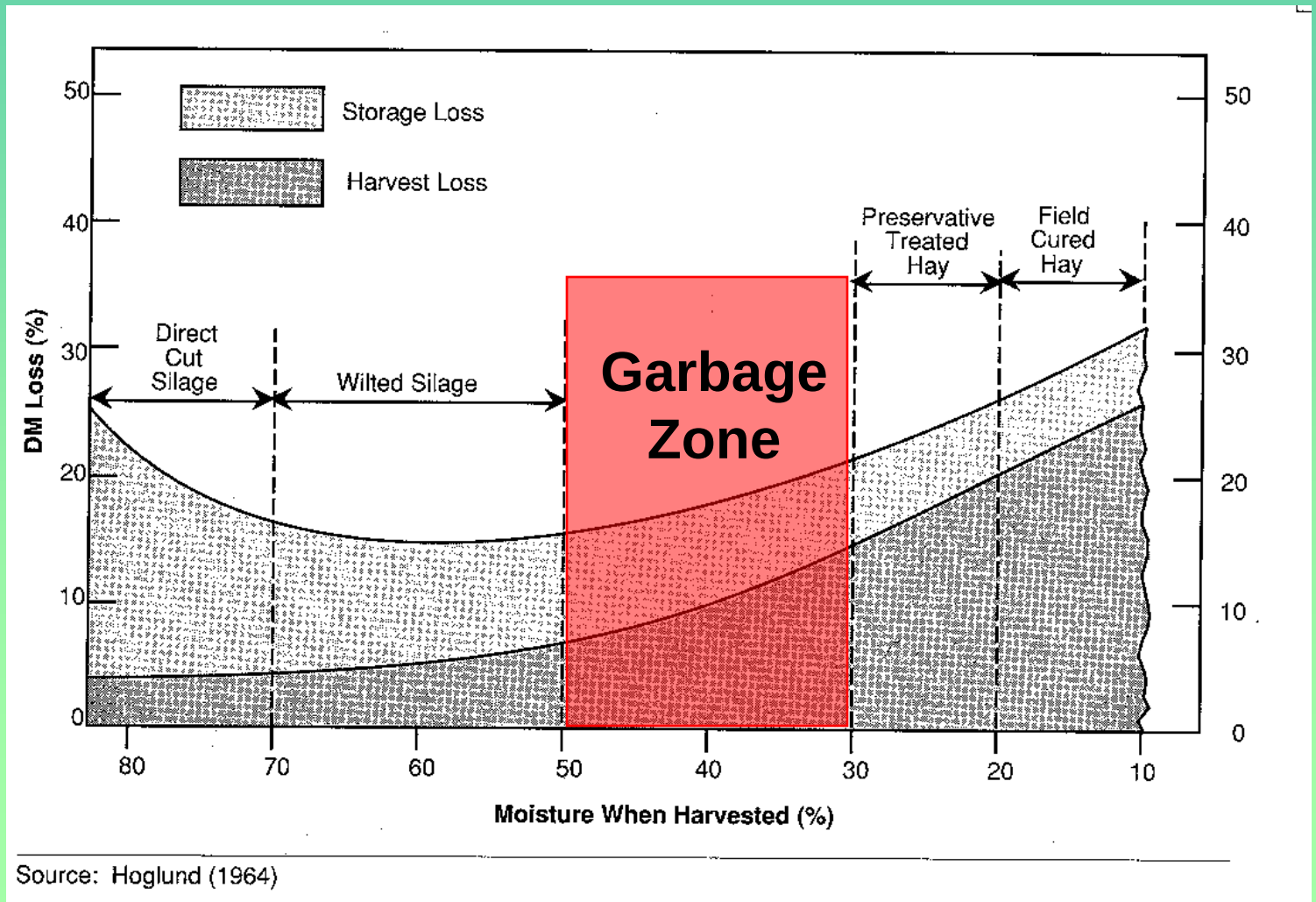
Feeding
-8%

70% Left

Important Factors for Quality Hay

- Forage species
- Cutting - stage of maturity at harvest
- Baling - moisture content at baling
- Handling
- Storage conditions
- Feeding methods

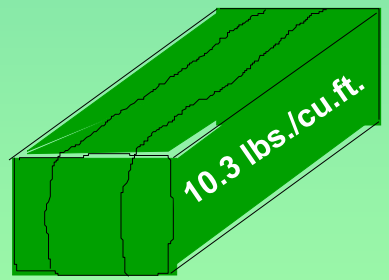
Forage Moisture Affects Dry Matter Harvest & Storage Losses



Source: Hoglund (1964)

Shape Dictates Moisture Content at Baling

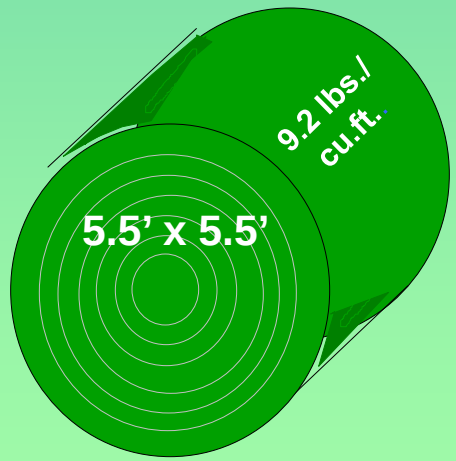
Small Square Bales



60 lbs. ÷ 21.3 sq.ft.

= 2.8 lbs./sq.ft.

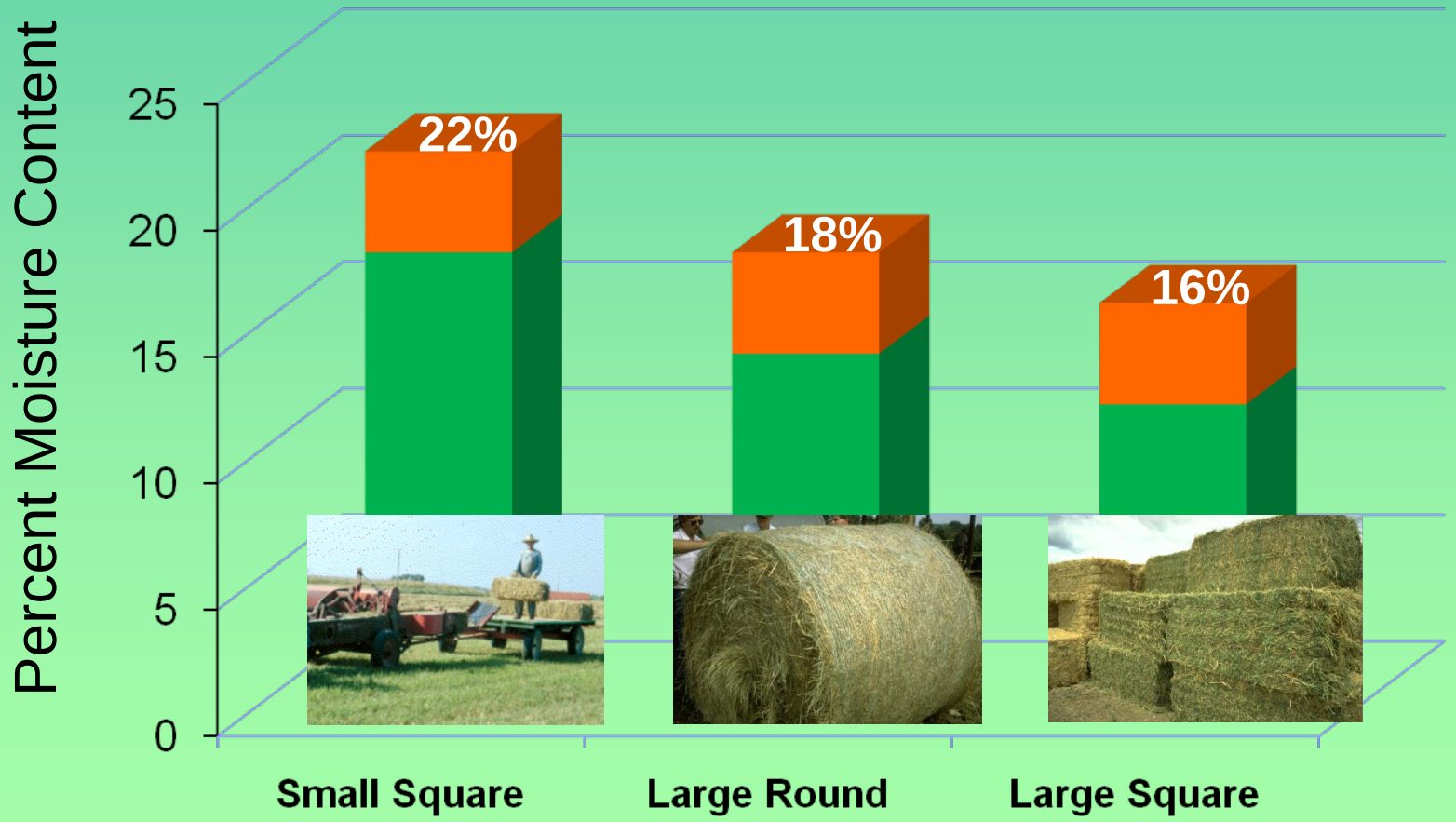
Large Round Bales



1200 lbs. ÷ 142.5 sq.ft.

= 8.4 lbs./sq.ft.

Maximum Hay Moisture Content (%) at Baling



Reference: MU Guide G3151 Using a Microwave Oven to Determine Moisture in Forages
http://extension.missouri.edu/publications/DisplayPub.aspx?P=G3151

Round Bale Silage - Baling

- Bale at 50-60% moisture content

Forage Moisture Testing

Heater/fan dryer (Koster® unit) $365

Photo Credit:
www.enasco.com/product/C08633N

Electrical conductance moisture meter $450

Photo Credit:
www.enasco.com/product/C16283N

Microwave $50 - $100

Photo Credit:
www.agry.purdue.edu/ext/forages/publications/ID-172.htm

Reference: Determining Forage Moisture Concentration
http://pubs.ext.vt.edu/442/442-106/442-106.html

Prices as of January 2014

What Do the Round Bales Weigh?

Density = 9.2 lbs./cu. ft. Moisture content = 18%

Length (feet)	Diameter (feet)	Weight (lbs.)	Surface Area (sq.ft.)	Volume (cu.ft.)	Weight per Surface Area (lbs./sq.ft.)	Dry matter per bale (lbs.)
4.0	4.0	**462**	75.4	50.3	6.1	379
4.0	5.0	**723**	102.1	78.5	7.1	593
5.0	5.0	**903**	117.8	98.2	7.7	741
5.0	5.5	**1,093**	133.9	118.8	8.2	896
5.0	6.0	**1,301**	150.8	141.4	8.6	1,067
5.5	5.5	**1,202**	142.5	130.7	8.4	986
6.0	6.0	**1,561**	169.6	169.6	9.2	1,280

What Do the Square Bales Weigh?

Small Square Bales
Density = 10.3 lbs./cu. ft. Moisture content = 22%

Height (in.)	Width (in.)	Length (in.)	Weight (lbs.)	Surface Area (sq.ft.)	Volume (cu.ft.)	Weight per Surface Area (lbs./sq.ft.)	Dry matter per bale (lbs.)
14.0	18.0	40.0	**60**	21.3	5.83	2.8	47
16.0	18.0	40.0	**69**	22.9	6.67	3.0	54

Large Square Bales
Density = 10.3 lbs./cu. ft. Moisture content = 16%

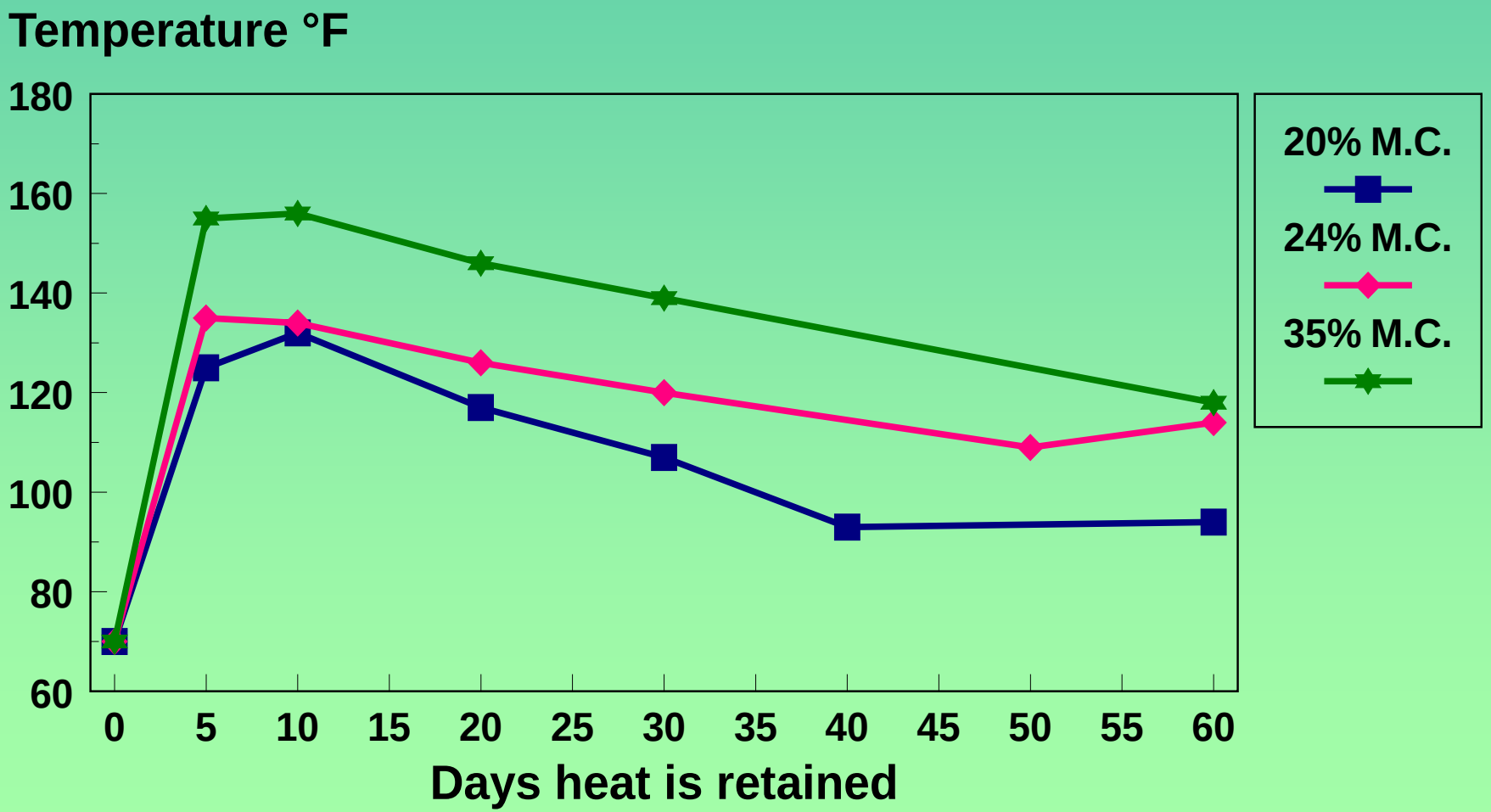
Height (in.)	Width (in.)	Length (in.)	Weight (lbs.)	Area (sq.ft.)	Volume (cu.ft.)	Weight per Surface Area (lbs./sq.ft.)	Dry matter per bale (lbs.)
36.0	36.0	96.0	**742**	114.0	72.00	6.5	623
36.0	48.0	96.0	**989**	136.0	96.00	7.3	831
48.0	48.0	96.0	**1,318**	160.0	128.00	8.2	1,107

Final Moisture Content of Baled Hay, %

Temperature, °F	Relative Humidity, %			
	30	**50**	**70**	**80**
70	10	13	21	39
80	8	12	20	38
85	7	10	18	37
95	5	8	16	36

At a given temperature and relative humidity, there is a corresponding moisture content below which the hay will no longer release moisture.

