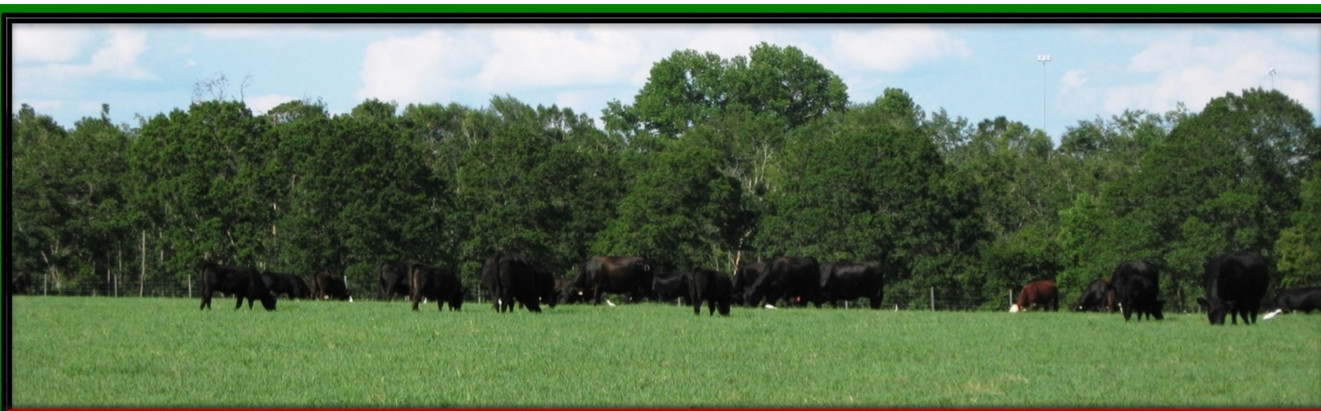

Georgia Grazing School

Sept. 20-21, 2016 | Univ. of Georgia | UGA Tifton Campus
Tifton, GA

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Georgia Cattlemen's Association

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DFA
Dairy Farmers of America

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BEEF
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GRASS
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USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

UGA extension

Agenda

2016 Georgia Grazing School

Univ. of Georgia | College of Agricultural & Environmental Sciences
Tifton Campus |

Tuesday, September 20th, 2016

NESPAL Conference Room (2356 Rainwater Rd., Tifton, GA)

8:00 **Registration. Coffee and snacks.**

8:45 **Welcome, Introductions, and Getting to Know One Another**
Drs. Dennis Hancock, Jacob Segers, and Jennifer Tucker, UGA
Philip Brown, NRCS Grazinglands Specialist

9:15 **Manipulating forage growth and grazing behavior.**
Dr. Dennis Hancock, UGA

10:00 **Break (Visit Sponsor's Booths)**
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10:30 **Southern Forages: Yield, distribution, and quality.**
Philip Brown, NRCS Grazinglands Specialist

11:00 **Soil fertility and nutrient cycling in grazing systems**
Dr. Dennis Hancock, UGA

11:30 **Managing, utilizing, and maintaining legumes**.
Philip Brown, NRCS Grazinglands Specialist

12:00 **Lunch (Visit Sponsor's Booths)**

Tuesday, September 20th, 2016 (cont'd):

1:00 **Segregating herds based on animal class and nutritional need**
Dr. Jacob Segers, UGA

1:40 **Grazing systems, methods, and tricks.**
Dr. Jennifer Tucker, UGA

2:10 **Optimizing the size, number, and layout of your paddocks**
Dr. Dennis Hancock, UGA

2:40 **Break (Visit Sponsors)**
Sponsored by: Athens Seed Co.

3:10 **Managing forage surplus and deficits**
Dr. Jennifer Tucker, UGA

3:40 **Sketching Out the Ideal: Planning the Grazing System**
Philip Brown, NRCS Grazinglands Specialist

4:10 **Extending the grazing season and critically evaluating novel grazing systems**
Dr. Dennis Hancock, UGA

4:50 **Cost-share programs that aid the transition**
Craig Bevan, USDA-NRCS

5:15 **Travel to UGA's Black Shank Farm**

5:30 **Good grazing = inc. soil moisture, inc. soil health, and lower erosion.**
Michael Hall, NRCS Grassland Conservationist (Ret.)
Nathan Lowder, NRCS Soil Health Specialist

6:30 **Supper and Discussion** – Travel funds provided by: GGLCC Georgia Grazing Lands Conservation Coalition www.gglcc.com

Experiences with Silvopasture

George Owens
Co-owner, George and Pat Owens Farm
Chipley, FL

Wednesday, September 21st, 2016

UGA Tifton Bull Evaluation Center (2283 GA Hwy 32W, Chula, GA)

7:30 **Coffee and snacks.**

8:00 **Choosing the right fence, fence charger, and wire or tape for your grazing system**
Dr. John Worley, UGA

8:30 **Selecting the right watering system and sizing the water supply for your grazing system**
Dr. John Worley, UGA

9:00 **Using winter and summer annuals to ease seasonal transitions**
Deidre Harmon, UGA

9:30 **Economics of Better Grazing Management**
Dr. Levi Russell, UGA

10:10 **Break**
Sponsored by: Dairy Farmers of America

10:40 **Sprayer calibration exercise and lightbar demo**
Dr. Dennis Hancock, UGA

11:15 **New weed management tools for grazed pastures.**
Dr. Patrick McCullough, UGA

12:00 **Lunch**

Demonstrations:

(1:00 p.m. to 3:00 p.m.)		
Split Up into Smaller "Herds" and Rotate Stations		
Orange Herd Order of Stations	**Blue Herd Order of Stations**	**Yellow Herd Order of Stations**
Hay/Baleage Sampling Demonstration (10 min.)	Grazing Stick/Rising Plate Meter Demo (10 min.)	Pasture Condition Score (10 min.)
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Setting Up Water Troughs w/ Grazing In Mind (20 min.)	Calibrating & Adjusting a No-Till Drill (20 min.)	Weed ID in the Field (20 min.)
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Speakers: Hay/Baleage Sampling Demonstration: *Dr. Jacob Segers, UGA*
Weed ID in the Field: *Dr. Patrick McCullough, UGA*
Grazing Stick/Rising Plate Meter Demo: *Dr. Jennifer Tucker, UGA*
Pasture Condition Score: *Philip Brown, USDA-NRCS*
Calibrating & Adjusting a No-Till Drill: *Deidre Harmon, UGA*
Setting Up Water Troughs w/ Grazing In Mind: *Randy Odum, USDA-NRCS*

Wednesday, September 21st, 2016 (cont'd):
Deep Grass Graziers (600 Meadowlark Rd., Fitzgerald, GA 31750)

3:30 **Farm Visit: Deep Grass Graziers**
Dan Glenn, co-owner

Deep Grass Graziers is a grass-finished beef farm that Dan Glenn's family has owned and farmed for four generations. They are dedicated stewards of soil, animal, and human health. Their goal at Deep Grass Graziers is to regenerate soil health while producing flavorful, succulent grass-finished beef. They use excellent cattle genetics, feed them high quality forages, and handle them humanely, to ensure a superior product. For more on their farm, visit http://www.deepgrassgraziers.com.



~5:30 **Evaluation and Dismiss (Have a Safe Trip Home!)**

List of Exhibitors:
R.W. Griffin Feed, Seed & Fertilizer
Southern Silage Supply
Wax Company
Dairy Farmers of America
Georgia Cattlemen's Association
Athens Seed Company

Others pending…

Special Thanks to:
Drs. Jennifer Tucker and Jacob Segers
J.D. Hale, UGA Forage Research Tech
Deidre Harmon, UGA PhD Student
Taylor Hendricks, UGA PhD Student
Tayler Denman, UGA M.S. Student

UGA extension
Forage Team
www.georgiaforages.com

Georgia Grazing School 2016

SEPTEMBER 20-21, 2016
NESPAL CONFERENCE ROOM
TIFTON, GEORGIA

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<u>PRESENTATION HANDOUTS AND SUPPLEMENTARY INFORMATION</u>

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[1] Available online only
[2] Available online and on the publication table

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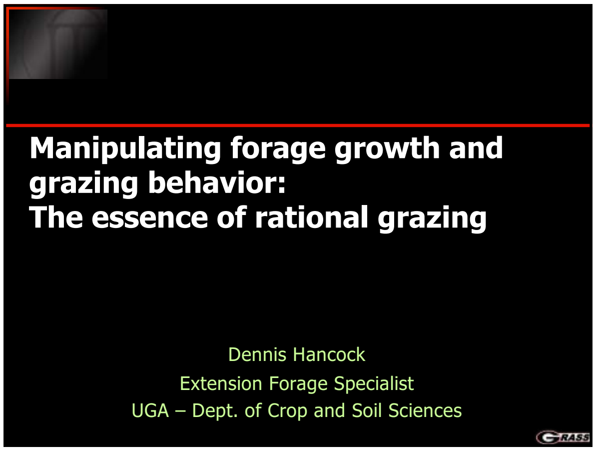
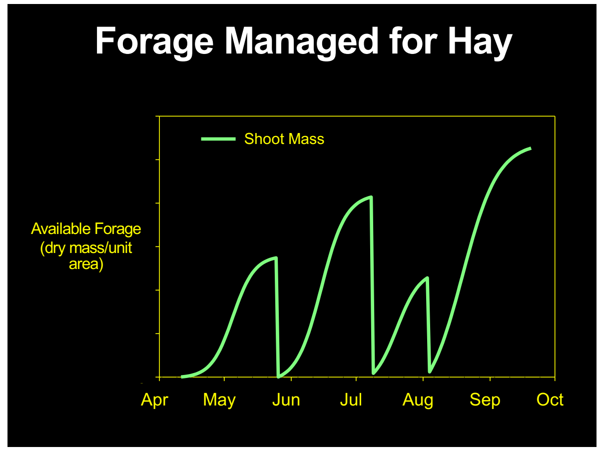
Section 1
Manipulating Forage Growth and Grazing Behavior.
Dr. Dennis Hancock, UGA

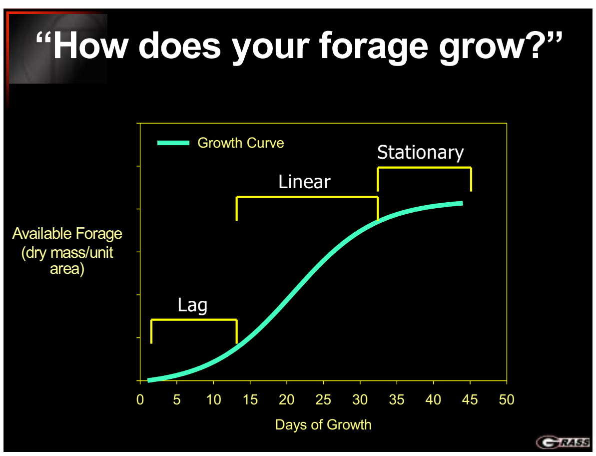
2016 Georgia Grazing School:

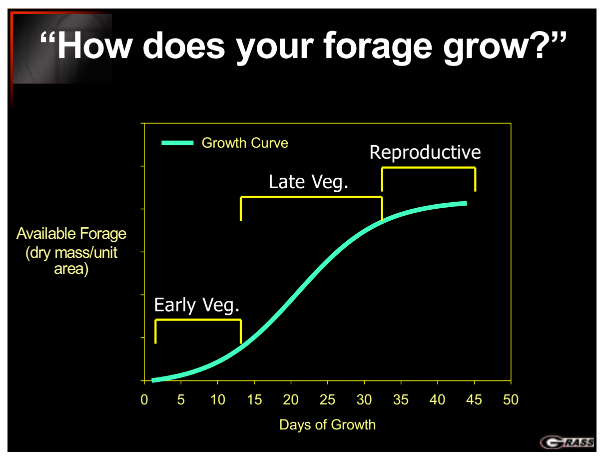
Manipulating forage growth and grazing behavior

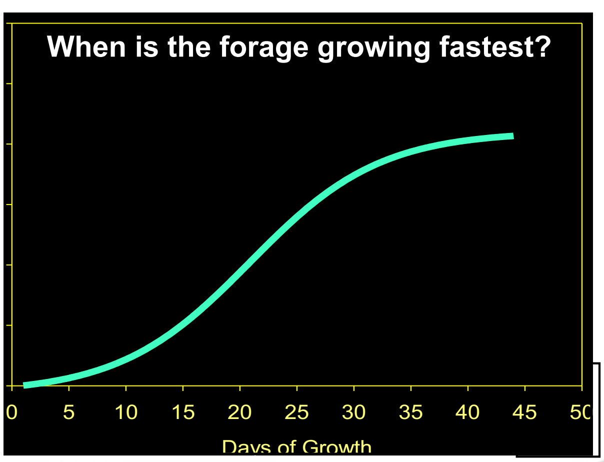
Dr. Dennis Hancock
Assoc. Prof. & Forage Ext. Specialist

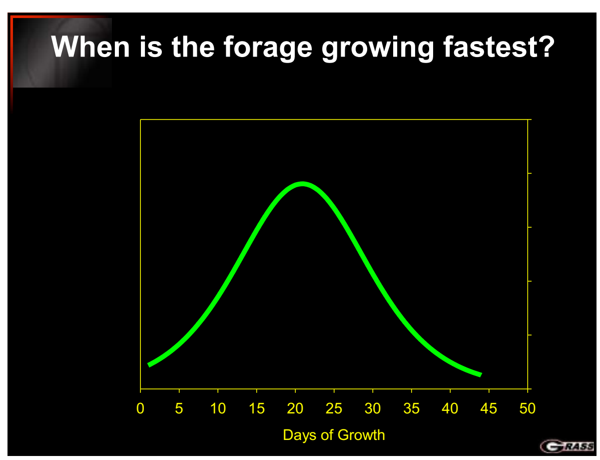












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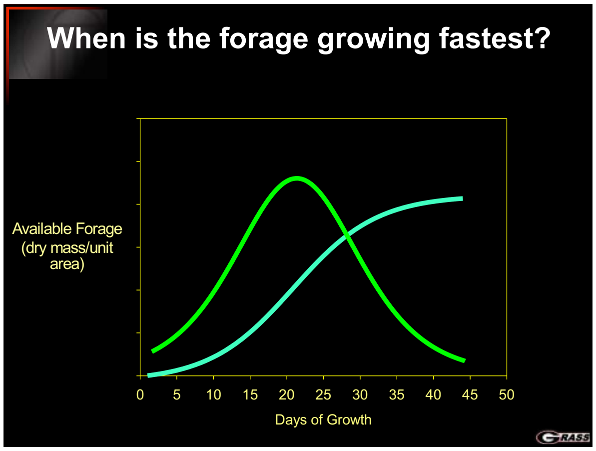

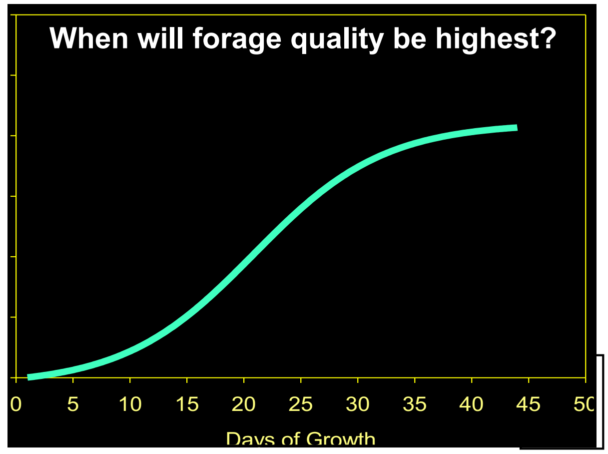

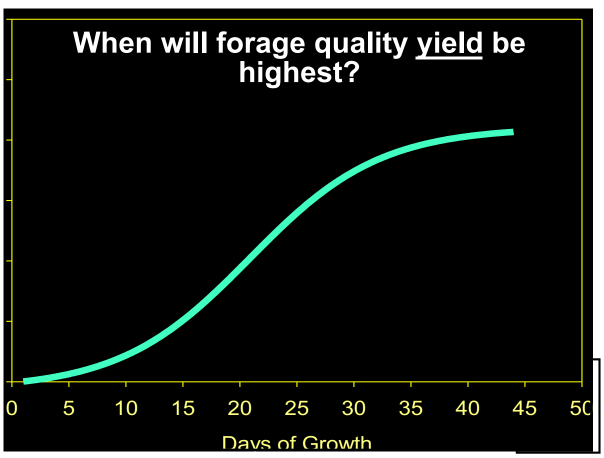

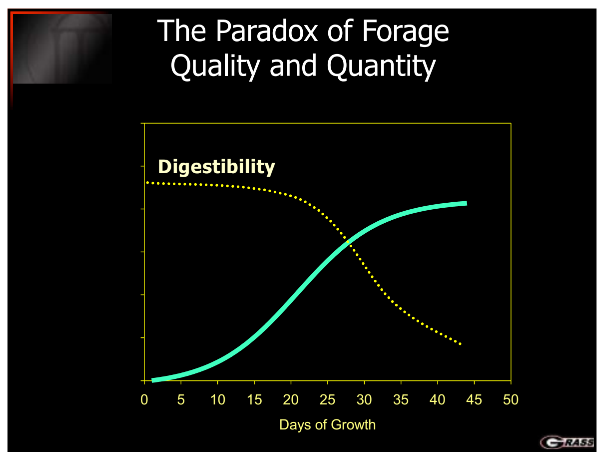

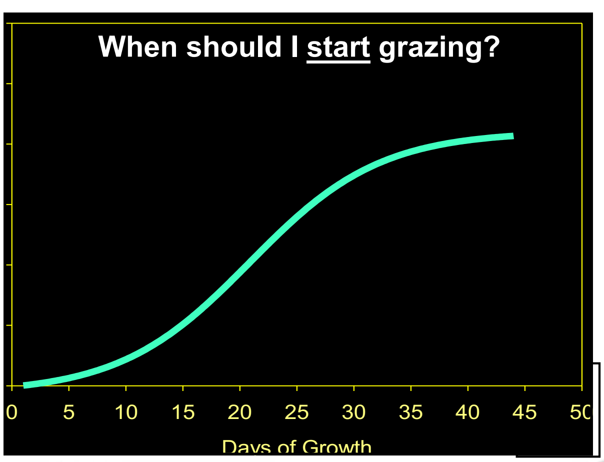

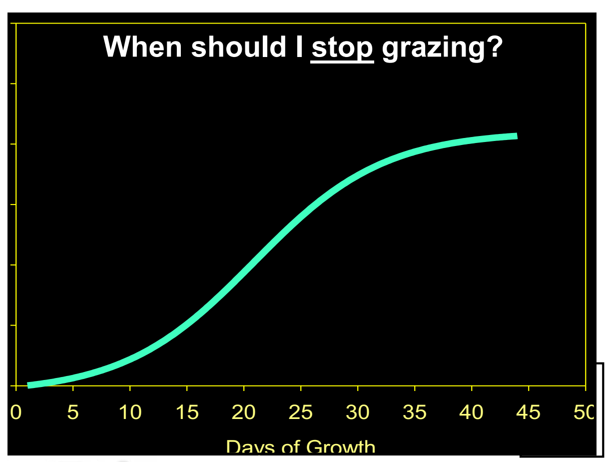

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2016 Georgia Grazing School:

Manipulating forage growth and grazing behavior

Dr. Dennis Hancock
Assoc. Prof. & Forage Ext. Specialist

Write this down in BIG **BOLD** letters!

"GRASS GROWS GRASS."

Benefits of Rational Grazing

1. Better utilization of forage
2. Growth rate of forage is optimized
   - Kept in linear/exponential growth phase
   - Higher yield of forage

Animal productivity is primarily a function of feed intake.

Forage Intake

- Animal productivity (gains, milk, fiber, etc.) is primarily a function of feed intake.
- Forage Intake is a function of:
  - Bite size
  - Bite rate
  - Grazing time

$$\text{Forage Intake} = \left(\frac{\text{mass}}{\text{bite}} \times \frac{\text{bites}}{\text{min.}} \times \text{Minutes}\right)$$

Forage Intake

$$\text{Forage Intake} = \left(\frac{\text{mass}}{\text{bite}} \times \frac{\text{bites}}{\text{min.}} \times \text{Minutes}\right)$$

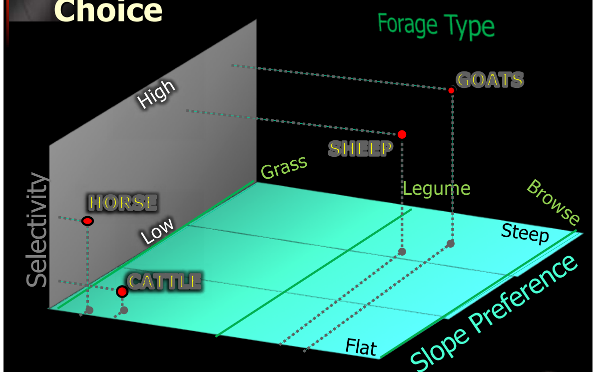
What happens when:

1. Pastures are very short
2. Pastures are tall
3. The animal's mouth size is below average
4. Animal is ill or uncomfortable (heat stress)
5. Grazing time is restricted

Extra Credit:

a. Animal starts feeling full
b. Forage is very fibrous
c. Intestinal passage rate is slow (fast)

Graphical Description of Diet Choice



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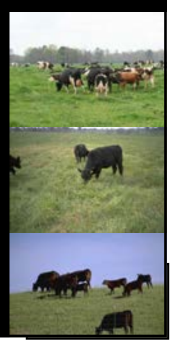
Grazing Behavior: Cattle

- Spend up to 8 hrs/day grazing
  - "Cows are union members. They refuse to graze more than 8 hours per day." - Voisin
  - Longest bouts are at dawn, late afternoon, and at sunset.
- Grass length affects bite rate:
  - 4-5 in. = swallowed right down
  - 10-12 in. = it has to be masticated.
- Bite rate generally runs 30-90 bites/min.

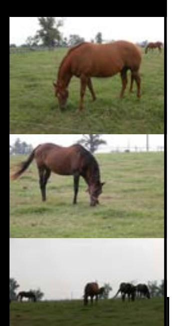
Grazing Behavior: Cattle

- Grazing time is genetically influenced.
  - Identical twins graze almost exactly the same amount of time (+/- 2%), but differences between pairs of twins will differ (+/-40%).
  - Bite rate is relatively constant (48-54 bites/min.), but some graze longer and sustain high rate longer.
  - Implication: Good grazers can be selected
- Grazing objectives:
  - ~~Exercise and activity~~
  - Eat and retreat
  - Meet nutritional needs
  - Maintain relatively full gut



Grazing Behavior: Horses

- Spend 14.5 – 16.8 hrs/day grazing
  - 60-70% of the day
  - Mostly around dawn and before sunset
- Grazing time is altered by conditions.
  - Time dec. with heat, insect, etc. stressors.
  - Low forage quality = inc. passage rate & inc. forage intake



Grazing Behavior: Horses

- Tend to graze in 3 – 7 extended bouts/d
  - Bite rate ranges from 12-50 bites/min.
  - Single grazing bouts of up to 180 min.
  - Grazing bouts increase as group size increases from 1 to 4 horses
- Grazing objectives:
  - Meet nutritional needs
  - Maintain relatively full gut
  - Exercise and activity
  - Social (implications for selectivity)

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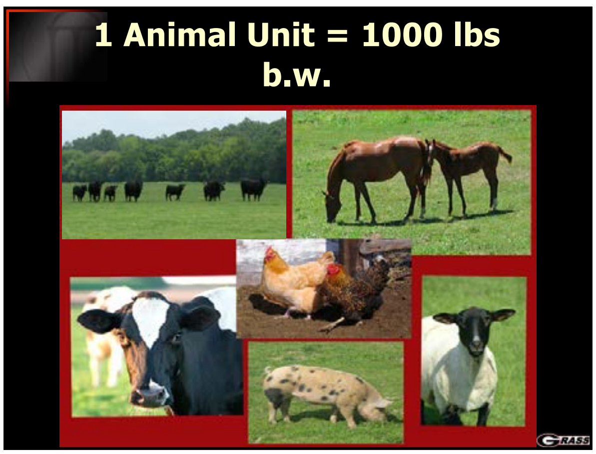

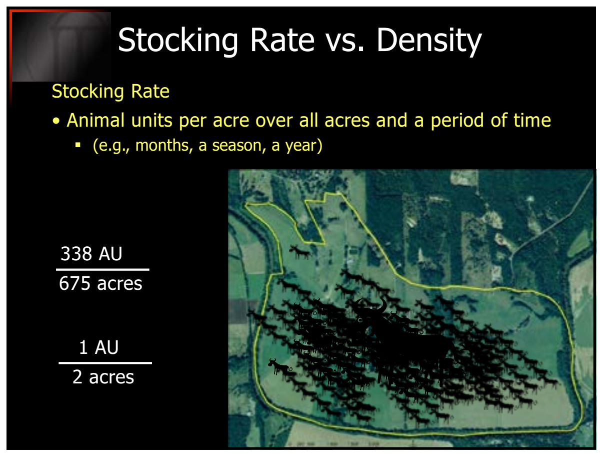

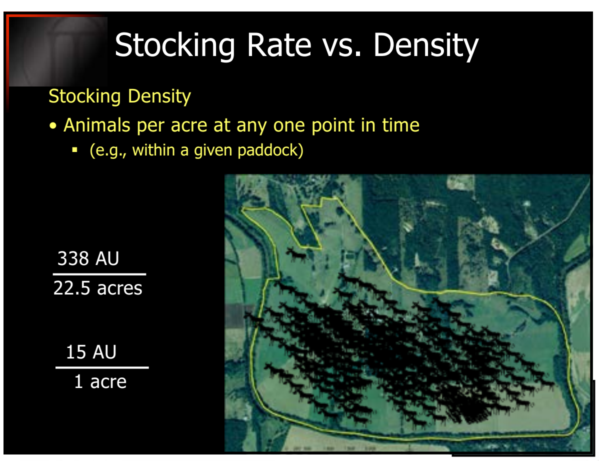

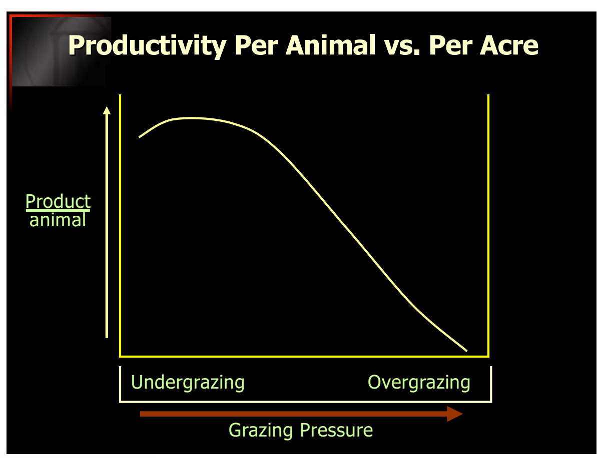

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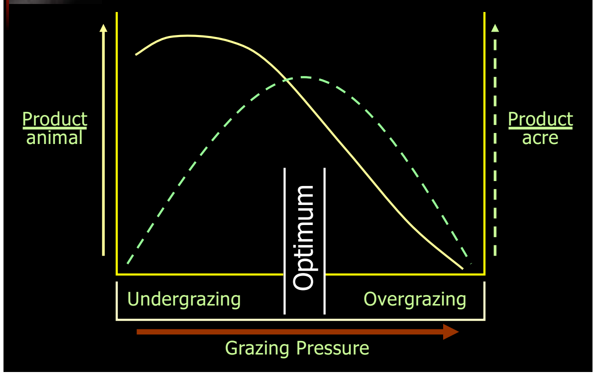
Productivity Per Animal vs. Per Acre



Benefits of Rational Grazing

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4. More animal gains/milk production per acre

Effects of rotational stocking on performance of beef cattle grazing bermudagrass and endophyte-free tall fescue in central Georgia.

Item	Continuous	Rotational	Difference*
Cow weight at calving, lbs	1037	1017	NS
Cow weight at weaning, lbs	1090	1071	NS
Stocking rate, cows/acre	0.50	0.69	+38%
Pregnancy rate, %	93	95	NS
Weaning weight, lb	490	486	NS
Calf production, lb/ac	243	334	+37%

* NS = not statistically significant

Increase in gain per acre in rotational compared to continuous stocked pastures in studies from various southern states.

State	% Increase
Arkansas	44
Georgia	37
Oklahoma	35
Virginia	61

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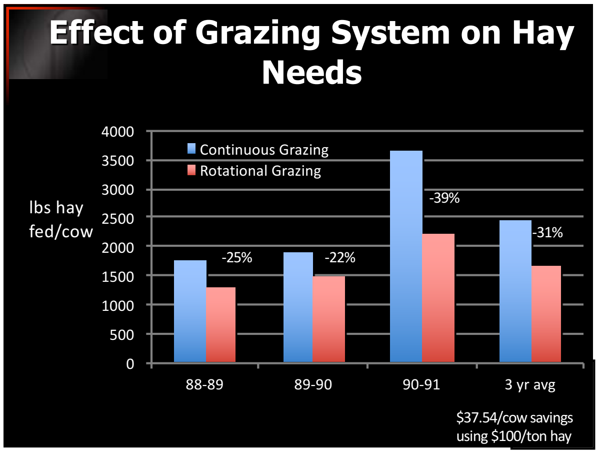

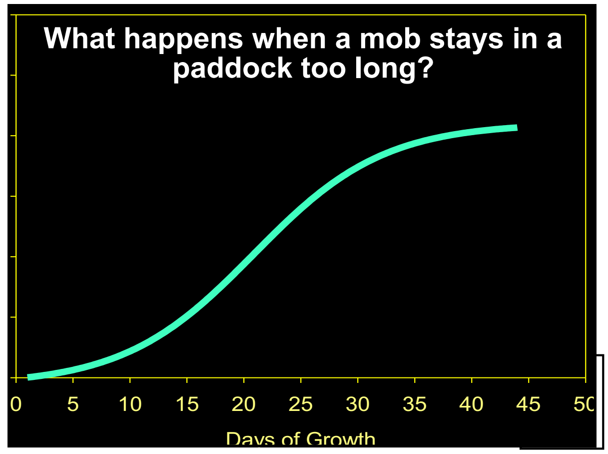

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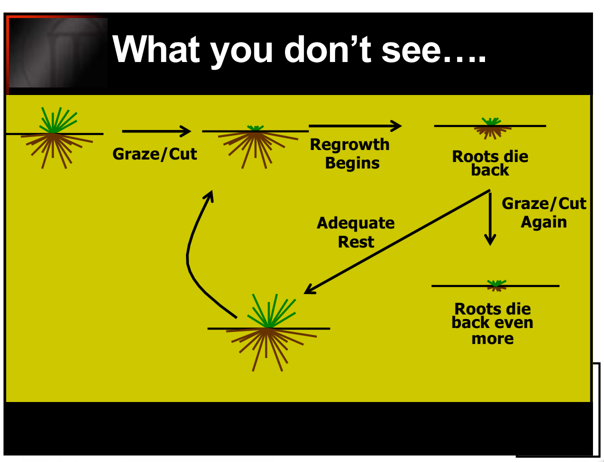
6. Better persistence of desirable forages
   - Especially clover and legume species



Proper Rest Following Grazing is Key!

- In continuously grazed pastures, most plants are grazed every 2 – 7 days.
- With recommended rest periods, roots will redevelop to approximately the same depth as uncut plants.

Picture staged by: C. Mackoviak, Univ. of Florida

2016 Georgia Grazing School:

Manipulating forage growth and grazing behavior

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Grazing Rules of Thumb

Crop	Target Height (inches) Begin Grazing	End Grazing*	Recommended Rest Period (days)
Alfalfa (grazing types)	10-16	2-4	15-30
Annual Ryegrass	6-12	3-4	7-25
Bahiagrass	6-10	1-2	10-20
Bermudagrass	6-12	2-6	10-20
Clover, White	6-8	1-3	7-15
Clovers, Other	8-10	3-5	10-20
Orchardgrass	8-12	3-6	15-30
Pearl millet	20-24	8-12	10-20
Small grains	8-12	4	7-30
Sorghum/sudan	20-24	8-12	10-20
Switchgrass	18-22	8-12	30-45
Tall Fescue	4-8	2-3	15-30

* Height at end of grazing may need to be higher to optimize intake of quality forage or vigorous re-growth.

Management of residual stubble height and rest period ("length of round") on carbohydrate storage in Tifton 85 stems/stolons.*

Stubble Height	Rest Period or "Round"(d) 14	21	28
in.	-------------- (g TNC/m2) ------------		
3			
6			
9			

* Adapted from Liu et al., 2011. Crop Sci. TNC = Total non-structural carbohydrates.

Management of residual stubble height and rest period ("length of round") on effective Tifton 85 yields.*

Stubble Height	Rest Period or "Round"(d) 14	21	28
in.	-------------- (lbs/acre) ------------		
3			
6			
9			

* Adapted from Liu et al., 2011. Crop Sci. Yields are grazing season totals (3-yr avg.) and include only that forage above the managed residual stubble height. SH did not affect CP or IVOMD. Both CP and IVOMD dec. (L from 60.2% to 58.2%) as rest inc. from 14 to 28 d.

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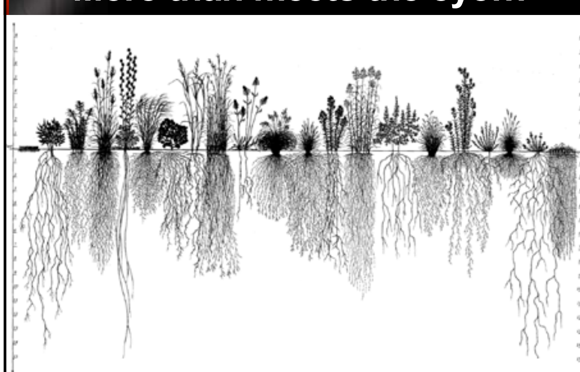
6. Better persistence of desirable forages
   - Especially clover and legume species
7. Better weed suppression

"More than meets the eye…"



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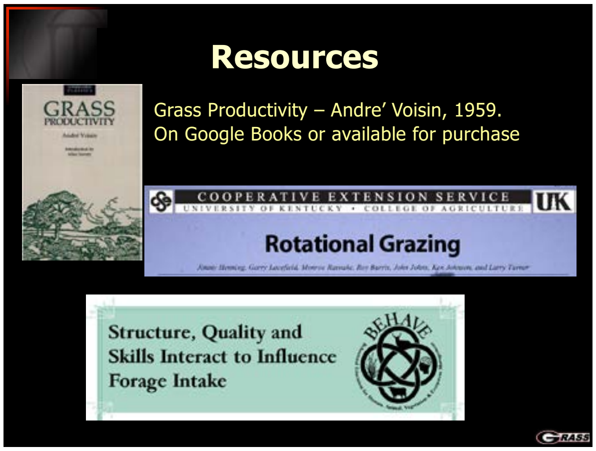

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Grass Productivity – Andre' Voisin, 1959.
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UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE
UK
Rotational Grazing
Structure, Quality and Skills Interact to Influence Forage Intake
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MANAGEMENT-INTENSIVE GRAZING
What is Management-Intensive Grazing?
Quick Links

Questions?
GRASS

Structure, Quality and Skills Interact to Influence Forage Intake

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Behavioral Education for Human, Animal, Vegetation & Ecosystem Management

In general, the more livestock eat, the more weight they gain or milk they produce. Thus, forage intake is key to animal performance. Agronomists manage for correct plant density and height to ensure herbivores maximize intake. While plant structure is important, intake is not dictated by structure alone. Forage quality, current nutritional state, and experience also affect forage intake by herbivores.

Calculating Intake. Daily intake can be calculated using the following equation: Intake = BS x BR x GT where BS = bite size or the amount of forage per bite; BR = bite rate or the amount of forage eaten over time; and GT = grazing time or the amount of time herbivores spend grazing during in a 24 hour period.

Structure Matters. According to a number of research studies bite size has the greatest effect on intake. Managers can maximize bite size by maintaining pastures in a vegetative state - immature and leafy - and by keeping plant height no more than 6 - 8 inches and no less than 2 to 2.5 inches. When forage grows above 6 to 8 inches, nutritional quality declines as the proportion of stems relative to leaves increases; bite size also decreases as animals attempt to select leaves over stems. When forage height drops below 2.5 inches, bite size declines due to a decrease in forage availability. Herbivores must spend more time grazing and increase their bite rate to ingest the same amount of food. If forage is too short, herbivores cannot graze fast enough or long enough to maintain intake and performance.

Differences in the size and physical characteristics of different plant species cause changes in rates of intake by large herbivores. Intake rates in deer and elk increase as their diet changes from grasses to mixed forages and browse because increasing leaf size allows for bigger bites.

Nutritional Quality Matters. Studies of plant structure rarely consider how nutritional quality affects intake because forages used in these studies are typically kept in a high quality state - immature and leafy. In studies where quality and structure both vary, the effects of structure and quality cannot be separated because forages high in nutrients are typically leafy with few stems and easy to eat, while foods low in nutrients are stemmy or woody and difficult to eat.

In cases where structure and quality have been separated, researchers found that diet selection is influenced by the nutrient content of the food as well as by intake rates. Sheep grazing a grass pasture took smaller bites of forage because they preferred to eat only leaves. They could have maintained higher rates of intake by taking larger bites and eating both leaves and stem. Sheep that took larger bites consumed a lower quality diet than sheep that ate only leaves. In addition, animals prefer foods with lower rates of intake if those foods contain needed nutrients or are higher in nutrients than alternative foods. For example, in one study lambs on a high-protein diet were offered a choice between ground barley and alfalfa pellets. Even though intake rates were lower for ground barley than alfalfa pellets, they preferred ground barley because barley is higher than alfalfa in energy relative to protein.

These results have implications for managers of high-producing livestock, such as dairy cows, because the type of forage animals selects on pasture is influenced by the nutritional composition of supplements fed in the barn. Dairy cows fed high-protein supplements in the barn spend more time grazing grass and less time grazing clover compared to cows fed a supplement lower in protein even though rates of intake are higher for clover than grass.

Many believe that the rate of food intake is fixed, and determined solely by bite size and rates of chewing and swallowing, which are determined by plant density, height, and toughness. However, food quality is a key factor influencing intake rates. For example, when sheep were given a solution of starch and water with a stomach tube every time they ate long wheat straw, bite size, bite rate and intake all increased. Thus, structure alone does not determine intake. Likewise, lambs fed a high-energy diet ate high-energy barley more slowly than lambs maintained on a diet high in protein relative to energy. Thus, an animal's current nutritional state and prior postingestive experience with the food both affect rates of intake.

Experience Matters. Small amounts of experience browsing or grazing a food can mean big changes in rates of intake. Naive lambs fed chopped serviceberry in boxes were compared with lambs with 30 hours experience browsing serviceberry. Experienced lambs had faster bite rates and intake rates were 27% higher compared with naive lambs. Naive lambs took larger bites than experienced lambs but could not make up for their slower bite rate. In addition, naive lambs had more difficulty nipping bites off the plant than experienced lambs. Young animals learn foraging skills more quickly than older animals. Six-month-old goats browsing blackbrush had faster bite rates than 18-month-old goats even though both groups of goats had browsed the shrub for 30 days. In addition, after 30 days bite rates for 6-month-old goats were still increasing whereas bite rates for 18-month-old goats had leveled off.

To some degree, skills acquired by lambs on one type of plant - grass or shrub - are specific to that plant form. Lambs experienced browsing shrubs are more efficient at harvesting shrubs than lambs experienced grazing grass, and vice versa. Nevertheless, skills transfer from one shrub to another. Goats with experience browsing blackbrush were more efficient at harvesting oak leaves than goats without browsing experience.

Implications. Intake rate is often thought to be solely dependent on plant structure. However, plant structure, current nutritional state of the animal, prior feedback from nutrients, and the acquisition of foraging skills interact to influence rates of intake. Managers can improve intake rates in their animals by keeping pastures at the correct height, feeding foods in the barn that complement the nutritional composition of forages in pastures and exposing young animals to the forages they will be required to eat later in life.

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Section 2

Southern Forages: Yield, Distribution, and Quality.

Philip Brown, NRCS Grazinglands Specialist

2016 Georgia Grazing School:

Southern Forages:
Yield, distribution, and quality

Philip Brown
USDA-NRCS Grassland Conservationist

Yield, Distribution, and Quality

- Understand these so that forages can be managed according to their needs
- Use species adapted to your area that match:
  - The soil types and soil conditions on your site
  - Your livestock
  - Your management level
  - Your budget

Maximize Grazing Days

Hay Production is Expensive

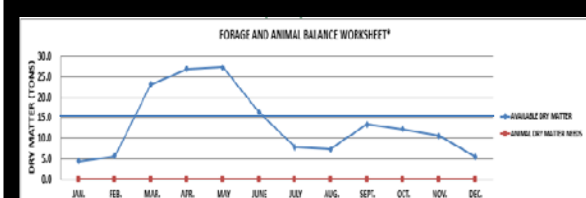
Table 1. Calculating cost of hay production (assuming six tons per acre production).

	Number of Cows					
	35	**50**	**100**	**200**	**300**	**500**
Tons/cow	2	2	2	2	2	2
Acres required	12	17	34	67	100	167
Total VC[a]	$470	$470	$470	$470	$470	$470
VC/Ton	$80	$80	$80	$80	$80	$80
FC[a]	$8,750	$8,750	$8,750	$8,750	$8,750	$8,750
FC/ton	$125	$88	$44	$22	$15	$9
TC[a]	$14,350	$16,750	$24,750	$40,750	$56,750	$88,750
TC/ton	$205	$168	$124	$102	$94	$89
TC/1,000# roll	$103	$84	$62	$51	$47	$45
TC/Cow	$410	$336	$248	$204	$188	$178

[a] VC = variable cost, FC = fixed cost, TC = total cost.

Grazing costs 1/2 to 1/3 of hay production

Forage Distribution



Forage Distribution

- There is No Miracle Forage:
  - That grows all year long
  - Is always high quality
  - Fixes Nitrogen
  - Withstands continuous overgrazing
  - Tolerates all weather extremes
  - Eliminates erosion
  - Doesn't need nutrients…………………

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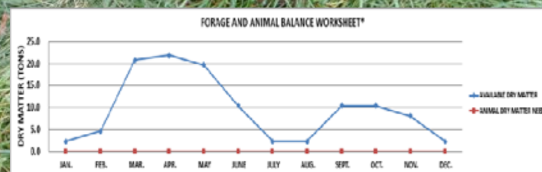
Forage Distribution

- Perennials as the base
  - Tall Fescue
  - Bermudagrass
  - Bahiagrass
  - Often in combination with Perennial Legumes
- With Complementary plantings of annuals
  - Annual Ryegrass
  - Annual Legumes
  - Warm Season Annuals
  - Brassicas

Cool Season Perennial Grasses

- Tall Fescue – 2-5 Tons/Acre
- Base forage for the Moutain & Piedmont Regions
- Stockpiles extremely well for Fall & Winter Grazing
- Toxicity Issues



Introduced Warm Season Perennial Grasses

- Bermudagrass – Base Forage for the Flatwoods, Coastal Plain, and Piedmont Regions
  - Common - 2-6 Tons/Acre
  - Hybrid – 4-8 Tons/Acre
- Bahiagrass – Best Adapted to the Flatwoods & Coastal Plain Regions
  - 3-5 Tons/Acre

Native Warm Season Perennial Grasses

- 3-6 Tons/Acre
- Forage Quality – 8-16% Crude Protein / 58-62% TDN

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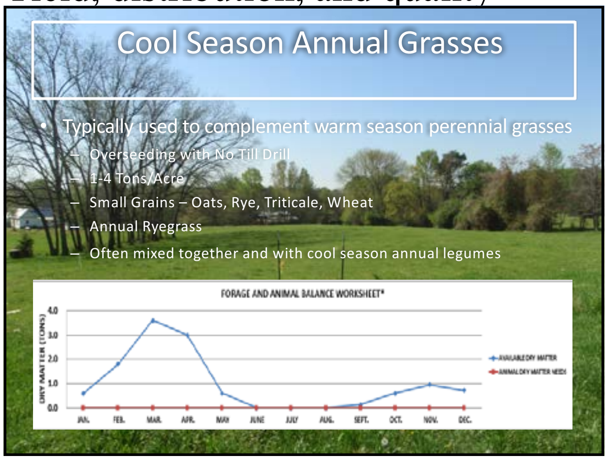

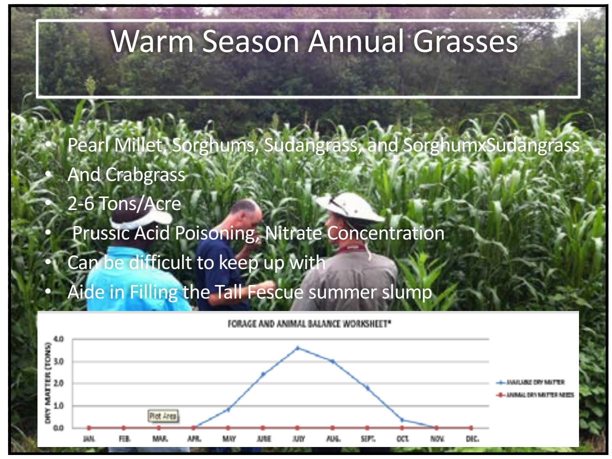

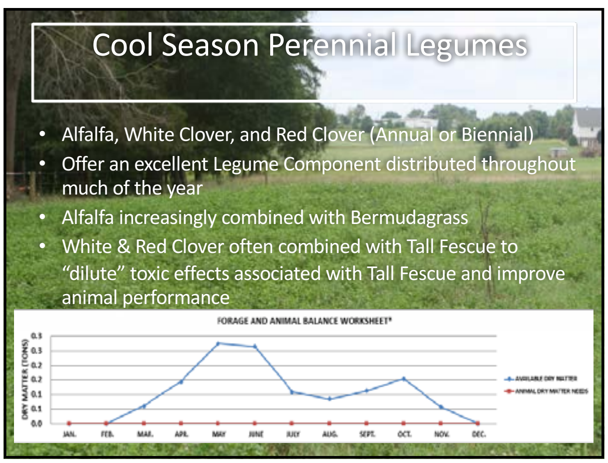

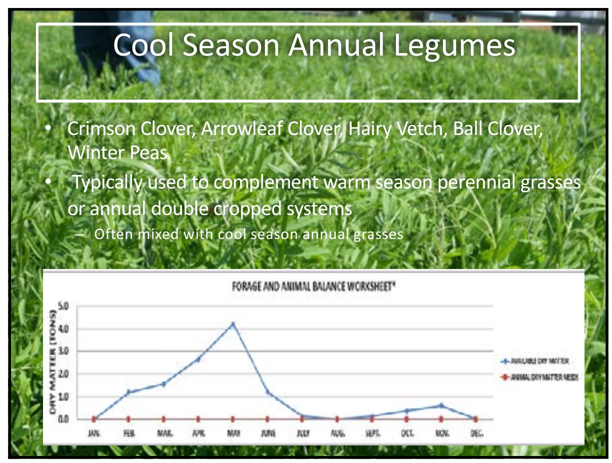

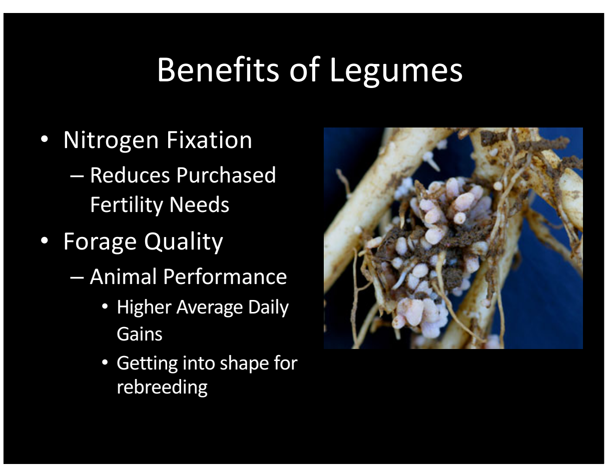

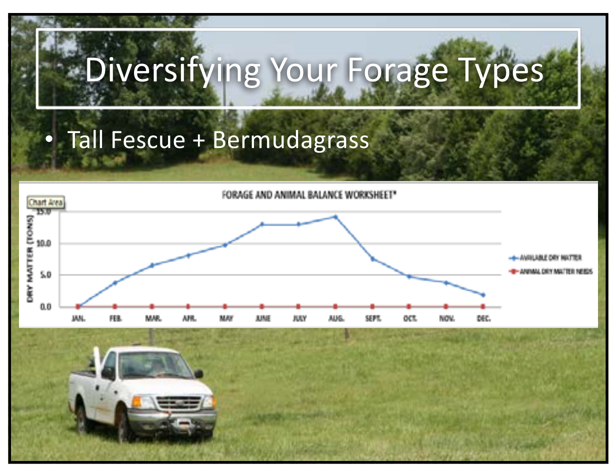

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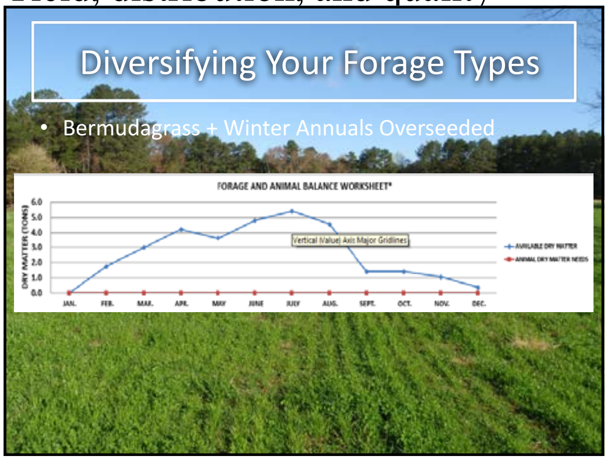

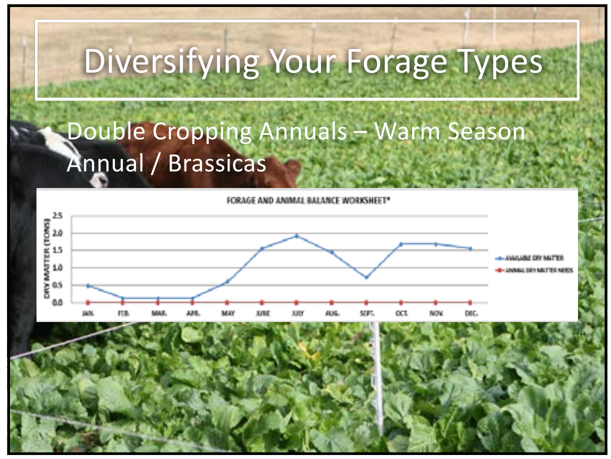

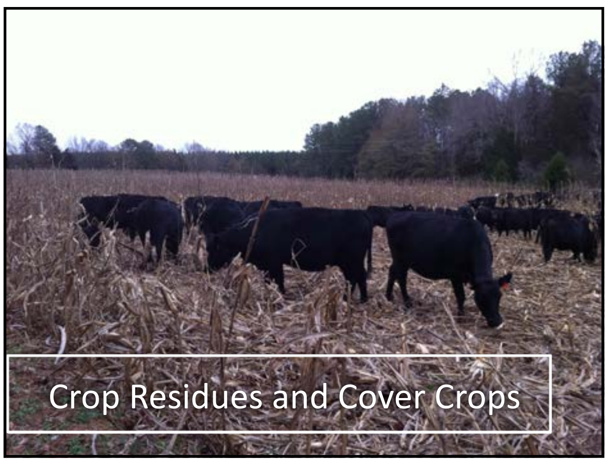

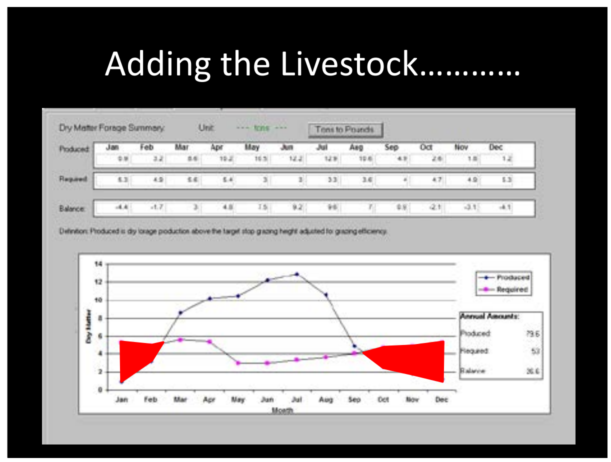

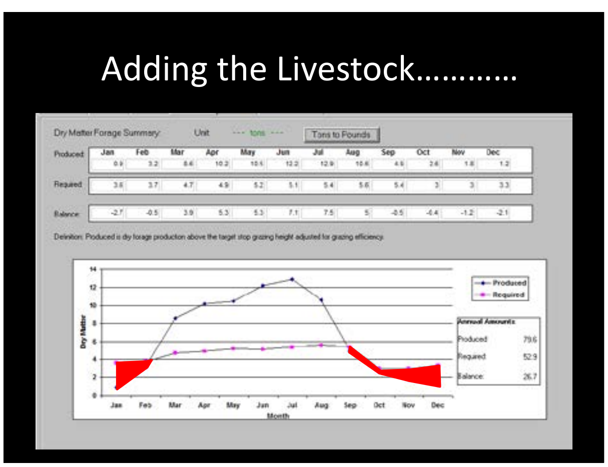

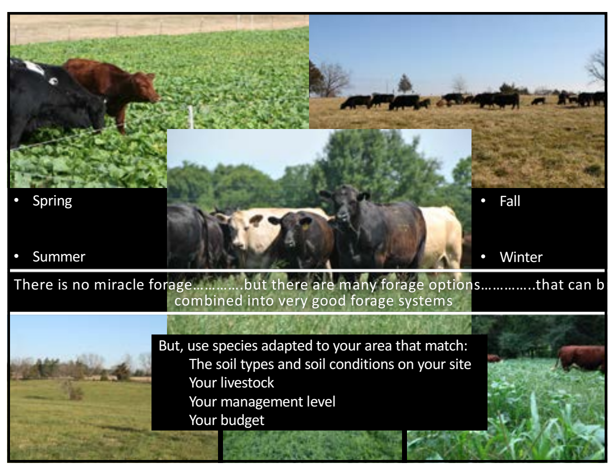

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Typical Yield and Quality

Table 1. Dry Matter Productivity, Recommended Grazing Heights, and Estimated Regrowth / Recovery Period by Forage Species

Forage Species	Average Production* (lbs/Ac.-Inch)	Production Range* (lbs/Ac.-Inch)	Annual Production* (lbs/Ac.)	Plant Height to End Grazing* (inches)	Plant Height to Start Grazing (inches)	Approximate Recovery / Regrowth (Days)
Warm Season Grasses						
Bahiagrass	225	100-300	8,000	1-2	3	20-28
Bermudagrass, common	200	150-300	8,000	2-3	5	18-28
Bermudagrass, hybrid	260	150-500	12,000	3-5	6	18-28
Big Bluestem	200	50-250	8,000	4	8	25-40
Crabgrass	180	75-200	6,000	2-3	7	18-28
Dallisgrass	250	150-350	6,000	2-4	5	21-36
Eastern Gamagrass	200	50-250	8,000	8	12	28-42
Indiangrass	200	50-250	8,000	5	10	28-40
Johnsongrass	150	100-250	7,000	8	20	21-30
Millet	150	100-250	10,000	9	15	21-30
Sorghum-Sudan hybrids	150	100-250	8,000	6-8	18	21-30
Switchgrass	200	50-250	8,000	8	12	30-42
Cool Season Grasses						
Annual Ryegrass	250	75-400	6,000	2-3	5	14-21
Orchardgrass	180	75-300	7,000	3-5	8	20-30
Small Grains	150	75-250	6,000	3-4	8	14-21
Tall Fescue	210	100-350	8,000	3-4	8	21-30
Cool Season Legumes						
Alfalfa	225	75-400	8,000	3	8	20-25
Clover (arrowleaf or crimson)	200	100-400	7,000	2-4	6	14-27
Clover, red	220	100-500	7,000	2-3	4	18-25
Clover, white	200	75-300	3,000	2-3	4	18-30
Warm Season Legumes						
Lespedeza, annual	150	50-250	3,000	2-3	4	20-30
Sericea Lespedeza	200	150-250	4,000	4-8	8	18-25
Mixtures						
Bermudagrass / legumes	250	100-400	8,000	2-3	6	14-30
Tall Fescue / alfalfa	225	75-400	7,000	3	7	20-30
Tall Fescue / bermudagrass	250	150-350	8,000	3	6	18-30
Tall Fescue / legumes	200	80-325	4,000	3	6	18-30

Forage Species	% Crude Protein	% TDN
Grasses		
Bahiagrass	6-12	45-60
Bermudagrass, common	6-12	45-60
Bermudagrass, hybrid	6-14	45-60
Big Bluestem	8-16	50-69
Crabgrass	10-15	50-65
Dallisgrass	6-14	50-58
Eastern Gamagrass	8-16	50-69
Indiangrass	6-14	50-67
Johnsongrass	8-12	50-65
Pearl Millet	6-16	50-65
Orchardgrass	8-16	56-66
Annual Ryegrass	8-16	59-68
Small Grains	8-16	59-68
Sorghum-Sudan hybrids	8-12	50-58
Switchgrass	6-14	50-57
Tall Fescue	8-16	56-66
Mixed Grass	6-15	45-65
Legumes		
Alfalfa	9-26	50-67
Clover, arrowleaf or crimson	6-21	55-65
Clover, red	6-21	59-70
Clover, white	9-25	60-80
Mixed Grass/Legume	6-17	50-60

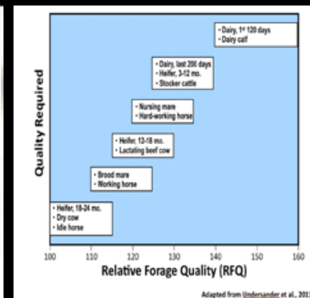
Forage Quality Needs By Animal Class

Table 32. Total digestible nutrient (TDN) and crude protein (CP) requirements of selected animal classes.

Animal class	TDN, %	CP, %
Growing beef steer		
450 lb (1.5 lb/day gain)	65	11-13
650 lb (1.7 lb/day gain)	68	10-11
Beef cow		
Lactating	60	10-12
Dry, pregnant	50	7-8
Sheep		
Lamb (finishing)	70	12
Ewe (lactating)	65	13
Ewe (maintenance)	55	9
Deer		
Doe (lactating)	66	14-16
Growing buck	60-64	12-14
Meat-type goat		
Doe (lactating)	62	12
Growing buck	62-66	12-13
Horse (maintenance)	70	10-11

Source: M.A. McCann, Animal Science Dept., Virginia Tech University.

Taken From: "Forage Crop Pocket Guide"
Developed By: D.M. Ball, C.S. Hoveland, and G.D. Lacefield
Edited By: D.L. Armstrong and B.C. Darst



Forage Quality

- **F**orage quality can be defined as the extent to which a forage has the potential to produce a desired animal response.
  - What influences our determination of Forage Quality
    - Palatability
    - Intake
    - Digestibility
    - Nutrient Content
    - Anti-Quality Factors
    - Animal Performance

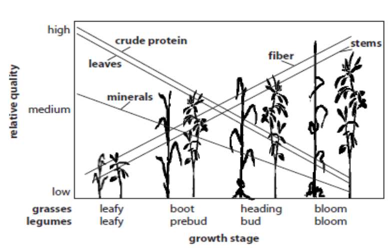
Management Factors that Affect Forage Quality

Importance	Factor	Recommendations
High	Forage Maturity	Cut the forage in the late vegetative or early reproductive stages of growth. See the harvest recommendations in Table 5 for detailed information on individual species.
High	Forage Species	Use a high-quality forage species that persists and can be produced economically in your environment. Species resistant to drought and temperature extremes should be used.
Moderate	Forage Utilization	Grazed forage is generally higher quality than conserved forage (i.e., hay, silage, etc.) because of animal selectivity and because fresh forage is generally higher in digestible nutrients. However, selectivity may reduce overall forage utilization compared to mechanically harvested systems.
Moderate	Variety	Use varieties that have proven to provide a good balance of high quality and high yields. Select disease- and insect-resistant varieties.
Moderate	Storage	Protect hay bales from rainfall and weathering during storage (e.g., barn, tarp, etc.). Properly pack and exclude oxygen from forage that is being ensiled.
Moderate	Rain Damage	Avoid cutting if significant rainfall (> 0.50 inches) is predicted during curing, but take care to avoid allowing forage to become overly mature.
Moderate	Heat Damage	Dry forage to the appropriate moisture for making hay (Round: 15%; Square: 18%) and store in a manner that allows adequate ventilation. Maintain integrity of oxygen barrier in silage storage.
Low	Fertilization	Fertilize based on soil test recommendations and at recommended times to sustain CP/mineral concentrations in the forage and to maximize vegetative mass in the standing forage.

Taken From: UGA Extension Bulletin 1425 – Understanding and Improving Forage Quality, D.W. Hancock, et.al.

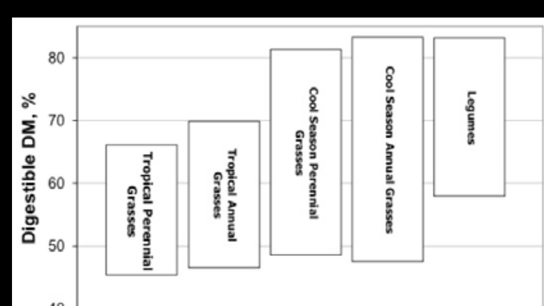
Forage Quality – Stage of Maturity

Figure 3. Effect of plant maturity on forage intake and digestibility.



Source: *Adapted from Blaser, R., R.C. Hammes, Jr., J.P. Fontenot, H.T. Bryant, C.E. Polan, D.D. Wolf, F.S. McClaugherty, R.G. Klein, and J.S. Moore. 1986. Forage–animal management systems. Virginia Polytechnic Institute, Bulletin 86-7.*

Forage Quality - Species



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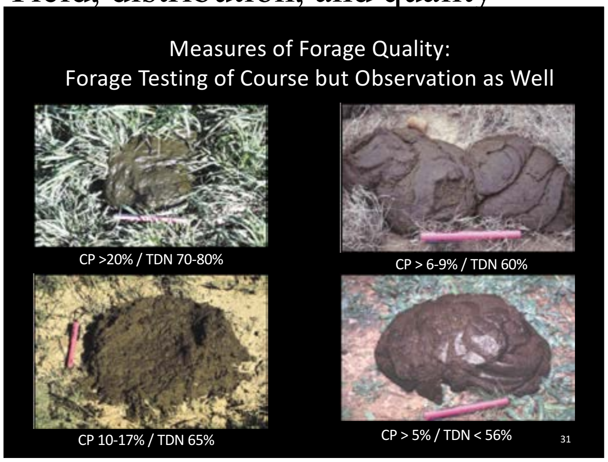

Conservation Take Home

- Good Forage Systems Conserve:
  - Soil (and build soil)
    - Good Ground Cover
  - Animal Condition
    - Adequate Quantity and Quality
  - Income
    - Good seasonal distribution = Less hay production and feeding
  - Quality of Life
    - See Income Above
    - Less hay production = the livestock do more of the work

Principles of Plant Growth ...

Factors Which Affect Growth and Persistence of Plants and Implications for Grazing Management

The goal of any serious grazier or forage producer is to manage plants in such a way that **high yields** of **satisfactory quality** feed can be **grown for long periods of time.** Grasses and legumes, whether grazed or stored as hay or silage, are the very basic "raw products" being produced, processed and marketed from the farm. Profitable and sustainable livestock production requires a reasonable understanding of the growth processes and management responses of plants, as well as the animals consuming the plants. Therefore, it is important that one understand the interactions of plants with environment, harvest schedules and/or the grazing animal.

UNDERSTANDING PLANT GROWTH

The pasture sward is composed of thousands of individual tillers or plants (often called shoots or stems). The management of a pasture is merely the management of thousands of plants growing in association. It is important that one understands how green leaves, reserve energy storage location and plant "growing points" affect plant survival and production.

This paper will present some aspects of "plant physiology" and "plant morphology" that impact pasture management decisions.

Plant physiology... is the study of chemical and organic functions of plants; it is the understanding of how plants live, grow, age and die in response to various environmental and management factors.

Plant morphology... describes the plant physically; it is the outward appearance or physical stature of the plant as it is growing in place.

The following questions can be answered based on an understanding of the physiological and morphological aspects of plants:

1. How often can a particular forage or pasture be grazed or cut each year?
2. How close to the soil can pasture plants be grazed or cut each time?
3. What is the seeding rate and when is the best time to plant a particular crop or mixture?
4. When is the best time to fertilize, how much should be applied, and how often should it be applied?
5. What is the feed value or expected animal performance when grazing a particular pasture species or mixture?
6. How many years can one expect a particular species to live if it is grazed rather than harvested for hay or silage?
7. How long will a species persist if properly managed: annual or perennial?
8. What season does it make it's most growth: cool or warm season?
9. Will it fix nitrogen: grass vs legume?
10. What type of root system does the species have (tap vs fibrous), and how does that affect soil adaptation?

PRIMARY SITE Of PLANT FOOD" PRODUCTION....*The Green Leaf*

It's understood that all parts of the plant are critical to optimizing plant growth. However, the "**green leaf"** is the actual site of "plant food" production (Figure 1). The "physiological" process of "plant food" production is called **photosynthesis**, which means light synthesis or production of organic matter with light. The very basic compound produced by photosynthesis is a "simple sugar", and these simple carbohydrates are combined to form the building blocks for protein, wax, cellulose, hemicellulose, pectins, lignin and other materials used in plant maintenance and development.

The root system is critical for the uptake of water and minerals, but the **green leaf** is where the foundation or "food" for growth starts. In other words, all of the increase in "organic matter" which we call **growth** (and use for food and fiber) comes from the combination of carbon, water, minerals and water in the green leaf.

It's estimated that 95% of the raw materials used to assimilate organic matter (feed) comes from the atmosphere (CO_2, sunlight) and only 5% of it from the soil (minerals).

GENERAL PLANT DEVELOPMENT

Plants, like all living organisms, go through various growth phases between germination or birth to maturity. Generally the growth is slow initially, followed by a rather rapid phase until near maturity, when it slows again. This development is often illustrated using an "S-shaped" curve as shown in Figure 2. Generally, managers want to keep the plants in the most active growth stage as much as possible. For pastures grown in the Mid-Atlantic region regrazing is done when plants reach 6-12 inch height and leaving 2-4 inches of stubble after grazing. The amount of time it takes the plants to recover to the optimum growth phase after grazing will depend on things such as soil moisture, temperature, leaf area remaining, storage carbohydrates and animal traffic.

Table 1 provides a summary of some of the plant characteristics one might see when plants are in the three phases of growth.

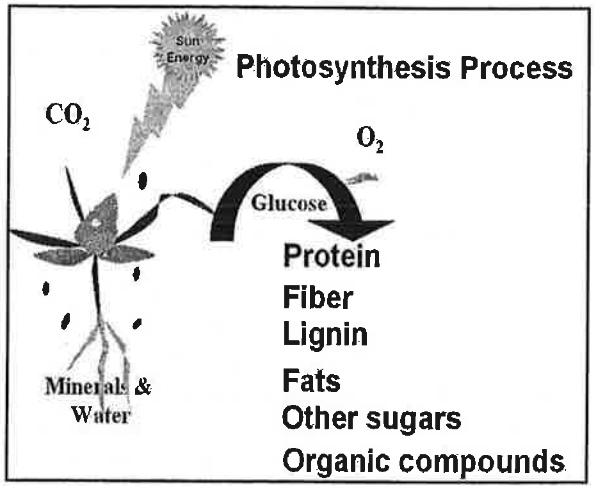

Figure 1. Illustration of the process and gross products of photosynthesis.

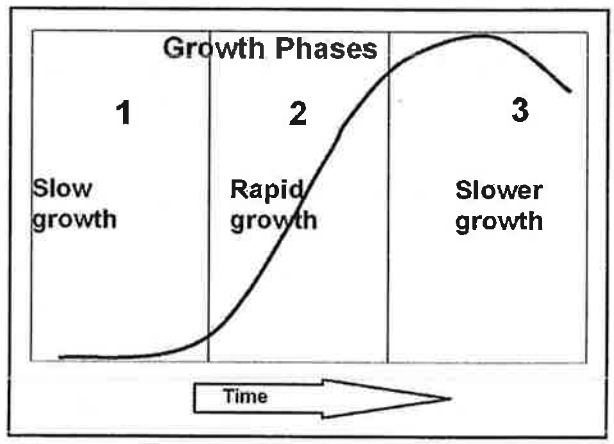

Figure 2. Illustration of plant growth over time following harvest or new seedling development (Voisin, 1959).

WHAT ARE THE FACTORS ESSENTIAL FOR PLANT GROWTH?

All plants require the same things for growth and development:

A. Sunlight
B. Favorable temperature
C. Water
D. Nutrients
E. Carbon dioxide
F. Oxygen

Plants growing in mixtures may actually compete for some of the above resources if they become limiting (such as water, nutrients, light). Even though all plants require the above resources, they may require them differentially because of physiological or morphological responses.
Understanding how plants respond differently to those factors in various situations is very important to successful management of crops and pastures. The farmer who can manipulate the plants or environment to optimize growth and its utilization with the grazing animal will be the most successful.

HOW ARE "ESSENTIAL FACTORS" USED IN PLANT GROWTH?

Sunlight..... is the energy source for all growth on earth. We certainly cannot control its output on the farm (day length, light quality, wave length, or density). However, we can control the amount of energy that is captured by plants and mixtures by controlling the stand density, height of canopy, grazing frequency, degree of defoliation and fertilization.

Rate of plant growth is favored when there are enough **green leaves** to capture 95% of the incoming sunlight; any light striking the earth's surface is essentially wasted in terms of producing organic matter (feed). Maximum light reception usually occurs when the pasture canopy is between 4-10 inches tall, or when the leaf area is 3-6 times that of the soil area on which it is growing (Tables 1 and 2).

