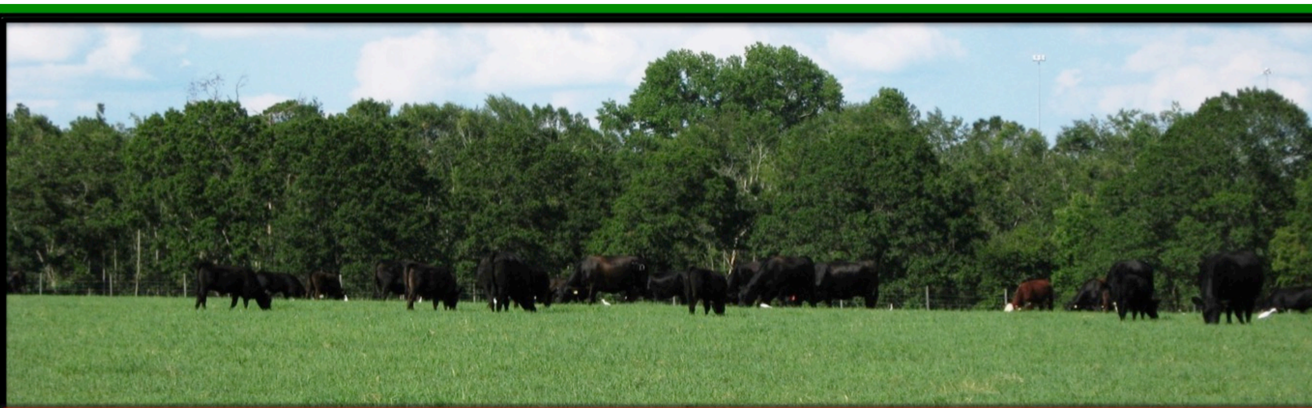

Georgia Grazing School

Sept. 15-16, 2015 | Univ. of Georgia | Carroll Co. Extension Ag Center
Carrollton, GA



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GRASS
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UGA extension

Agenda

2015 Georgia Grazing School

Univ. of Georgia | College of Agricultural & Environmental Sciences
Carroll Co. Extension Office
(Ag Center | 900 Newnan Rd., Carrollton, GA)

Tuesday, September 15th, 2015

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

8:30 **Welcome and Introduction**
Dr. Dennis Hancock, UGA
Paula Burke, Carroll Co. Extension Coordinator
Philip Brown, NRCS Grazinglands Specialist

8:45 **Manipulating forage growth and grazing behavior.**
Dr. Dennis Hancock, UGA

9:30 **Southern Forages: Yield, distribution, and quality.**
Philip Brown, NRCS Grazinglands Specialist

10:00 **Break (Visit Sponsor's Booths)**

GALLAGHER™

10:30 **Soil fertility and nutrient cycling in grazing systems**
Dr. Dennis Hancock, UGA

11:00 **Managing, utilizing, and maintaining legumes**.
Philip Brown, NRCS Grazinglands Specialist

11:30 **Grazing systems, methods, and tricks.**
Paula Burke, Carroll Co. Extension Coordinator

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

R.W. Griffin
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Tuesday, September 15th, 2015 (cont'd):

12:45 **Segregating herds based on animal class and nutritional need**
Dr. Lawton Stewart, UGA

1:30 **Optimizing the size, number, and layout of your paddocks**
Cindy Haygood, USDA-NRCS

2:00 **Managing forage surplus and deficits**
Dr. Dennis Hancock, UGA

2:30 **Choosing the right fence, fence charger, and wire or tape for your grazing system**
Dr. John Worley, UGA

3:00 **Selecting the right watering system and sizing the water supply for your grazing system**
Dr. John Worley, UGA

3:30 **Break (Visit Sponsors)**

PENNINGTON™

4:00 **Economics of Better Grazing Management**
Dr. Tommie Shepherd, UGA

4:45 **Cost-share programs that aid the transition**
Philip Brown, NRCS Grazinglands Specialist

5:15 **Sprayer calibration exercise and lightbar demo**
Dr. Dennis Hancock, UGA

5:45 **Good grazing = inc. soil moisture, inc. soil health, and lower erosion.**
Michael Hall, USDA NRCS Grassland Conservationist (Ret.)
Dan Wallace, USDA NRCS State Resource Inventory Coor.

6:30 **Supper and Discussion** – Sponsored by:

SunSouth
www.sunsouth.com

Good Grazing Management
Made the Difference on My Farm
Terry Chandler,
Owner/Operator
Still Water Farms
Danielsville, GA

Wednesday, September 16th, 2015

7:30 **Coffee and snacks.**

8:00 **Transport to Jerry and Angie Stober's Farm**

8:30 **Welcome to Jerry and Angie Stober's Farm**
Farm overview and philosophy

Demonstrations:

(9:30 a.m. to 11:30 a.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.)
Grazing Stick/Rising Plate Meter Demo (10 min.)	Pasture Condition Score (10 min.)	Hay/Baleage Sampling Demonstration (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: *Lucy Ray, Morgan Co. Extension*
Weed ID in the Field: *Dr. Patrick McCullough, UGA*
Grazing Stick/Rising Plate Meter Demo: *Sam Ingram, Effingham Co. Extension*
Pasture Condition Score: *Philip Brown, USDA-NRCS*
Calibrating & Adjusting a No-Till Drill: *Dr. Dennis Hancock, UGA*
Setting Up Water Troughs w/ Grazing In Mind: *Cindy Haygood, USDA-NRCS*

11:30 **Return to Carroll Co. Extension Office | Ag Center**

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

Carroll EMC
Valuable. Reliable. Powerful.

12:45 **New weed management tools for grazed pastures.**
Dr. Patrick McCullough, UGA

1:30 **Extending the grazing season and critically evaluating novel grazing systems**
Dr. Dennis Hancock, UGA

2:00 **Sketching Out the Ideal: Planning the Grazing System**
Philip Brown, NRCS Grazinglands Specialist

2:30 Break (Visit Sponsor's Booths)

Cosby Farm,
Keith Herndon

3:00 Keynote Session: Weeds are Great Forage. Teach Your Livestock to Eat Them

Kathy Voth, Livestock for Landscapes, LLC and Editor of On Pasture magazine

Since 2004, Kathy Voth has been teaching cows to eat weeds in just 8 hours spread over 7 days. Along the way she's discovered that most weeds are the equivalent of alfalfa in nutritional value and that if you get livestock to try one new food in their pastures, they'll go on to add other weeds to their diet and they'll teach their herd mates and offspring as well. That means that for an investment of less than $200, you can win your war on weeds and increase your forage by about 30%. Here she'll tell you everything you need to know to get started, plus if you volunteer to tell her a little about your operation, she'll help you adapt the training process to your own needs.

~5:00 Evaluation and Dismiss (Have a Safe Trip Home!)

List of Exhibitors:
SunSouth
Carroll EMC
R.W. Griffin Feed, Seed & Fertilizer
Pennington Seeds
King's AgriSeeds
Southern Silage Supply
Gallagher Animal Management
Tru-Test
Pasture Management Systems

Others pending…

Special Thanks to:
Carroll Co. Extension
J.D. Hale, UGA Forage Research Tech
Deidre Harmon, UGA PhD Student

UGA extension
Forage Team
www.georgiaforages.com

Georgia Grazing School 2015

SEPTEMBER 15 & 16, 2015
CARROLL COUNTY EXTENSION AG CENTER
CARROLLTON, GEORGIA

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PRESENTATION HANDOUTS AND SUPPLEMENTARY INFORMATION

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

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UGA extension   Center for Sustainable Grazing Systems   GRASS www.georgiaforages.com

Table of Contents (cont'd)

Section 1

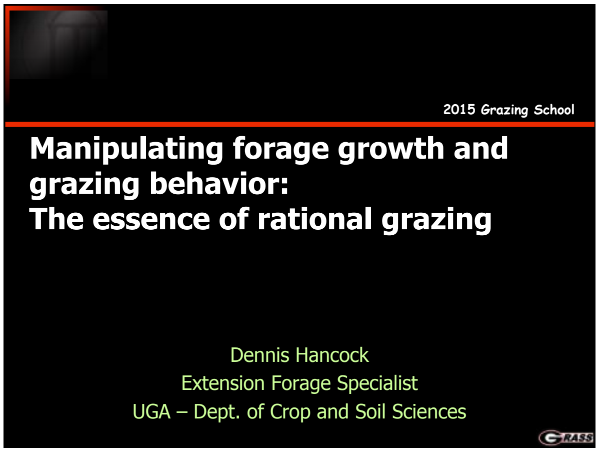
Manipulating forage growth and grazing behavior

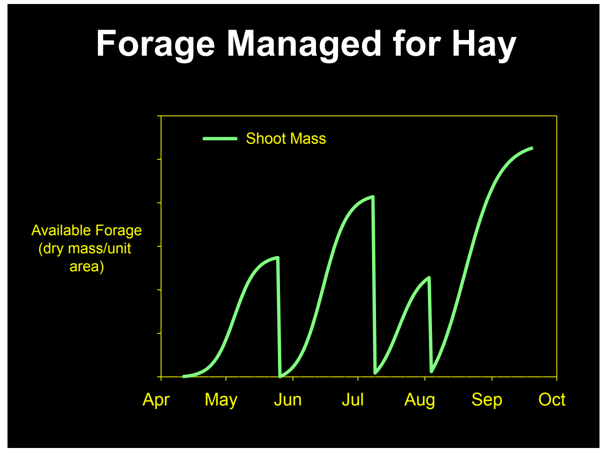
Dr. Dennis Hancock, UGA

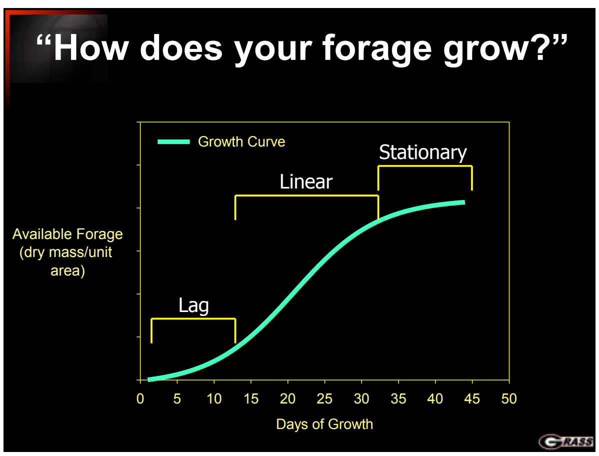
2015 Georgia Grazing School:

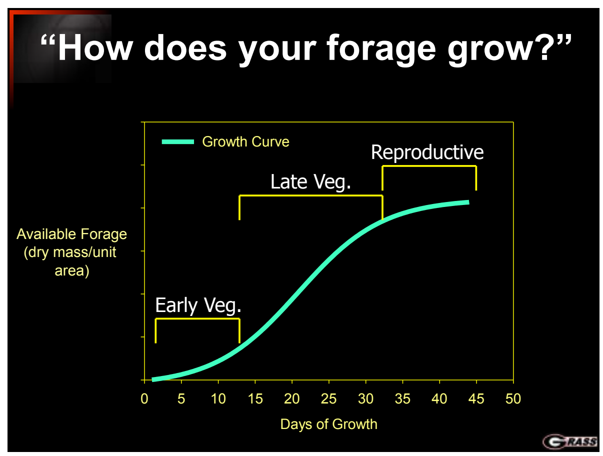
Manipulating forage growth and grazing behavior

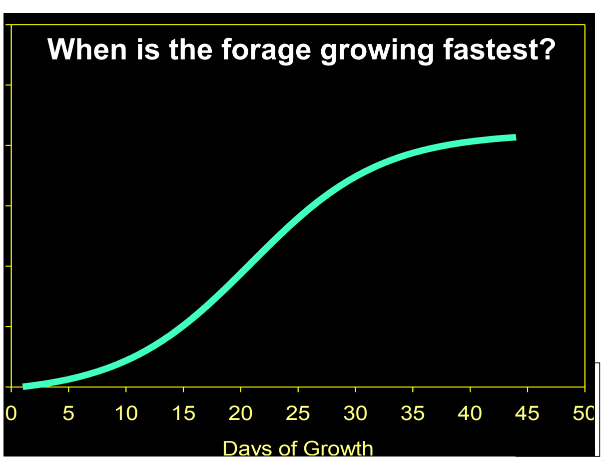
Dr. Dennis Hancock
Assoc. Prof. & Forage Ext. Specialist

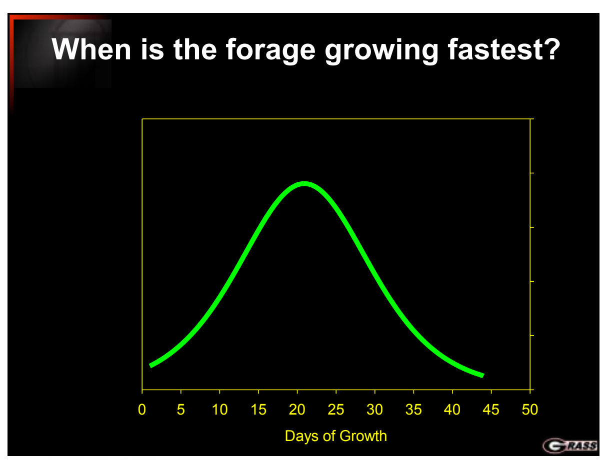












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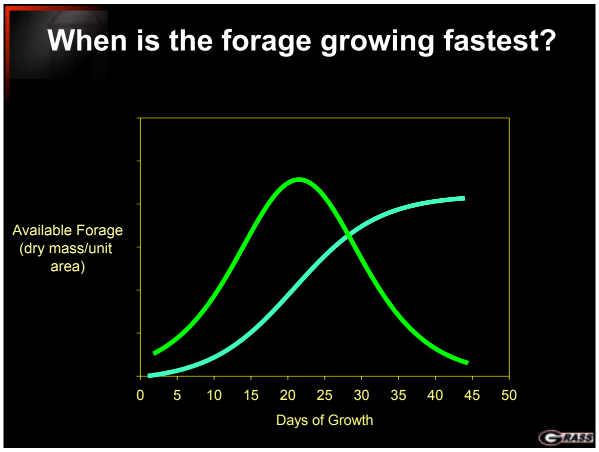

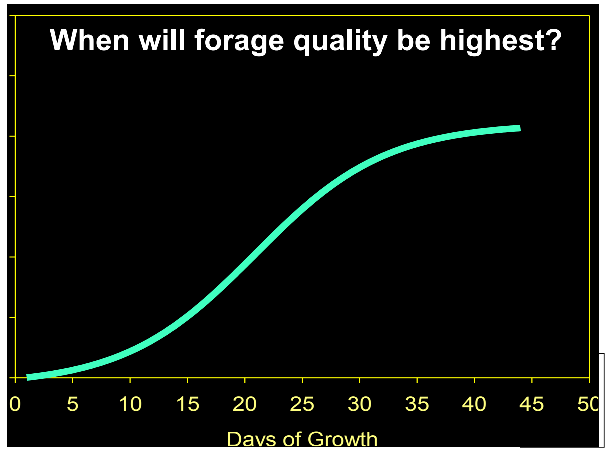

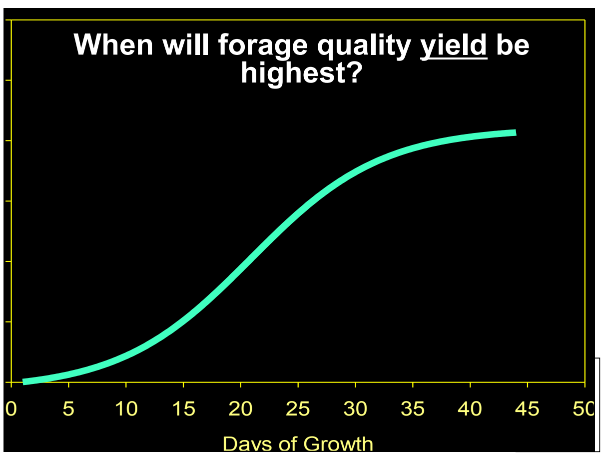

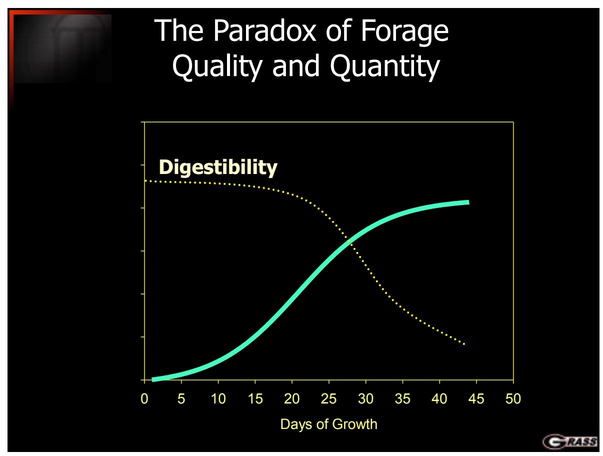

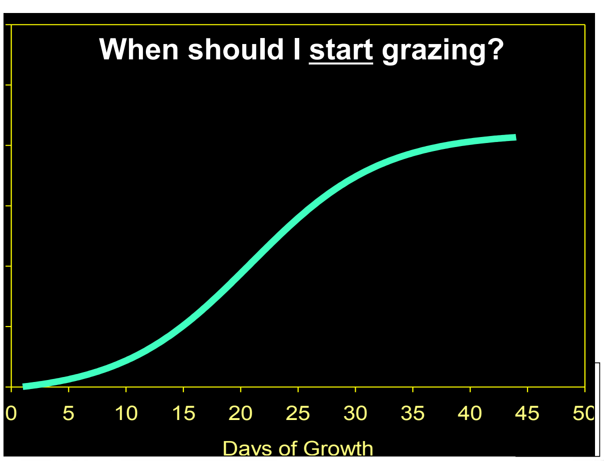

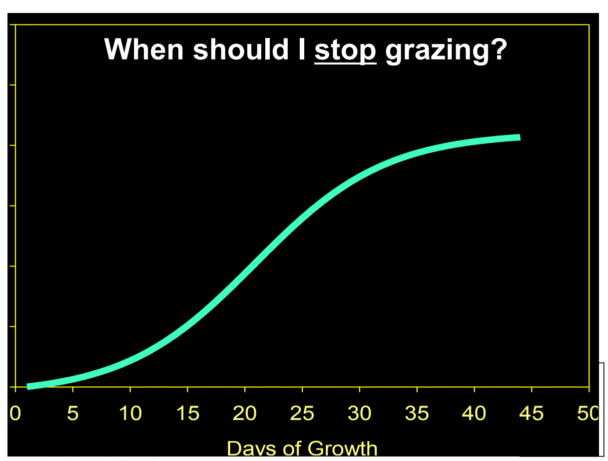

2015 Georgia Grazing School:

Manipulating forage growth and grazing behavior

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Assoc. Prof. & Forage Ext. Specialist

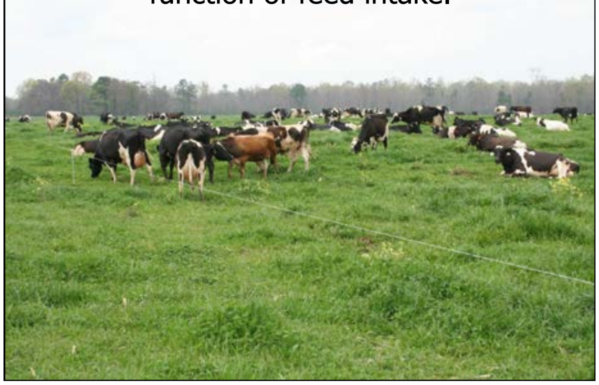
Write this down in BIG **BOLD** letters!

"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

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

Forage Intake

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

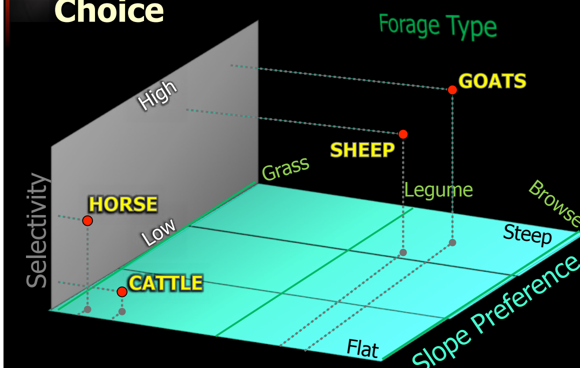
What happens when:

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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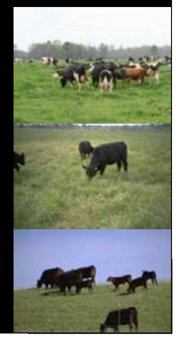
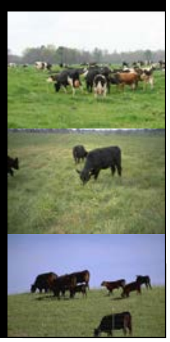
Grazing Behavior: Cattle

- 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.



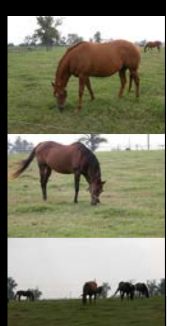
Grazing Behavior: Cattle

- 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



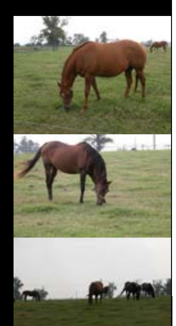
Grazing Behavior: Horses

- 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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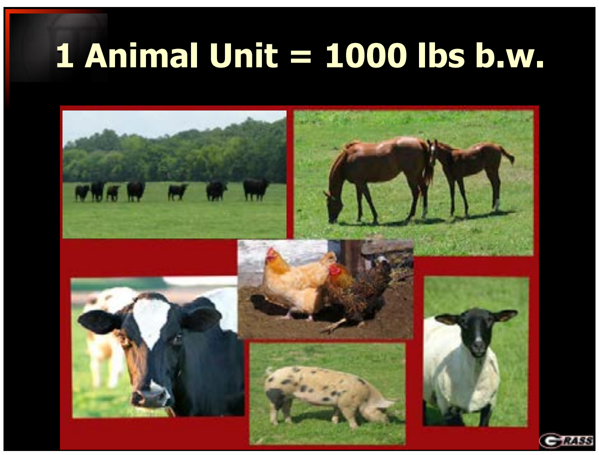

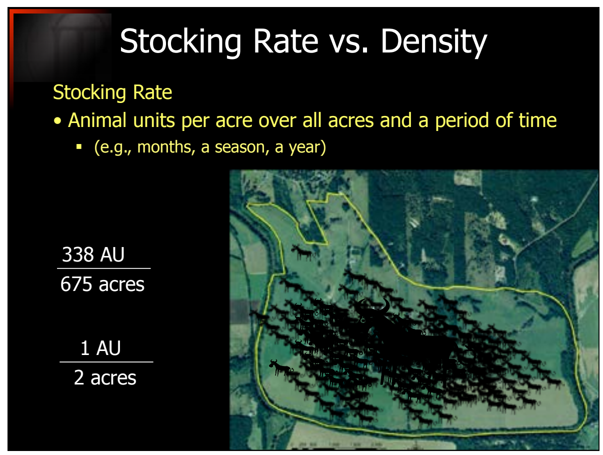

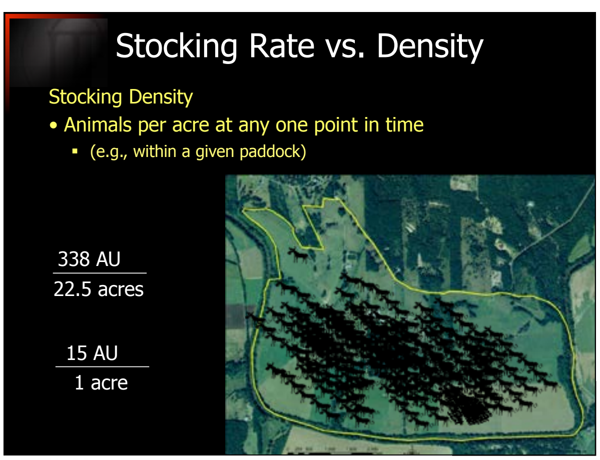

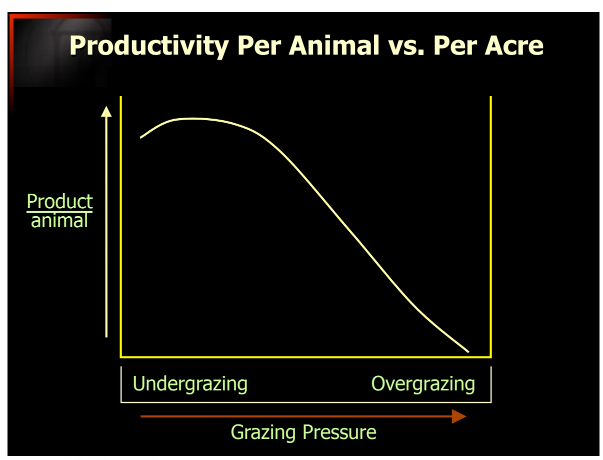

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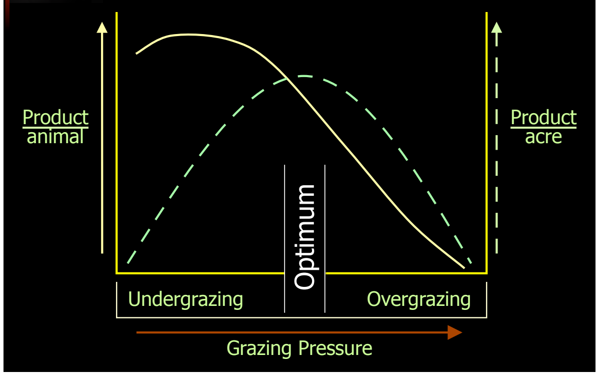
Productivity Per Animal vs. Per Acre



Benefits of Rational Grazing

1. Better utilization of forage
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   - Kept in linear/exponential growth phase
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3. Higher stocking rates

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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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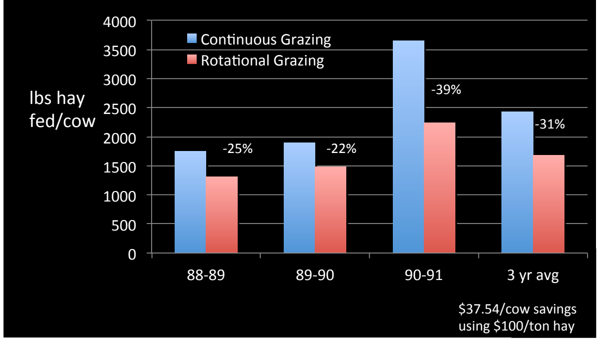
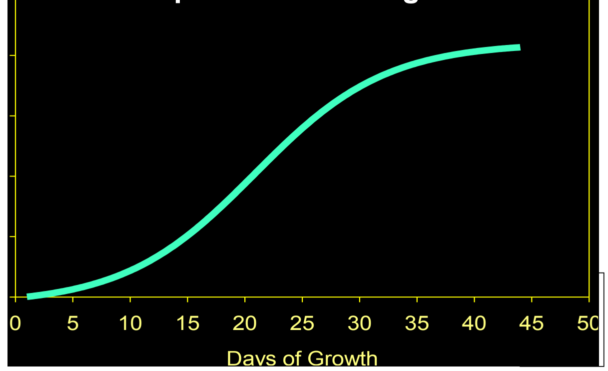
Effect of Grazing System on Hay Needs



What happens when a mob stays in a paddock too long?



Recreational Grazing
(Selective)

Benefits of Rational Grazing

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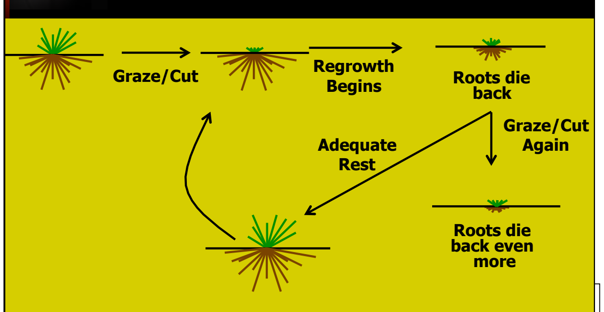
   - Higher yield of forage
3. Higher stocking rates
4. More animal gains/milk production per acre
5. Reduced feeding of conserved forage or supplements
6. Better persistence of desirable forages
   - Especially clover and legume species

What you don't see….



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

2015 Georgia Grazing School:

Manipulating forage growth and grazing behavior

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Assoc. Prof. & Forage Ext. Specialist

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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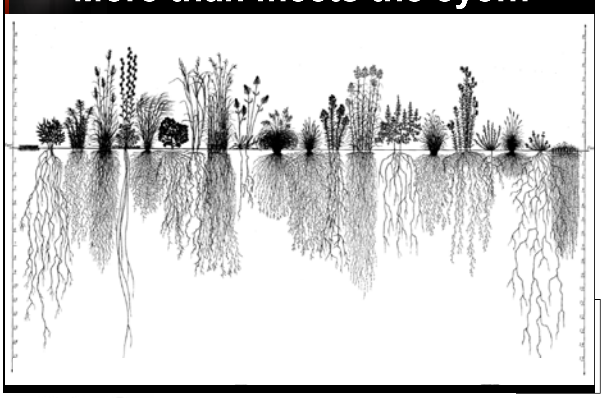
   - Higher yield of forage
3. Higher stocking rates
4. More animal gains/milk production per acre
5. Reduced feeding of conserved forage or supplements
6. Better persistence of desirable forages
   - Especially clover and legume species
7. Better weed suppression

"More than meets the eye…"



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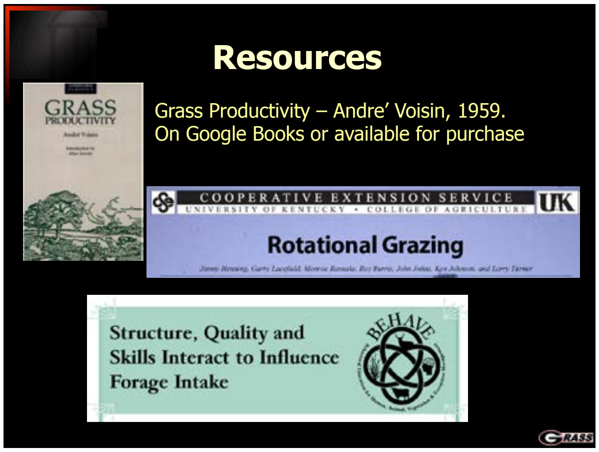

Structure, Quality and Skills Interact to Influence Forage Intake

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 Grassland Conservationist

2015 Georgia Grazing School:
Southern Forages:
Yield, distribution, and quality

Philip Brown,
USDA-NRCS Grazinglands Specialist

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

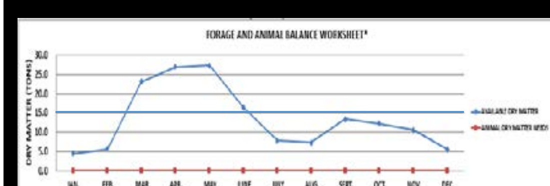
Table 1. Calculating cost of hay production (assuming six tons per acre production).

	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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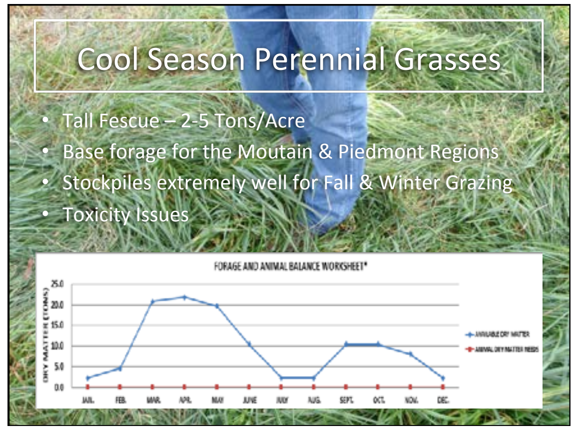
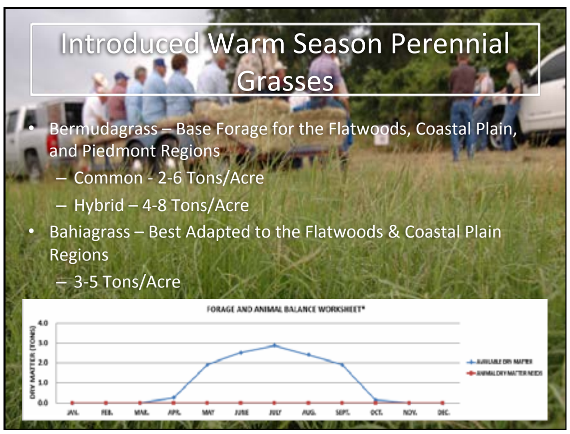
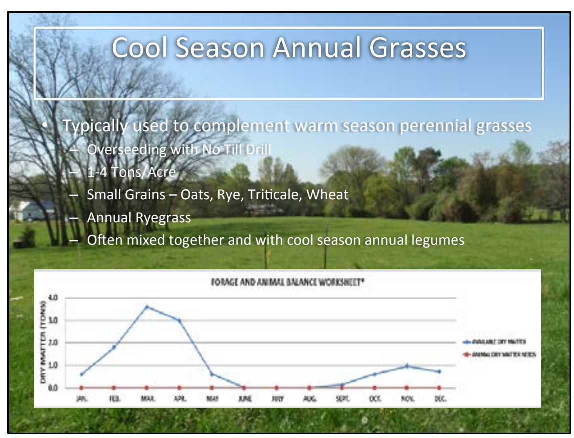
Forage Distribution

- 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







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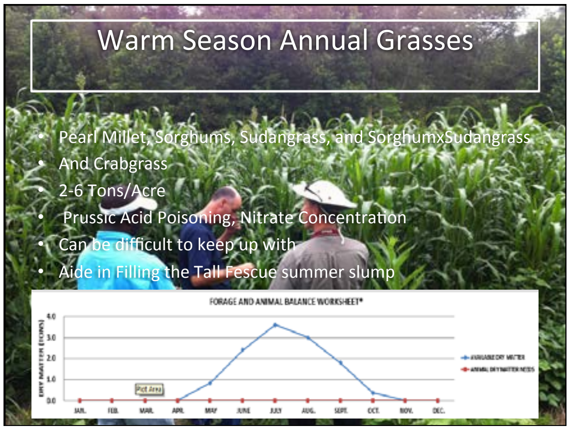

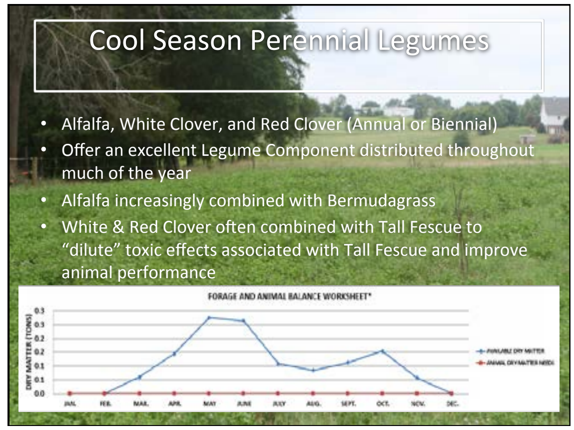

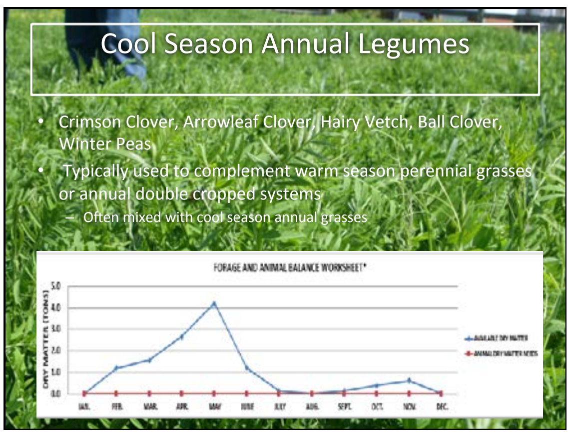

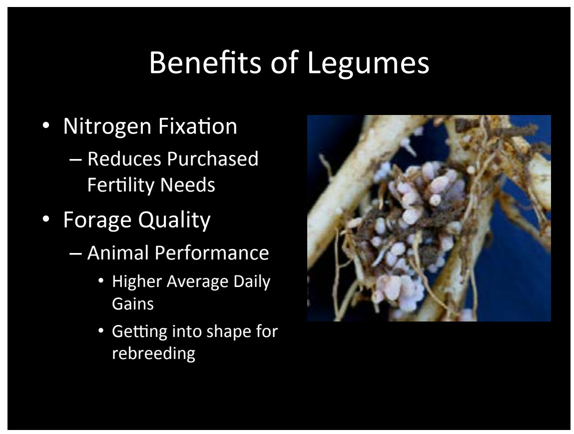

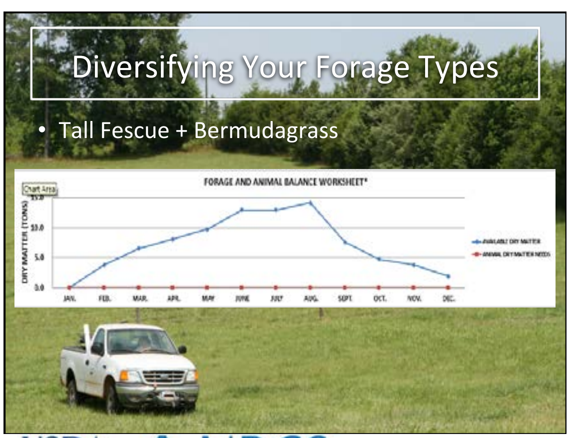

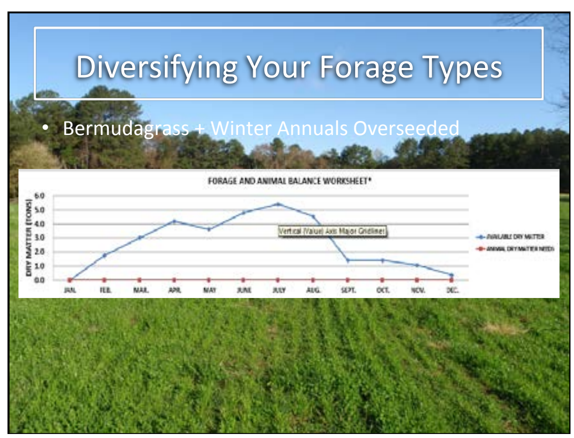

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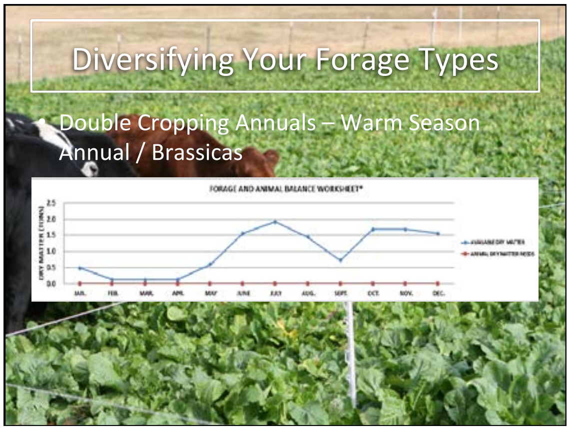

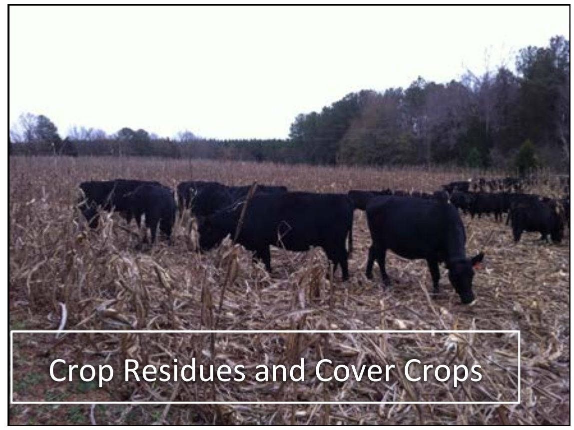

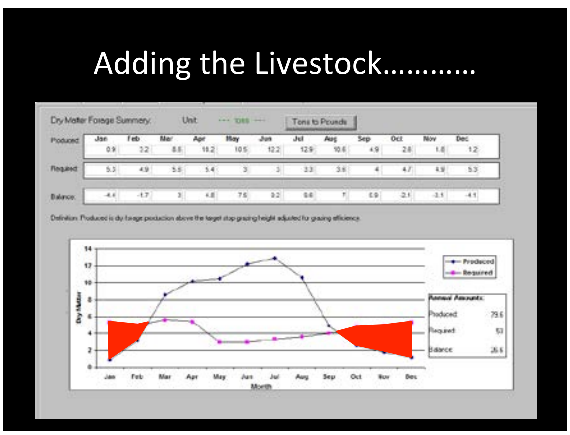

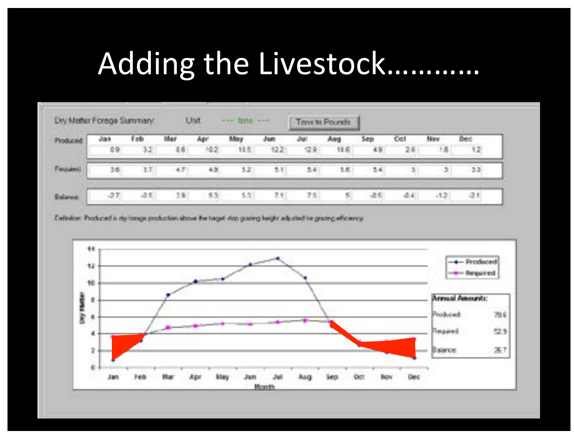

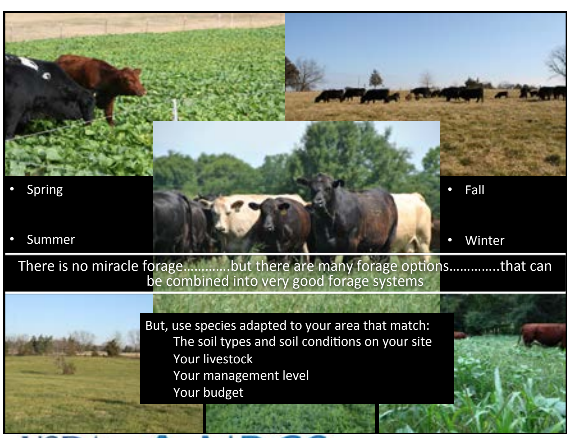

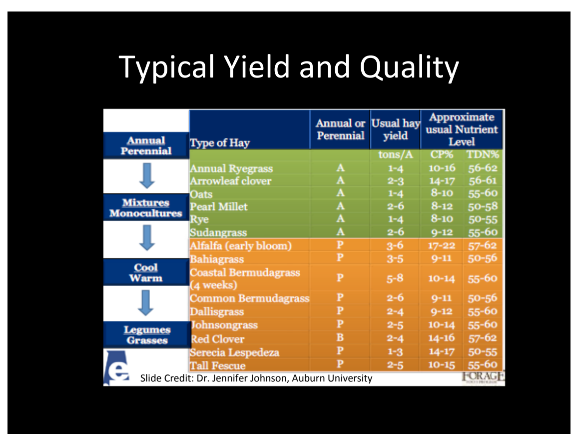

Type of Hay	Annual or Perennial	Usual hay yield	Approximate usual Nutrient Level	
		tons/A	CP%	TDN%
Annual Ryegrass	A	1-4	10-16	56-62
Arrowleaf clover	A	2-3	14-17	56-61
Oats	A	1-4	8-10	55-60
Pearl Millet	A	2-6	8-12	50-58
Rye	A	1-4	8-10	50-55
Sudangrass	A	2-6	9-12	55-60
Alfalfa (early bloom)	P	3-6	17-22	57-62
Bahiagrass	P	3-5	9-11	50-56
Coastal Bermudagrass (4 weeks)	P	5-8	10-14	55-60
Common Bermudagrass	P	2-6	9-11	50-56
Dallisgrass	P	2-4	9-12	55-60
Johnsongrass	P	2-5	10-14	55-60
Red Clover	B	2-4	14-16	57-62
Serecia Lespedeza	P	1-3	14-17	50-55
Tall Fescue	P	2-5	10-15	55-60

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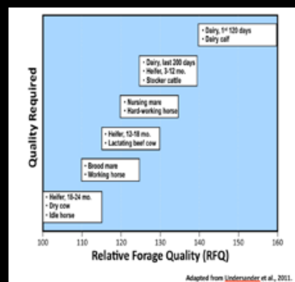
Forage Quality Needs By Animal Class

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)	65	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

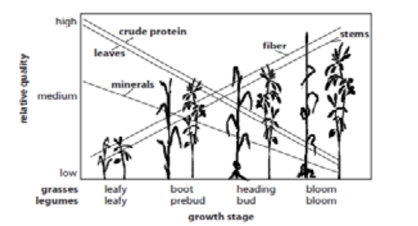
Management Factors that Affect Forage Quality

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.

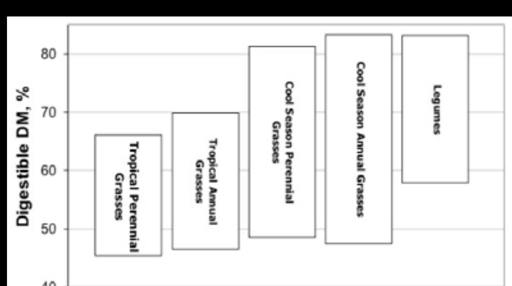
Forage Quality – Stage of Maturity

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

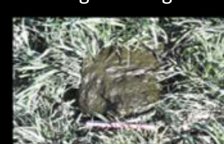


Source: *Adapted from Blaser, R., R.C. Hammes, Jr., J.P. Fontenot, H.T. Bryant, C.E. Polan, D.D. Wolf, F.S. McClaugherty, R.G. Klein, and J.S. Moore. 1986. Forage–animal management systems. Virginia Polytechnic Institute, Bulletin 86-7.*

Forage Quality - Species



Measures of Forage Quality:
Forage Testing of Course but Observation as Well



CP >20% / TDN 70-80%

CP > 6-9% / TDN 60%

CP 10-17% / TDN 65%

CP > 5% / TDN < 56%

30

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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

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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.

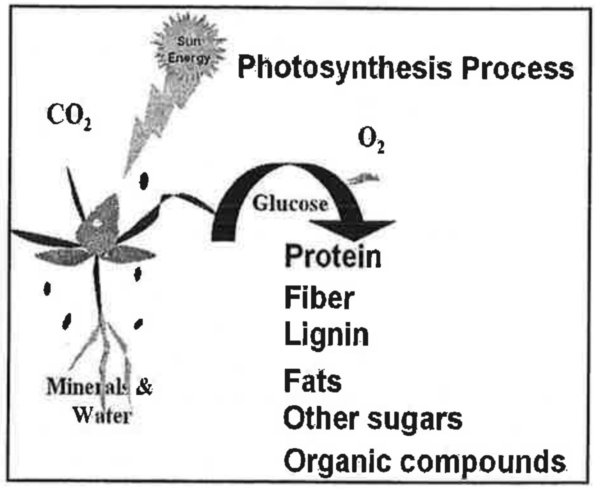

Figure 1. Illustration of the process and gross products of photosynthesis.

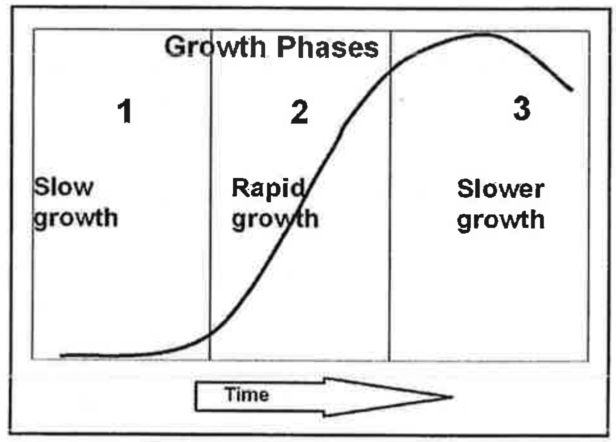

Figure 2. Illustration of plant growth over time following harvest or new seedling development (Voisin, 1959).

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.

	GROWTH PHASES		
CHARACTERISTIC	**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

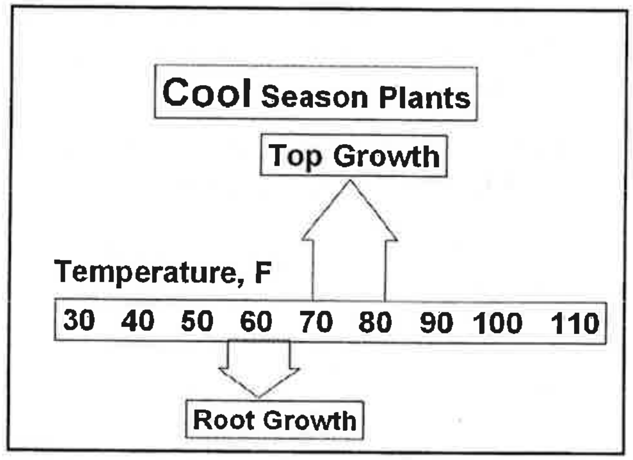

Figure 4. Optimum temperature for growth of cool season plants.

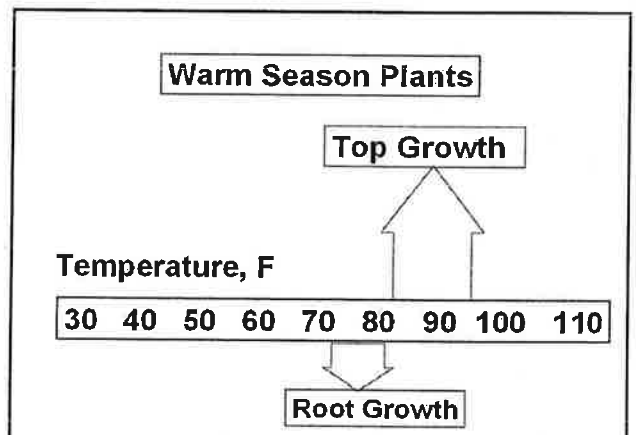

Figure 3. Optimum temperature for growth of warm season plants.

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.

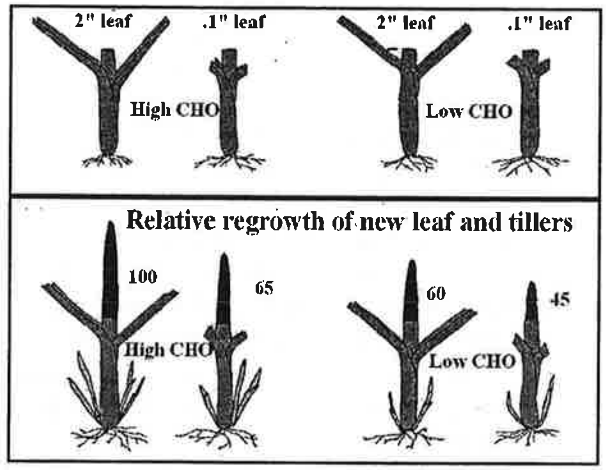

Figure 6. Illustration showing the effect of leaf area and charbohydrate (CHO) status on regrowth of primary leaf blade. (Blaser, 1986).

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 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.

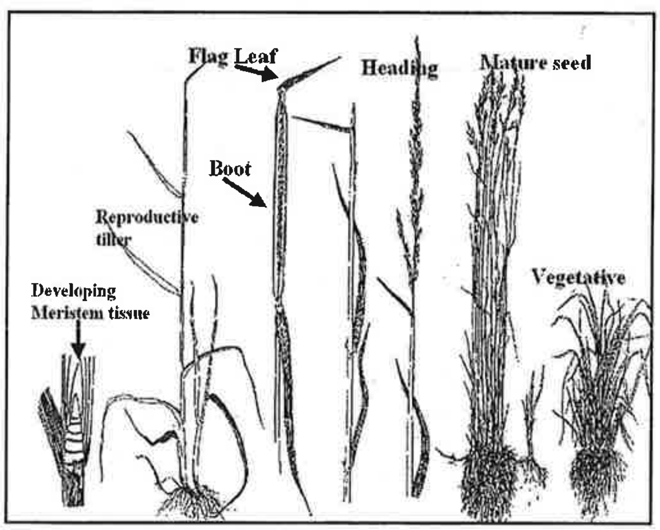

Figure 7. Morphological stages of growth of a grass plant: from left note the meristem region found at the tiller base and subsequent reproductive stages and vegetative stage. (Blaser, 1986)

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).

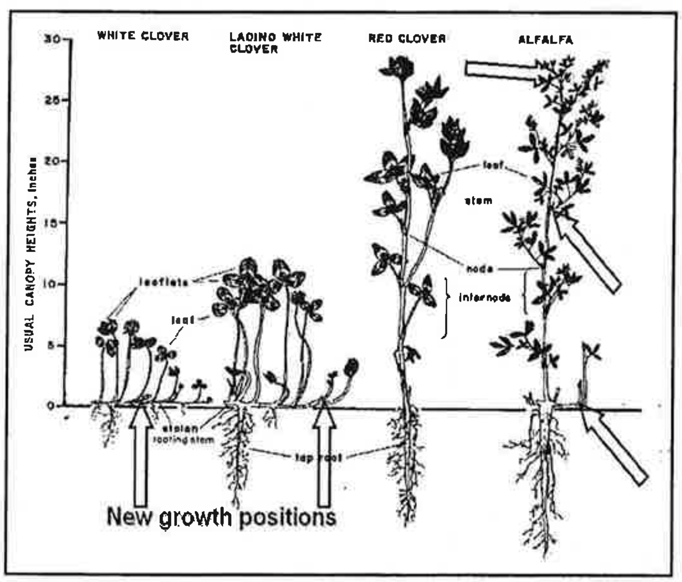

Figure 8. Morphological nature of selected legumes showing prostrate, close growing white clovers as compared to the erect red clover and alfalfa; note location of growing points and tap roots and stolons (Blaser1986).

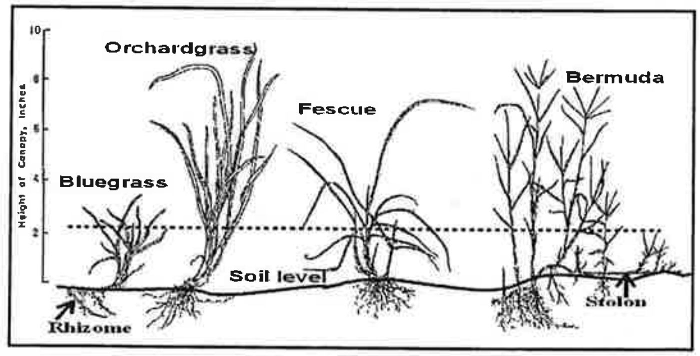

Figure 9. Morthpological nature of selected grasses showing location of their storage organs and the amount of leaf area near the soil surface; note how the presence of stolons or rhizomes can impact grazing height as compared to plants with only stroage in lower stem base (Blaser, 1986).

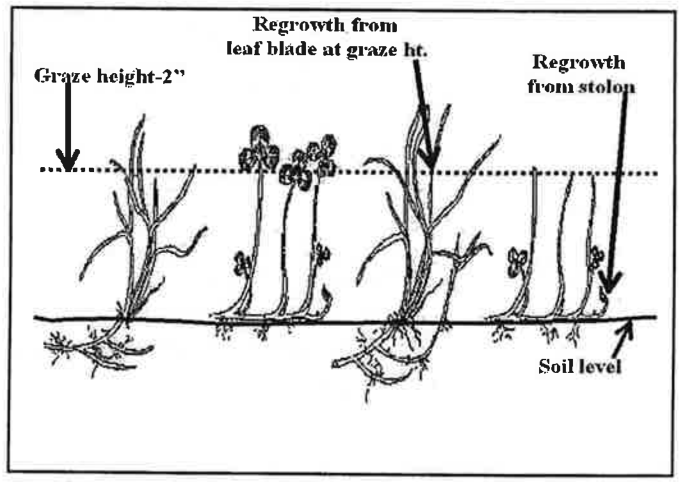

Figure 10. Illustration showing location of growing points and leaf area on bluegrass and white clover.(Blaser, 1986)

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.

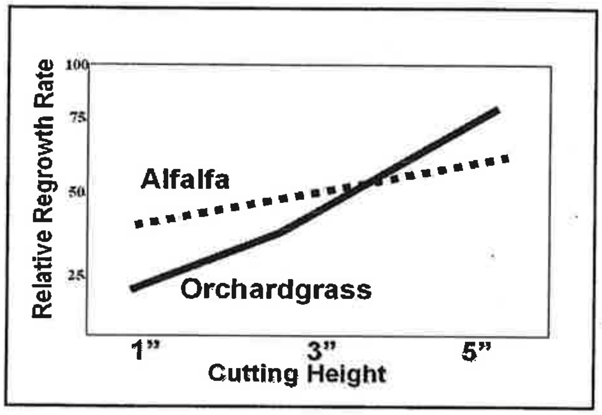

Figure 11. Effect of cutting height on relative regrowth rate of alfalfa/orghardgrass cut at three stubble heights.

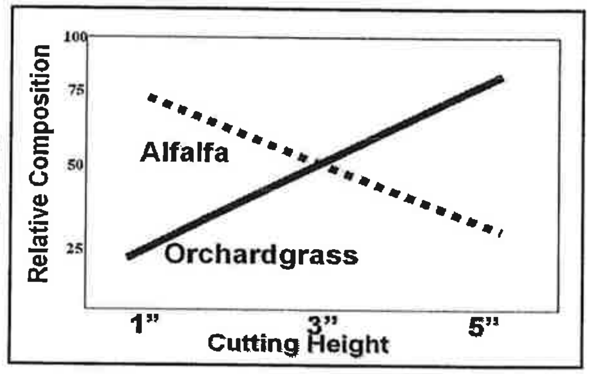

Figure 12. Effect of cutting height on change in botanical composition of a mixture of alfalfa/orchardgrass 4 cuts/yr.

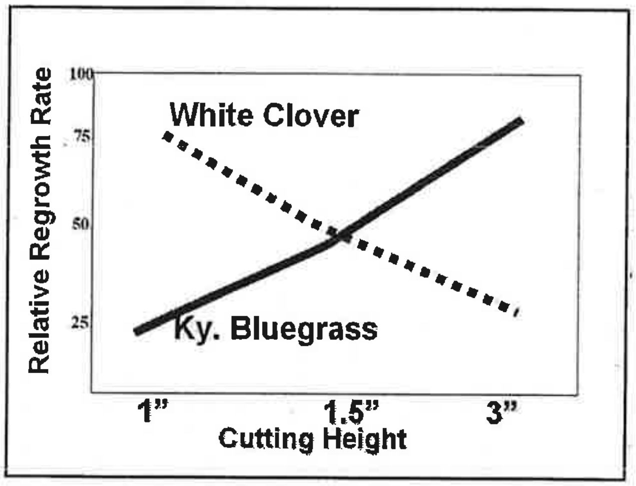

Figure 13. Effect of cutting height on relative regrowth rate of bluegrass and white clover.

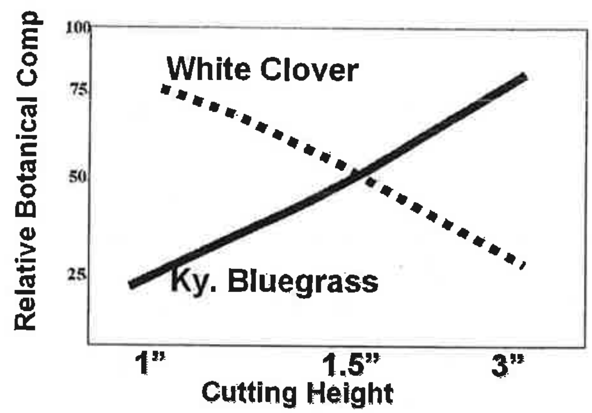

Figure 14. Effect of cutting height on botanical composition of bluegrass-white clover mixture (6 cuts/yr).

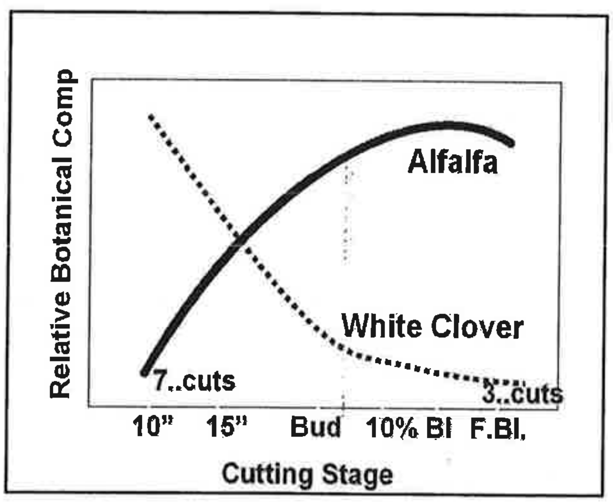

Figure 15. Effect of harvest frequency on botanical composition of a mixture of white clover/alfalfa.

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.

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November, 2000

FORAGE PHYSIOLOGY

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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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Agricultural Extension Service, Billy G. Hicks, Dean

Section 3

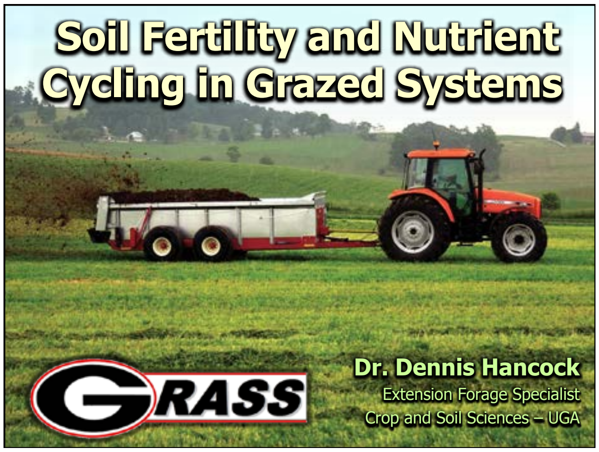
Soil fertility and nutrient cycling in grazing systems

Dr. Dennis Hancock, UGA

2015 Georgia Grazing School:

Soil fertility and nutrient cycling in grazing systems

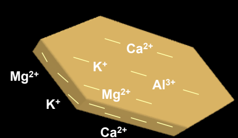
Dr. Dennis Hancock
Assoc. Prof. & Forage Ext. Specialist



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

How Soil Holds Nutrients

Soil Particle



e.g., CEC = 10

Organic Matter

e.g., CEC = 200

Plant Nutrients

Macro- (Primary)

Element	Available Form
Oxygen	O_2, OH^-
Carbon	$C0_3^{-2}$, HCO_3, CO_2
Hydrogen	H^+, OH^-
Nitrogen	NO_3^-, NH_4^+
Phosphorus	HPO_4^{-2}, $H_2PO_4^-$
Potassium	K^+

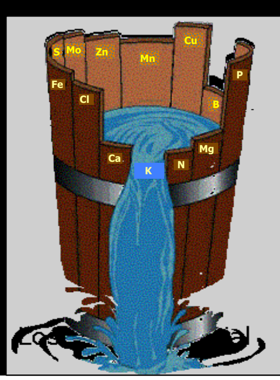
Meso- (Secondary)

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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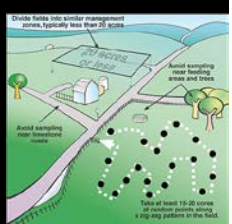
Soil Sampling

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

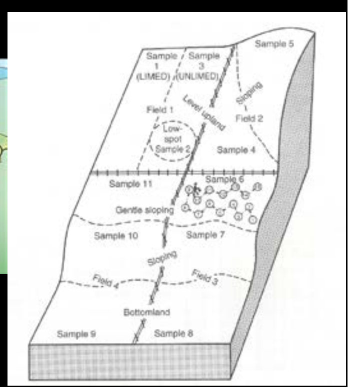
Sampling is Critical

- 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.

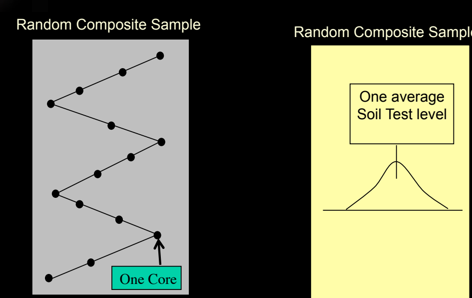
Sample Individual Paddocks



Courtesy: Univ. of Missouri Extension

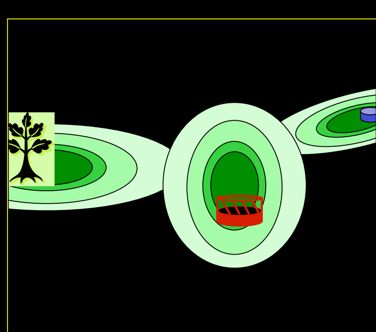


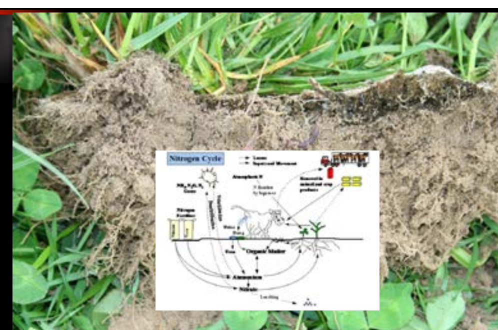
Field Average Sampling



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

Soil Sampling in Pastures





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

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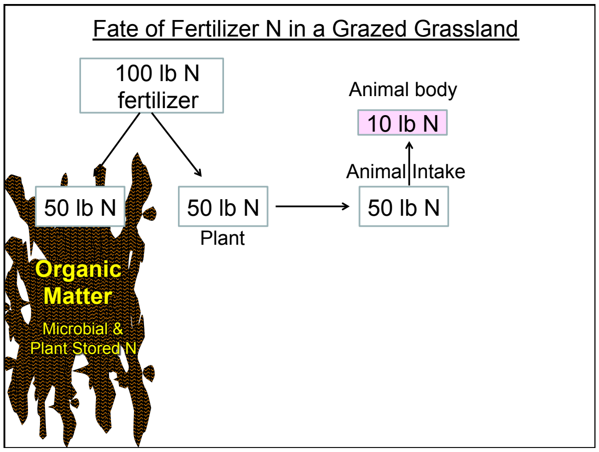
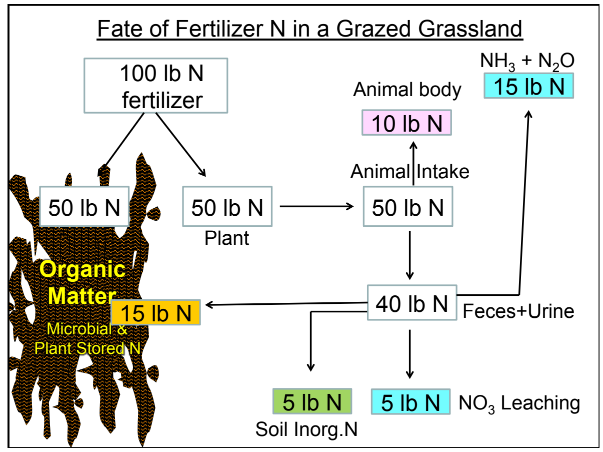




Organic N accumulation rate in upper 12 inches of soil during 12 years of haying or grazing with a yearly application of 220 lb N/acre as NH_4NO_3.

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%)

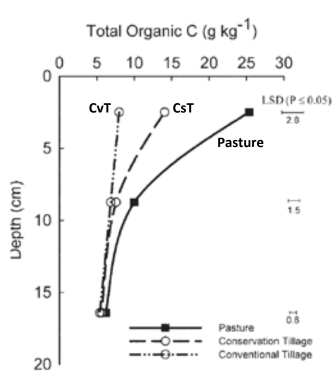
Franzluebbers and Stuedemann (2009)

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!!!

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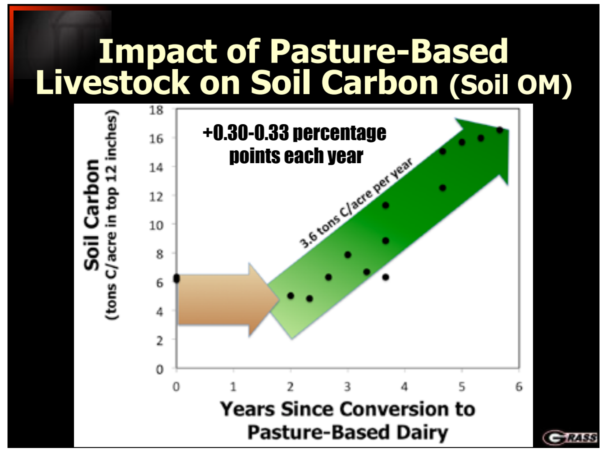

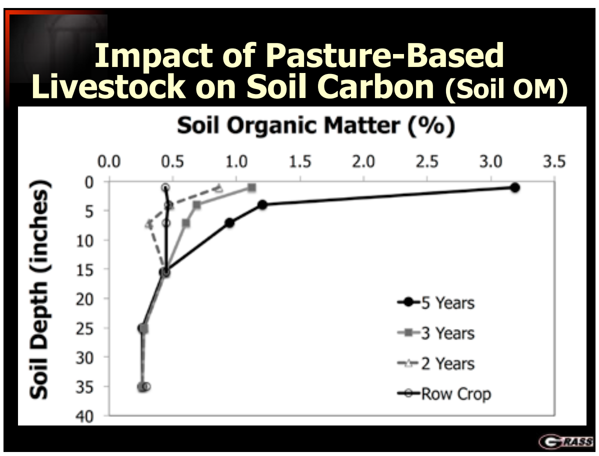

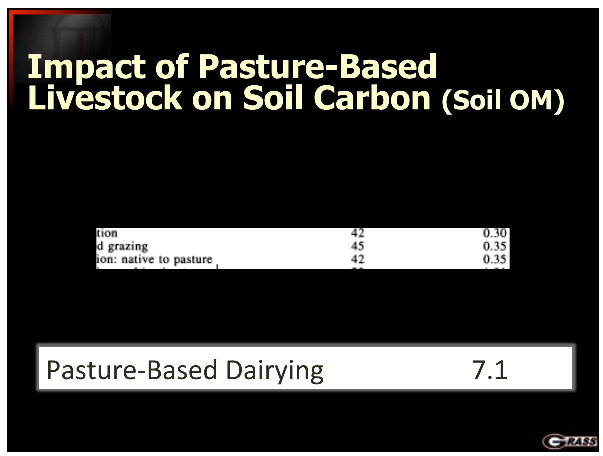

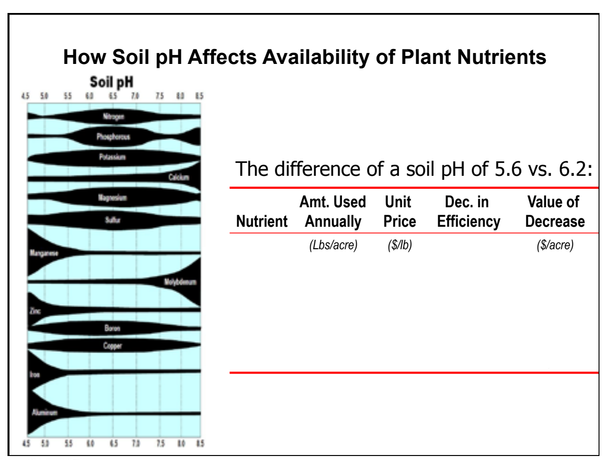

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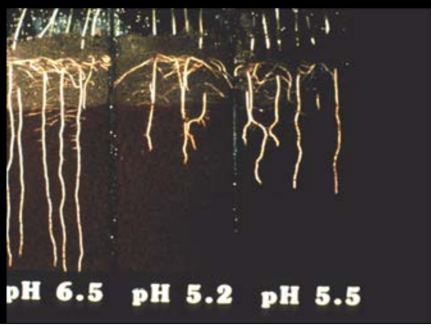
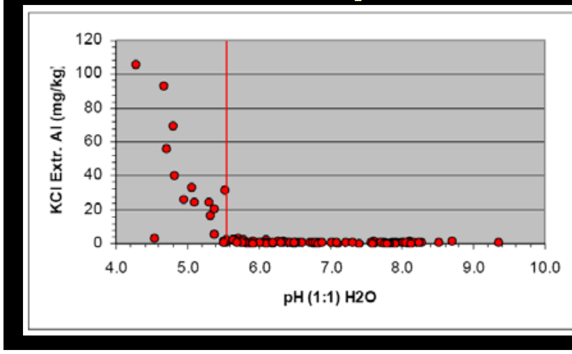
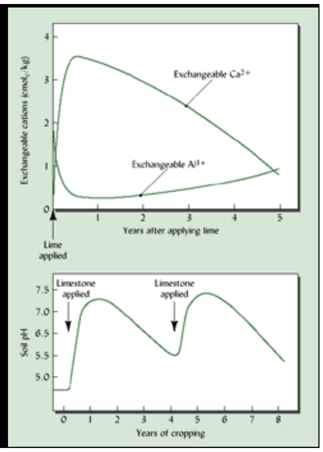
Get at the Root of a Problem: Soil pH Problems



Low Soil pH = Aluminum Toxicity



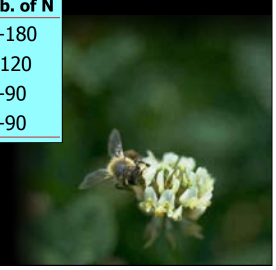
Applications of lime every 3 to 4 years are needed in Southeastern soils to maintain appropriate chemical balances in the soil.