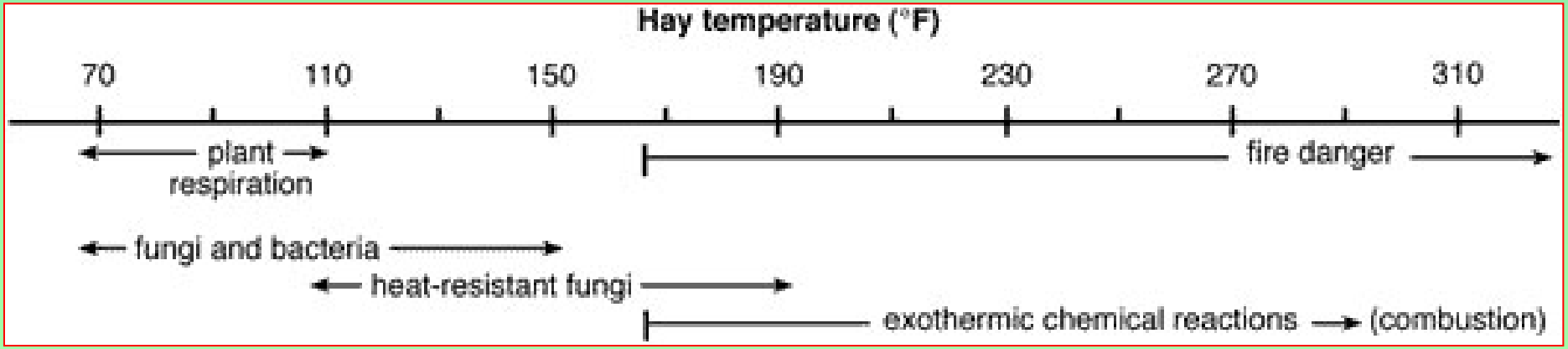
Effect of Moisture at Baling Time on Heat Retention in Big Bales



Source: University of Missouri, 1979

Critical Bale Temperatures

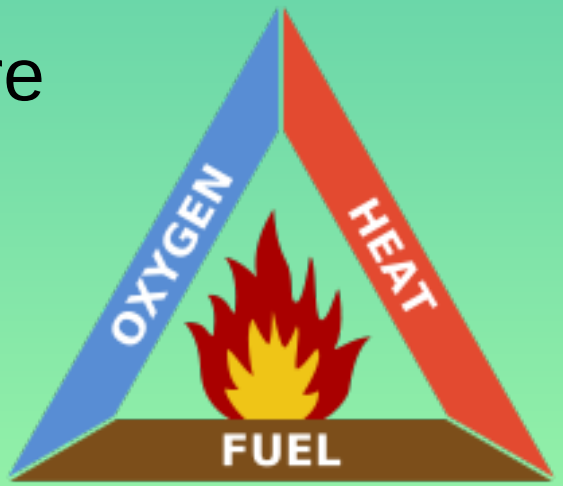
Bale Temperature	Considerations
<120 °F	**Safe**
120 °F – 160 °F	**Caution:** Monitor for temperature increase
>160 °F	**Fire is likely!!** Call fire department. Remove susceptible bales to safe area away from other hay



Reference: MU Guide G4575 Making and Storing Quality Hay
http://extension.missouri.edu/publications/DisplayPub.aspx?P=G4575

Heating Losses

- Fire



- Mold damage
- Maillard reaction (browning)
  - Formation of sugar/protein polymers
  - Lowers digestibility of available protein and sugars
  - Test for available protein as well as total protein

Round Bale Storage Alternatives

- Outside
  - In field
  - In rows
  - Individual covers
  - Wrapped
  - Pyramid stack
- Inside
  - Pyramid stack
  - On-end stack

Outside-Stored Round Bales

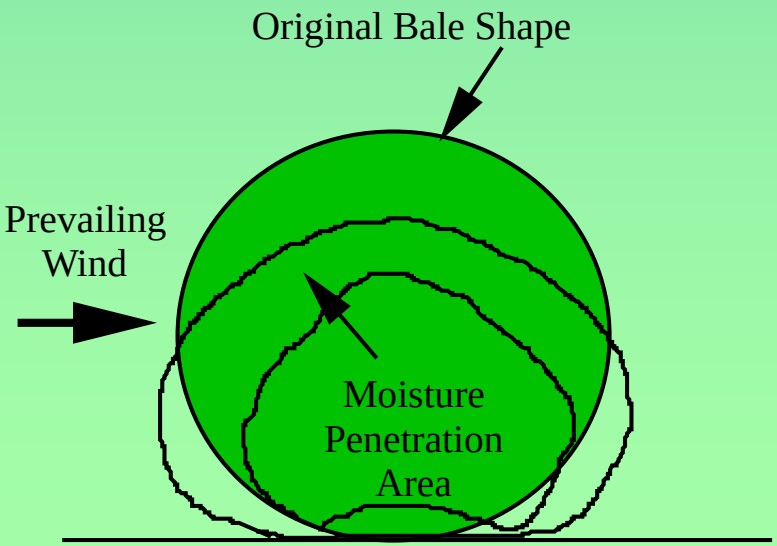
- **Less dense** → more squat → more damage
- **Under trees** → less drying → more damage
- **Flat ground** → less drainage → more damage
- **Rounded sides touching** → more damage
- **Smaller diameter** → more damage

Bale Density Affects Weathering

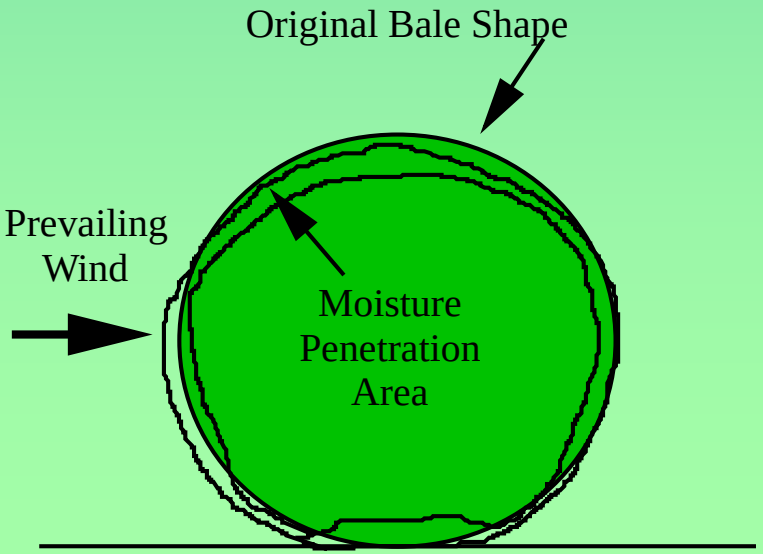
Precipitation = 3 inches

Storage Time = 100 days

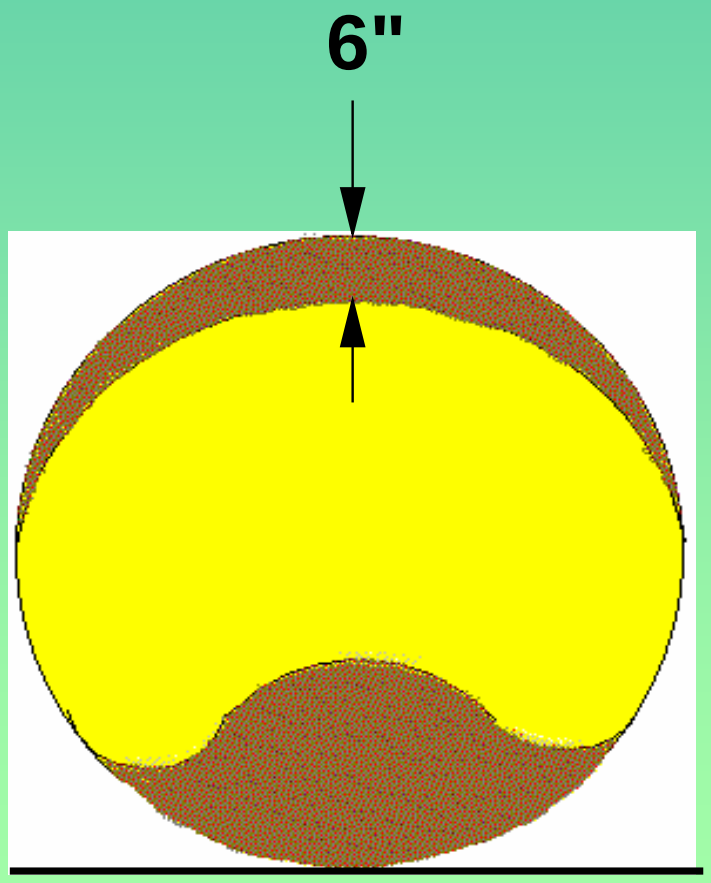
Moisture penetration = 16.3"
74% of original height
Very difficult to handle



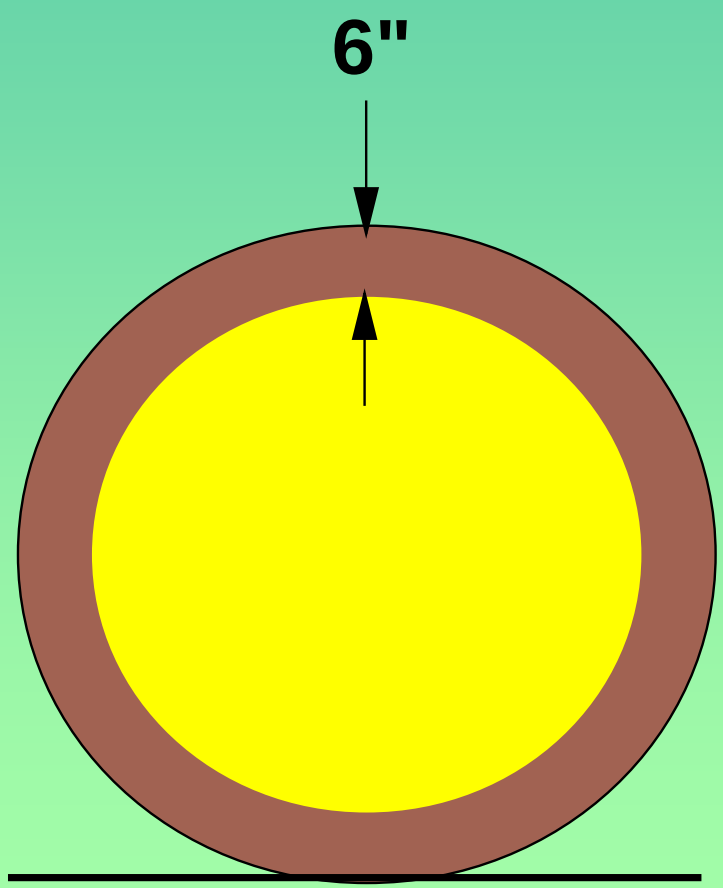
Moisture penetration = 3.5"
91% of original height
Easy to handle



Estimating
Round Bale Spoilage Depth

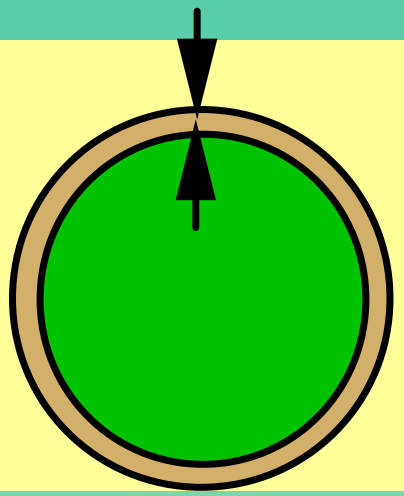


Actual spoilage pattern



Equivalent spoilage

Amount of Dry Matter in Outer Layers of Round Bales

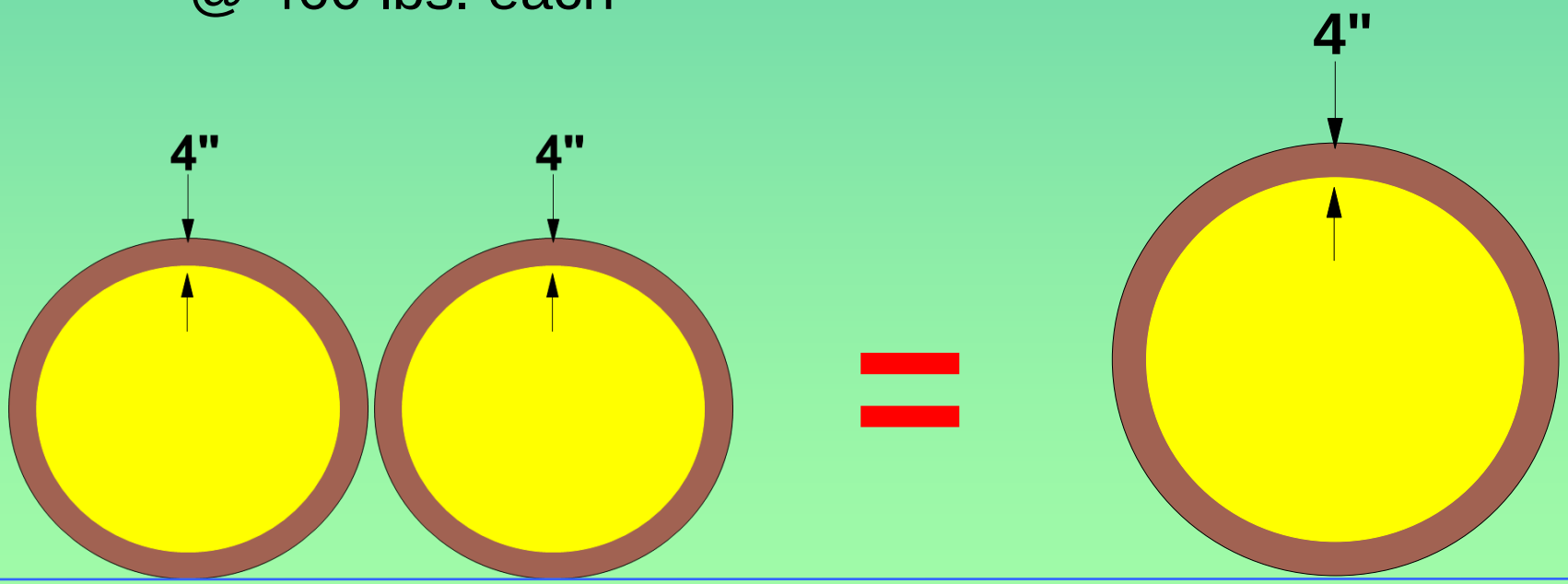


Bale Dia. (feet)	Outer Layer Depth (inches) 2"	4"	6"	8"	10"	12"
	% Dry Matter					
3.0	21	40	56	69	80	89
3.5	18	35	49	62	73	82
4.0	16	31	44	56	66	75
4.5	14	27	40	51	60	69
5.0	13	25	36	46	56	64
5.5	12	23	33	43	51	60
6.0	11	21	31	40	48	56

Which Has More Spoilage?