Shading within a canopy can cause the lower leaves to turn yellow; this reduces growth rate and feed quality. To minimize shading of leaves within the canopy of fescue/ orchardgrass/ bluegrass, forage should be grazed from 6-10 inches back to 2-4 inches. Since plants tolerate different levels of shade and they actually "compete" for light, farmers can influence the plant species composition of mixtures by controlling the height and

Table 1. Generalized characteristics during the three growth phases(note Figure 2) of plants or canopies.

CHARACTERISTIC	GROWTH PHASES		
	I	II	III
GROWTH (lbs/acre/day)	LOW	RAPID	MEDIUM
LEAF AREA	LOW	MED-HIGH	VERY HIGH
GREEN LEAF	LOW	HIGH	MED-JIGH
LIGHT INTERCEPTION	LOW	HIGH	VERY HIGH
WITHIN CANOPY SHADING	LOW	MEDIUM	VERY HIGH
PHOTOSYNTHESIS/LAI	HIGH	MED-HIGH	LOW
REGROWTH DEPENDENCE ON CHO	HIGH	LOW	LOW
INTAKE, lbs/head/day	LOW	HIGH	MED
FEED QUALITY	VERY HIGH	HIGH	MED-LOW
YIELD (lbs/acre)	500	2000	4000

frequency of defoliation. For example, shading within the canopy is usually the reason why white clover cannot be maintained in mixtures with grasses; lax grazing or haying management usually allows the grass to shade the growing points of clover which are located on the stolons running along the ground surface. Frequent, close grazing will favor clover.

Shade tolerance of species...some plants are more tolerant of shade than others and managing this aspect can help control botanical composition of mixtures. For example (> is more tolerant than):

Tall Fescue >Ky Bluegrass> Orchardgrass
Red clover >Alfalfa> White Clover

Tiller density is markedly affected by the amount of light getting to the base of plants. The tiller buds located at base of plants cannot develop and survive unless some light periodically reaches them. For example, lawns and frequently grazed pastures have much "thicker or denser" stands than do hay fields, partially a result on light penetration to base of plants.

Flowering (beginning of seed formation) is a response to day length and/or temperature requirement. For example, somc plants (fescue, orchardgrass, ryegrass, bluegrass) normally produce a seed head only once per year. Tillers will remain vegetative unless vernalized (exposed to long nights-short days and cool temperatures). Other plants like alfalfa, clover, bermudagrass, millet, sudangrass, crabgrass, bromegrass will produce a flower or seed stalk after each regrowth because they do not need the vernalization effect.

Temperature...The optimum temperature range for growth of fescue, orchardgrass, bluegrass, ryegrass, bromegrass, timothy, small grains, white clover, red clover and alfalfa is 65-80° F. (Fig. 3) The optimum range for bermuda, switchgrass, crabgrass, sudan, millet, corn is 85-95° F. (Fig. 4) Since no one specific species grows year-round, it is necessary to have a combination of cool and warm season species to provide a long growing season. For example, a farm may need 15-30% of the acreage in warm-season species and the rest in cool-season crops in order to provide the longest grazing season. Some noted exceptions to the optimum temperatures: fescue, rescuegrass and smallgrain rye will grow more than any other species when temperature are in the 40's; alfalfa will grow quite well at temperatures above 85° F; bermudagrass and crabgrass do not grow rapidly at temperatures below 70° F, with almost no growth at 55° F or less; switchgrass, howeve,r will make significant growth at temperatures in the 70's and often greens up earlier than other warm season plants.

The favorable temperature is not the same for

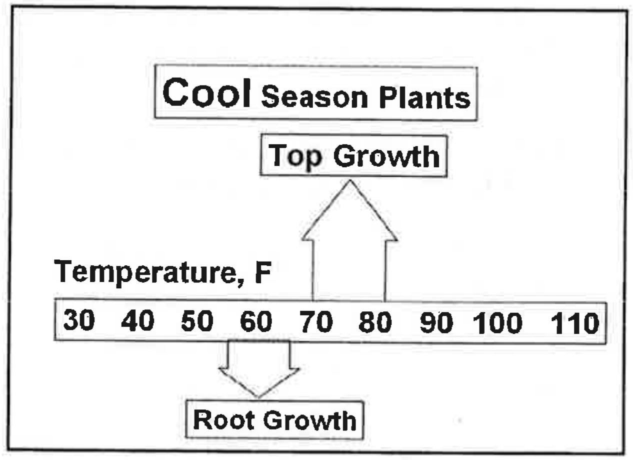

Figure 4. Optimum temperature for growth of cool season plants.

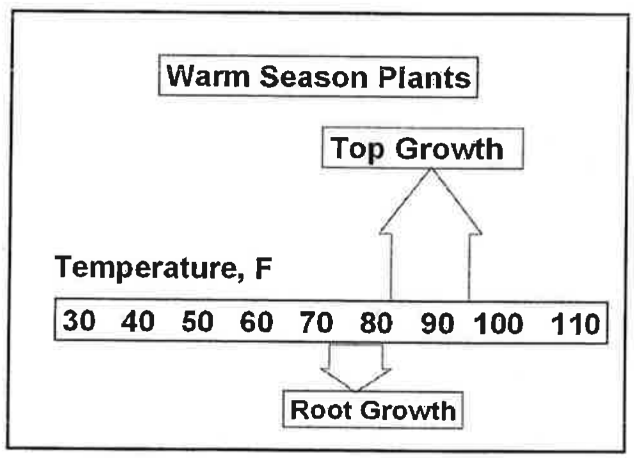

Figure 3. Optimum temperature for growth of warm season plants.

photosynthesis and growth (cell expansion and cell division). For example, when the temperature drops below the optimum range for growth, the rate of photosynthesis may continue at a relatively high level in fescue, orchardgrass, ryegrass, bluegrass and other cool season grasses. This often results in an accumulation of carbohydrates "plant food" in the plants. The quality of most cool season plants will be higher when the temperature is just slightly below optimum for growth, but not low enough to stop photosynthesis.

High summer temperatures cause many plants to become less digestible because of the relative changes in carbohydrate and fiber composition; this often results in accelerated "aging" and "browning" of plant tissue, which results from a change in the relative amount of carbohydrate within the plant.

Soil Moisture...Moisture is important in the photosynthesis process, but its prime contribution is for plant cooling and nutrient transport. Warm season plants tend to be more efficient in terms of producing dry matter per lb of water than the cool season plants. High temperatures are usually associated with the "dry" conditions which further hampers the growth of the cool season forages. Some generalizations about moisture and plant growth:

a. when moisture becomes limiting, growth stops before photosynthesis stops, therefore, plants may actually accumulate carbohydrates which can be used for survival or for regrowth after the stress is relieved.

b. when moisture becomes limiting, growth and metabolic processes slow or stop, resulting in "un-assembled" products within the plant cells. For example, nitrate accumulation may occur when plants have access to soil N and the plant growth is "stalled" because of moisture or temperature stress.

c. moisture stress generally has more detrimental effect on "yield" of feed than it does on "quality" of feed, at least in the early stages. In other words, if plants are young, leafy and green, the feed quality may still be excellent even though yield is low. However, when high temperatures are associated with moisture stress for extended periods of time, quality is adversely affected through increased dead tissue and elevated fiber composition.

Nutrients... Fertilizer or nutrient management is the one aspect of plant growth that everyone recognizes to be important for high yields. Soil testing is the best way to monitor nutrient needs. Below are a few principles which may help in understanding the role of nutrients in the physiology of plant growth.

a. High N and high temperatures (85-90° F) can cause cool season grasses to die because of high cell respiration rates. This is the reason why it is not recommended to apply N or manure to such crops in summer months of June-August.

b. Lack of nutrients will restrict yields much more than it will affect feed quality. If properly grazed and kept in a leafy condition, the feed quality of low fertility plants may be surprisingly good. This occurs because photosynthesis will be relatively high as compared to "growth", resulting in an accumulation of "plant food" in the storage organs and leaves. This plant food (carbohydrates) is highly digestible.

How Do Plants Regrow after Grazing or Harvesting or Dormancy???...when green leaves are not present.

When plants have plenty of young, green leaves "plant food" production from photosynthesis often exceeds growth requirements, therefore the "excess" is stored for use later by new developing buds or regrowing tillers. **Growth of the plant has first priority for use of "plant food"**, but once that need is met, the excess "plant food" being produced by the green leaves is stored somewhere in the plant (Figure 5). The regrowth after cutting, grazing, or dormancy from temperature or moisture stress, depends heavily on **"reserve energy"** which has been previously stored in specific organs of the plant. This "reserve energy" is often referred to as **"root reserves"** or **"energy reserves"** or **"stored energy."** Fescue/orchardgrass/bluegrass/clover canopies will be roughly 4-8 inches tall and provide between 1000 - 2500 lbs of dry matter per acre by time plant "replinishes" reserve levels.

Storage Organs for Species

Stem base	Rhizomes	Taproots	Stolons
bahia	bahia	alfalfa	bermuda
bluegrass	bermuda	lespedeza	crabgrass
bromegrass	bluegrass	red clover	white clover
crabgrass	bromegrass	white clover	
dallisgrass	Johnsongrass	other legumes	
gamagrass	switchgrass		
orchardgrass	tall fescue		
millet			
rescuegrass			
ryegrass			
smallgrains			
sudangrass			
switchgrass			
tall fescue			

Figure 5. The primary organs where reserve energy (carbohydrates) are stored for several plants.

WHERE IS THE "RESERVE ENERGY" STORED IN PLANTS

Grazing or harvesting height is primarily based on the location of storage organs in forage plants (Figure 5). For example, animals can remove the storage organ in orchardgrass or sudangrass by grazing the lower stem base, but they are not likely to eat the tap root of alfalfa nor the stolon of white clover. Plants like bermuda and quackgrass, which store reserve energy in rhizomes and stolons, are more tolerant of close, frequent grazings, partially because of location of reserve energy and the amount of leaf left following defoliation..

HOW DO PLANTS REGROW AFTER GRAZING OR HARVESTING?
...When Leaf Area Is Remaining

All plants are dependent on reserve energy for regrowth following harvesting or natural dormancy, however the number of green leaves remaining after defoliation also has a significant influence on the amount and rate of new growth. Some plants seem to maintain many green leaves near the soil surface (bermuda, bluegrass, endophyte fescue), especially under grazing situations. For example, bluegrass and white clover are very tolerant of frequent and close grazing because they have tremendous reserve energy storage capacity (rhizomes, stolons, stem bases), and they can maintain green leaves within a half-inch of the soil surface. Regrowth is boosted by reserve energy in addition to continued photosynthesis from remaining leaf area as

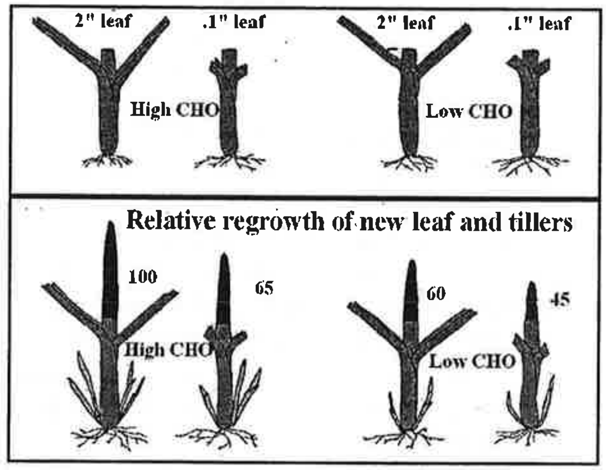

Figure 6. Illustration showing the effect of leaf area and charbohydrate (CHO) status on regrowth of primary leaf blade. (Blaser, 1986).

illustrated by the orchardgrass in Figure 6 .

WHEN TO RE-GRAZE

Regrowth rate will vary by location and environment, so the manager has to constantly observe plant growth to make good decisions. Table 2 provides a guideline on when to start and stop grazing certain species and the general length of rest before regrazing.

Plants which usually utilize reserve energy more than leaf area near soil surface for rapid regrowth after harvesting or grazing.

These plants depend heavily on **reserve energy** for rapid regrowth, however, almost all of them will, in various management situations, have some amount of leaf area remaining after grazing; after cutting, most will have very few leaves remaining.

Alfalfa...new growth following harvest primarily comes from crown buds and axillary buds which are dependent on energy from the tap root. Alfalfa does not tolerate frequent grazing except in early spring where many green leaves remain after grazing.

Red Clover... relative to alfalfa, it usually has more leaf area near soil surface, therefore is somewhat more tolerant of frequent defoliation.

White Clover... stolons and tap roots provide large reserves for regrowth, but the plant easily adapts to close frequent grazing by developing new leaves on very short petioles. It often thrives under frequent and close grazing, because light penetration to the stolons is so important to survival of developing buds.

Orchardgrass... is largely dependent upon reserves stored in stem bases, but it can adapt by producing leaf area near soil surface when the canopy is frequently grazed. Most varieties cannot tolerate close (<3") frequent grazings as well as endophyte infected fescue.

Sorghum-sudan or Pearl millet... regrowth is highly dependent upon reserves stored in lower stem base (lower 6" of stem), therefore frequency of grazing and height of stubble are critical to rapid regrowth.

Switchgrass & gamagrass...these grasses store energy in stem base, but also in the upper root (short rhizomes) system. When cut for hay they retain very few leaves, but when grazed in the vegetative to preboot stage they remain leafy and tiller more profusely.

Rescuegrass/prairiegrass...stores energy in stem base, and its regrowth is rapid when 3-4 inches of stubble remain after grazing or harvesting. It is a leafy grass, but fairly "upright" with not many prostrate leaves near the soil surface.

Plants which usually utilize leaf area near the soil surface more so than reserve energy for rapid regrowth after harvesting or grazing.

These plants are usually most tolerant of close frequent grazing because they retain significant leaf area near soil surface. However, their regrowth rate following hay harvesting depends upon reserve energy in the stem base since there are few leaves remaining below the harvest height.

Tall fescue...under grazing it can produce leaves within 1-2 inches of soil surface. Endophyte infected fescue can tolerate close, frequent grazing but endophyte free varieties will not be as tolerant; these differences are related to the effects of the endophyte on plant adaptability. Endophyte free varieties should be managed similar to orchardgrass.

Kentucky bluegrass... under grazing it is extremely leafy near soil surface and has short rhizomes which store energy reserves in addition to the lower stem base.

Bermudagrass... it is well adapted to close grazing because it can produce leaves within ½ inch of the soil surface. It also has vast reserve energy storage capacity in stolons and rhizomes.

Bahiagrass & Dallisgrass...these grasses retain leaves near soil under most management conditions. Bahia has short rhizomes and very stout stolons which make it well adapted to close grazing. Dallisgrass occasionally has short rhizomes, so most energy is in stem base.

Crabgrass... There are many variations and types of crabgrass. Some are much more prostrate than others. Stems often lodge onto soil surface and root at the nodes with leaves near the soil. Generally, there is considerable leaf area remaining after grazing.

MORPHOLOGICAL ASPECTS OF PLANT MANAGEMENT

Definition....Plant morphology describes the plant physically (Figures 7-10); it is the outward appearance or physical stature of the plant as it is growing in place. The following aspects help describe the morphology of plants:

- **(1) size of canopy**
- **(2) erect or prostrate growth habit**
- **(3) presence of stolons, rhizomes, or tiller branches for propagation**
- **(4) kind (tap or fibrous) and depth of root system**
- **(5) location and presence of axillary buds that form roots or shoots**
- **(6) location of growing point**
- **(7) stem:leaf ratio**

The Plant Tiller.....The grass tiller (**shoot**) is composed of a **growing point** (apical meristem which may turn into a seedhead), a **stem**, **leaves, roots, nodes** (joint) and **dormant buds (Figure 7). Buds** are located at the nodes which are at the base of the shoot (**basal buds**), on the stem (**axillary buds**) and at the nodes on the stolons or rhizomes. The dormant or inactive buds have potential to produce a **new tiller** (shoot) with a new growing point.

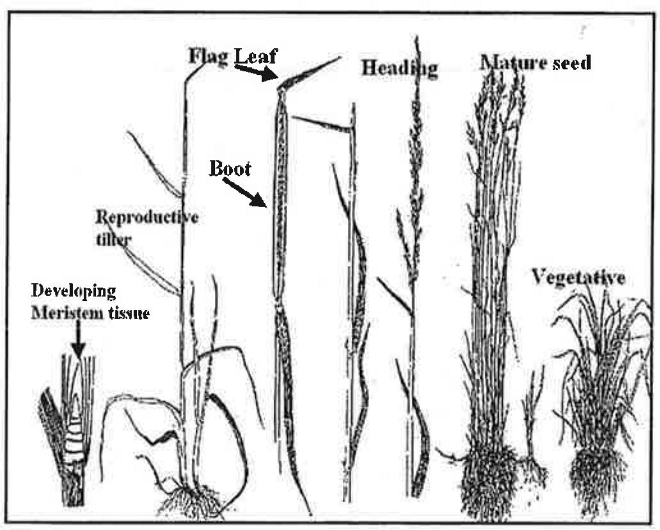

Figure 7. Morphological stages of growth of a grass plant: from left note the meristem region found at the tiller base and subsequent reproductive stages and vegetative stage. (Blaser, 1986)

A tiller developing in the spring season from a dormant bud can be compared to an annual plant developing from seed. In effect, the tillers of perennial grasses act as annual plants. The number of tillers in a sward is strongly related to the amount of sunlight reaching the tiller buds at base of plants. All grass tillers begin growth from a growing point arising from a dormant bud **at or below** ground level.
As long as the tiller is vegetative, it has the potential to produce an indefinite number of leaves, however it will rarely have more than 3 to 5 leaves at a time. When the growing point of the tiller is triggered to elevate or become reproductive, there is no further potential for new leaf initiation in that tiller.

Jointing or stem elongation is a transitional stage between the vegetative and reproductive stages of growth. If the tiller has become reproductive, a seedhead will emerge. Grasses like fescue, orchardgrass and bluegrass become reproductive once per year (spring) and all subsequent growth is vegetative. As a result, the growing point on these vegetative tillers is always near the soil surface.

Following the removal of the growing point in a tiller, new growth may come from the development of buds at one of three places: 1) **an intact growing point** of the defoliated tiller (the most rapid growth occurs here); 2) the **basal and rhizome buds**, are second source of rapid growth; 3) **aerial tillers**, although active on some grasses like switchgrass and reed canarygrass, are the least productive of the new tillers.

How does understanding plant morphology help in grazing or harvesting management of plants?

The position of axillary shoot and root buds often determines stand longevity and survival when plants are exposed to extremes in temperatures during winter and summer. The depth of root system influences the plant's adaptation to flooded or very dry soil sites. Rhizomatous species provide protection to buds thus they have survival advantages under stressed environments.

Size of canopy (or top growth) and its erect or prostrate growth habit help to determine whether a species is useful for silage, hay, grazing, or stockpiling. It also helps determine extent and frequency of defoliation. Nutritional quality is influenced by the leaf:stem ratio of forage on offer.

The rate of seeding is related to morphology.

1. alfalfa and white clover are not compatible in mixtures - prostrate canopies of white clover are eliminated by lack of light from tall erect alfalfa canopies.

2. species with rhizomes and/or stolons can be seeded at low rates since they invade bare areas more readily.

3. differences in seedling growth rate and canopy development helps determine mixture combinations.

Plant succession and changes in botanical composition are often controlled by size of species (canopies and roots), presence of stolons or rhizomes, and location of storage organs and regrowth tissue, all of which strongly influences competition for light, moisture, and soil nutrients (Figures 8-10).

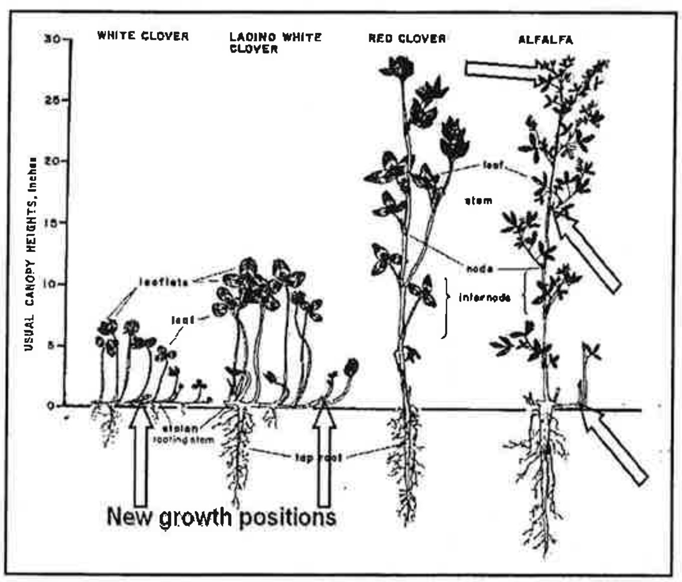

Figure 8. Morphological nature of selected legumes showing prostrate, close growing white clovers as compared to the erect red clover and alfalfa; note location of growing points and tap roots and stolons (Blaser1986).

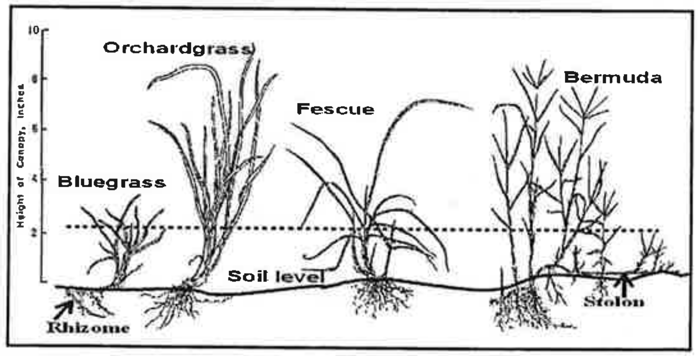

Figure 9. Morthpological nature of selected grasses showing location of their storage organs and the amount of leaf area near the soil surface; note how the presence of stolons or rhizomes can impact grazing height as compared to plants with only stroage in lower stem base (Blaser, 1986).

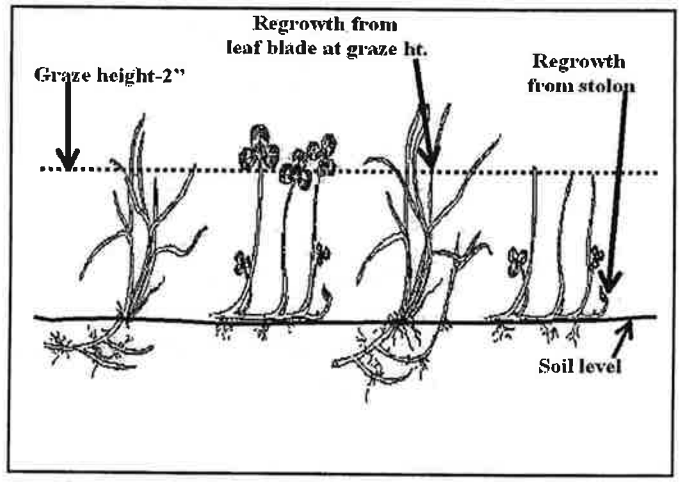

Figure 10. Illustration showing location of growing points and leaf area on bluegrass and white clover.(Blaser, 1986)

Figures 11-14 show the effect of cutting height on the relative rate of regrowth and change in botanical composition in two mixtures with widely differing morphological characteristics. Alfalfa and orchardgrass are up-right plants with few leaves near the soil surface after clipping, whereas, bluegrass and white clover are much more prostrate with leaves near the soil surface.

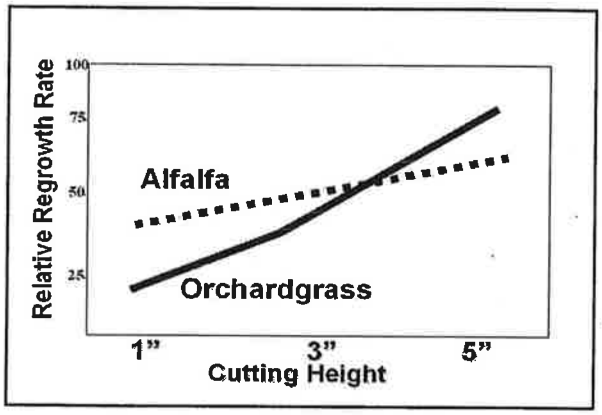

Figure 11. Effect of cutting height on relative regrowth rate of alfalfa/orghardgrass cut at three stubble heights.

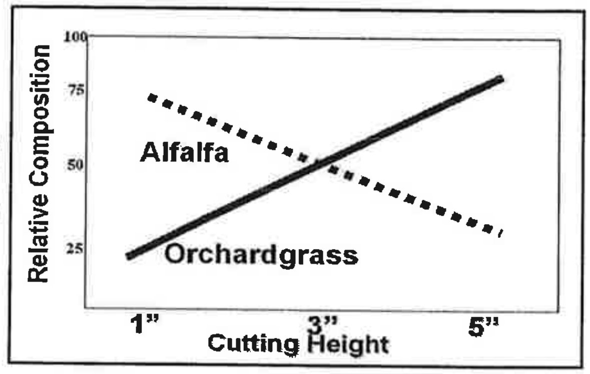

Figure 12. Effect of cutting height on change in botanical composition of a mixture of alfalfa/orchardgrass 4 cuts/yr.

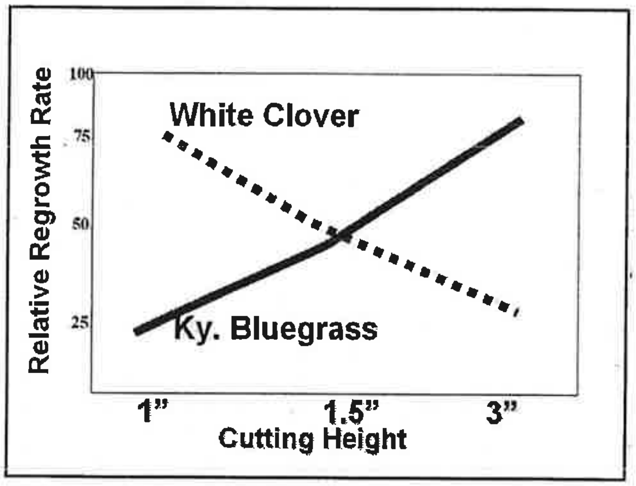

Figure 13. Effect of cutting height on relative regrowth rate of bluegrass and white clover.

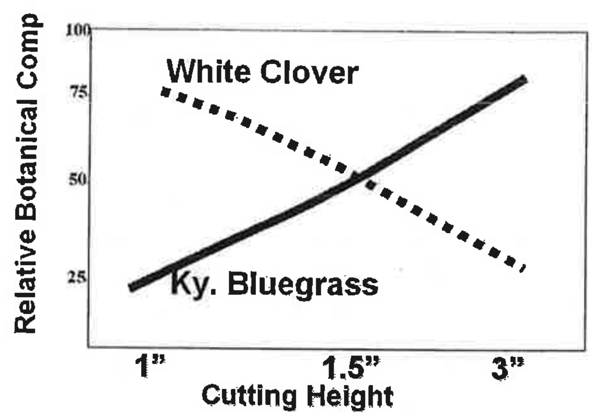

Figure 14. Effect of cutting height on botanical composition of bluegrass-white clover mixture (6 cuts/yr).

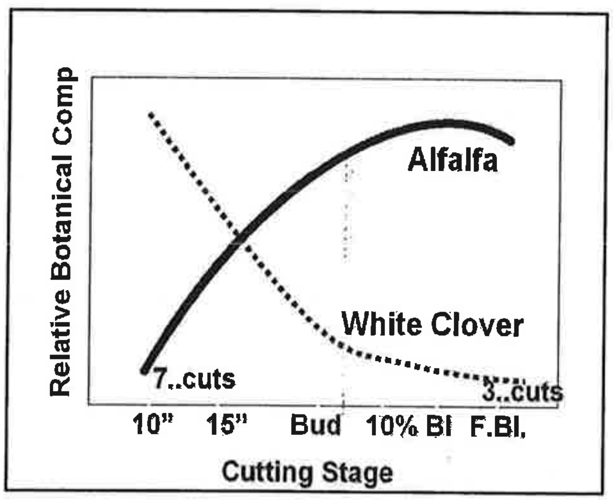

Figure 15. Effect of harvest frequency on botanical composition of a mixture of white clover/alfalfa.

Figures 11-12 show the influence of cutting height on alfalfa-orchardgrass. Cutting at 1 inch stubble reduces the amount of energy and leaf area available for regrowth for both species, but it hurts the orchardgrass more than it does alfalfa. At the 5-inch height there is plenty of leaf area for photosynthesis and the storage organ of orchardgrass has not been harmed; thus growth rate is maintained. Since most new growth from alfalfa comes from crown bud shoots, which depend upon energy from tap root, the height of cut is not as important as with orchardgrass where the storage is above ground and close cutting reduces leaf area.

The one inch stubble would allow quicker regrowth of alfalfa than of orchardgrass, thereby creating shading of orchardgrass. At the five inch cutting, orchardgrass would shade new bud shoots of alfalfa creating a shift in the botanical composition. If frequency of cutting or grazing changed to 8 times per year, expect alfalfa to be hurt much more than the orchardgrass due to the depletion of reserve energy.

Figures 13-14 show similar responses for a mixture of bluegrass and white clover as with the alfalfa-orchardgrass. The major difference is that the regrowth rate of white clover drops more drastically than alfalfa at the tallest cutting heights; this is related to the location of white clover growing points which are on the soil surface and three inches of bluegrass canopy is very competitive for light (Figure10). Tall stubble heights or lax grazing usually results in less legume in the mixture.

UNDERSTANDING OF ANIMAL BEHAVIOR AS WELL AS PLANT GROWTH

Grazing management ....is the manipulation of animal grazing in such a way that allows one to accomplish certain goals (milk, meat, fiber, stand persistence). It is important to understand that the grazing behavior of animals (cattle, sheep, goats, horses) differs considerably, therefore their grazing effect on the growing plant differs somewhat. Since some of the more useful forages have reserve energy storage organs above ground, the grazing characteristics of specific animals can influence how plants survive various defoliation intensities.

For the most part, animals don't prefer to bite plants off at the soil surface, but when feed availability is limited, they may graze the plants so close that reserve energy storage is consumed. If sufficient rest (time for the plant to replenish reserve energy and leaf area) is not provided prior to the next defoliation the plant cannot maintain its vitality; each successive defoliation makes the plant weaker and weaker. Under such grazing practices, animals are not able to meet their daily nutrient requirement because of limited intake. In such cases the plant is being sacrificed to provide very limited feed supply, and the animal is not performing because of under feeding. From the animal's standpoint, it is important that enough leaf area be present to allow easy "biting." Usually when the canopy is tall enough for "easy grazing" the leaf mass is sufficient for optimum photosynthesis and growth.

Cattle... can graze plants to 1-inch or less, but they only do that when feed availability is short. However, they will "spot" graze certain areas within a pasture, and this happens because feed supply is high enough that animals have maximum ability to selectively graze what they want. The "spots" are areas of short, young, green and leafy growth which is of very high quality resulting from continual, frequent defoliation. Plants in those spots will eventually weaken and not produce to their potential because of low leaf area and low reserve energy storage, due to lack of sufficient rest or recovery time. In addition, botanical composition will likely shift to species most tolerant of short frequent defoliation (like bermuda, crabgrass, bluegrass, endophyte fescue, white clover).

Sheep.... can be very selective in choosing very specific plant parts because of their lip and teeth arrangement. In situations where the grass may be of an ideal height for cattle to graze easily (leaving 2-4 inch stubble), sheep will often bit the leaves from the stems or even bite the entire tiller off near the soil surface. If animals remain on an area too long, they may bite all plants off to a one-fourth inch stubble. Such grazing will have significant impact on reserve energy storage and regrowth rates. Plants which have underground storage of reserve energy or lots of leaves near the soil surface survive best in sheep pastures. Sheep pastures are usually denser than cattle pastures because they keep the vegetation grazed short allowing plenty of sunlight to reach the basal tiller buds.

Goats... do not prefer to graze close to the ground and will only do so when feed supply is severely limited. Goats can be the most selective in what plant parts they eat. High animal performance requires high quality forage or browse. Even though goats will graze leaves of grasses, they prefer to browse above their knee height. They will eat seed stalks, heads and other plants which cattle or sheep do not readily eat. They generally prefer grass over clover in mixtures, which may shift the botanical composition toward more legume. Such a shift would favor the performance of cattle and sheep because of the improved forage quality of clover-grass mixtures. Goats tend to graze a canopy from the top down in a fairly uniform manner, therefore they are ideal animals to graze new seedling stands to avoid seedling damage. They do not spot graze as much as other animals.

Horses... can bite plants at the ground surface, which is extremely damaging to plants with reserve energy storage in the stem base. They tend to spot graze regardless of frequency of movement. Because they do bite plants near the soil surface, almost regardless of the amount of forage on offer, it is very important that rotations allow sufficient rest between grazings to allow the plants to fully recovery with several inches of regrowth.

IMPLIMCATIONS FOR GRAZING MANAGEMENT

A compromise is necessary....Graziers realize that a "compromise" between what is good for the plant and what is good for the animal is necessary for long term successful grazing programs. The management goal is to graze or harvest the canopy in such a way as to meet the needs of the grazing animal, while leaving the plants in a condition for rapid regrowth and long term production. For example:

1. The best quality feed and highest daily animal performance comes from using immature, young leaves. While young, short pasture may be of high quality, it's limited availability may restrict consumption and performance of the grazing animal. Keeping the plants in a very young stage of growth can eventually restrict acre production and stand longevity because of low photosynthetic capicity.

2. Because animals preference certain species and because plants compete differentially for nutrients, water and sunlight, the botanical composition of pastures is in a constant state of change. This change may affect animal consumption and performance, as well as acre production.

SUMMARY COMMENTS

Understanding the physiology of plants is the foundation for knowing how to manage them for production and use as animal feed. Knowing why plants respond to various environmental and management factors allows farmers to anticipate changes in growth, persistence and feed quality. Review the questions on the first page and think about how the answers are related to how plants grow. Learning about the basics of plant growth allows one to quickly manage any "new" or different plant which may come onto the scene.

Another way to summarize is to think about the similarities between pasture management and lawn or playground management?

Many of the grasses used for pastures are used for lawns, and they each have the same basic requirements for growth and persistence, whether it is for aesthetics, erosion control or animal feed.

How does one maintain grass cover in a lawn or playground?

1. **Fertilize and lime adequately.......** Many people apply "plenty" of nutrients two or more times per year. Even though this is not necessarily the environmentally friendly thing to do, it keeps the lawn "looking" like the owner wants.

2. **Soil testing service is free**, and it is the only way to know the nutrient supplying capability of soils. This service is the most cost effective way to grow plants economically and minimize the potential for nutrient contamination of the environment. This management practice should be routine for any farm or garden operation.

3. **Controlling the mowing activities...** The mower on a farm is the grazing animal; the only way to control where it "mows" is with a fence or "leash".

4. **Height prior to mowing.....**Most homeowners know that grass should reach 3-5 inches height before it is re-mown; pasture managers should also know how tall grass should be prior to allowing the animals to regraze. This varies with different plant species.

5. **Knowing how close to the soil to mow.....** Homeowners know that they cannot mow "too short" or they eventually kill the grass. Plant survival depends on maintaining green leaves for continued photosynthesis (plant food production) after mowing or grazing. The pleasing "green" appearance is the green leaves and they are absolutely essential for survival and growth of the plants.

6. **Knowing how often to mow....** Homeowners know that they cannot mow before the plant regrows a "certain amount"; most do not mow every 2-3 days because the plants haven't had time to recover from the previous defoliation. Yet, many pasture managers will let animals repeatedly "regraze" new growth at their pleasure.

   The period between mowings allows plants to "rest" and recover. This rest period is necessary for the plant to accumulate reserve energy and green leaves for rapid regrowth prior to the next defoliation event. **How much corn would you grow in the garden if you took the leaves off the stalk every few days.**

7. **Controlling the traffic patterns** Homeowners understand why the path around the house or play area is bare; such areas are a result of walking patterns or play areas of people or pets. Everyone knows grass does not survive when traffic is not controlled; grazing animals do the same thing when not controlled.

James T. Green
Crop Science Extension Specialist (Forages)
North Carolina State University
November, 2000

FORAGE PHYSIOLOGY

Dr. Carl S. Hoveland
Crop & Soil Sciences Dept., Univ. of Georgia, Athens

Forage physiology refers to the processes and activities that occur with the functions of a grass or legume forage plant. Having some knowledge of this can be usehl in understanding how forage grasses or legumes grow in order to manage them for optimum productivity and stand persistence. This can be helphl to a livestock producer in managing pastures and hay for improved animal performance.

You are a grassland farmer

It is important to remember that grassland is the crop and animals are the harvesting equipment and commodity that is sold. Thus, the major emphasis should be on how to manage the grass crop and not simply the animal as is often the case. **Leaves** are the desirable part of the plant desired by animals. The leaves are the harvested product but they are also essential for capturing solar energy. Unlike other crops, forages must tolerate frequent loss of leaves while being able to capture adequate amounts of solar energy. Thus, good pasture management is a critical balance between maintaining adequate leaf numbers to capture sunlight for growth while supplying forage high in protein and digestible energy.

How do leaves grow?

Leaves arise from **tillers** growing from the base of the grass plant. Tillers remain alive for only a limited time, ranging from a few weeks to several months. This means that it is essential to have a large number of new tillers developing throughout the growing season to provide leaves. New grass tiller development is affected by a number of factors:

- Temperature. Tiller development in cool season grasses such as tall fescue is optimum at 60 to 70F, declining sharply in hot summer weather. In warm season grasses such as bahiagrass and bermudagrass it is most abundant at 80 to 85F.
- Light is essential for tiller development. Thus, large accumulations of ungrazed grass in a pasture or hayfield causes severe shading of the plant basal areas so new tiller development is minimal and few new leaves are produced.
- Nitrogen and potassium fertilization increases new tiller development.
- Adequate soil moisture favors tiller development.

Light

Although soil nutrients and water are essential for forage plant growth, the most important input is solar energy. This energy is used, together with carbon dioxide from the air in the process of photosynthesis to produce sugars and starch. Leaves are like photoelectric cells that produce energy from the sun for a fence charger. A pasture or a hayfield is like a massive solar panel collecting energy from the sun. Grassland farming is managing a pasture or a hayfield to collect as much of the incoming sunlight as possible and converting it into usable forage for livestock.

Several factors affect the amount of solar energy captured by forage plants during photosynthesis:

- Warm season grasses such as bermudagrass have a different photosynthetic pathway and can capture about twice the total energy of cool season grasses such as tall fescue during their main growing season. However, cool season grasses such as tall fescue can utilize sunlight over a much wider range of temperature than warm season grasses which have little photosynthesis below 60F but have much more growth at high temperatures.
- Young leaves actively capture sunlight, peaking at about three weeks and cease after four to six weeks in summer. Leaf aging occurs more slowly during cool weather. Thus, old leaves are unproductive and should be removed from a pasture by grazing to be replaced by young leaves.
- As leaves accumulate in a pasture, shading of lower leaves reduces the amount of sunlight reaching them so less photosynthesis occurs. Forage species differ in their ability to allow sunlight penetration into the leaf canopy. Warm season grasses such as bermudagrass have leaves at a more acute angle which allows sunlight to penetrate through more leaf layers than cool season grasses such as tall fescue. This, together with greater ability of individual leaves to utilize much more of the sunlight than cool season grasses, results in the very high forage yield of bermudagrass during a shorter growing season. In contrast, clovers have their leaves in a more horizontal position which causes a great deal of self-shading of lower leaves. This means that clover should be grazed frequently to supply adequate light to leaves. In general, accumulating large amounts of old grass in a pasture will increase the percentage of dead leaves while reducing the amount of leafy green forage desired by grazing livestock.
- Overgrazing of a pasture, in addition to not providing adequate forage for grazing animals, results in few leaves to capture sunlight. Thus, most of the light reaching an overgrazed pasture falls on bare areas of soil or dead leaves and is wasted. Too few solar collectors are available to utilize sunlight and produce sugars for plant growth.
- Undergrazing of pastures provide plenty of forage for animals but much of it is dead leaves and stems so nutritive quality declines. These pastures also have massive numbers of aging leaves that are unable to utilize sunlight and thus contribute nothing to growth. A dense thick leaf canopy also prevents light from reaching lower leaves and reduces development of new buds for new tiller production.

Forage plant carbohydrate reserves

Storage carbohydrates (sugars and starch) serve as the plant bank savings account to:

- Support plant respiration needs of living cells during winter or summer dormancy.
- Supply food for regrowth of new leaves afier close grazing, hay cutting, or dormancy.
- Aid cold and heat resistance of forage plants.

Excess energy from photosynthesis is moved from leaves and stored as starch or sugars in:

- Roots (alfalfa, red clover, sericea lespedeza, kudzu).
- Base of stems (tall fescue, orchardgrass, dallisgrass, big bluestem, switchgrass).
- Rhizomes (bahiagrass, bermudagrass, johnsongrass, perennial peanut).
- Stolons (white clover).

Forage species differ in their carbohydrate storage reserves and is an important factor that can affect their tolerance to grazing:

- Tall fescue and orchardgrass - tolerate fairly close grazing during cool season but close grazing during summer depletes carbohydrates and weakens stand, especially of endophyte-free tall fescue and orchardgrass.
- Berrnudagrass and bahiagrass - they have abundant rhizomes for carbohydrate storage and many leaves close to the ground so can be closely grazed.
- Switchgrass, big bluestem, eastern gamagrass, and johnsongrass - have few leaves close to the ground and limited rhizomes so must be rotationally grazed or stands weaken.
- Alfalfa, red clover, and sericea lespedeza - erect-growing legumes with few basal leaves that require rotational grazing to maintain adequate carbohydrate storage in roots for stand survival and productivity. Grazing-tolerant alfalfa varieties are much more tolerant of close continuous grazing but will benefit from rotational grazing.
- White clover - has many stolons for carbohydrate storage so can tolerate close grazing. The new Durana and Patriot white clover varieties are much more tolerant of close, continuous grazing than commercial ladino varieties because they have more leaves close to the ground and far more stolons for carbohydrate storage, resulting in much longer stand life in grass sods.

Practical grazing and hay management

Although forage species differ in their tolerance to grazing, there are some general principals that should be considered in practical grassland management.

- Grazing should be frequent enough to remove leafy green forage but maintain abundant new tillers and enough leaves for photosynthesis to stimulate new growth.
- Avoid continuous overgrazing as insufficient leaf tissue is available to utilize incoming sunlight.
- If rotational grazing is used, avoid too long a rest time between grazing periods.

As time between hay cuttings is extended, hay yield increases somewhat but regrowth is delayed due to fewer tillers, allowing weed seed to germinate and contaminate the crop. Cutting hay more frequently costs more but it results in high quality leafy hay which may reduce or eliminate the need for protein or energy supplements during winter hay feeding.

Good grassland farming involves managing a pasture or hayfield to collect as much of the incoming sunlight as possible and convert it into high quality forage.

Agricultural Extension Service
The University of Tennessee

SP 434-A

Small Grains, Ryegrass and Clovers for Forage

Gary Bates, Associate Professor, Plant and Soil Science
originally developed by Joe Burns, Professor Emeritus, Plant and Soil Science

Small grain crops are widely used in Tennessee for pasture, silage and hay. These crops produce high-quality forage during the fall, winter and spring. Including ryegrass will result in growth longer into the spring, while adding crimson or arrowleaf clover will decrease the amount of nitrogen that needs to be applied. All of these crops are cool-season annual plants, meaning they germinate in the fall, grow during the fall, winter and spring and then die in the late spring or early summer.

Even though these crops live for only one year, they have potential for use in several ways.

Dairy operations

Annual crops have long been used on dairy farms as a source of high-quality hay or haylage. Small grains have been used as a winter crop on land used for corn silage production during the summer. When harvested at the proper stage of maturity, the nutrient content of wheat or rye makes it an ideal feed for dairy cattle.

During the last several years, the percentage of dairy farmers using small grain pastures as a source of grazing for their cattle has increased. Wheat/crimson clover or rye/ryegrass pastures have been used to decrease the dependence on stored feed. Producers using these pastures have been able to replace between 20 and 50 percent of the dry matter intake that normally would come from silage. This has been accomplished by providing their cows access to small grain pastures for approximately an hour at a time, once or twice a day. The high nutrient content of these pastures allows dairy producers to reduce feed costs without losing milk production.

Beef operations

Backgrounding beef steers and heifers on cool-season annual pasture provides high-quality forage during the fall, winter and spring. Some cattle producers use these pastures as a creep pasture for calves or supplemental feed for cow herds.

Double-cropping

Land that has been used for crop production is often planted with a small grain as a cover crop. The forage from this crop can be easily used by either cutting for hay or silage, or putting up a temporary fence and grazing. Land that has been planted to a summer annual such as pearlmillet or sorghum-sudan hybrid for pasture, hay or silage can be planted with a winter annual to provide almost year-round production from this land. Small grains with or without crimson clover mature early and are relatively easy to kill, so they can be produced and harvested in time to plant a crop for summer production. Ryegrass is difficult to kill in late April or early May, and therefore is not generally recommended in the mixture when double-cropped with corn or where wheat will be planted for grain the next fall.

Seasons of growth

Rye — is the most cold-tolerant of the small grains. It provides the most fall grazing, but matures earlier than the other small grains or ryegrass.

Wheat — produces slightly less growth in the fall than rye, but is productive longer into the spring than rye.

Barley and oats — provides late winter and spring forage. Are generally not recommended for fall forage because of damage from barley yellow dwarf virus and winter kill.

Annual ryegrass — provides high-quality forage, with good fall and spring growth. Makes little growth after the first frost until spring. Produces forage later into the spring than any of the small grains. Is excellent in a mixture with wheat or rye because of the late spring growth.

Clovers —these plants provide high-quality and very palatable forage for the winter and spring. There are two annual clovers that can be used in mixtures with small grains and annual ryegrass:

Crimson clover - provides fall and early spring production.

Arrowleaf clover - provides late winter and spring production.

Steps for establishing small grains

1) Land selection — For fall production, select bottomland which stays moist during fall. For spring production, use upland that warms up early in spring.

2) Planting method — Both conventional and no-till methods of planting can be used. Conventional tillage ensures the reduction of competition from existing vegetation. For successful no-till planting, this vegetation must be killed chemically with a burndown herbicide such as Gramoxone Extra® or Roundup®. Seeds should be placed between $^1/_4$ and $^1/_2$ inch deep in the soil. No-till plantings have shown less winterkill than conventional seedings. Using no-till will also provide a firmer base for winter grazing than will conventional planting.

3) Planting dates — For fall production, seedings should be made early. Plantings made after October 1 usually produce little fall growth. Because of damage from barley yellow dwarf virus, wheat, barley and oats should not be planted prior to September 1. Late plantings with oats or barley should be avoided because of the potential for winterkill. Table 1 lists the window of planting dates suggested for establishment of cool-season pasture.

Table 1. Suggested planting dates for cool-season forages.

Species	Aug. 15-31	Sept. 1-15	Sept. 16-30	Oct. 1-15
Rye	✔	✔	✔	✔
Ryegrass	✔	✔	✔	✔
Crimson clover	✔	✔	******	******
Arrowleaf clover	✔	✔	******	******
Wheat		✔	✔	✔
Oats		✔	✔	******
Barley		✔	✔	✔

****** Use only in mixtures with rye, wheat or barley after September 15.

4) Seeding rates — Recommended seeding rates are shown in Table 2. If fall grazing is expected from pure stands of wheat or rye, rates should be increased by 50 percent. Check with your local Extension office for recom mended varieties. Table 3 provides information needed to convert from bushels to pounds and the number of seed that will be planted for the various cool-season annual crops.

Table 2. Seeding rates for cool-season forages.

Forage crop(s)	Seeding rate (per acre)
Wheat or Rye or Barley or Oats	2-3 bu
Ryegrass	20 lb
Crimson clover	20 lb
Arrowleaf clover	8 lb
Rye or Wheat + Ryegrass	1.5 bu + 15 lb
Rye or Wheat + Ryegrass + Crimson clover	1.5 bu + 15 lb + 10 lb
Rye or Wheat + Ryegrass + Arrowleaf clover	1.5 bu + 15 lb + 4 lb

5) **Fertilization** —Oftentimes a winter annual pasture will follow a summer crop that received high levels of fertilizer. A soil test should be taken to determine if there is a need for lime, potash or phosphate. Information from a soil test will provide assurance that the establishment and production of the pasture will not be limited by low nutrient levels, or that money is not wasted by excessive application of fertilizer. Small grain and grass pastures are highly responsive to nitrogen fertilizer. Table 4 gives recommended nitrogen fertilization rates for winter annual pastures.

Utilization

Once the winter annual pastures have been established, the forage produced should be used as efficiently as possible. Silage or hay harvest removes the growth with very little waste. Hay or silage harvest should be made at the late-boot stage of growth. At this stage, the head is beginning to emerge from the sheath and the quality of this forage will be high. Harvesting at a later stage may result in slightly higher yields, but the nutrient content of this forage will be reduced. Animals consuming this forage will have a lower nutrient intake and poorer performance than ones supplied forage harvested at the late-boot stage.

Harvesting the forage by grazing generally results in the greatest amount of waste, due to trampling and rejection of forage because of manure. The amount of pasture wasted can be decreased if animals are confined to small areas of the pasture (a paddock), and then rotated to another area when all of the forage in the first paddock has been consumed. Grazing should begin when the forage is approximately 8 inches tall. The animals should be removed when plants are grazed down to about 3 inches. Electric fencing can be used to divide a large pasture into several paddocks, with paddock size adjusted so that a minimum of three to seven days are required to graze it down. After the animals are rotated, the paddock should be clipped to remove any rejected areas that have become mature.

Summary

Small grains and ryegrass provide a producer with the flexibility to either graze high-quality forage during the fall, winter and spring, or cut silage or hay. No matter if planted in 100 acres for silage production, or five acres as a winter supplement to beef cows, the high nutrient content of these forages can provide excellent performance from any group of livestock.

Table 3. Cool-season forage seed information.

Forage species	lb(s) per bushel	Seeds per pound
Rye	56	18,000
Wheat	60	11,000
Oats	32	16,000
Barley	48	14,000
Ryegrass	24	224,000
Crimson clover	----	150,000
Arrowleaf clover	----	400,000

Table 4. Nitrogen fertilizer recommendations for cool-season forages.

	Nitrogen recommendation** (lb N/acre)
For fall and spring grazing (plantings before Oct. 1)	30-60 at seeding 30-45 March 1-15 30-45 April 15May 1, if ryegrass is included
For spring grazing only (plantings after Oct. 1)	30 at seeding 30-45 March 1-15 30-45 April 15 May 1, if ryegrass is included

** The lower nitrogen recommendation should be used if clover is included in the mixture.

Precautionary Statement

To protect people and the environment, pesticides should be used safely. This is everyone's responsibility, especially the user. Read and follow label directions carefully before you buy, mix, apply, store, or dispose of a pesticide. According to laws regulating pesticides, they must be used only as directed by the label.

Pesticides recommended in this publication were registered for the prescribed uses when printed. Pesticide registrations are continuously being reviewed. Should registration of a recommended pesticide be canceled, it would no longer be recommended by The University of Tennessee.

Use of trade or brand names in this publication is for clarity and information; it does not imply approval of the product to the exclusion of others which may be of similar, suitable composition, nor does it guarantee or warrant the standard of the product.

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Section 3

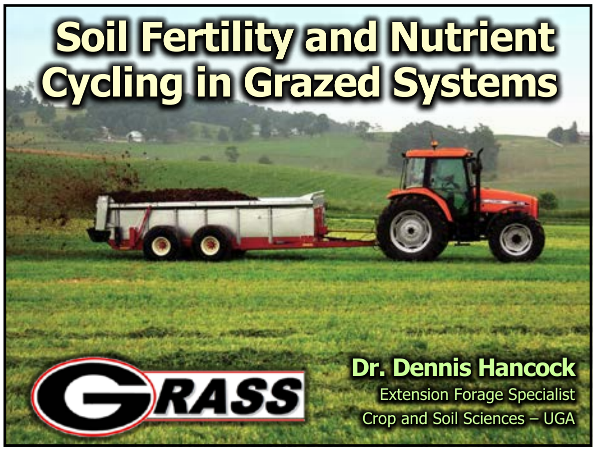
Soil Fertility and Nutrient Cycling In Grazing Systems.

Dr. Dennis Hancock, UGA

2016 Georgia Grazing School:

Soil fertility and nutrient cycling in grazing systems

Dr. Dennis Hancock
Assoc. Prof. & Forage Ext. Specialist



"What's in the soil, is in the plant, is in the animal, …."

How Soil Holds Nutrients

Plant Nutrients

Macro- (Primary)

Element	Available Form
Oxygen	O_2, OH^-
Carbon	CO_3^{-2}, HCO_3 , CO_2
Hydrogen	H^+, OH^-
Nitrogen	NO_3^- , NH_4^+
Phosphorus	HPO_4^{-2}, $H_2PO_4^-$
Potassium	K^+

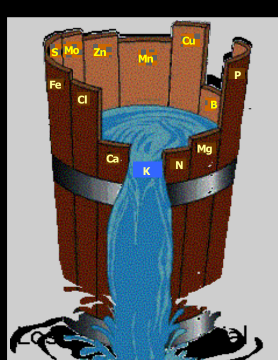
Meso- (Secondary)

Element	Available Form
Calcium	Ca^{+2}
Magnesium	Mg^{+2}
Sulfur	SO_4^{-2}

Micro- (Trace)

Element	Available Form
Iron	Fe^{+2} , Fe^{+3}
Copper	Cu^{+2} , Cu^+
Zinc	Zn^{+2}
Manganese	Mn^{+2} , MnO_4^-
Molybdenum	$HMoO_4^-$, MoO_4^{-2}
Boron	H_3BO_3, $B_4O_7^{-2}$
Chlorine	Cl^-

Liebig's Law of the Minimum



Soil Test and Follow Fertility Recommendations

Sample hay and crop fields every year and 1/3 of your paddocks each year.

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Assoc. Prof. & Forage Ext. Specialist

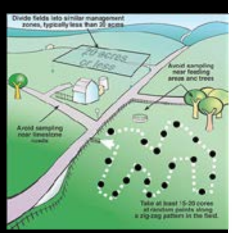
Soil Sampling

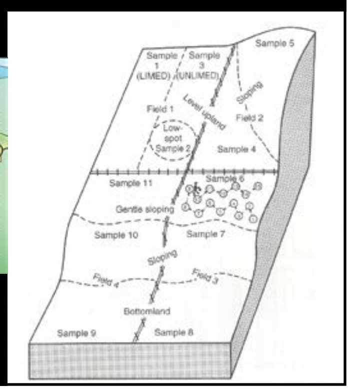
- Probe, shovel
- Sample to 4 inches.
- Discard thatch/duff.
- Collect samples in clean, plastic container.
- Mix, remove debris, split the sample if necessary.

Sampling is Critical

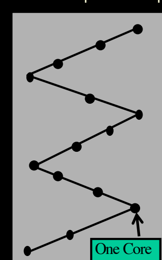
- A soil test is no better than the soil sample submitted for analysis.
- Sampling error is the most common source of error in soil test results.
- The goal of soil sampling is to obtain a representative sample for each paddock or management area.

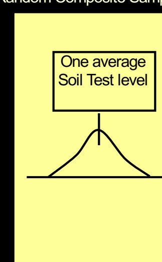
Sample Individual Paddocks





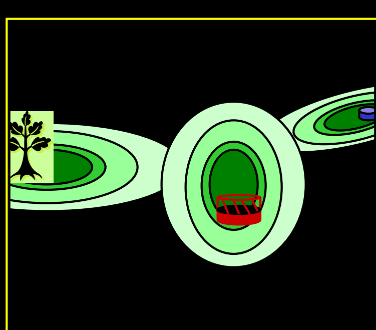
Field Average Sampling

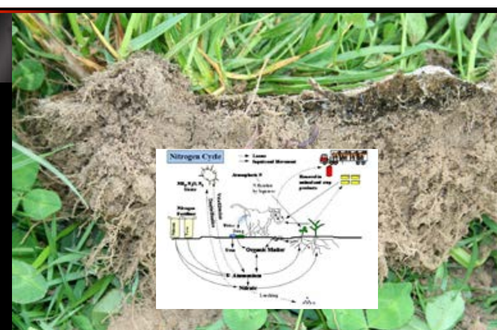




- Take 20-40 ***random*** samples for each 10 acres.
- Avoid areas near shade, troughs, trails.

Soil Sampling in Pastures





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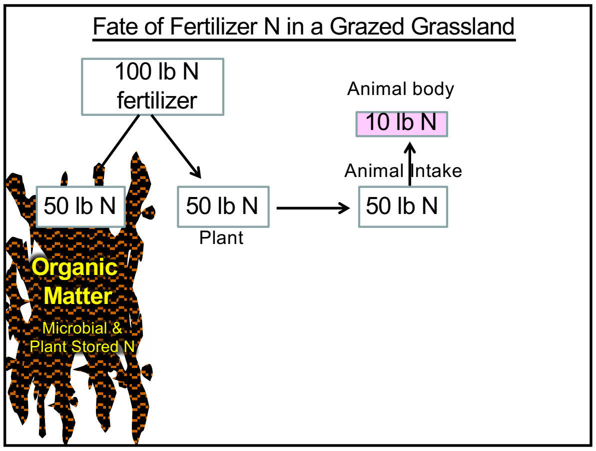
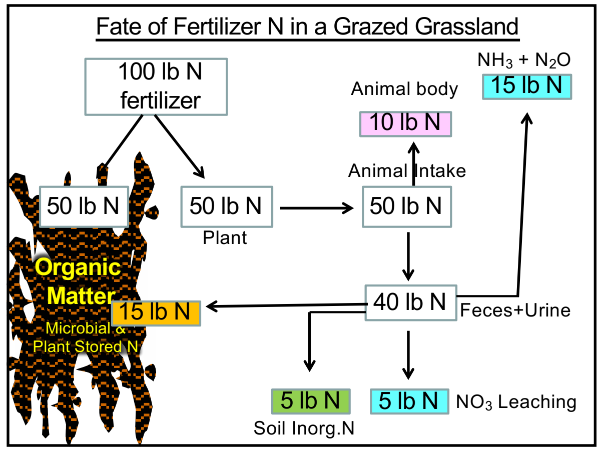




Organic N accumulation rate in upper 12 inches of soil during 12 years of haying or grazing with a yearly application of 220 lb N/acre as NH_4NO_3.

Treatment	Management	Organic N accumulation
		lb N/acre/year
Hayed	Monthly cuts to 2 inches	51 (23%)
High Grazing Pressure	Maintained at 1300 lb/acre	92 (42%)
Low Grazing Pressure	Maintained at 2600 lb/acre	122 (56%)

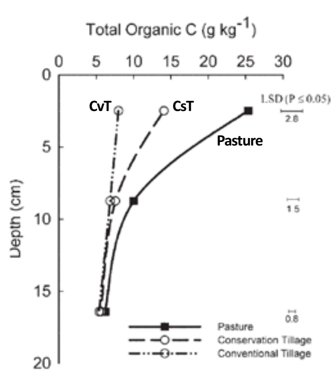
Franzluebbers and Stuedemann (2009)

Organic N accumulation rate in upper 12 inches of soil during 12 years of haying or grazing with a yearly applications of 230 lb N/acre as broiler litter.

Treatment	Management	Organic N Accumulation
		lb N/acre/year
Hayed	Monthly cuts to 2 inches	78 (34%)
High Grazing Pressure	Maintained at 1300 lb/acre	174 (76%)
Low Grazing Pressure	Maintained at 2600 lb/acre	182 (79%)

Franzluebbers and Stuedemann (2009)

Pasture vs. Conservation Tillage (CsT) and Conventional Tillage (CvT)



Causarano et al., 2008.
Soil Sci. Soc. Am. J. 72:221-230

Improvement in soil OM in 3 paddocks located in a pasture-based dairy in Wrens, GA. (2007-2009)

Paddock	Initial	1 year	2 years	3 years
	------ *Soil Organic Matter, %* ------			
P4	1.08	1.15	1.25	2.20
P8	1.01	1.17	1.59	2.18
P14	1.14	1.63	1.86	2.00
Avg.	**1.07**	**1.32**	**1.57**	**2.13**

3 years after grazing system started, averaging an inc. in soil OM of 0.35 percentage points per year!!!

GRASS www.georgiaforages.com | Grazing School | UGA extension | The University of Georgia College of Agricultural & Environmental Sciences

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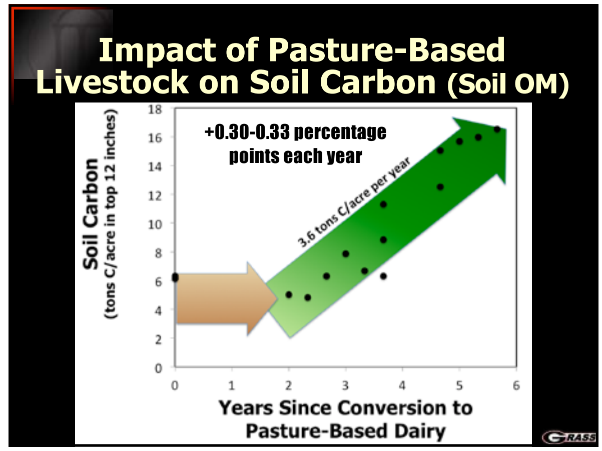
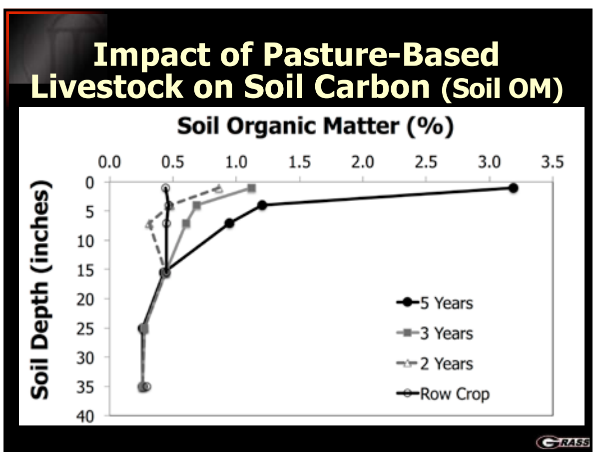
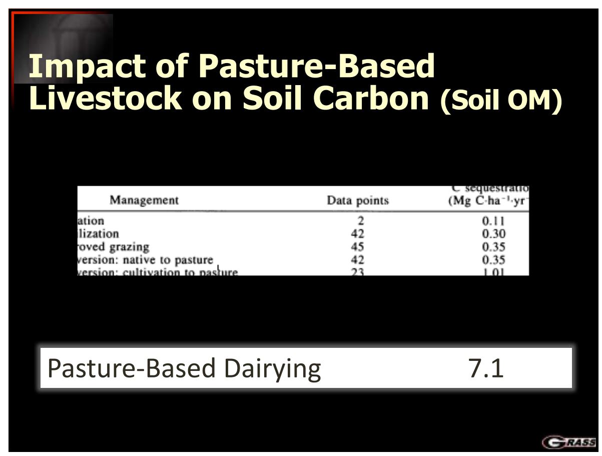
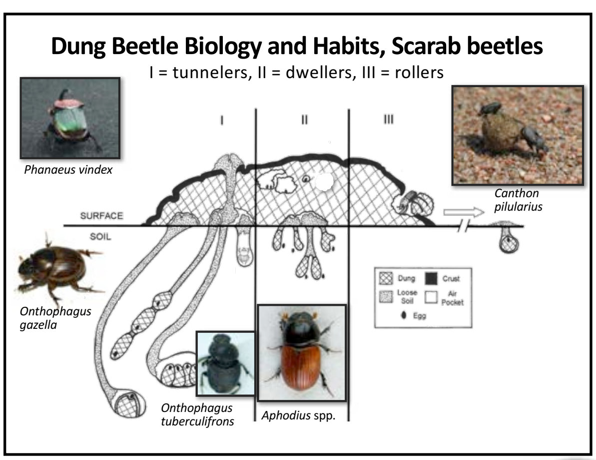






Management	Data points	C sequestratio (Mg C·ha⁻¹·yr
ation	2	0.11
lization	42	0.30
oved grazing	45	0.35
version: native to pasture	42	0.35
version: cultivation to pasture	23	1.01
Pasture-Based Dairying		7.1



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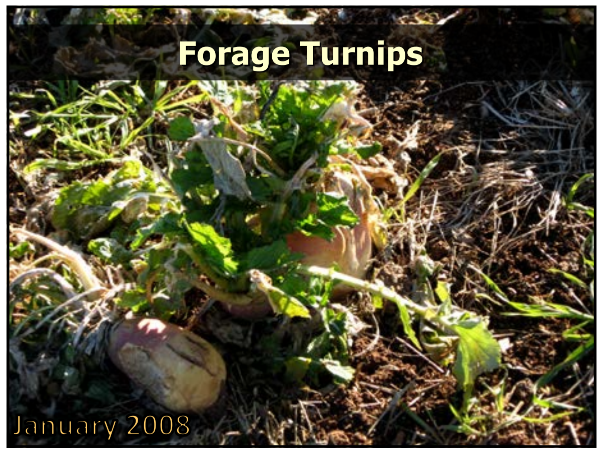

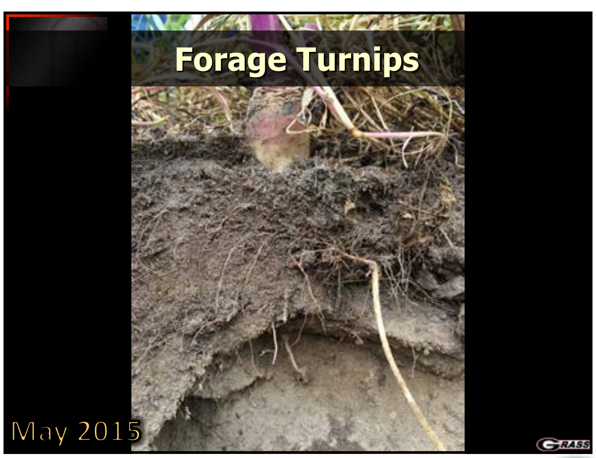

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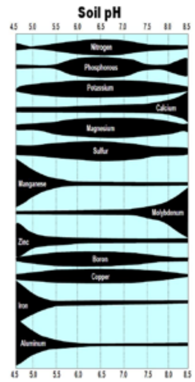
Get your priorities right!

Maintaining soil pH is job #1.

- Nutrient availability
- Soil structure
- Soil biological activity
- Aluminum toxicity

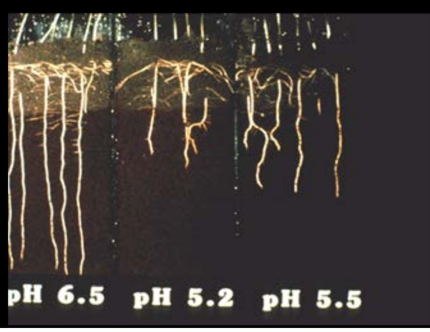
How Soil pH Affects Availability of Plant Nutrients



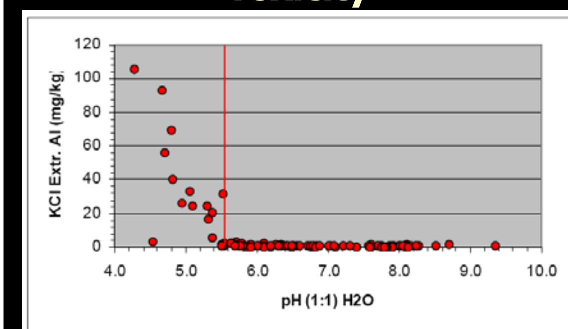
The difference of a soil pH of 5.6 vs. 6.2:

Nutrient	Amt. Used Annually	Unit Price	Dec. in Efficiency	Value of Decrease
	(Lbs/acre)	($/lb)		($/acre)

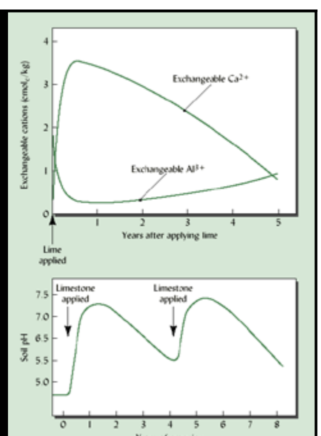
Get at the Root of a Problem: Soil pH Problems



Low Soil pH = Aluminum Toxicity



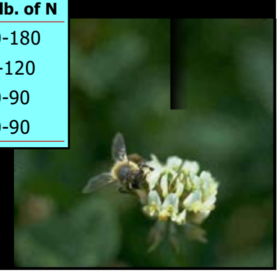
Applications of lime every 3 to 4 years are needed in Southeastern soils to maintain appropriate chemical balances in the soil.



Benefits of Adding Legumes

A valuable source of N (time-released).