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



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

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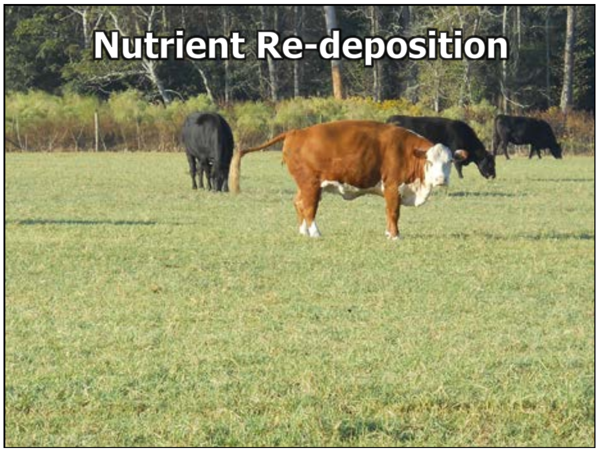
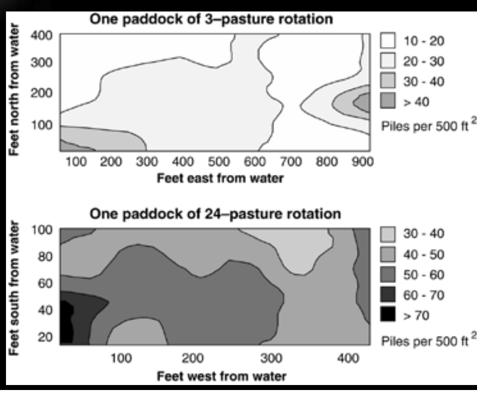


Benefits of Rational Grazing

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

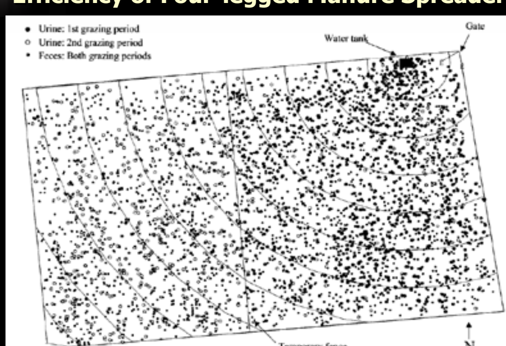
Manure Distribution



Manure Distribution

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

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

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).

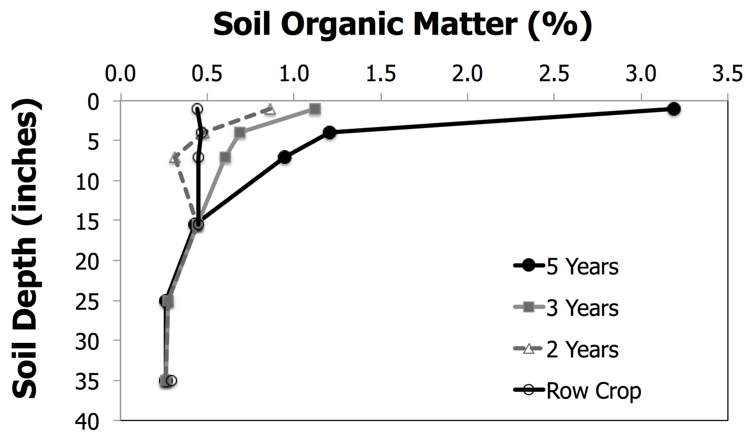


Figure 2. Soil organic matter in the soil profile for pasture-based dairies 2, 3, and 5 years following conversion from row crops.

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.

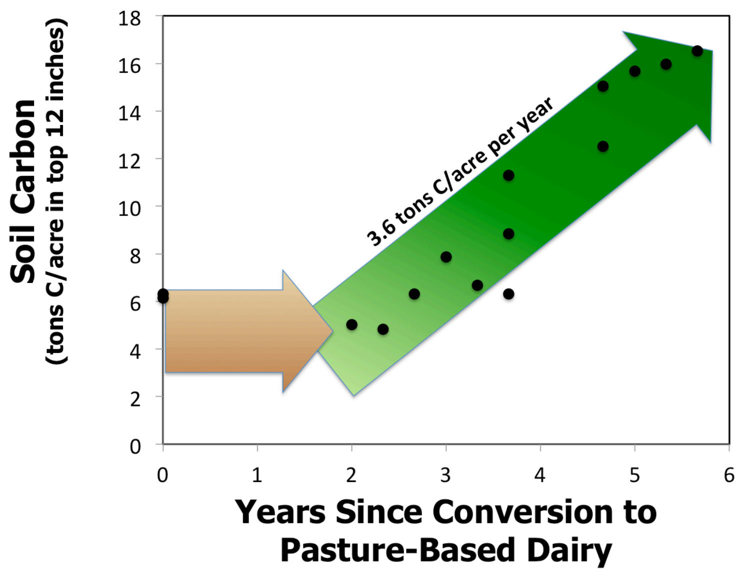


Figure 3. The amount of carbon in the soil in the years following conversion to pasture-based dairying. After an initial ~2-year lag phase when little carbon is added, the soil carbon increases linearly (3.6 tons C/acre per year) at least until 6 years after conversion.

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.

Are There Cheaper Inputs?
A Look at Municipal Biosolids for Forages

Julia Gaskin, Bio & Agricultural Engineering Dept
Glen Harris, Crop and Soil Science Dept.
University of Georgia

Good soil fertility is essential for maintaining productive pastures. In addition to commercial fertilizer inputs, there are many different byproducts that have been used in Georgia to maintain fertility. One of the most common is municipal biosolids or treated sewage sludge. Biosolids are beneficial in supplying nutrients, some liming potential, micronutrients, and organic matter; however, because they are not specifically formulated for a particular site's nutrient requirements, they may require special management considerations.

Municipal Biosolids

There are several municipal byproducts that are used in agriculture including biosolids, drinking water residuals, and composts from municipal solid wastes or yard wastes. Of these, biosolids are most commonly used in Georgia. Approximately 30% of the municipal biosolids in Georgia are land applied and most of these are land applied on pastures and hayfields. Many producers in Northwest Georgia, the Macon, and the Burke County areas have had good success using biosolids as a pasture fertility amendment.

Many people think municipal biosolids are the same as raw sewage. This is not the case. Biosolids are treated and stabilized sewage sludge that is suitable for land application. The treatment process begins with the raw sewage being screened to remove large trash and debris. Then microbes use the raw organic material to grow and reproduce. As these microbes die their bodies become part of the raw sewage sludge. The raw sewage sludge can be further digested by microbes, thickened, or dewatered. These processes further stabilize the organic matter to reduce odors and reduce pathogens. If these treatment processes result in an organic material that meets regulatory requirements for use land application, then these are known as biosolids.

The land application of biosolids is regulated by the US EPA under Part 503 of the Clean Water Act. The Part 503 regulations set pollutant limits, operational standards, and management practices for the land application of biosolids. In Georgia, the municipal wastewater plants wanting to land apply their biosolids must have each field that will be receiving biosolids permitted by the Department of Natural Resources Environmental Protection Division (EPD). The wastewater treatment plant is responsible for testing the biosolids for nutrients and metals, and for tracking the amount of biosolids applied to each field. The wastewater treatment plants are also responsible for periodic soil testing to ensure the soil pH is maintained at 6.5. Data on the amount of biosolids applied, soil pH, and other testing are reported to EPD yearly.

Biosolids are a good source of nitrogen (N) and phosphorus (P). They also contain some potassium (K), calcium, sulfur and other micronutrients such as iron, copper, zinc, manganese, chloride, boron, molybdenum, cobalt, and selenium. The typical fertilizer value of biosolids is 4-6-0.5. This translates to 80 lbs N, 120 lbs P_2O_5, 10 lbs K_2O per ton. The advantage and disadvantage of the material is that most of the N is in an organic form, which means it has to be converted to ammonium or nitrate before it is available to the forages. How fast this occurs depends on both moisture and temperature as well characteristics of the biosolids themselves. The conversion or mineralization will occur more quickly under moist, higher temperature conditions. Although this means that the full amount of nitrogen present in the biosolids will not be immediately available like commercial fertilizer, it also means that nitrogen is available over the entire growing season as the organic nitrogen mineralizes.

There are some potential management issues with using biosolids. With biosolids and all organic amendments, you get what's in the byproduct rather than nutrients specifically formulated for the fertility needs of your site. Land application of biosolids is permitted based on the nitrogen need of the crop. When biosolids are applied at the needed nitrogen rate, phosphorus is overapplied and potassium underapplied.

For example, extension recommendations for hybrid bermudagrass hay grown on fields with low soil test phosphorus and potassium are 300 lbs/ac N, 80 lbs/ac P_2O_5, and 250 lbs/ac K_2O. We will assume biosolids at a typical nutrient concentration of 4% N, 2% P, and 0.5% K will be applied to satisfy the nitrogen need of the crop. We will also assume 1.5% of this nitrogen will be ammonium-nitrogen and 20% of the organic nitrogen will be mineralized during the year. This means 7.5 tons per acre of biosolids would need to be applied to meet the forage nitrogen need. At this application rate, 300 lbs/ac of P_2O_5 would be applied, resulting in an overapplication of 220 lbs/ac. Only 75 lbs/ac of K_2O would be applied, which results in an underapplication of 175 lbs/ac.

One further point, the 7.5 tons/acre application rate would only be applicable for the first year. The regulations for land application of biosolids assume only 20 to 30% of the nitrogen is available the first year, this means there is still about 300 lbs/acre of organic nitrogen in the field left to mineralize. This residual nitrogen has to be accounted for and application rates reduced during following years. The wastewater treatment plant will calculate the new loading rate that accounts for the residual nitrogen.

Another advantage of using biosolids is that the wastewater treatment plant usually supplies lime or limes the fields where the biosolids are applied. This is due to the EPD permit requirement to keep the soil pH at 6.5.

We've discussed several things you should be aware of: phosphorus overapplication that can lead to environmental problems, potassium underapplication that can lead to winterkill of bermudagrass, and the residual nitrogen left in the soil. There are also other concerns. These include metals, man-made organic chemicals, pathogens, and odors.

Biosolids do contain metals. Many of these metals are also micronutrients needed by plants or animals for good health. The key to whether metals are a problem is the loading or the amount present in the soil that is available for plants to use. The US EPA Part 503 regulations set levels for eight metals: arsenic, cadmium, copper*, lead, mercury, molybdenum*, nickel*, selenium*, and zinc*. The starred metals are either plant or animal micronutrients.

Metals are present in biosolids, animal manures, and in some commercial fertilizers (Table 1). The metal concentrations in biosolids are typically higher than those for animal manures. Phosphate fertilizer can have higher concentrations of arsenic and cadmium than biosolids, but the amount applied per acre is much less, creating a lower loading. Again the loading, which is the amount of metal per acre, is an important factor along with how available the metal is to plants.

Table 1. A comparison of metal concentrations in municipal biosolids, animal manures, and phosphate fertilizer. All values in mg/kg. Loading from phosphate fertilizer would be much lower than for biosolids and manures on a nitrogen basis.

Metal	Biosolids[1]	Poultry Litter	Dairy	Phosphate Fertilizer[2]
Arsenic	3.6	15.7[3]	1.0	11
Cadmium	2.26	2.5	0.2	8.1
Lead	64.9	36	2.0	5.7
Mercury	1.54	NA	0.02	0.03
Zinc	705	338	162	82

1. Data adapted from Stehouwer (2000)
2. Data adapted from McBride and Spiers (2001)
3. Data from Jackson et al. (2003)

Although there is not data available for Georgia, studies in other parts of the United States show that metal concentrations in biosolids have been decreasing over the past thirty years (Table 2). Metal concentrations are well below the level the US Environmental Protection Agency has set as safe. This is the result of required pretreatment programs for industries that discharge to municipal wastewater treatment plants that limit the amounts of metals that can be released.

Table 2. Selected metal concentrations in municipal biosolids over time. The 2000 data are the medians from a Pennsylvania study by Stehouwer (2000). The 1990 data are the means from 1990 National Sewage Sludge survey. Table 3 Limit is the lower threshold for metals set by the US EPA Part 503 Rules.

Metal	2000	1990	Table 3 Limit
	-------------- mg/kg	--------------------------	
Arsenic	3.60	9.9	41
Cadmium	2.26	6.94	39
Lead	64.9	134.4	300
Mercury	1.54	5.2	17
Zinc	705	1,202	2,800

The bigger question for cattle producers is, "Will I have metals in my forages?." There are several studies on how biosolids effect forages in the Southeast. Some of these studies have found higher metals in forages where biosolids were used as a fertilizer, but the increases were small. A study in Burke County, Georgia found no difference in overall forage quality in bermudagrass forage from fields fertilized with commercial fertilizer and those that had received biosolids for more than six years. None of the studies have found metal concentrations in forage near levels that would be toxic to cattle. These studies indicate that applying biosolids at the nitrogen need of the forage and according to the Part 503 regulations should not create a metals problem for cattle producers. Some studies have seen a change in copper to molybdenum ratios in the forage or an increase in the sulfur content. A low copper:molybdenum ratio and higher sulfur content can induce a copper deficiency in cattle. Because our soils are naturally very low in copper, it is a good idea to feed mineral supplements with sufficient copper to ensure good nutrition. Animal scientists at UGA recommend mineral supplements with 2000 to 2500 ppm copper for cattle.

Man-made organic chemicals are a source of concern for some people. The 1990 National Sewage Sludge survey found low concentrations of most organic chemicals in biosolids. Due to these low concentrations, currently there are no pollutant limits for organic chemicals in the Part 503 regulations. However, studies are underway to evaluate the levels of organic chemicals in biosolids, better understand what types of chemicals are not broken down during the treatment process, and what types of risks they may pose.

Biosolids also can potentially contain pathogens such as *Salmonella* sp., *E. Coli.*, *Shigella* sp., *Hepatitis A*, or *Gardia lambia*. Pathogens in the raw sewage are greatly reduced by the wastewater treatment processes and the Part 503 regulations have standards that must be met for pathogen treatment; however, pathogens can still be present in biosolids that are land applied. Most biosolids land applied in Georgia are Class B. This means that site restrictions are used to prevent direct contact with the biosolids after land application. Cattle are restricted from grazing for 30 days on fields where Class B biosolids have been applied. Public access is also restricted for 30 days after land application. Although research is ongoing, the studies available generally do not indicate properly treated and land applied biosolids pose a large risk to human or animal health. There are case studies that attribute human health effects to land applied biosolids and the risk to people with compromised immune systems, such as those undergoing chemotherapy, is unknown.

A more common problem may be odor. The Part 503 regulations require that the organic matter in biosolids be stabilized to reduce potential odor; however, biosolids do have an odor when first applied. This should disappear after a few days or after the first rain. Setbacks from neighbors who might be sensitive can help prevent complaints.

Setbacks are also required by Georgia EPD from surface water bodies such as streams and ponds, wells, and houses. These setbacks should be followed to minimize potential surface water or well water contamination. More information on the use and regulations pertaining to biosolids can be found in the Resources and Links sections under Land Application at the www.agp2.org website.

Good Management Practices

Municipal biosolids can be effective fertility amendments for pastures and hayfields when handled and applied properly. Although the wastewater treatment plants have primary responsibility for this when land applying municipal biosolids, the producer should make sure proper management practices are being followed. These include:

- Ask for a report showing the amount of nitrogen, phosphorus and potassium supplied by the biosolids. If metals are present in the biosolids above what is known as the “Pollutant Concentration”, the report will also have the amount of each metal applied to each field. You should also be able to get a copy of the soil test results. This will tell you the pH of each field and if more phosphorus or potassium is needed. Soil pHs at 6.0 to 6.5 keep most metals from being readily taken up by plants.

- Don’t apply additional nitrogen to biosolids applied fields unless you receive information that the application rate will not meet forage nitrogen requirement, and then only apply what is needed to fulfill the deficit.

- Do apply the needed potassium fertilizer to prevent winterkill.

- Be aware of conditions that cause excessive nitrates in forage, such as lush growth after a drought period.

- Feed animals the proper mineral supplements to ensure good nutrition. Cattle need supplements with additional copper.

- Make sure proper setbacks are flagged and followed to avoid application near sensitive areas such as streams or wellheads.

- Be sensitive to neighbor concerns with odors or water quality. Communicate when you will be applying and the importance of fertility in maintaining healthy pastures and hayfields.

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).

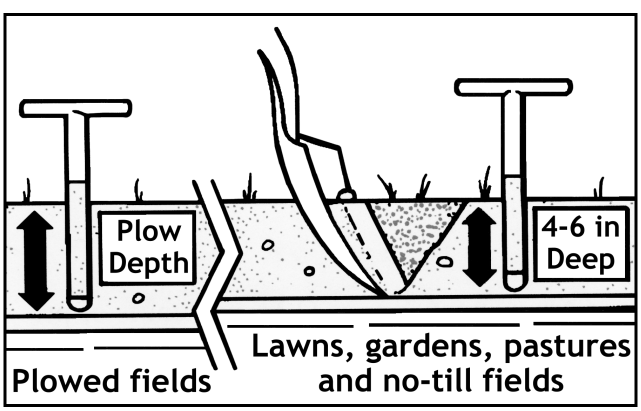


Figure 1. Take a thin vertical slice to desired depth.

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

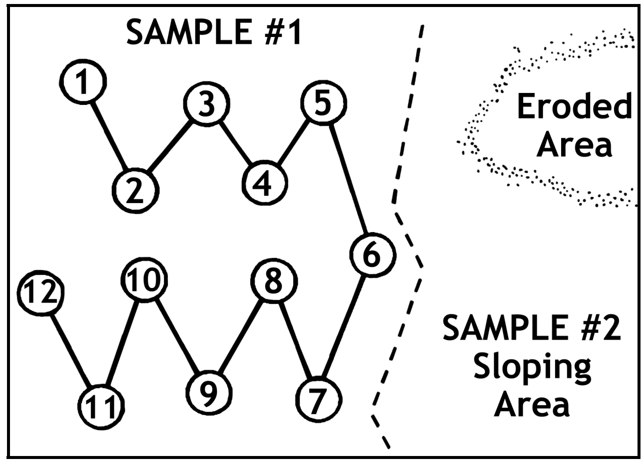


Figure 2. Soil Sampling Scheme

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.

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.

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Gale A. Buchanan, Dean and Director

Section 4

Managing, utilizing, and maintaining legumes

Philip Brown, NRCS Grassland Conservationist

2015 Georgia Grazing School:

Managing, utilizing, and maintaining legumes

Philip Brown,
USDA-NRCS Grazinglands Specialist

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

Increased Gain

Table 3. Average daily gain and gains/acre of steers grazing tall fescue and tall fescue-clover pastures.

Pastures	Daily gain (lb/steer)	Total gains	
		lb/steer	lb/ac
Tall fescue* + Ladino clover	1.53	307	582
Tall fescue* + 150 lb N/ac	1.06	203	374

Hoveland, C.S., et al. 1981. Bulletin 530. Auburn, AL

*The tall fescue used in this study 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

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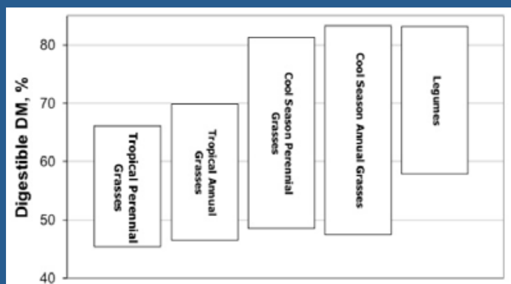
2015 Georgia Grazing School:
Managing, utilizing, and maintaining legumes

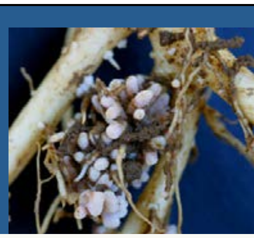
Philip Brown,
USDA-NRCS Grazinglands Specialist

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, I would look to MWD to Poorly Drained Sites in the Coastal Plain and Flatwoods
- Alfalfa – Well Drained, Fertile Sites throughout the State

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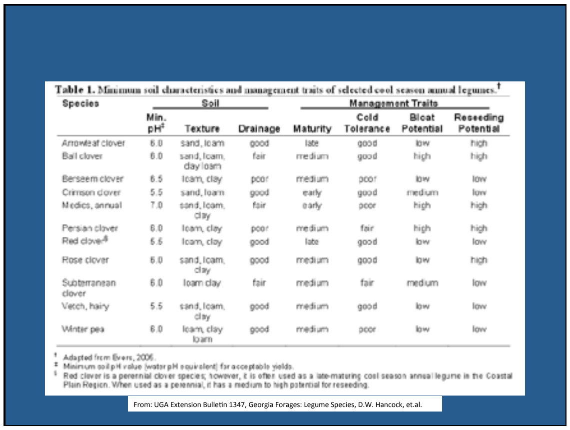
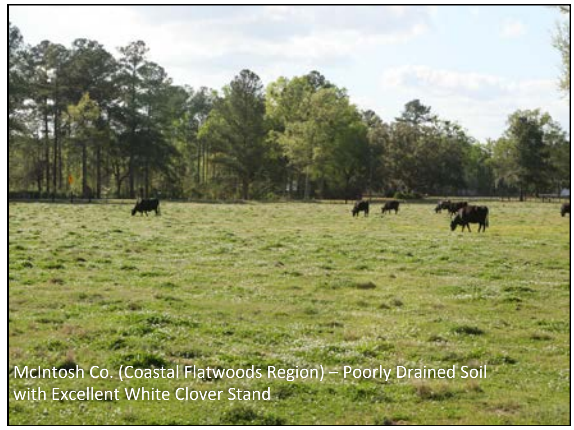


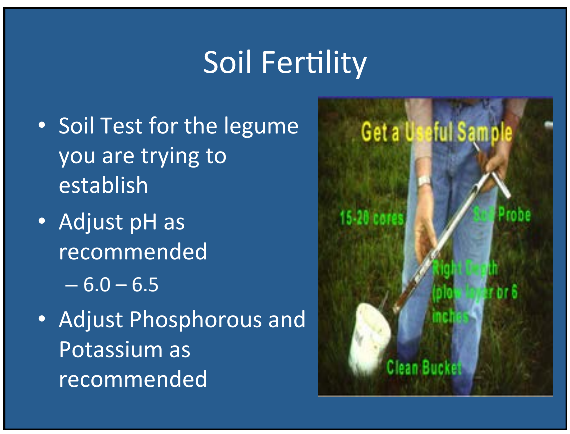
Table 1. Minimum soil characteristics and management traits of selected cool season annual legumes.†

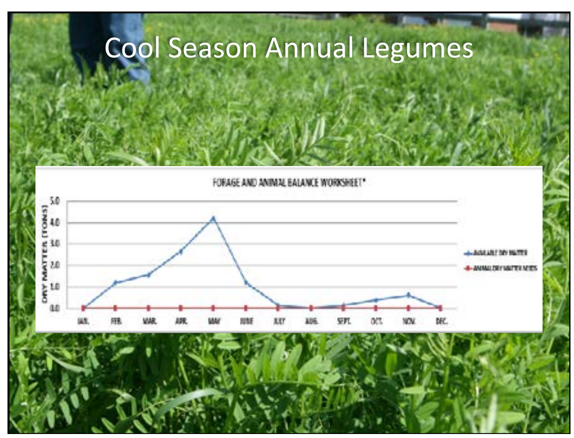
Species	Soil			Management Traits			
	Min. pH‡	Texture	Drainage	Maturity	Cold Tolerance	Bloat Potential	Reseeding Potential
Arrowleaf clover	6.0	sand, loam	good	late	good	low	high
Ball clover	6.0	sand, loam, clay loam	fair	medium	good	high	high
Berseem clover	6.5	loam, clay	poor	medium	poor	low	low
Crimson 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§	6.5	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, 2006.
‡ 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.







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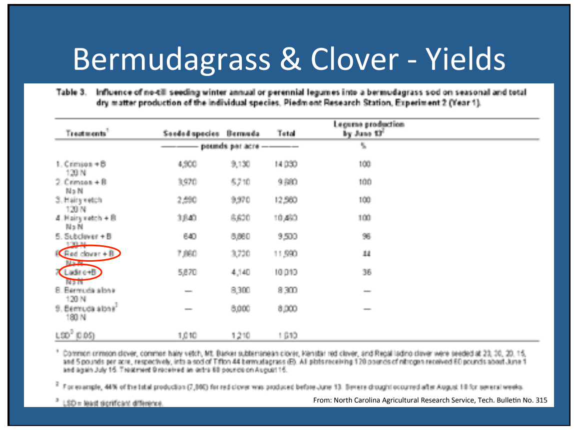


Table 3. Influence of no-till seeding winter annual or perennial legumes into a bermudagrass sod on seasonal and total dry matter production of the individual species. Piedmont Research Station, Experiment 2 (Year 1).

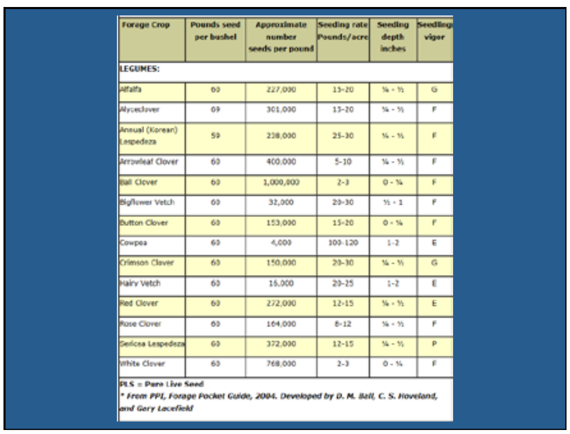
Treatments[1]	Seeded species	Bermuda	Total	Legume production by June 13[2]
	pounds per acre			%
1. Crimson + B 120 N	4,900	9,130	14,030	100
2. Crimson + B No N	3,970	5,710	9,680	100
3. Hairy vetch 120 N	2,590	9,970	12,560	100
4. Hairy vetch + B No N	3,840	6,620	10,460	100
5. Subclover + B 120 N	640	8,860	9,500	96
6. Red clover + B No N	7,860	3,730	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[3] 180 N	—	8,000	8,000	—
LSD[3] (0.05)	1,010	1,210	1,010	

[1] Common crimson clover, common hairy vetch, Mt. Barker subterranean clover, Kenstar red clover, and Regal ladino clover were seeded at 23, 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 60 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 18 for several weeks.

[3] LSD = least significant difference.

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



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*

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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 %

Warm SeasonLegumes

- Annuals
  - Cowpeas
  - Annual Lespedeza
  - Soybeans
- 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

Questions?

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Grazing School

GEARING UP FOR WINTER GRAZING
October 2013 Georgia Cattleman
Dennis Hancock, Forage Extension Specialist
The University of Georgia

It is that time of year again! Yes, it is once again time to gear up and get ready to plant your winter grazing. As you grease up your no-till drill or pick up the one you're renting, here are some key considerations to help ensure your plantings are successful and cost-effective.

Clear Out and Clean Up

One should never take anything for granted. This is especially true for assumptions about no-till drills. For example, one is likely to find that at least one of the drop tubes or feed cups will be clogged or has a spider web in it that will obstruct normal flow (Figures 1 and 2). Spiders seem to have an affinity for seed tubes. Use compressed air or something similar to blow out the tubes. After blowing them out, use little wads of paper to pass through the drop tube to test to make sure it is clear of obstruction. If it doesn't drop through easily, take off the tube and treat it with more vigor.

Figure 1. This feed cup (under each seed box) is full of seed from the previous use.

One might also find that the last person to use the drill left a surprise in the hopper. Several years ago, I picked up a no-till drill that I had rented. Apparently, when the last person finished with it, they failed to empty out the seed. Since this drill was stored outside and the lid wasn't watertight, I found a cake of half-rotten tall fescue seed in the bottom of the hopper and a bunch of seedlings growing like a Chia pet on top. Surprise!

Set Up for Proper Drop

Larger seeded species, including any that are larger than tall fescue or annual ryegrass seeds, can usually be planted using the large seed box without any problem. This is handy because the large seed box usually holds much more volume than the small seed box. Many of our forage seeds are small and require a shallow seeding depth. Any seed that is the size of tall fescue, annual ryegrass, or smaller should be able to be sown using the small seed box. Seeds that are approximately the size of tall fescue or annual ryegrass can be sown using either seed box.

Figure 2. Parts of a no-till drill.

Check to make sure that the feed cups are appropriately set up according to the manufacturer's instructions. Ensure these are properly set BEFORE pouring seed into the box, otherwise your seed will flow right through and form neat little piles under each opener.

Check for Unusual Wear

Running a no-till drill across some of our rough (and sometimes rocky) terrain is hard on it. Check to make sure that the coulters on the front, the openers in the middle (where the furrow is opened), and the press wheels in the back are not chipped, bent, or wobbling and that they run true with one another. Ensure that each moving part turns freely and that all bearings are sound and greased. Also, ensure that the openers are allowing sufficient gap for the seed to fall into place. These considerations are especially important when dealing with rented drills. No one who reads these articles would do this, but there are some people in this world who fail to pick up the drill when turning around. Such is commonly the case for rented drills and this will cause extreme wear and stress on the moving parts and result in failure.

Ensure Proper Planting Depth

Most of our most common forage species (e.g., annual ryegrass, bahiagrass, tall fescue, etc.) should be planted at a depth of ¼ to ½ inch. Some can be planted as deep as 1 inch without hampering emergence (e.g., rye, wheat, triticale, pearl millet, sorghum x sudangrass, etc.). In fact, when soil moisture is limited, it would be wise to plant those species at that depth. In contrast, most of the legumes (e.g., the clovers, lespedeza, alfalfa, etc.) should be planted no deeper than ¼ inch deep.

There are three major adjustments that can be made to adjust the planting depth. The first of these adjustments is the cutting depth of the rolling coulter in the front of the drill. As a rule of thumb, the coulter should be cutting twice as deep as the planned seeding depth. So, if the desired planting depth is ½ inch, then the coulter should make a 1-inch slice into the sod. This is usually adjusted by a "depth control" knob or hydraulic setup. Those who are unfamiliar with using a no-till drill may assume that turning the "depth control" knob is the only adjustment that is needed. Unfortunately, they may not realize that this only sets the coulter depth. There are two other adjustments that are necessary.

Second, ensure that the springs above the opener are providing sufficient down pressure (Figure 3). Typically, there are one or two springs for each row unit that pushes the opener down. These may be placed on their lowest down pressure setting when shipped from the manufacturer. This may be sufficient down pressure, at least at the start. However, in dense sod (e.g., when planting into thick bermudagrass or bahiagrass) or after a few seasons of use, these springs may not provide enough down pressure. To create more down pressure, shorten the length of the spring's travel according to the manufacturer's instructions (usually by removing the "W" clip at the bottom of the spring and moving it to a higher hole in the rod that runs through the spring).

The final step, adjusting the press wheels correctly, is equally crucial to no-till planting success. Most press wheels have a T-handle that can be adjusted forward (toward the tractor) allowing the depth to be shallower or backward (toward the press wheel) to enable a deeper seed placement. The press wheels are designed to ensure that the openers aren't pushed too deeply by the springs. The press wheels work in tandem with the springs to create what is called "reserve power." In other words, as the properly adjusted press wheel traverses the rough terrain of pastures and hayfields, there is enough travel in the spring that the openers are always positioned at the right depth. The springs and press wheels work together in the same way as the suspension system and the tires on your truck or car work to ensure that the wheel doesn't bounce off of the surface. Remember that conditions often vary within the field and will change throughout the day. Regularly check seeding depth and adjust the press wheels accordingly.

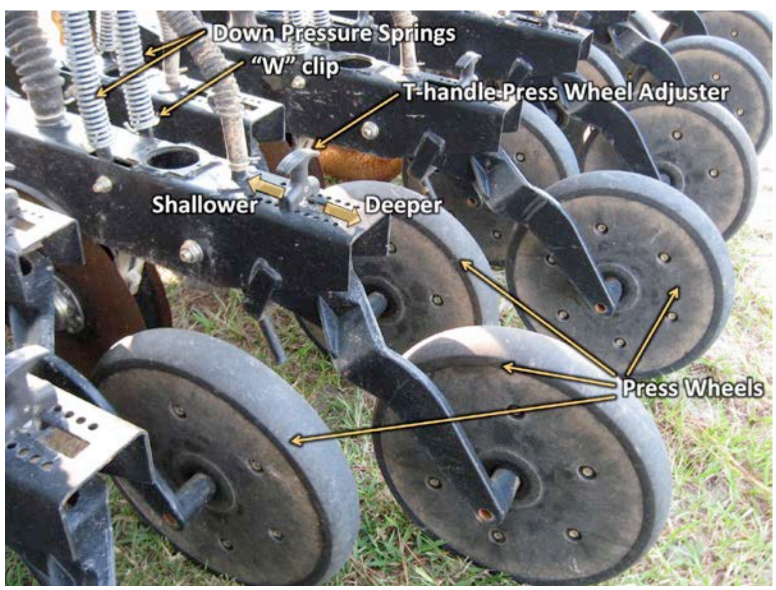


Figure 3. Parts important to ensuring proper opener/seeding depth.

For the shallow-planted (≤¼ inch) species, establishment success is often greatest when the seed is dropped directly in front of the press wheel. The press wheels can provide enough soil coverage to ensure adequate seed:soil contact. Some no-till drills are designed this way (such as the drill pictured herein). If working with a drill that is not designed in this fashion, the small seed box drop tube can be removed from where it is dropping seed into the opener, and it can be cable-tied or wired in place so that it drops the seed in front of the press wheel.

When checking depth, carefully scrape away the soil from the middle of the furrow outwards. Measure the depth relative to soil surface. Note that the layer of thatch or residue is not included in the planting depth. Checking planting depth can sometimes be difficult because the seed are hard to find. When adjusting the seeding depth, use a quart-sized bag full of seed that has been lightly sprayed with orange turf paint so that one can easily see the seed when measuring seeding depth.

Calibrate the Drill

The final step in preparing for planting is to ensure that the proper seeding rate is being sown. It is likely that your drill's manufacturer provides settings for most forage crops that you plan on seeding. However, these settings are not always perfect, nor do they account for normal wear with the moving parts. The manufacturer's recommended settings are a great place to start, but they may not be sufficiently accurate. With seed prices where they are currently, it has never been more important to calibrate your drill. Your drill's manufacturer likely has provided a step-by-step guide to calibrating your drill in the manual. Other methods for calibrating a drill are also provided on www.georgiaforages.com and in an Extension article from our colleagues at the University of Arkansas entitled "Calibrating Drills and Broadcast Planters for Small-Seeded Forages," which is directly linked here: http://bit.ly/15QUPG8.

More Information

Additional information about setting up and calibrating your no-till drill can be found by visiting our website at www.georgiaforages.com. If you have additional forage management questions, visit our website or contact your local University of Georgia Cooperative Extension office by dialing 1-800-ASK-UGA1.

got questions?

Have a question or topic that you want Dr. Hancock to address? Email him at: questions@georgiaforages.com.

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

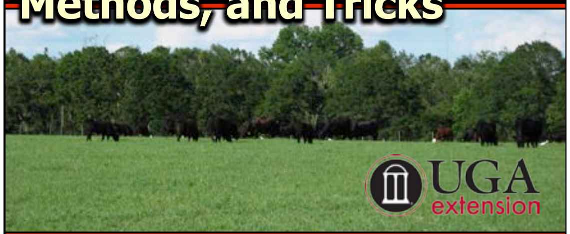
Grazing systems, methods, and tricks

Paula Burke, UGA Ext., Carroll County
Dr. Dennis Hancock, UGA

2015 Georgia Grazing School:
Grazing systems, methods, and tricks

Paula Burke
Carroll Co. ANR Extension Agent

Grazing Systems, Methods, and Tricks



Paula J. Burke
ANR Agent, UGA Extension Carroll County

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

Fencing + Animals ≠ Grazing System

System vs. Method
Strategy vs. Tactic

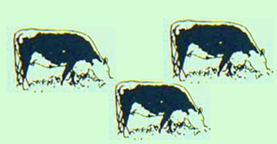
- Grazing system: "A defined, integrated combination of animal, plant, soil and other environmental components and the grazing method(s) by which the system is managed to **achieve specific results or goals**" Ex:
  - Continuous Grazing System
  - Management Intensive Grazing (or "Rational Grazing") System
  - Ultra-High Stock Density, Long Rest Period, Short Duration Grazing (or "Mob Grazing") System
- Grazing methods- "…technique of grazing management designed to **achieve a specific objective.**" Ex:
  - Deferred grazing ("stockpiling") to reduce fall hay feeding
  - Creep grazing to increase gain on calves still on the cow

Grazing Methods to Consider

Low-Management Grazing System
- Continuous stocking
  - Range or no pasture divisions

"Rational Grazing" System
- Rotational stocking
- Deferred grazing "stockpiling"
- Creep grazing
- Strip grazing
- Limit grazing
- Leader-follower, first-last, or forward grazing

Continuous Stocking



Can work well with warm season perennials like bermudagrass or bahiagrass

Photo credit: John Andrae, Clemson Univ.

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Grazing systems, methods, and tricks

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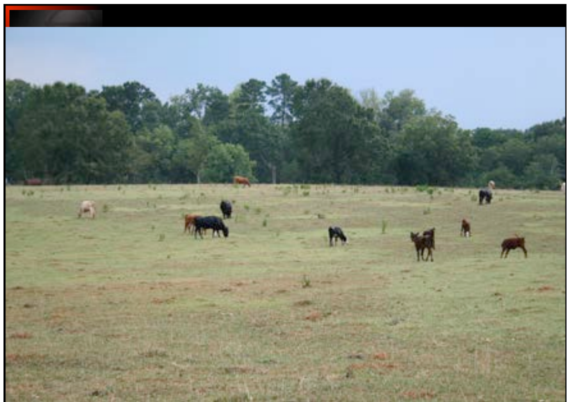
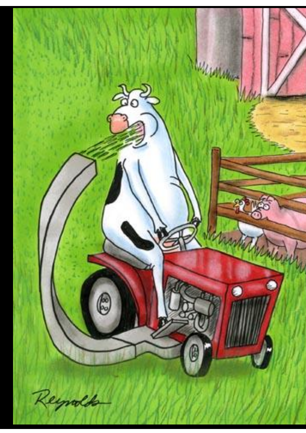
Carroll Co. ANR Extension Agent

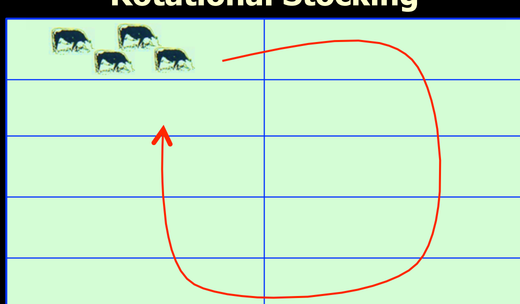


Efficiencies of Grazing and Mechanized Harvest

System/Method	Efficiency
Grazing	
Continuous Stocking	30-40%



Rotational Stocking



Efficiencies of Grazing and Mechanized Harvest

System/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%

Better utilization of forage!

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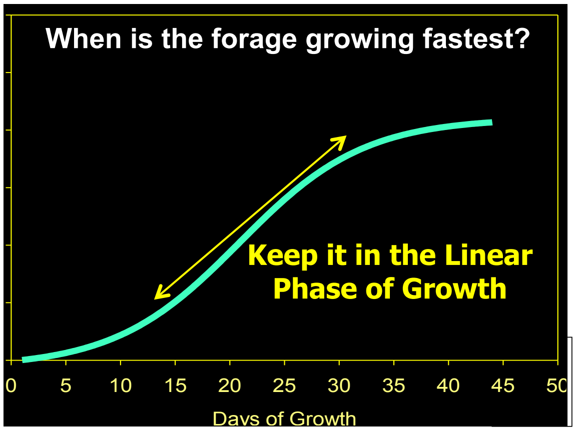


Effects of rotational stocking on performance of beef cattle grazing bermudagrass and endophyte-free tall fescue in central Georgia

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 grazing in studies from various southern states

State	% Increase
Arkansas	44
Georgia	37
Oklahoma	35
Virginia	61

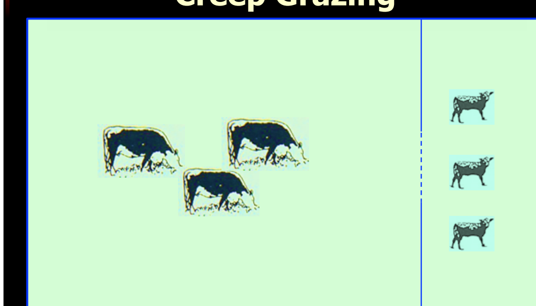
Efficiencies of Grazing and Mechanized Harvest

System/Method	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%

Real Benefits of Rotational Stocking

- Increased stocking rate (in many cases)
- Better persistence and productivity of pasture plants that are sensitive to close, continuous grazing
  - Alfalfa, red clover, tall fescue, orchardgrass, natives
- Improved utilization of more species in pasture
- Fewer weeds
- Less waste of forage
- Better distribution of urine and feces
- Better control of livestock
- Increases establishment options (clovers, “crop rotations”)
- Improves pasture management skills

Creep Grazing



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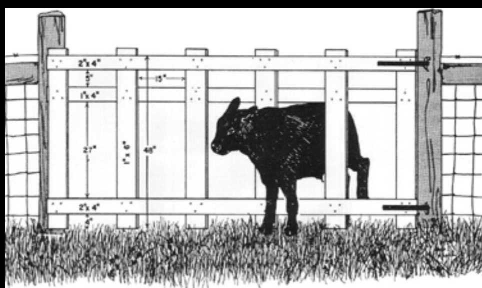
Standard Creep Gate



Creep Grazing Pearl Millet on Tall Fescue-Based Pastures

	Control	Creep Grazed
Calf gain, lbs	144	219
Calf ADG, lbs/d	1.38	2.10
Cow wt change, lbs	-60	+27

Data from Thomas, Eason, Ball and Ruffin; AL Agric. Exp. Stn. Highlights Vol 30 No 2

Effects of Creep Grazing Treatments on Average Daily Gain of Calves

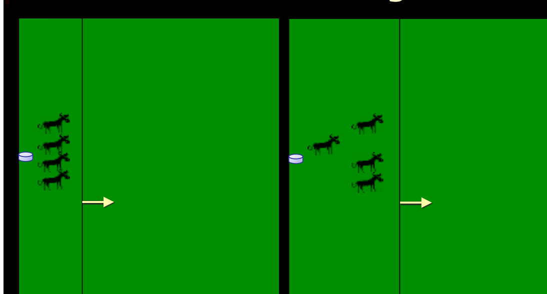
Creep Treatments	Calf ADG, lbs
Aeschynomene	1.98
Hairy Indigo	1.80
Tifleaf 1 Pearl Millet	1.80
Alyceclover	1.70
Commercial creep	1.86
No Creep	1.50

Data by Bill Ocumpaugh. IFAS Circular S-318, 1985. Gainesville FL. Bahiagrass based pastures.

Creep Grazing

- Excellent potential to improve calf gains
- Easy to implement into existing continuous grazing system
- Several forages have potential for creep grazing
  - Pearl millet, legumes, chicory, alfalfa, small grains and ryegrass

Frontal Grazing



Frontal Grazing

Best used where high utilization is needed, but not worried about regrowth. Ex:

- Stockpiled forages,
- Crop residues (e.g., corn, cotton, etc.)
- Overly mature summer annuals/grazing corn

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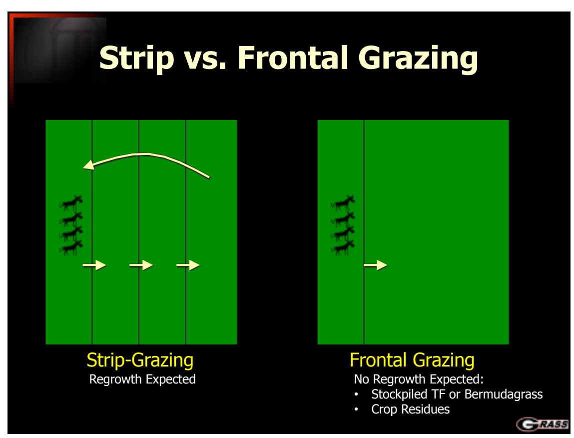

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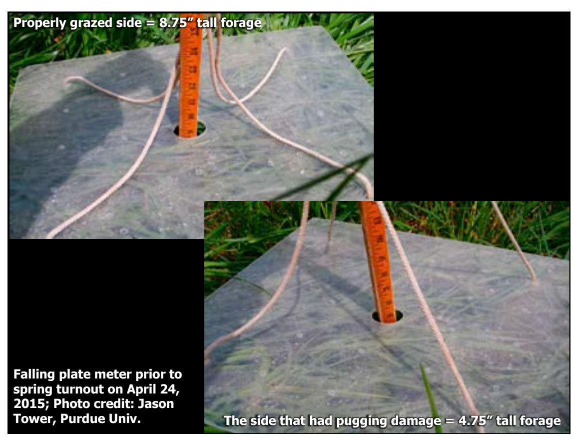
Strip (or "Break") Grazing

Best used where:

- High utilization is needed and available forage is short
  - Sacrificing small area to reduce press on the whole
- Waste potential is high or access needs to be controlled
- Animals have lower nutrient requirements



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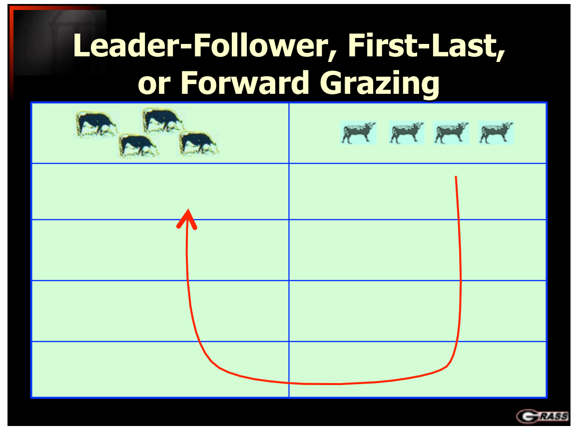

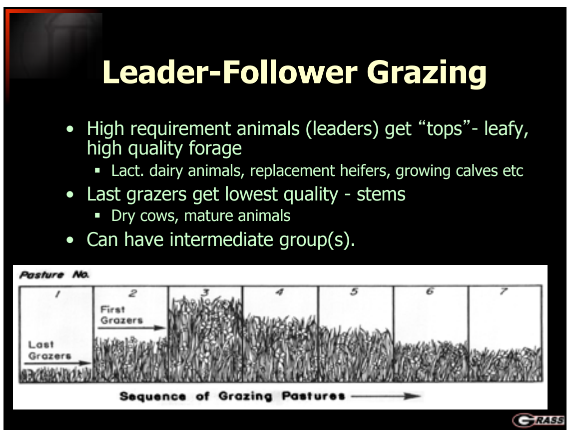

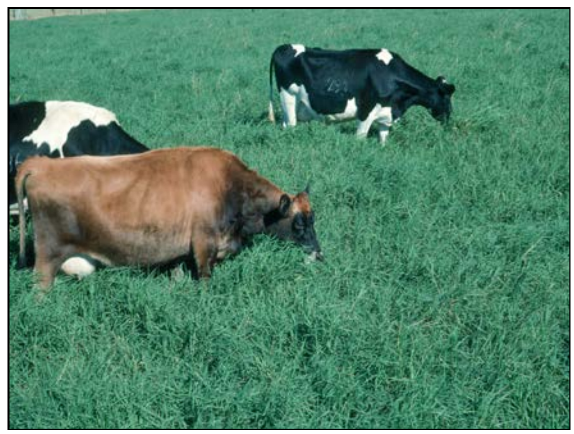

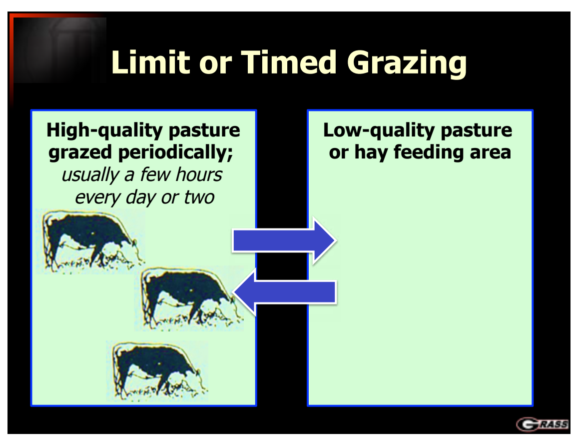

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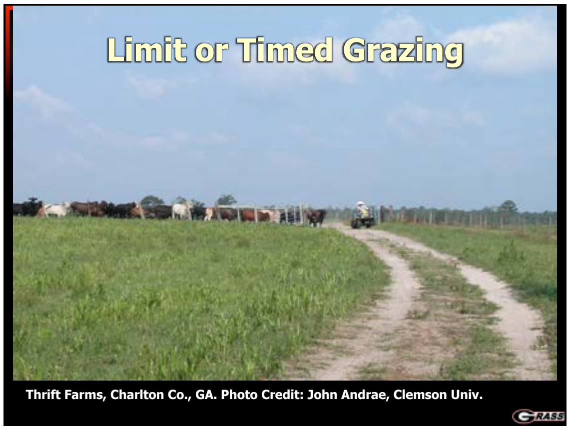

Limit or Timed Grazing

- Graze 2-3 h per day or on alternate day basis
  - Think of this as a supplement to lower quality pasture or hay
  - Allows cows to fill up
  - Consider implications of time of day on grazing behavior
    - Daybreak (2 x intake of any other period)
    - Sunset
    - About 3:00 p.m. for ~90 minutes.
  - Useful where forage quality greatly exceeds animal requirements or where limited access is needed
    - Winter annuals (70+% TDN vs beef cow req. 58%).

Summary

- The "System" is more general and reflects your general grazing strategy (or philosophy)
- Methods are TACTICS
  - All are at your disposal
  - Mix and match as needed to optimize efficiency
- The greatest advantage of a managed, rational grazing system is that it is FLEXIBLE!

Questions?

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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.

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J. Scott Angle, Dean and Director.

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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

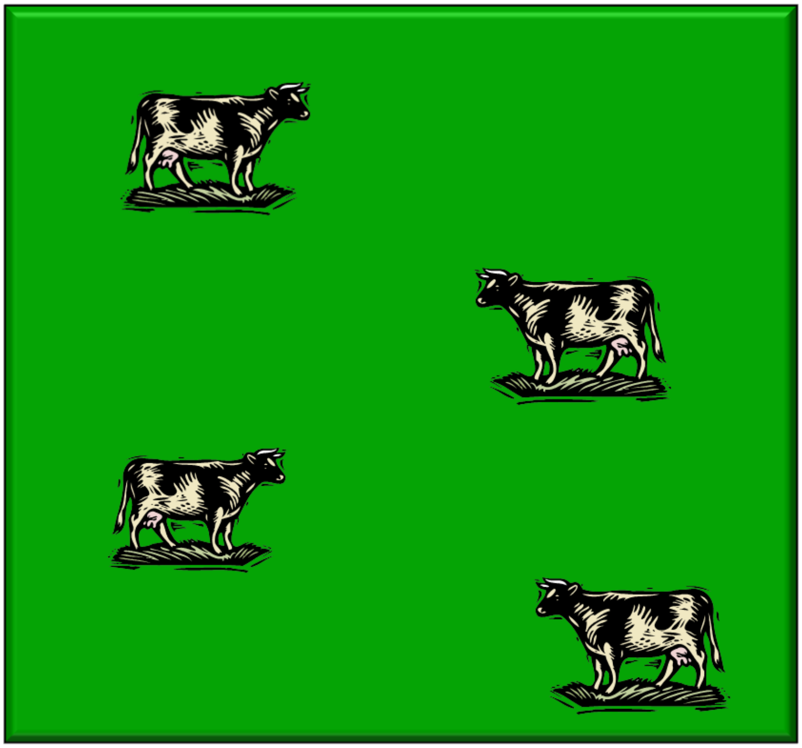
Match the Grazing Method with:

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

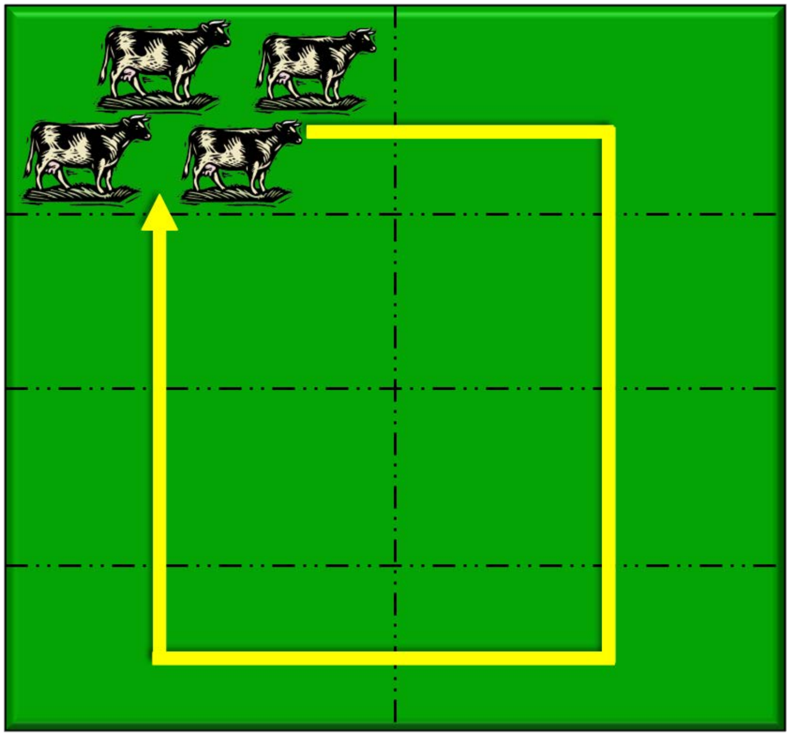
- Simple, most commonly used in Alabama
- Animals stocked on single pasture unit for the duration of grazing season.
- Animals are allowed to selectively graze
- Can result in high animal performance of individual animals, but low overall performance of herd
- May to lead to overstocking, overgrazing,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

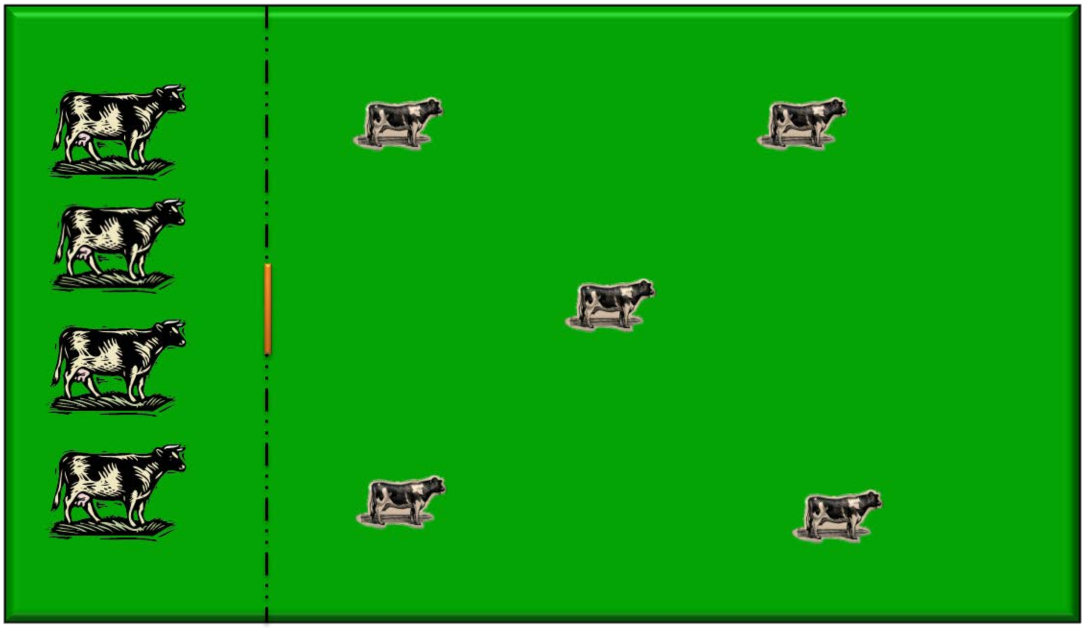
- A grazing method in which the grazed area is divided into a given number of smaller paddocks.
- Animals will graze plants to a desired height before "rotating" to a new paddock
- Expected outcome: potential increased uniform utilization of forage species compared to continuous stocking
- Rotations 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

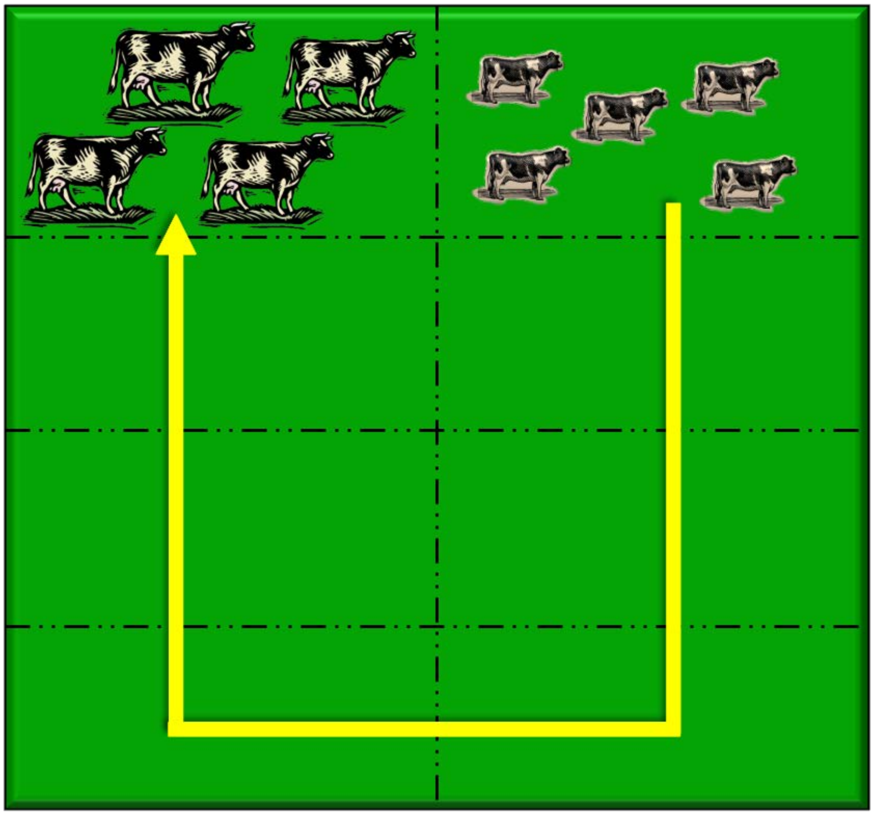
- Allows young animals with high nutrient requirements access to higher quality forages first
- Access to these paddocks provided either underneath electric fence or through a creep opening
- Dams maintained on traditional base forages
- Excellent potential to improve weaning weights of calves in Alabama

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.

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

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

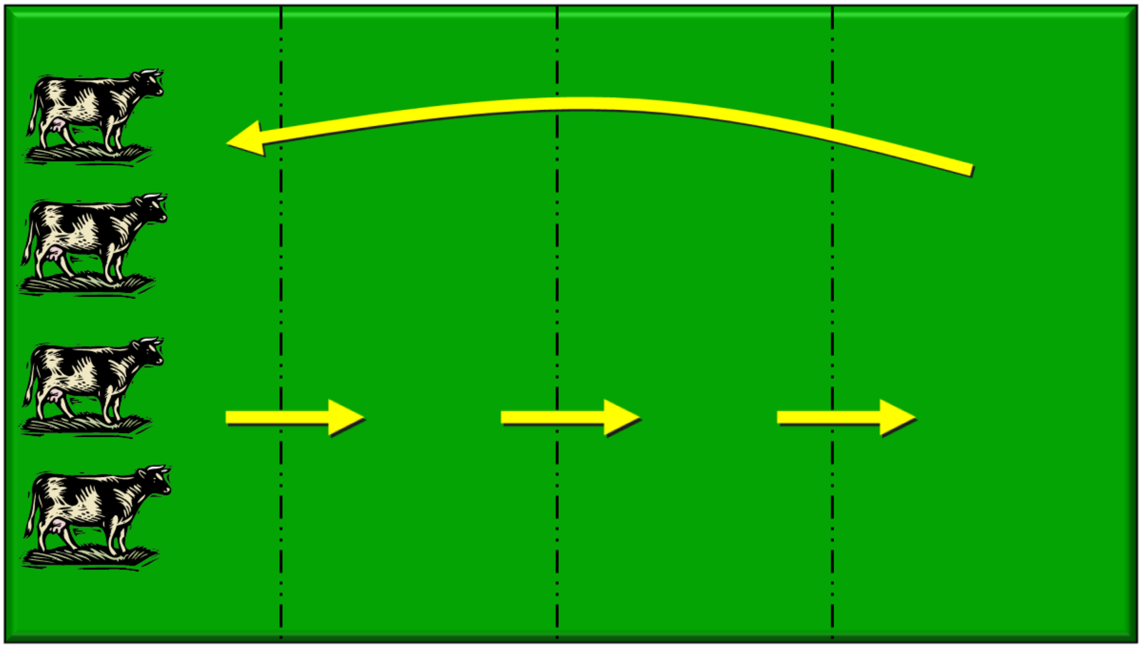
Level of Labor: Medium

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

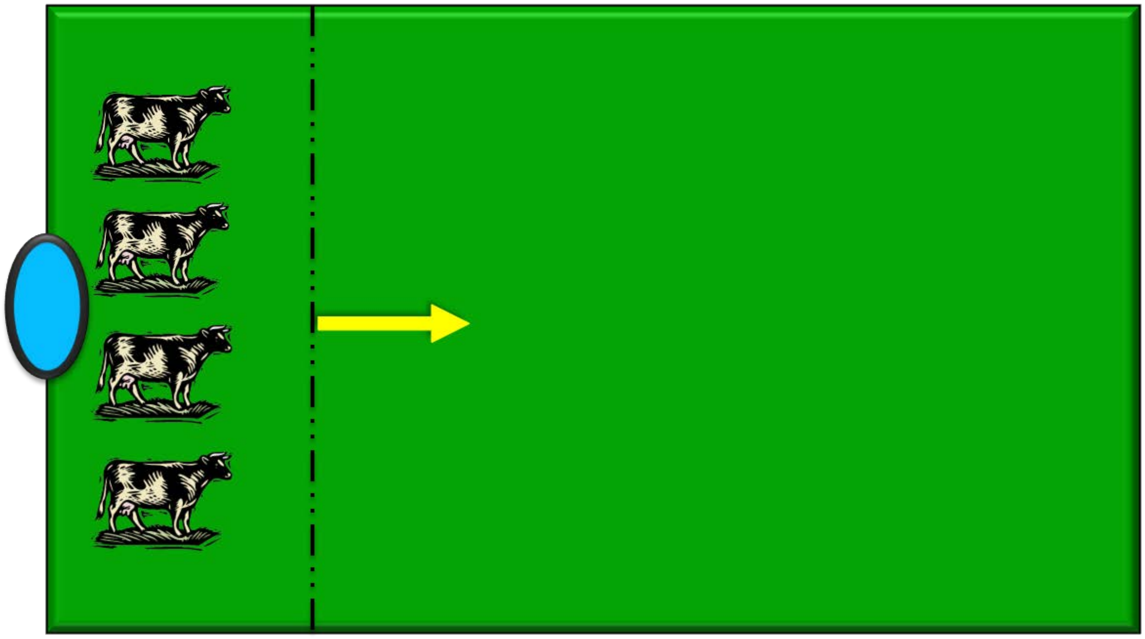
- Self-descriptive form of rotational stocking
- Animals are held in small areas (strips) by a temporary electric fence and normally graze a one or two day forage supply
- Once this area is grazed, the front fence is moved allowing them access to another small area of forage
- Back-wire may or may not 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!

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

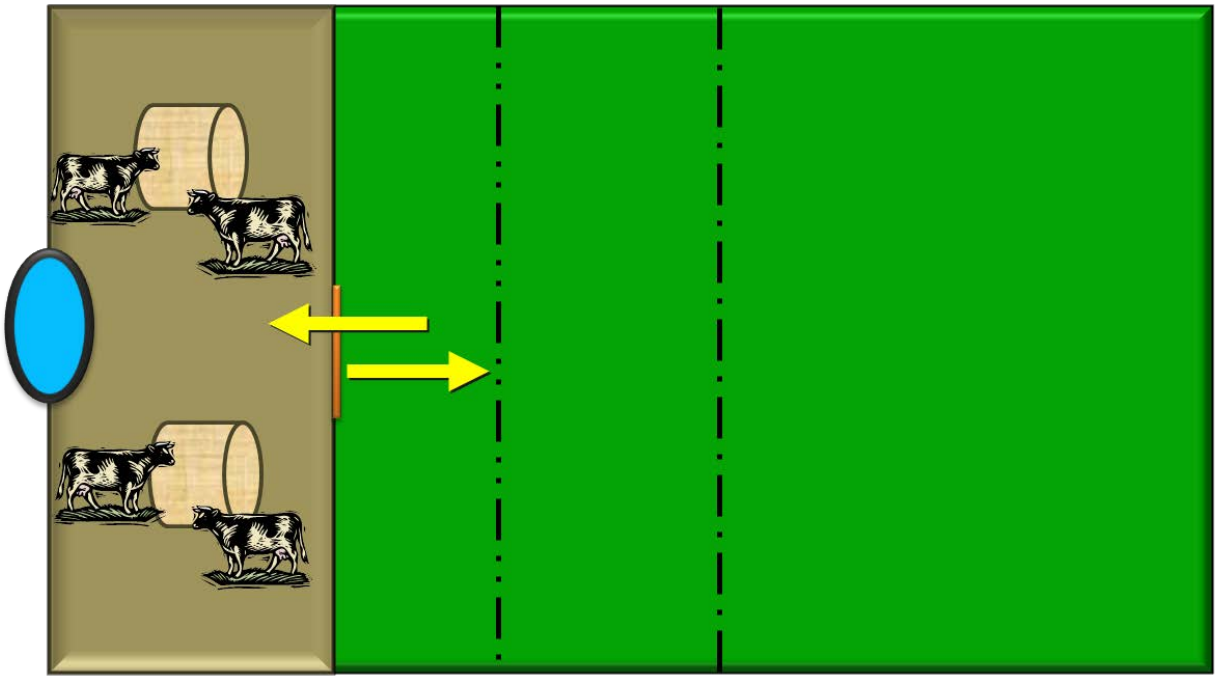
Common Forages Used: Tall Fescue, Bermudagrass

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.

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

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 6

Segregating herds based on animal class and nutritional need

Dr. Lawton Stewart, UGA

2015 Georgia Grazing School:

Segregating herds based on animal class and nutritional need

Dr. Lawton Stewart
Assoc. Prof. & Ext.Animal Scientist

Pasture-Based Nutritional Considerations for Beef Cattle

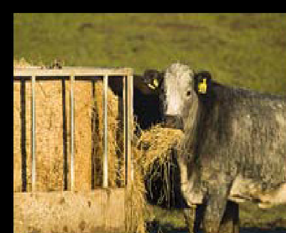
Lawton Stewart
Grazing School
May 6, 2010

Developing a Feeding Strategy

1. Understand your production system
   - Fall Calving
   - Spring Calving
   - Continuous
2. Understand your forage system
   - Pasture
   - Conserved forage
3. Develop an economical supplement

Basic Nutrients

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



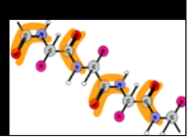
Crude Protein

-Proteins are the building block for animals and are chains of amino acids

-Crude protein is determined by the amount of Nitrogen (N) in a feed multiplied by 6.25

-Nitrogen is used to determine the amount of protein, because of the N is critical part of the amino acid structure and makes up approximately 16% of the protein structure.

-Protein Fractions:
Degradable Intake Protein (DIP)
Undegradable Intake Protein (UIP)



Energy

Energy is defined as the capacity to do work.

Common measurements of energy in ration formulation

- ***Net Energy (NE)* – Broken into maintenance, growth, lactation, etc.**
- ***Total Digestible Nutrients (TDN)* – A method that calculates energy based all sources of energy.**

Requirements change based on age, sex, stage of production, work.

Grazing School

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The University of Georgia College of Agricultural & Environmental Sciences

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Assoc. Prof. & Ext.Animal Scientist

Energy

Sources:

- Starch, fats, proteins and cellulose
  - Majority of energy in beef cattle rations is the cellulose in forage.



Nutrient Requirements

The amount of nutrient that an animal needs to perform a specific purpose.

- Determined by: weight, sex, age, growth rate, stage of production.



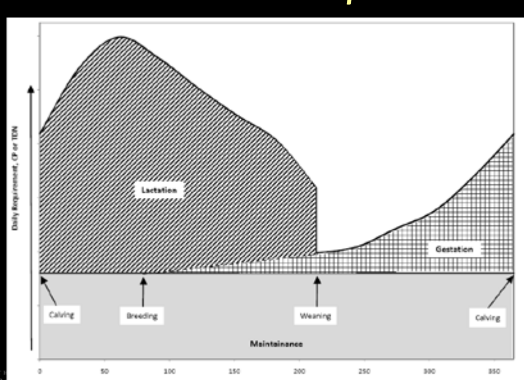
Reproductive Efficiency

- The most important factor affecting profitability
- Highly dependent on proper nutrition

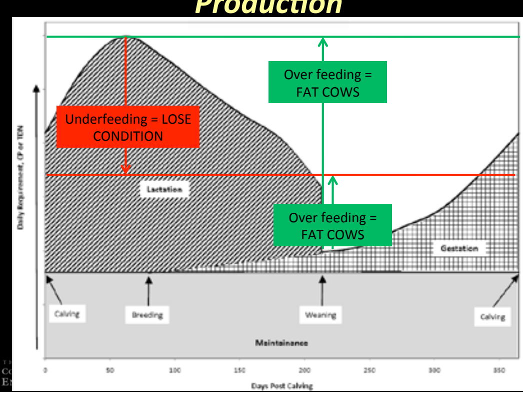
Nutrient Priorities

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

Brood Cow Nutrient Requirements



Separate Cows Based on Stage of Production



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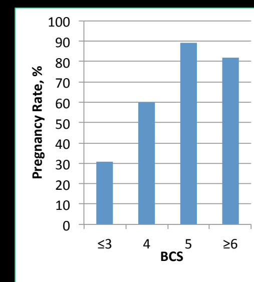
Body Condition Scoring???

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

Body Condition Scoring???



Kunkle et al., 1998

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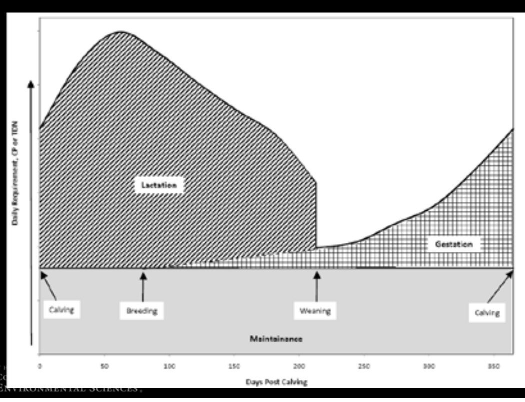
When to BCS?



Nutrients needed to increase BCS over a 70 day period*

	-----Mature BW, lb-----			
BCS	1100	1200	1300	1400
	-----Addition TDN needed above normal requirements-----			
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

* Nutrients need to move up to the given BCS

What does that mean???

A 1200 lb cow at weaning is a BCS 4

- How much more TDN does she need to get to a BCS 5 in 70 days?
- What would here total TDN requirement be?
- What would the requirement be post calving?

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What about her?

A 1200 lb cow at weaning is a BCS 6

- Can we utilize her energy reserve if forage is limited? **YES**
- Mobilized fat is worth 80% of dietary calories.
  - To get to BCS 6 takes an additional 10.4% TDN.
  - To go down from BCS 6 is (10.4 * 80% = 8.3% TDN)
- A diet of 40%TDN (48% requirement for dry cows – 8.3% = ~40%) will carry her 70d keep her above a BCS 5.

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Nutritional Requirements of Weaned Calves
Medium-frame steer calves

Wt (lb)	Daily Gain (lb)	Crude Protein (%)	TDN (%)
400	1.5	11.5	63.0
	2.0	12.7	67.5
	2.5	14.2	73.5
600	1.5	9.8	63.0
	2.0	10.5	67.5
	2.5	11.4	73.5
800	1.5	8.8	63.0
	2.0	9.8	67.5
	2.5	9.3	73.5

- Know the requirements to keep calves gaining
- Remember:
  - Gain and health = $$$$
  - Health is a function of **immunity** and **nutrition**

Potential Forages

Forage	CP (%)	TDN (%)	Suitable for: Peak Lactation	Late Lactation	Dry Cow	600 lb calf gain, lb/d
Poor Hay	7	48	No	No	Yes	0.5
Average Hay	10	55	No	Yes	Yes	1.25
Good Hay	12	60	Yes	Yes	Yes	1.35
Bermudagrass Pasture	13	64	Yes	Yes	Yes	1.60
Tall Fescue Pasture	14	62	Yes	Yes	Yes	1.50
Winter Annuals –Vegetative	16	72	Yes	Yes	Yes	2.5
Winter Annuals –Mature	12	58	No	No	No	1.3

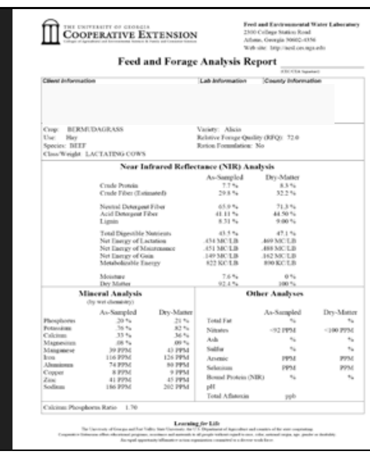
Available Forages

- Grazed Forage?
- Corn Silage
- Drought stressed crops
- Hay produced
  - High quality???
  - Low quality???
- Hay produced
  - Storage
  - Testing
  - Inventory

Hay Cutting	Production Phase
1. CP 14% TDN 60%	Dry Cow
2. CP 10% TDN 55%	Late Gestation
3. CP 6% TDN 47%	Early Lactation

TEST FORAGES!!!!