Two 4’ x 4’ bales
@ 460 lbs. each

One 5.5’ x 5.5’ bale
@ 1200 lbs. each



141 lbs. + 141 lbs.

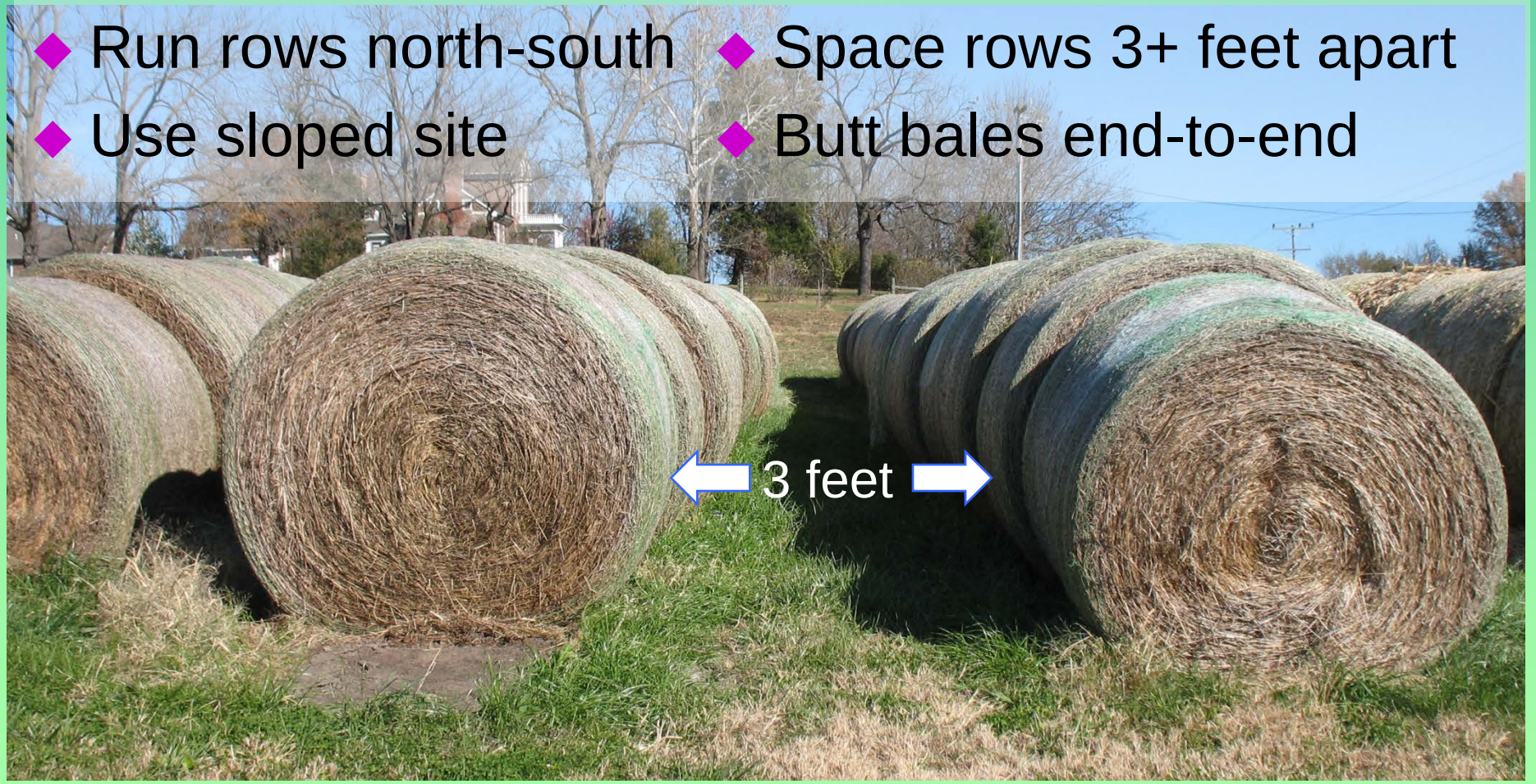
31% 31%

273 lbs.

23%

Outside Uncovered Storage

- Run rows north-south
- Use sloped site
- Space rows 3+ feet apart
- Butt bales end-to-end



Individual Bale Covers or Sleeves

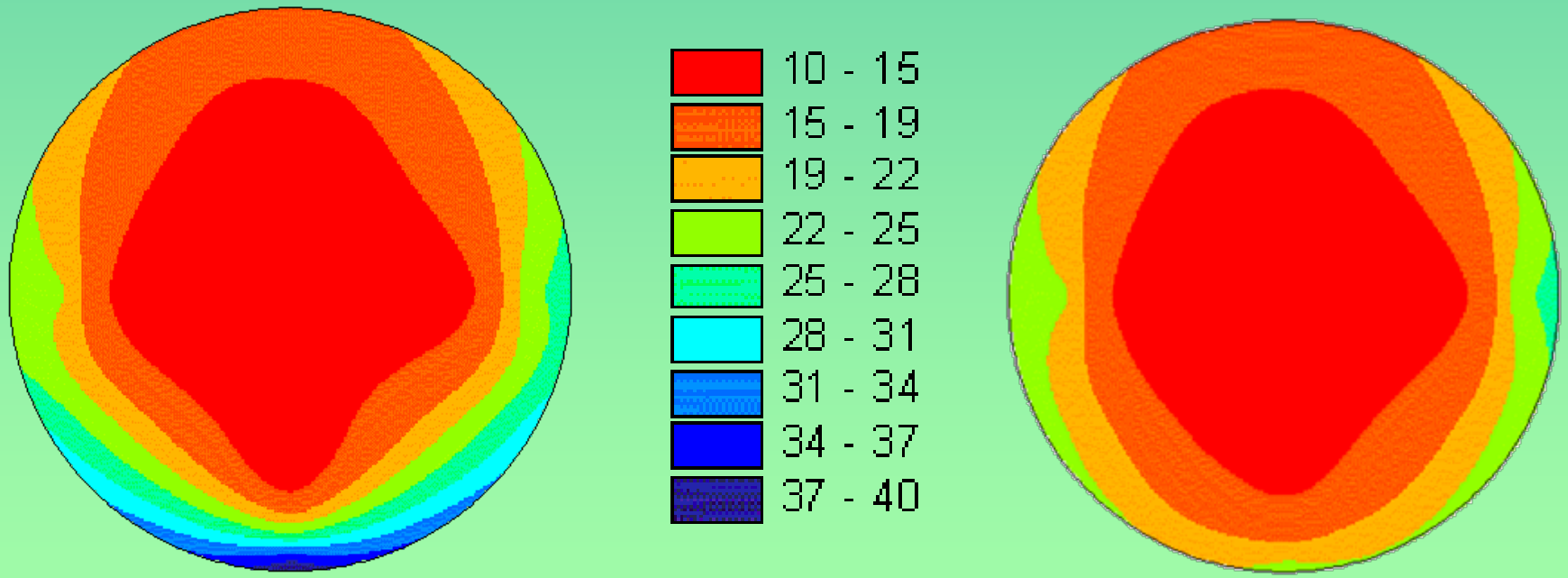
- Trap excess moisture under plastic
- Lost bonnet spikes can puncture tires
- Wind or animal damage likely
- Better than no cover at all

Reduce Ground Contact

Pallets, poles or railroad ties

Net wrap

Moisture Distribution of Twine Wrapped Alfalfa/Grass Round Bales Stored on the Ground vs. on Pallets



Soil Contact

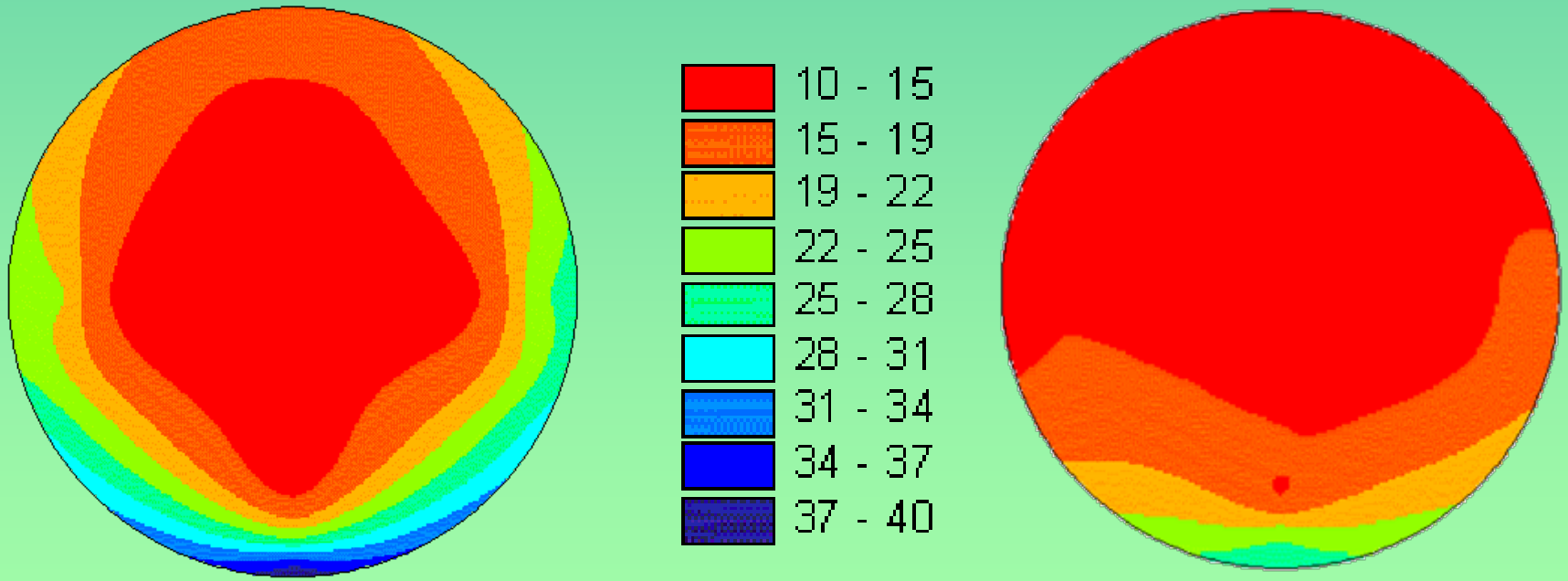
Pallet

Images courtesy of Dr. Kevin Shinners, U of Wisconsin

Is Net-Wrap Worth the Cost?

- Costs $.30 -$.50 more per bale than plastic twine
- Installs quicker than twine; saves fuel & labor
  - 10 seconds vs. 60 seconds
- Sheds water 2X better than twine (3” twine spacing)
- Helps hold bale shape better
  - Less wind damage & bottom rotting
- Can save lost hay if handled often
- May save time at feeding
  - Depends on mud & ice cover
  - Less so with elastic edge

Moisture Distribution of Twine Wrapped vs. Net Wrapped Alfalfa/Grass Round Bales Stored on the Ground



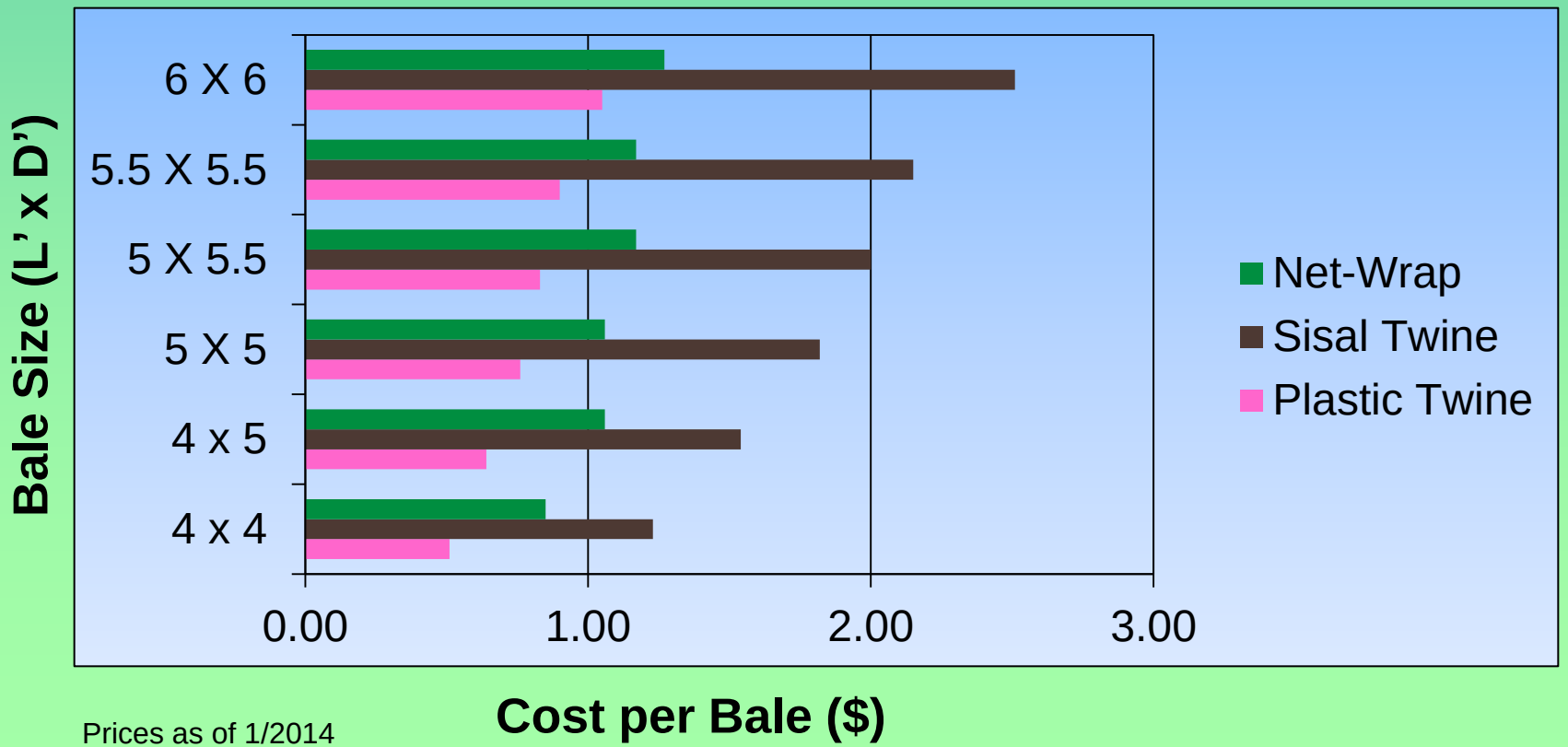
Twine Wrapped

Net Wrapped

Images courtesy of Dr. Kevin Shinners, U of Wisconsin

Economics of Net-Wrap vs. Twine

- **Net-Wrap: $210 per 64” x 7,000 ft. roll, 2¼ wraps/bale**
- **Sisal Twine: $40 per 9,000 ft. bale, 3" spacing**
- **Plastic Twine: $37 per 20,000 ft. bale, 3" spacing**