Species	Annual lbs (N/acre)	N value at $0.60/lb. of N
Alfalfa	200-300	$120-180
Red clover	100-200	$60-120
White clover	100-150	$60-90
Annual clover	50-150	$30-90



2016 Georgia Grazing School:

Soil fertility and nutrient cycling in grazing systems

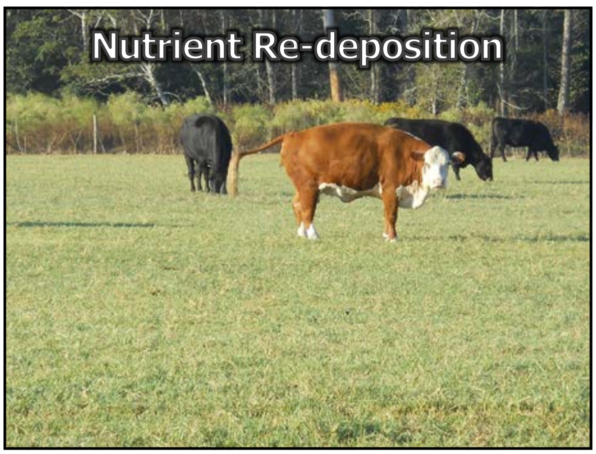
Dr. Dennis Hancock
Assoc. Prof. & Forage Ext. Specialist

K is for Persistence

Manure as Organic Fertilizer

		N	P_2O_5	K_2O	Moisture (%)
Solid Manures (lb/ton)					
Beef		11	7	10	80
Dairy		11	9	12	80
Swine		9	9	8	82
Broiler	(fresh)	55	55	45	20
	(stockpiled)	40	80	35	20
	(cake)	60	70	40	30
	(pullet)	40	68	40	25
	(breeder)	35	55	30	40
Layer		30	40	30	40
Liquid Manures (lb/1,000 gal)					
Holding Pit	Swine	36	27	22	96
	Dairy	31	15	19	94
Lagoon	Swine	4	2	4	99
	Dairy	4	2	3	98

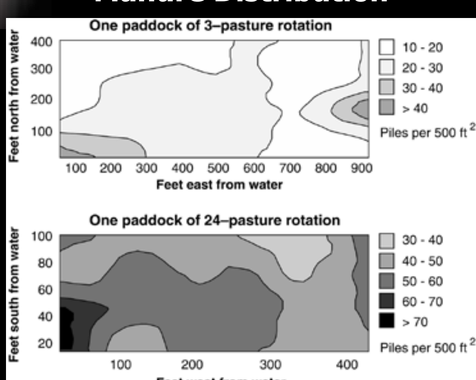
Nutrient Re-deposition



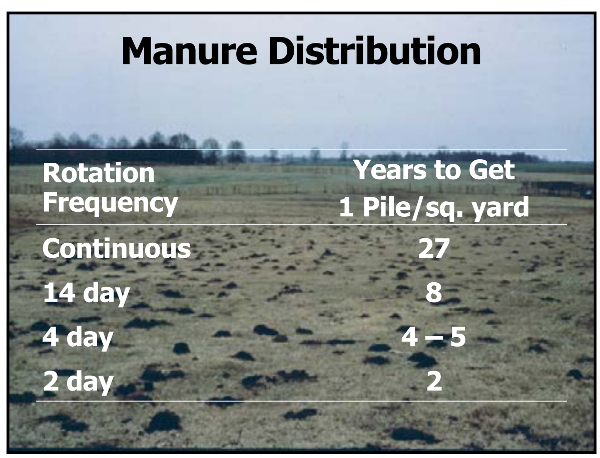
Benefits of Rational Grazing

1. Better utilization of forage
2. Growth rate of forage is optimized
   - Kept in linear/exponential growth phase
   - Higher yield of forage
3. Higher stocking rates
4. More animal gains/milk production per acre
5. Reduced feeding of conserved forage or supplements
6. Better persistence of desirable forages
   - Especially clover and legume species
7. Better weed suppression
8. Better manure distribution

Manure Distribution



Manure Distribution



Rotation Frequency	Years to Get 1 Pile/sq. yard
Continuous	27
14 day	8
4 day	4 – 5
2 day	2

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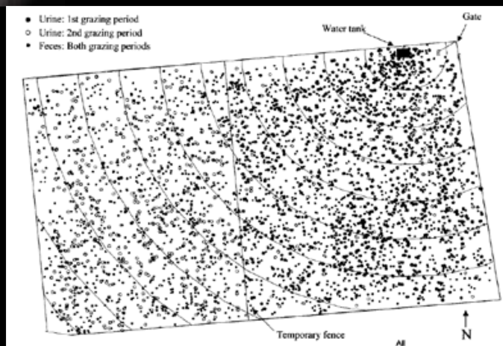
Efficiency of Four-legged Manure Spreaders



White et al., 2001 J. Environ. Qual. 30:2180–2187

Efficiency of Waste Management

Location	Time (% of Total)	Defecations (%)	Urinations (%)
Paddock	86.1	84.7	84.1
Feed Area	7.3	9.1	12.3
Lanes	2.6	1.3	0.0
Holding	1.7	4.4	3.4
Parlor	1.7	0.4	0.2
		4.8	3.6

White et al., 2001 J. Environ. Qual. 30:2180–2187

QUESTIONS?

THE IMPACTS OF MANAGEMENT INTENSIVE GRAZING ON SOIL ORGANIC MATTER

June 2015 Hay & Forage Grower Magazine

Dr. Dennis Hancock, Associate Professor and Extension Forage Specialist
University of Georgia College of Agricultural and Environmental Sciences' Department of Crop and Soil Sciences

Dairy producers have to keep a sharp pencil to ensure the milk check covers all their costs, but there is one factor that probably never shows up on the balance sheet that can help keep the farm in the black: soil organic matter (OM).

Scientifically speaking, soil OM is a collective term that refers to the amount of carbon-based material in the soil. In a sense, soil OM quantifies the living component of the soil (i.e., roots, fungi, bacteria, earthworms, etc.), such as that depicted in Figure 1. But why does soil organic matter matter?

Figure 1. Soils in a pasture are a site of much activity, albeit hard to see. Here, an earthworm navigates the root mass of annual ryegrass and arrowleaf clover plants under the remnants of a manure paddy.

Soil OM acts as a sponge. It holds more water, improves the soil's cation exchange capacity allowing it to hold more nutrients, and provides a host of other advantages. Dairymen who farm sandy soils, like those in the Coastal Plain of the Southeastern US, need all the help that they can get with these soil properties. Often, having good soil OM and the benefits that come from it can be the difference between losing and making money.

Since 2005, there has been a dramatic increase in the number of pasture-based dairies in Georgia and the Southeast. In Georgia, nearly 20% of the dairy herd is now "out to pasture." Most of these new farms have been going in where cotton, peanut, and corn had been produced for decades. A few years after these new pasture-based dairies were up and running, several of the producers indicated they were noticing some major changes in their pasture's productivity and need for inputs. These producers reported that they were irrigating less and needed progressively less nitrogen fertilizer to get the same amount of grazing. These producers are good graziers and they knew that their soil OM was going up and providing these very positive side effects.

Crop and soil scientists from the University of Georgia began to take soil samples to monitor these changes. The preliminary results on one farm showed the soil OM had increased from approximately 1.1% at a time point 3 years after conversion to over 2.1% in their farm's 6th year. Such rates of soil OM increase are unprecedented in the scientific literature! In fact, these results were so striking that no one in the group believed the data.

Subsequently, a research study was initiated to take a closer look at what was happening. The study, published in *Nature Communications* in late April of this year, confirmed that the soil OM is drastically increasing. The results are most astonishing in the top few inches of the soil on these farms (Figure 2). Five years after conversion, the soil OM in the top 4 inches of soil had essentially tripled. Additional research showed that the fastest rate of soil OM accumulation occurs on the pasture-based dairies between 2 and 6 years after converting from row crops. Carbon (C) in the top 12 inches of soil (OM is ~58% C) increased by approximately 3.6 tons of C per acre per year (Figure 3)! Incidentally, this rate of soil OM buildup is among the highest rates ever recorded in any system.

In fact, if one considers that the average automobile produces 1.5 tons of carbon per year (5.6 tons of CO_2 per year x CO_2 is ~27% C), according to EPA estimates, the average 500-acre pasture-based dairy farm in Georgia is sequestering the annual carbon emissions of over 1200 vehicles. In other studies, prediction models developed by USDA's Agricultural Research Service and refined for Georgia forages and conditions showed that pasture-based dairying in the Southeast has a carbon footprint similar to the free-stall dairies in this region (on per unit of milk produced basis).

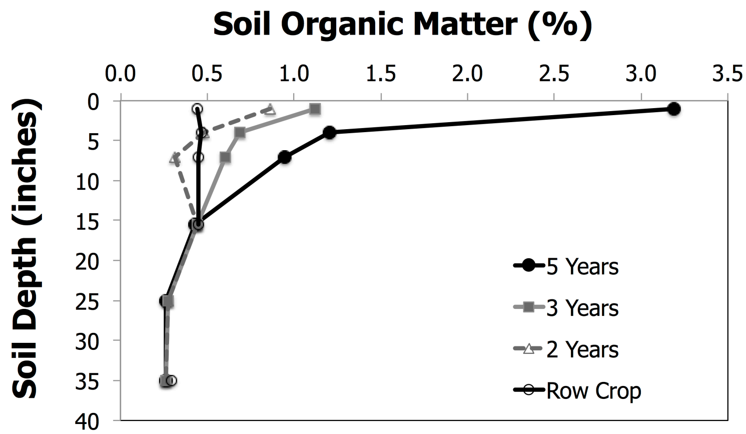


Figure 2. Soil organic matter in the soil profile for pasture-based dairies 2, 3, and 5 years following conversion from row crops.

It is worth noting that Rome wasn't built in a day and neither will be soil OM. The soil OM on the pasture-based dairies we studied did not show much increase in the first 1-2 years following conversion. This is probably the result of a lag in getting the population of soil microbes and earthworms built up. Additionally, it is unclear if that high rate of OM buildup can continue at these high rates. In some of our older pasture-based dairies, the soil seems to have stabilized at 3-4% OM, indicating that soil OM levels will eventually plateau.

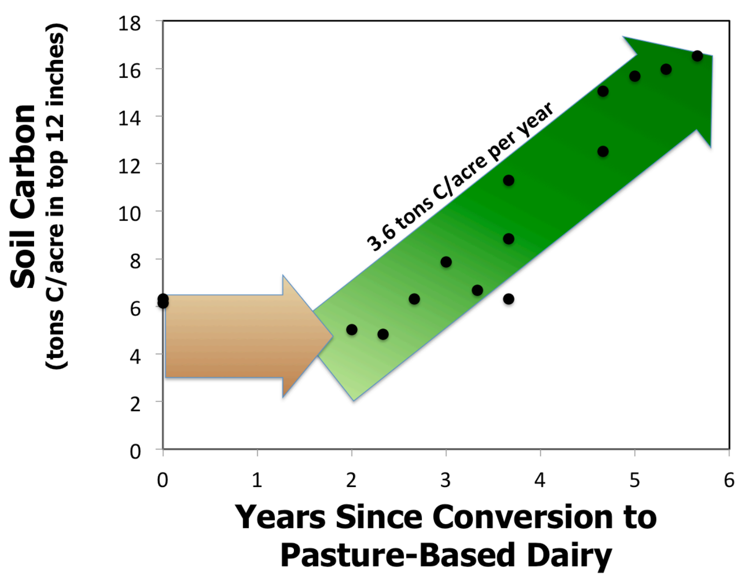


Figure 3. The amount of carbon in the soil in the years following conversion to pasture-based dairying. After an initial ~2-year lag phase when little carbon is added, the soil carbon increases linearly (3.6 tons C/acre per year) at least until 6 years after conversion.

In addition to continuing to monitor soil OM levels, this research has now moved into to trying to determine which part of the forage system contributes the most to this change in soil OM. The preliminary results seem to indicate that the roots and root exudates are the major sources of soil OM improvements. These results support the findings of a consortium of American and European scientists in a recent review in the journal *Nature*. Their report conclusively showed that roots and root exudates are the primary source of soil OM buildup, disproving the long-held dogma that crop residues and biomass on the soil surface are the primary sources of soil OM buildup.

"Carbon footprint" is a common catch phrase these days, but this research is now beginning to examine the "carbon fingerprint" of our forages. Cool season and warm season forages have distinctly different carbon radioisotope signatures. By monitoring the radioisotope signatures in the roots, plant litter, and animal manure from these different forages, scientists can better understand how much of the OM buildup is due to each of these forage types and the degree to which manure is playing a role. In so doing, scientists hope to build a forage system that provides high quality forage crops that suit the needs of the rumen microbes and the soil biota.

Soil Testing

Cooperative Extension Service/The University of Georgia College of Agricultural and Environmental Sciences

C. Owen Plank, Extension Agronomist

Determining the fertility level of a soil through a soil test is the first step in planning a sound lime and fertilization program. This step leads to higher crop yields and quality by following recommended application rates. A soil test provides the means of monitoring the soil so deficiencies, excesses and imbalances can be avoided.

Many Georgia soils are low in pH and one or more of the essential plant nutrients. Therefore, to maintain normal plant growth, lime and fertilizer must be supplied in sufficient quantity to meet the crop's requirement. A soil test will determine the soil's contribution to the crop requirement, with lime and fertilizer supplying the remainder.

The Soil Testing Laboratory

The Soil Testing Laboratory is located on the campus of the University of Georgia at 2400 College Station Road in Athens. It is equipped with the most modern instruments available for rapid and accurate soil analysis. Analysis results and fertilizer recommendations are returned to your county extension agent for dissemination and adjustments, if necessary.

The laboratory offers a number of tests to meet specific soil and cropping circumstances. The tests and their applications are listed in Table 1 (page 3).

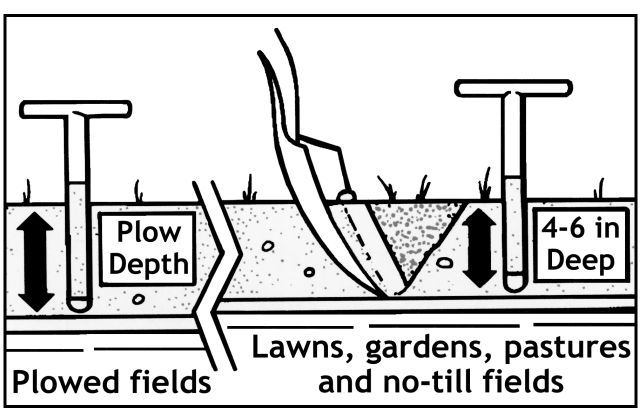


Figure 1. Take a thin vertical slice to desired depth.

Procedure

Use soil sample bags – available from your county extension office – for submitting samples to the laboratory. Supply all the information asked for on the sample bag.

List your **NAME AND ADDRESS, CROP** to be grown, **SAMPLE NUMBER** (please make these simple and do not exceed three digits, e.g., 1, 2, 3 ... 20, 21, 22 ... 321, 322, 323 ... 32A, 32B ...) and your **COUNTY AGENT'S ADDRESS.** This information is essential for the return of your sample results and fertilizer recommendations to the proper county extension office.

On the bag, indicate the tests you want by checking the appropriate space and/or spaces. For most agronomic needs, a routine test will be enough. If you are in doubt about whether to request a special analysis (OM, NO_3, B) refer to Table 1 or consult your local county extension office.

Sample Instructions

When soil samples are submitted to the laboratory for analysis, reliable analytical results are necessary for making limestone and fertilizer recommendations. A soil test result, however – regardless of analytics – can be no better than the sample submitted for analysis. For the sample to be representative of the area tested, follow these steps for sampling:

1. Use a soil sampling tube, auger, spade, trowel or other tool that can take a thin, vertical slice of soil to the desired depth (Figure 1).

2. Take at least 15 to 20 cores or thin slices at random over the field or area (Figure 2). In general, 15 acres should be the maximum size area represented by a single composite sample. Place the cores in a clean plastic bucket or other nonmetal container and thoroughly mix the soil. Fill the soil sample bag to the "fill line" marked on the bag. Fold the top of the bag and fasten the

metal flaps securely to avoid spillage during shipment. Note: Do not use a galvanized bucket for collecting samples, especially if the soil is to be analyzed for zinc or other micronutrients. Ensure that buckets and sampling tools are clean and free of fertilizer and limestone residues. Even a small amount of fertilizer transferred from the sampling tools to the soil can seriously contaminate the sample and produce misleading results.

3 The area included in the sample should have been uniformly fertilized and limed in the past. When collecting the sample, avoid small areas where the soil conditions are obviously different from those in the rest of the area – for example, wet spots, areas where wood piles have been burned, old building sites, fence rows, fertilizer bands, eroded areas and areas immediately adjacent to roads. If a field contains more than one soil type, collect separate samples from each soil area. Sample problem areas within a field separately (Figure 2).

4 Depth of sampling will vary depending on the crop or cropping conditions. The following sampling depths are recommended:

	Sampling Depth
Plowed fields	plow depth
No-till fields	4 inches
Pastures	4-6 inches
Orchards	8-12 inches
Lawns	4 inches
Gardens	6 inches

5 When sampling greenhouse benches or pots, collect a core of soil from the surface to the bottom of the pot. Collect from several areas or pots to provide enough soil to fill the sample bag ¾ full.

When to Sample

Soil samples can be taken any time during the year; however, fall is the most desirable time. Soils should be dry enough to till when sampling, and fields are usually dry and easily accessible in the fall. The soil pH and nutrient levels will be at or near their lowest points during late summer and early fall. Therefore, samples collected in the fall are more representative of the actual fertility conditions during the growing season than samples collected in late winter or early spring. Fall sampling also allows sufficient time for results and recommendations to be received from the laboratory so needed limestone and fertilizer can be applied before planting.

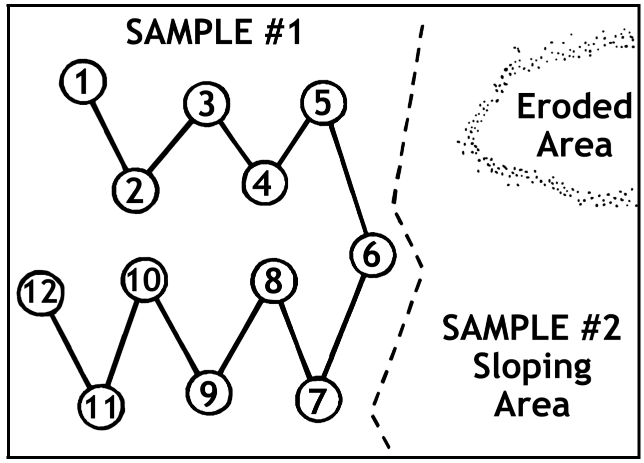


Figure 2. Soil Sampling Scheme

Soil nutrient levels change during the year depending on the temperature and moisture content of the soils. It's important, therefore, that samples be taken at or near the same time each year, so results from year to year can be compared.

How Often to Sample

For many situations, test soils every two to three years. However, test the soil when there is a suspected nutrient deficiency, once per crop rotation, or once every other year if the soil is fertilized and cropped intensively. Annual sampling is recommended (1) on areas where high-value cash crops such as tobacco and vegetables are grown and (2) on areas where the annual nitrogen application rate exceeds 150 pounds of N per acre. Collect soil samples also following crops where large amounts of nutrients are removed in the harvested portion of the plant, especially for silage crops, hybrid bermudagrass hay, and where peanut vines are used for hay.

Record Keeping

Keep previous soil test results for each field and refer to them when you plan limestone and fertilizer applications. The fertility level of a soil is similar to a bank account: If the amount deposited exceeds the amount withdrawn, there is a net buildup of the account. If the amount of nutrients applied in fertilizer and limestone exceeds the amount removed in harvested crops and the amount lost by leaching, there will be a net buildup of the soil fertility level. If the opposite is true, the fertility of the soil will decline. Periodic soil sampling of each field will help determine whether you are following a soil buildup or soil depletion program. If a sound soil testing program is not followed, a deficiency or an excess in fertilization rates can result.

Laboratory Tests and Fees

1. **Routine Tests:** pH, L.R., Soil Test P, K, Ca, Mg, Mn and Zn
2. **Micronutrient Tests:** Boron (B)
3. **Other Tests:** Organic Matter Content, Soluble Salts, Nitrate Content
4. **Commercial Greenhouse or Nursery Soil Test:** pH, Soluble Salts, NH_4, NO_3, P, K, Ca, Mg

The laboratory charges a nominal fee (subject to change) for these analyses. Please contact your county extension office for the most recent information about current fees.

A check to cover cost of tests should accompany the soil sample and be made payable to the Cooperative Extension Service.

Table 1. Selecting the Proper Soil Test Determination

Not all the soil tests apply equally to every soil and cropping situation. Suggestions for selecting the proper soil analysis and/or analyses are as follows:

ROUTINE TEST:	
pH, Lime Requirement (L.R.), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Manganese (Mn), Zinc (Zn)	Routinely recommended for all commercial field and vegetable crops as well as lawns and gardens
MICRONUTRIENT TESTS:	
Boron (B)	Primarily for sandy or eroded soils low in organic matter on which cotton, peanuts, alfalfa and vegetable crops are to be grown.
OTHER TESTS:	
Organic Matter Content (O.M.)	For all soils and crops, knowing the O.M. content is of primary interest for special situations where soil tilth and water-holding capacity are important.
Soluble Salts (S.S.)	Of interest where large quantities of fertilizers have been applied, particularly for potted plants, greenhouse beds, lawns or ornamental plantings or beds. Not generally applicable to field soils except in problem-solving situations.
Nitrate Content (NO_3)	Of particular interest for greenhouse soils, potted plants and beds. Not generally applicable for field soils. However, as more interest in pollution from fertilizer sources develops, this test may become more important in field crop situations. As the residual NO_3-N level of a soil increases, the application rate of fertilizer nitrogen should be adjusted downward.
COMMERCIAL GREENHOUSE OR NURSERY SOIL TEST:	
pH, Soluble Salts, NH_4, NO_3, P, K, Ca, Mg	For mixes that include soil, sand, peat, pine bark, pearlite, vermiculite used to produce greenhouse or potted vegetable, flower or ornamental plants. Not recommended for unamended soil.

When you have a question ...
Call or visit your local office of The University of Georgia's Cooperative Extension Service.

You'll find a friendly, well-trained staff ready to help you with information, advice and free publications covering agriculture and natural resources, family and consumer sciences, 4–H and youth development, and rural and community development.

Leaflet 99 **Reprinted March, 2000**

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Gale A. Buchanan, Dean and Director

Section 4

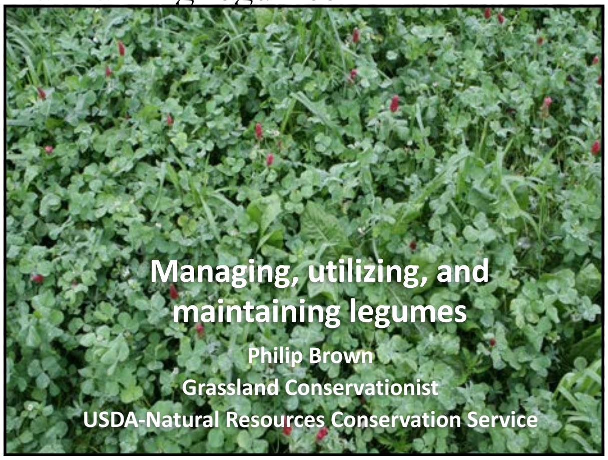
Managing, Utilizing, and Maintaining Legumes.

Philip Brown, NRCS Grazinglands Specialist

2016 Georgia Grazing School:

Managing, utilizing, and maintaining legumes

Philip Brown
USDA-NRCS Grassland Conservationist



Benefits of Legumes

- Increase Yield & Lengthen Grazing Season
- Forage Quality
  - Animal Performance
    - Higher Average Daily Gains
    - Getting into shape for rebreeding
- Dilute toxicity effects of Tall Fescue
- Nitrogen Fixation
- Renovate/fill thin pastures
- Issues
  - Weed Control
  - Annual planting or Persistence
  - Associated Management

Increased Yield

Table 1. Dry matter yields of fescue-clover vs. fescue-nitrogen, Lexington, 2-year average.

Treatments	Yields, lb/ac
Tall fescue-red clover	
6 lb seed/ac	11,100
Tall fescue + nitrogen	
0 lb/ac	3,900
90 lb/ac	6,700
180 lb/ac	9,900

Taylor, T.H., et al. 1978, University of Kentucky

From: Renovating Hay and Pasture Fields, Kentucky Agric. Ext. Ser. Pub. AGR-26

Increased Gain

Table 2. Animal performance on grass vs. legume-grass mixtures.

Species	Length of trials (yrs)	Gain/ head (lb/day)	Animal class	State
Tall fescue*	3	0.12	Cows	IN
Tall fescue* + red and ladino clover		0.74		
Tall fescue*	3	1.30	Calves	IN
Tall fescue* + red and ladino clover		1.80		
Orchard-grass	10	1.07	Steers	VA
Orchard-grass + ladino clover		1.28		

*The tall fescue used in each of these studies was endophyte infected.

From: Renovating Hay and Pasture Fields, Kentucky Agric. Ext. Ser. Pub. AGR-26

Improved Conception Rates

Table 4. Conception rates on grass vs. grass-legume pastures.

Species	Conception rate (%)	State
Tall fescue*	75	IL
Tall fescue* + legume	89	
Tall fescue*	72	IN
Tall fescue* + clover	92	

*The tall fescue used in each of these studies was endophyte infected.

From: Renovating Hay and Pasture Fields, Kentucky Agric. Ext. Ser. Pub. AGR-26

Yield & Quality - Coastal Plain Information

- Crude Protein Averages
  - Coastal Bermudagrass – 9.1%
  - Coastal Bermudagrass + Legume – 10.6 – 13%
- Yield
  - Coastal Bermudagrass + 100 lbs. N – 3 tons/acre Dry Matter
  - Coastal Bermudagrass + Legume – 3 Tons/acre Dry Matter
- G.W. Burton and E.H. DeVane. 1992. Growing Legumes with Coastal Bermudagrass in the Lower Coastal Plain.

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Grazing School

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

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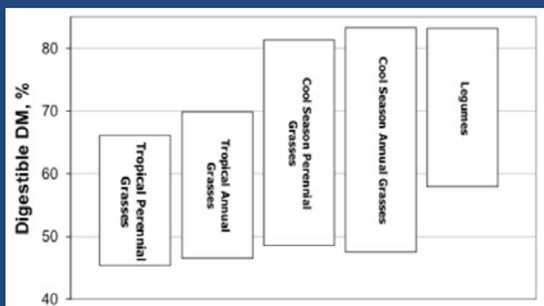
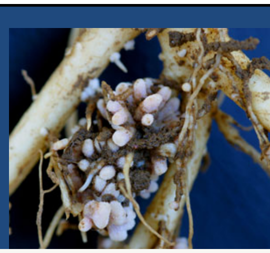
USDA-NRCS Grassland Conservationist

Forage Quality - Species



Pollinators……..

Nitrogen Fixation



- *Rhizobium* bacteria
- **Clover Group**
  - Type B - Ball, red, and white
  - Type O - Arrowleaf
  - Type R - Berseem, crimson, & Persian
  - Type WR - Rose and subterranean
- **Pea & Vetch Group**
  - Type C - Austrian winter pea and vetches
- **Inoculation**
  - Water works fine as a sticking agent avoid Soda products

Species	Annual lbs (N/acre)	N value at $0.70/lb. of N
Alfalfa	200-300	$140-210
Red clover	100-200	$70-140
White clover	100-150	$70-105
Annual clover Hairy Vetch	50-150	$35-105

Inoculation

- Pre-Inoculated or On Farm Inoculation
- Store inoculant out of direct sunlight in cool and dry conditions

- Do not mix inoculated seed with fertilizers
- Grazing management impacts amount of N fixed………

Where You are in the World…

- Arrowleaf Clover – Coastal Plain, Piedmont
- Ball Clover – Coastal Plain, Piedmont, Southern Counties of the Mountain Regions
- Crimson Clover – Coastal Plain and Piedmont
- Hairy Vetch – Statewide
- Red Clover – Statewide – best adapted to Mountains and Piedmont
- White Clover – Statewide, but avoid droughty sands, Moderately Well Drained to Poorly Drained Sites in the Coastal Plain and Flatwoods
- Alfalfa – Well Drained, Fertile Sites throughout the State

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USDA NRCS United States Department of Agriculture Natural Resources Conservation Service

2016 Georgia Grazing School:
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USDA-NRCS Grassland Conservationist

Table 1. Minimum soil characteristics and management traits of selected cool season annual legumes.[†]

Species	Soil			Management Traits			
	Min. pH[‡]	Texture	Drainage	Maturity	Cold Tolerance	Bloat Potential	Reseeding Potential
Arrowleaf clover	6.0	sand, loam	good	late	good	low	high
Ball clover	6.0	sand, loam, clay loam	fair	medium	good	high	high
Berseem clover	6.5	loam, clay	poor	medium	poor	low	low
Crimson clover	5.5	sand, loam	good	early	good	medium	low
Medics, annual	7.0	sand, loam, clay	fair	early	poor	high	high
Persian clover	6.0	loam, clay	poor	medium	fair	high	high
Red clover[§]	5.5	loam, clay	good	late	good	low	low
Rose clover	6.0	sand, loam, clay	good	medium	good	low	high
Subterranean clover	6.0	loam clay	fair	medium	fair	medium	low
Vetch, hairy	5.5	sand, loam, clay	good	medium	good	low	low
Winter pea	6.0	loam, clay loam	good	medium	poor	low	low

[†] Adapted from Evers, 2005.
[‡] Minimum soil pH value (water pH equivalent) for acceptable yields.
[§] Red clover is a perennial clover species; however, it is often used as a late-maturing cool season annual legume in the Coastal Plain Region. When used as a perennial, it has a medium to high potential for reseeding.

From: UGA Extension Bulletin 1347, Georgia Forages: Legume Species, D.W. Hancock, et.al.

McIntosh Co. (Coastal Flatwoods Region) – Poorly Drained Soil with Excellent White Clover Stand

Soil Fertility

- Soil Test for the legume you are trying to establish
- Adjust pH as recommended
  - 6.0 – 6.5
- Adjust Phosphorous and Potassium as recommended

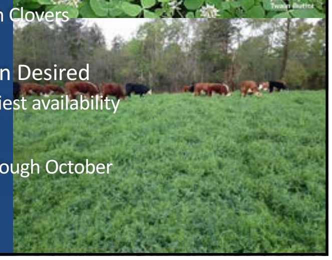
Soil Fertility

Weed Control

- Legume presence severely limits use of broadleaf herbicides
- Choose a field where weed pressure is minimal
- Be aware of herbicide residuals when establishing legumes

Which Legume to Pick?

- What's the base forage?
  - Warm Season Perennial Grasses
    - (Bermuda & Bahia)
      - Annual Cool Season Clovers Complement Well
  - Seasonal Production Desired
    - Crimson offers earliest availability
  - Planting Dates
    - Mid September through October



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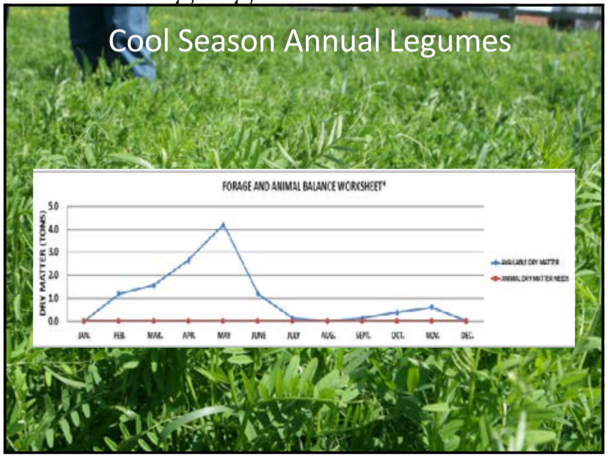
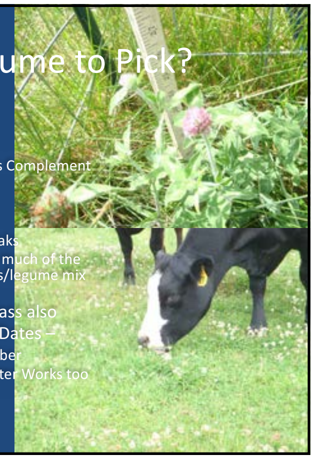
USDA-NRCS Grassland Conservationist

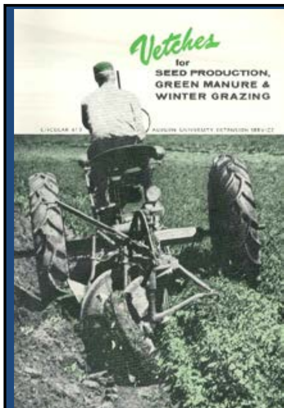
Cool Season Annual Legumes



Which Legume to Pick?

- What's the base forage?
  - Cool Season Perennial
    - Tall Fescue
    - Perennial Cool Season Clovers Complement Well
      - White Clover and Red Clover
  - Seasonal Production Desired
    - Spring and Fall Production Peaks
    - Can be a component through much of the summer – higher quality grass/legume mix for more of the year
  - Both Can Fit with Bermudagrass also
  - Red & White Clover Planting Dates –
    - Mid September through October
    - Mountain Regions – Late Winter Works too





Vetch is well adapted as fall and winter pasture when seeded alone or in mixtures with small grain and/or ryegrass (see fig. 6). It is also valuable for improving perennial grass pastures. Vetch seed are large, giving them certain advantages over smaller seeded legumes. Seedlings are vigorous and stands can be obtained under adverse conditions, such as in sods too dense for emergence of smaller seeded legumes. The large seed may also be planted deeper, an advantage under dry conditions. Don't graze until a dense growth 6 inches tall has occurred. Stocking rate should be such that the vetch growth is kept at this height.

– 15 –

Bermudagrass & Clover - Yields

Table 3. Influence of no-till seeding winter annual or perennial legumes into a bermudagrass sod on seasonal and total dry matter production of the individual species, Piedmont Research Station, Experiment 2 (Year 1).

Treatments[1]	Seeded species	Bermuda	Total	Legume production by June 13[2]
	pounds per acre			%
1. Crimson + B 120 N	4,900	9,130	14,030	100
2. Crimson + B No N	3,970	6,710	9,680	100
3. Hairy vetch 120 N	2,590	9,970	12,560	100
4. Hairy vetch + B No N	3,840	6,620	10,460	100
5. Subclover + B 120 N	640	8,860	9,500	96
6. Red clover + B No N	7,860	3,720	11,590	44
7. Ladino+B No N	5,870	4,140	10,010	36
8. Bermuda alone 120 N	—	8,300	8,300	—
9. Bermuda alone[2] 180 N	—	8,000	8,000	—
LSD[3] (0.05)	1,010	1,210	1,610	

[1] Common crimson clover, common hairy vetch, Mt. Barker subterranean clover, Kenstar red clover, and Regal ladino clover were seeded at 20, 30, 20, 15, and 5 pounds per acre, respectively, into a sod of Tifton 44 bermudagrass (B). All plots receiving 120 pounds of nitrogen received 60 pounds about June 1 and again July 15. Treatment 9 received an extra 50 pounds on August 15.

[2] For example, 44% of the total production (7,860) for red clover was produced before June 13. Severe drought occurred after August 10 for several weeks.

[3] LSD = least significant difference.

From: North Carolina Agricultural Research Service, Tech. Bulletin No. 315

Coastal Plain Yields

Table 1. Seasonal distribution of forage yield of various clovers at Gainesville in 1987-88.

Clover	Dry Matter Yield* 28 Jan. '87	2 Mar. '87	1 Apr. '87	1 June '87	Total
Cherokee	710	1140	4610	1000	7460
Kenstar Red	380	730	3340	850	5300
Yuchi Arrowleaf	190	400	2790	---	3380
Flame Crimson	1910	1400	2310	---	5620
FL 77 Alfalfa	1110	1460	2400	1830	6800

*Data from Dr. O. C. Ruelke, University of Florida, Gainesville, FL.

Yields – South Alabama

Species	February - March	April - May	June - July	Total
	Mean Yield (3 years)– lbs./acre Dry Matter			
Crimson	1,871	1,698	0	3,568
Berseem	1,359	2,327	589	4,276
Red	587	2,188	1,455	3,896
White	407	1,612	1,202	3,221
Arrowleaf	425	2,525	522	3,472
Ball	530	2,099	134	2,763
Subterranean	646	1,214	1,860	1,860

Evaluation of Annual Clovers in South Alabama. 1991. J.F. Pedersen and D.M. Ball

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Forage Crop	Pounds seed per bushel	Approximate number seeds per pound	Seeding rate Pounds/acre	Seeding depth inches	Seedling vigor
LEGUMES:					
Alfalfa	60	227,000	15-20	¼ - ½	G
Alyceclover	69	301,000	15-20	¼ - ½	F
Annual (Korean) Lespedeza	59	238,000	25-30	¼ - ½	F
Arrowleaf Clover	60	400,000	5-10	¼ - ½	F
Ball Clover	60	1,000,000	2-3	0 - ¼	F
Bigflower Vetch	60	32,000	20-30	½ - 1	F
Button Clover	60	153,000	15-20	0 - ¼	F
Cowpea	60	4,000	100-120	1-2	E
Crimson Clover	60	150,000	20-30	¼ - ½	G
Hairy Vetch	60	16,000	20-25	1-2	E
Red Clover	60	272,000	12-15	¼ - ½	E
Rose Clover	60	164,000	8-12	¼ - ½	F
Sericea Lespedeza	60	372,000	12-15	¼ - ½	P
White Clover	60	768,000	2-3	0 - ¼	F

PLS – Pure Live Seed
** From PPI, Forage Pocket Guide, 2004. Developed by D. M. Ball, C. S. Hoveland, and Gary Lacefield*

Establishment

- Broadcast prior to grazing existing sod
  - Allow livestock to "tread in" seed as they graze
- Graze closely
  - Leaving no more than 1 to 2 inches of residual
  - No-Till Drill seed in observing proper planting depths.
  - Or broadcast and scratch in with a drag harrow

From: "Gearing Up For Winter Grazing", October 2013 – Dennis Hancock

Alfalfa

- Increasingly interseeded into bermudagrass
- Dramatically improves forage quality
- UGA – Protocol
- Site Selection
  - Good Weed Control – No Herbicide Residuals
  - Well Drained
  - pH – 6.5 - 7.0
  - Excellent Fertility
    - Especially Potassium


Photo Credit: Dr. Joe Bouton

Forage Quality – Tifton 85 Bermudagrass

Crop: GRASS
Use: Hay
Species: BEEF
Class/Weight: DRY COWS

Variety: Tifton 85 Bermudagrass
Relative Forage Quality (RFQ): 123.6
Ration Formulation: No

Near Infrared Reflectance (NIR) Analysis

	As-Sampled	Dry-Matter
Crude Protein	5.3 %	12.8 %
Crude Fiber (Estimated)	11.2 %	27.0 %
Neutral Detergent Fiber	24.2 %	58.3 %
Acid Detergent Fiber	14.26 %	34.30 %
Lignin	2.08 %	5.00 %
Total Digestible Nutrients	24.6 %	59.2 %

Forage Quality – Tifton 85 Bermudagrass + Alfalfa

Crop: GRASS
Use: Hay
Species: BEEF
Class/Weight: DRY COWS

Variety: Tifton 85 Bermuda/Bulldog 805 Alfalfa
Relative Forage Quality (RFQ): 149.1
Ration Formulation: No

Near Infrared Reflectance (NIR) Analysis

	As-Sampled	Dry-Matter
Crude Protein	15.7 %	21.6 %
Crude Fiber (Estimated)	13.8 %	19.0 %
Neutral Detergent Fiber	27.8 %	38.2 %
Acid Detergent Fiber	22.08 %	30.30 %
Lignin	3.72 %	5.10 %
Total Digestible Nutrients	46.3 %	63.5 %

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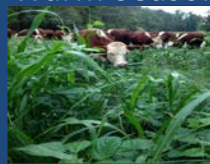
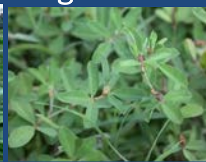
Warm Season Legumes

- Annuals
  - Cowpeas
  - Annual Lespedeza
  - Soybeans
  - Sunn Hem
- Perennial
  - Sericea Lespedeza

Maintenance

- Soil test and follow recommendations
- Nitrogen applications will favor grasses in any mix – keep N as minimal as possible
- Spot spray or mechanical weed control
- Good grazing management will give you the most benefits
- Plant only what you can manage…….
- Volunteer Reseeding – graze down late summer/early fall to remove grass competition and get sunlight to the surface

Conservation Take Home

- Including legumes conserves:
  - Animal Condition
    - Increased Quantity and Quality of Forage
  - Income
    - Good seasonal distribution = Less hay production and feeding
    - Nitrogen Production – Reduced need for purchased fertility
    - Increased Gains
  - Quality of Life
    - See Income Above

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SHOULD LEGUMES BE INCLUDED IN *MY* GRAZING SYSTEM?

Dr. Carl S. Hoveland
Crop & Soil Sciences Dept., Univ. of Georgia, Athens

What are legumes?

Legumes are broad leaved plants that produce seed in a pod, usually have a tap root, and generally have bright colored flowers. They include a wide range of plants such as white clover, red clover, alfalfa, crimson clover, arrowleaf clover, peanut, soybean, and kudzu. One reason that we should be interested in many of them is that the foliage is of generally higher nutritive quality for livestock than grasses. The other reason is that they have bacteria in nodules on their roots that fix atmospheric nitrogen for their own use as well as providing some to associated grasses in pastures. Legumes can provide 75 to 150 pounds of N/acre annually in a pasture, an attractive advantage as fertilizer nitrogen prices continue to rise.

Why do legumes improve animal performance on pasture?

Legumes are generally higher in protein, digestible energy, and minerals than grasses. For instance, in one study the digestible energy content of white clover was 80%, crimson clover 70%, as compared to 62% for tall fescue and 54% for bermudagrass. Crude protein content of the clovers was 20% while tall fescue was 13% and bermudagrass 10%. Calcium and magnesium content of the clovers was double that of the grasses. Phosphorus content of the clovers were also higher than the grasses.

Legume impact on beef cattle performance

Even a small amount of legume in the pasture can improve animal performance on a grass pasture. This is illustrated in a beef steer grazing trial in north Alabama where white clover, averaging 24% of the total forage in endophyte-infected tall fescue pasture increased average daily gain 44% over tall fescue alone. In northwest Georgia, beef steers on endophyte-free tall fescue pasture gained 2.3 pounds/day with white clover as compared to 1.9 pounds/day with nitrogen-fertilized grass. In southeastern Alabama, beef cows and calves were grazed on Coastal bermudagrass from late winter to autumn during three years. Calf gain was 1.9 pounds/day on pastures overseeded with crimson and arrowleaf clovers as compared to 1.5 pounds/day with nitrogen fertilization.

What legumes should you plant?

This depends on where you live and what kind of pasture grass you are growing. In bermudagrass or bahiagrass sods, an annual clover such as crimson, arrowleaf, ball, rose, or berseem can be planted.

Crimson clover has excellent seedling vigor and will make more winter growth than any other winter annual legumes but it matures more early than some other winter annuals. It has a lower percentage of seed with hard seed coats than other annual clovers so natural reseeding is poor. Improved varieties available are Flame and AU Robin with greater winter productivity.

Arrowleaf clover is the latest maturing of any winter annual clover, making it highly productive in pastures. It is not tolerant of soil acidity, requires a soil pH of 6, and does not tolerate poor drainage. Arrowleaf clover has a high percentage of hard seed and commercial seed must be scarified. Natural reseeding is excellent. Seedling growth is slow, generally resulting in little early winter forage. The leaves of this clover contain a small amount of tannin which makes it relatively free of bloat problems in cattle. This formerly popular clover is less planted today because of a major problem with virus diseases and root rots. Even so, many fanners continue to use it. In addition to the widely planted Yuchi variety, the new variety Apache developed in Texas has resistance to bean yellow mosaic virus and seed are now available.

Ball clover is a winter annual clover that is an outstanding natural reseeder in grass sods, is well adapted to poorly drained soils, and tolerates close grazing. It does not have a long productive season but can add a considerable amount of high quality forage to a pasture during spring at low cost. Bloat can be problem with this clover.

Berseem clover is a highly productive annual legume with a long growing season. This clover has less cold tolerance than other annual clovers and only the Big Bee variety is recommended for the Coastal Plain region. It requires a soil pH of 6.5 and good fertility. Berseem will tolerate some flooding. Bloat potential is low.

Red clover can also be used as a winter annual and will continue to grow much of the summer and improve pasture quality. It is easy to establish in grass sods but generally will not reseed. Red clover will tolerate a soil pH of 5.5 but responds well to phosphorus and potassium fertilizer.

Annual lespedeza is an excellent reseeding summer annual legume that can be planted in late winter or early spring to improve summer forage quality in either bermudagrass or tall fescue pastures where soil fertility inputs are low. It will not be successful where nitrogen fertilizer is being applied to the grass in spring. Forage yields of this legume are not high but the excellent quality of the forage makes it a valuable addition to low input pastures. Marion is the recommended variety because of its greater disease resistance.

Alfalfa (grazing-tolerant varieties) can be planted in grass sod but are much better suited to planting alone. Alfalfa is an excellent choice to plant on a small area for creep grazing by calves adjacent to where beef cows are maintained on bermudagrass. The drought tolerance and high quality of alfalfa pasture can increase calf weaning weights in late summer when nutritive quality of bermudagrass is low. White and red clovers are better suited for tall fescue and orchardgrass.

Red clover will make more summer growth than white clover during hot dry weather in summer. It has excellent seedling vigor and is easily established in grass sods during autumn or winter. During winter it can be successfully established by broadcast planting as well as drilling. However, red clover varieties now available do not tolerate close continuous grazing and generally survive only two years in central and northern Georgia pastures. Rotational grazing is recommended for red clover.

White clover planted in pastures is typically a ladino or giant-leaf type such as Regal or Osceola varieties. They are easily established by broadcast or no-till drill seeding in grass sods, high yielding, and tolerate close grazing better than red clover. However, ladino clover varieties generally survive only two and occasionally three years in tall fescue pastures over most of central and northern Georgia. Recommendations have been to plant seed every other year to maintain white clover in a pasture. Two new varieties of white clover developed by Dr. Joe Bouton at the University of Georgia are far superior to any ladino clover varieties now available. They were selected under close continuous grazing in grass pastures and have been tested in pastures over the past six years, most of this period being subjected to long periods of drought.

> The ***Durana*** variety has smaller leaflets and is somewhat lower yielding than ladino varieties but has a heavier bloom and seed crop, much higher stolon density for greater carbohydrate storage, and more leaves close to the ground. As a result, it is extremely tolerant of hard grazing, drought, and competes well with tall fescue and bermudagrass in north and central Georgia. It has survived well in grass pastures for six years while ladino clover disappeared after two years. In south Georgia, indications are that on good soils that Durana will persist in Tifton 85 bermudagrass but not in the tight sod of common bermudagrass.

> The ***Patriot*** variety is a cross of a virus-resistant ladino type with a Durana type. Patriot is higher yielding than Durana, but has larger leaflets, and more stolons and leaves close to the ground than ladino varieties. Survival in grazed grass pastures has been far superior to ladino varieties but slightly less than Durana under harsh conditions.

Should legumes be included in my grazing system?

The answer to this question is easy for livestock producers in north and central Georgia. Legumes are the cheapest way to improve forage quality and animal performance plus furnishing free nitrogen to your pastures. With the advent of two superior new white clover varieties, there is no excuse for not planting clovers in pastures. The cost is low and the potential benefits high. In the Coastal Plain of south Georgia, legumes can be valuable but are less attractive in many situations, provided nitrogen fertilizer prices do not continue to escalate. If the new white clover varieties succeed on better soils in this region, they will be a valuable asset. Winter annual clovers can be useful in many cases but the short growing season of these legumes limit their potential unless they naturally reseed.

Section 5

Segregating Herds Based On Animal Class and Nutritional Need.

Dr. Jacob Segers, UGA

2016 Georgia Grazing School:

Segregating herds based on animal class and nutritional need

Dr. Jacob Segers
Asst. Prof. and Ext. Beef Cattle Spec.



Segregating Herds Based on Animal Class and Nutritional Need

Jacob R. Segers, Ph.D.
Asst. Prof. and Extension Beef Specialist
Department of Animal and Dairy Science
University of Georgia – Tifton Campus

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Has Anyone Seen This Girl?

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Forage Nutrition Planning

- Develop a Nutritional Strategy
  1. Understand your production system
     - Fall Calving
     - Spring Calving
     - Continuous
  2. Understand you forage system
     - Pasture
     - Stored forage
  3. Develop a grazing plan
     - Only supplement when needed

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Livestock Considerations for Forage System Planning

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1. Basic Nutrients

- Six Key Nutrients
  - Water
  - Protein
  - Carbohydrates
  - Fats
  - Minerals
  - Vitamins

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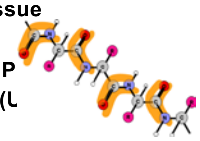
Protein

- Proteins are the building blocks for animal tissues and are composed from chains of amino acids
- Crude Protein (CP) is determined by
  - [N] x 6.25 = CP
  - Estimate because [N] is approximately 16% of protein structure in animal tissue
- Protein Fractions:
  - Degradable Intake Protein (DIP
  - Undegradable Intake Protein (U



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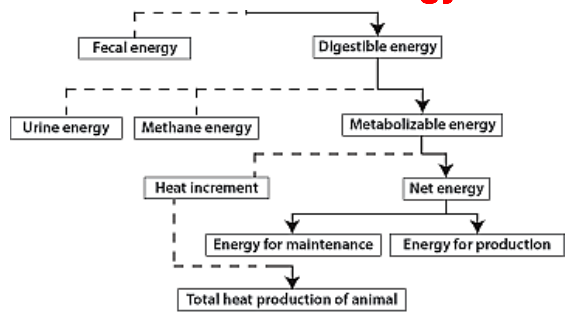
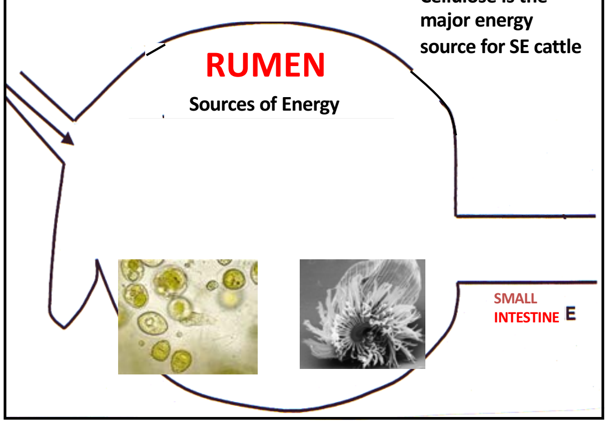
Energy

- Energy is defined as the capacity to do work
  - Common measures of energy that will be seen in production scenarios
    - *Net Energy (NE)* – Broken into maintenance, growth, and lactation
    - *Total Digestible Nutrients (TDN)* – method calculating energy based on contributions from all sources in the diet
- Sources: Starch, fats, proteins, and <u>cellulose</u>

Partition of Energy

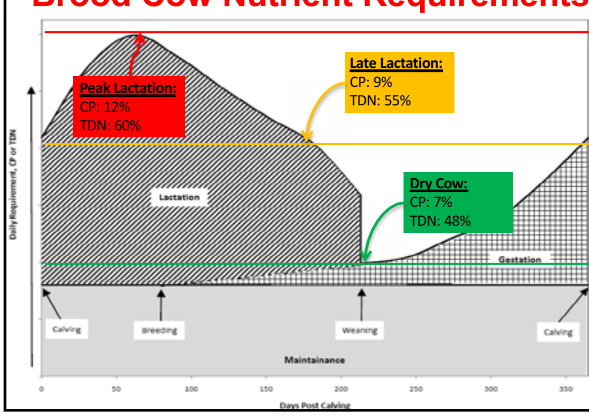




2. Feed to Meet Nutrient Requirements

- Nutrient Requirements - The amount of given nutrient that an animal needs to perform its specific purpose
- Influenced by: weight, sex, age, growth rate, and stage of production

Brood Cow Nutrient Requirements



3. Reproductive Efficiency

- Georgia's beef industry is composed primarily cow/calf operations
- Calf/ 365 days
  - The most important factor affecting profitability
- Highly dependent on proper nutrition

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Reproductive Efficiency and Profitability in the Cow Herd

Pregnancy Rate (%)	Calving Interval (days)	ADG (lb)	Calf WW (lb)	Income ($/calf)	Yearly Income [a] ($/cow)
43	414	1.60	374	359	142
61	381	1.75	460	396	222
86	364	1.85	514	416	329
93	364	1.85	514	416	356

[a]Calculated by multiplying the pregnancy rate by the income per calf.
Source: Rae et al., 1993.

How can we control reproductive efficiency?

- Genetics?
  - Sort of
- Management
  - Health
  - Environment
  - Nutrition

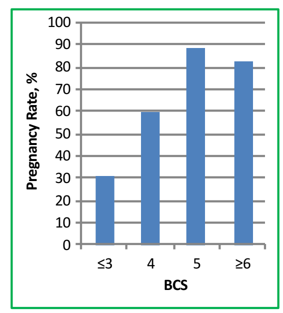
Body Condition Scoring???

- 1-9 – Assess the energy reserve status of a cow.

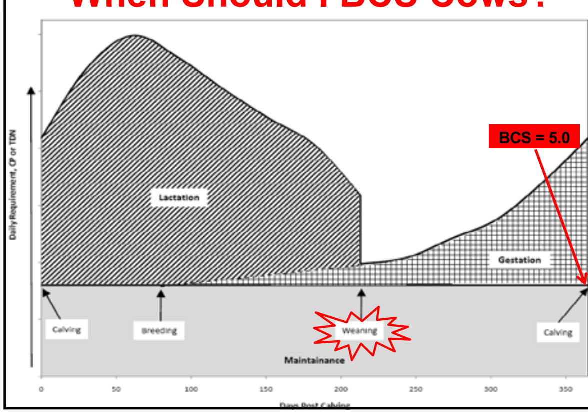
BCS-1

BCS-9

Body Condition Scoring???



When Should I BCS Cows?



Nutrients Needed to Increase BCS Over 70 day period*

	-----Mature BW, lb-----			
BCS	1100	1200	1300	1400
	---Additional TDN Needed Above Normal Requirements, %DM---			
2	5.9	6.4	6.9	7.4
3	6.5	7.1	7.7	8.2
4	7.3	8.0	8.7	9.3
5	8.3	9.0	9.8	10.5
6	9.6	10.4	11.3	12.2
7	11.1	12.2	13.2	14.2

*Increase in nutrient to reach the given BCS from the previous BCS

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How to Use the Table

A 1200 lb cow is a BCS 4 at weaning.

- **How much additional energy does she need to get to a BCS 5 in 70 days?**
- **What would her total TDN requirement be?**

TDN requried for dry cow is 48%

48% + 9.0% = 57% TDN

From Table

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4. Nutrient Priorities

1. Maintenance
2. Growth (Heifers)
3. Lactation
4. Reproduction

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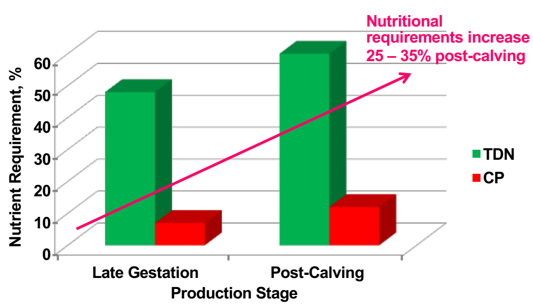
Nutrient Requirements Before and After Calving



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Nutritional Management

- **Realistically, post-partum period comes at a time when most producers are grazing winter annuals or feeding stored forage**
- **Forage Quality will determine how much work you have to do**
  - **Big argument of winter annuals**
- **Cow body condition is primary factor in ability to rebreed**

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Potential Forages

Forage	CP (%)	TDN (%)	Suitable for: Peak Lactation	Late Lactation	Dry Cow	600 lb calf gain, lb/d
Poor Hay	7	48	No	Yes	Yes	0.5
Average Hay	10	55	No	Yes	Yes	1.25
Excellent Hay	12	60	Yes	Yes	Yes	1.35
Winter Annuals -Vegetative	16	72	Yes	Yes	Yes	2.5

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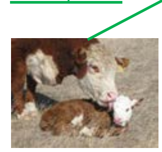
Post-calving Management Scenarios

60% TDN; 12% CP

55% TDN; 9%CP



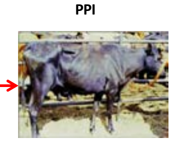
At calving fat is mobilized from the tissues to the udder

During lactation the calf will be initially depend solely on the cow, but by 90 days, 40% of calf's nutrition will come from some other source if available

Conception within acceptable PPI is almost totally influenced by environmental management during the PPI

48% TDN; 7% CP

48% TDN; 7% CP



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"If used incorrectly, this will be the biggest limit to your profitability."

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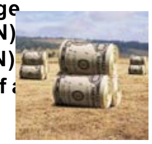
I have hay. Cows eat hay. What's problem?

- Quality = Digestibility
  - Digestibility is the animal's ability to extract nutrient (mainly energy) from diet
- On Average: Bermudagrass Hay is 10% CP and 55% TDN
- Every year various cuttings can range from really bad (6% CP and 47% TDN) to really good (16% CP and 62% TDN)
  - Roughly equivalent to requirements of a dry pregnant cow



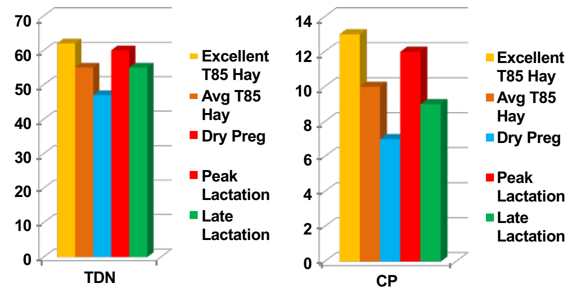
UGA extension

Nutritional Management in the Post-Partum Cow

- For spring calving herds post-partum period comes at a time when most producers are feeding stored forage
- Test your forage!!!
  - Forage Quality will determine strategy
- Understand that the quality of each hay cutting needs to be documented to ensure maximum efficiency of use

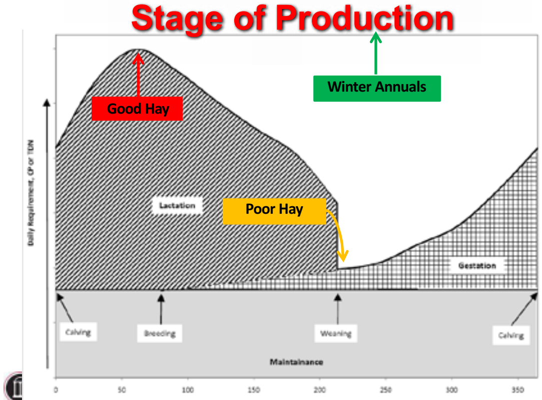
UGA extension

What About Lactating Cows?



UGA extension

Separate Cows Based on Stage of Production



If You Have To Use Hay…

- Hay produced
  - Storage
  - Testing
  - Inventory

Hay Cutting

1. CP 14% TDN 60%
2. CP 10% TDN 55%
3. CP 6% TDN 47%

TEST FORAGES!!!!

GRASS www.georgiaforages.com

Grazing School

UGA extension

The University of Georgia College of Agricultural & Environmental Sciences

2016 Georgia Grazing School:

Segregating herds based on animal class and nutritional need

Dr. Jacob Segers
Asst. Prof. and Ext. Beef Cattle Spec.

Final Thoughts

- Understand that nutrient requirements change throughout the production cycle
- Know your cattle, your forages, and your hay inventory
- Think about the bottom line when considering supplements
  - Don't be afraid to ask for help

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THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

Body Condition Scoring Beef Cows

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Introduction

Reproduction is the most important factor in determining profitability in a cow calf enterprise. To maintain a calving interval of 365 days, a cow must re-breed in 80 to 85 days after calving. Many cows in Georgia need a higher level of condition at calving and breeding to improve reproductive performance. Poor reproductive performance is directly linked to the percentage of body fat in beef cows. Body condition scoring (BCS) is an easy and economical way to evaluate the body fat percentage of a cow. Cows can then be sorted and fed according to nutritional needs. Body condition scoring can be an effective tool for cattle producers who cannot weigh cattle, and it may be an even better measurement of cow condition and reproductive performance than weight. Most studies show that body condition decreases at a faster rate than weight loss. Therefore, body condition scoring can estimate the probability of re-breeding.

Beef cattle have nutrient requirements in priority order for body maintenance, fetal development, lactation, growth and breeding. The nutrient intake is distributed in the body of the cow to fill these nutrient requirements. As each requirement is filled, the available nutrient is shifted to the next lower priority. The reverse shift is also obvious in beef cows. As nutrient requirements exceed intake, nutrients are shifted from the lower priority requirements to be sure that higher priority requirements are filled. Beef cattle store excess nutrients as body fat. The fat stores are mobilized when the nutrient demands exceed the available intake. In times of severe nutrient restriction, muscle tissue is mobilized once fat and other nutrient stores have been depleted. Researchers have determined that a certain amount of body fat is required for the reproductive system to function. Inadequate nutrition is most often the cause of poor reproductive performance. Developing a nutrition program is easier and more cost effective when all cows on the farm can be managed in a similar manner. This is especially true when all cows on a farm are managed in a single herd, which is often the case with small production units. Calving year-around will make it very difficult to maintain adequate body condition on all cows at the critical times.

Importance of Body Condition Scoring

Body condition affects both cow and calf performance. Poor body condition is associated with reduced income per cow, increased post-partum interval, weak calves at birth, low quality and quantity of colostrum, reduced milk production, increased dystocia, and lower weaning weights. Increasing post-partum interval will result in a younger, smaller calf at weaning the next year and will result in lower incomes if sold at weaning. Weak calves at birth may not get adequate colostrum and are more susceptible to disease, reduced weaning weights, reduced feedlot performance, and less desirable carcass traits. Research clearly shows that cows in moderate body condition will have a shorter interval from calving to first estrus than cows in thin condition. This supports the conclusion that BCS is one of the most important factors in determining subsequent reproductive performance.

Table 1. Description of body condition scores (BCS) (1 [thin] to 9 [obese])[a].

BCS	% Body Fat[a]	Detailed Description[b]
		Thin
1	3.77	Clearly defined bone structure of shoulder, ribs, back, hooks and pins easily visible. Little muscle tissue or fat present.
2	7.54	Small amount of muscling in the hindquarters. Fat is present, but not abundant. Space between spinous process is easily seen.
3	11.30	Fat begins to cover loin, back and foreribs. Upper skeletal structures visible. Spinous process is easily identified.
		Borderline
4	15.07	Foreribs becoming less noticeable. The transverse spinous process can be identified by palpation. Fat and muscle tissue not abundant, but increasing in fullness.
		Optimum
5	18.89	Ribs are visible only when the animal has been shrunk. Processes not visible. Each side of the tail head is filled, but not mounded.
6	22.61	Ribs not noticeable to the eye. Muscling in hindquarters plump and full. Fat around tail head and covering the foreribs.
7	26.38	Spinous process can only be felt with firm pressure. Fat cover in abundance on either side of tail head.
		Fat
8	30.15	Animal smooth and blocky appearance; bone structure difficult to identify. Fat cover is abundant.
9	33.91	Structures difficult to identify. Fat cover is excessive and mobility may be impaired.

[a] (Source: NRC, 2000)
[b] (Adapted from: Herd and Sprott, 1986)

How to Body Condition Score

To properly evaluate body condition for cattle, an observer must be familiar with skeletal structures and with muscle and fat positioning. Although there are several methods available to determine body composition, many cattlemen use a scoring system that involves ranking cattle on a scale. This manuscript will focus on the commonly used scale of 1 to 9, with 1 being emaciated and 9 being obese (Whitman, 1975).

Cattlemen can easily observe cattle under pasture conditions to obtain body condition scores. Familiarity with key skeletal structures listed in Figure 1 (p. 3) is required to apply an accurate body condition score. A description of each condition score is listed in Table 1.

Body condition scoring is a subjective measurement, meaning that one producer may score slightly different than another. The producer can gain experience using body condition scores by identifying cattle into one of three categories: thin (1 to 3), borderline (4), optimum (5 to 7) or too fat (8 and 9). Over time, as the producer becomes familiar with details of each specific body condition score, these categories can be further broken into actual condition scores. Research reported by the University of Florida (Table 2, page 4) demonstrates that as cattle decrease from a body condition score of 5 to 4, they may have reduced pregnancy rates by as much as 30 percent. An additional 30 percent of pregnancies can be lost when cattle drop from a 4 to a 3. Cattle that receive a BCS of 5 or below may have reduced pregnancy rates. Although most cattlemen tend to keep cows on the thin side, cattle that are obese (BCS of 8 to 9) may also have reduced pregnancy rates.

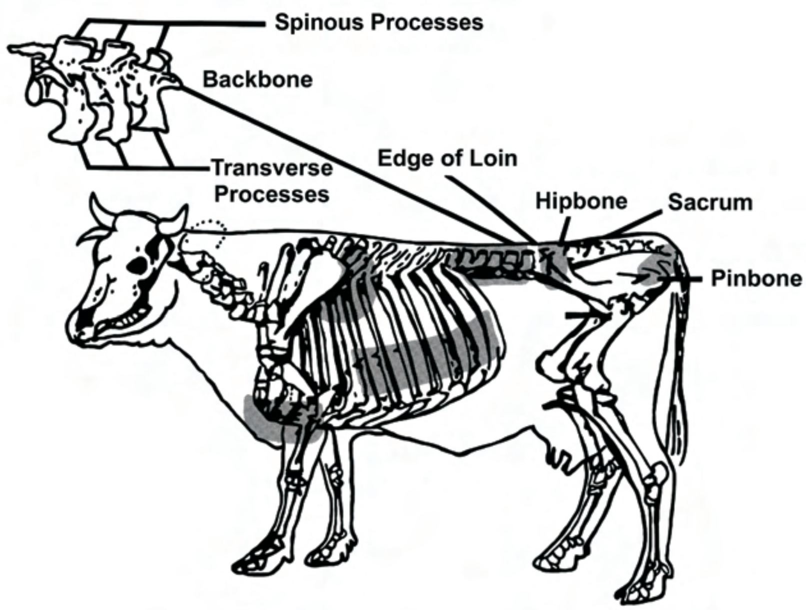

Figure 1. Skeletal structures of a cow used to evaluate body condition score.

BCS 2

BCS 3

BCS 4

BCS 5

BCS 6

BCS 7

Table 2. Relationship of parity and body condition score to pregnancy rate (%)[a].

	Body Condition Score[b] at Calving			
Parity	**≤3**	**4**	**≥5**	**All**
1	20	53	90	84
2	28	50	84	71
3	23	60	90	85
4-7	48	72	92	87
>8	37	67	89	74
All	31	60	89	82

[a](Rae et al., 1993; University of Florida)
[b](Scale of 1 [thin] to 9 [obese])

Table 3 shows the impact of BCS on pregnancy percentage, calving interval, calf performance, calf price and income. Cows in a borderline body condition (BCS of 4) have greatly reduced pregnancy rates, increased calving intervals, lower calf daily gain and greatly reduced yearly income. For example, a cow calving in a BCS of 4 will return an income of approximately $100 less than a cow calving in a BCS of 5. If BCS is taken 90 days prior to calving, the cows in borderline condition can be properly supplemented to achieve a BCS of at least 5 at calving. In most cases supplemental feed costs will be approximately $25 to $35 for feed that costs $100 to $150 per ton This is far less money spent on feed than would be lost if cows were allowed to stay in a BCS of 4. The impacts are even greater for a BCS of 3 and is a condition that should never happen with any of the cows in the herd.

When to Evaluate Body Condition

Many beef producers are involved in diversified farming operations. These operations may combine cattle with row crops, poultry houses, timber and many other time consuming production practices. Regardless of the combination, additional obligations may limit the amount of time producers can spend evaluating body condition. However, neglecting to properly observe and record body condition can have a substantial impact on overall productivity and profits.

To properly identify cattle that have increased nutritional needs, producers should evaluate body condition as often as possible, but a minimum of three times (weaning, 90 days pre-calving and breeding) per year is preferred. Cattle that are calving should have enough body condition to allow for a reduction in body mass due to weight being lost during the parturition process and fluids being displaced. Body condition score at calving time provides the best prediction of re-breeding performance. Evaluating BCS approximately 90 days prior to calving allows sufficient time to adjust the feed ration to ensure cows are in adequate body condition at calving.

Weaning

Evaluating body condition at weaning can be useful to determine which cows or heifers need the most gain prior to calving. Since calves will no longer suckle, lactating cows will be able to dry off and add needed weight before calving. The time period from weaning to calving has proven to be the easiest and most economical time to add condition to cattle. Producers who fail to evaluate body condition and adjust the nutri-

Table 3. Relationship of body condition score to beef cow performance and income[a].

BCS[b]	Preg. Rate (%)	Calving Interval (days)	Calf WA (days)[c]	Calf DG (lb)[d]	Calf WW (lb)[e]	Calf Price $/100[f]	Income ($/Calf)	Yearly Income $/Cow[g]
3	43	414	190	1.60	374	96	359	142
4	61	381	223	1.75	460	86	396	222
5	86	364	240	1.85	514	81	416	329
6	93	364	240	1.85	514	81	416	356

[a](Adapted from Kunkle et al., 1998; UF/IFAS Publication SP-144.
[b](Body Condition Score; scale of 1 [thin] to 9 [obese]).
[c](Weaning Age; 240 days for cows in BCS 5 and 6 and decreasing as calving interval increases).
[d](Daily Gain)
[e](Weaning Weight; calculated as calf age multiplied by calf gain plus birth weight [70 lbs]).
[f](Average price for similar weight calves during 1991 and 1992).
[g](Calculated as income/calf times pregnancy rate times 0.92 [% calves raised of those pregnant]).

tional needs of the cow herd after weaning may have difficulty adding condition later in the production cycle.

90 days Prior to Calving

Assessing body condition 90 days prior to the beginning of the calving season may be useful in preventing extended periods of anestrus. This score may be taken at weaning in herds that delay weaning until calves are 8 to10 months of age. However, weaning calves at least 90 days prior to the start of the calving season is recommended. Cow nutritional requirements are greatly lowered when non-lactating and should allow the cow to achieve adequate body condition at calving with minimal supplemental feeding. Nutrition can then be adjusted for cattle that receive body condition scores of less than 5 after this assessment. Although changes in weight can be achieved, take care to prevent excessive weight gain immediately prior to calving. Cows should be fed to calve in a BCS of 5 to 6 and heifers a BCS of 6.

Breeding

After undergoing the stress of parturition, cattle will lose body condition. The time period from calving to breeding is the most difficult in which to improve body condition. This is why it is very important to body con-dition score cows 90 days prior to calving and make ration changes to achieve optimum BCS prior to calv-ing. Approximately 90 percent of cattle in optimum body condition will resume estrus cyclic activity 60 days postpartum. Assessing body condition at breeding may offer useful information that may help explain reduced pregnancy rates.