L. Stewart, UGA Extension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Feed and Environmental Water Laboratory
2300 College Station Road
Athens, Georgia 30602-4356

Feed and Forage Analysis Report

Client Information | Lab Information | County Information

Crop: BERMUDAGRASS — Variety: Alicia
Use: Hay — Relative Forage Quality (RFQ): 72.0
Species: BEEF — Ration Formulation: No
Class/Weight: LACTATING COWS

Near Infrared Reflectance (NIR) Analysis

	As-Sampled	Dry-Matter
Crude Protein	7.7 %	8.3 %
Crude Fiber (Estimated)	29.8 %	32.2 %
Neutral Detergent Fiber	65.9 %	71.3 %
Acid Detergent Fiber	41.11 %	44.50 %
Lignin	8.31 %	9.00 %
Total Digestible Nutrients	43.5 %	47.1 %
Net Energy of Lactation	.434 MC/LB	.469 MC/LB
Net Energy of Maintenance	.451 MC/LB	.488 MC/LB
Net Energy of Gain	.149 MC/LB	.162 MC/LB
Metabolizable Energy	822 KC/LB	890 KC/LB
Moisture	7.6 %	0 %
Dry Matter	92.4 %	100 %

Mineral Analysis (by wet chemistry)

	As-Sampled	Dry-Matter
Phosphorus	.20 %	.21 %
Potassium	.76 %	.82 %
Calcium	.33 %	.36 %
Magnesium	.08 %	.09 %
Manganese	39 PPM	43 PPM
Iron	116 PPM	126 PPM
Aluminum	74 PPM	80 PPM
Copper	8 PPM	9 PPM
Zinc	41 PPM	45 PPM
Sodium	186 PPM	202 PPM

Other Analyses

	As-Sampled	Dry-Matter
Total Fat	%	%
Nitrates	<92 PPM	<100 PPM
Ash	%	%
Sulfur	%	%
Arsenic	PPM	PPM
Selenium	PPM	PPM
Bound Protein (NIR)	%	%
pH		
Total Aflatoxin	ppb	

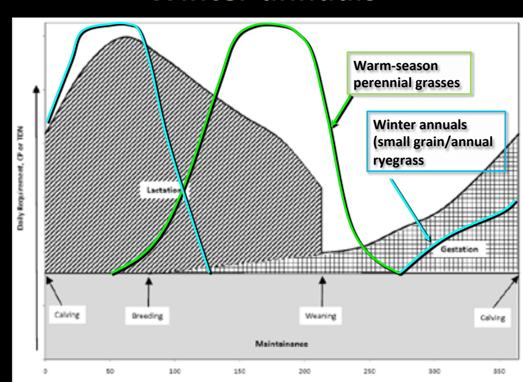
Calcium: Phosphorus Ratio 1.70

Learning for Life

Supplementation Strategies

1. Winter Annuals
2. Commercial Feeds
3. Liquid Feeds/Tubs
4. Byproducts

Winter annuals



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Assoc. Prof. & Ext.Animal Scientist

Lick Tanks, Tubs, and Blocks

Advantage:
1. Convenient
2. Reduced Labor
3. Additional minerals and vitamins

Disadvantage???
1. Intake?
2. Adequate nutrients?
3. Affordable?


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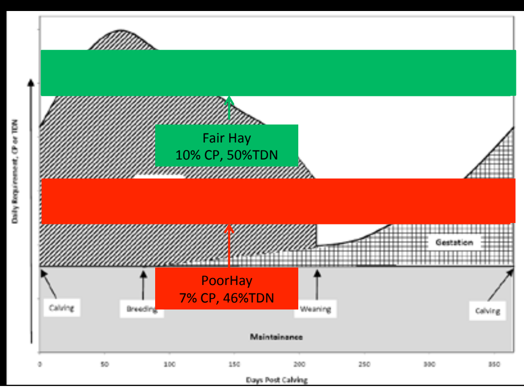
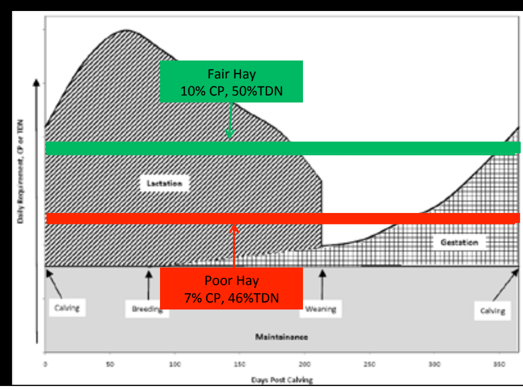
Do they work miracles?

"They'll eat the old hay from last year if I use liquid feed"

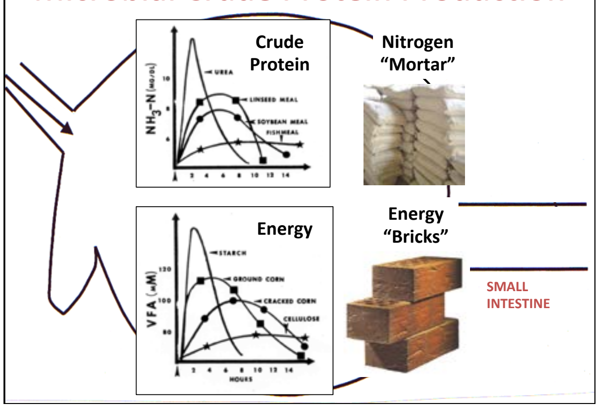
Using a Lick Tub for CP



Using a Lick Tub for Energy



Microbial Crude Protein Production



Byproduct Feeding

- **What's available**
- **Price**
  - Evaluate on DM basis
  - Look at $/nutrient
- **Handling / Storage**
- **Minerals**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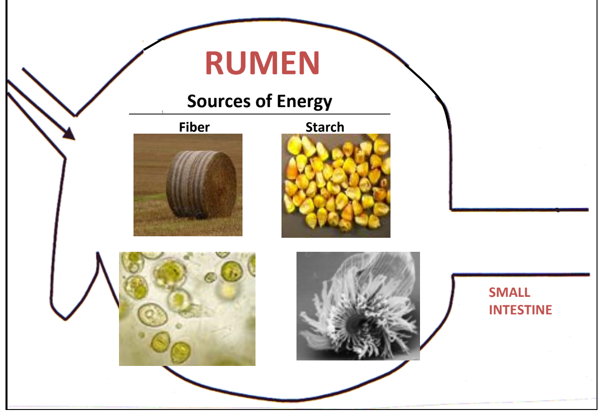
Potential Byproducts

1. Grain
   - Corn gluten feed
   - Distiller's grains
   - Soy Hulls
   - Wheat middlings
2. Cotton
   - Whole seed
   - Gin trash
   - Hulls
3. Sugar and starch production
   - Cane, beet & corn molasses
   - Salvage candy
4. Vegetable
   - Cull vegetables



Effect of Increasing Corn on Hay Intake and Digestibility

	Corn, lbs/day			
	None	2.2	4.4	6.6
Hay DMI lbs	19.3	18.0	14.1	11.2
DOMI, lbs	7.5	8.4	7.1	7.3
Hay OM Digest, %	36.5	35.1	23.6	18.9

Oklahoma State, 1987 JAS 65:557

Effect of Increasing Soybean Hulls on Hay Intake

	SH, lbs/day			
	None	2.2	4.4	6.6
Hay, OMI, lbs	21.4	22.3	21.6	19.9
DOMI, lbs	10.6	11.8	12.3	12.7
OM Digestibility, %	45.8	46.2	46.6	48.6

Oklahoma State, 1990 JAS 68:4319

Byproduct Feeding

- **What's available**
- **Price**
  - Evaluate on DM basis
  - Look at $/nutrient
- **Handling / Storage**
- **Minerals**

Nutrition Tools

- UGA Basic Balancer
- UGA Feed Cost Analyzer
- Commodity Feed Source List
- Plus Many More

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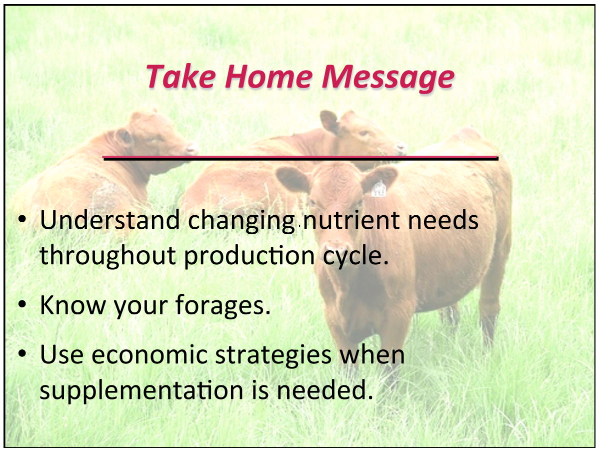

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Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

Body Condition Scoring Beef Cows

Lawton Stewart
Extension Animal Scientist – Beef Cattle
Ted Dyer
Extension Animal Scientist – Beef Cattle

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.

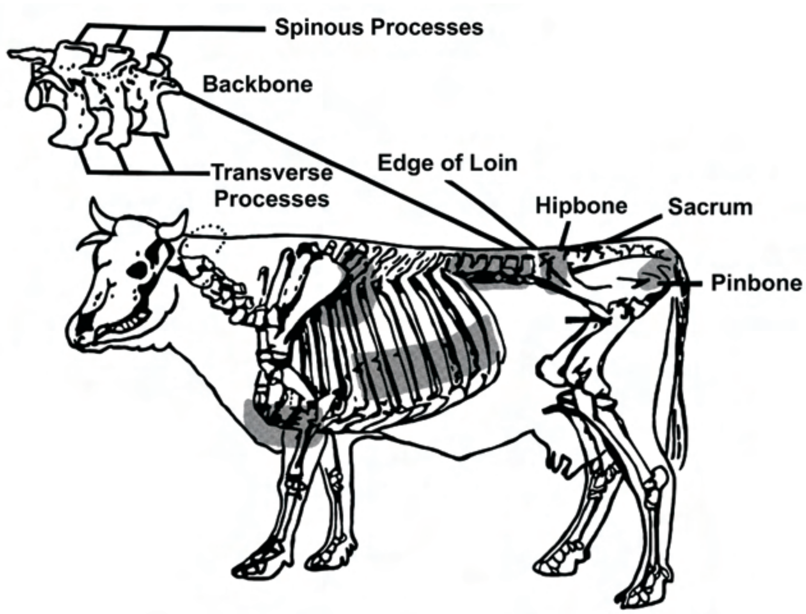

Figure 1. Skeletal structures of a cow used to evaluate body condition score.

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].

Parity	Body Condition Score[b] at Calving ≤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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Georgia Commodity Feed Sources

Sources of commodity feedstuffs are listed below and feedstuffs available are listed on the following page. Information is compiled by the University of Georgia Extension Personnel. Additional feed source listings are welcomed. If you want your company to be included in the feed source listing:

1. Complete a commodity feed source submission form.
2. E-mail listing information to lawtons@uga.edu.
3. Fax form to 706-542-9316

Sources:

ADM Alliance Nutrition, Inc.
Contact: Kem Bell
2201 E. 13th Ave
Cordele, GA 31015
Phone: 229-273-7400
Fax: 229-271-3113
Cell: 229-881-2087
-Feed Mixing Available: **YES**
-Deliver less than truckload lot: **YES**

Agri-Commodities, Inc.
Contact: Paul Rosenzweig, Jr.
3532 Pebble Beach Dr.
Augusta, GA 30907
Phone: 706-869-1075
Fax: 706-869-0146
Cell:706-284-3333
Email: paul@agricommodities.net
-Feed Mixing Available: **YES**
-Deliver less than truckload lot: **YES**

First United Ethanol, LLC
Contact: Brad Kusterman
4433 Lewis B Collins Rd
Pelham, GA 31779
Phone: 229-522-2822
Fax: 229-522-2824
-Feed Mixing Available: **NO**
-Deliver less than truckload lot: **NO**

Furst McNess Co.
Contact: Bill Bush
101 N. Harris St.
Cordele, GA 31010
Phone: 800-233-6596
Fax: 229-276-9817
Email: bill.bush@mcness.com
-Feed Mixing Available: **YES**
-Deliver less than truckload lot: **YES**

Georgia Farm Bureau
Contact: Joe McManus
1620 Bass Rd
Macon, GA 31210
Phone: 800-342-1196
Fax: 478-405-3430
Email: jcmcanus@gfb.org
-Feed Mixing Available: **NO**
-Deliver less than truckload lot: **NO**

Godfrey's Warehouse
Contact: Weyman Hunt/ Brian Lance
255 West Jefferson St
Phone: 706-342-0264
Fax: 706-342-0237
-Feed Mixing Available: **YES**
-Deliver less than truckload lot: **YES**

Mid-GA Farm Services, LLC
Contact: Daniel Weaver/ Randall Yoder
1799 Mennonite Church Rd
Montezuma, GA 31063
Phone: 478-244-0901
Fax: 478-472-7904
Cell: 478-472-7904
Email: Daniel.weaver@midga.com
-Feed Mixing Available: **YES**
-Deliver less than truckload lot: **YES**

Resaca Sun Products, LLC
Contact: Andrew Moore
1022 Fite Bend RD
Resaca, GA 30735
Phone: 706-629-7010
Fax: 706-629-2631
Cell: 770-548-2306
Email: sales@resacasun.com
-Feed Mixing Available: **NO**
-Deliver less than truckload lot: **YES**

Southern States
Contacts:
North GA – Steve Krueger
Phone: 678-445-6060
Southeast GA – JR Brykailo
Phone: 352-812-2244
Southwest GA: Tim Cooin
Phone: 251-227-1787
Email: Stephen.krueger@sscoop.com
-Feed Mixing Available: **NO**
-Deliver less than truckload lot: **YES**

-Feed Mixing Available: **NO**
-Deliver less than truckload lot: **YES**

Zeeland Farm Services
Contacts: David Lavender/ Ray Williams
107 Standard Elevator Rd
DeSoto, GA 31743
Phone: 229-874-3333
Fax: 229-874-9373
Email: DavidL@zfsinc.com
-Feed Mixing Available: **YES**
-Deliver less than truckload lot: **YES**

Georgia Commodity Feed Sources

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Company	Brewer's Grains	Citrus Pulp	Corn Gluten Feed	Corn	Cottonseed hulls	Cottonseed meal	Distillers grains	Hominy	Oats	Peanut Hulls	Soybean Hulls	Soybean Meal	Wheat	Wheat middlings	Whole Cottonseed	Other
ADM	X		X				dry				pellet	X				ARSOY (33% SBM)
Agri-Commodities			X	X	X	X	dry	X			loose or pellet				X	
FUEL							wet dry									
Furst McNess Co.			X	ground	X	X	dry	X			X	X				Alfalfa pellets Alfalfa meal
Georgia Farm Bureau		X	X	X	X	X			X		loose or pellet	X		X	X	Milo
Godfrey's Warehouse			X	steam rolled ground	X	X	dry		X		loose or pellet	X			X	Vitamin and mineral premixes
Mid-GA Farm Services		X	X		X		dry	X		X	X			X		Vitamin and mineral premixes
Resaca Sun Products											loose					Canola meal Sunflower meal Sunflower hulls Sunflower screenings
Southern States		X	X	whole cracked ground	X	X	dry	X	X	X	X	X			X	Minerals, vitamin premixes, protein tubs, and liquid supplements
Zeeland Farm Services	wet	X	X	whole cracked ground	X	X	dry	X	whole crimped	X	X	X		X	X	Beet pulp, Peanut skins, rice meal feed, alfalfa pellets, and vitamin and mineral premixes

Feed Library

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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 7

Optimizing the size, number, and layout of your paddocks

Cindy Haygood, USDA-NRCS

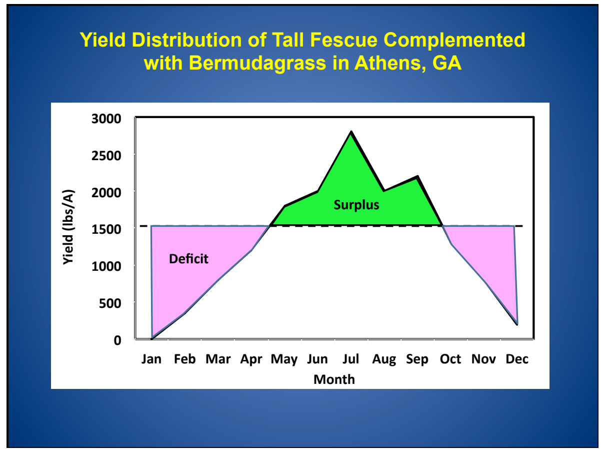
Section 8

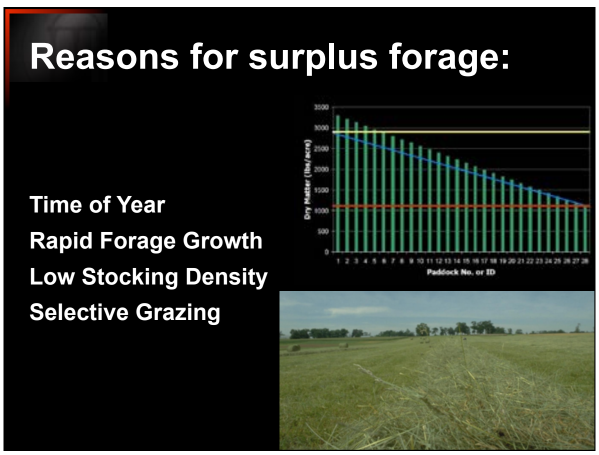
Managing forage surplus and deficits

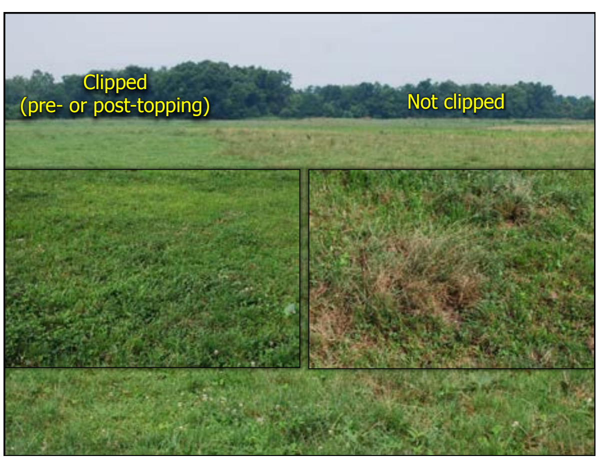
Dr. Dennis Hancock, UGA

2015 Georgia Grazing School:
Managing forage surplus and deficits

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







GRASS www.georgiaforages.com Grazing School UGA extension THE UNIVERSITY OF GEORGIA College of Agricultural & Environmental Sciences

2015 Georgia Grazing School:
Managing forage surplus and deficits

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

LOSS ACCUMULATE WITH EACH STEP

It's not unusual to see total losses of 70% or greater

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%

Hay Production

- Cut forage to maximize drying time
- Cut at appropriate height
- Allow swath to be spread wide to maximize drying rate.
- Ted the forage morning of next day(s)
  - Discontinue the use of a tedder when leaf shatter is occurring. (~10 a.m.)
- Bale at target moisture
  - < 15% for round bales
  - < 18% for square bales

Drying Times Vary

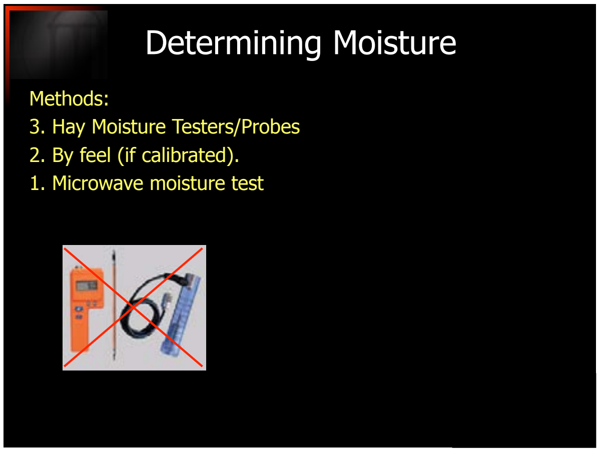
Hay Moisture Problems

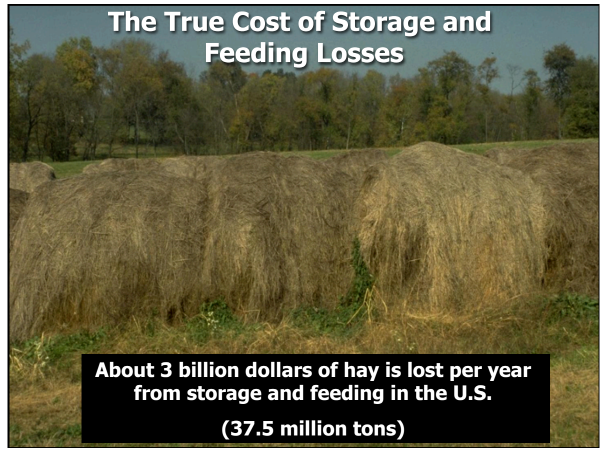
Hay Moisture Probe

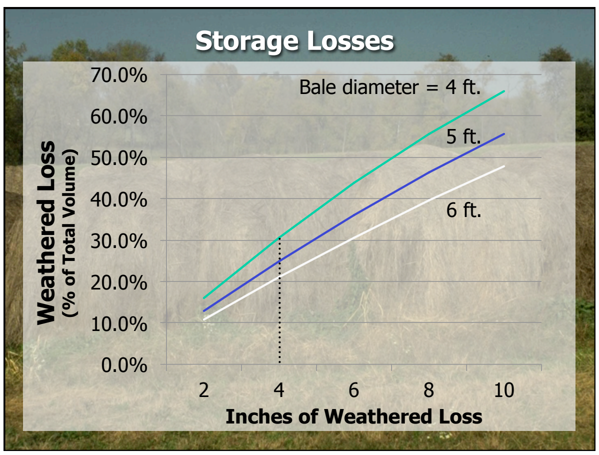
2015 Georgia Grazing School:

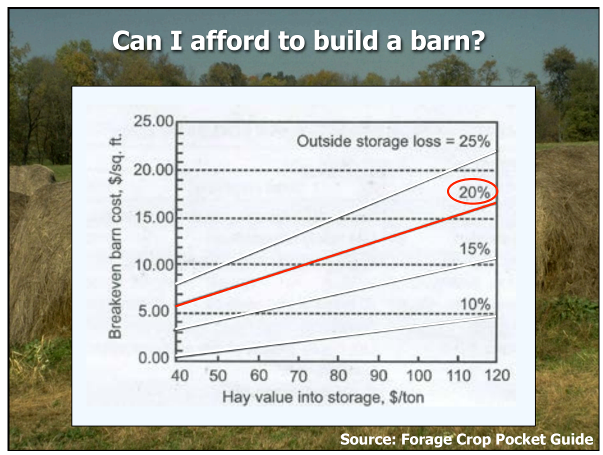
Managing forage surplus and deficits

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









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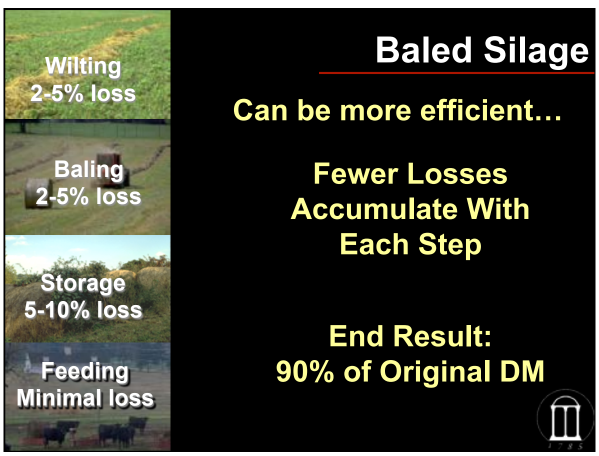
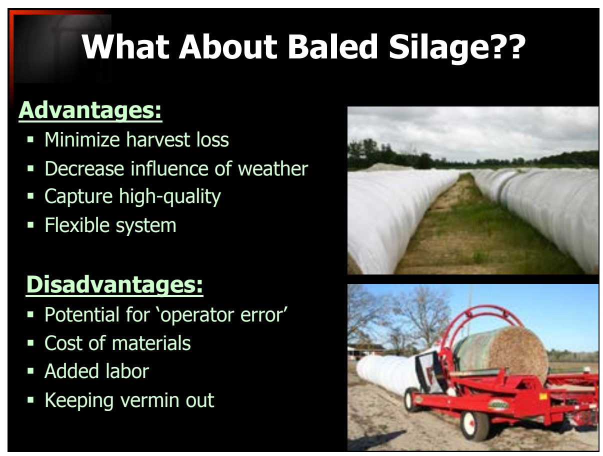
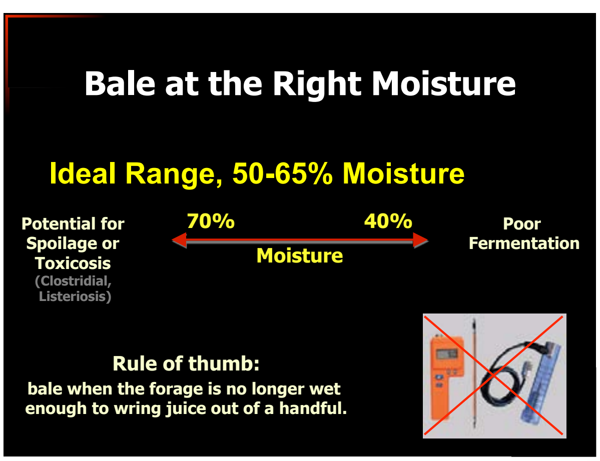






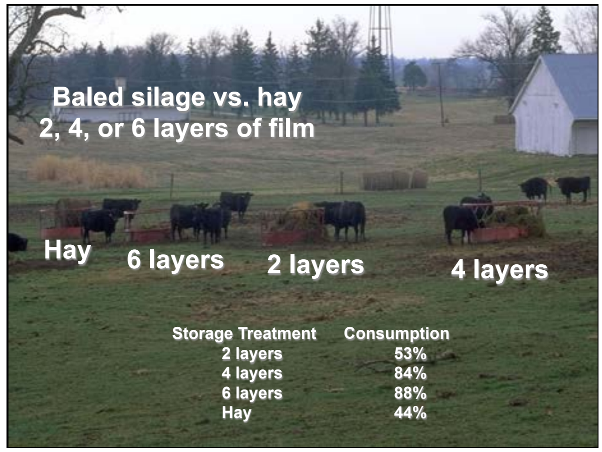
2015 Georgia Grazing School:
Managing forage surplus and deficits

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

Feeding Baled Silage

- Whole silage bales
  - ring feeder

- Mixed rations
  - tub-ground



Baled Silage – An Option for Harvesting High Quality

Treatment	CP	TDN	RFQ	ADG
	%	%		(lbs/hd/d)
Bermuda Hay	16.1 a	62.9 b	116 c	1.56 b
Ryegrass Baleage	16.3 a	65.9 a	174 a	1.94 a
Ryegrass Hay	14.7 b	62.4 c	133 b	1.26 b
$LSD_{0.10}$	0.22	0.35	3.2	0.341

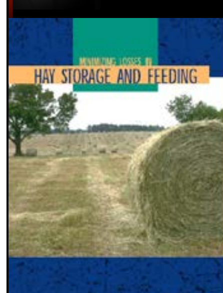
Resources

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE
Baling Forage Crops for Silage

Some Points on Feeding Baled Silage
Dennis W. Hancock, Extension Forage Specialist, The University of Georgia

Baled Silage: Frequently Asked Questions
Dr. Dennis Hancock, Forage Extension Specialist

Resources



West Virginia University Extension Service
Forage Management
PROPER HANDLING AND CURING OF HAY

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE
Quality Hay Production

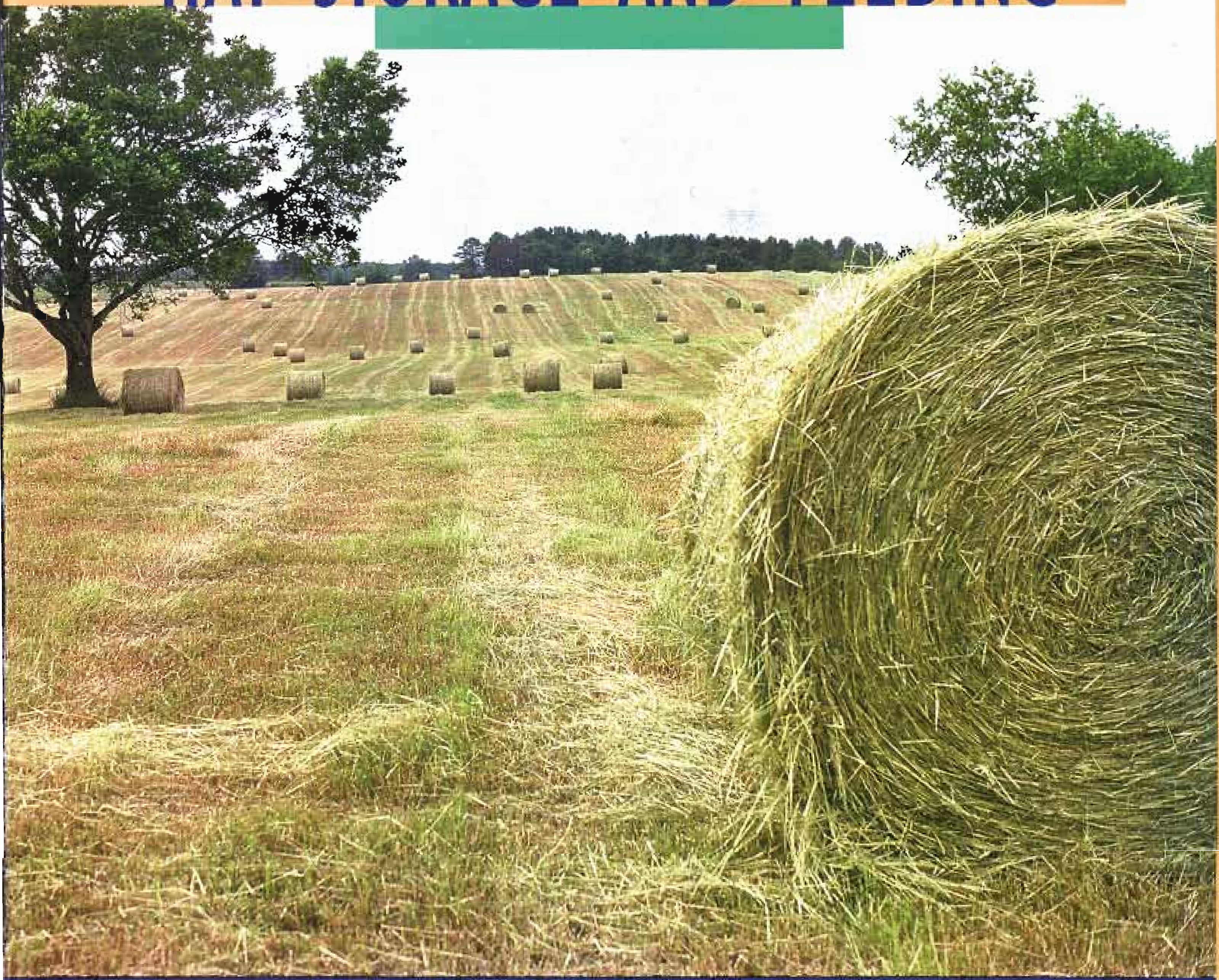
University of Georgia College of Agricultural and Environmental Sciences
Warm-Season Grass Breeding
(Turf, ornamentals and forage)
MAKING EXCELLENT HAY WITH THE TIFTON HYBRID BERMUDAGRASSES
Glenn W. Burton

For much of the South, the hybrid bermudagrasses top the list of forages that may be grown for hay. Properly managed, they are more dependable and produce more hay per acre at a lower cost per ton than any forage that I know. They contain more dry matter when cut (25 to 30%) and cure faster than other forages.

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

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.

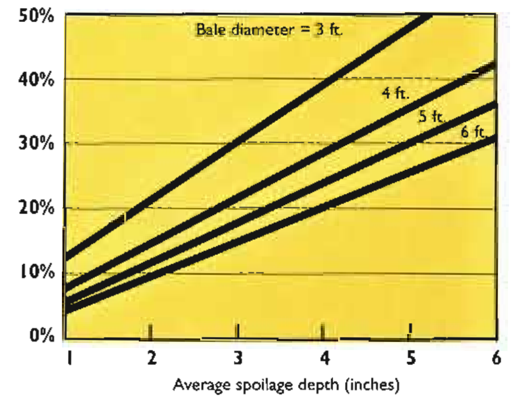
Heating of hay is related to moisture content. Peak temperature is often reached within a week after baling, but with higher moisture hay and conditions which limit heat escape, it may take as much as three weeks. At safe moisture levels (less than: 20% for rectangular bales; 18% for round bales; and 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.

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

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.

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 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 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. 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.

On many farms, particularly in the eastern United States, reduced hay storage losses can provide payback on barn construction within a few years.

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.

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.

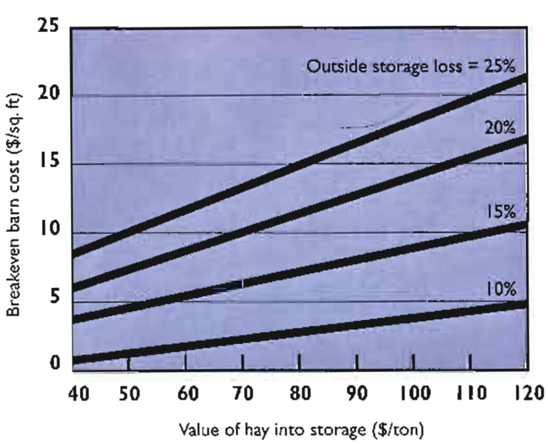


Figure 2. Break even barn cost for various levels of storage loss and varying hay value at harvest. (This analysis includes the following assumptions: in-barn average stacking height of three bales, ten-year barn amortization, and construction cost of $7.50/square foot. Inputs other than storage loss 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

Placing a barrier between the hay and the animals will reduce feeding losses.

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 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.

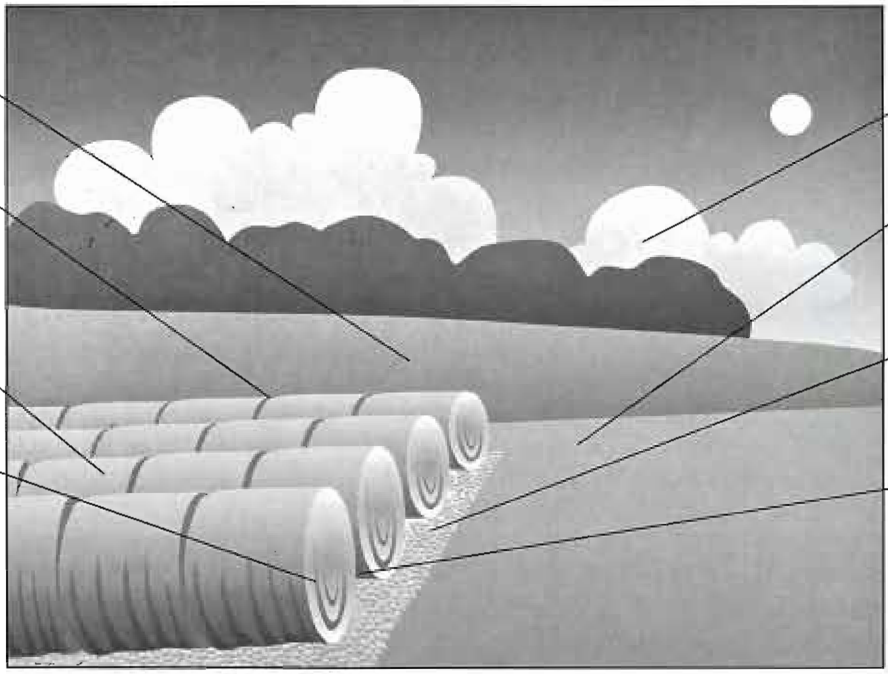
EXAMPLES OF THINGS YOU SHOULD NOT DO

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



No objects near hay which are likely to attract lightning

Flat ends of bales butted tightly together

Bale rows run up and down slope with north/south orientation; a southern exposure is best

High bale density resists water penetration

Tops and sides of bales can be protected from rain with any of a number of different types of covers

Bright, sunny location; no trees or other objects near hay to slow drying after rains

Storage area located on a gently sloping, well-drained site

Hay/soil contact avoided by placing bales on rock, wooden pallets, etc.

Rounded sides of bales <u>not</u> touching; at least 3 feet of space between rows

Fire risk can be reduced by storing hay in more than one location and by maintaining a no-vegetation zone of at least 3 feet in width around the storage area

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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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] %CP	EE %	NDF %	ADF %	NE_1 Mcal/lb	Ash %	NFC %
	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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Learning for Life

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MP434

Management of Hay Production

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UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE

Cooperative Extension Service

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.

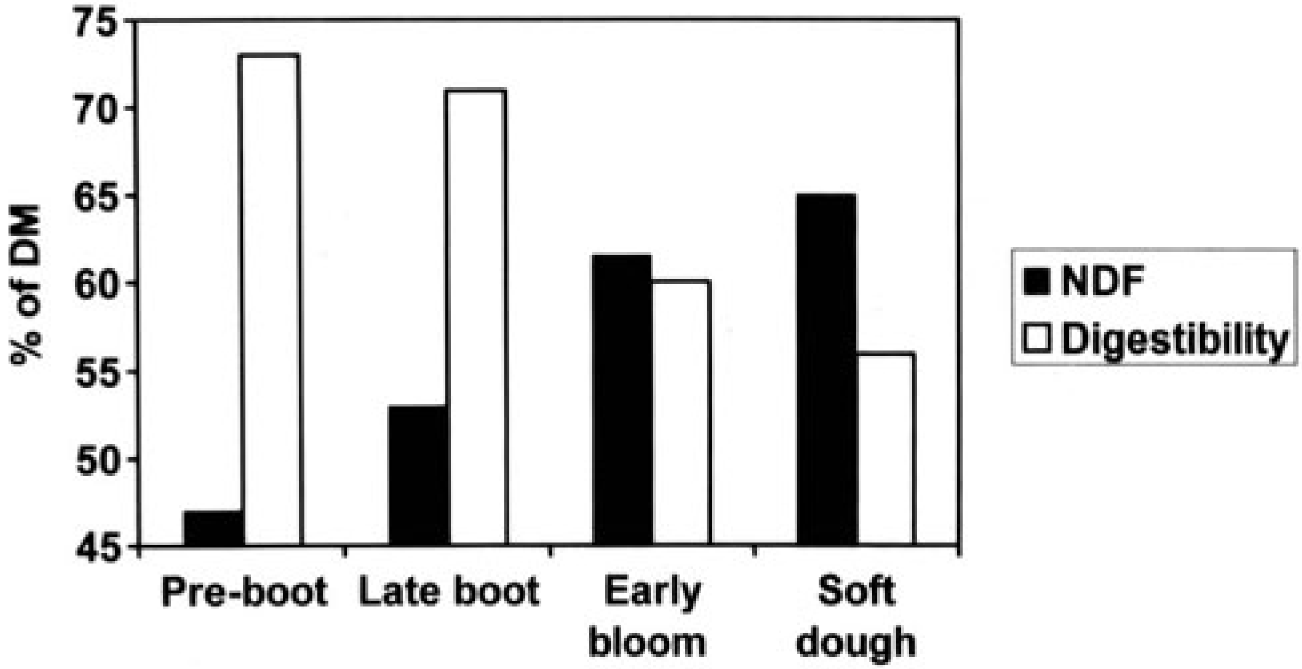


Table 3. Recommended growth stages or time intervals to harvest various hay crops[1].

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.

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.

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 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.

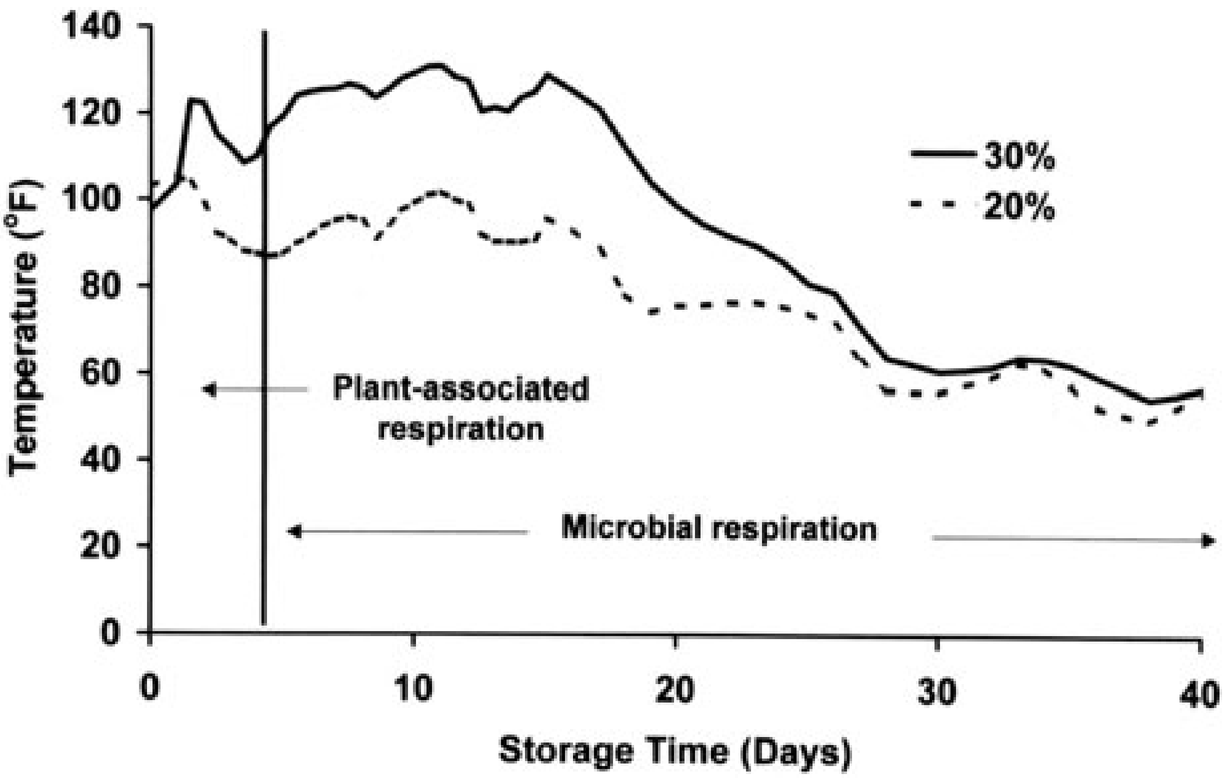
Measuring spontaneous heating. Under research conditions, spontaneous heating usually is not measured simply as internal bale temperature. The concept of heating degree days (HDD) is often used as a single index that incorporates both the magnitude and duration of heating during the entire storage period. 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.

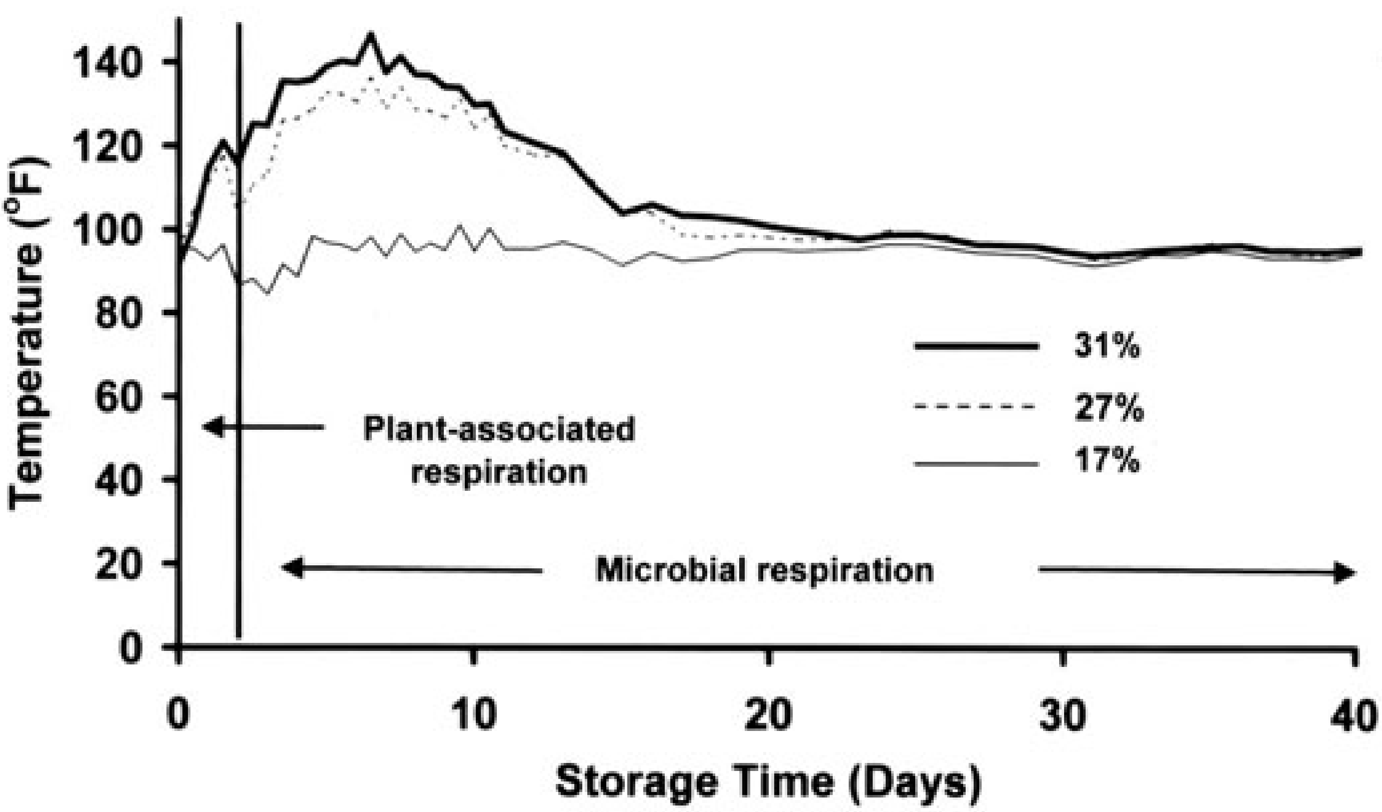


Figure 4. Relationship between heating degree days > 86°F (HDD) accumulated in conventional rectangular bales of alfalfa hay (■) and the concentration of moisture in the bale at packaging. Heating degree days can be interpreted as a single number that represents both the magnitude and duration of heating within the bale. Source: W. K. Coblentz.

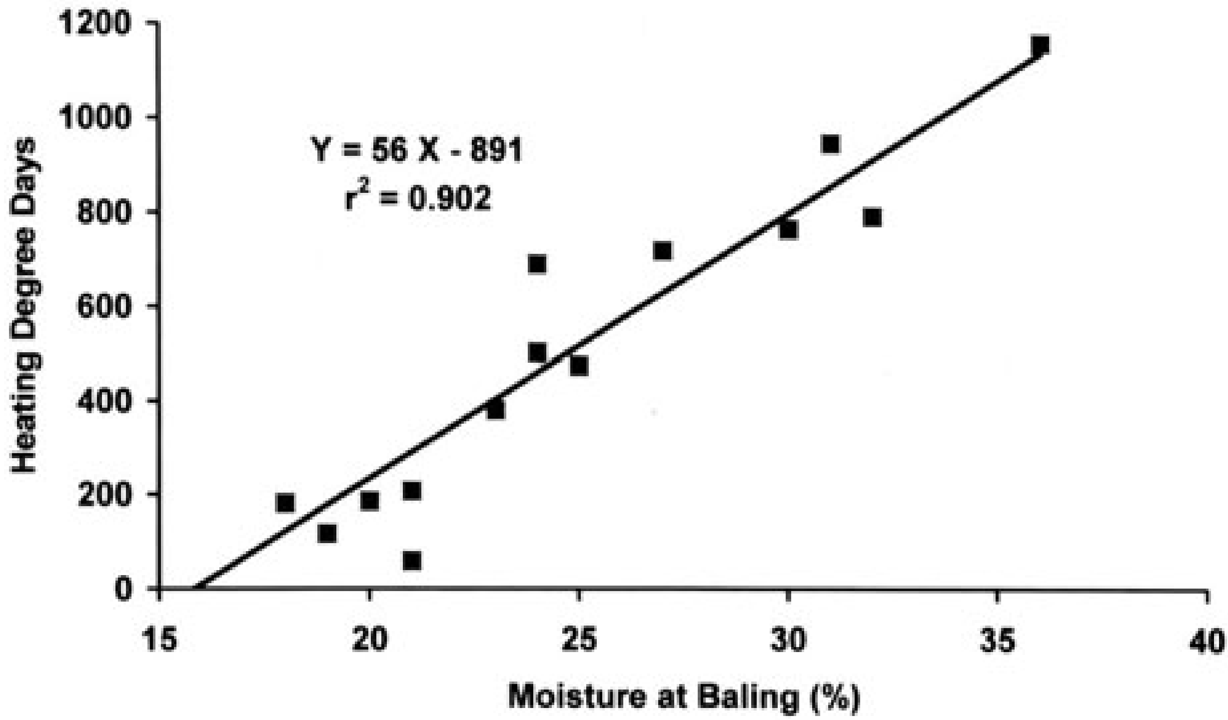
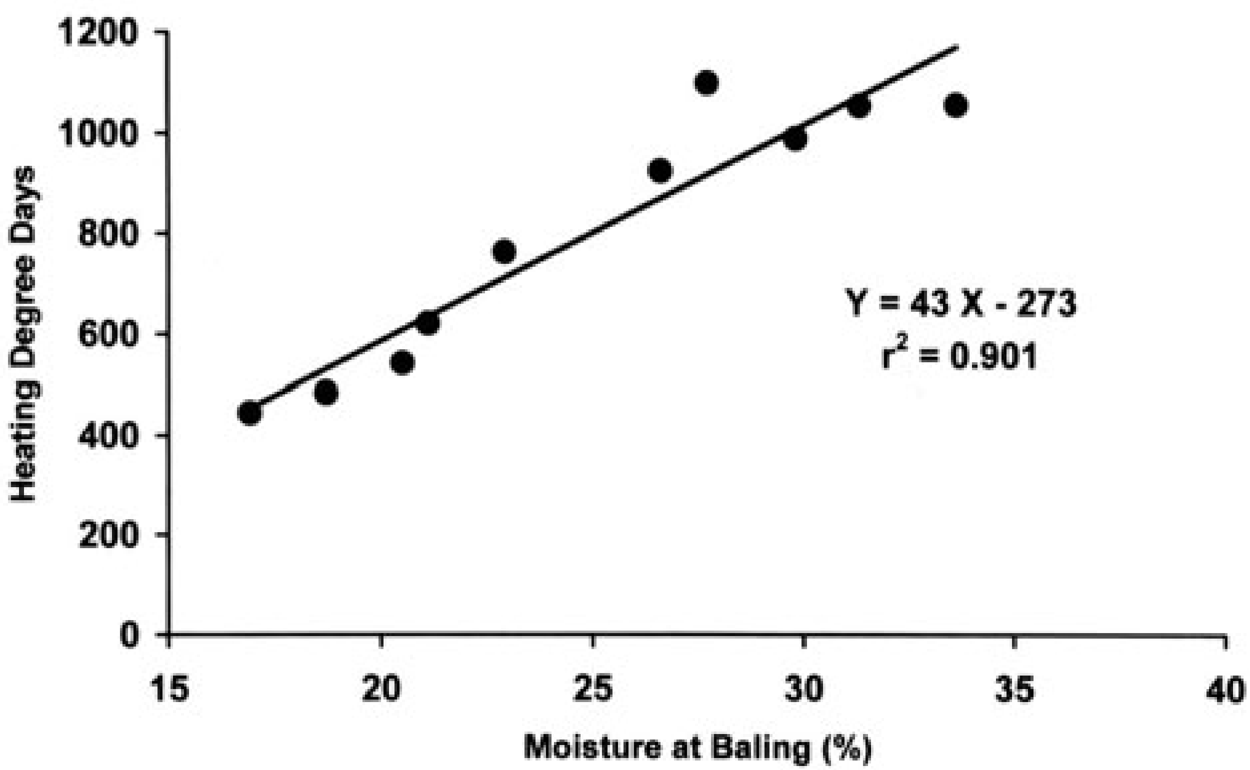


Figure 5. Relationship between heating degree days > 86°F (HDD) accumulated in conventional rectangular bales of bermudagrass hay (●) and the concentration of moisture in the bale at packaging. Heating degree days can be interpreted as a single number that represents both the magnitude and duration of 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

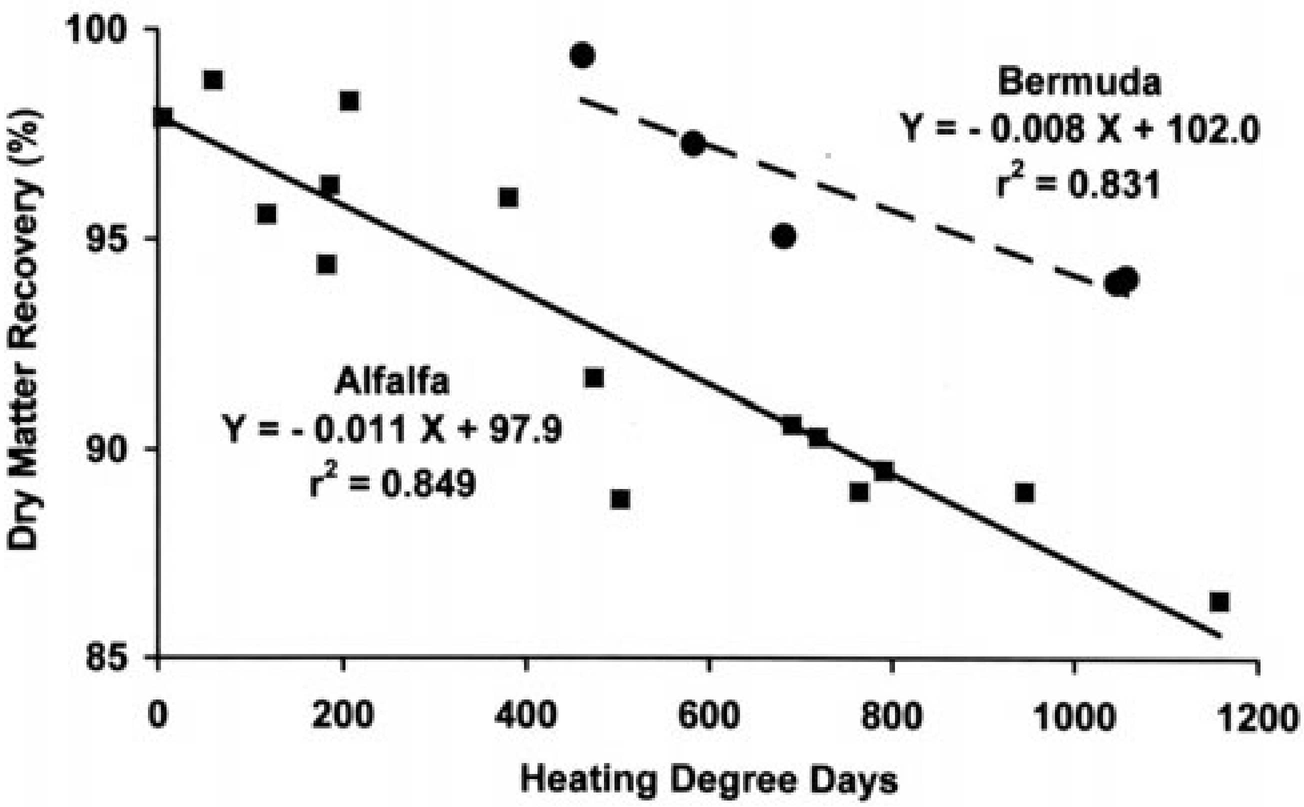
Dry matter is lost whenever heating occurs in hay bales. Dry matter losses occur in virtually all hay packages, but these losses are relatively minor without evidence of heating. Most of the DM that is lost during hay storage is nonstructural carbohydrate (plant sugars) that are respired to carbon dioxide, 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.

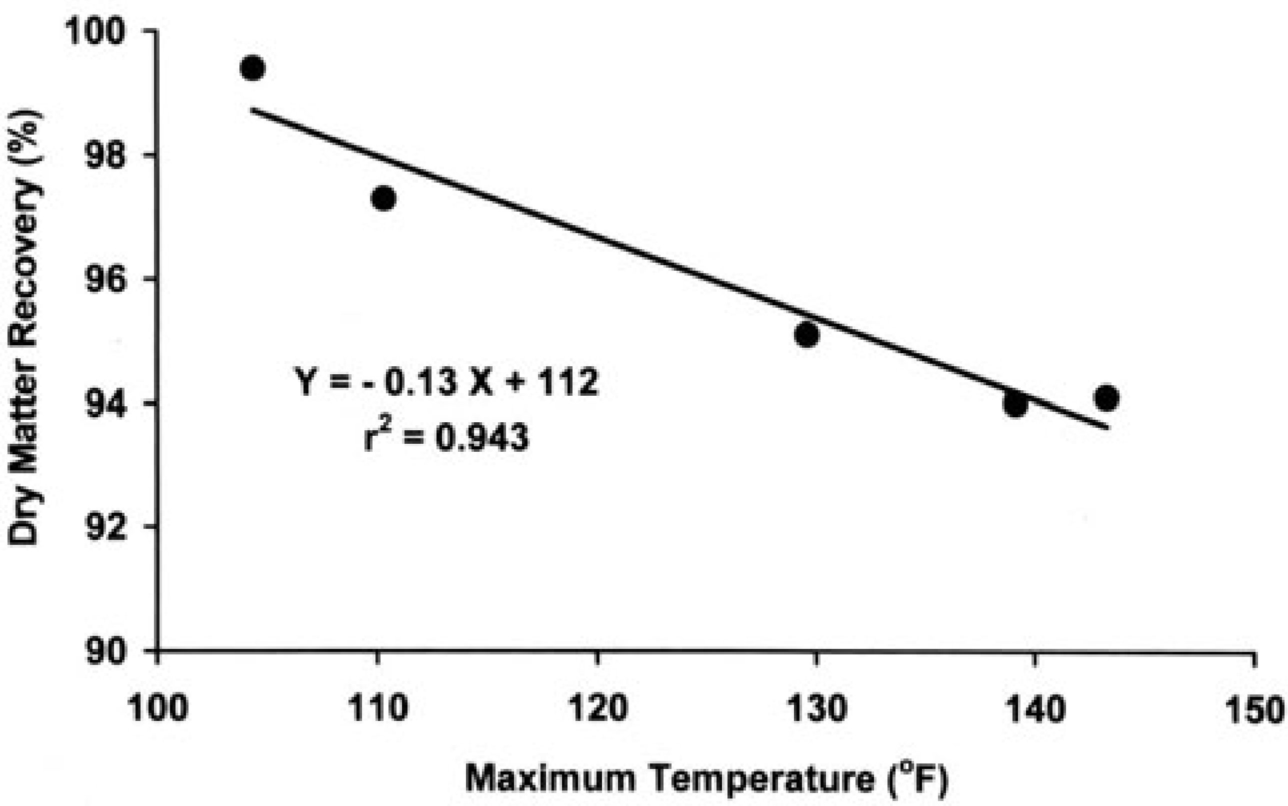


Figure 8. Relationship between the concentration of NDF and storage time for alfalfa hay packaged in conventional rectangular bales at 30 (—) and 20 (---) percent moisture in Manhattan, KS. Source: W. K. Coblentz.

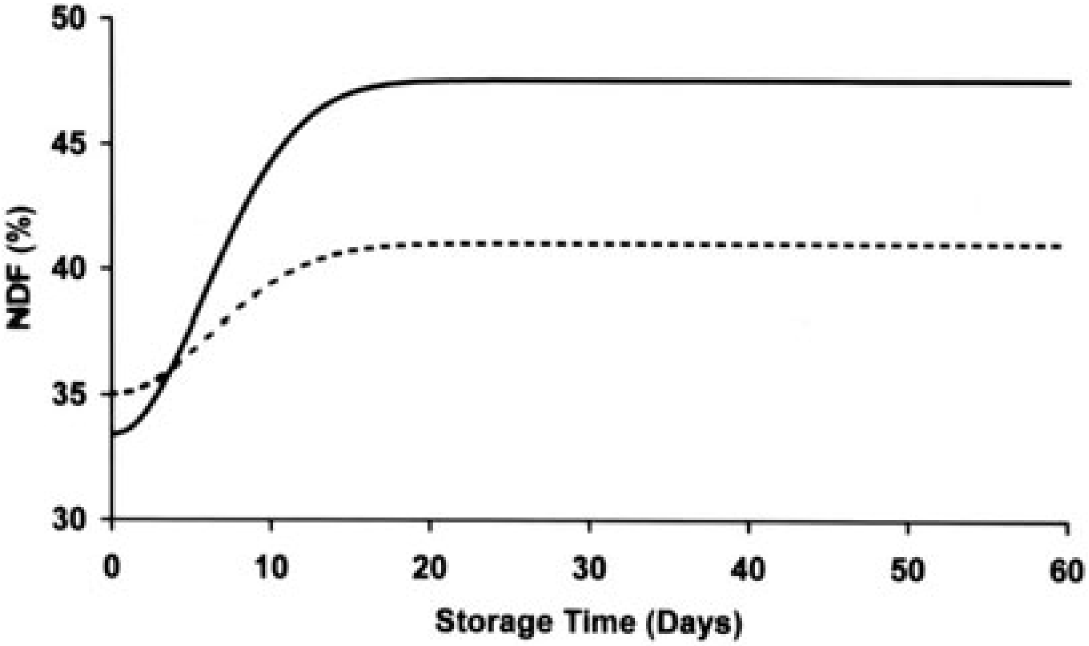
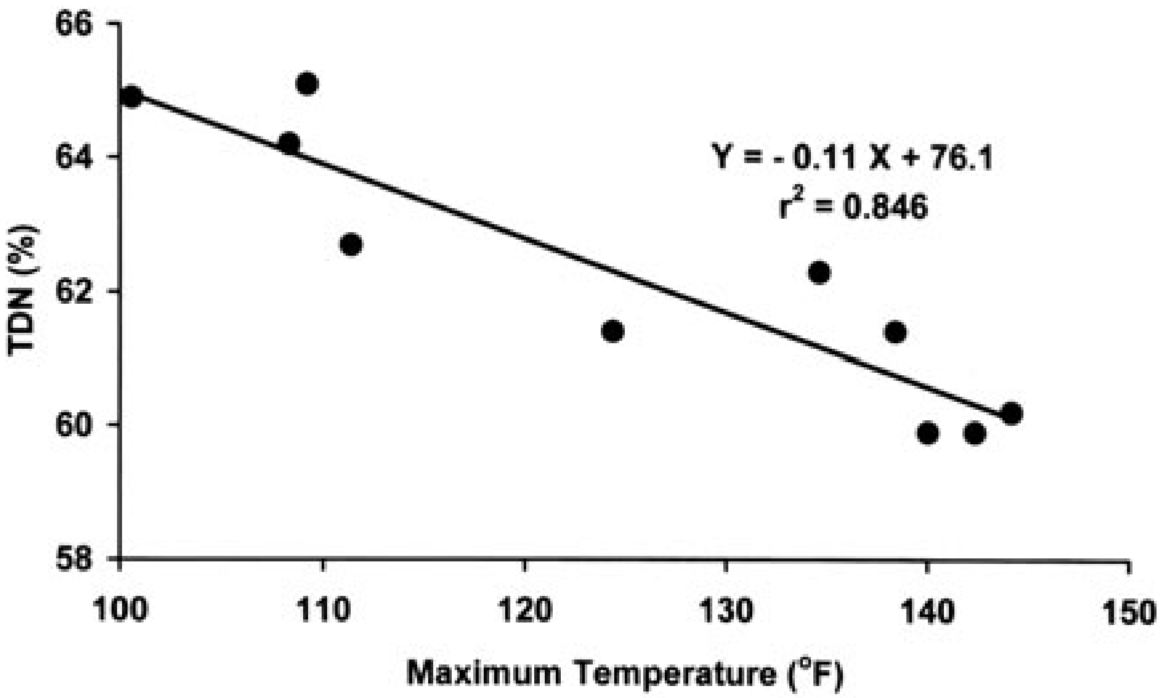


Figure 9. Relationship between energy content (TDN) and the maximum internal bale temperature for conventional rectangular bales of bermudagrass hay (●) made at Fayetteville, AR, in 1998. Source: W. K. Coblentz.



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

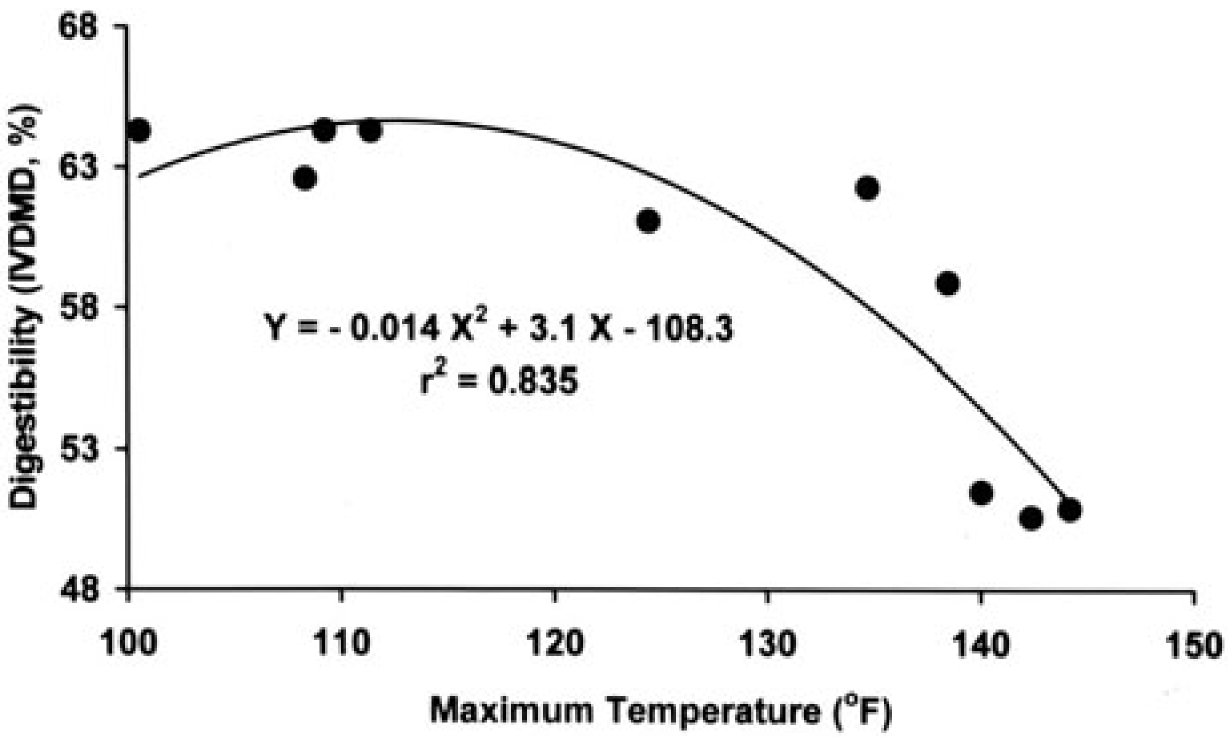
Table 7. Concentrations of crude protein (CP) for bermudagrass hay bales made from the same field and sampled after 60 days of storage at Fayetteville, AR, during 1998.[1]

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.

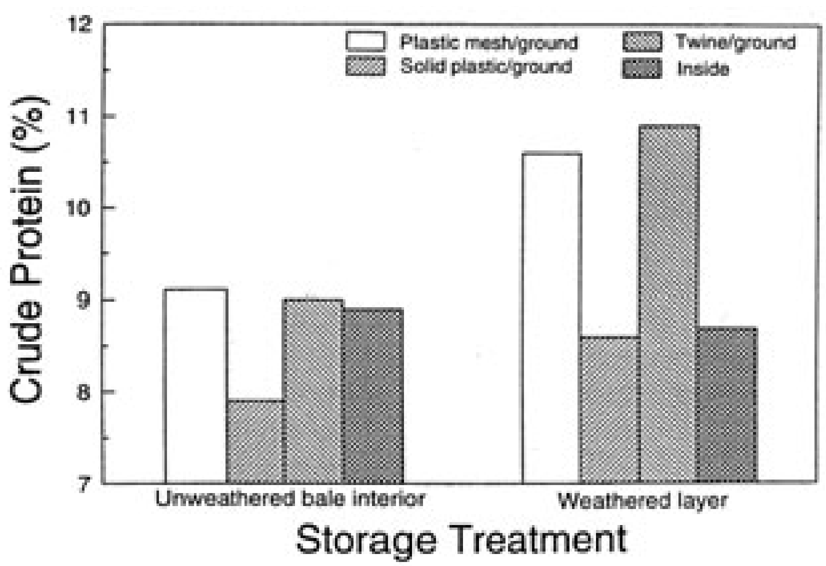
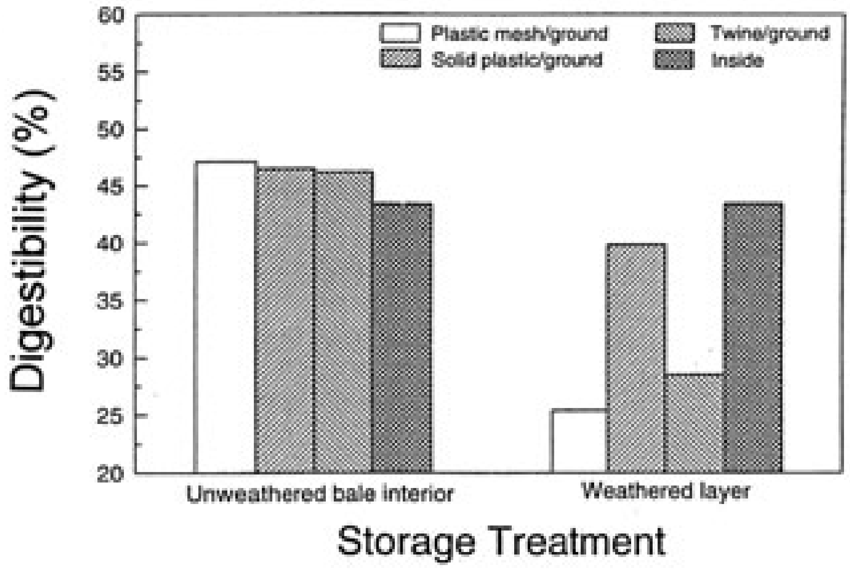


Figure 12. Digestibility of weathered and unweathered layers of tall fescue hay packaged in large round bales in Kentucky. Source: Collins, et al., 1995; *Journal of Production Agriculture* 8:507-513.



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

Choosing the right fence, fence charger, and wire or tape for your grazing system

Dr. John Worley, UGA

2015 Georgia Grazing School:

Choosing the right fence, fence charger, and wire or tape for your grazing system

Dr. John Worley
Professor

Choosing the Right Fence, Charger, and Wire or Tape for Your Grazing System

2015 Georgia Grazing School

John W. Worley

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

Fencing Systems

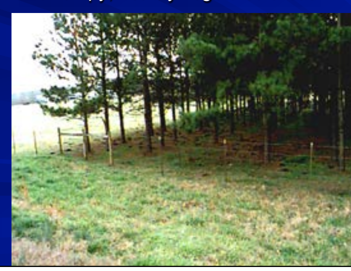
- Plan the system before building
- Choose the right materials
- Use the right construction techniques
- Perimeter Fence vs. Cross Fencing

Types of Fences

- Field Fence (Page wire, hog wire, woven wire) w/ barbed wire at top
  - Perimeter and baby calf areas and near busy roads

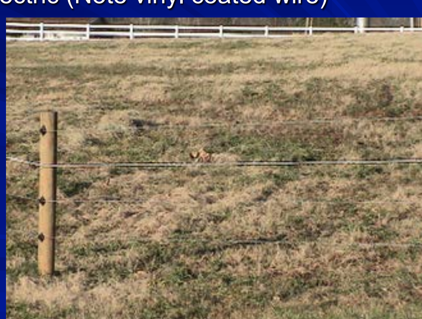
Types of Fences

- Barbed wire
  - Where electric doesn't work well
    - Swampy, heavily vegetated areas

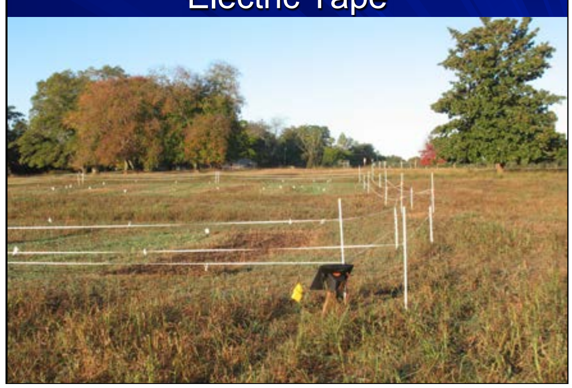


Types of Fences

- Electric (Note vinyl coated wire)



Electric Tape



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Dr. John Worley
Professor

Wire vs Tape

Wire Types

- Steel (Low Carbon vs **High Tensile**)
  - Single, barbed, woven
- Galvanizing (Class I or **Class III**)
- Vinyl Coated (including conductive)
- Electric Tapes and Ropes
  - Temporary
  - Permanent

Post Types

- Wood
  - **Treated (at least 0.4 lb/ft³) Ground Contact**
  - **CCA is preferred**
  - Untreated (Landscape Timbers are untreated or lightly treated)
- Steel (Painted or Galvanized)
- Plastic (Temporary electric)
- Fiberglass
  - Sucker Rod (High Density FG)

Materials

- Perimeter Fencing
  - Recommend High Tensile, Class III galvanized wire
  - Galvanized Steel or Treated Wood Posts
  - Class III galv. staples (1 ¾”)
- Cross Fencing
  - If truly temporary, use plastic posts and electric rope or tape

Components with Similar Lives

- Painted Posts with Class III galvanized wire

How Long Will It Last?