Prices as of 1/2014

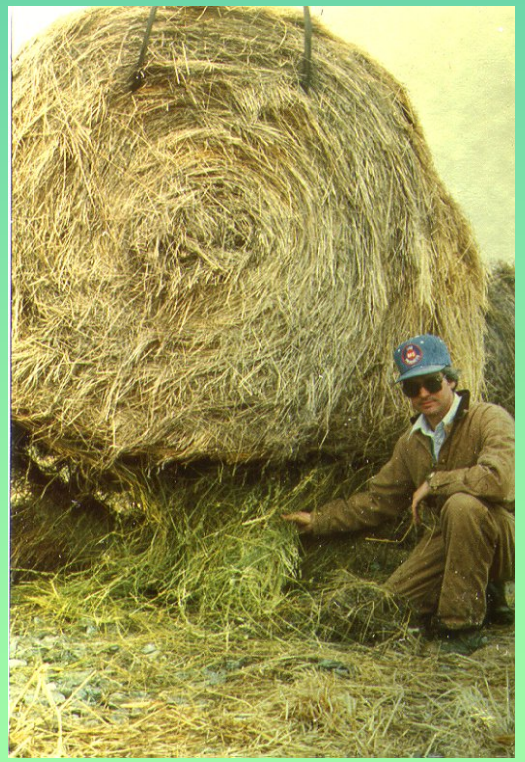
John Deere B-Wrap™
An Alternative to Indoor Storage

- Costs about $5 more per bale than net-wrap
- Sheds rain and snow; protects from ground moisture
- Microscopic pores allow bale moisture to escape
- Installs like net-wrap using a special baler kit
- 1 layer net-wrap + 1 layer B-wrap + 2 layers net-wrap
- Works with baled hay & crop residues; best on high-quality hay
- May achieve similar losses as hay stored in barn

Photo credit: www.deere.com

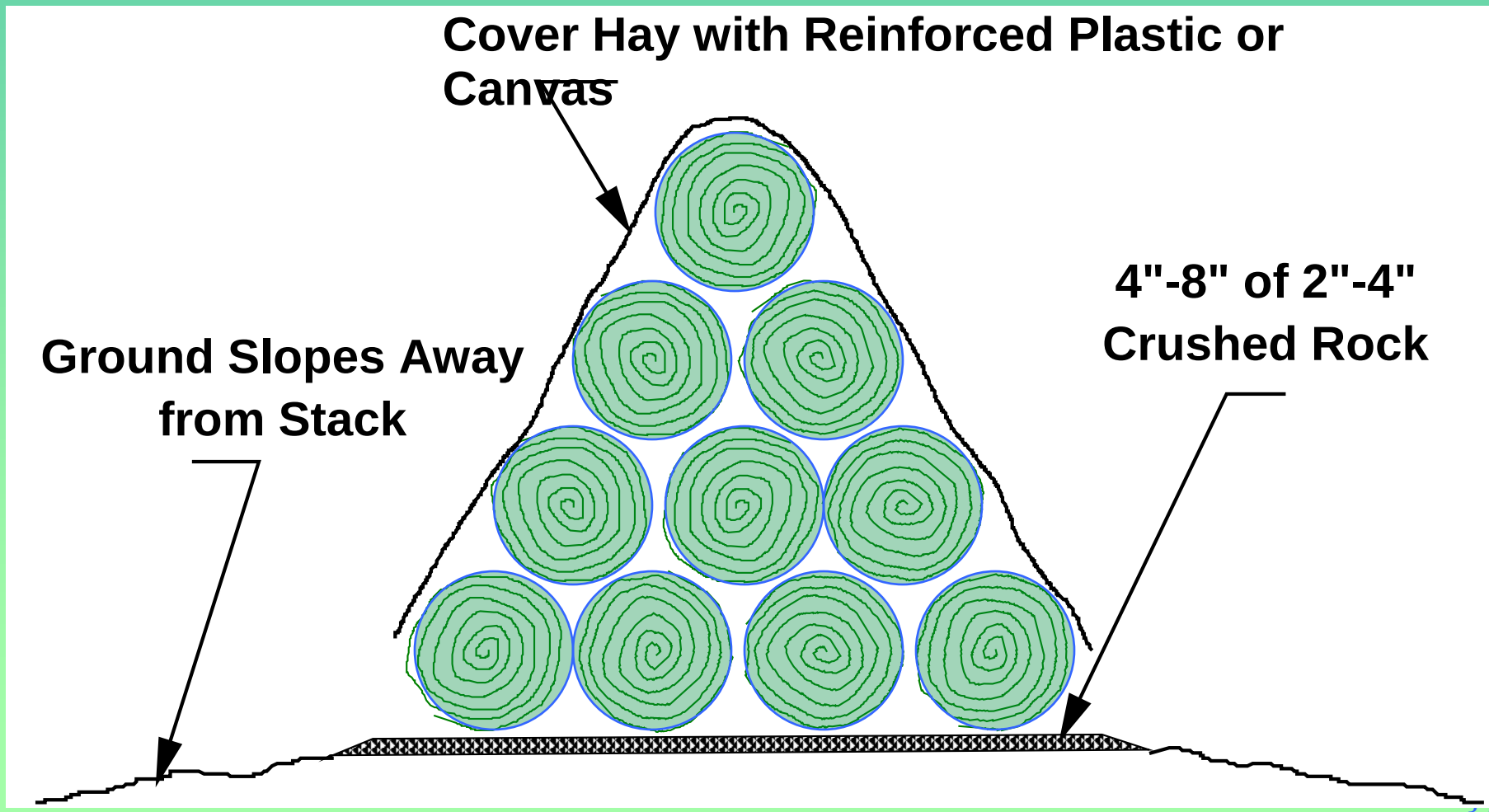
Pyramid Stacking + Rock Base

End ropes tie to post under stack.
Rebar “Ts” in grommets hold sides.



After 6 months
outside storage

Large Round Bale Outside Storage



Ownership Cost Summary for Crushed Rock & Reinforced Plastic Tarpaulin

Assumed:

a. 28' W x 120' L x 8" thick crushed rock pad

b. Pad holds 200 bales weighing 1200 lbs. each, 66" L x 66" D **(120 tons)**

c. Maintenance on rock and tarp is minimal for 3 year life.

Construction Cost::

a. 2"-4" dia. rock (50% <4" dia.), 140 tons @ $19.00/ton = $2,660

8" x 28' x 120' = 2240 cu.ft. = 83 cu.yd.

2240 cu.ft. x 125 lb./cu.ft. = 280,000 lb. = 140 tons

$13.00/ton FOB plant, plus $6.00/ton delivery within 15 mi.

b. Tarpaulin, 12-mil, reinforced polyethylene plastic = $1,430

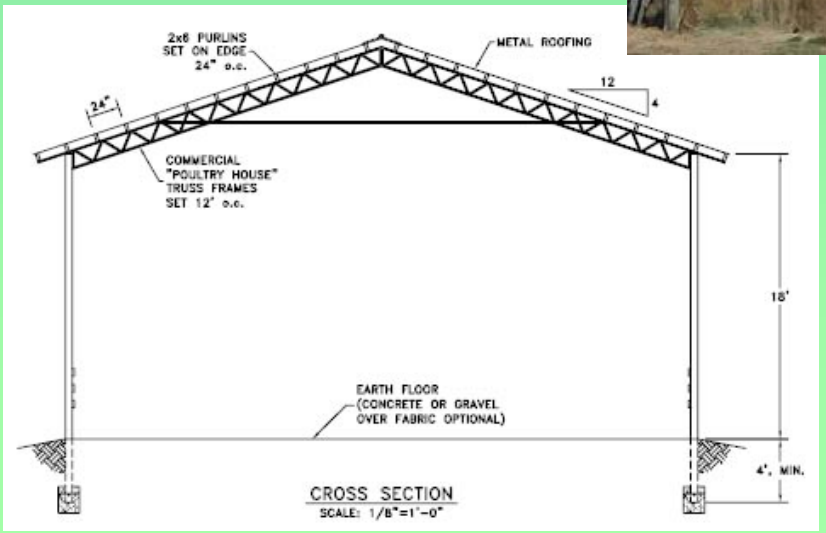
60' x 120' x $0.20/sq.ft.

Total Cost = $4,090

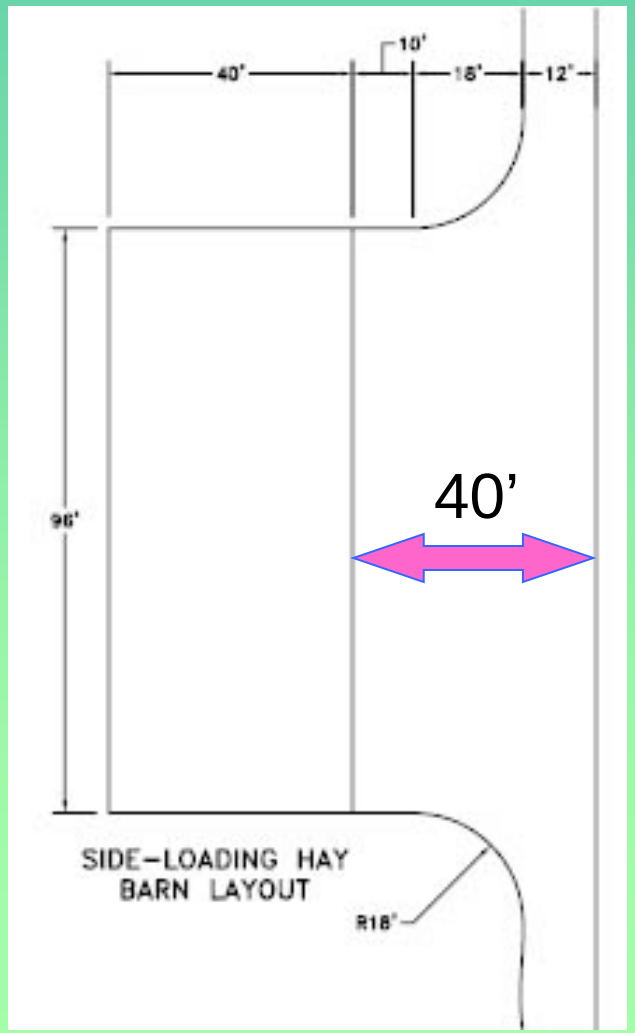
Prices as of 12/2010 --Rock cost ranges from $8-$14 per ton, depending on quarry
Reference: www.tarpaflex.com/acatalog/Silver_Heavy_Duty_Poly_Tarps.html