Body Condition Score and Calving Season

The calving season in Georgia varies widely among cattle operations, but most calves are born from Sep-tember through March. Calving season has a large impact on phase of the cow's yearly production cycle in which body condition score is most likely to be deficient.

In the southeast, cows calving in the fall months are likely to have adequate body condition score, so the winter feeding period usually begins shortly after the calving season begins. Therefore, cows are lactating throughout the winter feeding period. Increased de-mands of lactation and declining feed quality during the fall months often causes inadequate body condition by the start of the breeding season, which begins in early- to mid-winter. The majority of producers feed hay as the base diet during this period. Hay will likely require supplementation and the hay feeding period may last throughout the breeding period for cows calv-ing during the fall. In contrast, cows calving in late winter will be in late gestation and early lactation dur-ing the winter feeding period. Body condition score at calving will have to be monitored more closely than fall calving cows as the cows will be fed hay through most of the last trimester. Cows will likely be fed a hay based diet that requires supplementation during the early lactation period. However, supplementation can cease when hay feeding stops and grazing becomes available. Cows should be able to increase body condi-tion score when grazing lush spring growth of fescue, ryegrass, or small grain pasture.

Increasing Body Condition Score from Calving to Breeding

The easiest and most economical time to improve body condition score is from weaning to calving. In situations where cows calve in a less than adequate body condition, weight gain must be increased rapidly following calving to achieve acceptable pregnancy rates at the end of the breeding season. The most difficult period to maintain body condition is from calving to breeding. Body condition score and re-breeding rates can be improved in cows calving in less than a 5 condition score if fed to increase condition prior to the beginning of the breeding season. Mature cows, however, will respond to supplementation much better than first calf heifers. Table 4 illustrates the effects of body condition score at calving and subsequent body weight gain on pregnancy rates of first calf heifers. Heifers that calved in a body condition score of 5 or above had greater than 90 percent pregnancy rates when either gaining weight or maintaining weight. In heifers calving in a BCS of less than 5, pregnancy rate was increased from 36 to 67 percent by increasing daily gain from 0.7 to 1.8 pounds per day. Even though increasing daily gains improved pregnancy rates, the 67 percent pregnancy rate is not acceptable and was far below both groups calving in a condition score of 5 or greater. This study shows that, for first calf heifers, body condition score at calving is the key component to high re-breeding rates.

Table 4. Effects of calving BCS and subsequent weight gain on reproductive performance of first calf heifers.[a]

Calving BCS	Weight gain, lb/d[b]	Pregnancy %
< 5	1.8	67
< 5	0.7	36
> 5	1.0	94
> 5	0.1	91

[a]Adapted from Bell, et al. 1990
[b]Weight gain = daily weight gains from calving to the start of the breeding season.

Body condition score at calving is less critical for mature cows. Certainly, it is ideal to have cows in a body condition score of 5 at calving through breeding. Acceptable re-breeding rates, however, can be achieved in mature cows that calve in borderline (BCS of 4) condition if cows are fed to increase body condition score to a 5 at the start of the breeding season.

A study evaluated the effects of nutrient intake from the second trimester through the start of the breeding season. The first group was fed to maintain a body condition score of 5 from the second trimester to the start of the breeding season. The second group was fed to be a BCS of 4 during the second trimester, and then regain condition during the third trimester to a BCS of 5 at calving. The third group was fed to be in a BCS of 4 from the second trimester through 28 days post-calving, and then gain weight to be in a BCS of 5 at the start of the breeding season. Table 5 shows the body condition scores and Table 6 shows the post-calving weight gains and pregnancy rates. All groups were in a BCS of 5 just prior to the start of the breeding season as planned. Acceptable pregnancy rates occurred in all groups. Cows that calved in a BCS of 5 to 6 lost weight from calving to the start of the breeding season; cows that calved in a BCS of 4.8 had to be fed to gain 3.43 lbs per day to increase body condition to maintain an acceptable re-breeding rate. Such rapid weight gain would require a grain-based or corn silage based diet. Cows in a BCS of less than 5 at calving should be separated from the rest of the herd and a feeding program designed to increase BCS should begin immediately. The cows that calved in a BCS of 4.8 were only slightly below the desired BCS of 5 and cows calving in a BCS of less than 4 may not have acceptable pregnancy rates.

Table 5. Effect of restricted feeding on body condition score of mature cows.[a]

	Feeding Level[b]		
Days from calving	High-High-High	Low-High-High	Low-Low-High
-95	6.0	5.3	5.4
0	5.6	5.5	4.8
+58	5.2	5.1	5.2

[a]Adapted from Freetly et al., 2000.
[b]High-High-High = maintain BCS of 5.5 from weaning to breeding. Low-High-High = decline in BCS in second trimester and regain BCS to a five during third trimester. Low-Low-High = decline in BCS during second trimester through 28 days post-calving, then regain BCS to a five at breeding.

Table 6. Effect of restricted feeding on postpartum weight gain and pregnancy rates of mature cows.[a]

	Feeding Level[b]		
Item	High-High-High	Low-High-High	Low-Low-High
Weight gain, lb/d	-0.46	-0.64	3.43
Pregnancy rate, %	93	92	88

[a]Adapted from Freetly et al., 2000.
[b]High-High-High = maintain BCS of 5.5 from weaning to breeding. Low-High-High = decline in BCS in second trimester and regain BCS to a five during third trimester. Low-Low-High = decline in BCS during second trimester through 28 days post-calving, then regain BCS to a 5 at breeding.

Supplemental Feeding Based on Body Condition Score

Grouping by Body Condition Score

A body condition scoring system is much more effective when cows can be sorted and supplemented relative to target body condition score. The amount of sorting will depend on the availability of pastures and labor. Ideally, mature cows should be separated into an adequate (≥5 condition score) and inadequate BCS group (<5 condition score). In addition, first-calf heifers and developing heifers should remain in separate groups. Condition scores of heifers do not vary as greatly as those of mature cows, and heifers can usually be fed together.

Another option is to sort your cow herd into mature cows in condition score of 5 and greater in one group and heifers plus cows in condition score of less than 5 in another group. The primary benefit of grouping by body condition is to reduce supplemental feeding costs and implement a more specialized management system for thin cows.

Determining Needed Level of Supplementation

Body condition scores of cows must be determined prior to the beginning of a supplemental feeding program. Body condition score has a significant impact on the requirement for energy but only a small effect on the protein requirement. Many supplementation programs focus only on supplemental protein and fall short of providing enough energy to maintain an adequate BCS. Energy rather than protein is often the most limiting nutrient in Georgia forages.

To increase body condition, the first step is to determine how many pounds a cow needs to gain to reach the desired BCS. To increase one condition score, a cow needs to gain about 75 pounds. A dry pregnant cow would need approximately 375 pounds and a lactating cow 575 pounds of TDN (Total digestible nutrients) above maintenance to increase one body condition score in a 75-day period. This would equate to approximately 6.5 pounds of corn per day for a dry pregnant cow and 10 pounds of corn per day for a lactating cow.

Tables 7 and 8 list the requirements for TDN and crude protein for cows and heifers in different body condition scores. For example, a cow that is in body condition score of 4 at 60 days prior to calving needs to gain about 1.25 lb per day to reach a condition score of 5 at calving.

The next step is to determine if the feedstuffs available on the farm will support this gain. For example, a nutrient analyses indicated that the hay was 10 percent crude protein and 50 percent TDN. Assume that a dry cow will consume about 2.0 percent of body weight per day and a lactating cow will consume about 2.25 percent of her body weight per day in dry feed. Therefore, the dry cow in a body condition of 4 will consume about 24 lbs of hay per day. The 24 pounds of hay at 50 percent of TDN will yield 12 pounds of TDN. From the information in Table 7, the cow needs 16 pounds of TDN. Therefore, the cow must be supplemented with 4 pounds of TDN per day. There are many grains, by-product feeds and supplements that will work. The primary factor in determining which supplement to use is price. The crude protein supplied by the 24 pounds of hay is about 2.4 pounds per day, and the cow requires 2.1 pounds per day. Therefore, the supplemental feed does not have to be high in crude protein, and high energy, low crude protein feeds such as corn can be used. In most cases, hay will not supply sufficient nutrients to increase body condition score. Computer ration balancing programs are available through Cooperative Extension. These programs can rapidly balance diets for protein and energy to achieve the desired body condition score, but an accurate analysis of feeds is needed to accurately balance a diet.

Table 7. Daily requirements of TDN and crude protein for a 1,200 lb mature cow.

Stage of production	lbs of TDN		lbs of Crude Protein	
	BCS 4	BCS 5	BCS 4	BCS 5
Late gestation	16.0	12.7	2.1	1.7
Early lactation	18.4	15.0	2.9	2.6

Adapted from NRC, 1996.

Table 8. Daily requirements of TDN and crude protein for a 1,000 lb first-calf heifer.

Stage of production	lbs of TDN		lbs of Crude Protein	
	BCS 4	BCS 5	BCS 4	BCS 5
Late gestation	15.4	12.8	2.0	1.7
Early lactation	18.4	15.2	2.8	2.5

Adapted from NRC, 1996.

Choosing a Supplement

A wide range of supplements can supplement existing forage to maintain or increase body condition score. Nutrients may include energy, protein, minerals and vitamins. Minerals and vitamins are not altered significantly by BCS, so supplements will be chosen based on their energy and protein concentration. Factors impacting type of supplement used will be nutrient content of forage, lactation status, desired daily gain, cost of supplement, and availability of supplement. The only way to get an accurate assessment of hay quality is to have the forage analyzed for nutrient content. Type of supplement will then be dictated by how much protein and energy supplementation is required per day to reach the desired performance level. If energy is the only limiting nutrient, most any supplement will work. High energy supplements such as corn grain will usually be the most economical. If both energy and protein are required, then a by-product with a high level of protein such as corn gluten feed, distillers grains or whole cottonseed can be used. Example supplementation protocols are shown for lactating cows in Table 9 and for dry pregnant cows in Table 10.

Table 9. Hay quality and supplementation required for 1,200 lb lactating cow producing 15 lbs of milk/day[a]

Quality of hay	Crude Protein (%)	TDN (%)	Supplement Required
Excellent	11.2 & over	58 & over	None
Good	9.5 to 11.1	53 to 58	4 lbs corn gluten feed or 3 lbs corn and 1 lb soybean meal or 4.5 lbs of 20% crude protein cubes or 4 lbs of whole cottonseed
Fair to good	8.2 to 9.5	50 to 53	6 lbs of corn gluten feed or 5 lbs of corn and 1.5 lbs soybean meal or 7 lbs of 20% crude protein cubes or 6 lbs of whole cottonseed
Poor to fair	7.3 to 8.2	50 & under	8 lbs of corn gluten feed or 6 lbs of corn and 2 lbs soybean meal or 8.5 lbs of 20% crude protein cubes or 6 lbs of cottonseed and 2 lbs of corn
Very poor	under 7.3	49 & under	9 lbs of corn gluten feed or 6.5 lbs of corn and 2.5 lbs soybean meal or 10 lbs of 20% range cube or 7 lbs of whole cottonseed and 2 lbs of corn gluten feed

[a] Recommended feeding amounts assumes cow is in a BCS of ≥5.

Table 10. Hay quality and supplementation required for a 1,200 lb dry pregnant cow[a]

Quality of hay	Crude Protein (%)	TDN (%)	Supplement Required
Excellent	11.2 & over	56 & over	None
Good	9.5 to 11.1	53 to 56	None
Fair to good	8.2 to 9.5	50 to 53	3 lbs of corn gluten feed or 3 lbs of corn or 3.5 lbs of 20% crude protein cubes or 3 lbs of whole cottonseed
Poor to fair	7.3 to 8.2	50 & under	4.5 lbs of corn gluten feed or 4 lbs of corn and 0.5 lb soybean meal or 5 lbs of 20% crude protein cubes or 4 lbs of cottonseed
Very poor	under 7.3	49 & under	6 lbs of corn gluten feed or 5 lbs of corn and 1.0 lb soybean meal or 6.5 lbs of 20% crude protein cubes or 5.5 lbs of whole cottonseed

[a] The recommended feeding amounts assumes a cow is in a BCS of ≥5.

By-product feeds are an increasing source of winter supplementation in the southeast. They are often priced competitively with corn and oilseed meals. In addition, some by-product feeds have a moderate protein content, which reduces feed costs compared with a traditional corn-soybean meal mixture or a commercial protein supplement. In addition, by-product feeds such as soybean hulls, wheat middlings, corn gluten feed, distillers grains and citrus pulp are low in starch but high in digestible fiber. These by-products can be fed at higher levels than corn before forage intake and digestibility is depressed. The high starch content of corn causes a negative effect on digestion when supplementation level exceeds approximately 0.5 percent of body weight and worsens as supplementation level is increased. When high levels of supplement are needed, a low starch by-product feed is recommended.

Self-controlled supplements such as molasses lick tanks and hard compressed molasses or high protein blocks are popular choices because of low labor requirements. These supplements are designed to be primarily protein supplements. In most situations, cows require both supplemental protein and energy. Often, the hard block supplements cannot be consumed in great enough amounts to provide the desired level of energy. These supplements become less desirable as hay quality declines and supplement needs are increased. Additional energy may need to be supplemented when these products are fed. The liquid molasses-based supplements can be consumed at higher levels and will more closely match requirements for energy than hard pressed blocks. Consuming too much molasses, however, can cause a decrease in forage digestibility and intake.

Grazing cows on winter annual pastures is a popular choice for many producers in Georgia. Winter annual pastures are high quality, and they provide extra energy and protein for lactating cows while decreasing the feeding of hay. Winter pasture alone is too high quality for most cows; limit-grazing provides the most efficient use of these high quality forages for beef cows.

Winter pastures contain approximately 25 percent crude protein and 75 percent TDN and can meet supplemental protein and energy needs. The most popular method of grazing cows on winter pasture is limit-grazing a few hours every day. You can get satisfactory results, however, by grazing as little as every other day or just two or three days per week. Research has shown that grazing lactating cows for 7 hours per day for either two or three days per week is as effective in maintaining cow condition as grazing every day and is particularly effective for cows calving in the fall.

Economics of Supplemental Feeding

Providing supplemental feed to improve BCS for acceptable pregnancy rates is an economical practice. In almost every herd, first-calf heifers are the most difficult group to get re-bred. It has been estimated that a heifer that does not re-breed after calving costs the producer from $200 to $500. Research has shown that first-calf heifers having a BCS of 4 at breeding time will have pregnancy rates of approximately 50 percent, and first-calf heifers having a BCS of 5 at breeding time will have about a 90 percent pregnancy rate.

For example, a producer has a group of 10 heifers in a BCS of 5 at calving. If heifers are only fed poor quality hay (8% CP and 50% TDN) from calving to breeding, a decrease of one condition score is likely. The recommendation in Table 10 suggests that feeding 8 pounds of corn gluten feed a day will maintain a BCS of 5. This would cost approximately $0.48 per day or $28.80 for the entire feeding period if the gluten feed was priced at $100 per ton. The producer can provide supplemental feed to these 10 heifers for 60 days prior to the start of the breeding season to maintain a BCS of 5 at breeding time.

In this example, we would expect four more heifers to become pregnant compared with no supplemental feeding. This would save $800, assuming a total of $200 for each additional heifer bred. Using an example of corn gluten feed at $100/ton, the producer can buy 8 tons of corn gluten feed with the $800 and still break even on additional feed costs. However, it would only take approximately 2.5 tons of corn gluten feed to accomplish this goal. This does not include additional benefits of higher weaning weights and earlier calving cows the next year.

Clearly, it is economical to improve body condition of lactating cows rather than reduce feed costs and have reduced pregnancy rates. Supplemental feeding must begin shortly after calving, however. Waiting until the breeding season starts is too late. Poor pregnancy rates and an extended re-breeding period is certain.

Extended Breeding Season

Some producers believe that increasing the length of the breeding season will result in high re-breeding rates of cows in poor body condition. Cows, however, will not re-breed at acceptable levels as long as they are in poor condition. This is clearly illustrated in Table 11. Cows that were in a BCS of 4 or less had only 58 percent pregnancy rate, despite 150 days of exposure to the bull. Cows that do become pregnant at the end of an extended breeding season will wean smaller calves and will be unlikely to re-breed the following year.

Table 11. Effect of body condition score during the breeding season on pregnancy.

	Body condition during breeding	
Item	**4 or less**	**5**
Percent pregnant after 150 days	58	85

Adapted from Sprott, 1985

Salvaging the Breeding Season

When cows are in condition scores of less than 5 at the start of the breeding season, increasing nutrition will improve pregnancy rates but not enough to maintain high pregnancy rates and a yearly calving interval. To achieve high (≥90%) pregnancy rates and maintain a yearly calving interval alternative management strategies will need to be implemented. The most effective management practice is to wean the calf to remove the demands of lactation on the cow. This management practice is often employed with first calf heifers. However, it is an effective management tool to increase re-breeding rates in mature cows.

Early Weaning

In most herds, first calf heifers usually have the lowest body condition at the beginning of the breeding season. These heifers will likely need some cessation of nursing by reduced exposure to the calf or by weaning the calf to achieve high re-breeding rates. Early weaning the calf at the initiation of the breeding season will lead to high re-breeding rates if adequate supplementation is supplied. Removing the demands of lactation greatly reduces energy and protein requirements. Early weaning must be done by the start of the breeding season to improve re-breeding rates. Calves should be a minimum of 30 days old prior to weaning.

Table 12 compares weights and condition scores of heifers with calves weaned at the start of the breeding season with those with calves weaned at the end of the breeding season. Weight and BCS at the end of the breeding season were greater for heifers with early weaned calves. Most importantly, heifers with calves weaned at the start of the breeding season had a 90 percent re-breeding rate versus only 50 percent for heifers that nursed their calf throughout the breeding season.

Another advantage to early weaning is decreased feed costs of the cow. Cows will consume approximately 20 to 30 percent less feed after early weaning compared to lactating cows and gain significantly more weight than lactating cows. Research has also shown that TDN requirements are 50 percent less for a dry first calf heifer to maintain equal condition scores as a lactating first calf heifer. This would represent a substantial reduction in feed costs for fall calving cows, which are fed harvested feeds through much of the lactation period. The improvements in pregnancy rates and reduced feed costs make early weaning the best option for cows that are below the desired body condition score at breeding time.

The disadvantage to early weaning is increased feed costs and management of the early weaned calf. Calves must have access to high quality winter annual pasture or should be fed a high concentrate grain mix in a drylot. Feeding programs that have used winter annual pastures plus an energy supplement have been very successful for calves weaned at less than 80 days old. Table 13 shows daily gains of early weaned calves that grazed ryegrass pasture plus 1 percent body weight daily of a 16 percent crude protein supplement. Calves were stocked at approximately four calves per acre. Weight gains were similar between the early and normal weaned calves. The winter pasture plus supplement program would work well for most cattle producers in Georgia.

Table 12. Effect of early weaning first calf heifers on weight and body condition score.[a]

Item	Beginning of breeding season[b]	End of breeding season	Weaning[c]
Normal weaned, wt	941	919	982
Early weaned, wt	907	954	1074
Normal weaned, BCS	3.88	4.27	4.50
Early weaned, BCS	3.9	5.11	6.25

[a]Adapted from Arthington, 2002.
[b]Initial weight was collected at the start of the breeding season.
[c]Final weight was collected at weaning.

Table 13. Effect of early weaning first calf heifers on calf weight.[a]

Item	Early Weaned	Normal Weaned
Initial weight, lb[b]	200	192
Final weight, lb[c]	492	509
Daily gain, lbs	1.50	1.68

[a]Adapted from Arthington, 2002.
[b]Initial weight was collected at the start of the breeding season.
[c]Final weight was collected at weaning.

Management Factors Affecting Body Condition Score

Several management decisions can affect the body condition of the cow herd. Some of these include stocking rate, calving season and herd health. Calving season and the duration of the calving season can influence cow body condition. Supplementation must be well planned for cows calving in the fall and early winter months, as most of the calving to re-breeding period will be on harvested feeds. In addition, a shorter calving will allow the producer to feed the herd more efficiently, because all the cows in the herd will be in the same stage of production.

ear-round calving will cause significant under- and over-feeding unless calves are managed as multiple groups. Adjust stocking rates so adequate forage is available to maintain adequate condition during the grazing season. If hay or supplement must be fed every dry spell, the stocking rate is probably too high.

Treat cattle for internal and external parasites. Georgia is an excellent environment for worms, and the cows should be treated at least once per year.

Summary

A body condition score of 5 to 6 at calving and breeding time will result in acceptable pregnancy rates. Heifers calving in body condition score of less than 5 will have less than optimal reproductive performance, even when nutrition is greatly increased after calving. Cows are more responsive to increased nutrition after calving. Clearly, it is more economical to improve body condition rather than reduce feed costs and have reduced pregnancy rates. Supplemental feeding must begin, however, shortly after calving to improve or maintain body condition. Waiting until the breeding season starts is too late to efficiently change BCS and have an impact on reproductive performance, and poor pregnancy rates will likely result. Early weaning is a proven management practice to maintain high re-breeding weights in cows and heifers calving in less than a 5 body condition score.

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Feed Library

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THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

Legend

DM = Dry Matter
CP = Crude Protein
TDN = Total Digestible Nutrients
Ca = Calcium
P = Phosphorus
$/ton = dollars per ton of feed stuff

	Feeds	DM	CP	TDN	Ca	P	$/ton*
	FORAGE/ROUGHAGE						
1	Bermudagrass hay, good	85	12	58	0.38	0.22	
2	Bermudagrass hay, average	85	10	53	0.36	0.18	
3	Bermudagrass hay, poor	85	6	49	0.34	0.18	
4	Tall fescue hay, good	85	16	60	0.43	0.32	
5	Tall fescue hay, average	85	13	55	0.42	0.31	
6	Tall fescue hay, poor	85	10	50	0.41	0.3	
7	Peanut Hay	88	11	48	1.20	0.15	
8	Bermudagrass pasture	25	13	64	0.4	0.27	
9	Bahiagrass pasture	25	10	58	0.46	0.22	
10	Summer annual pasture	25	12	60	0.5	0.44	
11	Small grains pasture - vegetative	22	18	70	0.45	0.35	
12	Small grains pasture - mature	25	12	58	0.4	0.3	
13	Ann. Ryegrass pasture - vegetative	22	20	72	0.65	0.41	
14	Ann. Ryegrass pasture - mature	25	12	58	0.6	0.35	
15	Tall fescue pasture	25	14	62	0.44	0.33	
16	Corn Silage	32	8	71	0.14	0.18	
17	Cottonseed Hulls	90	4	45	0.15	0.09	
18	Gin Trash	85	12	47	0.90	0.20	
19	Peanut Hulls	90	8	25	1.20	0.10	
	PROTEIN						
21	Brewer's Grains	25	27	75	0.30	0.60	
22	Chicken Litter	85	18	50	3.00	2.00	
23	Corn Gluten	90	25	83	0.08	0.54	
24	Cottonseed Meal	90	46	78	0.21	1.00	
25	Distiller's Grains	90	28	95	0.05	0.88	
26	Liquid Feed	67	45	80	0.00	0.00	
27	Molasses Block	76	30	80	2.00	1.00	
28	Range Cubes	85	25	75	1.75	0.50	
29	Soybean Meal	90	49	84	0.30	0.70	
30	Sunflower Meal (GA)	90	44	75	0.50	1.68	
30	Urea	99	291	0	0.00	0.00	
32	Whole Cottonseed	90	25	95	0.21	0.64	

Continued on next page

	Feeds	DM	CP	TDN	Ca	P	$/ton*
	ENERGY/TDN						
33	Barley	90	13	84	0.05	0.35	
34	Citrus Pulp	90	7	82	1.80	0.15	
35	Corn	90	8	90	0.02	0.35	
36	Grain Sorghum	90	12	76	0.05	0.34	
37	molasses	78	9	78	1.10	0.10	
38	Oats	90	13	77	0.07	0.38	
39	Soybean Hulls	90	12	78	0.55	0.20	
40	Wheat	90	13	85	0.05	0.43	
41	Wheat Midds	90	18	83	0.15	1.00	
42	50:50 CGF:SH	90	18	80	0.31	0.37	
43	50:50 DDG:SH	90	19	81	0.31	0.37	
44	60:20:20 SH:CGF:Corn	90	13	82	0.30	0.32	
45	65:25:10 SH:CGF:PH	90	15	74	0.50	0.28	
	MINERAL						
46	Basic	99	0	0	12.00	8.00	
47	Low P	99	0	0	10.00	2.00	
48	Limestone	99	0	0	39.00	0.00	

MISSISSIPPI STATE UNIVERSITY EXTENSION SERVICE

Feeding Considerations for Byproduct Feeding

Jane Parish, Extension Animal Scientist

Corn Products

Corn

Corn is typically considered the gold standard energy feed for beef cattle and is heavily used in beef cattle diets including finishing diets.

- Extremely high energy feed
- Quite palatable to cattle
- Contains low calcium, high phosphorus levels like most feed grains

Corn Gluten Feed

Corn gluten feed is a by-product of the corn milling process which produces high-fructose corn syrup used as a sweetener. It consists primarily of the bran and meal remains from the grain after starch removal.

- Good protein content but protein quality too low for poultry and swine diets
- Works as a protein and energy supplement
- TDN value about equal to corn as a supplement at 0.5% of body weight or less on high-forage diets
- Often prices in as a cost-effective feed ingredient
- Should not make up more than 50% of daily dry matter intake
- Can be fed in self-feeders along with hay or pasture, but caking possible in humid conditions
- Excessive heating during processing lowers feed value and palatability and darkens color
- Wet form use only practical in areas relatively close to mills
- Low in calcium
- Can contain high sulfur levels that necessitates mixing with other feeds in the diet

Hominy Feed

Hominy feed is made up of the corn bran, germ, and part of the starchy portion of the corn kernel from degermed corn meal production.

- Roughly equal to ground corn in feeding value
- Very palatable to cattle
- Higher protein levels than corn grains
- Fat content normally 6% or more
- Low fat form has less energy
- Finely ground product suitable for mixing with other feeds
- Can be stored, handled, and fed similarly to ground corn
- Best to use up supplies in one month or less to avoid stale smell

Dried Distillers Grains

Distillers grain is a by-product from the fermentation of grain to produce alcohol (e.g., ethanol).

- Availability generally limited to areas near distilleries and ethanol plants
- Excellent source of protein and energy
- Can be fed as a majority of the total diet
- Drying facilitates storage, transportation, and handling

Soybean Products

Soybean Hulls

Soybean hulls are a by-product of the soybean oil milling process.

- Very palatable and digestible feed
- TDN value varies depends on amount fed and type of diet
- Roughly equal to corn as a supplement at 0.5% of body weight or less on highforage diets
- Decent protein source but can vary widely from load to load
- High fiber content not effective fiber, adequate roughage source also needed
- Can be fed in self-feeders along with hay or pasture
- Conducive to bloat when fed at high levels (over 7 lbs. per day)
- Bulky, dusty, best when pelleted or mixed with silage or molasses to reduce dust
- Good source of calcium but low in phosphorus
- Widely used ingredient in Mississippi beef cattle diets

Soybean Meal

Soybean meal is another by-product of the soybean oil milling process.

- Excellent protein source

Cotton Products

Whole Cottonseed

Whole cottonseed is a major by-product of the cotton ginning process.

- Excellent beef cattle feed, good energy and protein levels
- 2 lbs. cottonseed roughly equal to 1 lb. each of corn and cottonseed meal
- Readily available in cotton-producing areas
- High fat content limits use levels to 25% or less of total dry matter intake
- Feed no more than 5 to 6 lbs. per head per day to mature cattle
- Feed no more than 2 to 3 lbs. per head per day to weaned calves
- Do not feed at more than 20% of the diet for cattle in stocker or finishing programs
- Must be hand fed
- Flow limitations in feeding bins and equipment, difficult to auger or gravity flow

Cottonseed Hulls

Cottonseed hulls are a by-product of the cotton industry.

- Extremely palatable
- High in crude fiber, lowly digestible
- Can be used as the sole roughage source in cattle diets
- Good hay-replacer diet ingredient or alternative to chopped hay in mixed feeds
- Bulky with excellent mixing qualities at low levels in concentrate diets
- Should not exceed 10 to 25% of diet for growing or finishing cattle
- Often expensive

Cottonseed Meal

Cottonseed meal is a by-product of the cottonseed oil milling process.

- Excellent locally available protein source
- Works well in a hot-mix (mixed with salt and offered free-choice)

Cotton Gin Trash

Cotton gin trash is a by-product of the cotton ginning process. Gin trash contains boll residues, leaves, stems, and lint.

- Bulky
- Unpalatable, high fiber, low energy feed
- Inexpensive feed with limited uses
- Practical use is in hay-replacer diets when mixed with other feeds

Cotton Mote

Cotton mote is the cotton extracted by a gin’s lint cleaner during the cotton ginning process.

- High fiber, low energy feed
- Palatability usually not a problem
- Most baled into 4’ x 4’ x 5’ bales
- Can be handled and fed with same equipment used for large round hay bales
- Practical use is in hay-replacer diets with other supplemental feeds

Wheat Products

Wheat

- Should be mixed with other ingredients to reduce acidosis risk
- Feed at no more than 0.5% of animal body weight
- Coarsely cracked or rolled wheat is more digestible than whole grain wheat
- Not commonly used as a feed grain in Mississippi

Wheat Middlings (Midds)

Wheat midds result from the wheat milling process.

- Good energy and protein content
- Available as loose meal or pellets
- Pelleted form cannot be stored for any length of time during hot, humid weather
- Practical use in Mississippi only during winter
- Should be combined with other ingredients to reduce risk of founder and bloat
- Moderately palatable
- Limit to 50% or less of total dry matter intake
- High phosphorus levels relative to calcium levels

Peanut Products

Peanut Hay

Peanut hay is composed of the vines and leaves of peanut plants after the peanuts are harvested.

- Protein content is fair to good
- Energy content is low
- Extremely palatable to cattle
- Highly susceptible to spoilage and losses unless stored under wrap or cover
- Can be used as the primary forage in cattle diets when supplemented properly

Peanut Hulls

Peanut hulls are the by-product of the peanut shelling process.

- Extremely bulky and difficult to handle
- High in fiber, extremely low in energy and protein
- Availability depends upon proximity to shelling plant
- Uses in hay-replacer diets and as an extender in stocker concentrate diets
- Do not use finely ground or pelleted peanut hulls (health risk to cattle)

Peanut Skins

Peanut skins are the result of skin removal from the peanut kernel.

- Very limited potential in beef cattle diets
- Difficult to handle, light, bulky, flow problems, can be blown by wind
- Moderate protein and energy levels
- High tannin levels that reduce protein digestibility and decrease palatability
- Do not use at levels of more than 10% of dietary dry matter

Raw Peanuts

Raw, whole peanuts are typically valued higher for uses other than as cattle feed.

- Very good energy and protein levels
- High fat content limits feeding levels
- Maximum of 4 lbs. per day should be fed to mature cattle
- Must be introduced to cattle gradually
- Check aflatoxin levels before feeding (do not exceed 200 ppb in cattle diets)

Rice Products

Rice Bran

Rice bran is a by-product of the rice milling process.

- Finely ground material, handling and storage in bins difficult, blending with other feeds improves flow
- Moderate protein levels
- High fat content unless defatted, limit to no more than one-third of diet
- Substantially less energy than soybean hulls even with high fat levels
- High fat rice bran less palatable and susceptible to rancidity in warm weather
- High phosphorus content

Rice Millfeed

Rice millfeed is a by-product of the rice milling process.

- Finely ground material
- Combination of rice hull and rice bran
- Often highly variable in composition
- Founder is possible when fed at high levels
- Handling characteristics similar to rice bran
- Typically less expensive and longer storage life than rice bran

Rice Hulls

Rice hulls are a by-product of the rice milling process.

- Extremely low nutritional value in beef cattle diets

Additional By-Product Feeds

Brewers Grains

Brewers grains are a by-product of beer production.

- With wet brewers grains, 75% of product transported is water
- Shelf life is a concern with wet feed
- Should be stored in anaerobic conditions or stacked and fed rapidly
- Good protein content
- Usefulness limited due to high water content

Cane Molasses

Cane molasses is a by-product from sugar manufacture.

- Extremely palatable
- Excellent energy source
- Commonly blended with vitamins and minerals

Citrus Pulp

Citrus pulp is made by shredding, liming, pressing, and drying the peel, pulp, and seed residues from citrus fruit.

- Availability and cost-effectiveness for use in Mississippi is limited
- Good energy supplement
- Very digestible, low protein, high fiber feed
- Excellent feed if acquired, best deals usually in mid-winter
- Should be limited to one-third or less of the diet for growing beef cattle
- Initial palatability problems with calves quickly overcome
- Often pelleted to facilitate transportation
- Darkening toward a black color indicative of overheating

Cow ID:	**Cow Birth Date:**	**Cow Weaning Wt:**

Sire:	**Sire Breed:**	**Dam:**	**Dam Breed:**

Source of Cow:	**Reason for Culling:**	**Culling Date:**

Comments:

Pre-Weaning									**Weaning**						**Cow Status**		
Calf No	Year	Birth Date	Sex	Birth Wt.	Calving Ease Score	Calving Interval	Sire No.	Sire Breed	Wean Date	WW or Selling Wt	205-day Adj Wt	Wt Ratio	Calf Price	Calf Value	Condition Score	Preg Check Date	Preg or Open

Treatment Records

Date	Diagnosis	Product Name	Batch Number	Route/Location of Injection	Dosage	Preslaughter Withdrawal	Administered by:	Comments

Section 6

Grazing Systems, Methods, and Tricks.

Dr. Jennifer Tucker, UGA

2016 Georgia Grazing School:

Grazing systems, methods, and tricks

Dr. Jennifer Tucker
Asst. Prof. and Ext. Specialist

GRAZING SYSTEMS, METHODS, AND TRICKS

Jennifer J. Tucker, Ph.D
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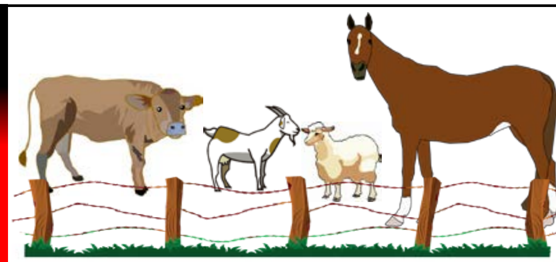
Beef Nutrition and Forage Management
UGA – ADS – Tifton



Fencing + Animals =/= Grazing System

Grazing Management

When **grazing management** occurs through the implementation of **grazing methods** within a **grazing system**, a number of goals and objectives can be achieved successfully!

Grazing Management: Goals

1. Improved grazing efficiency
2. Reduce pasture waste
3. Conserve surplus forage (hay or silage)
4. Increase animal performance
5. Improve forage quality at time of use

Grazing Management: Objectives

1. To manage the pasture and other feed inputs to efficiently produce animal products
2. To effectively managing forage quantity and quality over the grazing season, regardless of grazing method utilized
3. To adjust livestock stocking rates to improve grazing efficiency and animal production per unit of land

System vs Method

Grazing System

- "a defined, integrated ***combination*** of animal, plant, and other environmental components and the grazing method by which the system is managed to **achieve specific results or goals.**"

- Continuous Grazing System
- Management Intensive Grazing (MIG) System
- Ultra-High Density, Long Rest Period, Short Duration Grazing (Mob Grazing)

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System vs Method

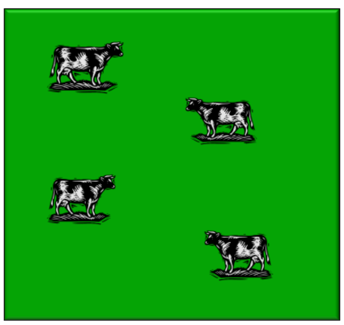
Grazing Method

- "a defined ***procedure or technique*** of grazing management designed to **achieve a specific objective**"

Grazing Methods

- Continuous Stocking
- Rotational Stocking
- Creep Grazing
- Strip Grazing
- Deferred Grazing
- Limit Grazing
- Leader-Follower, First-Last, or Forward Grazing

Continuous Stocking



Continuous Stocking

- Simplest, most commonly used in Southeast
- Animals stocked on single pasture unit for duration of grazing season.
- Can work well with warm season perennials like Bahiagrass and Bermudagrass

Continuous Stocking

- Low input requirement
- Animals are allowed to selectively graze
- Can result in high animal performance of individual animals, but low overall performance of the herd
- Difficult to achieve optimal forage utilization
- May lead to overstocking, overgrazing, and lower forage production
- Least efficient of all Grazing Methods

Efficiencies of Grazing Systems

Grazing System	Efficiency
Continuous Stocking	30-40%

Adapted from D. Hancock UGA

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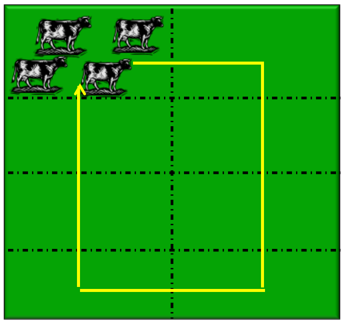
Rotational Stocking



Rotational Stocking

- Grazing system in which the grazing area is divided into several small "paddocks."
- Animals will rapidly graze plants to a desired height before "rotating" to a new paddock

Rotational Stocking

- Greater Input Requirement
- Expected outcome: potential increased uniform utilization of forage species.
- Effective rotational stocking involves focusing on forage quality and utilization
- Improves pasture management skills!

Effect of year-round continuous and rotational stocking of endophyte-free tall fescue and common bermudagrass mixed pastures in the Piedmont of GA

Item	Continuous	Rotational	Difference
Cow weight at calving, lbs	1037	1017	
Cow weight at weaning, lbs	1090	1071	
Stocking rate cow calf units/acre	0.50	0.69	+38%
Pregnancy rate, %	93	95	0
Calf weaning weight, lbs	490	486	0
Total calf gain, lb/ac	243	334	+37%
Hay fed/cow, lb	2430	1680	-31%

- 12 paddocks rotated every 2 days
- Three-year average

Source: Hoveland, McCann and Hill: 1997

Increase in gain per acre in rotational compared to continuous grazing

State	% Increase
Arkansas	44
Georgia	38
Oklahoma	35
Virginia	61

Source: Hoveland, McCann and Hill: 1997

Efficiencies of Grazing Systems

Grazing System	Efficiency
Continuous Stocking	30-40%
Slow Rotation (3-4 paddocks)	50-60%
Moderate Rotation (6-8 paddocks)	60-70%

Adapted from D. Hancock UGA

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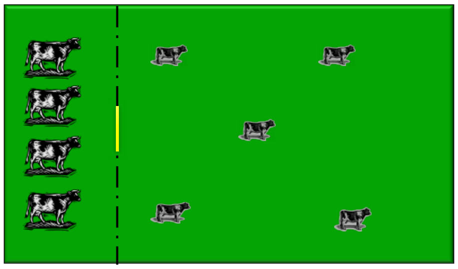
Creep Grazing



Creep Grazing

- Allows young animals with high nutrient requirements access to high quality forages first
- Access to these paddocks provided either underneath electric fence or through a creep opening
- Dams maintained on traditional base forages

Creep Grazing

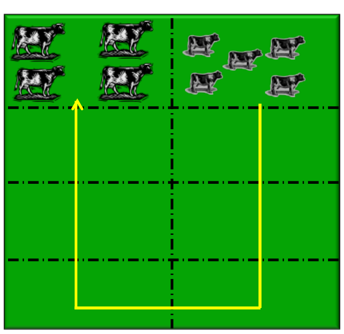
- Excellent potential to improve weaning weights of calves
- Easy to implement into existing systems

Creep Grazing of Beef Calves on pearl millet when cow-calf pairs were maintained on tall fescue pasture in Northern Alabama

	Control	Creep Grazing
	lbs	
Calf weight gain	144	219
Calf Average Daily Gain	1.38	2.10
Cow weight change	-60	+27

Source: Thomas, Eason, Ball and Ruffin; AL Agric. Exp Stn. Highlights, 30:

Leader-Follower



Leader-Follower, First-Last, or Forward Grazing

- Herd is sorted into nutrient requirement groups.
- The higher nutrient requirement group (leader/first) group is rotated through paddocks before the low nutrient group allowing them to select high quality diet to meet growth or production needs.
- The follower group then grazes the lower quality forage

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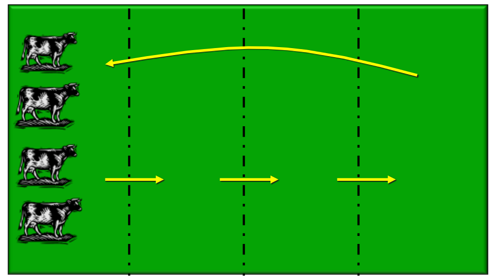
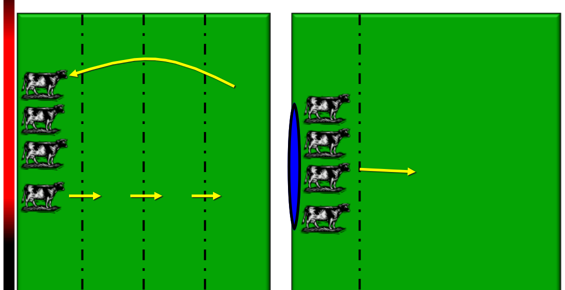
Leader-Follower, First-Last, or Forward Grazing

- Rotation off paddocks allows for rest and regrowth of high quality forage for continued rotational use
- Allows animals which need the highest quality feed (i.e. calves, yearlings, lactating dairy cows, etc) to have first access to a pasture or feed source

Strip Grazing



Stockpiling



Strip-Grazing

Frontal Grazing

Strip Grazing

- Self-descriptive form of Rotational grazing
- Animals are held in small areas (strips) by a temporary electric fence and normally graze a one or two day forage supply
- Once this area is grazed the front fence is moved allowing them access to another small area of forage

Strip Grazing

- Most efficient grazing method for forage utilization
- With low quality forage, average daily gains may be lower due to less selective grazing
- Commonly used with annual grasses
- High labor requirement

Efficiencies of Grazing Systems

Grazing System	Efficiency
Continuous Stocking	30-40%
Slow Rotation (3-4 paddocks)	50-60%
Moderate Rotation (6-8 paddocks)	60-70%
Strip Grazing	70-80%

Adapted from D. Hancock UGA

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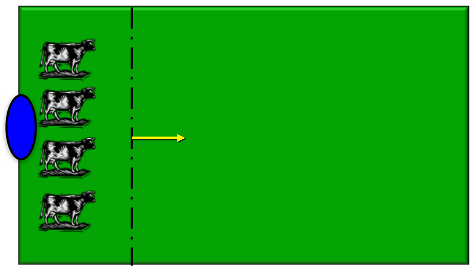
Dr. Jennifer Tucker
Asst. Prof. and Ext. Specialist

Deferred/Frontal Grazing



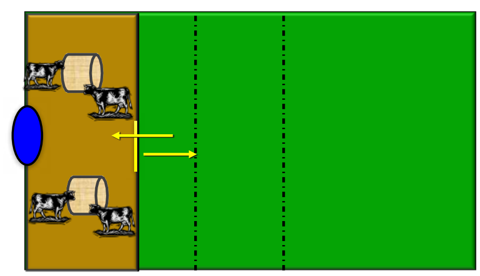
Deferred/Frontal Grazing (Stockpiling)

- Largely underutilized
- Forage production is deferred from grazing until later in the season
- Typically performed in the fall months to reduce hay needs

Deferred/Frontal Grazing

- Most commonly used when stockpiling forage or grazing crop residues
- Much like "strip" grazing, except less of a need for a back fence
- Typically only allow access to enough forage for 2 to 3 days

Limit Grazing



Limit Grazing

- Animals are allowed limited time in a typically higher quality forage paddock, and then removed and returned to a lower quality forage area (pasture and/or hay).
- Typically practiced when animals are grazing a base paddock containing low quality forages (dormant species/low quality hay) and are allowed periodic access to typically higher quality/higher cost pastures (winter or summer annual forages)

Limit Grazing

- This method is extremely effective when animals 'limit graze' a pasture for a few hours per day OR on an 'alternate day' basis – thus helping the animal to balance nutrient requirements
- This method sharply increases the efficiency of utilization of high quality forages

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Rest Period for Forage Species

Forage Species	Cool weather	Hot weather
	Days rest	Days rest
Cool-season grasses Annual ryegrass, tall fescue	10-14	35-50
Warm-season grasses bermudagrass, dallisgrass	35-40	14-21
Legumes clovers, alfalfa	21-28	30-40

Adapted from Southern Forages 5th Edition

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Proper Height and Rest = The Key to Grazing Success

- Most plants are grazed every 2-7 days
- Animals will chose new growth over older more mature, stemmy plants
- With recommended rest periods, roots will redevelop to approximately the same depth as uncut plants.

Continuously Grazed

Rotational Grazing

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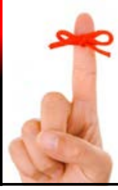
Remember:

There is NO “one size fits all” method for all farms, each method is farm/situation specific.

Several methods may be used on a farm in different pastures or at different times in a given pasture!



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Remember:

- Each operation has unique circumstances that weigh into grazing management decisions
- Carefully consider the individual goals and needs of your operation
- All of the systems require management skills and inputs

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Good **Grazing Management** occurs when you…

Match the **Grazing Method** with:

The Plant
The Animal and
The Producer Needs

To Implement a Successful **Grazing System**!

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Rule of Thumb: Continuous Stocking

A continuously stocked pasture can be just as productive and efficient as any other method provided that available forage is controlled by adjusting stock numbers as needed.

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Rule of Thumb: Rotational Stocking

The more paddocks you have, the shorter the grazing period in each particular paddock!

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Rule of Thumb: Creep Grazing

When using temporary fencing for rotational stocking:
place fence height at level to confine the dams!

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Rule of Thumb: Strip Grazing

Once animals are adapted to the system, they may linger at the fence as forage is grazed down..

A sign to tell you it's time to move them!

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Rule of Thumb: Deferred Grazing/Frontal

Remember to focus on **forage quality**:

accumulated forage that is overly mature is NOT Stockpiling!

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Rule of Thumb: Limit Grazing

Pull animals out when they begin to loaf or lay down and are no longer actively grazing for higher efficiency!

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THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

What is Management-intensive Grazing (MiG) and what can it do for my farm?

Dr. Dennis Hancock
Extension Forage Specialist
University of Georgia

Dr. John Andrae
Extension Forage Specialist
Clemson University

Management-intensive grazing (MiG; sometimes called "rotational grazing") is a topic frequently discussed among forage producers. Many testimonials have been made regarding the benefits of MiG. Some claim that simply implementing a MiG system will allow doubling or even tripling stocking rates and total elimination of fertilizer inputs. These claims rarely are truly realized; however, MiG does offer substantial benefits to forage-based livestock producers. Benefits include improved animal productivity, increased plant persistence, conservation of environmental resources, and improved animal temperament. This article will serve as a general overview of MiG and examples are taken in part from Southern Forages 4th Edition and a large three year grazing study conducted by Drs. Carl Hoveland, Mark McCann, and Nick Hill at the University of Georgia.

What is MiG?

MiG is any grazing method that utilizes repeating periods of grazing and rest among two or more paddocks or pastures. "Rotational grazing" is commonly used as a general term and there are many other terms used by producers and scientists for MiG. A few of these include **rotational grazing, managed grazing, intensive grazing, rational grazing, controlled grazing,** and **rotational stocking**. However, MiG is a preferred description because it places emphasis on the "management" aspects of improved grazing systems.

Several methods of MiG grazing are used, including **rotational stocking, buffer grazing, strip grazing, creep grazing, deferred grazing, limit grazing, first-last grazing, mixed species grazing, sequence grazing,** and **frontal grazing**. Each of these methods will have specific situations where they are best applied. For example, limit grazing is an excellent practice for improving utilization of winter annual forages by mature beef cows, rotational stocking is beneficial when stocker cattle graze winter annuals or paddocks containing clovers, and creep grazing can be used to improve calf weaning weights on bermudagrass pastures. Some grazing methods can be combined for further flexibility. **Deferred grazing** allows the stockpiling of forage (e.g., stockpiled tall fescue or bermudagrass), and this stockpiled forage can be efficiently grazed later in the season using either **frontal** or **strip grazing** systems. More information on these terms can be found in a related factsheet entitled "Common Grazing Methods and Some Specific Farm Applications" (http://www.caes.uga.edu/commodities/fieldcrops/forages/questions/023FAQ-grazmethods.pdf).

For simplicity, further discussion in this article will use the more general term "MiG" since it encompasses all of these improved grazing methods. The principles discussed herein can be applied to each of these grazing methods and the impact they generally have on animal requirements, plant needs, and environmental conditions (drought, muddy soils, stream protection etc.).

Why Should I Implement MiG?

Forages are often inefficiently utilized when pastures are continuously stocked. Many times grazing animals will only utilize 30-40% of the forage in a pasture with the rest refused or wasted. There are many reasons for this waste. The grazing herd, like people, is typically lazy and will heavily graze areas close to shade or water and ignore more distant areas. Animals also prefer young, tender, and leafy portions of forages and refuse stemmy mature material when allowed a choice. When there is an excessive amount of forage present, the grazing animal frequently returns to grazed areas to utilized fresh regrowth and refuse large amounts of previously ungrazed forage because it is too "tough".

Effects on Animal Performance

Many times the benefits of implementing MiG are exaggerated. Claims of doubling or even tripling stocking rate are sometimes made. Don't believe these claims! It is certainly possible to increase stocking rate and decrease hay and fertilizer inputs using MiG. Stocking rate increases of 35-60% have been reported in the scientific literature (Table 1). However, as a general rule, stocking rates should only be increased by 10-25% during the first few years, so as to allow your pastures and forage management skills to improve. In the meantime, any excess forage production can be harvested as hay or mowed and returned to the soil.

Table 1. Increase in gain per acre in rotational compared to continuous grazing.

State	% Increase
Arkansas	44
Georgia	37
Oklahoma	35
Virginia	61

There are situations where MiG is not particularly helpful from an animal performance perspective. Forcing the grazing animal to consume forage to a predetermined height eliminates their ability to select high quality leaves and often reduces individual animal performance (daily gain per head). This is particularly important when animals with high nutrient requirements like stocker cattle or replacement heifers are rotationally grazed on relatively low-quality forages, such as bermudagrass or bahiagrass. Remember that although individual animal performance is reduced, it is possible to increase stocking rate resulting in higher gain per acre. For producers grazing animals with lower nutrient requirements, like mature cows, this can be a great advantage. In a three year study conducted in central Georgia, rotational stocking improved cow-calf stocking rate by about 38% and improved calf production per acre by 37%. Individual cow or calf performance was not affected in this study (Table 2).

Table 2. Effects of rotational stocking on performance of beef cattle grazing bermudagrass and endophyte-free tall fescue in central Georgia.

Item	Continuous	Rotational	Difference*
Cow weight at calving, lbs	1037	1017	NS
Cow weight at weaning, lbs	1090	1071	NS
Stocking rate, cows/acre	0.5	0.69	+38%
Pregnancy rate, %	93	95	NS
Weaning weight, lb	490	486	NS
Calf production, lb/ac	243	334	+37%

* NS = not statistically significant

Effects on Plant Persistence

While increased animal production per acre is often what sells producers on a MiG system, plant performance is also improved. Many plants respond well to short grazing and long rest periods. Rest periods allow plants to produce new leaves which collect energy, transform it into sugars, and store these sugars so that more leaves can be produced following the next grazing cycle. Not only is regrowth potential improved, but root depth and stand life are improved as well.

Practicing controlled grazing also decreases the amount of trampling and pugging (hoof damage) of plants and soils (particularly on wet prepared fields). This can improve productivity and persistence of forages.

Under MiG in the central Georgia study conducted by Hoveland and others, endophyte-free tall fescue productivity and persistence was greatly improved. This resulted in less hay feeding in the rotational stocked system (Table 3). In fact, over the three year grazing study, cattle in the rotationally stocked system required

31% less hay per head. If this hay were priced at $110 per dry ton, an annual average savings of $41.30 per cow would be realized for each of the three years. Reductions in supplement costs and labor for feeding hay would also add to the advantage of MiG.

Table 3. Pounds of winter hay fed per cow as affected by grazing method during three year study. Cows grazed bermudagrass/endophyte-free tall fescue mixture. (From Hoveland. McCann and Hill. 1997).

	1988-1989	1989-1990	1990-1991	3-year Average
Rotational	1310	1480	2240	1680
Continuous	1750	1900	3650	2430
Decrease, %	-25%	-22%	-39%	-31%

MiG systems can also improve legume establishment and persistence. Clover can be broadcast seeded and trampled in by animals grazing small paddocks in late winter. MiG also allows flash grazing of paddocks to prevent small legume seedlings from grass shading. After clovers are established, the improved grazing control allows producers to favor clover regrowth.

Intangible effects

There are many benefits of practicing MiG that are difficult to quantify. Notice that the scope of this article's subtitle "What can it do for my farm?" is much larger than merely animal performance. Two of the most important benefits MiG offers your farm are 1) improved control and 2) improved flexibility.

Control: Cross fencing and water developments in large pastures effectively transfer the grazing decisions from the grazing animal to the farm manager. Before a pasture is cross-fenced, the grazing animals determine 1) where they want to eat, 2) what they want to eat or (more importantly) what they will refuse to eat, 3) how long they will eat, and 4) how often they will return to eat. Once cross-fences are erected the farm manager controls how many animals graze a set amount of acres for a set amount of time. Once available forage has been efficiently utilized, animals are allowed to move to another paddock and cannot return until forage is ready for another grazing.

Flexibility: Producers soon realize that there is no "set" schedule for rotating pastures and that the length of rest and grazing periods will change with weather and forage growth rate. This added flexibility is an often overlooked advantage to practicing MiG. Paddocks can be removed from the rotation for overseeding or complete stand renovation. Individual paddocks can also be skipped during times of rapid growth and stockpiled for later grazing or hay harvest. Low-lying paddocks with drainage problems can be left ungrazed during wet periods to minimize trampling injury and improve stand productivity and longevity.

Summary

Practicing MiG offers many advantages for most producers. Less forage is wasted by animals, which normally allows stocking density to increase. MiG systems also improve the persistence of some forage species and can greatly decrease hay requirements when managed appropriately. Recent fencing and watering equipment developments have made grazing systems easier and cheaper to implement. These advances have "opened the door" for many producers to adopt improved grazing management practices. Other reasons for implementing grazing systems include improved nutrient distribution and environmental stewardship. Animal handling is also usually improved with MiG systems. Frequent movement and exposure to people usually improves animal temperament. This frequent exposure also allows the farm manager to detect diseases or other problems quicker so that they can be treated in a timely manner.

AGRONOMY AND SOILS SERIES

TIMELY INFORMATION

Agriculture & Natural Resources

F 2014-5 **Sept. 2014**

A Quick Guide to Grazing Methods

Jennifer M. Johnson, Ph.D, Extension Agronomist, Alabama Cooperative Extension System
Kim Mullenix, Ph.D, Extension Beef Systems Specialist, Alabama Cooperative Extension System

Grazing System – "any integrated combination of animal, plant, and other environmental components and the ***grazing method*** by which the system is managed to meet specific results or goals"

Grazing Method – "a defined procedure or technique of grazing management designed to achieve a specific objective.

There's no "one size fits all" method for all farms, each method is farm/situation specific. Several methods may be used on a farm in different pastures or a different time in a given pasture.

Grazing Management – Goals and Objectives:

When grazing management occurs through the implementation of grazing methods within a grazing system a number of goals and objectives can be achieved successfully.

Goals:

1. Improved Grazing Efficiency
2. Reduce Pasture Waste
3. Conserve Surplus Forage (hay, silage)
4. Increased Animal Performance
5. Improved Forage Quality at time of use

Objectives:

1. To manage the pasture and other feed inputs to efficiently produce animal products.
2. To effectively manage ***forage quantity*** and ***quality*** over the grazing season, regardless of grazing method utilized.
3. To adjusting livestock stocking rates to improve grazing efficiency and animal production per unit of land

Grazing Efficiency is an Effect of Management

Grazing Method	Estimated Typical Efficiency
Continuous Stocking	**30-40%**
Slow Rotation (3-4 paddocks)	**50-60%**
Moderate Rotation (6-8 paddocks)	**60-70%**
Strip Grazing	**70-80%**

Grazing Management Good Rules of Thumb:

- There is no "one size fits all" grazing method
- Each operation has unique circumstances that weigh into grazing management decisions
- Carefully consider the individual goals and needs of your operation
- *All* of the systems require management skills and inputs

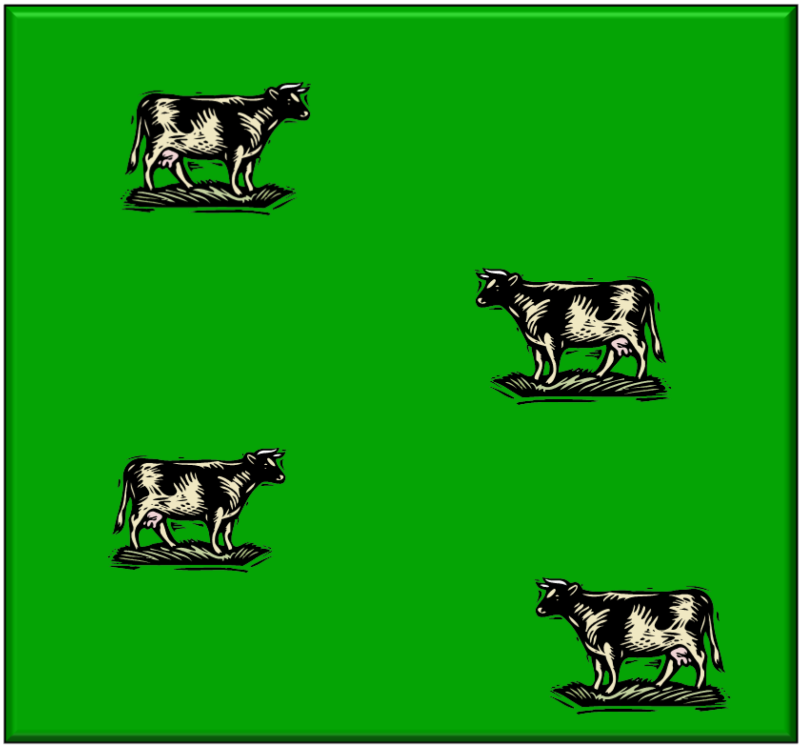
Match the Grazing Method with:

The Plant, The Animal, and the Producer Needs

To Implement a Successful Grazing System!

Prepared by: Jennifer M. Johnson, Ph.D, Extension Agronomist and Kim Mullenix, Ph.D, Extension Beef Systems Specialist, Alabama Cooperative Extension System

Continuous stocking



Pros and Cons

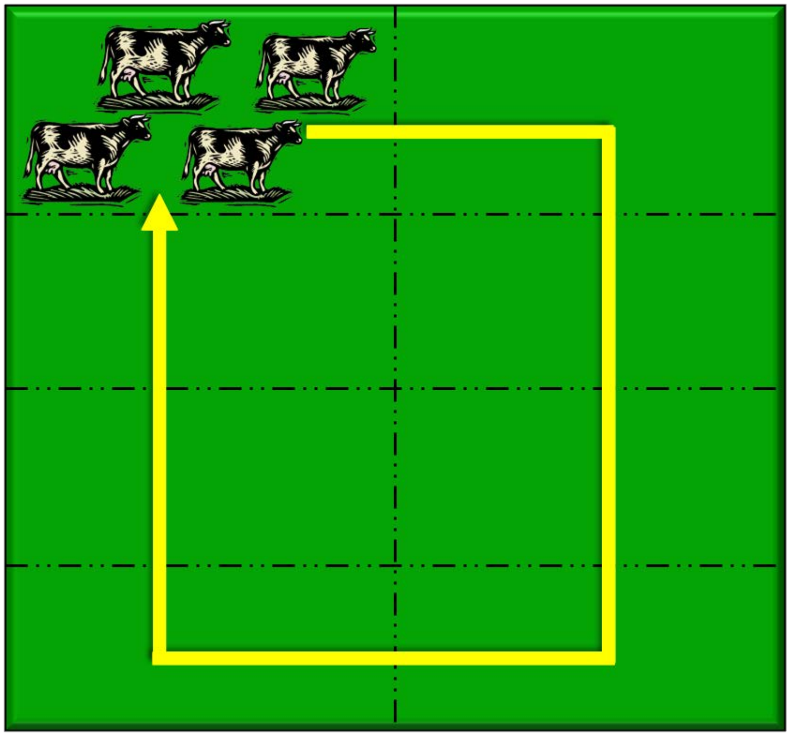
- Simple, most commonly used in Alabama
- Animals stocked on single pasture unit for the duration of grazing season.
- Animals are allowed to selectively graze
- Can result in high animal performance of individual animals, but low overall performance of herd
- May to lead to overstocking, overgrazing, and lower forage production
- Least efficient of all grazing methods

Level of Labor: Low

Good Rule of Thumb: A continuously stocked pasture can be just as productive and efficient as any other method provided that available forage is controlled by adjusting stock numbers as needed.

Prepared by: Jennifer M. Johnson, Ph.D, Extension Agronomist and Kim Mullenix, Ph.D, Extension Beef Systems Specialist, Alabama Cooperative Extension System

Rotational stocking



Pros and Cons

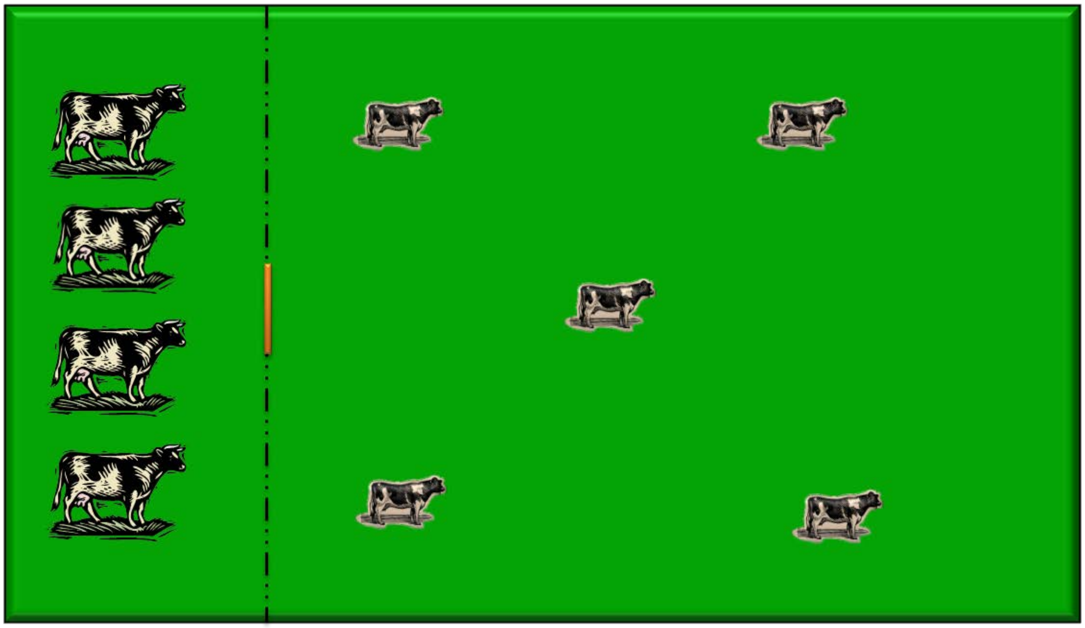
- A grazing method in which the grazed area is divided into a given number of smaller paddocks.
- Animals will graze plants to a desired height before "rotating" to a new paddock
- Expected outcome: potential increased uniform utilization of forage species compared to continuous stocking
- Rotations can occur anytime but are typically between 1 and 15 days during active forage growth
- There are no specifications for the number of paddocks required – alternating between 2 paddocks is still rotational stocking.
- Effective rotational stocking involves focusing on forage quality and utilization

Level of Labor: Ranges from low to high depending on the number of paddocks

Good Rule of Thumb: The more paddocks you have, the shorter the grazing period in each particular paddock.

Prepared by: Jennifer M. Johnson, Ph.D, Extension Agronomist and Kim Mullenix, Ph.D, Extension Beef Systems Specialist, Alabama Cooperative Extension System

Creep Grazing



Pros and Cons

- Allows young animals with high nutrient requirements access to higher quality forages first
- Access to these paddocks provided either underneath electric fence or through a creep opening
- Dams maintained on traditional base forages
- Excellent potential to improve weaning weights of calves in Alabama

Level of Labor: Low to Medium

Good Rule of Thumb: When using temporary fencing for rotational stocking, place fence height at level to confine dams.

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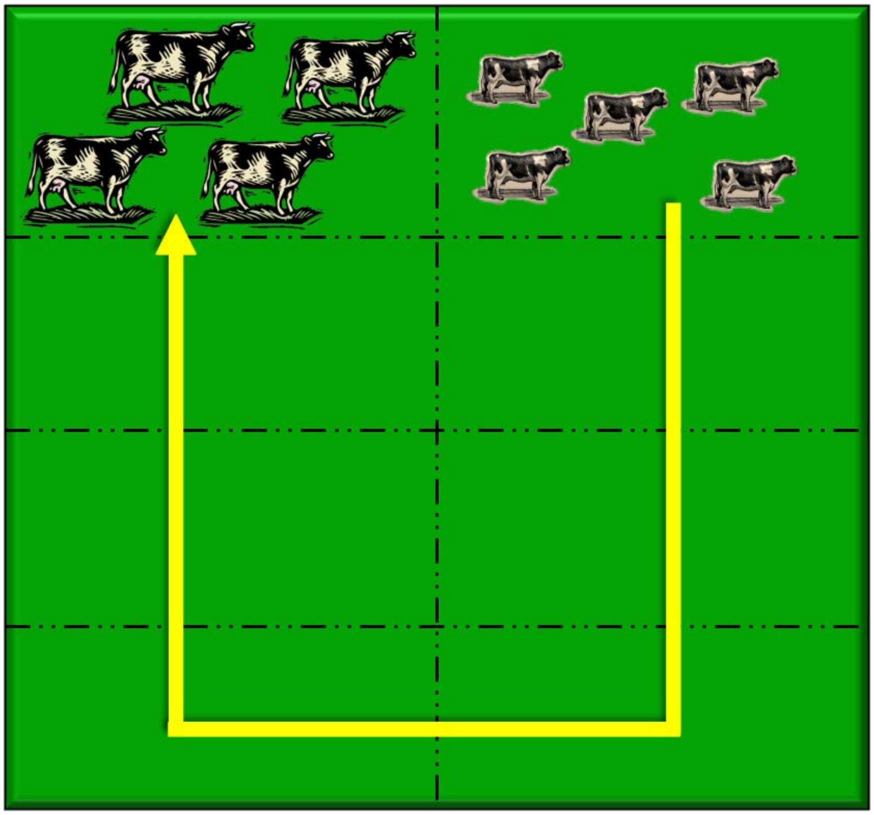
Leader-Follower/ First-Last Grazing



Pros and Cons

- Herd is sorted into nutrient requirement groups.
- The higher nutrient requirement group (leader/first) is rotated through paddocks before the low nutrient group, allowing them to select high quality forage to meet growth or production needs.
- The follower group then grazes the remaining lower quality forage and rotation off paddock allows for rest and regrowth for continued rotation
- Allows animals which need the highest quality feed (i.e. calves, yearlings, lactating dairy cows, etc.) to have first access to a pasture or feed source

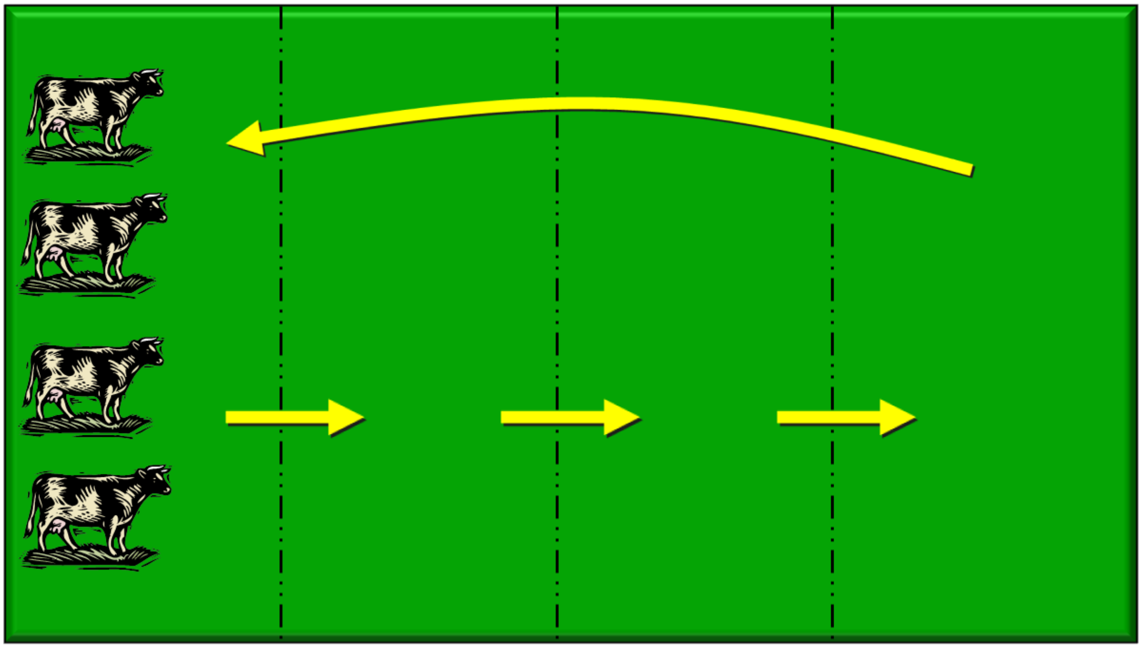
Level of Labor: Medium

Good Rule of Thumb: In Stocker and Dairy Operations.