- Painted Posts with Class III galvanized wire

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How Long Will It Last?

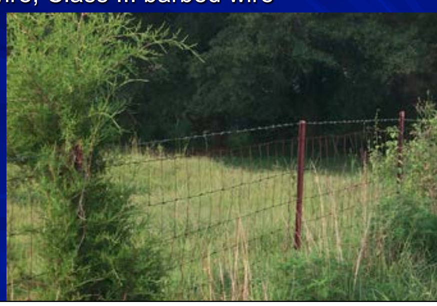
- Galvanized Posts with Class I galvanized wire

How Long Will It Last?

- Galvanized Posts with Class I galvanized wire

How Long Will It Last?

- Painted Posts, Class I woven wire, Class III barbed wire



Fence Chargers
(Controllers, Energizers)

- Look for Low-Impedance charger
- Look for ratings at different loads (ohms)
  - 50,000 ohms (fence in good condition)
  - 5,000 ohms
  - 500 ohms
  - 100 ohms (fence in poor condition)
- At least 1000 volts @100 ohms

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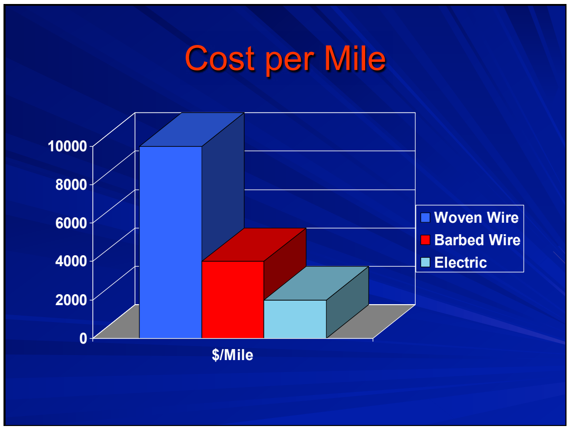

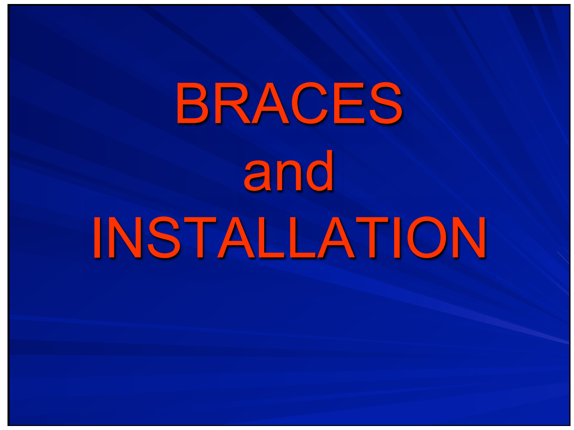

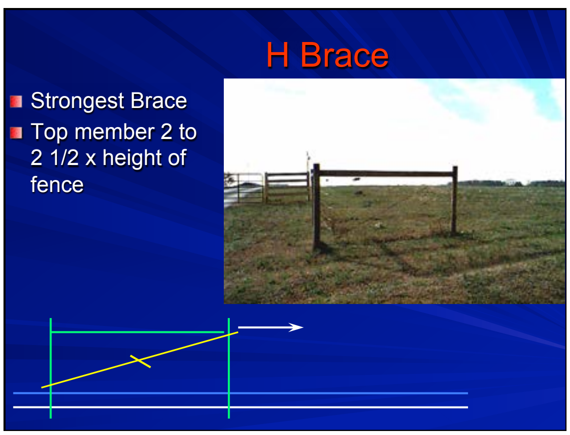

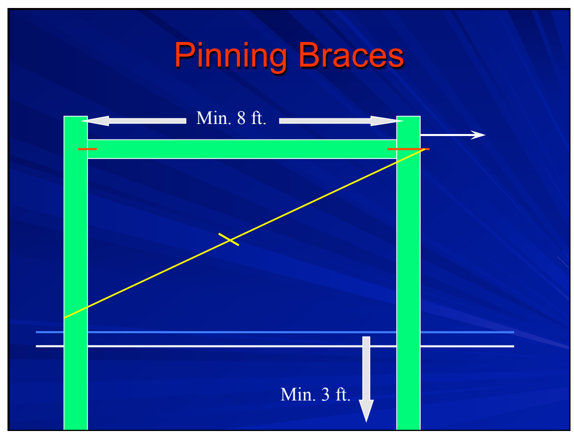

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Nailed Braces

- Not Recommended

Nailed Braces

- Not Recommended

Installing Brace Wire

- Tensioning the wire brace

Pass-thru Line Brace

- Not recommended

Photo courtesy of NRCS

Line Brace

- Wire Wrapped Around Post

Correct Line Brace

- Each end wrapped around center post
- Can go 660 ft between braces if terrain allows and properly constructed.

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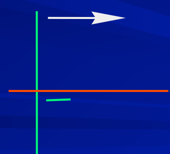
Dead-Man Brace

- Need Larger Post
- Not as Strong
- Easier to Build



Stapling Technique

- Leave Wire Loose
- Only Horizontal Wires
- Rotate from Vertical (Rotate away from slashes)
  - Right for right-handed staples
  - Left for left-handed
- 1 3/4" Galvanized Staples

Post Installation

- Driven wooden posts are stronger
- Drive Small End Down

Post Installation

- Proper Tamping Procedure

Electric Fence Grounding

- Proper grounding of charger is vital
  - 3 or more 8-ft rods
  - 10 ft apart
  - Separate from other electrical grounds
  - Drive and connect all rods
  - Never Concrete Over
- Ground Alternate Wires

Lightning Protection

- Good grounding is essential
- Nothing is "Lightning Proof"
- Use devices sold by charger manufacturer to maintain warranty

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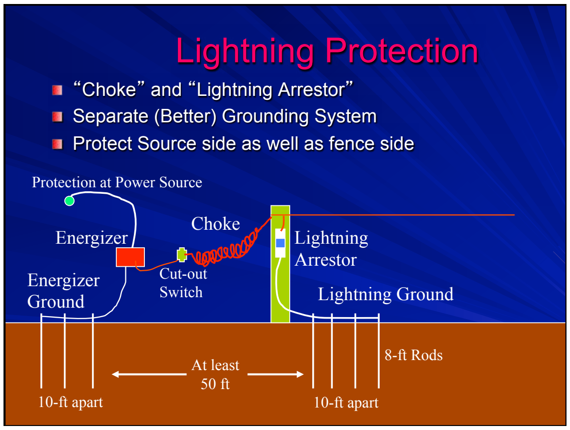
Lightning Protection
"Choke" and "Lightning Arrestor"
Separate (Better) Grounding System
Protect Source side as well as fence side
Protection at Power Source
Energizer
Choke
Lightning Arrestor
Energizer Ground
Cut-out Switch
Lightning Ground
8-ft Rods
At least 50 ft
10-ft apart
10-ft apart


QUESTIONS ?
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Fencing Options for Grazing Systems
John W Worley

One of the challenges of establishing a grazing system is building a fencing system that allows you to easily rotate cows from one grazing site to another. Ideally, this fencing system will be inexpensive, easy to build, and easy to maintain. In reality we sometimes have to sacrifice one or more of these goals to achieve another. Sometimes, for instance, it is better to put a little more into a fence to start with in order to lower long-term maintenance. Many times, "temporary" fences become permanent fences with high maintenance requirements. This presentation will attempt to give some pointers on choices of building materials, equipment, and construction methods that will reduce the overall cost of fencing systems.

Types of Fences

Rotational grazing fences usually fall into one of the following categories:

1) Field fence (also known as woven wire, page wire, or hog wire) – Excellent holding power with low maintenance, but high initial cost. Usually used for perimeter fencing.
2) Barbed wire – Lower cost (about half that of field fence), good holding ability as long as tension is maintained. Also good where vegetation tends to interfere with electric fencing.
3) Electric
   a) Permanent – about half the cost of barbed wire, excellent holding power with good maintenance. Vegetation control and monitoring are necessary.
   b) Temporary – Low cost, fast installation. Cost may be higher per foot than permanent because of higher priced materials, but flexibility is improved. This is especially beneficial for temporary cross fencing.

Wire

One of the most significant innovations in fencing has been the introduction of high-tensile, Class III galvanized steel wire. "High-tensile" means that the steel is much stronger than standard steel. The cost is usually less than standard steel wire because of the smaller wire size, yet the smaller wire is stronger than the larger standard steel wire. Perhaps more important than the cost difference is the fact that high-tensile steel wire is much more likely to stretch under stress (cows pushing against it, trees falling on it) and then return to its original length than is standard steel wire, which tends to stretch and stay stretched. As a result, **if the fence brace assemblies are adequate**, line posts can be spaced much farther apart (20 to 25 ft) than posts in standard wire fences (10 to 12 ft). Many people have reported cutting fallen trees off of high-tensile wire fences and watching the fence spring back to its original position with little or no repair work necessary.

Class III galvanizing is simply an extra thick coating of zinc on the wire. This typically gives the wire about twice the life that it would have with standard (Class I) galvanizing.

High-tensile, Class III galvanized wire is available in single wires (electric fencing), barbed wire, and field fence. There is one drawback to this type of fence wire. Since it is a harder, stronger wire, it is also harder to work with than standard steel wire. It is hard to bend, tends to break if you bend it too sharply, and is hard to cut. You need a cutting tool designed to cut this steel wire, else the cutting blades will be quickly dulled. If you have a pair of wire cutters designed for high-tensile steel wire, you must be careful not to twist the cutters or use them for pulling laterally since the cutting edges are very hard and therefore brittle, and they will break rather than bend. Once you learn how to work with high-tensile steel wire and have the right tools, I think you will find that its advantages (lower cost, longer life, resiliency, fewer line posts) outweigh its disadvantages.

For temporary fences, conductive ropes or tapes are generally recommended because they are very flexible and easy to roll up, move, and reinstall. Ropes seem to last longer than tapes, but tapes are more visible which is important when cattle encounter a fence where they are not accustomed to seeing it. Vinyl coated wire is another useful option on permanent electric fencing because it adds to the visibility of the fence. Vinyl coating is available in a conductive form so that the electric wire is still effective at shocking.

Posts

Traditionally, treated wood posts have been the most commonly used fence posts. Posts should be labeled for ground contact, which means they have enough chemical added to prevent rot when in contact with the ground.

Steel posts are another popular option, and the relative market price of steel vs. wood determines which is the best buy. One of the biggest problems with steel posts is that they are commonly painted rather than galvanized. A painted post will begin rusting in a very few years, resulting in rusting and early failure of the wire. A wire that should last 30 to 40 years may have its life cut in half by rust from non-galvanized metal posts, not to mention the degradation of fence appearance. If possible, I would obtain Class III galvanized posts so that you can take advantage of the full, expected life of the Class III galvanized wire. If wooden posts are used, use Class III galvanized staples for the same reasons.

High-density fiberglass posts are another good choice for electric fencing since they do not require insulators, have a long life, and are very strong. These posts are made from “sucker rod”, a byproduct of the oil industry, and are sometimes readily available, and sometimes hard to find. Their cost is similar to a wooden line post. These posts should be handled with gloves, especially after they are exposed to the weather for a few months because they are made of fiberglass, and the glass fibers will easily penetrate the skin.

For temporary fencing, there are a number of plastic and fiberglass “tread-in” posts available as well as small metal posts with insulators. These posts typically don’t have much lateral strength, but for electric fences, as long as the fence is straight and properly energized, that doesn’t usually present much of a problem.

Chargers

For electric fences, one of the most expensive **and most important** components is the fence charger (also known as the energizer or controller). Probably the most important factor to look for in a charger is how well it holds up when the fence gets in poor repair (vegetation touching the fence, spider webs, broken insulators, etc.) ASABE (American Society of Agricultural and Biological Engineers) has established a standard for testing fence chargers. Basically, the voltage and the energy output (in Joules per pulse) are measured with the following resistors placed between the fence terminal and the ground terminal.

50,000 ohms (represents a fence in excellent condition)
5,000 ohms
500 ohms
100 ohms (represents a fence in very poor condition)

I would encourage you to look for a controller that has been tested by this standard and maintains a high voltage (at least 1,000 volts) under the extreme conditions of a 100-ohm resistor. This will assure you a strong charge even when the fence is compromised by vegetation and other maintenance factors.

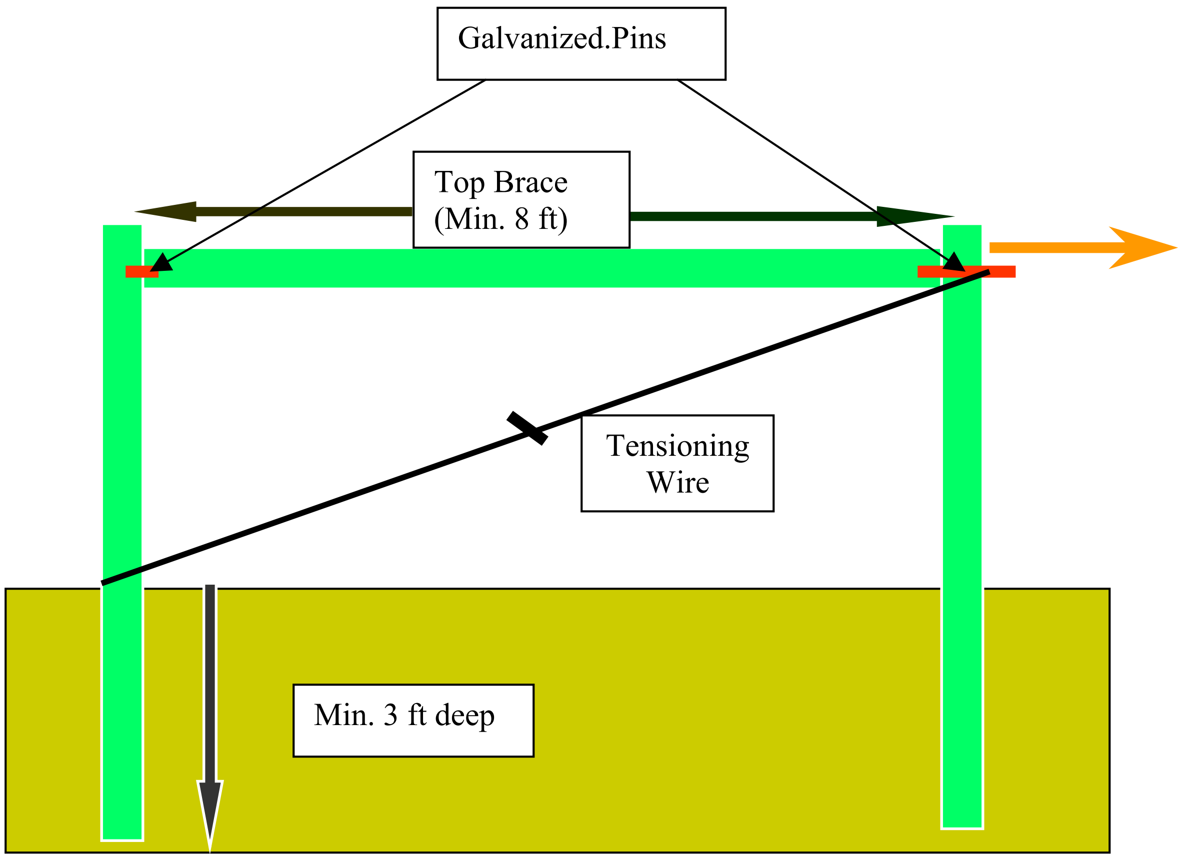
Construction

Building a fence is somewhat like building a house or a barn. Each component plays an important part in the success of the structure, but the one component that everything else depends on is the foundation. Without a good foundation, a building will lose its integrity regardless of how the rest of the structure is built, and the same is true of a fence. The foundation of a fence is the brace assemblies. Each section of fence is basically two brace assemblies with wire stretched between them and line posts to help keep the wires in the right position. Line posts are used to guide the wires along gentle curves, up and down over rolling terrain, and to keep the wires spaced properly. More line posts are needed for standard steel wire than for high tensile wire because standard steel will not recover its original shape as well and thus tends to sag more. High tensile steel will sag as well due to seasonal temperature differences, but if properly installed, can be retensioned easily.

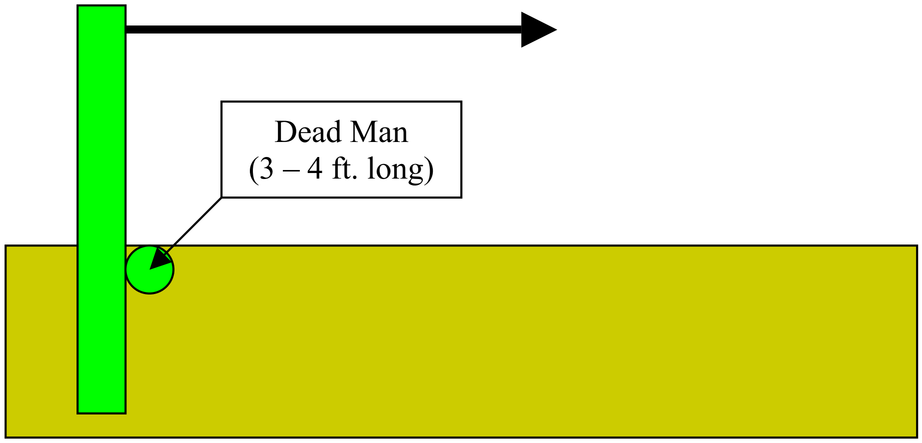
There are two common types of brace assemblies – the H-Brace and the Dead Man.

H-Brace: The H-Brace (shown below) works by transferring the load from the top of the corner post to the bottom through the horizontal brace post and the tensioning wire. There are two keys to making the H-brace work to its maximum advantage that are often overlooked.

1. The top (horizontal) brace post must be held in place. Over time, the ground tends to shift and cause the post to move so that it no longer supports the brace. The best way to accomplish this is to use small (1/2") galvanized pins as shown in the figure below. "Toenailing" with nails will not hold as well as this method.
2. The tensioning wire must be installed at a low angle with the ground. Otherwise, the wire will try to pull the corner post out of the ground when it is tightened. To assure the proper angle, the top brace post should be 8 to 10 feet long (for a 4-ft. high fence).



Dead Man Brace: The "dead man brace" uses a short post about 3 to 4 ft. long buried in the ground at the bottom of the corner post and perpendicular to the post and the fence (see illustration below.) The strength of this brace comes from the fact that the corner post must push the "dead man" through the soil in order to move in the direction of the fence pull. If a large corner post is used, this is a fairly effective brace, especially for short runs of a few hundred feet, and is cheaper and easier to build than the H-brace. For longer runs (up to a quarter mile), I would recommend using the H-brace.



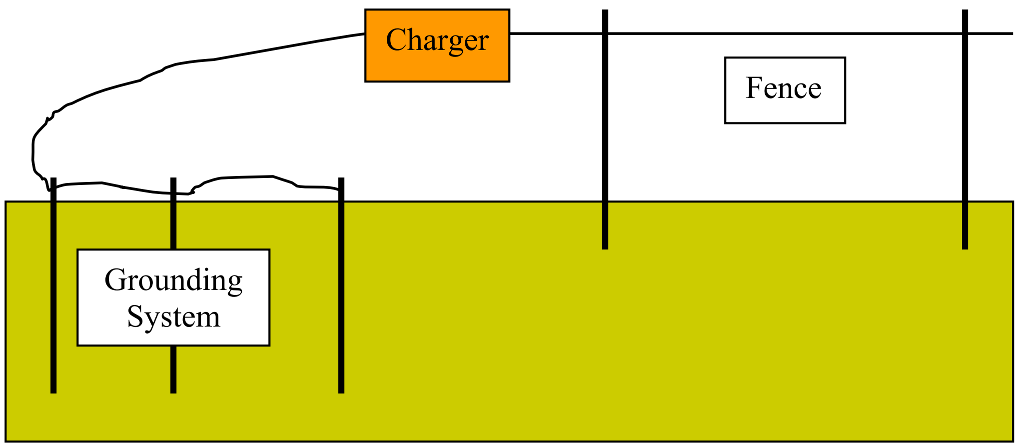
Post Installation: Wooden posts can be installed either by digging a whole and tamping dirt around the post or by driving it into the ground with a post driver. Driven posts tend to be stronger. If driven, the posts should be driven with the small end down. If tamped, it is important to put a small amount of dirt into the hole, tamp it, and then put more dirt in. You can't fill the hole up and then tamp it or it will not hold. Metal and fiberglass posts are best driven into the ground by hand or with a power post driver.

Staples: Again, I would recommend using Class III galvanized staples, and they should be 1 ¾" long if used in soft (pine) wood. Here are a few important tips to remember about the proper installation of staples.

1. Staples should be driven into line posts in such a way as to allow the wires to move under the staples. This allows the wire to move on impact or when heated or cooled by the weather, and then return to its original position. Staples should only be driven tightly on brace post assemblies.
2. Only horizontal wires should be stapled.
3. Staples should be installed with a slight rotation from vertical. Installing a staple vertically (parallel to the post) tends to encourage splitting of the wood. It is important that you rotate the staple in the right direction in order to cause the ends of the staple to spread out and greatly increase the holding power of the staple. There are two types of staples on the market, commonly referred to as right-handed and left-handed staples. Put the staple in your hand with the points aiming away from your body. If there is a slash (flat area) visible on the right-

hand point, it is a right-handed staple. Rotate it slightly to the right (clockwise) before driving. If the slash is visible on the left-hand side, rotate it to the left.

Fence Charger Installation: One of the most important things to remember about installing a fence charger is getting a **good grounding system**. Current can only flow through a complete circuit, and the completion of the electric circuit depends on getting current back through the ground to the grounding system and thus back to the charger. The better the grounding system is, the easier it is for the charger to accomplish this task. Follow the charger recommendations, but usually they recommend installing at least 3 8-ft copper-clad ground rods at least 10 ft apart and connected together with heavy (#6 or #8 copper) wire. This grounding system should be completely separate from any other farm grounding system to minimize the chance of getting stray voltage onto the farm electrical systems.

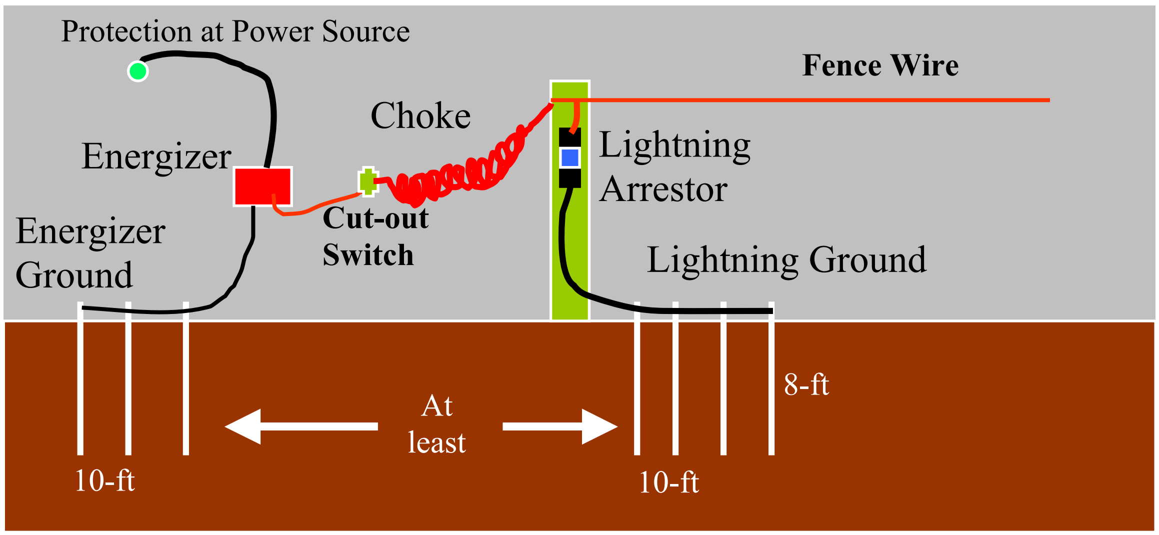


Another strategy that can help, especially in times of drought, is to **ground every other wire (connect them directly to the ground of the charger**.) When the ground is dry, it makes a poor conductor, and it is hard to get current to pass through cows and the dry ground and get back to the charger. If every other wire is a ground wire, then the cow only has to touch two wires, and the current will pass from the hot wire through the cow to the ground wire.

Lightning Protection: Another important issue for any fence, but especially for electric fences is lightning protection. Lightning will always find a path to ground, and it usually will find a number of paths. The goal is to get lightning to the ground through a path that will not cause harm to cattle or equipment. Here are a few things to remember about lightning protection:

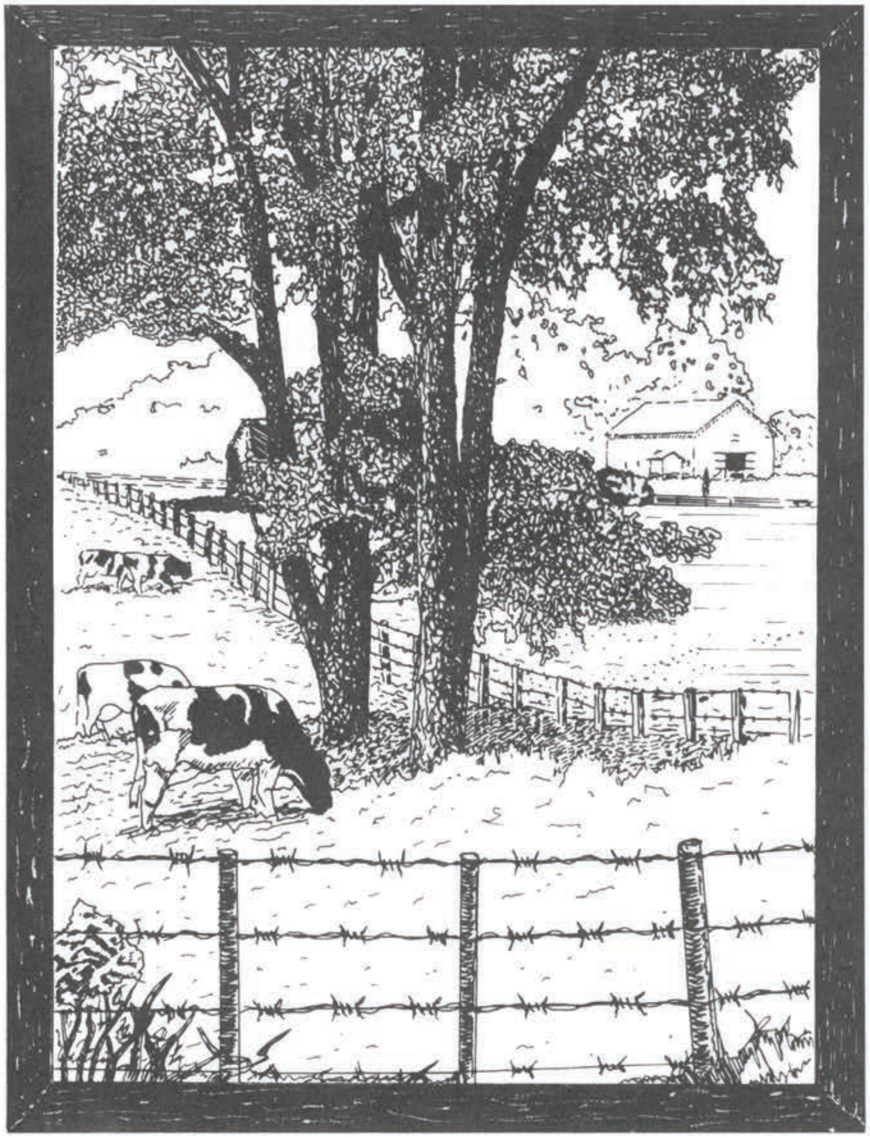
1. Nothing is lightning proof! If it hits directly enough, it will destroy almost anything.
2. I recommend using lightning protection supplied by the fence charger manufacturer to protect the charger. That makes it more likely that their warranty will be honored (if they have a warranty against lightning damage).

3. It is a good idea to ground the fence about every ¼ mile by driving a ground rod and attaching it electrically to any grounded wires in the fence. This will provide multiple paths to ground for the lightning. Obviously, if you use metal posts, this would be unnecessary.
4. The figure below shows some guidelines for a good lightning protection system.



Summary

Desirable qualities of a fence are resiliency (springs back after being hit or stretched), high visibility, economy, and ease of installation. If you plan carefully, use the right materials, and put a little extra effort into the installation, your fence should be a good investment that will require a minimum of maintenance and will help make your rotational grazing system a success.



FENCES

For the Farm

UGA extension

Table of Contents

Fences for the Farm

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Fences may be used to protect or divide property, to improve its appearance, to confine animals, or to exclude animals. Whatever its purpose, one should plan a fence carefully. This is especially important on farms where fences represent a large investment and their location and arrangement may affect production efficiency.

Permanent fences — those intended to last for many years with minimal repairs — should be well constructed and made of good materials. Temporary fences — those intended to stay in place only a short time — need not be so sturdily constructed and may be made of less expensive materials. Whether you select permanent or temporary fencing, careful consideration of uses and proper maintenance is necessary.

Planning the Fence

Fencing is a long term investment. Good fences should last from 25 to 50 years. Planning is the key to good fencing. This is true whether fencing an area for the first time or replacing old, worn-out fences. If present fences are in good shape you may want to develop plans around them. But look ahead to the day when these fences, too, may have to be replaced. It is not wise to construct new divider fences if boundary fences are in disrepair and failing.

Sketch Map of Your Farm

The easiest way to prepare a sketch of your farm is to start with an aerial photograph. A good aerial photo shows details of the present farm layout, plus some indications of the lay of the land. Aerial photographs have been made of practically all farming areas. You can get one that includes your farm from the Farm Service Agency (formerly Agricultural Stabilization and Conservation Service) or your local tax office. You can also obtain one from any commercial aerial survey firm listed in the classified section of telephone directories in major cities.

Add Land Capability to Map

This step may already be complete if your land is in a Soil Conservation District. Land capability maps, available from the Natural Resources Conservation Service (formerly Soil Conservation Service), generally show types of land and spell out use and management plans for the farm (Figure 1).

If an NRCS plan is not available for your farm, use the sketch of your land which you previously obtained. Divide your land into areas that are best suited for: (1) permanent pastures or hay production, (2) woodlands not to be pastured, (3) woodlands that can be pastured and (4) cultivated crop production (Figure 2, page 4). These land assignments are made based on uses that will return the greatest possible profit for each type of land.

Consider the following points when developing your plan. If possible, locate fences in terraced fields at terrace's crest and other natural water divides. Avoid running your fences down-slope across terraces. If your field needs to be cross-fenced, try to plan a contour fence parallel to a terraced ridge. If a fence must be located at the outlet end of a terrace, allow for a fence location that will not block the outlet water movement from channels.

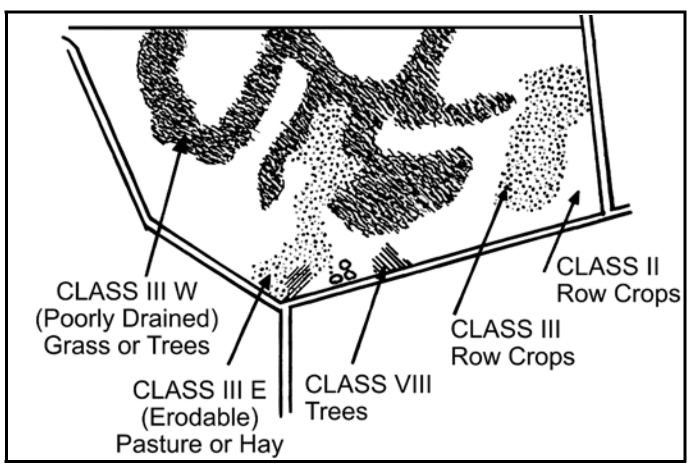

Figure 1. A land capability map will look something like this if prepared by the Natural Resources Conservation Service.

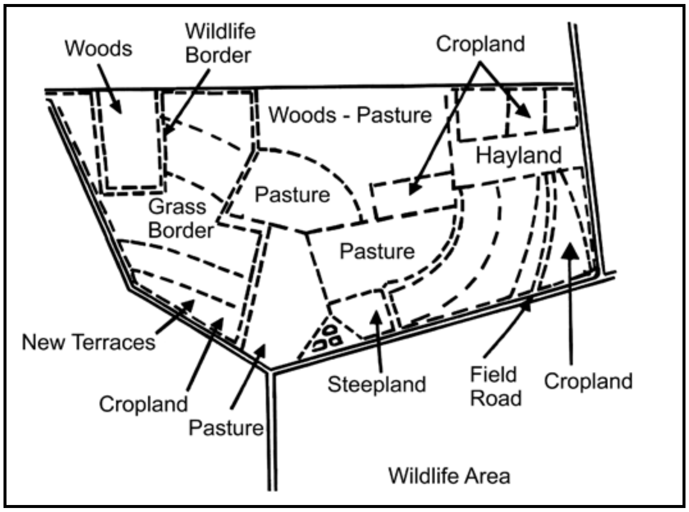

Figure 2. Land capability layout.

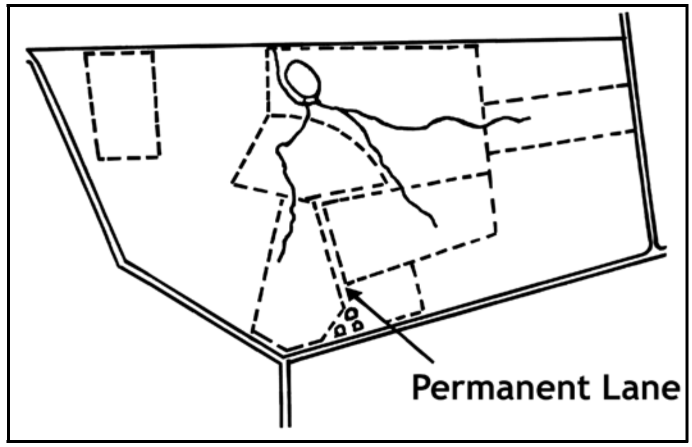

Figure 3. Locate permanent lanes to avoid erosion yet allow access to as many fields as possible.

Pastures located at the end of terraced land provide good grass receiving areas for excess water flow. Wherever possible, plan for straight fences; they are cheaper and easier to build.

Locating Lanes and Gates

Ideally, a lane should connect livestock buildings and working pens with every field that eventually may be pastured (Figure 3). Keep in mind that a permanent pasture located between other fields can be considered a lane itself.

Locate lanes in the driest areas possible, such as along a terrace or natural ridge; otherwise gullies may develop after repeated use. If a well-drained location is impossible, plan on movable lane fences which can be relocated after a year or two. If lanes are used frequently, it may be desirable to grade the area and install geotech fabric covered with six inches of compacted crusher-run gravel in the lane. Specifications for such "heavy use areas" can be found at your local NRCS office. They can be installed for about half the price of concrete.

Wherever possible, locate gates and passageways for livestock and equipment in the corner of each field closest to farm buildings. If you have fields on opposite sides of a road or highway, locate gates opposite each other so livestock can go directly across.

Locating Permanent Fences

First, a permanent fence around the farm boundary is highly desirable. This will establish a fixed property line between you and your neighbor. It will also help confine your livestock to protect both them and the driving public from possible highway collisions. If a fence around the entire boundary is not affordable, then install the parts which are most helpful in your operations. Other boundary fences can be added at a later date.

Next, permanent pastures which will be used year after year also deserve high priority in fencing plans. Plan to fence ponds, also, to control livestock access. Since these fences are not apt to be moved, plan for well built, low-maintenance construction. If the plan includes a lane that gives livestock access to water, this fence should also have high priority. Livestock may enter and damage a well managed timber stand if there are gaps in surrounding fences. Such fences should have a high priority.

Also consider permanent fencing for cultivated fields used for pasture. If you follow the practice of "hogging" corn or peanuts, or of turning your livestock into a field for "grazing down" after it has been harvested, a permanent fence is highly desirable. With careful study, temporary or movable fences such as electric fences may do the job economically and effectively around cultivated fields. However, movable fences usually don't last more than three years and may not be economical replacements for permanent fences.

Locating Temporary Fences

Temporary fences are intended for use over a period of a few weeks or months. After that they will be removed and used in some other location or stored until needed.

Movable fences cost less to build than permanent fences, but they are not as effective and will not last more than one to three years the way most of them are built. They do not take the place of permanent fences, but can be very beneficial in some instances.

Movable fences have a definite place in any livestock program. They can be used temporarily in place of permanent fences until you can afford permanent fencing. They can be relocated from year to year until you decide what field layout best fits your needs. They are easily moved to allow pastures to be rotated and are especially desirable for intensive rotational grazing programs. They can also help adjust the size of a temporary pasture to the amount of livestock being grazed.

Selecting the Fence

Now that you have your fencing plan laid out, your next job will be to decide what kind of permanent or movable fence to select. The kinds of fences commonly used on farms include board, barbed wire, woven wire, cable, mesh, high-tensile, electric or a combination of any of these.

The type of fence that you will need depends on the livestock, crops, and other vegetation that border the fence. Horses will run through a fence or get tangled in it causing harm to themselves. Cattle will crawl over fences, sheep try to crawl under. Hogs, of course, try to root their way under a fence. Any livestock will put a fence to its greatest test when there is a lush green crop on the opposite side.

Rail Fences

Rail fences are typically used as border fences around farm buildings or the home. They are also popular on horse farms where expensive show-animals are confined. Today, many choices are available for building board fences including PVC plastic, vinyl coated wooden boards, treated wood, and painted wood. PVC plastic fences are not as strong as wood and cost more, but they are very attractive and do not require painting since they are the same color all through the material. White PVC boards may require periodic washing with mildew removing agents, especially in the humid South. Numerous heights of board fences are possible, but 4 to 5 feet are most common for livestock. The cost of lumber, nails, paint and other materials along with labor is generally higher for rail fences than for most other fences.

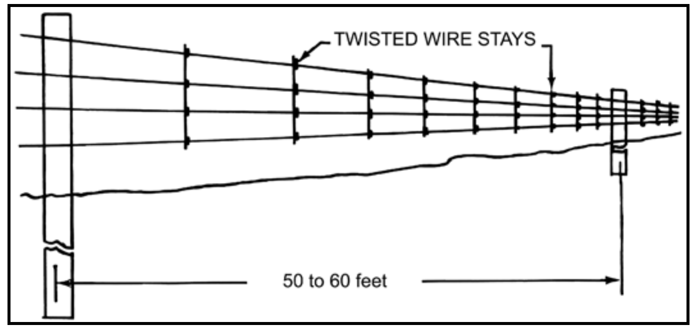

Figure 5. Typical barbed wire suspension fence.

One type of fence that has the appearance of a rail fence, but is actually a wire fence is called a high-tensile polymer fence. The “rails” consist of vinyl plastic 4 to 6 inches wide with two to three high-tensile steel wires encased. It is less expensive than a rail fence, is very strong, and has a nice appearance and good visibility, but the wires must be tightened once or twice per year to maintain the proper tension. (This is true of any high-tensile fence.)

Barbed Wire Fences

Barbed wire fences are generally classified in two categories: standard barbed wire fences and suspension barbed wire fences.

Standard barbed wire fences (Figure 4) usually have posts spaced 10 to 12 feet apart and use three to five strands of wire.

Suspension barbed wire fences (Figure 5) consist of four to six strands of barbed wire. Each strand is stretched *taut* so there is no more than three inches sag between posts. The suspended barbed wires are held apart by twisted wire stays or short pieces of fiberglass posts spaced approximately 10 to 12 feet apart. Line posts are spaced from 50 to 60 feet apart. The suspen-

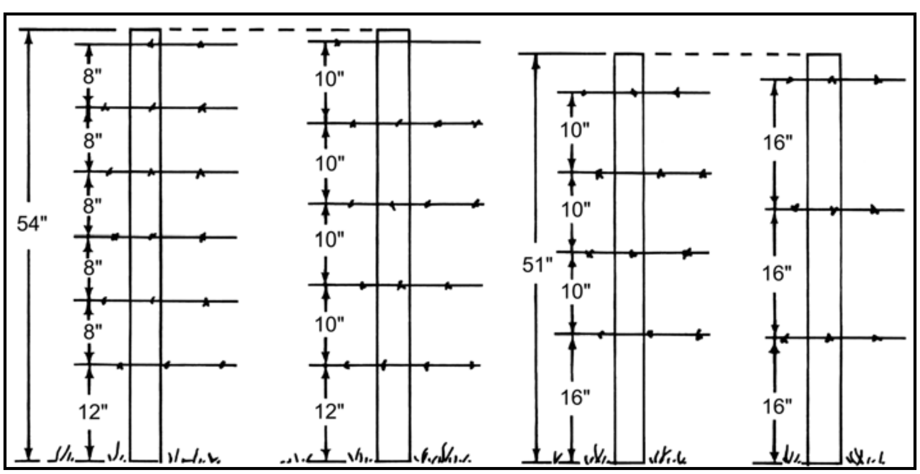

Figure 4. Common spacings of wire in barbed wire fences.

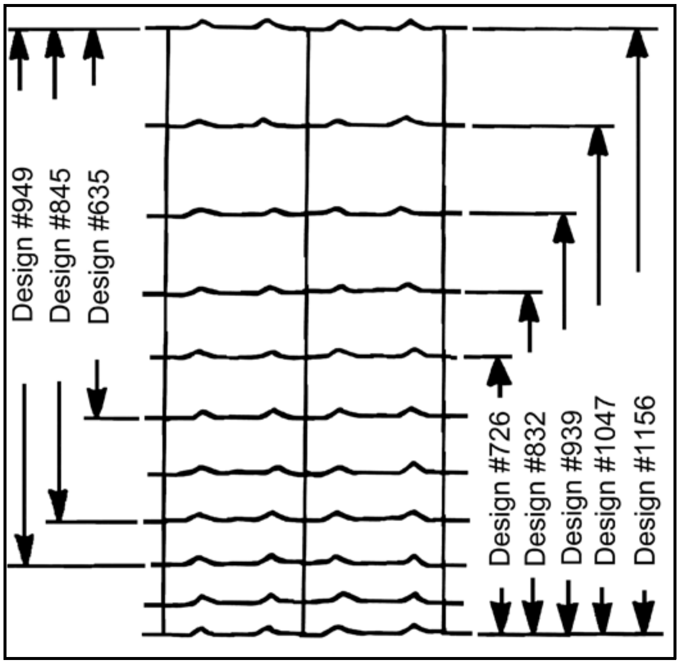

Figure 6. Some common woven wire designs. Standard design numbers describe the wire: 949-12-11, for instance, means the fence has 9 horizontal wires and is 49 inches high; has 12-inch spacing of stay (vertical) wires and 11-gauge stay and intermediate wires. (Top and bottom wires are usually two sizes larger.)

sion barbed wire fence sways back and forth in the wind or when animals hit it. The swaying motion helps keep animals away from the fence and discourages them from fighting through it. For this reason the lower end of the stays must not touch the ground or the effectiveness of the suspension fence will be reduced.

Woven Wire Fences

Woven wire fences consist of a number of horizontal lines of smooth wire held apart by vertical wires called stays. Spacing between horizontal line wires may vary from as close as $1^1/_2$ inches at the bottom for small animals to 9 inches at the top for large animals. Spacing of the wires generally gets wider as the fence gets higher.

Stay wires are spaced 6 inches apart for small animals and 12 inches for large animals. The height of most woven wire fencing materials ranges from 26 to 48 inches. The height needed will depend on the size and jumping ability of the animals. Many combinations of wire sizes and spacing as well as a number of fence heights are available. Standard woven wire fence designs are shown in Figure 6.

Cable Wire Fences

These fences usually consist of $^3/_8$-inch smooth, steel wire cables stretched from one anchor post to another (Figure 7). Each cable is normally made out of seven strands of wire twisted together. Heavy springs are placed at one end of each cable to absorb any shock on the wires. The other end is rigidly attached to the next anchor post. Cables are usually passed through holes in wooden posts. If other kinds of line posts are used, cables are attached to them with heavy wires. A fence may have as many cables as desired, however, a six cable fence is common. Spacing between wires depends upon the kind of animal to be confined. Cable wire fences are expensive, thus they are mostly used for confinement areas such as holding pens, feed lots or corrals.

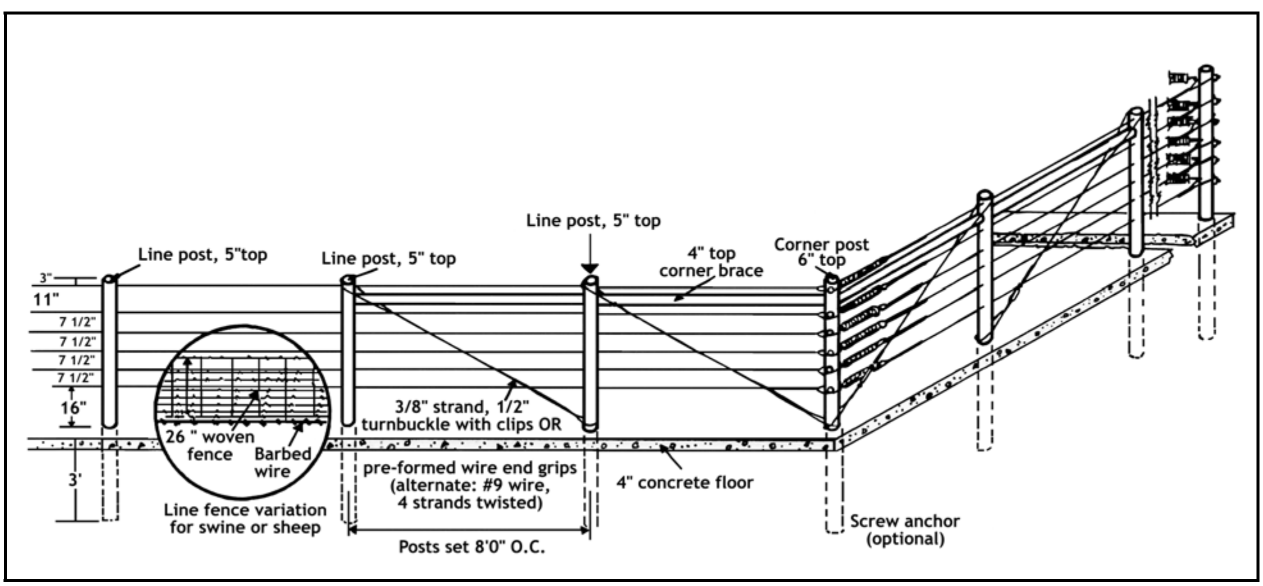

Figure 7. Cable fence — one type of installation.

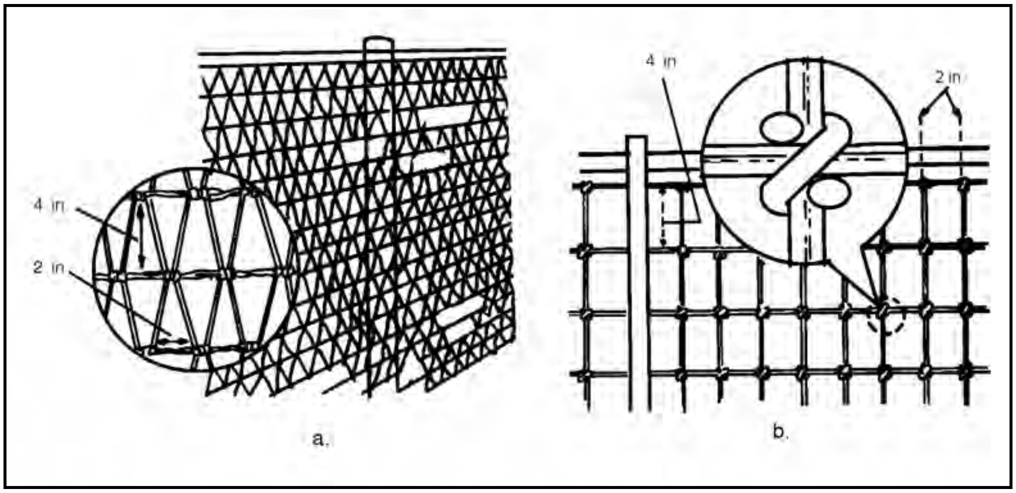

Figure 8.a. - Detail of diamond-mesh fence; b. - Stiff-stay, square-knot fence design.

Mesh Wire Fences

Mesh wire fences are strong and provide great safety to animals. They are replacing wood board fencing in many areas, but are even more expensive than good woven wire. Because of the cost they are used primarily for confinement fencing such as that around corrals, feed lots, or small crop acreage areas. They also make an excellent large area fence for valuable horses. They have small openings so horses don't tend to get their hooves caught in them, and they have no exposed sharp wire ends to cut an animal. Two types of mesh wire are the diamond mesh (Figure 8a), which uses two wires twisted together in a diamond formation, and the square knot mesh (Figure 8b), which has single horizontal lines with the wire spaced 2 to 4 inches apart.

High-Tensile Wire Fences

High-tensile wire fences potentially have longer life and lower costs than conventional fences. Single, smooth wires are held in tension between pressure-treated wood end-post assemblies with a combination of posts and battens or droppers to keep the wires properly spaced between posts. Tension in the wire is maintained by permanent in-line stretchers and tension springs. Best results are achieved when tensioners are used in conjunction with springs. Attach wires to any intermediate posts in such a way that they can move laterally and be retensioned. Wires should be retensioned at least once or twice per year. Commonly one to five or more strands of high-tensile wire are used in a fence. It is recommended that one or more of the strands be electrified in order to prevent animals from scratching on the battens and thus moving them out of position. If this happens, it could result in long unsupported lengths of wires, allowing animals to get through the fence.

If properly designed and constructed, high-tensile smooth wire fencing has many advantages. It is easier to handle, safer for livestock, easily adapted to specific needs, has longer life, requires little maintenance, causes minimum damage to livestock hides, has a neat appearance and gives better livestock restraint and predator control when electrified.

Figure 9 shows a typical five-wire high-tensile fence with in-line wire tensioners.

Electric Fences

Electric fences can be built for temporary or permanent use. In addition, a strand of electrified wire added to other types of fence usually improves their effectiveness tremendously. The temporary or movable fence is usually made with one or two strands of smooth wire or a rope or tape with small electric wires woven into it. Tape or rope is more flexible than smooth wire and much easier to handle and move from one location to another. It is also more visible, an important factor when a fence is to be moved periodically to new locations

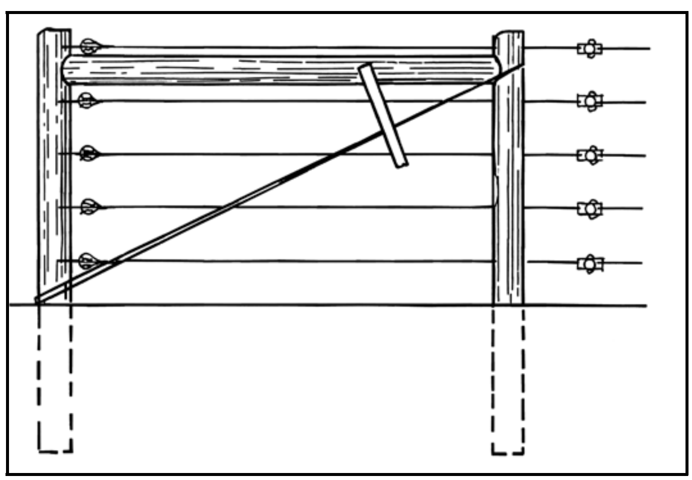

Figure 9. Typical high-tensile fence brace and wire tensioner location.

where livestock are not used to seeing it. An electric fence controller is used to energize the wires. The moist earth is used to allow the current to return to the controller. Alternatively, one strand of wire can be grounded, so that the circuit can be completed even when the earth is very dry and thus a poor conductor. Corners and end posts in temporary electric fences require less bracing than permanent fencing. Line posts may be small with wide spacing since the fence will generally be used for a short period of time.

Permanent electric fences may also be built. These fences have from two to eight smooth wires placed on stronger posts. Instead of using the earth for a return path, many electric fences use alternate wires as the hot wire and the grounded return to the charger. This arrangement enables a completed circuit when an animal touches any two adjacent wires and improves the performance of the fence tremendously in drought conditions. Cost of permanent electric fence is much less than that of comparable barbed or woven wire fences. Some of the advantages of electric fencing are low initial cost, low operating cost, and portability. They can be used to protect or extend the use of old permanent fences and they can be used to protect livestock or poultry from many predators.

There are a few disadvantages, however. A home-built unit can be highly dangerous. Only approved fence chargers should be used. Livestock will require training when first using electric fences. The electric fence charger must be operated full time, especially with cattle and sheep. Also, if no return ground wires are used, electric fences may not be effective in dry weather. This is especially true if the controller is not well grounded. Another potential problem is that the charged wire may short-circuit and become ineffective if heavy vegetation is allowed to contact the wires. It is imperative that electric fences be inspected and that vegetation be controlled in order to minimize short circuiting. For this reason, an electric fence may not be a good choice near wooded or swampy areas with heavy vegetative growth.

Comparison of Fence Types

As previously states, the type of fence needed depends on livestock, border crops, predators and other factors – including cost. Table 1 (page 9) shows some general comparisons for use when selecting a fence.

Fencing Materials

Wire

Wire is covered with zinc, commonly called galvanizing, to protect it from rusting. The length of time before wire begins to rust depends on the weather but also on the thickness of the zinc coating. More zinc means more years of service before rusting starts. Fence manufacturers and the American Society for Testing Materials have established "classes" of zinc coatings for fence wire. Class 1 has the lightest coating of zinc and Class 3 has the heaviest (two to three times as much, depending on the wire size). The expected life of a fence depends on many factors, but Class 3 galvanizing can easily add 5 to 10 years of life to fence wire in a humid climate like Georgia's.

Because of competition, many suppliers of fencing materials only stock Class 1 fencing or a limited number of products in Class 3. Commonly, a light gauge Class 3 barbed wire is stocked along with a heavier gauge Class 1 barbed wire since both of these products sell for about the same price. Other products with Class 3 galvanizing may have to be special ordered, but it is usually worth the extra cost and effort, especially in the humid southeastern climate. If consumers demand a higher quality product, dealers will certainly supply that need.

Staples

Selecting the appropriate staple is just as important to the overall strength and longevity of the fence as selecting the right wire. Staple pull-out is a common fencing problem when using softwood posts. To avoid this problem, use $1^3/_4$-inch or 2-inch long, 8- or 9-gauge, hot-dipped, galvanized staples with cut points and barbs. If using hardwood posts, shorter staples can be used because they cannot be pulled out of hardwood as easily.

Fence Posts

Wooden posts are plentiful in Georgia. Some major advantages of wood posts are strength and resistance to bending, misalignment and withdrawal. Permanent fences will require decay resistant fence posts. The most common wooden posts are pine pressure treated with CCA (chromated copper arsenate.) These posts have a greenish color, and they last longer and are harder than older treatments such as creosote and Penta (pentachlorophenol.) This quality of hardness tends to help prevent staples from being pulled out. Some native, untreated trees are still used to a limited extent for fence posts. Table 2 (page 10) shows the life expectancy of different tree varieties when used as fence posts.

Table 1. Comparison of Common Fences

Types	Comparative Cost Index[1] (Material Only)	Approximate Life[2] (Humid Climate) - yrs	Upkeep
A. Permanent Types			
4-Rail (Posts spaced 8 feet)			
1" x 6" Treated Boards	200	10-20	Medium
2" x 6" Treated Boards	350	10-20	Medium
PVC Rails	500-600	20	Low
High-Tensile Polymer Coated			
5-inch rail width	330	33	Medium
Barbed-Wire Fencing (One post per 10 feet)			
5 strands	35	33	High
Suspension Fencing (Posts 50 feet apart)			
5 strands	25	33	Medium
Woven Wire Fencing			
39-inch with 2 strands barbed wire	75	33	Medium
Cable Fence			
5 cable (5')	500	30	Low
Mesh Wire			
$12\frac{1}{2}$ gage	150	38	Low
Permanent Electric[3] - ($12\frac{1}{2}$ gage) **and High-Tensile Fences**			
4 strands	20	25	Medium
B. Moveable Electric Fences[3]			
Steel Wire (Smooth, 1-strand)			
12 gage	7	33	High
Reflective Tape or Rope			
$\frac{1}{2}$-inch	11	30+	Medium

[1] Cost index figures are to show relative cost, not actual costs. For example, fence with an index figure 25 costs about twice as much per foot as a fence with an index figure of 12.
[2] Fence life based on combination of post and wire life expectancy.
[3] Costs of electric controller not included.

Wood posts from $5^1/_2$ to $8^1/_2$ feet long and from $2^1/_2$ to 8 inches or larger diameter are readily available. The larger the top diameter, the stronger the post. Line posts can be as small as $2^1/_2$ inches, but larger ones will provide for a stronger, more durable fence. Corner and gate posts should have a top diameter of at least 8 inches. Brace posts should be 5 inches or more in diameter.

Be careful when buying wooden posts that the posts are properly treated for contact with the soil. Most treated lumber (including 4-by-4s often used as posts) bought in builder's supply stores is treated at 0.25 lb of CCA per cubic foot of lumber. This level of treatment will not protect against termites. Sawn lumber should be treated at 0.5 to 0.6 lb/ft^3 of CCA if it is to be in contact with the earth. Fence posts can be treated at 0.4 lb/ft^3. Many people are tempted to use "landscape timbers" for fence posts because they are extremely cheap at times due to over-supply. These timbers are a byproduct of the plywood industry. They are what is left after the veneer has been peeled off of a large log. The danger in using these for fence posts is that many times they are not treated for ground contact since they are not designed to support a load and sometimes are not labeled, so it is unclear what, if any, treatment has been applied.

Steel posts have four major advantages. They cost less, weigh less, can be driven into the ground rather easily, and are fireproof. They also help ground the fence against lightning when the soil is moist. Steel posts vary from 5 to 8 feet long. A wide variety of steel posts are available with widely varying prices and quality, so be careful when comparison shopping to make sure you are comparing equal quality posts. Steel posts do not have as much strength against bending as wood posts. Wooden line posts can be placed every 50 to 75 feet to help keep steel posts from bending and improve fence stability.

Various kinds of posts are available for electric fence line posts as the requirements for strength are much less than for nonelectric fences. Posts are available in wood, plastic, steel, and fiberglass. Wood and steel posts require insulators to prevent short-circuiting the fence through the posts. Where available, high-density fiberglass posts (commonly known as *sucker rod*) make excellent electric fence posts. These posts are byproducts of the oil industry and are not always available. They are usually gray in color, are very strong and durable and are nonconducting, so insulators are not required.

All posts must be long enough for the fence height and depth of setting. Add together the height of the top wire above the ground, the depth of the post in the ground, and 6 extra inches to get the desired length.

Table 2. Life Expectancy of Wood Fence Posts

Type of Wood	Untreated	Treated	Type of Wood	Untreated	Treated
Ash	3-7	10-15	Larch	3-7	10-20
Aspen	2-3	15-20	Maple	2-4	15-20
Bald Cyprus	7-15	20-25	Oak (red)	5	15
Balsam Fir	4-6	10-15	Oak (white)	10	15-20
Basswood	2-3	15-20	Osage Orange	20-25	Not necessary
Beech	3-7	15	Pine	3-7	25-30
Birch	2-4	10-20	Red Cedar	15-20	20-25
Black Locust	20-25	Not necessary	Red Mulberry	7-15	15-30
Box Elder	2-7	15-20	Redwood	10-15	20-30
Butternut	2-7	15-20	Sassafras	10-15	20-25
Catalpa	8-14	20-25	Spruce	3-7	10-20
Cedar	15-20	20-25	Sweetbay	2-6	10-20
Cotton Wood	2-6	10-15	Sweetgum	3-6	20-30
Douglas Fir	3-7	15-18	Sycamore	2-7	20-25
Elm	4	15	Tamarack	7-10	15-20
Hackberry	3-7	10-17	Tupello (black)	3-7	15-20
Hemlock	3-6	10-25	Willow	2-6	15-20
Hickory	5-7	15-20	Yellow Poplar	3-7	20-25
Honey Locust	3-7	10-20			

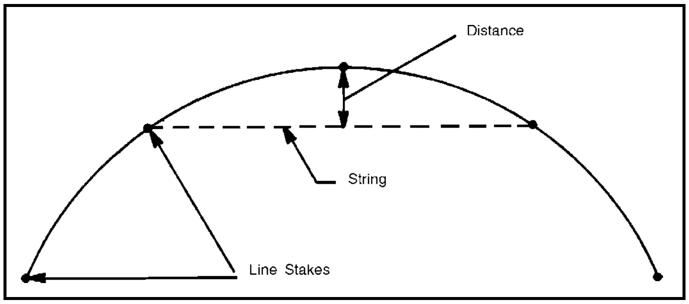

Figure 10. Fence post spacing around curves.

Electric Fence Controllers

Most people will agree that touching an electric fence is a very unpleasant experience. The experience for animals is no different. When animals come in contact with an electric fence, the shock they receive affects their nervous systems. The severity of the shock depends on the voltage and amperage, as well as the duration of the shock and the sensitivity of the animal. It takes at least 700 volts to effectively control short-haired breeds of cattle, pigs, and horses and around 2000 volts for long-haired cattle, sheep, and goats. The controller, sometimes called the charger or energizer, that delivers this shock is the heart of any electric fence and should be selected carefully.

The thing that makes controllers safe yet effective is the short duration of the charge. The charge is powerful, yet does not last long enough to damage the heart or to cause electrical burns. Modern low-impedance controllers have the capacity to power long distances of multi-wire fences and are not affected as much as earlier controllers by some contact with grass or other vegetation.

Controllers are available in battery powered models as well as 120-volt AC models. When 120-volt power is available, the 120-volt models have the obvious advantage since batteries do not have to be purchased or recharged. Cost of operation is minimal (usually less than $1 per month) for these units. If commercial power is not available near the fence to be energized, battery-powered units are available to fill this need. These units operate on 12, 24, or 36 volts (one, two, or three 12-volt batteries in series). The batteries must be recharged every 2 to 6 weeks depending on the system and amount of use. Solar collectors are also available to recharge the batteries daily. Deep-cycle, marine and RV type batteries are best suited for battery-operated controllers. Batteries designed for use in automobiles will not last as long as deep-cycle batteries.

It is important to match the capacity of the controller to the fence you want to charge. Most manufacturers indicate the strength of the unit by the number of miles it will power. A good rule of thumb for sizing controllers is to determine the number of miles of electrified wire in the fence and add 25 percent to offset any power drain caused by vegetation touching the fence. For example, if you have 4 miles of five-strand high-tensile wire with three of the strands electrified, you would need a controller rated for at least 15 miles (3 wires x 4 miles = 12 miles + 25% = 15 miles.)

Construction

Like most construction and maintenance jobs around the farm, fence construction requires proper techniques and common-sense judgment. Every fencing job presents slightly different problems. A few basic principles are good starting points for every fencing job. Here are some to consider.

Establishing the Fence Line

Where a permanent fence is installed on a property line, make sure of the exact location of property lines. A mistake here can be very costly. Once this is done and any trees and brush are removed, you are ready to establish the fence line.

On level ground, an end post can be installed at each end of the run and a string or a single strand of wire stretched between the two posts to establish the line. On rolling ground where hills are too high to sight from one end-post to the next, surveying equipment can be used if available to establish the location of intermediate points on the line. Alternatively, intermediate sighting stakes can be driven at the tops of hills. Two of these temporary stakes should be driven about 8 to 10 feet apart at the approximate position where the line will cross the crest of the hill. If both posts appear to be lined up when sighted from each end post, they represent a true midpoint of the line. If not, they can be moved back and forth until they are properly aligned.

When the fence must go around a curve, place small stakes every 16 feet around the smooth curve. Then start figuring the post hole positions where the curve is greatest. The sharper the curve, the closer the posts should be. Select three stakes at a point of maximum curvature. String a line from the first to the third stake (Figure 10). Measure the distance from the center stake to the string, and space the posts as given in Table 3.

Table 3. Fence Post Spacing Around Curves

Distance from Center Stake to String	Post Spacing
Inches	*Feet*
8 or less	12
8 to 14	10
14 to 20	8

End, Corner, and Gate Post Brace Assemblies

For any wire fence, corner-post and end-post assemblies are probably the most important structures in the entire fence. They are the foundation upon which the fence is built. When wire is first stretched, the pulling force on a corner or end may be 3000 pounds. Winter cold can cause contraction of wire which increases that force to 4500 pounds. Both corner and end assemblies must be strong enough to withstand these forces.

Figure 11 shows proper construction of a double span **H**-brace assembly for wooden anchor posts. A double span assembly is more than twice as strong as a single span; use it whenever the fence span will be more than 200 feet long. A corner post will need a brace assembly for each fence line leading to it. Post depths shown in Figure 11 are minimums. Use deeper settings for sand or wet soil conditions. Figure 12 shows the proper way to secure brace wire.

When a fence is more than 650 feet between corner posts, use braced line post assemblies every 650 feet in the fence line. A braced line assembly is the same as a single span braced corner except that a second diagonal brace wire is used to take fence pull in the opposite direction.

Figure 13 (page 13) illustrates anchor and brace locations for fences. Steel corner post and brace assemblies can be used in place of wood assemblies. The steel posts should be set in concrete anchors. Corner post anchors should be 20 inches square and $3^1/_2$ feet deep. Braces are anchored in 20-square-inch blocks that are 2 feet deep.

There are some other brace assemblies that are not as strong as the **H**-brace, but will work in many cases for short pulls and in favorable soil conditions. One is commonly called a "dead man" brace (Figure 14, page 13).

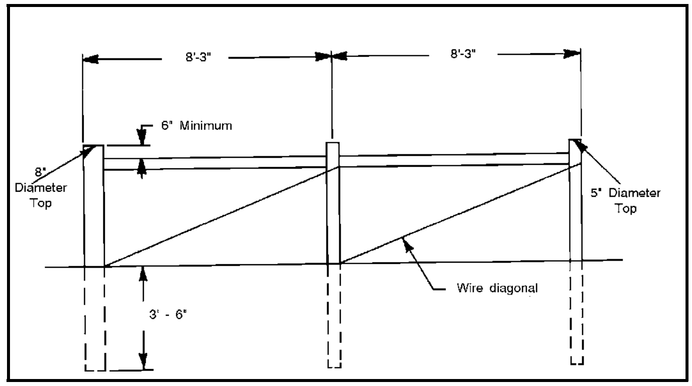

Figure 11. Double span brace post assembly. Post depths shown are considered to be minimum.

The end post should be a large (10-12") post at least 4 feet in the ground. The "dead man" is a short (4 foot) piece of post buried just under the surface perpendicular to the end post on the loaded side. This positioning supports the post such that when the post tries to lean, it must push the "dead man" through the soil sideways.

A second type of brace, called an angle brace, is shown in Figure 15 (page 13). The keys to making this brace work are (1) making sure the end post is deep in the ground (about 4 feet), (2) placing a 1 to 2 square foot rock or piece of concrete under the angle brace post, and (3) properly tensioning the tension wire. It is the tension wire that gives this brace its strength, not the angle post. If the fence starts to sag, it can usually be tightened by retensioning the tension wire.

Fence Post Setting

Steel posts are almost always hand or power driven. Wood posts are frequently driven with power driving equipment. Driving posts is faster than digging holes and tamping posts in. Driving also results in a stronger

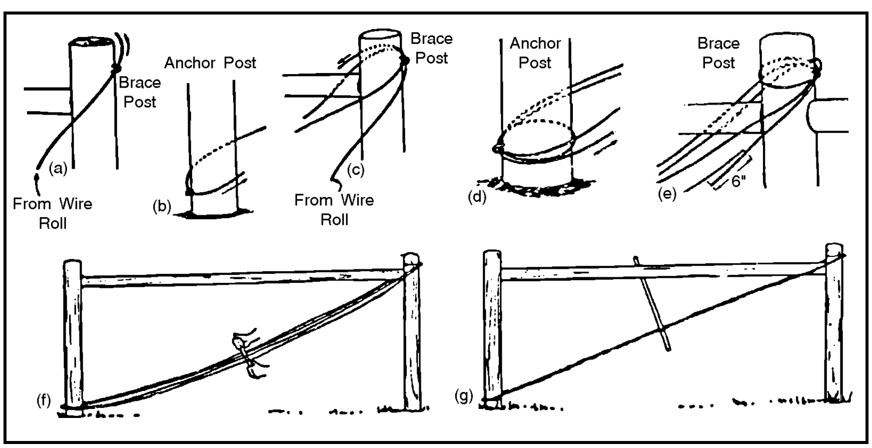

Figure 12. Correct procedure for threading the nine gauge smooth wire used as diagonal in the brace assembly.

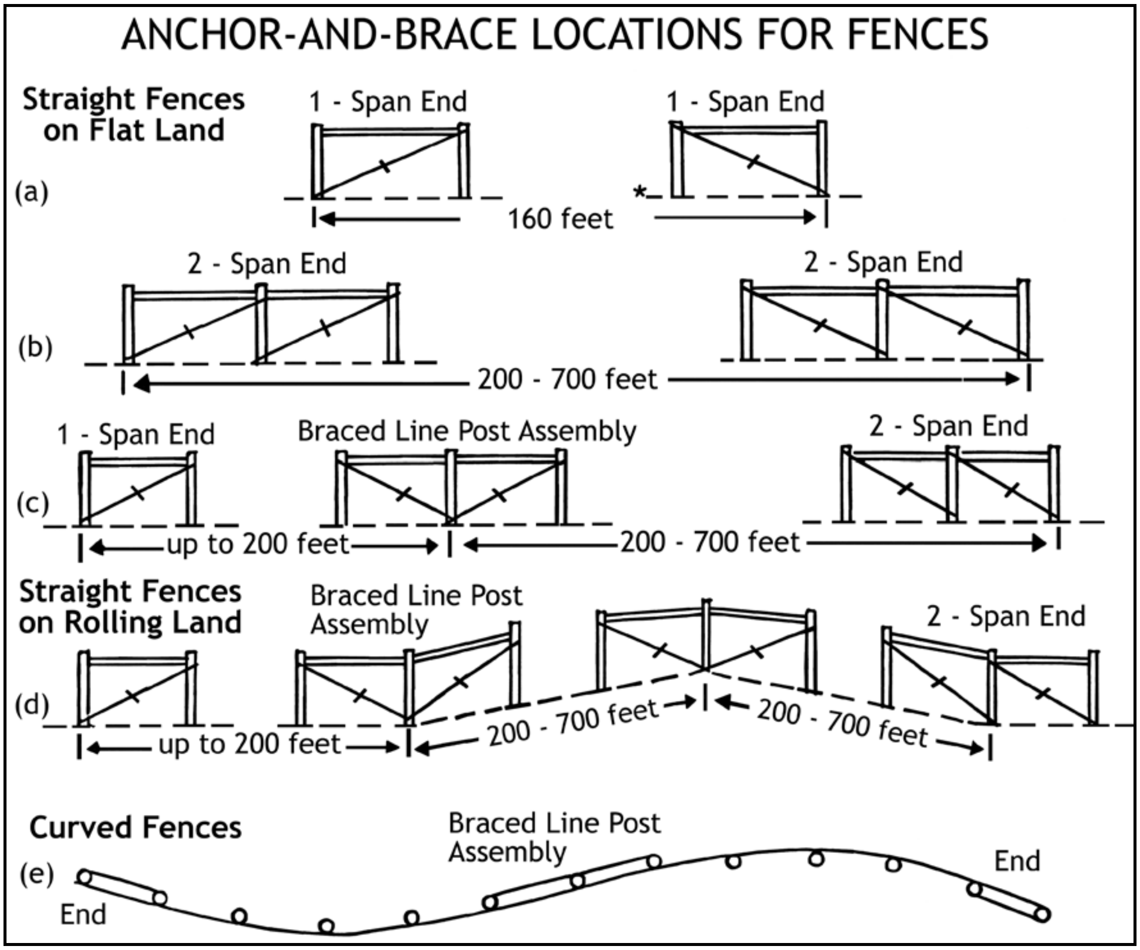

Figure 13. Types of anchor-and-brace assemblies and where to locate them. (a) For fence lengths of 160 feet or less, use single-span end construction. (b) For fence lengths of 200 to 700 feet, use double-span end construction. (c) for fences more than 700 feet long, use a brace-line-post assembly to divide the fence lengths. (d) On rolling land, fence stretching is easier if braced line-post assemblies are located at the foot and top of each hill. (e) Contour fences, more than 350 feet long, should have a braced-line-post assembly installed to keep the stretches to 350 feet or less. Install in straight section at least one post span away from a curve. Don't install on a curve; it won't hold well.

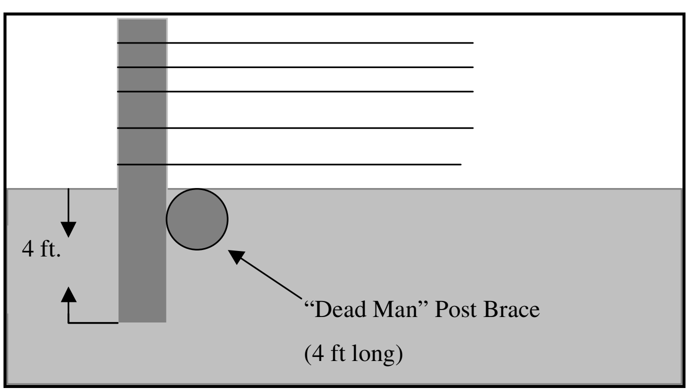

Figure 14. "Dead Man " brace.