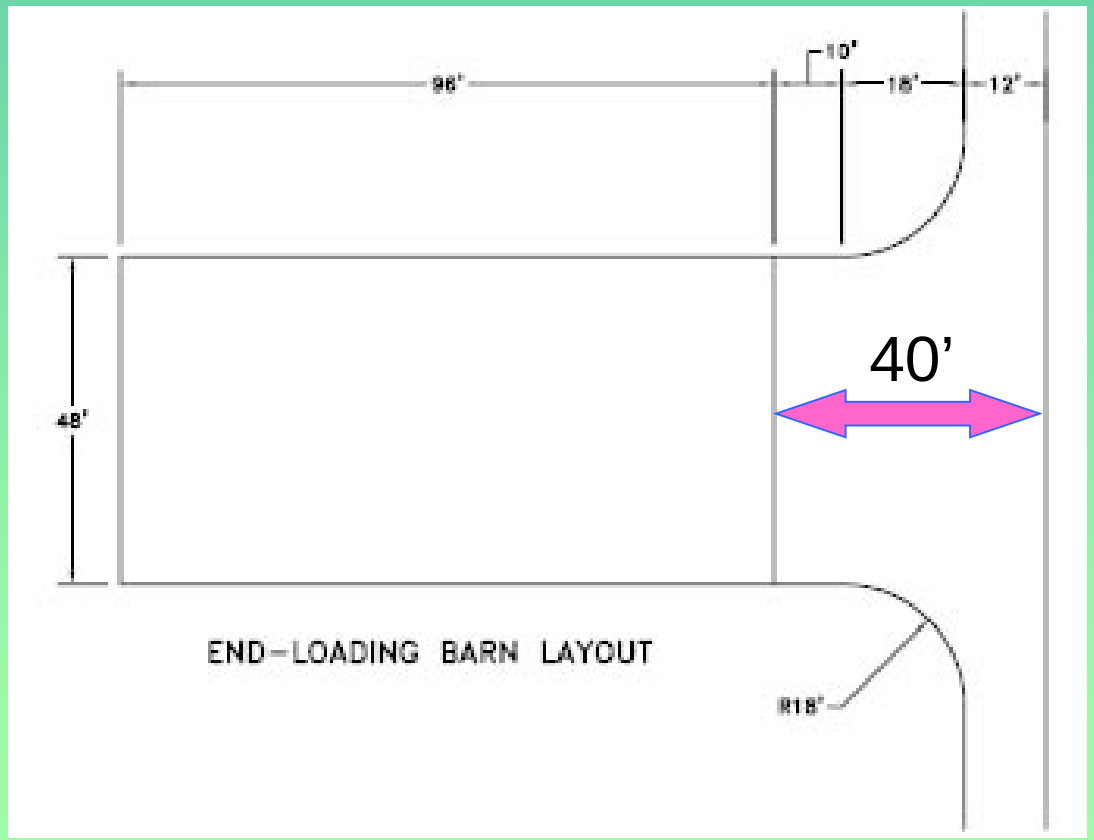
Building Planning

- What type?
  - Wood truss
  - Steel truss
  - Metal hoop



Location and Layout – Site Selection





Location and Layout – Legalities

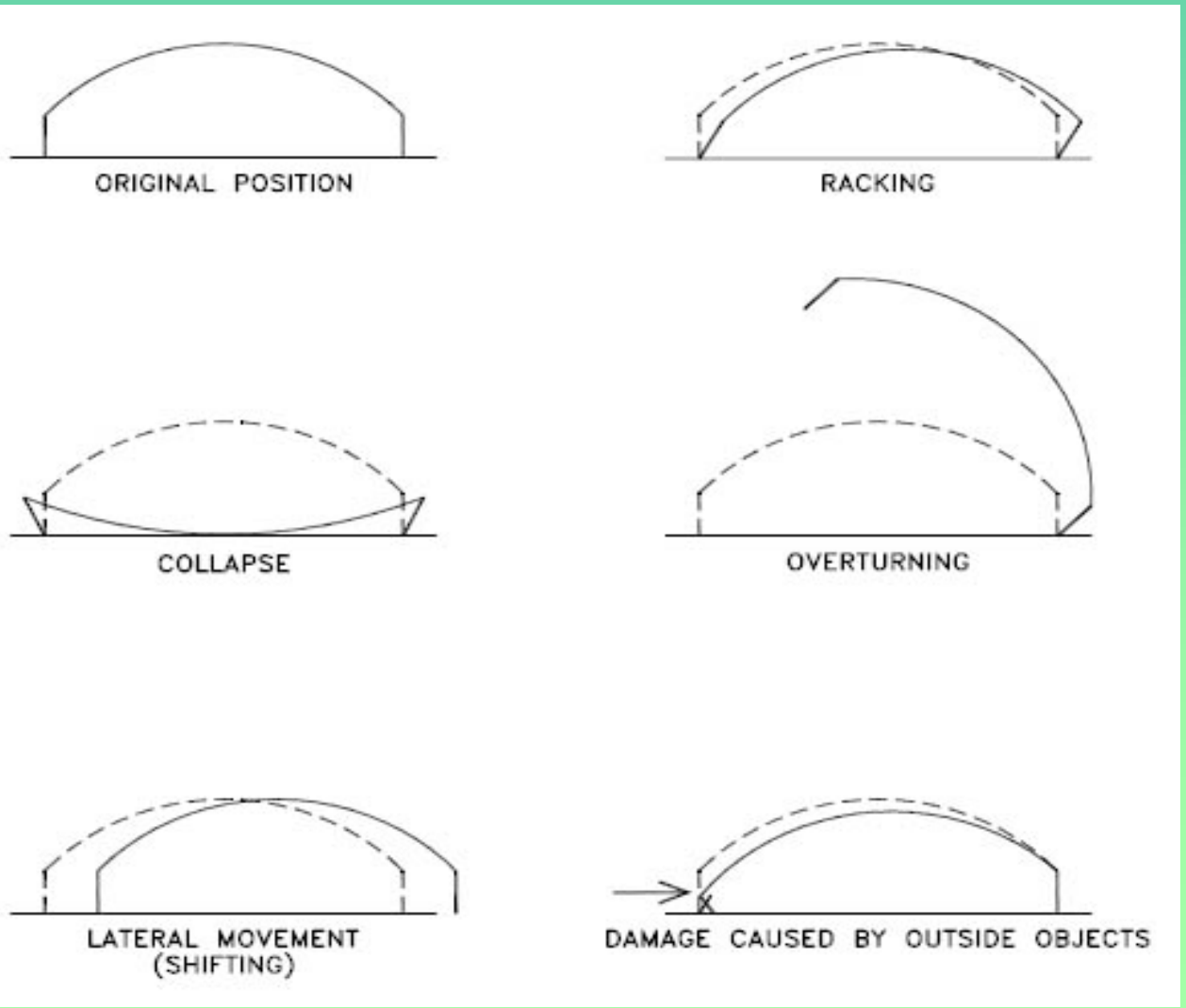
- Zoning
- Building permits
- Codes and inspections

Building Design

- Dead loads
  - Weight of building materials
  - Assume 5 lbs./sq. ft. for open trusses
  - Add more if ceiling or if trusses will support hanging items
- Live loads (for the Ozarks)
  - Snow (15 lbs./sq. ft. uniform loading)
  - Add 5 lbs./sq. ft. for uneven loading (ice)
  - Wind (90 MPH minimum)

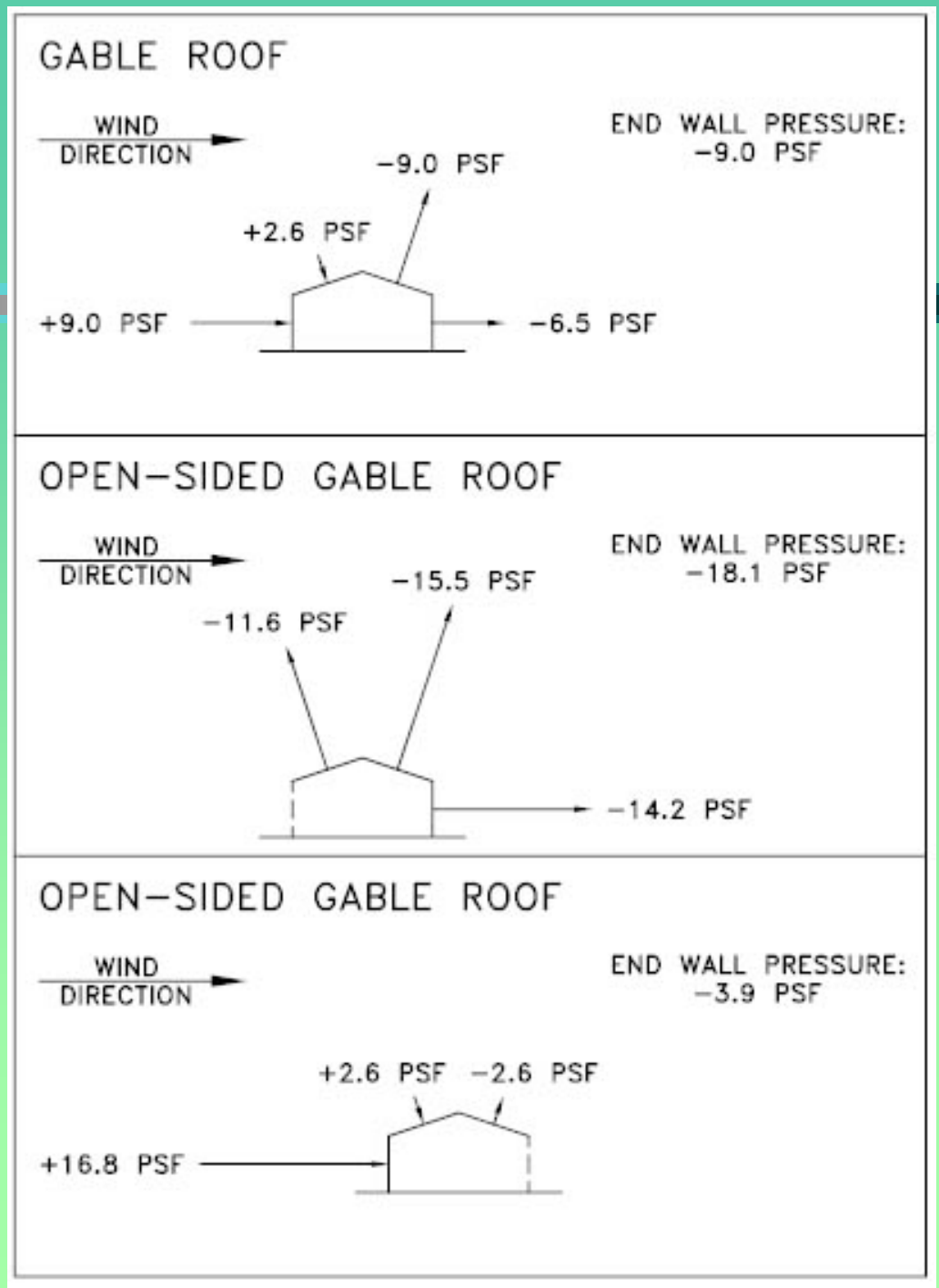
Total load = 25 lbs./sq. ft. minimum

Buildings – How They Fail



Live Load – Wind Loading Pressures

- Design for 90 MPH winds
- Not tornado-proof



Maximum Spacing (ft.) of Posts on Closed Gable Roof

No. 2 Southern Pine	Eave Height (ft.) with 90 MPH Wind Speed			
Post Size	**10’**	**12’**	**14’**	**16’**
6x6	5.7	NR	NR	NR
6x8	10.5	7.3	5.4	4.1
6x10	16.9	11.7	8.6	6.6
8x8	14.4	10.0	7.3	5.6

NR = Not Recommended

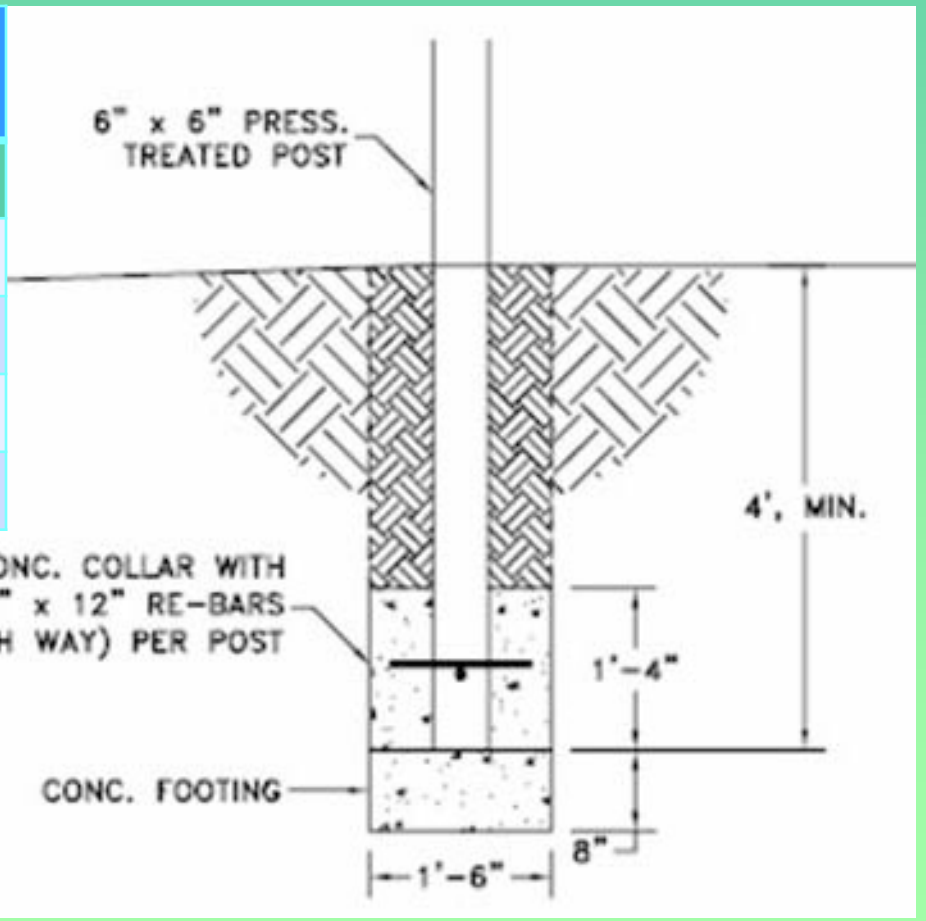
- Use ACQ-approved fasteners
- Frost depth = 30 in.

Reference: NRAES-1 Post-Frame Building Handbook
http://extension.missouri.edu/publications/DisplayPub.aspx?P=NRAES1

Post Embedment Depth (in.) for Buildings up to 60 ft. wide

Sandy Silt Soil (1500 psf vert.)	Eave Height (ft.) with 90 MPH Wind Speed			
Post Spacing (ft.)	**10’**	**12’**	**14’**	**16’**
4	54	60	66f	66f
6	60	66f	66f	66f
8	66f	66f	66f	NR
10	66f	66f	66f	NR

f = full concrete collar
NR = Not Recommended



Reference: NRAES-1 Post-Frame Building Handbook
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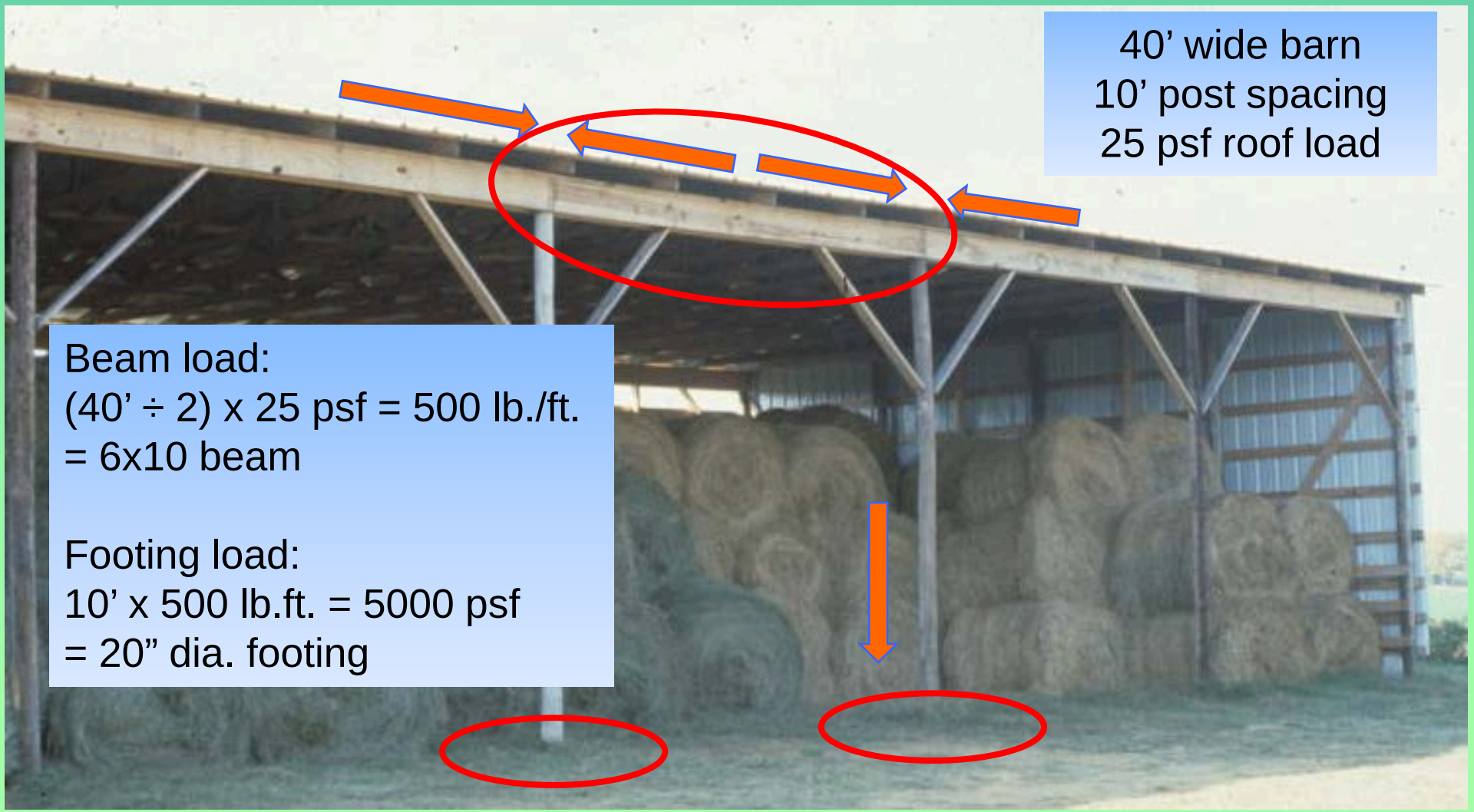
Beam & Footing Sizing