Stocker: Growing calves grazing in-front of cow/calf pairs.

Dairy: Usually two or three groups (Lactating cows lead, calves and dry cows follow).

Strip Stocking (Strip Grazing)



Pros and Cons

- Self-descriptive form of rotational stocking
- Animals are held in small areas (strips) by a temporary electric fence and normally graze a one or two day forage supply
- Once this area is grazed, the front fence is moved allowing them access to another small area of forage
- Back-wire may or may not be used in this situation to limit access to previously grazed area and allow for regrowth?
- Most efficient grazing method for forage utilization
- With low quality forage average daily gains may be lower due to less selective grazing

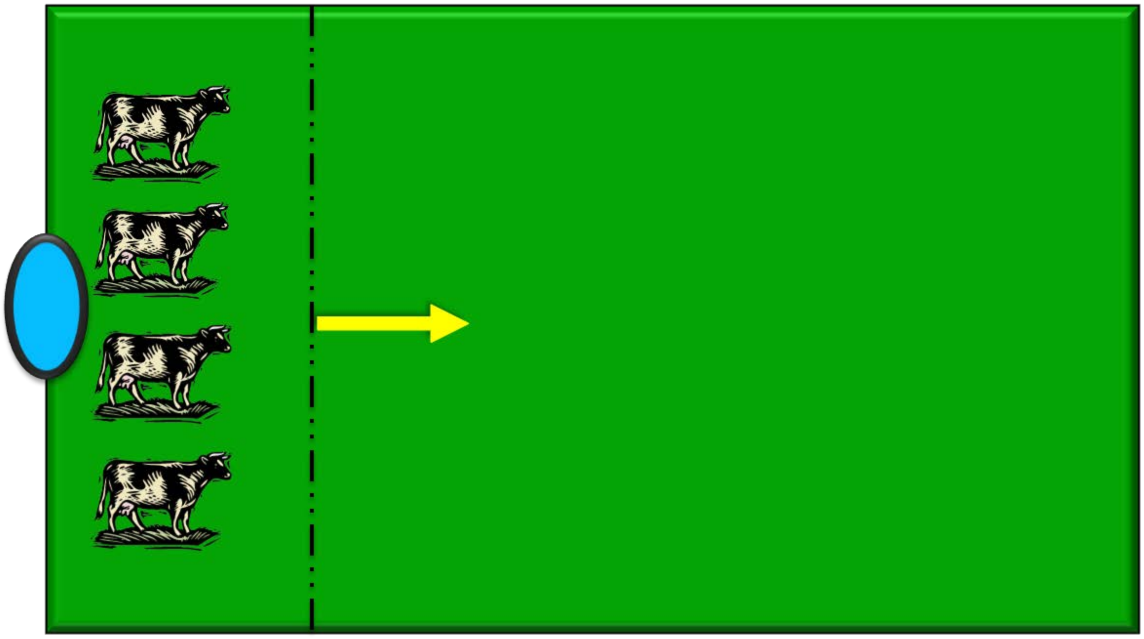
Common Forages Used: Annual Grasses

Level of Labor required: Medium to High

Good Rule of Thumb: Once animals are adapted to the system, they may linger at the fence as forage is grazed down…a sign to tell you it's time to move them!

Prepared by: Jennifer M. Johnson, Ph.D, Extension Agronomist and Kim Mullenix, Ph.D, Extension Beef Systems Specialist, Alabama Cooperative Extension System

Forward/Frontal Grazing



Pros and Cons

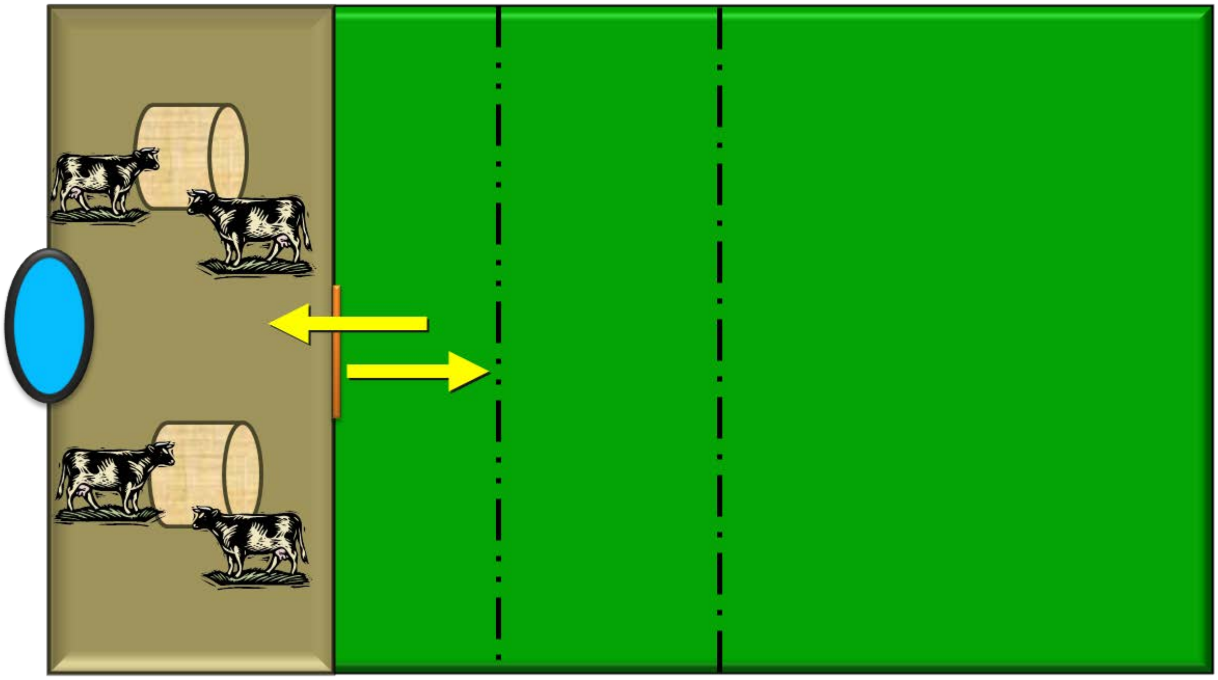
- Most commonly used when stockpiling forage or grazing crop residues
  - Stockpiling: Deferred use of a forage until a later time when available forage is often limited (i.e. Late Fall/Winter)
- Much like "Strip" grazing, except forage is often in a dormant stage therefore no need to limit access to previously grazed area
- Allow access to area closest to available water first, and then move fence away from water as forage is grazed down to a given level
- Typically only allow access to enough forage to sustain the herd for 2 to 3 days

Common Forages Used: Tall Fescue, Bermudagrass

Level of Labor required: Medium

Good Rule of Thumb: Remember to focus on forage quality – accumulated forage that is overly mature is NOT stockpiling – Stockpiling typically occurs 4 to 6 weeks before first anticipated killing frost which induces dormancy of many perennial species.

Limit Grazing



Pros and Cons

- Animals are allowed limited time in a typically higher quality forage paddock, and then removed and returned to a lower quality forage area (pasture and/or hay)
- Typically practiced when animals are grazing a base paddock containing low quality forages (dormant species/low quality hay)
- Animals are allowed periodic access to a high quality (usually higher cost) pasture.
    - Representative of winter or summer annual forages
    - May have greater associated annual costs of establishment and typically higher levels of forage quality than perennial forage options
- This method is extremely effective when animals 'limit graze' a pasture for a few hours per day OR on an 'alternate day' basis – thus helping the animal to balance nutrient requirements.
- This method sharply increases the efficiency of utilization of high quality forages.

Common Forages Used: Winter Annuals, Summer Annuals

Level of Labor required: High

Good Rule of Thumb: Pull animals out when they begin to loaf or lay down and are no longer actively grazing for higher efficiency.

Section 7

Optimizing the Size, Number, and Layout of Your Paddocks

Dr. Dennis Hancock, UGA

2016 Georgia Grazing School:

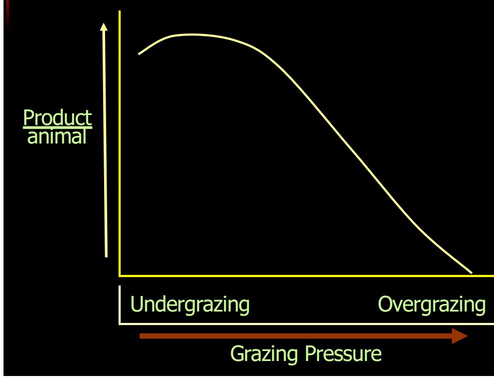
Optimizing the size, number, and layout of your paddocks

Dr. Dennis Hancock
Assoc. Prof. & Forage Ext. Specialist

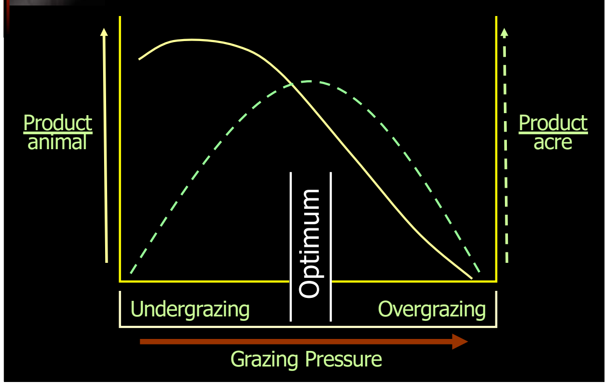
Optimizing the size, number, and layout of your paddocks

Dr. Dennis Hancock,
Extension Forage Specialist
UGA – Dept. of Crop and Soil Sciences

Productivity Per Animal vs. Per Acre



Productivity Per Animal vs. Per Acre



Basic Grazing Numbers

Forage Need
- Animal Data
  - Animal Weight (lbs)
  - Rate of Dry Matter Intake (DMI, %)
  - Head

Logistics
- Grazing Data
  - Rest Period (d)
  - Days in a Given Paddock (d)
  - Number of Paddocks
  - Grazing Efficiency (%)
  - Paddock Size (acres)

Available Forage
- Production Data
  - Acres Available (acres)
  - Available Forage$_{before}$ (lbs/acre)
  - Available Forage$_{after}$
  - Available Forage$_{diff}$
  - Stocking Rate
  - Stocking Density

Basic Grazing Numbers

Forage Need
- Animal Data
  - Animal Weight (lbs)
  - Rate of Dry Matter Intake (DMI, %)
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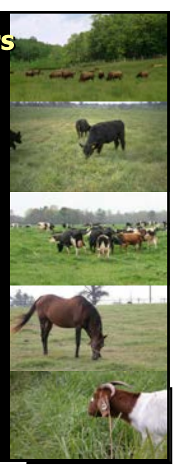
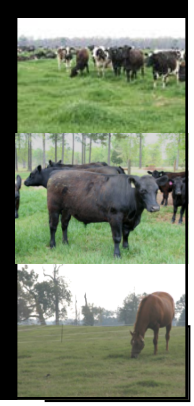


Estimating Forage Need

By % of body weight (Table Data):

Animal Class	Forage Intake Range (DM as a % of b.w.)
Dairy cow	2.0 - 4.0
Dairy heifer	2.2 - 2.8
Bull	1.5 - 1.9
Beef, cow (dry)	1.7 - 2.0
Beef, cow (late gest.)	1.8 - 2.1
Beef, cow (early lact.)	1.9 - 2.4
Beef, stocker (steer)	2.4 - 3.2
Beef, stocker (heifer)	2.2 - 2.6
Beef, finishing	2.3 - 2.5
Beef, replacement heifers	2.0 - 2.4
Sheep, ewes (dry)	1.5 - 2.0
Sheep, ewes (late gest.)	2.2 - 3.2
Sheep, ewes (early lact.)	3.0 - 4.8
Horse, Mature (maint.)	1.0 - 2.0
Horse, Mature (late gest.)	1.0 - 2.0
Horse, Mature (early lact.)	1.3 - 2.6
Horse, Weanling (< 600 lbs)	2.3 - 2.8
Horse, Yearling (600-1000 lbs)	2.0 - 2.3
Goat, nanny (dry)	1.5 - 2.0
Goat, nanny (late gest.)	2.2 - 3.2
Goat, nanny (early lact.)	2.8 - 4.8



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Estimating Forage Need

By % of body weight (Table Data):

Animal Class	Forage Intake Range (DM as a % of b.w.)
Dairy cow	2.0 - 4.0
Dairy heifer	2.2 - 2.8
Bull	1.5 - 1.9
→ Beef, cow (dry)	1.7 - 2.0
Beef, cow (late gest.)	1.8 - 2.1
Beef, cow (early lact.)	1.9 - 2.4
Beef, stocker (steer)	2.4 - 3.2
Beef, stocker (heifer)	2.2 - 2.6
Beef, finishing	2.3 - 2.5
Beef, replacement heifers	2.0 - 2.4
Sheep, ewes (dry)	1.5 - 2.0
Sheep, ewes (late gest.)	2.2 - 3.2
Sheep, ewes (early lact.)	3.0 - 4.8
Horse, Mature (maint.)	1.0 - 2.0
Horse, Mature (late gest.)	1.0 - 2.0
Horse, Mature (early lact.)	1.3 - 2.6
Horse, Weanling (< 600 lbs)	2.3 - 2.8
Horse, Yearling (600-1000 lbs)	2.0 - 2.3
Goat, nanny (dry)	1.5 - 2.0
Goat, nanny (late gest.)	2.2 - 3.2
Goat, nanny (early lact.)	2.8 - 4.8

Estimating Forage Need

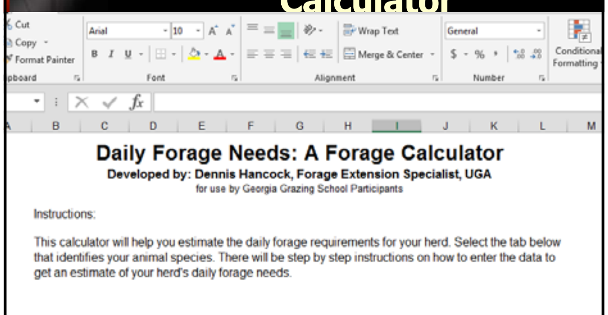
By % of body weight (Table Data):

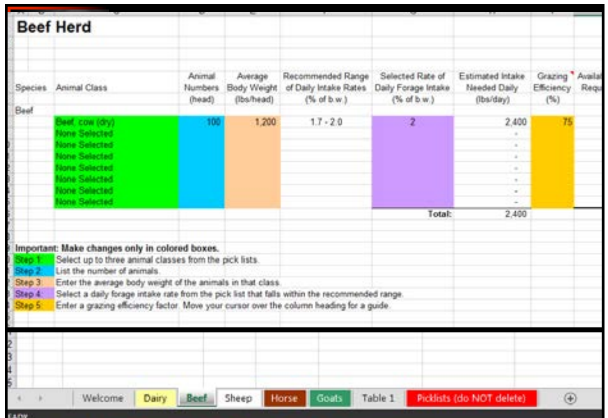
Animal Class	Forage Intake Range (DM as a % of b.w.)
→ Beef, cow (dry)	1.7 - 2.0

2400 lbs/d= 1200 lb cow x 2.0%/hd/d x 100 hd

Daily Forage Need - Calculator

Daily Forage Need Calculator





Basic Grazing Numbers

Forage Need
- Animal Data
  - Animal Weight (lbs)
  - Rate of Dry Matter Intake (DMI, %)
  - Head

Logistics
- Grazing Data
  - Rest Period (d)
  - Days in a Given Paddock (d)
  - Number of Paddocks
  - Grazing Efficiency (%)
  - Paddock Size (acres)

Available Forage
- Production Data
  - Acres Available (acres)
  - Available Forage$_{before}$ (lbs/acre)
  - Available Forage$_{after}$
  - Available Forage$_{diff}$
  - Stocking Rate
  - Stocking Density

Grazing Rules of Thumb

Crop	Target Height (inches) Begin Grazing	End Grazing*	Recommended Rest Period (days)
Alfalfa (grazing types)	10-16	2-4	15-30
Annual Ryegrass	6-12	3-4	7-25
Bahiagrass	6-10	1-2	10-20
Bermudagrass	6-12	2-6	10-20
Clover, White	6-8	1-3	7-15
Clovers, Other	8-10	3-5	10-20
Orchardgrass	8-12	3-6	15-30
Pearl millet	20-24	8-12	10-20
Small grains	8-12	4	7-30
Sorghum/sudan	20-24	8-12	10-20
Switchgrass	18-22	8-12	30-45
Tall Fescue	4-8	2-3	15-30

* Height at end of grazing may need to be higher to optimize intake of quality forage or vigorous re-growth.

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Optimizing the size, number, and layout of your paddocks

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Assoc. Prof. & Forage Ext. Specialist

Paddock Number

How many paddocks should I use?

- Ideally, one should first consider the needs of the grass.
  - How much rest period is needed?
  - How long should I keep them in a paddock?
    - i.e., how many days between rotations?

$$\text{Number of Paddocks} = \frac{\text{Days of Rest}}{\text{Days of Grazing}} + 1$$

$$\text{9 Paddocks} = \frac{\text{24 days of rest}}{\text{3 days of grazing}} + 1$$

Tall Fescue 24 days rest 3 days grazing

Paddock Size

How big should my paddocks be?

- This is where it all comes together…
  - In the meantime, let's refresh our memory on grazing efficiency.

$$\text{Paddock Size} = \frac{\text{Animal Weight x \%DMI x Head x Days in Paddock}}{\text{Available Forage}_{\text{diff}} \text{ x Grazing Efficiency \%}}$$

Efficiencies of Grazing and Mechanized Harvest

Method	Efficiency
Grazing	
Continuous Stocking	30-40%
Slow Rotation (3-4 paddocks)	50-60%
Moderate Rotation (6-8 paddocks)	60-70%
Strip Grazing, Daily Rotation	70-80%
Mechanical	
Hay	30-70%
Silage	60-85%
Green Chop	70-95%

Paddock Size

How big should my paddocks be?

- This is where it all comes together…

$$\text{Paddock Size} = \frac{\text{Animal Weight x \%DMI x Head x Days in Paddock}}{\text{Available Forage}_{\text{diff}} \text{ x Grazing Efficiency \%}}$$

- 100 head herd
- 500 lb heifers with 3% daily forage intake
- 4 day grazing in paddock
- 2000 lb available forage per acre
- Grazing efficiency of 60%

Paddock Size

$$\text{Paddock Size} = \frac{\text{500 lb x 3 \% DMI x 100 Head x 4 Days in Paddock}}{\text{2000 lb per acre x 60\%}}$$

$$\text{Paddock Size} = \text{5 acres}$$

- 100 head herd
- 500 lb heifers with 3% daily forage intake
- 4 day grazing in paddock
- 2000 lb available forage per acre
- Grazing efficiency of 60%

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Basic Grazing Numbers

Forage Need

- Animal Data
  - Animal Weight (lbs)
  - Rate of Dry Matter Intake (DMI, %)
  - Head

Logistics

- Grazing Data
  - Rest Period (d)
  - Days in a Given Paddock (d)
  - Number of Paddocks
  - Grazing Efficiency (%)
  - Paddock Size (acres)

Available Forage

- Production Data
  - Acres Available (acres)
  - Available Forage$_{before}$ (lbs/acre)
  - Available Forage$_{after}$
  - Available Forage$_{diff}$
  - Stocking Rate
  - Stocking Density

The Primary Calculations

$$\text{Available Acres} = \text{Paddock Size} \times \text{Number of Paddocks}$$

$$\text{Paddock Size} = \frac{\text{Animal Weight} \times \text{\%DMI} \times \text{Head} \times \text{Days in Paddock}}{\text{Available Forage}_{diff} \times \text{Grazing Efficiency \%}}$$

$$\text{Number of Paddocks} = \frac{\text{Days of Rest}}{\text{Days in Paddock}} + 1$$

Grazier's Arithmetic: A Grazing Calculator

Grazing Calculator

Grazier's Arithmetic: A Grazing Calculator (ver. 1.0)
Developed by: Dennis Hancock, Forage Extension Specialist, UGA

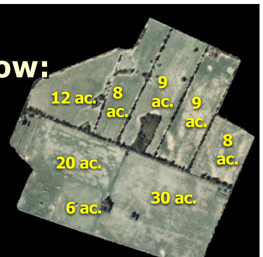
Instructions:

Have a question about grazing arithmetic? Select a question and click on the link to the right to calculate the answer. Once on the calculation page, enter or alter the numbers that are blue in the "To answer this, you need to know" section.

Questions:	
How many head can I carry?	Click Here
How many acres do I need for the number of animals that I have?	Click Here
What should the rest period be?	Click Here
How many days should I leave the animals in the paddock before I rotate them?	Click Here
What should I use as a target level for the residual forage (in dry lbs/acre)?	Click Here

1	How many head can I carry?		
2			
3	To answer this, you need to know:		
4	Animal Data		
5		Animal Weight	1200
6		Rate of Dry Matter Intake (DMI, %)	2.0%
7			
8			
9	Grazing Data		
10		Rest Period	24
11		Days in a Given Paddock	2
12		Grazing Efficiency	70%
13		Number of Paddocks	10
14			
15			
16	Production Data		
17		Acres Available	200
18		Available Forage$_{before}$	3000
19		Available Forage$_{after}$	1500
20		Available Forage$_{diff}$	1500
21			
22	Answer		
23		Head	336.5385
24		Ideal Paddock Size	15.38462
25			
26		Stocking Rate	1.682692
27		Stocking Density	21.875
28			
29		Return to Question Page	
30			
31			

Convinced? Then, here's how:



- Do a pasture inventory.
  - Acreage, water, soil fertility…
- Seek advice.
- Identify cost-assistance.
- Sketch out the "ideal."
- Develop a phase-in plan.
- Use training wheels.
  - Temporary: Learning/Laborious
  - Permanent: Convenient/Fixed
- Build in flexibility.

Resources

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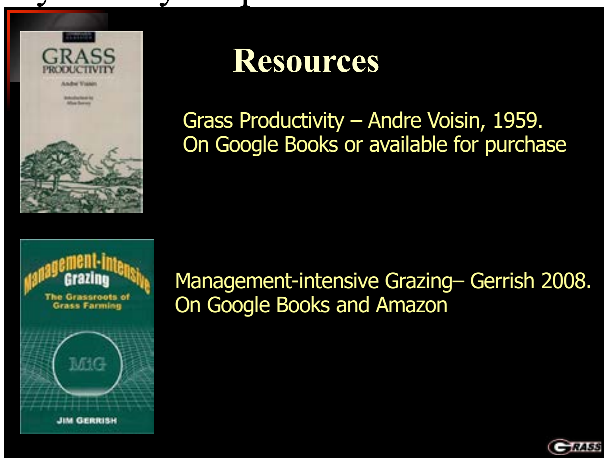
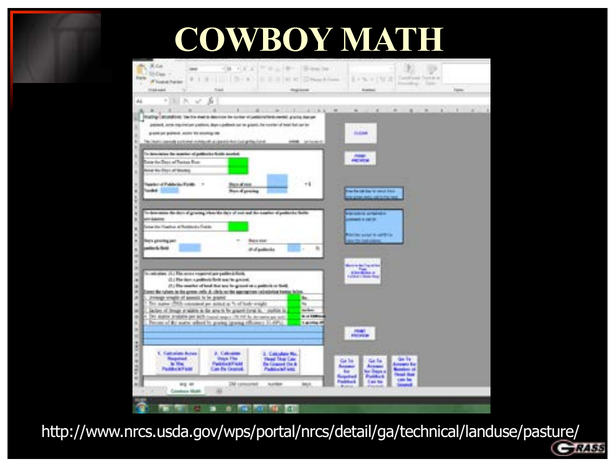




Section 8

Managing Forage Surplus and Deficits

Dr. Jennifer Tucker, UGA

2016 Georgia Grazing School:
Managing forage surplus and deficits

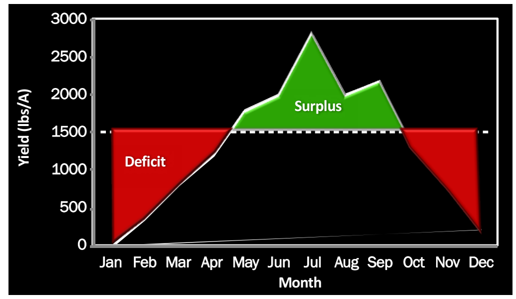
Dr. Jennifer Tucker
Asst. Prof. and Ext. Specialist

MANAGING FORAGE SURPLUS AND DEFICIT

Jennifer J. Tucker
Assistant Professor/Extension Specialist
Beef Nutrition and Forage Management
UGA – ADS – Tifton

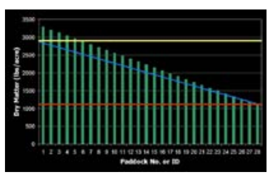
Dennis Hancock
Extension Forage Specialist
UGA- Crop and Soil Sciences

Yield and Distribution of Tall Fescue Complemented with Bermudagrass in Athens, GA



Reasons for Surplus Forages:

- Time of Year
- Rapid Forage Growth
- Low Stocking Density
- Selective Grazing



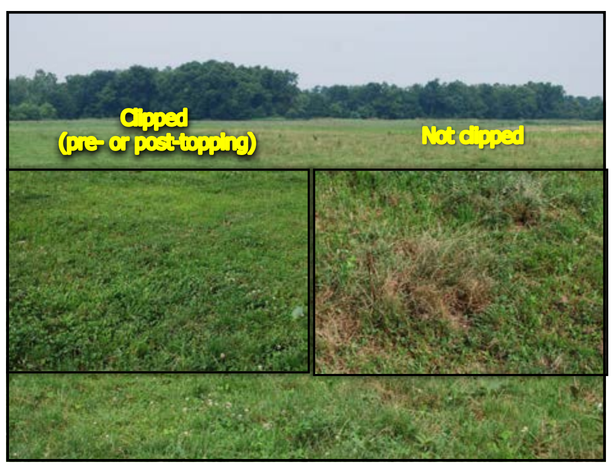
How do we deal with "Too Much Forage"?

- Do Nothing, Let it stay
  - Interference with Growth?
  - Lower Forage Quality
- Mow to a Uniform Height
  - Pre-top (prior to grazing)
  - Post-top (after grazing)
  - Dealing with residual
- Mow and Remove
  - Hay
  - Baled Silage
  - Nutrient Removal

Maturity Matters

Crop	Maturity	CP	TDN	NDF	ADF
Bermudagrass					
	4 weeks old	10-12	52-58	33-38	63-68
	8 weeks old	6-8	45-50	40-45	70-75
Tall Fescue					
	Vegetative – Boot	12-16	61-66	30-36	50-56
	Boot – Head	8-12	56-61	36-42	56-62
Ryegrass					
	Vegetative – Boot	12-16	63-68	27-33	47-53
	Boot – Head	8-12	59-63	33-39	53-59
Alfalfa					
	Bud	22-26	64-67	28-32	38-47
	Early Flower	18-22	64-64	32-36	42-50
	Mid Bloom	14-18	58-61	36-40	46-55
	Full Bloom	9-13	50-57	41-43	56-60

Source: Adapted from J.C. Henning and G.D. Lacefield, University of Kentucky



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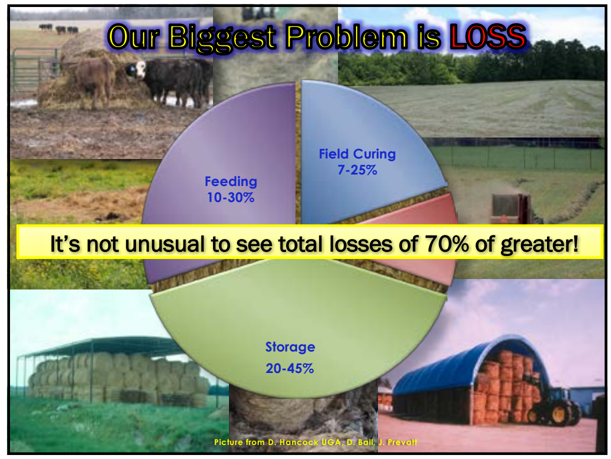

Efficiencies of Grazing and Mechanized Harvest

System	Efficiency
Grazing	
Continuous Stocking	30-40%
Slow Rotation (3-4 paddocks)	50-60%
Moderate Rotation (6-8 paddocks)	60-70%
Strip Grazing	70-80%
Mechanical	
Hay	30-70%
Silage	60-85%
Green Chop	70-95%

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HAY PRODUCTION

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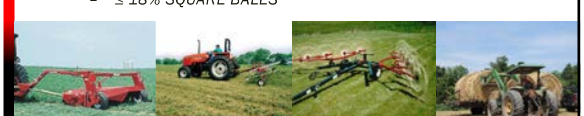
- Cut forage to maximize drying time
- Cut at appropriate height
- Allow swatch to be spread wide to maximize drying rate
- Ted the forage morning of next day(s)
  - *Discontinue the use of tedder when leaf shatter is occurring (~ 10 a.m.)*
- Bale at target moisture
  - *≤ 15% ROUND BALES*
  - *≤ 18% SQUARE BALES*



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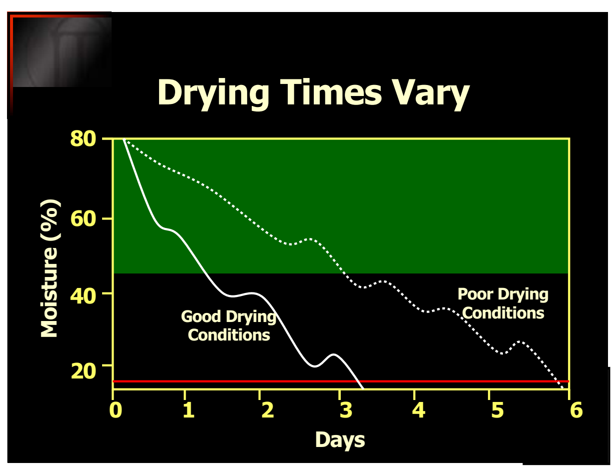

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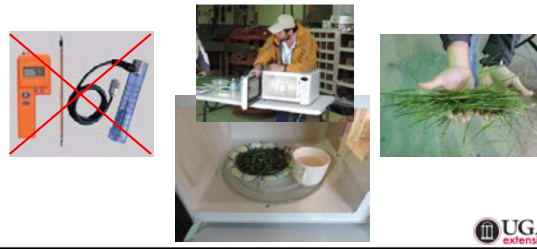
Don't Regret Baling Too Wet!

https://c2.staticflickr.com/8/7416/10893799664_b4cec52a19_b.jpg

Determining Moisture Levels

Methods:

- × Hay Moisture Testers/Probes
- ○ By Feel (if Calibrated)
- √ Microwave Moisture Test

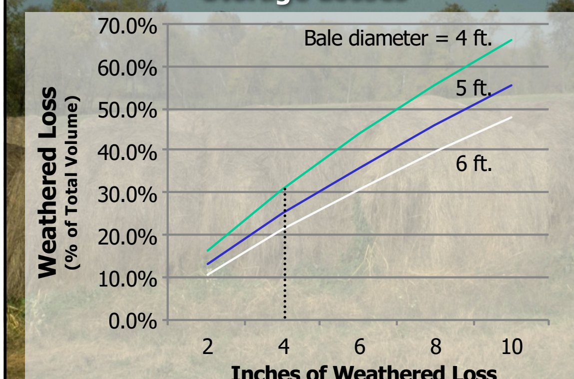


The True Cost of Storage and Feeding Losses

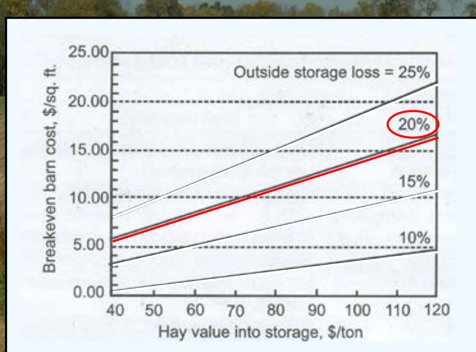
About 3 billion dollars of hay is lost per year from storage and feeding in the U.S.

(37.5 million tons)

Storage Losses



Can I afford to build a barn?



Source: Forage Crop Pocket Guide

Other Storage Options

- Elevated Stacks
- Tarped Stacks
- Hay Sheds
- Hoop Structures

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Effect of various storage methods on hay losses and animal refusal

Storage Method	% Losses	
	Handling and Storage	Animal Refusal
On the ground	43	66
On gravel	32	49
On tires	37	43
On a wooden rack	31	38
-- with plastic cover	12	14
In a pole barn	2	3

Source: Southern Forages 4th edition

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Feeding Losses

Feeding System	Associated Feeding Losses
On the ground – no feeding method	up to 50%
Elevated Hay Wagon	10-20%
Confined in Ring or Cone Type Feeder	Below 10%

Source: Ball et al., 2007 Pictures from University of Kentucky, J. Prevatt AU

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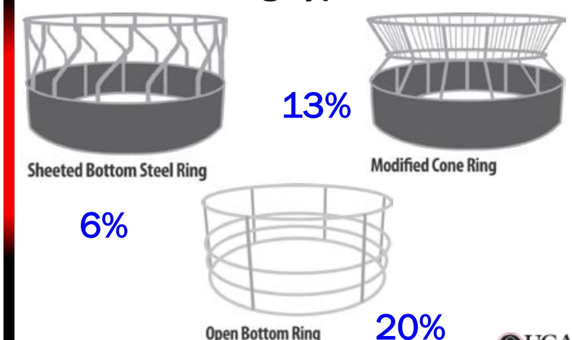
Feeding Methods Ring-Types



Source: The Noble Foundation
Slide Courtesy of: K. Mullenix, AU

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BALED SILAGE

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Advantages:

Improved
- Harvesting efficiency
- Forage quality
- Storage

Decreased
- Curing time (from cutting to baling)
- Mechanical handling reduces leaf loss
- Weather effect

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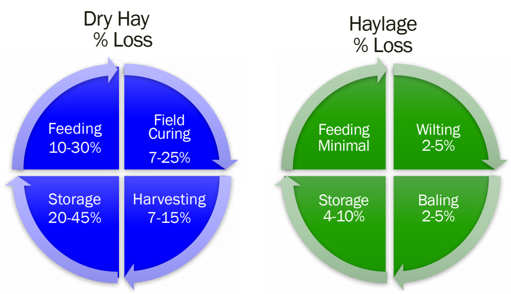
Efficiency



Can be more efficient

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Disadvantages

- Cost of materials
- Spoilage potential
- Transportation and Feeding
- Plastic Disposal
- Potential for 'Operator Error'

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Haylage & Forage Quality

Eliminates weather factor	• Easier to maintain timely harvest schedule • Lowers risk of rain damage
Reduces Leaf Loss to Shatter	• More leaves = better quality
Higher Forage Quality Parameters	• Lower NDF, ADF, ADL • Higher CP • Increased Digestibility • Increased Palatability

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Moisture is KEY!

Just a few percentage points up or down could ruin your stored forage!

Too Wet

- Reduces feed quality
- Reduces the amount of dry matter per bag
- Greatly increases storage costs
- Potential for spoilage and toxicosis

Too Dry

- Reduces fermentation
- Increases leaf and nutrient loss
- Increase mold production
- Greatly increases storage losses

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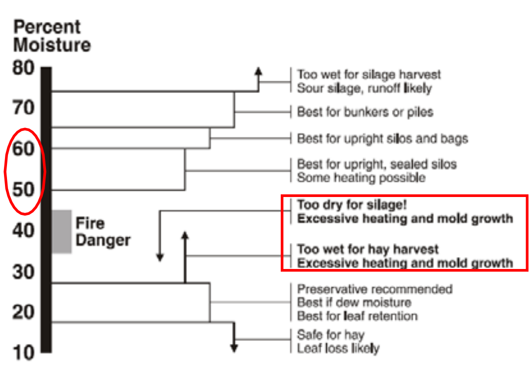

Figure 2. Moisture management guide for preserving forages as silage or hay.

J.W. Schroeder, Extension Dairy Specialist, "Haylage and Other Fermented Forages" NDSU

Bale at the Right Moisture

Ideal Range, 50-65% Moisture

Potential for Spoilage or Toxicosis (Clostridial, Listeriosis)	70% ← Moisture → 40%	Poor Fermentation

Rule of thumb:
bale when the forage is no longer wet enough to wring juice out of a handful.

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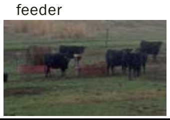
Feeding

Individually Wrapped
- Best to feed a sufficient numbers of animals that will consume the bale within one to two days

In-line (tube) wrapped
- Open the tube to remove the bale and reseal the tube – this can minimize significant spoilage for up to two weeks

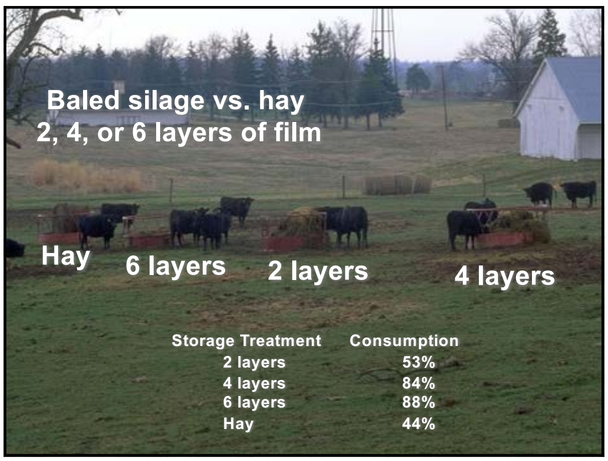
Whole Silage Bales
- Feed in a confined ring-feeder



Mixed Rations
- Tub-grind

Feed the Bales within 9 Months

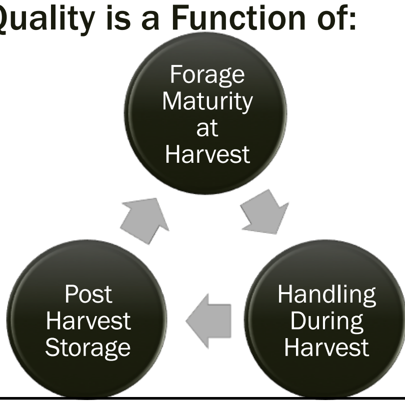
- Bales will squat and be difficult to handle
- Plastic will deteriorate over time
- Bales will begin to spoil



Storage Treatment	Consumption
2 layers	53%
4 layers	84%
6 layers	88%
Hay	44%

A NOTE ON FORAGE QUALITY:

Quality is a Function of:



Remember:

- Ensiling forage will NOT improve forage quality
- Quality is only as good as the forage you start with

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8 week old bermudagrass,
harvested and wrapped as haylage,
is still poor quality 8 week old bermudagrass.

In other words

Trash In = Trash Out

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Questions?

www.georgiaforages.com

www.ugabeef.com

1-800-ASK-UGA1

BEEF UGABEEF.COM

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Sources

- Baling Forage Crops for Silage
  Jimmy C. Henning, Michael Collins, David Ditsch, and Garry D. Lacefield, UK
- Baled Silage: Frequently Asked Questions
  Dr. Dennis Hancock, Forage Extension Specialist, UGA
- Some Points on Feeding Baled Silage
  Dr. Dennis Hancock, Forage Extension Specialist, UGA

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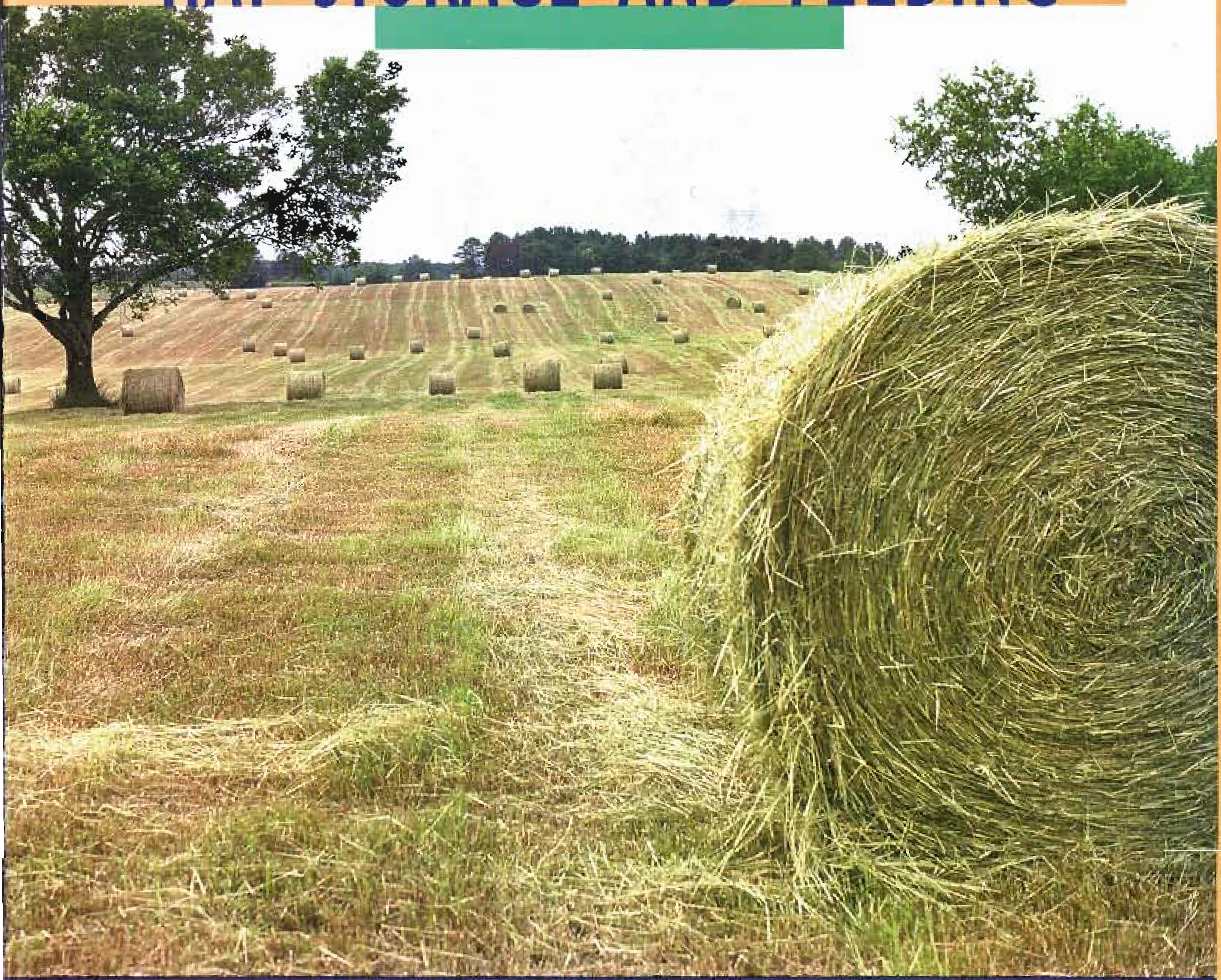
MINIMIZING LOSSES IN

HAY STORAGE AND FEEDING



MINIMIZING LOSSES IN HAY STORAGE AND FEEDING

Each year more than 60 million acres of forage crops are harvested for hay in the United States. Annual production from this acreage is over 150 million tons of hay valued at more than 12 billion dollars. Hay is the most widely grown mechanically-harvested agronomic crop in the United States.

As a source of nutrition for livestock, hay offers numerous advantages. It can be made from many different crops; when protected from the weather it can be stored indefinitely with little nutrient loss; package sizes and shapes can vary greatly; and harvesting, storage, and feeding can vary from being done by hand to being completely mechanized. Hay often can meet, or almost meet, the nutrient needs of many classes of livestock.

Because of its many merits, hay is the most commonly used stored feed on livestock farms across the nation. Unfortunately, losses of hay during storage and feeding are often high, particularly with round bales stored outside in high rainfall areas such as the eastern United States. It is estimated that the total value of hay storage and feeding losses nationwide exceeds three billion dollars annually! On some farms, such losses account for over 10% of the cost of livestock production.

These are real, and not just potential, losses (time, labor, and monetary inputs are lost along with the hay). Unfortunately, many producers probably do not realize how large their losses really are, or that with relatively little effort or expense they could be reduced considerably. The purpose of this publication is to provide information as to how and why hay losses occur, and how they can be reduced.

TYPES OF STORAGE LOSSES

Hay storage losses vary greatly depending upon several factors, but storage technique is of utmost importance. Losses of dry hay stored inside a barn are usually of little concern. However, even for barn stored hay, losses rise sharply as moisture levels increase above 20%, and losses from round bales stored outside under adverse conditions can be much larger. During storage, hay can be subject to dry matter losses as well as losses of forage quality.

Dry Matter Losses

Dry matter losses during storage result from plant respiration (the continuation of normal plant processes), microbial activity, and weather deterioration. Even at low moisture levels (20% or less) there is some loss due to respiration and low numbers of microorganisms, but this is constant across hay types and essentially unavoidable.

At higher moisture levels (above 20%) where mold growth is likely to be visibly detectable, dry matter losses are greater, and significant levels of heating (which can also lower forage quality) occur due to microbial activity. Although numerous bacteria are present in hay, fungi account for most of the microbial growth.

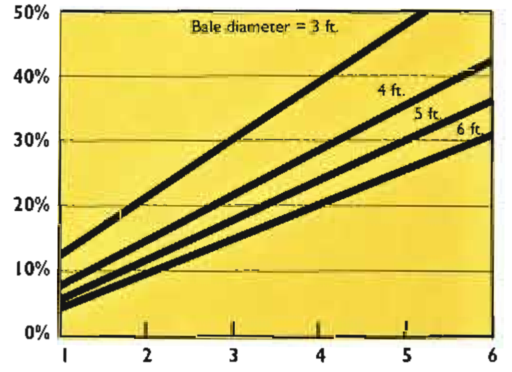
Heating of hay is related to moisture content. Peak temperature is often reached within a week after baling, but with higher moisture hay and conditions which limit heat escape, it may take as much as three weeks. At safe moisture levels (less than: 20% for rectangular bales; 18% for round bales; and 16% for large rectangular packages) inside storage losses are typically around 5% of dry matter, but losses several times higher have been reported for extremely moist hay.

"Weathering" (the term which is commonly used to refer to the effects which climatic conditions have on hay) is partially a physical process. Some of the dry matter loss which occurs during outside storage is caused by leaching, which refers to the dissolving and removal of nutrients by the passage of rain water over the surface of, and through, the bale. The more digestible nutrients are, the more soluble they are, and thus the more likely they are to be removed by leaching.

The switch from small rectangular bales to large round bales on most U.S. farms has resulted in higher storage losses (in many cases, several times higher). Round bales are not inherently subject to greater losses, but they are much more likely to be subjected to adverse storage conditions, often remaining outside with no protection between baling and feeding. Feeding losses are usually sharply higher with round bales as well, partly because big round bales are generally fed on sod while rectangular bales are often fed in bunks.

The extent of weathering damage during outside storage varies mainly with climatic factors and with forage species. Weathering primarily affects hay in the outside circumference of a large round bale rather than in the ends. Consequently, package size (mainly the diameter) affects the proportion of the bale contained in the surface layer, and thus the magnitude of losses (Figure 1).

Figure 1. Dry matter loss vs. average spoilage depth in round bales of various diameters.*



*SOURCE: Buckmaster, D.R., 1993. Evaluator for Round Hay Bale Storage. J. Prod. Agric., 6:378-385.

In the eastern United States it is not unusual for 4 to 8 or more inches of spoilage to occur on the outside of large round bales stored outside with no protection. A weathered layer 6 inches in depth on a 5.6 foot x 5.6 foot bale contains about one-third of the package volume. Other things being equal, the percentage of hay lost decreases as bale size increases because a smaller proportion of the bale volume is contained in the surface layer. This has important implications regarding baler purchase decisions.

Forage Quality Losses

Storage conditions can also have a dramatic effect on hay chemical composition and feeding value. Typical effects on the interior (unweathered) and exterior (weathered) portions of bales on crude protein, acid detergent fiber (ADF), and in vitro digestible dry matter (IVDDM) are shown in Table 1. Even if there were no dry matter losses or additional feeding losses with weathered hay, changes in forage quality would be of great concern.

Total crude protein declines with weathering, but the percentage of crude protein may increase due to dry matter losses (a phenomenon which has been reported to also occur with rain damage of field-curing hay). This is because protein is less subject than other plant constituents to weathering loss. However, the proportion of digestible crude protein may decrease, especially if the hay undergoes heating due to excessive moisture.

Sampling each lot of hay for nutritive analysis is necessary if hay is to be fed in an efficient manner.

Soluble carbohydrates, which are highly digestible, decline during weathering as shown by increases in ADF and decreases in IVDDM; thus carbohydrate levels differ greatly between the weathered and unweathered portions of round bales. Declines in hay quality from weathering are

Table 1. Forage quality of the interior and exterior portions of alfalfa round bales stored outside.*

Portions Of Bales	Crude protein	Acid detergent fiber	IVDDM
	- - - - - - - - % of dry weight - - - - - -		
Interior	18.9	38.6	61.4
Exterior	19.4	45.8	46.9

*SOURCE: Anderson, P.M., W.L. Kjelgaard, L.D. Hoffman, L.L. Wilson, and H.W. Harpster. 1981. Harvesting practices and round bale losses. Trans. ASAE.24:841-842.

HAY QUALITY- THE KEY TO ANIMAL PERFORMANCE

Hay quality is critically important, especially for animals having high nutritional requirements, and the ultimate test of hay quality is animal performance. Hay quality is considered satisfactory when animals consuming it perform as desired. For anyone who is producing, feeding, buying, or selling hay, forage quality should be a major consideration.

Factors which affect hay quality include: growing conditions, fertility, species, varieties, pests, presence of weeds, harvesting, curing, handling, and storage. However, the stage of maturity when harvested is the most important factor, and the one where management can have the greatest impact.

As plants advance from the vegetative to the reproductive stages, fiber and lignin increase, while protein, digestibility, metabolizable energy, and acceptability to livestock decrease. Early cut hay makes a more desirable feed because it contains more nutrients. Hay cut at an early stage of maturity is also more palatable and is more readily consumed by livestock.

Evaluating Hay Quality

Several methods exist for evaluating hay quality: visual, chemical, near infrared reflectance spectroscopy (NIRS), and animal performance. Visual estimates can help, but vary considerably. Descriptions based on these estimates show high quality hay to be early cut, leafy, soft, free of mold and foreign material, and having a pleasant odor. Color can be misleading, because hay having a bright green color may be mature and fibrous, while faded hay may often have excellent nutritional value.

The most precise way to determine the nutrient content of hay is through laboratory analysis. If a representative sample is taken and analyzed for nutritive content, the results can help determine how much and what type of supplementation, if any, is needed in order to meet the nutrient requirements of the animals being fed, and to obtain the level of performance desired. This leads to efficient and economical feeding programs.

Sampling For Forage Quality Analyses

When hay is tested, a random, representative sample must be obtained because laboratory results will be only as accurate as the sample submitted. A sample should be taken for each lot of hay. A "lot" represents a group of bales of hay which were grown in the same field, harvested under the same conditions and at the same time, and stored in the same way.

When collecting samples, a hay probe should be used which has a minimum cutting diameter of 1/2 inch and a minimum length of 12 inches. Samples should be taken from the ends of conventional rectangular bales or from the radial sides of large round bales, with 15 to 20 probe samples being composited and then submitted for analysis from each lot of hay. Samples should be stored in an airtight bag for shipment to the laboratory. Sampling of weathered hay for nutritive value is more complex than sampling unweathered hay. Ideally, weathered and unweathered portions of bales should be sampled separately and the analysis results from the two fractions weighted according to their relative contributions to entire bales.

Table 2. Losses of forage quality during storage of round-baled grass and grass-legume hay.*

Hay type	Fraction	Crude protein	in vitro digestible dry matter	Relative feed value	$ value loss
		- - - % of dry wt. - - -		index	$/T
Grass	unweathered	13.5	58.8	72	—
	weathered	16.4	42.5	75	9.72
Alfalfa	unweathered	14.2	56.5	86	—
	weathered	16.9	34.2	79	22.68

*SOURCE: Lechtenberg, V.L., K.S. Hendrix, D.C. Petritz, and S.D. Parsons. 1979. Compositional changes and losses in large hay bales during outside storage. pp. 11-14 In Proc. Purdue Cow-Calf Res. Day. West Lafayette, IN, 5 Apr. 1979. Purdue Univ. Agric. Exp. Stn. West Lafayette, IN.

I Hay value determined: Y = (0.81 x RFV index) - 14.8 where Y = $/ton of hay. Minnesota Quality-Tested Hay Auction Data. SOURCE: Martin, N.R., & Duane Schriever. 1996. Minnesota forage update Vol. XXI, No. 2, p. 5.

usually greater for legumes than for grasses (Table 2).

Some heating of hay is normal, but extreme heating (above 120°F) lowers forage quality along with dry matter. Microbial activity associated with heating uses soluble carbohydrates, which reduces digestibility and increases fiber levels. A reduction in voluntary intake accompanies excessive increases in NDF.

In addition to causing huge dry matter losses, weathering lowers forage quality, reduces palatability and intake, and increases feeding losses due to animal refusal. Cattle ate only the center portion of this highly weathered bale.

UNDERSTANDING THE WEATHERING PROCESS

From the preceding discussion, it should be obvious that most of the hay storage losses which occur are associated with hay being stored outside in a situation in which it is exposed to the elements, resulting in weathering. The longer hay is exposed to unfavorable weather conditions, the greater losses will be.

How Weathering Occurs

Bales stored outside on the ground without covers increase sharply in moisture content during storage. This is especially true for the outer 2 to 3 inches of the bale in which moisture may increase by as much as 120%. Weathering begins slowly, but then accelerates because weathered hay is more easily penetrated by rain, and doesn't dry as rapidly thereafter.

In areas of high and/or frequent rainfall, or with hay which does not shed water readily, the method of storage can make the difference between less than 5%, or more than 50%, dry matter loss from weathering! Furthermore, losses of more than 14% of the total crude protein and more than 25% of the total digestible nutrients can occur in the most highly weathered portions of a bale. An important associated factor is that the palatability of weathered portions of bales is decreased, which lowers intake and increases refusal.

Thatch Formation

In theory, a round bale should form a thatch that will, at least initially, shed almost all of the rain which falls on the top of the bale, but any of several factors may prevent this from occurring. Examples of forage crops which have the potential to thatch well when packaged in a uniform, dense bale are fine-stemmed, leafy, weed-free bermudagrass or tall fescue.

Hay made from coarse-stemmed forage crops will not thatch well. This is due to large stems, hollow stems, or other physical factors which do not allow thatch formation. For example, water can easily penetrate the tops of bales of many summer annual grasses, thus quickly beginning the weathering process. Coarse-stemmed weeds within hay can also provide an avenue for water to penetrate bales.

Once a wet layer forms, a bale does not shed water well and moisture levels inside the bale are likely to continue to increase during the storage period. As the wet, moldy area on the top of the bale deepens, less and less drying occurs between rains. Hence, once weathering gets underway, it usually proceeds much faster than with newly baled hay.

Understanding the importance of thatch formation is made easier by considering the amount of water which must be shed during storage. A 6 foot long by 6 foot diameter bale will receive about 22 gallons of water for each inch of rain. Therefore, if there

In the eastern United States, storing bales outside unprotected for several months will typically result in at least 5 or 6 inches of hay around the top and sides which has essentially no feeding value. Losses on the bottoms of bales are usually even greater due to contact with wet soil.

are 30 inches of rainfall during the storage period, a bale will receive 660 gallons of water.

Location Of Weathering

For hay harvested at a low moisture level, weathering usually occurs in three layers. The outside is typically wet, dark, and rotten and has no feeding value. Underneath is a thinner layer of moist and heavily molded hay which is of relatively low quality. A third transition layer, which may exhibit light mold and have a higher moisture content than the outer surface layers, usually surrounds the unweathered interior.

The sides of round bales shed water better than the tops because less surface is directly exposed to rain. Therefore, an isolated uncovered bale should have less weathering on the sides than on the top. However, moisture can be trapped where bales touch on the rounded sides, and this trapped moisture delays drying and thus results in greater weathering during storage.

Data suggest that often 50% or more of the storage losses associated with outside storage occur in the vicinity of the bale/soil interface (that is, at the bottom of the bale). Dry hay touching damp soil draws moisture into the bale. Hence, if hay and soil are in contact, large weathering losses occur on the bottoms of bales even when they are stored on a well-drained site. As a bale begins to weather on the bottom, it will flatten and allow even more hay/soil contact, and more top area will be horizontally exposed to rainfall, each of which increases the amount and rate of weathering.

FACTORS AFFECTING OUTSIDE STORAGE LOSSES

In research trials in the eastern United States in which large round bales have been stored outside without protection for six months or more, dry matter losses of 30% or greater have been common. Some of the most important factors relating to the extent and dollar value of outside storage losses are as follows:

Bale Density

In general, the denser or more tightly hay is baled, the lower the amount of spoilage that will occur, assuming hay moisture at baling is 18 to 20% or lower. Bale density is affected greatly by the type of baler being used, with some large round balers providing a density up to twice as great as other balers. The average density of a bale is less critical than the density on the outer surface.

Other factors may also affect bale density. By making proper baler adjustments and taking time to do a good job, an experienced baler operator can often produce bales which are much tighter than those someone else might produce using the same equipment. Some fine-stemmed hays such as bermudagrass naturally tend to produce a tight bale which sheds water much better than coarse-stemmed hays such as johnsongrass, pearl millet, or sorghum-sudangrass.

Having well-formed, tight bales is an important factor in reducing storage losses. Most haying equipment companies can provide information that discusses the steps (or tricks) required to produce dense, uniform bales when using their products. The density of round bales (at least in the outer few inches) should be a minimum of 10 pounds of hay/cubic foot.

While increased bale density reduces spoilage by reducing moisture penetration, it also reduces the rate at which moisture and heat can escape from a bale.

Thus, as density increases, it becomes increasingly important to make certain that hay is in a safe moisture range for baling. Unfortunately, leaf shatter from legume hays also increases with decreasing hay moisture levels.

A low moisture content, use of a forage crop with stems fine enough to form a thatch, and a bale density of at least 10 pounds/cubic foot in the outer portions of bales are important factors affecting resistance to weathering during outside storage.

Other Field Operations Or Techniques

Reduction of storage losses can begin with the formation of the hay swath prior to baling. A uniform swath of proper size for the baler being used will help to produce a dense, uniform bale. Other things being equal, smaller windrows facilitate dense bales because they result in more layers per roll; however, leaf shatter of legumes, as well as baling time, may be increased. Operating rakes, tedders, and balers in the same direction as hay was cut may also help make a tighter bale.

DEFINITION OF SELECTED FORAGE QUALITY TERMS

CRUDE PROTEIN (CP)
The total quantity of true protein and nonprotein nitrogen present in plant tissue. This can be calculated by multiplying the nitrogen fraction by 6.25.

DRY MATTER (DM)
The percentage of a plant sample which remains after all water has been removed.

NEUTRAL DETERGENT FIBER (NDF)
The percentage of cell walls or other plant structural material present. This constituent is only partially digestible by animals. Lower NDF levels are generally associated with higher animal intake.

ACID DETERGENT FIBER (ADF)
The percentage of highly indigestible plant material. Higher ADF levels are generally associated with lower digestibility.

DIGESTIBLE DRY MATTER (DDM)
The percentage of a sample which is digestible. DDM is a calculated estimate based on feeding trials and from the measured ADF concentration.

IN VITRO DIGESTIBLE DRY MATTER (IVDDM)
is a similar term which indicates that the digestibility level was determined via a laboratory test as opposed to one which utilized live animals fitted with a port open to the rumen which allows digestion of small samples inside the animal.

DRY MATTER INTAKE (DMI)
This is the amount of forage an animal will eat in a given period of time. Estimates of DMI are based on results from animal feeding trials and the measured NDF concentration of a forage or feed.

DIGESTIBLE DRY MATTER INTAKE (DDMI)
An estimate of how much DDM an animal will consume in a given period of time. It is calculated as follows:
DDM X DMI/100.

RELATIVE FEED VALUE (RFV)
A measure of a forage's intake and energy value. It compares one forage to another according to the relationship DDM X DMI/100 divided by a constant. RFV is expressed as percent compared to full bloom alfalfa which has an RFV of 100. In most cases, as RFV increases forage quality also increases.

Moisture content at baling can be an important consideration, and this is especially true in the case of large hay packages. Some studies have shown that hay baled at only 2 to 3% higher moisture than other hay from the same field will maintain a higher moisture content for several months thereafter, thus favoring microorganism growth. Because large hay packages have restricted ability to lose moisture, even relatively small differences in moisture level can have a measurable negative impact (lower total and digestible dry matter and higher fiber).

Bale wrapping has some influence on storage losses of large round bales stored outside. A Missouri study showed weathering losses increased as the spacing between the twine on bales increased from 2 to 8 inches. However, wrapping bales with twine spaced closely together increases costs because more twine is used and more time is required for wrapping.

Most studies have shown net wrap to be slightly better than twine in preventing storage losses. Producers who use net wrap have also indicated that they can wrap a bale with only two to three revolutions and produce more bales per hour than with twine. Net wrap has the additional advantage of stabilizing bales better than twine, thus making bale handling and storage easier, but it also increases cost.

Though not a storage procedure per se, a preservative is sometimes applied to the swath or to forage as it enters the baler. The preservative is often a buffered acid which decreases mold and mildew growth. This allows hay to be baled at a higher moisture level which may increase leaf retention of legume hays, thus slightly improving harvest yield and forage quality, as well as hastening baling by one-half to one day, thus reducing the risk of rain damage.

Acid-treated hay which is protected from rain during storage may have slightly lower storage losses than untreated hay if stored for only a few months, but after storage for as long as six months, there may be no difference between treated and untreated hay. Acid treatment does not appear to retard the weathering process with hay stored outside, however. Furthermore, acids can result in corrosion of hay equipment.

Injecting hay with anhydrous ammonia increases crude protein by adding nonprotein nitrogen. It has also been shown to increase digestibility of grass hay, and can be quite effective in reducing or eliminating mold growth and heating. In addition, because injected bales must be sealed airtight to avoid ammonia loss, weathering loss is avoided. However, the caustic nature of this product creates danger to humans, and has occasionally caused hay to be toxic to animals (particularly with high moisture, high quality hays).

As fields are cut, baled, and stored, some system for identifying hay as to field and cutting date should be implemented. This information is useful in determining the effect of management practices on forage quality and/or animal performance, and in testing the nutritive quality of hay to allow the formulation of rations which efficiently meet animal nutritional requirements.

Climatic Influences

Climatic conditions obviously play an important role in determining the extent of spoilage loss of hay stored outside. In general, the higher the rainfall during outside storage, the greater the amount of storage loss which will occur. However, rainfall distribution also has an influence (in fact, results from some studies have implied that rainfall distribution can be considerably more important than rainfall amount). To illustrate, a rainstorm which results in 2 inches of rain falling very quickly is likely to have much less impact than the same rainfall coming in small amounts every other day over a period of two weeks.

Other climatic factors such as high humidity, which slows drying of wet hay, likewise enhance storage losses. Temperature also has an effect, because microbial activity within the bale is favored when warm, humid, overcast conditions prevail. Hay which is stored in a sunny area which receives the benefit of unobstructed breezes dries more quickly and tends to have lower spoilage losses than hay stored in shady and/or less well-ventilated areas.

Outside storage of hay normally presents little or no problem in the arid western United States, so in this area large stacks of hay are often stored outside totally unprotected from the elements. However, in high rainfall/high humidity areas, outside storage losses can be extensive and quite costly.

Site Selection

If hay is to be stored outside, it is desirable to locate the storage site close to the feeding area because bales become more difficult to handle as they weather. It is easier to move them a greater distance when they are new and tightly wrapped.

Well-drained upland storage sites are best. Bottom areas should generally be avoided as they tend to be heavier soils. Also, many bottom areas are prone to flooding, which is detrimental to hay and may limit vehicle access during rainy periods. Hay/soil contact should be avoided if at all possible, but if hay must touch the soil, a sandy, well-drained area is greatly preferable to a heavy soil and/or a poorly drained site.

It is also advisable to select a storage site where the danger of fire is minimized. Several steps which can be taken to reduce the likelihood of fire are discussed in a later section titled "Reducing Fire Risk."

Bale Orientation/Placement

Once the storage site has been located, attention should be given to bale placement and orientation. Except when multiple-bale covers are used, large round bales should be stored in rows with sides not touching so as to avoid creating a moisture-holding area between sides. However, the flat ends of bales should be firmly butted against one another. This conserves space and may help protect the bottoms of bales (other than the one on the upper side of the slope) from water flowing down the slope. Properly done, this protects the ends almost as well as if they were part of one continuous bale.

If possible, rows should run north and south so as to allow maximum exposure of the rounded sides to the sun. This increases drying of the rounded surface of bales during the day. At least 3 feet should be left between bale rows to ensure sunlight penetration and allow good air circulation.

If direct hay/soil contact cannot be avoided, taking steps to minimize the amount of water reaching the bales, and the length of time they stay wet, will at least help. A gently sloping site (preferably with a southern exposure to maximize solar drying) will allow water to quickly drain away from the hay. Bales should be oriented up and down the slope so that they will not create a dam for surface water, and placed near the top of the slope to minimize the amount of water flowing around the hay.

Protecting The Tops Of Bales

There are numerous types of commercially available coverings for large round hay bales, and they vary in both effectiveness and cost. These include small "caps" which are staked or pinned to the bale and which cover the top third to half of the bale. If handled carefully, such products often can be used more than one season, which makes them less expensive and therefore more feasible to use. Some individual bale covers may be difficult to keep securely in place for an extended period of time.

One can also buy a large roll of plastic sheeting and cut individual bale covers, although experience has proven this method to be time consuming and the pieces somewhat awkward to handle. If plastic sheeting is used, it should be at least 6 mil thick. Individual bale covers are most suitable for producers who use relatively small quantities of hay in a given feeding season.

The expense of a tarp, plastic sheeting, or other fabric covering, as well as the labor involved to cover hay, can be reduced by placing a group of bales under one cover. Often bale rows are stacked in a triangular fashion with two or three rows forming the base. This gives either three or five rows of hay per stack, with the total number of bales varying with the length of the stack.

A cover must be secured firmly to prevent wind from blowing it off during storage. It is desirable to leave the flat ends of the outside bales uncovered and to leave a few inches uncovered along the sides of the rows to allow moisture to escape and air to circulate under the bales. However, winds of only 15 to 20 mph can exert a considerable lifting force as it blows across the top of a plastic or tarp, and even a slight breeze may lift a loose edge of a poorly secured cover.

Another disadvantage of using plastic sheets is that condensation may occur under the bales if hay was moist when stored or if water gets under, and into, the bales. The result is that a significant amount of spoilage may occur next to the plastic even though rain cannot reach the hay. (This makes a strong case for making certain any hay stored using this technique is quite dry, preferably 18% moisture or less, before being covered and is not in contact with the soil.) In addition, disposal of plastic after use may be a problem.

At least one commercially available hay cover is made from a slightly porous fabric. It is marketed in large tarp-sized sheets, and can be used to cover several bales at a time, usually with one row of bales stacked on top of two other rows in triangular fashion. This reusable product offers the advantage of shedding a high percentage of rain water while still allowing moisture to escape during sunny, drying days. However, bottom spoilage may occur on bales which touch the ground unless steps are taken to prevent it.

If a cover is used (particularly a plastic cover), it may be desirable to relate the size of individual stacks to the rate at which hay is to be fed. Once a row end is uncovered and bales are removed for feeding, covers are seldom placed back as securely as they were initially. The result is that wind may blow a cover off, or partially off, resulting in some weathering of the remaining hay. Therefore, minimizing the amount of hay stored under one cover may help reduce weathering losses in some situations.

Use of a rock pad is one effective yet inexpensive way to eliminate hay/soil contact.

Other companies market equipment which places either individual bales or several bales inside plastic "sleeves." This approach effectively protects the tops and sides of bales, but it is quite important to make certain that the hay is dry when baled and to make certain there is no way for moisture to enter the bales or for condensation to "pool" at the bottom of the plastic during storage. Otherwise, there may be high spoilage losses on the bottoms of bales. When each sleeve covers only one bale, the sleeve should be tight. Despite the plastic on the bale bottoms, individually sleeved bales should not be stored directly on the ground.

Some companies produce equipment which completely wraps or seals individual bales in stretch plastic. Done correctly, this may be the most effective way to eliminate weathering losses with outside storage. However, depending on the equipment design, this may be expensive in terms of labor, equipment, and plastic, plus disposal of plastic after feeding is required.

Several research studies have involved spraying bales with water repellent substances. Hydrogenated animal fats and plant oils have been used most frequently, and offer the attributes of being natural, environmentally friendly, and biodegradable. With most such products, animal refusal of treated hay does not appear to be a problem, but the fat or oil may attract insects, which can include fire ants in areas where they are present. Additional research is needed to determine the feasibility of this approach.

Protecting The Bottoms Of Bales

Several studies have shown that it can be more important to protect the bottoms, as opposed to the tops, of bales. The bottoms of bales can be protected in countless ways, limited only by imagination and ingenuity. The bale bottom is protected when it is held off the ground by something that does not trap and hold water. For example, wooden pallets, telephone posts, scrap pipe, and cross ties have all been successfully used in hay storage. The most important point is to prevent hay/soil contact, but providing some air flow under the hay is also desirable.

Wooden pallets offer an inexpensive method of eliminating hay/soil contact, but are labor intensive as they need to be moved as hay is used. They make it easy to change storage location(s) from year to year because they have to be moved anyway. However, pallets contain nails which can puncture tires or cause other damage.

Another relatively inexpensive and effective storage technique is to place hay on rock pads. A good rock pad keeps bales off the soil, and also provides all weather support for equipment. Rocks 1 to 3 inches in diameter should be piled 4 to 8 inches deep, depending on the soil type and the weight of the equipment to be used. This size rock traps no water and effectively channels water away.