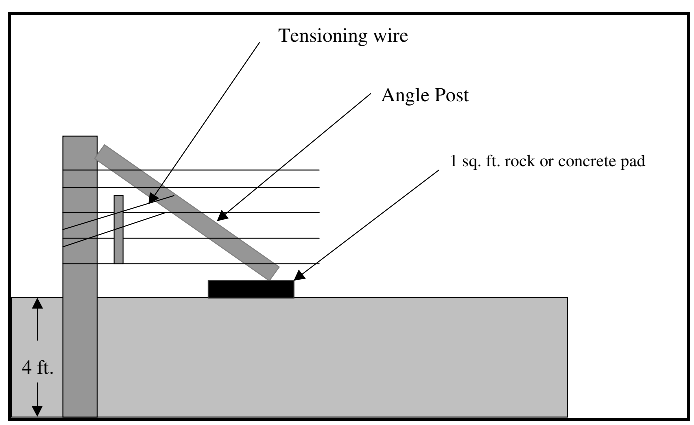

Figure 15. Angle brace.

foundation for the post. Posts should be driven with the small end down. The results may look strange (large end up), but they are much stronger and damage to the post during driving is minimized. Corner posts can be driven as well, but it is sometimes necessary and always advisable to drill a pilot hole about 3 to 4 inches smaller than the post before driving. The pilot hole reduces driving resistance and gives more control over the direction of lean of the post. (End posts should be driven at a slight angle away from the direction of pull so that they will be straight when tensioned.)

When setting posts in holes, center them before tamping. This makes tamping easier and gives the tightest possible soil-pack around the post. Wooden line posts should be set at least two feet deep, preferably deeper. In most soils, studded "**T**" posts need to be driven only until the anchor plate is beneath the surface. For uniform depth, mark the digging tool or steel post to desired depth. A gauge pole, cut to desired length, is handy for spacing posts. Space line posts about 10 to 12 feet apart for most fences. Narrow spacings are better over irregular ground and in contour fences.

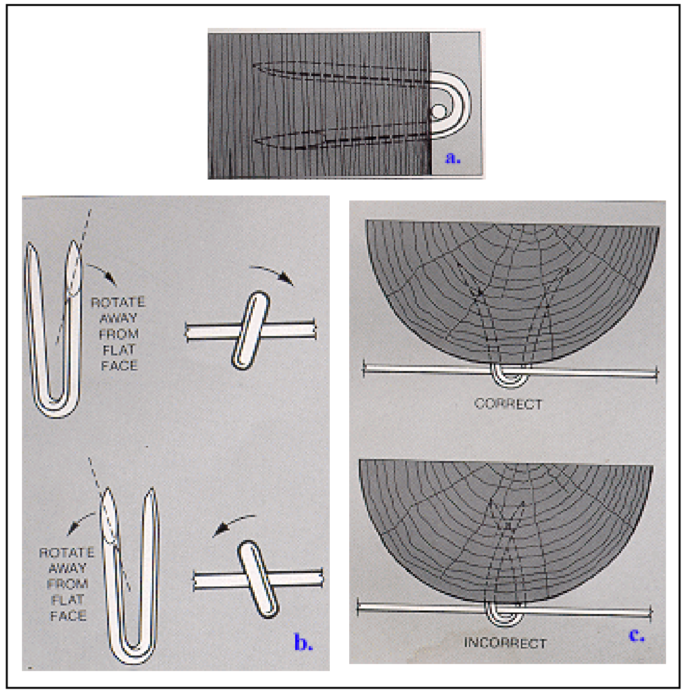

Figure 16. Proper stapling techniques.

Installing Wire on Fences

In general you will want to install and stretch wire in sections, running from one corner and/or brace post assembly to the next. Always work from the bottom up when installing wire. Install the bottom wire first, then the next highest, etc. Attach wire to the side of the post nearest livestock except where appearance is important. Use galvanized staples or the wire clips that come with steel posts to attach wire to posts. Staples should never be smaller than $1^1/_2$ inches long, preferably $1^3/_4$ or 2 inches. Do not staple the vertical or stay wires of woven wire. Drive staples so the wire is held close to the post but not tight (Figure 16a). The wire should be able to move through the staple to allow expansion and contraction of the wire. Good brace assemblies should keep the wire tight. Driving staples parallel with the grain should be avoided since that will weaken the grip of the wood on the staple. Slash cut staples should be rotated in a certain direction depending on whether the staples are right or left cut (see Figure 16b). Place the staples parallel to the grain and then rotate slightly away from the flat faces of the staple points. This will result in the desired direction of staple penetration (Figure 16c) and a staple that has 40 percent more resistance to withdrawal than staples rotated the wrong way.

Electric Fence Controllers

One of the best ways of assuring good performance of a fence controller is to provide a good grounding system. The controller grounding system should be separate (at least 30 feet away) from any other driven grounds. Failure to do this could cause stray voltage problems on the farm electrical system. The grounding system should consist of at least 24 feet (usually three 8-foot driven rods spaced 6 feet apart) of ground rod. In addition, a driven ground rod should be placed every 3000 feet (1500 feet in arid climates) of fence and attached to the grounded wires in the fence. Proper grounding will make the job of the charger easier and thus improve its performance. Lightning arresters are available and help protect the controller if the lightning strike is not too close, but will probably not prevent damage by a direct hit. Making the top wire on the fence a grounded wire sometimes helps protect the controller by shunting lightning to the ground instead of through the controller.

Gates and Cattleguards

You can buy or build gates or cattle guards. Both should be sturdily built and adequately supported. One of the most common (and aggravating) mistakes made when building fences is inadequate bracing of gates which results in gates dragging on the ground. Several plans for gates, man passages and cattle guards are available through your local county extension office.

Maintenance

A fence that is properly cared for will give long and trouble-free service. Include some of the following suggestions in your regular maintenance program:

- ❒ Repair or replace anchor post assemblies whenever they show signs of weakness.
- ❒ Refasten loose wires to posts and splice broken wires when necessary.
- ❒ Keep the fence wires properly stretched. This will be needed once or twice per year for high-tensile fences.
- ❒ Keep weeds and brush cleared from the fence line, especially on electric fences.
- ❒ Plan and follow a regular inspection routine for any needed maintenance.

References

Planning Fences, American Association of Vocational Instructional Materials, 1980.

Planning & Building Fences on the Farm, University of Tennessee Agricultural Extension Service PB 1541, 1996.

www.extension.uga.edu/publications

Circular 774 **Reviewed February 2015**

Section 10

Selecting the right watering system and sizing the water supply for your grazing system

Dr. John Worley, UGA

2015 Georgia Grazing School:
Selecting the right watering system for your grazing system

Dr. John Worley
Professor

Watering Options for Your Grazing System

2015 Georgia Grazing School

John W. Worley

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

Watering Systems

- Provide water in all locations
- Provide adequate watering space
- Provide adequate flow and pressure
- Remember safety and sanitation

Picture Courtesy of NRCS

"The Creek"

- Fencing across a creek is always a challenge
- Damage to creek banks impair water quality
- "Not enough creeks to go around" for rotational grazing systems

Mechanical Watering Systems

- Advantages
  - Put the water where you want it
  - Improve water quality (for the cows and the neighbors)

Picture Courtesy of NRCS

Mechanical Watering Systems

- Disadvantages
  - Cost (especially for multiple units)
  - Availability of power for pumping
  - Mud around waterers

Picture Courtesy of NRCS

Reduce # of Required Waterers

- Place Waterer across fence to provide access from both sides

Picture Courtesy of NRCS

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2015 Georgia Grazing School:

Selecting the right watering system for your grazing system

Dr. John Worley
Professor

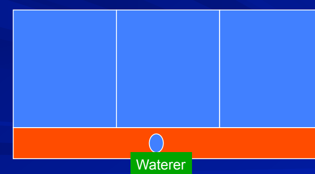
Reduce # of Required Waterers

- Make sure adequate space is available from either side
  - One bowl for each 15 cows
  - One ft of space for each 10 cows

Pictures Courtesy of NRCS

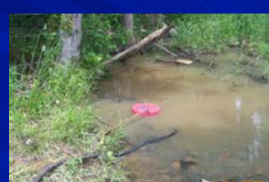

Reduce # of Required Waterers

- Place waterer in an area accessible to more than one paddock
- Could be a lane or a working pen



Power in Remote Areas

- Solar Power
  - Best for surface or shallow well
  - Provide extra storage for nights and cloudy days

Pictures Courtesy of NRCS

Power in Remote Areas

- Solar Power
  - Provide extra storage for nights and cloudy days
  - 12 gal/day x 2 to 3 days x # of cows
  - Can be in storage tank or watering trough


Pictures Courtesy of NRCS

Power in Remote Areas

- Ram Pumps
  - Another alternative where flowing water is present nearby
  - Works on the momentum of flowing water
  - See Publications in notebook

Mud Around Waterers

Picture Courtesy of NRCS

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Mud Around Waterers

- Siting
  - **High well-drained area**
- **Maintenance**
  - Check Valves regularly
- Heavy Use Areas
- NRCS FOTG
  - HUA Code 561
  - Watering Fac. Code 614
- (See Univ. of KY pub in notebook)

Picture Courtesy of NRCS

Mud Around Waterers

- Heavy Use Areas
  - Originally used to stabilize dirt roads
  - Roughly half the cost of concrete
  - Concrete "moves mud to edge of concrete"

Picture Courtesy of NRCS

Heavy Use Area

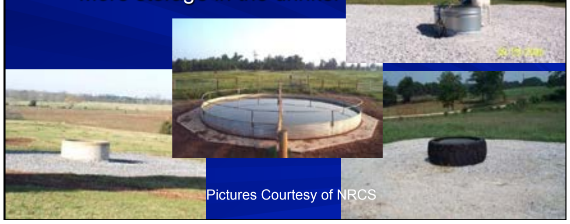
- Geotech Fabric – stabilizes foundation
- Coarse aggregate 4-6" No. 3 or 4 gravel
- Fine aggregate 2-3"
  - "crusher run"
  - "dense grade"
  - Sand
  - crushed limestone
  - fly ash? Other materials?
- Make sure edges of fabric are buried
- Pack Mechanically

Heavy Use Area

- Watering area
  - At least 15 ft from watering trough for cattle
  - 8 ft for sheep and goats
- Travel Lanes
  - 8 to 15 ft wide
  - Fence to force use
  - Crown the center of lanes for drainage
  - Avoid use by vehicles except for scraping and maintenance

Drinker Types

- Troughs (Concrete, Galvanized Steel, others)
  - More access space
  - Usually lower cost
  - More storage in the drinker



Pictures Courtesy of NRCS

Drinker Types

- Individual Drinker
  - Fresher, cleaner water
  - Some are "freeze proof"
  - Less storage in the drinker

Pictures Courtesy of NRCS

2015 Georgia Grazing School:

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Control Valve

- Can be under water for freeze protection
- Must be siphon proof
- Must have min. pressure to operate properly



Pictures Courtesy of NRCS

Sizing the supply system

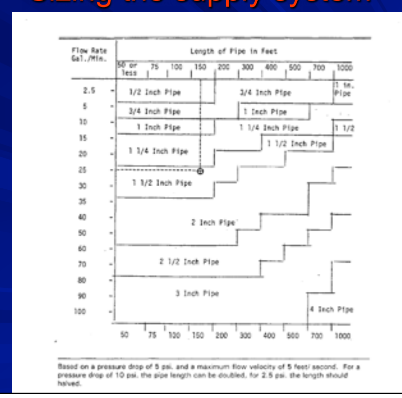
- Need to pump daily need in 4 hours
- 18 gal/day/cow x 100 cows = 1800 gpd
- 1800/4 hrs = 450gph = 7.5 gpm @ operating head (resistance)
- Can reduce pumping rate by increasing storage (especially useful in solar systems)

Picture Courtesy of NRCS

Sizing the supply system

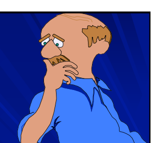
- Pump – operate efficiently at flow rate and pressure expected
- Pressure Head
  - Elevation Change
    - Water level in well or pond
    - Elevation of drinker or top of storage tank
    - (10 ft = approx. 4.3 psi)
  - Speed of water in pipe
  - Length of pipe
- Limit friction drop to 5 psi
  - Most home systems operate at approx. 40 psi
  - Drinkers need at least 5-10 psi

Sizing the supply system



Sanitation

- Anti-siphoning valves should always be used on livestock waterers to prevent contaminated water from returning to well when pressure is lost.
- Drinkers should be easy to drain and clean



QUESTIONS ?

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Watering Options for Grazing Systems

Dr. John W Worley

One of the challenges of designing a grazing system is providing an abundant supply of clean drinking water to cattle that are located in multiple areas (paddocks or pastures.) The use of surface water (creeks) has multiple drawbacks. Fencing across a creek is always a challenge because of storm flows damaging the fence, and the fence preventing debris from flowing down the creek. Also, cattle tend to degrade the banks of the creek increasing sediment loading and decreasing water quality.

Mechanical watering systems have many advantages, but also present some challenges of their own. 1. They cost money to install and operate. 2. Many times, there is no electricity available for pumping at remote locations. 3. Multiple pastures or paddocks mean multiple waterers that are not fully utilized when the cows are in a different paddock. 4. Cows tend to congregate around waterers, the waterers tend often leak, and cows spill water, all of which leads to a muddy area around many waterers. Some of these challenges can be addressed and costs minimized by proper planning. This document will describe some of the strategies that have been used to overcome these potential obstacles.

Reducing the number of waterers required

Placing a waterer through a fence enables one waterer to be used from two paddocks. (See Figure 1.)

Figure 1: Waterer between two paddocks.

Care must be exercised to provide enough watering space for cows from each side of the fence, however. For waterers where only one cow can drink at a time, it is recommended to have at least **one cup or bowl for each 15 cows**. (Beef Housing and Equipment Handbook) For a drinking tank, it is recommended to provide **one foot** of accessible tank perimeter **per 10 cows**. That means one ft/10 head on each side of the fence for a split installation. Cows tend to drink as a group, so adequate access to the waterers is important.

Another option for reducing the number of waterers required is to place a waterer in a lane or a common area that can be shared by a number of paddocks. A waterer can also be placed in a working pen that can be accessed from a number of paddocks. This not only provides a common watering site, but accustoms the cows to going into the working pen. Care must be exercised to not allow the working pens to become too muddy however.

Availability of Power

If electricity is unavailable at a remote site, water can be pumped by solar power or a ram pump. (For more information on ram pumps, see
http://www.caes.uga.edu/departments/bae/extension/pubs/documents/rampump3.pdf
and
http://www.caes.uga.edu/departments/bae/extension/pubs/documents/homeram.pdf
Solar energy can be used to pump water, and in some cases, may be the most economical choice.

In general, solar pumps are most efficient when pumping from surface water or shallow ground water (less than 50 ft deep.) Pumping from deep ground water requires more energy and considerably more investment in solar panels. Due to the intermittent availability of solar power (nights and cloudy days) a solar powered watering system requires considerable reserve storage, either in the waterer itself or in a tank that feeds the waterers. Another alternative is to have backup batteries that store solar power for use during those times when solar is not available. The batteries and required sensing and switching mechanism for this system are usually more expensive than providing extra water storage. I would recommend 2 to 3 days of storage capacity. A typical 1,000 lb cow would drink up to 18 gallons of water per day in hot weather, but on rainy or cloudy days, would drink considerably less, so I would use a figure of 12 gallons/head/day. This reserve storage could be in the drinkers, the tank, or a combination of the two.

Stream crossings are still an option for livestock watering, although they have the drawbacks mentioned above, and precautions should be used.

Mud around waterers

"Heavy Use Areas" can be installed around waterers to minimize mud problems. An excellent publication on these surfaces is available from the University of Kentucky at: (http://www.ca.uky.edu/agc/pubs/aen/aen79/aen79.pdf) The idea originated in the road construction industry for stabilizing dirt roads. The principle of heavy use area construction is to stabilize the soil underneath the top layer so that it does not move, settle, and form mud holes.

Figure 2: Prefabricated Concrete Watering Tank on Heavy Use Area

Basically by putting down a layer of geotech fabric, the rock placed on top of the fabric cannot move from side to side, and thus depressions are prevented from forming. Typically this type of construction costs about ½ that of a concrete pad. When choosing the site for waterers, it is wise to choose a site that is high and well drained. In addition, regular checking and maintenance of valves and pipes is important in preventing excess mud as well as wasted water.

Choice of Drinker Type

Individual drinkers like the one shown in Figure 1 have the advantage that they help keep the water cooler and cleaner in hot weather and that they are virtually freeze proof in cold weather. Tank waterers (Figure 2) which can be made of galvanized steel, plastic, or concrete; have the advantage of greater accessibility to a number of animals and more water storage in the waterer itself. Individual waterers must have water provided to them at all times because the water would be quickly depleted if the supply were cut off. That is especially a consideration when solar pumps are used to supply the waterers.

Note that the concrete waterer in Figure 2 has the control valve mounted in the bottom middle of the tank. That protects it from both mechanical damage (cows rubbing against it or running into it) and freezing and eliminates many of the maintenance problems associated with top mounted valves.

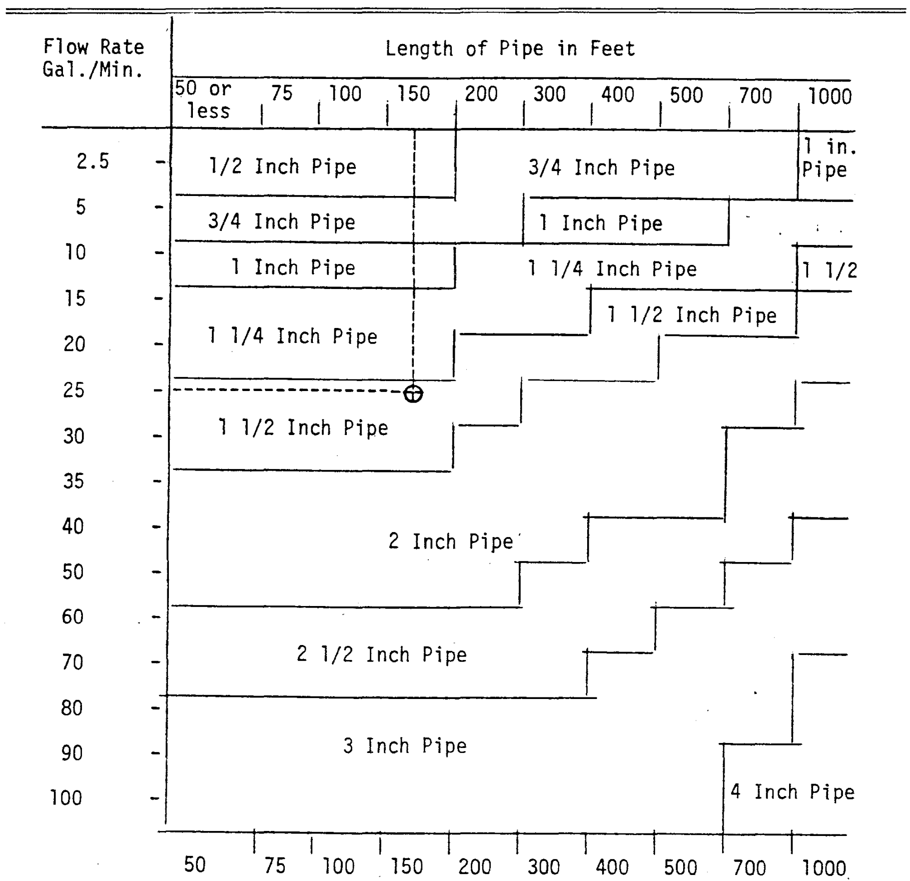
Sizing the Supply System

Whether using solar or conventional electric power to pump water, it is important to size the pump and pipe to deliver the maximum needed flow of water without excessive friction loss in the pipe. Three things potentially contribute to pressure drop in water pipes, the length of the pipe, the flow rate of water, and the elevation change from one end to the other. If we try to force too much water through a small pipe, friction loss will reduce the pressure at the waterer reducing the flow rate and sometimes causing the valve not to operate properly. The supply system should be able to pump water for a day in about 4 hours since cows tend to drink as a herd. With a maximum rate of 18 gal/day, 100 cows would need 1800 gallons of water. To pump that in 4 hours, the flow rate would be 7.5 gal/min.

Figure 3 may be helpful in sizing the pipe needed to supply the waterer(s). In the above example, if the flow rate is 10 gal/min, and the watering site is 300 ft from the pump, a 1 ¼ inch pvc pipe would be needed to limit the pressure drop to 5 psi. If sufficient pressure exists to allow 10 psi pressure drop, a 1 inch pipe would suffice. Generally, most home water systems operate around 40 psi, and the drinker valve should have at least 10 psi of pressure at all times. Also, remember that if you are pumping up hill, you will lose pressure as well. For every 10 ft of elevation, the pressure drops (or increases if going down hill) by approximately 4.3 psi. The pump needs to be sized to deliver the needed flow rate at the total pressure it will be working against, including elevation from the water level (bottom of the well or surface of a pond), friction loss in the pipe, and the operating pressure in the system.

Sanitation

Waterer control valves should always be fitted with anti-siphoning devices. This prevents contaminated water from being sucked from the trough down into the well or water source when the pump shuts off.



Based on a pressure drop of 5 psi. and a maximum flow velocity of 5 feet/ second. For a pressure drop of 10 psi. the pipe length can be doubled, for 2.5 psi. the length should halved.

TO USE: Move downward in pipe length column and horizontally on flow rate, read pipe size in area where lines intersect.
EXAMPLE: Length of 150 feet and flow rate of 25 gal./min. requires 1-1/2 inch pipe.

Figure 3: Recommended Size for PVC or Plastic Pipe

References:

Beef Housing and Equipment Handbook, Fourth Edition. Publication MWPS-6, Midwest Plan Service, Ames, Iowa (www.mwps.org)

HYDRAULIC RAM MADE FROM STANDARD PLUMBING PARTS

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

There are a number of companies that manufacture hydraulic rams. While manufactured rams come pre-assembled and offer the highest degree of convenience and efficiency, they can be quite expensive. Fortunately, inexpensive ram pumps can be assembled from pipe fittings that are commonly available at most hardware and farm stores.

Assembly is fairly quick and easy. All that is needed is a pair of pipe wrenches, Teflon tape or other thread sealant, PVC cleaning solvent and PVC cement. Table 1. lists all of the parts shown in Figure 1. When assembling threaded fittings liberally apply thread sealant, or use 3-4 turns of Teflon tape and tighten all fittings securely to prevent leaks.

All ram pump fittings except the delivery pipe should be made of either of galvinized steel, brass, or schedule 40 or higher PVC. The delivery pipe can be made of any material provided it can withstand the pressure leading to the delivery tank. Make sure that the swing check and the spring loaded check valves are installed as shown in Figure 1. The flow direction arrow on the body of the swing check valve must point down. The valve below the pressure guage should be kept closed except while making readings in order to protect the guage from water hammers.

A bike, weelbarrow or scooter inner tube serves as an air bladder for the pressure tank. Insert the inner tube into the pressure tank and fill it slightly with air (less than 10 psi). Some inner tubes may need to be folded in order to fit them inside the pressure tank casing. The sealed volume of air contained in the tube prevents either water-logged or air-logged conditions in the pressure tank.

There are several nonessential, but useful parts included in this ram assembly. The ball valves, union fittings, and guage assembly are all optional. The ball valves on both the drive and delivery pipes are helpful for starting the ram and controlling its flow. The union fittings, also on both the drive and delivery pipes, are helpful for removing the ram for maintenance and/or repairs. The gauge assembly is useful for making

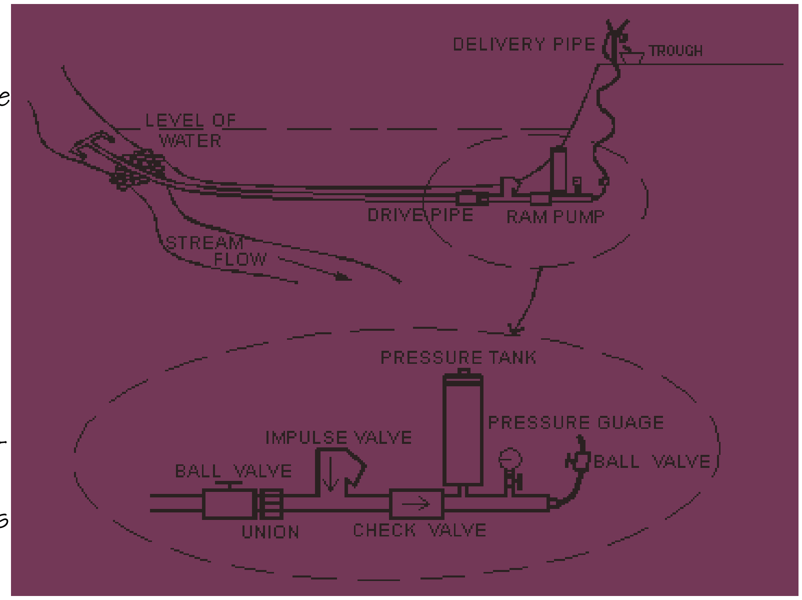


Figure 1. Hydraulic Ram Assembly

pressure readings, especially while starting the ram. Any or all of these fittings can be left out of the ram assembly without affecting pump performance. However, the absence of these parts will make it more difficult to start and maintain the ram.

With the exception of the pressure tank's air bladder, all air trapped in the drive pipe, ram assembly, and delivery pipe must be displaced with water before these rams will pump properly. A few minutes of manual operation, and several re-starts, may be required to displace the trapped air

Pumping to Low Elevations

If the discharge elevation (delivery head) is less than 30 feet, it may be necessary to install either a ball valve or an adjustable pressure relief valve on the discharge (watering trough) end of the delivery pipe. Either of these valves can be used to regulate the water flow through the delivery pipe, which in turn regulates the back pressure on the ram assembly. A back pressure of up to 10 - 12 psi (as read on the pressure gauge) may be required for proper ram performance.

Table 1. Parts List for Hydraulic Rams Made up of Standard Plumbing Parts

Metal Ram Pump

1. Screened water supply
2. 1¼" drive pipe
2. 1¼" ball valve
3. 1¼" x 2" nipple
4. 1¼" union
5. 1¼" x 2" nipple
6. 1¼" tee
7. 1¼" close nipple
8. 1¼" brass swing check valve
9. 1¼" close nipple
10. 1¼" spring loaded check valve
11. 1¼" x 2" nipple
12. 1¼" tee
13. 1¼" x 2" nipple
14. 4" x 1¼" reducing coupling
15. 4" threaded pipe 36" long
16. Inner tube (slightly inflated)
17. 4" pipe cap
18. 1¼"close nipple
19. 1¼" x ¾" reducing coupling
20. ¾" x 2" nipple
21. ¾" tee
22. ¾" x ¼" bushing
23. ¼" x 2" nipple
24. ¼" ball valve
25. Pressure gauge
26. ¾" x 2" nipple
27. ¾" union
28. ¾" x 2" nipple
29. ¾" ball valve
30. ¾" delivery pipe

PVC Ram Pump

1. Screened water supply
2. 1¼" drive pipe
3. 1¼" ball valve
4. 1¼"union
5. 1¼" slip x male adaptor
6. 1¼" threaded tee
7. 1¼" close nipple
8. 1¼" brass swing check valve
9. 1¼" close nipple
10. 1¼" spring loaded check valve
11. 1¼" slip x male adaptor
12. 1¼" slip x slip female tee
13. 1¼" male adaptor
14. 4" x 1¼" reducing coupling
15. 4" pipe 36" long
16. Inner tube
17. 4" pipe cap
18. 1¼" x ¾" reducing coupling
19. ¾" tee
20. ¾" x ¼" slip x female bushing
21. ¼" x 2" nipple
22. ¼" threaded ball valve
23. Pressure gauge
24. ¾" union
25. ¾" ball valve
26. ¾" delivery pipe

Adjusting the Ram

These rams can be adjusted in one of two ways. The swing check valve may be adjusted by first rotating it so that its pivot is in line with the drive pipe and then twisting the valve and tee away from the vertical by as much as 30 degrees. This allows the swinging flap to partially close, which shortens the stroke period. The other way to adjust these rams is to alter the length of the drive pipe. Lengthening the drive pipe will increase the stroke period. Conversely, shortening the drive pipe will shorten the stroke period.

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Hydraulic Rams For Off-Stream Livestock Watering

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The benefits of off-stream watering are numerous. Watering livestock away from the water source can improve water quality, animal health, animal productivity, pasture utilization and manure distribution. As both pasture management techniques and pressure to protect the environment intensify, producers are being forced to look for new and better ways to water their livestock.

Recent cattle grazing studies show that off-stream watering significantly reduces stream bank erosion and lowers the amount of nutrients, sediment, and fecal bacteria entering the water source. In fact, many scientists feel that off-stream watering is a cost effective alternative to stream bank fencing.

For maximum production and pasture utilization, animals need plenty of water. By providing animals with easy access to water, off-stream watering helps insure that water is not a limiting factor to animal weight gains. These additional water sources also open up pasture management options, like rotational grazing, which can increase pasture carrying capacity and/or enhance forage utilization.

From the standpoint of animal health, some diseases are spread by animals coming into contact with urine and/or feces discharged from infected animals. Also, studies have shown that the incidence of foot rot and mastitis are greater among cattle herds that are allowed to enter wet, muddy areas. Off-stream watering helps solve these problems, by allowing

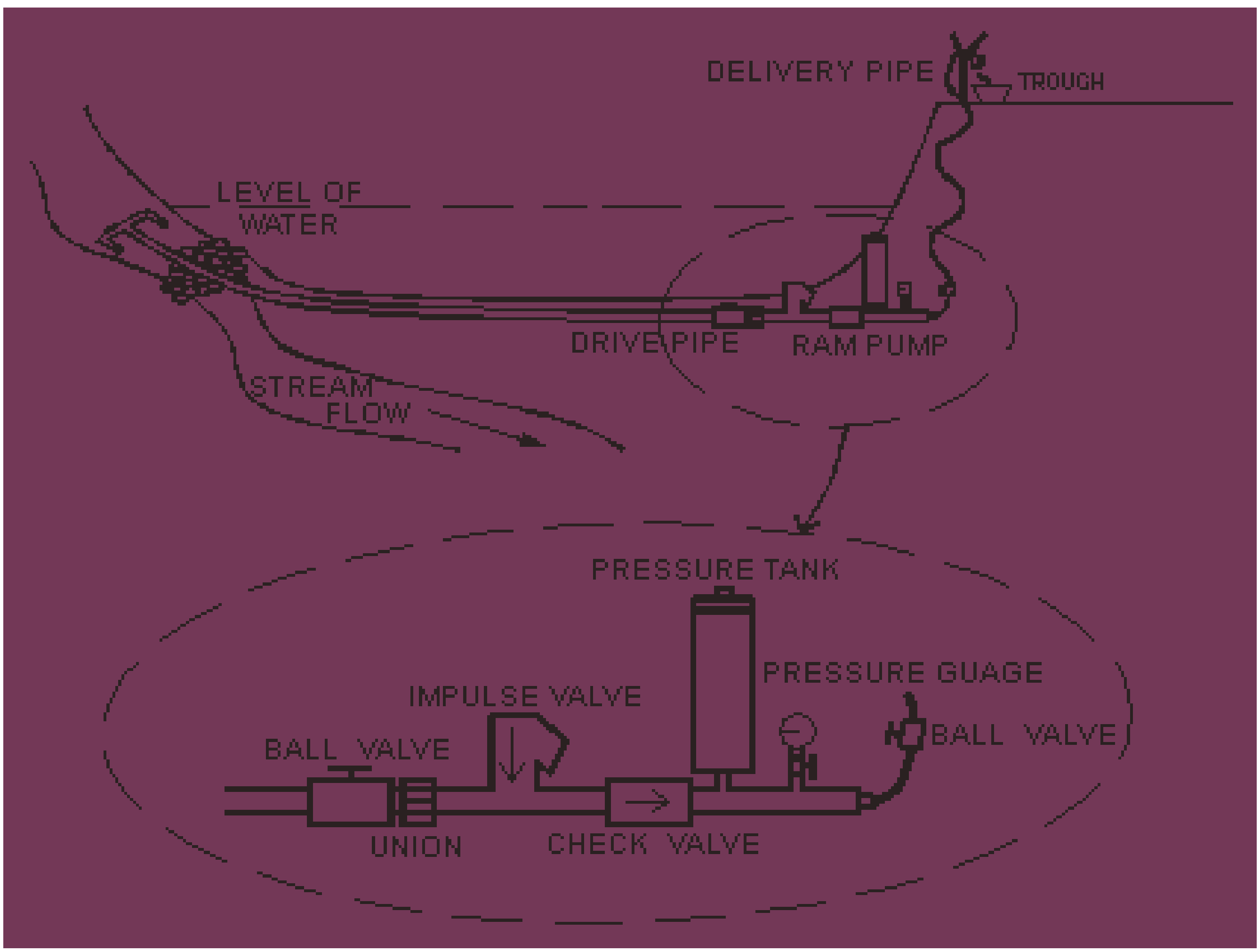


Figure 1. Hydraulic Ram Installation

producers to remove cattle from many of the areas that harbor disease organisms.

Were it not for the initial cost of setting up watering systems, escalating energy costs, and limited access to electricity, off-stream watering would probably be far more widespread than it is today. The hydraulic ram pump overcomes many of these obstacles. It is a motorless, low flow rate pump that uses flowing water as an energy source to operate the pump. Hydraulic rams are ideal for use where small quantities of water are required, such as for livestock watering.

PRINCIPLE OF OPERATION

A hydraulic ram uses the kinetic energy of falling water to pump water. The mechanics of the hydraulic ram are pictured (Figure 1) and described below. Water from a spring, creek, artesian well, or stream flows down the drive pipe and out through the impulse valve until its velocity is sufficient to close the valve. The sudden closing of the impulse valve forces a moving column of water to pass through a check valve and into the pressure tank. The momentum of the flowing water compresses the tank's air-bladder until the pressure of the trapped air is so great that the bladder begins to rebound, pushing water back down and out of the pressure tank. Water flowing out of the pressure tank forces the one way check valve to close which diverts all water flow through the delivery pipe to its destination. The closing of the check valve also creates a slight vacuum, which permits the impulse valve to reopen, and the pumping cycle begins again.

Table 1. Daily Water Requirements

Livestock (drinking)	gallons/animal/day
Milking cow	25-45
Dry cow	12-30
Calf	6-12
Beef animal	1.5/100 lbs. weight
Hog	4
Horse	10-15
Sheep	2
100 Chickens	4-5/100 birds
100 Turkeys	18/100 birds

PUMP SELECTION

A ram's size must be selected to produce a required flow rate while generating enough pressure to lift the water to the desired elevation. The fall from the water supply source to the ram must be at least 2 feet and the minimum flow of water needed is roughly 1-2 gallons per minute (gpm). The relationship between pump output and water source can be expressed as:

$$Q = \frac{V \times F}{E} \times 0.60 \text{, where:}$$

Q = pumping flow rate (gpm)
F = vertical fall of the drive pipe (ft)
V = available flow through drive pipe (gpm)
E = vertical distance or eleveation that the water will be raised (ft)
0.60 = efficiency of a ram installation
** Each of these parameters is further defined below**

Note: The length of the delivery pipe is not considered in this equation because friction losses are normally small due to low flow rates. However, if the discharge pipe is extremely long or if the flow rate is high, friction losses in the delivery pipe will affect pump flow rates.

Pumping Flow Rate (Q)

Before installing a ram pump, you need to have an estimate of your water requirements. Use Table 1 to determine water requirements. Multiply the number of animals that the pump will serve by the daily water requirement for that animal in order to determine a total daily water requirement in gallons. Next, divide that number by 1440 to determine desired pumping flow rate (Q) in gallons per minute.

Measuring Available Water Flow (V)

If the flow of water from the source is small it can be measured by timing how long it takes to fill a bucket of known capacity with water from the supply source. However, for larger flows it may be necessary to use a weir or flow meter to measure available water. This measurement should be taken during the driest season of the year. Be sure that the flow (V) is calculated in gallons per minute.

Vertical Fall (F) & Lift Elevation (E)

The fall from the supply source to the ram can be determined using a leveling instrument or by using a carpenters level securely fastened to the top of a pole (*See Figure 2*). Starting at the proposed ram sight, place the pole-level on the ground and observe where the line of sight hits. Continue in this manner until you reach the level of the source. Add the measurements together to obtain the vertical fall of the water (F) in feet.

The same procedure can be used to determine lift elevation (E). In this case, measure from the proposed ram sight up to the point of discharge.

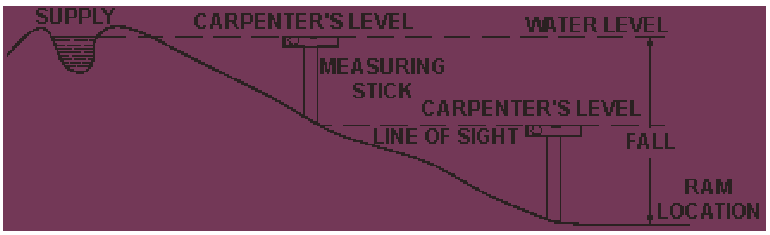


Figure 2. Determining Vertical Fall (F) and Lift Elevation (E) Using a Carpenter's Level

INSTALLATION & CONFIGURATION

Matching Rams to Available Water Flow

Hydraulic rams come in drive pipe sizes from 3/4" to 8" diameters, delivery pipe sizes from ½" to 4" inch diameters, and drive water requirements of $^{3}/_{4}$ to 400 gpm. Table 2 can be used as a guide in matching new pump size to available water flow.

Foundation

The ram should be bolted or securely fastened to a very stable and level foundation.

Source

The water source should be screened to prevent trash from entering the drive pipe and clogging the ram.

Drive Pipe

The drive pipe is probably the most important part of a ram installation. It carries the water from the source to the ram and contains the pressure surge.

Table 2. Hydraulic Ram Specifications

Drive Pipe Diameter (inches)	Delivery Pipe Diameter (inches)	Min. Intake (gpm)	Max. Intake (gpm)
¾	½	¾	2
1	½	1½	6
1¼	½	2	10
1½	¾	2½	15
2	1	3	33
2½	1¼	12	45
3	1½	20	75
4	2	30	150
6	3	75	400
8	4	400	800

- ✦ Should be galvanized steel or at least schedule 40 PVC
- ✦ Should be as straight as possible. Minimize bends and avoid elbows.
- ✦ Should be at least one size larger than delivery pipe
- ✦ Should be watertight and rigidly anchored
- ✦ The upper end of the drive pipe should be installed at least one foot under water in order to avoid whirlpools from forming and sucking air into the drive pipe

Determining Drive Pipe Length

Recommendations for drive pipe length are based on empirical data from systematic experiments. Calvert (1958) found that the output and stability of a ram installation depend on the ratio of drive pipe length (L) to diameter (D). He found that hydraulic rams will work satisfactorily if L/D is between 150 and 1000.

For example, to determine the minimum length of a drive pipe that has a 1½ inch diameter: L/D = 150, so D x 150 = L, or 1½" x 150 = 225" (18.75'). To calculate the maximum length for this same drive pipe: L/D = 1000, so D x 1000 = L, or 1½" x 1000 = 1500" (125').

When drive pipe length falls outside of this range both performance and stability are impaired. Increasing the drive pipe length within this range produces no change in waste or output, but it does lower the beat frequency (fewer beats per minute.) Practical aspects such as valve wear, fatigue of pipe fittings, and the amount of noise generated all favor a low beat frequency, and hence a longer drive pipe than the minimum necessary for good performance.

Supply Pipe and Stand Pipe

If you have to go downstream for a great distance in order to obtain adequate vertical fall, a stand pipe and a supply pipe will need to be installed between the water source and the drive pipe with a tee joint *(see Figure 3).* The supply pipe and stand pipe will not be exposed to as much stress as the drive pipe. Therefore, the strength of the materials used in their construction is not as critical. It is not imperative that these pipes run on a straight incline. However, it is essential that they be sized to carry more water than the ram can use, so that air is not sucked into the drive pipe.

Supply Pipe

- ✦ Can be made from any material that will stand up to the pressure exerted by the water source
- ✦ Must be at least one size larger than the drive pipe
- ✦ Should run on a straight incline where possible
- ✦ The top of the supply pipe should be installed with a screen that is at least one foot under water

Stand Pipe

- ✦ Can be made from any material that will stand up to the pressure exerted by the water source
- ✦ Must be at least two sizes larger than the supply pipe
- ✦ The top of the stand pipe should be at least a few inches above the level of the water at the source of supply

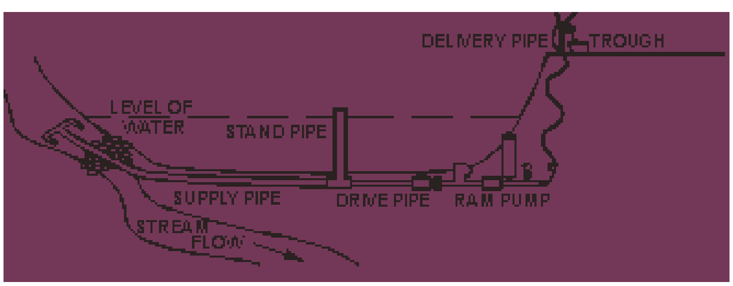


Figure 3. Hydraulic Ram With a Distant Supply

Delivery Pipe

- ✦ Can be made from any material that will stand up to the pressure of the water leading to the watering trough.
- ✦ Avoid right angled elbows wherever possible.
- ✦ To avoid excessive pressure losses due to friction, make sure that the diameter of the delivery pipe is large enough so that the velocity of the water running through it does not exceed 5 feet per second.

$$\text{Velocity} = \frac{Q}{2.45 \times D^2} \quad \text{where:}$$

Q = pumping flow rate (gpm)
D = inside diameter of delivery pipe (in)

Drain Tile

The total amount of vertical fall can often be greatly increased by sinking a ram pump deep into the ground and extending drainage tile to divert unused water. A frost pit or well casing can be used to bury a ram, but a drain tile is essential to carry off the waste water.

Installation of Two or More Rams

Rams are often installed in batteries or groups if a single pump does not meet the water requirement, or if available flow in the water source varies during the year. If two or more rams are installed alongside each other, each ram must have its own drive pipe, but all of them can pump into one common delivery pipe of sufficient size to carry the water (*see Figure 4*).

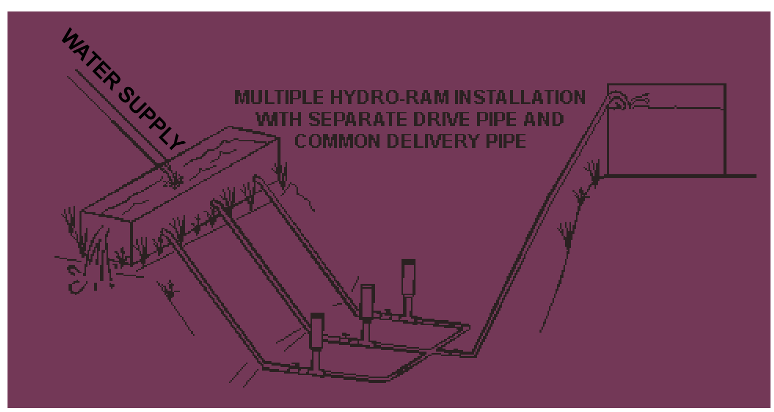
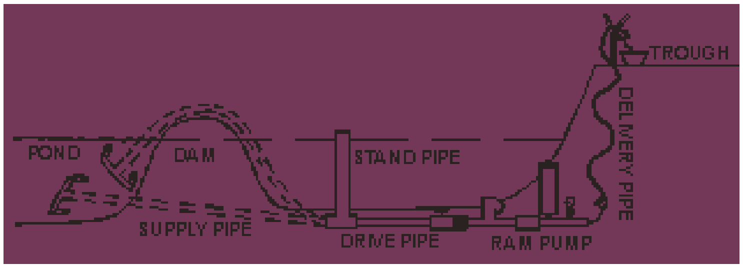


Figure 4. Installation of Hydraulic Rams in a Battery

Installation of a Ram Behind a Dam

Water from lakes, ponds and springs can be pumped by placing a ram on the backside of a dam. The water for the ram's operation can either be piped directly through the dam, or it can be siphoned over the dam. Because the pipe in a siphon system is bent, it should



be treated like a supply pipe. Therefore, a stand pipe should be installed between the siphon and the drive pipe with a tee joint (*see Figure 5*).

Figure 5. Installation of a Ram behind a Dam

STARTING A RAM PUMP

- ✦ If there is a valve between the ram and the drive pipe open it
- ✦ If there is a valve between the ram and the delivery pipe it should be closed
- ✦ Push down on the impulse valve for two seconds and release. Repeat this step until the ram begins to work automatically
- ✦ When the pressure in the storage tank reaches 10 - 20 psi, the valve between the ram and the delivery pipe should be opened slowly. A gauge installed between the pressure tank and the ball valve on the delivery pipe is useful for making these pressure readings *(see Figure 1*).

HYDRAULIC RAM SIZING DATA SHEET

The following data sheet can either be used to help you correctly size a ram pump yourself, or you can fill it out and send it to a manufacturer, so that they will have the information needed to size it for you.

Site Characteristics:
1. Available supply of water (gpm)

____

2. Vertical Fall (ft)

____

(Measure the amount of vertical fall in feet from the water level of the source supply down to the level of the foundation on which the ram will rest.)

3. Distance from source of supply to ram (ft)

____

4. Vertical distance or elevation that water will be raised (ft)

____

5. Distance from the ram to the watering trough (ft)

____

6. Total daily water requirement (gallons)

____

A PARTIAL LIST OF RAM MANUFACTURERS

B & L Associated Industries
Rt. 1, Box 118-B
Rusk TX 75785
903-743-5555

Folk Water Powered Ram Pumps, Inc.
2770 White Court, N.E.
Conyers GA 30207
770-922-4918

Rife Hydraulic Engineering Mfg. Co.
P.O. Box 367
Wilkes-Barre PA 18703
1-800-227-8511
The Ram Company
247 Llama Lane
Lowesville VA 22967
1-800-227-8511

Mention of these companies does not constitute any endorsement by The University of Georgia nor does it imply any exclusion of other companies that provide similar goods or services.

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Section 11

Economics of better grazing management

Dr. Tommie Shepherd, UGA

ROTATIONAL GRAZING: WILL IT PAY?

The beef industry is important to the agricultural economy of Mississippi. According to the National Agricultural Statistics Service[1], the value of cattle and calf production in Mississippi totaled more than $218 million in 2000, placing cattle fifth in terms of value of sales for Mississippi agricultural and forestry products. This represents the production from 24,000 beef operations managing a total of about 1.1 million cattle.

Cattle production takes place in virtually every part of the state. Beef production is probably more widespread than production of any other commodity. According to the Mississippi Agricultural Statistics Service, cash receipts from cattle and calf sales in 2000 exceeded $1 million dollars in 66 of the state's 82 counties. Because beef production is so important to our state, efforts to improve profits of beef operations have tremendous potential to impact our agricultural economy.

A closer look at cost and return data from beef operations suggests that improving the productivity and use of forages provides a real opportunity to increase net returns for beef producers. One of the best ways to reduce feed costs is to provide more of the herd's nutritional requirements through grazing standing forage. Data from the Iowa State Beef Cow Business Record program illustrates this point very clearly.[2] According to this program's production records from 1995 through 2000, the most profitable 25 percent of producers fed 880 pounds less harvested feed per cow than did the least profitable 25 percent of producers (3,509 pounds/cow compared to 4,388 pounds/cow). Differences in feed costs directly translate into significant differences in the bottom line: the most profitable producers realized an average return to capital, labor, and management of $127/cow, whereas the least profitable producers realized an average return of -$144/cow. Given a climate that permits a much longer grazing season than in Iowa, Mississippi producers should be able to reduce harvested feed needs well below the levels in this example.

Producers who want to change their forage management systems to make their livestock operations more productive are faced with two questions: how do I get more out of my forages, and how much will it pay to do so? The answer to the first question is more-or-less straightforward. The management practices that increase the productivity of pasture-based livestock systems are well known and have been promoted by agronomists and animal scientists for years. Things like fertilizing according to soil test results and controlling access to forages through some type of pasture rotation have been shown to increase the productivity of pasture-based livestock production systems in countless university demonstrations as well as on many working farms and ranches.

The second question – how to make improved forage production systems pay – is much more difficult to answer. It is not enough simply to produce more forage. That forage must be fully used in producing livestock to be of value. Implementing an improved forage production system and making the fullest use of the available forage will involve significant changes in management from traditional continuous grazing of perennial pastures. It may also involve significant capital investment. These two factors – the need for more intensive management and for an increase in capital investment – represent significant barriers to adopting improved grazing systems; however, improved grazing systems often represent a great opportunity for producers to enhance the long-term sustainability of their livestock operations.

If you are considering adopting improved pasture systems, you should note several things. First, recognize that successfully operating improved grazing systems requires a greater commitment to management than traditional continuous grazing systems. Timely pasture rotation and routine pasture maintenance require a level of management many producers (such as part-time producers with significant off-farm commitments of their time) may find burdensome. In addition to the obvious management obligations, rotational grazing systems can give rise to herd health and nutrition management issues that can be different from those of continuous grazing systems. Increasing beef production per acre in a forage-based production system is generally possible through increasing forage production, improving the efficiency of use, and/or managing stocking rates more closely. However, that does not guarantee increased profits. Without the producer's commitment to acquire new skills and make significant changes, intensive grazing systems are unlikely to be successful.

The second fact to point out is that implementing intensively managed grazing systems will involve additional costs. Improving pastures, putting up fences, and installing watering systems cost money. Recovering these costs will require an offsetting increase in revenue — for example, from increased beef production and/or the sale of extra hay. In spite of these considerations, though, moving to more intensively-managed grazing systems can increase profits and enhance the sustainability of livestock operations.

INTENSIVE GRAZING FOR COW/CALF PRODUCERS

In thinking about shifting from a continuous to a more management-intensive grazing system, you should first consider whether or not the long run profitability of the farm will be improved. To do this, a partial budget can be a very useful tool. Basically, a partial budget is made up of four components; two identify changes in the operation that will increase profits, and two identify changes in the operation that will decrease profits. Interpreting the results of a partial budget is very simple: if increased profits exceed decreased profits, then the change is a good one.

1) Changes that Increase Revenue2) Changes that Decrease Revenue
\+ 3) Changes that Reduce Costs+ 4) Changes that Increase Costs

Increased Profits Decreased Profits

The difficulty in applying a partial budget to a particular problem is accounting for all cost and return changes that will result. Each profit-changing item must be included to determine whether or not the change to more intensive grazing will be profitable.

Very often, the reason for moving to intensive grazing is to increase revenues (item 1) from the livestock operation. These increased returns will result from selling heavier weights, stocking more head on the same ground, or both.

Cost savings (item 3) may not be an obvious area, but if improved nutrient management leads to reduced fertilizer needs or if pasture clipping or forage harvesting are reduced, you should include these costs. Additionally, costs associated with feeding hay may be reduced, since more forage is harvested by grazing rather than mechanically.

Generally, we would not expect to see decreased revenues (item 2). However, if the plan were to reduce the size of the herd and graze fewer acres, then there might be an entry in the decreased revenue section.

Increased costs (item 4) are often the most obvious items to include in a partial budget. Pasture renovation costs, fencing costs, and water system upgrades are readily identified costs associated with increased rotational grazing. Less obvious, but no less important, are management and labor costs and other costs associated with producing more pounds of meat. Certainly, if rotational grazing adds animals to the herd, then acquisition and ownership costs of the extra animals should be included.

A COW/CALF EXAMPLE

Following is an example of a 70-cow beef operation considering a move to rotational grazing. Keep in mind this is simply "an" example, not "the" example. There is far too much variability in herds, resources, and management to make a blanket statement about the profitability of such a decision.

ABC Farms currently has 70 cows grazing 200 acres of typical Mississippi pasture. The partial budget put together for the farm is based on the assumption that rotational grazing and improved pastures will allow an increase in stocking rates of 30 percent (that is, 21 head). In addition, implementing rotational grazing will reduce nitrogen fertilization requirements and the amount of hay fed through the winter. In spite of the increased revenue and decreased costs, with $300 calves, $700 replacements, and $350 cull cows, this is not a break-even proposition. The operation would lose about $875 on the transition to rotational grazing. Four-hundred-dollar calves present a different story. Profits would increase by almost $1,100 when stocking rates increase by 30 percent. On the next page is a complete summary of the partial budget for this example (assuming $400 calves):

ABC FARMS: *Annualized Partial Budget of Cow/Calf Expansion*

Increased Revenue		Decreased Revenue	
Additional Calves	19	None	
Revenue/calf	$400		
Additional Calf Revenue	$7,600	**Increased Costs**	
		Woven Wire Fence	$389
Extra Hay (tons)	18	Poly Tape Fence	697
Revenue/ton	$45	Underground Water Line	265
Additional Hay Revenue	$810	Portable Water System	195
		Pasture Renovation	1,530
		Investment in Cows	1,801
Decreased Costs		Subtotal	$4,877
Reduced N fertilization (30 lbs/ac on 200 acres @ $0.30/lb of N)	$1,800		
		Additional Labor (15 hrs/mo for 6 months @ $7/hour)	$630
Decreased Hay Feeding (600 lbs/head to 70 head @ $45/ton)	$945		
		Additional Cow Costs (25 more cows @ variable cost of $180/hd)	$4,500
Increased Profits	**$11,155**	**Decreased Profits**	**$10,007**
Change in Profits: $11,155 - $10,007 = $1,142			

Other assumptions critical to this analysis include investment in new fencing and water facilities of $7,496, costs for overseeding ryegrass of $51/acre on 30 acres, and $14,700 for herd expansion (21 additional cows at $700 per head). Here is a summary of investment in new facilities and equipment, including the calculation of additional costs on an annual basis:

ABC FARMS: *Investment in Rotational Grazing System*

Cow/Calf Example

	Price	Cost	Life	Repair %	Deprec.	Repairs & Maint.	Non-cash Interest
1/2 mile woven wire	$1.05/ft	$2,772	20	5%	$139	$139	$111
2.5 miles poly tape	$0.12/ft	$1,584	5	20%	$317	$317	$63
1/2 mile underground water line	$1.00/ft	$2,640	25	2%	$106	$53	$106
Portable water system	$500	$500	5	15%	$100	$75	$20
21 Cows	$700	$14,700	8	N/A	$919	N/A	$882
Total		**$22,196**					

Total new investment equals $22,196 in this example. From a cash flow standpoint, a five-year loan for this amount at 8% interest would require principle and interest payments of $5,560 per year. The principle and interest payments plus additional variable cost of $6,660 would result in a negative cash flow of about $1,100 per year until the loan was paid off. Here is a summary of this cash flow situation:

ABC FARMS: *Cash Flow Requirements for Implementation of Rotational Grazing*

Cow/Calf Example

Loan payment		$5,560
$22,196 financed for 5 years @8%		
Additional variable costs		$6,660
Increase in cow variable costs	$4,500	
Additional labor costs	$630	
Annual pasture overseeding	$1,530	
Total additional cash flow requirements		$12,220
Increase in available cash (from earlier table)		$11,155
Net Cash Flow*		($1,065)

** Represents average annual cash flow situation until the loan financing grazing system investment is paid.*

If only the cattle were financed, with other investments financed out-of-pocket, the principle and interest payment would be $3,682. In this situation, a positive cash flow of just more than $800 would appear to be possible.

Remember, this is only one example. Different cost and return assumptions will lead to different results. In addition, different assumptions related to what portion of the new investment is financed and to the terms of that financing could lead to very different cash flow situations. Each situation must be evaluated on its own merit and all changes in revenue and costs must be identified and included.

A STOCKER CALF EXAMPLE

The goal of intensive grazing does not necessarily have to be expanding the cow herd. If you are seeking to diversify into other types of livestock production, you might consider intensive grazing as a means of creating capacity for additional livestock enterprises on the same land base. Grazing stocker calves in addition to the cow herd is an example of this type of system. Seasonally grazing stocker calves could, in fact, be easier to implement than expanding the cow herd. As the previous example shows, expanding the cow herd can lead to a very tight cash flow situation. Either you must repay a large loan (if you financed buying the cows), or you must reduce heifer marketings (if the expansion occurs through increased heifer retention). Either way, an uncomfortably long period of low or negative cash flows can result from the move to intensive grazing. This may be the case even if intensive grazing is expected to improve the long-run profitability of the farm.

Beginning a stocker operation may have less of an impact on cash flow because you keep calves for a relatively short time and then re-sell (or sell for the first time in the case of retained calves). Thus, cash flow is generated more quickly than with brood cows. In addition, in grazing-based stocker systems, there is minimal cash outlay for feed.

In spite of these points, stocker operations are not for everybody. Stocker operations tend to be quite capital intensive. That is, they can tie up much of a farm's equity. Producers with limited equity may find it difficult to finance a stocker operation. In addition, management challenges in a stocker operation can be significantly different from those in a cow/calf operation. For example, monitoring herd health and treating illnesses in a timely and effective manner are absolutely essential to the success of a stocker operation. This requires experience and technical skill that cow/calf producers may have to acquire.

To illustrate how beginning a stocker operation may affect the rotational grazing decision, we will look at the ABC Farms partial budget again. In this case, though, instead of increasing the size of the cow herd by 30%, the owners of the farm are considering running stocker calves on ryegrass pasture. In this example, 300-pound stocker calves will be purchased each year for grazing from the beginning of November through the end of April.

Referring to the partial budget in the earlier example and the assumptions in the second example, all fencing and watering equipment will remain the same. In addition, $1,500 will be spent on handling/feeding facilities for the stockers. The budget below assumes 40 acres of prepared seedbed ryegrass will be planted each fall, which should provide enough grazing for 80 calves. Note that the stocker purchase is given in the increased cost portion of the partial budget.

ABC FARMS: *Annualized Partial Budget of Seasonal Stocker Operation*

Increased Revenue		**Decreased Revenue**	
Fall Stockers	78	None	
Revenue/calf	$450		
Revenue from Fall Stockers	$35,100		
		Increased Costs	
Extra Hay (tons)	18	Woven Wire Fence	$389
Revenue/ton	$45	Poly Tape Fence	697
Additional Hay Revenue	$810	Underground Water Line	265
		Portable Water System	195
Decreased Costs		Ryegrass Planting	2,240
Reduced N fertilization (30 lbs/ac on 200 ac @ $0.30/lb of N)	$1,800	Facilities	360
		Stockers (80 @ $350/head)	28,000
		Labor ($5/head)	400
		Variable Costs ($30/head)	2,400
Increased Profits	**$37,710**	**Decreased Profits**	**$34,946**
Change in Profits: $37,710 - $34,946 = $2,764			

In this example, implementing intensive grazing along with a seasonal stocker-grazing program increases profits by about $2,700. Cash flow implications are also significant. Buying stocker calves each year requires $28,000 in this example, although that will obviously vary from year to year, depending on the cattle market. Total investment in facilities and fencing/watering equipment is $8,996 (cost of fencing and watering equipment plus an additional $1,500 invested in facilities). Financed for five years, this results in an annual payment of $2,253. Additional variable costs (including interest on calf purchases) and labor total $2,800. In addition, the cost of planting ryegrass each year (40 acres @ $56/ac) is assumed to be paid out-of-pocket as well. The total annual cash flow requirement for the operation is, therefore, just more than $35,000 ($2,253 loan payment + $2,800 additional variable costs + $2,240 ryegrass planting cost + $28,000 calf purchases). Thus, in this example, positive cash flow is possible. Obviously, this cash flow will be affected by the profitability of the stocker operations in any given year as well as by the terms of financing on the investment in facilities and fencing/watering equipment.

The examples presented here illustrate the importance of budgeting production and price parameters that are realistic for the individual farm. General statements about the value of rotational grazing could be misleading because of very significant differences in pasture quality, field layout, water availability, and management ability among farms. What can be stated categorically is that the economic benefits of rotational grazing depend on the cattle price as well as costs of implementing the system. Producers who implement rotational grazing need to be aware not only of how this management change will affect the long-run profitability of their operations but also of how their cash flow will be affected in the short- and intermediate run. Herd expansion, in particular, may have a pronounced negative effect on cash flow, depending upon how the expansion is financed and/or the time frame over which the expansion occurs.

For additional information on fencing systems and associated costs, see Gerrish, Jim, “Fence Systems for Grazing Management,” Arkansas Grazing Manual, 5th ed., University of Arkansas Cooperative Extension Service; Turner, L.W., C.W. Absher, and J. K. Evans, Planning Fencing Systems for Intensive Grazing Management, ID-74, University of Kentucky Cooperative Extension Service, 1997; or Mayer, Ralph, Estimated Costs for Livestock Fencing, FM 1855, Iowa State University Extension, February 1999.

[1] Data taken from Meat Animals: Production, Disposition, and Income, USDA-NASS, Washington DC, April 2001; and Cattle, USDA-NASS, Washington DC, January 2001.

[2] From 2000 Summary: Iowa Beef Cow Business Record, IBC-16, Iowa State University Extension, July 2001.

ROTATIONAL GRAZING: WILL IT PAY?

Mississippi State University Extension Service

MSUcares.com

By **Dr. John D. Anderson**, Extension Agricultural Economist, **Dr. Malcolm L. Broome**, Extension Forage Specialist, and **Dr. Randall D. Little**, Associate Professor, Agricultural Economics

Publication 2299

Extension Service of Mississippi State University, cooperating with U.S. Department of Agriculture. Published in furtherance of Acts of Congress, May 8 and June 30, 1914. JOE H. MCGILBERRY, Interim Director (500-03-02)

Partial Budgeting Form for______________________________

Additional Costs	**Additional Revenue**
Reduced Revenue	**Reduced Costs**
Total additional costs +reduced revenue = A	**Total additional revenue +reduced costs = B**
	Total Profit = B-A

ANNUAL PAYMENTS FOR $1,000 AT VARIOUS INTEREST RATES AND YEARS TO PAYBACK

NUMBER OF YEARS TO PAYBACK

	INTEREST RATE					
	3.00%	4.00%	6.00%	8.00%	10.00%	12.00%
1	$1,030.00	$1,040.00	$1,060.00	$1,080.00	$1,100.00	$1,120.00
2	$522.61	$530.20	$545.44	$560.77	$576.19	$591.70
3	$353.53	$360.35	$374.11	$388.03	$402.11	$416.35
4	$269.03	$275.49	$288.59	$301.92	$315.47	$329.23
5	$218.35	$224.63	$237.40	$250.46	$263.80	$277.41
6	$184.60	$190.76	$203.36	$216.32	$229.61	$243.23
7	$160.51	$166.61	$179.14	$192.07	$205.41	$219.12
8	$142.46	$148.53	$161.04	$174.01	$187.44	$201.30
9	$128.43	$134.49	$147.02	$160.08	$173.64	$187.68
10	$117.23	$123.29	$135.87	$149.03	$162.75	$176.98
15	$83.77	$89.94	$102.96	$116.83	$131.47	$146.82
20	$67.22	$73.58	$87.18	$101.85	$117.46	$133.88
25	$57.43	$64.01	$78.23	$93.68	$110.17	$127.50
30	$51.02	$57.83	$72.65	$88.83	$106.08	$124.14
35	$46.54	$53.58	$68.97	$85.80	$103.69	$122.32
40	$43.26	$50.52	$66.46	$83.86	$102.26	$121.30

To use this table, simply multiply the amount financed (in thousands) by the appropriate payback period and interest rate. For example, the annual payments for $100,000 in principal paid back over 10 years at 8% interest would be $14,903. This payment is determined by locating the intersection of 10 years and 8% which is $149.03 and then multiplying this number by 100 ($100,000 divided by $1,000)

Section 12

Cost-share programs that aid the transition

Philip Brown, NRCS Grazinglands Specialist

2015 Georgia Grazing School:
Cost-share programs that aid the transition

Philip Brown,
USDA-NRCS Grazinglands Specialist

United States Department of Agriculture
Natural Resources Conservation Service
USDA NRCS

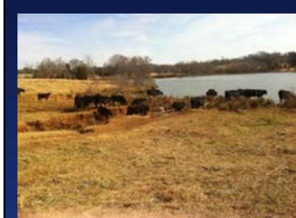
United States Department of Agriculture
Natural Resources Conservation Service
USDA NRCS

History of NRCS

- 1933 the Soil Erosion Service was established
- Changed to the Soil Conservation Service (SCS) in 1935
- 1994 SCS's name was changed to the NRCS

United States Department of Agriculture
Natural Resources Conservation Service
USDA NRCS

NRCS GA



- NRCS provides technical and financial assistance on natural resources issues and assist individuals, groups, communities, and counties in implementing soil and water conservation practices to protect the 34 million acres of privately owned land in Georgia.

United States Department of Agriculture
Natural Resources Conservation Service
USDA NRCS

NRCS is NOT a regulatory agency

- NRCS works with landowners on a voluntary basis

United States Department of Agriculture
Natural Resources Conservation Service
USDA NRCS

CTA– Conservation Technical Assistance

- Provide technical assistance in...
  - the development of conservation plans designed to address specific resource concerns
  - design & engineering
  - implementation of techniques used to reduce soil erosion, improve water quality, and protect natural resources

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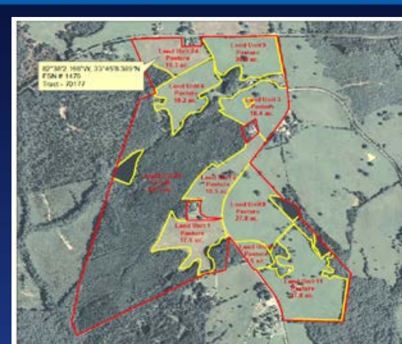
Natural Resources Conservation Service
USDA NRCS



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EQIP: Environmental Quality Incentives Program

- Program objectives are achieved through the implementation of a conservation plan to address resource concerns.
- Financial assistance payments for structural, vegetative, and land management practices may be made to help address the resource concerns and to implement the plan.

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USDA NRCS

A Few Popular EQIP Practices:

614 – Watering Facility
561 – Heavy Use Area
382 – Fencing
314 – Herbaceous Weed Control
512 – Forage and Biomass Planting

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11

Fencing – Facilitating Managed Grazing

Fencing – Facilitating Managed Access to Sensitive Areas

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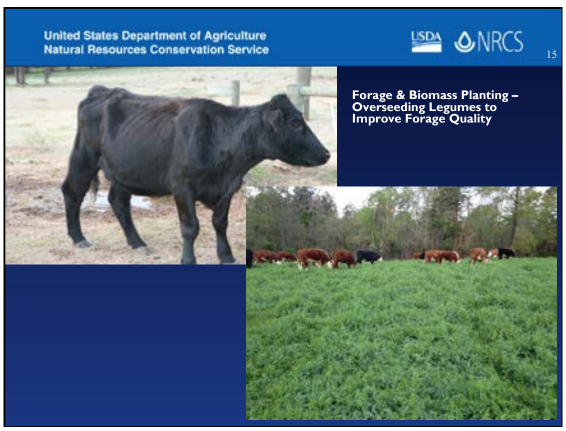

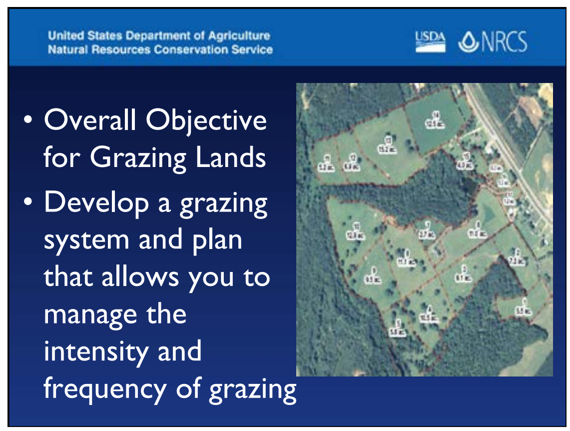

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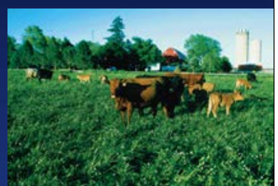
ACEP: Agricultural Conservation Easement Program

- **Agricultural Land Easements** – NRCS helps Indian tribes, state and local governments, and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land.
  - Permanent Easements only



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Program Applications

- Continuous sign up process
- Land and Participant must be eligible
- Ranked to measure resource needs & environmental benefits gained
- Not all applications are funded
- Can always re-submit an application

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Natural Resources Conservation Service
USDA NRCS

General Program Eligibility

- USDA Records Established?
  - Farm Number
  - Tract Number
  - Crops Reported (important for CRP)
- Filed/Update AD-1026 (Highly Erodible Land and Wetland Conservation Certification)
- Filed/Update CCC-931 (Payment Eligibility Average Adjusted Gross Income (AGI) Certification)
- Filed/Updated CCC-902 (Farm Operating Plan for Payment Eligibility Review)

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Land Eligibility
(Program Specific)

Land Eligibility:

- Cropping history (FSA records, tax records)
- Record keeping (nutrient/pest applied, crops planted etc.)
- Irrigation history (2 out 5 years)
- Animals present (cows, goats, etc.)

Goal is to address a resource concern(s):

soil, water, air, animal, plants

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USDA NRCS

I've got a contract. What Next?

- Make sure you fully understand each practice and what is required to implement it.
- If you are unsure of anything contact your local NRCS representative
- Keep records of quantities, rates, dates, etc.
- After completion of a practice contact NRCS to arrange for certification and payment

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Natural Resources Conservation Service
USDA NRCS

Summary of NRCS Technical and Financial Assistance

- Voluntary – You volunteer to follow standards and other Farm Bill Rules
- Address resource concerns
- Standards for how each conservation practice is to be installed and used
- Financial assistance comes with obligation and accountability

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Grazing School

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Cost-share programs that aid the transition

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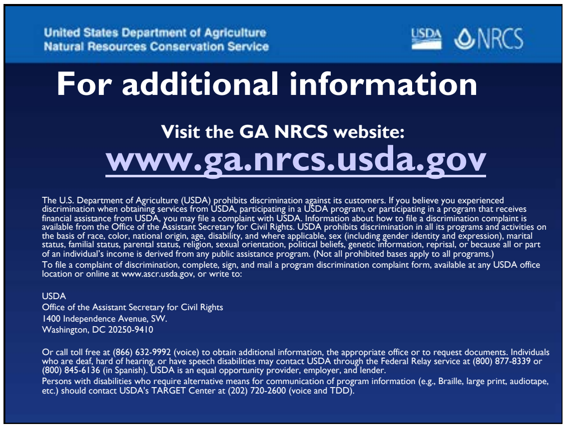

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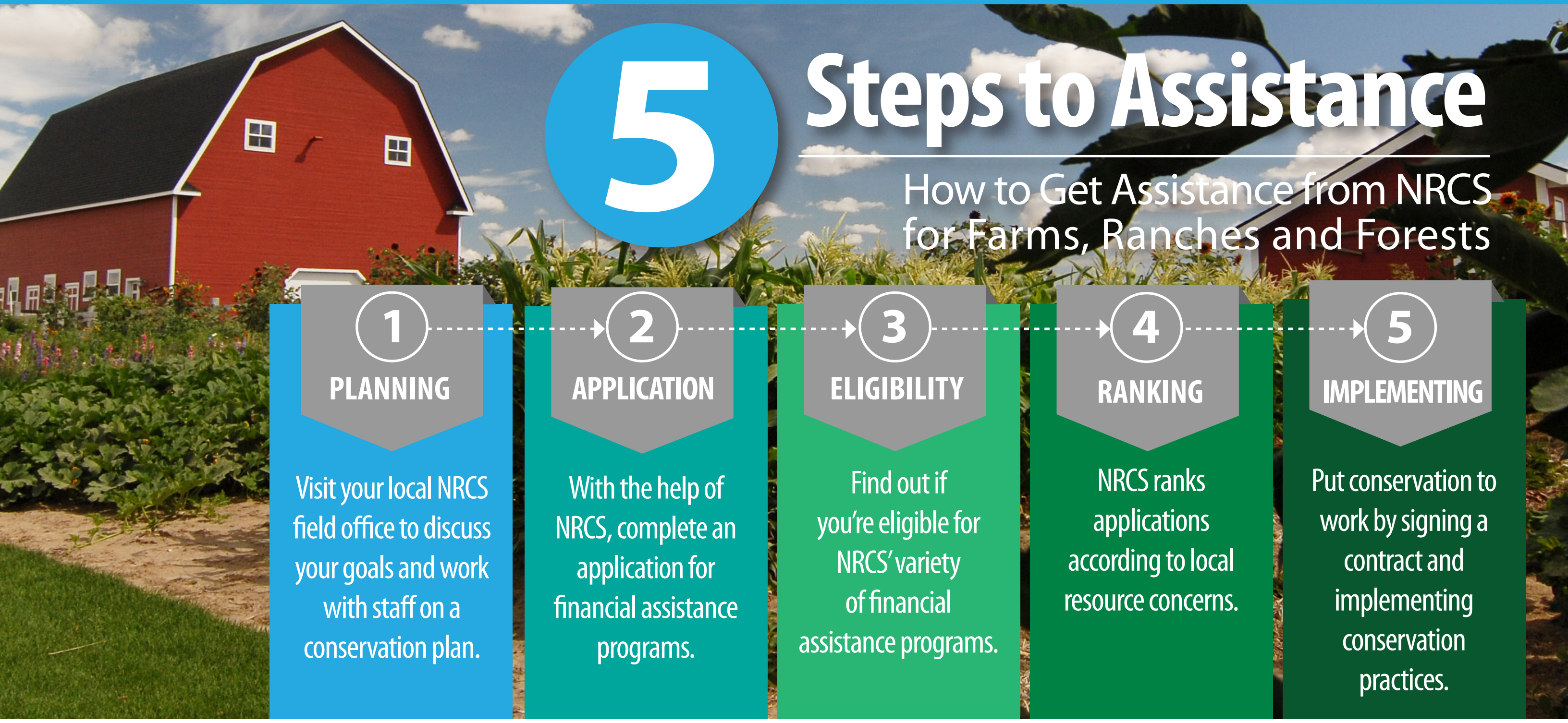
Grazing School



5 Steps to Assistance

How to Get Assistance from NRCS for Farms, Ranches and Forests

1 PLANNING
Visit your local NRCS field office to discuss your goals and work with staff on a conservation plan.

2 APPLICATION
With the help of NRCS, complete an application for financial assistance programs.

3 ELIGIBILITY
Find out if you're eligible for NRCS' variety of financial assistance programs.

4 RANKING
NRCS ranks applications according to local resource concerns.

5 IMPLEMENTING
Put conservation to work by signing a contract and implementing conservation practices.

Get Started with NRCS

Do you farm or ranch and want to make improvements to the land that you own or lease?