40’ wide barn
10’ post spacing
25 psf roof load

Beam load:
(40’ ÷ 2) x 25 psf = 500 lb./ft.
= 6x10 beam

Footing load:
10’ x 500 lb.ft. = 5000 psf
= 20” dia. footing

Pressure-Treated Lumber

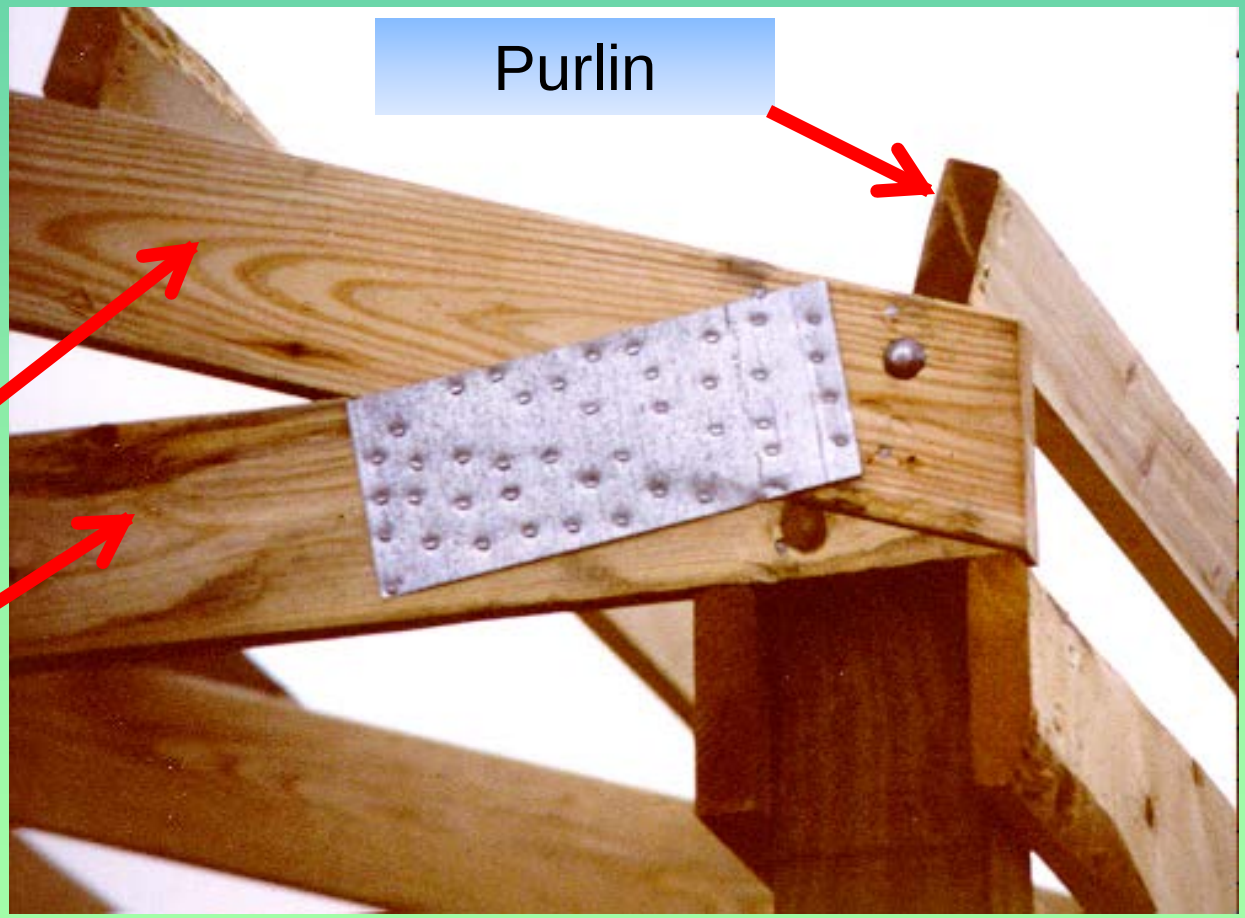
- CCA → Chromated Copper Arsenate
- ACQ-C → Alkaline Copper Quat Type C
- ACQ-D → Alkaline Copper Quat Type D Carbonate
- CBA-A and CA-B →Copper Azole Types A and B
- SBX/DOT → Sodium Borate
- Zinc Borate
- MCQ → Micronized Copper Quat