Rock pads last for many seasons and can easily be repaired if damaged. An erosion cloth can be placed below the rock pad to help slow the rate at which heavy equipment may push rocks down into the soil and therefore increase the life of the pad (which can be ten years or more).

COSTS VERSUS BENEFITS OF HAY STORAGE

Many producers probably do not fully realize the economic importance of storage losses because the amount of loss is difficult to determine on a farm, and total hay costs are considerably higher than out-of-pocket expenses.

Before making decisions regarding hay storage, a producer should obtain and study hay budgets to determine the actual cost of hay production and the dollar value of hay storage losses. Budgets are usually available from County Agricultural Extension Agents.

Cost Of Hay Losses

Proper hay storage has a cost in terms of both time and effort, and this must be considered by producers seeking to reduce losses. Material and labor costs expended to store hay, as well as the nutritional value of hay, dictate which storage techniques are most cost effective. The higher the quality of the hay, the greater the economic cost of storage and feeding losses (Table 3).

Storage losses increase the quantity of hay needed, plus they may lower forage quality of the remaining hay enough that additional supplementation of animal diets is required. The cost of storage losses can readily be calculated based on the selling price of hay of various qualities. The economic values of dry matter losses provided in Table 4 were calculated using Minnesota quality-tested hay auction prices. This information can be used to calculate how much one can afford to spend in constructing overhead storage or in improving site drainage.

Table 3. Cost of hay consumed as affected by storage and feeding losses.

	Beginning hay value, $/ton[1]		
% Loss	50	70	90
5	52.69	73.68	94.74
10	55.55	77.78	100.00
15	58.87	82.35	105.88
20	62.50	87.50	112.50
25	66.68	93.33	120.00

[1] Numbers listed under a given beginning hay value represent the cost of unweathered hay fed (that is, losses due to storage and feeding, in essence, increase the cost of hay).

Table 4 illustrates that as hay value increases, a greater investment in time, energy, and money can be justified to reduce losses. Furthermore, in addition to the value which is lost due to weathering, the lost hay must then be replaced. For example, dry matter losses of 15 to 20% require a livestock producer to harvest 15 to 20% more hay, which further adds to the costs of production, harvesting, and storage.

Table 4. Economic value of loss (storage and feeding) of hay by quality test.

Test standard	Average quality RFV[1]	Price	Value of loss[2] 5%	10%	20%	40%
	index	$/T				
Prime	168	121	6.05	12.10	24.20	48.40
1	138	97	4.85	9.70	19.40	38.80
2	115	78	3.90	7.80	15.60	31.20
3	97	64	3.20	6.40	12.80	25.60
4	81	51	2.55	5.10	10.20	20.40
5	60	34	1.70	3.40	6.80	13.60

[1] Represents the mean test values from 11 years of quality test auction data in Minnesota.
[2] Y = (0.81 x RFV index) - 14.8, where Y = $/ton of hay. This calculated loss value assumes a 4 inch weathering loss and 5 foot diameter bales (25% of the hay volume).

Barn Storage

Barn storage is usually considered to be a consistently highly effective method of storing hay, so it is often used as the standard against which other techniques are compared. When the typical dry matter storage loss of dry hay during inside storage (usually around 5%) is compared to the 30% or more common with hay stored outside in the humid portions of the United States, it isn't difficult to see that reduced losses can often provide payback on barn construction within a few years. The more valuable or porous the hay, the higher and/or more frequent the rainfall, and/or the longer the period of storage, the more easily barn construction can be justified.

For commercial hay producers there may also be considerable benefit from the improved appearance which results from barn storage. Outside storage hurts the appearance of hay even when actual losses are minimal. Appearance is not closely linked to nutrient content or feeding value, but it is often important in marketing, and may justify barn storage even in relatively low rainfall climates.

Storage buildings may provide benefits in addition to those which result from storing hay. For example, part of a hay barn might be used for other purposes during a portion of the year. Furthermore, the overall value of a farm should increase with the addition of a hay barn.

Bale density is another important consideration affecting the cost effectiveness of barn storage. The density of small rectangular bales is usually around 9 pounds per cubic foot, while the density of large round bales can vary from less than 5 to more than 10. Even when high density round bales are used, at least a third less round bale hay than rectangular bale hay can be stored in a given storage structure due to the wasted space between bales.

When a storage facility is constructed for round bale storage, dimensions should be based on the diameter and length of the bales that will be stored. For such structures, a design which does not require interior roof-supporting poles is desirable so that equipment operation will not be impeded.

On many farms, particularly in the eastern United States, reduced hay storage losses can provide payback on barn construction within a few years.

Costs And Risks Of Barn Storage

The cost of building a hay storage structure can vary greatly. Comparisons of structures of various types and sizes should be made on a cost-per-square-foot basis. Material costs are higher in some areas than others, and climate largely determines siding costs. Even in high rainfall areas at least one side may be left open without significant adverse results.

Labor costs typically account for around 35% of the cost of erecting a hay storage structure. Thus, a producer who can provide most or all of the labor for building a storage structure can substantially reduce out-of-pocket construction expenses.

Costs other than construction which are associated with barn storage are greater than might be expected. Before making decisions regarding erecting storage facilities or pricing hay which has been stored inside, the following items should be taken into consideration.

Shrinkage- Hay which has been stored inside for several months will typically lose 5 to 10% of its weight as compared to freshly baled hay due to a combination of dry matter loss and moisture loss.

Depreciation- The economic value of a building declines steadily over time. Generally, depreciation is considered to be around 5% of the initial value per year.

Interest on investment- This is "opportunity cost" or the amount of return which could have been made with the money used to build a storage structure if it had been invested elsewhere.

Repairs- A good figure to use is that approximately 1 to 2% of the value of a building must annually be spent on repairs. Most of this will occur during the latter part of its useful life.

Taxes and insurance- Taxes vary greatly with location, so to determine tax costs a producer should check with local officials. Having insurance on a storage facility is generally advisable, but each producer must decide whether he needs it and, if so, how much. Some farm policies may cover such additional buildings at little extra cost. Often the combined costs of taxes and insurance amount to about 1% of the average value of the building over its useful life.

Other- If a barn has an earth floor, water from outside should not be allowed to run under the hay. Otherwise, spoilage will occur on the bottom bales even though the hay is under shelter.

Bale dimensions, how high bales will be stacked, and the anticipated length of usefulness of the storage facility will also affect the economics of barn storage. For example, if a building costs a certain amount per square foot to build, but bales will be stacked three high and the facility is expected to last for 20 years, the cost per square foot for bale storage per year (construction cost only) can be determined by dividing the construction cost by 3 and then by 20. The cost/bale/year can then be obtained by multiplying the cost per square foot by the square footage of the size of bales to be stored (for example, a 5 foot x 6 foot bale will occupy about 30 square feet of storage space).

In the final analysis, in order to determine whether it is economically feasible to build a hay storage structure a producer must calculate anticipated construction costs, then compare this figure with an estimate of the value of hay being lost without it. Figure 2 provides the break even costs for barn construction at various loss levels, costs/square foot, and hay values.

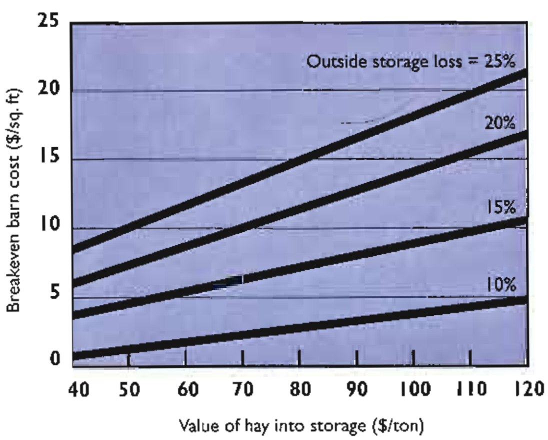


Figure 2. Break even barn cost for various levels of storage loss and varying hay value at harvest. (This analysis includes the following assumptions: in-barn average stacking height of three bales, ten-year barn amortization, and construction cost of $7.50/square foot. Inputs other than storage loss and hay value are not included.)

SOURCE: Buckmaster, D.R. 1993. Evaluator for Round Hay Bale Storage. J. Prod. Agric., 6:378-385.

Table 5. Average and range of increase of percentages of dry matter and digestible dry matter with barn storage as compared to various protection techniques used for hay stored outside. (Medium rainfall areas.)*

	Increase With Barn Storage, % Units	
Treatment Compared To Barn Storage	Dry Matter	Digestible Dry Matter
On Ground Without Cover	8.7	12.7
	(3.6 - 14.5)[1]	(3.3 - 17.2)
Drained Surface (Rock, Pallets, etc.)	2.4	6.8
	(-1.3 - 6.7)	(-0.4 - 13.4)
Plastic Cover On Bale Tops	3.2	3.6
	(0.6 - 4.6)	(2.9 - 4.3)
Drained Surface + Plastic Cover	0.3	-1.4
On Bale Tops	(0.9 - 2.9)	(-2.1 - 1.8)
Net Wrap	1.5	—
	(0.6 - 1.5)	—
Plastic Sleeve	0.6	—
	(-1.4 - 2.7)	
Pyramid Stack + Cover On Top	3.7	—

*SOURCE: Russell, Jim, and Ray Huhnke. 1997. Winter Feed Management To Minimize Cow-Calf Production Costs: Hay Storage And Feeding. The Forage Leader (a periodical published by the American Forage and Grassland Council, Georgetown, TX). [1]Parentheses denote the range of values in tests included in this summary.

The costs versus the benefits of using other techniques to protect hay should be compared to: (1) hay stored outside with no protection, and (2) building a hay storage facility. Experiments have generally shown that more than half (and sometimes nearly all) the difference in storage losses between outside storage on the ground with no protection and barn stored hay can be eliminated through the use of various strategies. A summary of 12 experiments comparing storage losses of barn stored hay to various other storage techniques is provided in Table 5.

Barn Safety Considerations

Safety considerations should be a high priority when planning barn storage of hay. These include making certain that equipment available on the farm is capable of safely placing bales in stable stacks, having a shield on stacking equipment to prevent injury to the operator if a bale falls, and making certain that excessive pressure will not be exerted on the walls or supports of the storage facility (stacking bales on end reduces the latter hazard).

REDUCING FIRE RISK

Each year there are many reports of hay barns burning, as well as of fires occurring in hay stored outside. Fire is always a concern with hay, but it takes on even greater importance when an expensive barn can be lost in addition to the hay.

Fire in stored hay may occur from either external or internal causes. Internally started fires are a result of hay going through an extreme heat. As discussed earlier, heating is a direct result of microorganism activity in hay stored at excessively high moisture levels. Even if excessive heating does not result in a fire, it will reduce forage quality.

Combustion Due To Extreme Heating

The principal way to avoid fire resulting from internal heating (sometimes referred to as "spontaneous combustion," though this term is misleading) is to bale hay at proper moisture levels. Hay in round bales should contain no more than 18% moisture when placed inside a barn, while hay in small rectangular bales should contain no more than 20% moisture. Hay that is suspected of being too wet should be stored outside for about three weeks until the danger of combustion due to heating is past. New crop hay should never be placed against dry hay.

The danger of fire from heating of hay of higher-than-optimum moisture can be decreased somewhat by "loose stacking" the bales so good air movement and ventilation can occur. Hay preservatives, which reduce fungal and bacterial growth, sprayed on hay during the baling process help reduce (though do not always prevent) excessive heating in higher moisture hay. Bales known to contain, or suspected of containing, excessive moisture can be temporarily loosely stacked outside, then moved inside after the danger of fire is past.

External Causes

External fires have many causes ranging from lightning to the mindless tossing of a cigarette. Common sense and an alert eye can eliminate most causes of external fires. For example, it is best to avoid stacking hay close to anything that can attract lightning such as power lines, metal fence posts, trees, or towers such as antennas.

It is also advisable to avoid storing hay adjacent to vegetation that might support a fire, and to maintain a no-vegetation buffer area around stacked hay to prevent wildfire from moving into the stored hay. This is especially true if the grass or other plants in the storage area are warm season species that go dormant in winter. Risk of hay loss from fire can further be reduced by storing hay in two or more sites rather than just one.

It is a good idea to post "No Smoking" signs in conspicuous places around a hay barn and to strictly enforce this policy. A herbicide or tillage can be used to create a bare ground buffer zone at least 3 feet wide around the edge of the barn to reduce risk from wildfire.

If there is a need to check the temperature of hay, it can be done by fitting a sharpened end on a 10-foot section of 1/2 inch pipe, then driving it into the hay, followed by lowering a thermometer into the pipe. Temperatures below 120°F are normal, and 120° to 140° are in the caution range. Hay heating to 160° or higher is in serious danger of catching fire. Temperature can build in hay, particularly within the first week or two after baling, and therefore periodic monitoring of temperature until it is clear there is no danger of fire is advisable.

HAY FEEDING

On many farms, hay feeding losses are as high as storage losses, particularly if hay is fed outside (This is logical because as the amount of weathered hay increases, animal refusal also increases). Some hay losses during feeding can be expected with any feeding system, but the amount of loss varies with the system used. The major objective for any feeding system should be to keep losses to a practical minimum level, thus permitting animals to consume the majority of hay offered at feeding.

Feeding losses include trampling, leaf shatter, chemical and physical deterioration, fecal contamination, and refusal. The levels and costs of these losses will be determined by feeding method, intervals between feedings, amounts fed at a time, weather conditions, the number of animals being fed, and forage quality or hay value.

In research trials, feeding losses have ranged from less than 2% when great care was exercised, to more than 60% where no attempts were made to reduce loss. Feeding losses of 3 to 6% are quite acceptable for most feeding programs, although such low levels of loss are usually associated with systems which require high labor inputs and daily feeding.

Use Of Hay Quality Information

Hay can be most efficiently fed when separated into lots according to quality, and when classes of animals are separated and fed according to needs. This allows hay quality to be matched to livestock needs. For example, on a cattle farm the best quality hay might be fed to animals having high nutritional requirements such as young calves, yearlings, bred heifers, and lactating cows. Lower quality hay could be saved for mature, dry pregnant cows and bulls when not in breeding season.

High quality hay is early cut, leafy, pleasant smelling, and free of foreign material and toxic factors. When chemically analyzed, such hay will usually be high in protein and digestible energy, and low in fiber. The best quality hay will also be the most valuable hay and thus should be fed with the greatest care.

Feeding Methods

If not ground for use in formulating a total mixed ration, small rectangular bales are normally stored under shelter, then are usually either moved from the shelter and placed in some type of structure (bunk, manger, rack, wagon, trough, etc.) or taken to an outside area where cattle are located. Either system requires a considerable amount of labor. Most large hay packages are fed on sod whether stored inside or outside.

Feeding hay on sod offers the advantage of distributing hay on pasture land rather than concentrating it along a feed bunk or in a barn. When hay is fed on sod, livestock usually waste and refuse less hay in situations in which they have a solid footing. Dry, well-drained, or frozen sites should therefore be chosen for feeding hay outside.

Feeding in only one area permits selection of a convenient feeding location which is easily accessible and which minimizes the size of the area in which sod is killed. However, it causes excessive sod destruction, usually creates muddy conditions, often results in heavy spring weed pressure, and can result in soil compaction and/or ruts in the field.

Some livestock producers who feed in only one area prefer to feed on concrete or to haul in large gravel so the hay can be placed on a solid foundation. Also, some producers feed the lowest quality hay first, thus initially causing excessive hay wastage but providing a foundation for further feeding.

Frequently moving the feeding area allows manure to be spread more uniformly over the field(s) and therefore improves the soil fertility in bare or thin spots, while reducing the severity of (though not necessarily the total area which sustains) sod damage. It can also facilitate the "trampling in" of legume seed (usually white clover or red clover) which was broadcast over a field during early winter. Regardless of the approach used when feeding hay on sod, any areas where sod kill is encountered should be reseeded as soon after the feeding season as possible.

When hay is fed on sod, the amount of hay wasted will be much less when only a one-day hay supply is given, and when hay is fed in such a manner that all animals have access. However, unrestricted animal access to large round bales or stacks will result in grossly excessive feeding waste.

If substantial quantities of hay must be put out at one time, erecting a barrier between the hay and the feeding animals will reduce waste. The barrier

Placing a barrier between the hay and the animals will reduce feeding losses.

can be an electric wire, feeding racks or rings, panels, wagons, or gates. Feeding racks and rings are available in a variety of shapes and sizes (racks which prevent hay from contacting the ground are particularly effective). In addition, blueprints for home construction of bale protectors are available through many universities, including from County Agricultural Extension Agents.

When racks or panels are not used, enough animals are needed to eat the amount of hay offered in a relatively short period of time. Waste can be reduced by having at least one cow for each foot of outside dimension (circumference) of the hay package. Forcing animals which have low nutritional requirements to clean up hay in feeding areas before more hay is put out can also help reduce waste.

A few producers use balers which package hay in relatively small round bale packages which are left in the field and later fed at the spot where they were dropped from the baler. This system lends itself to large hay storage losses if hay is stored in this manner for very long because the hay is unprotected from the elements and there is high bale surface area exposure. When this system is used, an electric wire should be used to limit access and thus at least reduce feeding losses.

Feeding Priority Of Various Hays

Obviously, the longer hay is exposed to the elements, the greater storage losses will be. Therefore, hay stored outside should generally be fed before hay stored inside. Porous hay which is highly susceptible to damage should be fed before hay which is tightly baled. Other things being equal, the best quality hay stored outside should be fed before lower quality hay, though animal nutritional requirements may also affect feeding priority.

Altering Hay Bales Before Feeding

Several types of equipment are available for grinding, shredding, unrolling, or cutting and windrowing large hay packages. These methods usually require additional equipment, but can work well under proper management. Grinding or shredding hay facilitates limit feeding (limiting the amount fed at a time) and also tends to lower feeding losses by reducing the ability of animals to selectively consume unweathered hay and refuse weathered material.

The least expensive method is to simply unroll the bale to enable livestock to line up much like at a feed bunk. Again, feeding only enough for one day reduces waste but increases labor.

Minimizing Hay Requirements

The objective of any hay feeding program is to provide adequate quantities of high quality hay to meet livestock needs not being met by pasture. However, stored feed, including hay, is normally much more expensive than pasture forage, so it is economically advantageous to minimize stored feed requirements to the extent possible. Examples of ways this might be done include stockpiling forage, grazing crop residues, and lengthening the grazing season by growing various pasture crops which have differing periods of production.

KEY CONCEPTS REGARDING OUTSIDE HAY STORAGE

1. Weathering of hay results in losses of dry matter, lowered forage quality, and (perhaps even less well recognized) reduced hay intake and greater refusal.
2. The more valuable the hay, the easier it is to justify spending time and money to reduce storage losses.
3. Hay/soil contact is usually the most important source of spoilage of hay stored outside and should be eliminated if possible. This can be accomplished by placing bales on crushed rock, a concrete pad, or some object such as wooden pallets. If placing bales on the ground cannot be avoided, selection of a well-drained area (preferably with sandy soil) should be selected.
4. Water should quickly drain away from any bales stored on the ground. Storing bales near the top of a sloping area reduces the amount of water flowing around them. Bale rows should run up and down a sloping area to avoid trapping surface water.
5. Hay should be stored in a sunny location, preferably in an area where frequent breezes occur. Hay should never be stored under trees or other areas where drying is slow.
6. It is preferable for bale rows to run north and south rather than east and west. Also, a southern, rather than a northern, exposure is best.
7. The flat ends of bales should be butted together, but the rounded sides should not touch. Unless rows are put together to facilitate covering with sheets of plastic or similar material, at least 3 feet of space should be left between rows to allow air circulation.
8. The larger the bale, the lower the total percentage of weathering of hay stored outside. However, there are some disadvantages associated with handling larger bales.
9. As hay density is increased (particularly in the outer portion of the bale), outside storage losses decline. A minimum of 10 pounds of hay/cubic foot is recommended for round bales stored outside. Course-stemmed forages are more vulnerable to weathering than fine-stemmed forages which form a thatch.
10. The efficiency and cost of various methods of storing hay outside vary greatly. Whether a particular technique or combination of techniques can be justified depends on the cost of the technique(s) versus the value of hay which will otherwise be lost.

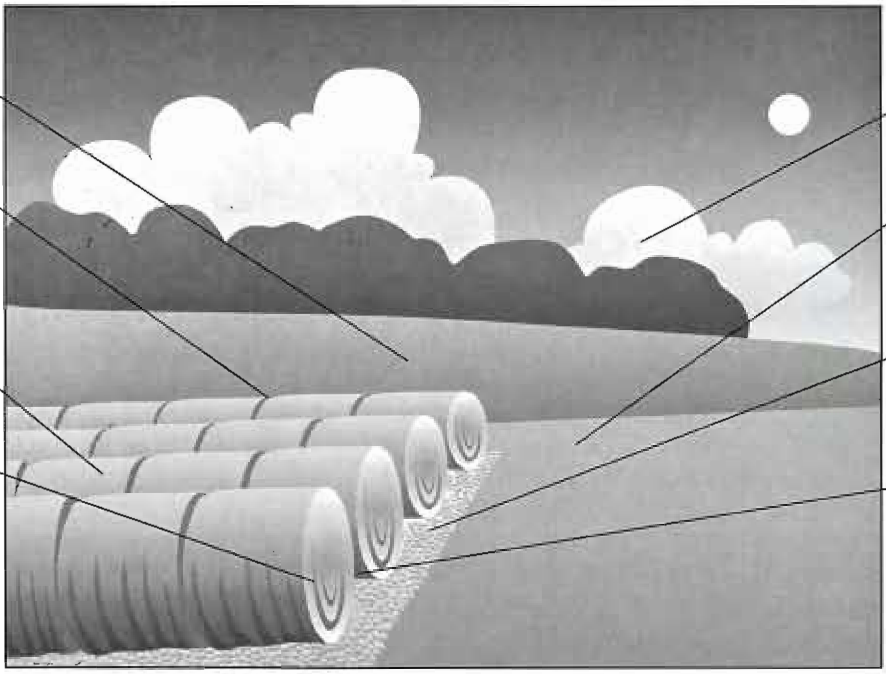
EXAMPLES OF THINGS YOU SHOULD NOT DO

Bales should not be allowed to be in standing water, even on a temporary basis.

The rounded sides of bales should not touch.

Hay should not be placed under trees.

OUTSIDE HAY STORAGE RECOMMENDATIONS



KEY CONCEPTS REGARDING HAY FEEDING

1. Hay quality should be matched to animal needs.
2. When animals are fed outside, a well-drained site should be selected to reduce feeding losses.
3. Hay stored outside should be fed before hay stored inside; coarse, porous hay stored outside should be fed before fine-stemmed, densely baled hay stored outside; other things being equal, high value hay stored outside should be fed before low value hay stored outside.
4. Putting a barrier between animals and hay will help reduce feeding losses. Hay racks can be particularly effective.
5. Minimizing the amount of hay to which animals have access at one time will reduce feeding losses.
6. Forcing clean up of hay by animals which have low nutrient requirements before feeding more hay can help reduce hay waste.

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Many Different Approaches Can Be Used To Reduce Hay Storage Losses.

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Using By-Product Feeds

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Introduction

Feeding by-product feeds to cattle is not a new concept. Feed companies have used by-product feeds in commercial concentrates as a source of nutrients for years. However, the use of by-product feeds in rations mixed on-farm may be new to many producers. By-product feeds come from a variety of sources including grain processing, production of human foods and beverages, and manufacturing of fiber products. Although many of these feeds have been used for years, others are relatively new. Research has been conducted on most by-product feeds and the guidelines for their use are well documented; however, limited information is available on the feeding value or guidelines for using some by-product feeds. This publication will discuss factors that should be considered when feeding by-product feeds.

The primary reason producers should consider by-product feeds is to reduce feed cost. Feed is the primary cost associated with growing replacement heifers and producing milk, so cheaper feeds that offer the potential to lower feed cost and improve the bottom line are worth considering. Some by-product feeds provide nutrients in a specific form, such as rumen undegradable protein (RUP) or highly digestible fiber, that are desirable for improving ruminal fermentation and animal health. When forage supplies are limited during a drought or when animal numbers are increased without increased forage production, other high-fiber by-product feeds may be used to extend forage supplies.

Producers should consider disadvantages of by-product feeds as well. Additional time for purchasing and arranging delivery, and for formulating and mixing rations will be required. Specialized storage and feeding facilities needed for certain by-product feeds may require construction of additional buildings or equipment purchases, both of which will require additional investments. If a by-product feed is only available seasonally or in insufficient amounts, it is questionable whether changing the current feeding program would be justifiable. These factors must be taken into consideration before using by-product feeds.

Economics

The main factor producers should consider when using by-product feeds is economics. Producers should check with several brokers to determine the market price and nutrient profile of each by-product feed considered. Prices vary throughout the year, so a few phone calls can save several hundred dollars over the course of the year. Once a delivery price has been established, the next step is to calculate the true cost for using the by-product feed. A sample worksheet for computing the total cost of a by-product feed is presented in Table 1 (p.2). For example, a producer is considering a by-product feed that can be purchased for $125 per ton delivered to the farm. If 23 tons are delivered, then the initial cost is $2,875. Interest costs equal $71.88 assuming an interest rate of 10 percent and that the

Table 1. Calculating the true cost of a by-product feed.

Price delivered to the farm	_______	tons @ $_______	/ton	$_______
Interest	_______	% for _______	months	_______
Shrinkage and storage losses	_______	%		_______
Extra handling cost	_______	Hr @ $_______	/Hr	_______
Total cost				_______
Divide total cost by tons				
Total cost per ton				$_______

load will be fed in three months. Shrinkage losses vary, but range from 15 to 30 percent for wet by-product feeds, 4 to 10 percent for dry feeds stored in a commodity shed, and 2 to 6 percent for the dry feeds stored in bins. If shrinkage and storage losses are maintained at 7 percent, an additional $201.25 is added to the cost. Extra time for handling the by-product feed can easily add another $50 or more to the cost. The total cost of the by-product feed is actually $139.05 per ton. Failure to include these costs does not provide the producer a true evaluation of the by-product feed's potential for reducing feed cost.

Once the true cost of the by-product feed has been established, the impact of using this feed on feed cost should be calculated. One of the simplest approaches is to calculate the value of the by-product feed based on the energy and protein content of the feed compared with corn and soybean meal. However, this method does not account for other nutrients provided or differences in the nutrient form (i.e., degradable versus undegradable protein). There are computer programs, such as FEEDVAL (University of Wisconsin), that will calculate the cost of the by-product compared with other feeds using more nutrient information Another way of evaluating by-product feeds is to use a least cost ration formulation program to compare its value against feeds currently being fed. This approach provides an analysis of this particular by-product feed at the current price, but it doesn't provide any information on usage if the price of the by-product feed changes. To determine the price range that the by-product feed will be economical, additional rations must be formulated using a least cost ration formulation program. The cost of the by-product feed in the first formulation is set at $0/ton to determine the upper cost at which usage will be reduced. In the second formulation, the price of the by-product feed should be increased to the upper cost calculated in the first ration plus $0.01/ton; then reformulate the ration. This process is continued until the by-product feed is no longer used in the ration. The information from these simulations will determine the price range that the by-product feed will be economical to use as well as the impact on the usage of the by-product feed and other ingredients. In some situations the by-product feed may be economical to include in the rations, but the amount used is reduced so it is not practical to feed.

Storage and Handling

Storage facilities must not be overlooked. Certain by-product feeds such as dried distillers grains can be stored in grain bins; however, other by-product feeds require specialized storage facilities such as a commodity shed or a pit (for wet feeds). Some producers have modified existing facilities without problems, but an engineer should be consulted to avoid problems that can occur because of the density of the feeds placed into these structures. Without proper storage facilities, spoilage and shrinkage losses will be higher.

Equipment for handling by-product feeds must be considered. The size of equipment needed for unloading, reloading, mixing, and delivering the feed to the animals will vary depending on the number of animals fed and amount of feed mixed. Equipment used for handling by-product feeds should be in good repair and kept clean. Clean equipment that has been in mud or manure before use to avoid spreading any pathogenic bacteria from sick animals to healthy animals. Since many by-product feeds are stored in a commodity shed or pit, the equipment will come in contact with the by-product feed. Hydraulic fluid, motor oil, or engine coolants are potentially toxic to animals and must be avoided.

Another factor to consider is the type of feeding system present on the farm. Many commodities are not suitable for use in feeding systems that include small augers. For example, wet feeds such as corn gluten feed or brewers grain, or bulky feeds such as cottonseed or cottonseed hulls, are not feasible in these systems. Ideally, a mixer with scales is available for weighing each feed used in the ration. Scales allow producers to mix rations containing the desired nutrient concentrations. Guessing the amount of a particular ingredient that is mixed into the ration results in rations that have nutrient imbalances and do not support the desired level of animal performance.

In most situations, producers must take a tractor trailer load of a by-product feed to realize the full economic savings. If the by-product feed is not used in a reasonable period of time, interest cost will be higher. Longer storage times can increase spoilage and shrinkage losses, which reduce savings in feed cost.

Nutrient Analysis and Variation

The typical nutrient content of many by-product feeds is outlined in Table 2 (p. 4). Because of differences in raw materials and processing methods, the nutrient content can vary significantly from the values provided in Table 2. An example of the variation measured in four by-product feeds commonly used is presented in Table 3 (p.5). As an example, the average crude protein (CP) content of corn gluten feed in this study was 22.9 percent (DM basis) with a minimum of 19.4 percent and a maximum of 33.4 percent. Based on this data set, the CP content could vary 18.7 percent from one load to the next. Since brokers do not always ship by-product feeds from the same source each time, producers need to ask their broker for information about the typical nutrient analysis and variation they should expect.

The variation associated with each nutrient differs among by-product feeds. In general, there is greater variation, as measured by the coefficient of variation (CV), in mineral concentrations because of the low concentration in each feed, but that is not always the case. For example, there is greater variation in the amount of unavailable CP in corn gluten feed and distillers dried grains than in any other nutrient. For these by-product feeds, this variation is related to differences in drying and reflects the amount of potentially heat damaged protein, which is an important consideration. Although the coefficient of variation for calcium in hominy feed is very high, the calcium concentration in hominy feed is very low, so this is not as much of a concern.

Each load of a by-product feed should be sampled for nutrient analyses. Submit samples to a certified laboratory for analysis using wet chemistry. The actual nutrient concentration should always be used to formulate rations rather than average book values because of the variation that naturally exist. Book values do not always reflect the actual nutrient content and may cause an excess or deficiency of a nutrient needed for supporting growth or milk yield. Maintain a record of the nutrient analysis to monitor the variation associated with each by-product feed. It is recommended that producers develop a set of nutrient specifications for purchasing each by-product feed that includes minimum or maximum concentrations of select nutrients to reduce the variation.

Environmental Considerations

Some by-product feeds have higher phosphorus concentrations than traditional feeds. Feeding large quantities of these feeds increases the amount of phosphorus excreted by the animal. The results of feeding excess phosphorus means increased acreage needed for spreading waste to comply with nutrient management plans, potentially limit future expansion plans, or both. To minimize these potential problems, do not include supplemental phosphorus in the diet when by-product feeds provide adequate amounts to meet the National Research Council

Table 2. Average nutrient concentrations of by-product feeds.

	DM	CP	RUP[1]	EE	NDF	ADF	NE_1	Ash	NFC
	%	%	%CP	%	%	%	Mcal/lb	%	%
	DM Basis								
Oilseed									
Cottonseed, fuzzy	90.1	23.5	22.9	19.3	50.4	40.1	0.88	4.2	2.7
Soybeans, raw	90.0	39.2	30.4	19.2	19.5	13.1	1.25	5.9	16.2
Soybeans, roasted	91.0	43.0	39.4	19.0	22.1	14.7	1.23	5.0	10.9
Energy Supplements									
Bakery waste	84.7	12.5	23.7	9.5	13.9	6.5	1.53	3.8	60.3
Beet pulp	88.3	10.0	76.3	1.1	45.8	23.1	1.07	7.3	35.8
Citrus pulp	85.8	6.9	31.7	4.9	24.2	22.2	0.80	7.2	56.8
Hominy feed	88.5	11.9	31.2	4.2	21.1	6.2	0.85	2.7	60.1
Molasses, sugar cane	74.3	5.8	18.1	0.2	0.4	0.2	0.80	13.3	80.3
Rice bran	90.6	15.5	47.7	15.2	26.1	13.1	0.93	10.4	32.8
Soybean hulls	90.0	13.9	44.6	2.7	60.3	44.6	0.66	4.8	18.3
Tallow	99.8	0.0	—	99.8	—	—	2.06	0.0	—
Wheat bran	89.1	17.3	20.7	4.3	42.5	15.5	0.73	6.3	29.6
Wheat middlings	89.5	18.5	23.7	4.5	36.7	12.1	0.76	5.0	35.3
Medium Protein Supplements									
Brewers grains, wet	21.8	28.4	35.4	4.5	36.7	12.1	0.76	5.0	35.3
Corn gluten feed	89.4	23.8	30.0	3.5	35.5	12.1	0.79	6.8	30.4
Distillers grains with solubles	90.2	29.7	50.8	10.0	38.8	19.7	0.89	5.2	16.3
High Protein Supplements									
Blood meal	90.2	95.5	77.5	1.2	—	—	1.06	2.5	—
Corn gluten meal	86.4	65.0	74.6	2.5	11.1	8.2	1.08	3.3	18.1
Cottonseed meal	90.5	44.5	47.9	1.9	30.5	19.9	0.78	6.7	16.4
Feather meal	93.3	92.0	65.4	4.6	—	—	0.98	3.5	—
Fish meal, menhaden	91.2	68.5	65.8	10.4	—	—	1.06	19.7	—
Peanut meal	92.3	51.8	13.2	1.4	21.4	13.5	0.91	5.8	19.6
Soybean meal, 48%	89.5	53.8	42.6	1.1	9.8	6.2	1.00	6.4	28.9
Forage Extenders									
Cottonseed hulls	89.0	6.2	55.7	2.5	85.0	64.9	0.48	2.8	3.5
Peanut hulls	91.0	7.8	—	2.0	65.0	74.0	0.19	4.2	12.0
Rice hulls	92.0	3.3	—	0.8	82.0	72.0	0.08	20.6	0.0

Source: National Research Council. 2001.
[1]Rumen undegradable protein with DMI of 4% of body weight.

Table 3. Variation in the nutrient content of select by-product feeds.

		CP[1]	UCP	ADF	NDF	EE	Ca	P	Mg	K
WBG[2]	Avg[3]	27.0	2.7	18.0	37.3	6.3	0.24	0.65	0.27	0.26
	Min	24.2	1.6	15.8	33.0	5.7	0.19	0.59	0.25	0.19
	Max	30.6	3.6	20.5	43.6	6.9	0.28	0.76	0.32	0.34
	CV	8.3	24.4	10.6	9.2	6.5	11.03	8.69	8.11	20.02
CGF	Avg	22.9	0.8	12.5	38.8	3.4	0.03	0.84	0.36	1.24
	Min	19.4	0.4	10.7	31.5	2.9	0.02	0.63	0.28	0.95
	Max	33.4	1.9	13.9	44.4	4.4	0.03	1.04	0.46	1.66
	CV	18.7	57.4	8.0	9.9	13.0	19.86	13.93	14.95	16.17
DDG	Avg	31.2	9.4	20.3	35.6	13.0	0.07	0.80	0.02	1.01
	Min	30.4	5.7	11.3	26.5	11.7	0.06	0.77	033	0.93
	Max	32.3	12.8	25.1	45.1	15.7	0.07	0.85	0.39	1.10
	CV	2.0	32.4	29.1	23.0	10.2	7.21	3.57	5.36	5.31
H	Avg	11.0	0.9	6.9	19.8	6.5	0.02	0.61	0.24	0.72
	Min	10.1	0.5	4.8	15.8	5.6	0.01	0.46	0.19	0.55
	Max	11.7	1.3	9.9	24.8	8.1	0.06	0.71	0.27	0.84
	CV	5.8	28.2	22.1	15.3	12.3	63.56	13.02	11.58	13.99
SH	Avg	11.8	1.3	46.6	64.4	2.5	0.60	0.13	0.25	1.32
	Min	10.8	1.0	40.4	57.3	1.2	0.18	0.04	0.07	0.35
	Max	14.2	1.6	49.9	71.6	3.7	0.73	0.19	0.29	1.60
	CV	9.8	12.7	6.2	5.9	35.7	25.60	29.99	26.06	26.62

[1]CP = crude protein; UCP = unavailable crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; EE = ether extract; Ca = calcium; P = phosphorus; Mg = magnesium; and K = potassium.
[2]WBG = wet brewers grain; CGF = corn gluten feed; DDG = distillers dried grains; H = hominy; and SH = soybean hulls.
[3]Avg = average; Min = minimum; Max = maximum; and CV = coefficient of variation.
Source: DePeters et al. 2000. *Prof. Anim Sci.* 16:69-99.

recommendations. Numerous research trials have demonstrated that feeding excess phosphorus does not improve reproduction efficiency or health of dairy cows. When phosphorus is fed in excess of NRC recommendations, additional calcium may be required to maintain normal calcium--phosphorus ratios in the diet. Producers and their nutritionists may need to consider limiting the amount of by-product feeds included in the diet to maintain phosphorus balance and comply with nutrient management plans. Researchers are working on technology to reduce the amount of phosphorus in by-product feeds and lessen these concerns.

Wet by-product feeds, such as wet brewers grains, wet corn gluten feed, and vegetable byproducts, must be stored in structures that minimize the runoff of nutrients that leach out during storage. Nutrients in runoff can potentially have a negative impact on ground or surface water supplies if not contained. These wet by-product feeds should be stored in facilities that will contain the runoff, such as pits or plastic bags.

Risk and Additional Responsibilities

Several risks and additional responsibilities are associated with using by-product feeds. As discussed previously, additional time is required for checking prices, managing inventories, and feeding (if the current feeding system is not set up for using by-product feeds). If a producer does not have sufficient time to devote to these tasks, then it may not be desirable to add by-product feeds into feeding programs. Large amounts of money can be invested in inventory that may reduce cash flow. The extent of investment depends on the number of by-product feeds, amounts fed, and the producer's current cash flow position.

The producer assumes complete responsibility for balancing rations to support desired growth or milk production levels and animal health with by-product feeds. Also, the producer assumes the responsibility for quality control including screening for any contaminants or poor quality feeds that feed companies normally provide. By-product feeds can be contaminated by a number of products, especially those that do not come from the food processing industry. For example, aflatoxin and other mycotoxins are potential risks in certain by-product feeds such as peanut meal, cottonseed, and grain screenings. Cotton products may contain gossypol that can be toxic when fed to certain monogastric or young ruminants or if too much is fed to mature ruminants. Residues from herbicides, pesticides, etc., must be avoided because of potential animal health problems and the risk of contaminating the resulting milk and meat. Most by-product feeds from the production of human foods have already been checked for these residues, but that may not be the case for by-product feeds from other sources.

Limits on Amounts Fed

Producers frequently ask how much of a by-product feed can be included in a ration. Table 4 (p.7) outlines some suggested limits for common by-product feeds in dairy rations. There are several reasons for limiting the amount of a particular by-product feed in rations including cost, palatability, moisture content of the total diet, protein balance, carbohydrate balance, fiber levels, and fat concentrations.

By-product feeds such as cottonseed meal and corn gluten meal are normally included in amounts needed to meet the protein requirements. Feeding more only increases feed cost. Excessive amounts of degradable protein in rations may not maintain production levels in high producing cows during early lactation. By-product feeds such as blood meal, feather meal, and fish should be restricted due to poor palatability.

Similarly, the need for a balance of carbohydrates may limit the amount of high-fiber feeds such as corn gluten feed, soybean hulls, or wheat middlings. Fiber levels normally determine the upper limit of high fiber feeds such as cottonseed hulls, peanut hulls, or rice hulls. Rice hulls also have high concentrations of silica, which will damage the digestive tract of the cow and should be limited if fed. By-product feeds such as bakery waste, distillers grains, and hominy feed have high concentrations of fat, which could interfere with normal fiber digestion if excessive amounts are included in the diet, especially if oilseeds are fed as well.

Moisture levels in the total diet should not exceed 50 percent under normal circumstances, which may limit the amount of wet by-product feeds such as brewers grain, corn gluten feed, and distillers grain. This is especially true when large amounts of silage are fed. However, research data has indicated that diets containing large amounts of wet by-product feeds can be fed in certain situations even when the moisture level exceeds 50 percent.

Whole Oilseeds

Whole oilseeds such as cottonseed and soybeans are good sources of energy, protein, and fiber. They are typically included in the ration to increase the energy density of the diet while maintaining acceptable fiber levels. These feeds contain approximately 20 percent ether extract (EE) or fat and should be limited based on the fat content of the ration. These feeds can be used to provide an additional 2 to 3 percent fat above that provided by the basal ingredients in the ration with no more than 5 to 6 percent total fat in the DM. Amounts greater than this may interfere with fiber digestion and normal rumen function. If additional fat is needed, it should be provided by a ruminally inert or protected fat source.

Table 4. Suggested limits for by-product feeds in rations.

	Maximum % of DM	Maximum lb DM per day[1]
Oilseed		
Cottonseed, fuzzy	10 - 15	4.5 - 6.7
Cottonseed, delinted	10 - 15	4.5 - 6.7
Soybeans, raw	10	4.5
Soybeans, roasted	10 - 15	4.5 - 6.7
Energy Supplements		
Bakery waste	8 - 10	3.6 - 4.5
Beet pulp	20 - 30	9 - 13.5
Citrus pulp	20 - 40	9 - 18
Hominy feed	20 - 35	9 - 15.7
Molasses	3 - 5	1.3 - 2.2
Rice bran	10 - 15	4.5 - 6.7
Soybean hulls	15 - 25	6.7 - 11.2
Tallow	2 - 3	.9 - 1.3
Wheat bran	15 - 25	6.7 - 11.2
Wheat middlings	15 - 25	6.7 - 11.2
Medium Protein Supplements		
Brewers Grains	15 - 25	6.7 - 11.2
Corn gluten feed	20 - 40	9 - 18
Distillers grains	15 - 40	6.7 - 18
Protein Supplements		
Blood meal	3 - 4	1.3 - 1.8
Corn gluten meal	No Limit	No Limit
Cottonseed meal	No Limit	No Limit
Feather meal	3 - 4	1.3 - 1.8
Fish meal	3 - 4	1.3 - 1.8
Linseed meal	No Limit	No Limit
Meat and bone meal	3 - 8	1.3 - 3.6
Peanut meal	No Limit	No Limit
Soybean meal	No Limit	No Limit
Forage Extenders		
Cottonseed hulls	30 - 35	13.5 - 15.7
Peanut hulls	12 - 15	5.4 - 6.7
Rice hulls	10 - 15	4.5 - 6.7

[1]Amounts are based on an intake of 45 lb dry matter per day and should be adjusted for actual dry matter content.

Whole cottonseed contain gossypol, which is toxic to monogastric and young ruminants. Although mature dairy cattle can detoxify gossypol, no more than 10 pounds of cottonseed products (cottonseed meal plus whole cottonseed) should be included in rations to prevent toxicity. Soybeans may be fed raw or roasted and can be cracked. Do not include raw soybeans in rations containing urea as they contain an enzyme, urease, which breaks urea into ammonia that will decrease the palatability of the ration. Roasting increases the amount of protein escaping rumen degradation. Roasted soybeans are especially effective when rations based on haylage are fed to high producing cows during early lactation. Do not grind oilseed since this releases the oil directly into the rumen and may interfere with digestion. Extruded oilseed are very digestible, but limit the amount fed to reduce the negative effect the free oil will have on fiber digestibility.

Energy Supplements

Several by-product feeds are good sources of energy. Some of these feeds have high concentrations of digestible fiber that the rumen microbes use for energy rather than starch. Other by-product feeds contain high concentrations of sugars, processed carbohydrates, or fats. The amount included in the ration should be based on the form of carbohydrate and fat concentration provided as well as total dietary concentrations. Saturated fats are more suitable for cattle than unsaturated fats as they are less likely to interfere with fiber digestion when fed at recommended amounts.

One measure many nutritionists use to describe the form of carbohydrate in a diet is non-fibrous carbohydrate (NFC). The NFC fraction represents the starch, sugar, and other soluble carbohydrates present in the feed. Corn contains approximately 75 percent NFC, which is primarily starch. Typically rations should be formulated to contain 32 to 40 percent NFC since higher levels of rapidly fermentable carbohydrate decrease ruminal pH, causing metabolic problems such as subclinical acidosis and laminitis as well as milk fat depression. High-fiber, by-product feeds are useful for balancing carbohydrate types to dilute NFC.

Soybean hulls are generally restricted to less than 25 percent of the ration DM due to their rapid passage rate through the small intestine. Beet pulp and citrus pulp are restricted more commonly due to total fiber levels and the need for minimal levels of NFC. Hominy feed also contains high concentrations of fat, which limits its use in diets. Rice bran, wheat bran, and wheat middlings are normally limited to less than 25 percent of the rations due to poor palatability. Peanut skins contain tannins that may decrease protein digestibility.

Bakery waste is normally limited to a maximum of 10 to 15 percent of the ration DM because of the high fat concentrations that could alter normal ruminal fermentation. The amount of fat from these sources reduces the amount of oilseed that may be included in the ration to keep fat concentrations from exceeding 5 to 6 percent of the total ration DM. Molasses is generally restricted to no more than 5 percent of the ration DM due to the possibility of digestive upsets that can occur with excessive amounts.

Tallow is considered to be more ruminally inert and may be used as a source of fat when the proper handling facilities are available. Limit blends of animal and vegetable fat to no more than 2 to 3 percent of the total ration DM. Vegetable oils contain high concentrations of unsaturated fatty acids that reduce fiber digestion in the rumen.

Medium Protein Supplements

The medium protein supplements contain moderate concentrations of protein and energy and normally include brewers grain, corn gluten feed, and distillers grains. These feeds are commonly available in wet or dry form. In some cases, dry matter intake and milk yield decrease when the total moisture content of the ration exceeds 50 percent, especially when large amounts of fermented feeds are used. However, recent research suggests that greater amounts of wet feeds, such as brewers grains, can be fed during the summer even though the moisture level of the diet may exceed 50 percent. Wet by-product feeds including brewers grains, corn gluten feed, and distillers grains should be used quickly and stored in a manner that reduces spoilage, especially during the summer. These feeds can also be used to extend or replace a portion of the forage as long as fiber concentrations are maintained and the amount of undegradable protein and NFC in the diet is balanced.

High Protein Supplements

The high protein by-product feeds contain greater amounts of protein and lesser amounts of energy. These protein supplements have higher concentrations of undegradable protein, which makes them useful for growing calves and high producing dairy cows. Blood meal, feather meal, fish meal, and porcine or poultry meat meals are not very palatable and must be limited to avoid depressed intake. Current FDA regulations prohibit feeding ruminant derived meat meal or meat and bone meal to ruminants to prevent bovine spongiform enchphalopathy (BSE).

Other protein supplements are not limited in the ration except for meeting the protein requirements since any excess increases ration cost. The amount of cottonseed meal may be restricted to a greater degree or not even used for very young ruminants if it contains gossypol due to the potential for toxicity. Peanut meal should be checked for aflatoxin as well due to the potential for toxicity.

Forage Extenders

Several by-product feeds can be used to provide bulk in the ration when forage is limited. These by-product feeds provide very limited amounts of protein and energy. Cottonseed hulls have been used most commonly and have worked very well in built-in-roughage type rations. Peanut hulls should be checked for aflatoxin prior to using them in rations. The use of rice hulls should be limited because of high concentrations of silica that is abrasive to the intestinal tract of the animal if used in moderate quantities.

Other By-product Feeds

Several other “unusual” by-product feeds are occasionally used by cattle producers. Some examples include candy, cocoa by-product, fruit pomace, fresh vegetables or fruits, and vegetable residues. Before using these feeds, the producer (or nutritionist) must know the nutrient composition of these products to determine what limitations should be imposed. For example, most candies are predominately sugar and should be treated like molasses. Producers should also determine if the by-product feed contains any compound, either naturally occurring or added during processing, which may be toxic to animals. For example, cocoa by-product contains theobromine, which can stimulate appetite when fed at 1 percent of the diet but is toxic when fed at 3 percent of the ration DM.

Handling is one of the biggest challenges for using many of these unusual by-product feeds. Many times these by-product feeds are still in individual wrappers (candy), packaged (donuts) or canned (milk) when received. The wrapping must be removed before the product can be fed. Although there are specialized machines that can remove the wrapping, the cost of this equipment is prohibitive given the volume of product available. Some individuals have devised means of getting the product separated from the wrapper without great expense.

Another challenge with some of these odd products is that the producer has to take all of the by-product feed produced and move it out of the plant as contracted. This requires some advanced planning since the plant may have a continuous production schedule that may require picking up a load at odd times.

Many of these unusual by-product feeds are wet, which presents a challenge in storing to prevent spoilage. Also, many of these by-product feeds may be available for short periods of time, such as cannery waste. Once the handling and storage issues have been addressed, the same guidelines for determining the nutrient content and the use apply. The nutrient composition of several unusual by-product feeds is presented in Table 5 (p. 10).

Table 5. Chemical analysis of unusual by-product feeds (DM basis).

Item	DM (%)	TDN (%)	NE_1 (Mcal/lb)	NE_m (Mcal/lb)	NE_g (Mcal/lb)	CP (%)	EE (%)	ADF (%)	Ash (%)	Ca (%)	P (%)	K (%)	Mg (%)
Apple pulp	21.4	74.0	0.77	0.78	0.47	7.8	6.3	26	4.9	0.10	0.10	—	—
Bakery waste	92.0	89.0	0.94	1.00	0.69	10.7	12.7	13	4.4	0.14	0.26	0.53	0.26
Beans, cannery residue	9.4	72.5	0.75	0.76	0.45	23.5	3.0	17	—	—	—	—	—
Beans, green	89.0	63.0	0.65	0.63	0.35	16.9	3.8	32	9.0	—	—	—	—
Bread, waste	68.3	89.3	0.95	1.00	0.69	15.0	2.2	3	2.8	0.14	0.20	0.23	0.05
Cabbage	9.5	85.3	0.89	0.93	0.63	25.3	4.2	20	14.7	0.64	0.35	2.53	0.21
Cantaloupe	10.0	66.0	0.68	0.68	0.37	20.4	8.3	26	—	—	—	—	—
Carrots	12.0	84.0	0.88	0.64	0.64	9.9	1.4	11	8.2	0.40	0.35	2.80	0.20
Cereal byproduct	88.5	87.6	0.90	0.96	0.66	9.1	3.5	4	3.2	0.17	0.29	0.33	0.10
Chocolate byproduct	95.2	102.7	1.16	1.16	0.82	11.9	20.5	16	2.1	0.22	0.30	1.18	0.22
Cookie byproduct	90.1	95.0	1.02	1.06	0.74	9.7	10.6	7	3.0	0.23	0.29	0.46	0.13
Corn, cannery waste	23.0	70.0	0.72	0.73	0.42	8.8	2.7	29	5.9	3.40	0.63	—	—
Cotton gin trash	90.0	44.0	0.43	0.39	0.03	7.4	1.7	46	5.9	0.65	0.12	—	—
Lettuce	5.0	51.0	0.51	0.47	0.15	22.0	4.1	14	15.9	0.86	0.46	4.52	—
Melons	4.1	70.7	0.73	0.74	0.43	11.5	3.3	29	6.6	—	—	—	—
Onions, dried	91.4	57.6	0.59	0.57	0.25	12.6	2.0	28	8.0	1.80	0.21	1.76	0.16
Peaches	10.0	80.0	0.83	0.86	0.55	8.9	3.7	13	—	—	—	—	—
Peanut skins	94.0	65.0	0.67	0.65	0.37	17.4	25.5	16	3.0	0.19	0.20	—	—
Potatoes, fresh	23.0	81.0	0.85	0.90	0.60	9.5	0.4	3	4.8	0.04	0.24	2.17	0.14
Tomatoes	6.0	69.0	0.71	0.70	0.43	16.4	5.0	11	—	0.16	0.49	4.21	—
Turnips, fresh	9.0	85.0	0.89	0.95	0.65	11.8	1.9	34	8.9	0.59	0.26	2.99	0.22

Source: Waller. 2004.

Summary

By-product feeds can be used to provide economical sources of nutrients for cattle. These feeds should be sampled and analyzed frequently to determine their nutrient content, and rations should be balanced using the actual nutrient concentrations rather than table values to assure that desired nutrient concentrations are provided. The amount of a by-product feed included in a ration should not exceed the recommended guidelines under most conditions. If the limits are exceeded, the producer must examine the nutrient profile of the ration carefully to insure that desired production levels can be achieved and animal health will be maintained. The moisture level of wet by-product feeds and the total ration should be monitored to insure that proper amounts of the by-product feed are added to the ration and that intake is maintained. Producers should store by-product feeds properly to reduce shrinkage and prevent molding and spoilage. Additional time and management are required if commodities are to be used; however, the benefits are generally considered worthwhile to most producers.

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MP434

Management of Hay Production

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University of Arkansas, U.S. Department of Agriculture, and County Governments Cooperating

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Introduction

The production and storage of hay is an integral component of most livestock enterprises in Arkansas. Some producers maintain a full line of hay equipment and produce large quantities of hay; others prefer to purchase hay to meet their needs. An understanding of the processes involved in harvesting and storing hay is critical to the success of hay feeding. This publication will discuss the management of hay production, measures or indicators of forage nutritive value, toxic substances in hays, hay sampling, hay analysis and ration formulation.

Hay Testing and Interpretation of Results

Hay Analysis. The first step in developing a hay feeding program that optimizes livestock production is to test all hay for nutrient value. Estimating the nutritive value of hay from book values or visual evaluation will lead to errors in feeding. This results in reduced animal performance, costly errors in under or overfeeding and loss of potential profit.

Nutrient composition data from the University of Arkansas Cooperative Extension Service Forage Database is used here to illustrate the variability in nutrient content of hays (Table 1). The database contains nutrient composition values for 2,979 samples of bermudagrass hay. The crude protein (CP) values of bermudagrass hays ranged from 3.7 to 23.7 percent, and total digestible nutrients (TDN) ranged from 40 to 81 percent. These data and other values shown in Table 1 indicate that it is futile to attempt to estimate the nutrient content of hay. **An efficient hay feeding program must start with hay analysis.**

A representative sample of the hay available for feeding should be submitted for analysis before the hay feeding period. The University of Arkansas Agricultural Services Laboratory will analyze samples submitted through Cooperative Extension Service offices, or samples may be sent to a private laboratory. In some cases, an analysis may be provided by a feed company.

A routine hay analysis usually includes (1) moisture or dry matter (DM) content, (2) CP and (3) analysis of structural plant fiber that may be reported as crude fiber, acid detergent fiber (ADF) or neutral detergent

Table 1. The percentages and ranges of dry matter (DM), crude protein (CP), total digestible nutrients (TDN), calcium (Ca) and phosphorus (P) of Arkansas hays (DM basis).

Hay	Number Samples[1]	DM Avg[2] (Range)[3]	CP Avg (Range)	TDN Avg (Range)	Ca Avg (Range)	P Avg (Range)
Alfalfa	364	88 (63-95)	18.5 (6.1-33.1)	61 (37-78)	1.25 (.56-2.07)	.31 (.19-.43)
Bahiagrass	173	88 (72-94)	9.6 (4.1-17.6)	57 (46-77)	.49 (.30-1.07)	.21 (.10-.32)
Bermudagrass	2,979	87 (61-97)	12.4 (3.7-23.7)	60 (40-81)	.51 (.10-1.21)	.28 (.08-.61)
Bluestem	57	87 (66-94)	9.4 (2.6-15.6)	56 (37-71)	.49 (.32-.64)	.28 (.18-.40)
Bromegrass	29	88 (79-93)	10.7 (3.9-27.4)	56 (50-65)	.63 (.45-.78)	.10 (.08-.12)
Clover	45	87 (68-93)	14.0 (6.1-21.3)	56 (31-66)	1.12 (.55-1.93)	.27 (.09-.50)
Dallisgrass	32	89 (80-94)	10.8 (6.3-20.4)	58 (42-79)	.55 (.51-.58)	.26 (.22-.30)
Fescue	906	87 (64-97)	11.2 (3.9-22.4)	54 (42-70)	.50 (.24-.85)	.30 (.11-.51)
Johnsongrass	123	85 (63-94)	11.0 (4.0-21.7)	62 (48-73)	.57 (.22-1.01)	.32 (.19-.48)
Legume/grass mix	200	87 (63-94)	12.6 (5.6-26.6)	55 (41-71)	.78 (.30-1.32)	.28 (.11-.47)
Mixed grass	2,376	87 (60-99)	11.1 (2.1-24.8)	53 (35-72)	.58 (.12-3.06)	.30 (.04-.66)
Orchardgrass	157	87 (62-95)	13.5 (6.3-23.6)	57 (45-68)	.51 (.16-.92)	.34 (.17-.49)
Ryegrass	195	87 (64-96)	11.8 (3.9-26.7)	56 (45-68)	.50 (.26-1.15)	.29 (.10-.53)
Sudangrass	254	84 (65-95)	11.6 (2.5-20.2)	62 (42-83)	.69 (.36-.96)	.31 (.21-.43)
Wheat	66	87 (68-93)	11.3 (4.4-19.4)	55 (38-68)	.43 (.36-.53)	.38 (.23-.48)

[1] Indicates the number of samples in the database which were averaged for CP and TDN values. Fewer samples were analyzed for calcium and phosphorus.
[2] Average value. Values for DM and TDN were rounded to the nearest whole number.
[3] Range indicates the lowest and highest value observed. Range values for DM and TDN were rounded to the nearest whole number.

fiber (NDF). Most commonly, both ADF and NDF are reported; crude fiber is a remnant of the old proximate analysis system and is rarely used today. Concentrations of net energy or TDN are calculated using prediction equations based on CP and fiber levels. Mineral levels can be obtained from additional tests.

In most situations, cattle diets are formulated to meet requirements for CP and energy (TDN or net energy), assuming adequate feed intake. If a mineral deficiency, imbalance or toxicity is suspected, a mineral analysis should also be requested.

Hay Sampling. Inaccurate sampling of hay may lead to even greater errors than using average values from hay composition tables. A “lot” of hay is defined as the entire amount of hay cut from one field at one time. All hay in the lot should have been cut at the same stage of maturity, wilted under the same climatic conditions and stored such that weathering effects were the same. Each lot of hay should be sampled and analyzed independently.

Hay can be most accurately sampled using a bale core sampler. A minimum of ten core samples, one per bale, should be collected from each lot of hay. Core samples should be taken from the end of conventional rectangular bales and from the side of round bales and stacks. Angle the core sampling tool in an upward direction when sampling bales stored outside. This will avoid creating a passageway for water to enter the inside of the bale. In most Arkansas counties, county extension agents have sample bags, sampling equipment and information on obtaining hay samples for analysis.

Proper sampling technique for round bales.

Interpretation of hay analysis results. The results on a Feed Analysis Report should be evaluated relative to the nutrient requirements of the cattle that will be fed the hay. For example, the nutrient requirements of beef cattle are based on the animal’s weight, age, frame size, stage of production and expected performance.

A publication entitled *Beef Cattle Nutrition Series, Part 3: Nutrient Requirement Tables*, MP 391, is available at University of Arkansas Cooperative Extension Service offices. For beef cattle, hay tests results should be interpreted by using values in that publication.

For example, the following routine hay test shows nutrient values on an “as-fed” and DM basis. To determine whether the hay needs to be supplemented with either a CP or energy (TDN) supplement, use the DM basis column on the hay analysis report. A typical hay analysis follows.

HAY ANALYSIS

Chemical Composition	As-Fed Basis	DM Basis
Moisture	12.0%	
DM	88.0%	
CP	7.9%	9.0%
Total Digestible Nutrients	47.5%	54.0%

The CP and TDN requirements for 1,100-pound mature beef cows as shown in MP 391 are as follows:

NUTRIENT REQUIREMENTS

	Diet Nutrient Density, DM Basis	
	CP	TDN
Beef cows, 11 mo. since calving (last 1/3 pregnancy)	7.7%	52.1%
Beef cows, 2 mo. since calving, 20 lb peak milk	10.9%	60.4%

To properly interpret the hay analysis for a 1,100-pound mature beef cow at 11 months after calving (last 1/3 of pregnancy), compare the CP value of the hay on a DM basis to the nutrient requirement. The hay contains 9 percent CP, and the cow requires 7.7 percent. The hay has a higher level of CP than required. Therefore, no protein supplement is needed when this hay is fed free-choice to these beef cows during the last third of pregnancy. Likewise, the TDN value of the hay (54 percent) is greater than the TDN requirement (52.1 percent), so no supplemental energy is needed.

Supplementation is needed, however, for the lactating beef cow fed this hay. The requirements for CP (10.9 percent) and TDN (60.4 percent) are greater than the nutrients in the hay (9 percent CP and 54 percent TDN). Therefore, both supplemental protein and energy (TDN) would be required. In this case, the amount of supplement needed to meet the nutrient needs of the lactating cows could be determined with a computerized ration formulation program or by manual calculation. Other nutrient deficiencies (calcium, phosphorus, trace minerals, etc.) in hay can be determined by using the same procedure.

Using hay analysis results to match hay to cattle needs. Most cattle producers bale or purchase several lots of hay for feeding their animals. Due to environmental conditions and other factors, hay quality often varies. Analysis can be used to designate the highest quality hay for the cattle with the highest nutrient needs and the lowest quality hay for animals with the lowest nutrient needs. By matching hay to the nutrient needs of cattle, hay is used more efficiently, overfeeding and underfeeding errors are reduced, less supplement is needed, cattle performance is usually improved and profit potential is increased.

Hay quality of different forage species. The primary forages used for hay throughout Arkansas are fescue, bermudagrass and mixed grasses. Several other forage species are used to a lesser extent (Table 1). Only two forages, bluestem and bahiagrass, had CP values that averaged below 10 percent. Alfalfa hay averaged over 14 percent CP. Generally, beef cows require a diet containing less than 12 percent CP, but growing cattle, especially lightweight calves, often need more than 12 percent CP. Lactating dairy cows usually need higher levels of CP than can be provided by many hays. The use of high CP hays by beef cattle generally results in inefficient use of protein.

In hays produced in Arkansas, energy (TDN) is the most common deficiency for beef cattle. The average TDN values shown for hays in Table 1 would often be satisfactory for beef cattle, but the lowest quality hays (at the bottom of the range) would need to be supplemented with TDN, especially for growing and lactating cattle.

Visual Appraisals of Hay Quality

Can the nutritive value of hay be estimated by simply looking at it? The short answer is **no**! Generally, the CP or TDN content of forages can't be estimated by visual appraisal alone. The only way to accurately determine the feeding value of a specific lot of hay is by a laboratory analysis. Even if the hay looks the same as another hay crop, it may have drastically different nutrient levels. Variation in nutritive value occurs from year to year, field to field and cutting to cutting due to weather, management and several other factors.

Unfortunately, laboratory results are often not available when you are buying hay. The seller may offer an assessment of the hay such as, "it was fertilized," or, "it is that new hybrid everybody wants," but these comments really tell you nothing about hay quality. Fertilization or forage variety do influence hay quality, but other factors have a greater effect. In the absence of a hay test, certain visual characteristics of baled hay can help assess relative quality. With experience, these factors can be judged to help sort different lots of hay into groups of poor, average or good quality. Characteristics that should be considered when visually evaluating hay are forage maturity, condition, purity, color and smell. Once hay is purchased, it should be sampled and analyzed so that a feeding program can be developed.

Maturity. Forage maturity at harvest has greater influence on hay quality than any other single factor. Forages that become too mature before cutting have high concentrations of fiber that result in poor digestibility. Mature, high-fiber forages have lower CP and TDN levels than forages cut at less mature stages of growth. Some indicators of desirable forage maturity include:

1) the absence of seedheads and seed stems (mature blooms for legume hay);
2) small or fine stems;
3) a high percentage of leaf that is green compared to dead;
4) high leaf-to-stem ratio.

Condition. Hay condition refers to the leafiness and texture of the forage. Condition often reflects the harvest methods and conditions, as well as forage maturity. Desirable indicators of forage condition include:

1) a high leaf-to-stem ratio;
2) small, fine stems;
3) large leaves;
4) intact leaves with little evidence of shattering;
5) a soft feel or texture.

Legumes that are baled too dry will often have a large percentage of shattered leaves. Hay that is baled too wet is often very dusty or moldy; after storage, individual bale flakes also may be difficult to pull apart.

Purity. Hay purity is simply an observation of the relative proportion of weeds or foreign material in the hay. Certain weeds can decrease the nutritive value of the hay or be poisonous to livestock. Undesirable weeds easily can be established by feeding weedy hay purchased off the farm. High weed content can be the result of low soil fertility or other poor production practices. Foreign material such as dead forage matter, sticks and trash also can reduce hay quality and acceptability.

Color. Color probably has the biggest influence on sale price at hay markets and in private sales, and it easily biases visual appraisals. Although it can give an indication of harvest and storage conditions, **color is not a strong indicator of hay quality**. Yellow or bleached hay may indicate poor harvest conditions, advanced forage maturity or a lengthy storage period, but other factors should be considered before that conclusion is reached. Hay that is cut when wet may become bleached in the field, resulting in a yellow appearance. This can occur even though tests show it to be of good nutritive value. Hay that gets rained on during harvest may also become bleached in color. Additionally, research has shown that hay can have better nutritive value if it is cut at the right stage of maturity and gets rained on than other hay that is harvested at a more mature growth stage without rain damage. Hay stored outside that is exposed to the sun also may become bleached; the outside of a bale may be yellowed or bleached while the interior of the bale may still be green. Conversely, hay that is bright green may have poor nutritive value if it was harvested at an advanced stage of growth. A brown color inside the bale that is coupled with a tobacco-like odor indicates that spontaneous heating has occurred.

Smell. The smell or odor of hay is affected by the concentration of moisture in the hay at baling. A typical fresh hay odor is desirable. Hay that smells musty or moldy was baled at higher than desirable moisture levels or became wet during storage. Some hays that are baled before they are adequately dried have a tobacco-like odor and are brown in color.

Differences in forage species. As a general rule, cool-season grasses have less fiber and higher concentrations of CP than warm-season grasses when they are compared at the same stage of growth. This quality difference is due to plant physiology and not management factors. Cool-season grasses include ryegrass, cereal grains, tall fescue, orchardgrass and smooth bromegrass. Warm-season grasses include bermudagrass, bahiagrass, switchgrass and dallisgrass. Both cool- and warm-season grasses can have very good quality if harvested at the proper maturity. Generally, legumes have higher nutritive values than most grasses. Legumes include annual and perennial clovers, hairy vetch, lespedeza and alfalfa. Clover-grass mixtures will usually have higher nutritive value than grasses grown alone. Legumes also can improve the nutritive value of mixed hays harvested when the grass component is more mature than desired. Clover planted with fescue or ryegrass can lower nitrogen fertilizer costs and help to maintain good nutritive value if harvest is delayed.

Summary. To develop an economical feeding program, there is no substitute for hay analysis. In the absence of laboratory analysis, visual appraisal of hay can be useful in choosing good hay compared to poor hay. Hay with the best combination of desirable visual characteristics will generally be of good nutritive value, although a livestock ration can't be balanced from visual estimates. When visually appraising hay, more emphasis should be placed on maturity, condition and purity than on color or smell. Visual appraisal is learned by experience and by comparing visual observation with hay analysis results. Hay contests and field days are excellent opportunities to visually compare hay samples with results from laboratory analysis. **Visual appraisals should not be relied on for developing a livestock feeding program. Hay should be tested to determine actual forage quality.**

Mowing, Wilting and Baling Hay Crops

Harvest timing. No single factor affects the quality of hay or silage as much as the maturity of the forage when the mower is first pulled into the field (Table 2). As plants mature, stem is increased in the total forage mass, and therefore, the leaf-to-stem ratio is reduced. Increased proportions of stem usually result in higher concentrations of fiber (usually measured as NDF and ADF) and lower concentrations of CP and digestible DM. Unfortunately, the management of forage crops is complicated by the need to allow adequate initial growth, and either adequate regrowth or harvest intervals (depending on the crop) to maintain plant vigor and the health of the stand. Clearly, these competing management concerns require some compromise.

Table 2. Effects of maturity on forage quality[1].

Forage	CP	NDF	ADF	TDN
	- - - - - - - - - -	% of DM	- - - - - - - - -	
Alfalfa hay				
Early vegetative	23	38	28	66
Late vegetative	20	40	29	63
Early bloom	18	42	31	60
Midbloom	17	46	35	58
Full bloom	15	50	37	55
Bermudagrass hay				
Early vegetative	16.0	66	30	61
Late vegetative	16.5	70	32	54
15 - 28 days growth	16.0	74	33	55
29 - 42 days growth	12.0	76	38	50
43 - 56 days growth	8.0	78	43	43

[1] *Nutrient Requirements of Dairy Cattle* (1989).

For alfalfa, the general rule of thumb is to harvest before the crop reaches 1/10 bloom; however, the quality characteristics of alfalfa harvested at this growth stage may not allow producers to sell to top-dollar dairy markets. Bermudagrass should generally be harvested in intervals of about four weeks during the growing season. Individuals wishing to market or feed bermudagrass hay of the highest quality may reduce this interval by a few days, but haying intervals of less than 22 days are very rare. Tall fescue and other cool-season perennial forages should be harvested at the boot or early heading stages of growth. The interrelationships between maturity, concentrations of fiber (NDF) and digestibility for tall fescue are shown in Figure 1. The most rapid changes in fiber content and digestibility occur between the late boot and early bloom stages of growth. Weather permitting, producers should make every effort to harvest these crops at the best compromise between nutritive value and yield. The ideal harvest maturities for various forage crops are summarized in Table 3.

Figure 1. Digestibility and neutral detergent fiber (NDF) in Kentucky-31 tall fescue at various maturities. Source: C. S. Hoveland and N. S. Hill, University of Georgia.