Natural Resources Conservation Service offers technical and financial assistance to help farmers, ranchers and forest landowners.

1 Planning

To get started with NRCS, we recommend you stop by your local NRCS field office. We'll discuss your vision for your land.

NRCS provides landowners with free technical assistance, or advice, for their land. Common technical assistance includes: resource assessment, practice design and resource monitoring. Your conservation planner will help you determine if financial assistance is right for you.

2 Application

We'll walk you through the application process. To get started on applying for financial assistance, we'll work with you:

- To fill out an AD 1026, which ensures a conservation plan is in place before lands with highly erodible soils are farmed. It also ensures that identified wetland areas are protected.
- To meet other eligibility certifications.

Once complete, we'll work with you on the application, or CPA 1200.

Applications for most programs are accepted on a continuous basis, but they're considered for funding in different ranking periods. Be sure to ask your local NRCS district conservationist about the deadline for the ranking period to ensure you turn in your application in time.

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3 Eligibility

As part of the application process, we'll check to see if you are eligible. To do this, you'll need to bring:

- An official tax ID (Social Security number or an employer ID)
- A property deed or lease agreement to show you have control of the property; and
- A farm tract number.

If you don't have a farm tract number, you can get one from USDA's Farm Service Agency. Typically, the local FSA office is located in the same building as the local NRCS office. You only need a farm tract number if you're interested in financial assistance.

4 Ranking

NRCS will take a look at the applications and rank them according to local resource concerns, the amount of conservation benefits the work will provide and the needs of applicants.

5 Implementing

If you're selected, you can choose whether to sign the contract for the work to be done.

Once you sign the contract, you'll be provided standards and specifications for completing the practice or practices, and then you will have a specified amount of time to implement. Once the work is implemented and inspected, you'll be paid the rate of compensation for the work if it meets NRCS standards and specifications.

United States Department of Agriculture

Natural Resources Conservation Service (NRCS)

LOCATE YOUR LOCAL SERVICE CENTER

COUNTY	LOCATION	PHONE
Appling, Bacon, Jeff Davis	Baxley	912-367-4368
Atkinson, Charlton, Pierce, Ware	Waycross	912-285-5975
Baker, Dougherty, Mitchell	Albany	229-430-8509
Baldwin, Greene, Hancock, Putnam, Taliaferro	Greensboro	706-453-7021
Banks, Jackson, Madison	Commerce	706-335-7145
Barrow, Clarke, Oconee, Walton	Monroe	770-267-1359
Bartow, Cherokee, Gordon, Pickens	Calhoun	706-629-2582
Ben Hill, Irwin, Tift, Turner	Tifton	229-382-4776
Berrien, Clinch, Cook, Echols, Lanier, Lowndes	Nashville	229-686-5557
Bibb, Crawford, Peach, Taylor	Fort Valley	478-827-0016
Bleckley, Dodge, Twiggs	Eastman	478-374-8140
Brantley, Camden, Glynn, Wayne	Brunswick	912-265-8043
Brooks, Thomas	Thomasville	229-228-0459
Bryan, Chatham, Liberty, Long, McIntosh	Richmond Hill	912-459-2350
Bulloch, Candler, Tattnall, Evans	Statesboro	912-871-2605
Burke, Columbia, Jenkins, Richmond	Augusta	706-724-2247
Butts, Clayton, Henry, Fayette, Spalding	McDonough	770-957-5705
Calhoun, Early, Miller	Blakely	229-723-3825
Carroll, Haralson, Heard	Carrolton	770-832-8942
Chattahoochee, Harris, Marion, Muscogee, Talbot	Buena Vista	229-649-3131

COUNTY	LOCATION	PHONE
Clay, Quitman, Randolph	Cuthbert	229-732-6211
Cobb, Douglas, Fulton, Paulding	Marietta	770-792-0594
Coffee, Telfair	Douglas	912-384-4811
Colquitt, Worth	Moultrie	229-985-5399
Coweta, Meriwether, Troup	Newnan	770-251-4283
Crisp, Dooly, Wilcox	Cordele	229-443-0182
Dade, Catoosa, Murray, Walker, Whitfield	LaFayette	706-638-2207
Dawson, Forsyth, Hall, Lumpkin	Gainesville	770-536-6981
DeKalb, Gwinnett, Rockdale	Lawrenceville	770-963-9288
Decatur, Grady, Seminole	Bainbridge	229-567-3994
Effingham, Screven	Sylvania	912-564-2207
Elbert, Franklin, Hart	Hartwell	706-376-5451
Emanuel, Montgomery, Toombs, Treutlen, Wheeler	Swainsboro	478-237-8037
Fannin, Gilmer, Rabun, Towns, Union	Blairsville	706-745-2794
Floyd, Chattooga, Polk	Rome	706-291-5651
Glascock, Jefferson, McDuffie, Warren	Louisville	478-625-7771
Habersham, Stephens, White	Toccoa	706-779-2134
Houston, Macon, Pulaski	Perry	478-987-2280
Jasper, Jones, Morgan, Newton	Madison	706-342-1315
Johnson, Washington	Sandersville	478-552-6073
Lamar, Monroe, Pike, Upson	Barnesville	770-358-0787
Laurens, Wilkinson	Dublin	478-275-0425
Lee, Terrell	Dawson	229-995-5811
Lincoln, Oglethorpe, Wilkes	Washington	706-678-2630
Schley, Stewart, Sumter, Webster	Americus	229-924-4056

Visit the Georgia NRCS Web site at www.ga.nrcs.usda.gov.
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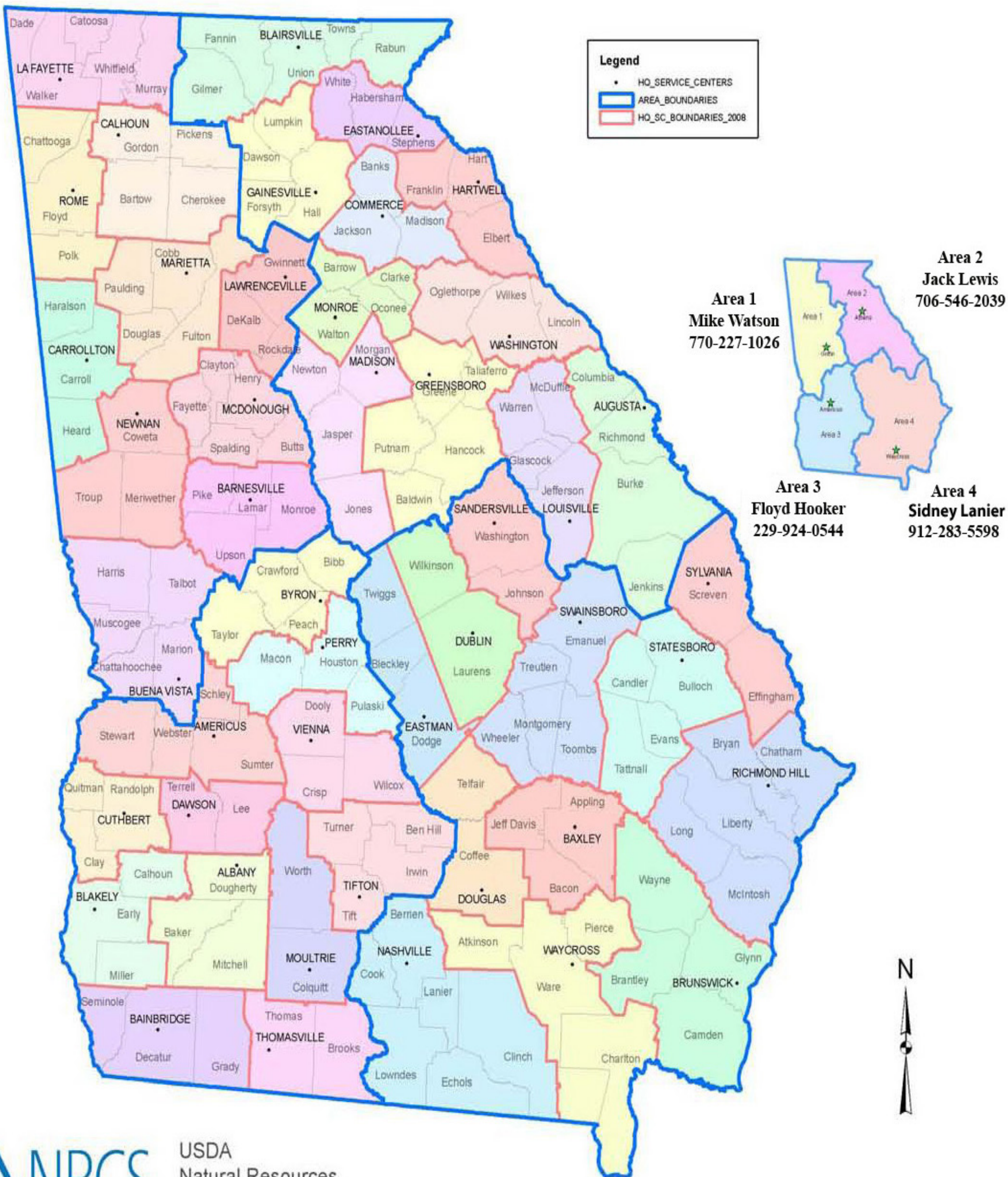
As of July 2014

Natural Resources Conservation Service
Georgia Service Center Administrative Areas (SCA)



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FY2009

WHAT'S NEXT?

WHAT SHOULD I EXPECT NOW THAT I AM IN A CONSERVATION PROGRAM?

NRCS requires the participant adhere to the following once they enter into a Conservation Program Contract (CPC):

1. Start at least one practice in the contract within the first 12 months of the contract. **Note: Secure prior approval from NRCS before initiating construction on practices requiring an engineering design.**
2. Complete contract items as scheduled in the CPC. Contract items may be accomplished anytime prior to the year scheduled. (Exception: Conservation Stewardship Program (CSP) contract items do not have funds obligated to them ahead of schedule and therefore cannot be completed in advance.) If a practice will not be completed on schedule, you will need to contact your local NRCS office and work with them to review your contract's schedule. All required treatment must be installed at least 12 months before the end of the contract period.
3. Submit to NRCS an application for payment (Form NRCS-CPA-1245) when practice(s) are completed (CSP, Environmental Quality Incentives Program (EQIP) and Wildlife Habitat Incentives Program (WHIP).
4. Submit receipts for practices completed. This is not required, but encouraged to assist NRCS in maintaining current cost data.
5. Permit free access for NRCS and/or its agents to provide technical assistance and to inspect the work at any reasonable time during the life span of the installed practices.

(Continued)

6. Forfeit all rights to further payments under the contract, refund to NRCS all contract payments received, and pay liquidated damages upon termination of the contract as outlined in the CPC Appendix.
7. Forfeit all rights to further payments under the CPC if the land under contract is transferred.
8. Upon cancellation of the contract, refund to NRCS all payments made under the contract as outlined in the CPC Appendix and as determined by specific program requirements.
9. Maintain the conservation treatment or practice installed on the land *for the life span of each practice*, as identified on the contract documents.
10. Share responsibility for ensuring that your conservation plan and contract documents are accurate and complete. The NRCS has no authority to compensate participants for practices and/or activities that are not in the contract at the time of obligation.
11. Ask questions! If you do not understand specific items or terms of the contract and its associated Appendix, let your local NRCS know. They will be happy to answer questions you may have.

USDA - Natural Resources Conservation Service

Other Online Resources:

GovDelivery: **www.ga.nrcs.usda.gov**

Twitter: **@USDA_NRCS_GA**

YouTube: **www.youtube.com/user/nrcsga**

USDA NRCS Natural Resources Conservation Service

Georgia NRCS

Entity Steps for: Applying for Conservation Programs Natural Resources Conservation Service (NRCS)

Your State NRCS Office is located at:

355 E. Hancock Avenue
Athens, Georgia 30601

Tel: Office: 706-546-2272
Fax: 855-417-8490

www.ga.nrcs.usda.gov

Helping People Help the Land

2013

ENTITY STEPS...

Entity – any partnership, joint venture, corporation (limited liability or other), estate, trust, non-profit association or group, or unit of state or local government that uses an employee identification number (EIN) or social security number (SSN) to apply for conservation program assistance.

1. **Applicant** indicates interest in a conservation program by signing appropriate program application forms.
2. **Applicant** establishes a customer record in the Service Center Information Management System (SCIMS). This will require the applicant set up an appointment with the Farm Service Agency (FSA) to complete record and necessary applicant eligibility information.
3. **Applicant** completes forms* to determine eligibility for USDA programs:
   - AD-1026 Highly Erodible Land and Wetland Conservation Certification
   - CCC-901 Members Information
   - CCC- 902E Farm Operating Plan for Payment Eligibility Review
   - CCC-931 Payment Eligibility Average Adjusted Gross Income (AGI)

These eligibility forms can be accessed on-line for your convenience. Please visit our eForms site at: http://forms.sc.egov.usda.gov/eForms/welcomeAction.do?Home

***The process of establishing applicant eligibility may take several weeks. Some forms may need to be updated annually. You must maintain eligibility status throughout the life of the conservation program contract in order to receive program benefits.**

(Continued)

4. **Applicant** sets up an appointment with local NRCS office to visit the operation and develop a current **conservation plan**. This process can take several visits—both in the office and in the field.
5. **NRCS** develops a program application package based on the approved conservation plan and discussions with the applicant.
6. **NRCS** reviews program applications and selects eligible applications for funding based on ranking criteria and available funding *when funding is available*. Because NRCS programs rely on funds being available, this step may occur weeks or months after your program application package is submitted.
7. **Applicant** provides additional information if NRCS determines their application *may be considered* for funding. This additional information includes:
   - Evidence that the business is in current good standing.
   - Business Documents** outlining
     1. Official business name
     2. The current members of the business
     3. The member(s) of the business who have legal authority to sign on behalf of the business

   ***** See "Typical Types of Business and Acceptable Evidence and Signature Authority" for more information***

   - Document from the IRS that indicates the **name** and **Employee Identification Number (EIN)** for the business. All applicants earning program benefits will receive IRS-1099's based on this information. If you do not have a form available, you may request one from the IRS:
   - Request a **Form LTR 147C** by calling IRS Customer Service @ 800-829-4933 or

     Department of the Treasury
     Internal Revenue Service
     Ogden, Utah 84201
   - Completed SF-1199 Direct Deposit Form. All program payments will be direct deposited using this banking information.

(Continued)

   - Power of Attorney Form (FSA 211 may be used) if the authorized individual wants to allow another individual to sign on their behalf.
8. **Applicant** must document control of the land for the contract period using any of the following:
   - Deed
   - Lease or
   - Other written authorization from the landowner ("NRCS—Farm Bill Conservation Programs Land Eligibility Certification Form" may be used)
   - Land must be considered an *eligible land use* for the program.

Failure to provide the required information may cause your application to be considered "ineligible" for the program year.

If your application is not considered for funding in the year you apply, your application may be considered in future years based on funding and meeting the requirements outlined above.

WHAT'S NEXT?

WHAT SHOULD I EXPECT NOW THAT I AM IN A CONSERVATION PROGRAM?

NRCS requires the participant adhere to the following once they enter into a Conservation Program Contract (CPC):

1. Start at least one practice in the contract within the first 12 months of the contract. **Note: Secure prior approval from NRCS before initiating construction on practices requiring an engineering design.**
2. Complete contract items as scheduled in the CPC. Contract items may be accomplished anytime prior to the year scheduled. (Exception: Conservation Stewardship Program (CSP) contract items do not have funds obligated to them ahead of schedule and therefore cannot be completed in advance.) If a practice will not be completed on schedule, you will need to contact your local NRCS office and work with them to review your contract's schedule. All required treatment must be installed at least 12 months before the end of the contract period.
3. Submit to NRCS an application for payment (Form NRCS-CPA-1245) when practice(s) are completed (CSP, Environmental Quality Incentives Program (EQIP) and Wildlife Habitat Incentives Program (WHIP).
4. Submit receipts for practices completed. This is not required, but encouraged to assist NRCS in maintaining current cost data.
5. Permit free access for NRCS and/or its agents to provide technical assistance and to inspect the work at any reasonable time during the life span of the installed practices.

(Continued)

6. Forfeit all rights to further payments under the contract, refund to NRCS all contract payments received, and pay liquidated damages upon termination of the contract as outlined in the CPC Appendix.
7. Forfeit all rights to further payments under the CPC if the land under contract is transferred.
8. Upon cancellation of the contract, refund to NRCS all payments made under the contract as outlined in the CPC Appendix and as determined by specific program requirements.
9. Maintain the conservation treatment or practice installed on the land *for the life span of each practice*, as identified on the contract documents.
10. Share responsibility for ensuring that your conservation plan and contract documents are accurate and complete. The NRCS has no authority to compensate participants for practices and/or activities that are not in the contract at the time of obligation.
11. Ask questions! If you do not understand specific items or terms of the contract and its associated Appendix, let your local NRCS know. They will be happy to answer questions you may have.

USDA - Natural Resources Conservation Service

Other Online Resources:

GovDelivery **www.ga.nrcs.usda.gov**

Twitter: **@USDA_NRCS_GA**

YouTube **www.youtube.com/user/nrcsga**

USDA NRCS Natural Resources Conservation Service

Georgia NRCS

Individual Steps for: Applying for Conservation Programs Natural Resources Conservation Service (NRCS)

Your State NRCS Office is located at:

355 E. Hancock Avenue
Athens, GA 30601

Tel: Office: 706-546-2272
Fax: 855-417-8490

www.ga.nrcs.usda.gov

Helping People Help the Land

2013

INDIVIDUAL STEPS...

Individual – any individual who controls the enrolled land and uses their personal *social security number (SSN)* to apply for conservation program assistance.

1. **Applicant** indicates interest in a conservation program by signing appropriate program application forms.
2. **Applicant** establishes a customer record in the Service Center Information Management System (SCIMS). This will require the applicant set up an appointment with the Farm Service Agency (FSA) to complete record and necessary applicant eligibility information.
3. **Applicant** completes forms* to determine eligibility for USDA programs:
   - AD-1026 Highly Erodible Land and Wetland Conservation Certification
   - CCC- 902-I Farm Operating Plan for Payment Eligibility Review
   - CCC-931 Payment Eligibility Average Adjusted Gross Income (AGI)

These eligibility forms can be accessed on-line for your convenience. Please visit our eForms site at: http://forms.sc.egov.usda.gov/eForms/welcomeAction.do?Home

***The process of establishing applicant eligibility may take several weeks. Some forms may need to be updated annually. You must maintain eligibility status throughout the life of the conservation program contract in order to receive program benefits.**

4. **Applicant** sets up an appointment with local NRCS office to visit the operation and develop a current **conservation plan**. This process can take several visits—both in the office and in the field.

(Continued)

5. **NRCS** develops a program application package based on the approved conservation plan and discussions with the applicant.
6. **NRCS** reviews program applications and selects eligible applications for funding based on ranking criteria and available funding *when funding is available*. Because NRCS programs rely on funds being available, this step may occur weeks or months after your program application package is submitted.
7. **Applicant** provides additional information if NRCS determines their application *may be considered* for funding. This additional information includes:
   - Completed SF-1199 Direct Deposit Form. All program payments will be direct deposited using this banking information.
   - Power of Attorney Form (FSA 211 may be used) if the authorized individual wants to allow another individual to sign on their behalf.
8. **Applicant** must document control of the land for the contract period using any of the following:
   - Deed
   - Lease or
   - Other written authorization from the landowner ("NRCS—Farm Bill Conservation Programs Land Eligibility Certification Form" may be used)
   - Land must be considered an *eligible land use* for the program.

Water Troughs with Heavy Use Area

(Continued)

Failure to provide the required information may cause your application to be considered "ineligible" for the program year.

If your application is not considered for funding in the year you apply, your application may be considered in future years based on funding and meeting the requirements outlined above.

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers. If you believe you experienced discrimination when obtaining services from USDA, participating in a USDA program, or participating in a program that receives financial assistance from USDA, you may file a complaint with USDA. Information about how to file a discrimination complaint is available from the Office of the Assistant Secretary for Civil Rights. USDA prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex (including gender identity and expression), marital status, familial status, parental status, religion, sexual orientation, political beliefs, genetic information, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.)

To file a complaint of discrimination, complete, sign, and mail a program discrimination complaint form, available at any USDA office location or online at www.ascr.usda.gov, or write to:

USDA
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW.
Washington, DC 20250-9410

Or call toll free at (866) 632-9992 (voice) to obtain additional information, the appropriate office or to request documents. Individuals who are deaf, hard of hearing, or have speech disabilities may contact USDA through the Federal Relay service at (800) 877-8339 or (800) 845-6136 (in Spanish). USDA is an equal opportunity provider, employer, and lender.

Persons with disabilities who require alternative means for communication of program information (e.g., Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

Section 13

Sprayer calibration exercise and lightbar demo

Dr. Dennis Hancock, UGA

CALIBRATION METHOD FOR HYDRAULIC BOOM AND BAND SPRAYERS, AND OTHER LIQUID APPLICATORS

Gary L. Hawkins, Extension Engineer
Glen C. Rains, Extension Engineer

The procedure below is based on spraying 1/128 of an acre per nozzle or row spacing and collecting the spray that would be released during the time it takes to spray the area. Because there are 128 ounces of liquid in 1 gallon, this convenient relationship result in ounces of liquid caught being directly equal to the application rate in gallons per acre.

Calibrate with clean water when applying toxic pesticides mixed with large volumes of water. Check uniformity of nozzle output across the boom. Collect from each for a known time period. Each nozzle should be within 10 percent of the average output. Replace with new nozzles if necessary. When applying materials that are appreciably different from water in weight or flow characteristics, such as fertilizer solutions, etc., calibrate with the material to be applied.

Exercise extreme care and use protective equipment when active ingredient is involved.

Step 1. Determine type of application to be made and select appropriate procedure from Table 1. For example, for a Herbicide Broadcast, use Procedure A.

Table 1. Corresponding procedures for different spray applications.

TYPE OF APPLICATION	PROCEDURE	COVERAGE BASIS
	Herbicide, Insecticide, Nematicide, Fungicide, or Liquid Fertilizer	
Broadcast	A	Broadcast (gal/ acre)
Band	B	Broadcast (gal/acre of band)
Row (See note)	C (Use this procedure when rates are given for row treatment)	

Note: Determine and use average row spacing for modified row patterns. In skip row patterns, use width of area covered per row as row spacing.

Step 2. Determine and use average row spacing for modified row patterns. In skip row patterns, use width of area covered per row as row spacing.

(A) Broadcast Application: Outlets or nozzles must be evenly spaced. Measure outlet (nozzle, etc.) spacing. Find this spacing in left column of Table 2 and read the corresponding calibration distance. For example, for a 19-inch spacing the distance would be 214.9 feet.

(B) Band Application: Measure band width. Find this band width in the left column of Table 2 and read the corresponding calibration distance. For example, for a 12-inch band, the distance would be 340.3.

(C) Row Application: Measure row spacing for evenly spaced rows. Find this row spacing in the left column of Table 2 and read the corresponding calibration distance from the column on the right. For example, for a 38-inch row spacing, the distance would be 107 .5 feet. (See note above for modified and skip rows.)

CAUTION: AGRICULTURAL CHEMICALS CAN BE DANGEROUS. IMPROPER SELECTION OR USE CAN SERIOUSLY INJURE PERSONS, ANIMALS, PLANTS, SOIL, OR OTHER PROPERTY. BE SAFE: SELECT THE RIGHT CHEMICAL FOR THE JOB. HANDLE IT WITH CARE. FOLLOW THE INSTRUCTIONS ON THE CONTAINER LABEL AND INSTRUCTIONS FROM THE EQUIPMENT MANUFACTURER.

Step 3. Measure and mark calibration distance in a typical portion of the field to be sprayed.

Step 4. With all attachments in operation (harrows, planters, etc.) and traveling at the desired operating speed, determine the number of seconds it takes to travel calibration distance. Be sure machinery is traveling at full operating speed the full length of the calibration distance. Mark or make note of engine RPM and gear. Machine must be operated at same speed for calibration.

CALIBRATION METHOD FOR HYDRAULIC BOOM AND BAND SPRAYERS, AND OTHER LIQUID APPLICATORS

Step 5. With sprayer sitting still and operating at same throttle setting or engine R.P.M. as used in Step 4, adjust pressure to the desired setting. Machine must be operated at same pressure used for calibration.

Step 6. For Procedure A, Step 2, broadcast application, collect spray from one nozzle or outlet for the number of seconds required to travel the calibration distance.

For Procedure B, Step 2, band application, collect spray from all nozzles or outlets used on one band width for the number of seconds required to tr avel the calibration distance.

For Procedure C, Step 2, row application, collect spray from all outlets (nozzles, etc.) used for one row for the number of seconds required to travel the calibration distance.

Table 2. Calibration distances with corresponding widths.

ROW SPACING, OUTLET SPACING OR BAND WIDTH (Whichever Applies) (Inches)	CALIBRATION DISTANCE (feet)
48**	85.1
46	88.8
44	92.8
42	97.2
40	102.1
38	107.5
36	113.4
32	127.6
30	136.1
24	170.2
20	204.2
19	214.9
18	226.9
14	291.7
12	340.3
10	408.4
8	510.5

To determine distance for spacing or band width not listed, divide the spacing or band width expressed in feet into 340.3. Example: for a 13" band the calibration distance would be 340 divided by 13/12 = 314.1.

** To increase calibration accuracy for a wide nozzle spacing, multiply calibration distance by a factor (for example, 2); then, divide the fluid amount collected by the same factor for GPA. For narrow nozzle spacings with long calibration distances, divide calibration distance by a factor (for example, 4); then, multiply the fluid amount collected by the same factor for GPA.

Step 7. Measure the amount of liquid collected in fluid ounces. The number of ounces collected is the gallons per acre rate on the coverage basis indicated in Table 1. For example, if you collect 18 ounces, the sprayer will apply 18 gallons per acre. Adjust applicator speed, pressure, nozzle size, etc. to obtain recommended rate. If speed is adjusted, start at Step 4 and recalibrate. If pressure or nozzles are changed, start at Step 5 and recalibrate.

Step 8. To determine amount of pesticide to put into a sprayer or applicator tank, divide the total number of gallons of mixture to be made (tank capacity for a full tank) by the gallons per acre rate from Step 7 and use recommended amount of pesticide for this number of acres.

CALIBRATION METHOD FOR HYDRAULIC BOOM AND BAND SPRAYERS, AND OTHER LIQUID APPLICATORS

Band Application

Use the recommended **broadcast** pesticide rates to make tank mixtures for band applications when calibrating with procedure (B) of this method. The number of gallons per acre determined in Step 7 is the gallons that will be applied to each acre of actually treated band.

To determine the gallons of spray mixture required to make a band application on a field, the number of acres that will be in the actually treated band must be determined. When all treated bands are the same width and all untreated bands are the same width, which is usually the case, the acres in the actually treated band can be calculated by placing the width of the treated band over the sum of the widths of the treated band and the untreated band, and multiplying this fraction times the number of acres in the field. Example - How many acres will actually be treated in a 30 acre field if a 12” band of chemical is applied over the drill of rows spaced 36” apart. The treated band width is 12”. The untreated band width is (36” - 12”) = 24”. Acres actually treated will be 12” divided by (12” + 24”) times 30 acres equals 10 acres. The amount of mixture required will be 10 times the number of gallons per acre from Step 7. The amount of chemic al required will be 10 times the recommended broadcast rat e for one acre.

Check rate recommendations carefully as to type of application, broadcast, band or row, and type of material specified, formulated product, active ingredient, etc.

Calculating Formulation Requirements For Active Ingredient Rates.
To determine amount of liquid pesticide required for a rate given in pounds of active ingredient per acre, divide recommended rate by pounds active ingredient per gallon stated on label. Example – Pesticide label states 4 lbs. active ingredient (AI) per gallon and recommends 1/2 pound AI per acre. Amount of pesticide required: 1/ 2 lb. AI per acre divided by 4 lb. AI per gal. = 1/8 gal. per acre

To determine amount of wettable powder required for a rate given in pounds active ingredient per acre, divide recommended rate by percent active ingredient stated on label. Example - Pesticide label states powder is 50% active ingredient. Two pounds of active ingredient is recommended per acre. Amount of pesticide powder required: 2 lbs. AI per A divided b y 0.5 AI per lb. = 4 lbs. per AI

CALIBRATION METHOD FOR BOOMLESS BROADCAST SPRAYERS

Gary L. Hawkins, Extension Engineer
Glen C. Rains, Extension Engineer

All sprayers should be calibrated often to ensure that pesticide is being applied at the correct rate. Most broadcast applications are made with a boom arrangement where the nozzle tips are spaced evenly along the boom. However, in some situations this may be impossible or undesirable, so a cluster nozzle or a single nozzle with a wide spray pattern may be used.

Calibrate with clean water when applying toxic pesticides mixed with large volumes of water. When applying materials that are appreciably different from water in weight or flow characteristics, such as fertilizer solutions, etc., calibrate with the material to be applied. Exercise extreme care and use protective equipment when active ingredient is involved.

The following instructions outline a simple method to calibrate a boomless broadcast sprayer.

Step 1. Determine spray width. The spray width is the distance between successive passes through a field. This is usually given in the manufacturers' literature for a specific nozzle. If you are unable to find this in the catalogs, use 80 to 85 percent of the wetted spray width.

Step 2. Using the spray width in Step 1, determine the calibration distance from Table 1.

Step 3. Measure and mark calibration distance on typical terrain to be sprayed.

Step 4. With all attachments in operation and traveling at the desired operating speed, determine the number of seconds it takes to travel the calibration distance. Be sure machinery is traveling at full operating speed the full length of the calibration distance. Mark or make note of engine RPM and gear. Machine must be operated at same speed for calibration.

Step 5. With sprayer sitting still and operating at same throttle setting or engine R.P.M. as used in Step 4, adjust pressure to the desired setting. Machine must be operated at same pressure used for calibration.

Step 6. Collect spray from all nozzles or outlets for the number of seconds required to travel the calibration distance.

Table 1. Calibration distances with corresponding widths.

SWATH WIDTH (feet)	CALIBRATION DISTANCE (feet)
40	85.1
38	89.5
36	94.5
32	106.3
30	113.4
28	121.5
24	141.8
20	170.2
18	189
16	212.7
12	283.6
10	340.3
8	425

To determine distance for swath width not listed, divide the swath width expressed in feet into 340.3 and multiply by 10.
Example: for 13 feet swath the calibration distance would be 340.3 divided by 13 multiplied by 10 = 261.8.

CALIBRATION METHOD FOR BOOMLESS BROADCAST SPRAYERS

Step 7. Measure the amount of liquid collected in fluid ounces.

Step 8. <u>Divide the total number of fluid ounces by 10 to obtain gallons per acre applied</u>. For example, if you collect 180 ounces, the sprayer will apply 18 gallons per acre. Adjust applicator speed, pressure, nozzle size, etc. to obtain recommended rate. If speed is adjusted, start at Step 3 and recalibrate. If pressure or nozzles are changed, start at Step 5 and recalibrate.

Step 9. To determine amount of pesticide to put into a sprayer or applicator tank, divide the total number of gallons of mixture to be made (tank capacity for a full tank) by the gallons per acre rate from Step 8 and use recommended amount of pesticide for this number of acres.

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CALIBRATION METHOD FOR GRANULAR APPLICATIONS

Gary L. Hawkins, Extension Engineer
Glen C. Rains, Extension Engineer

Applicators used in granular applications should be calibrated to insure uniformity and accuracy of the application. A more accurate and uniform application can reduce the quantity of an active ingredient required for a given degree of control, which benefits the environment as well as the producer.

Several factors influence the amount of granular material applied to a given area. Granular material is usually metered with an adjustable orifice. The amount of material that flows through the orifice per revolution relies on orifice opening size and may rely on rotor speed. A wide variation in product characteristics, such as size, density, and shape, requires that a calibration be made for every chemical applied. Also changes in climatic conditions, such as temperature and humidity, can result in a different flow rate.

CAUTION: Calibration is done using the chemical to be applied. Protective equipment, such as rubber gloves, etc. should be used to avoid contact with the chemicals to be applied.

Granular application is usually done in combination with another operation, such as planting or cultivating. The applicator may be ground driven or driven with a small electric motor. The following procedure will give the pounds (total weight) of material applied per acre broadcast or row basis as indicated. A weight scale incremented in ounces is required for this procedure.

Step 1. Determine type of application to be made and select appropriate procedure from Table 1. Example - Broadcast - Procedure A.

Table 1. Corresponding procedures for different spray applications.

TYPE OF APPLICATION	PROCEDURE	COVERAGE BASIS (VOLUME OF APPLICATION)
Broadcast	A	Broadcast (lbs /acre)
Band	B	Broadcast (lbs/acre of band)
Row (See note)	C (Use this procedure when rates are given for row treatment)	

Note: Determine and use average row spacing for modified row patterns. Use width of area covered per row as row spacing in skip row patterns for broadcast rates

Step 2. Using procedure A, B, or C below as selected in Step 1, determine appropriate calibration distance from Table 2.

(A) Broadcast Application: Outlets must be evenly spaced. Measure outlet spacing. Find this spacing in left column of Table 2 and read the corresponding calibration distance. Example - for a 19” spacing the distance would be 214.9 feet.

(B) Band Application: Measure band width. Find this band width in the left column of Table 2 and read the corresponding calibration distance. Example - for a 12” band, the distance would be 340.3.

(C) Row Application: Measure row spacing for evenly spaced rows. Find this row spacing in the left column of Table 2 and read the corresponding calibration distance from the column on the right. Example - for a 38” row spacing, the distance would be 107.5 feet.

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Step 3. Measure and mark calibration distance in a typical portion of the field to be applied.

CALIBRATION METHOD FOR GRANULAR APPLICATIONS

Step 4. With all attachments in operation (harrows, planters, etc.) and traveling at the desired operating speed, determine the number of seconds it takes to travel calibration distance. Be sure machinery is traveling at full operating speed the full length of the calibration distance. Mark or make note of engine RPM and gear. Machine must be operated at same speed for calibration.

Step 5. **Multiply the number of seconds required to travel calibration distance by 8**. This is the number of seconds to collect.

Step 6. With applicator sitting still and operating at same speed as used in Step 4, adjust gate openings to desired setting. Check uniformity of outlets across the swath or rows. Collect from each outlet for a known time period. Each outlet should be within 5 percent of the average outlet output.

Table 2. Calibration distances with corresponding widths.

ROW SPACING, OUTLET SPACING OR BAND WIDTH (Whichever Applies) (Inches)	CALIBRATION DISTANCE (feet)
48*	85.1
46	88.8
44	92.8
42	97.2
40	102.1
38	107.5
36	113.4
32	127.6
30	136.1
24	170.2
20	204.2
19	214.9
18	226.9
14	391.7
12	340.3
10	408.4
8	510.5

To determine distance for spacing or band width not listed, divide the spacing or band width expressed in feet into 340.3.
Example: for a 13-inch band the calibration distance would be 340 divided by 13/12 = 314.1.

* To increase calibration accuracy for a wide outlet spacing, multiply calibration distance by a factor (for example, 2); then, divide Step 8 material collected by the same factor for pounds per acre. For narrow spacings with long calibration distances, divide calibration distance by a factor (for example, 4); then, multiply Step 8 by the same factor for pounds per acre. Keep in mind that application accuracy will decrease when factoring narrow outlet or band spacings.

Step 7.**For procedure (A), Step 2, broadcast application, collect from one outlet for the number of seconds indicated in Step 5.
For procedure (B), Step 2, band application, collect from all outlets used on one band width for the number of seconds indicated in Step 5. For procedure (C), Step 2, row application, collect from all outlets used for one row for the number of seconds indicated in Step 5.
**** For ground driven equipment, multiply the calibration distance by 8 and collect from each outlet while traveling the calibration distance; then divide step 8 material collected by 8**

CALIBRATION METHOD FOR GRANULAR APPLICATIONS

for pounds per acre.
Step 8. Weigh the amount of material collected in ounces. <u>The number of ounces collected is the pounds per acre rate</u> on the coverage basis indicated in Table 1. For example, if you collect 18 ounces using procedure (A) or (B), the applicator will apply 18 pounds per acre on a broadcast coverage basis. Adjust applicator speed, gate opening, etc. to obtain recommended rate.

Step 9. Applicators should be checked for proper calibration every 4-8 hours of use. Simply repeat steps 7 and 8. If there is a difference of more than 5 percent of original calibration, check the system.

Band Application

Use the recommended **broadcast** pesticide rates to make tank mixtures for band applications when calibrating with Procedure B of this method. The number of gallons per acre determined in Step 7 is the gallons that will be applied to each acre of actually treated band.

To determine the gallons of spray mixture required to make a band application on a field, the number of acres that will be in the treated band must be determined. When all treated bands are the same width and all untreated bands are the same width, which is usually the case, the acres in the treated band can be calculated by placing the width of the treated band over the sum of the widths of the treated band and the untreated band, and multiplying this fraction times the number of acres in the field. Example - How many acres will actually be treated in a 30 acre field if a 12-inch band of chemical is applied over the drill of rows spaced 36-inches apart. The treated band width is 12 inches. The untreated band width is (36 inches – 12 inches) = 24 inches. Acres actually treated will be 12 inches divided by (12 inches + 24 inches) times 30 acres equals 10 acres. The amount of mixture required will be 10 times the number of gallons per acre from Step 7. The amount of chemical required will be 10 times the recommended broadcast rate for one acre.

Check rate recommendations carefully as to type of application, broadcast, band or row, and type of material specified, formulated product, active ingredient, etc.

Calculating Formulation Requirements For Active Ingredient Rates.
To determine amount of liquid pesticide required for a rate given in pounds of active ingredient per acre, divide recommended rate by pounds active ingredient per gallon stated on label. Example – Pesticide label states 4 lbs. active ingredient (AI) per gallon and recommends 1/2 pound AI per acre. Amount of pesticide required: 1/ 2 lb. AI per acre divided by 4 lb. AI per gal. = 1/8 gal. per acre.

To determine amount of wettable powder required for a rate given in pounds active ingredient per acre, divide recommended rate by percent active ingredient stated on label. Example - Pesticide label states powder is 50% active ingredient. Two pounds of active ingredient is recommended per acre. Amount of pesticide powder required: 2 lbs. AI per A divided by 0.5 AI per lb. = 4 lbs. per acre

CALIBRATION OF BACKPACK SPRAYERS 1000 Ft^2 Method

Gary L. Hawkins, Extension Engineer
Glen C. Rains, Extension Engineer

Backpack sprayers are often used to treat ornamental or small areas of turf. Herbicide recommendations are based amount per acre and amount per 100 0 ft^2. Regardless of the type of sprayer used to apply herbicides, the speed, pressure and nozzle height must be kept constant for accurate application. The backpack sprayer may require some modification so that it is better suited for application. A pressure gauge mounted on the tank side of the shutoff valve will allow continuous monitoring of the tank pressure, which must remain uniform. Optimum pressure control can be achieved by inserting a pressure regulator between the pressure gauge and nozzle. To prevent dripping after the shutoff valve is closed, use a quick, positive pressure shutoff valve or a strainer with a check valve. Nozzle clogging, a problem associated with the use of wettable powders (as well as dry flowable [DF] and water dispersible granular [WDG] formulations) can be reduced by inserting a 50 mesh in-line strainer and keeping the solution constantly agitated. The following is a procedure of 1000 ft^2.

Step 1. Measure the length and width of the test area to be sprayed. Then calculate the area to be covered.

Test Area is: lengthft X width ft = _____ ft^2 _____

Step 2. Fill sprayer with water and spray the test area. Record the amount of water to refill the sprayer.

Volume (ounces) per test area _____

Step 3. Find the label rate of material to be applied per 1000 ft^2 .

Rate _____ per 1000 ft^2

Step 4.

$$\frac{\textit{1000 ft}^2 \textit{ x Volume (ounces) per test area}}{\textit{Test Area (ft}^2\textit{)}} = \textit{Volume (ounces) per 1000 ft}^2$$

Step 5. Calculate the area covered per tank as follows:

$$\frac{\textit{Tank volume (ounces) x 1000 ft}^2}{\textit{Volume per 1000 ft}^2} = \textit{Area covered per tank (ft}^2\textit{)}$$

Step 6. Calculate amount of material to add to tank.

$$\frac{\textit{Area per tank (ft}^2\textit{) x Label rate per 1000 ft}^2}{\textit{1000}} = \textit{Amount to add (rate units)}$$

CALIBRATION OF BACKPACK SPRAYERS 1000 Ft^2 Method

Solutions derived from the above may need to be converted to a smaller unit in order to accurately measure the pesticide accurately. The following conversion will help simplify this problem.

Conversions:

VOLUME		WEIGHT	
gallons x 128	= fluid ounces (fl oz)	pounds x 16	= weight ounces (wt oz)
pints x 16	= fluid ounces (fl oz)	wt. ounces x 28.35	= grams (g)
fl oz x 29.57	= milliliters (ml)	grams x 1000	= milligrams (mg)
gallons x 4	= quarts (qts)		
quarts x 2	= pints (pts)		
fl oz x 2	= Tablespoons (Tbs)		
tsp x 3	= Tablespoons (Tbs)		
tsp x 5	= milliliters (ml)		

An example of using this conversion chart. If the rate calls for 0.25 gallons of material then converting to ounces would be done as follows: 1 gallon has 128 ounces, so multiply 0.25 gallons by 128 to get 32 ounces. So, you would need to measure out 32 ounces for your application. The same thing for a weight. If you need 0.25 pounds, then multiply 0.25 by 16. This is calculated as 0.25 pounds times 16 to get 4 weight ounces of material.

PESTICIDE RATE AND DOSAGE CALCULATIONS

Dan Horton, Extension Entomologist

HOW TO CALCULATE PESTICIDE DILUTIONS AND DOSAGES FOR LARGE AREAS

Pesticides for use in sprays are generally available as wettable or soluble powders and as liquid concentrates. These must be diluted, usually with water, before use. Other diluents, such as de-odorized kerosene, may be used for special applications.

The precise amount of water applied to an acre (or other given area) is of modest concern as long as gallonage falls within a recommended range, delivers the recommended amount of pesticide, provides adequate coverage, and does not result in excessive runoff or drift. If you know the area (acres, sq. ft., etc.) or units (trees, cows, etc.) covered by a given amount of spray you can determine the dosage or rate of active ingredient each receives by adding the proper quantity of pesticide to that amount of water. Dusts and granules are applied without dilution by the user. Therefore the amount applied per acre or unit is much more critical because you have no other way of controlling the dosage or rate of active ingredient.

The amount of active ingredient in liquid concentrates is expressed in pounds per gallon. In granules, dusts, wettable or soluble powders, and other solids it is nearly always expressed as percent by weight. Application rates are usually expressed as amount of pesticide product but some- times they may be expressed as pounds of active ingredient or actual toxicant. Actual toxicant and active ingredient are practically synonymous.

1. To find the pounds of wettable powder (WP), dust (D) or granules (G) per acre to obtain the desired pounds of active ingredient (a.i.) per acre:

$$\textit{lbs. of WP, D or G per acre} = \frac{\textit{lbs. a.i. desired x 100}}{\textit{\% a.i. in WP, D, or G}}$$

2. To find the pints of liquid concentrate per acre to obtain the desired pounds of active ingredient (a.i.) per acre: pints of liq.
   **If you want the answer in gallons, quarts, or fluid ounces substitute l, 4, or l28 respectively for 8.*

$$\textit{conc. per acre} = \frac{\textit{lbs. a.i. desired x 8*}}{\textit{lbs. a.i. per gallon of liq. conc.}}$$

3. To find the amount of wettable powder (WP) or liquid concentrate to use in a given amount of spray:

   amt. of WP or liq conc. = no. of acres treated with amount of spray X desired amount of WP or liq. conc. per acre*
   **Trees, animal, etc. can be substituted for acres.*

4. To find the pounds of wettable powder needed to obtain a desired percentage of active ingredient in water:

$$\textit{lbs. of WP} = \frac{\textit{gals. of spray desired x \% a.i. desired x 8.3**}}{\textit{\% a.i. in WP}}$$

5. To find the gallons of liquid concentrate needed to obtain a desired percentage of active ingredient in water:
   ***One gallon of water weighs approximately 8.3 pounds. If another diluent is used the weight per gallon of the other diluent should be substituted for 8.3.*

$$\textit{gal. of liq. conc.} = \frac{\textit{gals. of spray desired x \% a.i. desired x 8.3**}}{\textit{lbs. a.i. per gal. of liq. conc. x 100}}$$

PESTICIDE CONVERSION TABLE FOR LARGE AREAS

LIQUID FORMULATIONS

Amount of Commercial Product to Add to Spray Tank for Each Acre Treated

FORMULATION LBS./GAL. ACTIVE INGREDIENT	Desired Rate Per Acre of Active Ingredient, Lbs.															
	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1	1.1	1.5	2	2.5	3	4	6	9
1.5	10 oz	17 oz	26 oz	34 oz	43 oz	51 oz	64 oz	85 oz	96 oz	128 oz	171 oz	213 oz	256 oz	341 oz	512 oz	768 oz
2	8 oz	13 oz	19 oz	26 oz	32 oz	38 oz	48 oz	64 oz	72 oz	96 oz	128 oz	160 oz	192 oz	256 oz	384 oz	576 oz
3	5 oz	9 oz	13 oz	17 oz	21 oz	26 oz	32 oz	43 oz	48 oz	64 oz	85 oz	107 oz	128 oz	171 oz	256 oz	384 oz
4	4 oz	6 oz	10 oz	13 oz	16 oz	19 oz	24 oz	32 oz	36 oz	48 oz	64 oz	80 oz	96 oz	128 oz	192 oz	288 oz
6	2.6 oz	4.3 oz	6.4 oz	9 oz	11 oz	13 oz	16 oz	21 oz	24 oz	32 oz	43 oz	53 oz	64 oz	85 oz	128 oz	192 oz
6.7	2.3 oz	3.8 oz	5.7 oz	7.6 oz	9.6 oz	11.5 oz	14.3 oz	19.1 oz	21 oz	29 oz	38 oz	48 oz	57 oz	76 oz	115 oz	172 oz
7	2.2 oz	3.7 oz	5.5 oz	7.3 oz	9.1 oz	11 oz	13.7 oz	18 oz	20 oz	27 oz	37 oz	46 oz	55 oz	73 oz	110 oz	165 oz
8	2 oz	3.2 oz	4.8 oz	6.4 oz	8 oz	9.6 oz	12 oz	16 oz	18 oz	24 oz	32 oz	40 oz	48 oz	64 oz	96 oz	144 oz

WETTABLE POWDER FORMULATIONS

Pounds of Commercial Product to Add to Spray Tank for Each Acre Treated

% ACTIVE INGREDIENT	Desired Rate Per Acre of Active Ingredient, Lbs.																
	0.2	0.3	0.4	0.5	0.6	0.8	0.8	1	2	2	3	3	4	4	5	8	10
50	0.4	0.6	0.8	1	1.2	1.5	1.6	2	2	3	4	5	6	8	10	16	20
75	0.3	0.4	0.5	0.7	0.8	1	1.1	1.3	2	2	3	3	4	5.3	6.6	10.7	13.33
80	0.3	0.4	0.5	0.6	0.8	0.9	1	1.2	2	2	3	3	4	5	6.2	10	12.5

PESTICIDE CONVERSION TABLE FOR LARGE AREAS (continued)

GRANULES AND DUSTS
Pounds of Commercial Product to Apply Per Acre

% ACTIVE INGREDIENT	Desired Rate Per Acre of Active Ingredient, Lbs.					
	1	2	3	4	5	10
2.5	40	80	120	160	200	400
5	20	40	60	80	100	200
10	10	20	30	40	50	100
15	6.6	13.3	20	26.6	33.3	66.6
20	5	10	15	20	25	50

CONVERSION TABLES FOR SMALL AREAS

LIQUID FORMULATIONS[1]
Amount of Commercial Product to Add to Spray Tank to Treat l000 Sq. Ft.

FORMULATION LBS./GAL. ACTIVE INGREDIENT	Desired Rate Per Acre of Active Ingredient, Lbs.							
	0.25	0.5	1	2	4	8	10	12
0.5	3 Tbs[1] (43.4)[3]	3 oz[2] (86.8)	6 oz (173.7)	11 oz 1 Tbs (347.4)				
1	1 Tbs 1 tsp (21.7)	3 Tbs (43.4)	3 oz (86.8)	5 oz 1 Tbs (173.7)				
2	2 tsp (10.8)	1 Tbs 1 tsp (21.7)	3 Tbs (43.4)	3 oz (86.8)	5 oz 1 Tbs (173.7)	11 oz 1 Tbs (342.4)		
4	1 tsp (5.4)	2 tsp (10.8)	1 Tbs 1 tsp (21.7)	3 Tbs (43.4)	3 oz (86.8)	6 oz (173.7)	7 oz 2 tsp (217.1)	8 oz 4 tsp (260.6)

[1] approximate values
[2] refers to level measure
[3] figure in parentheses refers to milliliters

PESTICIDE RATE AND DOSAGE CALCULATIONS

CONVERTING LARGE VOLUME RECOMMENDATIONS TO SMALL VOLUMES OR AREAS

Frequently, pesticide recommendations are given only for large volume applications, i.e. amount per l00 gallons or per acre, but only a small amount is needed. Conversion of liquids to smaller quantities is relatively easy and precise because suitable equipment such as measuring spoons are readily available. While scales sensitive enough to handle small quantities of solid materials are available, it is often more practical to use volumetric measures. Various conversion tables have been prepared on the premise that there are 200 to 300 teaspoons (roughly 2 to 3 pints) per pound of solid pesticide product. These tables are grossly inaccurate because of the wide variation in bulk density among solid pesticide formulations. For instance, a pint of almost any insecticide wettable powder will weigh much less than a pint of fungicide that has a high metal content. Greater accuracy can be obtained if one first determines the weight of a given volume of the solid material and then calculates the volumetric measure. This will usually provide acceptable accuracy but it is still not as accurate as actually weighing a solid formulation. When coupled with a little simple arithmetic the following formulas will enable you to convert large volume recommendations to smaller quantities.

1. To find the amount of liquid concentrate per gallon when label recommendations are given in pints per 100 gallons:

    teaspoons/gallon = recommended pints per 100 gallons x 1*
    or
    teaspoons/gallon = recommended pints per l00 gallons x 0.96
    or
    milliliters/gallon = recommended pints per 100 gallons x 4.73*

2. To find the amount of wettable powder (WP) or other solid formulation per gallon when label recommendations are given as pounds per 100 gallons:

    teaspoons/gallon = recommended lbs./ 100 gals. x cups in 1 lb. of formulation x 0.053*
    or
    teaspoons/gallon = recommended lbs./100 gals. x Tbs. in 1 ounce of formulation x 0.53*
    or
    grams/gallon = recommended lbs./100 gals x 4.54*

3. To find the amount of liquid concentrate to apply per 1,000 square feet when label recommendations are given as pints per acre:

    teaspoons/1,000 sq. ft. = recommended pints/acre x 2.20*
    or
    milliliters/1,000 sq. ft. = recommended pints/acre x 10.9*

4. To find the amount of dust (D), granules (G) or wettable powder (WP) to apply per 1,000 square feet when label recommendations are given as pounds per acre:

    lbs./1,000 sq. ft. = recommended lbs./acre x 0.023*
    or
    Tbs/1,000 sq. ft. = recommended lbs./acre x cups in 1 lb. of formulation x 0.37*
    or
    Tbs/1,000 sq . ft. = recommended lbs./acre x Tbs. in 1 lb. of formulation x 0.023*
    or
    grams/1,000 sq. ft. = recommended lbs./acre x 10.4*

*These values have been rounded off to facilitate calculations.

Section 14

Rainfall simulator

Michael Hall, NRCS Grassland Conservationist

Dan Wallace, NRCS State Resource Inventory Coor.

unlock the secrets in the soil basics & benefits

Healthy, fully functioning soil is balanced to provide an environment that sustains and nourishes plants, soil microbes and beneficial insects.

Managing for soil health is one of the most effective ways for farmers to increase crop productivity and profitability while improving the environment. Positive results are often realized within the first year, and last well into the future.

Soil Health

Soil is made up of air, water, decayed plant residue, organic matter from living and dead organisms, and minerals, such as sand, silt and clay. Increasing soil organic matter typically improves soil health since organic matter affects several critical soil functions. Healthy soils are also porous, which allows air and water to move freely through them. This balance ensures a suitable habitat for the myriad of soil organisms that support growing plants.

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Natural Resources Conservation Service

January 2013

It's not difficult to improve soil health. Here's how: till the soil as little as possible; grow as many different species of plants as possible through rotations and a diverse mixture of cover crops; keep living plants in the soil as long as possible with crops and cover crops; and keep the soil surface covered with residue year round.

Soil Health Benefits

Farmers who manage their land in ways that improve and sustain soil health benefit from optimized inputs, sustainable outputs and increased resiliency. Healthy soils benefit all producers – managers of large, row crop operations to people with small, organic vegetable gardens. Healthy soils provide financial benefits for farmers, ranchers and gardeners, and environmental benefits that affect everyone.

Healthy soils lead to:

Increased Production – Healthy soils typically have more organic matter and soil organisms which improve soil structure, aeration, water retention, drainage and nutrient availability. Organic matter holds more nutrients in the soil until the plants need them.

Increased Profits – Healthy soils may require fewer passes over fields because they are only minimally tilled and they aren't over-reliant upon excessive nutrient inputs to grow crops. Healthy soils can increase farmers' profit margins by reducing labor and expenses for fuel, and optimizing inputs.

Natural Resource Protection – Healthy soils hold more available water. The soil's water-holding capacity reduces runoff that can cause flooding, and increases the availability of water to plants during droughts. Good infiltration and less need for fertilizers and pesticides keep nutrients and sediment from loading into lakes, rivers, and streams. Groundwater is also protected because there is less leaching from healthy soils. Additionally, fewer trips across fields with farm machinery mean fewer emissions and better air quality.

Soil Health Management Systems

Implementing Soil Health Management Systems can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it. Soil Health Management Systems allow farmers to improve profitability because they spend less on fuel and energy while benefiting from the higher crop yields resulting from improved soil conditions.

Contact your local NRCS office to learn more about Soil Health Management Systems and the technical and financial assistance available to help "Unlock the Secrets in the Soil."

unlock your farm's potential discover the cover

unlock the SECRETS IN THE SOIL

Biodiversity increases the success of most agricultural systems.

Biodiversity helps to prevent disease and pest problems associated with monocultures. Using cover crops and increasing diversity within crop rotations improves soil health and soil function, reduces costs, and increases profitability. Diversity above ground improves diversity below ground, which helps create healthy productive soils.

Cover Crops

Cover crops can be an integral part of a cropping system. Cover crops can be managed to improve soil health, as they help to develop an environment that sustains and nourishes plants, soil microbes and beneficial insects.

Cover crops are typically planted in late summer or fall around harvest and before spring planting of the following year's crops. Examples of cover crops include rye, wheat, oats, clovers and other legumes, turnips, radishes, and triticale. Planting several cover crop species together in a mixture can increase their impact on soil health. Each cover crop provides its own set of benefits, so it's important to choose the right cover crop mixture to meet management goals.

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Cover Crop Benefits

Restoring Soil Health – Cover crops help increase organic matter in the soil and improve overall soil health by adding living roots to the soil during more months of the year. Cover crops can improve water infiltration into the soil. Deep-rooted crops like forage radishes create natural water passages. Legume cover crops serve as natural fertilizers while grasses scavenge nutrients that are often lost after harvest or during winter.

Natural Resource Protection – Along with crop residue above ground, cover crops protect the soil against erosive heavy rains and strong winds. Cover crops trap excess nitrogen, keeping it from leaching into groundwater or running off into surface water – releasing it later to feed growing crops.

Livestock Feed – Cover crops can provide livestock producers with additional grazing or haying opportunities.

Wildlife Habitat – Cover crops provide winter food and cover for birds and other wildlife. During the growing season, they can provide food for pollinators.

Soil Health Management Systems

Implementing Soil Health Management Systems can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it. Soil Health Management Systems allow farmers to enjoy profits because they spend less on fuel and energy while benefiting from the higher crop yields resulting from improved soil conditions.

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unlock the SECRETS IN THE SOIL

If soil health is your goal, till as little as possible.

Tillage can destroy soil organic matter and structure along with the habitat that soil organisms need. Tillage, especially during warmer months, reduces water infiltration, increases runoff and can make the soil less productive. Tillage disrupts the soil's natural biological cycles, damages the structure of the soil, and makes soil more susceptible to erosion.

Benefits of Reduced-Till/No-Till

Aiding in Plant Growth – Soils managed with reduced/no-till for several years contain more organic matter and moisture for plant use. Healthy soils cycle crop nutrients, support root growth, absorb water and sequester carbon more efficiently.

Reducing Soil Erosion – Soil that is covered year-round with crops, crop residue, grass or cover crops is much less susceptible to erosion from wind and water. For cropping systems, practices like no-till keep soil undisturbed from harvest to planting.

Saving Money – Farmers can save money on fuel and labor by decreasing tillage. Improving nutrient cycling allows farmers to potentially reduce the amount of supplemental nutrients required to maintain yields, further reducing input costs.

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Providing Wildlife Habitat – Crop residue, grass and cover crops provide food and escape for wildlife.

Production Inputs

Soils can be disturbed if inputs are not applied properly, potentially disrupting the delicate relationship between plants and soil organisms. Soil Health Management Systems help minimize that potential disturbance, while maximizing nutrient cycling, which can lead to greater profitability for producers.

Livestock Grazing

Improperly managed grazing can disturb the soil. There are several ways to graze livestock to reduce environmental impacts. For example, implementing a rotational grazing system instead of allowing livestock to continuously graze pasture allows pasture plants to rest and regrow.

Soil Health Management Systems

Implementing Soil Health Management Systems can lead to increased organic matter, more soil organisms, reduced soil compaction and improved nutrient storage and cycling. As an added bonus, fully functioning, healthy soils absorb and retain more water, making them less susceptible to runoff and erosion. This means more water will be available for crops when they need it.

Soil Health Management Systems allow farmers to enjoy profits over time because they spend less on fuel and energy while benefiting from the higher crop yields resulting from improved soil conditions. Healthy soils also provide a buffer for precipitation extremes (too wet or too dry).

Contact your local NRCS office to learn more about Soil Health Management Systems and the technical and financial assistance available to help "Unlock the Secrets in the Soil."

healthy, productive soils checklist for growers

Managing for soil health is one of the best ways farmers can increase crop productivity while improving the environment.

Results are often realized immediately and last well into the future. Following are four basic principles to improving the health of your soil.

1. Keep the soil covered as much as possible
2. Disturb the soil as little as possible
3. Keep plants growing throughout the year to feed the soil
4. Diversify as much as possible using crop rotation and cover crops

Use the checklist on the back of this page to determine if you're using core Soil Health Management System farming practices. It is important to note that not all practices are applicable to all crops. Some operations will benefit from just one soil health practice while others may require additional practices for maximum benefit. These core practices form the basis of a Soil Health Management System that can help you optimize your inputs, protect against drought, and increase production.

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June 2013

Soil Health Management Systems Include:

What is it?		What does it do?	How does it help?
Conservation Crop Rotation Growing a diverse number of crops in a planned sequence to increase soil organic matter and biodiversity in the soil.		• Increases nutrient cycling • Manages plant pests (weeds, insects, and diseases) • Reduces sheet, rill and wind erosion • Holds soil moisture • Adds diversity so soil microbes can thrive	• Improves nutrient use efficiency • Decreases use of pesticides • Improves water quality • Conserves water • Improves plant production
Cover Crop An un-harvested crop grown as part of planned rotation to provide conservation benefits to the soil.		• Increases soil organic matter • Prevents soil erosion • Conserves soil moisture • Increases nutrient cycling • Provides nitrogen for plant use • Suppresses weeds • Reduces compaction	• Improves crop production • Improves water quality • Conserves water • Improves nutrient use efficiency • Decreases use of pesticides • Improves water efficiency to crops
No Till A way of growing crops without disturbing the soil through tillage.		• Improves water holding capacity of soil • Increases organic matter • Reduces soil erosion • Reduces energy use • Decreases compaction	• Improves water efficiency • Conserves water • Improves crop production • Improves water quality • Saves renewable resources • Improves air quality • Increases productivity
Mulch Tillage Using tillage methods where the soil surface is disturbed but maintains a high level of crop residue on the surface.		• Reduces soil erosion from wind and rain • Increases soil moisture for plants • Reduces energy use • Increases soil organic matter	• Improves water quality • Conserves water • Saves renewable resources • Improves air quality • Improves crop production
Mulching Applying plant residues or other suitable materials to the soil surface to compensate for loss of residue due to excessive tillage.		• Reduces erosion from wind and rain • Moderates soil temperatures • Increases soil organic matter • Controls weeds • Conserves soil moisture • Reduces dust	• Improves water quality • Improves plant productivity • Increases crop production • Reduces pesticide usage • Conserves water • Improves air quality
Nutrient Management Managing soil nutrients to meet crop needs while minimizing the impact on the environment and the soil.		• Increases plant nutrient uptake • Improves the physical, chemical and biological properties of the soil • Budgets, supplies, and conserves nutrients for plant production • Reduces odors and nitrogen emissions	• Improves water quality • Improves plant production • Improves air quality
Pest Management Managing pests by following an ecological approach that promotes the growth of healthy plants with strong defenses, while increasing stress on pests and enhancing the habitat for beneficial organisms.		• Reduces pesticide risks to water quality • Reduces threat of chemicals entering the air • Decreases pesticide risk to pollinators and other beneficial organisms • Increases soil organic matter	• Improves water quality • Improves air quality • Increases plant pollination • Increases plant productivity

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HEALTHY SOILS ARE: *covered all the time.*

Cover Saves Scarce Water

Extreme temperature changes and high winds characteristic of the semiarid, short-grass prairie of the the Great Plains can have drastic and devastating effects on exposed soil. In the High Plains sub-region of the Great Plains, more than 65 percent of the soil must remain covered to limit evaporation of water. Bare soil heats up quickly in direct sunlight; and the hotter it gets, the faster water evaporates from it.

In this rainfall-limited area (average annual rainfall is 10-20 inches), maintaining soil cover is a key to profitable agricultural production.

The combination of high winds and hot temperatures wastes water if soils aren't covered. However, ground cover (both living and residues) limits the drying effect of wind, shades the soil from hot sun, and traps snow during winter. All of which add up to more water infiltrating into the soil and less evaporating into the air.

unlock the SECRETS IN THE SOIL

IF YOU'RE TRYING TO MAKE YOUR SOIL HEALTHIER, YOU SHOULDN'T SEE IT VERY OFTEN.

In other words, soil should always be covered by growing plants, their residues, or a combination of the two. Keeping the soil covered all the time makes perfect sense when you realize that healthy soils are full of life and that the microorganisms living in the soil have the same needs as other living creatures. They need food and cover to survive.

When you have a vegetative cover on the soil, especially a living cover, you offer those microbes both food and shelter. Some scientists say when you till the soil and remove crop residues, the effects are as devastating to soil microbes as a combination of an earthquake, hurricane, tornado, and forest fire would be to humans. From the perspective of the living creatures within the soil, a tillage tool like a chisel shank has the effect of ripping the ground like an earthquake; removing residue is like a tornado ripping the roof off a house; uncovered soil can be drenched and whisked away by gushing water and wind like that of a hurricane—or scorched in the hot sun like an out-of-control fire.

STOP THE SPLASH, HARVEST THE BENEFITS

When a falling raindrop explodes as it hits bare soil, it dislodges unprotected soil particles, and begins the process of soil erosion. Cover crops and plant residue prevent that violent splash on soil, protecting soil aggregates from being pounded by falling raindrops.

Safe from disintegration by the hammering energy of raindrops, the structure of healthy soils remains intact, which prevents soil crusting. In this protective environment, water infiltrates the soil and becomes available to plant roots.

A mulch of crop residues or living plants on the soil surface also suppresses weeds early in the growing season, giving the primary crop a competitive

HEALTHY SOILS ARE: *covered all the time.*

advantage. This is especially the case if the cover crop is rolled prior to planting the main crop because the entire soil surface is covered and protected.

Cover crops can build moisture reserves far better than row crops can by themselves. Cover crops open pores and small channels in the soil for better water infiltration, and the organic matter they build helps retain both moisture and nutrients.

The cool, moist soil of cover crops also provides favorable habitat for many organisms that decompose residues and recycle nutrients for the next crop. Providing a good habitat for these organisms can increase residue decomposition, and improve nutrient cycling, by up to 25 percent.

LIVING PLANTS GO BEYOND COVER

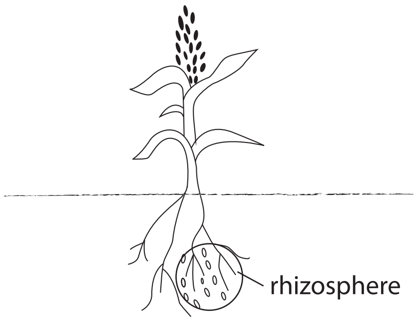
While it's easy to see the importance of giving the soil protection above the ground, it's not always as easy to recognize benefits living covers provide below the surface.

Through their roots, living plants offer soil microbes their easiest, most reliable food source. Because these soil microbes need a consistent food source throughout the year to thrive, cropping plans that include crop rotations with cover crops throughout the growing season (or perennial grasses and legumes) can help sustain them year-round.

WANT TO LEARN MORE?

VISIT WWW.NRCS.USDA.GOV

Living in the Rhizosphere



Every soil organism has something it eats…and something that eats it. Each organism and each bit of plant residue is important to the complex food web under the soil surface. While each source of microbial food is important to a balanced food web in a healthy soil, there is no better food for soil microbes than the sugars exuded by living roots.

Living plants maintain a rhizosphere, an area of concentrated microbial activity close to the root. The rhizosphere is the most active part of the soil biology because it is where the most easy-to-eat food is available for microbes. It's also critical for plant growth and health, because those microbes, in turn, provide essential nutrient cycling for crops.

Because living roots provide the easiest source of food for soil microbes, growing perennial crops or long-season cover crops is the key to feeding the foundational species of the soil food web—so they'll be healthy and ready to perform throughout the primary growing season.

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HEALTHY SOILS ARE: *well-structured.*

Give it the Stake Test!

Does your soil have good structure? Give it the slake test! Ray Archuleta, an agronomist with the USDA Natural Resources Conservation Service with a passion for soil health, has done the test scores of times. Anyone can do it, he says, and he predicts it will open your eyes.

"What happens with poor soil structure is that the pores collapse in water and the soil breaks apart," Archuleta says. "Soil with good structure—the untilled soil—can still be intact for the most part even 24 hours later. The reason for the difference is soil structure. Biological cementing, the work of soil microbes, glues the aggregates of the untilled soils together."

In a similar test, an infiltration or rainfall simulation test, Archuleta puts the two soil samples in wire mesh inserted into empty jars, then simulates rainfall onto them.

"When you put a tilled soil and an un-tilled soil in yarn jars and simulate rainfall onto them, you quickly see the untilled soil allows the water to infiltrate the whole profile. On the other hand, water stays on top of the tilled soil much longer," Archuleta says.

Continued on back

unlock the SECRETS IN THE SOIL

"SOFT AND CRUMBLY." "LIKE COTTAGE CHEESE." "LIKE A SPONGE." "LOOSE AND FULL OF HOLES."

Those and other common descriptions of what healthy soil looks and feels like refer to good soil structure.

Soil structure, the arrangement of the solid parts of the soil and the pore space between them, is critical to how the soil functions. When the solid parts—sand, silt and clay particles—cling together as coarse, granular aggregates, the soil has a good balance of solid parts and pore space.

Highly aggregated soils—those granular, durable, distinct aggregates in the topsoil that leave large pore spaces between them—are soils with good tilth and good structure.

Well-structured soils have both macropores (large soil pores generally greater than 0.08 mm in diameter) and micropores (small soil pores with diameters less than 0.08 mm that are usually found within structural aggregates).

An interconnected network of pores associated with loosely packed, crumbly, highly aggregated soils allows rapid infiltration and easy movement of both water and air through the soil and provides habitat for soil organisms.

Chemical and physical factors play a prominent role in small aggregate formation in clay soils, while biological processes drive development of large aggregates and macropores. Earthworms, for instance, produce both new aggregates and pores. Their binding agents are responsible for the formation of water-stable, macro-aggregates, and their burrowing creates continuous pores linking surface to subsurface soil layers. As they feed, earthworms also speed plant residue decomposition, nutrient cycling, and redistribution of nutrients in the soil profile.

HEALTHY SOILS ARE: *covered all the time.*

Soil organic matter also helps develop stable soil aggregates. Soil microorganisms that are fed with organic matter secrete a gooey protein called glomalin, an effective short-term cementing agent for large aggregates. Organic glues are produced by fungi and bacteria as they decompose plant residues. Water-resistant substances produced by microorganisms, roots, and other organic matter, provide long-term aggregate stability from a few months to a few years.

TILAGE DESTROYS STRUCTURE

Management practices that reduce soil cover, disrupt continuous pore space, compact soil, or reduce soil organic matter, negatively impact soil structure. Since tillage negatively affects all of these properties, it's high on the list of practices damaging to healthy soils.

When tillage loosens the soil, it leaves soil particles exposed to the forces of wind and water. Transported by wind and water, detached soil particles settle into pores, causing surface sealing, compaction and reduced infiltration. When this happens less water is available to plants and runoff and erosion increases.

By contrast, soils that are not tilled and are covered with diverse, high residue crops throughout the year have better soil structure, are highly aggregated, with high levels of organic matter and microorganism activity, high water holding capacity, high infiltration rates, and little compaction.

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"I think these tests are powerful visual tools to help explain and help people remember how soils function" Archuleta continues. "I used to think if I tilled the soil—fluffed it up—it would allow more water in. But that's just not true. Tilling soil closes pore space and keeps rainfall from infiltrating. You've got to have pore space in your soil from top to bottom."

"The tests tell me in our watersheds we have an infiltration problem, not a runoff problem," he concludes. "What I mean is, if we focus on building healthy soils that result in more infiltration, we'll do what we need to do to eliminate much of the runoff."

How to do the Slake Test

The slake test compares two chunks of topsoil in water to see how well and how long they will hold together. Here are the steps:

1. Collect a chunk of topsoil—a size that would fit in your hand—from an area where you don't till, like a fencerow, or a field you've no-tilled or had in grass for many years.
2. Get a second spade-full or chunk of soil from a field you've tilled consistently. It should be the same soil type as the first sample.
3. Find two glass jars, yarn jars or some kind of clear glass jars large enough to hold the chunks of soil.
4. Put together some type of wire mesh that you can hook at the top of each jar that will allow the soil to be submerged in the water, yet be held within the top half of the jar.
5. Insert the wire meshes into each jar.
6. Fill the jars with water.
7. At the same time, submerge the tilled sample in one jar, and the untilled sample in the other.
8. Watch to see which soil holds together and which one falls apart. The soil with poor structure is the one that will begin to fall apart.

If you want to see "Ray the Soil Guy" demonstrate the test or the infiltration test, checkout our online resources.

Section 15

New weed management tools for grazed pastures

Dr. Patrick McCullough, UGA

WEED CONTROL IN GRASS PASTURES AND HAYFIELDS

(Including bermudagrasses, bahiagrasses, fescues, and other perennial pasture grasses)

Patrick E. McCullough, Extension Agronomist-Weed Science

USE STAGE/ HERBICIDE	BROADCAST RATE/ACRE: AMOUNT OF FORMULATION	BROADCAST RATE/ACRE: POUNDS ACTIVE INGREDIENT	REMARKS AND PRECAUTIONS
NEWLY SPRIGGED BERMUDAGRASS			
diuron Direx 4 L Diuron 4L Diuron 4L Diuron 80	 0.8-2.4 qt 0.8-2.4 qt 0.8-2.4 qt 1.0-3.0 lb	0.8-2.4 lb	Preemergence applications of diuron provide fair to good control of crabgrass, crowfootgrass and goosegrass. Also provides residual control of certain annual broadleaf weeds. Diuron should be applied immediately after sprigging before weeds emerge. Bermuda sprigs should be planted 2 inches deep to lessen chance of injury. Emerged bermuda at the time of treatment may be temporarily injured. Do not graze or feed treated foliage for 70 days after diuron application. Diuron is not labeled in established forage bermudagrass.
2,4-D Esteron 99C 4 lbs./gal. 2,4-D LV 4 Ester 2,4-D LV 6 Ester	 1.0-2.0 qts 1.0-2.0 qt 1.3-3.0 pts	1.0-2.0	Apply to emerged broadleaf weeds 3-4 inches tall. Provides poor preemergence control of crabgrass. Refer to specific herbicide label for use information.
2,4-D + *dicamba* WeedMaster 2.87 + 1.0 lb./gal.	2.0 to 4.0 pt	0.72 + 0.25 to 1.44 + 0.5	Apply 7 to 10 days after sprigging for the postemergence control of seedling broadleaf and grass weeds. Reduced control will occur if weeds are taller than 1.0 inch, or if weed seed germination occurs 10 or more days after application. Do not graze lactating dairy animals within 7 days of application. There is no grazing restriction after an application and non-lactating animals. Do not graze meat animals in treated areas within 30 days of slaughter. Do not cut for hay within 37 days of treatment.
ESTABLISHED DORMANT BERMUDAGRASS			
paraquat Firestorm 3.0 lbs.gal. Gramoxone Inteon 2.0 lbs./gal.	 0.7-1.3 pts 1.0-2.0 pt	0.25-0.5	Apply in 20 to 30 gallons of water in late winter or early spring (probably in February or March) before bermudagrass begins spring green-up. Add 1 pt. surfactant (non-ionic) per 10 0 gal. spray mix. Do not pasture or mow for hay until 40 days after treatment.
glyphosate Roundup PowerMax Roundup Original Max Roundup Weather Max 5.5 lbs./gal.	8.0 to 11 fl oz	0.34-0.47	Apply in mid- to late-winter months to bermudagrass pastures and hayfields for the control of little barley, cheat, and to suppress Italian (annual) ryegrass. Apply before new growth appears in the spring. Bermudagrass that is not dormant at the time of application may show a slight (2 to 4 week) delay in green-up. There is no grazing or hay restriction for any type of livestock.
ESTABLISHED FORAGE GRASSES			
2,4-D (various trade names) 4 lbs./gal.	1 qt-2 qt	1.0-2.0	Apply to weeds 2 -4 inches tall. Use low rates for small weeds, high rates for larger weeds. Apply low volatile esters from October through March. Apply only non-volatile AMINE or ACID formulations from late March through September. Do not graze lactating dairy animals for 14 days after treatment, or cut for hay for all types of livestock for 30 days after treatment. (Grazing and haying restrictions may vary - refer to product label). If thistles are present, apply while they are in the rosette stage of growth.
2,4-D (mixed amines) Hi-Dep 3.8 lbs./gal.	1.0-2.0 qt	0.95-1.9	Hi-Dep consists of dimethylamine and diethanolamine salts of 2,4-D formulated for low spray volume applications. DO NOT graze dairy cattle for 7 days after application. DO NOT cut for hay for 30 days after applications.