Use hot-dip galvanized or Types 304 or 316 stainless steel fasteners

Reference: www.treatedwood.com/main/faqs.php

Truss Anchorage

- One ½" bolt is equal to four 30d pole barn nails

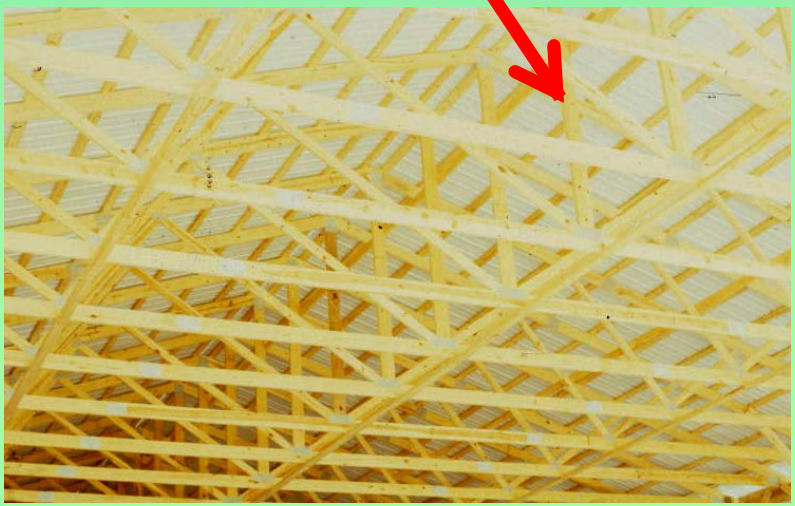


Wind Bracing & Ceiling Support

Purlin

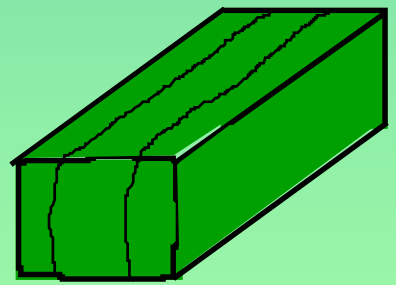
King post

Knee brace



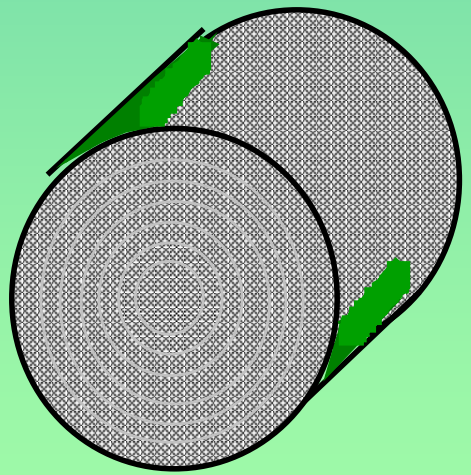
Sizing Hay Barns

Small Square Bales



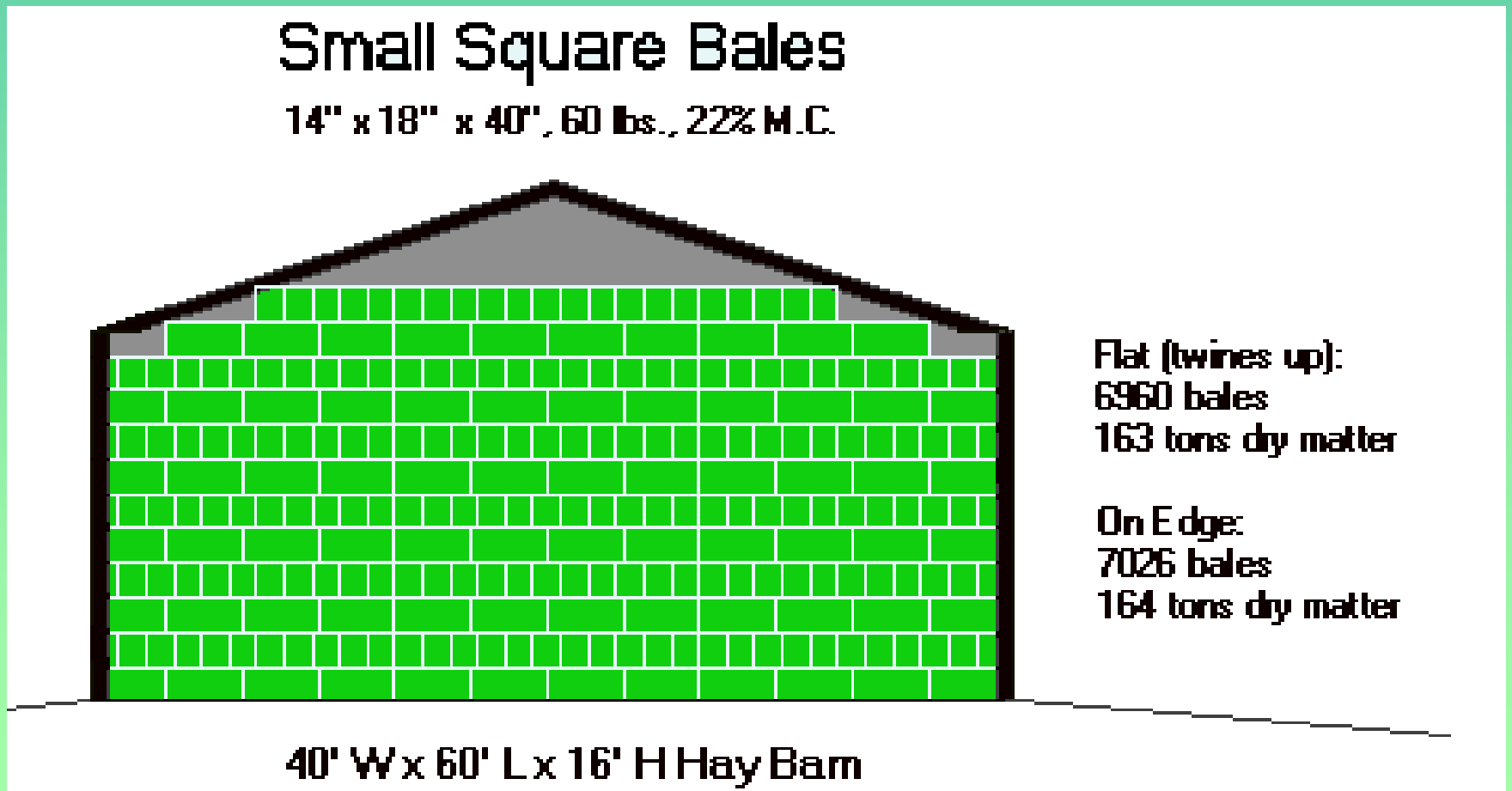
250 cu.ft. per ton

Large Round Bales

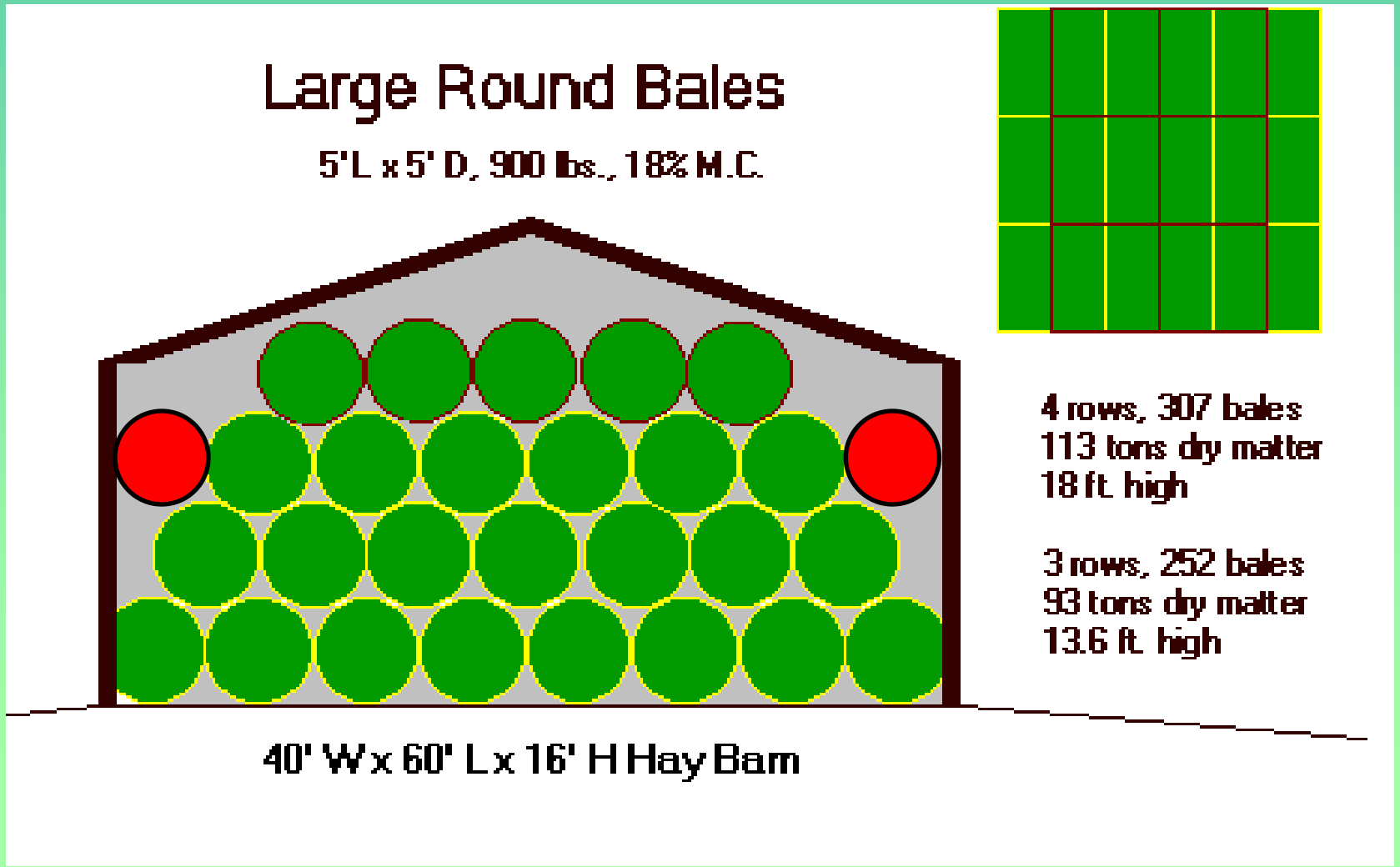


310 cu.ft. per ton

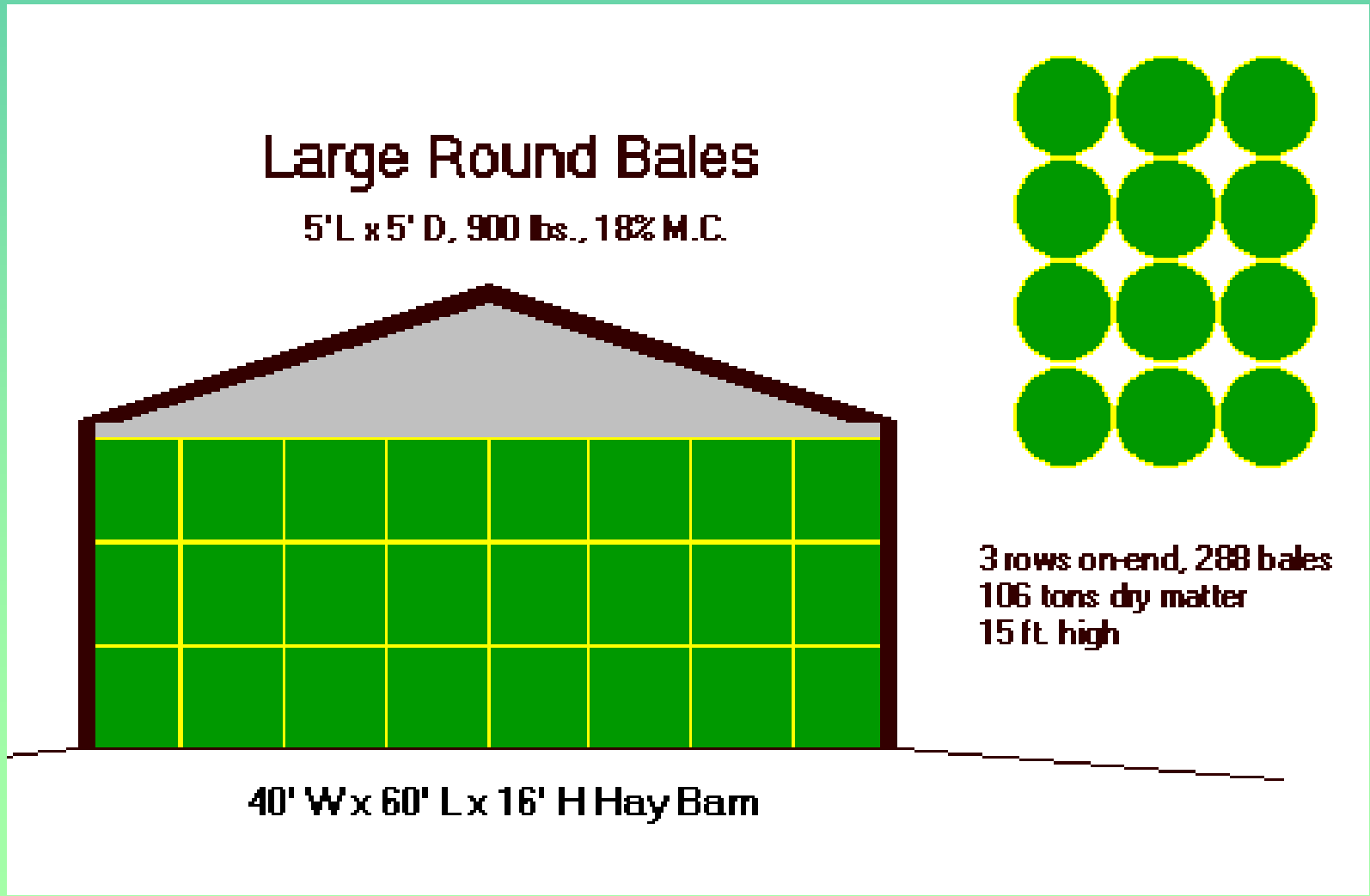
Inside Storage
Stacked Square Bales



Inside Storage - Pyramid



Inside Storage - On-End



Ownership Cost Summary for Clear-Span Wood or Steel-Truss Barn

Assumed:

a. 40' W x 60' L x 16' H barn rated at 25 psf total roof load.

b. Barn holds 200 bales weighing 1200 lbs. each, 66" L x 66" D **(120 tons)**

c. $7.50/sq.ft. cost = clear-span, colored metal, dirt floor, 15-20 year life.

Construction cost at $7.50 per sq.ft., including labor = $18,000

Annual Barn Cost (depreciated over 10-year life of 9% loan):

a. Depreciation ($18,000 ÷ 10 years)	= $	1,800
b. Interest (2/3 of annual interest rate on loan = 6%)	=	1,080
c. Repairs (0.7% of construction cost)	=	126
d. Taxes (1% of construction cost)	=	180
e. Insurance (0.3% of construction cost)	=	54
Total Annual Cost	**= $**	**3,240**

Hoop Structures for Hay Storage

- Specifications for this structure:
  - 30 ft. x 102 ft.
    (widths range from 24-70 ft., lengths in 10-ft. increments)
  - UV-treated polyethylene cover
  - Clearance: 11’4” + wall height
    (11’4” + 6’ = 17’4”)
  - Holds 270 bales weighing 1200 lbs. each, 66" L x 66" D **(160 tons)** in 6-5-4 pyramid
  - Estimated 10-year life

Hoop Structures for Hay Storage

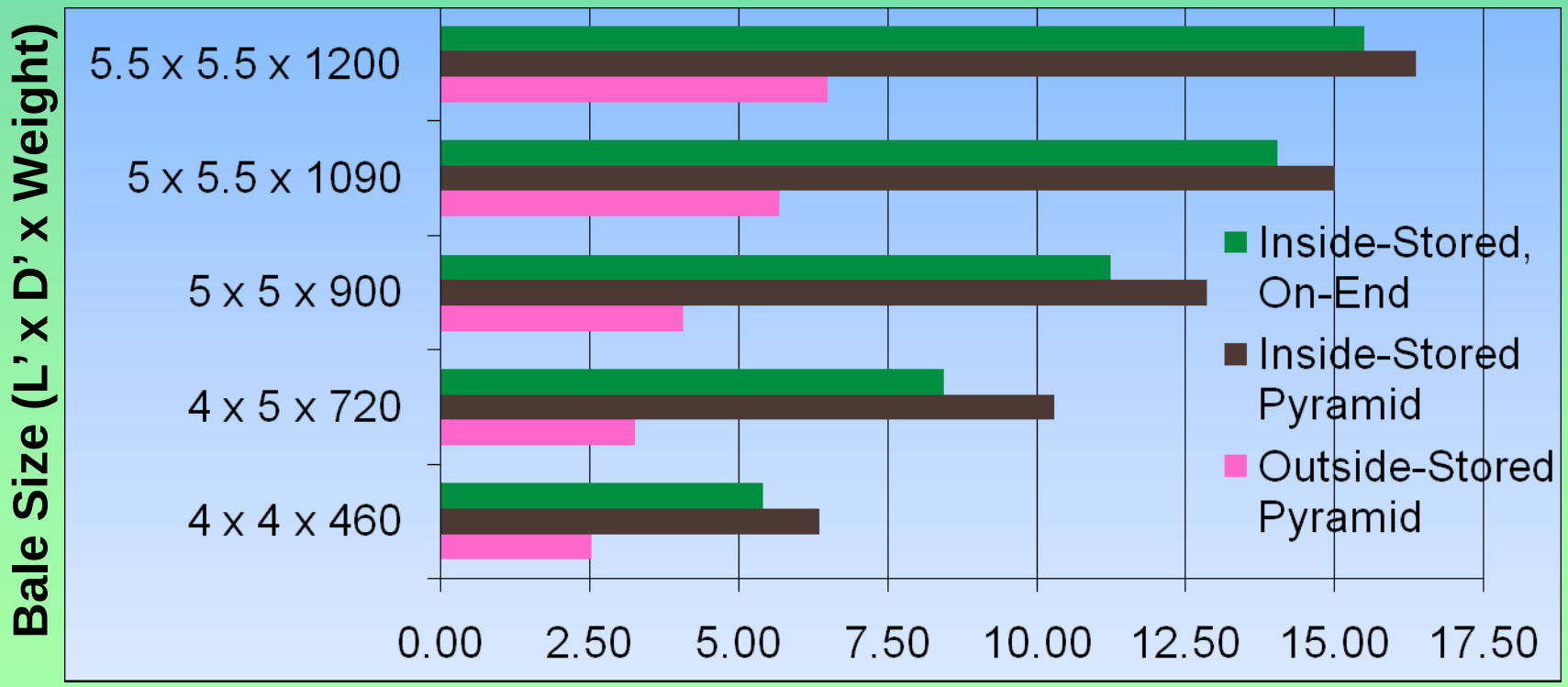
Item	Cost
Package (hoops, cover)	$10,080
Posts (42 ea.)	1,260
Concrete for posts & lumber for side walls	1,260
Approx. materials cost	**$12,600**
Approx. labor cost	$ 5,700
Approx. Total Cost	**$18,300**

= $6.00 per sq.ft.

Price estimate as of 12/2010

Round Bale Storage Economics

- **Outside: 28'W x 120'L x 8"H rock pad, $4,090 total cost ($1,363/year)**
- **Inside: 40'W x 60'L x 16'H barn, $18,000 construction cost ($3,240/year for 10 years)**



Affordability of Storage ($$ value of hay lost)

Storage loss (%)	Hay price (per ton) $40	$60	$80	$100	120
5	2	3	4	5	6
10	4	6	8	10	12
15	6	9	12	15	18
20	8	12	16	20	24
25	10	15	20	25	30
30	12	18	24	30	36
35	14	21	28	35	42
40	16	24	32	40	48

Note: Does not include losses associated with shrinkage or reduced quality.

= Tarp & Rock Pad

= Barn

Reference: Oklahoma State University factsheet BAE-1716 Round Bale Hay Storage
http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Rendition-6342/BAE-1716web.pdf

Hay Feeding Losses Can Be Significant

Up to 40% loss possible with this common method

Hay Wasted by Cows When Fed With and Without Racks

(Bell, S., and F.A. Martz., University of Missouri, 1973)

Type of Hay	Percent Wasted
Square bale in rack	7%
Large round bale in rack	9%
Large round bale without rack	45%

General Rules on Hay Feeding

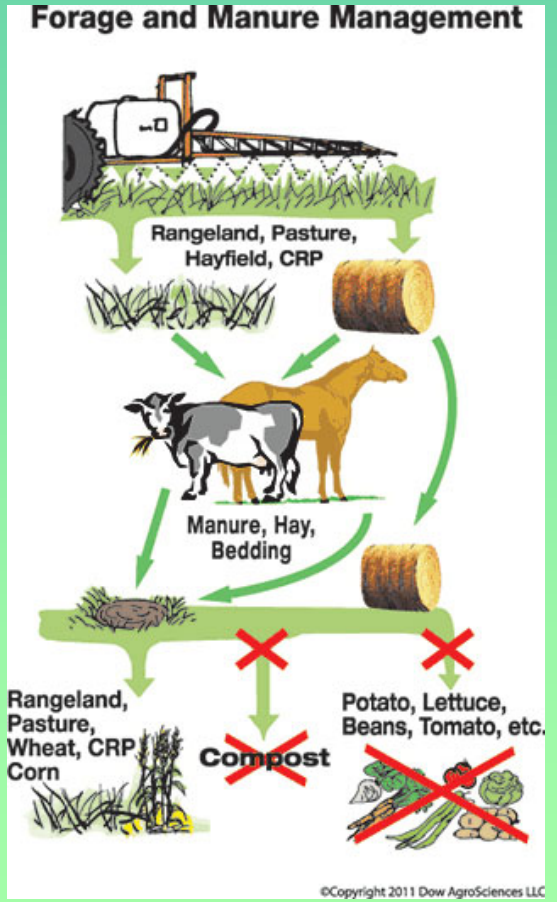
- Hay quality should be matched to animal needs
  - Sort cattle into groups based upon stage of production
  - Barns with side access work best for this
  - Feed lowest-quality hay to dry or non-lactating cows
  - Feed highest-quality hay to lactating heifers or cows
  - Feed “pounds of hay,” not “number of bales”
- Feed outside-stored hay before inside-stored hay
  - Animals fed high-quality hay early in the season will often refuse poor-quality hay when it is offered later

General Rules on Hay Feeding

- Feed coarse, less-dense, or high-quality outside hay before fine-stemmed, more-dense outside hay
- Feed hay in small amounts or in a feeder to minimize waste
- Feed hay in well-drained areas or move hay areas around
- Time feeding to force clean-up
  - Remember last part of hay is lowest quality – watch body condition!

Herbicide Precautions of Feeding Hay

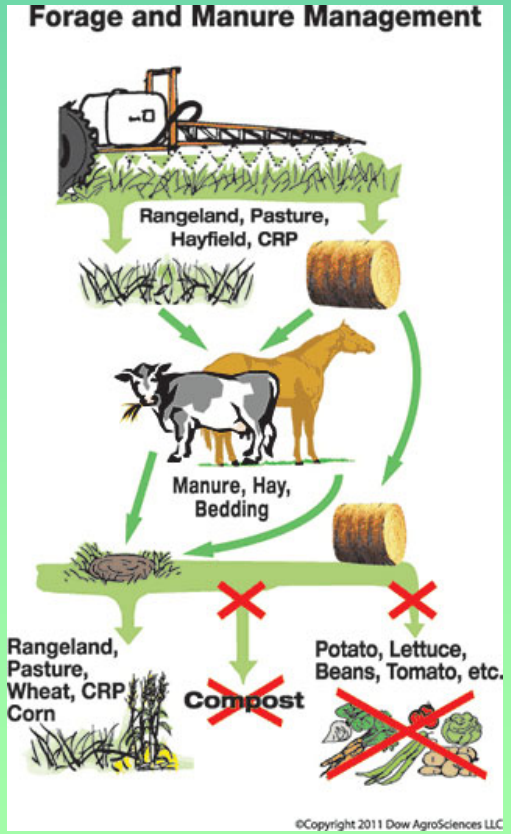
- Was hay treated with herbicide products containing aminopyralid?
  - GrazonNext® HL, Chaparral™, Milestone®
  - Aminopyralid readily passes through livestock, with no effect on the animal
  - Land planted to sensitive broadleaf crops can be impacted by herbicide residue in urine and manure
    - Alfalfa, soybeans, sunflowers, cotton, tobacco, peanuts, sugarbeets
    - Tomatoes, beans, lettuce, cucurbits, potatoes, strawberries, grapes, flowers



Graphic credit: www.dowagro.com/range/eSteward/south_index.htm
Reference: www.manurematters.com/na/en/

Herbicide Precautions of Feeding Hay

- If feeding hay you raised:
  - Stop feeding treated hay to cattle 3 days before moving them to sensitive fields
  - Manure can be spread on pasture grasses, grass grown for seed, wheat or corn
- If purchasing hay:
  - Ask if the hay you are buying has been treated with a herbicide
  - Do not use treated hay for compost or gardening
- As a hay producer:
  - Will the hay be used on-farm or will it be sold?
  - If sold, communicate precautions to the purchaser