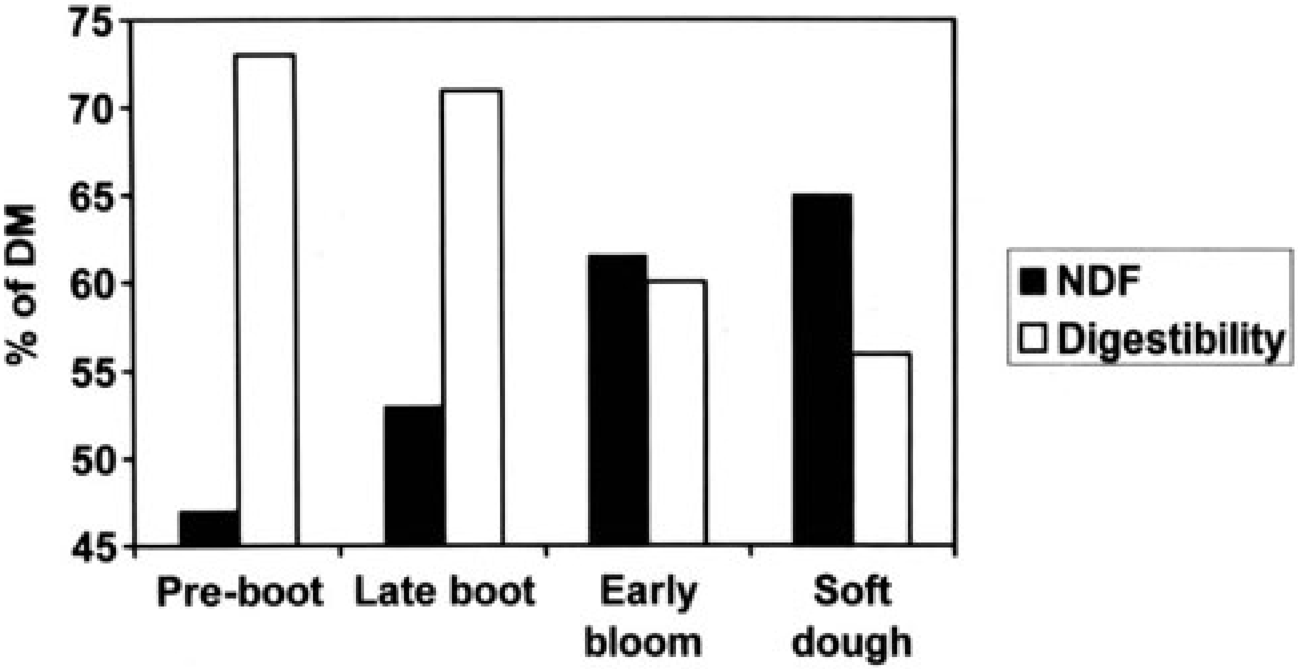


Table 3. Recommended growth stages or time intervals to harvest various hay crops[1].

Forage	Time of harvest
Alfalfa	First cutting: bud stage Second and later cuttings: 1/10 bloom First cutting following spring seeding: mid to full bloom
Orchardgrass, timothy or tall fescue	First cutting: boot to early heading Regrowth: four- to six-week intervals
Red, arrowleaf or crimson clovers	Early bloom
Sericea lespedeza	15 to 18 inches
Oats, barley, rye, ryegrass or wheat	Boot to early heading (nutritive value of rye will deteriorate much faster than other cereal grains after this growth stage is reached)
Annual lespedeza	Early bloom and before bottom leaves begin to fall off
Ladino or white clover	Cut at correct stage for companion grass
Hybrid bermudagrass	First cutting: 15 to 18 inches Second and later cuttings: every four to five weeks (intervals down to 22 days can be used for highest quality)
Birdsfoot trefoil	Cut at correct stage for companion grass
Sudangrass, sorghum-sudangrass and pearl millet	30 to 40 inches

[1] Ball, et al., 1996; *Southern Forages*, 2nd ed., Potash and Phosphate Institute and Foundation for Agronomic Research, Norcross, GA.

Mowing and wilting. The mechanics of hay production should begin with a caution to check and service all equipment thoroughly during the weeks before haying season. It is impossible to calculate the tons of hay that have been damaged because of poorly maintained equipment that was not field ready at harvest time.

The goal during the wilting process is to eliminate water as quickly as possible. This conserves nutrients by limiting respiration within the forage mass. Generally, grasses wilt much faster than legumes. Some legumes are notorious for their slow drying rate; for instance, red clover dries even slower than alfalfa. For this reason, it is essential that alfalfa and other legumes be conditioned when they are mowed. Normally, sickle-bar type mowers with conditioning rollers are used for this purpose. Generally, disc-type mowers are preferred for harvesting bermudagrass and other perennial grasses. Many grasses, such as bermudagrass, dry rapidly, and the conditioning step can often be omitted. When conditioning alfalfa hay, especially with roller-type conditioners, the risk of crushing blister beetles increases. Crushed blister beetles are lethal to horses consuming these forages; however, the stems of alfalfa plants dry so slowly that there is really no alternative to conditioning with either crushing rollers or a tine-type conditioner.

Summer annual grasses such as sudangrass, pearl millet and the sorghum-sudangrass hybrids should always be conditioned to increase the drying rate. In these forages, water can remain trapped in uncrushed stems long after the leaves are dry enough to bale. In contrast, conditioning rollers should be opened to a wide gap or disengaged when harvesting cereal grains with filling grain heads. By the soft-dough stage of growth, most of the nutritive value in these forages is associated with the grain head **and not the stover**. Therefore, an improperly adjusted conditioner that thrashes grain will greatly reduce the overall quality of the hay or silage.

Cutting height. The various mechanisms used by forages to convert carbon dioxide into sugars and then store these energy compounds to support regrowth after harvest have an important effect on forage management. Generally, plants that store their growth reserves underground, such as alfalfa, are unaffected by cutting height and can be mowed very short. In addition, plants that store growth reserves in stolons or “runners” that lay on the soil surface (bermudagrass and white or ladino clovers) typically are tolerant of close mowing or grazing heights. Many cool-season perennial forages, including smooth bromegrass, orchardgrass and, to a lesser extent, tall fescue, are somewhat sensitive to extremely close mowing heights. These types of plants store their growth reserves in the stem bases. Removal of this part of the plant by mowing too close will limit the regrowth potential of these forages, resulting in thin stands. Leave at least 2 to 3 inches of stubble when harvesting these forages.

Some types of forages require much higher (6- to 8-inch) mowing heights. These forages include sudangrass, pearl millet, sorghum-sudangrass hybrids, johnsongrass and eastern gamagrass. For annuals such as sudangrass, pearl millet and the sorghum-sudangrass hybrids, clipping at shorter heights will slow the regrowth response after harvest. In addition, these forages are notorious for accumulating nitrates when growing conditions are stressful. Typically, nitrates are most likely to accumulate in the highest concentrations in the lower portions of the stem. Maintaining a mowing height of 8 inches or higher will encourage aggressive regrowth and provide some help in reducing the risk of nitrate poisoning. Eastern gamagrass is a warm-season perennial that is extremely sensitive to close mowing heights. It is absolutely essential to leave at least 6 to 8 inches of stubble, measured from the top of the crown, when mowing this forage as a hay or silage crop.

Windrow width. If forages are to be baled as hay, they should be mowed in wide swaths to encourage drying. Dense, narrow windrows will not dry as fast; however, this can be used to slow wilting when alfalfa or other crops, such as cereal grains, are being harvested as silage and maintaining moisture in the windrow is essential. As the yields increase, the drying time required before baling increases regardless of windrow width.

Drying agents. Drying agents, such as sodium and potassium carbonate, that can be sprayed on alfalfa or other legumes at mowing are available. These products can reduce drying time, but the cost must be weighed against the likelihood of rainfall events. Drying agents do not usually enhance the drying time for cool-season grasses. This may occur because the leaf sheath prevents the drying agent from contacting the stem directly.

Mechanical manipulation. Unlike most grasses, alfalfa and other legumes should not be raked or tedded when the moisture content falls below 35 to 40 percent (Table 4). In addition, these processes should be as gentle as possible. The ground speed of the rake and the general aggressiveness of the raking mechanism should be reduced if leaves are obviously being shattered. Various mechanical process that are improperly managed will greatly encourage leaf and DM losses in alfalfa and most other legume hays (Table 4).

Grasses and legumes, however, are fundamentally different. In grasses, both the leaf and stem have some structural function; therefore, they are more similar in quality than in legumes. In alfalfa, the function of the stem is almost entirely structural, while the leaf is extremely fragile and contains most of the metabolic machinery of the plant. Therefore, legume leaves are extremely high in nutritive value, relative to the stem tissues that are heavily lignified. In addition, the quality of legume leaves changes only marginally with maturity, but the quality of the stems will decrease rapidly. In contrast, the digestibility of leaves and stems both decrease markedly with maturity in most grasses. Therefore, it is necessary to conserve the extremely fragile leaves of legumes during the haymaking process to maximize the nutritive value of the hay.

Balers. Using the proper baler is important when producing quality alfalfa hay. Generally, large round balers should be avoided. Some studies have reported losses of 13 percent of DM and 21 percent of alfalfa leaves with these balers. Conventional rectangular balers or large square balers that use a plunger system do a much better job of conserving leaves. The window of opportunity for baling alfalfa can be very short. Generally, alfalfa hay needs to be wilted to 20 percent moisture to prevent excessive spontaneous heating during storage; however, significant leaf loss will occur with any baler when the moisture content falls below this level. Preservatives are occasionally sprayed onto the forage at the baler in an effort to bale hay that is slightly wet, thereby conserving leaves. The most common of these preservatives is propionic acid, which can be effective in limiting the undesirable effects of respiration and spontaneous heating. These products generally permit the safe storage of hays that are marginally wet (probably < 30 percent moisture), and should not be viewed as a technique that allows producers to bale excessively wet hay.

Conservation of plant sugars. Plant sugars and other nonstructural carbohydrates are highly digestible; therefore, it is desirable to conserve these compounds during the haying process. Generally, perennial cool-season grasses have higher concentrations of nonstructural carbohydrates than either legumes or perennial warm-season grasses. Lush, immature forages usually have relatively low concentrations of sugars. Forages mowed late in the afternoon will have higher concentrations of plant sugars than those harvested in the morning; however, specific attempts to harvest sugars by postponing mowing until late afternoon are not necessarily advised except under arid drying conditions.

Nonstructural carbohydrates can be lost at several points during the haying process, and a large percentage of these compounds are lost even when weather conditions are ideal. During the wilting process, sugars are consumed (as an energy source) as plant cells try to continue functioning while the forage dries in the swath. This respiratory activity within plant cells is usually a minor cause of DM loss after the plant reaches about 40 percent moisture. Air temperature also affects respiration because enzymatic activity is increased at higher temperatures; however, this relationship is confounded because higher temperatures also increase drying rate. It is undesirable for mowed hay to remain in the swath for prolonged periods under poor drying conditions (high humidity, fog, etc.), even in the absence of rain. This will always result in poor recovery of nonstructural carbohydrates.

Rain damage. Unfortunately, research trials that describe the effects of rain on drying forage crops are quite limited. Most of this work has been confined to alfalfa and other legumes (Tables 5 and 6). Generally, rain will leach soluble nutrients (primarily sugars) from hay, resulting in DM loss, increased concentrations of fiber and decreased energy levels in the forage. The effects of rainfall on three legumes are shown in Table 5. These results illustrate the effects of leaching only; shattered leaf fragments were included in the analysis. When leaf shatter is also considered, quality depression and DM losses can be severe. Digestibility decreased from 72.7 to 49.3 percent and from 62.3 to 36.0 percent in response to a 2.4-inch rain event on dry alfalfa harvested at late bud stage and first flower, respectively (Table 6). Based on the few available research studies, the effects of rainfall appear to be more severe when the forage is dry. Generally, the effects of rainfall on drying grasses remain poorly defined; however, cool-season grasses contain large concentrations of sugars and other nonstructural carbohydrates that are water soluble and easily leached. Therefore, concentrations of less digestible structural plant fiber will likely increase after rainfall events. Leaf shatter that occurs as a result of rainfall is usually less of a problem with grasses than with legumes.

Table 4. Alfalfa losses of DM and leaves during various haymaking operations.[1]

Operation	% of DM Lost	% of Leaves Lost
Mowing	1	2
Mowing/conditioning:		
reciprocating mower, fluted rollers	2	3
disc mower, fluted rollers	3	4
disc mower, flail conditioner	4	5
Raking:		
at 70% moisture	2	2
at 60% moisture	2	3
at 50% moisture	3	5
at 33% moisture	7	12
at 20% moisture	12	21
Tedding:		
at 70% moisture	1	2
at 60% moisture	1	3
at 50% moisture	3	5
at 33% moisture	6	12
at 20% moisture	11	21
Baling, pickup + chamber		
at 25% moisture[2]	3	4
at 20% moisture	4	6
at 12% moisture	6	8
Baling at 18% moisture:		
conventional rectangular baler with ejector	5	8
round baler, variable chamber	6	10
round baler, fixed chamber	13	21

[1] Source: R. E. Pitt. *Silage and Hay Preservation.* Northeast Regional Agric. Engr. Service. NRAES-5. Ithaca, NY. Data compiled from: Kjelgaard [Trans. ASAE 22:464-469 (1979)]; Hundtoft [Extension Bulletin 364, Cornell University (1965)]; and Rotz [DAFOSYM: The Dairy Forage System Model. USDA- ARS (1989)].

[2] Requires a preservative for safe storage.

Table 5. Effects of rainfall and forage type on nutritive characteristics of three legumes. Analysis includes shattered leaf fragments.[1]

Treatment	% Leaf	Crude Protein	NDF[2]	ADF	Lignin	TNC	Forage Digestibility
	- - - - - - - - - - - - - - - - -	- - - - - - - - - -	- - - -	% of DM	- - - -	- - - - - - - - - -	- - - - - - - - - - - - - - -
Alfalfa							
Control	56.8	15.5	32.3	25.9	5.3	12.2	71.5
Wet 48 hours[3]	53.5	18.7	34.1	27.4	5.5	10.7	71.0
Wet 24 and 48 hours[4]	45.6	18.2	38.4	29.9	6.0	8.0	69.2
Red Clover							
Control	92.7	14.6	29.1	21.6	3.2	15.7	75.8
Wet 48 hours	97.0	16.9	32.7	24.1	4.0	12.7	72.6
Wet 24 and 48 hours	96.8	17.5	39.9	28.9	4.8	5.2	67.0
Birdsfoot trefoil							
Control	52.9	13.7	31.0	24.6	5.9	15.2	71.3
Wet 48 hours	48.1	13.9	36.0	29.6	7.1	13.4	70.2
Wet 24 and 48 hours	47.1	15.2	40.8	32.1	7.8	9.6	66.4

[1] M. Collins, *Agronomy Journal* 74:1041-1044 (1982).
[2] Abbreviations: NDF, neutral detergent fiber; ADF, acid detergent fiber; and TNC, total nonstructural carbohydrates.
[3] Artificial rainfall amount was 1.0 inch at 48 hours.
[4] Two applications of 1.0 inch of water at 24 and 48 hours.

Table 6. Effects of rain and plant maturity on alfalfa quality. Shattered plant matter was not included in the analysis.[1]

Maturity	No Rain	Rain[2]	Rain on Dry Hay[3]
	- - - - - - - - - - - -	% of DVM	- - - - - - - - - - - -
Crude protein			
Late bud	26.3	24.6	23.1
First flower	18.1	13.9	15.6
Digestibility			
Late bud	72.7	57.2	49.3
First flower	62.3	39.2	36.0
TNC [4]			
Late bud	4.65	2.00	1.21
First flower	4.46	1.89	0.98
NDF			
Late bud	32.4	45.4	54.8
First flower	42.2	64.1	69.8
ADF			
Late bud	27.5	38.5	46.2
First flower	36.4	53.0	58.4
Lignin			
Late bud	5.5	9.7	11.5
First flower	9.1	13.8	16.6

[1] M. Collins, *Agronomy Journal* 75:523-527 (1983).
[2] 1.6 inches of rain during curing
[3] 2.4 inches of rain on dry hay
[4] Abbreviations: TNC, total nonstructural carbohydrates; NDF, neutral detergent fiber; and ADF, acid detergent fiber.

Spontaneous Heating

Introduction. The negative consequences of baling hay before it is adequately dried are widely known to producers. Frequently, these problems are created by uncooperative weather conditions that prevent forages from drying (rapidly) to moisture contents that allow safe and stable storage of harvested forages. Negative consequences associated with baling hay before it is adequately dried include molding, spontaneous heating and undesirable changes in forage nutritive value.

Mechanisms. Spontaneous heating is the most obvious result of plant and microbial respiration within the hay bale. Respiration is the process in which plant cells and different microorganisms consume sugars in the presence of oxygen to yield carbon dioxide, water and heat:

plant sugars + oxygen➔➔➔➔➔carbon dioxide + water + heat

This process causes the internal temperature of any hay bale to increase and ultimately lowers the energy content and digestibility of the forage. Spontaneous heating actually helps to dry the hay because it encourages the evaporation of water. Many factors contribute to the extent of heating. These include:

1) moisture content at baling;
2) bale type;
3) bale density;

4) environmental factors, such as relative humidity, ambient temperature and air movement;
5) storage site;
6) use of preservatives.

Usually the extent of heating that occurs in any hay bale is a good indicator of the undesirable changes in nutritive value that may be observed after storage.

Figure 2 shows the typical patterns of spontaneous heating that occur over time in storage for conventional rectangular alfalfa hay bales made at 30 and 20 percent moisture. Beginning immediately after baling, the internal bale temperature rises due to respiration of both plant cells and microbes associated with the plant in the field. This heating usually lasts less than five days. Following a short period in which internal bale temperatures normally decrease (at 4 to 5 days post-baling), a prolonged period of heating begins that can last several weeks. This heating is the result of respiration by storage microorganisms. The hay bales made at 30 percent moisture maintained a higher internal bale temperature than the drier hay (20 percent moisture) for about 25 days. Similar trends can be observed for characteristics of spontaneous heating in bermudagrass hays (Figure 3).

Bale size and density also have a positive effect on heating in hay packages. However, the amount of heat developed per unit of DM is independent of bale density. This suggests that bale density increases spontaneous heating simply because more hay is packaged within the bale. Larger and denser packages also tend to have higher internal bale temperatures because the heat produced is more difficult to dissipate.

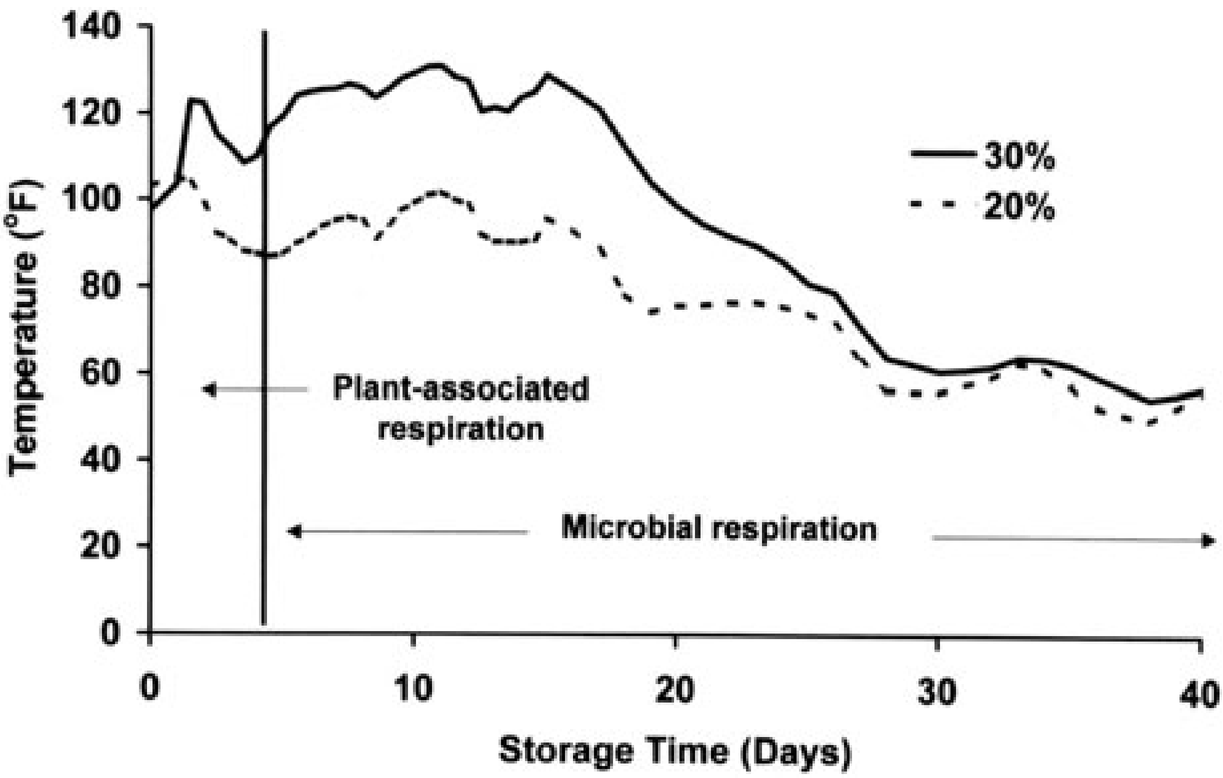
Measuring spontaneous heating. Under research conditions, spontaneous heating usually is not measured simply as internal bale temperature. The concept of heating degree days (HDD) is often used as a single index that incorporates both the magnitude and duration of heating during the entire storage period. Heating degree days usually are calculated by subtracting 86˚F (30˚C) from the daily internal bale temperature; these differences are then summed over all days in storage. An example of how HDD are calculated is summarized below:

Example:

Day	Bale Temperature, °F	Degrees > 86°F
1	108	22 (108-86)
2	104	18 (104-86)
3	115	29 (115-86)
	3-day total ➜	69

This concept is often used to limit effects of ambient air temperature and because negative changes in forage nutritive value are most noticeable when internal bale

Figure 2. Typical patterns of spontaneous heating in conventional rectangular bales of alfalfa hay packaged at 30 and 20% moisture and stored in small stacks in Manhattan, KS. Source: W. K. Coblentz.



temperatures exceed 86˚F. Heating degree days can be viewed as a relative measure of the heat produced within each bale. Heating degree days totaling 150 or less are indicative of relatively minimal spontaneous heating; conversely, totals in excess of 800 HDD are indicative of hay that was baled excessively wet, probably at about 30 percent moisture.

Of all the factors that affect spontaneous heating, moisture content at the time of baling is the most important. Figure 4 summarizes several alfalfa hay experiments conducted in Kansas. The relationship between moisture content and HDD is quite close ($r^2 = 0.902$). A one percentage unit increase in the moisture content of the forage at baling results in 56 HDD. A similar relationship was observed for bermudagrass hay baled in Fayetteville (Figure 5). In that study, about 43 HDD were accumulated for each increase of one percentage unit in the moisture content at baling. Regardless of the forage type, the level of heating that occurs is primarily driven by moisture content at baling, and this relationship is linear (HDD increases at a constant rate with bale moisture).

These studies were all conducted with conventional small rectangular bales. While it is generally assumed that similar relationships between moisture content and spontaneous heating exist in large round bales, there is limited documented research to support this. Typically, the recommended moisture content at baling for larger, round hay bales is lower than is necessary for conventional rectangular bales. A good rule of thumb for maintaining acceptable storage in conventional rectangular hay packages is to bale hay at 20 percent moisture or less; however this guideline is often reduced to 16 to 18 percent moisture for larger hay packages.

A recent study conducted with mixtures of orchardgrass and alfalfa at the University of Tennessee (Montgomery et al., 1986; *J. Dairy Sci.* 69:1847-1853) measured the internal bale temperature of 1,373-pound round bales made at 24 percent moisture during a 96-day storage period. These results were compared with those of 25-bale stacks of the same material baled as conventional rectangular bales. Maximum internal bale temperatures for both bale types occurred at about the same time (11 to 12 days of storage); however, the peak internal bale temperature for the round bales was about 190˚F compared to only 104˚F for the conventional rectangular bales. Internal bale temperatures in round bales can reach levels comparable to those in the University of Tennessee study through the respiratory processes of plant cells and microorganisms. However, higher temperatures are caused by oxidative chemical reactions that may occur as long as 30 days after baling. Clearly, large round bales are more prone to heat

Figure 3. Typical patterns of spontaneous heating in conventional rectangular bales of bermudagrass hay packaged at 31, 27 and 17% moisture and stored in small stacks in Fayetteville, AR. Source: W. K. Coblentz.

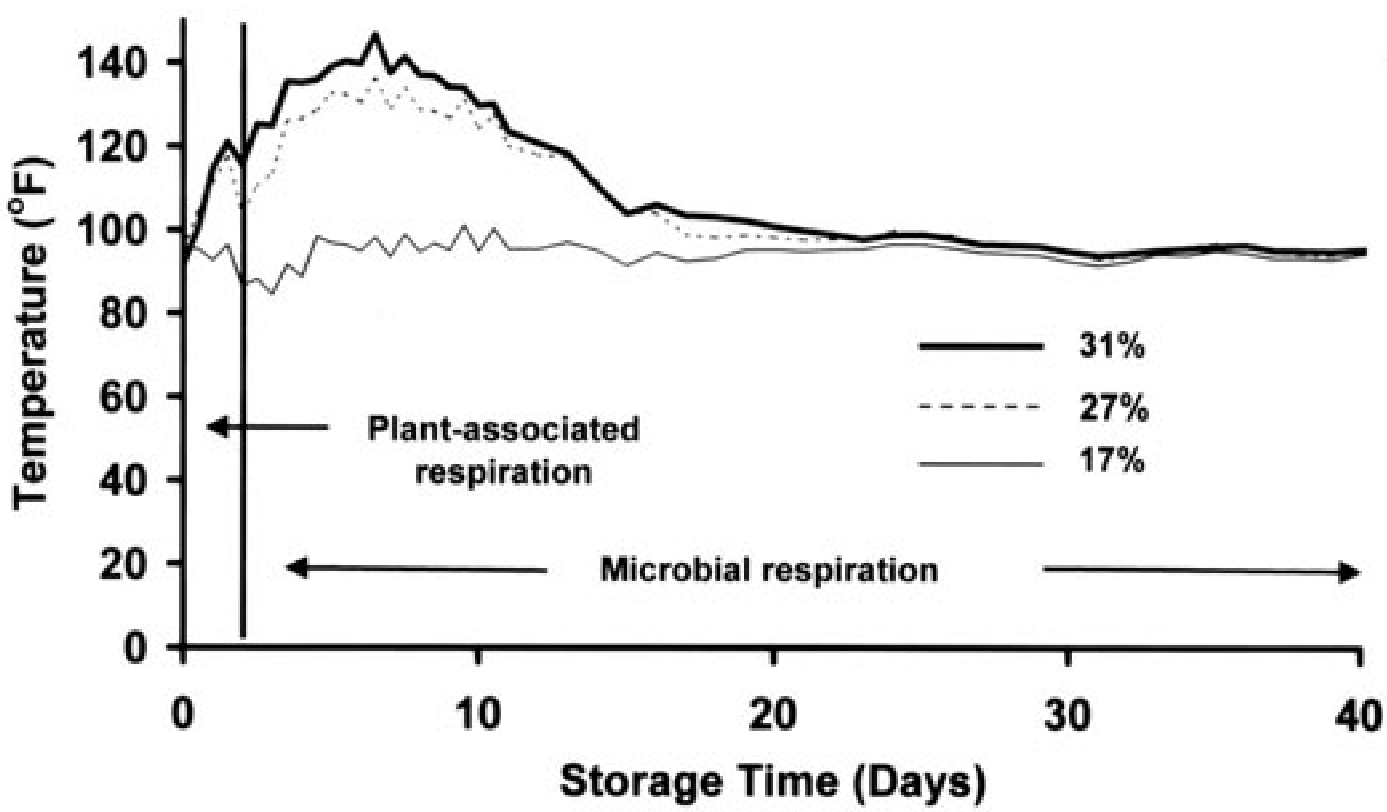


Figure 4. Relationship between heating degree days > 86°F (HDD) accumulated in conventional rectangular bales of alfalfa hay (■) and the concentration of moisture in the bale at packaging. Heating degree days can be interpreted as a single number that represents both the magnitude and duration of heating within the bale. Source: W. K. Coblentz.

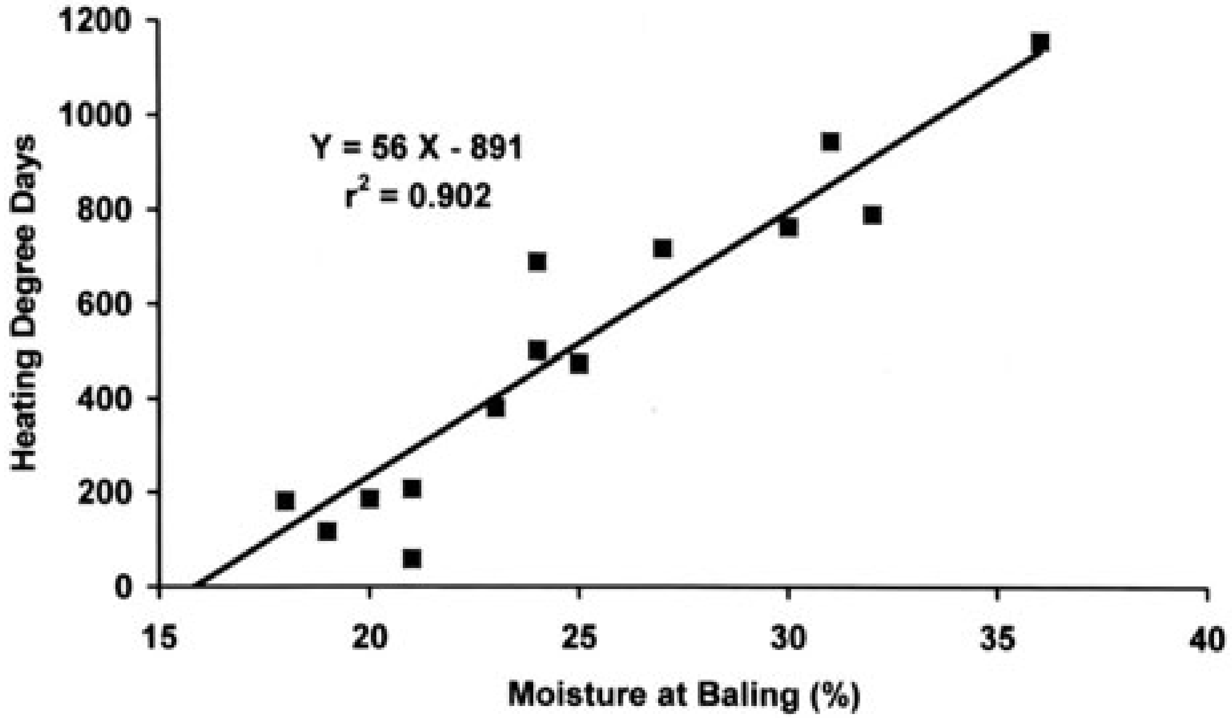
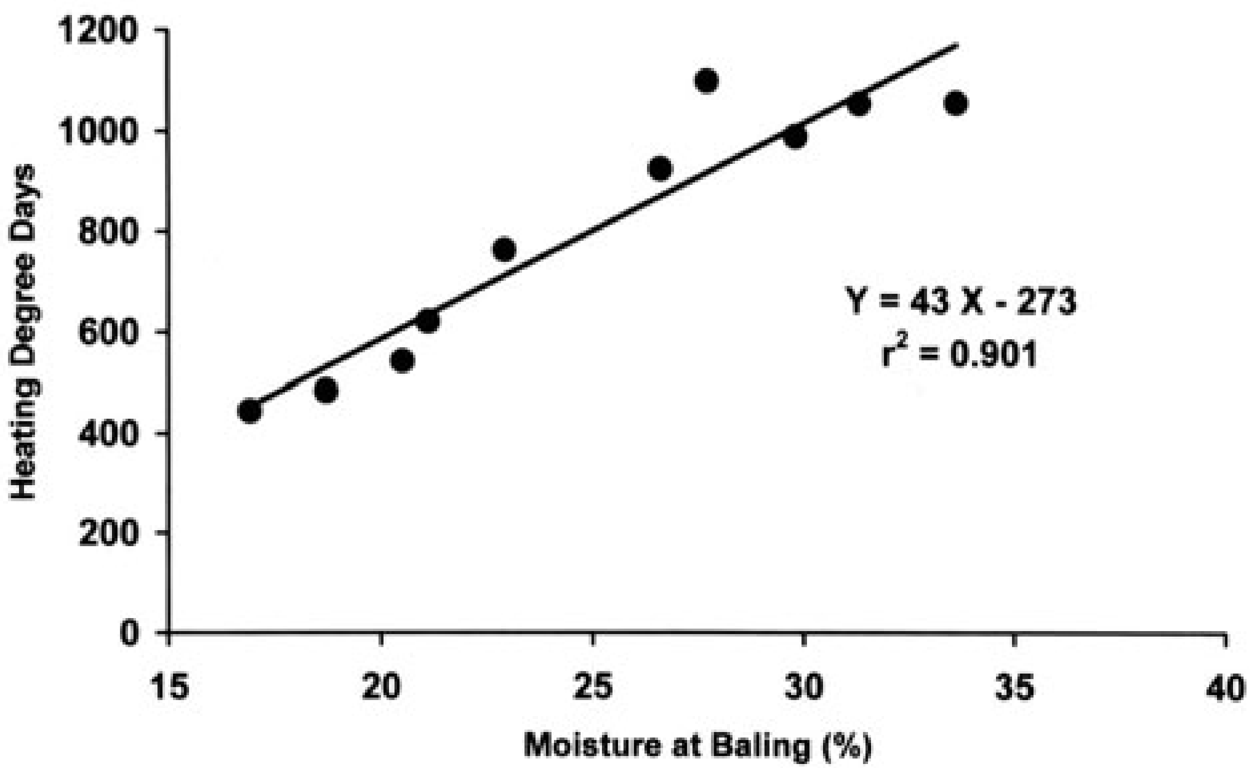


Figure 5. Relationship between heating degree days > 86°F (HDD) accumulated in conventional rectangular bales of bermudagrass hay (●) and the concentration of moisture in the bale at packaging. Heating degree days can be interpreted as a single number that represents both the magnitude and duration of heating within the bale. Source: W. K. Coblentz.



spontaneously and have a higher risk of combustion. Spontaneous combustion is thought to occur when internal bale temperatures reach about 340˚F. Normally, this does not occur in the center of the stack because lower concentrations of oxygen may limit temperature increases and make combustion less likely. It is more commonplace to observe spontaneous combustion near the outside of the stack where concentrations of oxygen are higher.

DM Recovery in Heated Hays

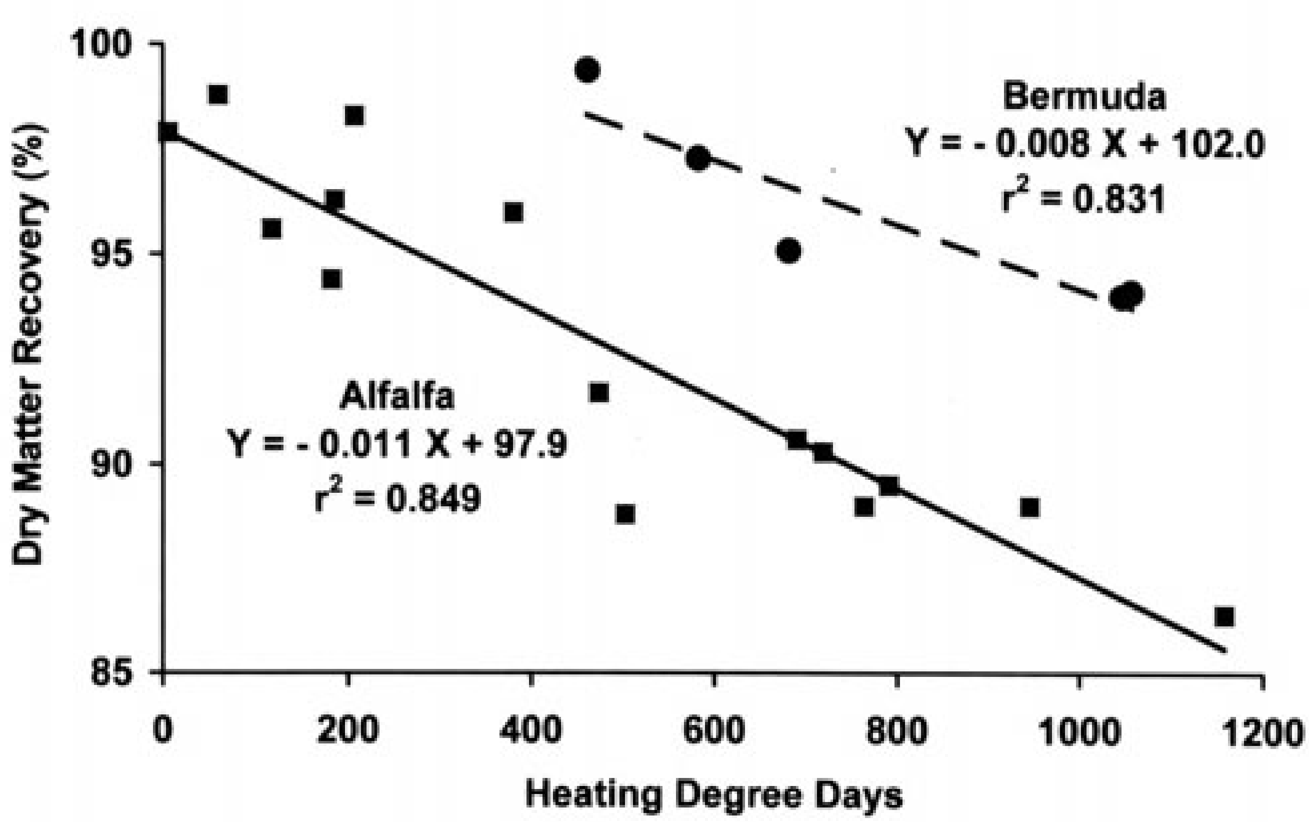
Dry matter is lost whenever heating occurs in hay bales. Dry matter losses occur in virtually all hay packages, but these losses are relatively minor without evidence of heating. Most of the DM that is lost during hay storage is nonstructural carbohydrate (plant sugars) that are respired to carbon dioxide, water and heat. Losses of DM will increase with increased moisture content at baling and subsequent spontaneous heating. Figure 6 summarizes DM losses in conventional rectangular alfalfa and bermudagrass hay bales over several experiments. For both hay types, about 1 percent of the initial DM in the bale is lost for every 100 HDD measured during storage. In the alfalfa hay, some DM loss (about 2 percent of the initial DM) occurred even when no HDD were measured during the storage period. This occurred because some respiration takes place when internal bale temperatures are below 86°F.

For bermudagrass hay, losses of DM also are related closely to the maximum internal bale temperature recorded during the storage period (Figure 7). These data indicate that bermudagrass hay packaged in conventional rectangular bales will lose 1.3 percent of the initial DM in the bale for every increase of 10˚F in the maximum internal bale temperature. It is important to note that Figures 6 and 7 both display data that was collected from conventional rectangular bales. Although it is assumed that these trends are similar in large round bales, these relationships cannot be applied directly to larger hay packages. Generally, DM losses associated with spontaneous heating are greater in larger hay packages.

Nutritional Characteristics of Heated Hays

Plant sugars. During the spontaneous heating process, sugars are oxidized. This results in increased concentrations of more stable plant components such as structural fiber (NDF, ADF) and, to a lesser extent,

Figure 6. Relationship between dry matter recovery after storage and heating degree days > 86°F (HDD) for conventional rectangular bales of alfalfa (■) and bermudagrass (●) hays made in Manhattan, KS, and Fayetteville, AR, respectively. Source: W. K. Coblentz.



protein. This results in a decrease in the energy content and digestibility of the forage. As a standing crop, the concentrations of nonstructural carbohydrates in alfalfa can exceed 20 percent of the total plant DM. Even when alfalfa is wilted under excellent drying conditions, the concentrations of nonstructural carbohydrates can fall to less than 8 percent of DM by the time the forage is baled. This occurs as a result of unavoidable plant respiration during the wilting process. During storage, alfalfa continues to lose nonstructural carbohydrates to microbial respiration. Hay packaged at 30 percent moisture has about half the concentration of nonstructural carbohydrates at the end of a 60-day storage period as hay packaged at 20 percent moisture. This is due to the greater heating that occurs in hay made at 30 percent moisture. The time interval when concentrations of nonstructural carbohydrates fall most rapidly (0 to 12 days) coincides with the period of most intense heating in hay bales (Figure 2). During this period of intense spontaneous heating, plant sugars in all hays are oxidized as a fuel source for rapidly proliferating microorganisms in the hay. Ultimately, this negatively affects the nutritive value of the hay because sugars are among the most digestible components of any forage.

Fiber components. Forage fiber components, such as NDF, ADF, crude fiber, lignin and ash, remain relatively stable during bale storage. These components essentially comprise the cell wall or structural portion of forages and are the least digestible parts of the plant. The NDF concentration of a forage is equated with the concentration of cell wall within the forage; low NDF concentrations normally indicate high nutritive value. The primary energy source for the respiratory processes in hay bales are nonstructural carbohydrates, or plant sugars. When hay bales heat spontaneously, concentrations of NDF, ADF and other fiber components increase. This is not because more plant fiber is actually constructed. The mechanism is indirect; as more plant sugars and other cell solubles are consumed during microbial respiration, the concentrations of the fiber components increase.

Recent research with alfalfa hay baled at 30 percent moisture showed that concentrations of NDF increased rapidly between 0 and 12 days of storage (the period of active respiration and high internal bale temperatures), but were relatively stable after 12 days (Figure 8). Higher concentrations of NDF were reached in the hay baled at 30 percent moisture because of the increased spontaneous heating that occurred in this hay. Similar relationships have been observed in bermudagrass hays made in Fayetteville, Arkansas, during the summers of 1998 and 1999.

Figure 7. Relationship between DM recovery after storage and the maximum internal bale temperature for conventional rectangular bales of bermudagrass hay (●) made in Fayetteville, AR, in 1998. Source: W. K. Coblentz.

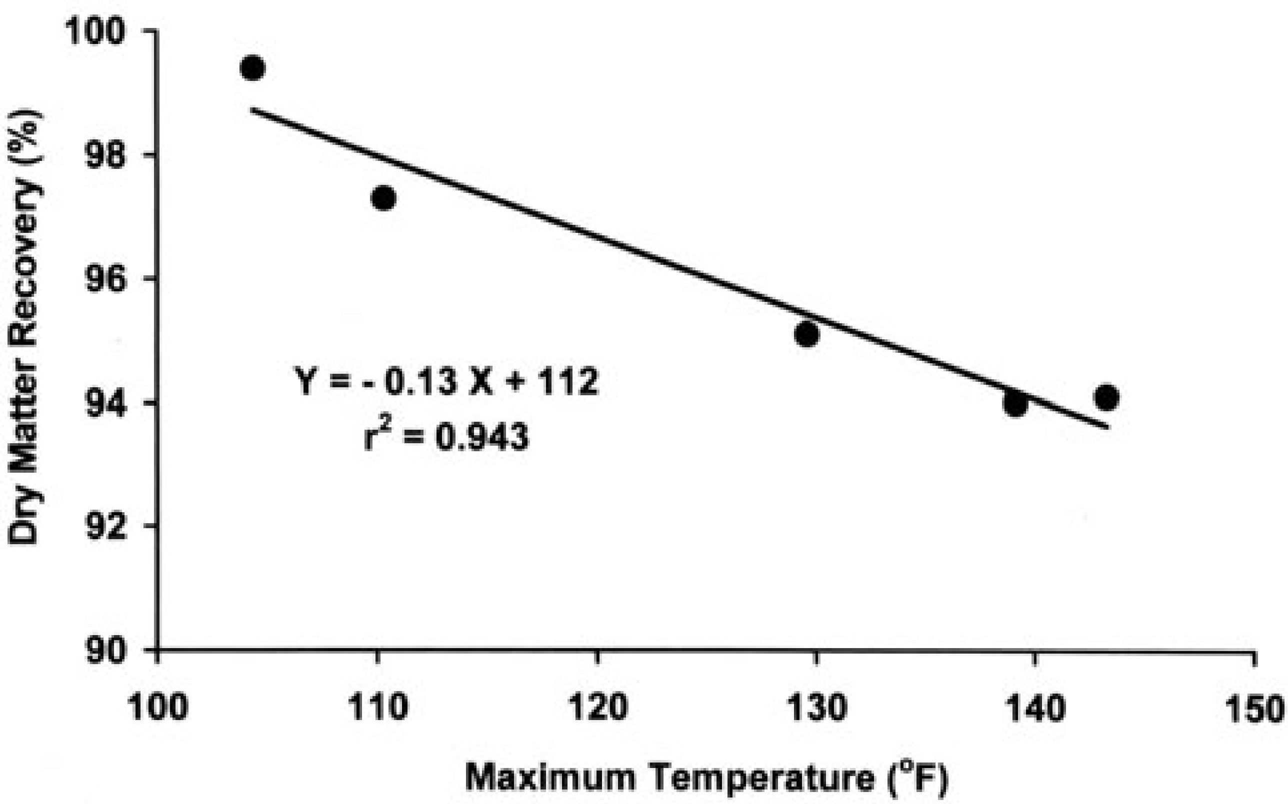


Figure 8. Relationship between the concentration of NDF and storage time for alfalfa hay packaged in conventional rectangular bales at 30 (—) and 20 (---) percent moisture in Manhattan, KS. Source: W. K. Coblentz.

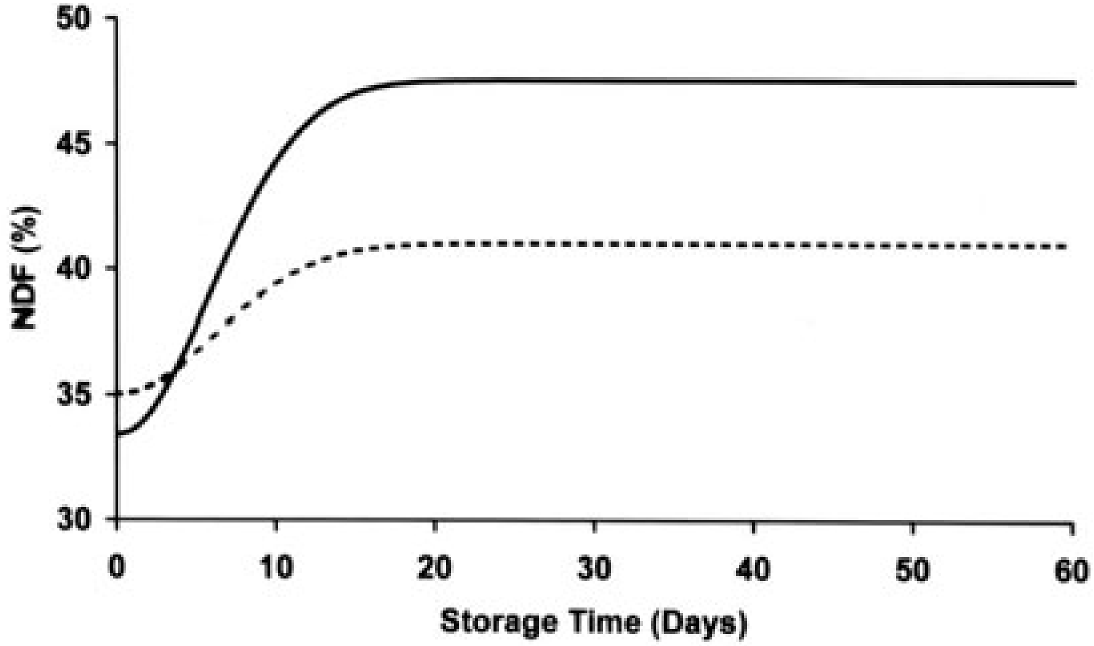
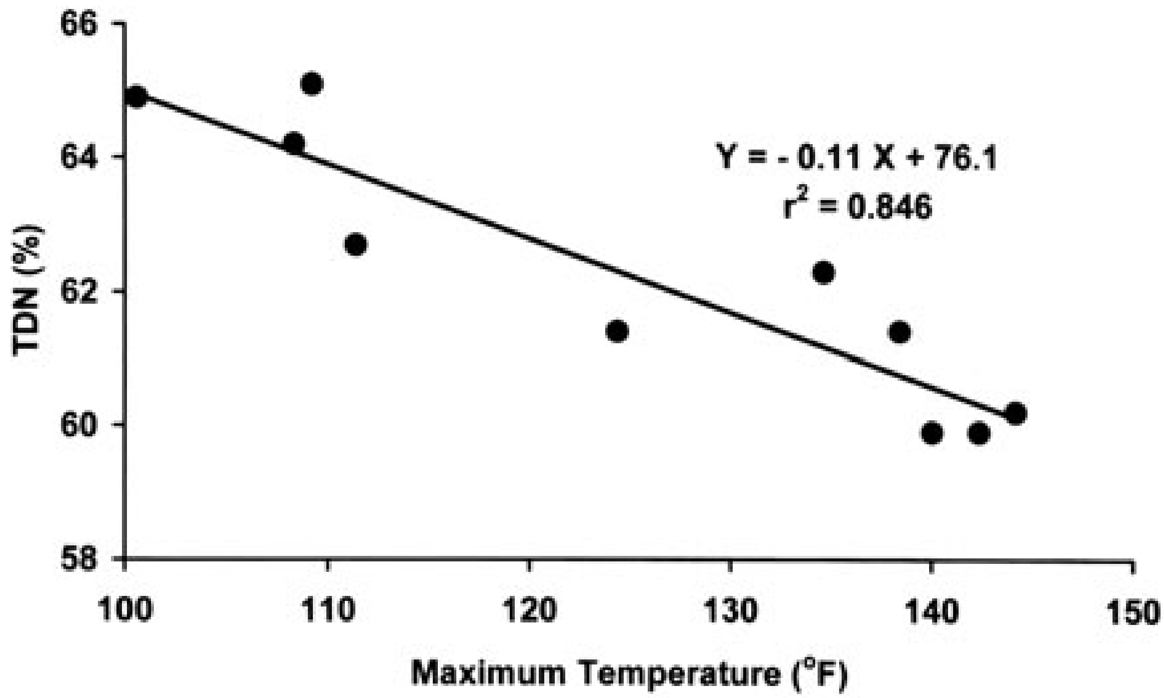


Figure 9. Relationship between energy content (TDN) and the maximum internal bale temperature for conventional rectangular bales of bermudagrass hay (●) made at Fayetteville, AR, in 1998. Source: W. K. Coblentz.



Total digestible nutrients (TDN). The concentration of TDN (or energy) in a forage is often predicted from equations on the basis of concentrations of fiber (ADF and/or NDF). As the concentrations of NDF and ADF increase, TDN usually declines. Any process (such as spontaneous heating or rain damage) that affects the concentrations of fiber components in a forage will often have a noticeable effect on the TDN content. In Arkansas, the TDN content of warm-season grasses is predicted from an equation that utilizes the concentrations of NDF, ADF and CP. Figure 9 illustrates the relationship between estimated TDN and the maximum internal bale temperature during storage for bermuda hay baled in conventional packages. The TDN content declined by

1.1 percentage units for every increase of 10˚F in the maximum internal bale temperature.

Digestibility. Most measures of forage nutritive value are affected negatively by spontaneous heating. Digestibility is no exception. As nonstructural carbohydrates and other highly digestible compounds within the forage plant are lost to respiration, concentrations of less-digestible plant components (particularly fiber components) increase noticeably. This often decreases the digestibility of the forage. For bermudagrass hay made in Fayetteville in 1998 (Figure 10), the effects of heating on forage digestibility appeared to be minimal when the internal bale temperature did not exceed 120˚F. However, as the internal bale temperature increased above 120˚F, forage digestibility decreased dramatically. In this study, forage digestibility dropped by about 14 percentage units when the maximum internal bale temperature exceeded 140˚F.

Crude Protein. Concentrations of CP are not stable during bale storage. Generally, the observed changes in concentrations of CP are somewhat dependent on time since baling. In the short term (< 60 days), CP content may actually increase in a similar manner to that described for fiber components; however, CP can also be used as a fuel for microbial respiration, particularly after supplies of plant sugars are exhausted. Table 7 shows the effects of spontaneous heating on the CP concentration of bermudagrass hay bales sampled after 60 days in storage. Although spontaneous heating has positive short-term effects on concentrations of CP, this should not be viewed as a justification for baling hay before it is dry.

The long-term effect of spontaneous heating during bale storage is to decrease CP content. Concentrations of CP are often reduced by 0.25 percentage units per

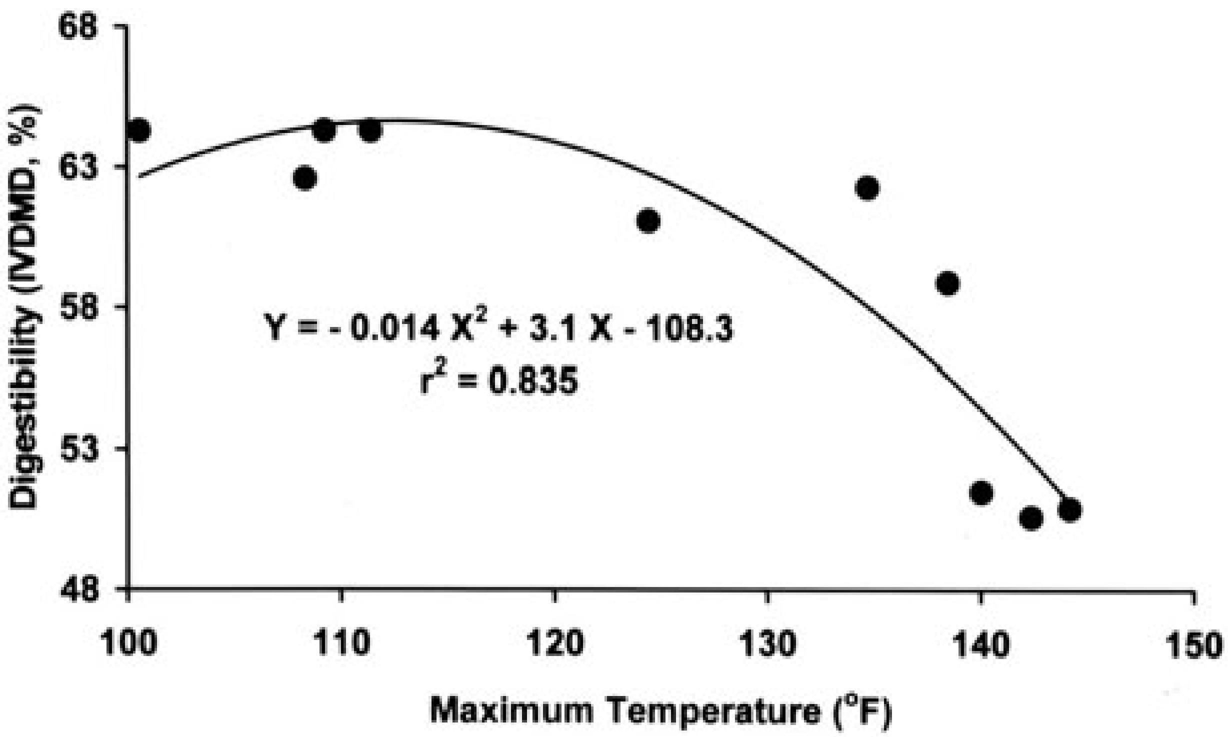
Table 7. Concentrations of crude protein (CP) for bermudagrass hay bales made from the same field and sampled after 60 days of storage at Fayetteville, AR, during 1998.[1]

Initial Moisture Content	HDD[2]	Maximum Temperature	CP
%		°F	%
31.3	1,055	144	15.3
33.6	1,057	142	15.7
27.7	1,100	140	15.0
29.8	990	138	15.0
26.6	925	135	15.8
22.9	763	124	14.2
21.1	621	111	14.0
20.5	542	109	15.4
16.9	445	101	14.2
18.7	484	108	14.5

[1] Source: W. K. Coblentz

[2] HDD = heating degree days > 86°F.

Figure 10. Relationship between digestibility and the maximum internal bale temperature for conventional rectangular bales of bermudagrass hay (●) made at Fayetteville, AR, in 1998. Source: W. K. Coblentz.



month of long-term storage due to volatilization of ammonia and other nitrogenous compounds; however, this loss is unlikely to continue indefinitely. Therefore, the concentrations of CP can increase in response to spontaneous heating during short-term storage (< 2 months) but decrease thereafter. The same forage sampled at different points in time can have noticeably different concentrations of CP that are not associated with laboratory errors.

Heat-damaged protein. Heat can damage forage proteins. Unlike fiber components, concentrations of heat damaged protein increase by direct mechanisms during bale storage. This causes forage protein to become indigestible when consumed by ruminants. Moisture content, the magnitude and duration of spontaneous heating and forage type all affect the amount of heat damage that may occur to forage proteins. Moisture plays a critical role in this process in two ways. First, it has a catalytic effect. This is the reason proteins in silages are more susceptible to heat damage than proteins in forages conserved as hay. Secondly, the moisture within the hay at baling stimulates spontaneous heating, which subsequently increases the probability of heat damage.

A positive linear relationship between heat damaged protein and spontaneous heating exists for both alfalfa and bermudagrass hay. All forages have some indigestible protein that is inherently unavailable to livestock. This fraction is small in most standing forages or unheated hays. Concentrations of indigestible protein in unheated alfalfa can range between 3 and 6 percent of all the protein in the forage. Typically, the indigestible protein in unheated warm-season grasses represents a higher percentage of the total forage protein. It can be higher than 20 percent in dormant forages. The concentrations of heat damaged protein increase at a rate of about 0.4 percentage units per 100 HDD in alfalfa hay, which is about half the rate observed for bermudagrass hay (0.8 percentage units per 100 HDD). Grass hays are typically more susceptible to this type of damage than alfalfa or other legumes. Ruminant nutritionists usually consider alfalfa hay to be seriously heat damaged when concentrations of heat damaged protein exceed 10 percent of all forage protein.

Other management factors, such as large round balers or higher-density hay packages, will increase the possibility of spontaneous heating and the probability of heat damage to forage protein. Even though concentrations of heat damaged protein increase by mechanisms different than those for NDF and ADF, most increases in concentrations of heat damaged protein still occur early in the storage period (< 20 days).

Ruminal protein digestibility. Considerable research effort has been devoted to assessing the ruminal digestibility of forage protein. This is the proportion of forage protein that is broken down or digested in the rumen. Forage protein that escapes the rumen intact is often referred to as "bypass protein." Much of this research effort has been centered around efforts to improve dairy production. High-quality forages, such as alfalfa, frequently have high concentrations of CP, but this protein is rapidly degraded in the rumen and inefficiently utilized by dairy cows and other livestock. Spontaneous heating limits both the rate and amount of forage protein digested in the rumen. While this may provide some benefit with respect to nitrogen retention and utilization, it should not be viewed as a justification for intentionally allowing forages to heat in the bale.

Digestion of protein in the rumen is naturally less rapid for warm-season grasses, such as bermudagrass. This natural resistance to ruminal digestion is associated with the differences in plant anatomy between warm- and cool-season plants. Unlike alfalfa and other legumes, it is not necessarily desirable to slow the rate of ruminal digestion of protein in warm-season forages. However, spontaneous heating will have the same effect on warm-season hays that it does on alfalfa.

Weathering Effects

Introduction. Spontaneous heating is not the only factor that can affect the nutritional value of stored hay. Over the last two decades, large round bales generally have replaced small rectangular bales as the preferred type of hay package largely because of the reduced requirement for labor. Many of these round bales are stored outside without any protection against the weather. The weathering of the outside layer can have a major impact on the nutritional characteristics and DM recovery of hay. It also may result in greater refusal and reduced intake by livestock.

Weathering is partially a physical process caused by the leaching of soluble forage nutrients during rainfall. Since most soluble compounds in forages are highly digestible, it is desirable to limit these losses during storage. A second type of weathering is the result of microbial activity that increases under moist, warm conditions. Infrequent heavy rains are likely to have less impact on weathering hay bales than smaller, more frequent, rainfall events. Losses are generally reduced in arid climates and in northern climates with severe winters because the environmental conditions are less favorable for microbial activity. Within any specific environment, DM losses are nearly proportional to storage time.

Crop factors. Some crops are naturally more resistant to weathering. Generally, fine-stemmed, leafy, weed-free crops, such as bermudagrass or tall fescue, form an excellent thatch that sheds water. Other crops with large, coarse stems do a poorer job of shedding water. Good examples of these types of forages include sudangrass, pearl millet, sorghum-sudangrass hybrids and johnsongrass. Water can easily penetrate bales made from these forages and accelerate the weathering process. Hays with coarse-stemmed weeds also do a poor job of shedding water and weather quicker than weed-free hays.

Bale size and density. Dense, uniform hay packages will limit weathering losses compared to loosely baled hay packages. Bales that have 10 pounds of hay per cubic foot in the outer layer will help to reduce penetration by rain. The density of the inner core is less important than the outer layer. Bale density can be increased by raking hay swaths into smaller windrows and reducing the ground speed of the baling tractor. These practices will result in more layers per bale and a greater overall bale density. Unfortunately, this also will increase leaf shatter in legume hays. While baling dense hay packages will help to limit weathering effects, it also will increase the likelihood of spontaneous heating. Therefore, every effort should be made to reduce the forage moisture content to 18 percent or less before baling. It should also be noted that larger hay packages have lower percentages of weathered forage than smaller hay packages; however, larger and more expensive tractors are often required to handle larger hay packages.

Limiting hay/soil contact. It is easy to overlook the importance of the bottom of the bale when discussing weathering losses. Some reports suggest that approximately 50 percent of the storage losses in hays stored outside occur at the hay/soil interface. This occurs because the dry hay acts as a wick, drawing moisture from the soil. Depending on the site, air movement may not be as great around the hay/soil interface as it is around the top of the bale. These factors combine to produce a moist environment at the bottom of the bale that is more favorable to microbial activity.

There are many ways to limit contact between hay and soil. Wooden pallets, railroad ties, pipe, tires and telephone poles can all be used to support hay bales and prevent contact with the soil. Ideally, any base should allow some air movement under the bales to facilitate drying. Crushed rock can be used as a base to limit contact with the soil. Crushed rock that is 1 to 3 inches in diameter and piled 4 to 8 inches deep should not trap water but should channel it away from the bales. Crushed rock also has the added advantage of lasting many seasons and repair of the storage site is simple. If bales must be placed directly on the ground, select a well-drained site with a sandy soil type.

Any site selected for the storage of hay bales should be in a sunny, breezy, well-drained area, possibly near the top of a slope. Bales should be oriented in rows that run up and down the sloping area, preferably with a southern exposure. Rows of bales oriented perpendicular to a sloping surface will trap moisture following rainfall. Rows of bales should be positioned with the flat ends of each bale butted together. The rounded sides of adjacent rows should not touch each other. There should be about 3 feet between adjacent rows to insure good air circulation and penetration of sunlight. Bales should not be stored under trees or ever rest in standing water. It is best to select a site that has no objects that will attract lightening, and the posting of no smoking signs may remind others that a hay crop represents a serious investment of time and money. It is also a good idea to have multiple storage sites. This will reduce the risk of a fire destroying an entire hay supply at one time.

Effects of storage method on losses of DM. Several studies have attempted to quantify storage losses of DM in large round bales. Table 8 summarizes a recent study with tall fescue conducted at the University of Kentucky. Four combinations of wrapping and storage methods were evaluated. These included 1) bales wrapped with

Table 8. Depth and volume of weathered layer and DM losses from tall fescue round bales stored inside and outside with different binding materials.[1]

Treatment	Dept of Weathered Layer	Weathered Layer as Percentage of Bale Volume	Actual DM Loss	DM Loss With All Weathered Layer Considered Lost[2]
	inches	%		
Plastic mesh wrap/ground	2.1	13.6	10.6	23.3
Solid plastic wrap/ground	0.6	3.9	3.6	7.8
Sisal twine/ground	4.4	26.8	18.2	34.1
Sisal twine/inside	0	0	5.7	5.7

[1] Collins, et al., 1995; *Journal of Production Agriculture* 8:507-513.
[2] Entire weathered layer considered to be unrecovered DM.

two layers of plastic mesh and stored outside, 2) bales wrapped with two layers of solid, 1.5-mil, self-adhesive wrap and stored outside, 3) bales tied with sisal twine spaced at 4-inch intervals and stored outside and 4) bales tied in the same manner as #3 but stored inside. Bales stored outside were positioned in a north-south orientation with 3 feet between adjacent bales. The storage site had a 5 to 7 percent slope. Bales stored inside were placed in a well ventilated structure that provided protection from the weather. All bales were stored for one year before sampling and analysis.

Twine-tied bales stored inside and solid plastic-wrapped bales lost relatively small amounts of DM (< 6 percent). This amount of DM loss is comparable to that observed in several other studies for round bales stored inside. Plastic mesh-wrapped and twine-tied bales stored outside lost considerably more (> 10 percent) of the total DM; however, the twine-tied treatment appeared to be the least desirable (18.2 percent DM loss). It is important to note that a relatively shallow (4.4 inches) weathered layer accounted for 26.8 percent of the total bale volume for twine-tied bales stored outside. Bales in the Kentucky trial measured 4 by 4.5 feet. Generally, the weathered layer in smaller bales will account for a larger portion of the total bale volume than a weathered layer of comparable depth in larger bales. However, even relatively shallow weathered layers can account for very large portions of the total bale volume. This suggests that producers are losing far more DM and nutritive value than they may realize.

Effects of storage method on nutritive value. In the University of Kentucky study, storage treatment had a large effect on the nutritive value of the exterior weathered layer after the one-year storage period (Figures 11 and 12). Concentrations of CP (Figure 11) were approximately two percentage units higher in the exterior weathered layer of bales wrapped with plastic mesh or sisal twine and stored on the ground than in the unweathered interior of the same bales. For bales wrapped in solid plastic and stored on the ground, concentrations of CP were a little more than half a percentage unit higher in the exterior weathered layer than in the unweathered interior of the same bales. There was essentially no difference between the weathered exterior and the unweathered interior for tall fescue hay bales stored inside. Elevated concentrations of CP in the weathered layer also can be observed in alfalfa hay (Table 9). These observations indicate that CP is more stable during the

Table 9. Forage quality of the interior and exterior portions of alfalfa round bales stored outside.[1]

Portion of Bale	CP	ADF	Digestibility
	- - - - - - - -	% of DM	- - - - - - - -
Unweathered	18.9	38.6	61.4
Weathered	19.4	45.8	46.9

[1] Anderson, et al., *Transactions of the American Society of Agricultural Engineers* 24:841-842 (1981).

Figure 11. Concentrations of crude protein (CP) in weathered and unweathered layers of tall fescue hay packaged in large round bales in Kentucky. Source: Collins, et al., 1995; *Journal of Production Agriculture* 8:507-513.

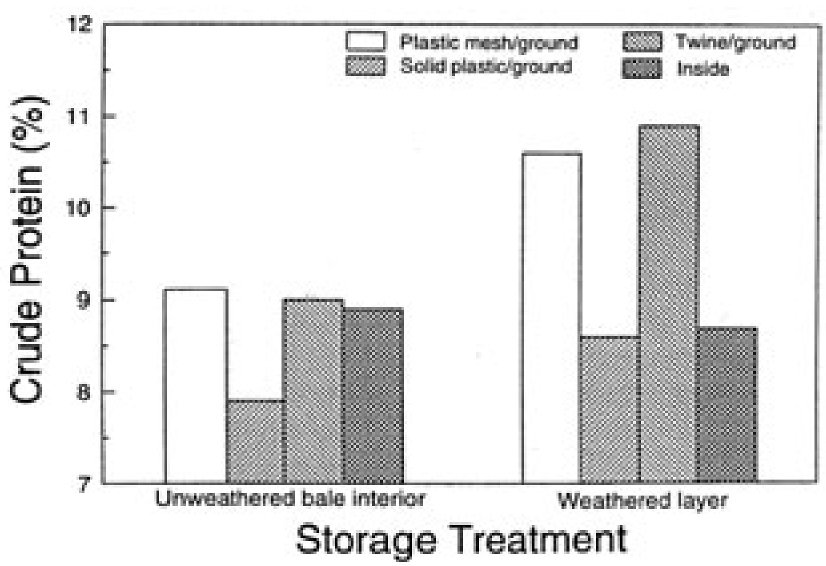
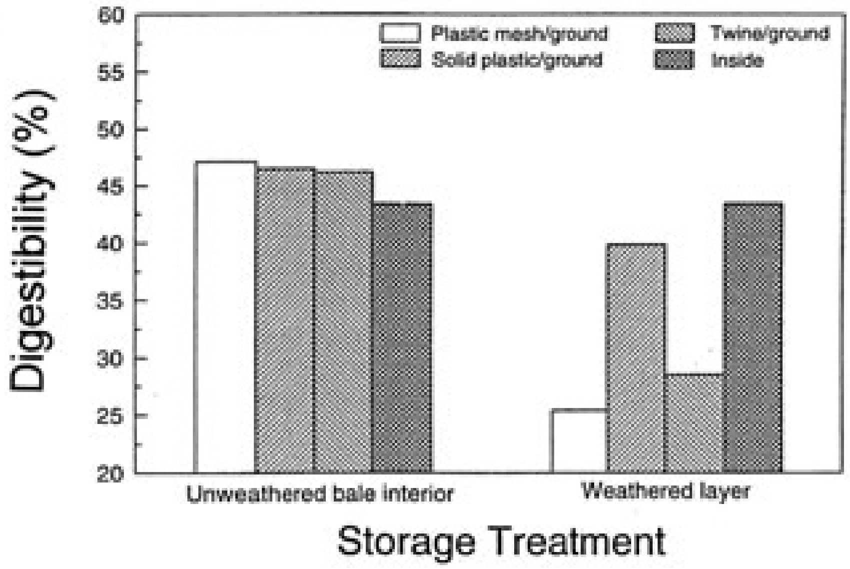


Figure 12. Digestibility of weathered and unweathered layers of tall fescue hay packaged in large round bales in Kentucky. Source: Collins, et al., 1995; *Journal of Production Agriculture* 8:507-513.



weathering process than other plant components (especially sugars), and that CP increases over time in the weathered layer because less stable plant components that are usually highly digestible are lost by leaching, oxidation or other processes.