USE STAGE/ HERBICIDE	BROADCAST RATE/ACRE AMOUNT OF FORMULATION	POUNDS ACTIVE INGREDIENT	REMARKS AND PRECAUTIONS
ESTABLISHED FORAGE GRASSES			
dicamba Banvel 4 lbs./gal. Clarity 4 lbs./gal.	1-3 pt 1-3 pt	0.5-1.5 0.5 -1.5	Controls a wide range of broadleaf weeds. There are no grazing restrictions for animals other than lactating dairy animals. Restrict grazing for lactating dairy animals as follows: **Days Before Grazing / Days Before Hay Harvest** Up to 1 pint: 7 / 37 Up to l quart: 21 / 51 Up to 2 quarts: 40 / 70 Remove meat animals from treated areas 30 days prior to slaughter. If thistles are present, apply while they are in the rosette stage of growth. This treatment will severely injure or kill clovers and alfalfa.
carfentrazone Aim EW 1.9 lbs./gal. Aim EC 2.0 lbs./gal.	1.0-2.0 fl oz 1.0-2.0 fl oz	0.015 to 0.03 0.016 to 0.031	Controls numerous annual broadleaf weeds less than 3.0 inches tall. Carfentrazone does not control weedy grasses or sedges. Apply with a nonionic surfactant at 0.25% v/v, or a crop oil concentrate at 1.0% v/v. For most weeds, carfentrazone is tank-mixed with other registered grass pasture and hay field herbicides. Combining carfentrazone with other herbicides often increases overall control and speed of control. There are no grazing or haying restrictions for any type of livestock for carfentrazone.
2,4-D + *dicamba* Weedmaster 2.87 lbs. + 1 lb./gal. Outlaw 1.45 + 1.1 lbs./gal	2.0 pt to 4.0 pt 2.0 pt to 4.0 pt	0.72 + 0.25 to 1.44 + 0.5 0.36 + 0.27 to 0.72 + 0.55	For control of a broad spectrum of weeds, apply in late spring or early summer to annual or perennial broadleaf weeds before flowering. Do not graze lactating dairy animals within 7 days. There is no restriction between application and grazing for non-lactating animals. Do not cut for hay within 37 days after treatment. Do not graze meat animals in treated areas within 30 days of slaughter. If thistles are present, apply while they are in the rosette stage of growth. For horsenettle, use the high rate. Weedmaster and Outlaw will severely injure or kill clovers or alfalfa.
2,4-D + *picloram* Grazon P+D GunSlinger HiredHand 2 lbs. + 0.54 lb./gal.	2.0 pt to 4.0 pt	0.5 + 0.13 to 1.0 + 0.26	Controls annual and perennial broadleaf weeds. Use only in PERMANENT GRASS PASTURES AND HAYFIELDS. 2,4-D + picloram may also be applied at 4.0 pts./acre or less to permanent pastures that will be seeded with cool-season grasses (ryegrass, tall fescue). Delay planting for 21 days after application. Small grains should not be planted in treated areas for 60 days after application. For permanent pastures that have been over seeded wit h small grains or ryegrass, do not apply at rates in excess of 1.5 pts./acre and until over seeded ryegrass or small grains are well-established and at the tillering stage of growth. Clover seeding restrictions are as follows: fall-seeding is permitted if Grazon P+D at 2 pts./acre or less is applied no later than June (4 month plant back). Spring (Feb. – Mar.) seeding is permitted the following spring for Grazon P+D at 2 to 3 pts./acre if applied no later than Sept. 15 the previous year. The Gunslinger label indicates that legume establishment may not be successful if done within 12 months of application. 2,4-D + picloram may be used at 1.5 pts./acre after establishment of newly-sprigged bermudagrass once stolons have reached 6 inches in length. This herbicide is not recommended for use in rotational systems that utilize broadleaf crops or in temporary summer or winter grazing grass systems unless temporary grass is seeded into a permanent pasture. Do not graze lactating dairy animals on treated areas within 7 days after application. There are no grazing restrictions for non-lactating dairy animals, horses, sheep, goats and other types of livestock. Do not harvest grass cut for hay from treated areas for 30 days. Do not use hay from treated areas for composting or mulching of susceptible broadleaf crops. Withdraw meat animals from treated forage at least 3 days before slaughter. Do not transfer livestock from treated areas, or from 2,4-D + picloram treated hay feeding areas on to broadleaf crop areas without first allowing livestock to graze for 7 days on an untreated grass pasture. Do not store or feed 2,4-D + picloram treated hay on fields that will be planted to broadleaf crops. Do not use manure from livestock grazing on 2,4 -D + picloram treated areas on gardens, broadleaf crops or orchards. 2,4-D + picloram will injure or kill legumes such as clovers and alfalfa. Restricted Use Herbicide.

USE STAGE/ HERBICIDE	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
	AMOUNT OF FORMULATION	POUNDS ACTIVE INGREDIENT	
ESTABLISHED FORAGE GRASSES			
picloram + *fluroxypyr* Surmount 1.2 + 0.96 lb./gal.	1.5 pt to 6.0 pt	0.22 + 0.18 to 0.9 + 0.72	Controls a wide range of herbaceous and woody broadleaf plants. Use 1.5 to 2.0 pts./ acre for herbaceous broadleaf weeds. Use 3.0 to 6.0 pts./acre for woody brush and trees. Use only in PERMANENT GRASS PASTURES AND HAYFIELDS. This herbicide is not recommended for use in rotational systems that utilize broadleaf crops or in temporary summer or winter grazing grass systems unless temporary grass is seeded into a permanent pasture. Do not graze lactating dairy animals on treated areas within 14 days after application. There are no grazing restrictions for non- lactating dairy animals, horses, sheep, goats and other types of livestock. Do not harvest grass cut for hay from treated areas for 7 days. Do not use hay from treated areas for composting or mulching of susceptible broadleaf crops. Withdraw meat animals from treated forage at least 3 days before slaughter. Do not transfer livestock from treated areas, or from Surmount treated hay feeding areas on to broadleaf crop areas without first allowing livestock to graze for 7 days on an untreated grass pasture. Do not store or feed Surmount treated hay on fields that will be planted to broadleaf crops. Do not use manure from livestock grazing on Surmount treated areas on gardens, broad leaf crops or orchards. Surmount will injure or kill legumes such as clovers and alfalfa. New legume plantings may not be successful if seeded within one year of application. Restricted Use Herbicide.
triclopyr + *fluroxypyr* PastureGard 1.5 + 0.5 lbs ./gal.	1.5 to 8.0 pt	0.3 + 0.1 to 1.5 + 0.5	Controls a wide range of herbaceous and woody broadleaf plants. Use 1.5 to 3.0 pts./ acre for herbaceous broadleaf weeds. Use 2.0 to 8.0 pts./acre for woody brush and trees. Do not graze lactating dairy animals on treated areas during the same growing season following application. There are no grazing restrictions for non-lactating dairy animals, horses, sheep, goats and other types of livestock. Do not harvest grass cut for hay from treated areas for 14days. Withdraw meat animals from treated forage at least 3 days before slaughter. Legumes may be planted 30 days after application. Do not reseed forage grasses for 21 days after application.
aminopyralid Milestone 2.0 lbs./gal.	4.0 to 7.0 fl oz	0.06- 0.11	Apply to permanent grass pastures and hayfields. Controls numerous annual and perennial broadleaf weeds - particularly effective for the control of horsenettle and tropical soda apple. There are no grazing or haying restrict ions for Milestone for any type of livestock. Do not transfer livestock from treated pastures, or from Milestone treated hay feeding areas on to broad leaf crop areas without first allowing livestock to graze for 3 days on an untreated grass pasture. Do not store or feed Milestone treated hay on fields that will be planted to broadleaf crops. Do not use manure from livestock grazing on Milestone treated areas on gardens, broadleaf crops or orchards. Milestone will injure or kill legumes such as clovers and alfalfa. Do not plant legumes or broadleaf crops until a field bioassay has shown that the aminopyralid concentration in the soil is not at a level that will injure broadleaf crops (see label for instructions on conducting field bioassay).
aminopyralid + *2,4-D* ForeFront GrazonNext 0.33 + 2.6 7 lbs./gal.	1.5 to 2.6 pt	0.06 + 0.5 to 0.11 + 0.9	Apply to permanent grass pastures and hayfields. Controls numerous annual and perennial broadleaf weeds - particularly effective for the control of horsenettle and tropical soda apple. Controls a wider spectrum of weed species than Milestone. There are no grazing restrictions for ForeFront and GrazonNext for any type of livestock. Do not harvest for hay within 7 days of application (all types of livestock). Do not transfer livestock from treated pastures, or from ForeFront or GrazonNext treated hay feeding areas on to broadleaf crop areas without first allowing livestock to graze for 3 days on an untreated grass pasture. Do not store or feed ForeFront or GrazonNext treated hay on fields that will be planted to broadleaf crops. Do not use manure from livestock grazing on ForeFront or Grazon Next treated areas on gardens, broadleaf crops or orchards. ForeFront and GrazonNext will injure or kill legumes such as clovers and alfalfa. Do not plant legumes or broadleaf crops until a field bioassay has shown that the aminopyralid concentration in the soil is not at a level that will injure broadleaf crops (see label for instructions on conducting field

USE STAGE/ HERBICIDE	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
	AMOUNT OF FORMULATION	POUNDS ACTIVE INGREDIENT	
ESTABLISHED FORAGE GRASSES			
aminopyralid + *metsulfuron* Chaparral DF 0.62 + 0.0945 lb./lb.	1.5-3.0 oz	0.06 + 0.0009 to 0.12 + 0.018	Apply to permanent grass pastures and hayfields. Bermudagrass should be established for 60 days and tall fescue for two years prior to use. Apply with 0.25% v/v nonionic surfactant per 100 gal. of spray mix. Controls numerous annual and perennial broadleaf weeds - particularly effective for the control of horsenettle and tropical soda apple. Also, controls 'Pensacola' bahiagrass. Controls a wider spectrum of weed species than Milestone. There are no grazing or haying restrict ions for Chaparral for any type of livestock. Do not transfer livestock from treated pastures, or from Chaparral treated hay feeding areas on to broad leaf crop areas without firs t allowing livestock to graze for 3 days on an untreated grass pasture. Do not store or feed Chaparral treated hay on fields that will be planted to broadleaf crops. Do not use manure from livestock grazing on Chaparral treated areas on gardens, broadleaf crops or orchards. Chaparral will injure or kill legumes such as clovers and alfalfa. Do not plant legumes or broadleaf crops until a field bioassay has shown that the aminopyralid concentration in the soil is not at not at a level that will injure broadleaf crops (see label for instructions on conducting field bioassay). On tall fescue, applications in the early spring may suppress seedhead production and reduce h ay yield. To minimize injury to tall fescue; a) tank-mix 2,4-D, b) use the lowest recommended rate for the target weeds, c) use a 1/16 to 1/8% v/v surfactant concentration, d) make application s in the late spring or fall months after 5 to 6 inches of new growth has occurred, and e) do not add a surfactant when applied with liquid N.
2,4-D + *triclopyr* Crossbow 2 lbs. + 1 lb./gal.	1-6 qt		Apply to established grass pastures for control of broadleaf weeds and woody plants. Woody plant control requires 6 qts./A. or higher rate. Desirable forage broadleaf plants such as clover or alfalfa may be killed if sprayed. <u>Grazing and haying restrictions</u>**: Grazing or harvesting of green forage: (1) Lactating dairy animals** - Two gallons/acre or less; Do not graze or harvest green forage from treated area for 14 days after treatment. Greater than 2 gallons to 4 gallons/acre: Do not graze or harvest green forage until next growing season. (2) Other livestock - Two gallons/acre or less: No grazing restrictions. Greater than 2 gallons to 4 gallons/acre: Do not graze or harvest green forage from treated areas for 14 days after treatment. Note: If less than 25% of a grazed area is treated, there is no grazing restriction. **<u>Haying (harvesting of dried forage):</u> (1) Lactating dairy animals:** Do not harvest hay until next growing season. **(2) Other livestock:** Two gallons/acre or less: Do not harvest hay for 7 days after treatment. Greater than 2 gallons to 4 gallons/acre: Do not harvest hay for 14 days after treatment.
triclopyr + *clopyralid* Redeem 2.25 lbs. + 0. 75 lb./gal.	1.5-4.0 pt	0.38 to 1.12 + 0.14 to 0.38	Apply for control of broadleaf weeds. Use 2.5 to 4.0 pts./acre to control dogfennel, spiny amaranth and horsenettle. Desirable forage broadleaf plants such as clover or alfalfa may be killed if sprayed. Do not apply to newly-seeded or sprigged grasses until they are well established as evidenced by tillering, development of a secondary root system and vigorous growth. <u>Grazing and haying restrictions:</u> **Grazing or harvesting of green forage: (1) Lactating dairy animals** - Do not graze or harvest green forage from treated area for 14 days after treatment. **(2) Other livestock** - No grazing restrictions. **Haying (harvesting of dried forage): (1) Lactating dairy animals:** Do not harvest hay until next growing season. **(2) Other livestock:** Do not harvest hay for 7 days after treatment.

USE STAGE/ HERBICIDE	BROADCAST RATE/ACRE: AMOUNT OF FORMULATION	BROADCAST RATE/ACRE: POUNDS ACTIVE INGREDIENT	REMARKS AND PRECAUTIONS
ESTABLISHED FORAGE GRASSES			
imazapic Impose Panoramic 2.0 lbs./gal	4.0-8.0 fl oz	0.063-0.125	Apply to established bermudagrass. Do not apply to other forage grass species. Provides postemergence control of crabgrass, sandbur, broadleaf signalgrass, johnsongrass, vaseygrass, nutsedge and certain other weeds. This herbicide does not control pricklypear cactus, dallisgrass and goosegrass. Apply in late spring to mid-summer after bermudagrass has reached 100% green-up growth stage. Do not apply during spring transition or to dormant bermudagrass. Imazapic is not recommended on newly-sprigged or seedling bermudagrass during the grow-in period. Research has shown that imazapic will moderately injure (yellowing of bermudagrass foliage), and suppress bermudagrass growth for approximately 20 to 40 days after application. Additionally, bermudagrass hay yields may be reduced 30 to 50% at the first hay harvest (usually 30 days) following application. Imazapic should not be applied unless a bermudagrass yield reduction is acceptable. No bermudagrass hay yield reduction has been observed at the 2nd, 3rd and 4th hay harvest following an application at 4.0 fl. ozs./acre. Add a nonionic surfactant (preferred) at 0.25% v/v or methylated seed oil at 1.5 to 2.0 pts./acre to the spray mix. The use of 2 to 3 pts./acre of 28% N, 32% N, 10-34-0 or ammonium sulfate in combination with the recommended rate of surfactant may increase control. Liquid fertilizer may be used as the sole spray carrier for imazapic, but control may be reduced. Do not add a surfactant or methylated seed oil if liquid fertilizer is used as the sole spray carrier. Annual ryegrass may be seeded 60 days after application. There is no grazing restriction for imazapic any type of livestock. Do not cut for hay for 7 days after application.
sulfosulfuron OutRider 75DF	1.33 oz	0.062	Recommended for the control of emerged johnsongrass and sedge species in bermudagrass and bahiagrass forage systems. DO NOT use OutRider on other forage grass species such as tall fescue. OutRider does not control annual grasses such as crabgrass and sandbur, or perennial grasses such as dallisgrass and vaseygrass. Apply to johnsongrass a minimum of 18 in. tall up to the heading stage. Apply to sedges 6 to 10 inches tall. Add a nonionic surfactant at 0.25% v/v. OutRider may be tank-mixed with other pasture herbicides; however, amine formulations may reduce johnsongrass control. Grazing may occur immediately before or after application; however, control may be reduced by grazing of johnsongrass foliage. For best results, do not graze or mow for two weeks before or after application.
pendimethalin Prowl H_2O 3.8 lbs./gal.	3.1-4.2 qt	3.0-4.0	Provides good preemergence control of summer annual grasses such as crabgrass and sandbur and some annual broadleaf weeds. Prowl H_2O is labeled only for established dormant bermudagrass. Applications to newly-sprigged bermudagrass, tall fescue, bahiagrass and other perennial forage grasses are not recommended. Apply Prowl H_2O to established bermudagrass in winter dormancy in the late winter and early spring. In most areas of Georgia, this would be February through early March. Crabgrass begins to germinate when soil temperatures average 55°F. Prowl H_2O must be applied before crabgrass or other annual grasses germinate. Research conducted in Georgia has shown that usually 3.0 to 4.0 lbs. ai/acre (3.1 to 4.2 quarts per acre) is needed for season-long annual grass control. Prowl H_2O may be tank-mixed with other herbicides registered for use on forage bermudagrass. Prowl H_2O should not be applied less than 45 days prior to bermudagrass hay harvest. Do not graze Prowl H_2O treated bermudagrass until 60 days after application.

WEED CONTROL IN GRASS PASTURES AND HAYFIELDS

USE STAGE/ HERBICIDE	BROADCAST RATE/ACRE AMOUNT OF FORMULATION	BROADCAST RATE/ACRE POUNDS ACTIVE INGREDIENT	REMARKS AND PRECAUTIONS
ESTABLISHED FORAGE GRASSES			
triclopyr Remedy 4 lbs./gal.	1.0-2.0 pts.	0.5-1.0	Apply to established grass pastures for control of broadleaf weeds and brush. Triclopyr may be tank-mixed with 2,4-D for broader spectrum weed control and control of sensitive woody species. Desirable forage broadleaf plants such as clover or alfalfa may be killed if sprayed. Applications at air temperatures > 85 F. may cause moderate to severe bermudagrass injury for two to three weeks. <u>Grazing restrictions:</u> **Grazing or harvesting green forage: (1) Lactating dairy animals:** Two quarts/acre or less: do not graze or harvest green forage from treated areafor 14 days after treatment. **(2) Other livestock:** Two quarts/acre or less: no grazing restrictions. **<u>Haying restriction):</u> (1) Lactating dairy animals:** Do not harvest hay until the next growing season. **(2) Other livestock:** Two quarts /acre or less: Do not harvest hay for 7 days after treatment. **Slaughter Restrictions:** Withdraw livestock from grazing treated grass or consumption of treated hay at least 3 days before slaughter.
glyphosate Roundup PowerMax 5.5 lbs./gal. supplemental label	10 fl oz	0.43	Apply after the first bermudagrass cutting when bermudagrass has not yet initiated regrowth. Controls crabgrass, field sandbur, seedling johnsongrass and most annual grasses. Applications made after regrowth has begun will damage bermuda grass. DO NOT graze or cut for hay for 28 days after application. Make only one application per year. DO NOT make an application after the first cutting if the field has previously received a glyphosate application during the winter months.
diflufenzopyr + *dicamba* Overdrive 76.4% DF 0.2 lbs. + 0.5 lbs./gal.	4.0 oz to 8.0 oz	0.05 + 0.125 to 0.1 + 0.25	Controls annual and perennial broadleaf weeds. Add a nonionic surfactant at 0.25% v/ v or methylated seed oil at 2.0 pts./acre to the spray mix. Diflufenzopyr has been shown t o improve t he activity of "auxin-like" herbicides such as triclopyr, clopyralid and picloram. May be tank-mixed with Grazon P+D, Remedy, Redeem, 2,4-D and Cimarron to increase spectrum of weed species controlled. Overdrive is rainfast within 4 hours after application. DO NOT plant any rotational crop within 30 days of an Overdrive application. There are no grazing or haying restrictions for Overdrive for any type of livestock.
metsulfuron Metsulfuron 60EG Patriot 60DF	0.1-0.4 oz	0.004-0.015	Apply to established bermudagrass for the control of 'Pensacola' bahiagrass and certain broadleaf weeds. Bermudagrass should be established for 60 days and tall fescue for two years prior to use. Apply <u>1 pt.-1 qt. nonionic surfactant per 100 gal. of spray mix.</u> On tall fescue, applications in the early spring may suppress seedhead production and reduce h ay yield. To minimize injury to tall fescue; a) tank-mix 2,4-D with metsulfuron, b) use the lowest recommended rate for the target weeds, c) use a 1/16 to 1/8% v/v surfactant concentration, d) make application s in the late spring or fall months, e) do not exceed 0.2 oz. product acre and f) do not add a surfactant when applied with liquid N. Metsulfuron tank-mixes with liquid fertilizer are not recommended for 'Pensacola' bahiagrass control. Not effective for the control of 'Common' and 'Argentine' bahiagrass. Spot treatments of metsulfuron at 1.0 oz. product per 100 gal. of water may be used for t he control of multi flora rose an d blackberry. Pasture legumes will be severely injured or killed by metsulfuron. There is no grazing or haying restriction for metsulfuron. Metsulfuron may be tank-mixed with Grazon P+D, Banvel, 2,4-D, Weedmaster, Milestone, ForeFront and Remedy or purchased as a co-pack product with 2,4-D + dicamba.

USE STAGE/ HERBICIDE	BROADCAST RATE/ACRE: AMOUNT OF FORMULATION	BROADCAST RATE/ACRE: POUNDS ACTIVE INGREDIENT	REMARKS AND PRECAUTIONS
ESTABLISHED FORAGE GRASSES			
metsulfuron 48% + *chlorsulfuron* 15% Cimarron Plus 63 DF	0.125-1.25 oz	0.004-0.04 + 0.001-0.01	Apply to established bermudagrass for the control of 'Pensacola' bahiagrass and certain broadleaf weeds. Bermudagrass should be established for 60 days and tall fescue for two years prior to use. <u>Apply 1 pt.-1 qt. nonionic surfactant per 100 gal. of spray mix.</u> On tall fescue, applications in the early spring may suppress seedhead production and reduce hay yield. To minimize injury to tall fescue; a) do not use more than 0.5 oz. product/acre, b) use the lowest recommended rate for the target weeds, c) use a 1/16 to 1/8% v/v surfactant concentration, d) make applications in the late spring or fall months, e) do not exceed 0.3 oz. product/acre and f) do not add a surfactant when applied with liquid N. Cimarron Plus tank -mixes with liquid fertilizer are not recommended for 'Pensacola' bahiagrass control. Not effective for the control of 'Common' and 'Argentine' bahiagrass. Pasture legumes will be severely injured or killed by Cimarron Plus. There is no grazing or haying restriction for Cimarron Plus. Cimarron Plus may be tank-mixed with Grazon P+D, Banvel, 2,4-D, Weedmaster and Remedy.
metsulfuron 60 DF + *2,4-D* + dicamba 2.9 + 1.0 lbs./gal Cimarron Max	0.25 oz + 1.0 pt	0.009 + 0.4 + 0.125	Cimarron Max is a 2 part (co-pack) product used for annual and perennial broadleaf weed control in bermudagrass pastures. Also controls 'Pensacola' bahiagrass. Bermudagrass should be established for 60 days and tall fescue for two years prior to use. <u>Apply 1 pt.-1 qt. nonionic surfactant per 100 gal. of spray mix.</u> On tall fescue only, applications in the early spring may suppress seedhead production and reduce hay yield. To minimize injury to tall fescue; a) use the lowest recommended rate for the target weeds, b) use a 1/16 to 1/8% v/v surfactant concentration, c) make applications in the late spring or fall months, and d) do not add a surfactant when applied with liquid N. Cimarron Max tank-mixes with liquid fertilizer are not recommended for 'Pensacola' bahiagrass control. Not effective for the control of 'Common' and 'Argentine' bahiagrass. Pasture legumes will be severely injured or killed by Cimarron Max. There is no grazing restriction for non-lactating animals for Cimarron Max. The grazing restriction for lactating dairy animals is 7 days. Do not harvest for hay for 37 days after treatment. Remove meat animals from treated areas 30 days prior to slaughter.
Chlorsulfuron Telar 75DF	0.25-1.0 oz.	0.012-0.047	Controls many broadleaf weeds such as blackberry, pigweeds, and wild radish. Not effective for the control of horsenettle and common ragweed. May be used at rates up to 0.5 oz./acre in tall fescue. In bermudagrass and bahiagrass rates as high as 1.0 oz./acre may be used. Add a nonionic surfactant at 0.25% v/v to the spray mix. Chlorsulfuron has no grazing or haying restriction for any type of livestock.
Nicosulfuron 56.2% + *Metsulfuron* 15.0% Pastora 71.2 WDG	1.0-1.5 ozs.	0.035 to 0.053 + 0.009 to 0.014	Pastora is recommended only for use on bermudagrass that has been established for one year. Pastora can temporarily injure (yellowing, stunting) bermudagrass. Injury can be decreased by using Pastora during bermudagrass winter dormancy, during green-up with less than 2 inches of new growth and within 7 days after cutting for hay. Applications at other times may reduce bermudagrass production. Pastora is not recommended for use during bermudagrass "grow-in" from sprigs or seed. Applications to tall fescue, bahiagrass, overseeded winter annual forage grasses and other perennial forage grasses are not labeled. This herbicide has shown good to excellent control of sandbur, Texas panicum, fall panicum, broadleaf signalgrass and barnyardgrass less than 2 inches tall. Correct application timing is critical for control of annual grasses. Pastora has also shown excellent activity on Italian ryegrass, johnsongrass and 'Pensacola' bahiagrass when treated as per label directions. Pastora at 1.0 oz/acre applied twice also has good activity on vaseygrass (see supplemental label). Broadleaf weeds controlled by Pastora include bitter sneezeweed, buttercup, chickweed sp., Carolina geranium, curly dock, dogfennel, henbit, horseweed, musk thistle, smartweed sp., and wild garlic. A nonionic surfactant at 0.25% v/v is the preferred adjuvant for Pastora. This herbicide has no grazing or haying restriction for any type of livestock

WEED CONTROL IN GRASS PASTURES AND HAYFIELDS

USE STAGE/ HERBICIDE	BROADCAST RATE/ACRE AMOUNT OF FORMULATION	BROADCAST RATE/ACRE POUNDS ACTIVE INGREDIENT	REMARKS AND PRECAUTIONS
POSTEMERGENCE - Spot or Wiper Applications			
glyphosate Roundup WeatherMax 5.5 lbs./gal. Roundup Original 4.0 lbs./gal.	Rate varies with species and application	Rate varies with species and application	Glyphosate may be applied in wiper applicators to weeds emerged above the forage grass, or applied as a spot treatment. Further applications may be made in the same area at 30-day intervals. Forage grasses, alfalfa, or clover coming in contact with the glyphosate will be injured or killed. Remove domestic livestock before application and wait 7 days after application before grazing livestock or harvesting. Other brands of glyphosate may also be labeled for this use.
tebuthiuron Spike 20P 20% pellet	See label.		Spike 20P pellets may be applied as a spot treatment in perennial summer grass pastures for control of individual trees or scattered stands of brush. Apply 0.75 ounce per 100 square feet of soil surface over the root systems of clump s of brush. Apply in early spring. Stands of cool season grasses such as fescue may be reduced by Spike application. Applications to or near pine trees will cause injury or death of the tree. Do not cut for hay for one year after application. Grazing is allowed after application if 20 pounds per acre or less is used.
MIXTURES - Grass-Lespedeza, Grass-Clover			
2,4-D amine 4 lbs./gal.	0.5-1 pt.	0.25-0.5	Apply only one treatment per year to perennial clovers. 2,4-D amine will cause slight to moderate injury to legumes. Refer to specific herbicide label for use information.
CONVERSION TO FUNGUS-FREE FESCUE			
paraquat Firestorm 3.0 lbs.gal. Gramoxone Inteon 2.0 lbs./gal.	0.7-1.3 pt 1.0-2.0 pt	0.25-0.5	Apply paraquat in the fall to actively-growing, endophyte-infected fescue 2 to 3 weeks prior to planting endophyte-free fescue. Apply paraquat again at planting. Apply in 20 to 40 gal. of water per acre. Always add surfactant when using paraquat. DO NOT graze the new planting for 60 days or until the new growth is 6 inches tall.
glyphosate RoundupWeatherMax Roundup Original Max Roundup PowerMax 5.5 lbs./gal.	See remarks.	See remarks.	Apply in the fall at 22 fl. ozs./A to endophyte-infected fescue 3-4 weeks prior to planting endophyte-free fescue. Tall fescue should have 6 to 12 inches of new growth before the first application. Apply again at planting at 11 fl. ozs./A. This treatment provides some suppression of common bermudagrass also. There is no waiting period between application and grazing if total application rate is less than 2.0 qt/acre. Other brands of glyphosate may also be labeled for this use.

TEMPORARY SUMMER GRAZING WEED CONTROL
(Millets, sudan grass, sorghum-sudan hybrids)

Patrick E. McCullough, Extension Agronomist-Weed Science

USE STAGE AND HERBICIDE	BROADCAST RATE/ACRE: AMOUNT OF FORMULATION	BROADCAST RATE/ACRE: POUNDS ACTIVE INGREDIENT	REMARKS AND PRECAUTIONS
TEMPORARY SUMMER GRAZING CROPS-Millets, Sorghum, Sudan Hybrids, etc.			
2,4-D various trade names 4 lbs./gal.	1.0 pt	0.5	Apply to emerged broadleaf weeds when crop is 8 to 12 inches tall. Do not graze lactating dairy animals for 14 days after treatment, or cut for hay for all types of livestock for 30 days after treatment. (Grazing and haying restrictions may vary-refer to product label). Refer to specific herbicide label for use restrictions. A 2,4-D formulation labeled on millet is Formula 40.
2,4-D + *dicamba* Weedmaster 2.9 lbs. + 1 lb./gal. Outlaw 1.45 + 1.1 lbs./gal.	1.0 pt to 2.0 pt 1.0 pt to 2.0 pt	0.36 + 0.125 to 0.72 + 0.25 0.18 + 0.14 to 0.36 + 0.27	Apply to emerged broadleaf weeds when crop is 8 to 12 inches tall. Do not graze lactating dairy animals within 7 days. There is no restriction between application and grazing for non-lactating animals. Do not cut for hay within 37 days after treatment. Do not graze meat animals in treated areas within 30 days of slaughter. Weedmaster and Outlaw will severely injure or kill clovers or alfalfa.
FORAGE SORGHUM			
metolachlor Dual 8E	1.5-2.0 pt	1.5-2.0	Apply after planting seed treated with Concep or Screen seed protectant. Apply before crop and weeds emerge.
FORAGE SORGHUM AND SORGHUM-SUDAN			
atrazine 80W atrazine 4L atrazine 90DG various trade names	1.5 lb 1.2 qt 1.3 lb	1.2 1.2 1.2	Apply with 1.0 gal./A of emulsifiable oil or 1.0 qt./A of crop oil concentrate after sorghum reaches the 3-leaf growth stage but before it exceeds 12 inches in height. Controls broad leaf weeds 2 to 3 inches tall and newly-emerged (l-leaf) annual grasses. DO NOT apply with fluid fertilizers or when sorghum is under stress from cold, wet weather, poor fertility or other factors, or when sorghum is wet and tender from a recent rainfall. DO NOT graze or feed treated forage for 21 days after application.

TEMPORARY WINTER GRAZING WEED CONTROL

Patrick E. McCullough, Extension Agronomist-Weed Science

USE STAGE AND HERBICIDE	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
	AMOUNT OF FORMULATION	POUNDS ACTIVE INGREDIENT	
TEMPORARY WINTER GRAZING CROPS-Small Grains, Ryegrass			
2,4-D various trade names 4 lbs./gal. *dicamba* Banvel 4.0 lbs./gal.	1 pt-1 qt 0.5 pt.	0.5-1.0 0.25	Apply in December, January or February to control swinecress, blessed thistle, wild garlic, curly dock and similar winter weeds after small grain tillering but before jointing. Grazing restrictions may vary among the different 2,4-D products. Several 2,4-D labels restrict grazing for dairy animals or meat animals being finished for slaughter for 14 days after treatment. For Banvel, restrict grazing for lactating dairy animals for 7 days after treatment and remove meat animals from treated areas 30 days prior to slaughter. For Banvel, there is no waiting period between treatment and grazing for non-lactating animals. Refer to specific herbicide label for additional use information.
2,4-D + *dicamba* Weedmaster 2.9 lbs. + 1 lb./gal. Outlaw 1.45 + 1.1 lbs./gal.	1.0 pt to 2.0 pt 1.0 pt to 2.0 pt	0.36 + 0.125 to 0.72 + 0.25 0.18 + 0.14 to 0.36 + 0.27	Apply to emerged broadleaf weeds when crop has 2 to 4 tillers. Do not graze lactating dairy animals within 7 days. There is no restriction between application and grazing for non-lactating animals. Do not cut for hay within 37 days after treatment. Do not graze meat animals in treated areas within 30 days of slaughter. Weedmaster and Outlaw will severely injure or kill clovers or alfalfa.
thifensulfuron-methyl + *tribenuron-methyl* Harmony Extra SG with TotalSol 50 SG	0.45-0.9 oz	0.0094 to 0.0188 + 0.0047 to 0.0094	Apply after two-leaf stage of wheat, barley, triticale and oats but prior to flag leaf being visible. Harmony Extra SG is not recommended for use on ryegrass or rye. Most winter annuals can be controlled with 0.45 to 0.6 oz/A; however, 0.75 to 0.9 oz/A is recommended for controlling wild garlic or small wild radish. Add 1 qt of nonionic surfactant per 100 gal of spray solution. For best results, apply when weeds are in the two- to four-leaf stage, temperatures are above 50° F, and not drought stressed. Wild garlic should be less than 12 in. tall and should have 2 to 4 in. of new growth. Liquid nitrogen may be used as the carrier. When using nitrogen as the carrier, reduce surfactant rate to 0.5 to 1.0 pint per 100 gal of solution (wheat burn may still be noted). May also tank mix Harmony Extra SG with 0.25 to 0.375 lb. ai/acre of 2,4-D or MCPA for improved control of wild radish. Do not use surfactant if Harmony Extra SG and 2,4-D or MCPA are applied in nitrogen. Do not graze within 7 days of application. This grazing restriction applies to all types of livestock. Allow at least 30 days between application and feeding of hay from treated areas to livestock.
SUPPRESSION OF BERMUDAGRASS OR BAHIAGRASS SODS			
paraquat Gramoxone Inteon 3.0 lbs./gal.	1.0-2.0 pt	0.25-0.5	Apply in early fall to sod not more than 3 inches tall, just prior to or at the time of seeding clovers or winter grasses. Add surfactant according to label directions.

WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

Patrick E. McCullough, Extension Agronomist – Weed Science

Not all herbicides are labeled for use on all forage crops. Refer to the recommendations shown for a specific herbicide or refer to the herbicide label.

TIME OF APPLICATION	PPI	PPI	PRE	PRE	PRE	POST	POST
	benefin (Balan)	**EPTC (Eptam)**	**Chateau**	**Kerb**	**Prowl**	**2,4-D**	**2,4-DB**
amaranth, spiny	G	G	E	P	F-G	F-G	F-G
bahiagrass	P	P	P	P	P	P	P
bermudagrass	P	P	P	P	P	P	P
bitter sneezeweed	P	P		P		E	G
blackberry	P	P		P	P	P	P
bracken fern	P	P		P	P	P	P
briars (Smilax)	P	P		P	P	P	P
broomsedge	P	P		P	P	P	P
buttercup	P	P		P	P	E	F
camphorweed	P	P		P	P	P	P
chickweed	F	E	E	G	F	P	P
crabgrass	E	G	G	F	G	P-F	
crotalaria, showy	P	P	G	P	P	G	
cudweed	P	P		P		F	
curly dock	P	P	G	P	P	F	P
dallisgrass	P	P	P	P	P	P	P
dandelion	P	E	G	P	P	E	G
dodder	P	P		E		P	P
dogbane, hemp	P	P			P	P-F	P
dogfennel	P	P		P	P	F	P
evening primrose	F	F-G	E	P		E	G
foxtails, green & yellow	G	G	F	P	F	P	P
gallberry	P	P		P	P	G	P
goldenrod	P	P		P	P	F	P

E = Excellent G = Good F = Fair P = Poor Control.	A blank space indicates weed response is not known. [1] Seedling johnsongrass only.

WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

Not all herbicides are labeled for use on all forage crops. Refer to the recommendations shown for a specific herbicide or refer to the herbicide label.

TIME OF APPLICATION	PPI	PPI	PRE	PRE	PRE	POST	POST
	benefin (Balan)	EPTC (Eptam)	Chateau	Kerb	Prowl	2,4-D	2,4-DB
henbit	F	G	E	P	F-G	P	P
honeysuckle	P	P		P	P	E	P
horsenettle	P	P		P	P	P	P
horseweed	P	P	G-E	P	P	G	P
Italian ryegrass	G	E		G		P	P
johnsongrass	G[1]	G[1]		P	G[1]	P	P
kudzu	P	P		P	P	P-F	P
Lespedeza, Sericea	P	P			P	P	P
little barley	G	G		E		P	P
maypop passion flower	P	P		P	P	P	P
mayweed				P		F	P
nettle, stinging	P	P		P	P	P	P
nutsedge	P	F	P	P	P	P	P
palmetto	P	P		P	P	P	P
perilla mint	P	P			P	P-F	
persimmon	P	P		P	P	P	P
pigweed species	G	G	E		F-G	G-E	G
plantain(s)	P	G	F	F	P	G-E	F
pokeweed, common	P	P		P	P	G	G
prickly pear	P	P		P	P	P	P
ragweed, common	P	P	G-E	P	P	E	G
red sorrel	P	P		P	P	P	P
rush species	P	P		P	P	G	P
sandbur	E	G		P	G	P	P
shepherdspurse	P	G	E	G	F	E	G
sicklepod	P	F	P	P	P	G	F
sida, arrowleaf & prickly	P	P	G-E	P	P	G	P
smartweed(s)	P	P	F	P	P	F	F

E = Excellent
G = Good
F = Fair
P = Poor Control.

A blank space indicates weed response is not known.
[1] Seedling johnsongrass only.

WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

Not all herbicides are labeled for use on all forage crops. Refer to the recommendations shown for a specific herbicide or refer to the herbicide label.

TIME OF APPLICATION	PPI	PPI	PRE	PRE	PRE	POST	POST
	benefin (Balan)	EPTC (Eptam)	Chateau	Kerb	Prowl	2,4-D	2,4-DB
smutgrass	P	P		P	P	P	P
swinecress	P	G		F		E	F
Texas panicum	G-E	G		P	F-G	P	P
thistles	P	P		P	P	E	F
tropical soda apple	P	P		P	P	P	P
vaseygrass	P	P		P	P	P	P
vervain, blue							
Virginia pepperweed	P	G		P	P-F	G	E
wax myrtle	P	P		P	P	G	P
wild cherry	P	P		P	P	E	P
wild garlic	P	P	P	P	P	G-E	P
wild plum	P	P		P	P	E	P
wild radish	P	P-F	G-E	P	P	G	P
wild rose	P	P		P	P	G	P
wooly croton	P	P		P	P	G	P

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WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

TIME OF APPLICATION	POSTEMERGENCE							
	bromoxynil (Buctril)	Chaparral	Cimarron Max	Cimarron Plus	Crossbow	dicamba (Banvel, Clarity)	ForeFront, Grazon Next	Grazon P+D
amaranth, spiny	P	E	E	E		G-E	E	G-E
bahiagrass	P	G	F-G	G	P	P	P	P
bermudagrass	P	P	P	P	P	P	P	P
bitter sneezeweed		E	E	E	E	E	E	E
blackberry	P	G-E	F	E	G	F	P	F
bracken fern			G		G	G		F
briars (Smilax)	P				P	F		
broomsedge	P		P	P	P	P	P	P
buttercup		G-E	E	E	E	P	E	E
camphorweed		G		G			G	G-E
chickweed	F	E	E	E	F	G	G	P
crabgrass	P		P	P	P	P	P	P
crotalaria, showy		G				G	G	E
cudweed	P	G	G	G	E	E	G-E	G
curly dock		G-E	G-E	G-E	G	E	G-E	G-E
dallisgrass	P		P	P	P	P	P	P
dandelion	P				E	E	G-E	E
dodder					P	P		
dogbane, hemp		P	P	P	F-G	F	P	F
dogfennel	P	P-F	G-E	F-G	E	E	F	G-E
evening primrose		G	G	G	E	E	E	E
foxtails, green & yellow	P		P	P	P	P	P	P

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A blank space indicates weed response is not known.

WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

TIME OF APPLICATION	POSTEMERGENCE							
	bromoxynil (Buctril)	Chaparral	Cimarron Max	Cimarron Plus	Crossbow	dicamba (Banvel, Clarity)	ForeFront, Grazon Next	Grazon P+D
gallberry	P				E	E		
goldenrod	P	P	G-E	P	G	G	G	G
henbit	F	G-E	E	E	E	G	F	P-F
honeysuckle	P				E	E		F
horsenettle	P	G-E	F	P-F	P-F	G	E	G-E
horseweed	P	G-E	E	F	G	E	E	E
Italian ryegrass	P		P-F	P-F	P	P	P	P
johnsongrass	P		P	P	P	P	P	P
kudzu	P	G	P-F	P-F	F-G	G	G	F
lespedeza, Sericea	P	P	F-G	G-E	P-F	P		P
little barley	P				P	P		P
maypop passion flower		P	P	P			P	P-F
mayweed	P		G	G	G	E	G-E	G-E
nettle, stinging		G-E	F-G	F-G	F-G	P	G	E
nutsedge	P		P	P	P	P	P	P
palmetto	P	P	P	P		F		
perilla mint					F-G	F-G		F-G
persimmon	P				G	E		P
pigweed species	F	G-E	E	E	E	E	E	E
plantain(s)	P	G-E	E	E	G	F	G	F-G
pokeweed, common	P	P		P	G	G	G	F
prickly pear	P	P	P	P		F	P	F-G

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WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

TIME OF APPLICATION	POSTEMERGENCE							
	bromoxynil (Buctril)	Chaparral	Cimarron Max	Cimarron Plus	Crossbow	dicamba (Banvel, Clarity)	ForeFront, Grazon Next	Grazon P+D
ragweed, common	G	G-E	G	G	E	E	E	E
red sorrel		E	G	G-E	E	G	E	
rush species	P	P	P	P	F-G	P		
sandbur	P		P	P	P	P	P	P
shepherdspurse	G				E	E	E	E
sicklepod		G	G	G	E	E	E	E
sida, arrowleaf & prickly	P		G	G	P-F	G	E	E
smartweed(s)	G	G-E	E	E	G-E	G	E	E
smutgrass	P		P	P	P	P	P	P
swinecress	E					E	E	E
Texas panicum	P			P	P	P	P	P
thistles	P	E	G-E	F-G	E	G	E	E
tropical soda apple	P	G-E	P	P	F	F-G	G-E	G-E
vaseygrass	P		P	P	P	P	P	P
vervain, blue							G	G
Virginia pepperweed	G					E	G	E
wax myrtle	P	P				E		
wild cherry	P					P	E	
wild garlic	P	G	G-E	G-E		F	F	F
wild plum	P					E	E	
wild radish	F-G	G-E	G-E	G-E	E	E	E	
wild rose	P	G	F	F	E	E	F	F
wooly croton	P	G-E	G-E	G	E	E	E	E

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WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

TIME OF APPLICATION	POSTEMERGENCE							
	hexazinone (Velpar)	imazamox (Raptor)	imazapic (Impose)	imazethapyr (Pursuit)	metribuzin (Sencor)	Metsulfuron	Milestone	paraquat
amaranth, spiny	F-G	F-G	G	F-G	P-F	E	G	F-G
bahiagrass	P		G-E		P	G	P	P
bermudagrass	P	P	P	P	P	P	P	P
bitter sneezeweed						E	G-E	
blackberry	F				P	G	G	P
bracken fern	F					G	G	P
briars (Smilax)	F				P			P
broomsedge	P	P	P	P	P	P	P	P
buttercup	G				G	E	G-E	G
camphorweed				P		G		P
chickweed	E	G		F	E	P	F	E
crabgrass	P	F	F-G	F	F	P	P	F
crotalaria, showy								
cudweed						G	E	G
curly dock	P-F	P-F		P-F		E	E	P
dallisgrass			P		P	P	P	P
dandelion	E	F-G		P-F	G	G-E	P	G
dodder								G-E
dogbane, hemp							P	
dogfennel						P-F	P	P
evening primrose	E				G	G	E	P-F
foxtails, green & yellow	P-F	G	F-G	G	P	P	P	F
gallberry	P				P			P

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WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

TIME OF APPLICATION	POSTEMERGENCE							
	hexazinone (Velpar)	imazamox (Raptor)	imazapic (Impose)	imazethapyr (Pursuit)	metribuzin (Sencor)	Metsulfuron	Milestone	paraquat
goldenrod						G-E	G	P
henbit	G-E	F		F	G	E	F-G	G
honeysuckle					P			P
horsenettle		P	P	P	P	P	E	P
horseweed	F	P	P	P	P	F	E	P
Italian ryegrass	G	G	F	P	P	P		G
johnsongrass	P	F	F-G	P	P	P	P	P
kudzu			P	P	P	P-F	F-G	P
lespedeza, Sericea						G-E		P
little barley	E				P	P	P	G-E
maypop passionflower		P		P	P	P	P	P
mayweed	F-G					G		E
nettle, stinging						F-G	E	
nutsedge	P	P-F	G	F	P	P	P	P
palmetto	P		P		P	P	P	P
perilla mint							P	
persimmon	F				P		P	P
pigweed species	G	G-E	G-E	G-E	G	E	E	G
plantain(s)	F-G	P		P	P	E	P	P
pokeweed, common						P	F	
prickly pear	P				P	P	P	P
ragweed, common	F	F	F	F	G	G	E	G
red sorrel						E		P-F

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WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

TIME OF APPLICATION	POSTEMERGENCE							
	hexazinone (Velpar)	imazamox (Raptor)	imazapic (Impose)	imazethapyr (Pursuit)	metribuzin (Sencor)	Metsulfuron	Milestone	paraquat
rush species		P	P	P		P		P
sandbur			G-E		F	P	P	G
shepherdspurse	E	E	E	E	E	G	P	G
sicklepod			G		F	G	P	F-G
sida, arrowleaf & prickly		P-F		P-F	F	F	P	P
smartweed(s)	F-G	G-E		G-E		E	E	E
smutgrass	G-E	P	P	P	P	P	P	P
swinecress	E	G	E		E		P	E
Texas panicum	P		P-F		P-F	P	P	G
thistles	E	P		P	G	F	E	G
tropical soda apple	F		P		P	P	E	P
vaseygrass			F		P	P	P	P
vervain, blue							F	
Virginia pepperweed	E	G		G	G		P	G
wax myrtle	P				P			P
wild cherry	E				P			P
wild garlic					P	G	P	E
wild plum	E	P	P	P	P			P
wild radish	E	G-E	E	G-E	E	G-E	P	P
wild rose		P	P	P	P	G	F	P
wooly croton	P	P		P	P	G	E	P

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A blank space indicates weed response is not known.

WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

TIME OF APPLICATION	POSTEMERGENCE							
	Pastora	PastureGard	Redeem	sethoxydim (Poast)	Spike	Surmount	Triclopyr (Remedy)	Weedmaster
amaranth, spiny	G-E	P-F	P	P		G-E		E
bahiagrass		P	P	F		P	P	P
bermudagrass	P	P	P	F-G		P	P	P
bitter sneezeweed	G-E	E	E	P	E	E	E	E
blackberry		G	G-E	P	G	G	G-E	P-F
bracken fern		F	P	P	G	F	G	
briars (Smilax)		G	P	P	G	F	P	F
broomsedge	P	P	P	P		P	P	P
buttercup	E	F	E	P	G	G	E	E
camphorweed		E		P		E	E	P
chickweed	E	E	G	P	E	G-E	F	F
crabgrass	F	P	P	G-E		P	P	P
crotalaria, showy		E				E	E	G
cudweed		G	E	P		G	E	G
curly dock	G-E	F	E	P		G	E	E
dallisgrass		P	P	P		P	P	P
dandelion	G	G-E	G	P	G	E	E	E
dodder		P	P	P			P	P
dogbane, hemp		F-G	P	P		G	F	F
dogfennel	P	E	E		G	E	E	G
evening primrose	F	G		P	G	E	E	E
foxtails, green & yellow	F-G	P	P	E		P	P	P
gallberry		E	G	P			E	G

E = Excellent, G = Good, F = Fair, P = Poor Control.
A blank space indicates weed response is not known.

WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

TIME OF APPLICATION	POSTEMERGENCE							
	Pastora	PastureGard	Redeem	sethoxydim (Poast)	Spike	Surmount	Triclopyr (Remedy)	Weedmaster
gallberry		E	G	P			E	G
goldenrod	G	G	E	P		G	G	E
henbit	E	G-E	G	P	G	G	F	P
honeysuckle		P	P	P	G	G	P	E
horsenettle	P	P-F	F	P	F	E	P-F	F
horseweed		G	G	P		E	G	E
Italian ryegrass	G-E	P	P	E		P	P	P
johnsongrass	G-E	P	P	G		P	P	P
kudzu		G	G-E	P	P	F	G-E	F
lespedeza, Sericea		E					G-E	P
little barley		P	P	F		P	P	P
maypop passion flower		F		P				P
mayweed	G-E	G	E	P	E	G-E	G	G
nettle, stinging		E	F	P		G	G-E	F
nutsedge	P	P	P	P		P	P	P
palmetto		G	P	P	F	P	F	P
perilla mint		F		P		F	F-G	F-G
persimmon		G-F	P	P		G	F	F
pigweed species	G-E	G	G	P		G	E	E
plantain(s)	F	F	P	P		F	F	G-E
pokeweed, common		P	P	P		G	P	G
prickly pear		F	P	P		E	G[2]	P

E = Excellent, G = Good, F = Fair, P = Poor Control.
A blank space indicates weed response is not known.

WEED RESPONSE TO HERBICIDES USED IN PASTURE, HAY AND FORAGE CROPS

TIME OF APPLICATION	POSTEMERGENCE							
	Pastora	PastureGard	Redeem	sethoxydim (Poast)	Spike	Surmount	Triclopyr (Remedy)	Weedmaster
ragweed, common		E	E	P		E	E	E
red sorrel		F	F-G	P		E	E	P-F
rush species		P	P	P		P	F	
sandbur	G-E	P	P	G		P	P	P
shepherdspurse		G	G	P	G	G	E	E
sicklepod	E	G	G	P		E	E	E
sida, arrowleaf & prickly		F	P	P		E	P	E
smartweed(s)	G			P				G
smutgrass		P	P	P		P	P	P
swinecress		G	G	P		G	G	E
Texas panicum	G-E	P	P	E		P	P	P
thistles	G	G	E	P		G-E	F-G	G
tropical soda apple	P	G	P	P	P	E	G	F
vaseygrass	F[3]	P	P	P		P	P	P
vervain, blue						E		
Virginia pepperweed		G		P			P	E
wax myrtle		G		P	F			G
wild cherry		G	F	P		G	E	E
wild garlic		F		P		P		G
wild plum		G	P	P	G	G		P
wild radish	G-E	G	F	P		E	E	E
wild rose		E	P	P	G	E	E	E
wooly croton	E	F	F	P		E	G	E

E = Excellent
G = Good
F = Fair
P = Poor Control.

A blank space indicates weed response is not known.
[2] For prickly pear cactus use 20% v/v Remedy plus 80% diesel fuel. Apply only as a spot treatment, as this treatment will severely insure desirable grasses.
[3] Apply in spring after full spring greenup of vaseygrass, or after hay harvest.

Section 16

Extending the grazing season and critically evaluating novel grazing systems

Dr. Dennis Hancock, UGA

2015 Georgia Grazing School:

Extending the grazing season and critically evaluating novel grazing systems

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

Extending the grazing season and critically evaluating novel grazing systems

GRASS

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

How Much Hay Do I Need?

Hay Acreage Required

$$\frac{\text{Head x lbs of b.w. x DMI, \% of b.w. x days}}{\text{Forage Use Efficiency x Hay Yield/acre}} = \text{Acres Required}$$

Hay Acreage "Required"

$$\frac{\text{100 hd x 1500 lbs/cow x 2.0\% x 120 days/yr}}{\text{70\% efficiency x 12,000 lbs/acre/yr}} = \text{43 acres}$$

Costs of Feeding Hay

$$1500 \text{ lbs/cow} \times \frac{\text{2.0 lbs of hay}}{\text{100 lbs of b.w.}} = \text{30 lbs/hd/d}$$

X

$$\frac{\text{\$100/dry ton of hay}}{\text{2000 lbs}} = \text{\$0.05/lb of hay}$$

$1.50/hd/d

Also,
Subtract an average of:

15% feeding loss
30% storage loss
15% other losses

$1.75 - $2.00 per head per day

Costs of Feeding Hay

$2.00/hd/d

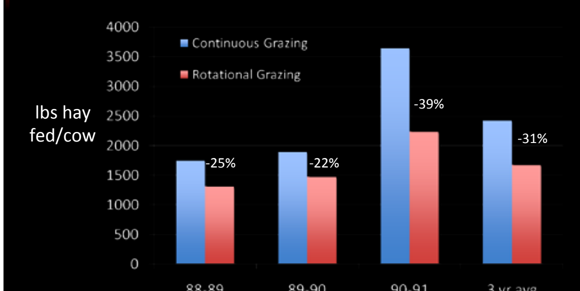
I have 100 cows.

If I cut out 30 days of feeding hay… ?

100 cows x $2.00 x 30 days = **$6000**

That's like having a 5-7% increase in your calf crop!!!

Effect of Grazing System on Hay Needs



$37.54/cow savings
using $100/ton hay

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Grazing School
UGA extension
The University of Georgia College of Agricultural & Environmental Sciences

2015 Georgia Grazing School:

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Assoc. Prof. & Forage Ext. Specialist

Grazing School Goals:

1. Provide a more comprehensive coverage of grazing management.
   - "Unlearn" much of the conventional wisdom about grazing.
2. Provide you the tools to develop a more efficient grazing system.
3. Encourage you to reduce your conserved forage (e.g., reduce hay feeding to less than 60 days).
   - 300 Days of Grazing

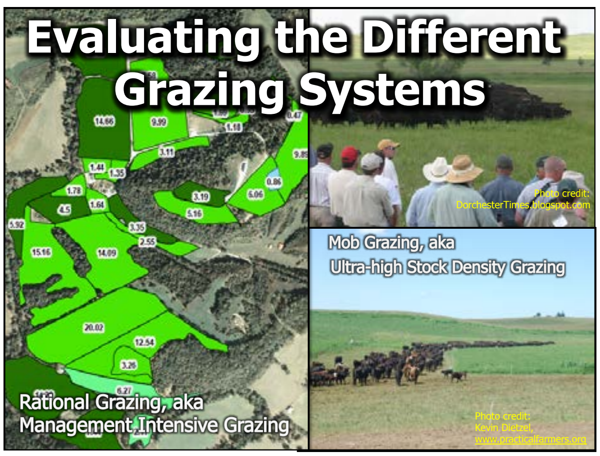
The Primary Calculations

$$\text{Acres Grazed per yr} = \text{Paddock Size} \times \text{Number of Paddocks}$$

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

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

Grazier's Arithmetic: A Grazing Calculator



Analyzing Strategic Changes

$$\text{Acres Grazed per yr} = \left(\frac{\text{Days of Rest}}{\text{d in Paddock}} + 1\right) \times \frac{\text{Animal Weight} \times \text{\%DMI} \times \text{Hd} \times \text{d in Paddock}}{\text{Available Forage}_{\text{diff}} \times \text{Grazing Efficiency \%}}$$

- Examples:
  - Changes in grazing system, forage rest period, etc.
  - Changes in supplementation rate
- But, remember that the system is very dynamic!

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Stockpiling Tall Fescue or Bermudagrass
"Average" Expectations

INPUTS

- Moisture
- N fertilizer (up to 60#/ac for TF; up to 80# for BG)
- More than typical grazing management
  - Improved bermudagrass

OUTPUTS

- 1500-3500+ lbs of standing dry matter (DM)/acre.
  - 30 – 60 days (more or less, depending on grazing method and weather)
- CP levels starting in 8 – 12% range, ending below 10%
- TDN levels ranging 55-58%

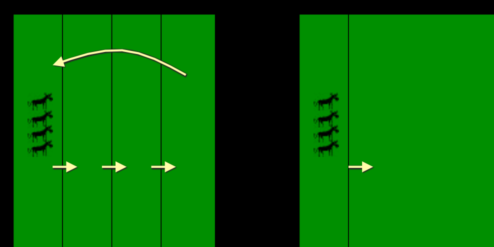
Stockpiling Tall Fescue or Bermudagrass
Steps Involved

1. Graze or take hay cutting (2-3")
   - TF: Early to mid-Sept.
   - BG: about 6-8 wks prior to first anticipated frost.
2. Add fertilizer like making a hay cutting.
3. Don't allow it to be grazed (if possible) until:
   - TF: After Thanksgiving
   - BG: After first killing frost

Stockpiling Tall Fescue or Bermudagrass
Steps Involved

4. Measure amt. of stockpiled forage that is available.
5. Take forage samples to determine supplement need.
6. Only let them have small strips (no more than 2-3 days worth) at a time (frontal grazing).
   - Each 1200 lb cow will need ~35-40 lbs of stockpile/day
   - Allow access to mineral, ionophore, and supplement as needed.

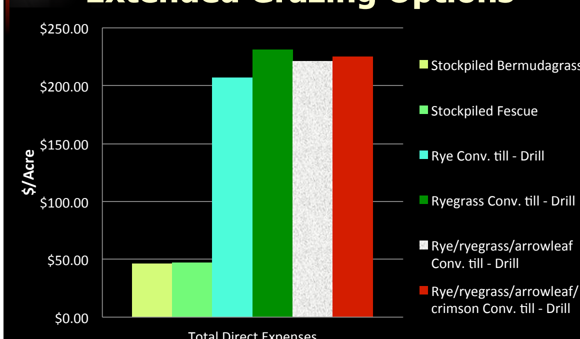
Grazing Methods



Grazing Methods

Available Forage	Continuous Stocking	Moderate Rotational Stocking	Frontal Grazing
(dry lbs/acre)	-------------------	(cow-days/acre)	-------------------
1500	19-25	31-38	41-47
2000	25-33	42-50	54-63
2500	31-42	52-63	68-78

Cost Comparison for Extended Grazing Options



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Grazing Crop Residue

- Very inexpensive feed
- Can last for several days
  - Frontal grazing makes for efficient utilization
- Corn residue: 1 cow/acre for 60-100 days
- Cotton residue: 1 cow/acre for 30-35 days

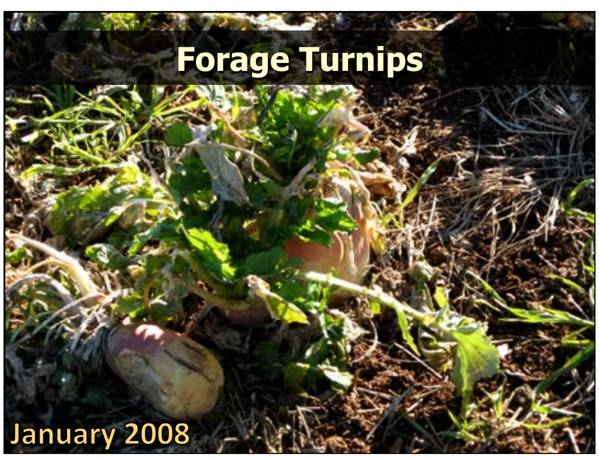
Grazing Cotton Residue

Item	Hay	Standing Residue	Mowed Residue

* Hay valued at $70/dry ton. 1 cow/acre for 44 days. Data from Plains, GA.

Grazing Crop Residue

- Check pesticide labels
- Check fence rows and weed species for poisonous plants
- No difference in animal performance between Bt and non-Bt crops.



Brassicas

Type[1]	November 21	January 24	March 26	Total
	lb/ac			
Rape				
Barnapoli	812	2898	4257	7968
Bonar	924	2630	4222	7776
Dwarf Essex	1232	3121	4855	9209
T-Raptor	1799	4112	6211	12123
Turnips				
Appin	1571	2657	3928	8256
Barabas	1402	1746	1957	5105
Barkant	1241	1902	2434	5577
FL Broadleaf	1512	2505	3473	7491
Pasja	1420	3661	5761	10842
Purpletop	2375	2201	3389	7965
$LSD_{0.05}$[2]	560	445	532	866

[1]Planted at 5 lb/ac and fertilized with 400 lb of 15-5-10 at planting and after each harvest.
[2]LSD = Least Significant Difference. LSD for comparison of varieties within each column.
Source: Lang et al., 2007. Brassicas as Alternative Winter Forage for Mississippi. Mississippi State Univ.

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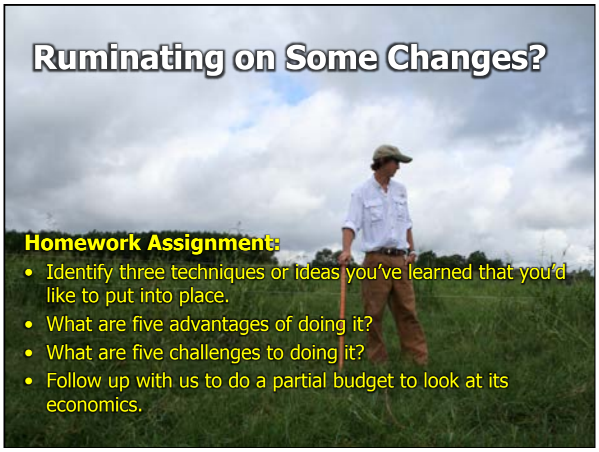

Forage News
Mississippi State University Extension Service

Forage Brassicas for Winter Grazing Systems

Rocky Lemus
Extension Forage Specialist
Visit us at **http://msucares.com/crops/forages/index.html**

Mississippi livestock producers looking for methods to reduce feeding costs may find forage brassicas a crop worth exploring. Brassicas fit well with forage based production systems by extending the grazing season into the late fall and early spring. The fall grazing of brassicas, along with other production techniques such as intensive rotational grazing and stockpiled grazing could allow producers to rely on forage as the main source of nutrition for their livestock enterprise along with other winter annuals such as small grains and ryegrass.

Forage brassicas are a cool season crop. Members of the forage brassica family include kale, rape, swede, and turnips. These are annual crops which are highly productive and digestible and can normally be grazed 80 to 150 days after seeding, depending on the species. Depending on the species, both tops (stems plus leaves) and roots (bulbs) can be grazed. Brassicas do have some limitations as a feed source due primarily to the chemical composition of most species, but properly managed could provide an excellent feed source in pastoral systems.

Types of Brassicas

Kale (*Brassica oleracea*): Kale is grown for its leaves and stems. Kale is very winter-hardy (survival tolerance down to 10°F), highly palatable, and high in protein. Because of its cold tolerance, it can be rotationally grazed well into the fall. Kale could have good forage dry matter production at 150 days with yields up to 6 tons/acre, making it ideal for dairy or beef cattle especially for late season forage. There are two types of varieties: narrow stem and stemless. Varieties with stems can grow to 60 inches in height with 2-inch stems and require 150 to 180 days to attain maximum production. Stemless varieties reach crop heights of 25 inches and mature in 90 days allowing a second harvest. Kale can be grazed by rotational or strip grazing into December and January most years. Average protein content ranges between 15 and 17%.

Rape (*Brassica napus*): Rape is a multi stemmed crop with fibrous roots. Stem height, diameter, and palatability vary with variety. Rape is considered to be very winter-hardy. Forage rape is ready to graze 60 to 120 days after establishment. There are two kinds of forage rape, a giant type which is leafy and upright and a dwarf type which is short and branched. The giant varieties are best suited for cattle grazing due to higher palatability. Most hybrids produce the greatest yields when allowed to grow for 60 days before the first harvest and 30 days after the second harvest. Plants develop a reddish tinge color when ready for harvest. Leaving a 10-inch stubble height is recommended to allow rapid regeneration or regrowth. For optimum yields, a 3 to 4 lb/acre seeding rate is recommended.

Swede (*Brassica napus*): Swede is a long-season plant with a large edible root. Swede yields are generally higher than turnips, but growth is slower and requires 150 to 180 days to reach maximum production and is best suited to late-fall grazing. Swedes usually produce a short stem but can have stems up to 2½ feet long when grown with tall crops that shade the swede and allow for crop competition.

Turnips (*Brassica rapa*): Turnips are short-season root brassicas that provide roots (bulbs), stems and leaf growth for rotational or strip grazing. Turnips have bushy tops and large white roots that are rich in carbohydrates. Turnips are seeded at rate of 2 to 3 lb/acre. Turnips, an excellent late-fall forage, can reach maximum production 80 to 90 days after establishment. Turnip's tops (stems and leaves) can be grazed 60 to 70 days after planting while roots can be utilized 12 to 14 weeks after planting. Turnips can germinate in soil as low as 40°F and they can continue to grow until temperatures drop between 15 and 20 °F (they might require several days of temperatures continually below freezing before they begin to die). The proportion of top growth to roots can vary from 90 percent tops and 10 percent roots to 15 percent tops and 85 percent roots. Some hybrids have fibrous roots that are not readily grazed by livestock. Turnips can be seeded any time from when soil temperature reaches 50 °F until 50 days prior to a killing frost. Many varieties can be grazed twice, once for top growth and then later for the roots. Turnips have a lower dry matter yield than kale or rape. The tops could have 15 to 24 percent protein while roots may contain 8 to 15 percent protein.

Establishment

Brassicas require good soil drainage and a soil pH between 5.3 and 6.8 for optimum production. Seeds should be planted ½ inch deep in a firm, moist, seedbed with 6- to 8-inch rows and cultipacking is recommended. Good stands can be established by planting 3 to 4 lb/ac of kale or rape, or 1 to 3 lb/ac of swede or turnip. **Table 1** gives the basic seeding information and utilization of different types of brassicas. The higher seeding rates are recommended for broadcast plantings. They can also be broadcast (higher rates are recommended for broadcasting) or seeded into an herbicide-killed sod with a no-till drill. When preparing a tilled seedbed for brassica planting, plow the ground several weeks before planting to allow weed seeds to germinate before secondary tillage is completed to form a firm and fine seedbed that is free of weeds.

Table 1. Suggested seeding rates and plant characteristics of different types of forage brassicas.

Type	Seeding Rate (lb/ac)	Plant Utilization	Days of Grazing	Regrowth after Harvest	% Utilization	Potential Yield (ton/ac)
Kale	3 – 4	Top	150 – 180	No	70 – 80	6 – 9
Rape	3 – 4	Top	70 – 110	Yes	80 – 90	4 – 6
Swede	1 – 3	Top[1] and root	150 – 180	No	80 – 90	9 - 10
Turnip	1 – 3	Top and root	60 – 120	Yes	85 – 95	3 – 5

[1]Tops include leaves and stems

Sources: Hall, 1992; Wrightson Seeds Brassica Brochure (2007).

Fertilization

Fertilizers should be applied at the time of seeding to give the brassicas a competitive edge on weeds. Fertility requirements should be based on soil test results. Phosphorus (60 lbs/acre) and potassium (100 lb/ac) soil test levels should be in the optimum range prior to planting to ensure optimum growth and help increase the crude protein levels. Nitrogen application rates of 50 to 70 lb/ac can be applied at planting and then again 60 to 80 days after planting to increase yields. It is recommended to avoid using fertilizer products that contain sulfate or sulfur since they may increase the levels of the amino acid compound S-methyl cysteine sulphoxide (SMCO) and the risk of anemia problems. Boron may also be needed. **Table 2** provides fertilization guidelines for different brassicas.

Table 2. Guide to brassica fertilization.

	Fertilizer			N Application Time	
Type	**Nitrogen (N)**	**Phosphorus (P_2O_5)**	**Potassium (K_2O)**	**At Plating**	**Later**
	---------------------- lb/ac ----------------------				
Kale	90 – 120	90 – 100	90 – 100	50%	50 % at 10 to 12 weeks
Rape	50 – 90	45 – 70	45 – 70	100%	Further N may be applied for regrowth
Swede	90 – 120	85 – 110	85 - 110	50%	50 % at 10 to 12 weeks
Turnip					
Grazing	50 – 70	35 – 45	35 – 45	100%	Further N may be applied for regrowth
Stubble	50 – 90	60 – 80	60 – 80	60%	40% at 6 to 8 weeks

Source: British Seed Houses: Forage Brassicas.

Forage Quality and Grazing Management

Brassicas have an off flavor and cattle may preference them less than grasses. Brassica quality remains high until vegetative growth ceases. Thereafter fungal diseases may develop following crop maturity that can cause quality losses. Above-ground parts of brassicas normally contain 20 to 25 percent crude protein, 65 to 80 percent *in vitro* digestible dry matter (IVDDM), about 20% neutral detergent fiber (NDF) and about 23% acid detergent fiber (ADF). The roots contain 10 to 14% crude protein and 80 to 85 percent IVDDM. The roots of turnips and kale usually have 10 to 14% crude protein (CP) and 80 to 85% digestibility. Dry matter digestibility generally exceeds 90 percent for all plant parts except kale stems at maturity. Brassicas are extremely low in fiber which affects proper rumen activity. Therefore, brassicas should never comprise more than 75% of the forage portion of livestock diet with the remainder provided by grass, hay, or stockpiled pasture. Animals should be gradually introduced to the crop to allow for development of the rumen microbial population that is adequate to digest the high levels of protein in the crop. Copper, manganese and zinc contents of forage brassicas do not meet the dietary requirements of ruminants, so mineral supplementation will be required. Iodine, iron and copper supplements help to prevent anaemia and goiter. Any mineral supplementation that is used should ensure that the calcium-to-phosphorus ratio in the feed does not exceed 7:1.

Brassicas are ready for grazing about 75 days after planting. **Table 3** provides information about different brassicas species grown in Mississippi. Strip grazing and rotational grazing provide the most efficient utilization of brassicas. Strip grazing where forage is rationed every day or two provides the most efficient usage. Grazing large areas increases trampling and wastes the available forage. Allow 90 days of turnip growth to maximize root development before grazing. Rape and kale have regrowth potential if not grazed below six inches and a four week rest period is allowed. Turnips will regrow if the growing point at the top of the bulb is not removed. Two or more cycles should be possible with rotational grazing if rainfall is adequate. Rapes and kale could be green chopped for confined animals. Brassicas are difficult to ensile because of their high water content, and wilting them down is impractical. If they are ensiled, chopped hay or straw can be added. However, harvesting and packing problems may still occur.

Table 3. Total and seasonal yield distribution of brassicas grown at Mississippi State University, 2006-2007.

Type[1]	November 21	January 24	March 26	Total
	--	lb/ac	--	
Rape				
Barnapoli	812	2898	4257	7968
Bonar	924	2630	4222	7776
Dwarf Essex	1232	3121	4855	9209
T-Raptor	1799	4112	6211	12123
Turnips				
Appin	1571	2657	3928	8256
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[1]Planted at 5 lb/ac and fertilized with 400 lb of 15-5-10 at planting and after each harvest.
[2]LSD = Least Significant Difference. LSD for comparison of varieties within each column.
Source: Lang et al., 2007. Brassicas as Alternative Winter Forage for Mississippi. Mississippi State Univ.

Animal Health Issues

Brassica crops can cause animal health disorders if not grazed properly. The low fiber content of brassicas can cause health disorders if they exceed 75 percent of the diet. Most brassica's related disorders with cattle occur during the first two weeks of grazing. The main disorders are polioencephalomalcia, hemolytic anemia (mainly with kale), pulmonary emphysema, nitrate poisoning, bloat and metabolic problems (glucosinolates).

Polioencephalomalacia is a brain degenerative disorder characterized by twitching of ears, eyes, and skin along with lack of coordination and blindness. Other behaviors include circling and convulsions. Treatment includes thiamin injections. A diet of pure brassicas can cause livestock to develop haemolytic anaemia and goiter. The amino acid compound S-methyl

cysteine sulphoxide (SMCO) which accumulates in the plants during the season is responsible for both of these conditions. Turnips contain a chemical that prevents the uptake of iodine by the thyroid gland. This results in hypothyroidism and goiter. Feed an iodized salt-trace mineral mix. Hemolytic anemia is characterized by red urine, pale mucous membranes, and unthrifty appearance. Some animals may collapse and suddenly die. Pulmonary emphysema causes rapid, difficult breathing accompanied by a grunt on expiration. Affected animals stand with extended heads, dilated nostrils, and open mouths with protruding tongues. Death may occur within two days. Surviving animals have a slow recovery over 7 to 20 days.

Nitrate poisoning has been documented from excessive nitrogen fertilization. Reported instances of high accumulation of calcium and potassium that can reduce the availability of magnesium to animals have also been observed. Utilize feed analyses to check and modify the mineral balance of animal diets. Bloat can also occur when grazing rape or turnips, causing abdominal distension. Some animals become chronic bloaters. To prevent bloat, ensure that cattle are full before putting them on rape pasture for the first time. Glucosinolates in brassicas can cause metabolic problems and taint milk in dairy animals. Livestock can suffer from rape poisoning if they graze stunted, low growing, and purple brassicas. This occurs when the crop is grown under very wet conditions on poorly drained soils, inadequate amounts of fertilizer have been used or an early frost occurs.