Estimated losses (% of hay offered) from different hay-feeding methods

Bale Type	With Rack		Without Rack	
	1-Day Supply	7-Day Supply	1-Day Supply	7-Day Supply
Small square	3.9	4.9	6.7*	
Large round or square	4.9	5.4	12.3*	43.0*
Formed haystacks	8.8	15.0	22.6	41.0
Small round bales (fed in place on pasture)			10.0	30.0

*** Bales spread or unrolled across pasture**

Reference: MU Guide G4570 Reducing Losses When Feeding Hay to Beef Cattle
http://extension.missouri.edu/explorepdf/agguides/crops/g04570.pdf

Advantages of Unrolling Hay

- Allows “boss” cows and timid cows to eat together
- Less hoof damage to feeding area because it is larger
- Controls the amount of hay allotted by portioning bales
- Can help overseed pastures with legumes
- Distributes fertilizer nutrients back on field

Bale Processors - Pros & Cons

- **Myth**: grinding forages will increase forage quality
- Quality may decrease, especially if hay is ground on a windy day (leaf loss)
- Decreased particle size = decreased rumen retention time = increased forage intake
- Allows a way to increase consumption of low to medium quality forages
- Allows a way to combine forages of differing quality for best use in a cow feeding diet
- Allows a way to manage problem forages, i.e., high nitrates
- Increased ownership cost of $20K-$25K equipment

Reference: www.extension.org/pages/17216/forage-feeding-losses-can-add-up

Bale Processors

Photo credit: www.environmental-expert.com

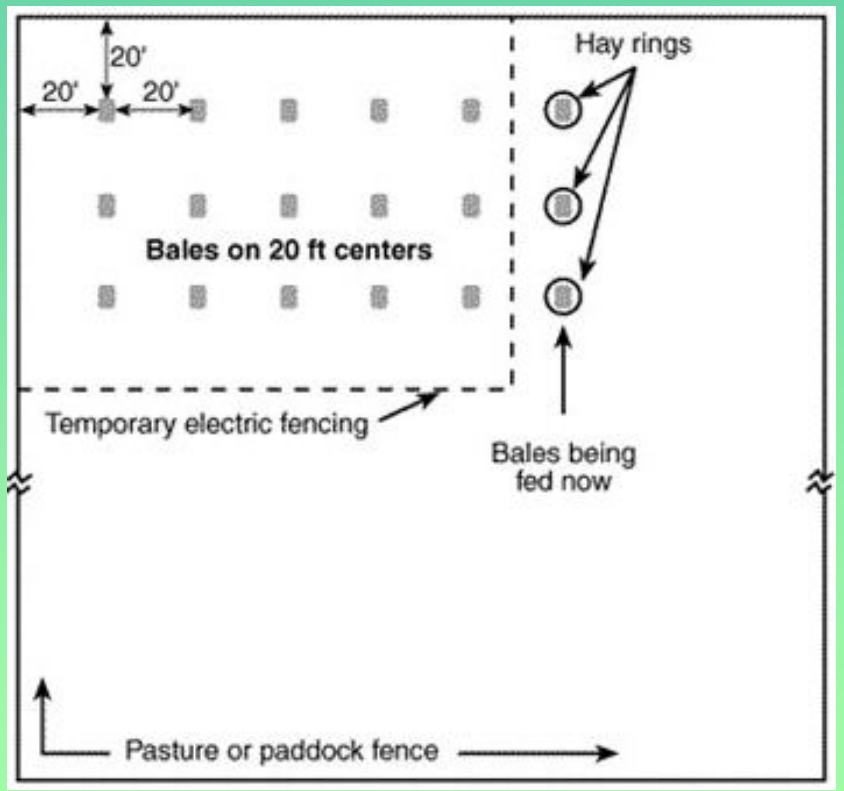
Photo credit: www.fastline.com

Feeding Method	100-cow herd, feeding cost per cow
PTO-powered bale processor	$128.10
Unrolling bales on ground	$113.90
Tapered-cone round bale feeder	$101.80

Rolling bales out on the ground or shredding into windrows with a bale processor increased hay consumption and winter feeding cost without enhancing cow performance

Reference: North Dakota State University, 2005 -- www.ag.ndsu.edu/archive/dickinso/research/2004/beef04r.htm

Low-Labor Hay Ring Management



- Space bales 20 ft. apart in pasture or paddock corner
- Enclose bales with movable electric fence
- Feed bales in hay rings
- Use multiple rings to reduce “boss” cow problems
- Move fence & rings as needed

Reference: MU Guide G4570 Reducing Losses When Feeding Hay to Beef Cattle
http://extension.missouri.edu/p/G4570

Feeder Design Affects Wastage

Cattle remove hay & step on it

Hay gets used as bedding

Feeder Design Affects Wastage

JAS 81:109 (Michigan State University, 2003)

Cone feeder 3.5% loss

Ring feeder 6.1% loss

Trailer 11.4% loss

Cradle 14.6% loss

Why the Big Differences?

Cone feeder = $1000 + shipping
vs.
Ring feeder = $120 - $350

- Slanted bars discourage cows from backing out of feeder
- Most dropped hay stays in feeder
- Boss cows less aggressive toward timid cows

Cone Feeder Pros & Cons

- Keeps hay off of the ground
- Saves 10-20% hay usage annually
- Saved hay stretches limited supplies
- Supports bales up to 2,500 lbs. in weight
- Top ring keeps cattle from pulling hay off of the top
- Much longer life compared to cheap hay rings
- Feeder weighs 600+ lbs. Cannot be easily moved by hand
- Higher initial cost

Can You Afford a Cone Feeder?

- Initial feeder cost = $725
- Assume 10% hay savings on $50 bale
- Assume 10-year life vs. 1-2 year life


Photo credit: Windmill Cattle Co., LLC

- Saves $500 for every 100 bales fed, or $5,000 for 1000 bales fed over 10 years

When might a cheap hay ring be better?.....

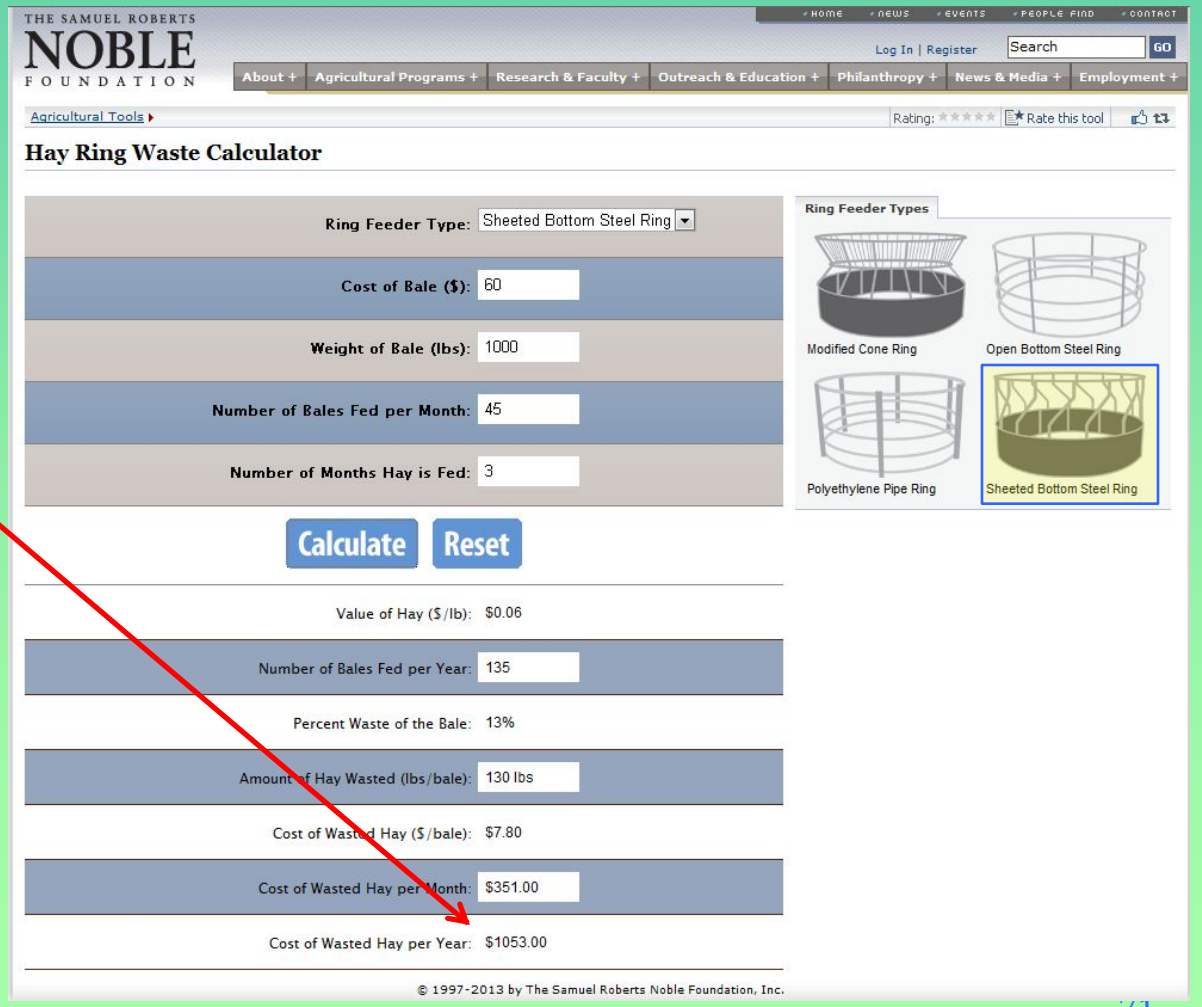
……when feeding junk hay that the cows are going to waste. It's easier to move the ring by hand more frequently.

Prices reviewed as of January 2014

Hay Ring Waste Calculator
Sheeted Bottom Steel Ring

Example:
50 cows for 3 months
30 lbs. hay per day
$60 per 1000 lb. bale

= **$1,053 hay wasted**

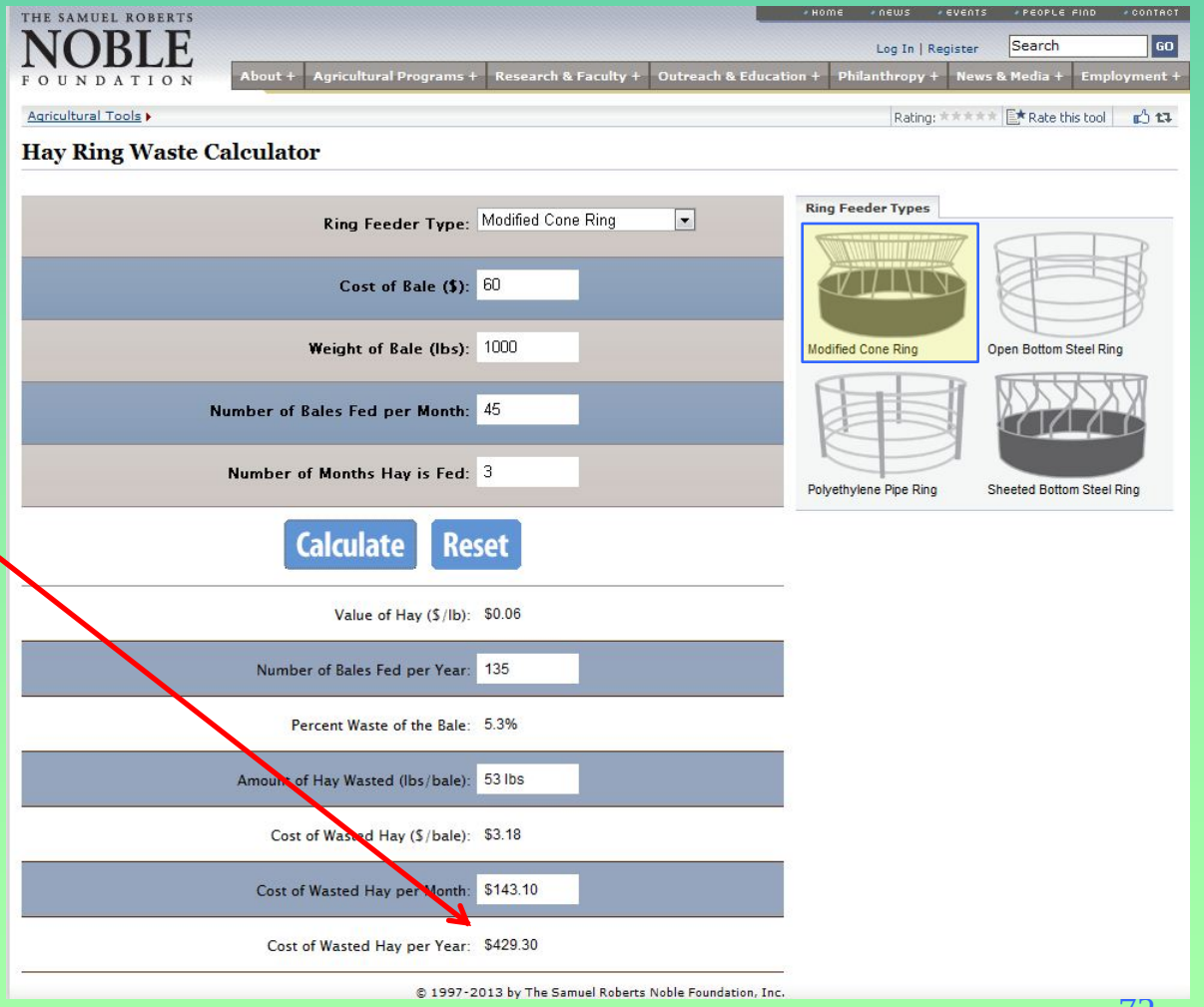


Reference: www.noble.org/ag/tools/livestock/hay-ring

Hay Ring Waste Calculator
Modified Cone Ring

Example:
50 cows for 3 months
30 lbs. hay per day
$60 per 1000 lb. bale

= **$429 hay wasted**



Reference: www.noble.org/ag/tools/livestock/hay-ring

Cone Feeder Styles

Photo credit: fyi.uwex.edu

Photo credit: www.applegatelivestock.com

Photo credit: www.weldyenterprises.com

Photo credit: www.franklinwaterers.com/bale.html

Photo credit: www.titanwestinc.com/bextra.html

Cone Feeder Styles

Photo credit: jlhaysavers.com

Photo credit: behlencountry.com

Photo credit: www.centurylivestockfeeders.com

Photo credit: www.haymizer.com/haymizer_I.htm

Photo credit: www.klenepipe.com

Feeding Strategies

Keep feeding areas as dry as possible

Feeding Strategies

Feed on a pad or elevated surface

Feeding Strategies

Make animals use up hay before adding more to feeder

Feeding Strategies

Cull aggressive animals

Feeding Strategies

Consider feeder durability vs. cost

Summary

- Harvest for quality or buy good hay
- Protect the hay from moisture
- Know what your bales weigh
- Test for nutrient quality before feeding
- Use some type of hay feeder if not limit-unrolling
- Select feeder that minimizes waste
  - At least solid lower panels and slanted bars
- Limit-feed in well-drained area
- Costly-to-buy feeders likely cheaper long-term

Questions?

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