Generally, the effects of weathering can be expected to increase the concentrations of fiber components (NDF, ADF, cellulose, hemicellulose and lignin) and reduce digestibility. The effects of weathering on the digestibility of tall fescue hay in the University of Kentucky study were quite substantial (Figure 12). The digestibility of the weathered layer for bales tied with plastic mesh or sisal twine and stored outside on the ground was reduced by about 22 and 18 percentage units, respectively, relative to the digestibility of the unweathered interior core of these same bales. For bales wrapped in solid plastic and stored outside on the ground, the digestibility of the weathered layer was reduced by about 6 percentage units relative to the unweathered core. There was essentially no change for bales stored inside. In a separate study, the digestibility of the weathered exterior layer for large round bales of alfalfa was 14.5 percentage units lower than the unweathered interior core (Table 9).

These findings indicate that the nutritive value of the weathered exterior layer of hays stored outside can be substantially poorer than the unweathered interior core of the bale. The effects of weathering on the bale as a whole will depend on the magnitude of changes in nutritive value between the unweathered and weathered portions, and the depth of the weathered layer. Simple management techniques should be used to limit weathering in hays stored outside. In general, it is much easier to justify expenditures, such as storage barns or sheds, to protect baled hays when the initial quality of the forage is high.

Cautions for Fertilization

Depletion of soil-test potassium. Some cautions are advised with respect to fertilization strategies for hay production. Although hay production is commonly driven by nitrogen fertilization from commercial sources or animal waste, it is important to remember that other nutrients are removed from the soil in addition to nitrogen. Placing fields with high levels of soil-test phosphorus in continuous hay or silage production is the most commonly suggested method for reducing soil-test phosphorus. This hay or silage should then be fed on other sites that are low in soil-test phosphorus. While this method is effective in reducing the available phosphorus loads in the soil, it will also reduce levels of potassium. This is of critical importance and must be addressed with potassium from commercial sources. Bermudagrass has a critical need for potassium. It is particularly important with respect to winter hardiness. Bermudagrass stands that are managed with continual fertilization with nitrogen but without any attention to potassium levels in the soil are prime candidates for winterkill and other problems.

These problems can surface rapidly. Table 10 illustrates this point. Bermudagrass from a high soil-test phosphorus site was fertilized with varying rates (0, 50, 100, 150, 200, 250, 300 lbs N/acre) of ammonium nitrate (34-0-0) and clipped on three dates during 2000. No other fertilizer was applied. The last waste

Table 10. Levels of soil test potassium on three dates in response to nitrogen fertilization and hay production (three harvests) on a high soil-test phosphorus site (571 lbs/acre) with a recent history of animal waste application. Source: W. K. Coblentz, J. L. Gunsaulis and M. B. Daniels.

N Fertilization Rate	Yield	Soil Test K (May 2000)	Soil Test K (November 2000)	Soil Test K (May 2001)
lbs N/acre	lbs/acre	- - - - - - - -	lbs K/acre	- - - - - - - -
0	9,692	511	370	325
50	10,310	506	375	306
100	11,198	442	367	293
150	11,684	480	343	318
200	12,467	524	350	316
250	12,564	495	347	301
300	12,532	514	372	291

application on this site was in 1999. In May 2000, soil tests indicated that potassium levels were considerably in excess of soil test recommendations, which is not unusual for sites with long histories of animal waste application. However, after one year of production (May 2001), levels of soil test potassium had fallen well below recommended levels, and supplemental fertilization was required. This was true at all levels of nitrogen fertilization. This response is much more rapid than is normally observed in attempts to "mine" phosphorus from these sites. Soils should be tested regularly to maintain acceptable levels of potassium in bermudagrass hay fields.

Nitrates. Certain forage crops (sorghum-sudangrass hybrids, sudangrasses, johnsongrass and others) are known to accumulate nitrates, particularly under stressful growing conditions. These crops should be fertilized conservatively with nitrogen fertilizer sources. Split applications are probably preferably to a single, larger application, but this will not insure acceptable nitrate levels in the forage. If possible, forages should be tested before mowing, grazing or feeding, especially if the climate conditions are stressful for plant growth. Consult with your county extension agent about submitting samples.

Nitrate poisoning can affect several species of livestock, including cattle, sheep and goats. It usually occurs after prolonged periods of cloudy, overcast days, and drought. Application of 2,4-D, plant diseases and soil nutrient imbalances may also cause these plants to accumulate nitrates. Nitrate toxicity typically occurs in cattle on a low plane of nutrition (low quality forages, not enough energy). Hungry, stressed cattle will usually consume more hay and become exposed to high levels of nitrates over a short period of time.

Nitrate itself is not especially toxic to cattle. It is normally converted to ammonia in the rumen and then incorporated by bacteria into microbial protein. Nitrate poisoning is caused by the accumulation of nitrite, an intermediate compound in this process. Nitrite absorbed in the blood affects oxygen-carrying capacity and can result in asphyxiation. There may be no clinical signs other than sudden death. If exposure is observed early enough, one may observe rapid breathing, restlessness, weakness, difficult breathing or convulsions. Treatment at this point is often unrewarding.

If samples are high in nitrates, the hay can often be fed safely, but it should be done with caution. Dilute the high nitrate hay with other hay that is low or free of nitrates. It is also important to make sure the cattle are gradually exposed to high nitrate hay. Maintaining a lower pH in the rumen will help to limit the accumulation of the nitrite intermediates. Feeding concentrate supplements with hays known to be high in nitrates will lower rumen pH and help to prevent the buildup of nitrites. Finally, water sources should be considered when managing high nitrate hays. Ponds, shallow wells and streams that collect drainage may accumulate high levels of nitrates. The effects of nitrate levels in forages, other feeds and water are additive; therefore, offering cattle water from deep wells or verifying that other water sources are low in nitrates may limit the risk of nitrate poisoning.

If nitrates are known or suspected to be high before the forage has been mowed, a couple of options are available that will subsequently reduce nitrate levels in the conserved forage. Most nitrates accumulate in the lower part of the stem; therefore, elevating the cutting height of the mower will reduce nitrate levels. Typically, nitrate levels are not reduced during the wilting or haymaking processes, but fermentation into silage will often cut nitrate levels by 50 percent. Producers who possess the equipment necessary to make silage can use this technique as an effective management tool when nitrate levels in the forage are known to be high.

Other Toxic Substances in Hay

When most people think of hay quality, they normally are considering its nutritional value for livestock. Another important, and sometimes overlooked, consideration is the presence of undesirable substances in hay which will affect livestock performance and, in a worst-case scenario, may result in death. In this section, these undesirable substances, the conditions under which they are produced and their effects on livestock are discussed.

Molds. The majority of mold contamination occurs in the field before harvest. A certain amount may occur secondarily during less than optimal storage conditions. The presence of molds may not always be obvious, and the signs observed in livestock may look similar to those observed for many other problems. Whether mold growth occurs early or late in the growing season depends on climate conditions. Typically mold production will be enhanced if there is stress during the early growing season, or when there are hot days followed by cool nights (promoting heavy condensation). Good observational skills and forage sampling techniques will reduce the risk of these health problems.

Most molds are harmless to livestock; however, their presence in feedstuffs causes decreased palatability and digestive problems. The molds that are of primary concern are those that produce toxic products known as mycotoxins. These mycotoxins can affect many of the animal's body systems. They interfere with many of the digestive enzymes and result in impaired growth and muscle formation. In addition, they can have detrimental effects on reproductive hormones, thereby resulting in impaired fertility, abnormal libido and decreased milk production. Mycotoxins can have adverse effects on the cells in the blood stream and can result in anemia and increased susceptibility to disease. Finally, they can affect the respiratory and nervous systems. These potential effects on multiple bodily functions make it difficult to pinpoint what might be wrong with the animal. This can have serious economic consequences.

There are several circumstances that would indicate there might be a mycotoxin problem. Frequently, only a few animals are affected rather than the entire herd. Outbreaks also may appear to be seasonal and often are associated with a particular climatic sequence. In addition, the treatment of affected animals with drugs and antibiotics often seems to be ineffective. There also may be evidence of fungal activity when the hay is examined. The level of mycotoxins can be quite uneven throughout the forage sample; therefore, it is important to take several samples from the same bale.

Fescue toxicity. The association of the fungus *Neotyphodium coenophialum* with tall fescue has a positive effect on plant persistence, but the negative effects of the toxins produced by this fungus can have a detrimental effect on livestock performance. Some estimates report losses of up to one billion dollars per year. The amount of fungal infection can vary widely from one pasture or hay field to another.

Fescue toxicity in cattle manifests itself in one of three ways: fescue foot, poor performance (summer slump) and fat necrosis. In mares, reproductive problems include prolonged gestation, abortions, birthing difficulty, thickened placentas, lack of milk production, large and weak foals and high foal mortality.

Fescue foot usually occurs in the late fall or winter but can occur at any time of the year. The animal will often lose weight and become lame on the hind limbs, and there may be gangrene of the feet, tail and tips of ears. Early signs may include a tendency to shift weight from one hind foot to the other and a slight arching of the back. Animals will eventually become unthrifty and reluctant to move.

In cattle, poor performance is the most common of the three effects. This is where most of the economic losses occur. The effects on cattle include weight loss, decreased milk production, reproductive problems, rough hair coat, diarrhea, elevated body temperature, increased respiration rate and excess salivation. Cattle with summer slump spend less time grazing and more time in the shade or in farm ponds.

Fat necrosis is characterized by accumulation of hard necrotic fat in the abdominal or pelvic cavity. There usually are no notable clinical signs. Fat necrosis has usually been associated with long-term ingestion of endophyte-infected fescue that has been heavily fertilized with nitrogen or poultry litter. One might observe digestive disturbances such as chronic bloating, decreased rumen function, reduced feed intake, weight loss and decreased amounts of feces. Some animals may become emaciated and die, others may just become poor performers. Large masses of fat in the pelvic cavity may also cause calving problems.

Animals with suspected fescue toxicosis can be removed from the infected pasture or switched to non-infected hays. Many animals exhibiting poor performance will gradually return to normal when an alternative forage is supplied. Providing other types of hay or pasture and a grain supplement can reduce the effects of the toxins produced within endophyte-infected forages. Generally, diluting the infected fescue in the diet is an effective management technique. Brahman and Brahman-cross cattle normally exhibit better tolerance of the combined effects of the toxins produced by the endophytic fungus and heat stress than other breed types. Endophyte-infected forages cut for hay will have lower levels of toxins if they are harvested early in the spring. Normally, the levels of toxins in these forages are reduced substantially during the wilting process prior to baling. After the initial curing process, concentrations of toxins in stored hay are relatively stable and decrease at very slow rate over time. Ensiling these forages is usually not as effective in reducing the concentrations of toxins produced by the endophyte.

Blister beetles. Alfalfa and other clovers may attract blister beetles. They may be found throughout the United States but are most frequently observed in the midwestern United States. The beetles tend to swarm when the hay or nearby weeds are in bloom. Mower-conditioners that cut and crimp the hay with conditioning rollers will trap dead beetles within the windrow or swath.

These beetles produce cantharadin, which is a potent toxin that causes severe irritation and necrosis of any mucus membranes that it comes in contact with. The beetles retain their toxicity in dry hay. All classes of animals that eat forages may be affected; however, most cases have been reported in horses. Animals may become severely dehydrated and will usually die from kidney failure and shock. The intestines and urinary tract are severely damaged. Animals with blister beetle poisoning should have the hay removed from the diet. The hay should be destroyed because the toxicity does not lessen with time. If it is not too far advanced, animals can be treated for kidney failure and shock. The outcome, however, is usually not successful.

The risk of blister beetle toxicosis can be reduced by certain management techniques. Normally, the first harvest of alfalfa each year is relatively safe. Blister beetles are attracted to flowering legumes; therefore, harvesting at bud stage or at first flower will reduce risks relative to waiting until full bloom. Some pesticides that are routinely applied to control alfalfa weevil and potato leafhopper have labeled effectiveness against blister beetle. Consult the label for detailed information. It would be helpful if alfalfa and clover hays could be dried without conditioning rollers that kill beetles and gather them in the windrow, but these crops have notoriously slow drying rates and this approach is not really practical. Ultimately, it is very difficult to guarantee the absence of blister beetles in alfalfa hay. Buyers are well advised to view such claims with skepticism.

Submitting samples for toxin analysis. The care used in collecting the sample of hay for laboratory analysis has a direct effect on the accuracy of the analysis. Many times this may not be possible, since all of the hay has already been fed. At least one quart of forage should be submitted, cut to a length of 3 inches or less. It is best to sample several areas of the bale that do not appear to have visual defects, as well as those that have visual defects (i.e., mold). Consult with your county Extension agent about where to submit these samples and how to package them for mailing to the laboratory. Make sure everything is labeled properly. The cost of the analysis may vary depending on what tests are run on the sample.

Summary

1) Whether purchased or home-grown, it is always best to test hay for nutritive value and balance livestock rations on this basis.

2) Color is not a good predictor of forage nutritive value. Place emphasis on maturity, condition and purity when making visual appraisals.

3) Visual appraisals should not be relied on for developing a livestock feeding program. Hay should be tested to determine actual forage nutritive value.

4) Harvest forage crops at the correct maturity. No factor affects forage nutritive value more than the maturity of the crop at harvest.

5) Use appropriate haymaking techniques. Hay should be baled at 18 and 20 percent moisture for large round and conventional rectangular bale packages, respectively.

6) Generally, the unrelated processes of rain damage to wilting forages, spontaneous heating and weathering will all reduce DM recovery, sugar content, digestibility and the energy value (TDN) of the forage. Conversely, the concentrations of the most stable components of the plant are increased by these processes, resulting in elevated concentrations of NDF, ADF and lignin.

7) The availability of forage proteins to livestock can be reduced by spontaneous heating during bale storage.

8) Use good management techniques when storing large round bales outside. Specifically, try to maximize drainage away from the storage area, maintain air movement around the bales, and limit bale/soil contact.

9) Do not be deceived by what appears to be relatively shallow weathered layers in hays stored outside. Weathered layers of 4 to 6 inches can account for 20 to 30 percent of the bale volume and may cause producers to greatly underestimate their losses.

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Baling Forage Crops for Silage

Jimmy C. Henning, Michael Collins, David Ditsch, and Garry D. Lacefield

Introduction

Forage may be stored for winter feeding when pasture production is limited, for use in confinement feeding systems, or for cash hay. Hay is the most popular storage method since it stores well for long periods and is better suited to cash sale and transportation than silage. However, silage may be more suitable in some situations where hay curing is difficult. It is possible to make high quality silage or haylage using long (unchopped) forage crops baled with large round balers, although balers may need modification to handle wet material.

Round bale silage (or balage) is the product of cutting forage crops with conventional hay harvest equipment, allowing the forage to wilt to between 40 and 60 percent dry matter, baling the forage into tight bales, and quickly wrapping the bales in plastic so that oxygen is excluded. The forage in the bale then goes through the ensiling process. The wrap keeps out air, allowing anaerobic microorganisms to ferment carbohydrates to lactic acid which inhibits the growth of other detrimental microorganisms. The ensiling process uses some dry matter or energy, but this loss is small compared to dry matter losses that result from raking, baling, tedding, and, particularly, storing round bales outside as hay.

Advantage and Disadvantages of Baling

Advantages of making round bale silage include:

- Plastic cost per bale is low (about $3);
- Capital investment required is lower than conventional silage storage;
- Higher quality feed is produced;
- Harvest and storage losses are lower;
- Weather damage is less than hay stored outside;
- Individually wrapped silage bales are more portable;
- Small amounts of forage that can be ensiled; and
- Baled silage feeding does not require specialized machinery.

Disadvantages of baled silage include:

- Long (unchopped) forage crops are harder to ensile (less fermentable carbohydrates) than chopped forage;
- Some balers cannot handle wilted (40 to 50 percent dry matter) forage;
- Bales can be very heavy, leading to larger tractor requirements;
- Plastic wrap material can tear or puncture, leading to spoilage; and
- Disposal of used plastic is necessary.

Forage Requirements

All of the major forages grown in Kentucky can be harvested effectively as balage. To do this, cut at the proper stage of maturity so that the forage contains adequate levels of fermentable carbohydrates for good ensiling. In general, harvesting forage crops in the transition stage between vegetative (leafy, immature) and reproductive, or flowering stage, will produce the best compromise between yield and quality (see *Quality Hay Production*, AGR-62, for more information on specific cutting recommendations for Kentucky forage crops).

Harvest losses (usually from leaf shatter and loss) are greatest for very dry forage but are low for herbage handled immediately after cutting. However, silage baled too wet is subject to excessive storage losses due to seepage and deterioration. Storage losses arise from microbial activity in moist forage and therefore are generally minimized by harvesting at low moisture levels. Minimum combined field and storage losses are achieved by harvesting forage in the middle of the moisture range, between 40 and 70 percent moisture. The reasons for field losses in forage harvesting are respiration, leaching, and some leaf loss.

The dry matter levels recommended for baled silage are generally between 40 and 60 percent, covering the range between wilted silage and haylage. The ideal dry matter content appears to be 40 to 50 percent because fermentation is adequate and heat damage is minimized. In producing bales for bagged or wrapped silage, it is important to remember that forage in the 50 percent dry matter range will weigh about twice what the same size bale of hay would weigh. Bale size is frequently reduced to restrict bale weight to 0.75 to 1.0 ton. Heavier packages may be difficult to transport.

Machinery Requirements

Equipment needs are quite simple. The mower does not need to have conditioning rollers, but mower-conditioners are useful because they concentrate the cut forage into a narrow swath. These narrow swaths allow baling without raking. If the mower leaves a wide swath, it should be raked to ensure adequate pickup into the baler.

Since the forage is wet and heavy, bale diameters generally range from 42 to 48 inches to avoid overloading either the baler or the transport equipment. Bales should be formed as tightly as practical. Some people believe belt-type balers make a more uniform bale than chain-type balers, but no research supports this claim. Fixed-chamber hay balers lack the flexibility of variable-chamber balers to vary bale diameter as a means of reducing bale weight in wetter crops. Fixed-chamber silage bales have smaller diameters.

The ground speed of the baler should be lower than speeds used in making field-cured hay. Downshifting one gear should help to guarantee a tighter, denser bale. A dry matter density of 10 pounds per cubic foot is considered ideal. A typical silage bale (4 feet in diameter by 5 feet in length) should weigh 1,300 to 1,550 pounds and contain 600 to 650 pounds of dry matter, but it may weigh as much as a ton.

Some baler manufacturers recommend retrofitting older balers with kits that aid in baling wet forage. Many manufacturers produce balers designed specifically for making balage. Some recent models of both fixed and variable chamber balers include knife mechanisms to chop the forage, allowing increased density. University of Kentucky research found that using a "chopping" fixed-chamber baler increased silage bale weights by about 300 pounds at the same bale diameter.

Traditional bale spears can be used to move round bales of silage, but have the disadvantage of puncturing the plastic if the bale is moved after wrapping. Wrapping the bales after they have been moved to their place of storage will avoid puncturing the plastic. Another more expensive option is the hydraulic bale squeeze that mounts on a front end loader. This implement allows the movement of wrapped bales without making holes in the plastic. Tractors with 50 or more horsepower have sufficient weight and power for safe lifting.

Bale-wrapping and Bagging Equipment

There are many ways to seal freshly baled forage, including individual bags, tubing machines, and individual or group bale-wrapping machines. All operate on the principle of quickly sealing out oxygen from the bale and keeping it airtight until the balage is fed. Use of plastic manufactured to withstand the damage from ultraviolet radiation in sunlight is strongly recommended. Some plastic manufacturers recommend using untreated sisal twine or plastic twine. In some cases, the oil from treated sisal twine breaks down the ultraviolet radiation inhibitor in stretch-wrap plastic.

Individual bags

Using individual bags has two advantages: extra equipment is not required, and the bags can be reused to reduce the cost. In practice, however, few bags can be salvaged for use in the next growing season. Disadvantages include the difficulty of getting all of the air out of the bags and maintaining a good seal on the open end of the bag. Making balage in individual bags is less reliable than with wrapping equipment. Rodent damage also appears to be more prevalent with individual bags compared to wrapped bales.

Long tubes

Round bales can be loaded mechanically into long plastic tubes that are mechanically stretched during loading and then allowed to contract. This process aids in getting a good seal around the bale. The number of bales per tube is flexible (plastic can be cut and sealed). Disadvantages include the need for a uniform ground base for tube placement (if large) and sizing bales to the tube. Also, a hole in a long tube exposes a large amount of silage to potential spoilage. Finally, large bales stored in tubes are less portable than individually wrapped bales.

Individually wrapped bales

The most popular form of baled silage is individual bales wrapped mechanically with four layers of stretch-wrap plastic. Each layer of stretch-wrap plastic adheres to the previous one, forming an airtight seal. Wrapping machines vary widely in cost ($4,000 to $15,000), depending on such features as whether they produce a completely wrapped bale and whether they include a self-loading arm.

The cheapest wrappers require a second person (or getting off the tractor) and manually moving the roll of stretch plastic while the bale is rotated on a spear, much like twine is applied to round bales of hay. The plastic is lapped over the ends of the bale about 12 inches. Single or multiple bales can be sealed by manually stretching plastic across the exposed ends. Jamming multiple bales together (flat end to flat end) allows the plastic from one bale to stick to the next, forming a tube. A uniform, level soil surface is necessary for good bale-to-bale contact and the maintenance of a good seal.

More expensive wrappers completely cover each bale by elevating the bale onto a rotating and revolving platform. Some have hydraulic lifts to elevate the bales onto the platform. Others require a second tractor with lifting capabilities to put the bale on the wrapper.

Other Considerations

Damage to plastic during handling or storage allows oxygen to enter the bale, causing spoilage. Any holes made during bale transport and placement into storage should be repaired immediately by taping. Holes allow oxygen to enter and lead to problems with silage quality due to aerobic deterioration. To minimize storage losses due to spoilage, bagged silage bales should be fed to livestock during the winter following their production.

Do not feed silage that has significantly deteriorated or has a bad odor. Silage that improperly ferments from being too wet can lead to botulism poisoning. To prevent this, do not make silage at moisture contents above 70 percent. Exposure to oxygen can also lead to deteriorated silage and animal toxicity. Unrepaired holes or having too few layers of stretch-wrap plastic can lead to oxygen infiltration of the bale.

The ability to make balage allows the harvest and storage of the fall cut of alfalfa or other forages that come in some years during October and November. In most years, this forage goes unused unless these fields can be grazed since curing conditions are too poor to get the forage dry enough to bale as hay. Ensiling conditions are not ideal during this time (low temperatures and low numbers of ensiling bacteria), and fall balage should be fed first during the winter. Silage inoculants have been shown to improve the ensiling characteristics of fall forage crops.

Time between baling and bagging or wrapping

The interval between baling and wrapping or bagging is critical to the success of the ensiling process and should be as short as possible. Prior to wrapping, high-moisture forage is subject to very high respiration rates and to the growth of undesirable microorganisms. Respiration reduces forage quality by consuming readily digestible carbohydrates. Significant increases in bale temperature are also associated with excessive delay between baling and bagging of silage bales. Data from the University of Missouri illustrate the importance of rapid bagging after baling (Table 1). Based on these data, even an eight-hour delay between baling and bagging resulted in greater temperatures during storage compared with those bales bagged immediately after baling.

Consider moving freshly baled forage to the storage area for wrapping. This allows the wrapping process to be done on more level, uniform ground. Bales can "walk off" the wrapping platform if the machine is not level. Minimizing movement of wrapped bales will reduce tearing of the plastic. Wrapped bales can be speared for movement if these holes are resealed.

Consider identifying different types of balage and different cuttings by marking with spray paint. Different colors could represent the various crops while the number of marks (dots or Xs, for example) could indicate the cutting (one dot for first cutting, two dots for second cutting, etc.).

Cost

If at least 300 bales are wrapped each year, wrapping costs $6.60 per bale or $22.01 per ton of dry matter if costs for machinery, labor, and plastic are included (Vough and Glick, 1993). For the same number of bales, bagging would cost $9.91 per bale or $33.03 per ton of dry matter. The higher per-ton cost of bagging is due to greater labor inputs and to the higher bag cost per bale ($7.00) compared with plastic ($3.50). These values compared favorably with the $30-per-ton cost of putting chopped silage in a tube-type silo or the $21- to $42-per-ton cost of storage in a concrete stave silo.

Benefits

Storing wet forage as balage will allow more timely cutting and harvesting of high-quality forage crops. University of Kentucky research (Table 2) compared baled alfalfa silage at three moisture levels with field-cured hay (stored outside on the ground). Baled silage retained initial protein and *in vitro* digestibility levels of the fresh forage better than the field-cured hay. Field-cured hay declined significantly in digestibility and had large dry matter losses compared to baled silage.

Summary

Baled silage offers a convenient and inexpensive way for Kentucky farmers to produce silage with present hay-making equipment (adapted to wet forage). Bale wrappers vary in cost from approximately $4,000 to more than $15,000, depending on the level of automation and control desired. The benefits of making baled silage come from more timely harvest, lower dry matter losses during curing and storage, less chance for rain damage, and better retention of leaves in high quality forage crops like red clover and alfalfa. Disadvantages include handling heavy bales, keeping bales airtight, adapting baling equipment to handle wet forage, and plastic disposal.

Reference

Vough, L.R., and I. Glick. 1993. Round bale silage. pp. 117-123. *Silage Production*, Proceedings, National Silage Production Conference, February 23-25, 1993. Syracuse, N.Y.

Table 1. Temperature (°F) in silage bales bagged immediately, after 8 hours, and after 24 hours.

	Interval Between Baling and Bagging (hours)		
Days After Ensiling	0	8	24
1	118	129	125
2	111	140	135
3	113	127	132

Source: University of Missouri, 1983 Research Reports.

Table 2. Forage quality and dry matter (DM) losses of alfalfa balage and hay, pre- and post-storage.

	Protein		Digestibility[1]		Bale Weight		DM Loss
	Pre-storage	Post-storage	Pre-storage	Post-storage	Pre-storage	Post-storage	
	% Dry Matter				Dry Matter (lb)		%
Balage 46% DM	23.7	22.6	63.0	63.8	548	554	Negligible
Balage 51% DM	23.1	22.3	62.0	65.0	537	541	Negligible
Balage 57% DM	22.1	21.0	65.1	64.4	587	583	Negligible
Hay	18.2	17.5	67.2	51.9	609	495	18.7

Mike Collins. 1995. University of Kentucky, Unpublished Research.
Storage Period: May to December. Hay is stored outside on the ground.

Baled Silage: Frequently Asked Questions

Dr. Dennis Hancock, Forage Extension Specialist

Increasingly, producers have recognized the potential of baled silage to reduce the losses associated with harvesting and storing forage, as compared to conventional haying methods and provide an alternative method of silage production to conventional silos. Inevitably, a new technology has many questions associated with it. Hopefully, the answer to these questions, along with the information in the enclosed Extension publication "Baling Forage Crops for Silage," will aid in the introduction of the baled silage technology.

Common Questions About Baled Silage

1) What will I need?
The requirements for baled silage are much the same as those for round baled hay. However, there are some additions. The minimum requirements are a mower, rake, baler, tractor of sufficient horsepower to make and carry these bales safely, bale handling equipment, and wrapper. Usually, the variable chamber balers (belt balers) are capable of baling wet forage into a dense package. Most variable chamber balers also allow the control of bale size. New, specially designed fixed chamber balers are also capable of making dense bales, but are not able to change bale size. Many balers have some type of chopping mechanism that aids in increasing bale density as well as reducing particle size for use in mixing rations. Bale spears are inexpensive ways of moving the bales. However, spears will make holes in the plastic if they are used after wrapping. Therefore, use the spears only in moving the bales to the wrapping/storage area and the feeding site. Many types of wrappers exist. Wrappers range in cost $3000-18,000 or more and differ considerably in labor and equipment requirements. Also, there are round bale wrappers, large rectangular bale wrappers, and even small square bale wrappers. Some custom operators are wrapping silage and some counties have purchased wrappers that can be rented, thus offering alternatives to the large capital investment of purchasing a wrapper.

2) What should I use to mow?
Mower-conditioners are the most popular and easiest to use for baled silage. This is mainly due to faster wilting and evenly formed swaths. Raking can be avoided if a narrow swath is formed. Other mowers can also be used very successfully.

3) When do I cut?
The crop should be cut at the optimum maturity stage that provides good yields and the quality needed for your feeding situation. This generally means that legumes should be cut at one quarter bloom and grasses at the late boot stage. Other crops such as oats, rye, triticale, and barley should be cut before the boot stage for the best results. These crops are hard to dry at this maturity but lose feed value quickly as they mature. Cutting at these earlier stages will produce good silage and excellent feed value per acre.

4) When should I bale?
Baling at the proper moisture content is important to success in producing baled silage. Forage containing less than 40% moisture or much above 65% moisture should not be baled for silage in order to avoid excessive molding or spoilage. Producing bales with too much moisture reduces the feed quality of the forage, increases the chance of undesirable, butyric acid fermentation, and reduces the amount of dry matter stored per storage unit, greatly increasing storage costs. Baling with inadequate moisture reduces fermentation and increases mold production, greatly increasing storage losses. Considering all factors, the optimum range for baled silage is probably in the 50-65% range.

5) How should I make the bales?
A slow ground speed during baling helps make tight, dense bales which are less likely to spoil. Plastic twine is recommended, but net-wrap or nontreated sisal twine can be used successfully. Sisal twine should be avoided since the oils and rodenticides applied during its manufacturing often degrade the plastic film and can result in large storage losses. The most popular bale size is 4 feet wide and 4 to 5 feet in diameter. These bales weigh 900-1300 lbs. or more, depending on density and moisture concentration, and are best for handling and feeding. Larger bales, which use relatively less film, can be made; however, handling difficulties may outweigh the advantages.

6) Should I apply additives?
Experimental work has shown that excellent baled silage can be made with or without the use of additives. This is true even when ensiling legume crops which have more difficulty reaching the pH range of stabilized fermentation. Therefore, inoculants can be added, but probably will not be necessary in baled silage.

7) How soon should I wrap the bales?
Unnecessary delay between the baling and wrapping processes may lower the quality of the bale because of microbial activity and excessive heating that may occur while the bale is exposed to oxygen. Too much time between the baling and wrapping process may also cause the bale to sag. A sagging bale is difficult to wrap, uses more wrap and wastes time. Ideally, wrapping should be carried out as soon as possible after bailing. However, instantaneous wrapping may not be economically feasible or efficient. Bales should always be wrapped within 12 hours of baling.

8) Where should I wrap?
Wrapping at the storage site ensures that handling of the bales, and likely damage to the individually wrapped bales, is kept to a minimum. Mishandling wrapped bales risks damage and spoilage of part or all of the bale. However, there is a wide range of special equipment available for transporting and stacking silage bales. Individually wrapped bales can be laid or stacked on their sides or ends. It is thought that stacking the bales on their flat ends may reduce potential damage to the plastic. Small holes in the bale's plastic can be patched using a repair tape that has been treated with a UV inhibitor. UV deterioration of other types of tapes, such as duct tape, makes them unacceptable for repairing holes. To avoid degradation of both the silage and the plastic, store the bales on a well-drained sod and away from trees. Spray the perimeter of the stack to kill weeds which harbor rodents and insects that might damage the plastic.

9) What kind of wrap should be used?
The plastic wrap used in baled silage is a polyethylene plastic film that is pre-stretched by the wrapper as it is applied to the bale. The plastic must be able to withstand the local environmental conditions such as UV radiation and changes in ambient air temperatures. Tear strength and the amount of tack or "stickiness" may also vary among brands of wrap. Most farm supply stores either carry or can obtain stretch-wrap plastic for baled silage. Check with the supplier and/or local producers to see which brands promote proper fermentation and are economically viable in your area. The use of white plastic wrap, to aid in preventing excessive heating, is recommended.

10) How much plastic needs to be applied?
Stretch-wrap plastic usually is one mil (0.001 in) thick and comes in 20 or 30 in. rolls which are 5,000 or 6,000 ft in length. The plastic is typically pre-stretched 50 to 55% on the wrapper's film dispensing unit to get the correct tension on the bale surface. Always ensure that the tension of the wrap (tacky side toward bale) is such that it is stretched uniformly on the bales. At least four layers should be applied to each bale if an individual (spinning platform) bale wrapper is used. If an inline wrapper is used, apply six layers of wrap to each bale with additional wrapping were bales butt-up against one another. The plastic used in baled silage does not create an airtight seal. Fortunately, this low density polyethylene plastic is four times more permeable to carbon dioxide gas than it is to oxygen gas, allowing the bales to vent excess carbon dioxide as fermentation begins.

11) How many bales can be wrapped per hour?
Depending on the type of wrapper used, experienced workers can wrap 25-30 bales, or more, per hour. This is about the same number of bales covered by a 20 in x 6,000 ft or 30 in x 5,000 ft roll of stretch-wrap plastic. However, plastic use will also be dependent on the wrapper type.

12) How much does it cost?
Since each roll is approximately $60-90 (1999 prices) and will cover 25-30 bales, the average cost per bale is $3-4. Because the cost of the wrapper varies and the type of wrapper determines the amount of labor and plastic that will be required, the total cost of baled silage per ton of dry matter (DM) is highly dependent on the type of wrapper used. The more expensive wrappers are usually less labor intensive and can use less plastic than the less expensive models. Producers should use a wrapper that will minimize the capital investment, the amount of plastic used, and labor costs for their specific system. The cost of baled silage, therefore, will vary from $9-11 per ton of DM. This is much less expensive than conventional silage methods and is very competitive with the cost of conventional

hay, when the losses associated with making and storing hay are taken into account.

13) What if I feed a molded bale?
Despite the best efforts of the producer to limit the amount of mold growth in silage bales, many bales will develop some white mold. This usually occurs on the flat ends of the bale and around previously undetected pinholes in the plastic. This type of mold is usually just surface mold, caused by a fungal colony's access (though limited) to oxygen, and rarely penetrates more than a few inches into the bale. The animal will usually eat around or even discard this portion. Even if ingested, this type of mold will not harm the animal. Severely spoiled, putrid bales can, however, contain harmful bacteria such as Listeria and botulism organisms and molds, and should not be fed. Such severe cases only occur when there was an excessive amount of topsoil in the bale, there was an extremely excessive amount of moisture, or the plastic hadn't sufficiently prevented oxygen entry.

14) Is baled silage higher in quality?
The feed value of the baled silage will be no better than the quality of the forage at the beginning, and can be worse if the bale was too wet and/or spoilage has occurred. As with conventionally prepared hay, quality is a function of forage maturity at harvest, handling during harvest, and storage. The adage "garbage in - garbage out" is very true concerning baled silage quality. Relative to hay, however, the forage going in is higher in quality due to decreased harvest losses, and the resulting silage will not exhibit the same degree of losses during storage. Therefore, baled silage will be higher in quality than a comparable hay.

15) How many bales will I need?
In order to justify the costs associated with storing forage, one should wrap as many bales as possible in a season. However, because of the possibility of less DM per bale in baled silage (depending of baler type and setting), one might be putting up more bales (up to 20% more) of the same size to feed the same number of animals, relative to the number of hay bales required. Yet, the amount of DM harvested will be approximately the same, and, therefore, from an acreage standpoint, the number of acres put up as stored forage will probably be approximately the same.

16) What kind of feeding system do I need?
With the costs associated with each wrapped bale, or any other type of stored forage, it is essential to control feeding losses and refusals. Some studies have shown that a considerable amount of forage was lost when large round silage bales were fed to cattle without placing the bales in a ring feeder. Use of a ring feeder, especially if the bale is elevated, can reduce losses such that only refused forage will remain. When feeding whole silage bales to any species, it is best to feed a sufficient number of animals that will eat the entire bale within about two days. Silage bales may also be integrated into rations if cut before grinding and mixing the ration.

17) What can I feed it to?
Traditionally, baled silage has been fed to beef and dairy cattle. However, there is no reason, physiological or otherwise, that it cannot be fed to sheep, goats, or even horses. Feeding molded silage bales to horses, as in hay, should be avoided. When prepared properly, baled silage can represent up to one third of a horse's ration, on a dry matter basis. To ensure the most efficient use of the quality in a silage bale, it is important to match the bale's quality to the animals' economic productivity.

18) What should I do with the used plastic?
Because the plastic can be used for baled silage only once, plastic disposal is a potential environmental problem. Every effort should be made to prevent this. Currently, there are no standard policies in Georgia for collection and disposal of used baled silage plastic, beyond landfill disposal. Used plastic, in the future, may be baled and collected for recycling. Such efforts have been successful in those areas that have enough plastic to warrant its collection and recycling. Check with your local government on applicable statutes in your area for disposal or recycling.

Some Points on Feeding Baled Silage

Dennis W. Hancock, Extension Forage Specialist, The University of Georgia

Silage makes an excellent feed for ruminant animals. However, feeding silage is much different than feeding hay. Silage, because it is much wetter than hay, is much more susceptible to deterioration. Sealed from oxygen during storage, the forage undergoes fermentation. However, when it is once again exposed to air when it is fed, it can still deteriorate quickly. Because of this, baled silage must be managed slightly different than hay.

Whether it is in an upright, bunker, pit, or bag silo or as a wrapped bale, the process of fermentation is very similar. Essentially, bacteria that occur naturally on the surface of dying plant leaves undergo massive population buildups once oxygen is excluded from their environment. They derive energy from the sugars that are inherent in plant cell sap and tissue via a fermentative process. They undergo many, many cycles of feeding and reproduction until their populations become so high that the waste of their fermentation processes leads to a buildup of acid. This is why silage has a low pH. The smell of silage is also the by-products of the fermentation process. Though this silage is produced in bulk in a silo or wrapped bale, the fermentation is essentially the same process that happens on a smaller scale when a ruminant animal such as a cow, sheep, or goat ingests forage. This is why this feed is such a natural fit for dairy, beef, sheep, and goat production. Essentially silage is“pre-ruminated” forage.

But, there in lies the major issue with feeding silage: instability. An analogy to our eating habits would be potato salad. Pre-cooked and prepared, it doesn't need to set out very long before we eat it. This is especially true at a summer picnic where temperatures can speed the deterioration. But, this can also occur in the winter time, even though it may take longer for it to spoil. In either case, it is not worth the chance of eating it if it has set out very long.

Thus as a "rule of thumb," never leave silage exposed to the air more than two days during feeding. If the daytime temperature exceeds 60° F, don't leave it exposed more than one day. This rule of thumb is especially important for producers who feed baled silage. It is extremely critical to those who use an in-line bale wrapper, since this determines the feed-out rate. If you have made baled silage using an in-line bale wrapper, you must be feeding enough animals that you can feed at least one bale per day in the winter. This is because as a bale is fed, the next bale is being exposed to air. Individually wrapped bales are usually not subject to exposure before they are fed, and thus the feeding schedule is somewhat more flexible.

Here are some additional "rules of thumb" on how to feed silage bales or, in some cases, what not to do.

- Ensure that the storage site doesn't increase the chances of exposure to air. Some storage sites increase the likelihood of punctures to the plastic wrap. Examples would be areas near trees that have dropped limbs, rodent and other varmint dens, or that are freshly mowed and have coarse weed stubble. Many of these may create punctures that go unnoticed until it is too late.
- Ensure that the forage is between 45-65% moisture before it is wrapped and ensiled. Baling when the crop is too dry is the most common problem because a field may start out at the right moisture and end up being too dry. Dry forage doesn't provide the bacteria enough moisture to allow sufficient fermentation. But, it does allow fungi to grow during storage and feeding that can lead to deterioration. Baling too wet is less common. However, high moisture silage spoils quicker when exposed to air.
- Don't spear into bales after they have been wrapped. Squeeze carriers or handlers are better, but may still stretch, tear, or puncture bales. Any hole in the plastic barrier can lead to small areas or even entire bales that deteriorate.
- To feed a bale that has been wrapped using an in-line wrapper, simply spear into the bale, lift, and pull away. The plastic between it and the next bale will tear away. Then cut over the top and peel the plastic off in one large section. To feed an individually wrapped bale, cut a large X in the end to

be speared and pull back the flaps. Spear the bale, lift, and cut across the top and down the other flat side to peel the plastic off in one piece. In both cases, twine should then be removed before placing in the paddock and placing a feeding ring around the bale. Wastage and refusal is rarely an issue with feeding baled silage, unless a bale is being fed to too few animals. If silage remains when the time frame for feeding has been exceeded, put out a fresh bale. Forcing animals to eat waste or refused silage may force them to eat deteriorated material and can lead to animal health issues. Bale size, which can usually be adjusted on the baler, should be determined during the growing season by considering the number of animals and the feed out rate that will be needed during the feeding period.

- The ensiling process usually completes within 2-6 weeks, depending on a large number factors. Yet, at essentially any point, the forage can be fed. The feeding rate should still be relatively quick, however, as excessive heating, as well as spoilage, could be significant if exposed for days or even hours.

Section 9

Sketching Out the Ideal – Planning the Grazing System.

Dr. Jennifer Tucker, UGA

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Planning the Grazing System

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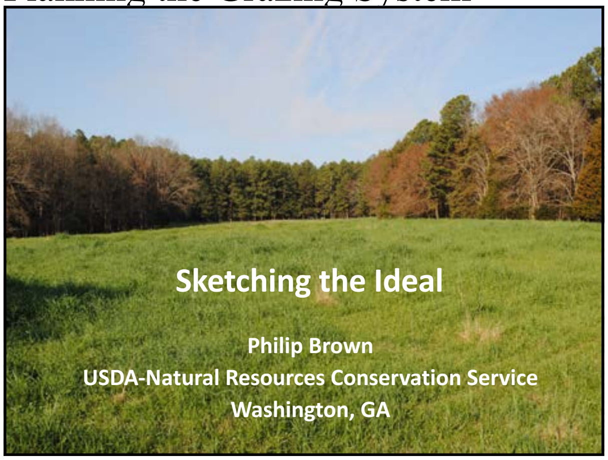
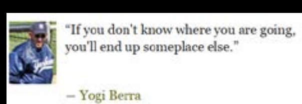
USDA-NRCS Grassland Conservationist



Sketching the Ideal – The Reality

- Ideal is site and manager specific
- The landscape may not fit the theoretical ideal

Sketching the Ideal - Developing a Plan



- A Good Plan Will Force You to Articulate Exactly What You Are Trying to Achieve

Determine Your Objectives

- What do you want to achieve?
  - Narrow Objectives – Install a watering facility in field # 1
  - Why?
    - Increase Grazing Efficiency in field # 1
    - Exclude livestock to the stream that borders field # 1
    - Improve water quality for livestock
  - What will accomplishing those do for your operation?

Determine Your Objectives

- Increase Grazing Efficiency in field # 1
  - Remove Inefficiencies
    - Extend Grazing Season
    - Increase Stocking Rate
- Exclude livestock to the stream that borders field # 1
  - Conserve soil resources
  - Improve downstream water quality
- Improve water quality for livestock
  - Increased animal performance

Determine Your Objectives

- Often adds up to Broader Objectives
  - Profitability
  - Time / Quality of Life

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Inventory Resources

- Money / Budget
- Time
- Labor
- Skills
- Equipment / Tools
- Soil/Landscape Resources
- Forage Resources
- Livestock Resources

Identify Problems

- What Resources do you lack?
  - What's the best workaround?
- What are the specific problems that exist related to your grazing system?
  - Lack of fencing and or water to adequately manage intensity and frequency of grazing
  - Seasonal distribution of available forage
  - Soil fertility

Analyze Your Information and Formulate a Plan/Plans

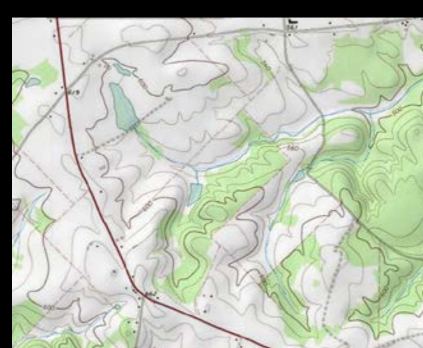
- With the resources you have or can obtain how are you going to address the problems encountered and achieve your objectives.

Soil/Landscape - Inventory Tools

- Google Earth & Other Web Based Tools

Web Soil Survey – Aerial Photography

Web Soil Survey – Topographic Images



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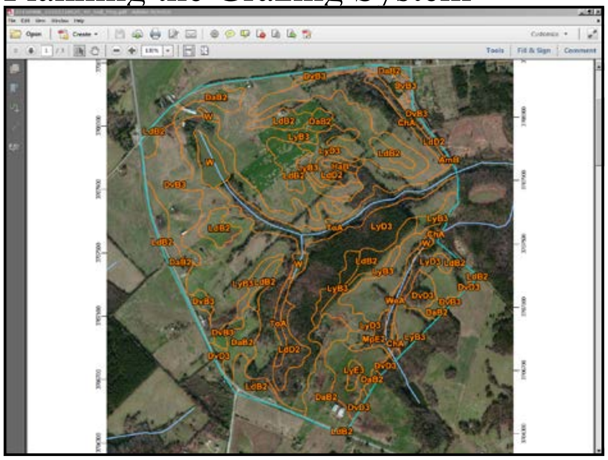


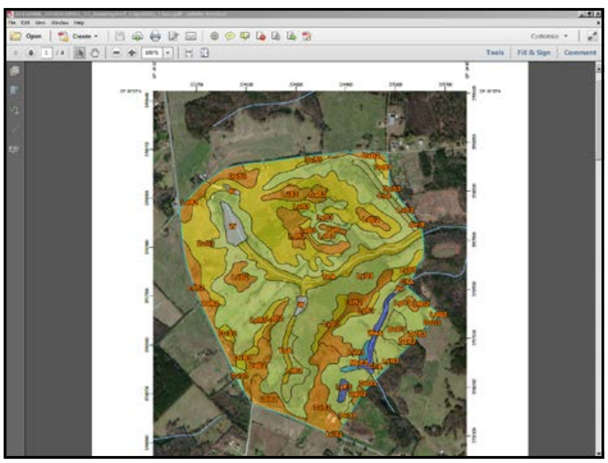
Web Soil Survey - Land Capability Class

Increased Intensity of Land Use

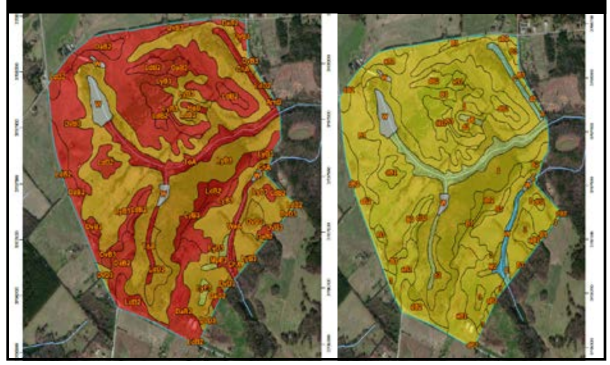
Land Capability Class	Wildlife	Forestry	Grazing: Limited	Grazing: Moderate	Grazing: Intense	Cultivation: Limited	Cultivation: Moderate	Cultivation: Intense	Cultivation: Very Intense
I	X	X	X	X	X	X	X	X	X
II	X	X	X	X	X	X	X	X	
III	X	X	X	X	X	X	X		
IV	X	X	X	X	X	X			
V	X	X	X	X	X				
VI	X	X	X	X					
VII	X	X	X						
VIII	X								

Increased Limitations and Hazards / Decreased Adaptability and Freedom of Choice of Uses

Figure 1. Intensity with which each land capability class can be used with safety. Note the increasing limitations on the uses to which the land can safely be put as one moves from Class I to Class VIII. (Modified from R. D. Hockensmith and J. G. Steele, 1949).



Web Soil Survey – Slope & Drainage Class



Google Earth Pro

- To add a topo layer, download the USGS Topo Map Layer and open it with Google Earth.
  - http://www.gearthblog.com/kmfiles/topomaps.kmz
  - After the layer is installed you can zoom into an area see topo maps of that region.
- To add a soils map layer, download the SoilWeb's Google Earth Interface and open it with Google Earth.
  - http://casoilresource.lawr.ucdavis.edu/soil_web/kml/SoilWeb.kmz
  - Other such tools from SoilWeb: http://casoilresource.lawr.ucdavis.edu/drupal/

Soil Type and Landscape Position

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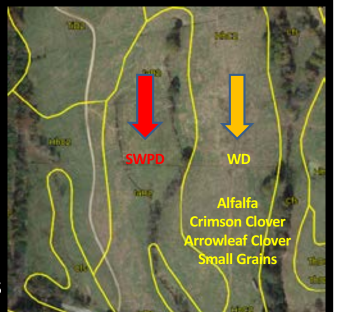
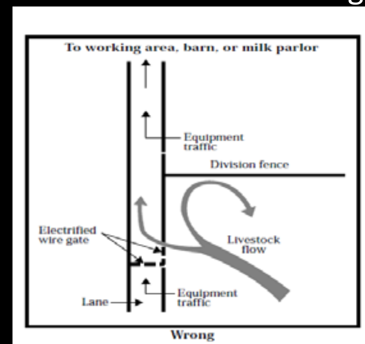
Landscape - Soils

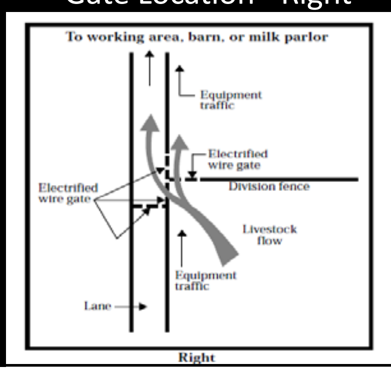
- Productivity
- Flooding & Ponding Durations
- Drainage Class
- Similar Soils Support Similar Productivity & Plant Communities



Animal Movement
Gate Location - Wrong



Animal Movement
Gate Location - Right



Animal Movement

- Ideally working facility would serve as a central "Hub" with easy access from all paddocks
- Realistically – landscape or infrastructure simply may not fit, or you are working with an existing facility badly placed for your new plan
- Objective – Minimize through paddock moves to other paddocks and working facility

Animal Movement

- Lanes May Be Necessary
- Follow Contours
- Avoid Poorly Drained Areas
- Keep Vehicle Traffic Off
- Wide Enough For Equipment
- Grazeable

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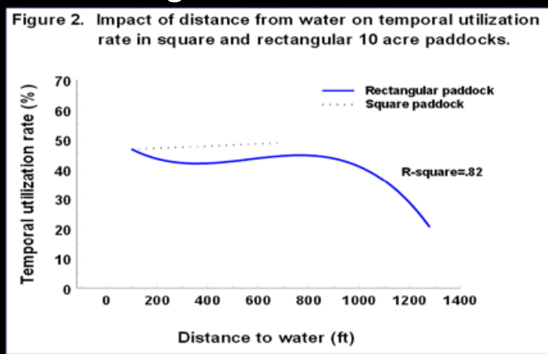
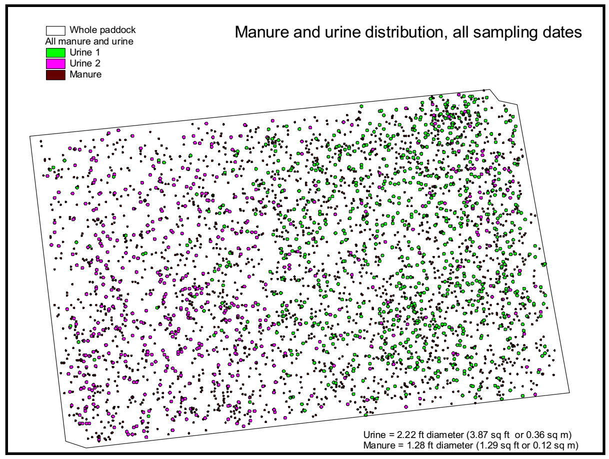
Grazing Distribution - Water





Providing Water

- Water Location
  - Centralized
    - Allows for easier subdivision and better animal distribution
  - Ideally all pasture would be within 800 feet or less of a water source
  - Away from shade and mineral feeder
- Think flexibility related to further subdivision. Whether temporary or permanent

Missed Opportunity….

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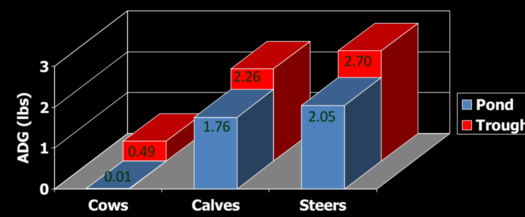
Water source effect on animal performance



Willms et al., 2002

32

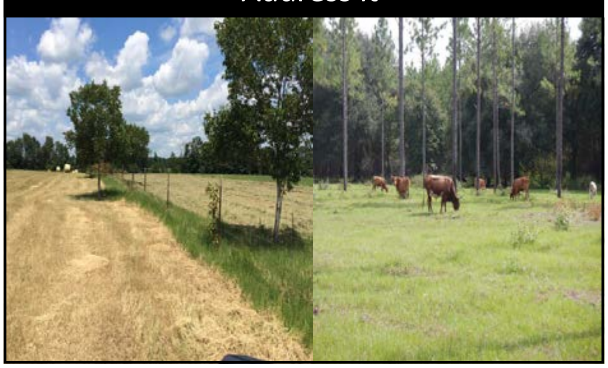
Mineral Feeder

- Portable Mineral Feeder
  - Easily moved away from water source and shade
  - Relatively inexpensive
  - Portability allows for flexibility
  - Don't Group Shade, Minerals, and Water

Heat stress and cattle performance

- Subject of lively debate.
- Radiant energy (sunlight) increases surface and air temperatures.
- Beef cattle in the sun vs. shade in hot environments had:
  - higher internal body temperature (Mitlöhner et al., 2001)
  - increased respiration (Mitlöhner et al., 2002)
  - increased heart rate (Brosh et al., 1998)
  - lower DMI, ADG and meat quality (Mitlöhner et al., 2002)
  - decreased conception rates (Roman-Ponce et al., 1976)

Heat Stress Problem – Sketch Ways to Address it



Heat Stress Problem – Sketch Ways to Address it

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Evaluate Your Plan

- Start and Stop Hay Feeding Dates
- Body Condition Scoring
- Manure Consistency
- Forage Quality Tests
- Livestock or Animal Days Per Acre
- Keep a few grazing records
  - On / Off Paddock Dates
  - Number of Animals Grazed
  - What went wrong……

Livestock or Animal Days Per Acre

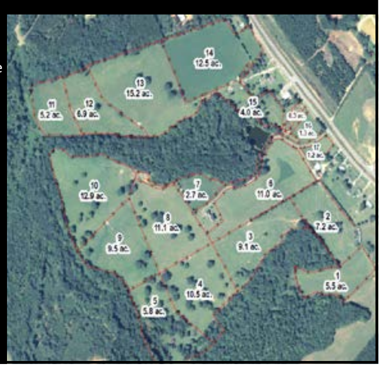
$$Livestock\ Days\ per\ Acre = \frac{\#\ Livestock\ \times Total\ Grazing\ Days}{Paddock\ Acres}$$

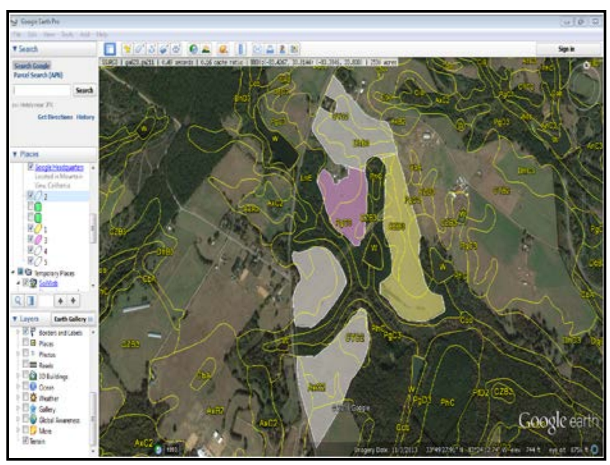
$$X = \frac{50\ head\ \times 32\ Total\ Days}{5\ Acres}$$

$$X = 320$$

Take Home Message

- Try to Develop a Flexible System That Gives You the Ability to Manage the Intensity and Frequency of Grazing
- Put the Ideal on Paper First
- Start Slow
- Evaluate and Adapt as Your Comfort Level Increases





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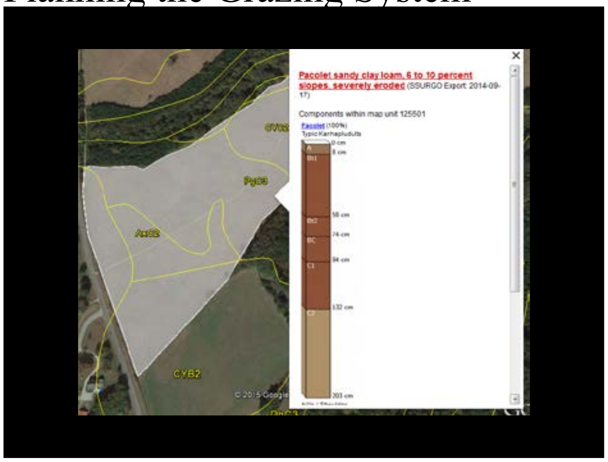

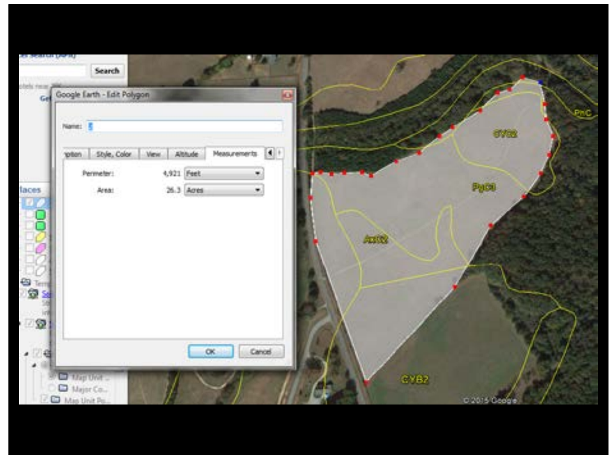

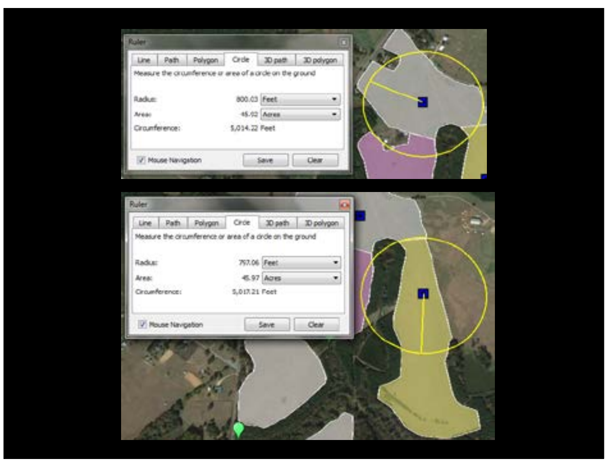

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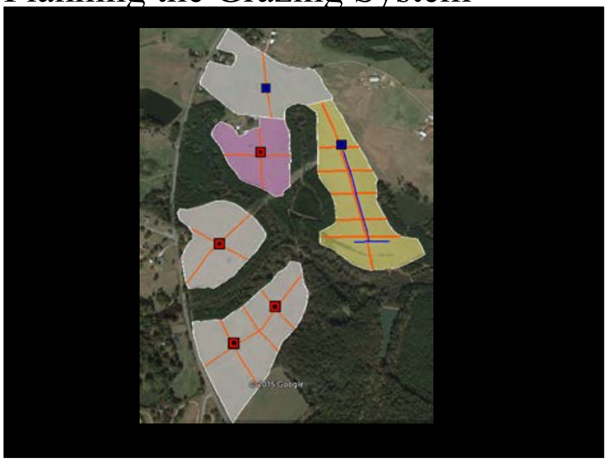

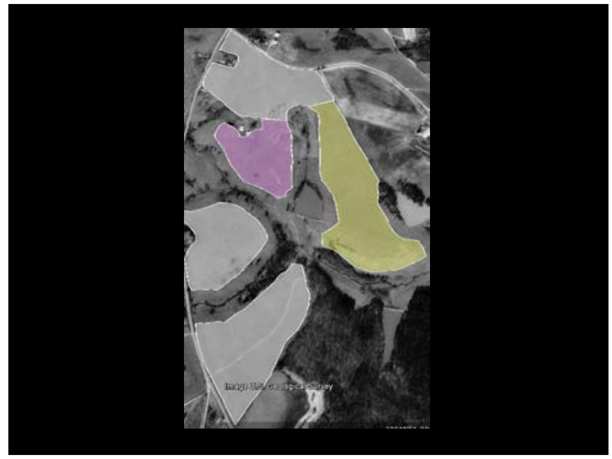

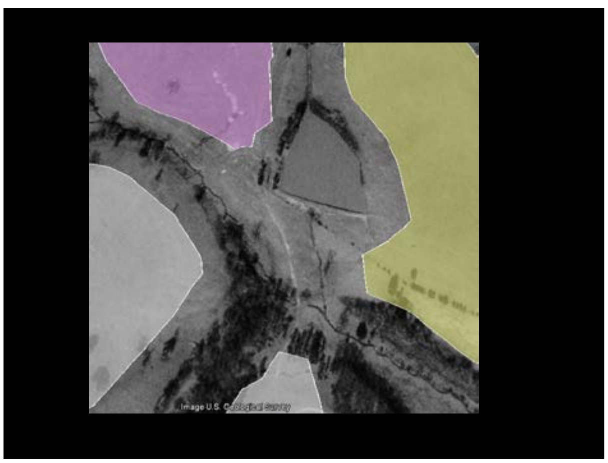

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Soil Survey Data

Soil survey data are a product of the National Cooperative Soil Survey, a joint effort of the USDA Natural Resources Conservation Service and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants.

Web Soil Survey (WSS)

The Web Soil Survey provides agricultural producers, agencies, Technical Service Providers, and others electronic access to relevant soil and related information needed to make land-use and management decisions. The WSS:

- Provides an alternative to traditional hardcopy publication,
- Provides the means for quicker delivery of information,
- Provides electronic access to full soil survey report content,
- Provides access to the most current data,
- Allows customers to get just the information they want, and
- Provides customers with the ability to download spatial and tabular soils data for use in GIS (replaces functionality of former Soil Data Mart).
- Additional help is available at "Contact Us" or by emailing soilshotline@lin.usda.gov.

Current, Custom

Soil Maps & Reports:

Fast.

Free.

Friendly.

Print a Hydric Soil Map

- Complete Steps 1, 2, and 3
- From the "Soil Data Explorer" tab, click on the "Suitabilities and Limitations for Use" tab
- Click on "Land Classifications"
- Click on "Hydric Rating by Map Unit"
- Click the "View Rating" button
- Click the "Legend" tab to open or close the map symbol legend
- Click the "Printable Version" button
- Click the "View" button
- On the browser menu bar, select File and Print; or click the print icon

Print a Soil Chemical Properties Report

- Complete Steps 1, 2, and 3
- From the "Soil Data Explorer" tab, click the "Soil Reports" tab
- Click on "Soil Chemical Properties"
- Click on "Chemical Soil Properties"
- Click the "View Soil Report" button
- Click the "Printable Version" button
- Click the "View" button
- On the browser menu bar, select File and Print; or click the print icon

Natural Resources Conservation Service
United States Department of Agriculture

National Cooperative Soil Survey

USDA is an equal opportunity provider and employer.

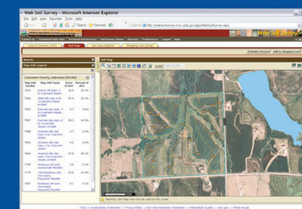
March 2014

Natural Resources Conservation Service
United States Department of Agriculture

Web Soil Survey

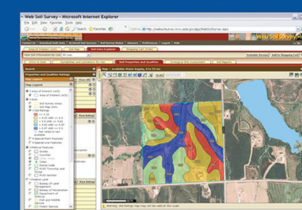
http://websoilsurvey.nrcs.usda.gov

Define.



Search / Locate

Collect.



Analyze Data

Develop.

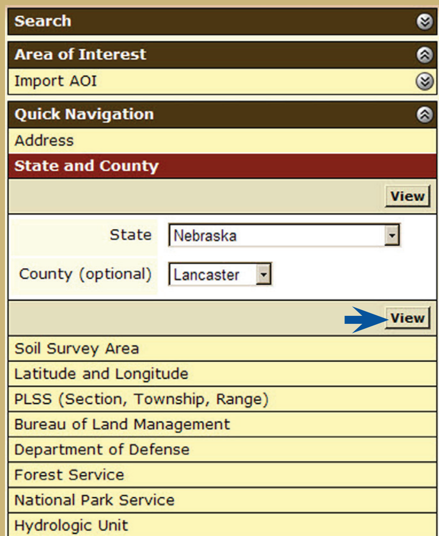
Custom Reports & Maps

"Helping People Help the Land"

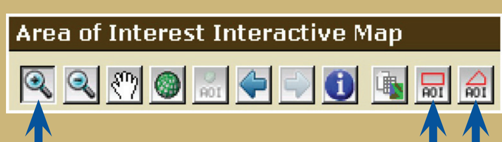
Accessing Web Soil Survey

- Open the Web Soil Survey (WSS) site at: http://websoilsurvey.nrcs.usda.gov and click the "Start WSS" button.

Step 1. Define Your Area of Interest (AOI)

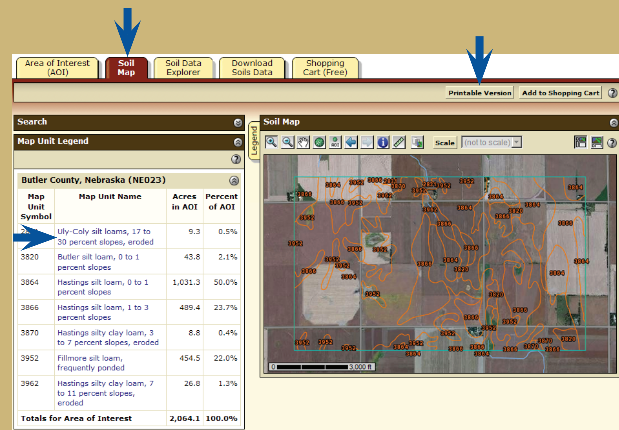


- Several methods are available to zoom into a geographic area of interest. You can enter an address; select a state and county; enter section, township, and range information; or you can import a boundary file from your local computer to set the AOI.
- Click the "View" button to see the area.



- Use the zoom in tool (plus sign) to click and drag a rectangular box around a specific area. Repeat, as necessary, to zoom further.
- Select an AOI tool to draw a rectangular box or irregular polygon that defines the AOI and allows selection of associated soil data. Once the AOI has been defined, you can save it for use at a later date.

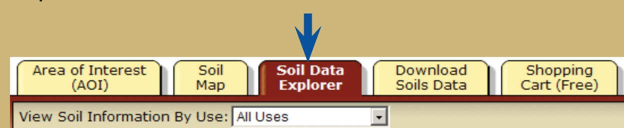
Step 2. View and Print Your Soil Map



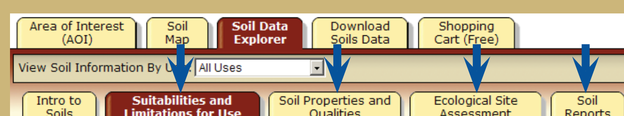
- Click on the "Soil Map" tab.
- Click on a map unit name to view a map unit description. Click the X to close the narrative.
- Print your soil map by clicking on the "Printable Version" button; then click the "View" button. On the browser menu bar, select File and Print; or click the print icon. Close the window.

Step 3. Explore Your Soil Information

WSS generates thematic maps of soil interpretations and chemical or physical properties. Tabular data reports are also available.



- Click on the "Soil Data Explorer" tab.

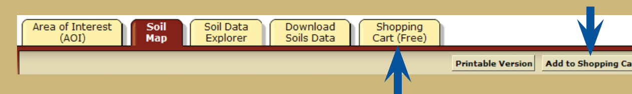


- Click on the tabs below "Soil Data Explorer" and explore available information (default tab is "Suitabilities and Limitations for Use").

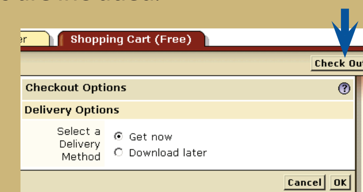
Step 4. Add Items to the Free Shopping Cart and Check Out

WSS allows you to collect a variety of thematic maps and reports in the Shopping Cart, then print or download the content into one file or document.

- Soil map, map unit legend, and map unit descriptions are automatically added.

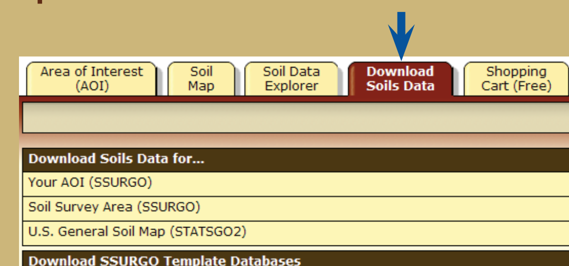


- Items viewed in Step 3 can be added by clicking the "Add to Shopping Cart" button.
- View your cart contents by clicking the "Shopping Cart (Free)" tab. Items checked on the Table of Contents are included.



- Get your Custom Soil Resource report.
  - -- Click the "Check Out" button
  - -- Select a delivery option and click OK

Step 5. Download Soils Data for Use in GIS



WSS now allows you to download spatial and tabular SSURGO and STATSGO2 soils data for use in your local GIS. SSURGO data can be downloaded for your defined AOI or for a soil survey area. STATSGO2 data can be downloaded for individual states or for the whole U.S.

NOTE: At any time during Steps 2, 3, 4, or 5, you can redefine the soil map location by clicking on the "Area of Interest" tab and clicking the "Clear AOI" button. Repeat Step 1.