Although there are many management factors to consider, forage brassicas do provide producers with a high yielding, quality forage option at a time when most cool season grasses are not available. Animal disorders can be avoided by the following three management practices: (1) Introduce grazing animals to Brassica pastures slowly (over first 5 to 7 days), (2) don't turn hungry animals that are not adapted to brassicas into a brassica pasture (two to three pounds of hay or straw should be fed to each animal each day), and (3) brassicas should not constitute more than 75 percent of the animal's diet. A good quality pasture can also be used as a preconditioning diet before grazing brassicas.

Section 17

Sketching out the ideal – planning the grazing system

Philip Brown, NRCS Grassland Conservationist

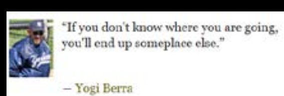
2015 Georgia Grazing School:
Sketching Out the Ideal: Planning the Grazing System

Philip Brown,
USDA-NRCS Grazinglands Specialist

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

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Grazing School

2015 Georgia Grazing School:
Sketching Out the Ideal: Planning the Grazing System

Philip Brown,
USDA-NRCS Grazinglands Specialist

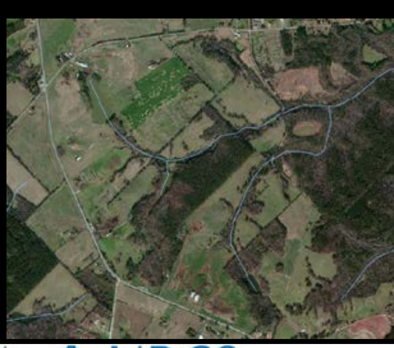
Inventory Resources

- Money / Budget
- Time
- Labor
- Skills
- Equipment / Tools
- Soil/Landscape Resources
- Forage Resources
- Livestock Resources

Soil/Landscape - Inventory Tools

- Google Earth & Other Web Based Tools

Web Soil Survey – Aerial Photography



Web Soil Survey – Topographic Images

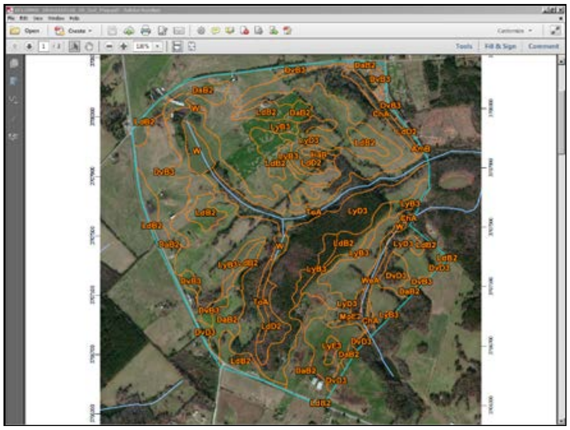
United States Department of Agriculture
Natural Resources Conservation Service

Grazing School

2015 Georgia Grazing School:

Sketching Out the Ideal: Planning the Grazing System

Philip Brown,
USDA-NRCS Grazinglands Specialist

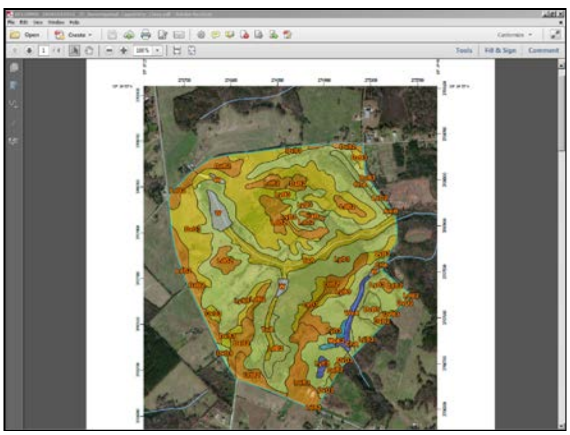


Web Soil Survey - Land Capability Class

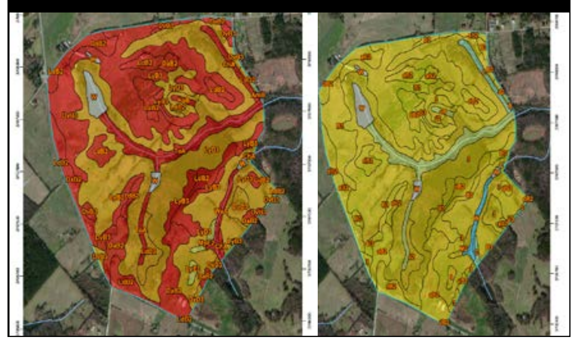
	Land Capability Class	Wildlife	Forestry	Grazing: Limited	Grazing: Moderate	Grazing: Intense	Cultivation: Limited	Cultivation: Moderate	Cultivation: Intense	Cultivation: Very Intense
Increased Limitations and Hazards / Decreased Adaptability and Freedom of Choice of Uses	I	X	X	X	X	X	X	X	X	X
	II	X	X	X	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 Intensity of Land Use

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).



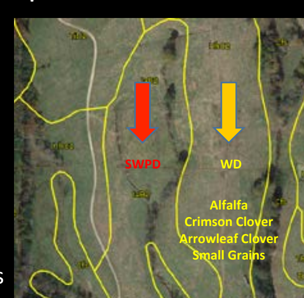
Web Soil Survey – Slope & Drainage Class



Soil Type and Landscape Position

Landscape - Soils

- Productivity
- Flooding & Ponding Durations
- Drainage Class
- Similar Soils Support Similar Productivity & Plant Communities



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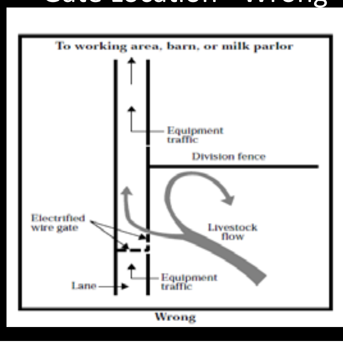
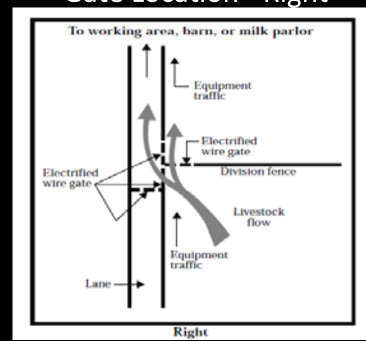
Animal Movement
Gate Location - Wrong



Animal Movement
Gate Location - Right



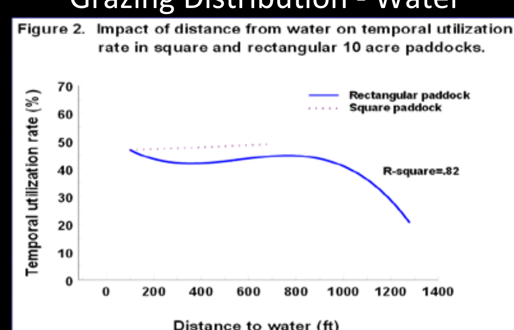
Animal Movement

- 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

Grazing Distribution - Water



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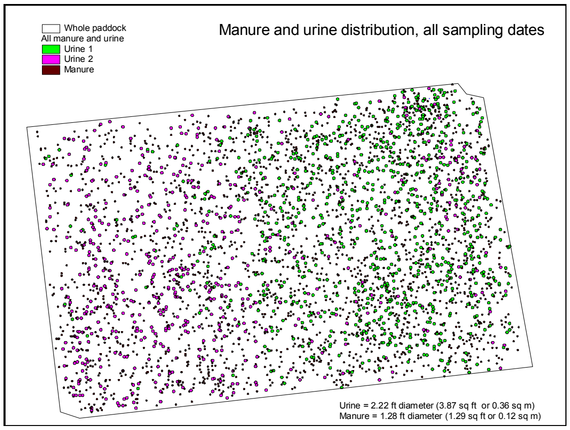

Providing Water

- 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

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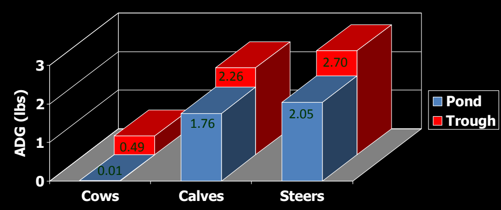
Water source effect on animal performance



Willms et al., 2002

31

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

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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

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

USDA Natural Resources Conservation Service
United States Department of Agriculture

National Cooperative Soil Survey

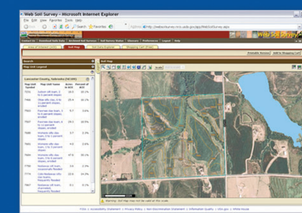
March 2014

USDA Natural Resources Conservation Service
United States Department of Agriculture

Web Soil Survey

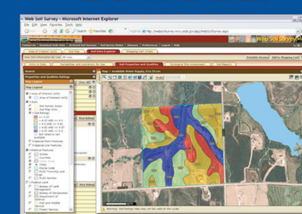
http://websoilsurvey.nrcs.usda.gov

Define.



Search / Locate

Collect.



Analyze Data

Develop.

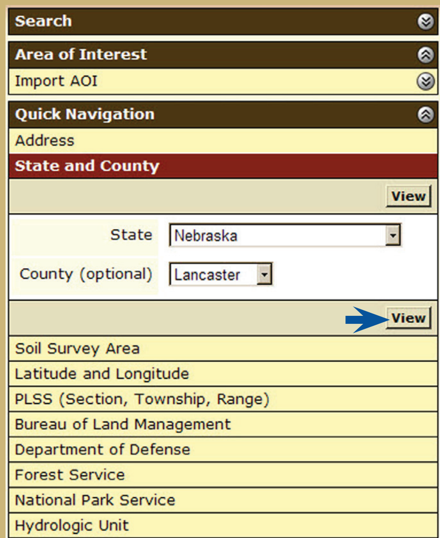
Custom Reports & Maps

"Helping People Help the Land"

Accessing Web Soil Survey

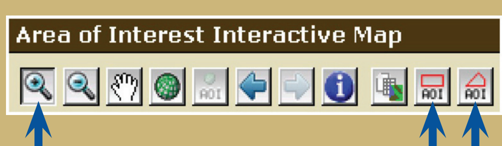
- Open the Web Soil Survey (WSS) site at: http://websoilsurvey.nrcs.usda.gov and click the "Start WSS" button.

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.

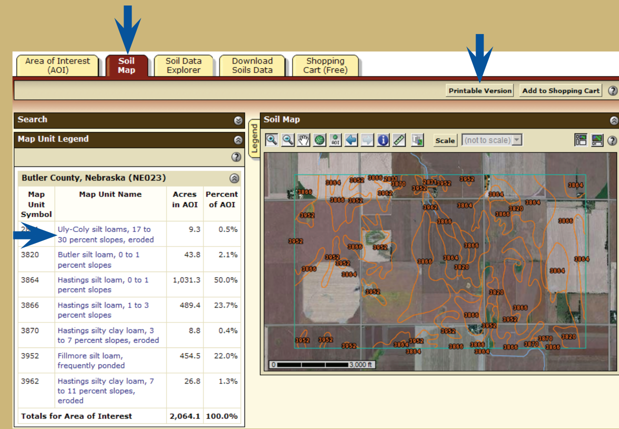
- Click the "View" button to see the area.



- 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



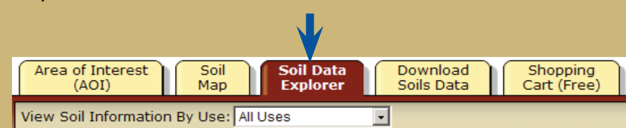
- Click on the "Soil Map" tab.

- Click on a map unit name to view a map unit description. Click the X to close the narrative.

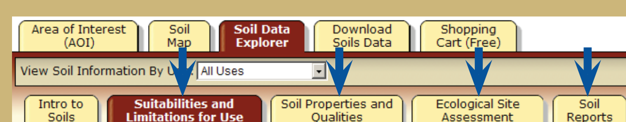
- Print your soil map by clicking on the "Printable Version" button; then click the "View" button. On the browser menu bar, select File and Print; or click the print icon. Close the window.

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.

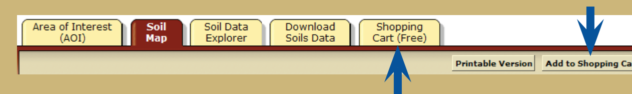


- Click on the tabs below "Soil Data Explorer" and explore available information (default tab is "Suitabilities and Limitations for Use").

Step 4. Add Items to the Free Shopping Cart and Check Out

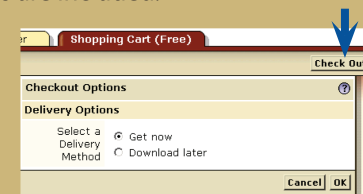
WSS allows you to collect a variety of thematic maps and reports in the Shopping Cart, then print or download the content into one file or document.

- 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.

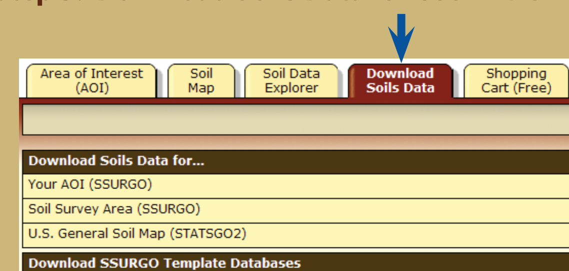
- View your cart contents by clicking the "Shopping Cart (Free)" tab. Items checked on the Table of Contents are included.



- 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.

Section 18

Weeds are great forage – Teach your livestock to eat them

Kathy Voth, Livestock for Landscapes

Appendix

Still Water Farm

Danielsville, Georgia

Georgia Grazing School – 2015

September 15 - 16

Owners: Terry and Deborah Chandler, Robert, Jennifer, and Kimberly

Farm History: The Chandlers purchased the exhausted and abandoned row crop farm in 1987 and began the mammoth task of returning the farm to production. The decision to move to livestock was simple . . . getting there was another story. A 600 head hog finishing floor was returned to service initially. Two 16,000 square foot houses for replacement pullets were built and began operation in April of 1988. Then, one rock, one old home-site, one privet hedge, one gully, one beaver dam, one weed, one fence and one challenge at a time, we began converting the farm to forage production.

Enterprises: Commercial Beef cattle, Embryo Recipient Hosting, Custom Bull and heifer management, Custom freezer beef, Backgrounding all calves, Replacement heifers, Replacement Heavy Breeder Pullets, Hog Finishing (ended in 2003 after 16 years), Tift 44 and Russell Bermuda and Ryegrass Hays and baleage, Fescue and millet for hay and mulch

Labor Force: Terry, Robert (2007 UGA grad, USMC Captain currently serving in Marine Reserves, just entering his final year Law School at Georgia State), Jennifer (Ophthalmologist Surgical assistant and formerly #1 tractor driver), Kimberly (my right-hand-man, part-time college student at Athens Technical College), annual Intern students from Madison County High School College and Career Academy.

Farm Layout: 202 acres plus 50 rented, (Grazeable: 180)

Forage System:

Forage Species	Variety	Acres
Fescue	Jesup Max-Q	15
Fescue/clover	Triumph/White Dutch, Kentucky 31	30
Bermuda	Tift 44, Russell, Coastal	96
Forage Brassicas	Pasja	10 - 15
Ryegrass	Marshall	85
Winter Mix	Wheat, rye, barley, vetch, red clover, arrowleaf clover, chicory, & forage brassicas	22

Grazing System: Intensive Rotational Grazing System: 9 ten acre pens each easily divided into two, 5-acre or four, 2.5 acre pens, and eleven 5-acre pens. Rented acreage is divided into 8 acre pens. The lay-out is designed to give maximum flexibility with water accessible in each pen separately and traffic lanes to move cattle quickly and easily from pen-to-pen and to the working facility. We target 30 days of rest for each pen, longer in the summer, and expect 2-3 days of grazing between rotations.

Approximate Fertilizer/Nutrients Applied: typically we apply 2-3 tons of broiler litter per acre, per crop annually approximately 100-100-80. Farm pH is 6.3-6.7

Grazing Herd Size: 110 Cow-calf pairs (all calves are preconditioned 60+ days before shipping), 50% of annual calf crop is ET, custom bull and heifer development dependent on demand and available forage, <10 fat steers, 20 – 30 replacement heifers annually

Calving Date Target and Range: We target a 60 day calving period, the first calves are ET (50%). The rest are Sim-Angus naturally sired. Our calving season starts in September 1 and extends to through October. We moved to a September-October calving season to maximize use of stockpiled fescue during re-breeding, and to capture the historical average peak market for 8cwt calves.

Days of Hay Feeding: Target of 60 days per year. (Has been as few as 45)

Supplementation Program: Ryegrass baleage and Ryegrass and Bermuda hay.

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

Grazing Lands Technology Institute

Guide to Pasture Condition Scoring

Introduction

A well-managed pasture is one whose productivity (plant and animal) is optimized while it does no harm to soil, water, and air quality. Pasture condition scoring is a systematic way to check how well a pasture is managed. If the pasture is located on the proper site and well managed, it will have a good to excellent overall pasture condition score. By rating key indicators and causative factors common to all pastures, pasture condition can be evaluated and the primary reasons for a low condition score identified. A condition that can lead to one or more pasture resource concerns such as poor plant growth, weedy species invasion, poor animal performance, visible soil loss, increased runoff, and impaired water quality.

Pasture condition scoring, to be most useful, should occur several times a year during key critical management periods throughout the grazing season. Scoring should be performed:

- At the start before placing livestock on pasture
- At peak forage supply periods
- At low forage supply periods
- As plant stress appears
- Near the end to help decide when to remove livestock

In addition, pastures used for year-round grazing benefit from pasture condition scoring:

- Going into the winter season
- Late in winter
- During thaws or wet periods

Pasture condition scoring can be useful in deciding when to move livestock or planning other management actions. It sorts out which improvements are most likely to improve pasture condition or livestock performance.

Pasture condition scoring involves the visual evaluation of 10 indicators, listed and described below, which rate pasture condition. In the *Pasture Condition Score Sheet*, each indicator or factor has five conditions described for it, ranging from lowest (1) to highest (5). This objectively ranks the extent of any problem(s) and helps sort out the likely cause(s). Evaluate each indicator separately. They may be combined into an overall score for the pasture unit or left as an individual score and compared with the other nine indicators. Indicators receiving the lowest scores can be targeted for corrective action as warranted. The plant vigor indicator can be analyzed further by rating six factors that cause plant vigor to be what it is. As one or more erosion indicators may exist on a site, they are split into four types: sheet and rill, gully, streambank or shoreline, and wind.

Indicator Descriptions

Percent desirable plants

This indicator determines if the pasture has the kind of plants that the livestock on it will graze readily. A desirable species is readily consumed, persistent, and provides high tonnage and quality for a significant part of the growing season. Undesirable species, such as woody invaders, noxious weeds, and toxic plants, are those that typically are not eaten (rejected) by most livestock or cause undesirable side effects when eaten, and that crowd out more desirable species.

A few forages for a time are undesirables during a specific growth stage when they produce toxins. Intermediate species are those which, while eaten, provide low tonnage or lose quality fast, and often have a short-lived grazing use period. Some examples are dandelions, wild plantains, and annual grasses, such as crabgrass. Estimate visually the proportion of desirable species present in the entire sward by weight, and score accordingly.

Plant cover

The percentage of the soil surface covered by plants is important for pasture production and soil and water protection. A dense stand (high stem count) ensures, when properly grazed, high animal intake and high sunlight interception for best forage growth. Bare, open spots allow for weed encroachment, increased water runoff during intense rains, and soil erosion. Visually estimate the total cover of all desirable and intermediate species. Assign a value based on either green leaf canopy or live vegetative basal area cover percentage. Use the most familiar method that provides a consistent, reliable estimate of plant cover for the pasture being rated.

Canopy cover works best on sod-forming pastures. It can be determined at any time on continuously grazed pastures provided stubble heights greater than 1 inch are present. On rotational pastures, estimate canopy cover of a paddock the day prior to livestock entry. This will represent the best possible condition. If it rates fair or lower at this growth stage, management changes are definitely in order.

Basal area works best on bunch grass pastures. It is hard to use on pastures where sod-forming grasses and broadleaf plants dominate. Estimate by eye or use either the step-point or the point-intercept methods. Basal area is measured by both methods by counting pin hits on live stems and plant crowns at ground level (within 1 inch above). Where it is most useful, basal area is more constant than canopy cover and thus is more reliable.

Plant residue

Plant residue, in various states of decay, provides additional surface cover and organic matter to the soil. However, too much standing dead material in the grass stand reduces the feed value of the forage consumed and animal intake, and inhibits new plant shoot growth. Excessive amounts of standing dead material may cause the forage to be rejected by the grazing animal. Less than 25 percent of the standing forage mass should be dead or dying leaves and stems. Buildup of thatch (mat of undecomposed residue) at the soil surface indicates retarded residue decay. Thatch promotes fungal diseases and retards or prevents shoot and seedling emergence. This results in forage stand decline.

Plant diversity

Plant diversity is the number of different forage plants that are well represented (20% or more of plant cover) in a pasture. Low species diversity causes season-long pastures, or a set of pastures grazed as a unit, to be less reliable suppliers of forage to livestock during the grazing season. Forage production varies more widely through the grazing season because of changing weather and light conditions and insect and disease pressure. Pastures that have high species diversity tend to be older, moderately grazed permanent pastures. Here planted and volunteer forages have adjusted to the management and the prevailing environmental stresses. No single forage species is so dominant as to crowd out others.

Having more than one functional plant group growing either in a pasture or in different, complementary pastures is highly important. This maintains the most consistent forage supply during the grazing season. Functional groups of forages are plant groupings that have similar growth habits and management needs. The four basic functional groups for improved pastures are cool-season grasses, warm-season grasses, legumes, and other grazable broadleaf plants (e.g., *Brassicas* and forage chicory). These basic functional groups can be split into more specific groups, such as upright versus prostrate and sod-formers versus bunch grasses. However, this extra detail is unwarranted in improved pasture condition evaluations.

Plants from different functional groups are most compatible when they can compete successfully together as managed. Mixed species pastures with at least two functional groups and three to four well-

Standing dead residue of mature plants reduce forage quality and cause livestock to selectively graze around them.

represented forage species are generally the most productive. Higher diversity (over six species) does not assure higher productivity. It may actually spur animals to avoid some species and graze others hard, as species differences in palatability and maturity are more likely. Potential forage is wasted. Less desirable species gain in area by outcompeting overgrazed desirable species. However, trying to prevent this selectivity by reducing forage on-offer and forcing animals to eat everything, reduces intake and gains. This also decreases productivity.

When plant diversity scores low, several courses of action are possible. The appropriate response depends on the region in which the pasture is located, its intended use period, and the species growing in it. Applying other treatment measures may be easier or more appropriate than trying to grow several plant species together within a single pasture. These measures include:

- Applying nitrogen fertilizer to a pasture with few or no legumes present
- Establishing a different forage functional group in a separate pasture
- Oversowing an annual forage crop into a perennial forage pasture going into dormancy

Always rate plant diversity even if you may ultimately not wish to change it in that pasture. Monocultures can be quite productive on seasonal and irrigated pastures. They can provide abundant production at times precisely when other pastures on the operating unit are unproductive. However, when plant diversity is rated low on an individual field, some alternative course of action must be in place or developed. Some, such as feeding hay or applying N fertilizer, are expensive alternatives.

Plant vigor

Desirable species should be healthy and growing at their potential for the season when rated. If not, they will be replaced by weeds and low quality forage plants. If plant growth conditions really suffer, bare soil will begin to appear. Some things to consider when rating plant vigor are color, size of plants, rate of regrowth following harvest, and productivity. Determine overall vigor of desirable and intermediate species, and record. If score is less than four, utilize the causative factors below to help determine what may be causing the lack of vigor. If scoring a pasture for the first time, review soil test results or get soil tests done for it regardless of plant vigor rating to determine the pasture's level of fertility and pH. It also pays to rate the other causative factors as well first time out; this provides initial facts vital to managing the pasture from here, on.

Soil fertility

Adequate, but not excessive, fertility is critical for good plant vigor. Test soil or plant tissue to determine nutrient status. Excessive amounts of nutrients, particularly N, P, and K, can also cause animal health and/or water quality problems. Rank, often lodged, dark green to blue-green forages are a warning sign of excessive soil fertility. Maintain adequate nutrient balance to not exceed maximum economic yield of desirable forage species. In some areas of the United States, excess salts and sodium are often present in the soil at levels that reduce plant vigor. Test those soils for electrical conductivity and exchangeable sodium. Reduce their levels, or plant forage species tolerant of the levels found.

When urine and dung patches are noticeably greener than the rest of the pasture, nutrients are limiting production.

Severity of use

Grazing management is critical in maintaining productive pastures. Close, frequent grazing (mown lawn appearance) often causes loss of vigor reducing yields and ground cover. Low stocking rates promote selective grazing that causes excessive residue buildup (presence of mature seed stalks and dead leaves). This standing residue blocks sunlight, reduces overall forage quality, and favors the spread of less palatable and/or taller, grazing intolerant forages. Assign a value based on the proportion of the pasture grazed closest and the height at which it is grazed. Compare that height to minimum stubble heights recommended for maintaining desired forages.

Site adaptation of desired species
Climate and soil type play a major role in the vigor of a given species. Consider these items when evaluating adaptability:

- cold hardiness
- tolerance to aridness
- summer heat and humidity levels
- frost heave or soil cracking
- soil wetness
- flooding or ponding
- soil acidity or alkalinity
- toxic elements
- salinity
- sodicity
- low or high nutrient levels

Two other factors to consider are the desired species tolerance to existing grazing pressure and soil and water management. Plants that hold their growing point close to the ground can be grazed close provided they are allowed some time between grazing events to push out new leaf area. Others that elevate the growing point into the grazing zone need grazing events timed to release new shoot growth. The presence and balance of desired species are compared with those species present now and their balance. This verifies how well adapted the desired species were to the site, grazing pressure, and management.

Climatic stresses
Extremely wet, dry, hot, or cold weather may threaten plant vigor even when climatically adapted forage species are present. When rating the pasture, consider recent weather events and their role in the present health of a forage stand. Extremely cold and wet weather can cause temporary nitrogen deficiency symptoms (yellowish leaves). A hard winter may weaken the stand. A drought can cause the stand to go dormant. Check for frost or freeze damage to foliage.

Soil pH
Soil pH influences plant vigor primarily through its effect on nutrient availability. It also influences the amount of nitrogen-fixing nodules formed on legume roots. Determine the pH in the surface 3 to 4 inches through a soil test or reliable field methods. Adjust pH to provide optimum yield of desirable forage species.

Note: Reduced yields may continue if the pH in the subsoil is too low or high. Contact a soil fertility or forage management specialist for further management options.

Insect and disease pressure
Look for signs of leaf, stem, and root damage caused by insects and disease. Assess their impact on forage quality, quantity, and stand life. Some are chronic, occurring yearly, but with little consequence to the forage stand life. Others take the forage species under attack out of the stand. Corrective actions to take are numerous and specific to the insect or disease involved. Consult with a local, respected forage expert when unsure of proper course of action.

Livestock concentration areas

Concentration areas are places in pastures where livestock return frequently and linger to be near water, feed, mineral or salt, or shelter, or to be in shade. Typically, well-worn pathways lead to these preferred areas. Depending on the degree of usage, these areas are usually bare and receive extra animal waste. Depending on where they are on the landscape and flow paths, they can direct sediment, nutrients, and bacteria to nearby waterbodies.

Heavy use areas, such as around this feed bunk, often wash during heavy rains. Note missing hay residue at the bare spots in foreground.

These areas can direct contaminated runoff to surface waters unless there is an intervening grass buffer between them and open channels. Note reed canarygrass riparian area buffer below feed bunk.

Uniformity of use

Spot grazing often occurs where forage growth exceeds livestock intake at least seasonally. Once established, it stays in place unless pattern is destroyed seasonally.

Check uniformity of use by observing animal grazing patterns. Uniform grazing results in all desirable and intermediate species being grazed to a similar height. Spotty or patterned grazing appears uneven throughout a pasture with some plants or parts of paddocks grazed heavily and others lightly. Individual forage species are being selected for or against by the livestock based on their palatability and nutritional value. Selectivity is also affected by forage species stage of maturity differences, amount of forage offered to livestock, and their length of stay

Areas that are grazed close contrasted with areas largely avoided. Several causes exist. The one shown is a deep, entrenched stream barrier and entry choice to pasture.

in the paddock. Zone grazing occurs when one end of the pasture is heavily grazed and the other end is ungrazed or lightly grazed. It occurs on long and narrow pastures and ones that run lengthwise up and down steep slopes. Other pastures that have shady areas, windbreaks, or hay feeding, creep feeding, and watering sites whose location and duration of use at that location skew foraging to one end of a pasture are often zone grazed as well. Physical barriers, such as streams, cliffs, and obstructing fencelines, can confine livestock to one area of a pasture causing zone grazing. When rating this factor keep in mind that while overgrazing may result in a uniform height (mown lawn appearance), it is to a height lower than that needed to maintain all desirable forage species.

Erosion

Sheet and rill

This erosion is soil loss caused by rain drop impact, drip splash from rainwater dropping off plant leaves and stems onto bare soil, and a thin sheet of runoff water flowing across the soil surface. Sheet and rill erosion increases as ground cover decreases. Evidence of sheet erosion in a pasture appears as small debris dams of plant residue that build up at obstructions or span between obstructions. Some soil aggregates or worm castings may also be washed into these debris dams. Rills are small, incised channels in the soil that run parallel to each other downslope. They join whenever the ground surface warps and deflects the direction of their flow. When rills appear, serious soil loss is occurring. This erosion type also includes most irrigation-induced erosion.

Streambank, shoreline, and gully

This erosion occurs in large, open drainage channels or around shorelines. When in pastures, these channels or shorelines can have heightened erosion problems and losses of vegetative cover that typically grows on them. These heightened damages result from grazing animal traffic in or on them. Open channels may be intermittent or perennial flowing streams or dry washes. The factors that affect the extent of disturbance livestock cause to gullies, streambanks, shorelines, and their associated vegetation are:

- Livestock traffic patterns
- Frequency of use
- Attractiveness of these channels or banks as sunning, dusting, travel lanes, watering, grazing, or rubbing areas
- Channel shape (depth, width, presence and frequency of meanders, and bank stability)
- Flow characteristics (frequency, depth, sediment carried, swiftness, and turbulence)

Wind

Erosion occurs when heavier, windblown soil particles abrade exposed soil and cause dust to become airborne. Deposition of the heavier soil particles occurs downwind of obstructions, such as fencelines, buildings, and vegetation. Often vegetative debris is windrowed against obstructions.

Percent legume

Legumes are important sources of nitrogen for pastures and improve the forage quality of a pasture mix when they comprise at least 20 percent of total air-dry weight of forage. Deep-rooted legumes also provide grazing during hot, dry periods in mid-summer. Visually estimate the percentage of legume present in the total forage mass. Rate this indicator even if site or grass species preclude successful legume establishment and reliable survival to have an effective legume component to fix nitrogen. Most pastures are nitrogen-limited since much of the nitrogen excreted by animals eludes plant uptake. Pastures with few or no legumes present need alternative means of supplying nitrogen for optimum forage production. When bloating legume content is greater than 60 percent of total forage dry weight; bloat incidence in livestock is likely without preventative steps.

Cool-season grass pastures should have 30 percent legume by weight.

Soil compaction

Soil compaction impacts water infiltration rates and runoff. Lack of infiltration decreases water available in the soil for plant growth. Instead, water runs off, increasing channel erosion downstream, and conveys contaminants, such as nutrients, from the site, reducing water quality. Soil compaction is best determined by measuring the bulk density (weight per volume of soil) at 1-inch increments to plow depth. However, compaction can be detected in the field using a soil probe, metal rod, or knife. As these tools are pushed into the soil, compacted soil layers interrupt their ease of penetration. Compare in-field resistance to penetration with resistance found at a grazed fenceline where the livestock cannot stand or walk on the soil surface. The more noticeable the difference in resistance between the two areas is, the worse the compaction is in the pasture.

Avoid grazing pastures too close that causes spreading, bloat-inducing legumes to become dominant (over 60 percent of stand by weight).

Warm-season grass pastures, like this rotationally grazed bermudagrass-white clover, should have 20 percent legume for good livestock performance and nitrogen self-sufficiency.

Wet soils are easily compressed and deformed by livestock hooves.

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Pasture Condition Score Sheet

Purposes

- Evaluate current pasture productivity and the stability of its plant community, soil, and water resources.
- Identify what treatment needs, if any, are required to improve a pasture's productivity and protect soil, water, and air quality.

Suggested uses

This score sheet may be used to rate different pastures in a single growing season or the same pasture over a period of years. Rating a pasture yearly can track trends, either improvement or decline, in its condition. Some indicators change slowly in response to stresses caused by management or climate. Also, some indicators may change as each season progresses. An indicator or causative factor may rank high at one time and low another. Uniformity of use, plant residue, percent legume, severity of use, weather, and insect or disease pressure can vary widely on the same pasture depending on when they are scored during the year and the degree of management the pasture receives. Therefore, it is often wise to score a pasture at different, key times during the year before deciding to make changes in management. Indicate on the form the date the scoring occurred.

Procedure

Step 1—Rate each pasture one by one that is occupied all at the same time by a herd or flock and separated from other pasture areas by portable or fixed fencing. Paddocks in rotational pastures may be rated separately or as a combined unit. It depends on how alike they are. If any indicator looks markedly different from paddock to paddock, it may pay to rate each one separately.

Step 2—Score all 10 indicators regardless of your feelings of their relative worth. To learn or recall how each indicator reflects on how well a pasture is being managed, see *Guide to Pasture Condition Scoring.*

Step 3—Using the attached score sheet and indicator criteria, read the scoring criteria for each of the 10 pasture condition indicators one at a time and rate before moving onto the next. Use the 1 to 5 scale provided. Estimate by eye or measure as precisely as you feel is needed to rate the indicator reliably.

Step 4—When scoring plant vigor, enter a score based on the general criteria given on page 2 using the most limiting trait listed. Use this number to determine the overall pasture score. If the plant vigor score is less than 4, refer to the plant vigor causative factors' criteria on page 6 to identify the plant stress(es) causing reduced vigor. Rate each causative factor independently on the score sheet provided on page 5. Do not average to adjust the original vigor score.

Step 5—When scoring erosion, rate sheet and rill erosion every time. Rate other types of erosion only if present. When present, indicate which one(s) by identifying the erosion type with a unique symbol next to its score. Divide the box as needed to score them separately. Erosion is rated by averaging the individual scores. A need remains to prioritize which erosion problem is controlled first and how.

Step 6—Total the score for each pasture and compare to the following chart. Also, focus on any low scoring individual indicators or causative factors.

Pasture condition score: Overall	Individual	Management change suggested
45–50	5	No changes in management needed at this time.
35–45	4	Minor changes would enhance, do most beneficial first.
25–35	3	Improvements benefit productivity and/or environment.
15–25	2	Needs immediate management changes, high return likely.
10–15	1	Major effort required in time, management, and expense.

Step 7—When an individual indicator's score falls below a 5, determine its worth to your operation. Then, decide whether to correct the cause or causes for the low rating. If you choose to correct, apply the most suitable management options for your area and operation.

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Pasture Condition Score Sheet

Indicator	Score 1	2	3	4	5
Percent desirable plants	Desirable species < 20% of stand. Annual weeds and/ or woody species dominant.	Desirable species 20–40% of stand. Mostly weedy annuals and/or woody species present and expanding. Shade a factor.	40–60% desirable forage species. Undesirable broadleaf weeds and annual weedy grasses invading. Some woodies.	60–80% of plant community are desirable species. Remainder mostly intermediates and a few undesirables present.	Desirable species exceed 80% of plant community. Scattered intermediates.
Plant cover (Live stems and green leaf cover of all desirable and intermediate species.)	Canopy: < 50% Basal area: < 15% Photosynthetic area very low. Very little plant cover to slow or stop runoff.	Canopy: 50–70% Basal area: 15–25% Photosynthetic area low. Vegetal retardance to runoff low.	Canopy: 70–90% Basal area: 25–35% Most forages grazed close, little leaf area to intercept sunlight. Moderate vegetal retardance.	Canopy: 90–95% Basal area: 35–50% Spot grazed low and high so some loss of photosynthetic potential. Vegetal retardance still high.	Canopy: 95–100% Basal area: >50% Forages maintained in leafy condition for best photosynthetic activity. Very thick stand, slow or no runoff flows.
Plant diversity	One dominant (> 75% of DM wt.) forage species. Or, over 5 forage species (all <20%) from one dominant functional group, not evenly grazed - poorly distributed.	Two to five forage species from one dominant functional (>75% of DM wt.) group. At least one avoided by livestock permitting presence of mature seed stalks. Species in patches.	Three forage species (each ≥ 20% of DM wt.) from one functional group. None avoided. Or, one forage species each from two functional groups, both supply 25–50% of DM wt.	Three to four forage species (each ≥ 20% of DM wt.) with at least one being a legume. Well intermixed, compatible growth habit, and comparable palatability.	Four to five forage species representing three functional groups (each ≥ 20% of DM wt.) with at least one being a legume. Intermixed well, compatible growth habit, and comparable palatability.
Plant residue (Rate ground cover and standing dead forage separately and average score.)	**Ground cover:** No identifiable residue present on soil surface. Or, heavy thatch evident (> 1 inch). **Standing dead forage:** >25% of air dry weight.	**Ground cover:** 1–10% covered with dead leaves or stems. Or, thatch 0.5 inch to 1 inch thick. **Standing dead forage:** 15–25% of air dry weight.	**Ground cover:** 10–20% covered with dead residue. Or, slight thatch buildup but < 0.5 inch. **Standing dead forage:** 5–15% of air dry weight.	**Ground cover:** 20–30% covered with dead residue. No thatch present. **Standing dead forage:** some, but < 5% of air dry weight.	**Ground cover:** 30–70% covered with dead residue, but no thatch buildup. **Standing dead forage:** none available to grazing animal.
Plant vigor *If plant vigor rating is less than 4, determine cause by rating 6 possible causes listed on page 5.*	No recovery after grazing or pale yellow or brown, or permanent wilting, or plant loss due to insects or disease, exercise lot only. Or, lodged, dark green overly lush forage. Often avoided by grazers.	Recovery after grazing takes 2 or more weeks longer than normal, or yellowish green leaves, or major insect or disease yield loss, or plants wilted most of day. Productivity very low.	Recovery after grazing takes 1 week longer than normal, or urine/ dung patches dark green in contrast to rest of plants, or minor insect or disease loss or mid-day plant wilting. Yields regularly below site potential.	Recovery after grazing takes 1 to 2 days longer than normal, or light green plants among greener urine and dung patches, or minor insect or disease damage. No plant wilting. Yields near site potential.	Rapid recovery after grazing. Healthy green color. No signs of insect or disease damage. No leaf wilting. Yields at site potential for the species adapted to the site's soil and climate.
Percent legume (Cool season stands. See foonote 3 of score sheet for warm season)	< 10% by wt. Or, greater than 60% of bloating legumes.	10–19% legumes. Or, losing grass, 40–60% spreading legume.	20–29% legumes.	30–39% legumes.	40–60% legumes. No grass loss; grass may be increasing.
Uniformity of use	Little-grazed patches cover over 50% of the pasture. Mosaic pattern throughout or identifiable areas of pasture avoided.	Little-grazed patches cover 25–50% of the pasture either in a mosaic pattern or obvious portion is not frequented.	Little-grazed patches cover 10–25% of the pasture either in a mosaic pattern or obvious portion is not frequented.	Little-grazed patches minor spots where isolated forage species is rejected. Urine and dung patches avoided.	Rejected areas only at urine and dung patches. No forage species rejection.

Pasture Condition Score Sheet

Indicator	Score 1	2	3	4	5
Livestock concentration areas	Cover >10% of the pasture; or all convey contaminated runoff directly into water channels.	Livestock conc. areas and trails cover 5–10% of pasture; most close to water channels and drain into them unbuffered.	Isolated livestock conc. areas and trails <5% of area; one close to water channel and drains into it unbuffered.	Some livestock trails and one or two small concentration areas. Buffer areas between them and water channels.	No presence of livestock concentration areas or heavy use areas sited or treated to minimize contaminated runoff.
Soil compaction	Infiltration capacity and surface runoff severely affected by heavy compaction. Excessive livestock traffic killing plants over wide areas. Very hard to push probe into soil without damaging the probe.	Infiltration capacity lowered and surface runoff increased due to large areas of bare ground and dense compaction layer at surface. Livestock trails common throughout. Off-trail hoof prints common. Hard to push probe past compacted layers.	Infiltration capacity lowered and surface runoff increased due to plant cover loss and soil compaction by livestock hooves. Soil resistant to soil probe entry at one or more depths within plow depth.	Infiltration capacity lowered and surface runoff increased due to reduced vegetal cover/retardance. Probe enters soil easily except at rocks. Scattered signs of livestock trails and hoof prints, confined to lanes or small, wet areas.	Infiltration capacity and surface runoff are equal to that expected for an ungrazed meadow; not affected by livestock traffic.
Erosion					
Sheet and rill	Sheet and rill erosion is active throughout pasture; rills 3–8 inches deep at close intervals and/or grazing terracettes are close-spaced with some slope slippage.	Most sheet and rill erosion confined to steepest terrain of unit; well defined rills 0.5–3 inches deep at close intervals and/or grazing terracettes present.	Most sheet and rill erosion confined to heavy use areas, especially in loafing areas and water sites; rills 0.5–3 inches deep. Debris fans at downslope edge.	No current formation of rills; some evidence of past rill formation, but are grassed. Scattered debris dams of litter present occasionally.	No evidence of current or past formation of sheet flow or rills.
Rate additional erosion categories below only if present					
Wind	Blowouts or dunes forming or present.	Soil swept from the established pasture being rated causing plant death by burial or abrasion.	Soil swept from adjacent fields or pasture during seedbed prep. and seedling growth to cause pasture plant death by burial or abrasion.	Some vegetative debris windrowed. Some dust deposition from offsite source. Minor wind damage to foliage.	No visible signs of windblown soil or trash. No wind related leaf damage.
Streambank or shoreline	Banks mostly bare and sloughing. No native streambank or shoreline vegetation remaining.	Banks are heavily grazed and trampled all over. Many are actively eroding laterally. Little native streambank or shoreline vegetation. Bank sloughing common.	Banks are close grazed, but few are unstable. Some native streambank or shoreline vegetation remaining. Livestock enter only at specific points, but use heavy. Remote alternative water site present.	Banks are grazed but stable. Mix of pasture plants and native water's edge species. Muddy livestock stream crossing(s) or pond entrance(s) not used heavily. Alternative water sites present.	Banks ungrazed or grazed infrequently. Abundant streambank or shore loving vegetation. Gravelly or constructed stable livestock stream crossing(s) or watering ramp(s). Or, alternative water sources present and close-by.
Gully	Mass movement of soil, rock, plants, and other debris; occurrence of landslides, debris avalanches, slumps and earthflow, creep and debris torrents. Found in mountainous or very hilly terrain.	Gully(s) advancing upslope cutting longer channel(s). Revegetation difficult without using constructed structures & livestock exclusion; continuous gully(s) with many finger-like extensions into the hillside.	Gully(s) present with scattered active erosion, vegetation missing at heavy use slopes and/or on bed below overfalls. New eroding channels present and new overfalls appearing along sides and bed of main channel.	One or more existing stable gullies present, vegetation covers gully bottom and slopes well; no visual signs of active cutting at gully head or sides. Some soil moved in channel bottom.	No gullies; natural drainageways are stable grassed channels. Spring or seep fed bare channels are small and stable, often covered with overhanging vegetation.

Plant Vigor Causative Factors

Factor	Score 1	Score 2	Score 3	Score 4	Score 5
Soil fertility (P & K status) 1/	Very low P & K, or very high P & K.	Low P and K; or low P, very high K; low K, very high P; opt. P, very high K; very high P, opt. K.	Low P, optimum K; or low P, high K; or optimum P, low K; high P, low K; or high P, high K.	Optimum P, high K; or high P, optimum K.	Optimum P and K
(Nitrogen status) 2/	N deficient or excessive.		N marginal or high.		Adequate N.
Upper 4-inch root zone pH 3/	< 4.5 or > 9.0	4.5-5.0 or, 8.5-9.0	5.1-5.5 or, 7.9-8.4	5.6-6.0 or, 7.4-7.8	6.0 to 7.3
Severity of use	All desirable species grazed out. Or no grazing, resulting in thatch and/or standing dead accumulation and woody invasion.	All edible plants grazed to lowest level feasible by the livestock type (mown lawn look). Or, undergrazed - mostly stemmy overgrowth and much dead leaf .	Spot grazing common. Equal amount of close-grazed and little-grazed areas. Close grazed areas are grazed as low as livestock can graze (mown lawn look.)	Some spot grazing, avoided areas primarily at dung and urine spots. Closer grazed areas are not grazed below proper height needed for plant vigor.	Forage species grazed within height ranges that promote dense sward and near maximum production.
Site adaptation of desired species	Properly planted and established (desired) species are no longer present.	Properly planted and established (desired) species are nearly gone. Volunteer unwanted species dominate.	One or more properly planted and established, or recruited desired species are missing. Unwanted species invading.	Properly planted and established, or recruited desired species still represented, but not in the desired proportions.	Properly planted and established, or recruited desired species are present in the desired proportions.
Climatic stresses	Brownout from drought. Or, frost heaved plants, most with severed roots and dying. Or, major loss due to submergence or ice sheets.	Wilted plants, little recovery during night. Or, some frost heaved plants, recovery slow. Some spotty stand loss due to submergence or ice sheets.	Wilting during heat of the day. Or, weak plants from winter damage or short-term submergence. Or, freezing damage to foliage.	Dry conditions, but no wilting. Or, above or below normal temperatures slowing growth. Or, slight leaf yellowing due to cold, wet conditions.	No climatic stress.
Insect and/or disease pressure	Severe insect attack, mortality high. Or, disease caused mortality high.	Insect or disease outbreak at economic threshold, treat now.	Insect or disease outbreak near economic threshold, continue watch and weigh options for treatment.	Some insect and/or disease present, but little impact on forage quality or quantity.	No visible damage.

1/ Names used to describe P & K levels not consistent nationwide; Very high referred to as excessive, and optimum as moderate or medium. Determined by approved soil testing procedures and comparing soil test results for exchangeable P and K with this table.

2/ Determined using chlorophyll meter or plant tissue test and comparing those results with this table.

3/ pH ratings may need to be regionalized to account for soil chemistry differences that influence range of acceptability as soils become more highly weathered or excess salts, exchangeable aluminum, or sodium begin to interfere with forage production. Establish exchangeable aluminum, electrical conductivity, and sodium absorption ratio criteria where their levels in the soil interfere with forage production.

Pasture Condition Score Sheet

Farm or ranch site:____ Date____________________

	Pasture Unit Description									
Indicators										
Percent desirable plants[1] Percent plant cover by weight that is desirable forage: **1** **2** **3** **4** **5** <20 20-40 40-60 60-80 >80										
Plant cover[1] [2] Percent live, leafy canopy cover of desirables and intermediates is: **1** **2** **3** **4** **5** <50 50-70 70-90 90-95 95-100 Percent live basal area cover of desirables and intermediates is: <15 15-25 25-35 35-50 >50										
Plant diversity[1] The diversity of well-represented forage species is: **1** **2** **3** **4** **5** (Read criteria and select appropriate number)										
Plant residue[1] Ground cover, standing dead forage, or thatch is: **1** **2** **3** **4** **5** (Read criteria and select appropriate number)										
Plant vigor (Read criteria and select appropriate number) Degree of stress of plant community is: **1** **2** **3** **4** **5** (If less than 4, see Causative factors table. Rate those factors)										
Percent legume[1] [3] Percentage of legume present as total air dry weight: **1**: <10, or >60 bloating legume **2**: 10-19, or 40-60 spreading legume **3**: 20-29 **4**: 30-39 **5**: 40-60 no grass loss										
Uniformity of use Degree of spot grazing is: **1**: >50% ungrazed **2**: 25-50% ungrazed **3**: 10-25% ungrazed **4**: Minor species rejection **5**: Urine and dung spots ungrazed										
Livestock concentration areas Presence of livestock conc. areas and proximity to surface water: **1** **2** **3** **4** **5** (Read criteria and select appropriate number)										
Soil compaction Degree of soil compaction is: **1** **2** **3** **4** **5** (Read criteria and select appropriate number)										
Erosion (Always rate sheet and rill; others only if present) Sheet and rill, and gully, streambank, shoreline, or wind erosion is: **1**: Very severe **2**: Severe **3**: Moderate **4**: Slight **5**: No visible										
Pasture condition score										

[1] Pastureland inventory worksheet helpful.
[2] Choose one proper, practical cover type estimation procedure to rate plant cover. The two procedures are not directly comparable.
[3] For warm season grass (C4)-legume stands, use the following criteria: 5, 30-40%; 4, 20-29%; 3, 10-19%; 2, 5-9%, and 1 <4%.

Pasture Condition Score Sheet

	Pasture Unit Description									
Causative Factors Affecting Plant Vigor										
Soil fertility (P & K status)* Phosphorus and potassium status of the soil are: **1 2 3 4 5** (Read criteria and select appropriate number)										
Soil fertility (N status)* Nitrogen status of the grasses is: **1 3 5** (Read criteria and select appropriate number)										
Soil pH* pH status of the soil for the upper 4-inch root zone best fits: **1** ≤ 4.5, or > 9.0 **2** 4.5-5.0, or 8.5-9.0 **3** 5.1-5.5, or 7.9-8.4 **4** 5.6-6.0, or 7.4-7.8 **5** 6.0-7.3										
Severity of use Degree of forage removal is: **1 2 3 4 5** (Read criteria and select appropriate number)										
Site adaptation of desired species Presence of planted or desired forage species is: **1 2 3 4 5** (Read criteria and select appropriate number)										
Climatic stresses Degree of plant stress due to recent weather events is: **1 2 3 4 5** (Read criteria and select appropriate number)										
Insects and disease pressure Degree of plant stress due to insect or disease pressure is: **1 2 3 4 5** (Read criteria and select appropriate number)										

* Rate electrical conductivity and sodium adsorption ratios in regions where appropriate. Where excess salts, exchangeable sodium, or exchangeable aluminum hinder plant growth they are the controlling factor rather than soil pH conditions. Use appropriate criteria for them as found in the National Range and Pasture Handbook under Evaluating and rating pastures, Pasture Condition Scoring. See pH criteria below for highly weathered soils.

Soil pH Criteria for Major Landuse Resource Areas with Oxisols and Ultisols

pH status of the soil for the upper 4" rooting zone best fits:

1	2	3	4	5
< 4.0, or > 9.0	4.0-4.5 or, 7.0-9.0	4.5-5.0 or, 6.5-7.0	5.1-5.5 or, 6.2-6.5	5.6-6.2

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Grazing Stick Instruction Manual

The ability to accurately estimate forage dry matter availability and animal forage dry matter demand is critical in balancing forage plant persistence and animal performance. A grazing stick is a tool that a grazing manager can use to estimate available standing dry matter. As with any tool, taking time to learn how to properly use it will increase the accuracy of the results.

A very basic first step is to understand that forage yields and animal forage demand are expressed in terms of dry matter or "dry matter basis." This simplifies calculations as moisture content of forage will vary according to season, growth stage and species. For example, a 1,100 lb dry cow has a dry matter requirement of approximately 30 lbs/day. If she is grazing a pasture that has a moisture content of 60%, to meet her dry matter demand of 30 lbs, she will consume a total volume of 50 lbs of forage. When moisture is included, this is termed "as-fed" or "as received."


Proper grazing stick use will help you better manage both forages and grazing animals.

Step 1
Determine Pounds Per Acre Inch
A direct relationship exists between inches of forage canopy height and pounds of standing dry matter (lbs/ac). This relationship varies depending on forage species and stand density (Table 1).

Table 1. Estimated Available Standing Dry Matter Pounds Per Acre Inch (lbs/ac in)

Forage	Average Good	Low-High Range
Bermudagrass	235	80-730
Fescue	160	50-265

A more complete table is found on your grazing stick. When measuring canopy height, take several measurements across the area to insure that canopy height is representative of the entire pasture. Measure to the top of the canopy. If the canopy has fallen over, straighten, but don't stretch, the canopy to measure (Figure 1).

Figure 1.
Correct use of the grazing stick to measure canopy height.

Example: A bermudagrass canopy height of 10" and an average good value of 235 lbs/ac in would equal a dry matter availability of 2350 lbs/ac.

To reduce the variation in the range of lbs/ac and calibrate both your eye and the grazing stick, clip random, representative forage samples using a frame measuring 12" x 23". Measure canopy height where forage is clipped. Weigh and record sample weights in grams. Save a sub-sample to determine forage moisture content (see formula on back).

Use the following formulas to determine lbs/ac with a 12" x 23" frame:
Grams wet wt X % dry matter = grams dry weight
Grams dry weight X 50 = lbs/acre
lbs/ac ÷ inches canopy height = lbs/ac in

You may continue to calibrate your eye and the grazing stick throughout the growing season or until you become comfortable estimating % dry matter and stand density. At that point, simply measure canopy height and convert lbs/ac in to lbs/ac.

Step 2
Convert Total Pounds Per Acre to Available Pounds Per Acre

- Total lbs/ac X % utilization = lbs/ac of grazeable forage
- Example: 2,350 lbs/ac bermudagrass X 65% utilization = 1527 lbs/ac available for animals to consume

Percent utilization will vary according to plant species, season and management goals. Introduced forages will generally have higher utilization rates than native forages. The rule of thumb is 65 to 70% for bermudagrass and 25 to 30% for native grass.

Step 3
Determine Animal Intake (Forage Demand)

This is determined by estimating what percent of an animal's body weight it will consume in dry matter in one day. The percentage will vary according to class of animal and forage quality (Table 2). An approximate range is 2 to 4%. A value of 2.5% is most often used.

• 1,100 lb cow X 2.5% intake = 28 lbs of dry matter demand per head per day

Table 2. Grazing Formulas

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

$$\text{Number of Animals} = \frac{\text{lbs/ac DM X Acres X \% utilization}}{\text{(Animal Wt X \% intake) X days}}$$

$$\text{Reserve Herd Days} = \frac{\text{lbs/ac DM X Acres X \% utilization}}{\text{(Animal Wt X \% intake) X No. Head}}$$

Dry Matter Forage Intake as a % of Body Weight

Dry Cow	2 to 3%
Lactating Cow	3 to 4%
Dairy Cow	3 to 4%
Stocker	2.5 to 3.5%
Horse	2 to 3%
Sheep and Goats	3.5 to 4%

Step 4
Putting it All Together

Grazing stick estimate of bermudagrass yield = 2,360 lbs/ac
2,360 X 65% utilization = 1527 lbs/ac available
1,100 lb cow X 2.5% intake = 28 lbs dry matter demand per day
1,527 lbs available/28 lbs demand = 54 days

Your grazing stick has helped you determine reserve herd days. In this example, one acre of bermudagrass will supply grazing for one cow for 54 days.

Determining Forage Dry Matter Using a Microwave Oven

1. Chop forage in 1" to 2" lengths.
2. Weigh out approximately 100 grams (3.5 ounces).
3. Spread forage thinly on a microwave-safe dish and place into microwave.
4. Heat for 2 minutes and reweigh.
   - If forage is not completely dry, reheat for 30 seconds and reweigh. (Microwaves vary considerably in drying capacity. It is better to dry for short intervals and reweigh until the last two weights are constant than to over-dry and run the risk of burning the forage and damaging the oven.) Continue this process until back-to-back weights are the same or charring occurs.
   - If charring occurs, use the previous weight.
5. Calculate moisture content using the formula:

$$\text{\% moisture content} = \frac{WI - W2}{WI} \text{ X } 100$$

- WI = weight of forage before heating
- W2 = weight of forage after heating
- Dry Matter (DM) is the percentage of forage that is not water
- DM equals 100% minus percent water
  Example: moisture content = 14%
  DM = 100-14 = 86%

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AGR-191

UNIVERSITY OF KENTUCKY
College of Agriculture

LEARNING, LABOR, AND SERVICE
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A collaborative publication of Berea College and the University of Kentucky

Using a Grazing Stick for Pasture Management

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Good management of livestock feeding enterprises requires an understanding of feed inventories and their use. Gathering this information is straightforward in grain-based feeding systems because bushels of stored grain are easily measured, and the amount fed per day is determined by the ration and the number of animals.

In pasture systems, however, keeping a forage inventory is more difficult. Feed may be allocated for more than one day, and feed quantity and quality are influenced by weather, fertility, stand density, and season. Not all of the feed available is consumed, and the plants continue to grow after they are grazed. Variation in feed quality and animal production status (pregnant, dry, lactating, growing, etc.) may also influence feed consumption.

This publication is intended to help producers meet animal forage needs in a rotational grazing system by mastering the use of a grazing stick to estimate pasture yield and pasture allocation.

Grazing sticks are useful for making immediate pasture management decisions, but good records of pasture yield, grazing days, and other data will provide a means to evaluate past efforts. Grazing sticks look like a simple measuring device, but are really a measurement system. They include a ruler for measurement, grazing guidelines, and conversion formulas for making immediate pasture management decisions. Grazing sticks are handy tools that simplify measuring pasture yield, allocating pasture to animals, and tracking productivity changes. These tasks are all critical aspects of good pasture management.

Grazing sticks vary somewhat from state to state. The Kentucky model consists of the following, shown on the stick itself:

- A ruler to measure forage height
- A quick guide to start and stop grazing on a paddock
- A table to convert stand density to dry matter per acre-inch
- Formulas for pasture allocation and management decisions
- General guidelines and planning information

Using the Grazing Stick

Yield Estimation

Keep in mind the estimate is only as good as the sample. If the forage stand and the topography are uniform, a minimum of one sample per acre is recommended. Take more measurements for fields with variable soils, topography, or forage stands.

Figure 1. Ruler used to measure height.

Step 1—Use the ruler to measure forage height (Figure 1). With most forages, plant height taller than 18-24 inches is really better suited to hay than to grazing. This is particularly true with endophyte-infected tall fescue, because toxins increase with stem growth and seed head development. See *Sampling Tall Fescue Endophyte in Pasture or Hay Stands* (PPA-30) for more information on dealing with infected tall fescue.

Height is not a measure, but rather an average, of the tallest plants. Spread your hand and lower it onto the canopy. The average height is measured at the point where you feel very modest resistance from the plant canopy. In Figure 1, the height is 7 inches. Record the height for each sample location in the pasture and then calculate the average height for the pasture.

Step 2—Stand density is the amount of the ground surface covered with standing forage. Your goal is to place the pasture into one of three density categories (less than 75%, 75 to 90%, or more than 90%).

Visually estimate stand density by looking directly down at each location where you have just measured canopy height. Do not include ground residue, only plant material tall enough for the livestock to consume. Stand density measurements using the grazing stick are most accurate when canopy height is approximately 8 inches.

Record the density reading for each location, then calculate the average stand density for the pasture. The density yield table (Table 1) can now be used to estimate forage yield per acre-inch. The table is more accurate with denser stands.

Step 3—Determine the dry matter (DM) yield per acre-inch using the density measured in Step 2. For example, if you are measuring a tall fescue pasture and you estimate that the available forage covers 85% of the ground area, this pasture would be assigned to the middle density category of 75 to 90% cover. According to Table 1, this density rating would be between 150 and 200 lb of DM per acre-inch. Based on your assessment of the stand, assign a yield. The thicker the stand, the closer the yield will be to the upper end of the range. Since 85% is in the upper end of this density category, 200 lb of DM per acre-inch would be a good estimate. If the average stand height is 8 inches and you want to maintain 3 inches of stubble after grazing, available forage equals:

5 inches x 200 lb/acre-inch = 1,000 lb DM/acre.

Step 4a—Calibration (quick estimate): A periodic check of your measurements can help you be consistent in using the grazing stick. Harvest 1 square foot of forage (cut at soil level), weigh it in grams, and multiply it by 20. This calculation will give an estimate of lb per acre assuming the forage is 20% DM. While this method is useful for a quick check, the DM content of forage does vary throughout the year, so the yield estimate will be more accurate if the sample is actually dried.

Step 4b—Calibration (better estimate):

1. Harvest 1 square foot of forage (cut at soil level) and chop the forage into 1- to 2-inch lengths.
2. Weigh the forage (in grams) then place it on a microwave-safe dish. Place the dish in a microwave oven along with a cup of water, which helps reduce the risk of burning the forage.
3. Heat on high for two minutes.
4. Weigh the forage.
5. If the forage is not dry, place it back in the oven and heat it for 30 seconds more.
6. Repeat steps D and E until the weight does not change. If the forage is charred, use the last weight.
7. Multiply the dry weight in grams by 100 for an estimate of dry matter yield in lb per acre.

Table 1. Estimated dry matter yield per acre inch based on density and forage type.

	Density		
	<75%	75-90%	>90%
Forage	Dry Matter Yield (lb)		
Tall fescue or orchardgrass	50-150	150-200	200-300
KY Bluegrass	50-100	100-175	175-250
Cool-season grass (clover)	50-125	125-200	200-275
Bermudagrass	100-200	200-300	300-400
Alfalfa	75-150	150-225	225-300
Red clover	75-125	125-175	175-250

Allocate Forage

Your pasture system will determine how you apportion forage for your animals. If you are using temporary electric fencing and allocating acreage to feed your animals for a specific number of days, you will need to calculate the acres needed per day. If you have a slow rotation with modest-sized paddocks, you will have to determine how many days a particular paddock will carry your herd. If you can vary animal numbers to fully utilize your available pasture, you will have to determine how many animals are required. Each situation will require you to estimate yield and to make the appropriate allocation. In addition to forage yield, the formulas for calculating pasture allocation require values for percent utilization (Table 2), animal weights, and animal intake (Table 3).

Table 2. Percent utilization of available forage based on grazing system.

System	Utilization
Continuous	30-40%
Slow rotation (3-4 paddocks)	40-55%
Fast rotation (8+ paddocks)	55-70%

Source: The Kentucky Grazing Stick.

Table 3. Forage intake guidelines.

Livestock Class	Dry Matter Intake as Percent of Body Weight
Dry beef cow	2
Lactating beef cow	3-4
Lactating dairy cow	2.5-5*
Stockers	2.5-3.5
Horses	2.5-3
Sheep & Goats	3.5-4

*May include grain.

Utilization is defined as the percent of the available forage that animals consume. Utilization rates vary with the intensity of the grazing system (Table 2).

Animals will only use 30-40% of the forage on a continuously grazed pasture because they have excess forage and graze selectively. The forage they do not eat may become mature and unpalatable. In addition, much of the available forage becomes waste because it is trampled or fouled with dung or urine.

With pasture rotation, the grazing period is shortened, animals cannot be as selective, and less forage is wasted (Table 2). With a slow rotation (three to four paddocks, animals moved every seven to 10 days), the utilization increases to 40-55%. A faster rotation will increase utilization to 55-70%. It is possible to achieve higher utilization (70-80%) with intensive rotational systems (animals moved once or twice a day).

Livestock species, class, and physiological condition all have profound effects on intake (Table 3). Forage intake may also be influenced by the stage of plant growth. Mature plants are a low-quality feed because they have high fiber content. Fiber digests slowly and limits the amount an animal can consume. See American Farm Bureau publication *Understanding Forage Quality* (pub. no. 1-01) for more detailed information. Lactating dairy cows need a high level of nutrition to maintain high levels of milk production and, as indicated in Table 3, some supplementation with grain may be necessary to provide sufficient intake for these animals.

Pasture Allocation Examples Using Formulas from the Grazing Stick

Calculate: The paddock size needed to feed a set number of animals.

Example 1: 100 dry cows, average weight 1,350 lb.

Acres required/paddock =

$$\frac{(\text{weight}) \times (\text{intake in \% body weight}) \times (\text{animal \#}) \times (\text{days/paddock})}{(\text{available DM/acre}) \times (\text{\% utilization})}$$

Step 1—Animals will be moved every three to five days in an eight-paddock system, so utilization is estimated to be 60% (Table 2).

Step 2—Set intake—because they are dry cows, use 2% (Table 3).

$$\frac{(1{,}350\ \text{lb/cow}) \times (0.02/\text{day}) \times (100\ \text{cows}) \times (4\ \text{days})}{(1{,}000\ \text{lb/acre}) \times (.60)}$$

= 18 acres

Calculate: The number of animals needed to utilize the available forage.

Example 2: The paddock size is 20 acres and the grazing period is 4 days.

\# of animals required to graze a paddock =

$$\frac{(\text{DM/acre}) \times (\text{acres}) \times (\text{\% utilization})}{(\text{animal weight}) \times (\text{intake in \% body weight}) \times (\text{days})}$$

$$\frac{(1{,}000\ \text{lb/acre}) \times (20\ \text{acres}) \times (.60)}{(1{,}350\ \text{lb}) \times (0.02/\text{day}) \times (4\ \text{days})}$$

= 111 cows would be needed to graze these pastures down in 4 days.

Calculate: The number of days a paddock will last.

Example 3: A herd of 100 cows on a fast rotation.

Days of grazing per paddock =

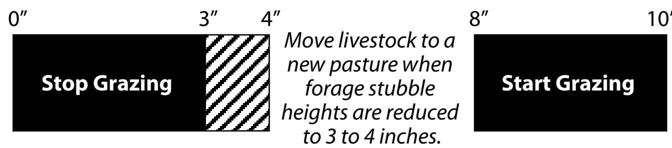
$$\frac{(\text{DM/acre}) \times (\text{acres}) \times (\text{\% utilization})}{(\text{animal weight}) \times (\text{intake in \% body weight}) \times (\text{\# animals})}$$

$$\frac{1{,}000\ \text{lb/acre} \times 20\ \text{acres} \times .60}{1{,}350\ \text{lb} \times 0.02/\text{day} \times 100\ \text{cows}}$$

= 4.4 days

The grazing stick also has a quick guide (Figure 2). If you carry the stick with you whenever you check animals or move fences, you can quickly assess pasture regrowth and readiness for grazing. The suggested starting height for grazing cool-season grasses is 8 to 10 inches, which ensures that forage is in a high-quality vegetative stage. The stop-grazing limit applies to grass or grass-legume pastures. The 3- to 4-inch stubble height ensures that some leaf tissue is available for grass regrowth. Removal of basal leaves will slow grass regrowth and limit yield. If pastures are growing quickly in the spring, you may need to harvest or clip them to keep them productive and in high-quality condition.

Figure 2. Quick grazing guide.



The guidelines for grazing vary according to the plant species (Table 4). For example, grazing is normally delayed until bud stage for alfalfa so that the plants can restore root reserves that were used in regrowth. Consistently grazing forages before the indicated height or stage may thin the stand. Overgrazing so that too little stubble remains after grazing may limit pasture yield because the plants will not have enough leaf tissue for photosynthesis and rapid growth. Rest periods and forage removal must be carefully balanced to keep pastures productive. One of the best ways to achieve this balance is by frequently observing pastures and the amount of pasture regrowth. In spring, pasture growth is often too rapid for optimum grazing, so rotations may need to be accelerated to maintain good pasture quality. In summer, cool-season plants grow more slowly, and the rotations may need to be slowed to allow full recovery from grazing. When planning grazing systems, you can calculate the number of paddocks necessary to provide a desired rest period.

Number of paddocks =

$$\frac{(\text{days of rest})}{(\text{days of grazing})} + 1$$

Table 4. Guidelines for Optimum Grazing Height (in inches).

Forage	At Beginning of Grazing	At End of Grazing
Cool-season grasses and legumes other than alfalfa	8-10	3-4
Alfalfa	Bud stage	2-3
Annual warm-season grasses	20-24	8-10
Native warm-season grasses	18-22	8-10
Bermudagrass	6-8	1-2

Good Record Keeping

You'll find the grazing stick a handy tool, but keep in mind that it provides only an estimate of pasture yield. You can improve your grazing system with good records of pasture yield, grazing days, and other data because they allow you to evaluate past efforts. If you keep good records and compare yield estimates with data from actual grazing days, you will be able to more closely calculate the actual yield for your farm and your conditions.

Grain producers determine the number of inputs to use based on the yield they will gain from each one. Because inputs and the resulting yield are easily measured, grain production systems can be quickly refined and improved. Good pasture records are slightly more difficult to collect, but they can also contribute to rapid improvement of pasture systems. One objective of pasture improvement is to increase yield, but changes in pasture management may also target herbage quality, yield distribution, or persistence. Pasture improvement may result in improved gains, increased carrying capacity, or reduced need for supplementation during summer months. Records help a manager place a value on improvements and make decisions on where to spend limited resources to maximize the benefits. These improvements are not necessarily obvious unless producers keep good records and study them.

More specific information about grazing, pasture management, and forage species is available in UK Cooperative Extension publications such as *Rotational Grazing* (ID-143). A list of recommended publications is included at the end of this document.

All your record information should be entered in a timely manner and regularly reviewed. It should include record year, paddock identification, paddock size, monthly rainfall, date and amounts of fertilizer, seed and pesticide inputs, and the most recent soil test data. In addition, each time a paddock is grazed, record the number and average size of animals, dates in and out, pasture height at the beginning and end of grazing, and yield estimate and stand density at the start of grazing.

Using Your Records for Planning

Records must be studied. Some people diligently keep records and file them at the end of the season. It will take some work to compile records into a form that you can use efficiently, but this effort is worthwhile. If you are going to keep records, commit yourself to using them.

Here are a few questions that might be answered by studying your pasture records:

- How much did legumes increase animal grazing days per acre during the summer?
- How much did fertilizer improve animal grazing days per acre?
- Which pastures and forages performed best in a dry year?
- How severe is the summer slump? Do you need to increase production during this period?
- Are your pastures improving or declining? Do you need to increase or decrease stock density to improve your pastures?
- Did your stockpile run out before spring growth began? How many more acres of stockpile do you need to support the herd? Can you fill gaps in forage production by grazing crop residues?
- Did your pasture management improvements result in reduced costs, increased carrying capacity, or better gains?

The following is a selection of the publications on forages and grazing available online at www.uky.edu/Ag/Forage/ForagePublications.htm or from your extension agent.

AGR-59—*Tall Fescue*

AGR-85—*Efficient Pasture Systems*

AGR-108—*Tall Fescue in Kentucky*

AGR-119—*Alternatives for Fungus Infected Tall Fescue*

AGR-162—*Stockpiling for Fall and Winter Pasture*

AGR-175—*Forage Identification and Use Guide*

ID-74—*Planning Fencing Systems for Intensive Grazing Management*

ID-97—*Grazing Alfalfa*

ID-143—*Rotational Grazing*

AE 2005-04—*The Economics of Renovating Pastures with Clover*

AE 2005-05—*The Economics of Using Improved Red Clover Varieties*

AE 2005-06—*The Economics of Pasture Fertilization*

PPA-30—*Sampling for the Tall Fescue Endophyte in Pasture or Hay Stands*

Tall Fescue Endophyte Concepts—Don Ball et al., 2003, Oregon Tall Fescue Commission, Spec. pub. No. 1-03

Understanding Forage Quality—Don Ball et al., 2001, American Farm Bureau pub. No. 1-01

Additional Useful References

Ball, D.M, C.S. Hoveland, and G.D. Lacefield. 2002. Southern Forages. 3rd ed., Potash and Phosphate Institute, Norcross, GA 30092.

Determining Forage Moisture Content Using a Microwave Oven

UGA extension — GRASS

Meeting Evaluation:
2015 Georgia Grazing School

Return to Dr. Dennis Hancock, Extension Forage Agronomist

Overall, how helpful was this meeting? (Check ONE).

- ☐ I plan to make some major changes.
- ☐ I might try a few things differently.
- ☐ Got me thinking, but that's about all.
- ☐ Total waste of time.

During this training, what percentage of the time were you saying to yourself…?

I knew that already! (i.e., it was too simple).	
That was new to me and I understood the idea!	
You lost me on that! (i.e., that was over my head)	
Must Total	**100**

How likely is it that you would recommend our company/product/service to a friend or colleague?

Extremely likely	10	9	8	7	6	5	4	3	2	1	Not at all likely

In general, how do you rate the content of this training? (Circle a number)

Better than I expected	5	4	3	2	1	Not as good as I expected
Good style & delivery	5	4	3	2	1	Poor presentation style & delivery
Well-organized	5	4	3	2	1	Totally unorganized
Too much information	5	4	3	2	1	Too little information

How did this workshop change… (Circle a number)

Your knowledge?	Greatly Improved	5	4	3	2	1	No change
Your interest in this topic?	Greatly Improved	5	4	3	2	1	No change
Your confidence in using these skills?	Greatly Improved	5	4	3	2	1	No change

As a result of this meeting, what do you plan to do differently in your operation? How has this workshop helped you?

If you could add one topic to the Georgia Grazing School agenda, what would it be and why?

Was there any topic that should have been left off the agenda?

(Do the back side, too!)

Please rate the effectiveness of each of the instruction modules and activities.

Module/Activity	*Excellent*	*Very Good*	*Good*	*Fair*	*Poor*
Manipulating forage growth and grazing behavior: the essence of rational grazing	5	4	3	2	1
Southern Forages: Yield, distribution, and quality	5	4	3	2	1
Soil fertility and nutrient cycling in grazing systems	5	4	3	2	1
Managing, utilizing, and maintaining legumes	5	4	3	2	1
Grazing systems, methods, and tricks	5	4	3	2	1
Segregating herds based on animal class and nutritional need	5	4	3	2	1
Optimizing the size, number, and layout of your paddocks	5	4	3	2	1
Managing forage surplus and deficits	5	4	3	2	1
Choosing the right fence, fence charger, and wire or tape for your grazing system	5	4	3	2	1
Selecting the right watering system and sizing the water supply for your grazing system	5	4	3	2	1
Economics of Better Grazing Management	5	4	3	2	1
Cost-assistance programs that aid the transition	5	4	3	2	1
New weed management tools for grazed pastures.	5	4	3	2	1
Demonstrations and farm exercises	5	4	3	2	1
Good Grazing Management Made the Difference on My Farm	5	4	3	2	1
Extending the grazing season and critically evaluating novel grazing systems	5	4	3	2	1
Sketching Out the Ideal: Planning the Grazing System	5	4	3	2	1
Weeds are Great Forage. Teach Your Livestock to Eat Them	5	4	3	2	1

Other Comments:

Thank you for joining us for the 2015 Georgia Grazing School!